Deep Borehole Disposal - a solution for HLW in Germany?

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Content

1. Final Disposal in Germany
2. Site Selection Commission
3. New Site Selection Process
4. Deep Borehole Disposal

Final Disposal in Germany

Restart of the site selection (HLW-repository)

2011

- Broad political consensus in Germany to phase out nuclear power
- Consensus to terminate the long lasting conflict with respect to final disposal of high active heat generating waste

2013

Decision to restart the site selection for a final disposal site HLW

- Consensus to restart process to select a site for high active and heat generating waste
- The decision was made that the law should be evaluated by a commission

2014 – 2016

The Commission prepared a report : May 2014 – July 2016

Present Waste Management Concept

Project	Geology / Formation	Purpose	Actual Status	Waste
HLW / New Site Selection 2017-≥ 2050	Salt Clay Crystalline	Repository for high-level and heat-generating waste	Proposal of the Site Selection Commission to be implemented	17,000 t HLW/spent fuel
LLW/ILW Konrad since 1982	Iron ore	Repository for long- lived waste with negligible heat generation	Licence issued 2002 Start of operation ≥ 2022 Operation: ≈ 35 years	300,000 m^3 LLW/ILW

Site Selection Commission

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Main Results

- The Final-Disposal-Commission agreed that the target of a new site selection process is to find a disposal site with the relatively best-possible safety.
- A site selection procedure with the goal of finding the “site with the best-possible safety” would necessarily have to be a **comparative procedure**.
- The Repository Site Selection Act therefore has the objective of applying a comparative procedure to identify **the best site for a repository for final disposal for a period of one million years**.
- No export for spent fuel (also not for research reactors)
- New organisations – new responsibilities
- The main option is the disposal in deep underground mine
- The site selection is a 3-phases-process with an intensive public involvement

New Site Selection Process

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Targets of the site selection procedure

Overall Target

- To define a site for which the licensing procedure can be granted
- To select a site which provides the best possible safety for ≥ 1 mill. years

Consensus

- A site for the disposal of HLW should be found in a nation wide consensus
- Participation of the citizens in all steps of the site selection process as a basis for acceptance
- Relevant decisions have to be made by the Parliament and the Federal Assembly

Safety

- Safety is a priority

Time frame

- The timeframe is not a priority

Site selection criteria

- Exclusion Criteria
- Minimum Criteria
- Weighting Criteria
- Safety requirements and requirements for safety investigations
- Planning Criteria

Site selection steps / phases

	Measures	Regions / Sites
P1	Start with a **white map**, application of exclusion criteria and minimum criteria	> 20-30
P2	Selection of sites for investigation from above ground, application of exclusion criteria and minimum criteria application of geoscientific weighting criteria application of socio-economic weighting criteria	6-8
P3	Selection of sites for investigations from below ground	2-3
	Selection of one site for licensing	**1**

Site selection according the site selection law

Timetable	Activities
2013	Enaction of the site selection act
2014 - 2016	Evaluation of the act
2017	Modification of the site selection act
2017 - 2031	Site selection, determination of the repository site/location starting with a „white“ German map
2031 - 2050	Detailed site selection, disposal concept, safety analysis, licensing procedure, granting of the license, erection of the repository
≈ 2050	**Start of operation**

Considered Disposal Options (Paths)

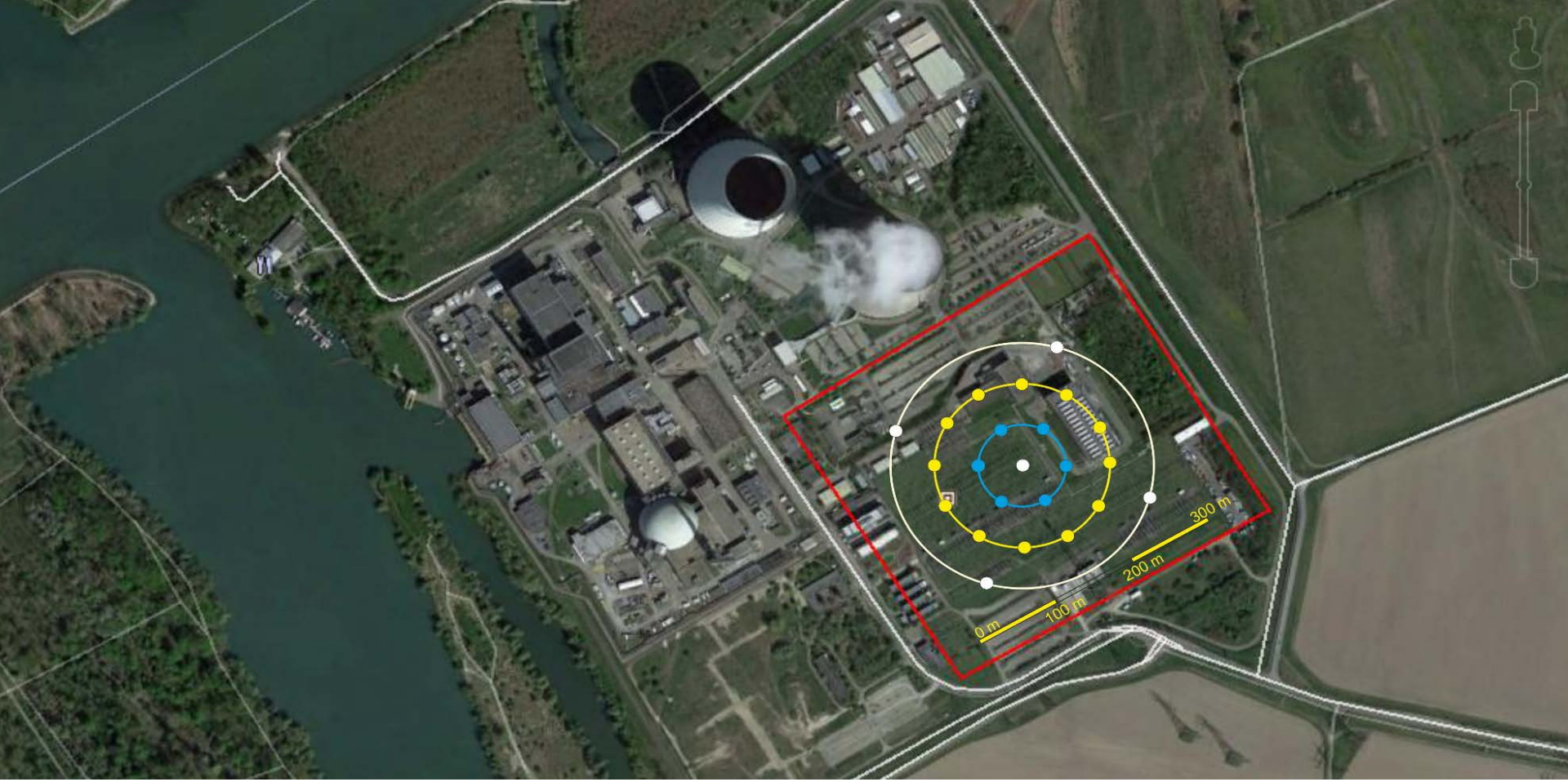
The commission has analyzed the different potential solutions to dispose HLW.

- **The preferred solution - called path - based on the present state of the art is the final disposal in deep geological formations in a mine.**
  Potential host rocks: Salt, Clay, Cristalline

Besides that, other potential solutions were considered.
These so-called sub-paths were:

- **Final disposal in deep boreholes**

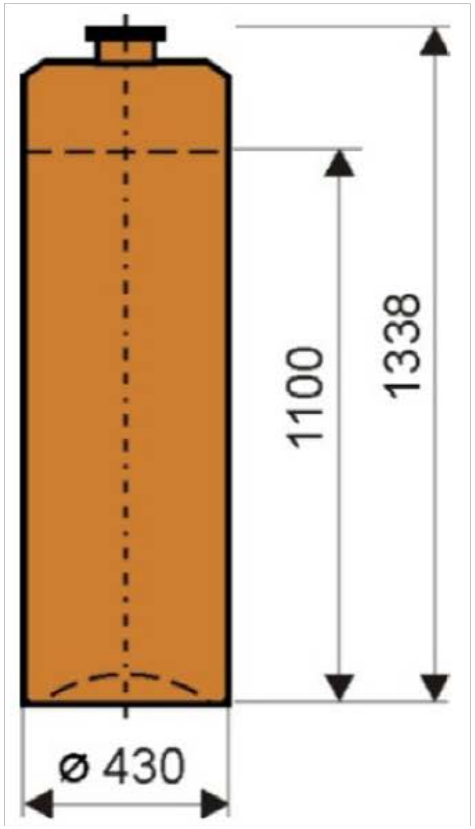
- Long-term interim storage
- Transmutation



Deep Borehole Disposal

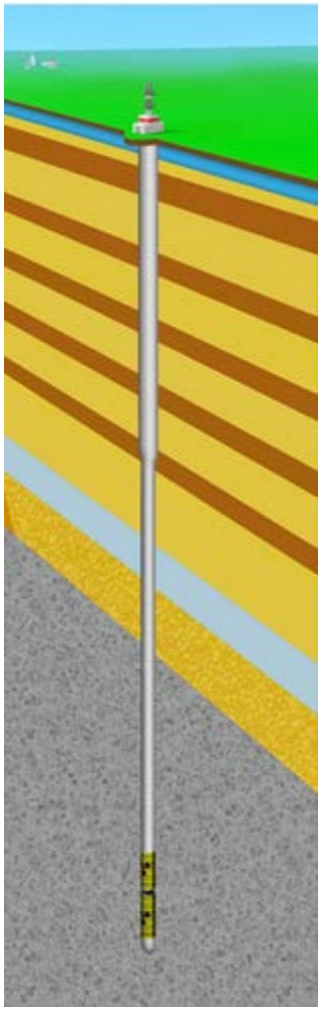
HLW in Germany

- Spent fuel elements
- Vitrified waste
- Spent fuel pebbles



Deep Borehole Disposal - Concept

- Disposal depth of 1500 – 3500 m
- Multiple barrier system with clay and salt layers (alternating strata)

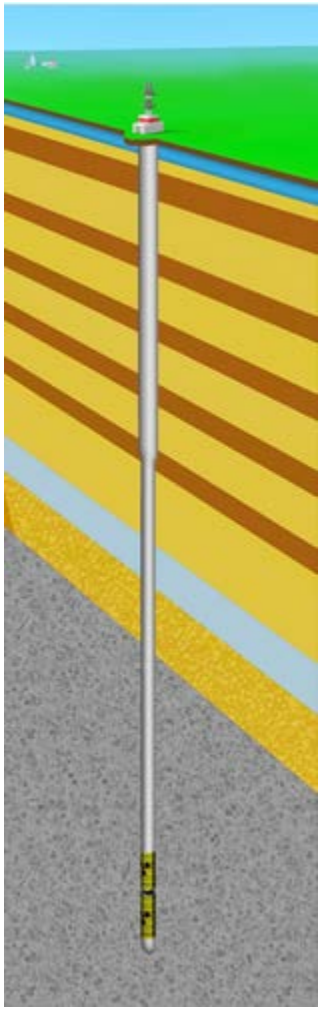


Deep Borehole Disposal - Concept

- Disposal depth of 1500 – 3500 m
- Multiple barrier system with clay and salt layers (alternating strata)

Requirements / Questions

- Diameter of borehole?
- Container?
- Availability in Germany?
- Reversibility?



Deep Borehole Container – Retrieval (DBC-R)

11 000 containers

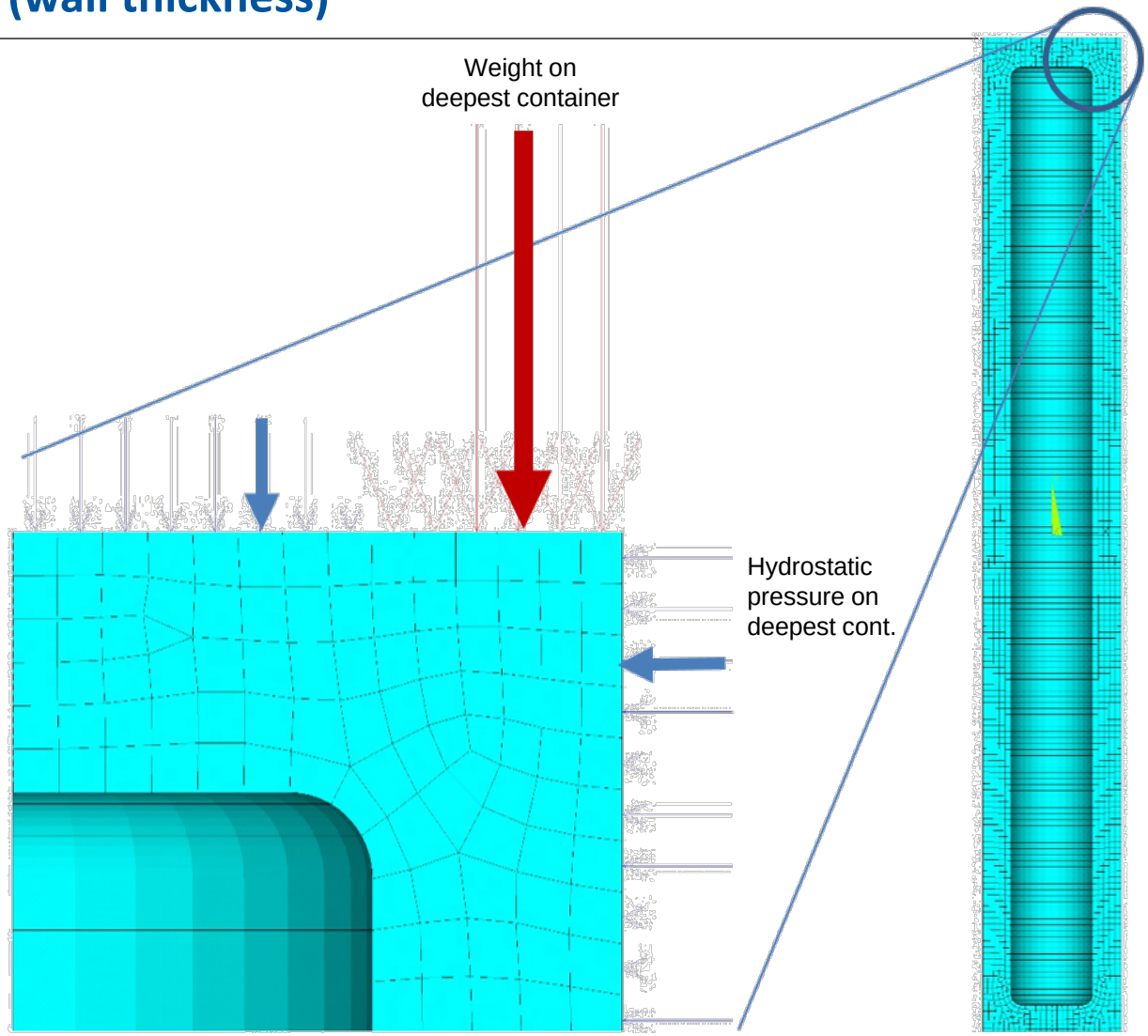
Net volume:
~ 0,72 m^3

Net mass container:
6,6 – 12 Mg

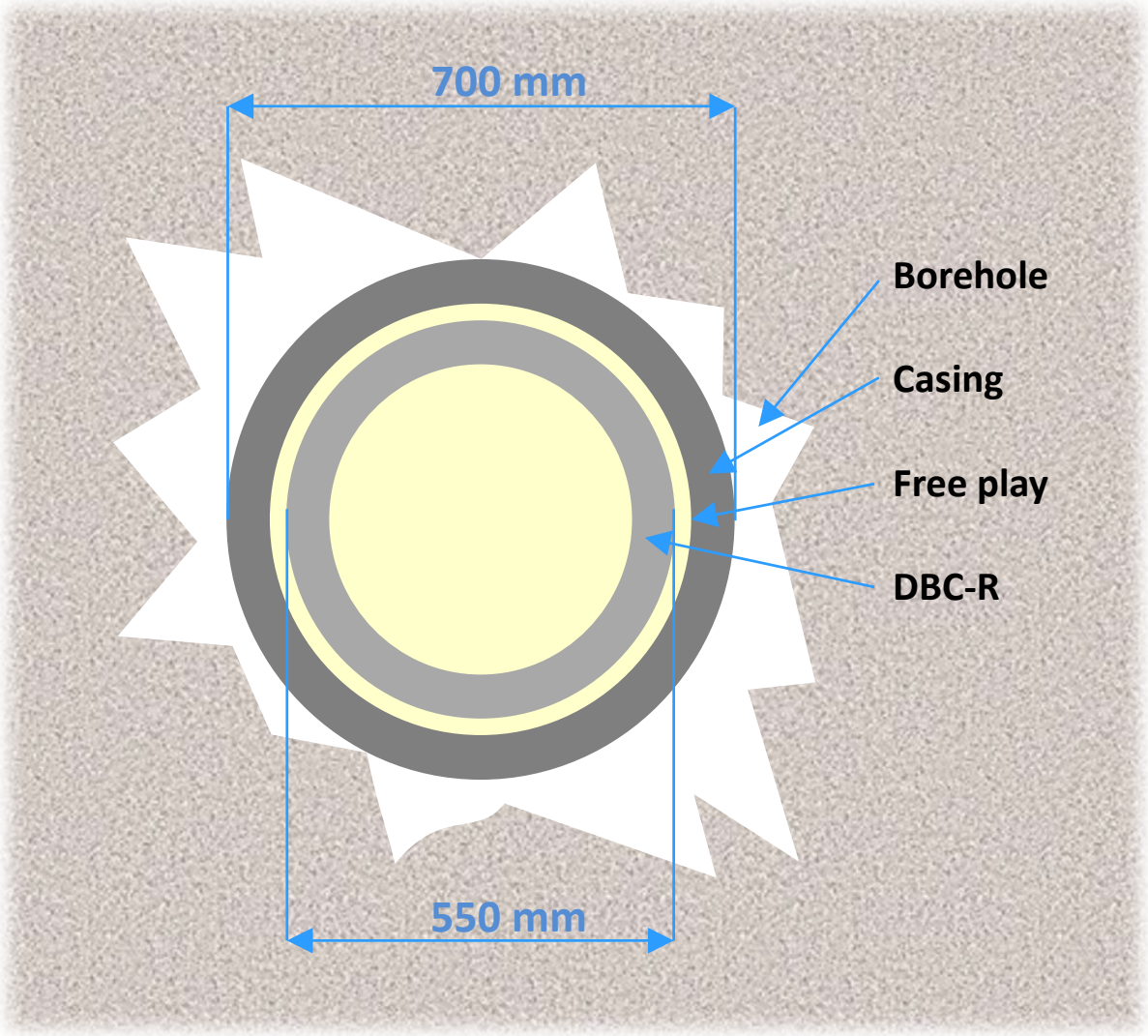
Gross mass DBC-R:
9,5 - 15,7 Mg

Requirements for container (wall thickness)

- Stacking
- Temperature / pressure
- Corrosion
- Tightness
- Retrievability / recoverability
- …



Casing / container



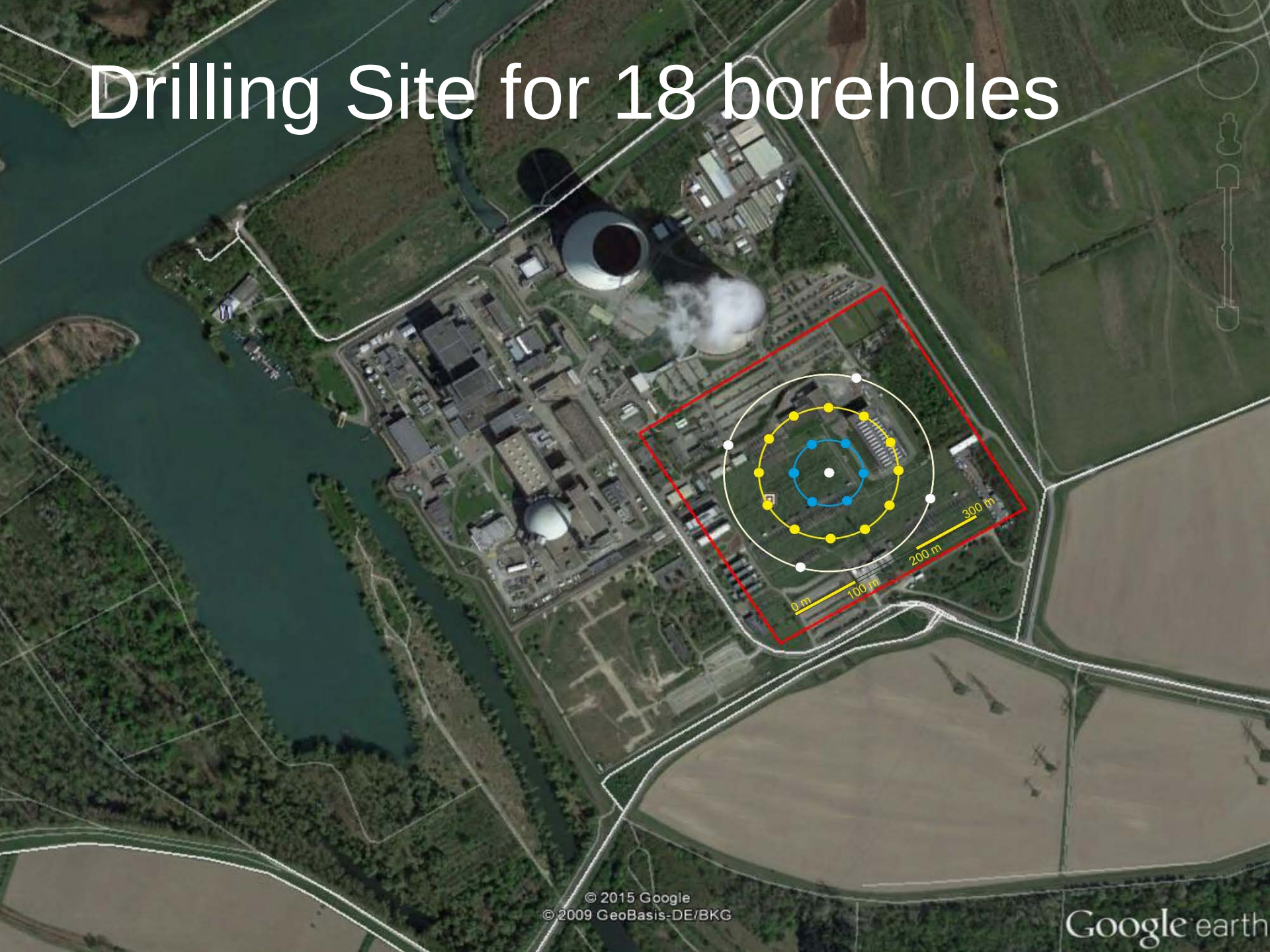
How many boreholes?

Disposal depth	Wall thick-ness DBC-R	DBC-R per borehole	Number of boreholes	Diameter of borehole
3 000 - 3 600 m	**4.5 cm**	**103**	**107**	**75 cm**
3 000 - 4 200 m	6.5 cm	205	55	80 cm
3 000 - 5 000 m	10 cm	363	31	90 cm

Research and Development

- Borehole diameter of 0.75 m beyond today´s standard shelf technology
- Considered feasible for 3 600 m
- Concept to be detailed (e. g. container, monitoring, technology)
- Operational and long-term safety analyses
- Feasibility demonstration (drilling, disposal and retrievability)
- Development of containers for recoverability for 500 years

Drilling Site for 18 boreholes



Some advantages ⇔ and disadvantages

- ✓ Multiple barrier system (great depth)
- ✓ Manless disposal
- ✓ Several sites possible
- ✓ No proliferation
- ✓ …

- – Research and development
- – Exploration for every drilling site
- – Corrosion of containers
- – Recoverability
- – …

Deep Borehole Disposal - a solution for HLW in Germany?

DBD should / could be a feasible and alternative technical option for deep geological disposal in Germany.

Conclusions

- Active support of research and development is needed
- The requirement of recoverability for 500 years should be reconsidered

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Site Selection Restart in Germany – Results of the Site Selection Commission

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