BGE TECHNOLOGY GmbH

DBD – ERDO Workshop

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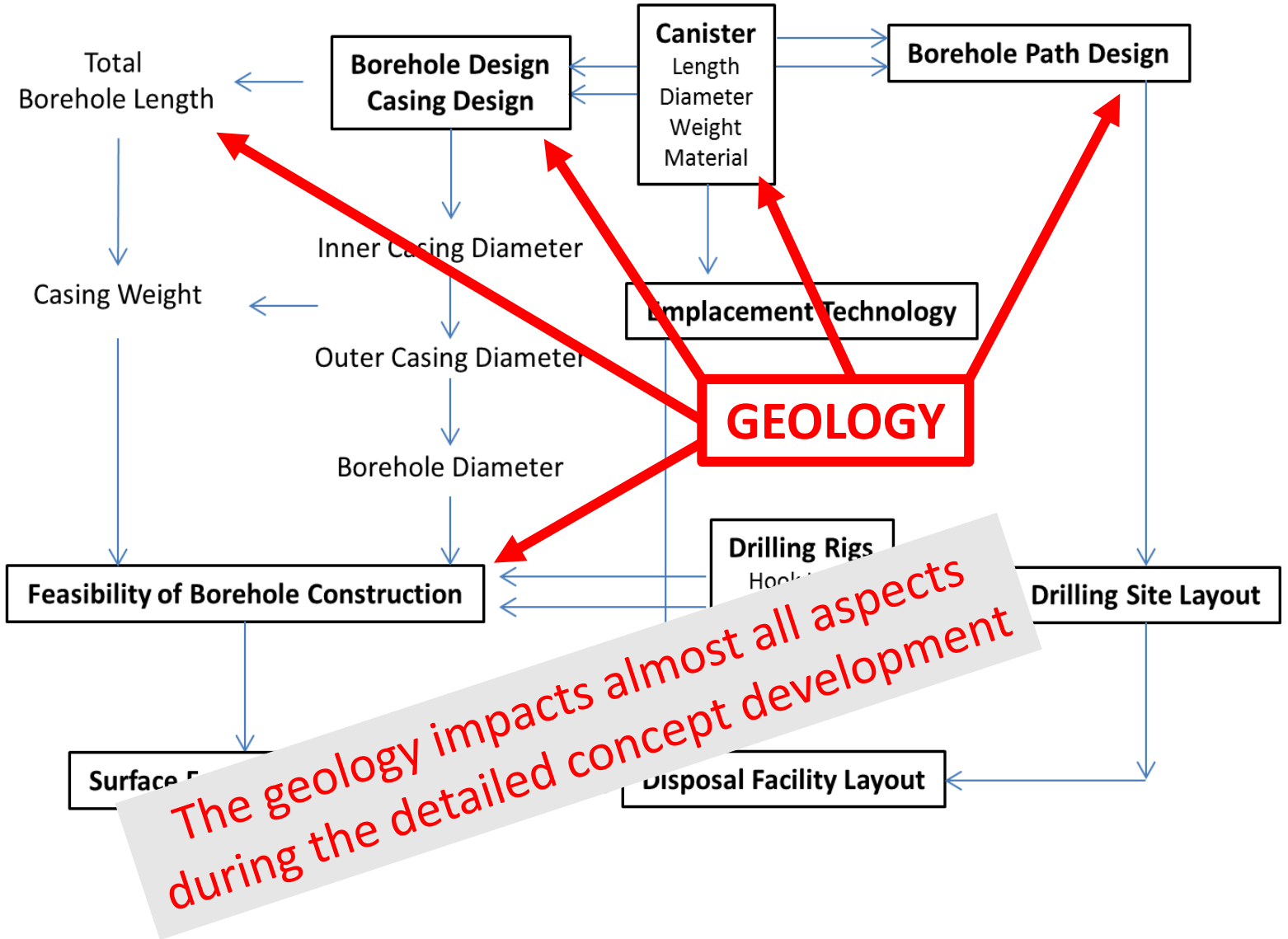
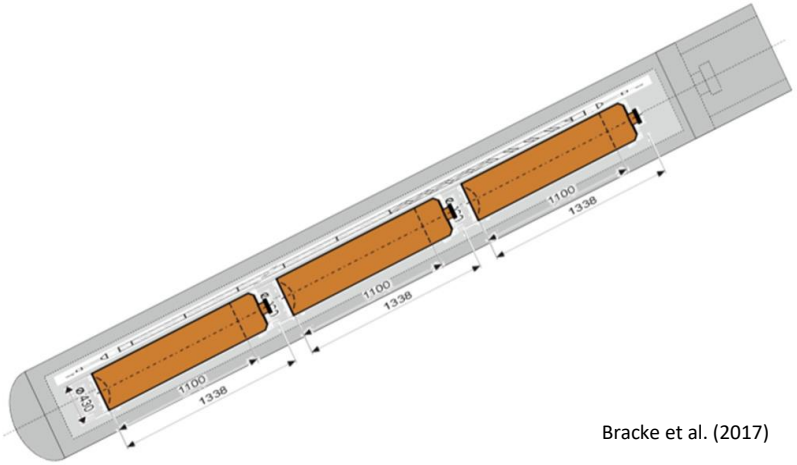
Complexity of the concept development



Waste Packages

- Different container designs are available → no commercialized product on the market yet
  - Most designs show similarities:
    - Length around 5000 mm
    - Conical shaped
  - Diameter vary between 430 mm to over 1000 mm

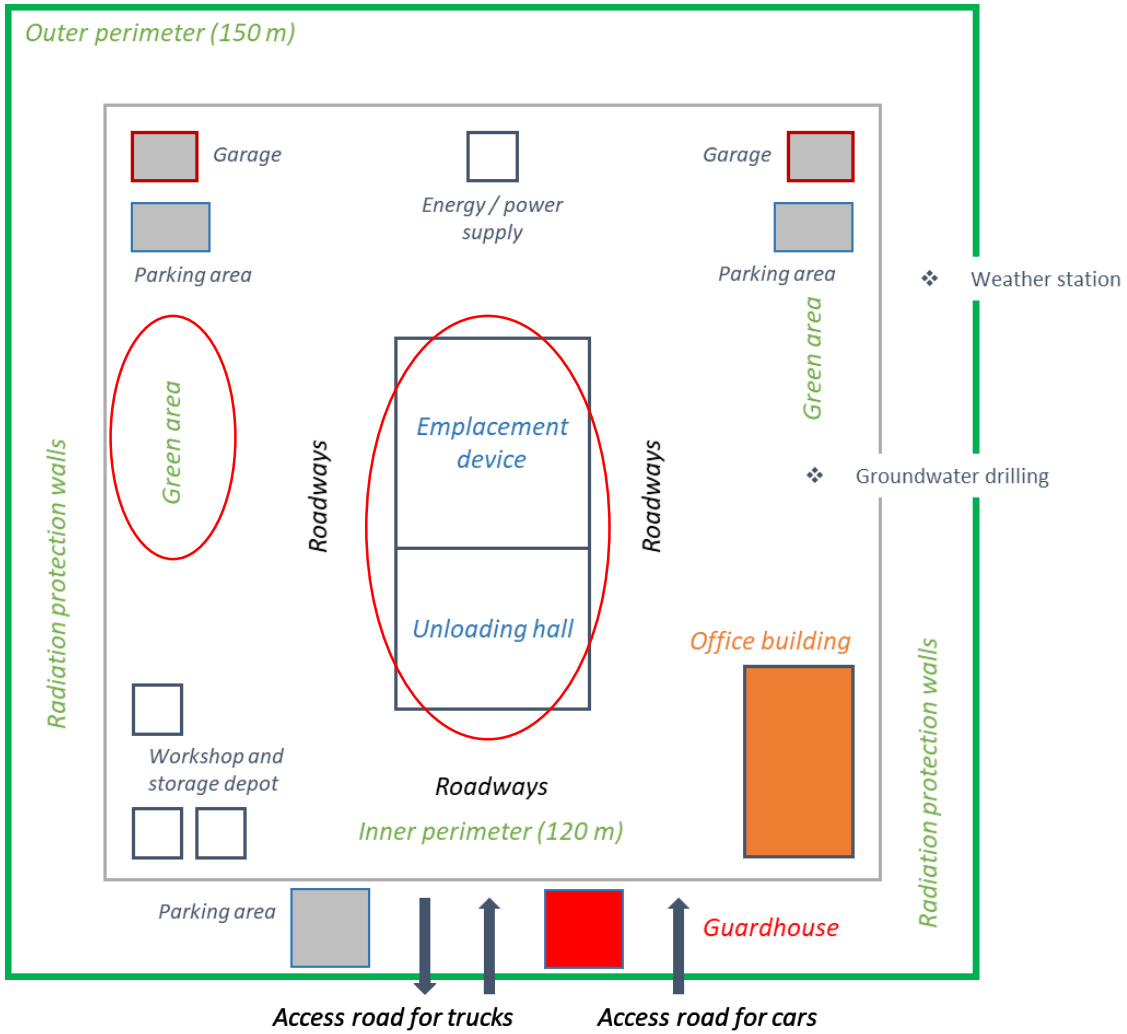


Bracke et al. (2017)

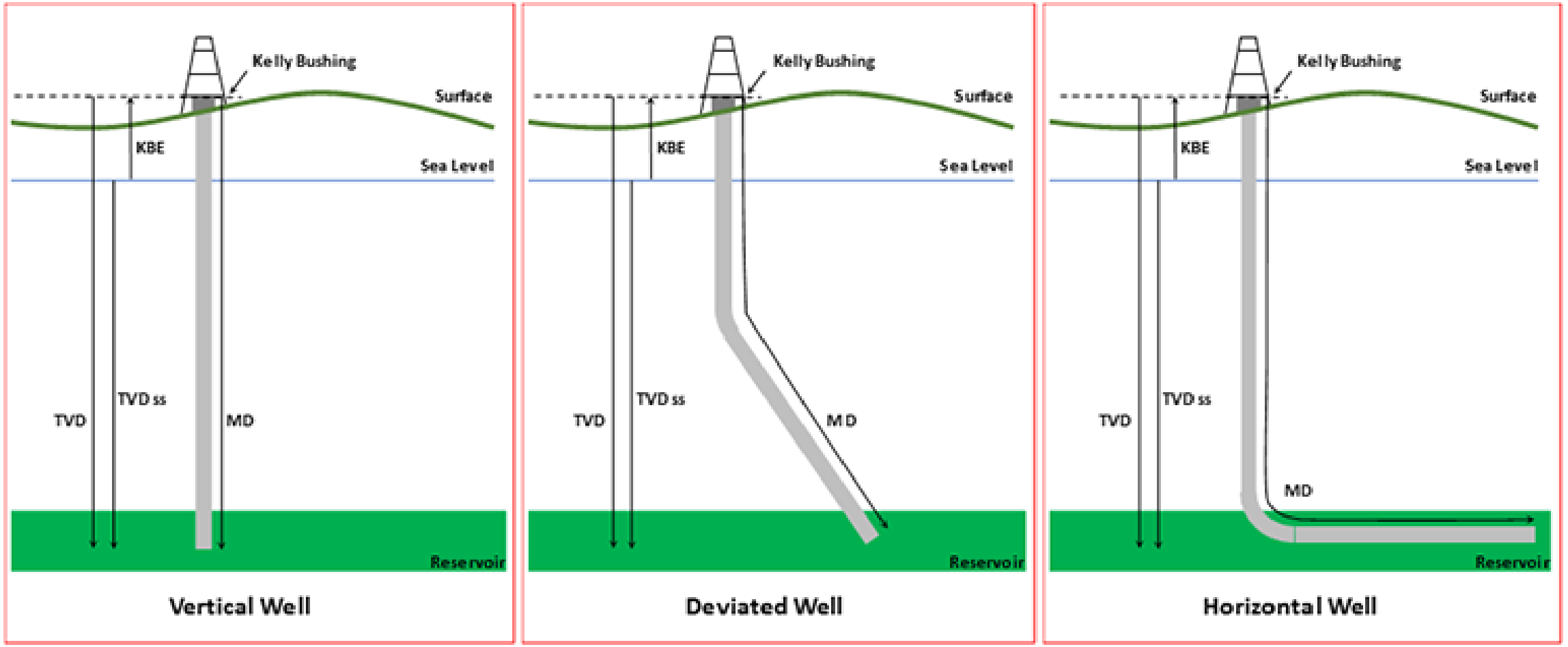
- Material:
  - Copper has been-studied the most and seems to be the most suitable (corrosion resistant)
  - Combination of a copper outer sheathing and a steel stabilization cage

- **Container dimensions set the basis for the borehole diameter**
  - ➢ Fixed diameter (maximum of 520 mm) for all containers
  - ➢ Length can be adapted individually for the waste types

Surface facility layout – drilling → emplacement



Construction – borehole trajectory



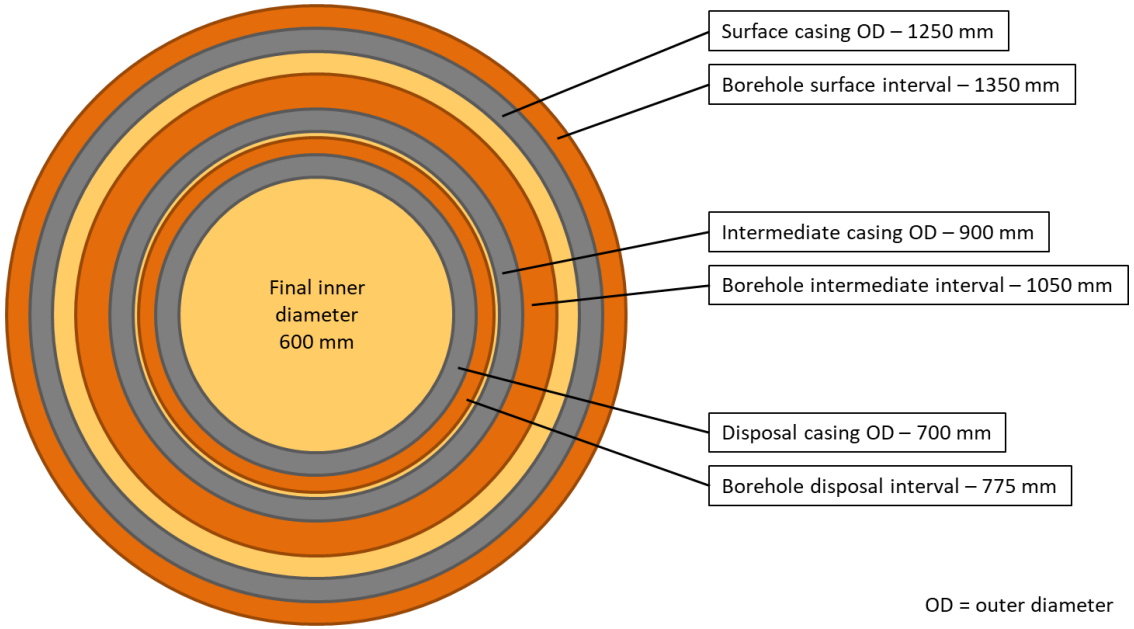
King (2020)

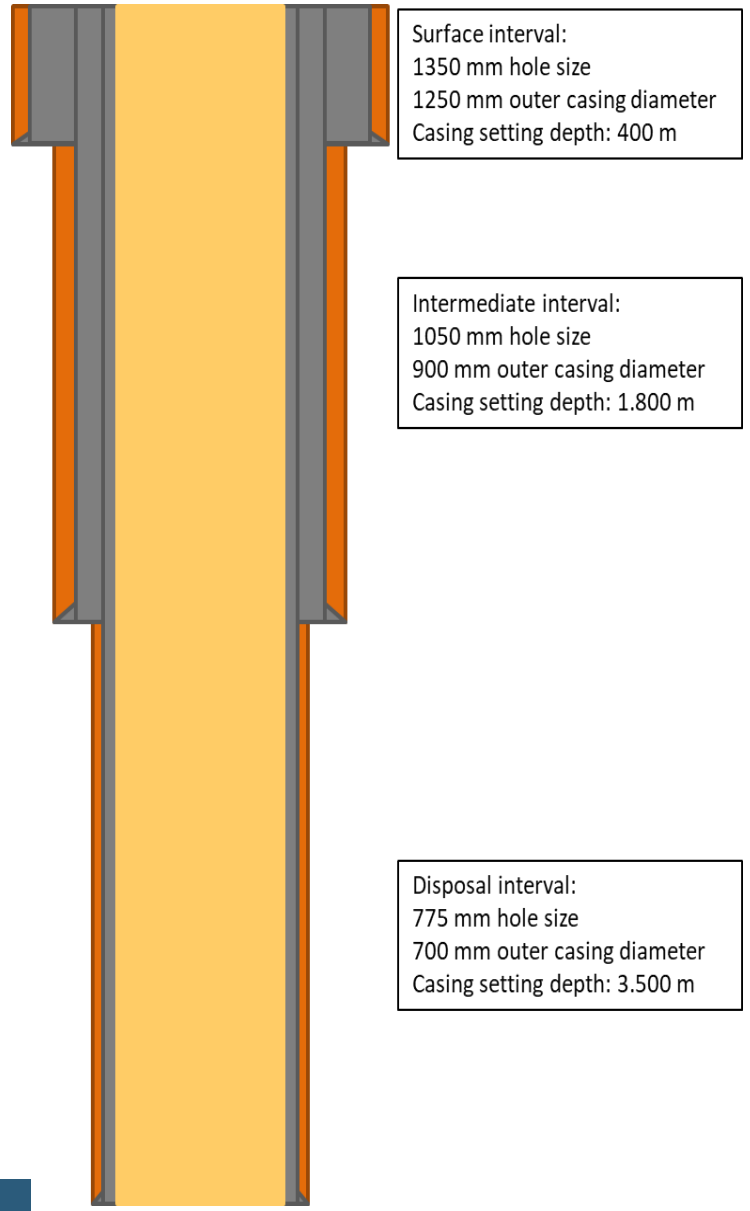
Construction – borehole trajectory

	Vertical wells	Deviated wells	Horizontal wells
Positive aspects	• Easiest to drill and complete • Possibility to minimize casing program • Disposal and retrieval relatively easy • Easy sealing and backfilling operations	• Several wells from on surface location to different subsurface targets possible • Reduced pressure on containers • Friction reduces forces on the rig caused by the casing	• Longest disposal zone • No potential flow path through the borehole (if the horizontal section is slightly upward) • No pressure put on disposal containers by other container
Negative aspects	• Short disposal zone • Potential flow path to the surface through the borehole • Great pressure on the lowest container by overlying containers • Only one borehole from one surface location	• Potential flow path to the surface through the borehole • Increased torque and drag during the drilling operation	• Complicated drilling operation (torque and drag etc.) • Cementation of horizontal part challenging • Disposal and retrieval difficult • Diameter might be limited • Uniform cement job in the horizontal section challenging

→ Compromise between the other two options
→ Includes positive aspects of the other two options

Construction – casing design



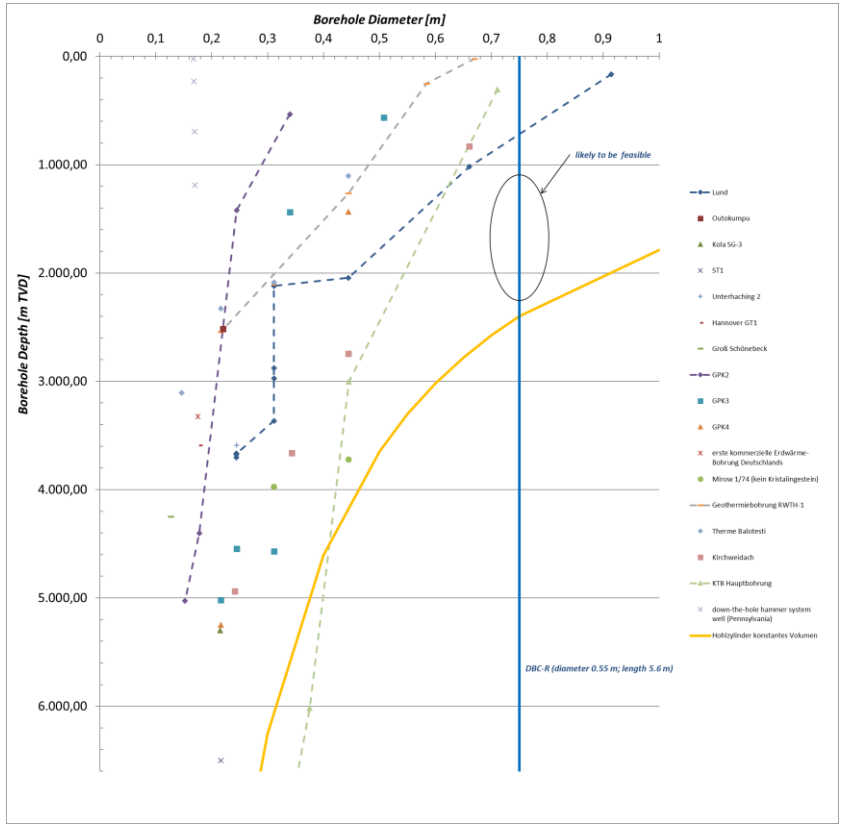


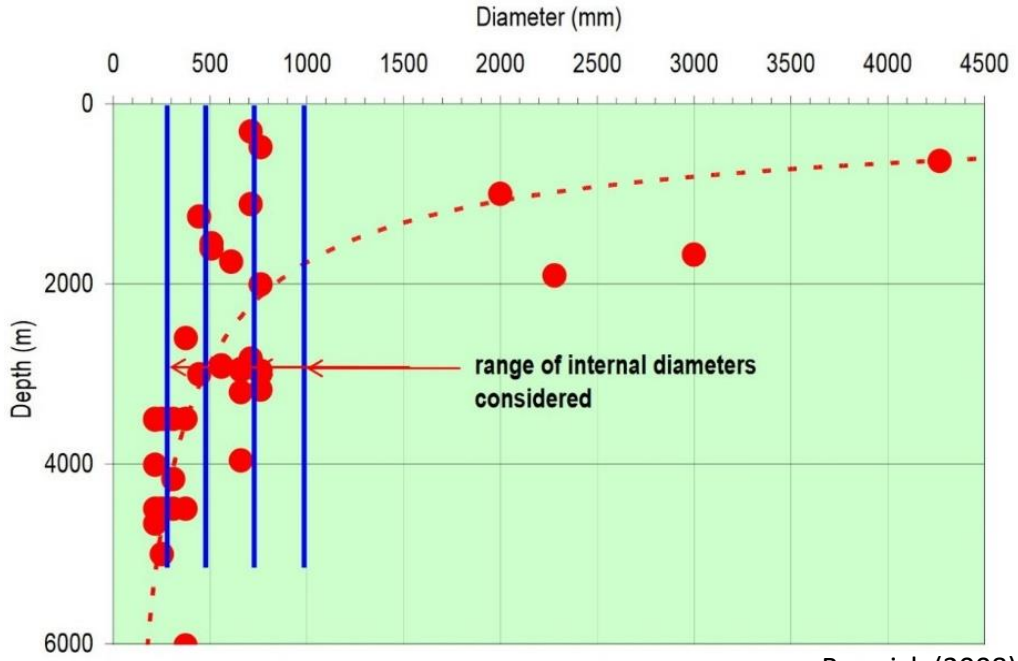
- No conductor casing displayed in the pictures
  - Outer diameter: 1500 mm
  - Setting depth: ~ 15 m
- BSK-R container (diameter 520 mm)
  - ➢ 40 mm clearance around the container
- Casing wall thickness 50 mm

Construction – feasibility

Borehole diameter and depth and

- What has been drilled previously?
- Where are limits?





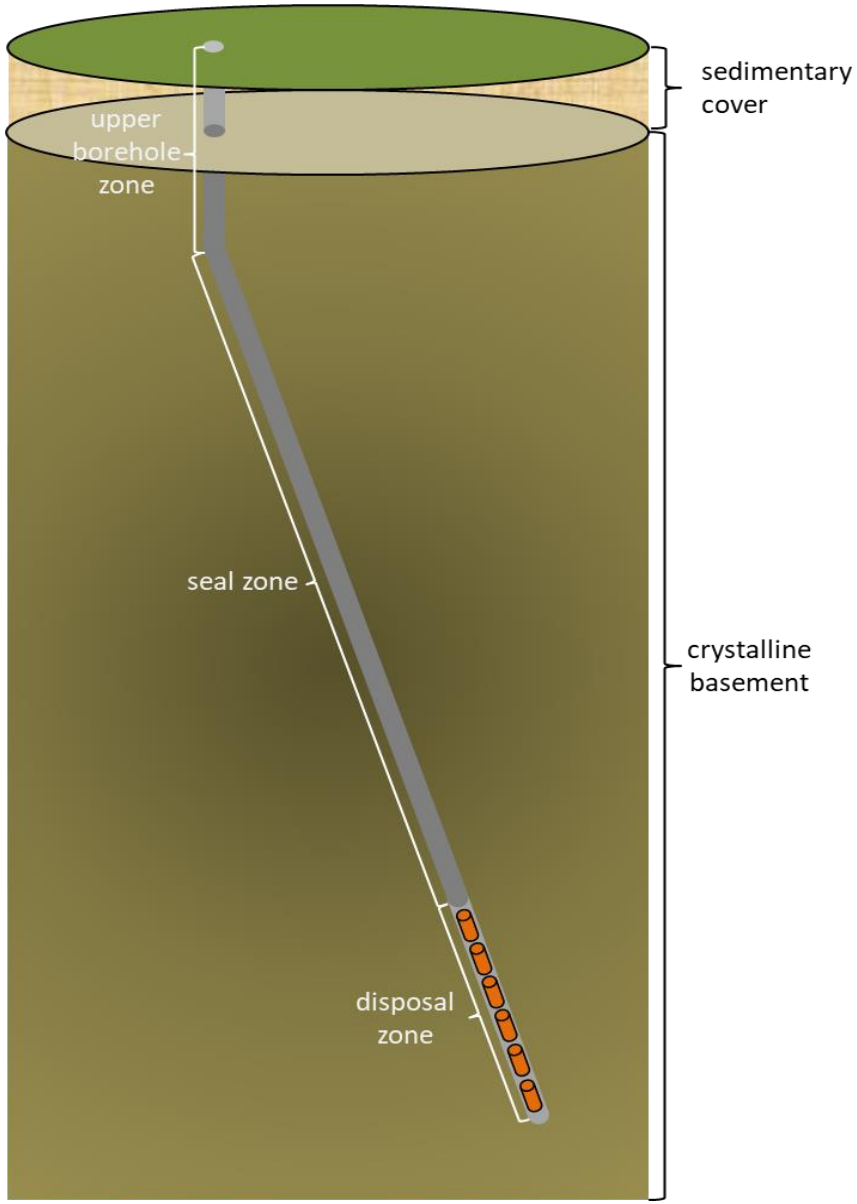
Beswick (2008)

Within the last decade few deep wells with large diameter have been drilled, since no industry requires both of these aspects!

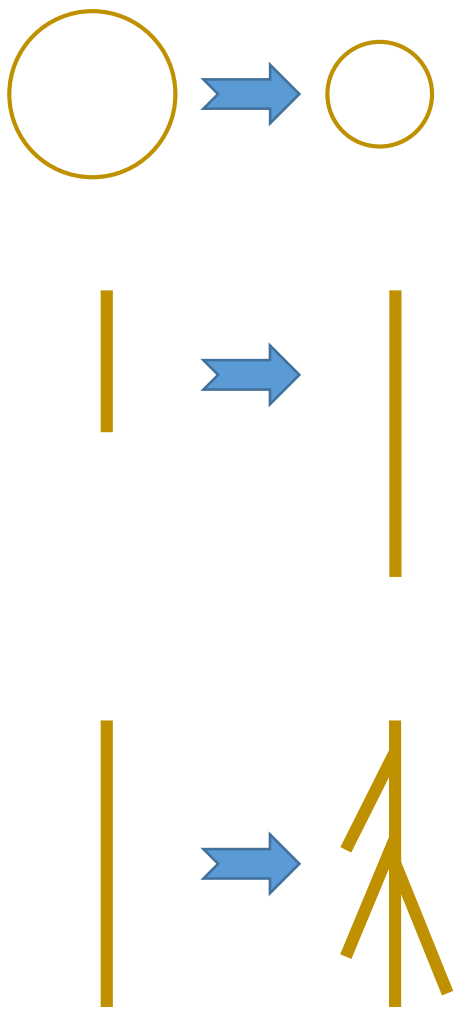
Proposed general borehole layout

Possible adaptations:

- Length of the different zones
- Deviation of the lower borehole part
- Diameter of the borehole
- Curvature of the borehole

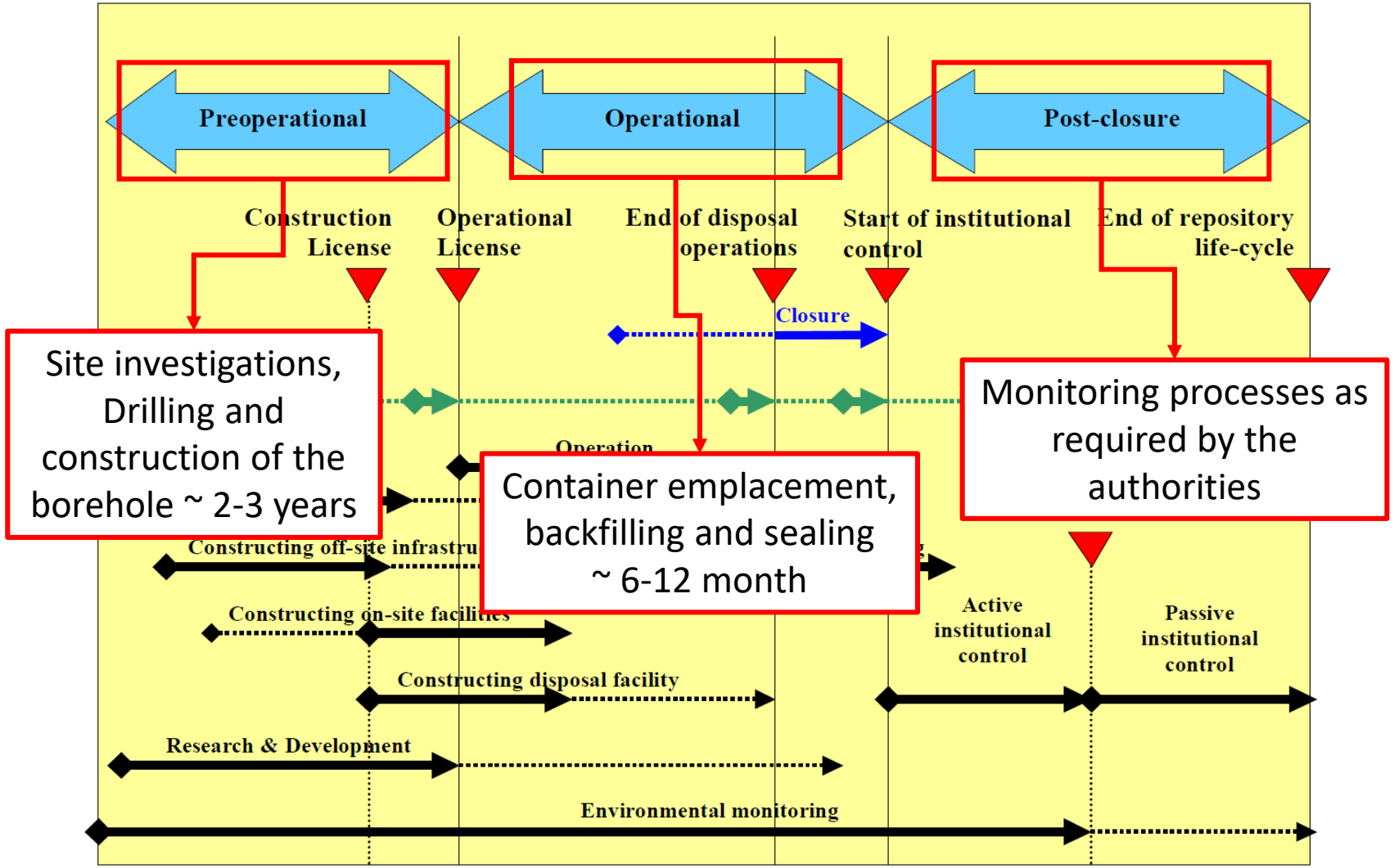


Alternative options



Alternative	Positive aspects	Negative aspects
Smaller borehole diameter	• conventional drilling technologies can be used	• boreholes need to be deeper → greater temperatures and pressures in deeper regions • more boreholes are required → every new borehole represents an additional risk and a potential flowpath/connection to the surface
Drilling deeper	• more waste can be disposed in one borehole without a totally new, additional drilling operation • greater geological barrier	• disposal might take longer (greater distance from surface to disposal zone needs to be covered) • greater temperatures and pressures → greater stresses on the containers
Drilling more boreholes	• parallel operation (drilling one hole, while the other can already be operated)	• several flowpaths / connections to surface • additional operational risk with each borehole
Using multilateral drilling operations	• only one potential flowpath to surface • greater disposal length with minimum effort/footprint on the surface • parts of the hole can be steered for independently → one part can be closed and sealed, while other parts can still be operated	• more complex operation

Operation – phases of the operation



Site investigations, Drilling and construction of the borehole ~ 2-3 years

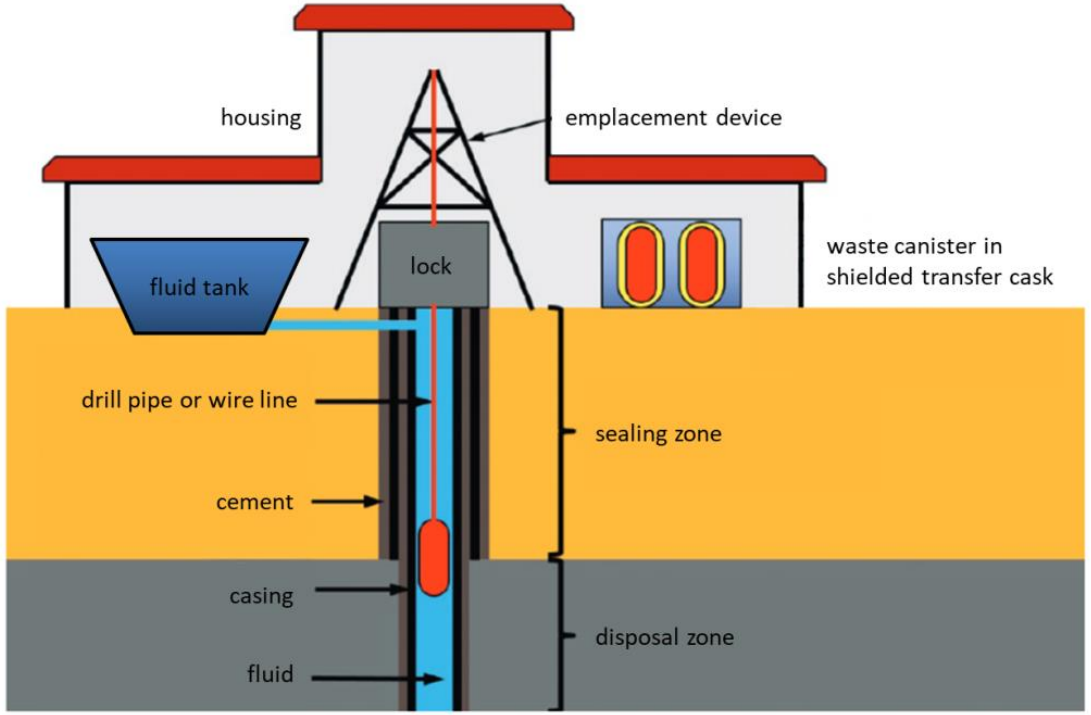
Container emplacement, backfilling and sealing ~ 6-12 month

Monitoring processes as required by the authorities

IAEA-TECDOC-1552 (2007)

Operation – emplacement techniques

1. ~~Free fall~~
2. Wireline
3. Use of drill pipe/drill strings
4. ~~Use of coiled tubing systems~~
5. ~~Conveyance liner~~



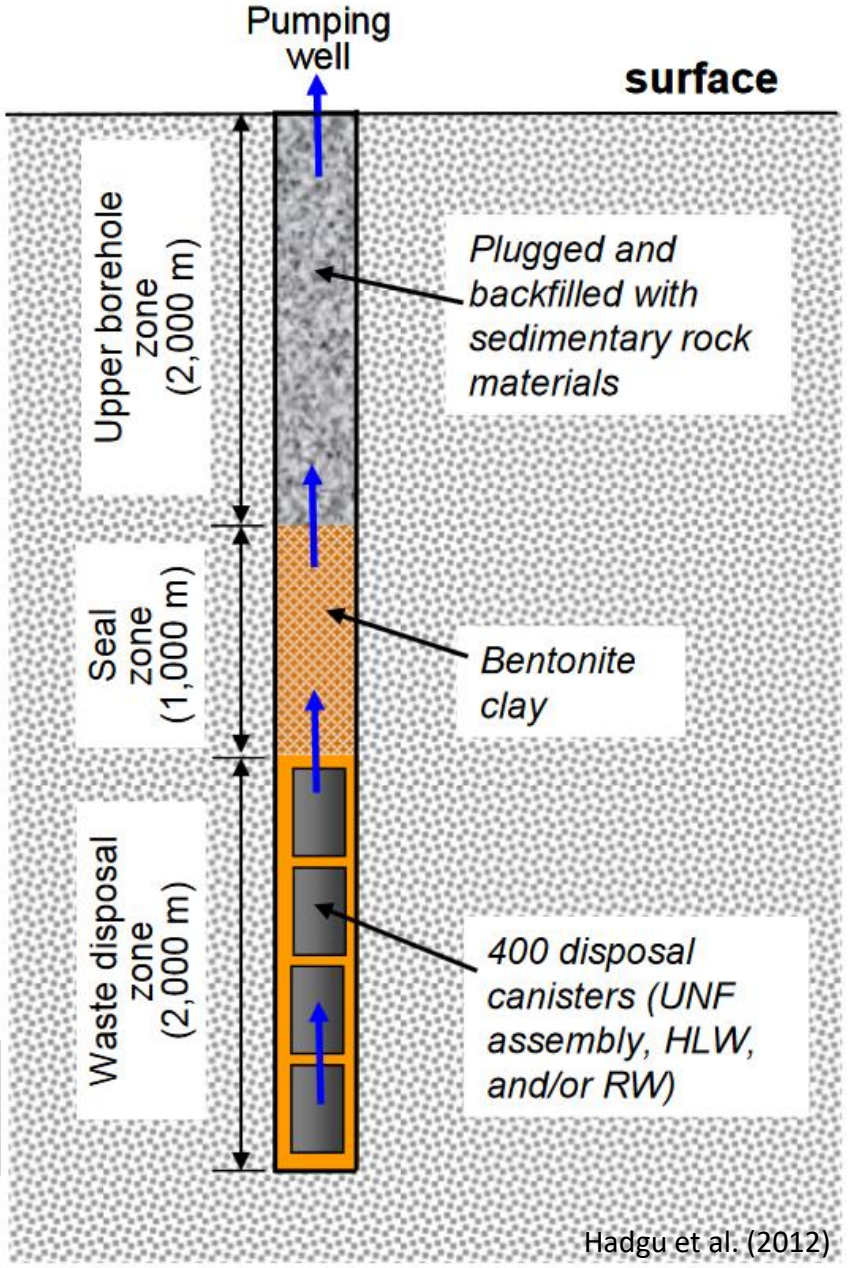
Rosenzweig et al. (2019)

Closure / sealing

- Combination of the geological barrier and an engineered barrier
  - ➢ sealing and eventually backfilling (depending on the depth of the borehole and the geology)
  - ➢ Most critical zone is the contact area → potential flowpath
    - Casing needs to be removed from the borehole to ensure a good bonding of the sealing material and the surrounding formation

- Preferably sealing should be created in vertical or strongly inclined borehole sections (making use of the effects of gravity)
- Suitable materials contain:
  - Clay (bentonites or mixtures with bentonites), bitumen/asphalt, cement based materials (grouts, mortars or concretes)

Note: this figure shows just one possibility for the closure and sealing of the borehole after the disposal



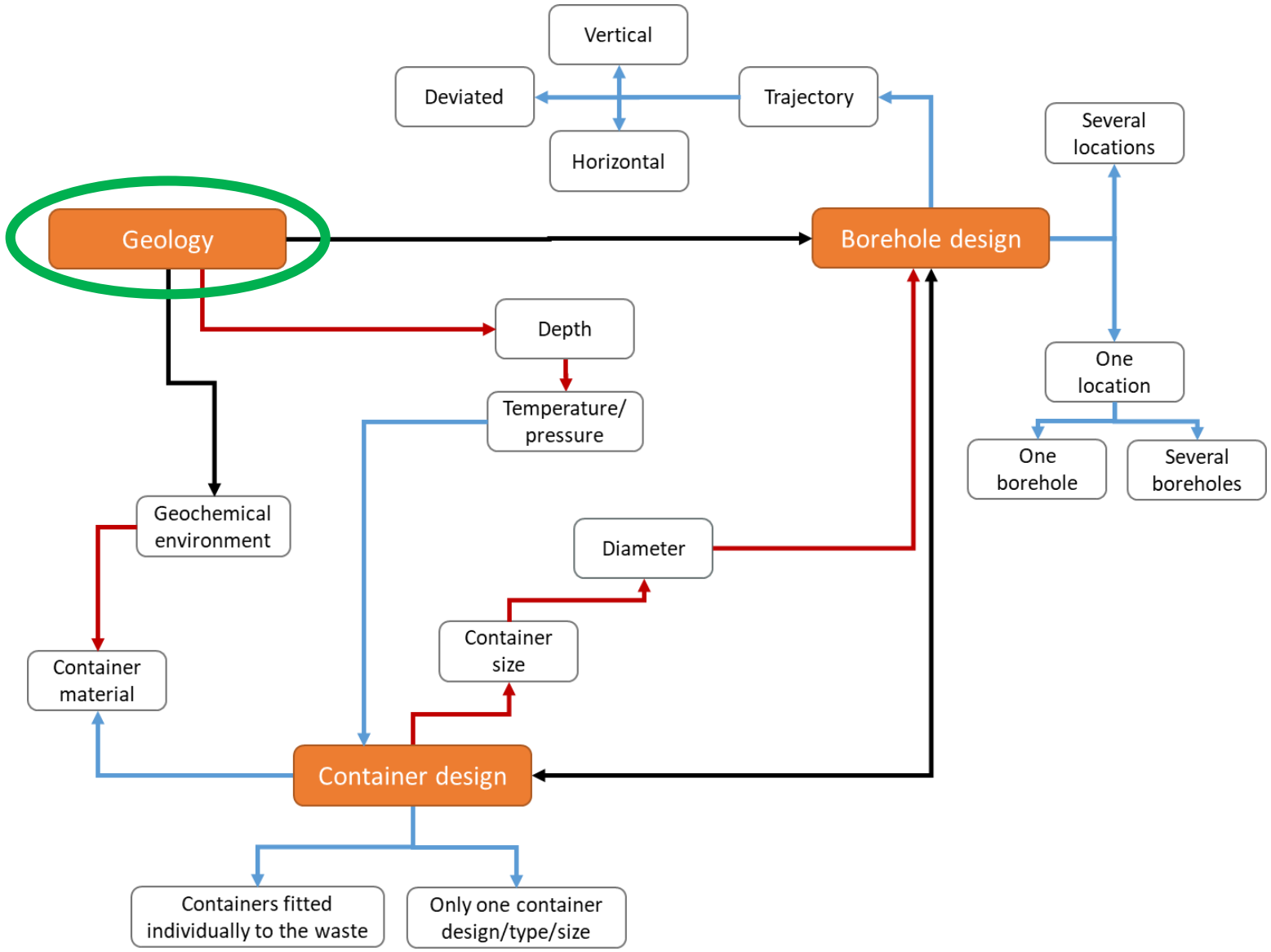
Hadgu et al. (2012)

Recommendations

- Three main decision points:
  - Geology (can be affect during the site selection process)
  - Container design
  - Borehole design

Minimize the variables!

Recommendations



Recommendations

- Three main decision points:
  - Geology (can be affect during the site selection process)
  - Container design
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Minimize the variables!

- ➢ <u>Most suitable approach is to base the concept development on the geology</u>
  1. Provides important information for the drilling engineer and sets borders of what is possible and what is not
  2. Waste packages can be designed to suit the geochemical environment
- ➢ Borehole and container design can be developed hand in hand

Thank you for your attention!