U.S. DEPARTMENT OF ENERGY
OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT

# NUCLEAR WASTE TECHNICAL REVIEW BOARD
# PANEL ON STRUCTURAL GEOLOGY & GEOENGINEERING

## SUBJECT: OVERALL APPROACH TO SEAL (BACKFILL) SHAFTS, RAMPS, AND UNDERGROUND OPENINGS


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| PRESENTER: | JOSEPH A. FERNANDEZ, P.E. | DR. MICHAEL HARDY |
| PRESENTER'S TITLE AND ORGANIZATION: | SENIOR MEMBER OF TECH. STAFF<br>SANDIA NATIONAL LABORATORIES<br>ALBUQUERQUE, NEW MEXICO | ASSOCIATE<br>JFT AGAPITO AND ASSOCIATES |
| PRESENTER'S TELEPHONE NUMBER: | (505) 844-2365 | (303) 242-4220 |


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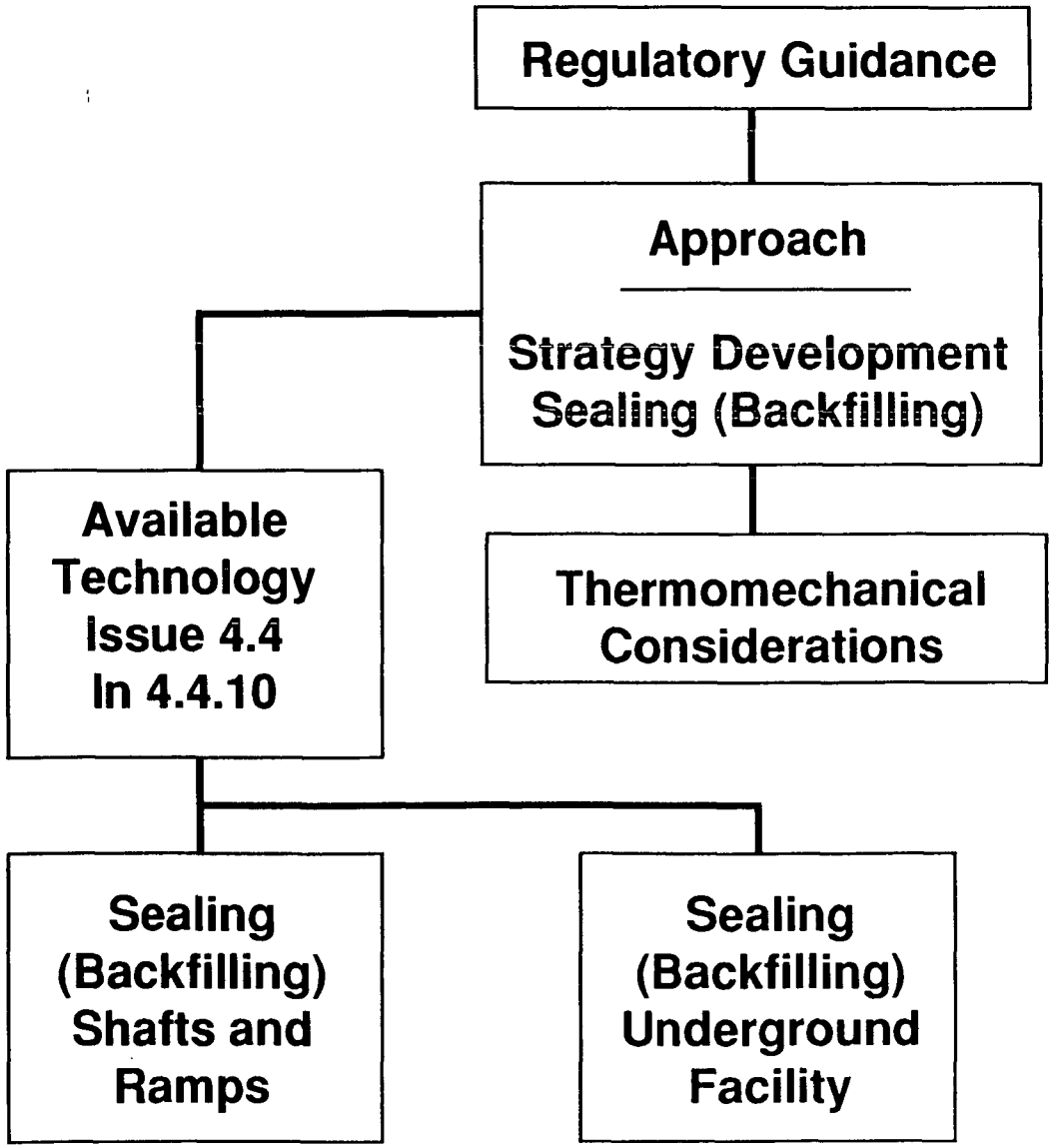
# Scope of Presentation



# Guidance for Backfill Performance

- No specific criteria for backfill from regulations
- Some specific criteria from analyses
- General criteria defined in regulations
  - 10 CFR60.112

    Geologic setting and engineered barrier system, shafts, boreholes, and their seals

    - Designed to comply with EPA environmental standards
  - 10 CFR60.133

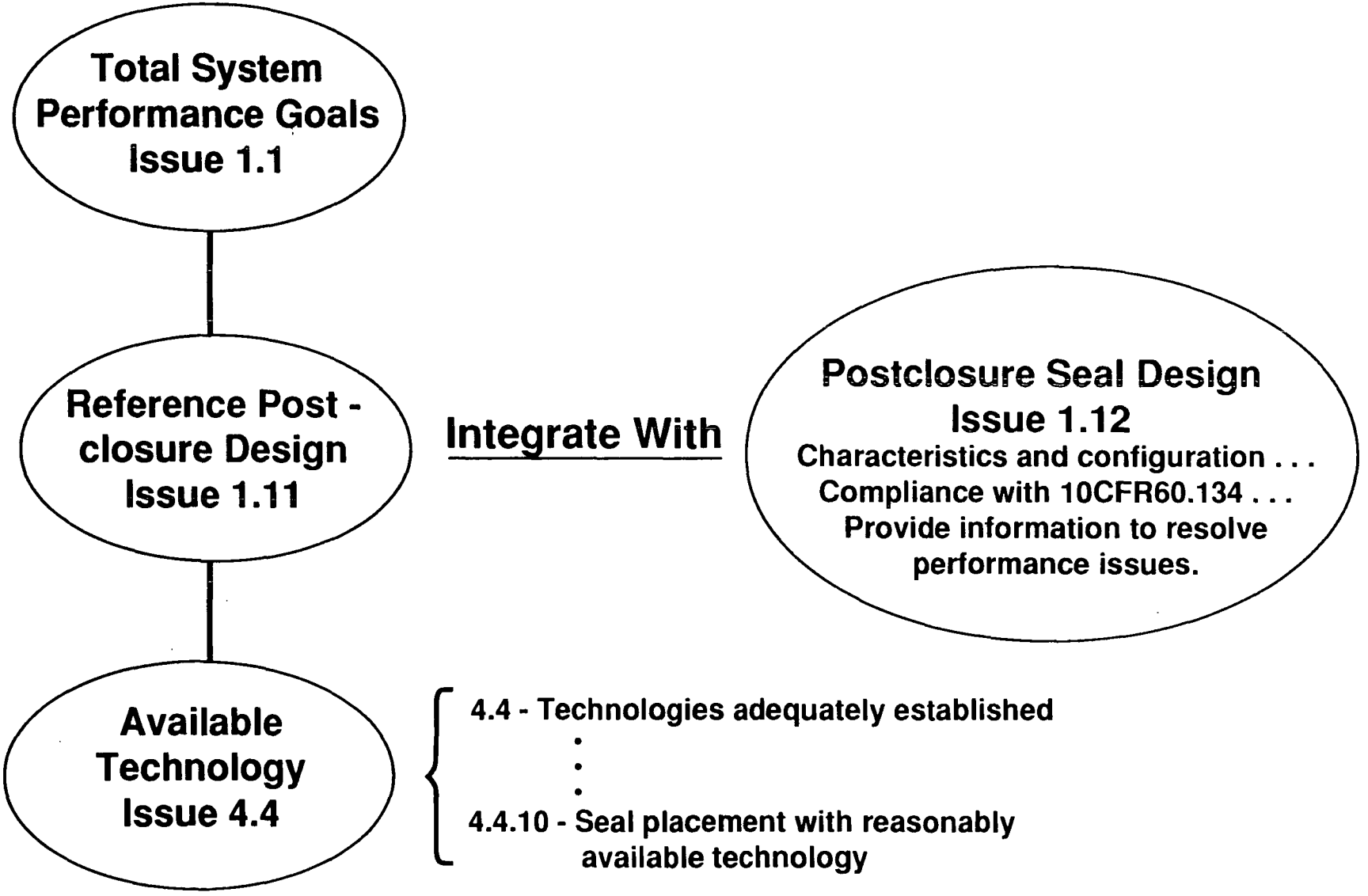
    a) Orientation, geometry, layout and depth
       - Underground facility engineered barriers
       - Contribute to containment and isolation

# Guidance for Backfill Performance *continued*

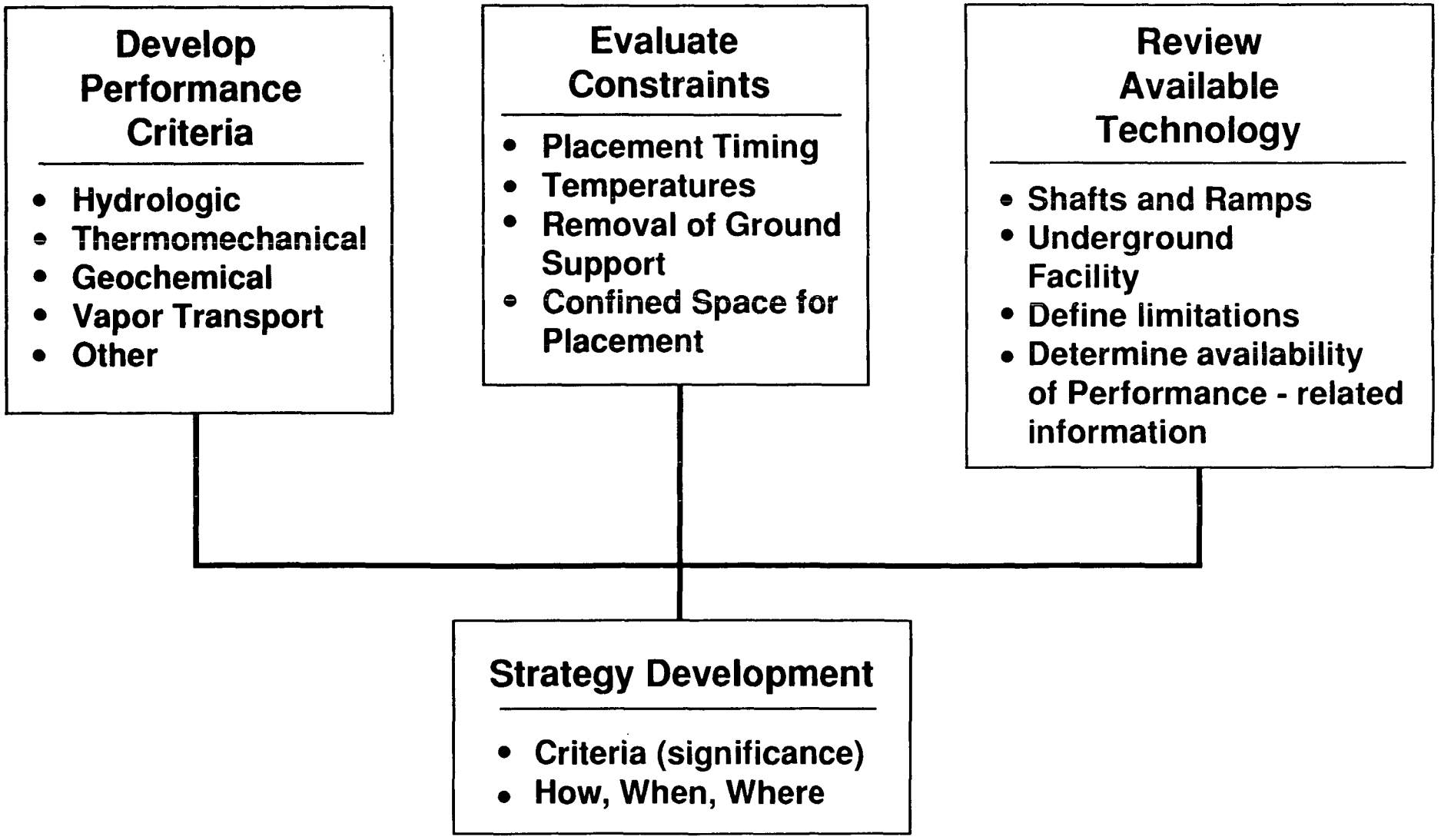
- 10 CFR60.133 *continued*

| | |
|---|---|
| d) Underground facility | • Provide control of water or gas intrusion |
| e) Underground openings | • Maintain retrievability option |
| f) Rock excavation techniques in underground facility | • Limit potential for creating preferential pathways |
| h) Engineered barriers | • Assist geologic setting to achieve performance objectives |

# Approach Used to Develop Strategy



# Approach Used to Develop Strategy (continued)



## Proposed Performance - Related Numerical Analysis

- Assess role of backfill in restricting lateral flow and vapor transport
- Define geochemical constraints and propose compatible material
- Assess long - term drift stability
  - intact rock
  - slip along joints and potential faults
- Assess effect of backfill on limiting yield around drift
- Evaluate orientation of faults/joints that could be activated with no backfill

# Available Technology for Sealing an Underground Facility, Shafts and Ramps

- Case histories - visited
  - Apex Mine
  - Billie Mine
  - Cannon Mine
  - White River Shale Oil Project
  - New Waddell Dam
  - NTS
- Case histories - reviewed
  - Pacheco Pump Plant
  - VAT Tunnel
  - Helms Pumped Storage
  - Dam histories
  - Sullivan Mine

# Overview
# Development of Backfill Mechanical Performance Criteria

- Regulatory requirements
- Establish thermomechanical environment
- Evaluate mechanisms impacting containment and isolation
  - Subsidence (preferential pathway)
  - Disturbed zone around drift/boreholes
  - Waste package loading (waste package integrity)
  - Fault/joint slip (preferential pathway)
- Potential backfill performance requirements
  - Timing of backfill placement
  - Temperature/ventilation
  - Removal of ground support systems
  - Backfill materials constraints
  - Confined working conditions

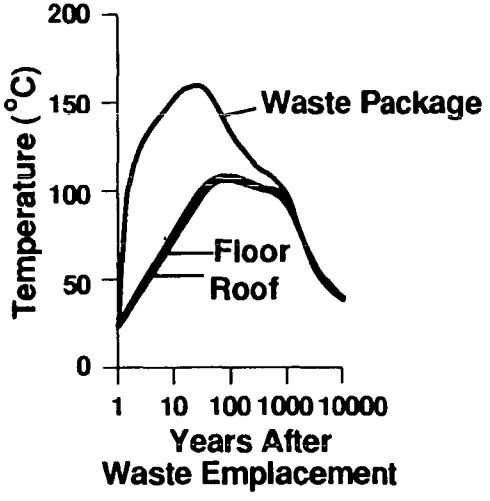
# Regulatory Requirements

- Limit deformation around drifts
- Limit changes to permeabilty of rock mass
- Limit subsidence potential
- Limit development of preferential pathways

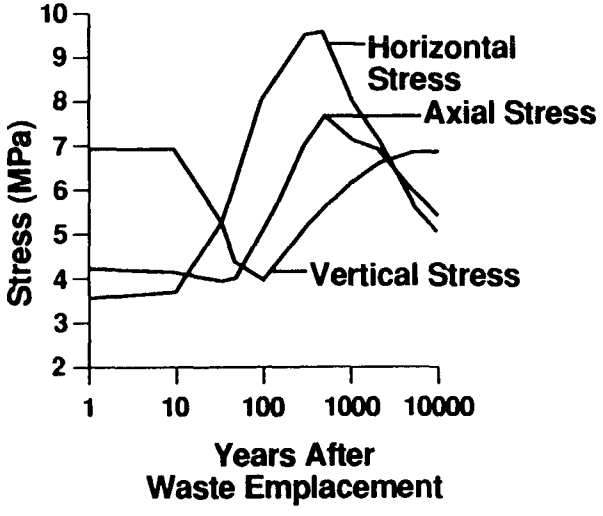
# Thermomechanical Environment

## Temperature and Stress History
(57 kw/acre base case SCP-CDR)

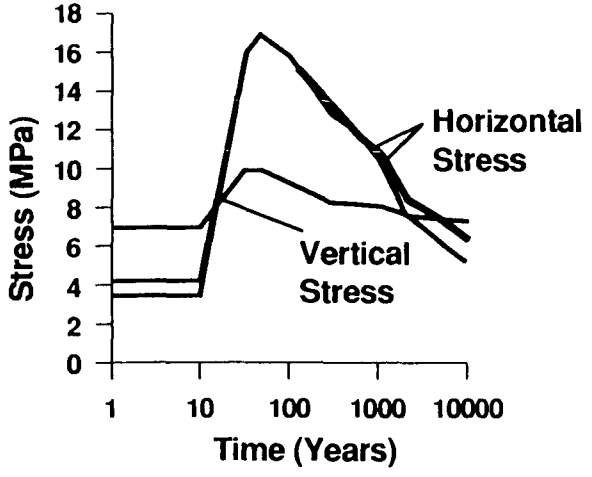
Emplacement Drift




Tuff Main Drift




Emplacement Drift

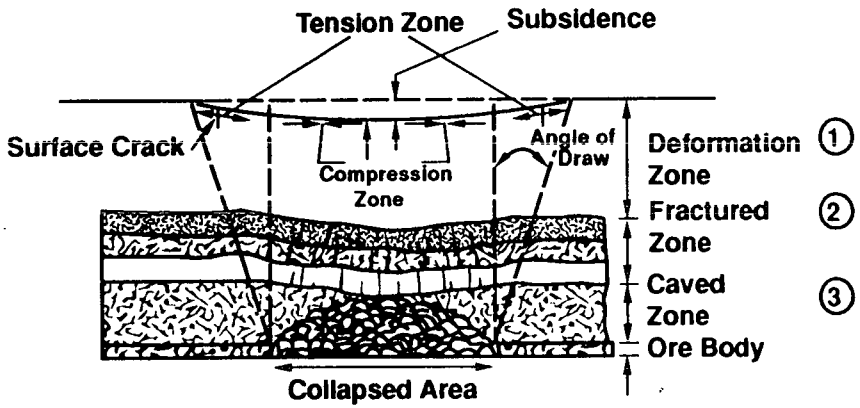


# Mechanisms Impacting Backfill Requirements

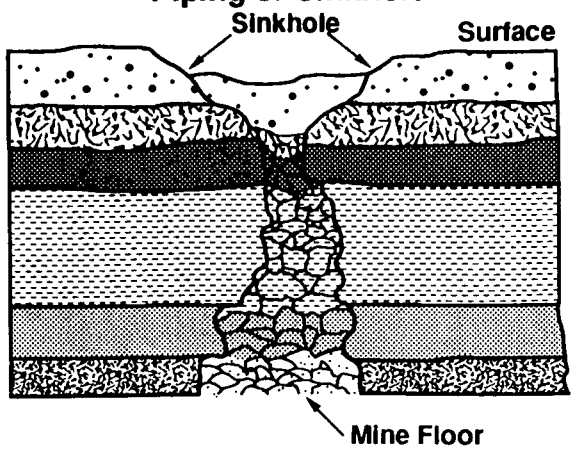
## I. Subsidence

### Mechanisms

### Subsidence in Longwall Coal Mining




### Piping or Sinkhole




### Comment

Unlikely because of wide spaced rooms, large pillars,and depth

### Comment

Unlikely to progress significant vertical distance because of small openings.

Backfill will greatly reduce risk of this type of subsidence

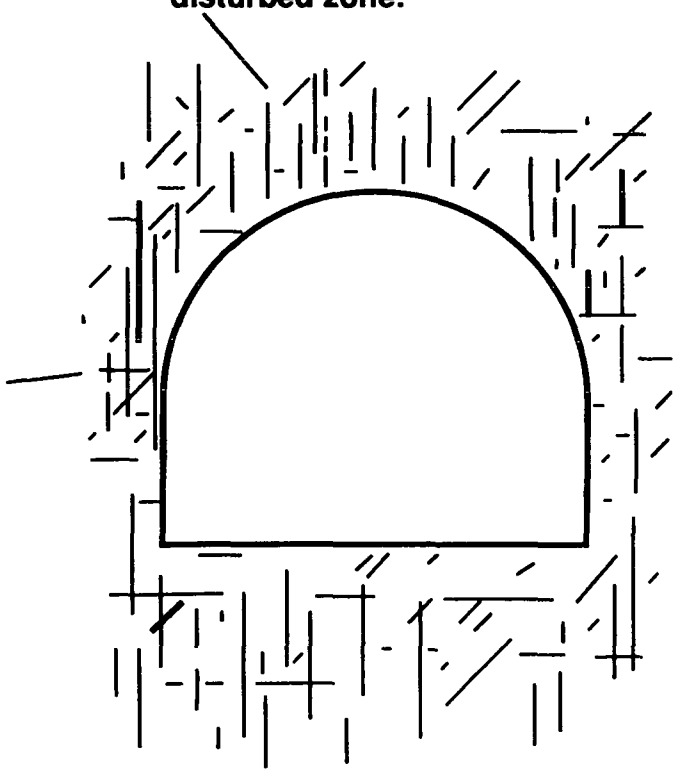
# Mechanisms Impacting Backfill Requirements

**II Disturbed Zone**

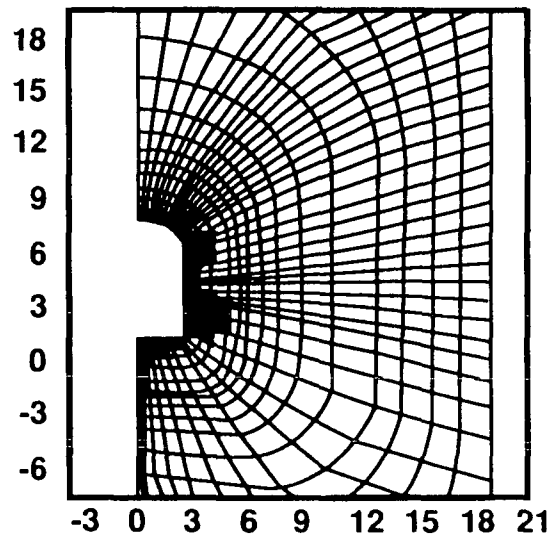
**Comment**

**Unstable to seismic loads, permeability changes.**

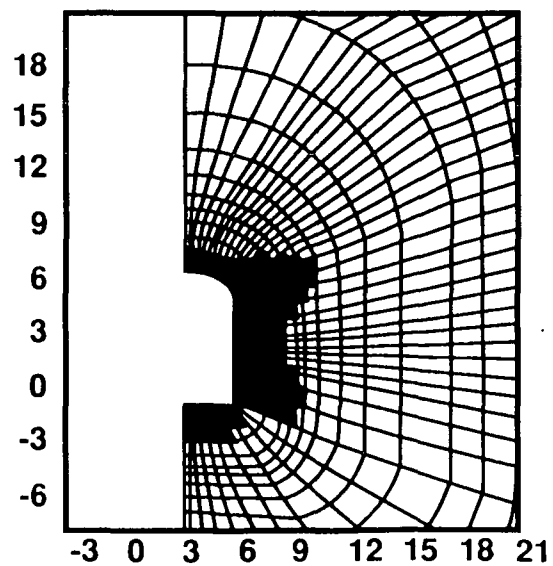
**Backfill can limit growth of disturbed zone.**



**Yield Zone Around Emplacement Drift**




a) at 100 years with design strength of the rock mass

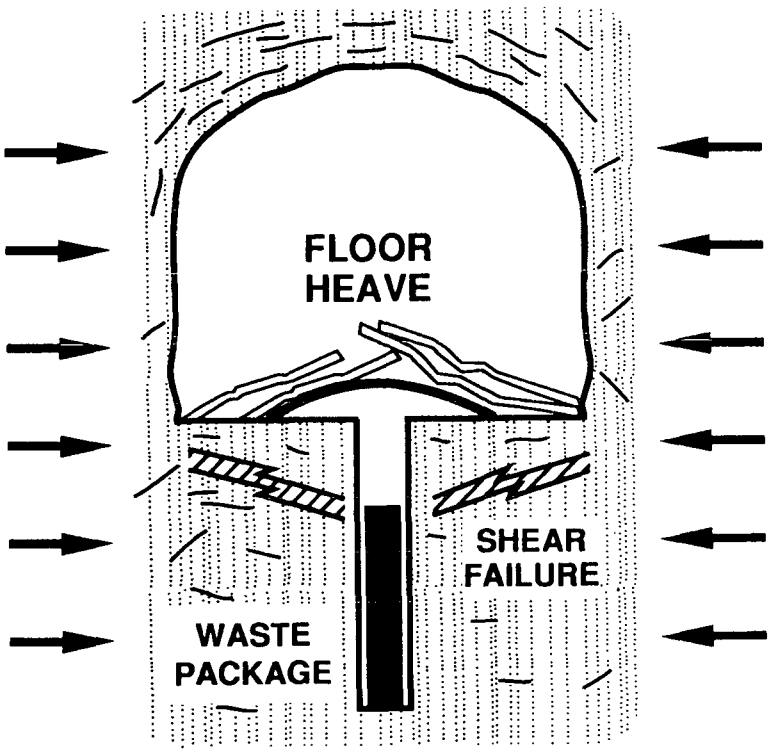



b) at later time when cohesion of the rock mass is reduced to zero

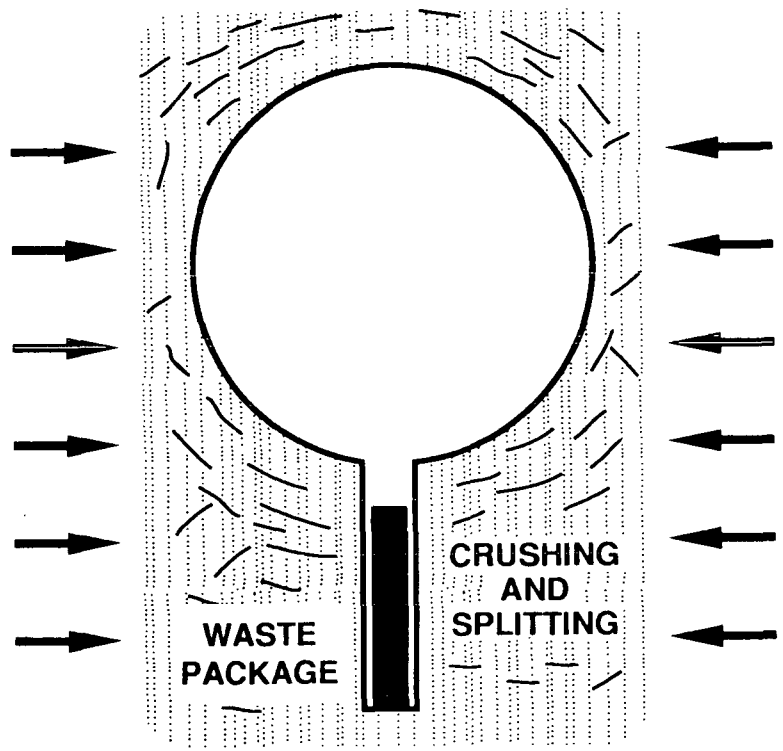
# Mechanisms Impacting Backfill Requirements

## III. Waste Package Loading

### SCP-CDR Drift




### Bored Drift




### Comments

- High stress concentration around drift floor
- Added stress concentration around borehole

- Potential damage from floor heave
  - Borehole collapse
  - Shearing in floor
- Stiff backfill could restrain floor heave

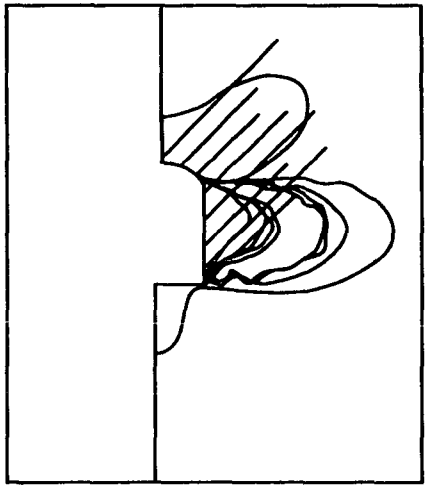
# Mechanisms Impacting Backfill Requirements

## IV Fault/Joint Slip

### Concern

Performance goals to limit slip along faults/joints.

Triggering seismic events along faults/joints in repository area.

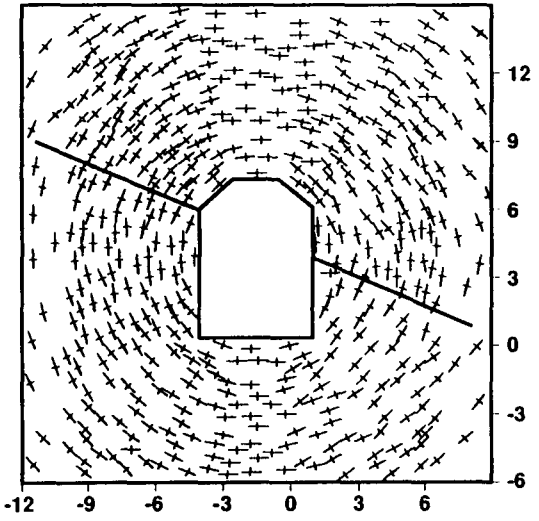


a) Zone where inclined joints likely to slip

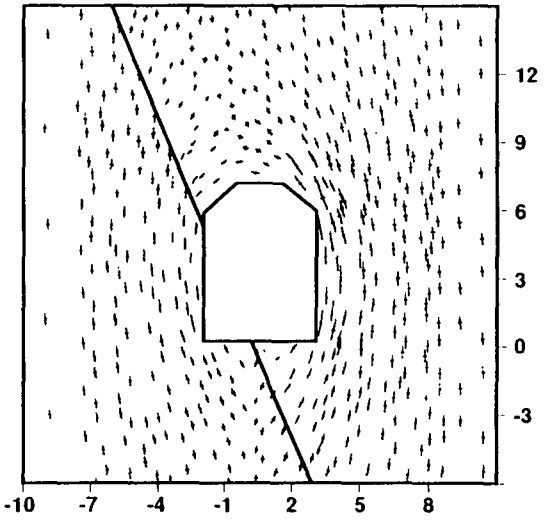
### Comment

Drift acts as stress raiser along joint.

Backfill could limit stress concentration effect, limit deformation.




b) Extent of fault slip-thermal loads




c) Extent of fault slip-in situ minus seismic loads

# Backfill Operational Constraints

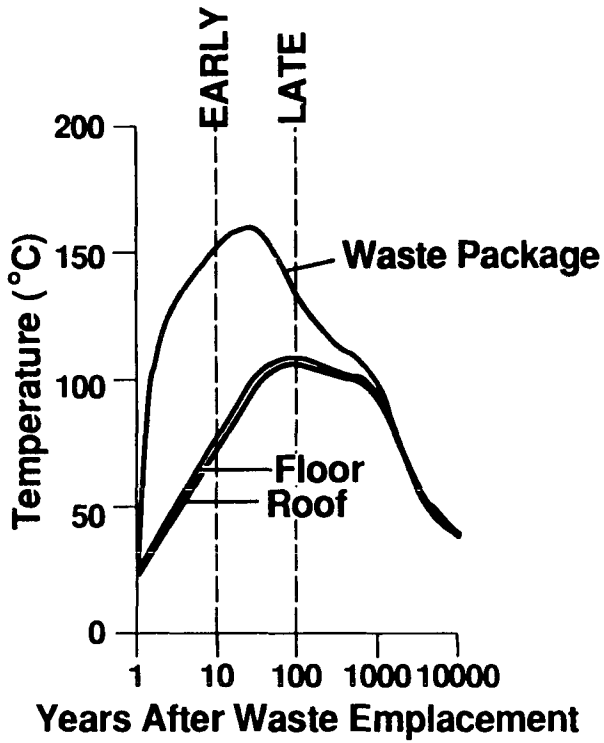
- Compatibility of hydrological and mechanical requirements
  - High modulus and high permeability may be difficult to achieve
- Placement timing
  - When to emplace backfill (see next slide)
- Temperature
  - Ventilation of drifts during backfilling
- Interaction with ground support system
  - Is removal of ground support system required?
- Material used for backfill/seals
  - Thermal and geochemistry

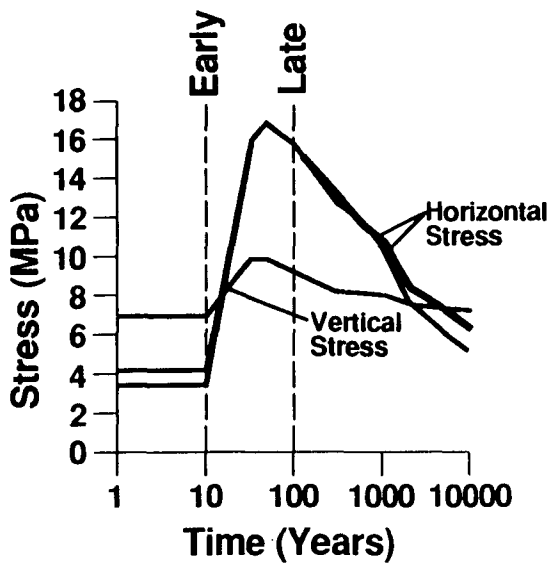
# Backfill Operational Constraints *continued . . .*

- **Emplacement techniques in confined space**
  - Ability to meet mechanical-strength deformability requirements

- **Backfill placement timing**
  - Responding to unfavorable conditions-abandonment of:
    a) An exploratory drift
    b) Drift /panel in unfavorable conditions

  - Routine backfilling-options available:
    a) Early: Backfill emplacement drifts as soon after emplacement as possible (Calico Hills exploratory drifting)
    b) Late: All backfilling after retrievability period, i.e., at closure
    c) Combination of the above




# Backfill Operational Constraints *continued ...*

Routine Backfill Timing Options

## COMMENT

### Early Backfilling

Most deformation and temperature increase occurs in the first 50-75 years after emplacement.

Requires less ground support.

Requires less maintenance during retrieval period.

Requires no cool down prior to emplacement.

Would require removal prior to waste retrieval.

May require backfilling around instrumentation.

### Late Backfilling

50 to 100 years after first emplacement requires cool down, maintenance, etc., no instrumentation.