



**ONDRAF/NIRAS**

# Preliminary R&D and design work for monitoring and retrieving waste in a geologic disposal facility in Belgium

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# Content

- **Context in Belgium**
- **Reversibility & retrievability**
  - Definitions
  - Update of disposal concept (2003-2006)
  - Update of layout (2015-2017)
- **Monitoring**
  - Definitions
  - Methodological aspects
  - Societal aspects
  - Technical aspects
- **Conclusions**

# In Belgium, progress towards disposal differs according to the type of waste

## Category A



- **Institutional decision = surface disposal**  
Law 1998: "solution (...) that is progressive, flexible and reversible"
- **License application submitted to authorities in 2013**
- **Integrated approach, societal involvement**

Low-level waste

Medium-level waste

High-level waste

Short-lived waste  
( < 30 years)

Category A

Category A

Category C

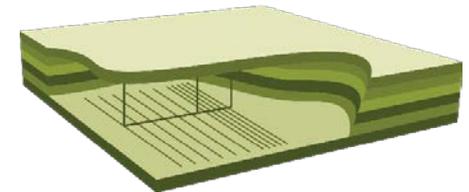
Long-lived waste  
( > 30 years)

Category B

Category B

Category C

heating



## Category B&C

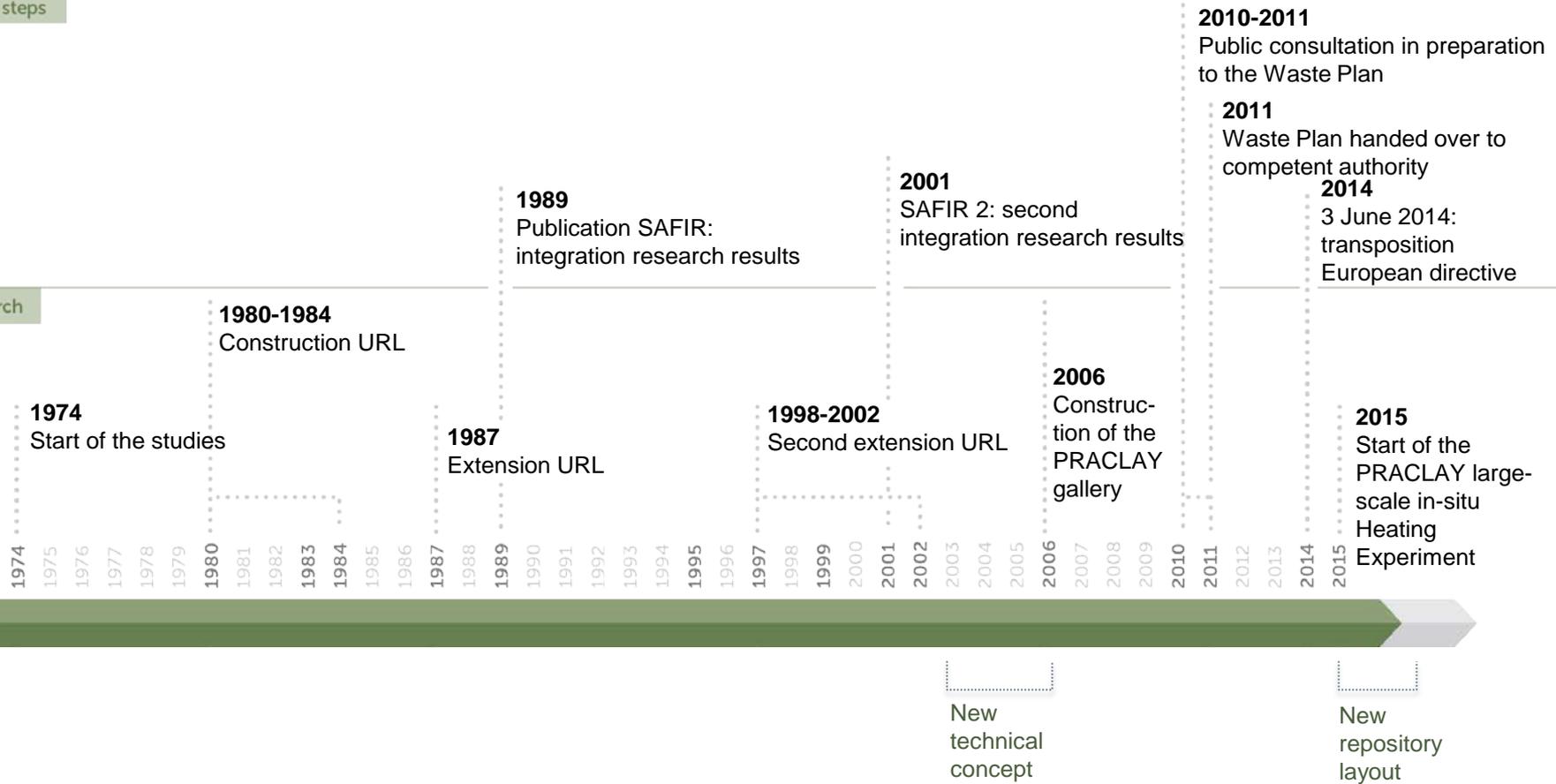
- No institutional decision
- Recommended solution = geological disposal



# Belgium has more than 40 years of RD&D on geological disposal in poorly indurated clays

## Policy steps

## Research



# But Belgium has no policy decision on the long-term management of high-level and/or long-lived waste

- 40 years of research on geological disposal in poorly indurated clays, a. o. with URL in Boom Clay since early 1980's
- However, no institutional decision for geological disposal of high-level and/or long-lived waste
- No full and fixed regulation available
- Reversibility & retrievability are legally requested since 2014, although not defined
  
- ONDRAF/NIRAS continues its RD&D on geological disposal with a focus on poorly indurated clays
  - To guarantee continuity
  - To update cost assessments
  - To iteratively integrate available knowledge and return of experience

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# Reversibility and retrievability (R&R) are imposed by law in Belgium but not defined

- **The Law of 3 June 2014 stipulates that national policies must contain methods for reversibility and retrievability, taking account of the need to ensure the safety of the repository**
- **The Belgian regulator defined the terms in some publications, but these definitions are not yet fixed by regulations**
  - Reversibility: taking back the waste during the operational phase, before backfilling or sealing, with similar means as by which the waste was emplaced. This is mandatory for the regulator.
  - Retrievability: taking back the waste after (partial) backfilling and sealing, probably involving other means than those needed to emplace the waste. Retrievability is not a question from the regulator, but might be based on societal demands. Attributes of retrievability should not endanger the long term safety. Retrieving waste will be subject to a specific licence, not included in the construction & operation licence of a geological facility.



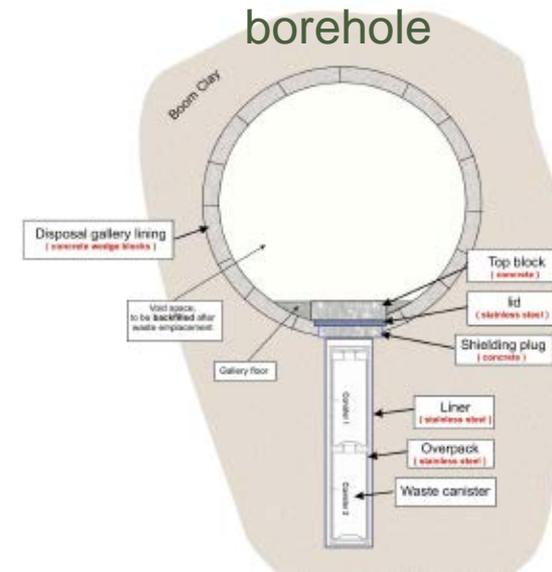
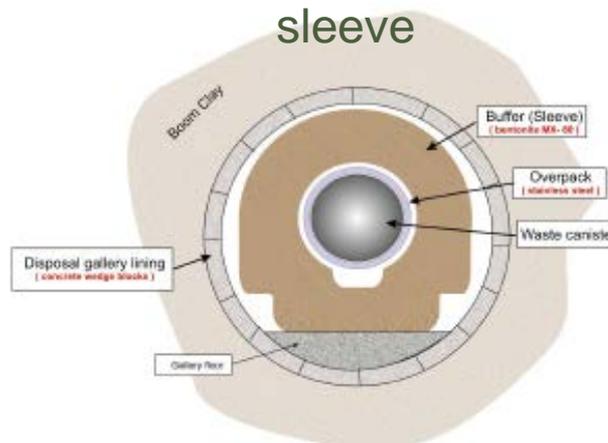
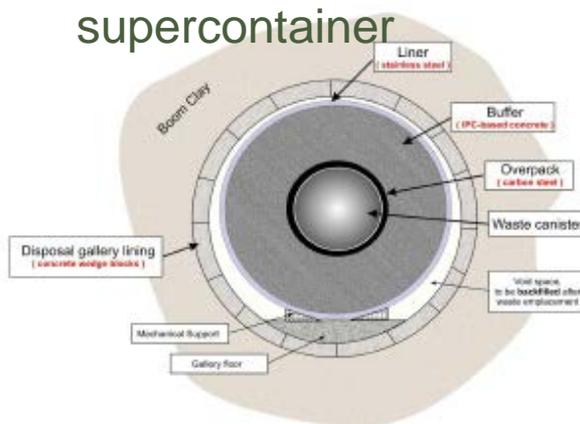
# O/N has updated its disposal concept in 2006, for technical reasons

- In line with the stepwise approach, a re-evaluation of the disposal concept was performed, based on the outcomes of SAFIR 2 (2001) and its peer-review (2003)
  
- O/N defined a safety strategy that incorporates the following main elements
  - Full containment during the thermal phase for HLW / SF
  - Do not unduly disturb the host rock
  - Preferences for materials and implementation procedures for which broad experience and knowledge already exists
  - Preferences for permanent shielding of the wastes and for minimisation of operations in the underground

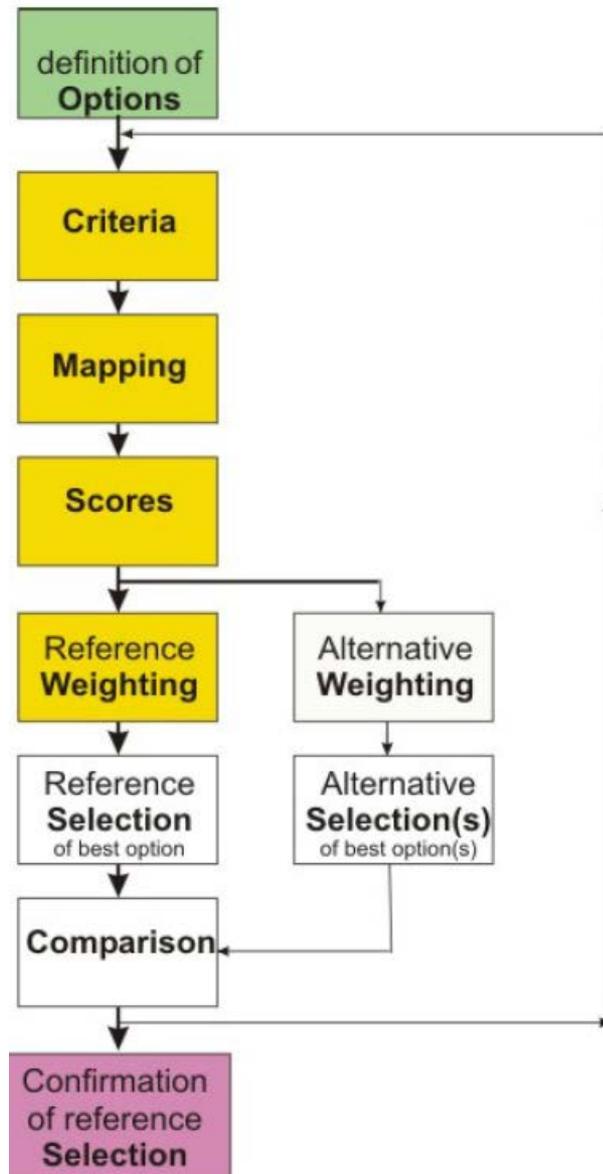
# The updated disposal concept had to comply with the new safety strategy

## ■ Approach

- **Structured** step-by-step approach, with justification of the key decisions taken, based on awareness of the consequences
- **Multi-disciplinary** task force, spanning different organisations from research and industry
- Consultation of internationally recognised experts (corrosion panel)
- Fully **documented** procedures



# The selection process included a multi-criteria analysis



- **Teamwork: discussion + working sessions**
  - Development of a set of criteria
  - Criteria weighting strategy
  - Agreement scores (proposed by experts)
- **Duration of the selection process**
  - January to November 2003
  - Dedicated sessions during 6 meetings

# The weight factor of R&R was rather low (3%)

Aspect	Criterion	Weight factor	
Engineered robustness	Containment	40	80
	Release from waste matrix	40	
	Delay and attenuation by EBS	0	
Host rock perturbation	Gas generation	20	80
	Chemical compatibility with host rock	20	
	EDZ	20	
	Loss of clay layer thickness	20	
Intrinsic robustness	Materials characterisation	50	100
	Materials interaction modelling	50	
Ease of demonstration	Natural and/or archaeological analogues	25	80
	Proven technology	25	
	QA/QC implementation	30	
Technical operation	Handling complexity	10	25
	Deposition rate	5	
	backfilling	10	
<b>Flexibility</b>	Transferability (flexibility to waste type)	35	50
	<b>Retrievability</b>	<b>15</b>	
Financial feasibility	Construction costs	25	50
	Operation costs	25	

# The concept with the highest score was selected

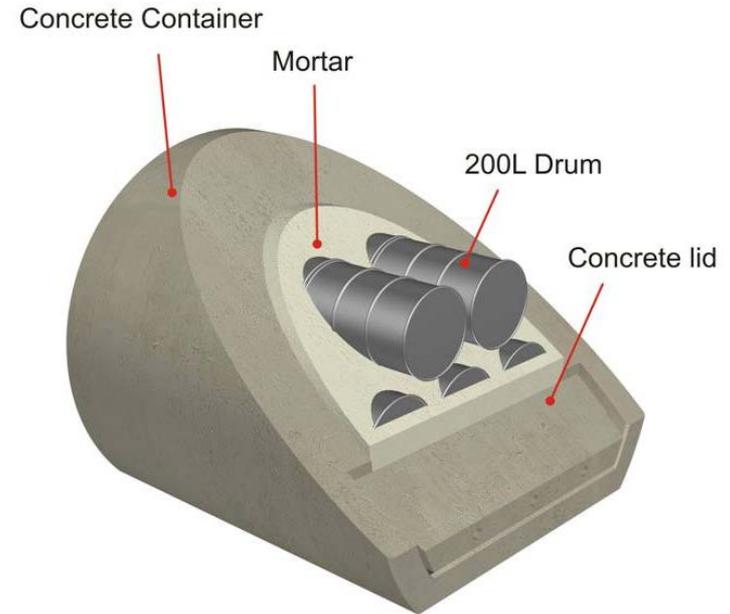
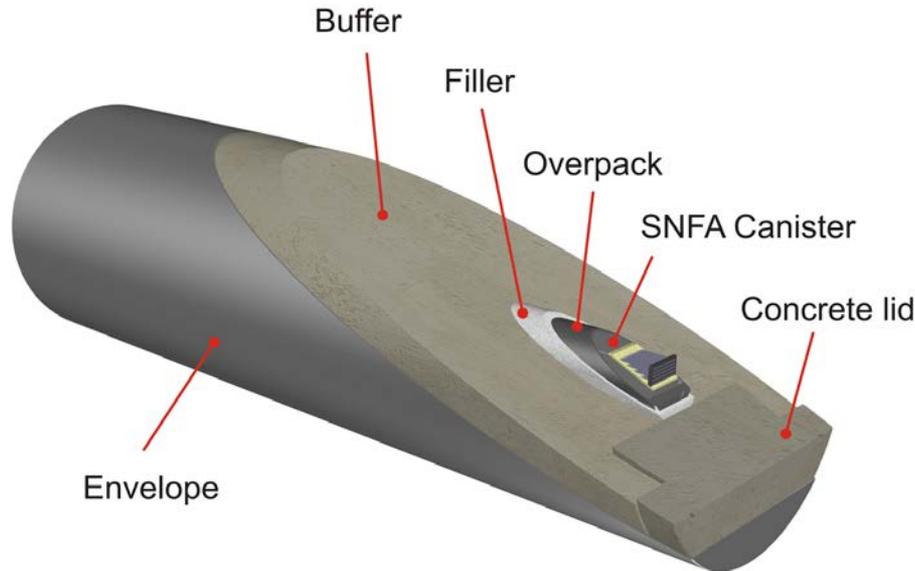
- Reference weighting (see before)
- Alternative weighting
  - Techno: increased weight on technical operation, flexibility and cost
  - Finance: increased weight on cost
  - Authorities: increased weight on ease of demonstration

	Reference	Techno	Cost	Ease of demonstration
SC – IPC	57	57	57	55
BH – V	54	54	54	53
SL	52	52	53	52
<b>SC – OPC</b>	<b>61</b>	<b>61</b>	<b>59</b>	<b>59</b>
BH - H	55	55	55	53

# The current reference disposal packages contain OPC

Supercontainer for high-level waste

Monolith for Category B waste



## Key rationale for selection:

- The requirement for a **watertight containment** of the waste during a predefined time, which means a design focussed on the control of the corrosion of the overpack
- The **ability to characterize** and to model phenomena (especially in the buffer): concrete is an industrial product, whereas bentonite is a natural product

# The law of 2014 does not call into question the supercontainer design, on the contrary

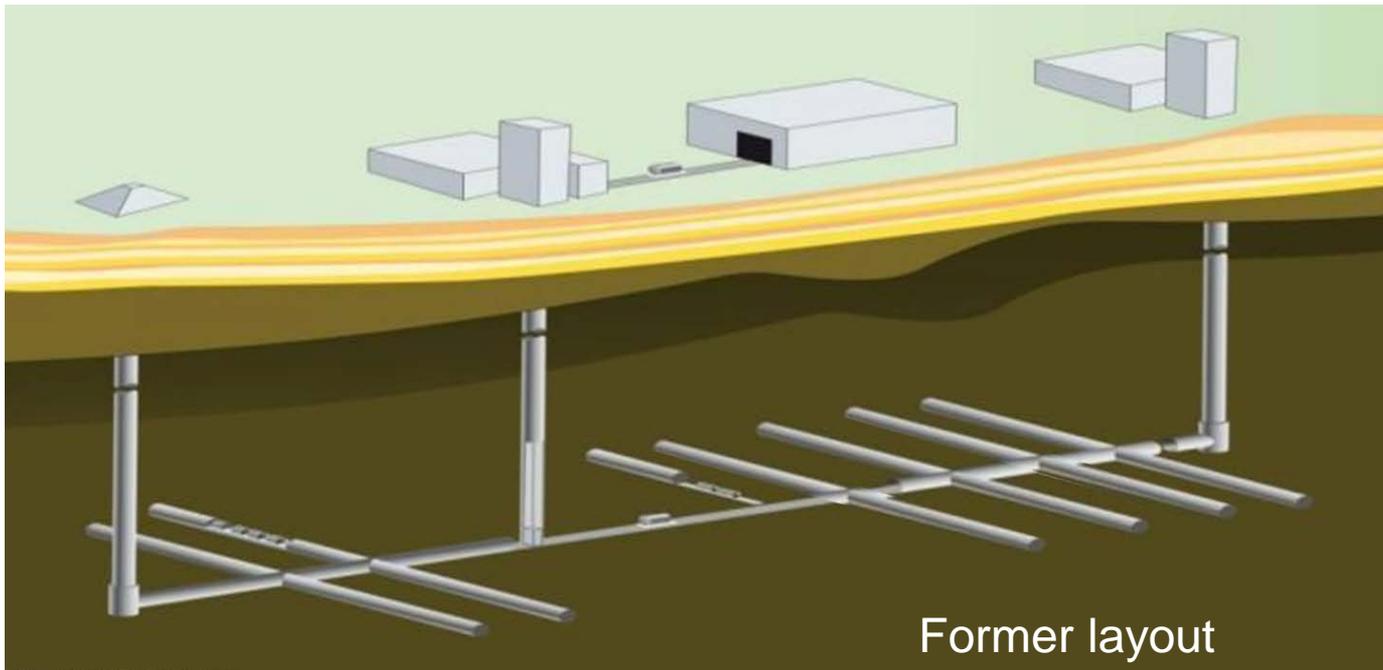
O/N re-evaluated the supercontainer design with respect to the R&R requirement



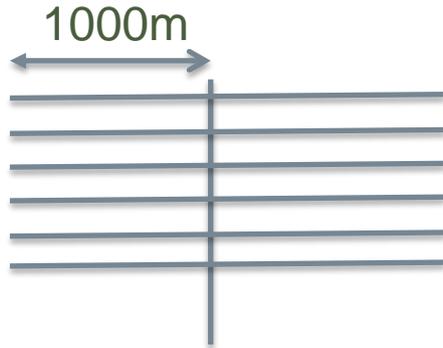
- Permanent shielding is evaluated positive
- Outer stainless steel envelope becomes mandatory instead of optional
- No arguments found to put into question the supercontainer design

# In 2015, O/N re-evaluated the layout of the repository

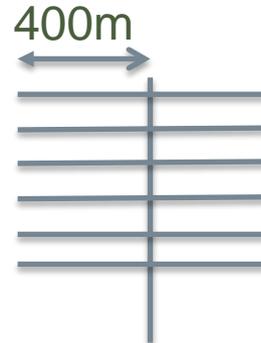
- in line with the stepwise approach, based on peer review and HAZID (HAZard IDentification)
- as the former layout presented several weaknesses:
  - not really integrating operational safety issues (as driven by long-term safety issues)
  - X-crossings seem today difficult to construct in poorly indurated clays at given depths
- and for more integration of R&R aspects



# Several alternatives were evaluated

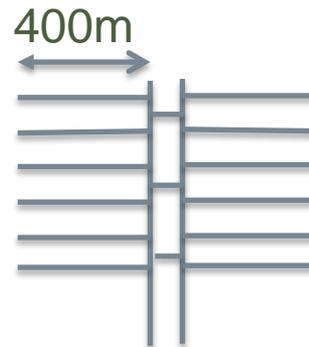


## a. Limit disposal gallery length



- Tunnel regulation
- German mining regulation

## b. Double access gallery



- Increase escape routes
- Avoid X-crossings

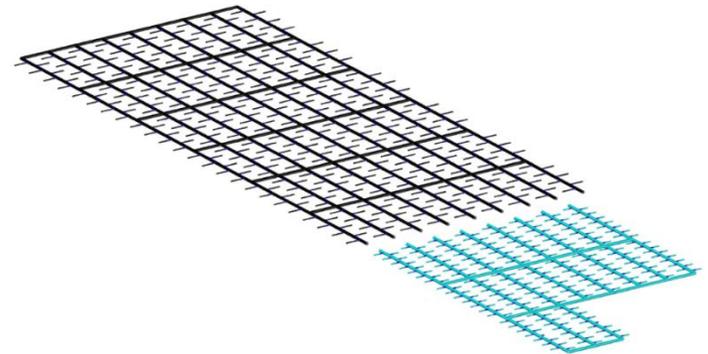
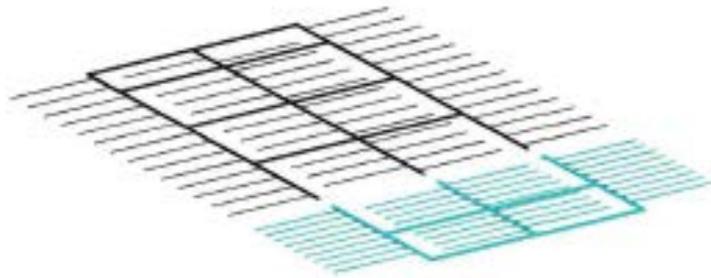
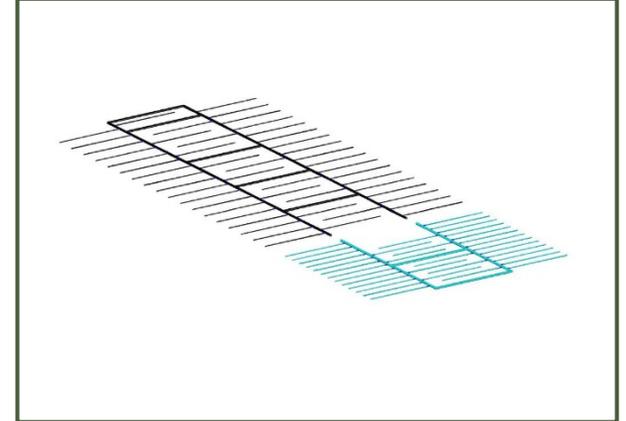
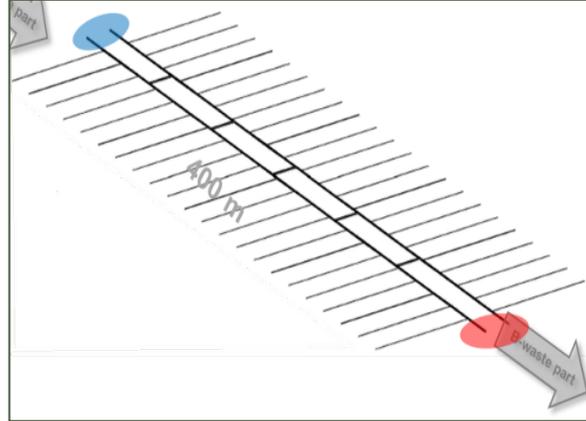
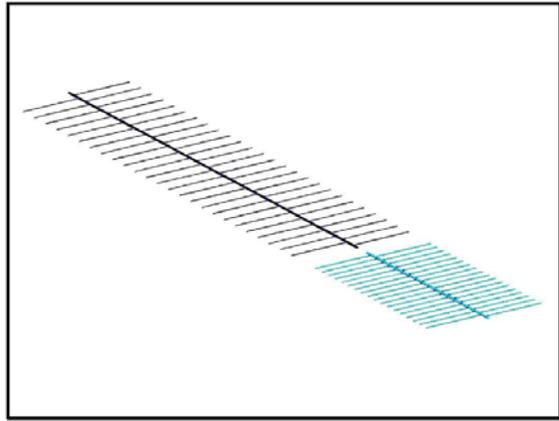
## c. Maximise reversibility

50m



- Backfill after emplacement of supercontainers is limited to 50m gallery length

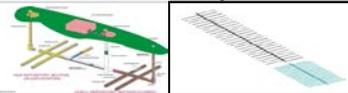
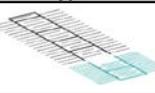
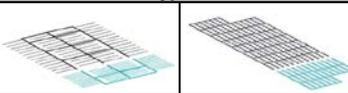
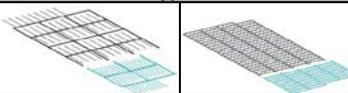
# Several variants of those possibilities to optimise shafts position and footprint



# Evaluation of alternatives

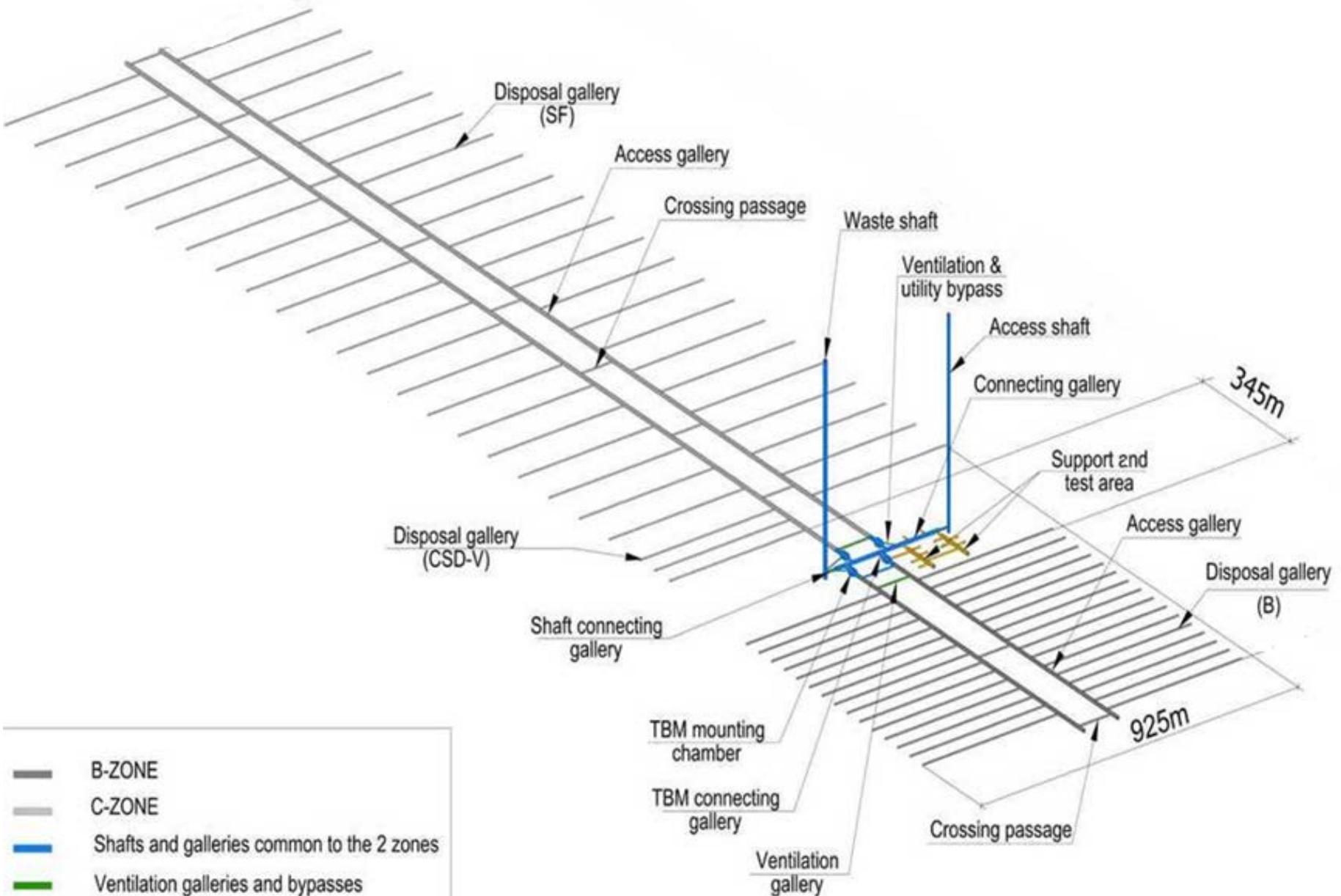
## The weight factor of R&R is now 15%

### Matrix Layout Evaluation

Evaluation Scale	1 - very bad	2 - bad	3 - indifferent	4 - good	5 - very good					
Weighting Scale	1 - low importance	2 - medium importance		3 - high importance						
evaluated by:		Reference Layout		Type C	Type D		Type E			
ONDRAF/NIRAS, DBE TECHNOLOGY GmbH, Tractebel Engineering s.a., EIG EURIDICE										
Criteria	Weight	1000 m DG	400 m DG	400 m DG	400 m DG	50 m DG	400 m DG	50 m DG		
Operational Safety	during Construction	4,00	3,50	3,75	3,00	1,50	3,00	1,50		
	during Operation	2,67	3,25	4,00	3,25	3,00	2,75	3,00		
	3	3,33	3,38	3,88	3,13	2,25	2,88	2,25		
Long-term safety	3	4,33	4,00	3,75	3,50	3,00	3,25	3,00		
Operation	Best available Technique	4,33	4,50	4,00	3,75	2,50	3,50	2,50		
	Time for Disposal per Package	4,67	4,50	4,25	3,50	2,00	3,25	2,00		
	3	4,50	4,50	4,13	3,63	2,25	3,38	2,25		
Reversibility <sup>1</sup>	2	1,67	2,25	2,25	2,25	5,00	2,25	5,00		
Flexibility	extension	1,67	1,50	3,50	3,50	3,50	3,50	3,50		
	separate pilot facility	3,00	3,00	3,50	3,50	3,50	3,50	3,50		
	1	2,33	2,25	3,50	3,50	3,50	3,50	3,50		
Surface area (Security)	1	2,33	1,75	4,75	4,50	4,50	4,50	4,50		
<b>= Sum of (Weighting of Criteria * Value of Evaluation)</b>		<b>44,50</b>	<b>44,13</b>	<b>48,00</b>	<b>43,25</b>	<b>40,50</b>	<b>41,00</b>	<b>40,50</b>		

<sup>1</sup> - Reversibility is defined as the possibility to safely take the waste out of the repository before the backfilling and sealing operations. In contrast to retrievability, it is assumed that retrieval can be achieved with similar techniques/equipment as used for waste package disposal.

# Current reference design



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# Monitoring

- **Public consultations (~2010) highlighted the social demand on 'control'. Within its context, ONDRAF/NIRAS has interpreted this as a demand for monitoring.**
- **Law of 2014 asks for monitoring, but does not define it. It stipulates that modalities need to be defined later together with stakeholders.**
- **Uncertainty on what to monitor**
  - Currently, focus is not on specific monitoring techniques or devices
  - Focus is on monitoring strategy (involving stakeholders) and flexibility to incorporate monitoring aspects

Monitoring strategy

### Boundary conditions

(inter-) national regulatory framework

- Other stakeholder requirements
- Regulator
  - Partnerships
  - Scientific community
  - Producers

Outcomes from former programme stage and available knowledge abroad

Protect Man and the environment, now and in the future

Passive safety through geologic disposal, based on safety functions isolation, confinement and retardation

Strategic choices related to local conditions and available geology

Safety concept

Technical & scientific demands: detailed to basic scientific aspects

Long term testing & monitoring programme

- Objective of monitoring
- Parameter prioritisation

Parameters Identification ↔ Measurement & technique development

Yes No  
New demands on monitoring from stakeholders?

No Yes  
Monitoring confirms the requirements?

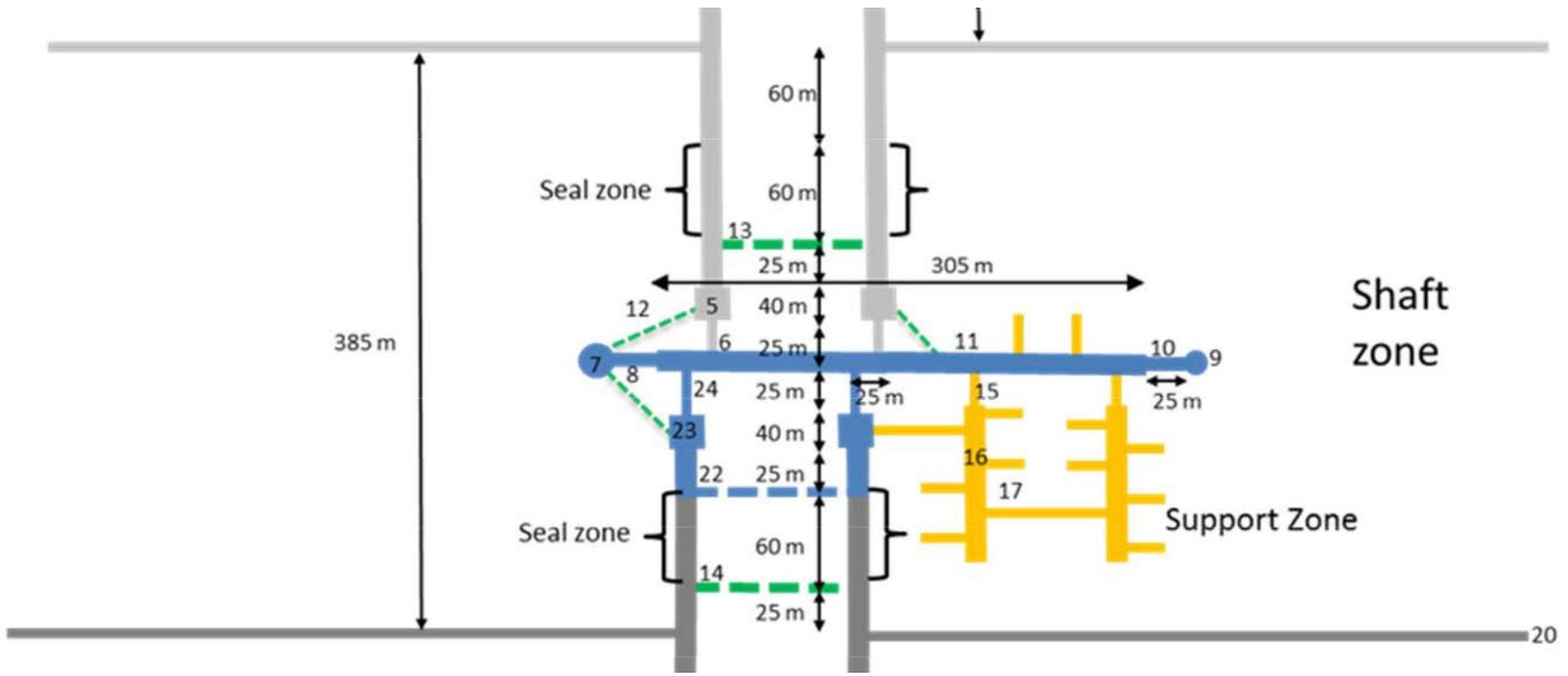
Next step in the programme

# Societal dialogues illustrated no clear view from the demands of everyone

- **Partnerships involved** in the development of the surface disposal facility give us **the unique opportunity** to discuss and **dialogue** on such issues with interested parties although far from implementation and site not known
- **Without context**, clear demand for measurement of leakage of radionuclides as close to the source as possible and full transparency of data to all members of the public
- **After context, monitoring is more nuanced and**
  - can be considered very broad including RD&D (also long-term, in-situ experiments) during operation
  - should not undermine long-term safety
  - should help in the decision making (e.g. wrt (partial) closure)
  - needs stepwise transparency (e.g. full transparency to some 'educated' members of the public and 'filtered' transparency once a year to all public)
  - demands intrinsically for alarms to be set

# Technical aspects: flexibility to incorporate monitoring

- Within the new layout: foreseen flexibility to perform monitoring tasks. This might take the form of a long-term in-situ experiment and/or pilot facility with a few real drums and fully instrumented



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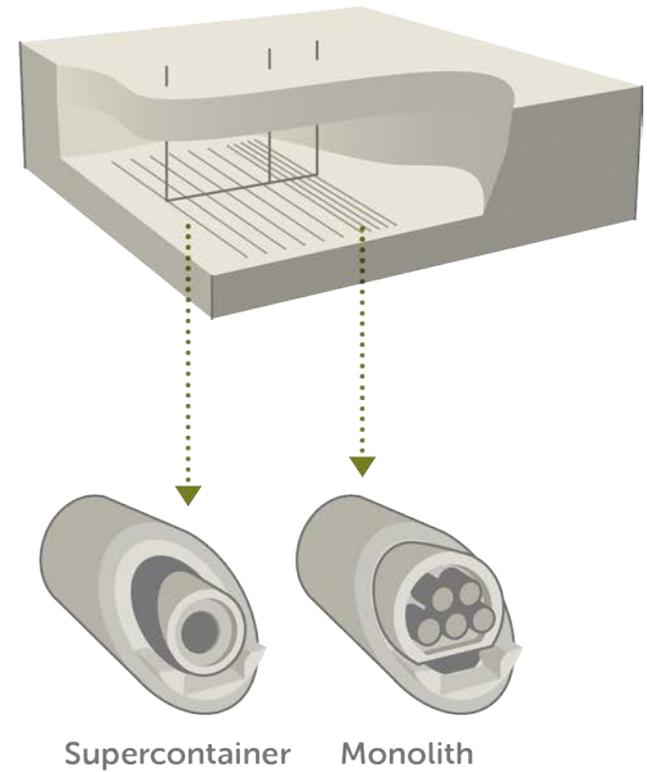
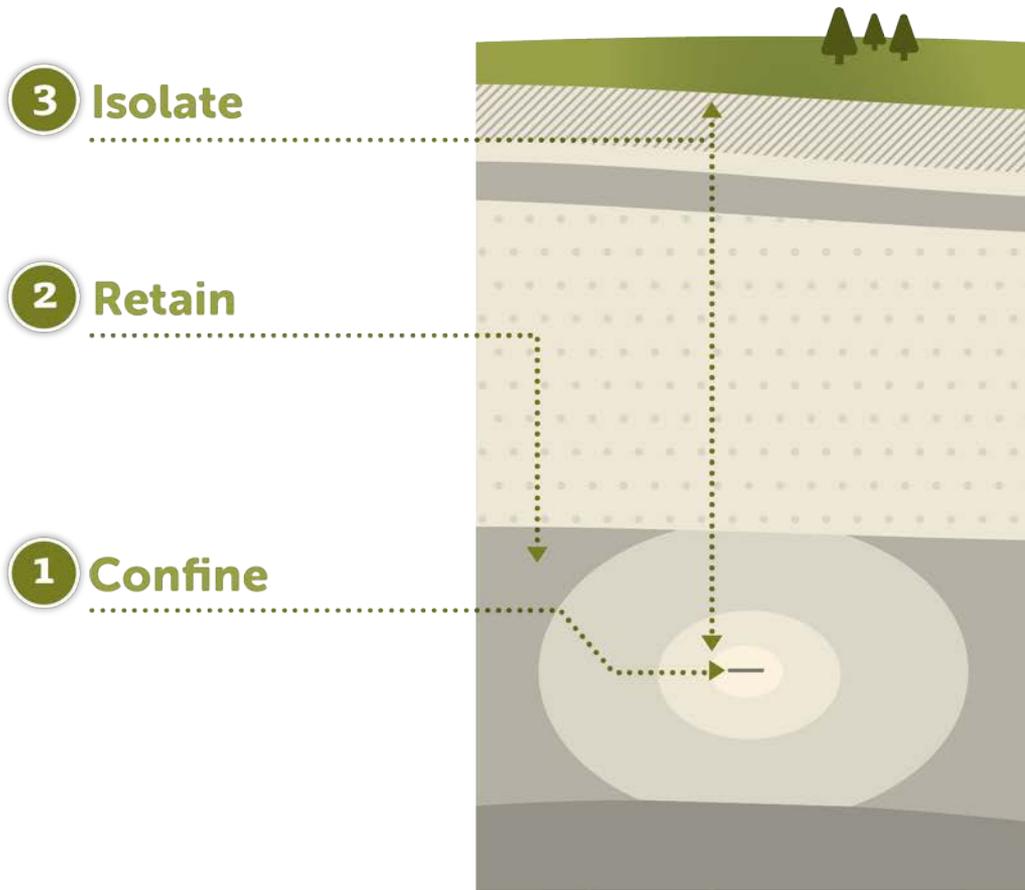
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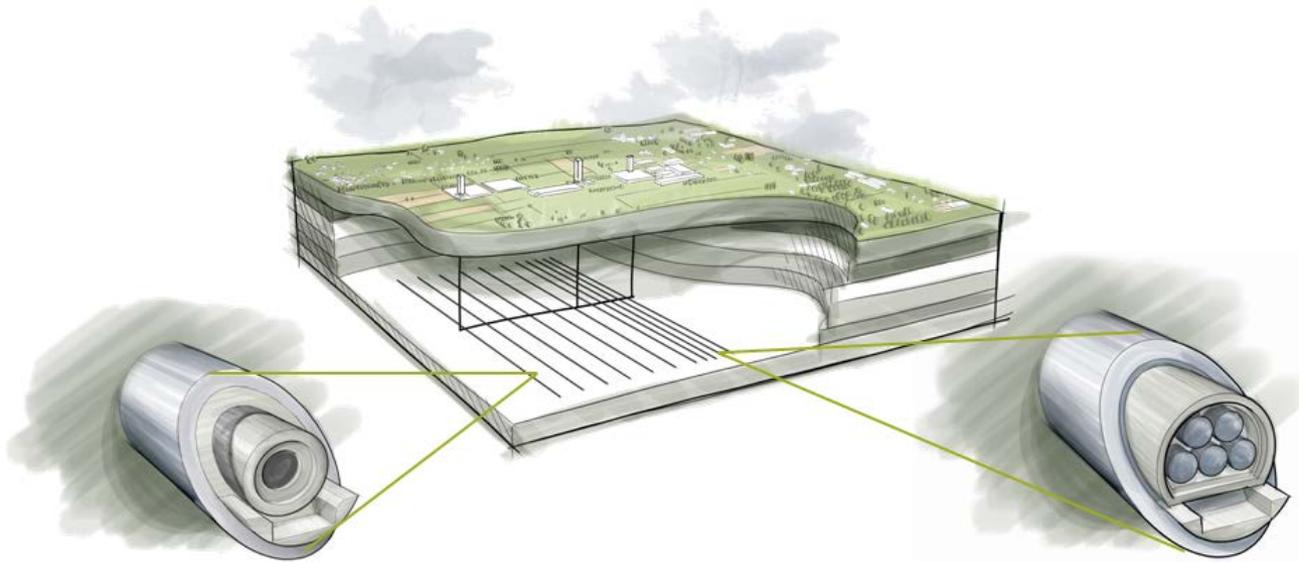
- **Policy decision on long-term management of B&C waste is still missing**
- **2001-2003: SAFIR 2 → update of concept needed from technical point of view**
- **2010-2014: public consultations and law of 2014 make clear that R&R and monitoring are important aspects, although not defined yet**
- **2003-2006: development of the supercontainer concept**
  - R&R already included in evaluation, but not major driver
  - Re-evaluation after 2014 did not reveal any problems with respect to current demands of R&R
- **2015-2017: development of a new repository layout**
  - R&R explicitly considered
  - Trade-off between operational safety and R&R
  - Flexibility to perform monitoring tasks included

# Additional slides

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# Geological disposal





Supercontainer for Category C waste

Monolith for Category B waste



# Underground facilities



# Hades laboratory



External diameter: 4.7 m  
Internal diameter: 3.5 m