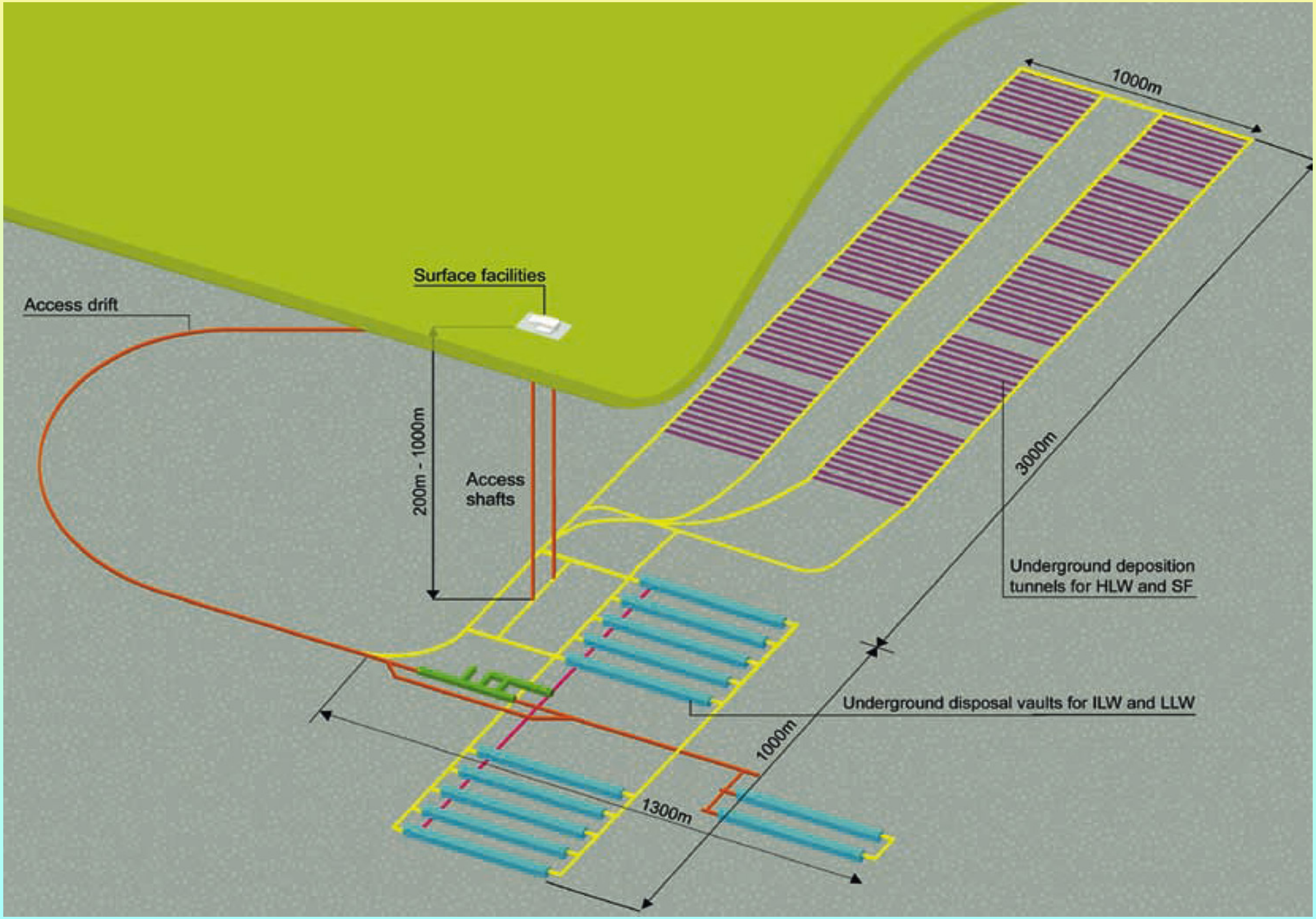
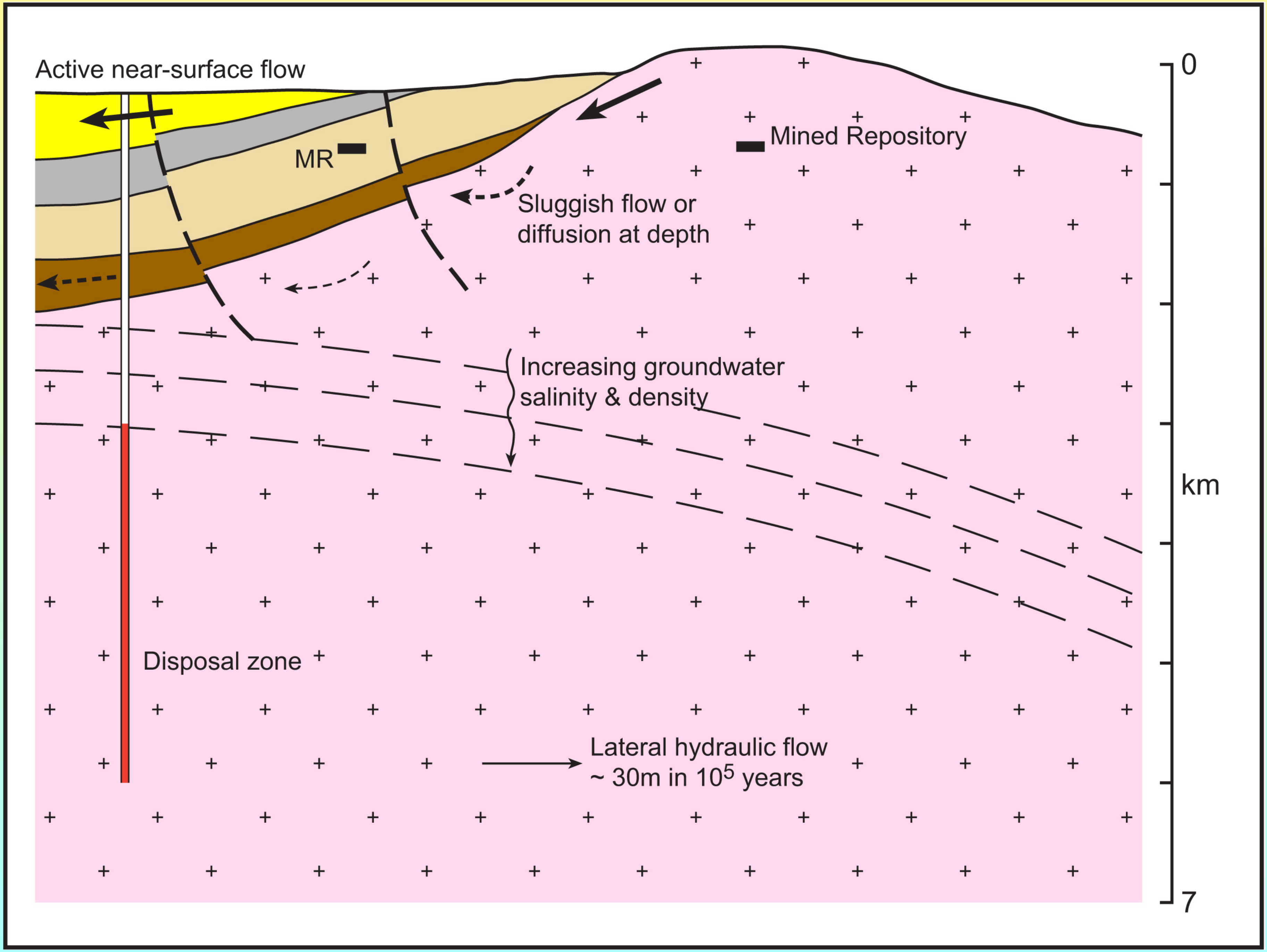
DEEP BOREHOLE DISPOSAL

Fergus Gibb

1. - The UK Position
2. - The Advantages
3. - The Concepts [Sheffield]
4. - Towards Full-scale Demonstration

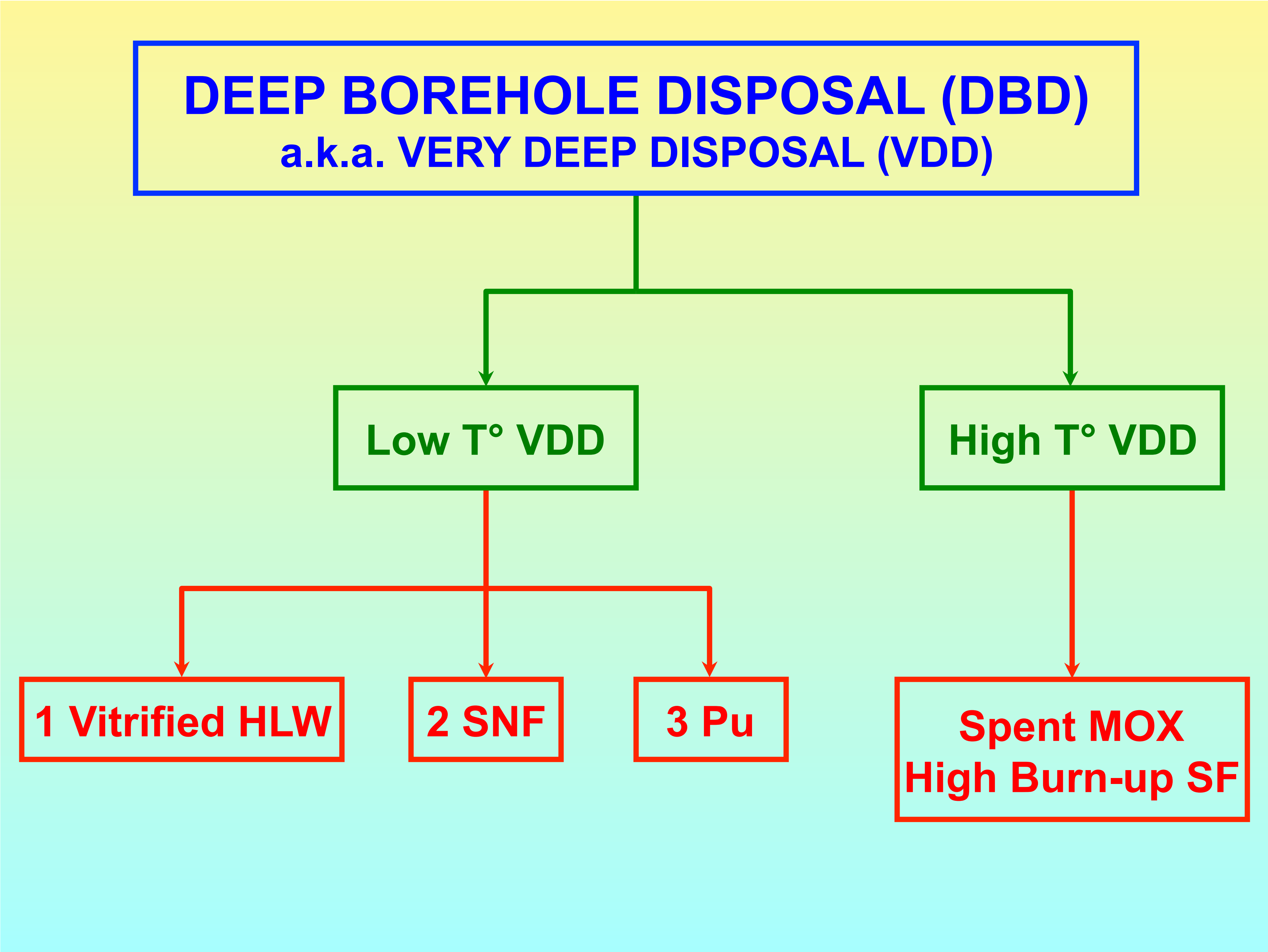
UK Government/NDA Reference Repository Concept – (Co-Location)

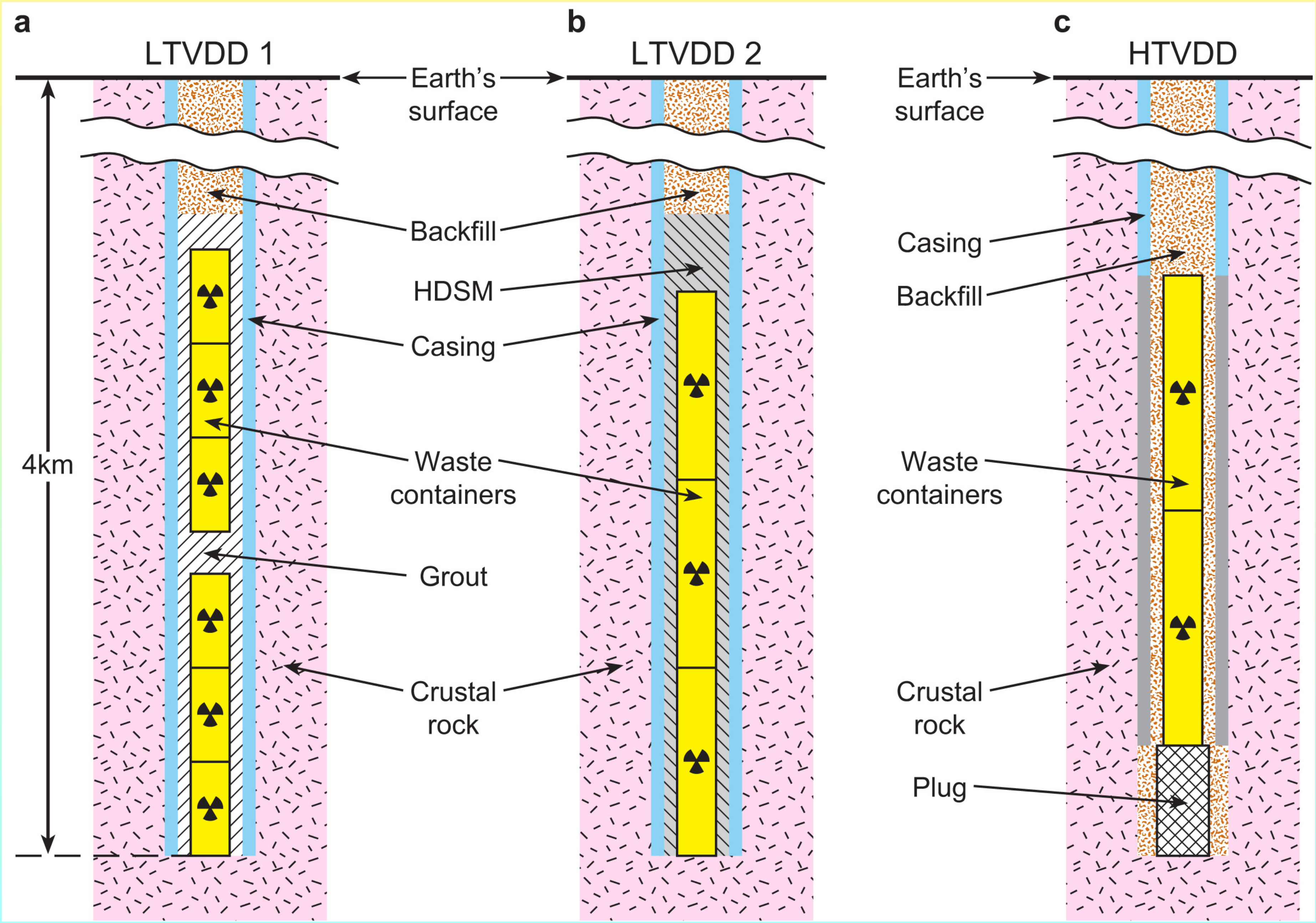



Active near-surface flow
MR
Mined Repository
Sluggish flow or diffusion at depth
Increasing groundwater salinity & density
Disposal zone
Lateral hydraulic flow ~ 30m in 10^5 years
0
km
7

Advantages of Deep Boreholes

1. SAFETY
2. COST-EFFECTIVENESS
3. ENVIRONMENTAL IMPACT
4. SMALL ‘FOOTPRINT’
5. SITE AVAILABILITY
6. DISPERSED DISPOSAL
7. FLEXIBILITY
8. INSENSITIVE to COMPOSITION
9. LONGEVITY
10. EARLY IMPLEMENTATION
11. ACCEPTABILITY ?


DEEP BOREHOLE DISPOSAL (DBD)
a.k.a. VERY DEEP DISPOSAL (VDD)
Low T° VDD
High T° VDD
1 Vitrified HLW
2 SNF
3 Pu
Spent MOX
High Burn-up SF



a
LTVDD 1
b
LTVDD 2
c
HTVDD
Earth's surface
Earth's surface
4km
Backfill
HDSM
Casing
Waste containers
Grout
Crustal rock
Casing
Backfill
Waste containers
Crustal rock
Plug

The University Of Sheffield.

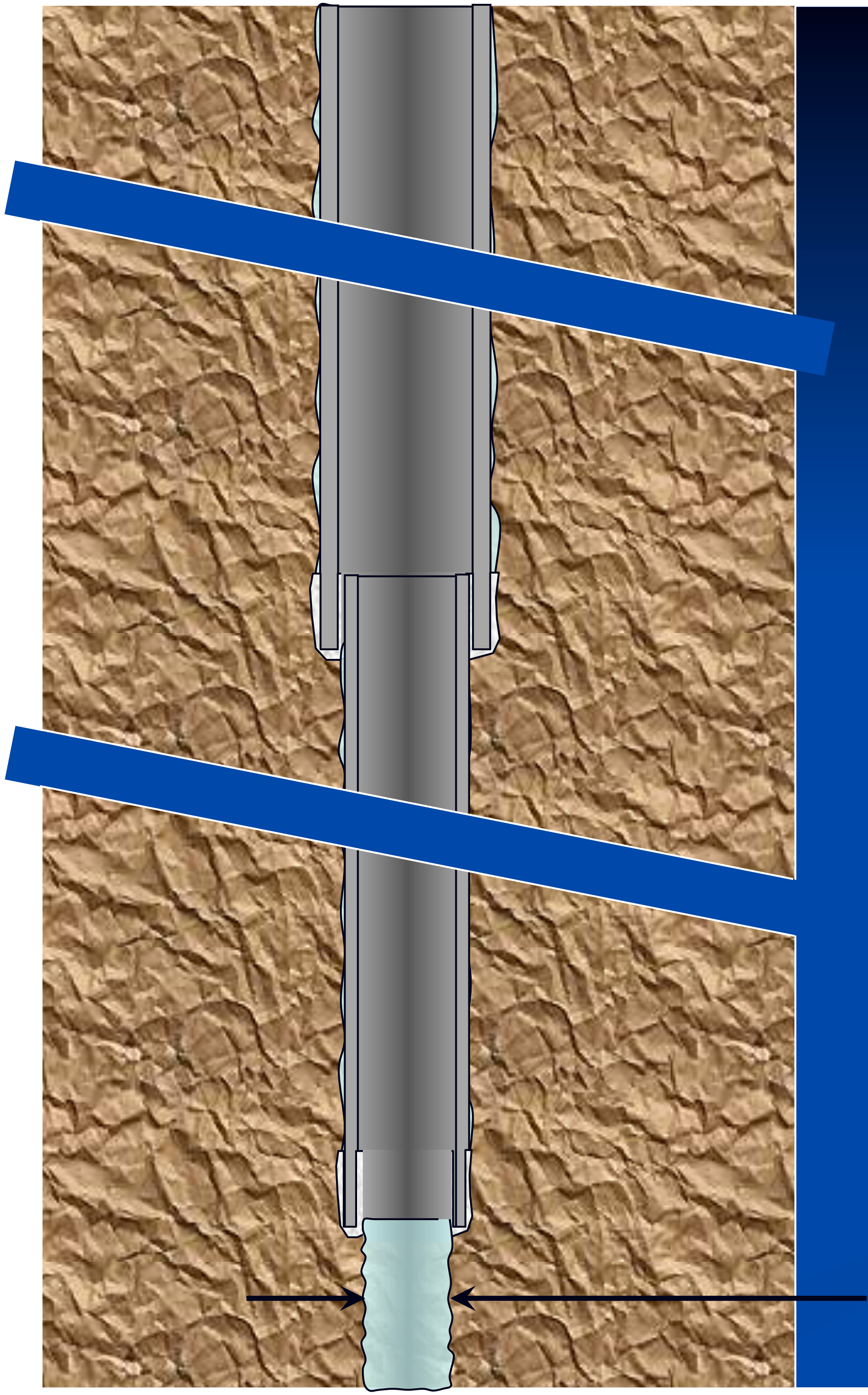
ISL

Thank you

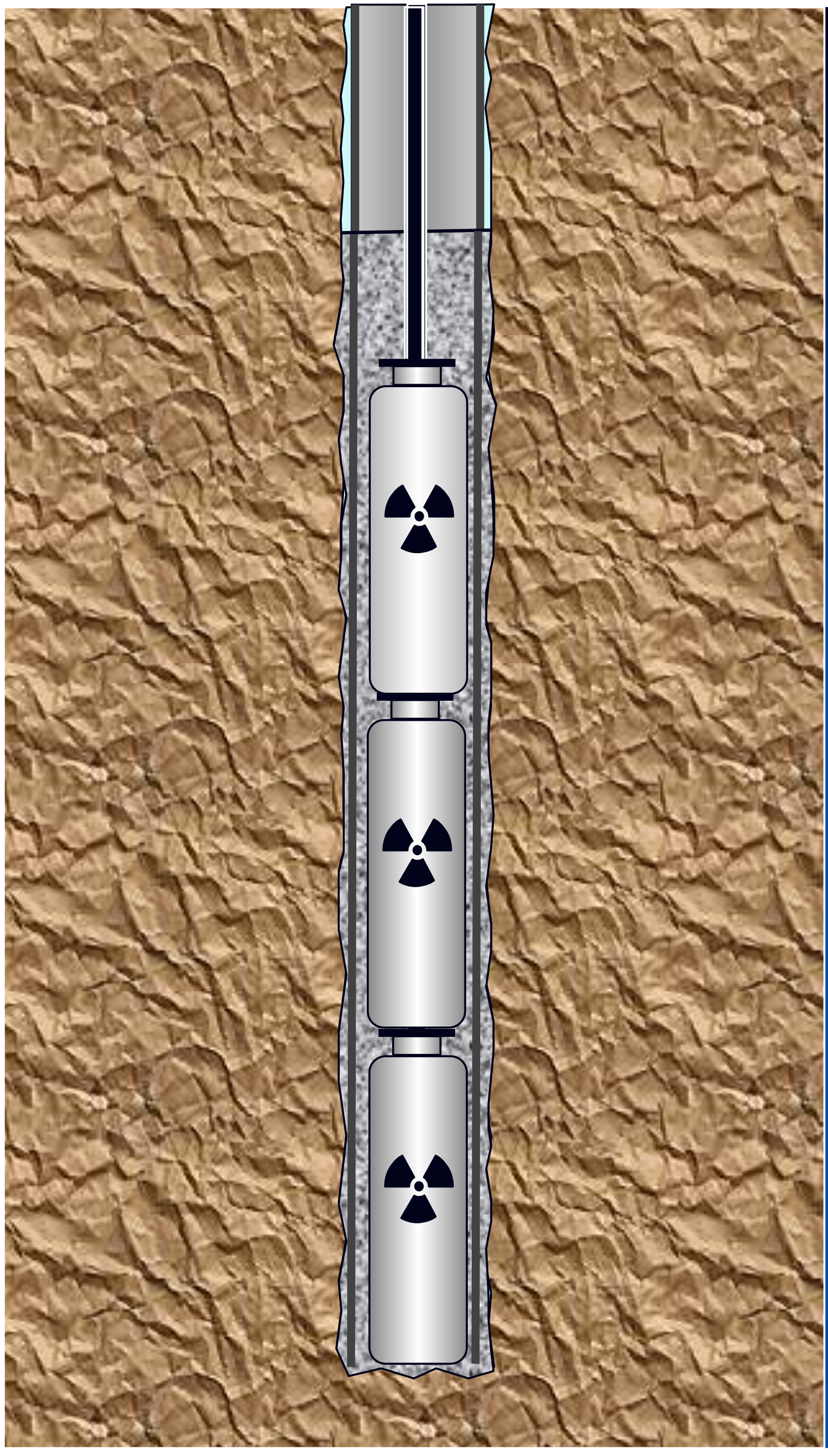
Constructing the borehole

- Drill the first stage of the borehole
- Insert the casing.
- Pour the cement base-plug.
- Drill the next stage of the borehole.
- Insert the casing.
- Pour the cement base-plug
- Drill the next stage of the borehole

And so on, down to > 4 kms



0.5 - 0.8 m diameter



Low Temperature Very Deep Disposal

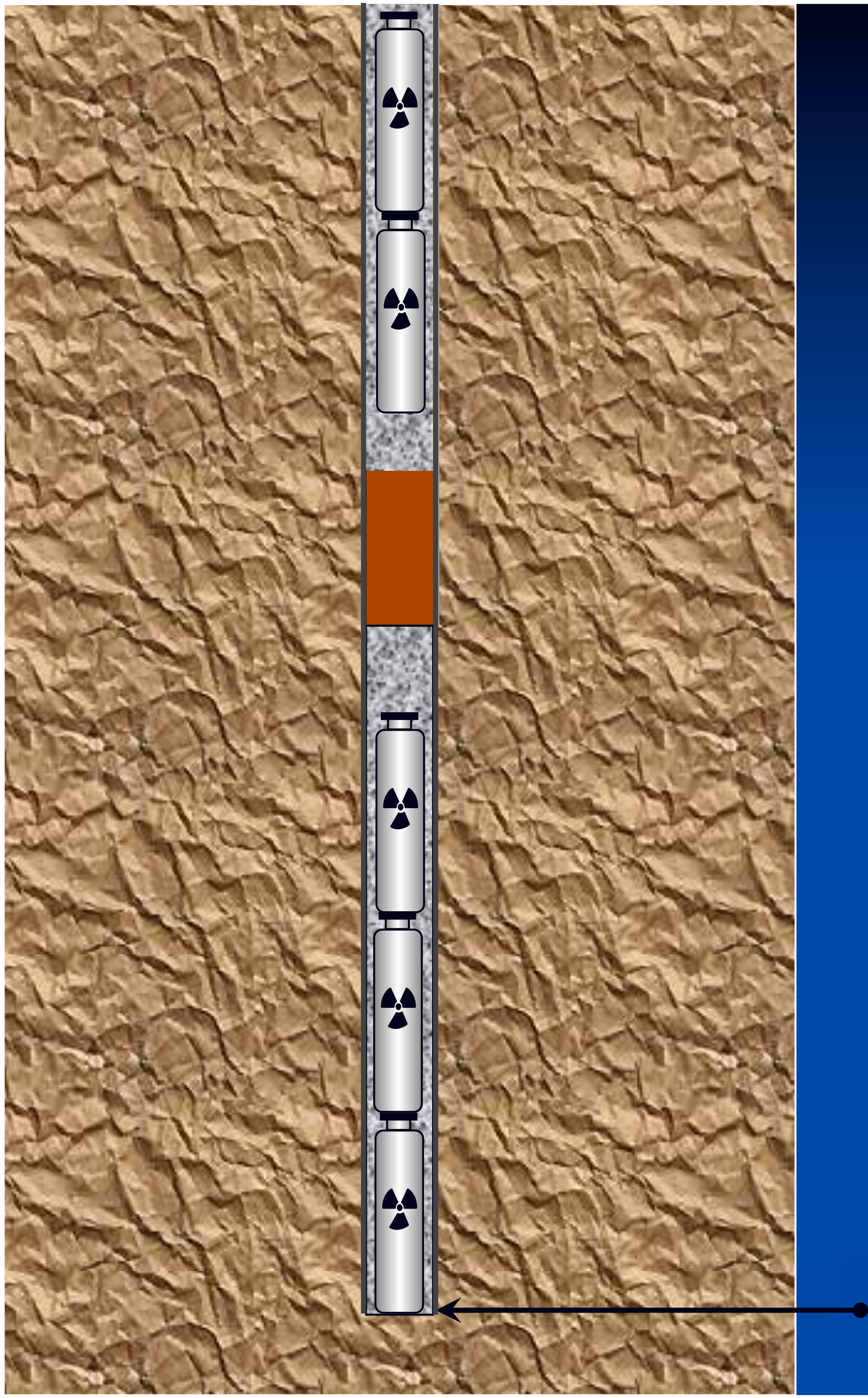
1

Vitrified waste

- Insert the final run of casing
- Emplace the first batch of HLW canisters
- Pump in the grout and allow it to set

Low Temperature
Very Deep Disposal

Vitrified waste

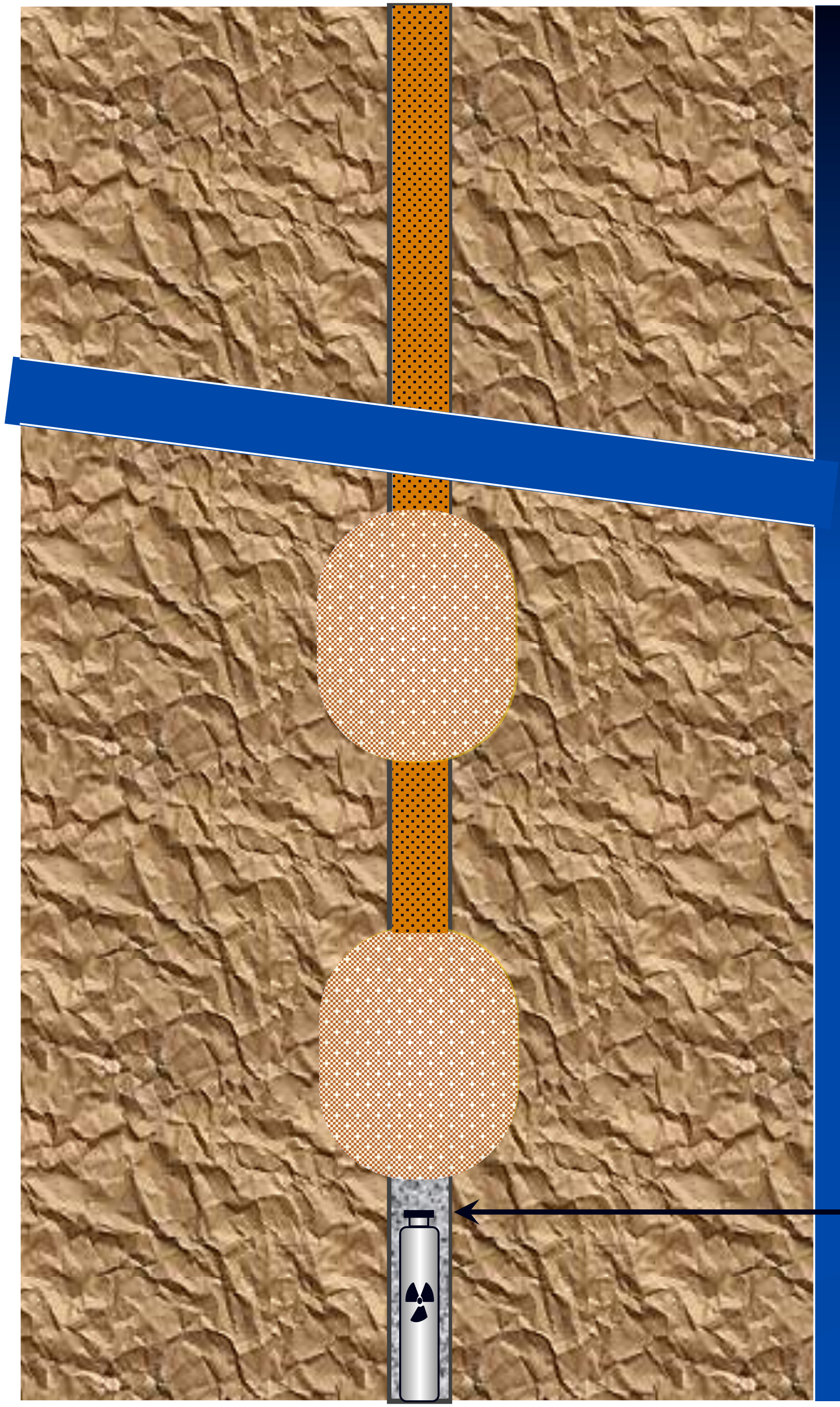


- Insert Bentonite clay (Optional)
- Insert another batch of canisters, pour grout & allow to set

Repeat until the bottom km of the borehole is filled

4 kms

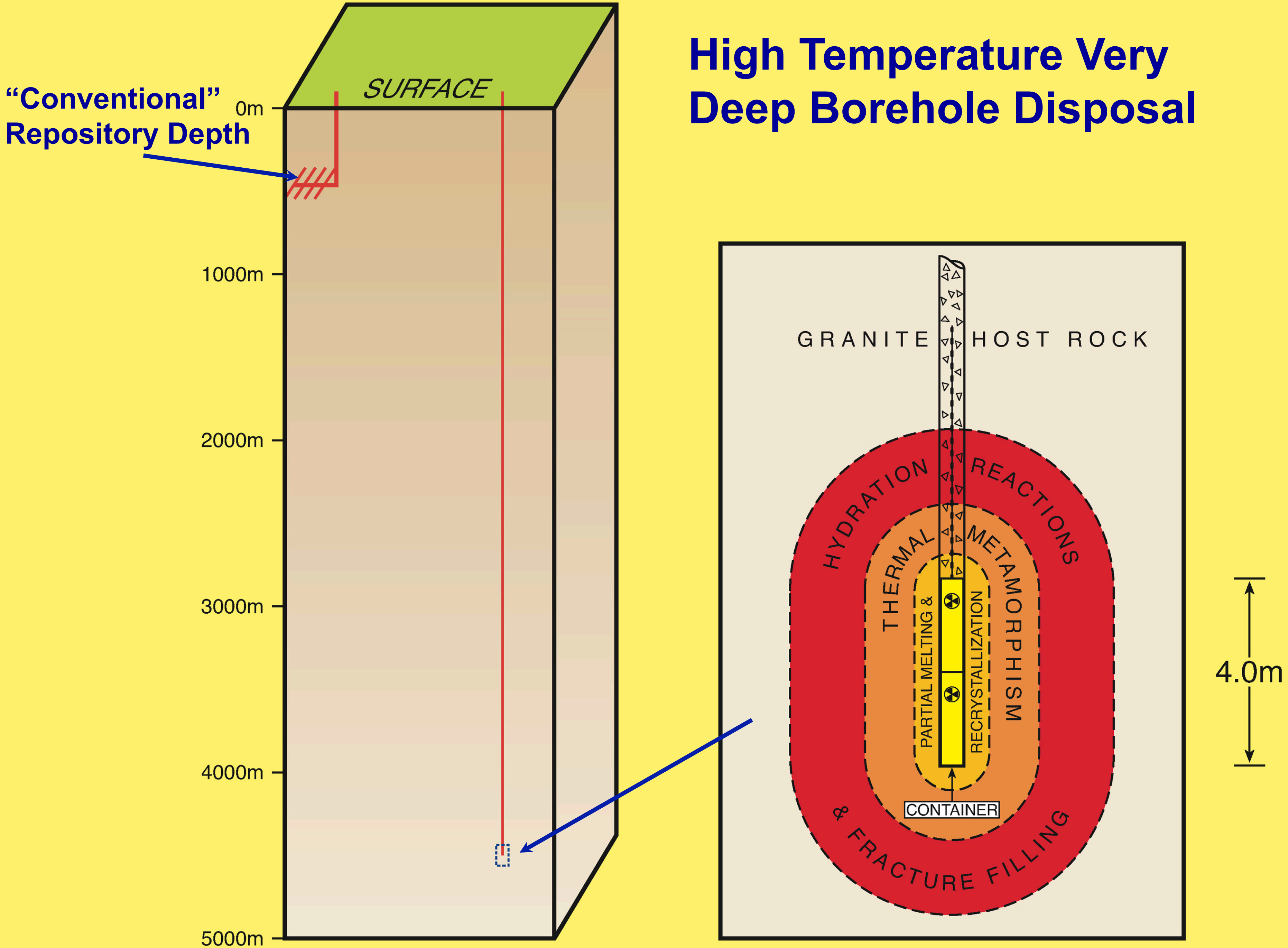
Sealing the borehole

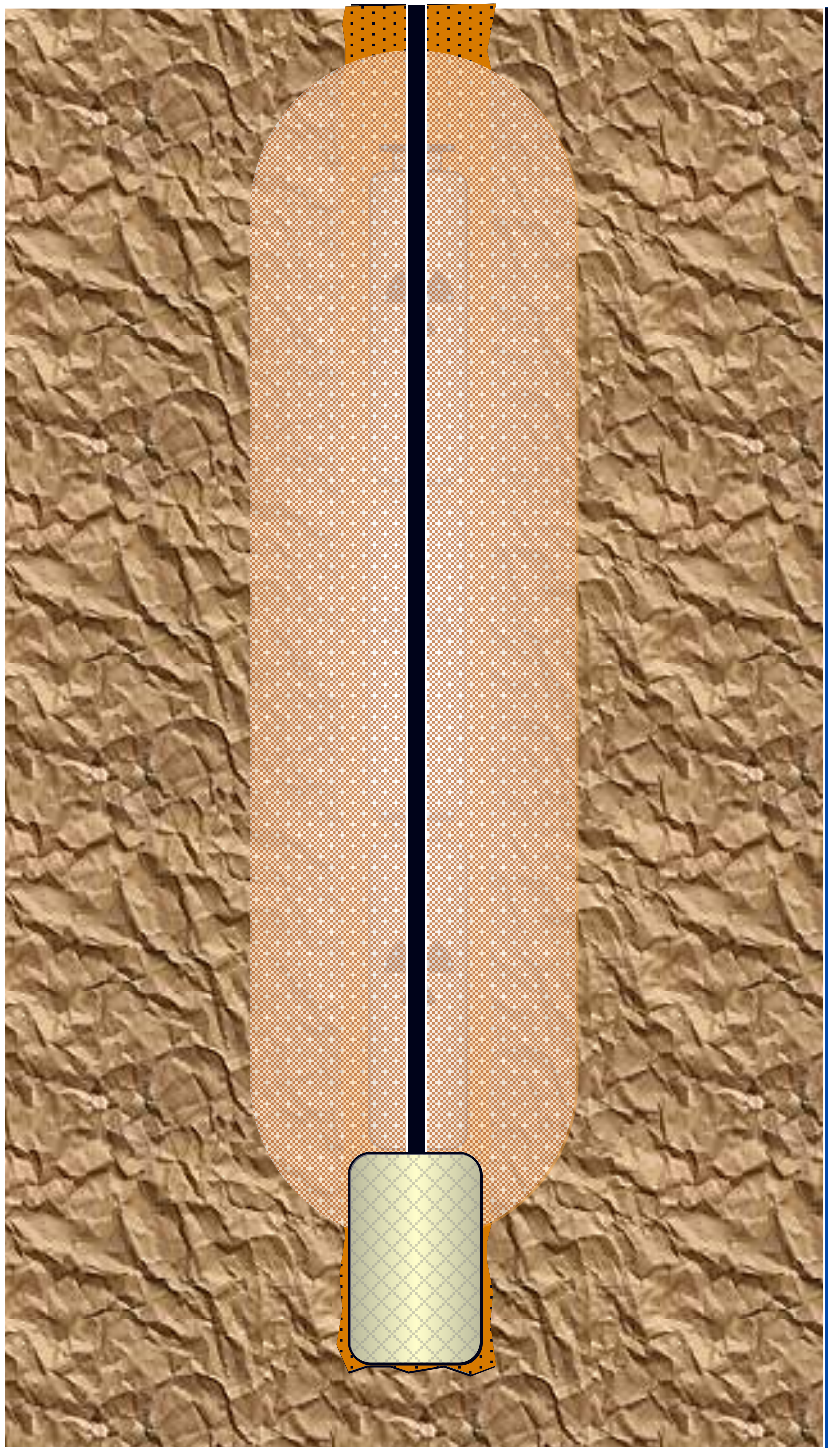


- Pour in some backfill (crushed granite)
- Insert heater and melt backfill & wall-rock to seal the borehole
- Pour in more backfill and seal the borehole again
- Repeat as often as required then fill the rest of the borehole with backfill

3 km deep (topmost canister)

High Temperature Very Deep Borehole Disposal





High Temperature
Very Deep Disposal

4

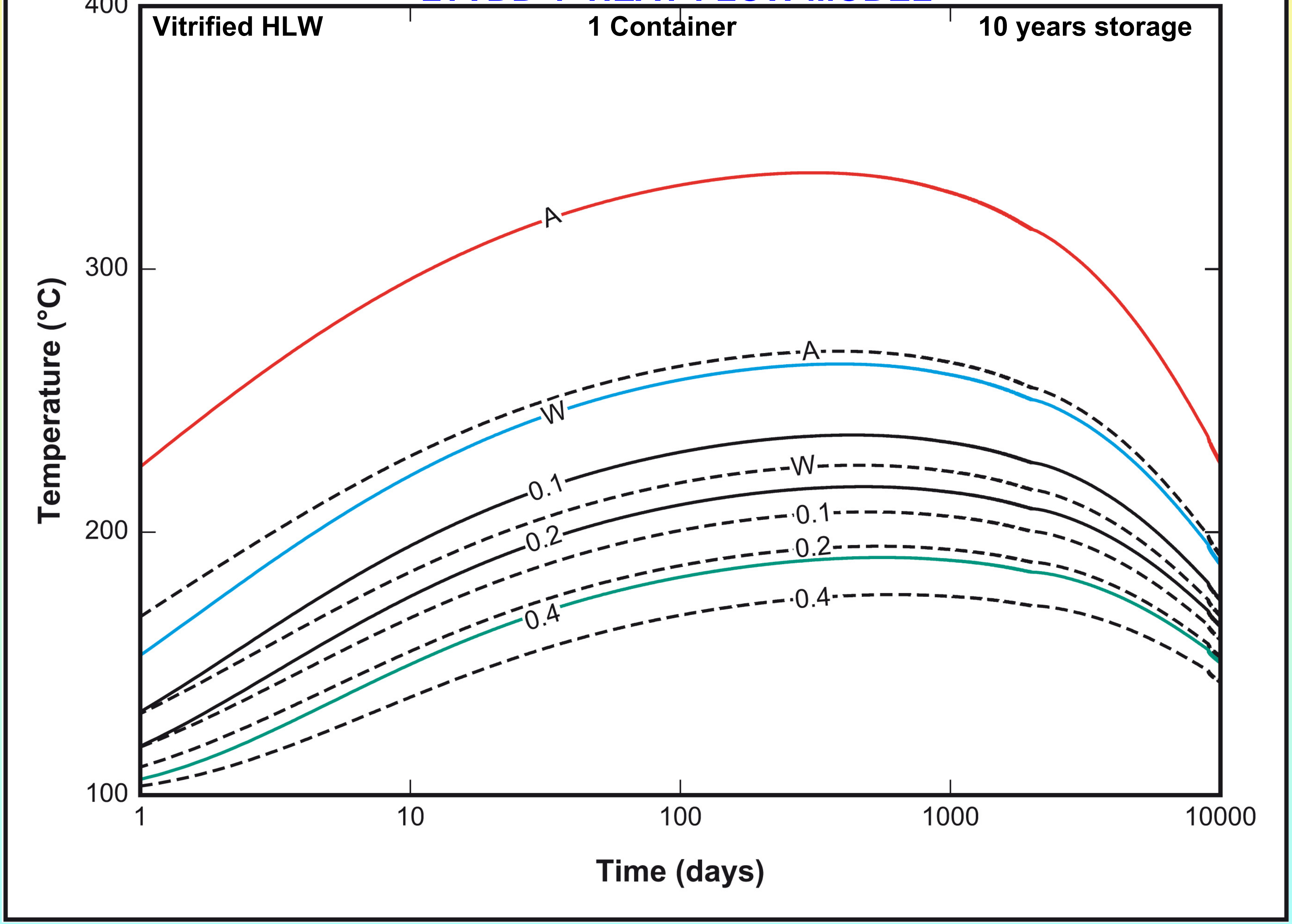
Young Spent Nuclear Fuel

- Insert a refractory plug
- Insert the casing and canisters
- Partly withdraw the casing (Optional)
- Pour in backfill
- Heat from the canisters melts the backfill & surrounding rock
- Granite sarcophagus forms around the canisters

POSSIBLE OPTIONS FOR UK HLWs

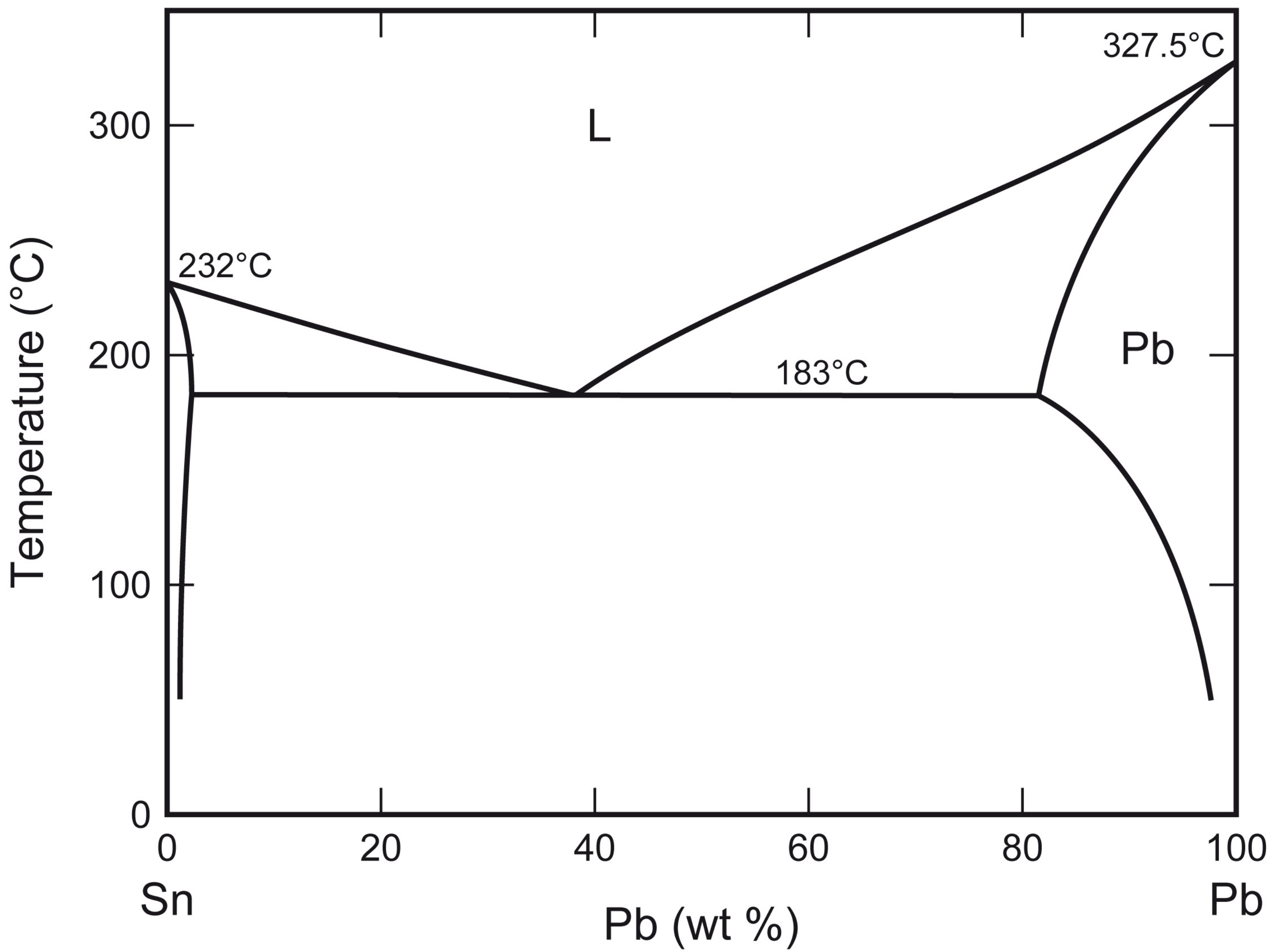
1. *Co-disposal in repository with ILW*
2. *Separate mined repository for HLW*
3. *Deep borehole disposal*
4. *Deep borehole disposal for HLWs unsuited to co-disposal with the rest co-disposed*

LTVDD-1 HEAT-FLOW MODEL



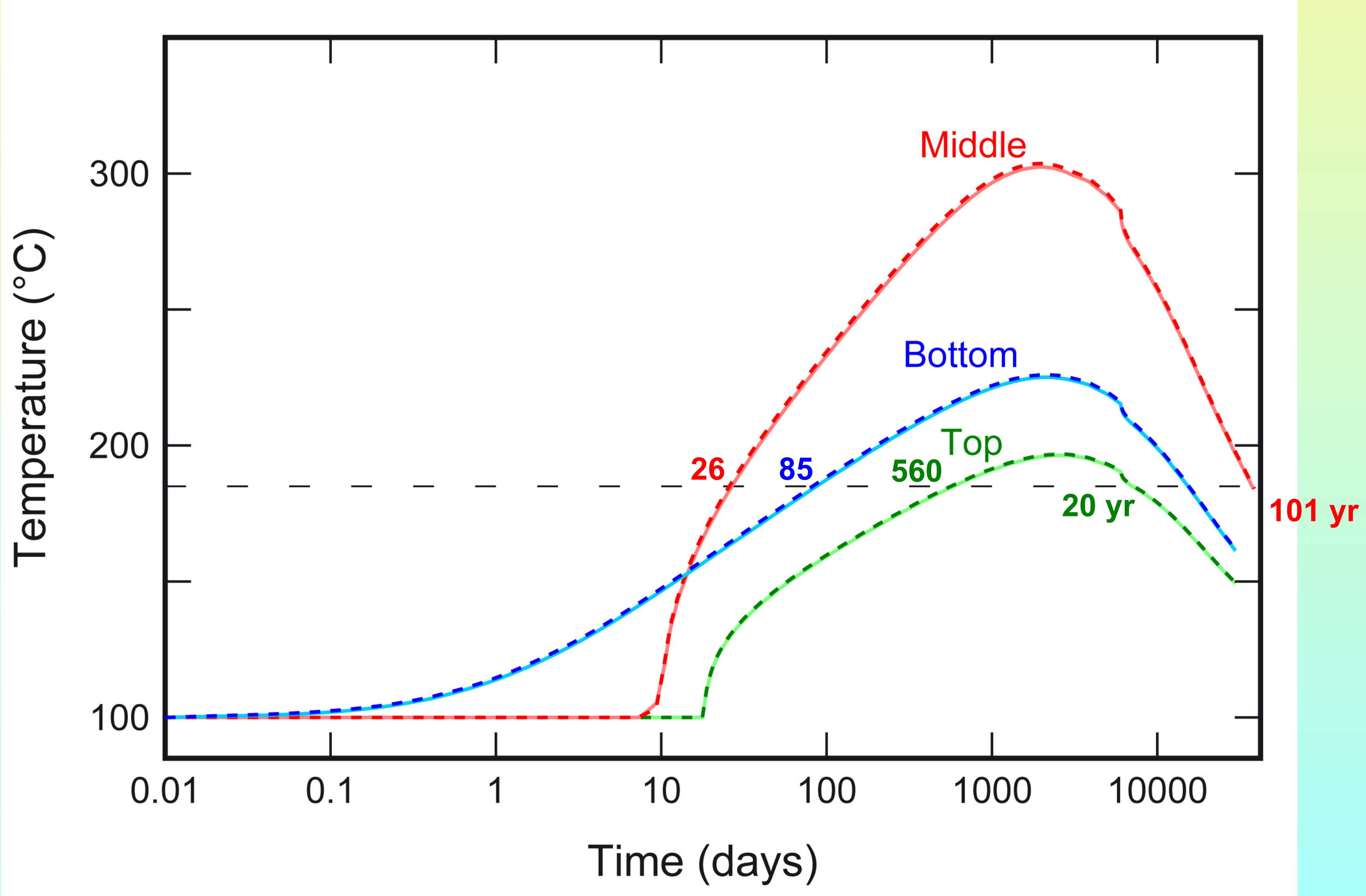
After Gibb, Travis, McTaggart & Burley (2008)

Phase Diagram for the System Pb - Sn



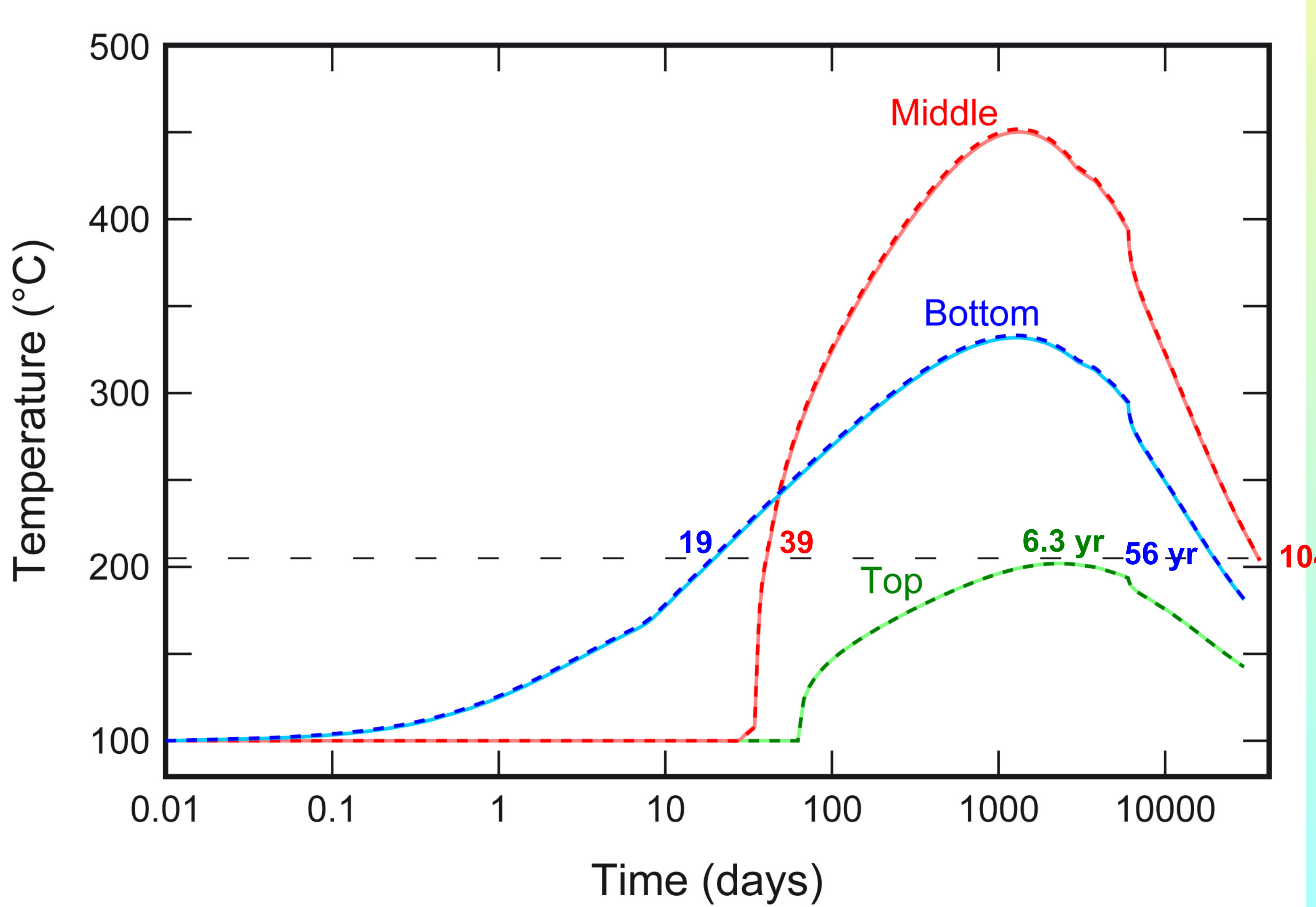
Case A.

Containers = Stack of 10 stainless steel [3.75 x 0.63 x 0.05(wall) m.]
Contents = 73%(vol.) 30-yr old PWR SNF [45 GWd/t] with Pb infill.
Deployment = One waste package every 2 days



Case B.

Containers = Stack of 10 copper [4.3 x 0.63 x 0.035(wall) m.]
Contents = 73%(vol.) 15-yr old AP-1000 SNF [45 GWd/t] with Pb infill.
Deployment = One waste package every 7 days



EXAMPLE OF DEEP BOREHOLE DISPOSAL OF Pu

Waste form = Y,Hf-stabilised Cubic Zirconia

Pu loading = 14 wt.%

Granite cylinder = 1 m x 0.25 m diameter

Pu waste form = 10% (volume)

Borehole diameter = 0.3 m

Borehole depth = 6 km

Pu content per granite cylinder = 4.18 kg

Pu disposal per km of borehole > 4 tonnes

Approximate cost of 6 km borehole = £4 M

SUMMARY & CONCLUSION

IMMOBILISATION — *Pu is in a stable (equilibrium) waste form*

↓

ENCAPSULATION — *Waste form is in (stable or metastable) equilibrium with encapsulating granite*

↓

STORAGE

↓

DEEP BOREHOLE DISPOSAL — *Granite cylinder is in equilibrium with intra-rock fluids & host granite*

Triple equilibrium guarantees Pu isolation from its environment until the physical destruction of the enclosing rocks by geological processes