Biosphere Assessment
within the Context of Disposal of Radioactive Waste in Switzerland

Aspects of Dealing with Environmental Change

IAEA EMRAS II / WG 3 Interim Meeting

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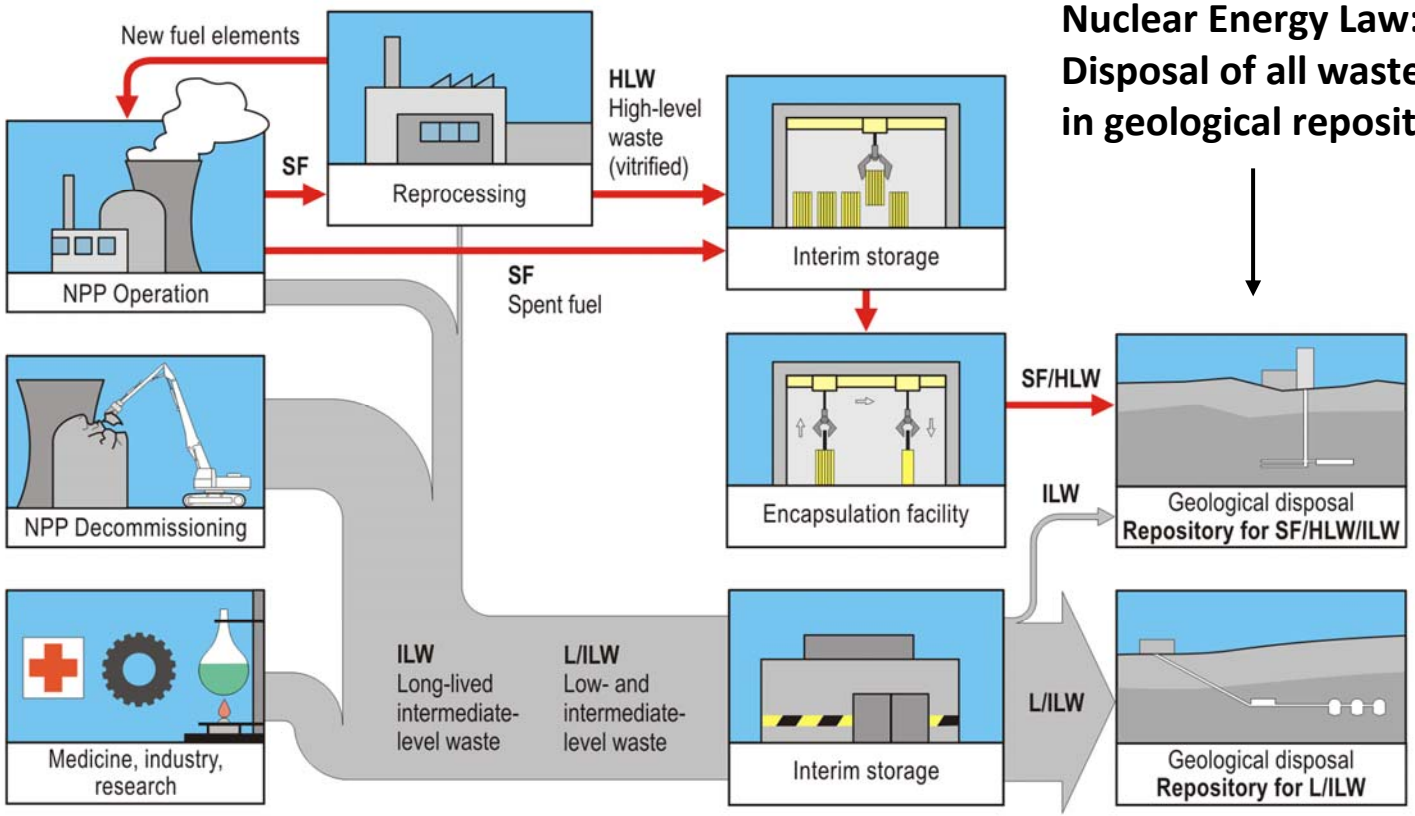
Swiss waste management concept



Nuclear Energy Law:
Disposal of all waste types
in geological repositories

- Spent fuel (SF) & vitrified high-level waste (HLW) ➔ HLW repository
- Long-lived intermediate-level waste (ILW) ➔ HLW repository (co-disposal)
- Low- and intermediate-level waste (L/ILW) ➔ L/ILW repository

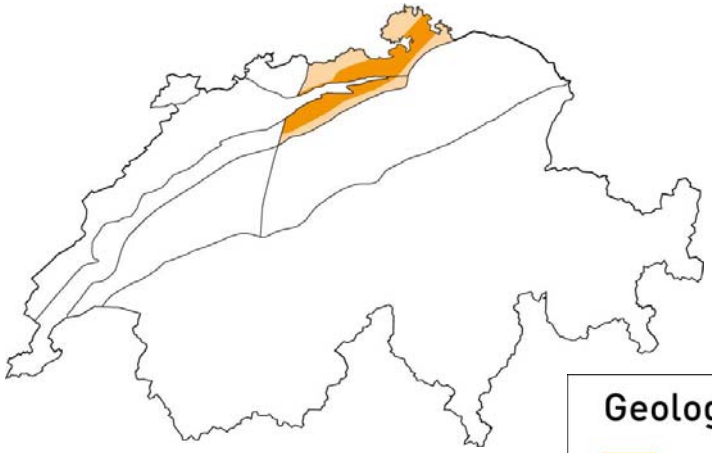
Swiss site selection plan (1)

- The Federal Government (**Federal Office of Energy**) is taking a **leading role** in the site selection process in Switzerland
- The site selection procedure was developed following a broad **participatory process** → Sectoral Plan
- Sectoral Plan issued on April 2, 2008, by the **Federal Government**
- **Stakeholder participation** and the roles of the stakeholders are **clearly defined** in the Sectoral Plan
- According to the Sectoral Plan, site selection follows a **stepwise process** (3 stages, see following slide)
- Afterwards: **general licence procedure**
  - preparation of documentation by implementer
  - authority review
  - government decision
  - ratification by parliament
  - facultative national referendum

Swiss site selection plan (2)

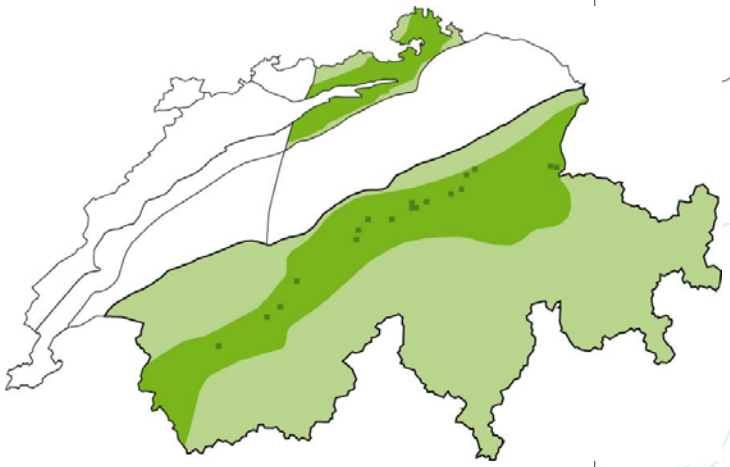
- **Part 1**: **Concept (published April 2008 by Swiss Federal Office of Energy)**
  - Aims, boundary conditions
  - Procedure (steps, role & responsibilities of stakeholders, products)
  - Criteria (safety & feasibility, land use planning & socio-economic issues)
- **Part 2**: **Implementation**
  - **Stage 1 (2.5 a)**: identification of potential **siting regions**
    focus: long-term safety & engineering feasibility → **geology**
  - **Stage 2 (2.5 a)**: identification of **sites for surface infrastructure** within potential siting regions & selection of ≥ **2 siting regions** for more detailed evaluation; focus for sites: land use planning & environmental impact (sites); "provisional safety analyses" for all siting regions → **sites for surface infrastructure & siting regions (safety)**
  - **Stage 3 (2.5 – 4.5 a)**: field investigations & selection of **1 site**;
    → **preparation of a safety case** for the repository at the selected site for the general licence application

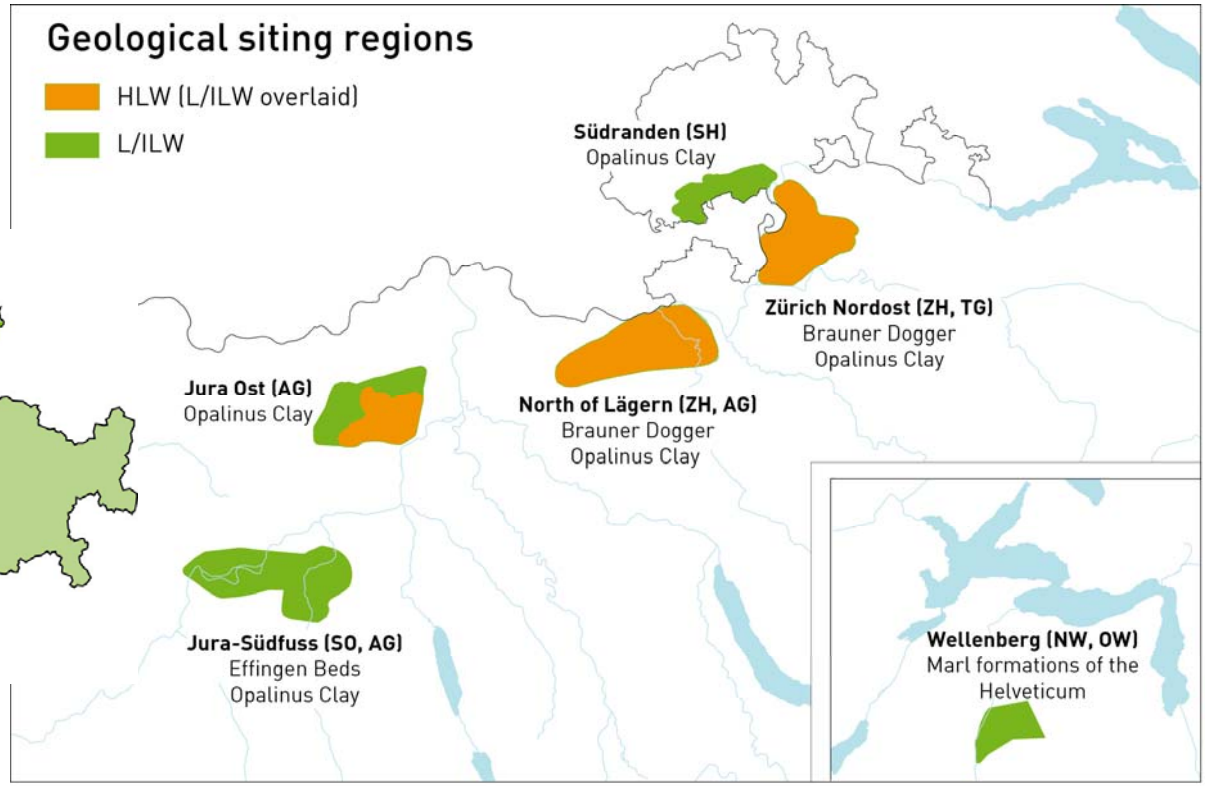
Sectoral Plan/Stage 1: Geological Siting Regions



Host rocks

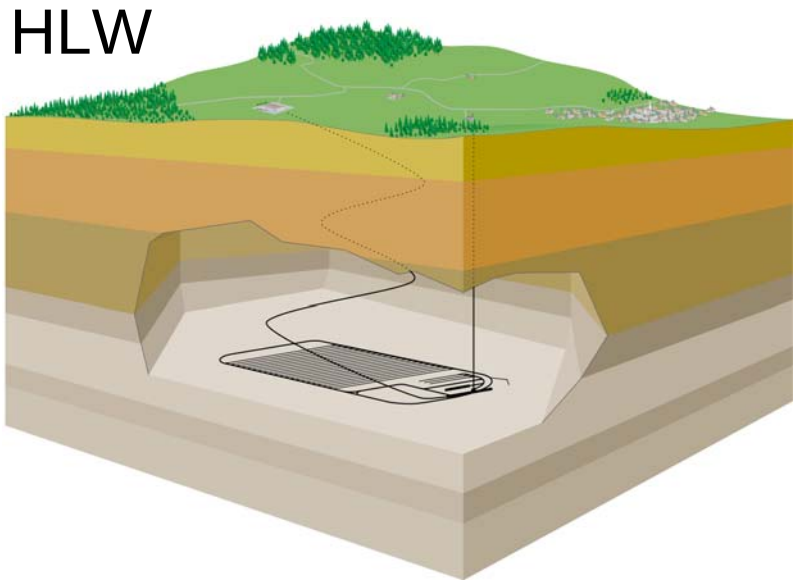
- **HLW**: Opalinus Clay
- **L/ILW**: Opalinus Clay, 'Brauner Dogger', Effingen Beds, marl formations (Alps)



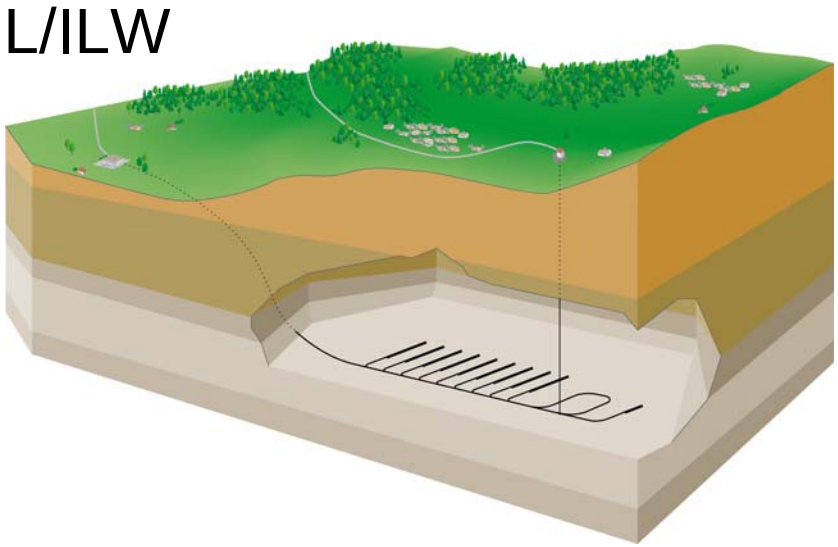


Geological repositories

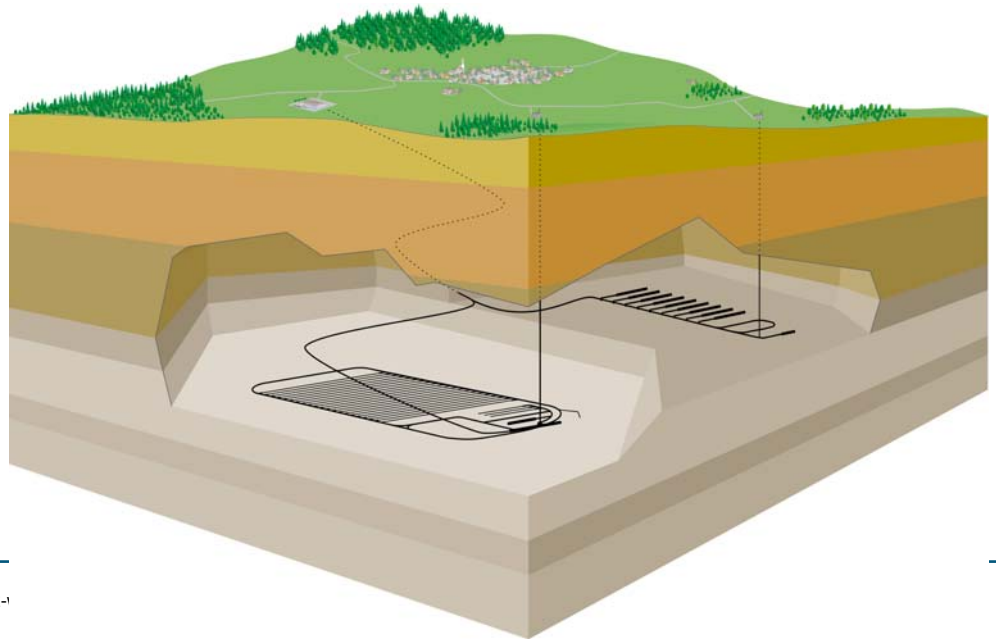
HLW



L/ILW



Option for a "combined repository"



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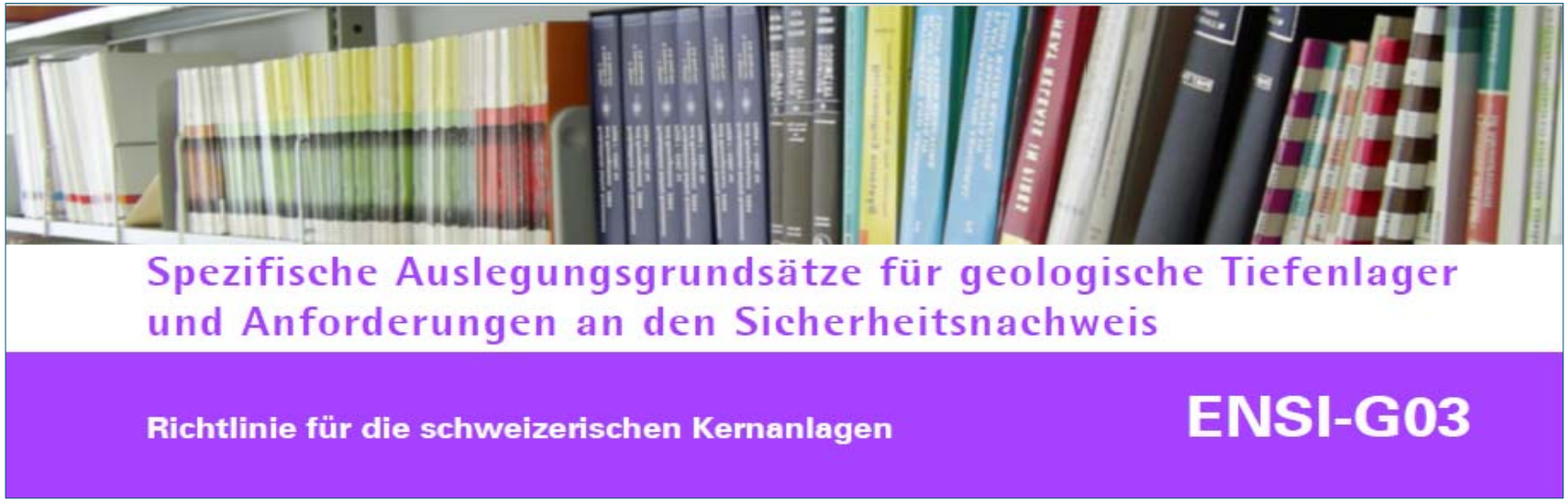
ENSI Guideline G03

- The Federal Nuclear Safety Inspectorate (ENSI) is the regulatory authority for nuclear safety and security in Switzerland.
- ENSI issues guidelines in its capacity as regulatory authority.
- Guidelines are support documents that formalise the implementation of legal requirements and facilitate uniformity of implementation practices. They reflect the current status of science and technology.



Two protection criteria (G03)

- “For each future evolution of a sealed repository classified as likely, the release of radionuclides may not lead to an individual dose exceeding 0.1 mSv per year.”

- “Future evolutions classified as less likely that are not considered under protection criterion 1 may not, taken together, constitute an additional individual radiological risk of health detriment exceeding one in a million per year.”

Application of protection criteria (aspects, G03)

- Protection criteria relate to the radiation exposure of an **average individual** within the population **group most affected** by the potential impacts of the repository.
- Calculations of radiological impacts in the **distant future** are **not** to be understood as predicted **radiation exposures** for a definable population group, **but** rather as **indicators** for evaluating potential radionuclide release to the biosphere.
- In time periods when **human settlement** at the surface within the area of influence of the geological repository can be temporarily **ruled out**, the release from the repository **must nevertheless not exceed the limits** set out in protection criteria 1 and 2. For these periods, the presence of humans in a reference biosphere is to be assumed.

Demonstrating safety – for how long?

- For a period **up to one million years**, it has to be shown as part of the safety case that the protection criteria can be met. For longer time periods, the **range of variation** of the potential regional radiological impacts from the repository has **to be estimated** taking into account inherent uncertainties. These impacts may **not** be significantly **higher than natural radiological exposure**.
- The influence of **uncertainties** on the calculated results has to be shown systematically and the **conclusions for long-term safety** presented.

ENSI-G03

- Time period for assessment as proposed by Nagra in the documentation for stage 1 of the sectoral plan
  - for HLW repository : 10^6 years
  - for L/ILW repository : 10^5 years

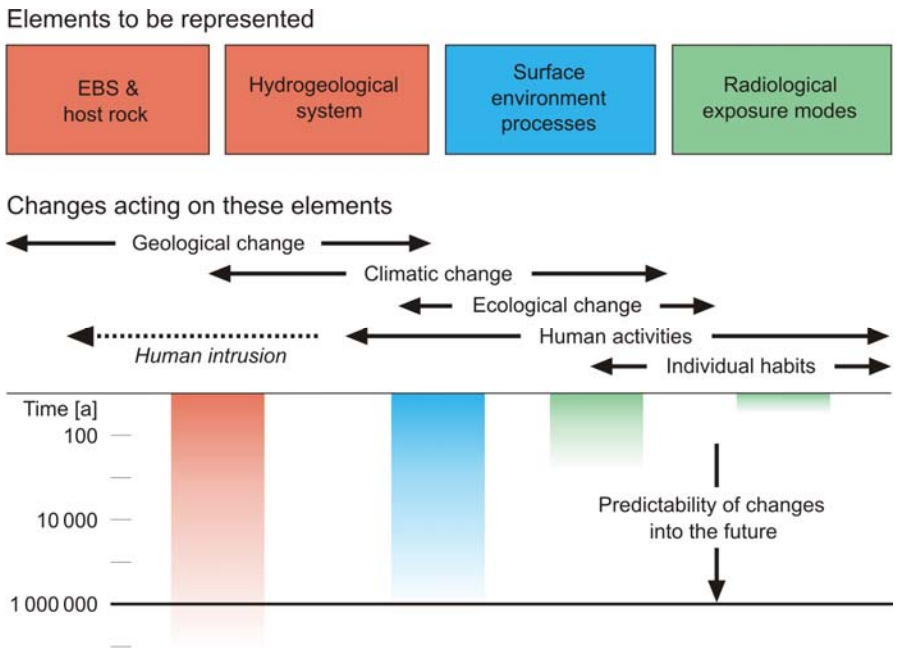
Sectoral Plan

Aspects of dealing with uncertainties (G03)

- possible variants for **climate evolution** and biosphere models to be defined and investigated
- scenarios in which the underground disposal area is increasingly exposed to surface influences as a result of **geological processes** to be considered
  - e. g. deep glacial erosion
- scenarios in which the safety of the repository is influenced by **human activities** are to be handled in a way that appears credible from the perspective of present-day society.

Environmental conditions in time and space

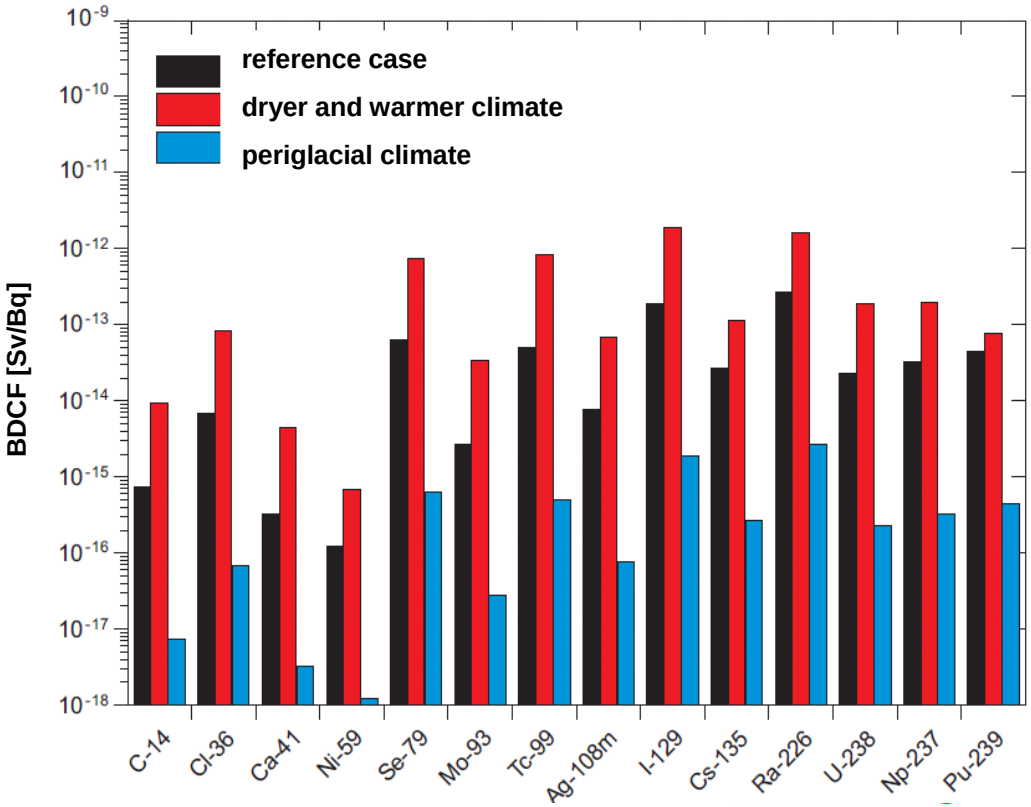
- very long time frame → environmental conditions change (climate, hydrology, geomorphology)



- different possible exfiltration areas in central and northern Switzerland to be considered for 6 candidate regions
  → different present conditions and possible future evolutions

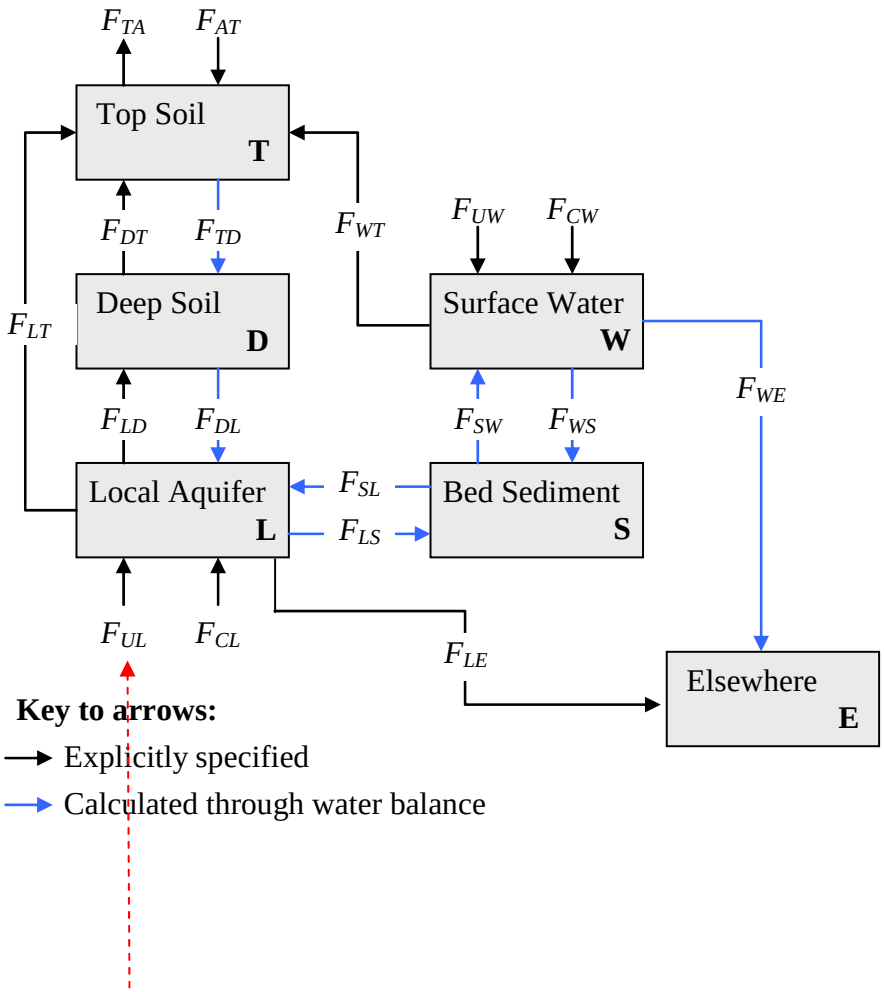
How the comparison is technically done

- Assessing impact of environmental change by comparing resluts of different models (i.e. Biosphere dose conversion factors/BDCF = dose response to a constant unit release of radionuclides to the biosphere)
- Example: Results for different climate conditions (today's reference climate, dryer & warmer, periglacial)

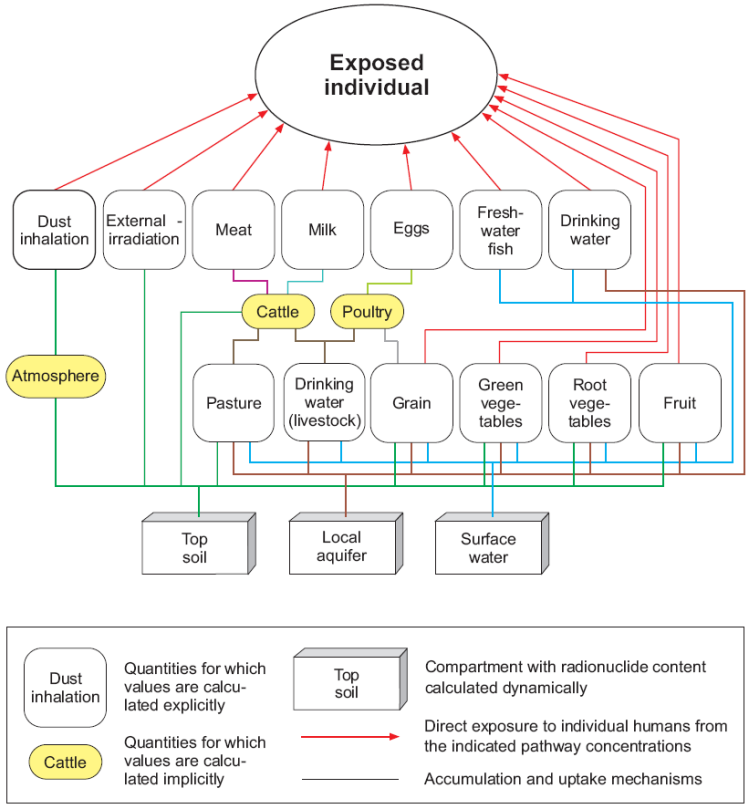


Model structure (TAME/SwiBAC)

sub-model for transport

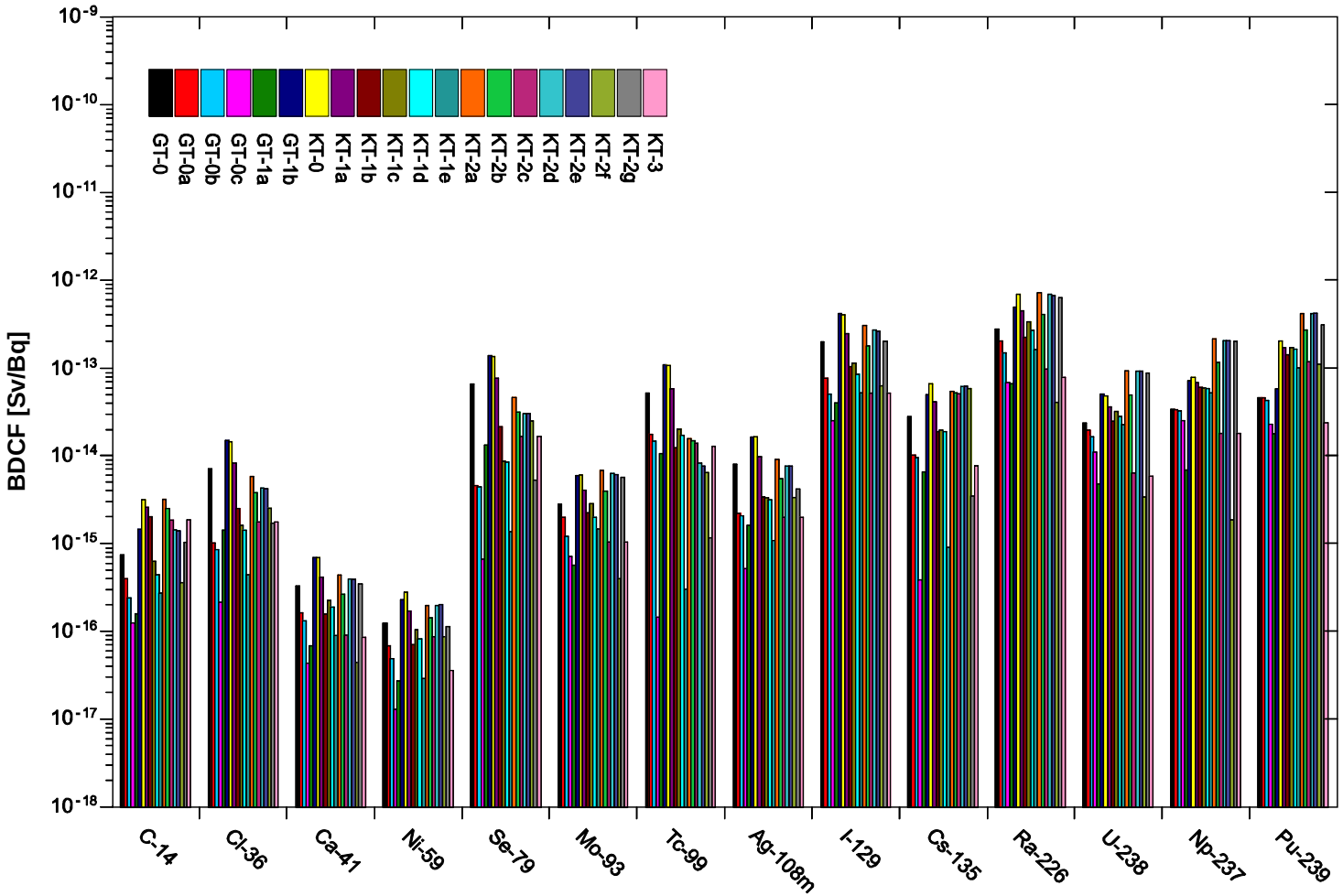


sub-model for exposure



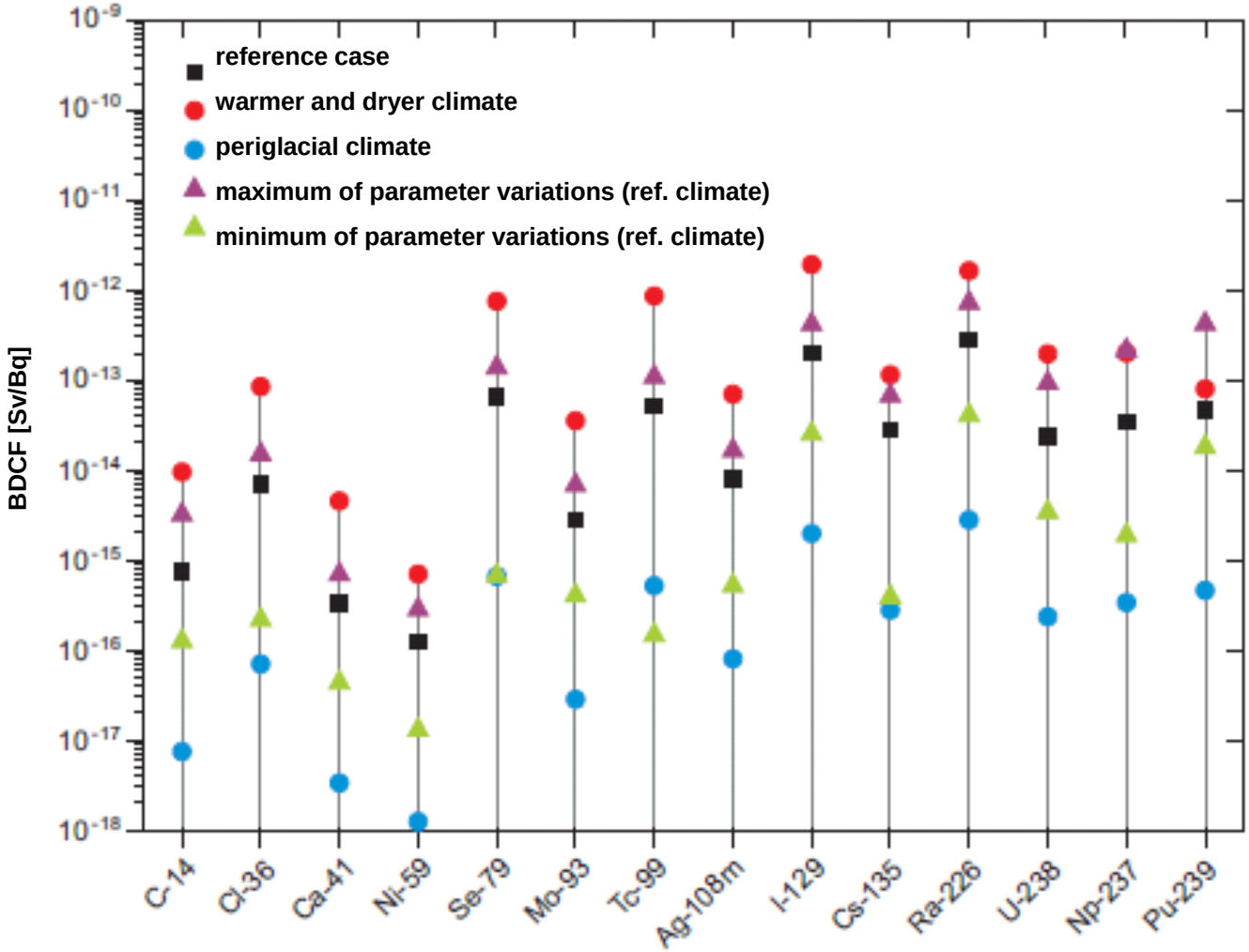
Ground water inflow is one of the most important parameters

Impact of local hydrology



The uncertainties concerning the future evolutions of local hydrology are larger than the variation in hydrology between different geological siting areas (F_{UL} varied between 1E5 and 1.1E7 m^3/a).

Impact of climate vs. different local conditions



Changing climate conditions for the reference setting show for almost all radionuclides a larger impact than variation of local conditions.

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Summary

- assessing changing environmental conditions is a requirement (ENSI-G03)
- impact of changing geomorphology to be assessed wrt to the specific exfiltration area (ENSI 33/115; mainly for HLW-sites)
- taking account of environmental change as a function of time for a given exfiltration area bounds the effects of considering different exfiltration areas for the six geological siting regions proposed by Nagra in stage 1 of the Sectoral Plan

thank you
for your attention

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