Focus On Isolation And Confinement Rather Than On Potential Hazard: An Approach To Regulatory Compliance For The Post-Closure Phase

Bruno Baltes, Angela Becker, Anke Kindt,
Klaus-Jürgen Röhlig

Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH Köln, Germany

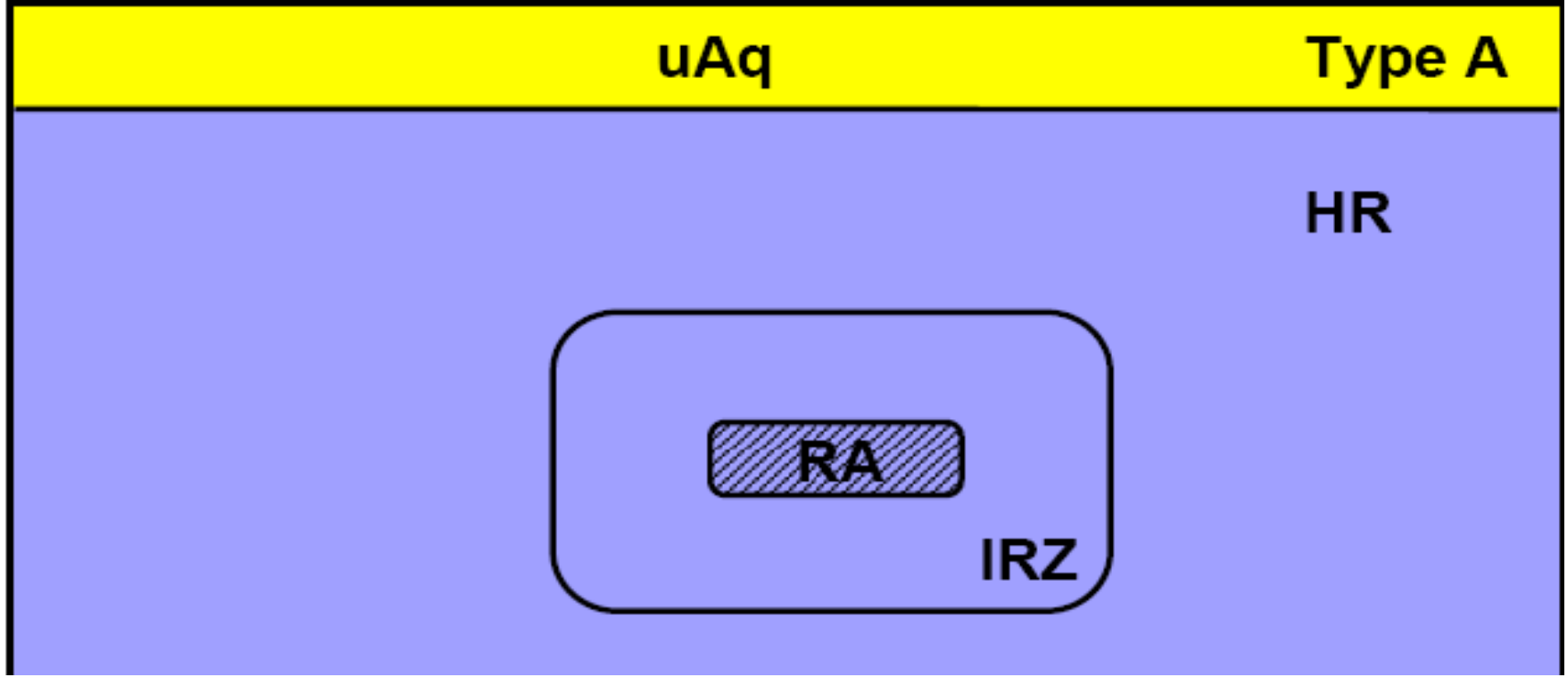
Outline

- Current regulations and ongoing revision of Safety Criteria
- Regulating for long-term safety: Constrained optimisation in course of stepwise approach
  - Role of the isolating rock zone
  - Requirements: Elements of the Post-closure Safety Case
  - Role of assessment calculations & calculated results
    - A set of indicators orientated on safety functions
  - Discussion & open issues

Current regulations and ongoing revision of Safety Criteria

- Safety criteria for underground disposal (BMI 1983)
- License submission in form of “Planfeststellung” = plan approval:
  - In principle a one-step procedure. Procedure might last over whole project.
  - “Concentrating effect” for several fields of law
- Need to update technical criteria according to state-of-the-art (Safety Case, WS-R-4)
- Desire to implement stepwise repository development and, accordingly, stepwise development of Safety Case
  - Constrained optimisation (ICRP-81, WS-R-4) as central approach
  - Challenge: consistency with current legislation?

implications



Rock body without safety-relevant barrier effect

Rock body with safety-relevant barrier effect

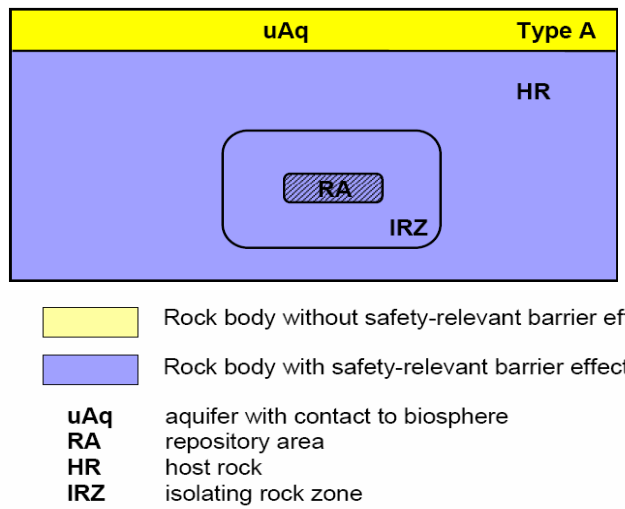
uAq	aquifer with contact to biosphere
RA	repository area
HR	host rock
IRZ	isolating rock zone

The isolating rock zone

- Based on AkEnd (Committee on a Site Selection Procedure for Repository Sites) ideas: It is possible to identify sites …
  - the evolution of which can be predicted over at least 10^6 years
  - where an “isolating rock zone” can be found which will maintain its crucial properties (conductivity, thickness, extent, …) over this timeframe

➢ Implications for safety concept: emphasis on geologic barrier (but challenge concerning sealing components!)

➢ Implications for optimisation process: optimisation becomes meaningless for times beyond timeframe of predictability



Requirements: Elements of the Post-closure Safety Case

- Evidence: necessary scientific & technical skills & knowledge
- Implementation of Safety Concept & Safety Management – Arguments from planning, layout, assessments based upon:
  - Site characterisation
  - Geoscientific long-term prognosis
  - Characterisation & long-term prognosis of technical barriers
  - Demonstration of sub-criticality
  - Quantitative PA: Safety Functions – confirmation of Safety Concept
  - Demonstration of adherence to Safety principles & Protection Objectives: Safety Analyses – Uncertainty Management – Robustness – Isolation capability
  - Evaluation of performance & safety: indicators

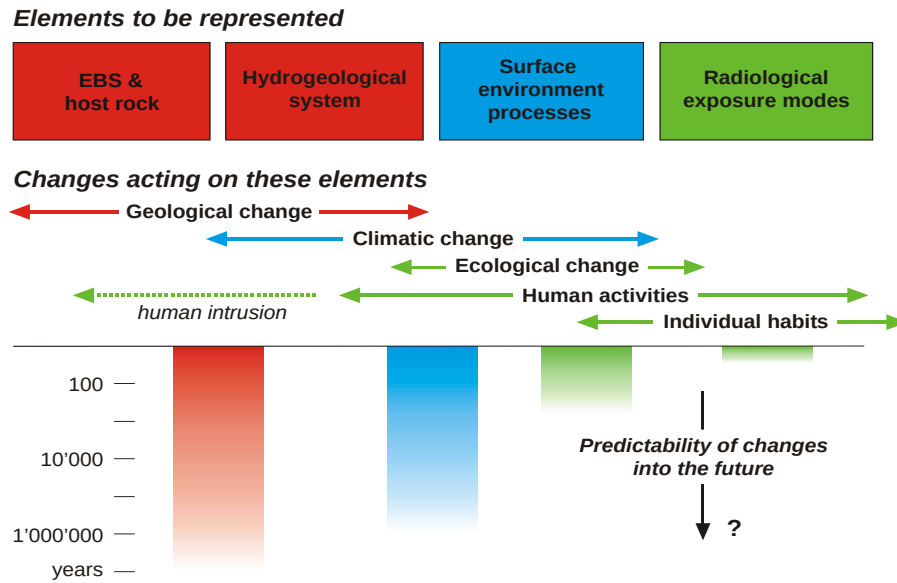
Role of assessment calculations & calculated results, i.e. potential consequences

- Important line of arguments
- Comparison of (radiological) results with regulatory limits / targets / constraints → ICRP
- But:
  - How reliable are the results?
    [ICRP: “No predictions, indicators …”]
  - How can we know that
    “needs and aspirations of future generations” (Joint Convention) are met?
  - How can we know that the (non-human) environment is protected?
  - How to address the “regulatory dilemma”:
    timeframe of hazard vs. timeframe of predictability?

  (Questions being asked e.g. by NEA/RWMC’s LTSC)

Completeness of confinement

- Confinement is considered to be complete if for likely scenarios consequences from released radionuclides do not cause significant increase of consequences from natural conditions
- Assessment calculations – reliability of results …



Elements to be represented

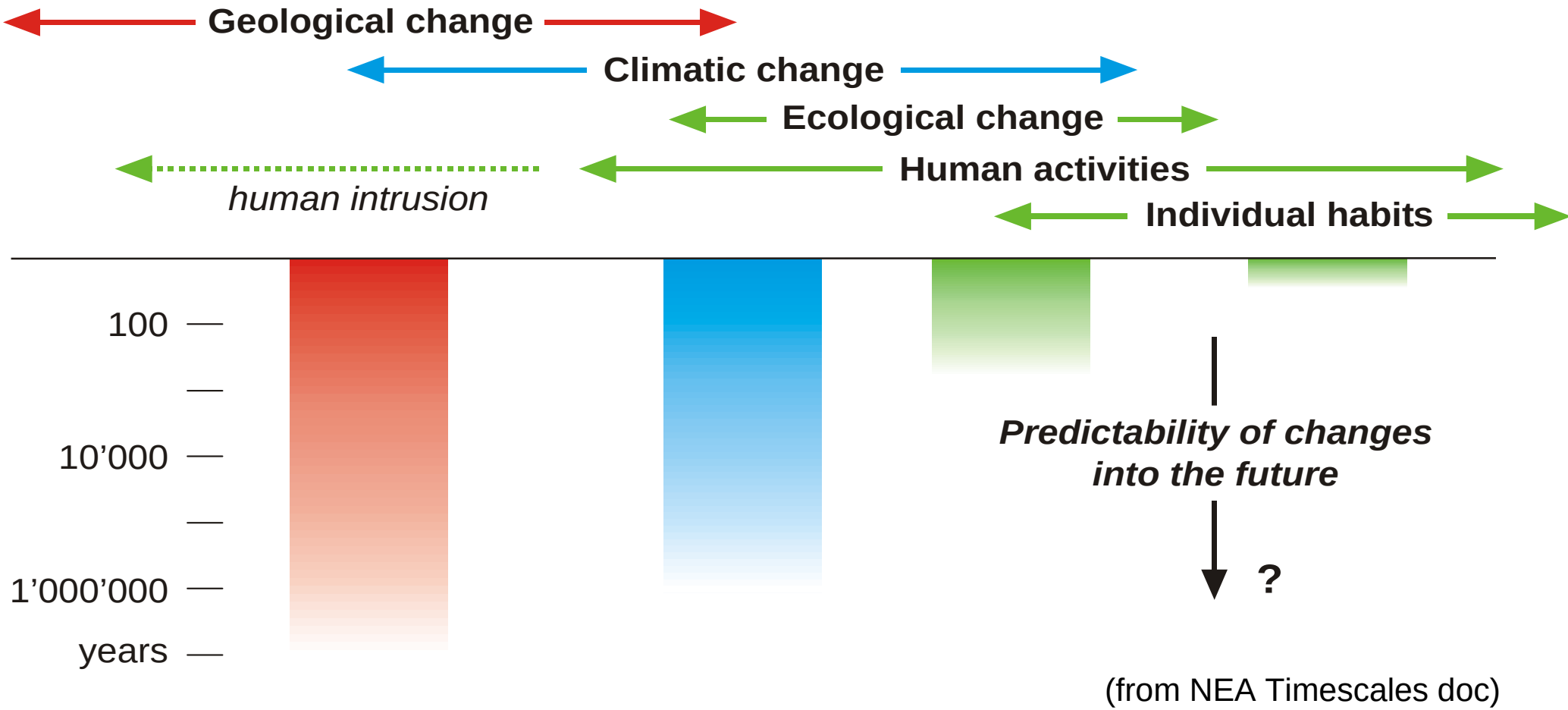
EBS & host rock

Hydrogeological system

Surface environment processes

Radiological exposure modes

Changes acting on these elements

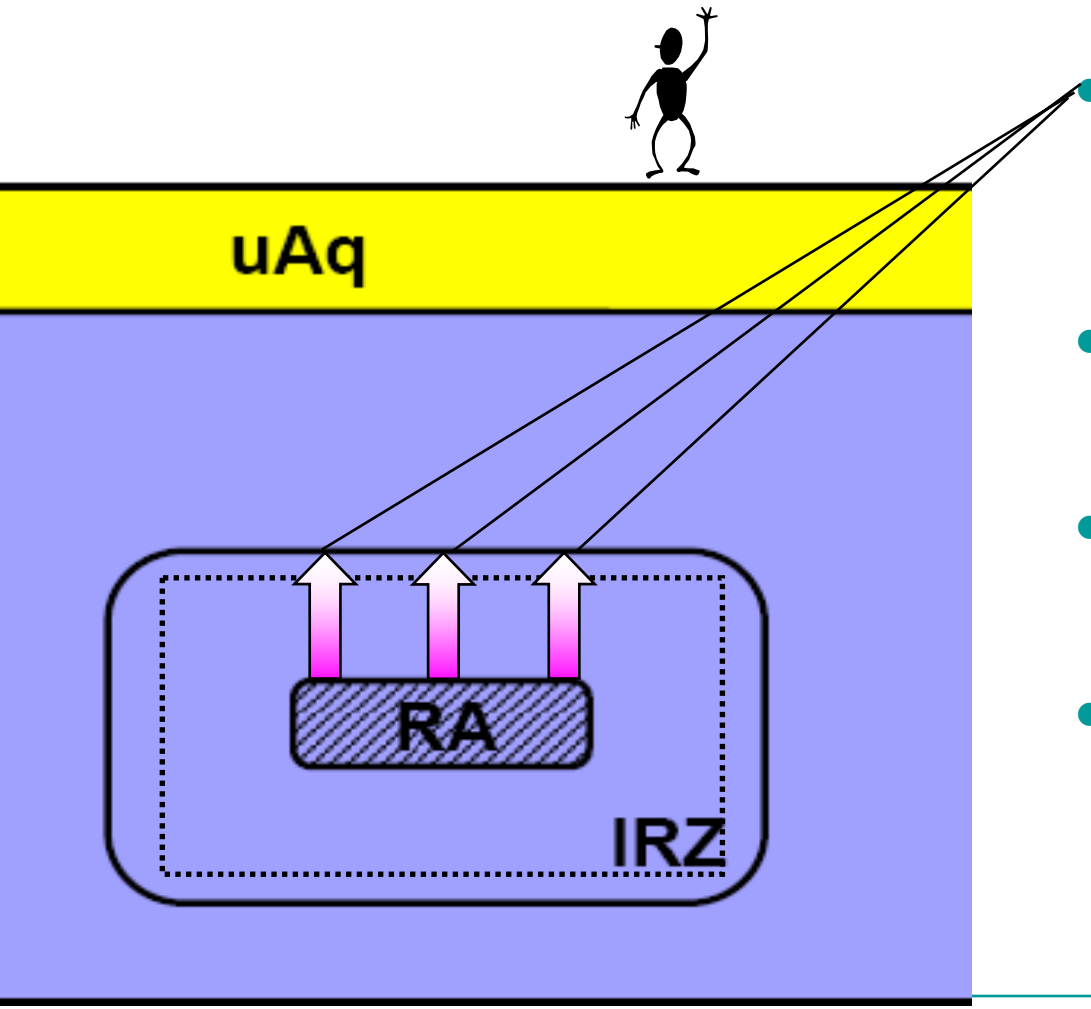


(from NEA Timescales doc)

Constraint on completeness of confinement

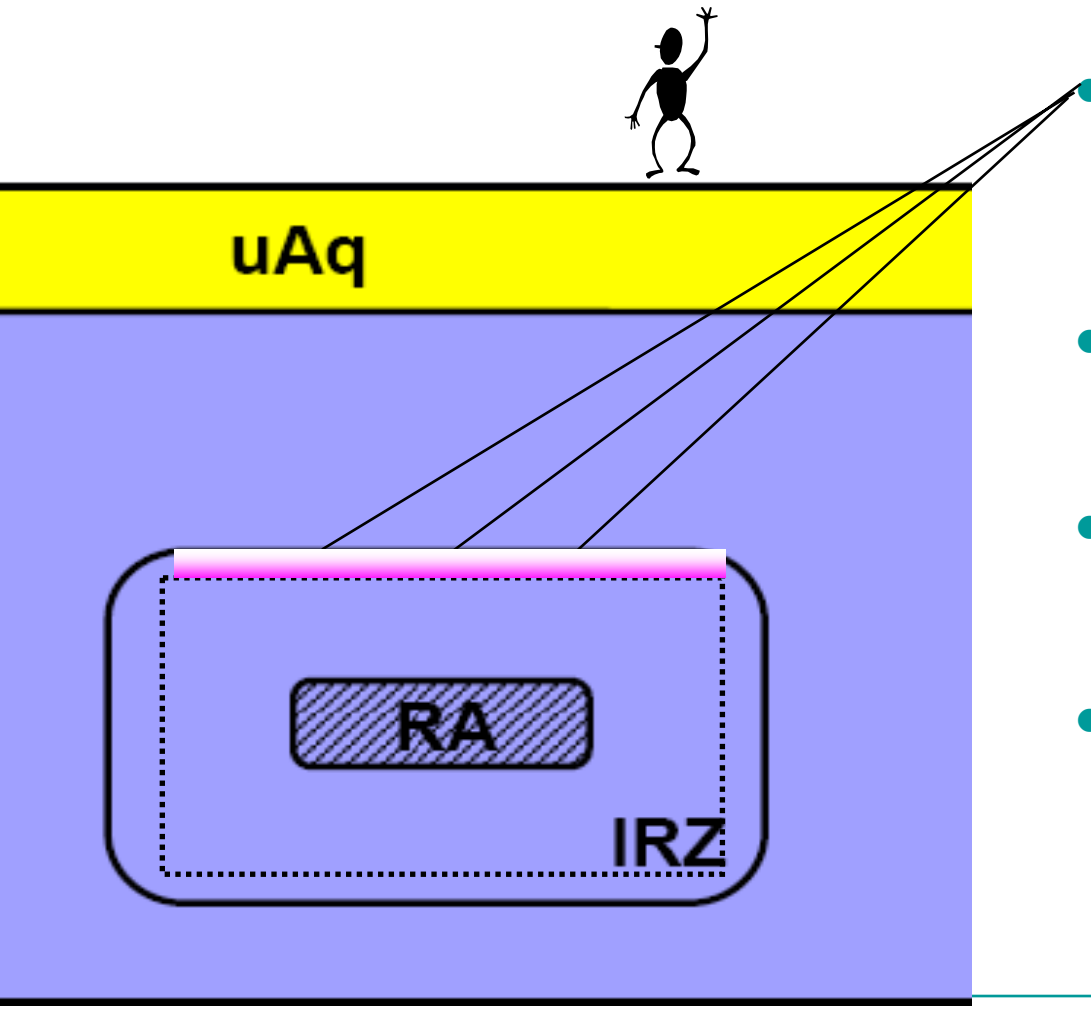
- Confinement is considered to be complete if for likely scenarios consequences from released radionuclides do not cause significant increase of consequences from natural conditions
- Assessment calculations – reliability of results …
- In the course of criteria & guideline development GRS attempted to address these problems by …
  - Developing a set of indicators which focuses on safety functions, i.e. on the system's ability to confine & isolate:
    If isolation/confinement is ensured, protection objectives are met
  - Deriving corresponding yardsticks which focus on preventing disturbances or changes in surrounding geosystems and biosystems
  - Role of the "**isolating rock zone**"

A set of indicators orientated on safety functions (1/6)



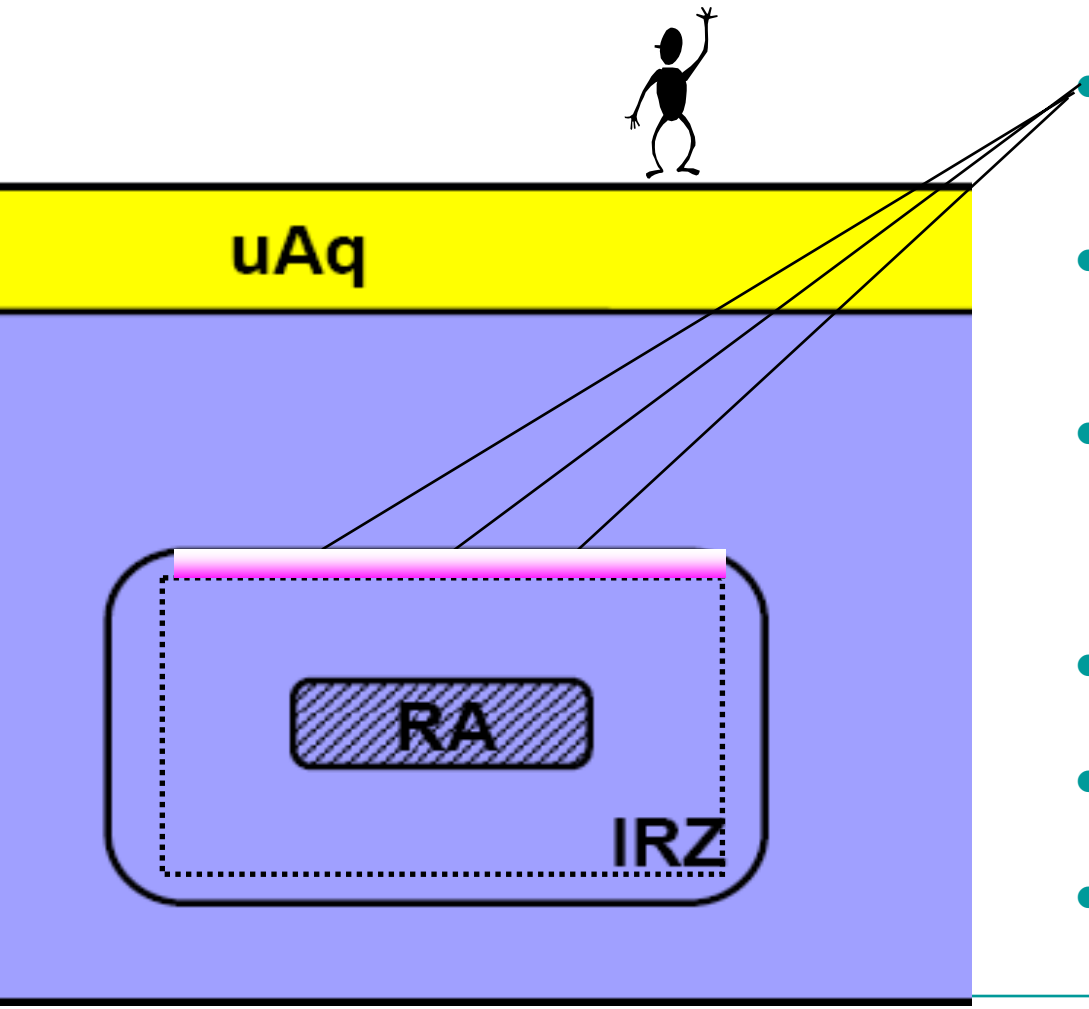
- Indicator: fraction of released amount of substance (cumulated over assessment time)
- Location: boundary of isolating rock zone
- Criterion: percentage of amount of substance disposed of
- Evaluation of confinement/isolation, no direct relationship to impact

A set of indicators orientated on safety functions (2/6)



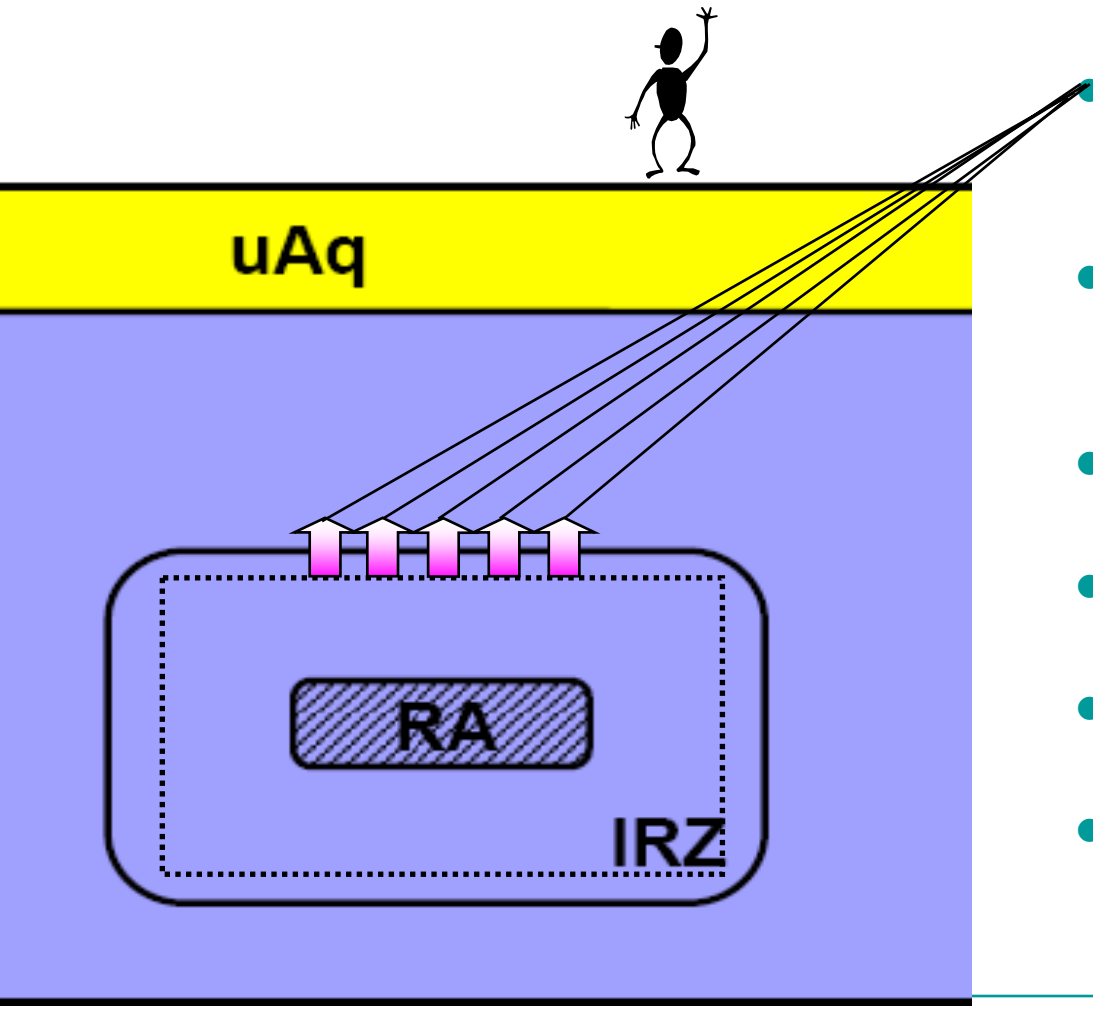
- Indicator: concentration of released U and Th (all isotopes)
- Location: boundary area of isolating rock zone
- Criterion: 1 μg/l U, 0.1 μg/l Th
- Addition to natural concentrations

A set of indicators orientated on safety functions (3/6)



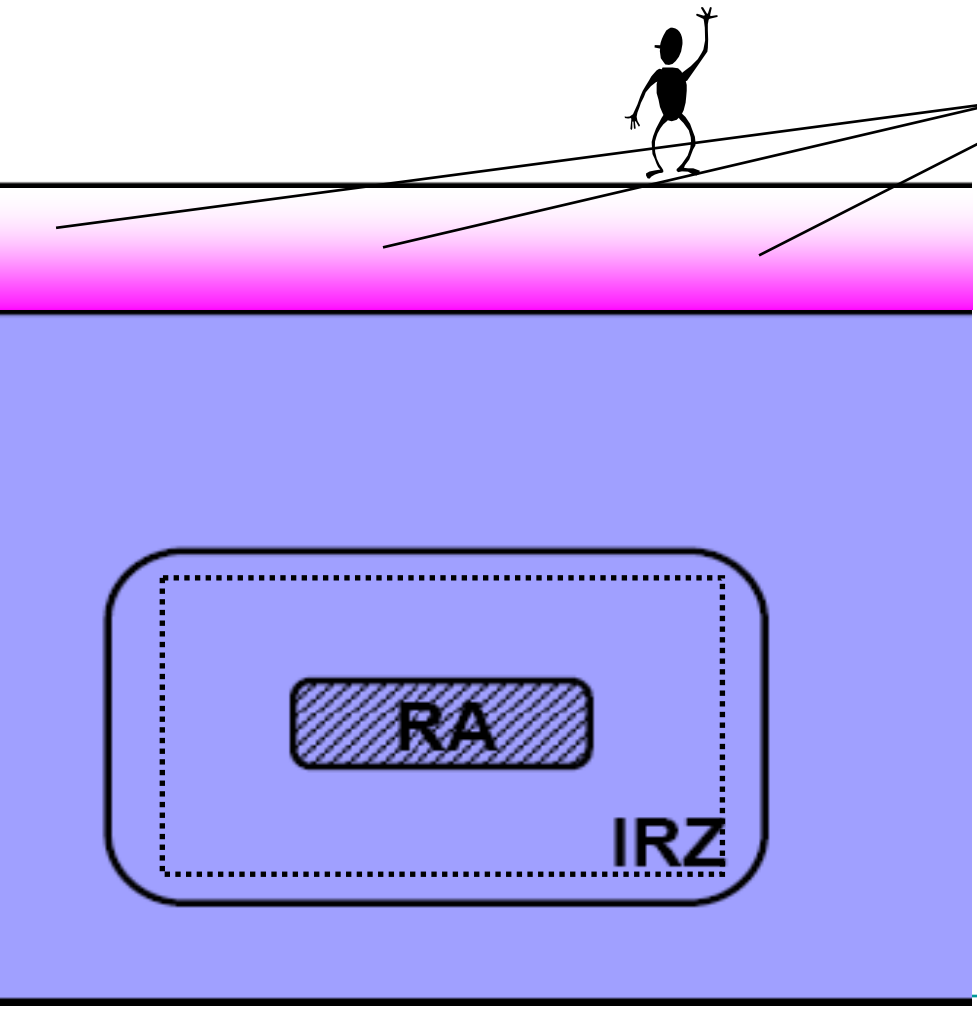
- Indicator: contribution to power density in groundwater
- Location: boundary area of isolating rock zone
- Criterion:
  0,1 MeV per l pore water
  (in case of indurated clay)
- Addition to natural radioactivity
- Aggregation (all nuclides)
- Indicator for impact (biota), but no dosimetry

A set of indicators orientated on safety functions (4/6)



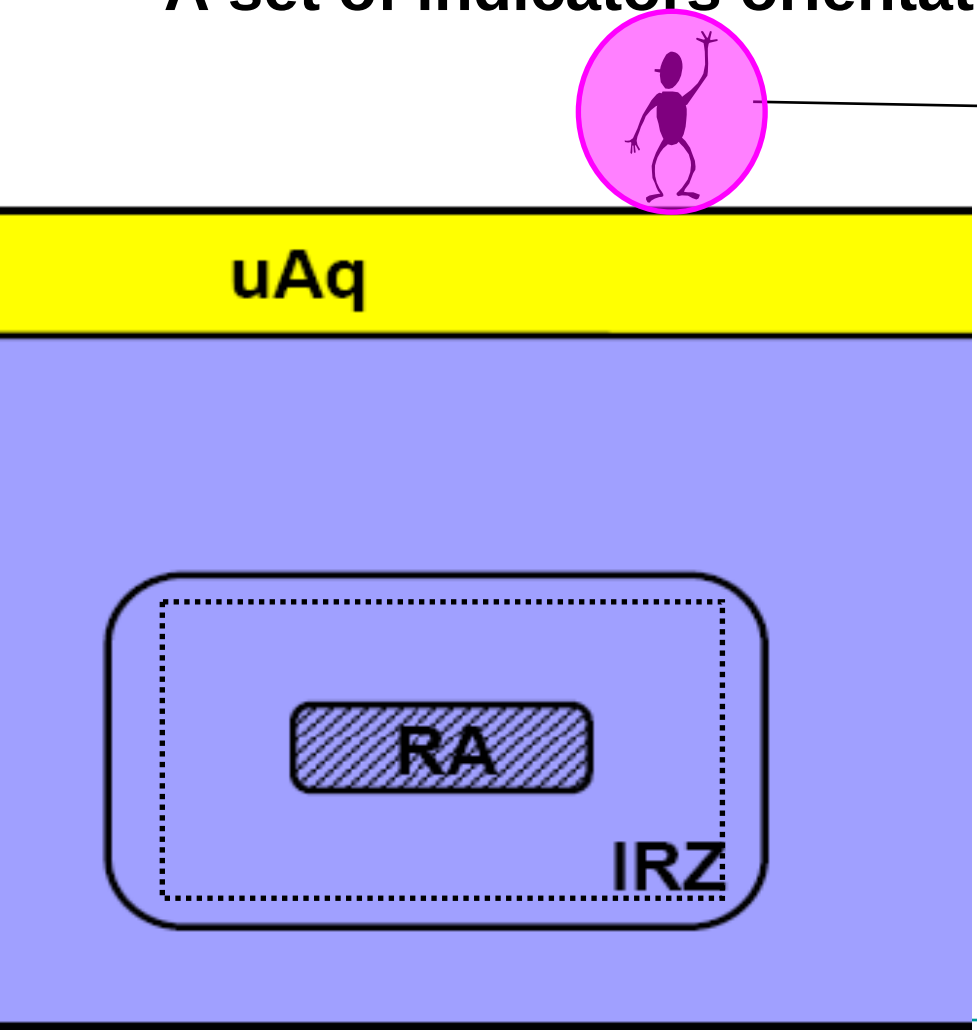
- Indicator: contribution to radiotoxicity in groundwater (flux)
- Location: boundary of isolating rock zone
- Criterion: 0.1 mSv/a
- Addition to natural radioactivity
- Aggregation (all nuclides)
- “shortcut” of aquifer system, standardised “biosphere”

A set of indicators orientated on safety functions (5/6)



- Indicator: nuclide concentrations in accessible groundwater (natural occurring nuclides)
- Location: surface aquifers
- Criteria: specific per nuclide
- Addition to natural concentrations
- No aggregation
- Present-day or plausible future hydrology (confirmatory - timeframe!)

A set of indicators orientated on safety functions (6/6)



- Indicator: effective individual dose per year
- Location: biosphere
- Criteria: 0.1 mSv/a
- Addition to natural radioactivity
- Aggregation (all nuclides)
- Present-day or plausible future hydrology, standardised “biosphere”
- Related to “impact”, confirmatory character (timeframe!)

Discussion of indicators

- We evaluate calculation results (which are one of multiple lines of evidence) in a way which focuses on the safety function “confinement/isolation”
- Line of argument:
  - **If confinement/isolation is ensured, protection objectives are met**
  - **Confinement/isolation is ensured if existing system is perturbed as little as possible**
    - Preferred in comparison to largely hypothetical biosphere models
    - As consequence, protection of humans and environment. “Needs and aspirations” discussion loses importance.
- “Additional indicators” being utilised (often required, but less often implemented)
- As far as possible: Reliance on indicators which can be calculated based on modelling of components …
  - … the evolution of which can be forecasted over assessment timeframe
  - … which are relevant for safety
- Limitation: artificial radionuclides – radiological models needed here!

Open issues

- General: Implementation of stepwise approach in existing legislation
- Indicators:
  - Role of those the predictability of which is limited in time but the use of which might be requested by radiation protectionists
  - Testing:
    - Indicators & yardsticks for likely scenarios have been tested (scoping calculations) for repositories in salt domes and in indurated clay formations
    - Testing for less likely scenarios still needed