



# Radioactive Waste Management

# Building a Safety Case

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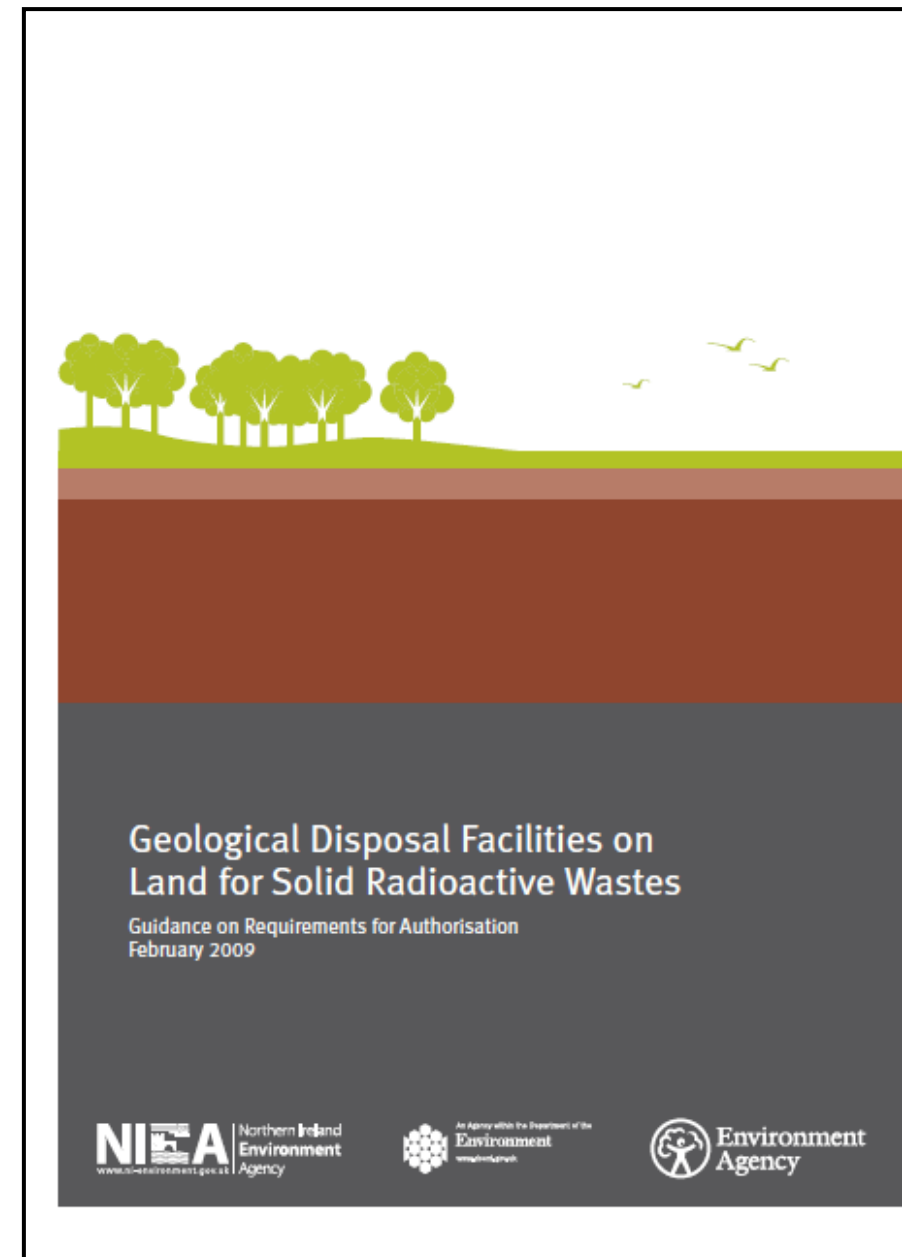
14 October 2015

# Overview

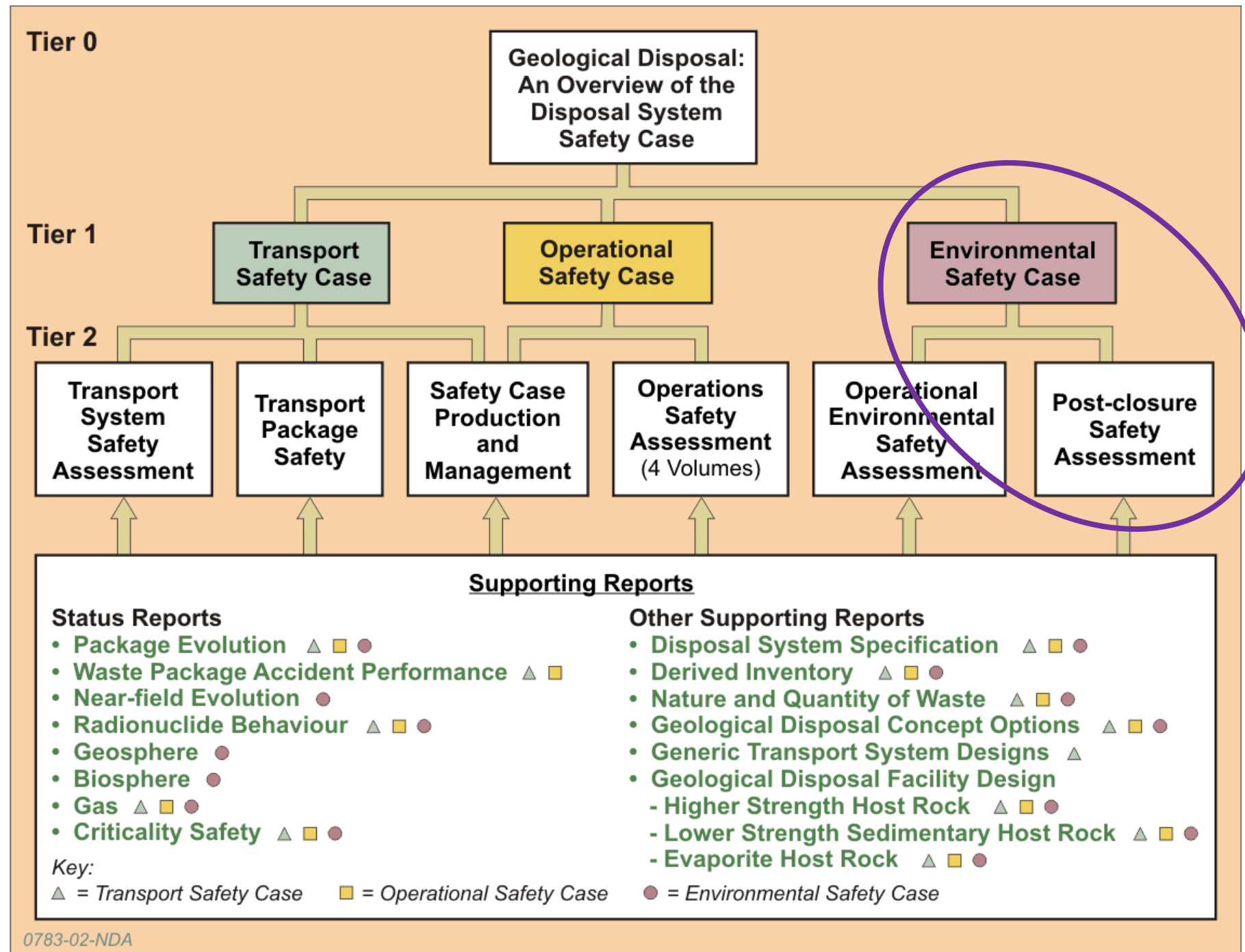
- What is a safety case?
- Role of Research
- Building an environmental safety case
- The multi-barrier concept
- Environmental safety functions
- Features, events and processes
- Modelling
- Safety over long timescales

# The post-closure safety case

- Examines long-term, environmental safety after the GDF has been sealed and closed, no longer any human intervention
- Considers long timescales (hundreds of thousands of years) and different evolution scenarios
- Identifies and assesses what is important to safety, in terms of environmental safety functions:
  - “the various ways in which components of the disposal system may contribute towards environmental safety, e.g. the host rock may provide a physical barrier function and may also have chemical properties that help to retard the migration of radionuclides” – UK GRA definition

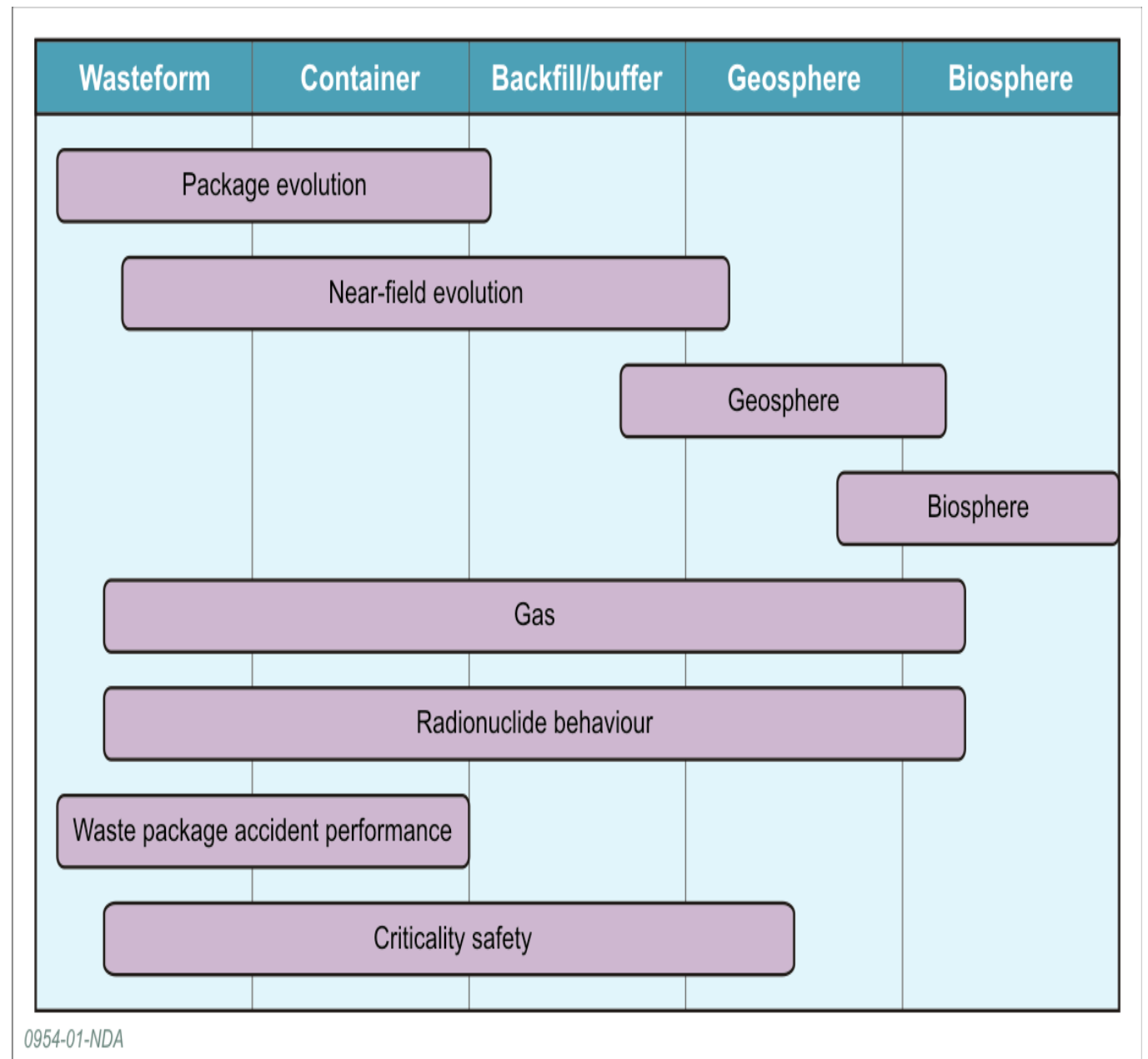


# UK example: The generic Disposal System Safety Case

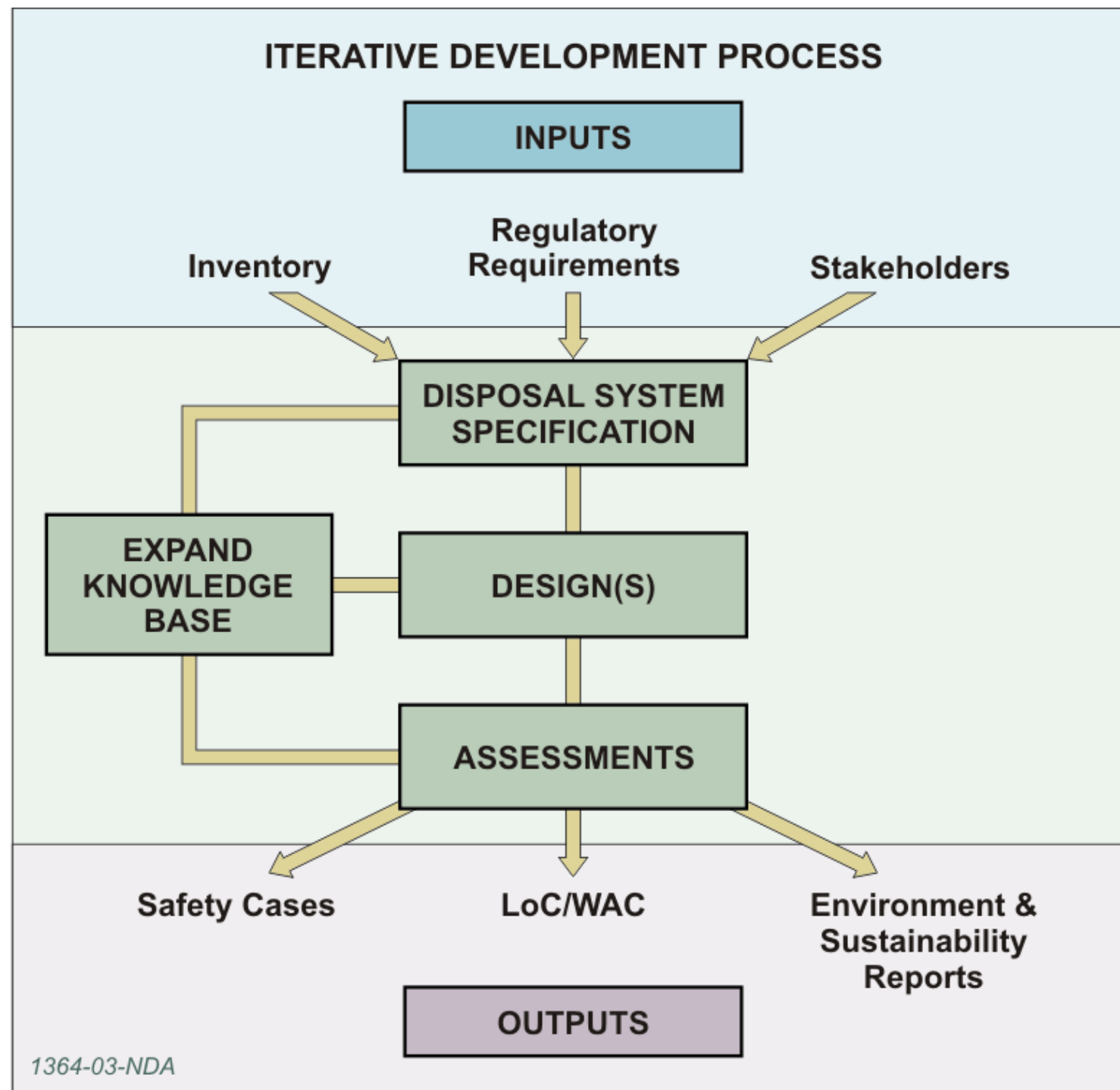


# Research status reports (for UK generic DSSC)

- Suite of reports on key topics
- Summarise evidence to support safety arguments in DSSC
- Draw on R&D carried out by and for RWM, sister organisations and others
- Justify key parameters used in DSSC
- Identify knowledge gaps – link to forward programme

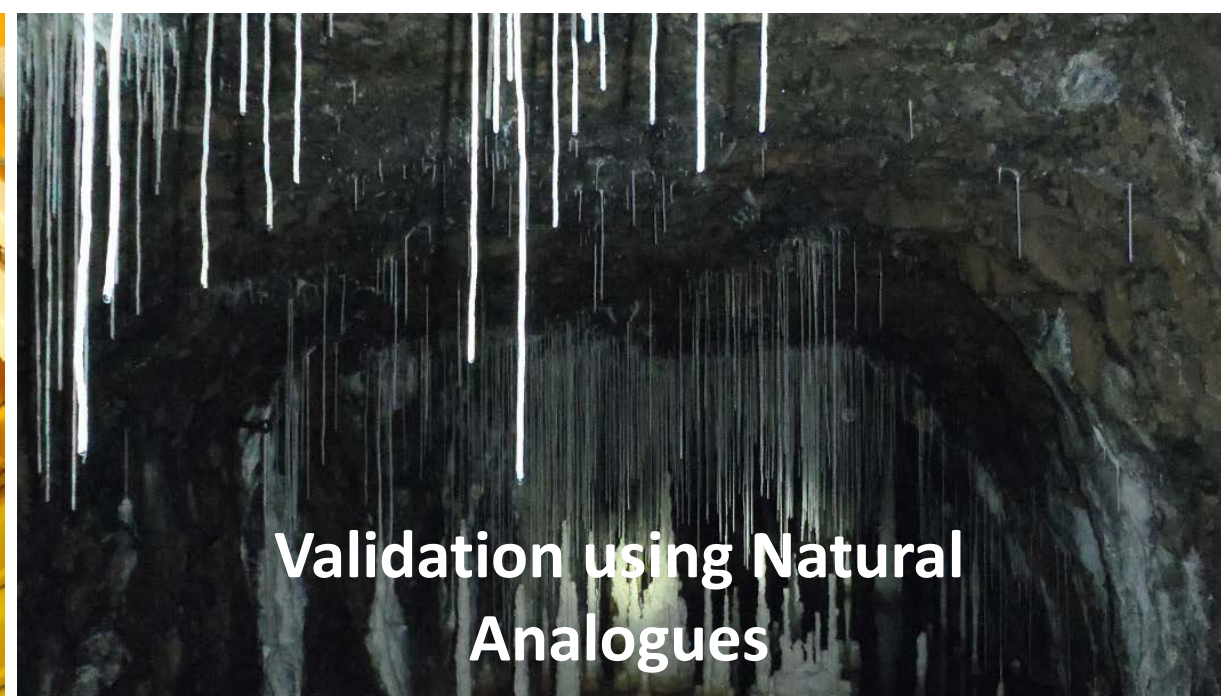
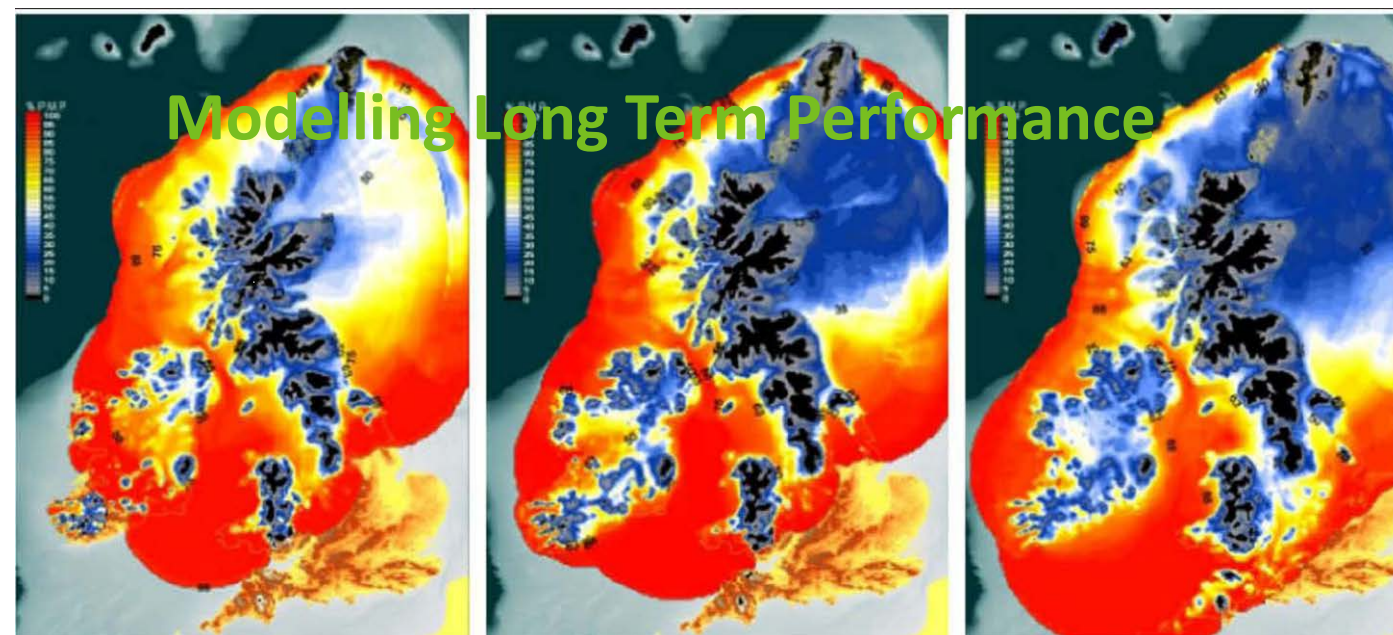
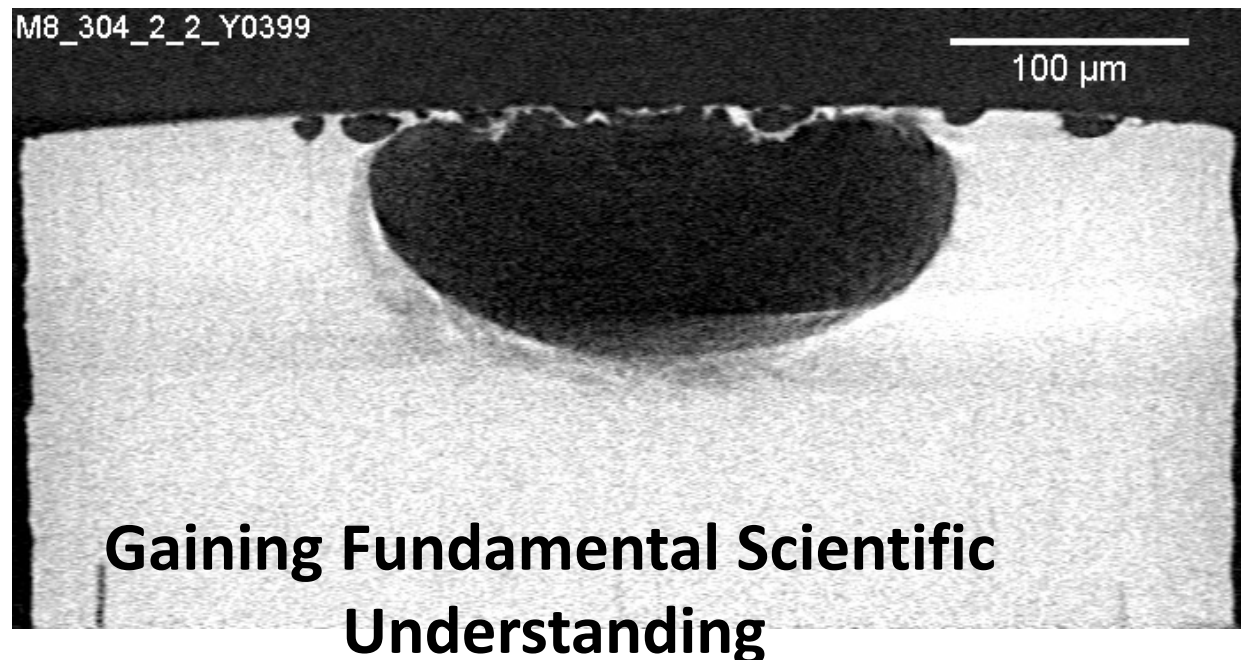


# The role of Research in safety case development



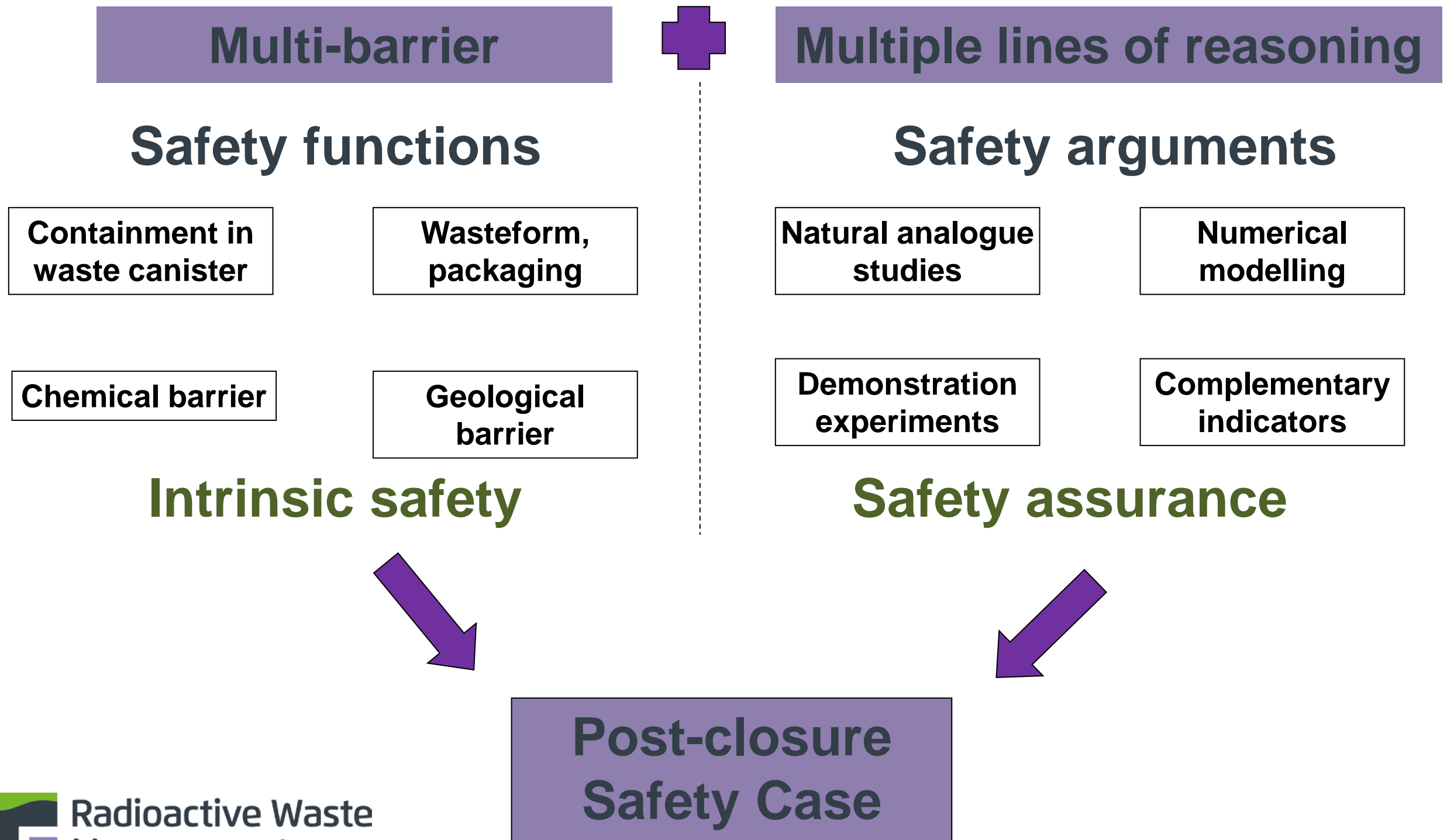


# Developing scientific understanding





# Multi-factor Safety Case



# Generic components of a multi-barrier disposal concept

- **Wasteform**
  - stability (e.g. cement or resin for ILW, glass for HLW)
- **Waste container**
  - safe transport and handling
  - physical barrier post-closure
- **Local backfill / buffer**
  - protection of containers
  - chemical barrier
- **Mass backfill**
- **Geosphere**
  - long-term isolation and stability
  - retardation and retention of radionuclides
- **Seals**

Why are we confident it is safe?



# Illustrative multi-barrier disposal concept for spent fuel

## Physical containment

HLW or spent nuclear fuel



Copper canister with cast iron insert

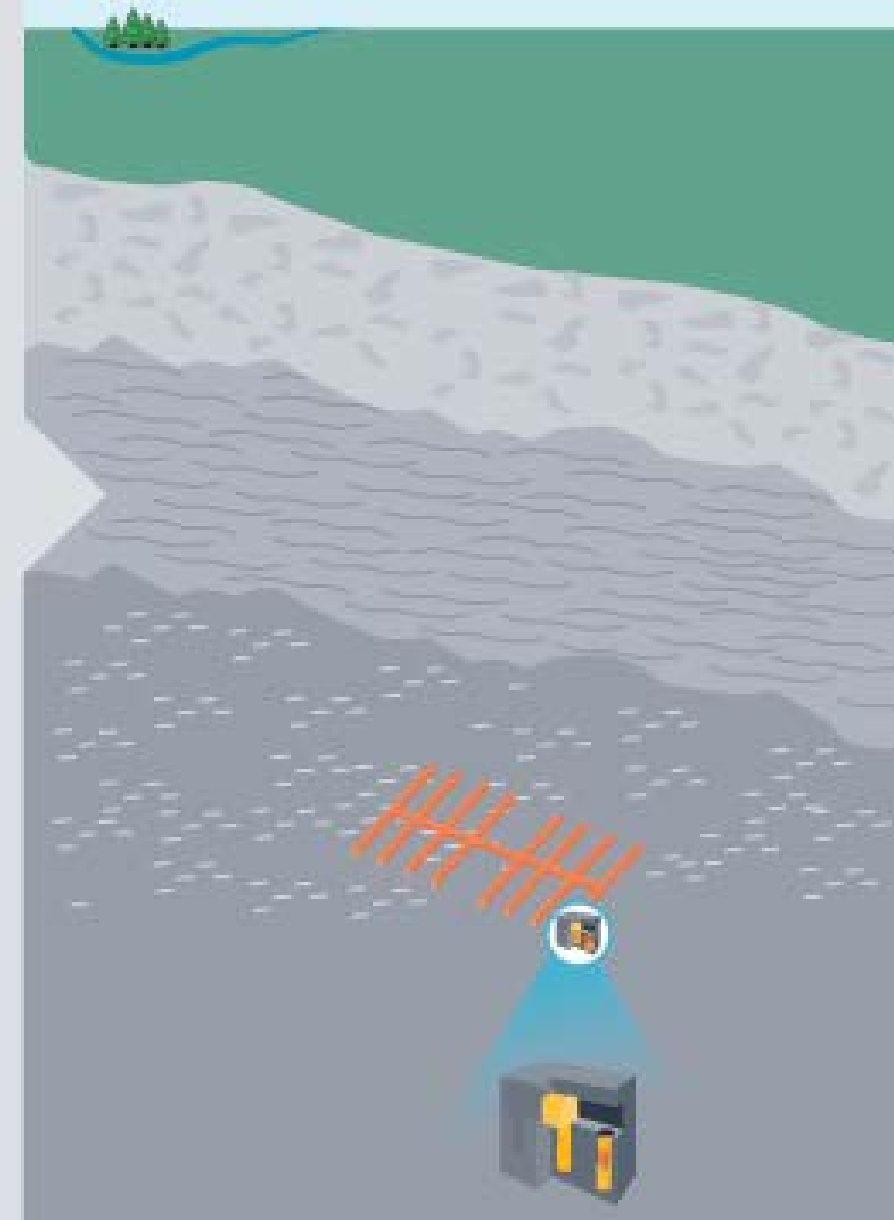
## Geological isolation

Bentonite clay



Host rock

## Geological containment




# Environmental safety functions

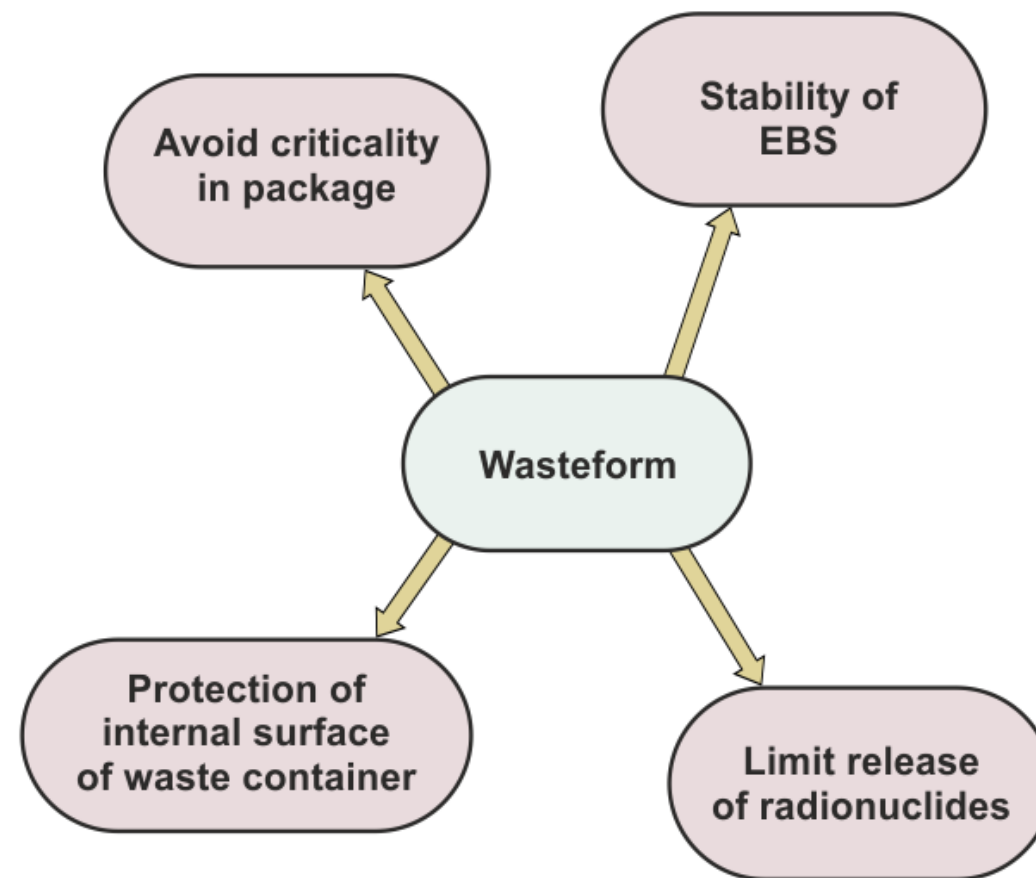
- **Isolation**
  - Removal of wastes from people and surface environment
- **Containment**
  - Retaining the radioactivity from the wastes within various parts of the disposal facility for as long as required to achieve safety
- **Hierarchy of environmental safety functions contribute to isolation and containment**
  - Provided by different components in a multi-barrier concept



Wasteform

**Key:**

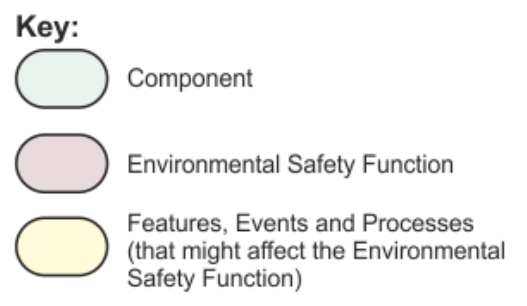
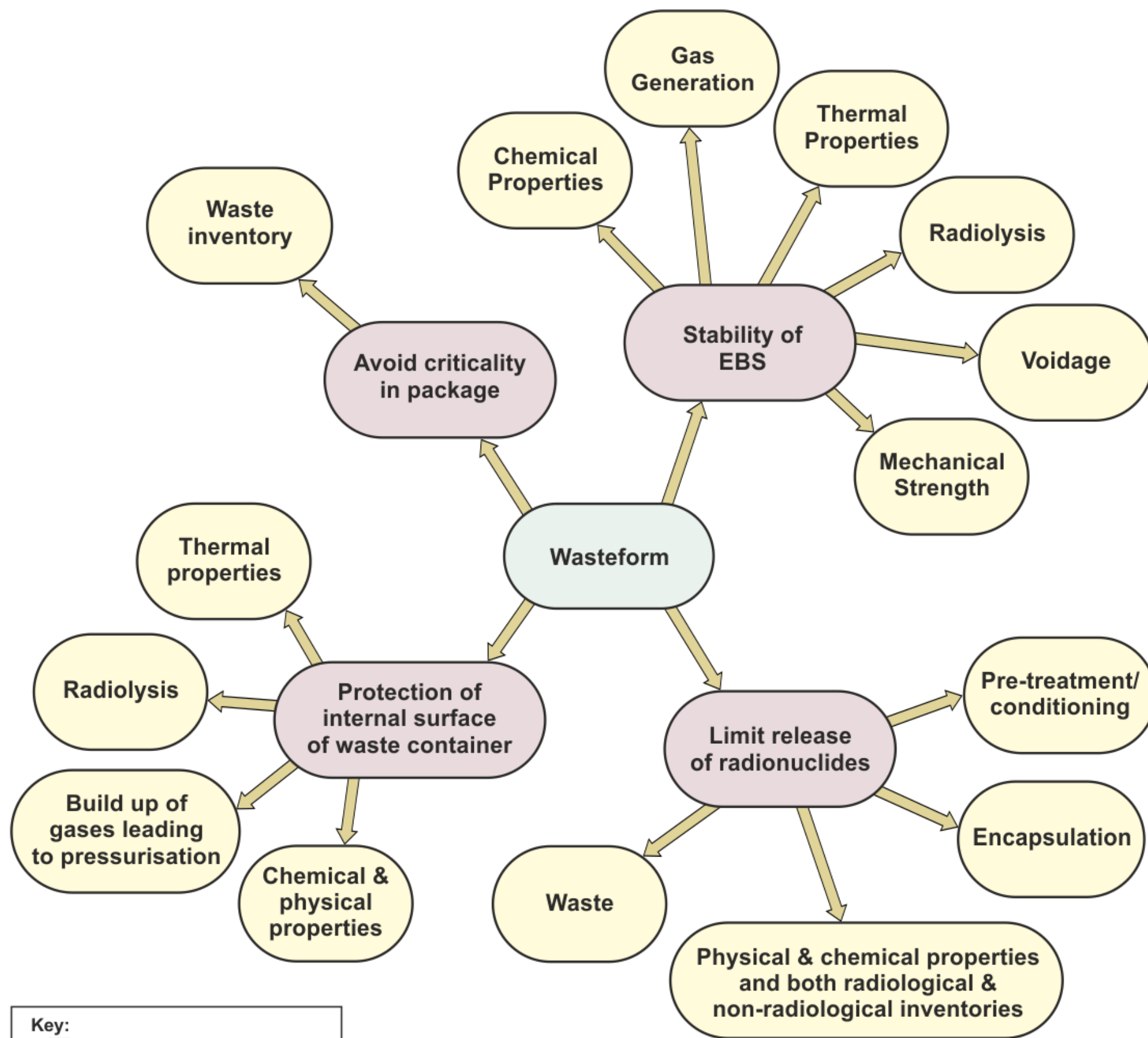
 Component

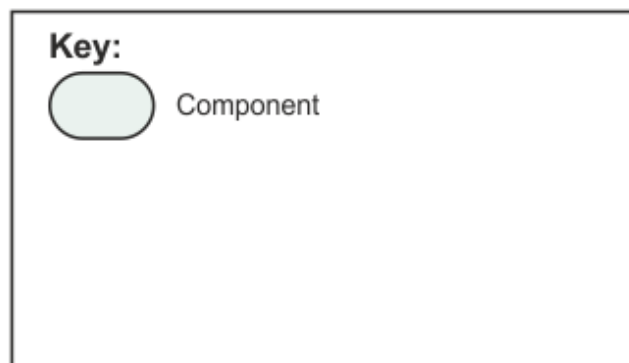
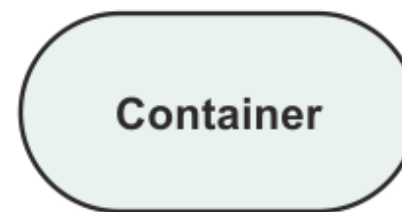


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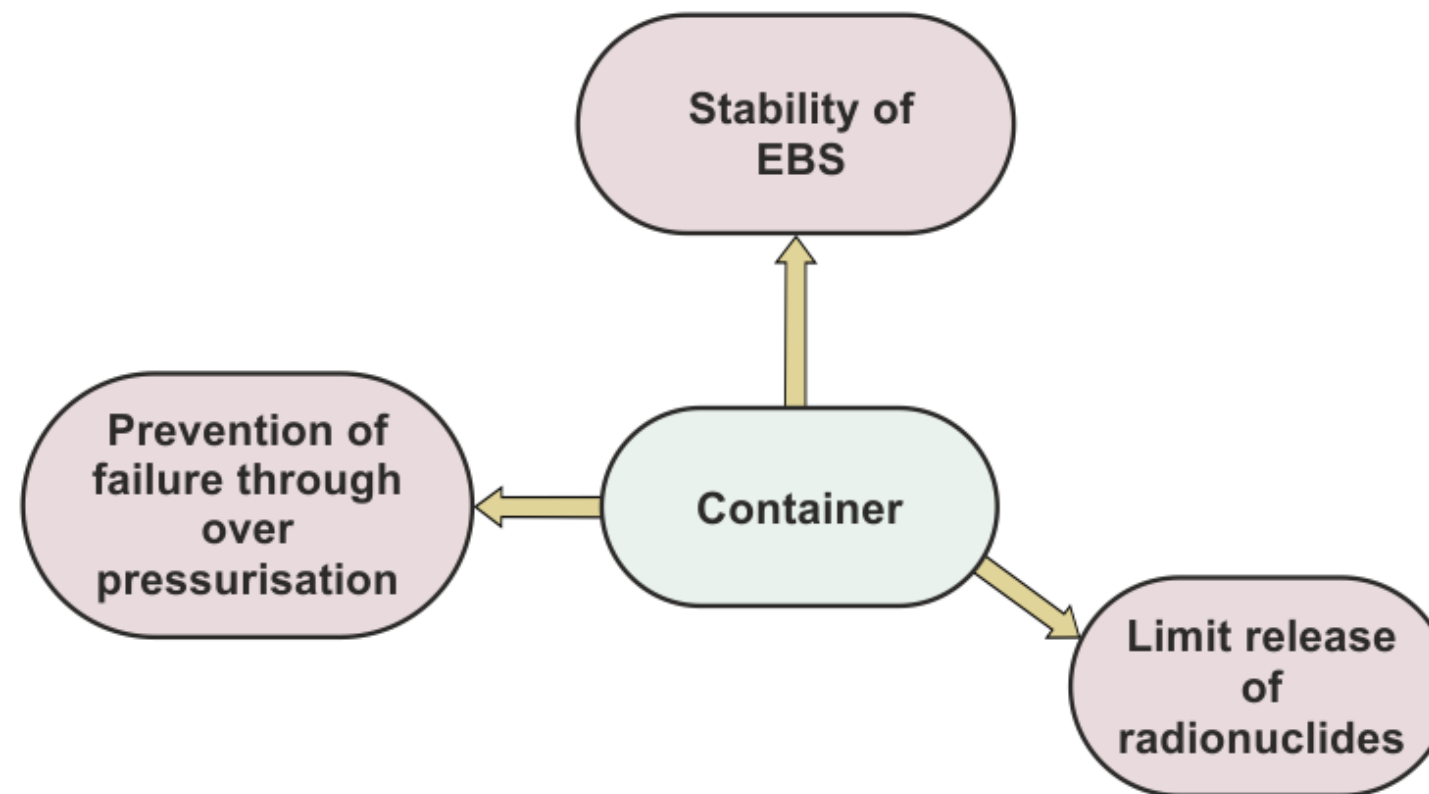
 Component

 Environmental Safety Function









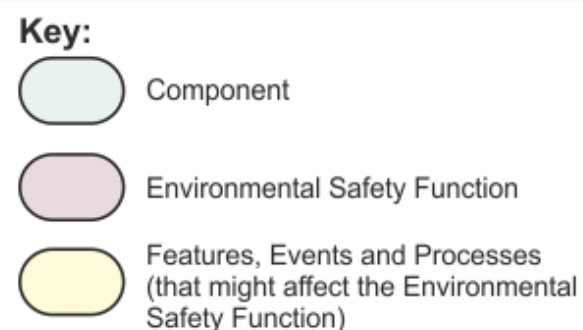
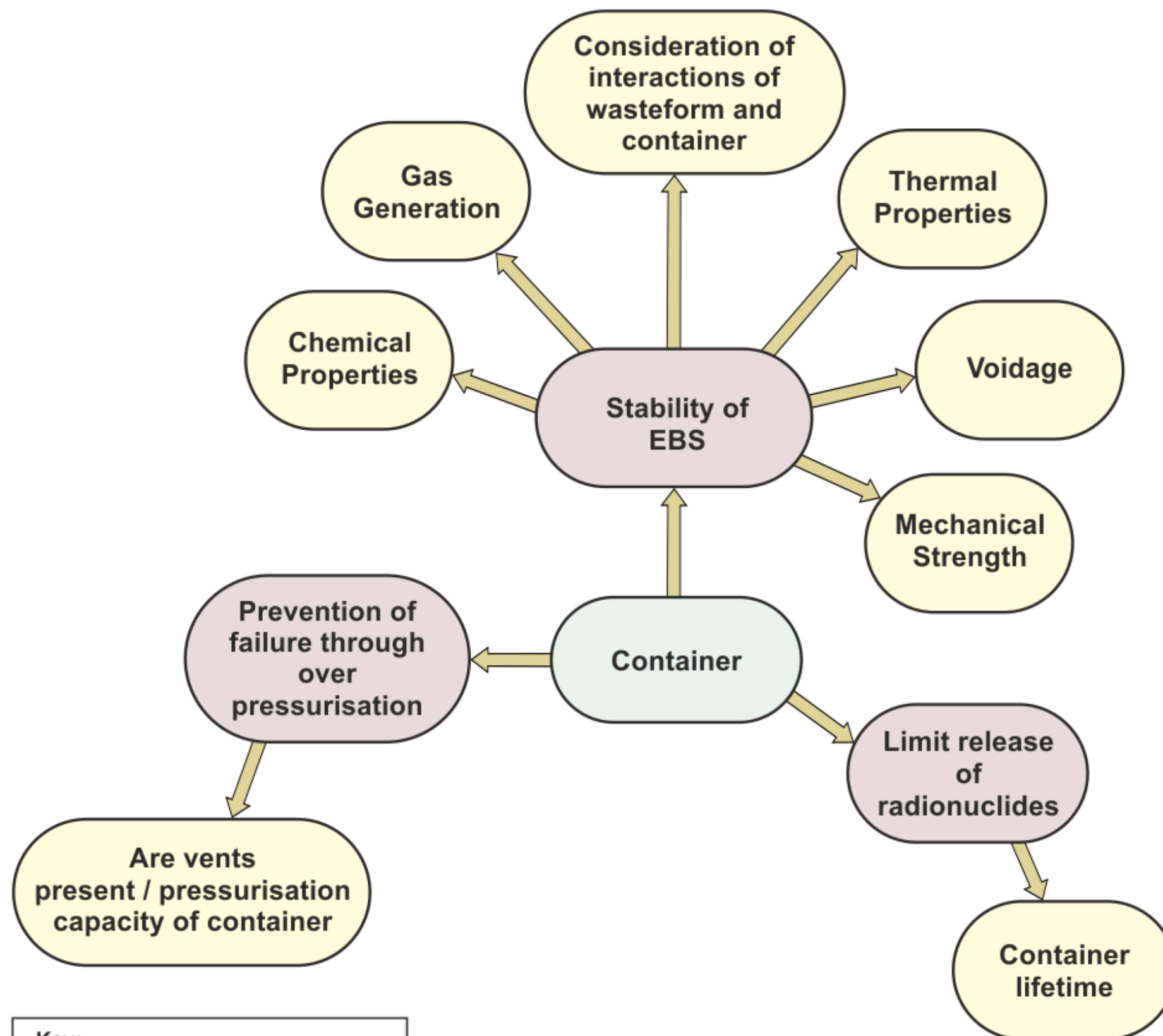
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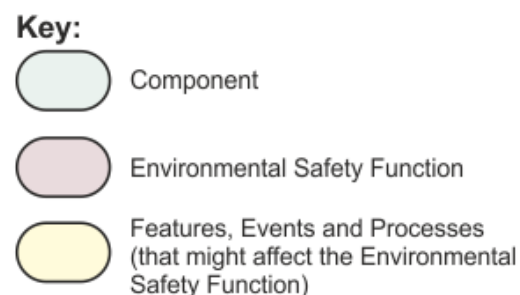
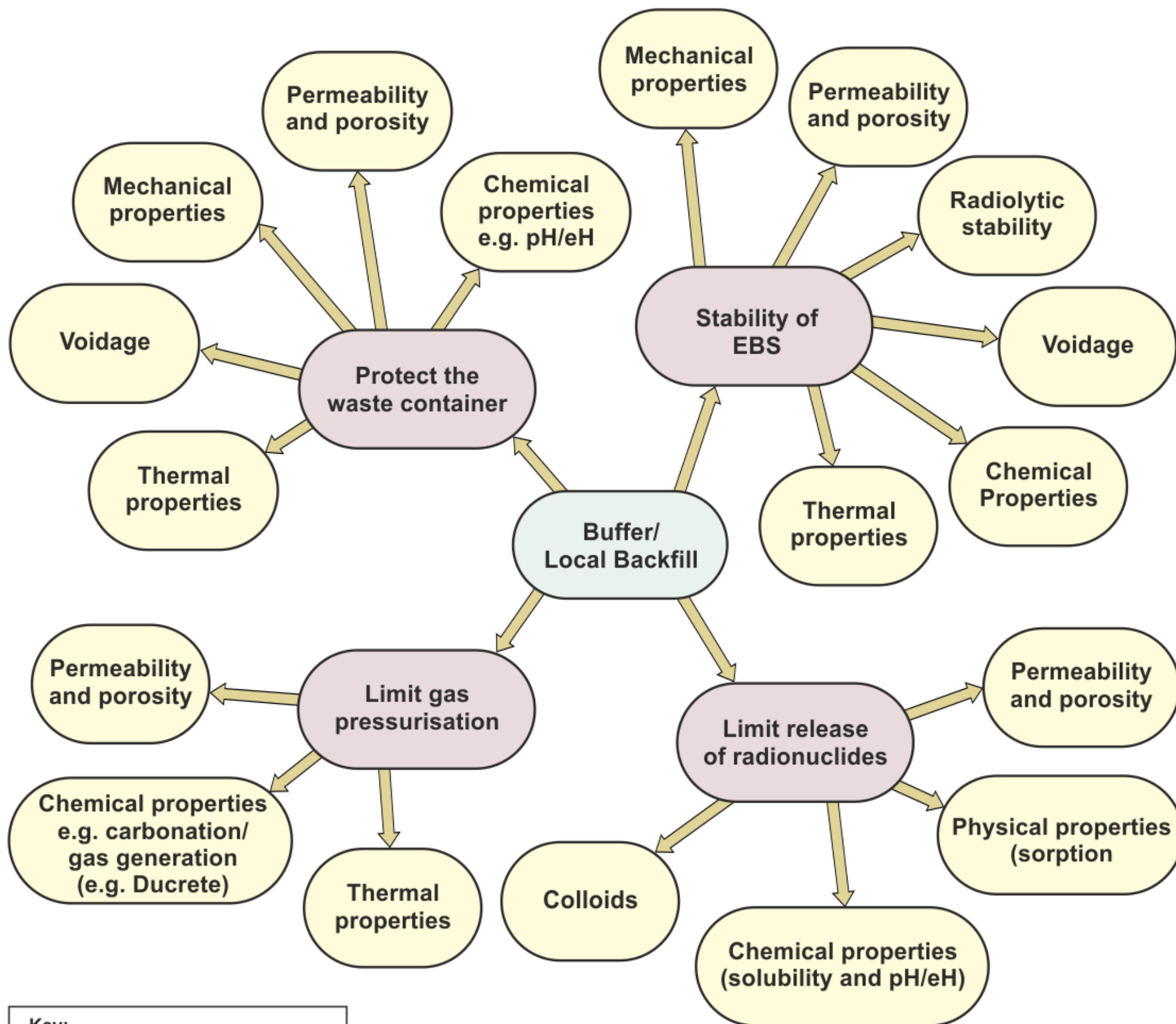


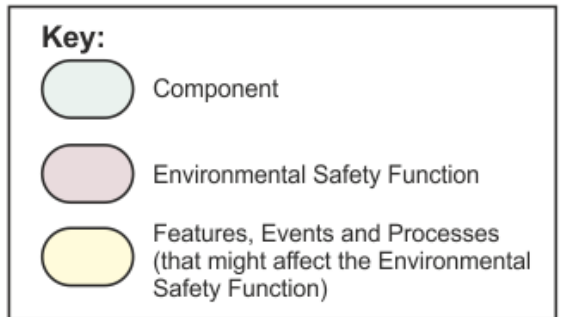
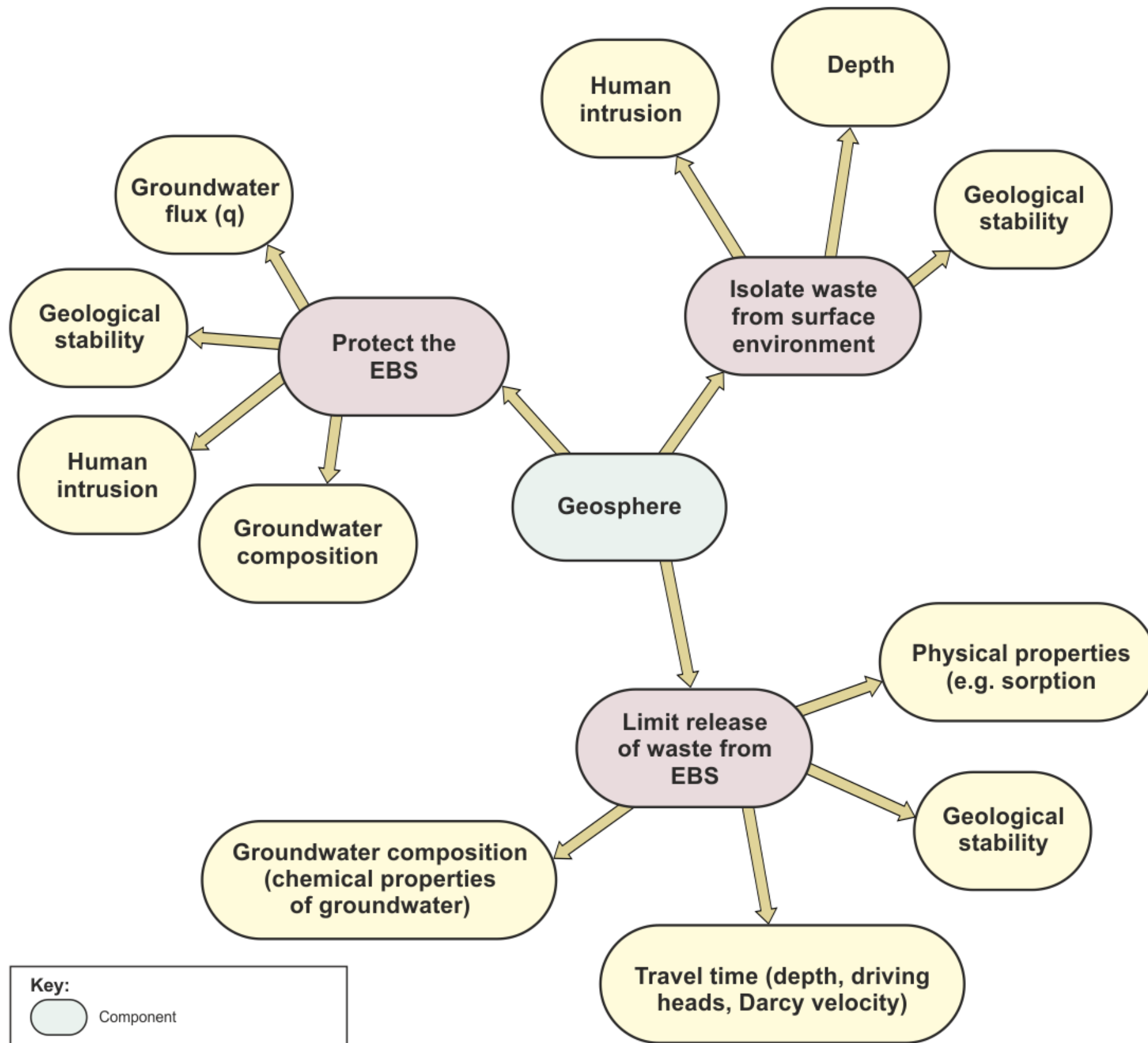
Component



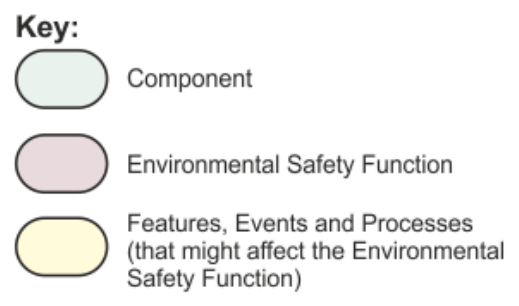
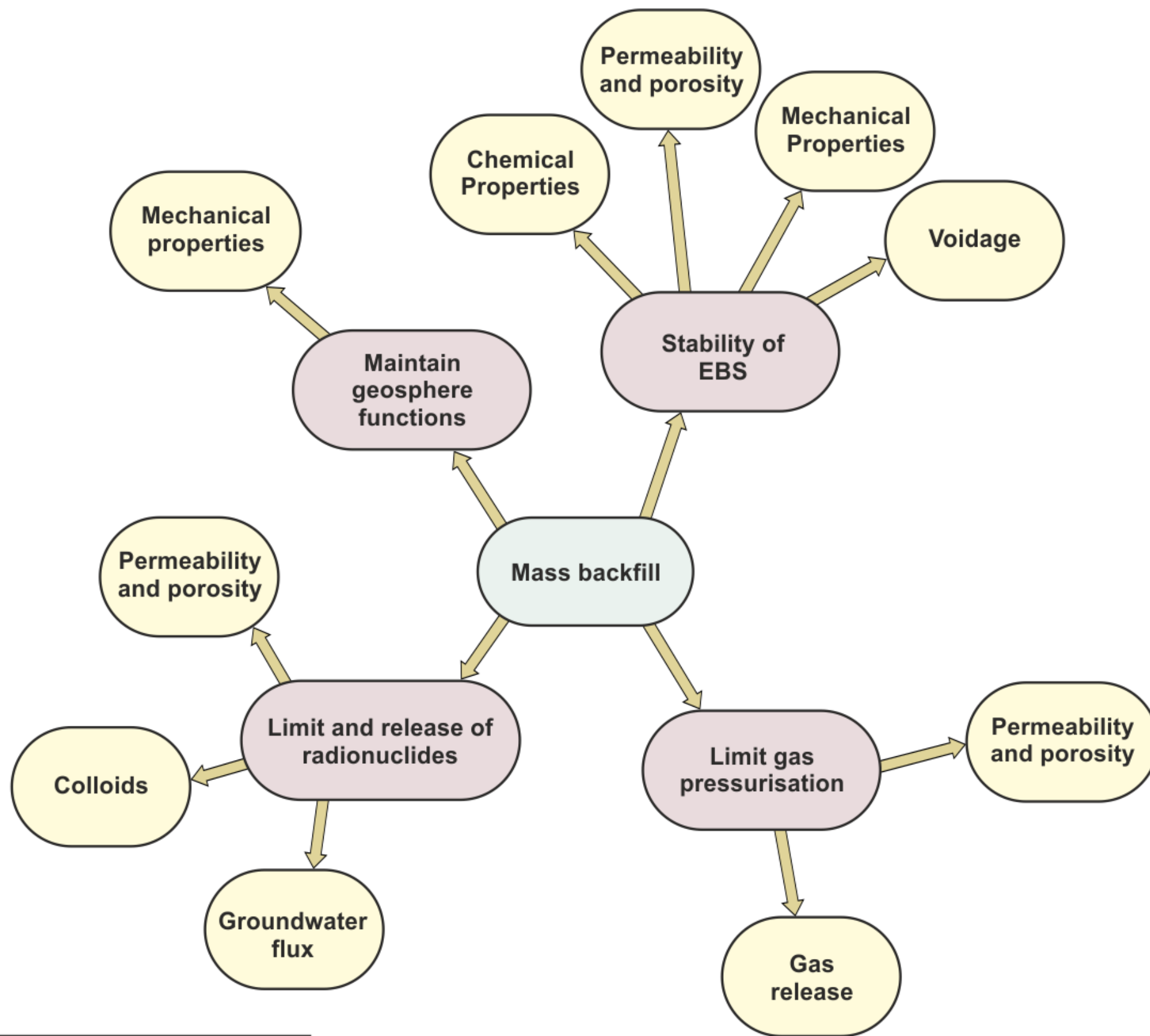
Environmental Safety Function





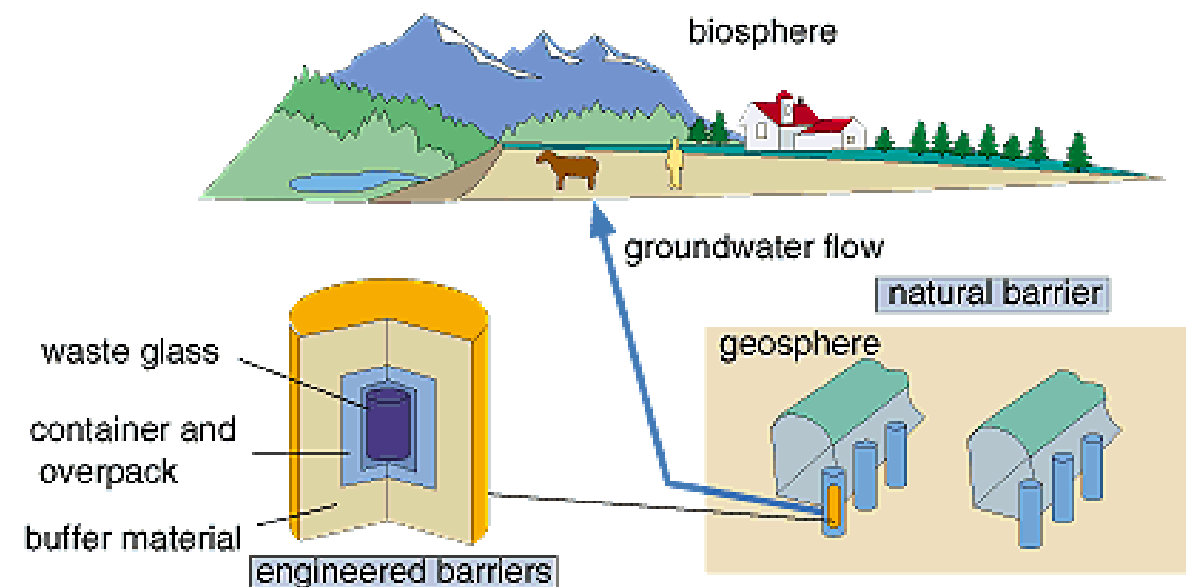






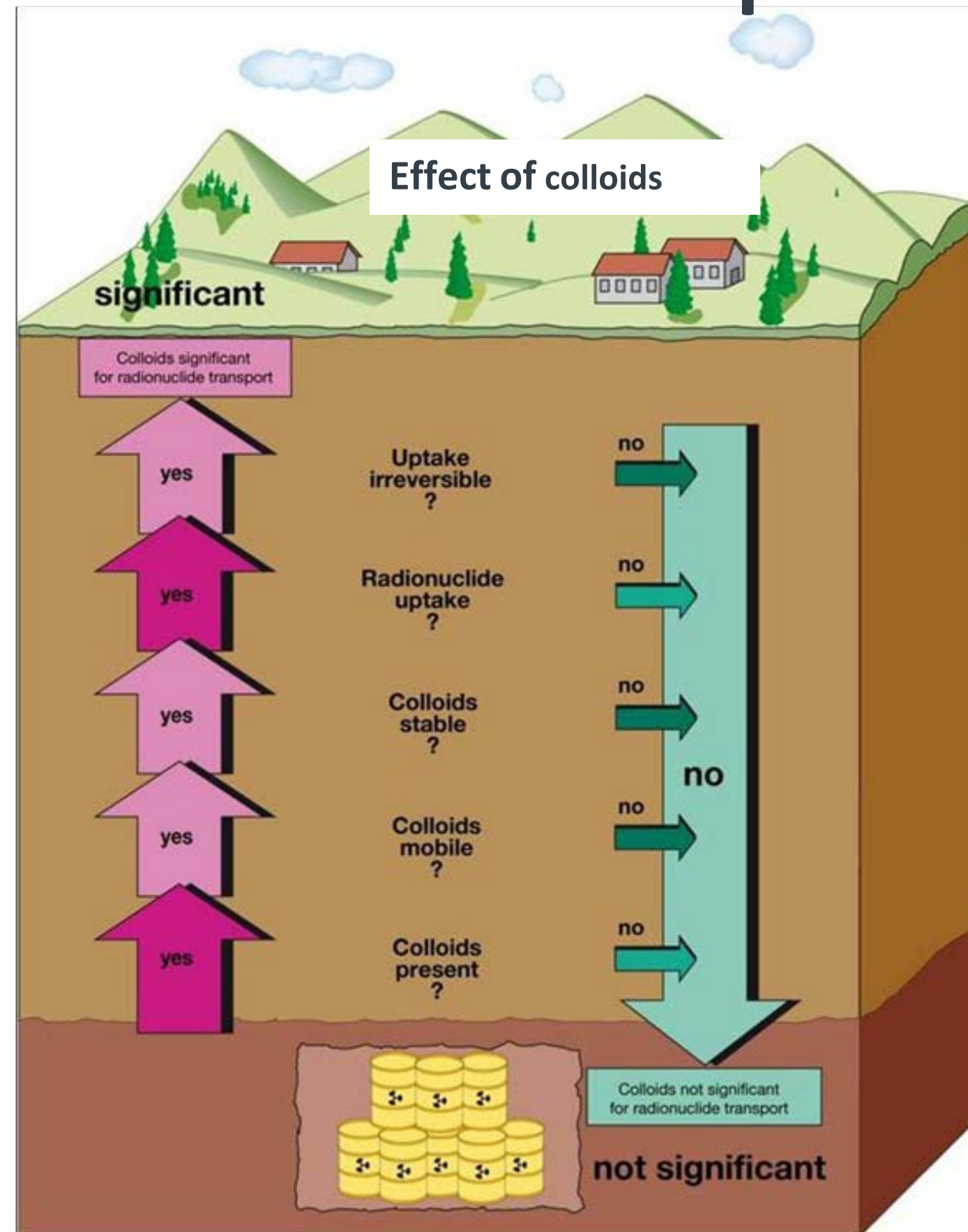
# Radionuclide behaviour in the safety case

- Two high level objectives of a GDF:
  - Isolate waste from biosphere
  - Contain radionuclides associated with waste
- Understanding radionuclide inventory and radionuclide behaviour enables evaluation of the containment afforded by the multiple barrier system
- Two main pathways for radionuclides to leave GDF:
  - Via groundwater pathway
  - Via gas pathway

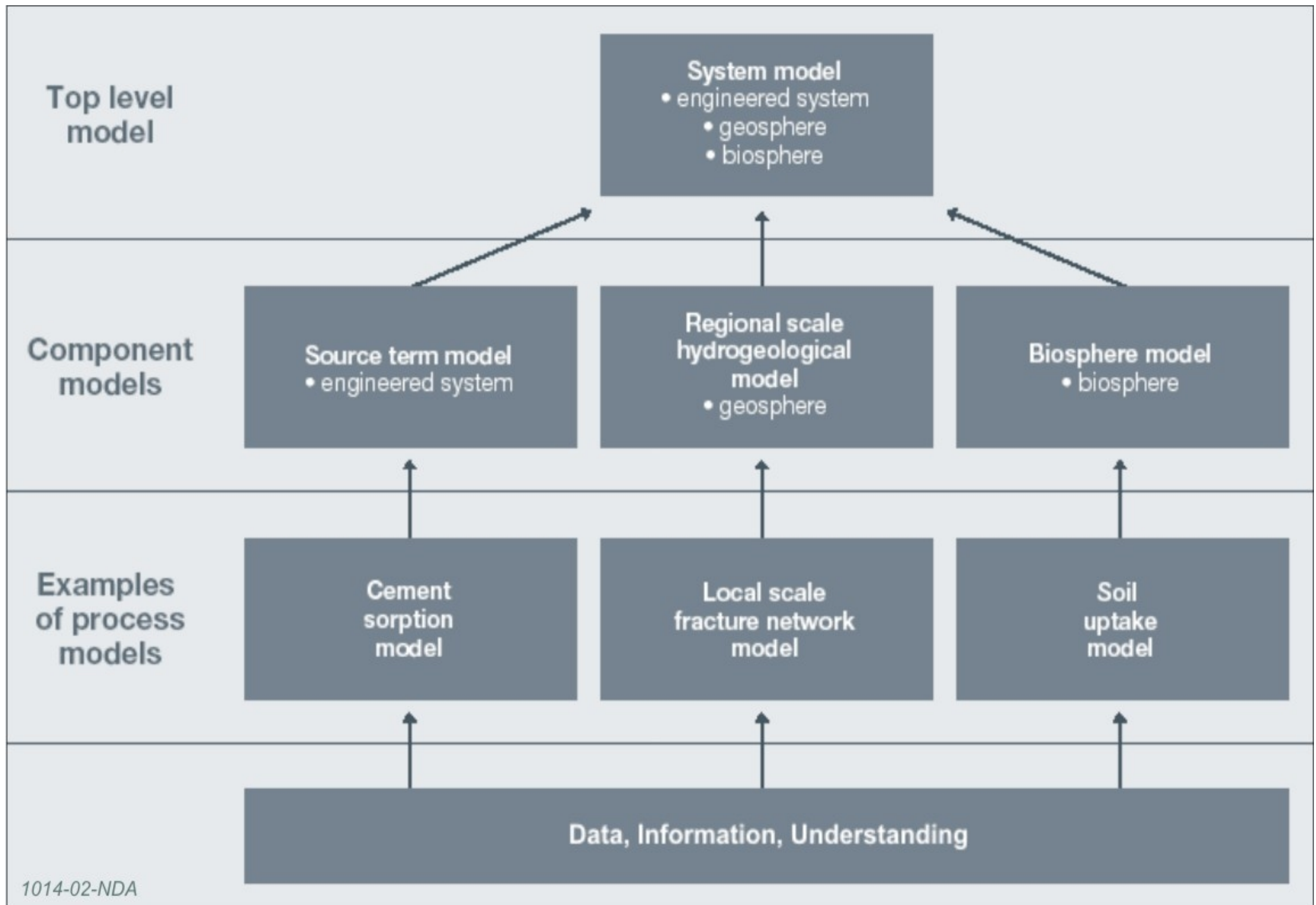


# Impact of colloids on radionuclide transport

- Solubility limitation, sorption and precipitation retard or immobilise radionuclides
- There are many factors which may affect solubility and sorption processes for example:
  - Colloids
  - Complexants
  - Microbes
- Need to understand these factors in order to assess them in safety case

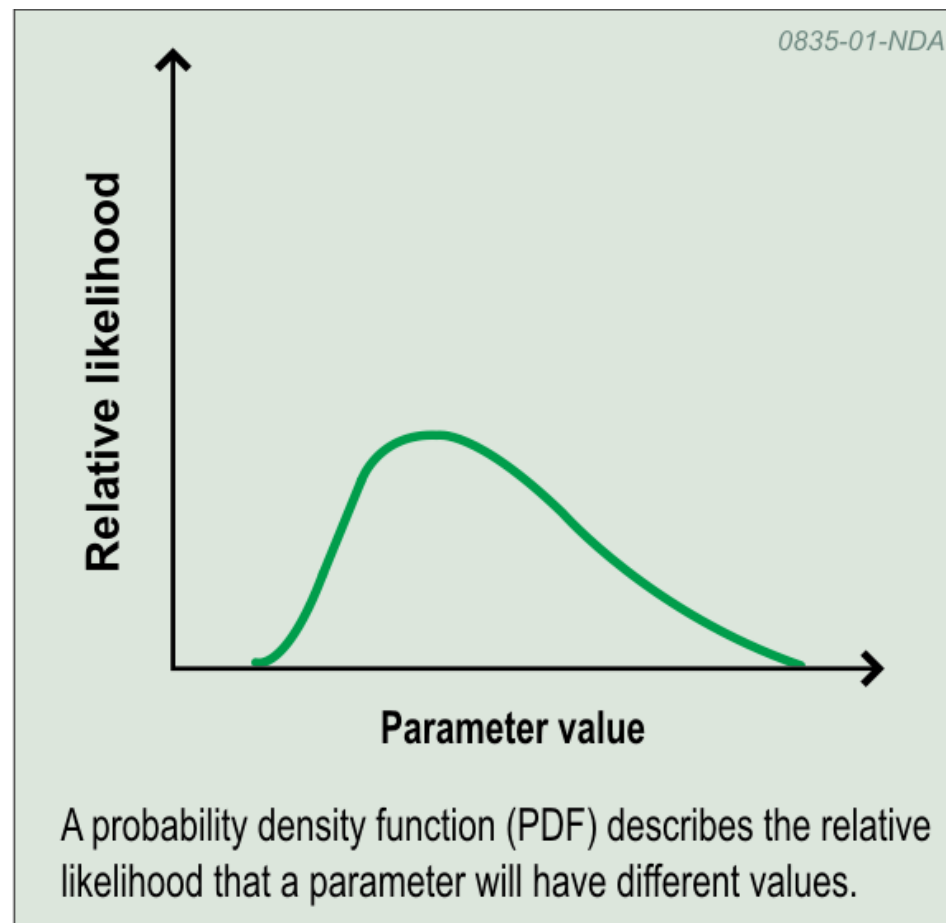


# General approach to modelling





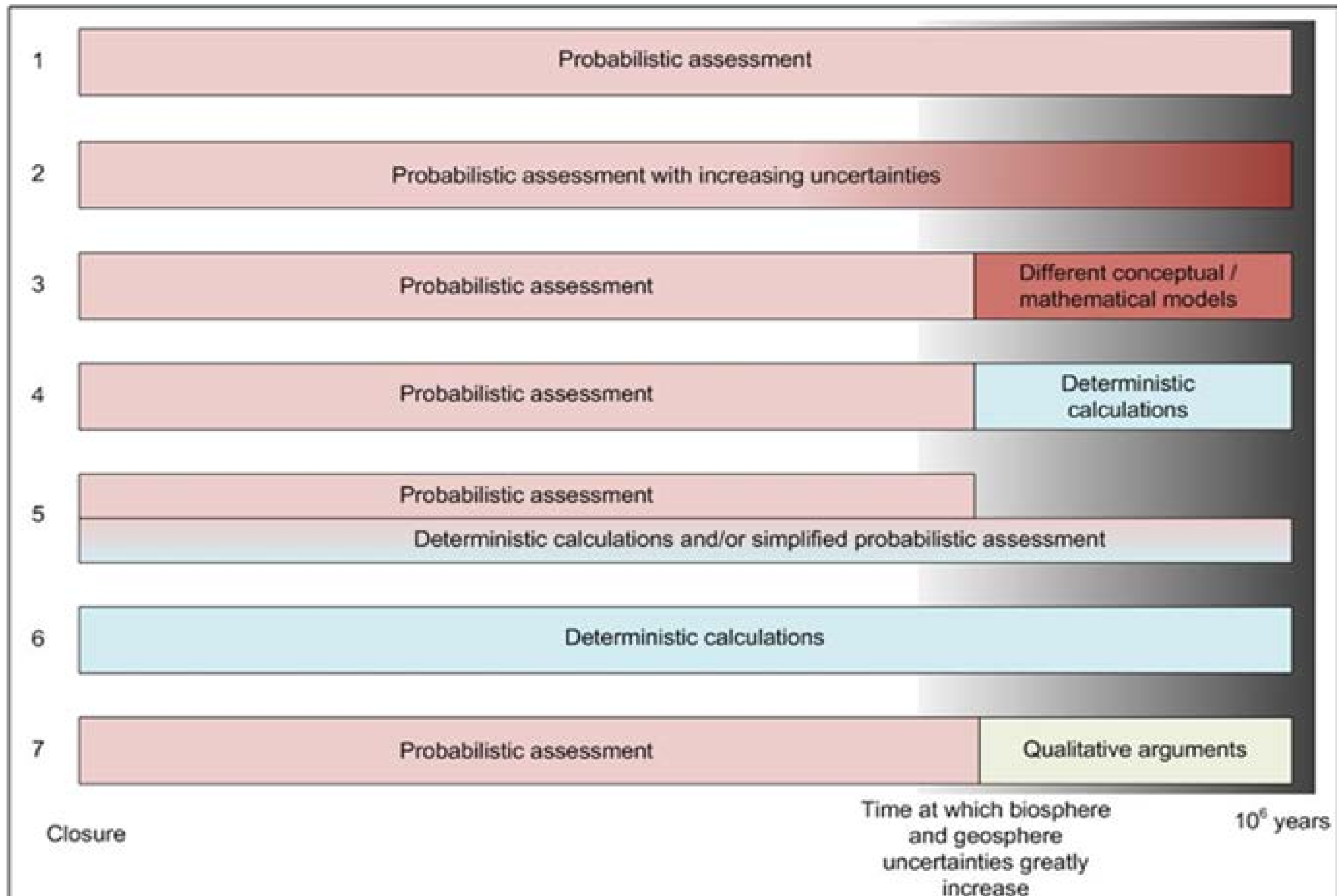
# Monte Carlo Simulation



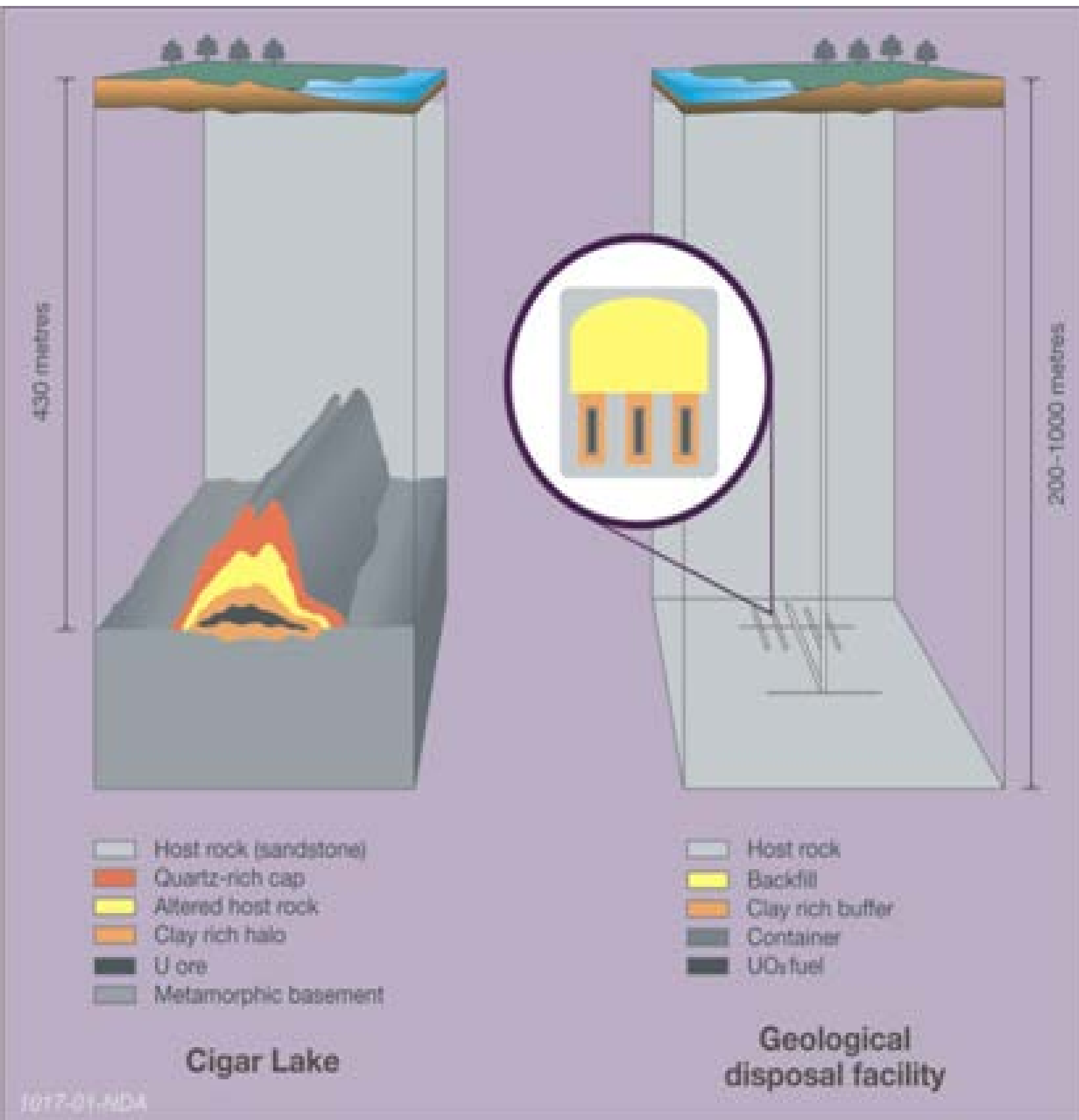
**Probabilistic calculations to explicitly represent parameter uncertainty**

**Experimental and process model data can be used to input into expert elicitation**

# Potential approaches to representing distant timeframes



# Cigar Lake, Canada – a geological analogue



- Uranium ore body formed 1,300 million years ago
- 430 metres depth
- Clay rocks surrounding ore have prevented release of uranium radionuclides to the surface
- Provides an analogue for a spent fuel disposal facility

# Thank you!

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