Derivation of Monitoring Parameters based on the Long-term Safety Assessment

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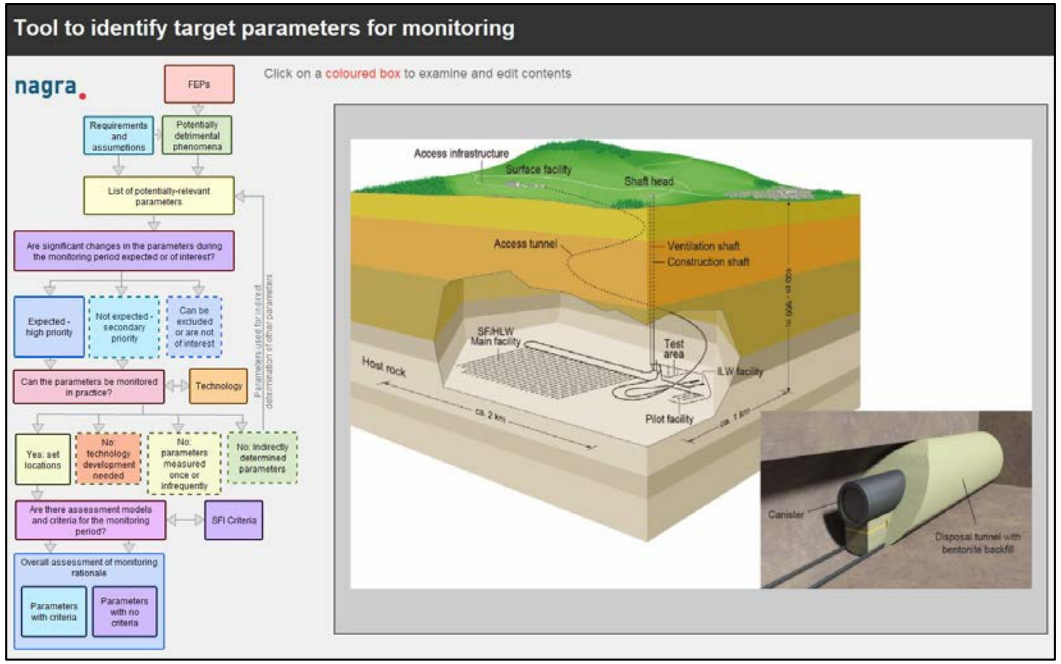
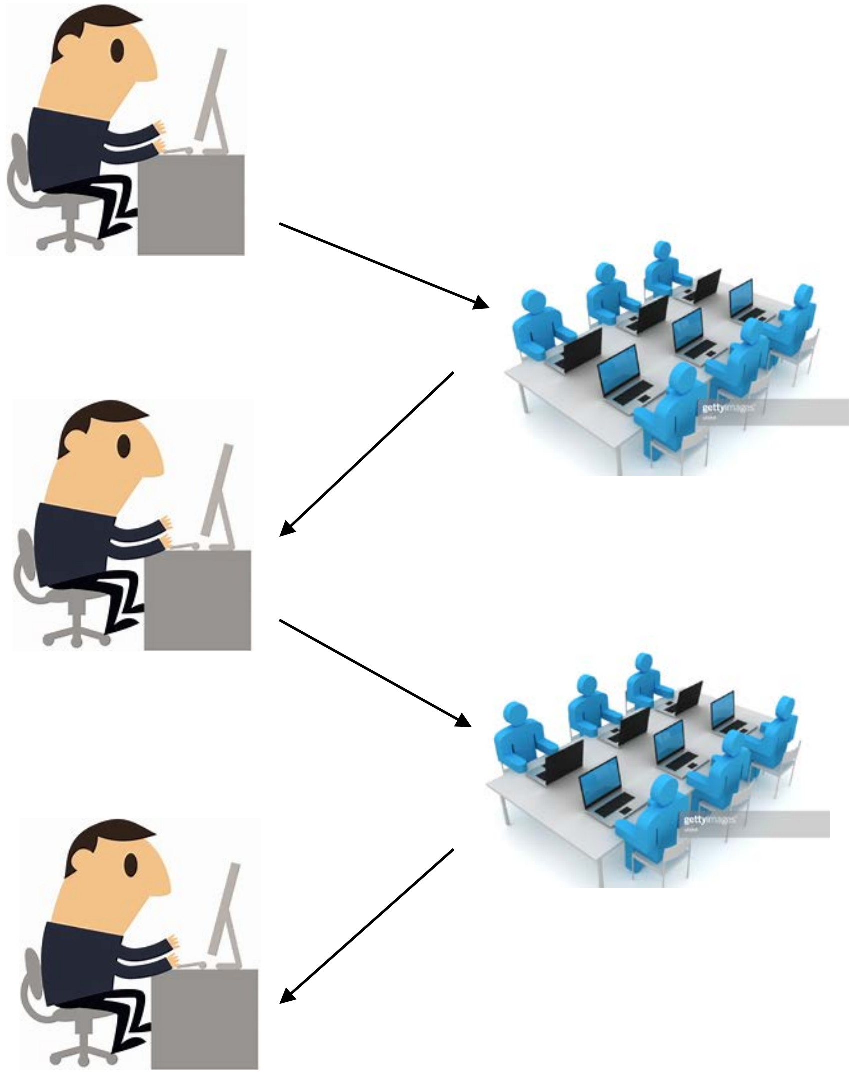
Development of the methodology

- Methodology implemented in relational database tool (FileMaker)





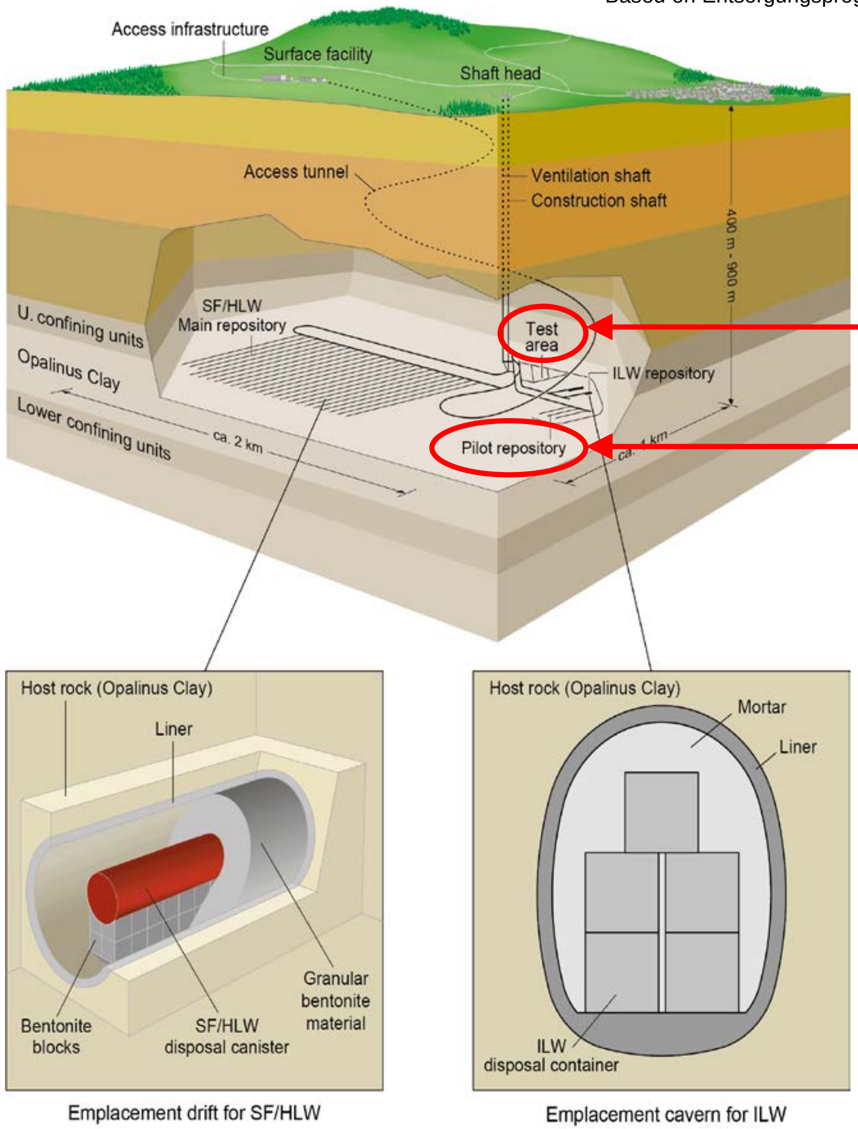
- Refined iteratively in a series of meetings with chosen experts (co-authors)
- Methodology cross-checked against Modern2020 screening methodology

Methodology to identify monitoring parameters

0. Describe the system
1. Identify key, safety-relevant parameters
2. Consider (without consideration of technical feasibility) whether monitoring of these parameters would be of interest, and set priorities
3. Consider technical practicability of monitoring those parameters identified as being or first and secondary priority
4. Identify whether models exist for evolution of those parameters that can be monitored and whether safety-relevant criteria exist that parameters should meet
5. Assess overall rationale for monitoring those parameters identified in Steps 2 through 5

START: System description

Based on Entsorgungsprogram 2016

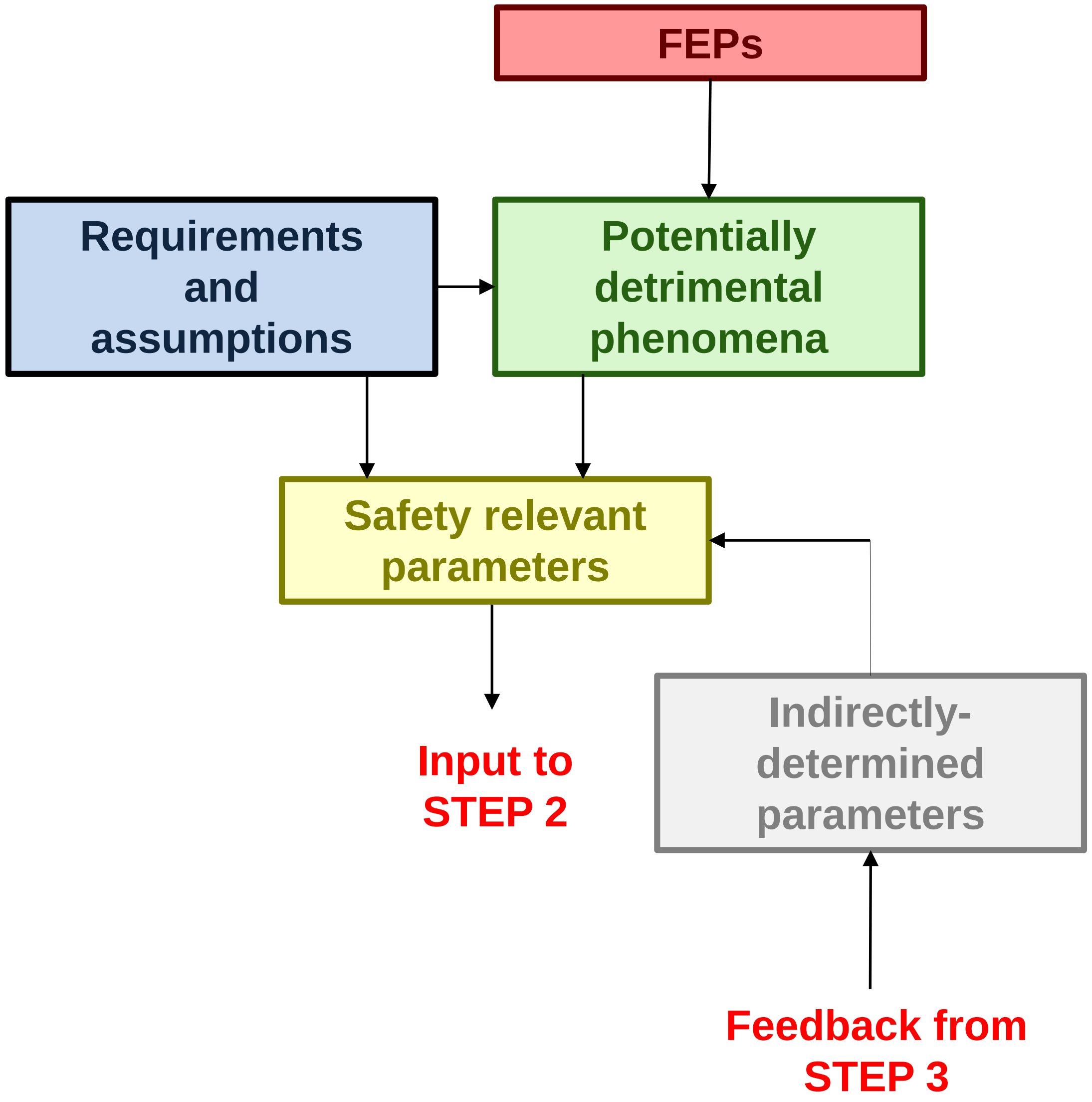


Emplacement drift for SF/HLW

Emplacement cavern for ILW

- **Test facility (site-specific URL)**
  - Not necessarily a single facility (rather, a series of experiments at different locations)
  - Provide the **information required before the main facility can start operation** (and for subsequent decisions)
- **Pilot facility**
  - Contains **representative fraction of waste**
  - Serves as **demonstration facility** for emplacement technology
  - Provides information to better understand the **behaviour of barrier system** and to check **predictive models**
  - Allows early detection of any **unexpected and undesirable system evolution**
  - Provides **input for decisions** regarding commencement of operations and eventually the closure of entire facility

STEP 1: key, safety-relevant parameters



Category*	Definition
Requirements and assumptions	Define safety-related requirements on the overall system and on sub-system components (in particular, the canister, buffer and host rock) and/or reference assumptions for safety assessment
Potentially detrimental phenomena	Quantify, influence, or indicate occurrence of potentially (safety) detrimental phenomena • that might compromise ability of system to meet safety-related requirements or conform with reference assumptions for safety assessment, and/or • that are present in Nagra's FEP List and are clearly detrimental
Indirectly-determined parameters	Are needed for the evaluation of other key parameters that cannot be measured or monitored directly

*a parameter may fall into one or more of these categories

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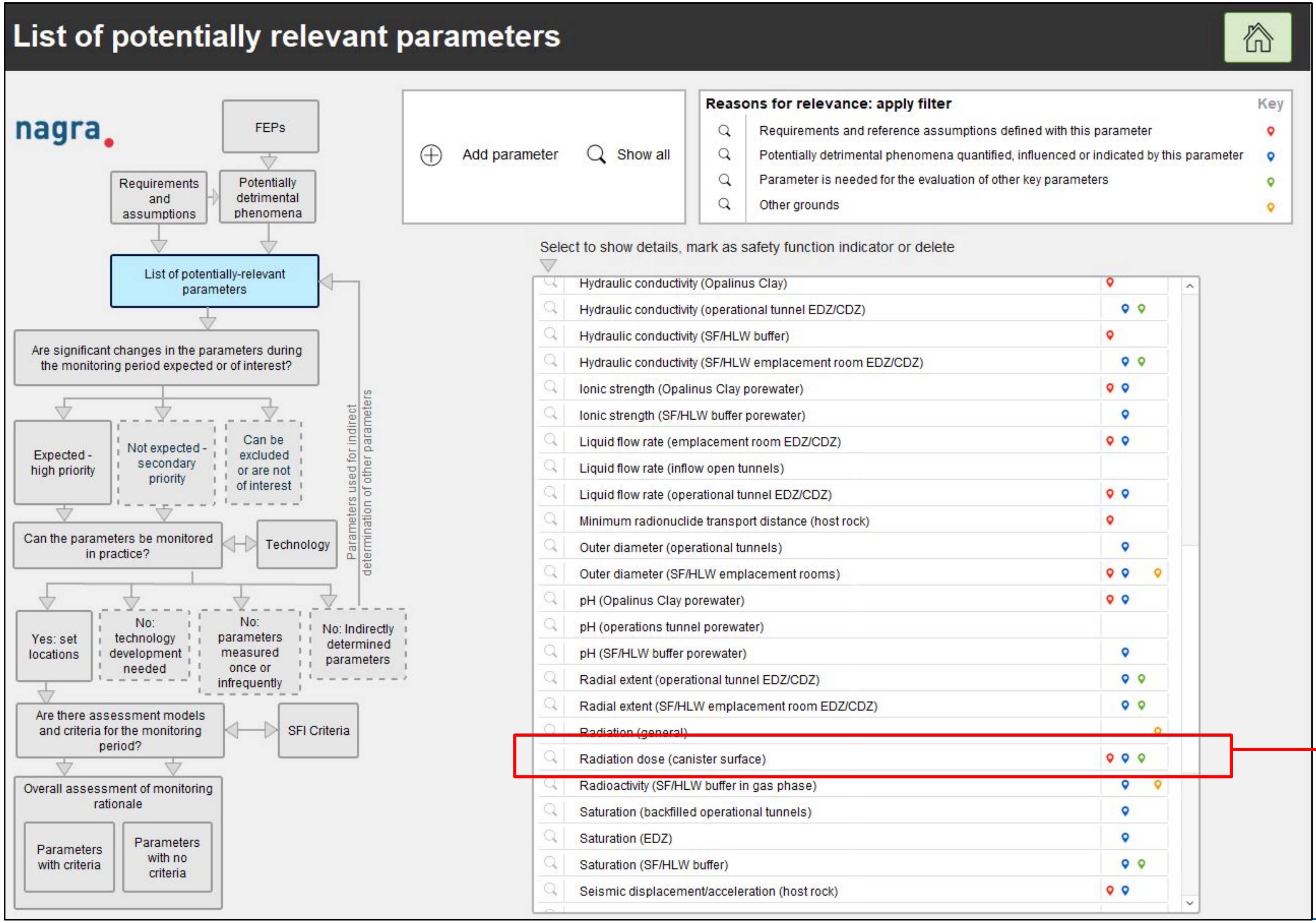
STEP 1: key, safety-relevant parameters



- Requirement related to canister wall thickness
  - *The wall thickness should ensure long-term structural integrity and that the radiation dose rate at the canister outer surface is < 1000 mSv/hr in order to preclude radiation-induced corrosion.*
- Requirement on the radiation dose itself
  - *Radiation dose at the canister surface after leading and sealing of the canister should be less than 1000 mSv/h to avoid radiation-induced corrosion.*

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STEP 2: Prioritisation

- Prioritisation based on
  - likelihood of (and uncertainty in) changes to parameter value during monitoring period
  - safety-relevance of such changes

Priority	Basis	Examples
High priority	Significant changes expected during the pre-closure monitoring period (especially if there are significant uncertainties associated with those changes)	• Near-field temperature • Near-field pore pressures
Secondary priority	Significant changes not expected, but cannot be completely excluded	• Geometry - underground structures
None	Significant changes in a parameter can be confidently ruled out or are irrelevant to safety	• Thickness of uncorroded canister wall

Input to STEP 3

Park

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STEP 3: technical feasibility of monitoring

High- and secondary-priority parameters from STEP 2

Amenable to monitoring in practice?		
Yes	Examples	
	• Fluid (pore) pressure; pH porewater • Temperature	
No	Reason	Examples
	Technology development needed	• Far-field stress changes; reactivation of faults
	Parameters measured once or infrequently	• Porewater composition
	Indirectly determined parameters	• Heat fluxes • EDZ permeability

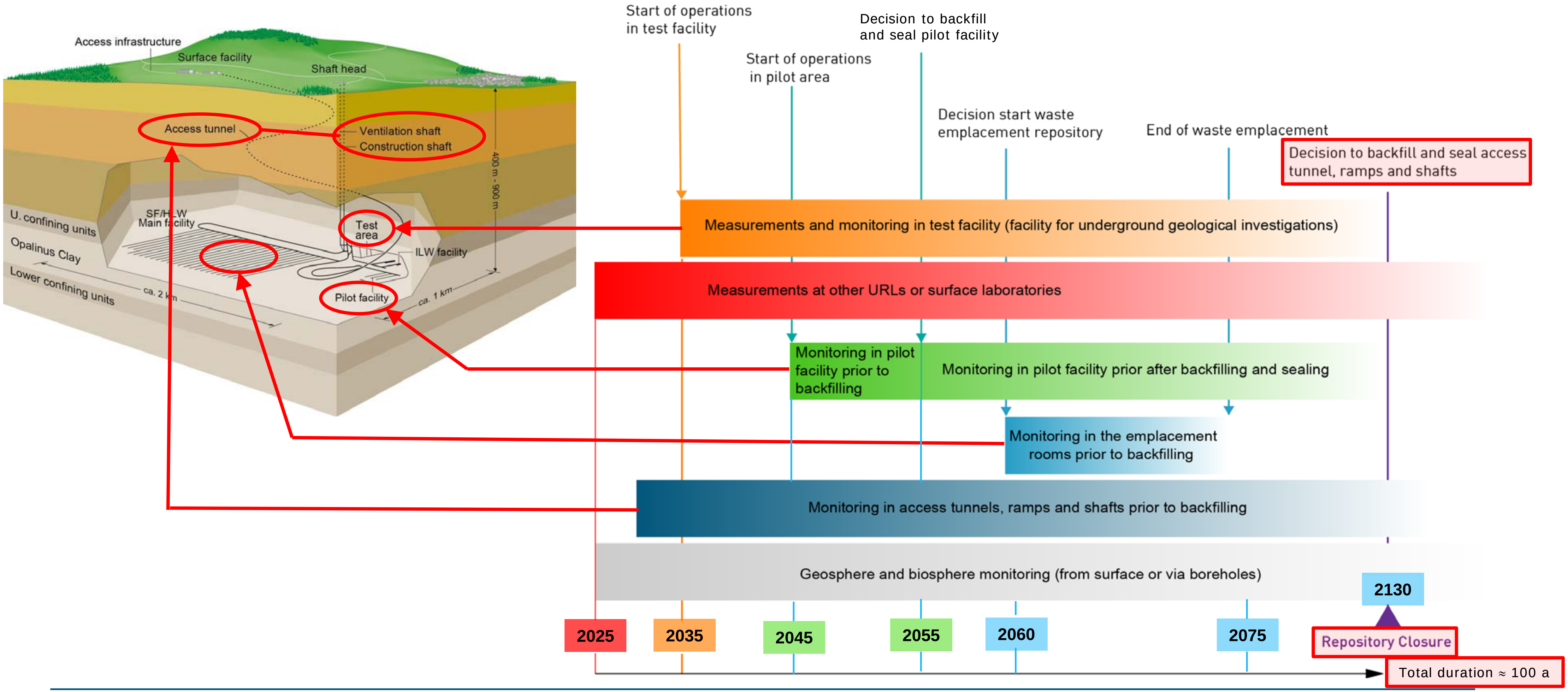
Yes → **Determine how, where and when to monitor** →

Technology development needed → **Park**

Parameters measured once or infrequently → **Park**

Indirectly determined parameters → **Feedback to STEP 1**

Tentative schedule and opportunities for measurements/monitoring



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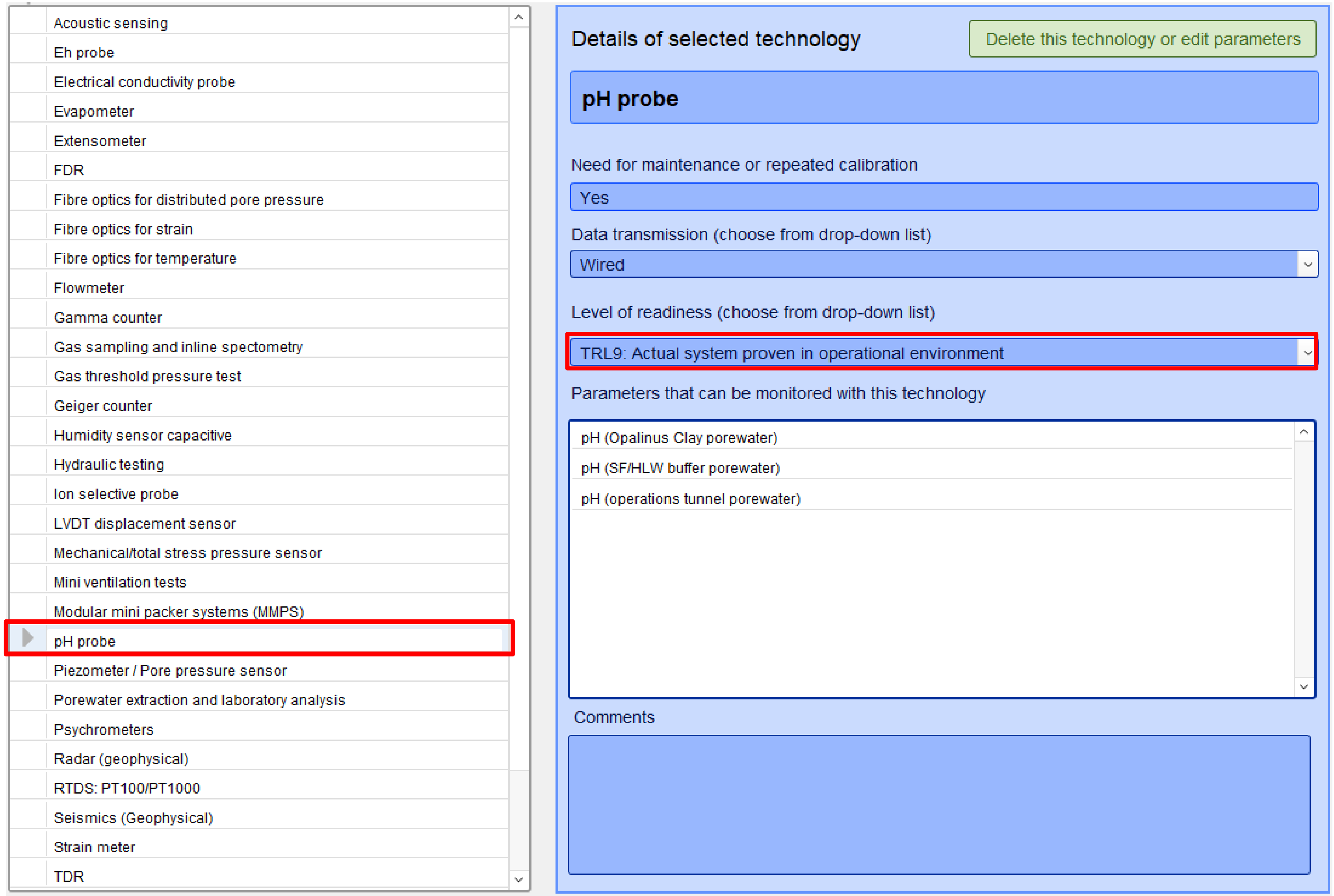
Example of the assessment of a potential monitoring technology

pH probe

TRL 9



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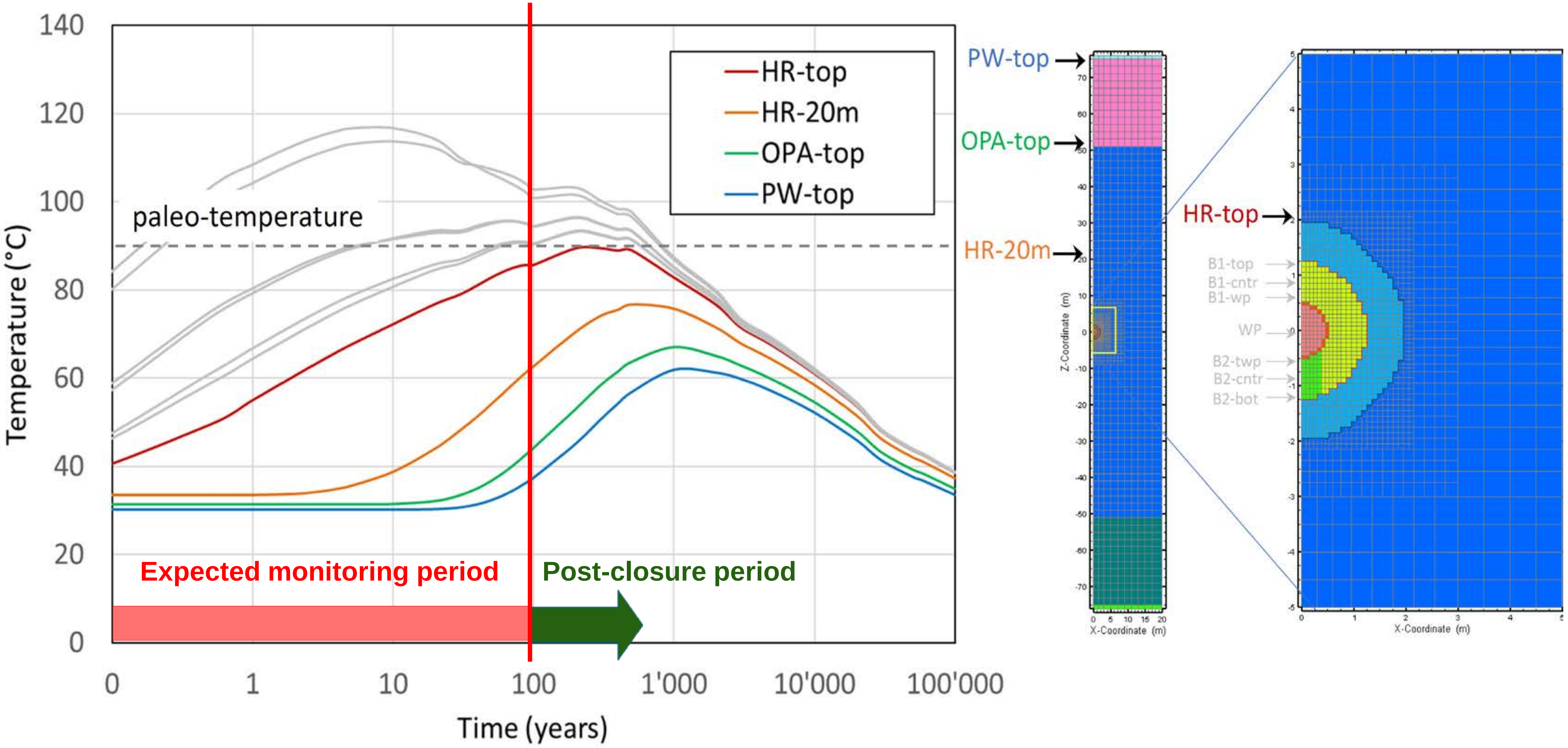
STEP 4: Models and safety-relevant criteria exist?

- Example of temperature evolution



STEP 5: Overall rationale for monitoring

	Prioritisation	
	Secondary	High
Currently with criteria	4	2*
No criteria	16	14

Rationale for monitoring

1. Build confidence that each barrier meets its requirements and conforms with reference assumptions

Set as rationale? Yes: high priority

2. Build confidence that potentially detrimental phenomena do not compromise safety

Set as rationale?

- a. Confidence in general understanding of the phenomena — Yes: high priority
- b. Confidence in input parameters for modelling the phenomena — Yes: high priority
- c. Confidence in model predictions, including adherence to criteria — Yes: high priority

3. Build confidence in the parameter values used for the evaluation of other key parameters

4. Other reasons to monitor this parameter

Set as rationale?

- a. Support decision making (e.g. when to backfill a section of repository) — Yes: high priority
- b. Stakeholder demands/reassurance — No
- c. Other grounds — No

*Fluid pressure (Opalinus Clay) and temperature (Opalinus Clay)

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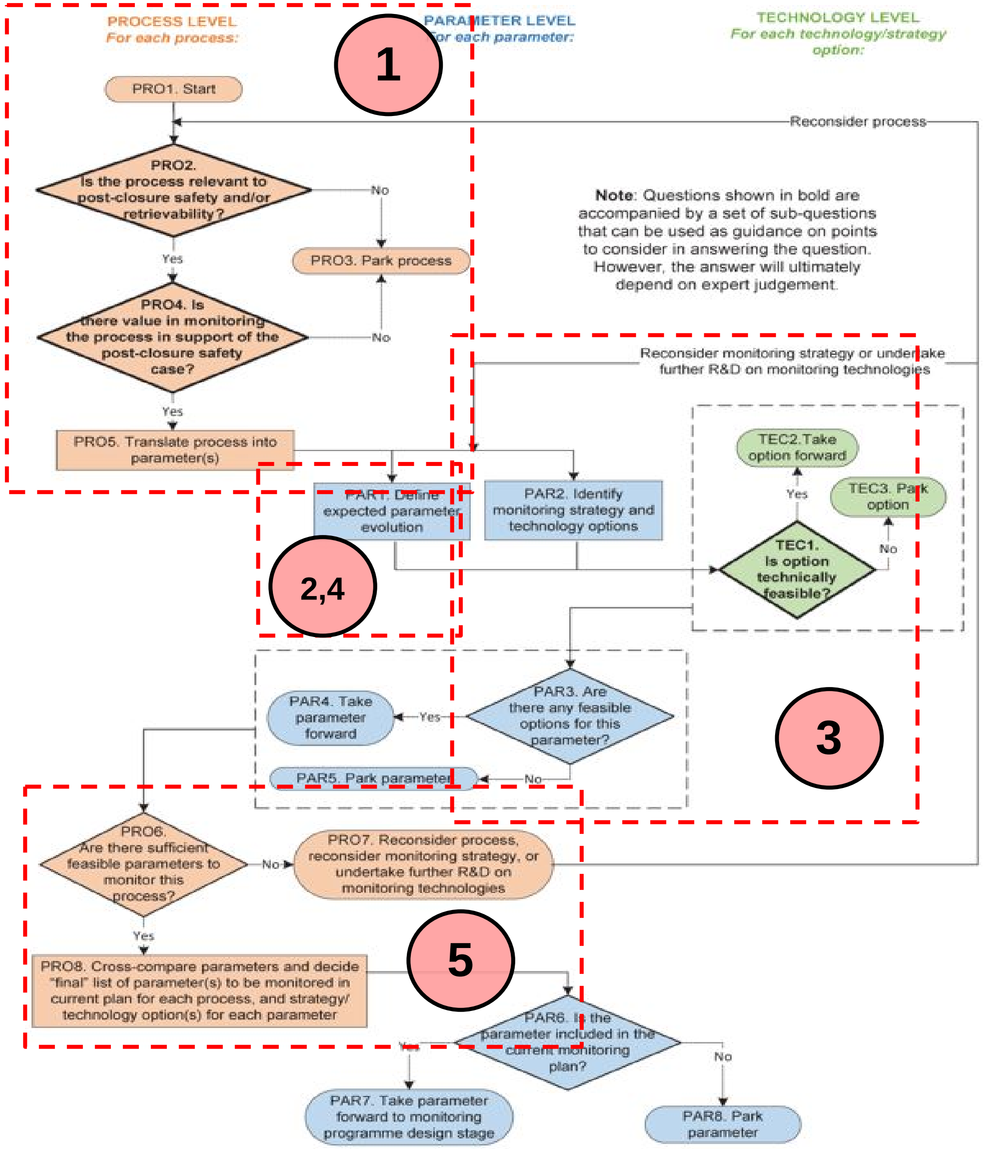
Comparison with Modern2020 Screening Methodology

- Each of the steps of Nagra's methodology can be mapped onto the generic Modern2020 Screening Methodology; a few differences noted:

Modern2020	Nagra
Translates processes into parameters	Also includes parameters that define requirements and model assumptions
-	Prioritises parameters on the basis of significant or relevant changes
-	Acknowledges some parameters are evaluated indirectly from other (monitored) parameters
Includes development of monitoring plan and programme	-*

*Work currently in progress



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Thank you for your attention!

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