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Thermal Analyses of a Generic Salt Repository with High-Level Waste

Waste Management Conference

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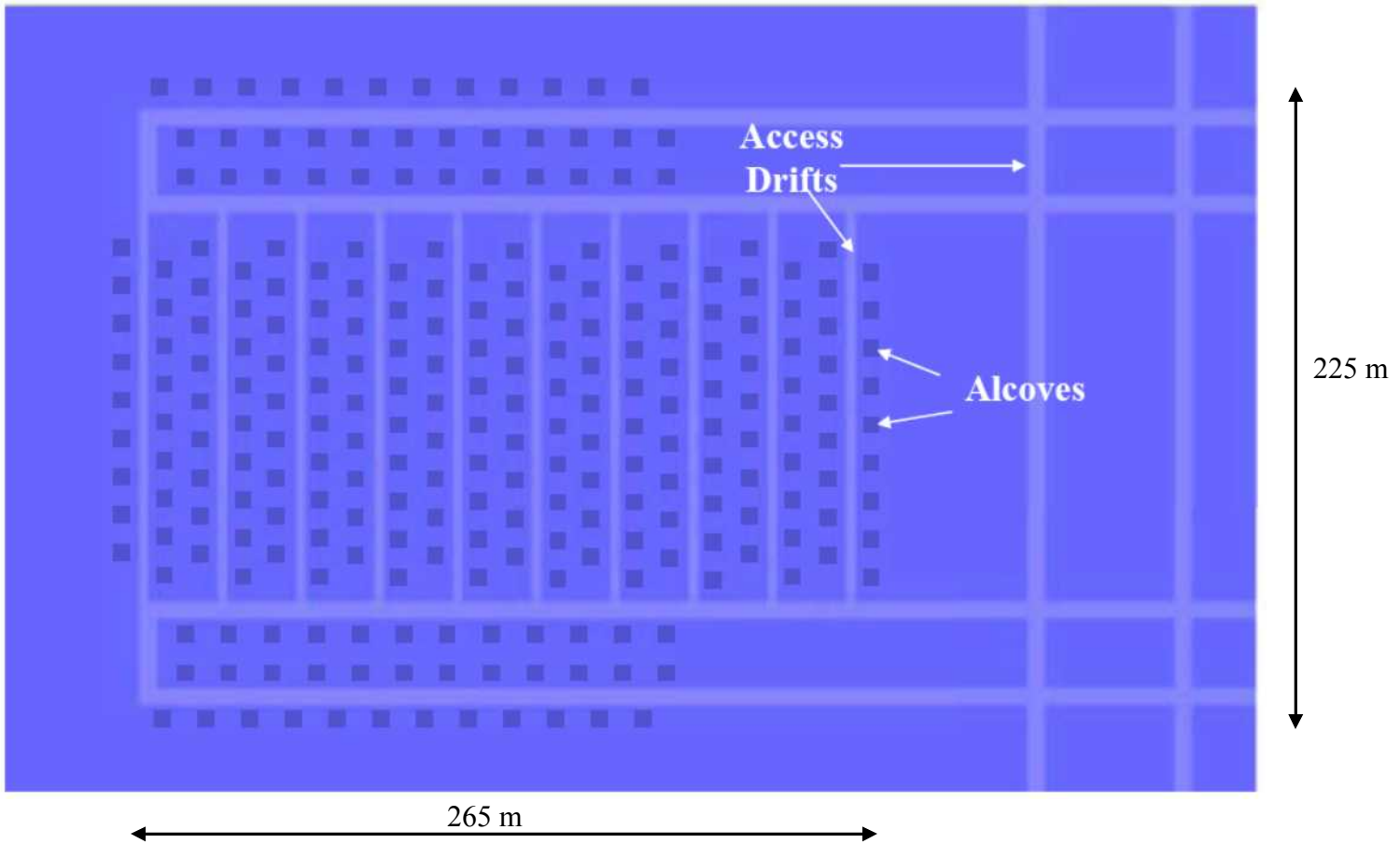
Bedded Salt Was Chosen for the Siting of the US Defense Nuclear Wastes

1957 recommendation by the NAS

"The most promising method of disposal of high level waste at the present time seems to be in salt deposits. The great advantage here is that no water can pass through the salt. Fractures are self sealing…"

- Salt can be mined easily
- Salt has a relatively *high thermal conductivity*
- Wide geographic distribution (many potential sites)
- Salt is plastic
- Salt is essentially impermeable
- Fractures in salt are self healing
- Salt has existed underground for millions of years

Generic Salt Repository Concept



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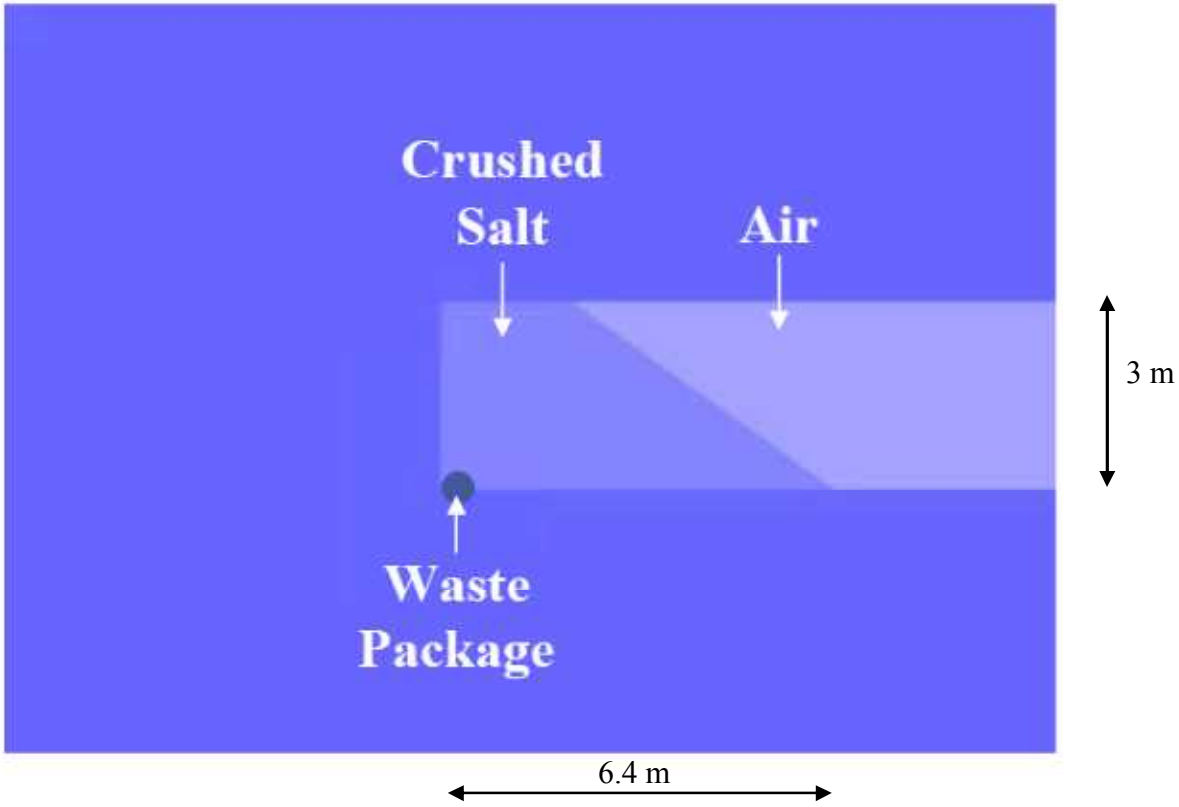
Generic Salt Repository Concept



Generic Salt Repository Thermal Analysis

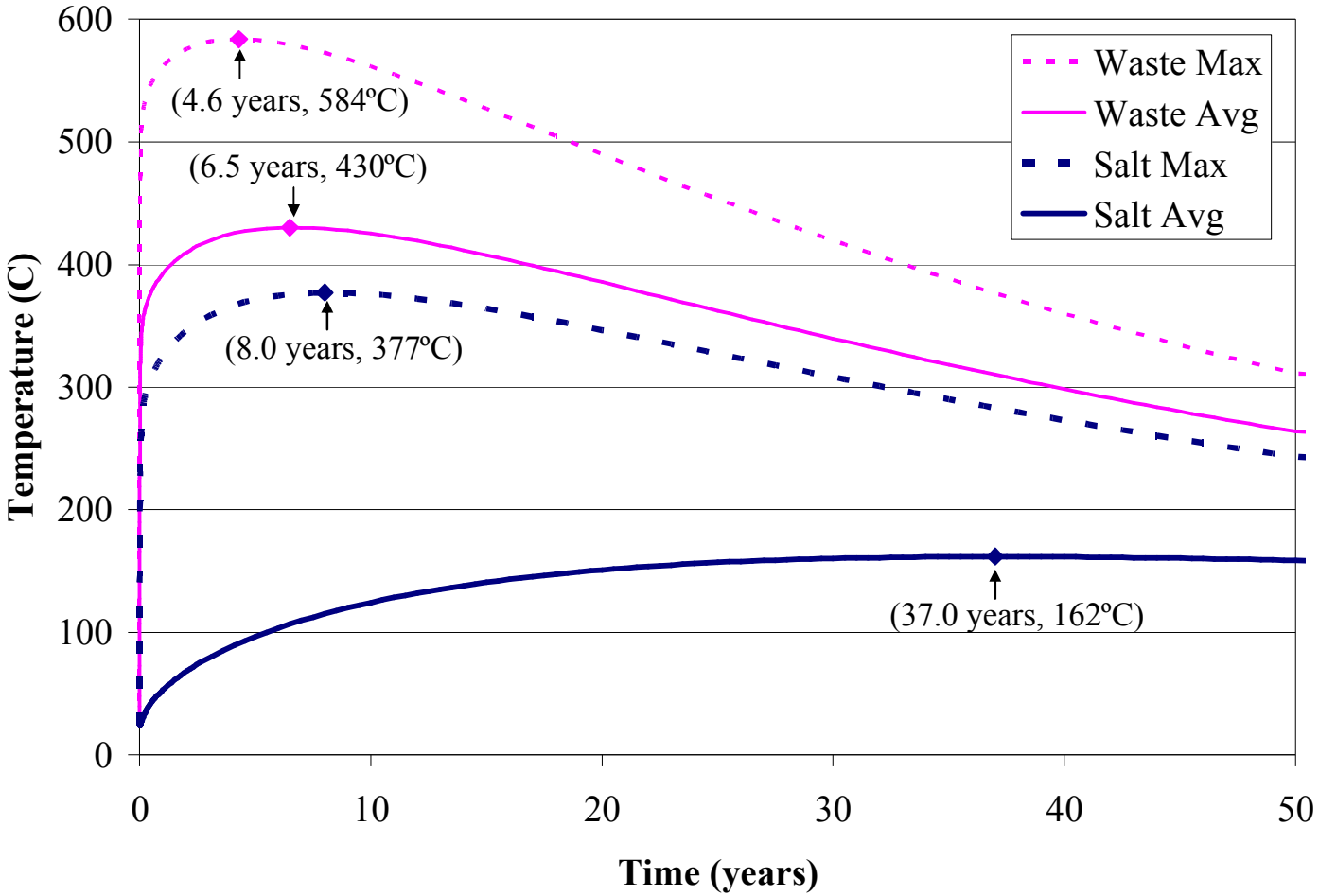
- Main objectives
  - Temperatures
    - Waste and Salt
    - Average and Peak
  - Thermal pulse
    - Looked at 100ºF isotherms
    - Lateral migration
      - Alcove to alcove
      - Panel to panel
    - Vertical migration

- Sensitivity to other factors
  - Salt creep and reconsolidation
  - Heat load
  - Emplacement rate and sequence
  - Emplacement of other waste
  - Waste configuration
  - Multiple factors

Base Case

- Waste configuration
  - 8.4 kW
  - 0.6 m diameter
  - 2.7 m length
- Properties of intact salt used for both the crushed salt backfill and drift
  - Assumes instant reconsolidation
- Alcoves filled one per day
  - Middle from back to front
  - Edges from middle outward

Base Case Temperature Versus Time



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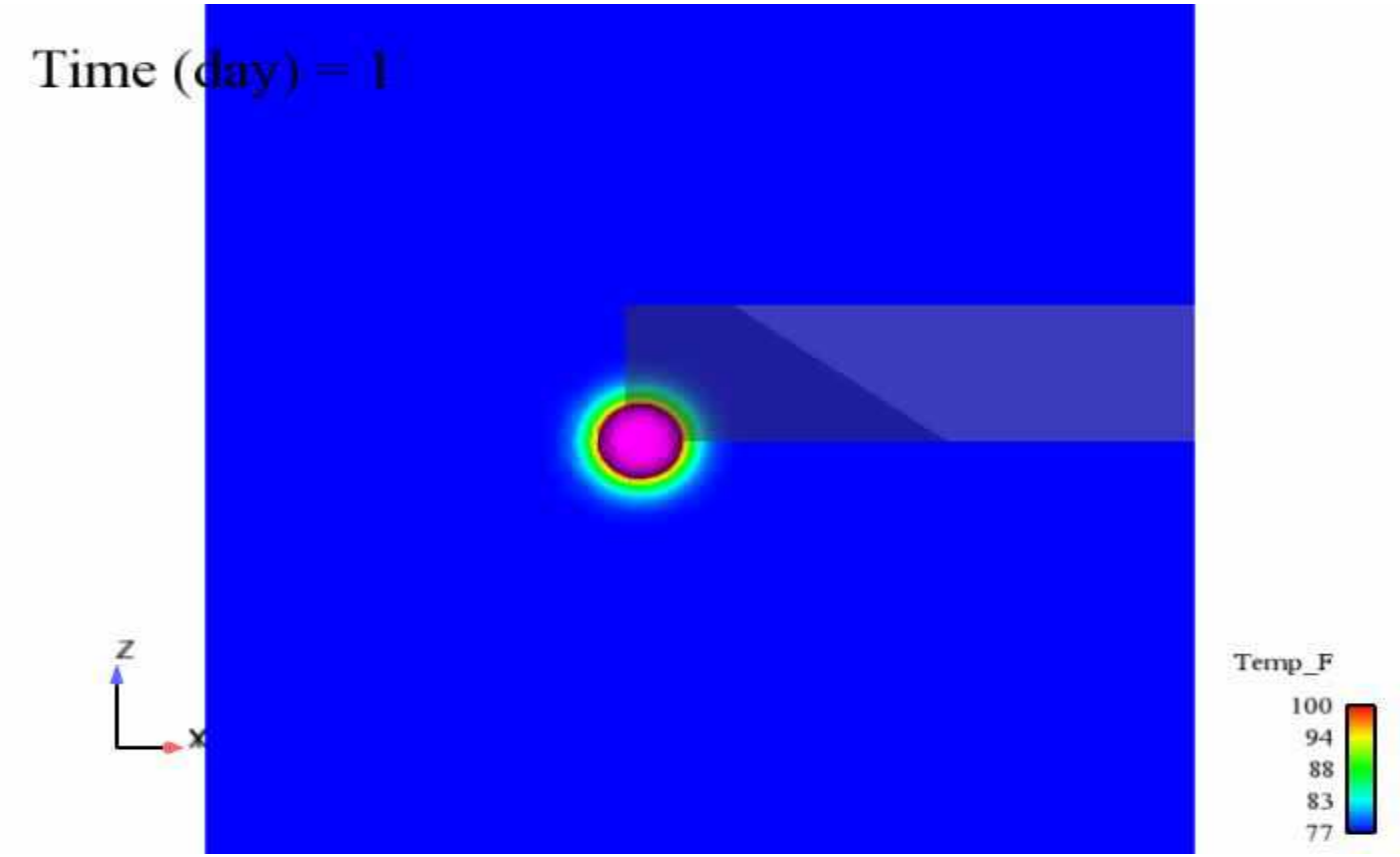
Side View Alcove 1st Year 100°F Isotherm (purple)



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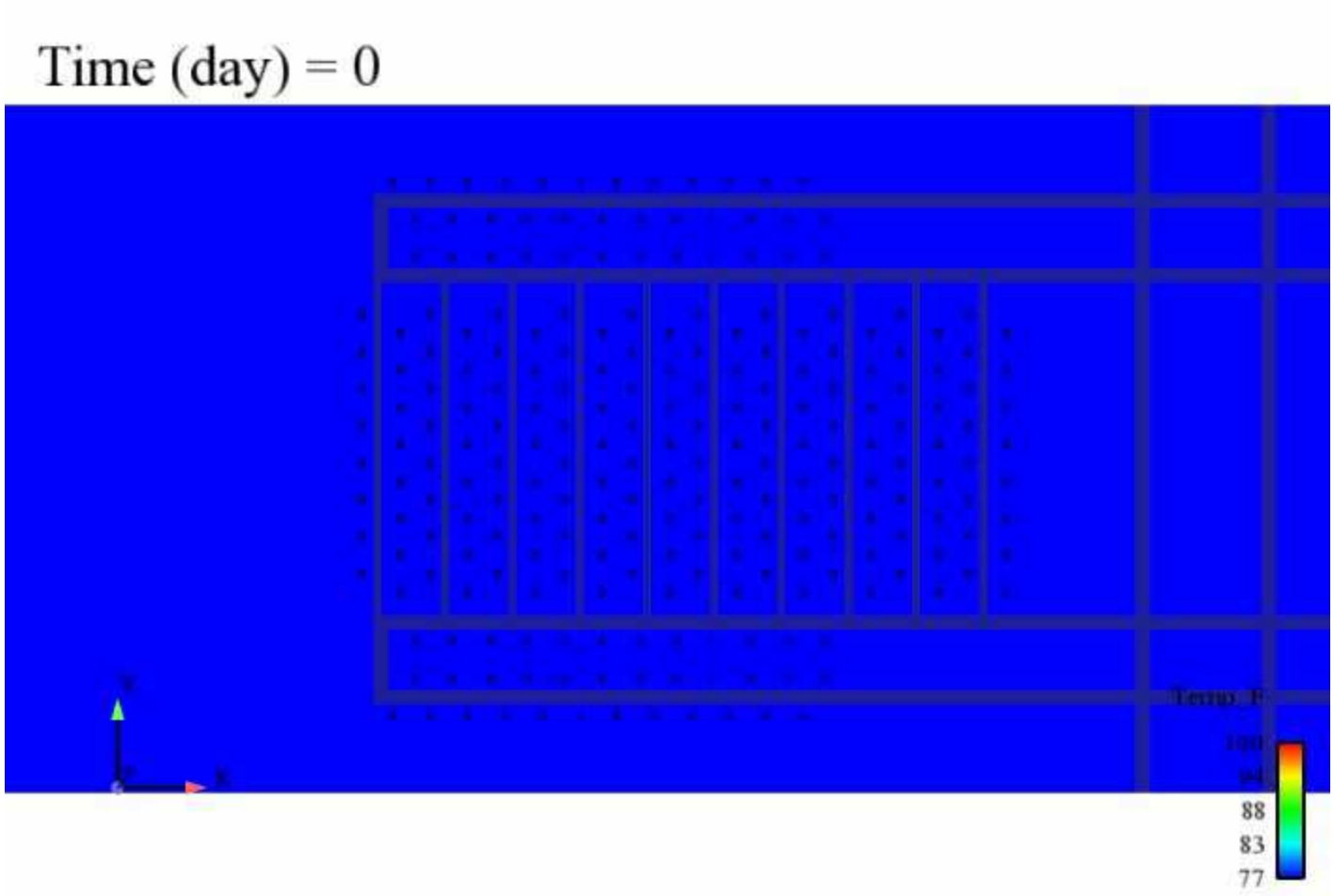
Plan View Panel 5 Years 100°F Isotherm (purple)



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Thermal Pulse (100ºF Isotherm)

- Lateral Migration (Alcove to Alcove)
  - 20 ft @ 75 to 120 days
- Lateral Migration (Panel to Panel)
  - 100 ft @ 7 to 12 years
  - 200 ft @ 50 years
- Vertical Migration
  - 100 ft @ 5 years
  - 385 ft @ 50 years

Sensitivity Cases

- **Salt Reconsolidation and Creep**
  - Backfill and drift persisted as crushed salt and air for entire simulation
- **Heat Load**
  - Thermal load decreased to 7.0 kW, 4.2 kW and 2.4 kW
  - Repeated cases while maintaining the initial areal thermal loading
- **Emplacement Rate and Sequence**
  - Doubled and halved the emplacement rate
  - Modified emplacement sequence

Sensitivity Cases (continued)

- **Emplacement of Other Waste**
  - Utilized bounding cases of insulating and conductive material to represent other waste
- **Waste Configuration**
  - Reduce volume by ½ and place two in each alcove
  - Place a copper plate on the alcove floor
- **Multiple Factors**
  - Combinations of other sensitivity cases

Peak and Average Temperature Sensitivities

- **Salt Reconsolidation and Creep**
  - Increased peak while average was maintained
- **Heat Load**
  - Peak and average decreased with decreasing heat load
  - Average not impacted when constant areal thermal loading is maintained
- **Emplacement Rate and Sequence**
  - Negligible impact on peak and average (<1 ^{o}C)
- **Emplacement of Other Waste**
  - Not significantly affected (<1 ^{o}C)
- **Waste Configuration**
  - Minor peak temperature reduction

Lateral Thermal Front Migration Sensitivities

- Salt Reconsolidation and Creep
  - Alcove to Alcove - Minor increases in timing (5 days)
  - Panel to Panel - No change in timing
- Heat Load
  - Decreased with decreasing heat load in all directions for decreased overall thermal loading
  - Same as Base Case when constant areal thermal loading is maintained
- Emplacement Rate and Sequence
  - Alcove to Alcove - No change in timing
  - Panel to Panel – Minimal thermal pulse migration difference after 2-3 years
- Emplacement of Other Waste
  - Thermal pulse migration not significantly affected
- Waste Configuration
  - Minor impact on thermal pulse migration

Vertical Thermal Front Migration Sensitivities

- Salt Reconsolidation and Creep
  - No change in timing, shifted downward slightly
- Heat Load
  - Decreased with decreasing heat load in all directions for decreased overall thermal loading
  - Same as Base Case when constant areal thermal loading is maintained
- Emplacement Rate and Sequence
  - No change in timing
- Emplacement of Other Waste
  - No change in timing
- Waste Configuration
  - No change in timing

Summary and Conclusions

- Reasonable temperatures are achievable
- Sufficient time would be available for waste emplacement
- Thermal loading is the primary driver of repository-wide heat effects
- Decay storage, decreasing the heat load and changing the waste configuration reduce peak temperatures
- Inclusion of other non-HLW has minimal effects on thermal response

What's Next

- Laboratory and in situ studies of intact and crushed salt thermomechanical response
- Track moisture movement and vapor phase transport in situ
- Measure the effect of temperature on radionuclide solubility
- Demonstrate a proof-of-principle salt disposal concept