MODERN 2020

Development and Demonstration of monitoring strategies and technologies for geological disposal

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safe solutions for radioactive waste

Modern2020

Monitoring During the Operational Period to Provide Further Confidence in the Post-Closure Safety Case: Strategies and Parameters

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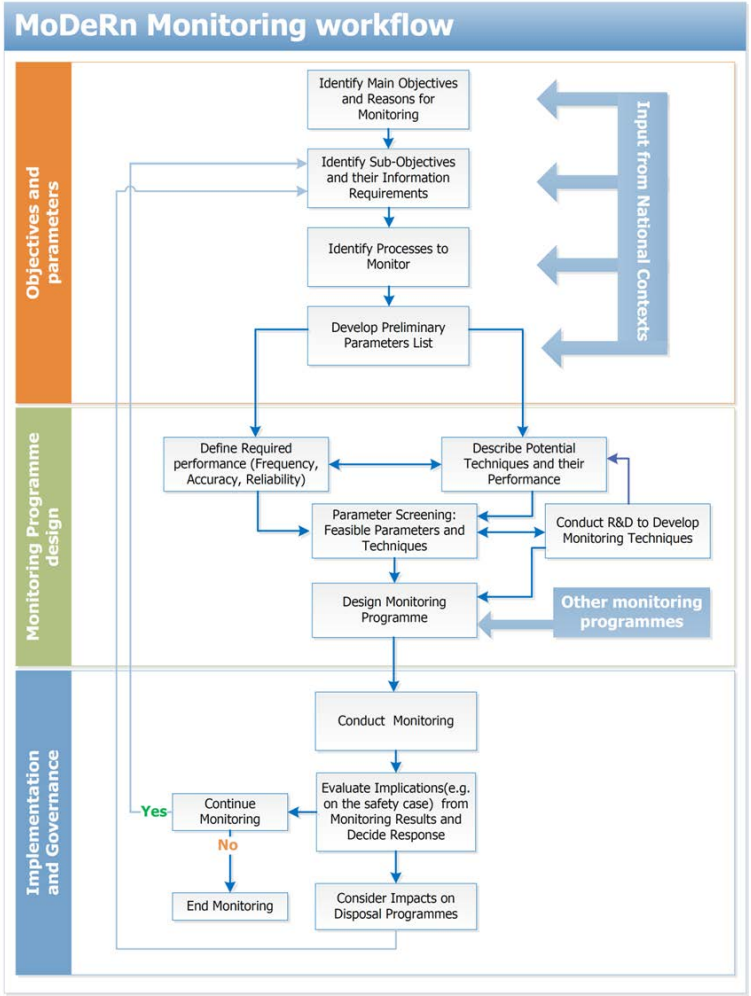
Background

- The MoDeRn Project formulated a reference framework and a generic workflow for developing and conducting a monitoring programme
- Further work was required to consider explicitly how monitoring parameters could be identified



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Recommendation from the Nuclear Energy Agency

Monitoring of Geological Disposal Facilities: Technical and Societal Aspects" (NEA, 2014)

- *The current, and justifiable, tendency is to measure as many parameters as possible*
- *With the transition from the repository development stage to implementation, it becomes necessary to optimise the selection of the parameters*
- *The identification of those parameters which would sufficiently demonstrate the attainment or approach to the passive safety status of the disposal system would be of substantial benefit*
- The recommendations of the NEA have been addressed in Modern2020 through the development of a generic structured approach to the selection of parameters
  - ✓ The Modern2020 Screening Methodology

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Presentation Structure

- Describe the context for monitoring in support of building further confidence in the post-closure safety case
- Present the Modern2020 Screening Methodology
- Draw conclusions on the selection of parameters to be included in a monitoring programme focused on providing further confidence in the post-closure safety case

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Monitoring during the Operational Period and the Post-Closure Safety Case

- To receive a licence to operate, a WMO must demonstrate confidence that the repository will be safe if implemented as designed
- Confidence is underpinned by an extensive research, development and demonstration programme
- The approach to the post-closure safety case explicitly addresses uncertainty and sensitivity of safety to different scenarios
- Demonstration that the repository is implemented correctly is undertaken through Quality Control against design specifications
- The safety case will be updated periodically during the operational period, monitoring during this period could be a significant input
- During the operational period monitoring can be used to build further confidence in the post-closure safety case

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Why Monitor?

- The emphasis placed on different reasons for monitoring the near field during the operational period differ from programme one to another
- Monitoring may provide an opportunity to demonstrate understanding of the thermal, hydraulic, mechanical and chemical processes occurring, thereby demonstrating WMO understanding and building further confidence
- Monitoring programmes might focus on the short-term evolution of the repository system to show that this evolution is consistent with the safety case
- Monitoring may also provide the means for continuing to engage with stakeholders and check the evolution of the disposal system following waste emplacement

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Limitations in Monitoring the Near Field to Build Further Confidence

- Monitoring has the potential to impact the passive safety of the repository system
  - ✓ Explicit demonstration of the significance of any impact is required
  - ✓ It may be that we accept a minor and insignificant reduction in passive safety to gain additional understanding of near field processes
- The relevance of processes occurring in the first few decades after EBS emplacement to long-term safety may be difficult to determine

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Strategies

- All programmes agree that it is impractical to monitor all of the repository
- High-level strategies will be used to monitor specific parts of the repository during the operational period
- In Modern2020 a strategy consists of four elements:
  - ✓ Where: main repository, pilot repository, underground rock characterisation facility
  - ✓ What: waste packages and near field; dummy packages and near field; specific EBS elements; the geological barrier; the biosphere
  - ✓ When: during construction (baseline for operations); during emplacement; after emplacement; during closure; after closure
  - ✓ How: the types of technologies used, including *in situ* sensors; borehole-based sensors; surface –based technologies; air-based technologies

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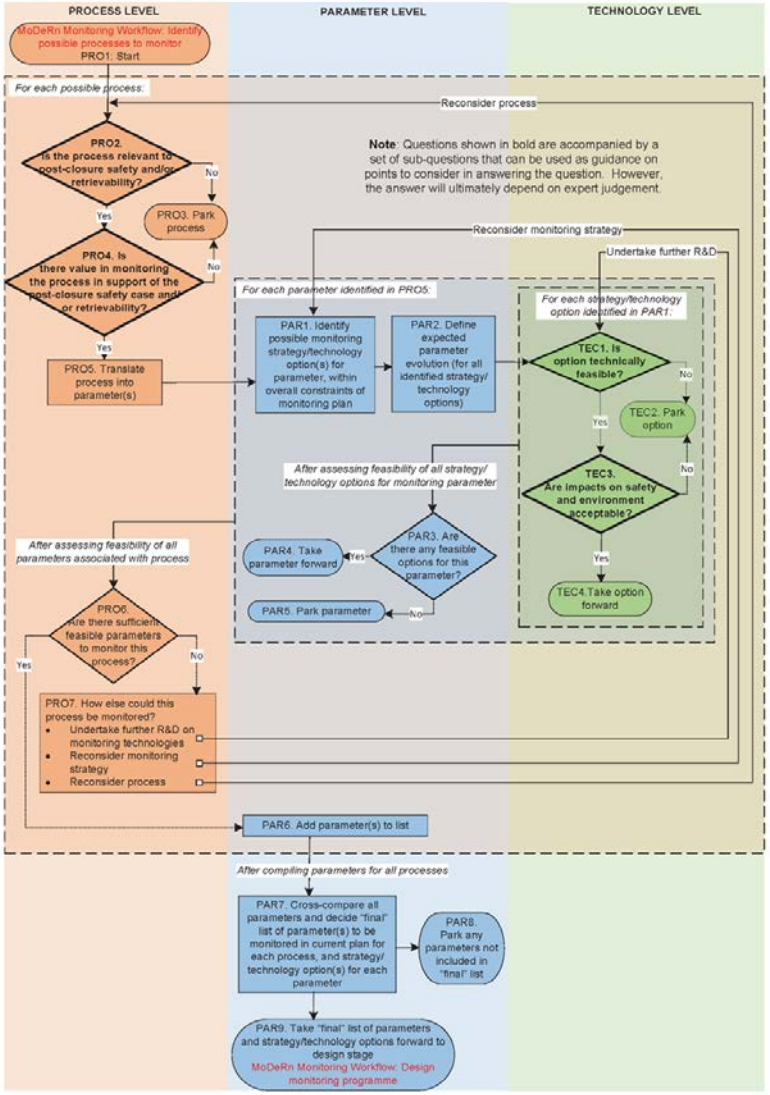
The Modern2020 Screening Methodology

- The Methodology is presented as three strands: processes, parameters and technologies
- Starting point is list of processes or parameters that have been proposed for monitoring
- Basis for decisions are judgements based on existing knowledge
- The Methodology is a stepwise process to allow for traceability and transparency
- Judgements used as a basis for decisions may change, so processes and parameters are parked and not rejected



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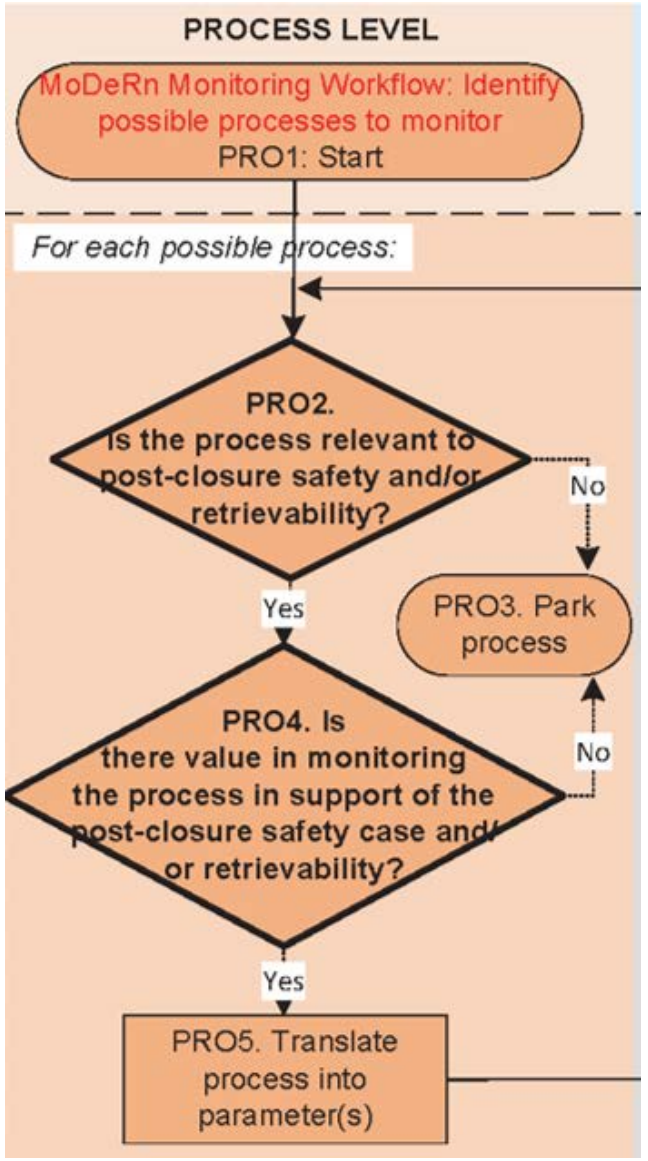
Identifying Parameters that are Valuable to Monitor

- The first step in the Methodology is to determine if there is value in monitoring a proposed process
- Is the process relevant to post-closure safety and/or retrievability
  - ✓ Link to safety functions, safety function indicator, safety assessment parameter or relevant to retrieval
- Is there value in monitoring the process in support of the post-closure safety case?
  - ✓ Could monitoring the process: reduce uncertainty further, provide additional confidence, be detectable, support repository design enhancements, result in greater system understanding?



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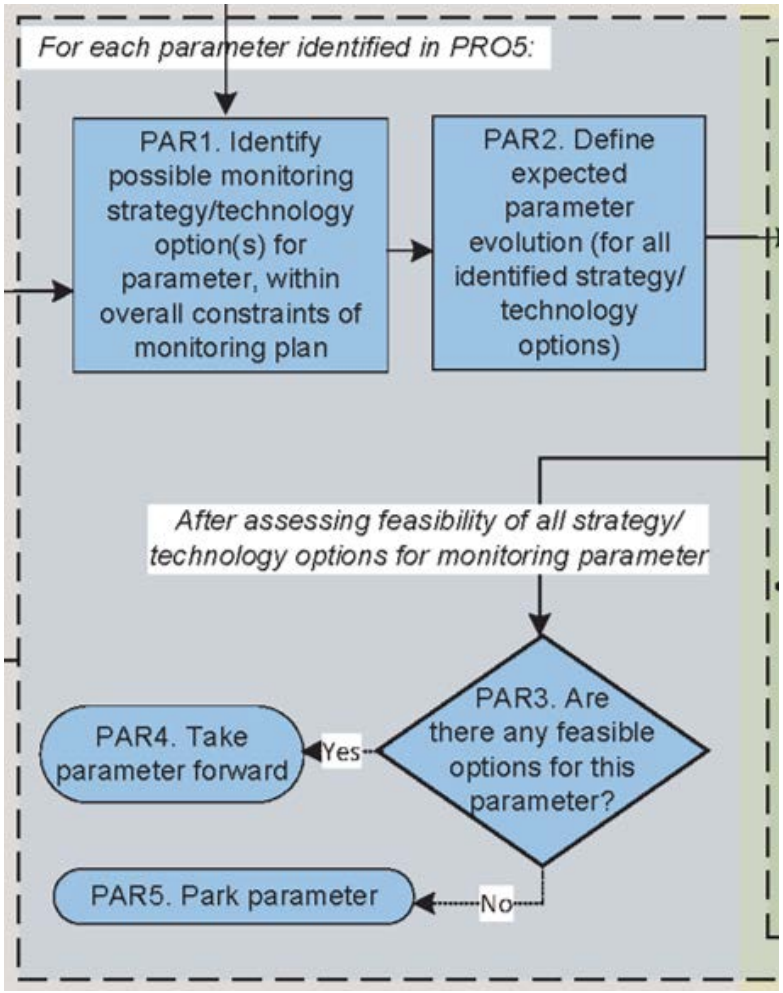
Identifying Strategy/Technology Options and Parameter Predictions

- For each parameter identified, there is a need to assess the feasibility of monitoring it
- This requires a proposal for the strategy and technology option, and a prediction of the parameter value over the monitoring period



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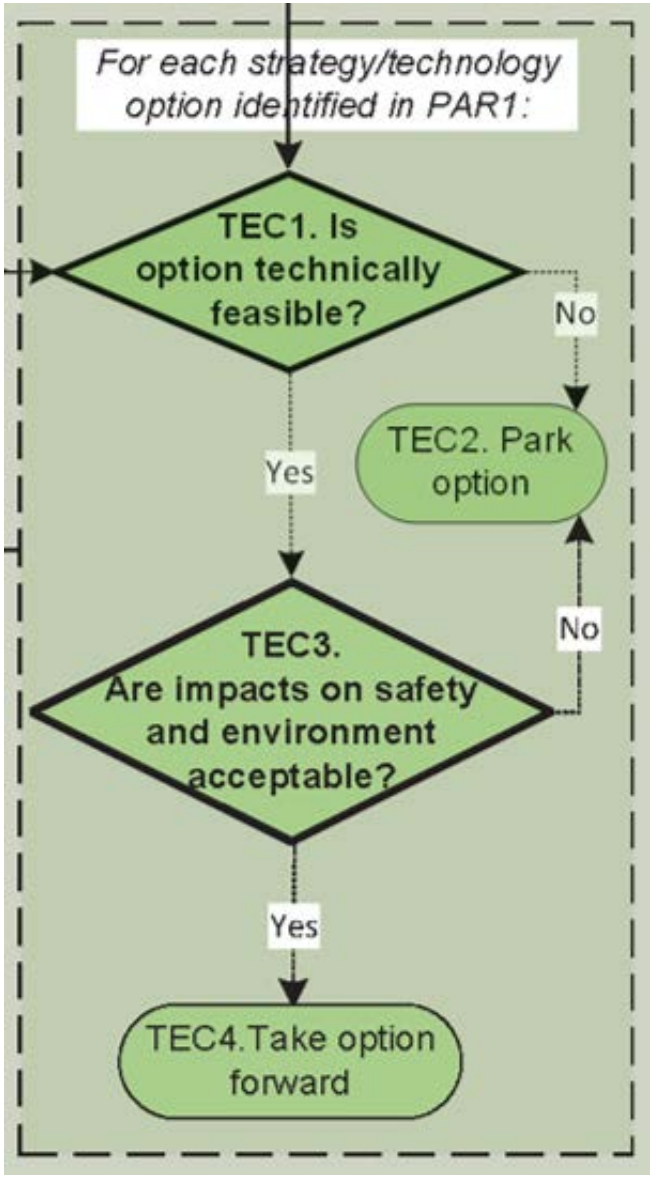
Feasibility for each Strategy and Technology Option for each Parameter

- For each strategy and technology option, there is a need to determine technological feasibility
- Is the option technically feasible?
  - ✓ Can the proposed technology: meet the required accuracy and frequency requirements; function effectively under repository conditions; be undertaken safely; be used without unacceptable operational impacts?
- Are impacts on safety and environment acceptable?
  - ✓ Can the technology be applied without significantly affecting the passive safety of the repository system?
  - ✓ Are risks to workers acceptable?
  - ✓ Is the likely impact of the development, manufacture or deployment of the technology on the environment acceptable?



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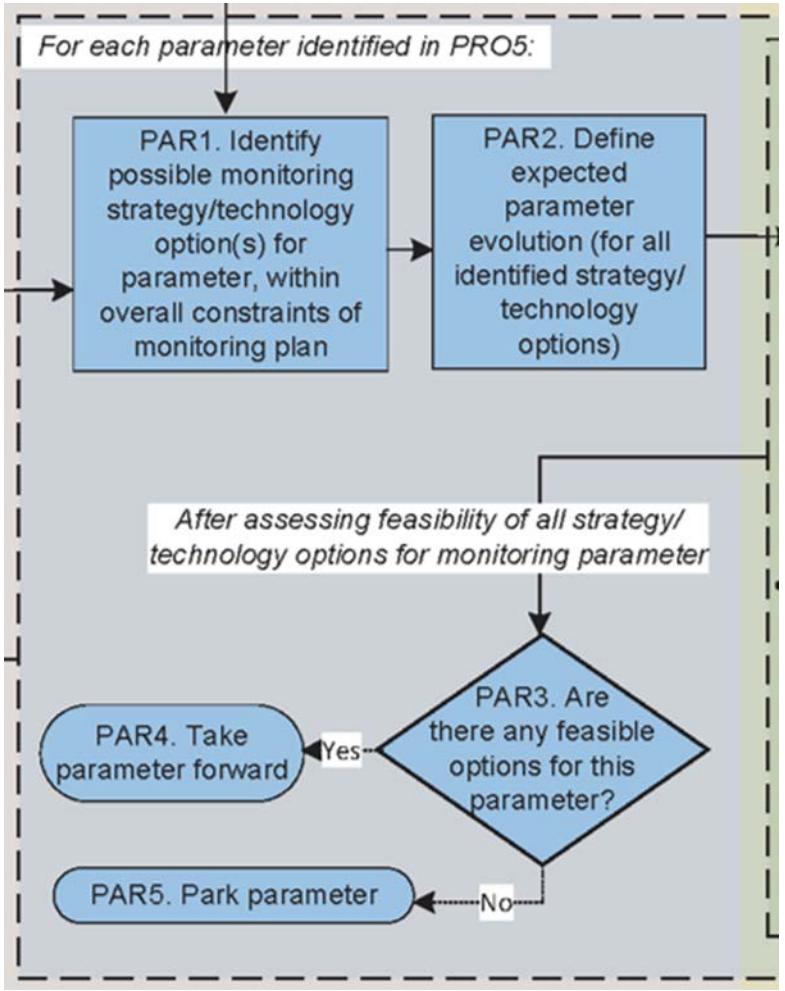
Can Parameter be Monitored?

- Once the technical feasibility of monitoring each parameter, for each strategy and technology option, has been assessed a check is made that there are one or more feasible options that allow the parameter to be taken forward
- Step included in Methodology to ensure process is transparent and traceable



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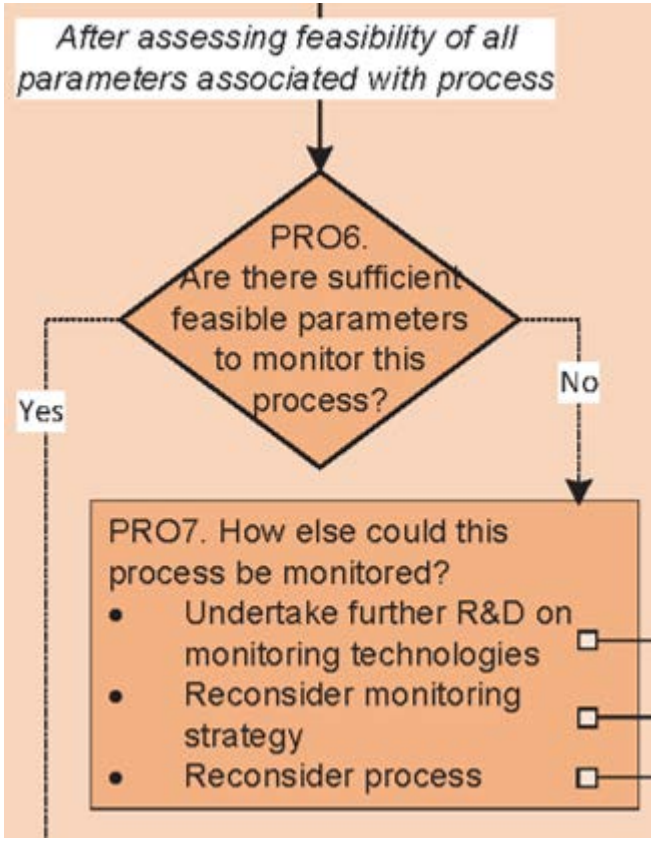
Can Process be Monitored?

- Once the list of feasible parameters is available, there is a need to check that each process in the list can be monitored
- If there are insufficient parameters to monitor a process, there needs to be reconsideration of earlier steps in the process



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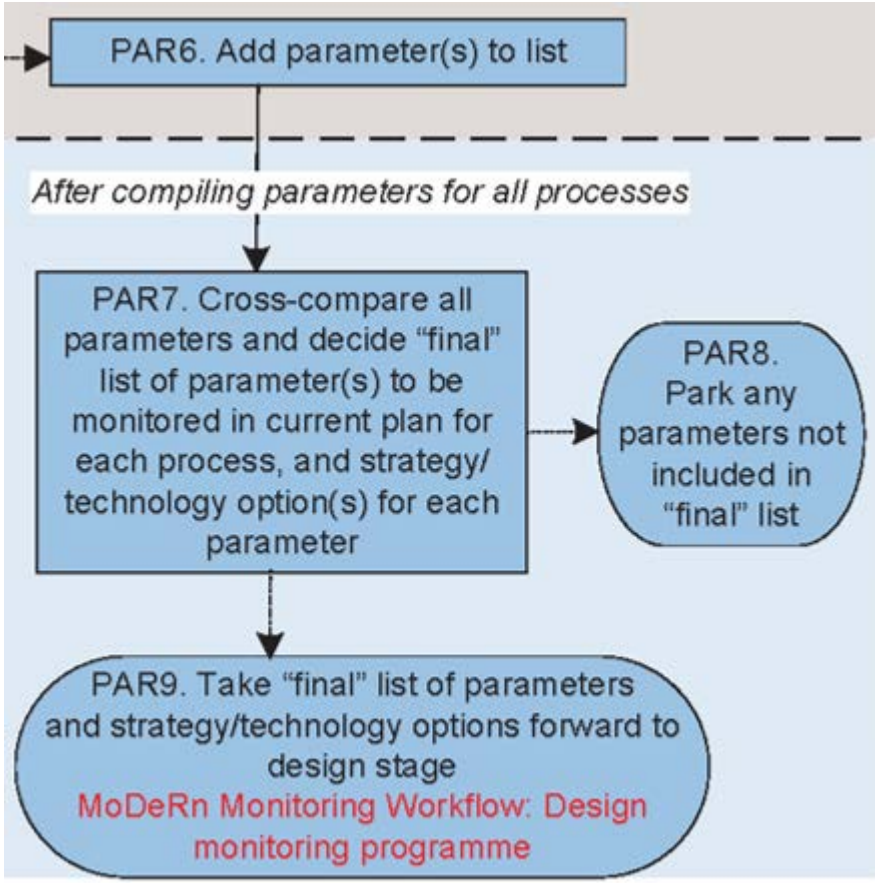
Development of Parameter List for Current Iteration of Monitoring Programme

- The final step in the Modern2020 Screening Methodology is a cross-comparison of feasible parameters
- Project-specific procedures should be identified to ensure that "final" list of parameters provides sufficient redundancy and diversity to meet requirements on confidence of acquired data



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Test Case Parameters

- Parameters need to be linked to disposal concept, monitoring strategy, disposal system element/component and technology, examples of parameters include:

- Temperature
- Porewater pressure
- Fluid (gas) pressure
- Permeability/groundwater flow velocity
- Confining pressure
- Swelling pressure
- Diameter
- Displacement
- Hydrogen concentration
- Oxygen concentration
- Relative humidity
- Water content/saturation
- Porewater pH
- Porewater/groundwater chemistry
- Redox Potential
- Thickness
- Corrosion rate
- Mineralogy and chemistry
- Density (dry and bulk)
- Pore structure
- Piping and Erosion

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Conclusions

- Deciding on parameters is a value judgement
- Monitoring during the operational phase will be conducted over many decades, and justification for the monitoring parameters will be iterated multiple times
- The Modern2020 Screening Methodology is flexible and can be adapted to programme-specific boundary conditions
- Modern2020 Screening Methodology was trialled in seven test cases to identify several potential monitoring parameters

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