# U. S. Department of Energy
# Office of Civilian Radioactive Waste Management

# Engineered Barrier System

Hugh A. Benton
Manager, Waste Package/EBS Development
M&O/B&W Fuel Company
Las Vegas, Nevada

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# Outline

- EBS Development Program
- Design Options
- Technical Approach
- Current Activities

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- **EBS Development Program**
- **Design Options**
- **Technical Approach**
- **Current Activities**

# Engineered Barrier System

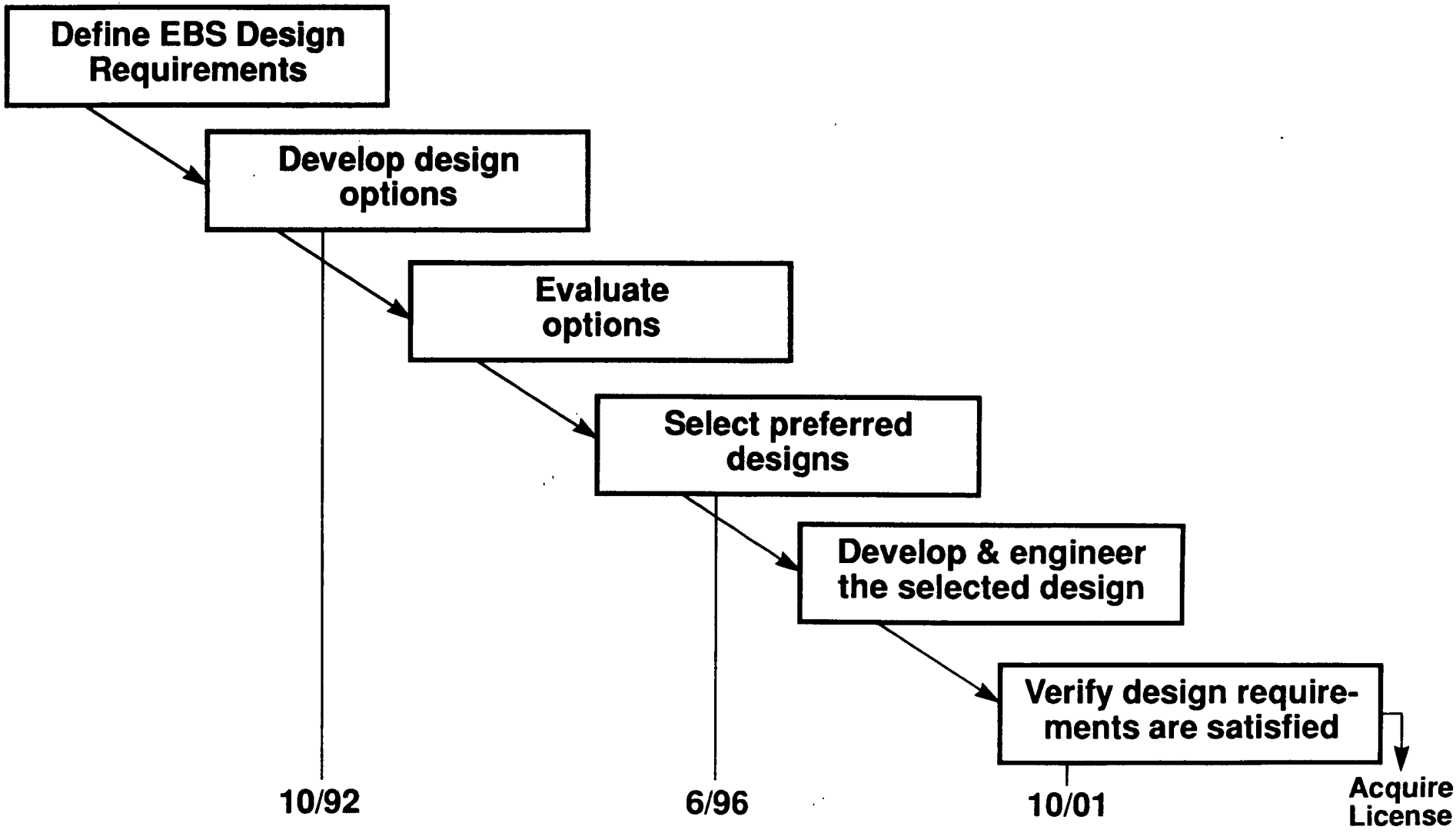
- **Waste forms**
  - Spent fuel
  - High-level waste glass
- **Canisters**
- **Basket and containers**
- **Fillers and packing**
- **Air gaps (if in boreholes)**
- **Other material surrounding waste packages**
- **Backfill**
- **Near-field environment**

# Engineered Barrier System Goal

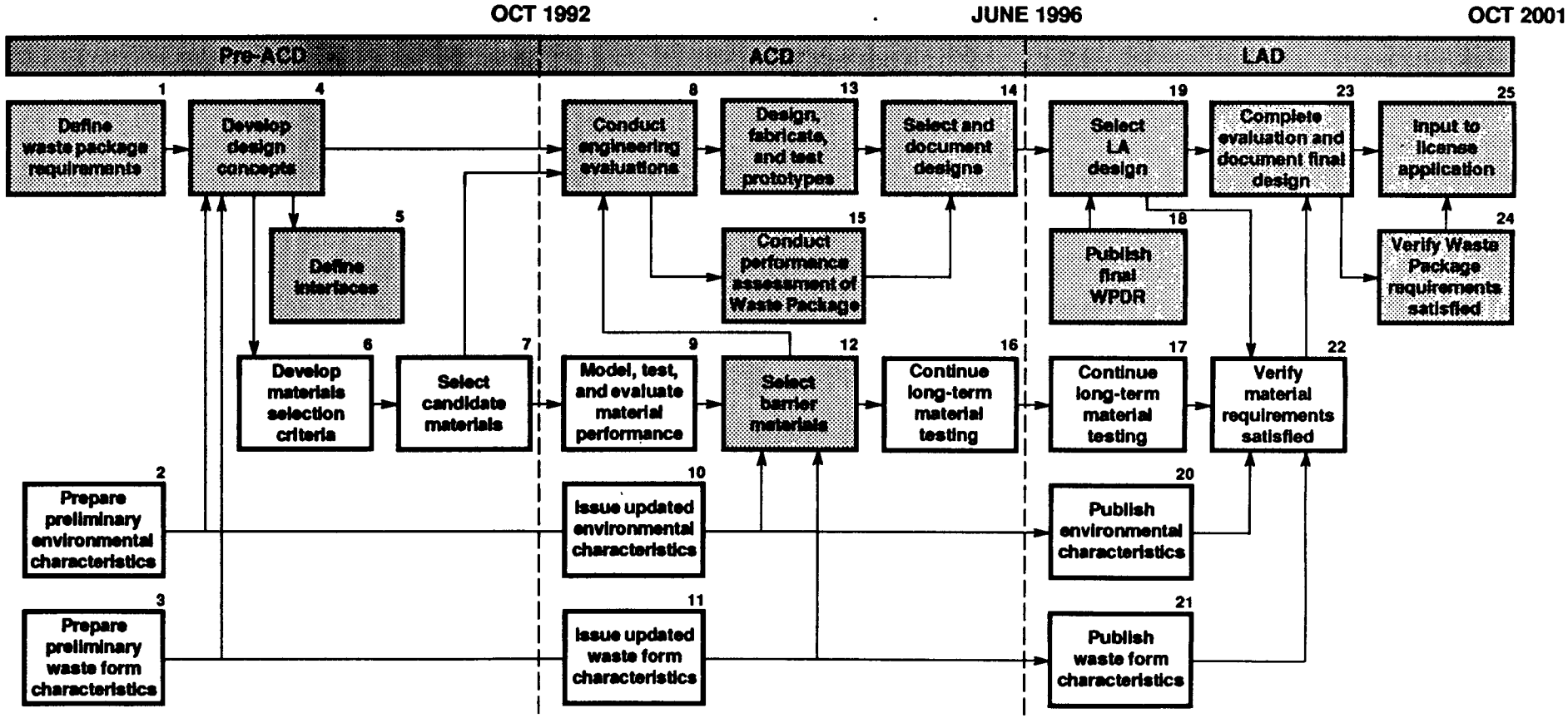
**Achieve a design that**

- **Can be licensed**
- **Can be shown to meet regulatory requirements with sufficient margin for uncertainty of performance predictability**
- **Is compatible with rest of waste management system**
- **Can be deployed at acceptable cost**

# A Systems Engineering Approach will be Used



# Flow Diagram of Waste Package Program



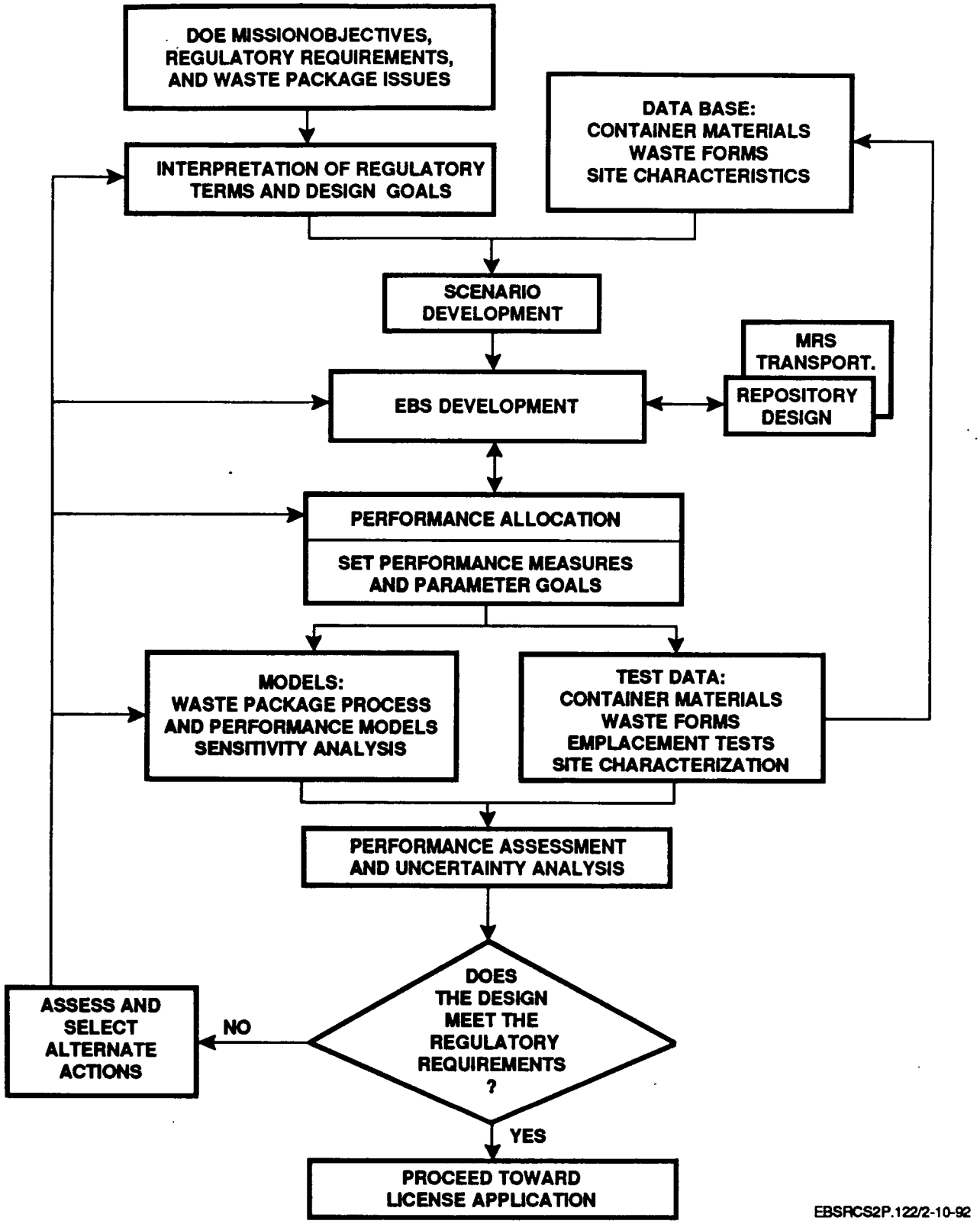

**Shaded activities performed by M&O**

WPPFLOW.125.NWTRB/6-25-92

# EBS Regulatory Compliance Process

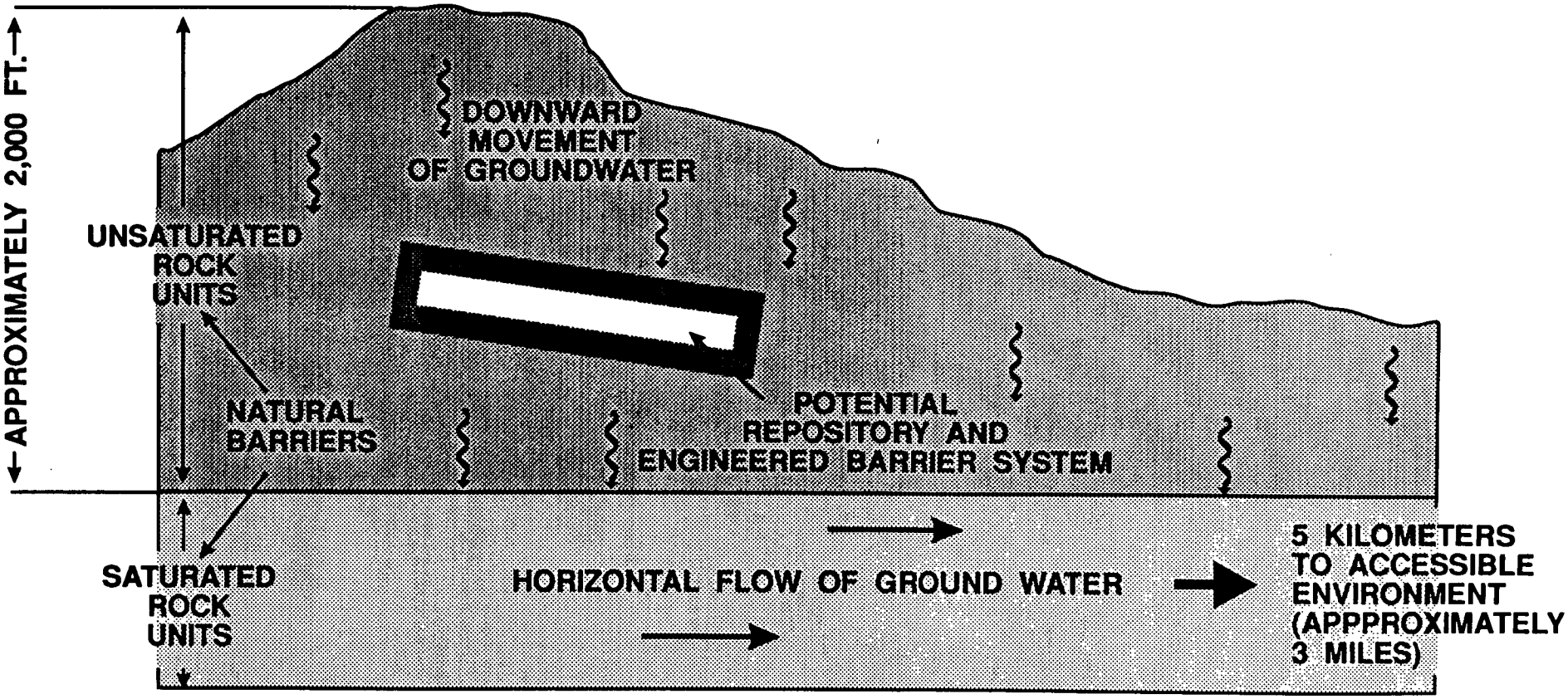







EBSRCS2P.122/2-10-92

# Schematic Representation of Potential Repository at Yucca Mountain that Isolates Radioactive Materials by Using Natural and Engineered Barriers



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# Engineered Barrier System Design Options

- **Starting with SCP design**
  - Thin-wall stainless steel container
  - Contains 3.4 tons spent fuel or HLW glass in container
  - In vertical borehole
  - 40,000 to 50,000 containers

- **Evaluating longer-lived waste package alternatives**
  - Larger, thicker-wall container
  - Includes corrosion-resistant and corrosion-allowance materials
  - Contains up to 15 tons spent fuel
  - In drift
  - As few as 11,000 containers total

# Range of Alternatives to be Considered During ACD

- Accommodate thermal loading from below boiling to above boiling for >> 1000 years
- Include drift and borehole emplacement options
- Provide radiation shielding for each container or on transporter
- Include sizes and weights up to operational limits
- Permit loading of like spent fuel assemblies (no blending)
- Allow for long-term monitoring, selective retrieval and relocation

# Range of Alternatives to be Considered During ACD

(Continued)

- Accommodate future system-wide decisions
  - Universal or dual purpose casks
  - Multiple element sealed canisters
- Accommodate consolidated and unconsolidated spent fuel
- Accommodate high-level waste glass canisters
- Use proven, reliable technology
- Considering designs that could last substantially beyond 1000 years

# Materials Evaluations

- **Alloys that have been studied**
  - **Austenitic stainless steel**
  - **Austenitic nickel-based alloy**
  - **High-purity copper**
  - **Copper-nickel alloy**
  - **Aluminum bronze**
  - **Nickel-based alloy**
  - **Titanium alloy**

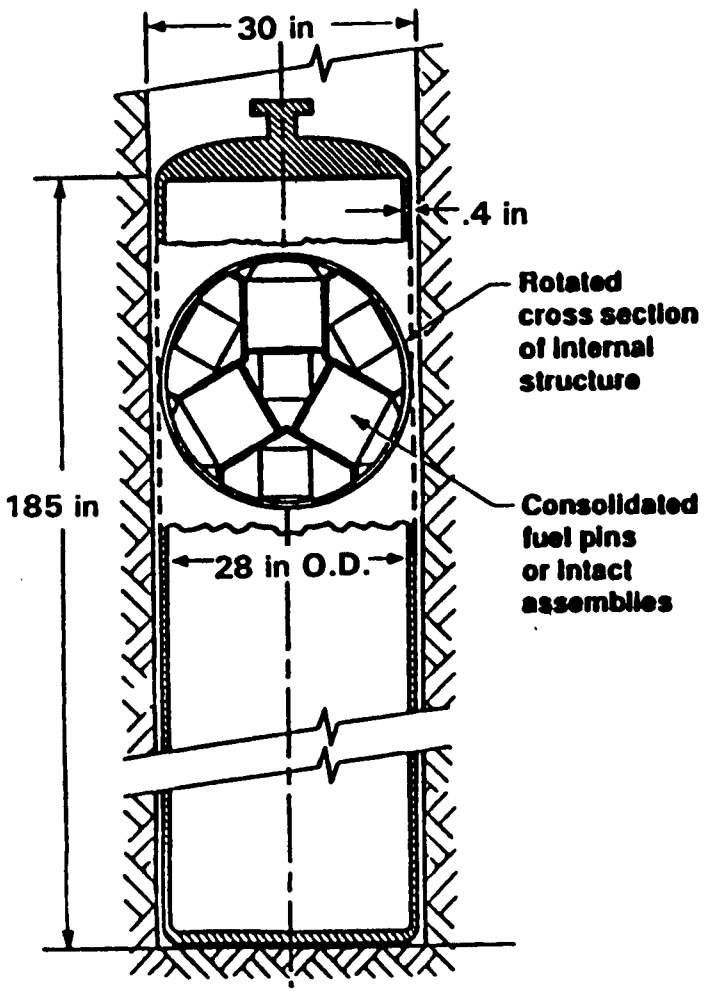
# Materials Evaluations

(Continued)

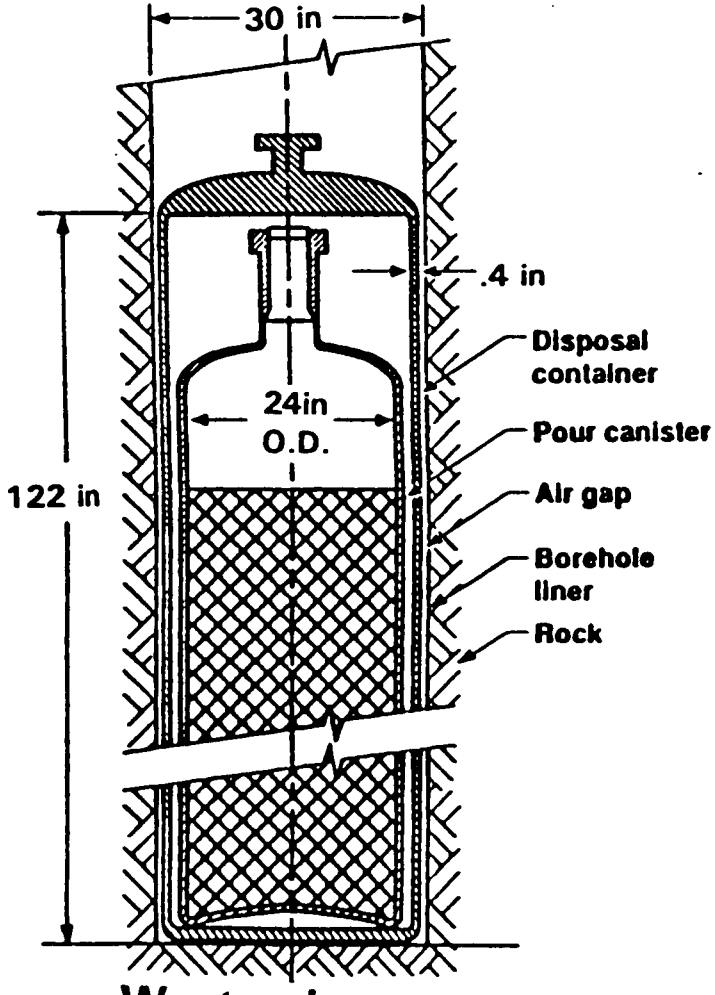
- **Lawrence Livermore National Lab used selection criteria to rank material alloys with highest scores**
  - **Titanium grade 12**
  - **Nickel-based alloy C-4**
  - **Austenitic Incoloy 825**

**Ref. R.D. McCright et al; "Candidate Container Materials for Yucca Mountain Waste Package Design," Proceedings FOCUS '91, Nuclear Waste Packaging, Oct. 1991, Las Vegas, NV, pp125-135.**

# SCP Waste Package Designs



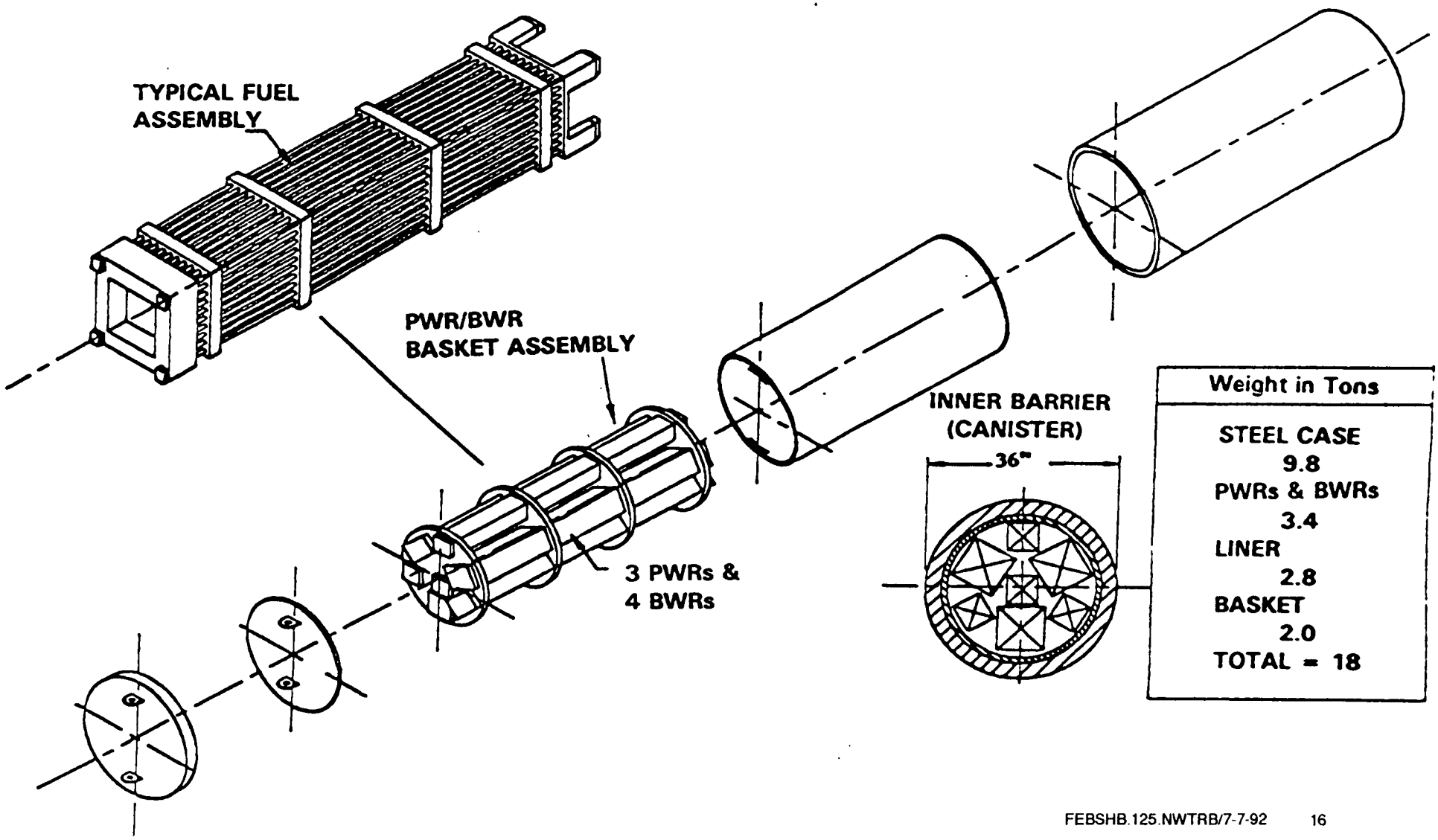

Spent fuel containers



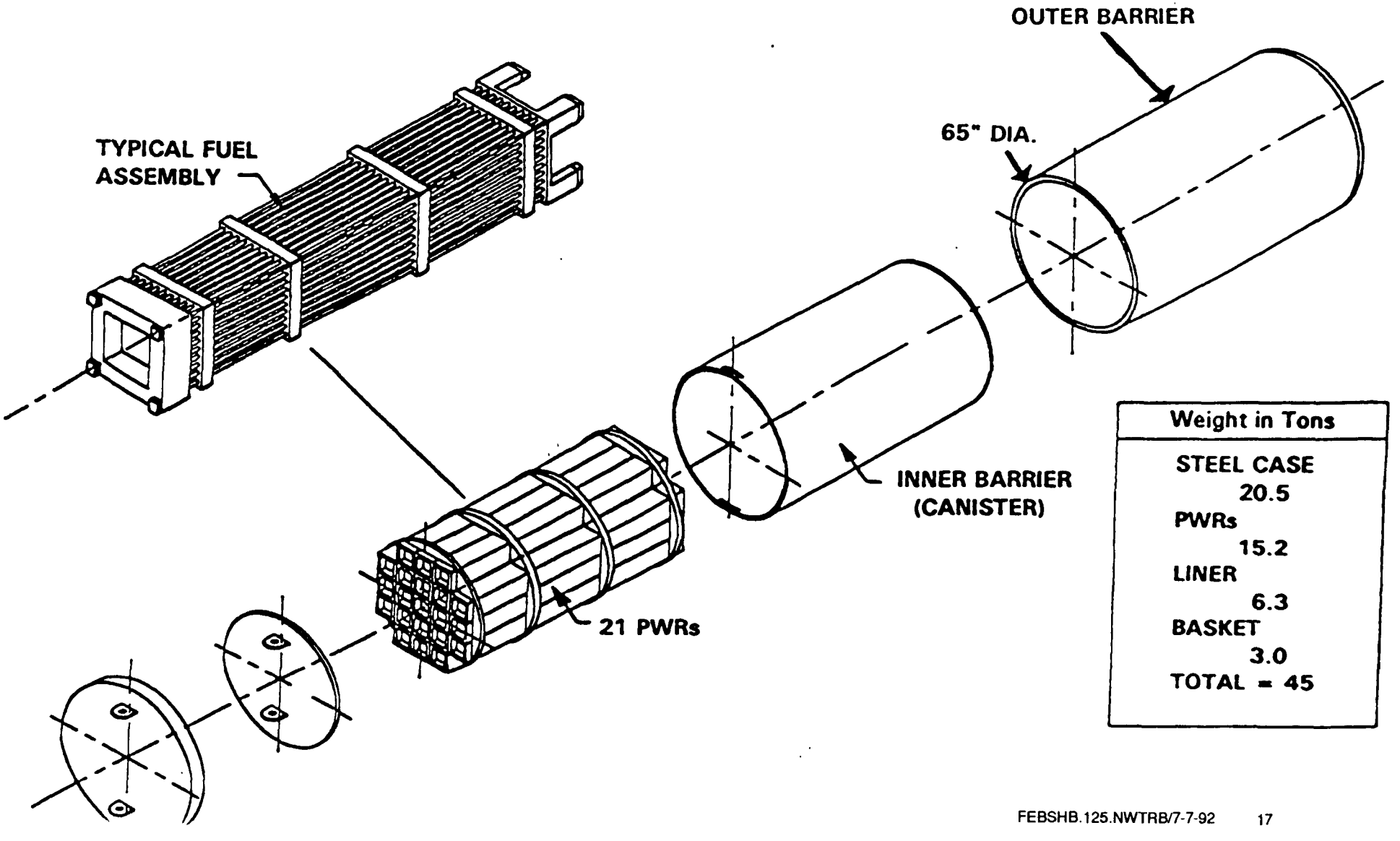

Waste glass containers

# Robust Waste Package

## SCP-CDR Hybrid Design with Overpack



# Robust Waste Package
## 21 PWR or 52 BWR Assemblies

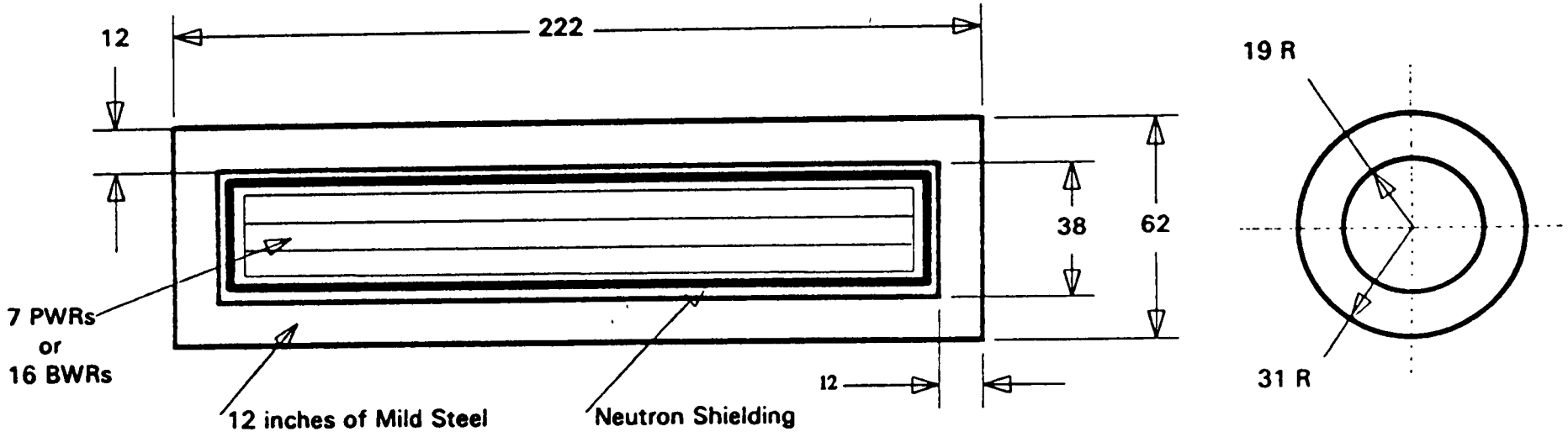



| Weight in Tons | |
|---|---|
| STEEL CASE | 20.5 |
| PWRs | 15.2 |
| LINER | 6.3 |
| BASKET | 3.0 |
| TOTAL = | 45 |

# Self Shielded Waste Package

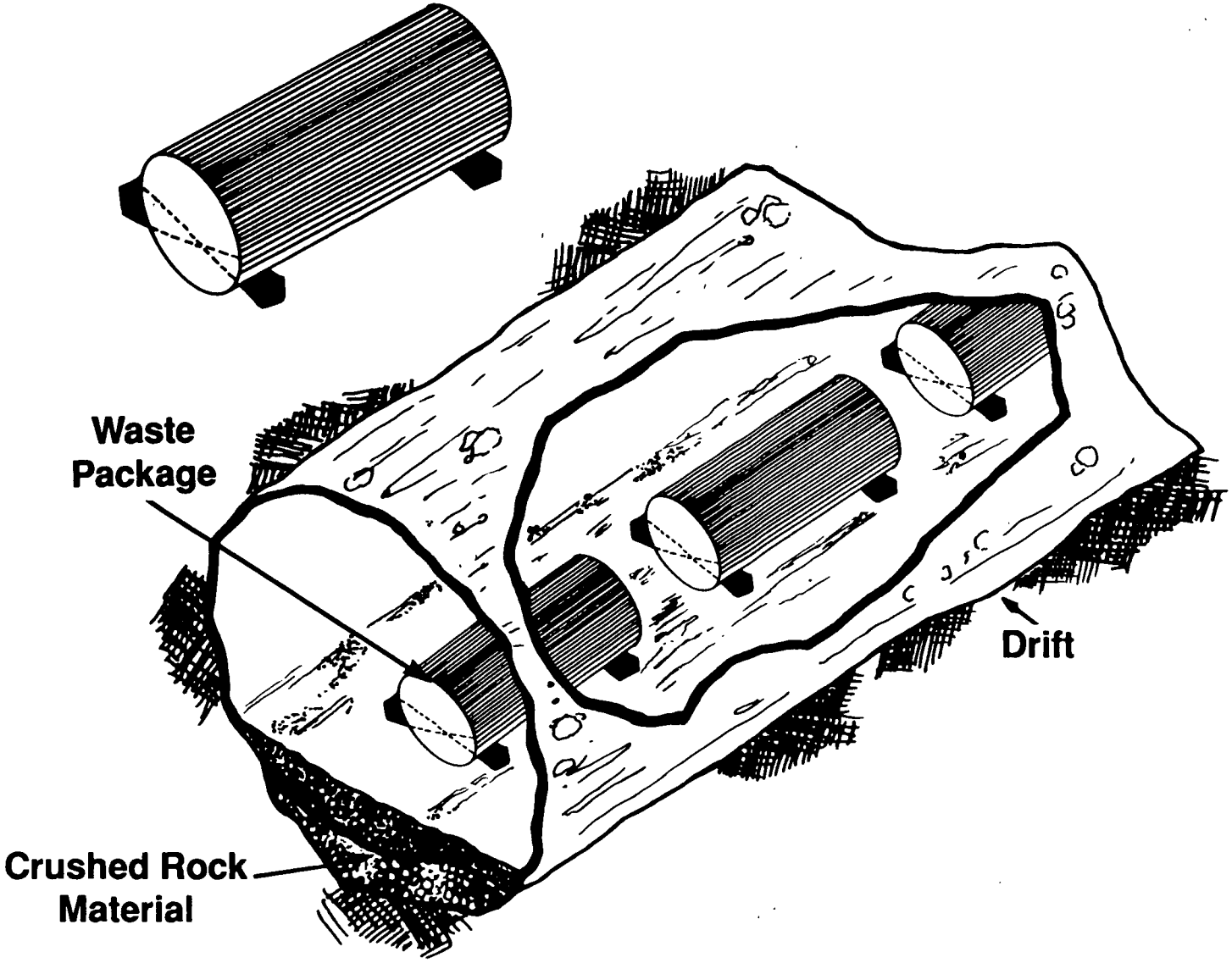
## 7 PWrs or 16 BWRs Assemblies

## Total Weight 80 Tons




(Dimensions in Inches)

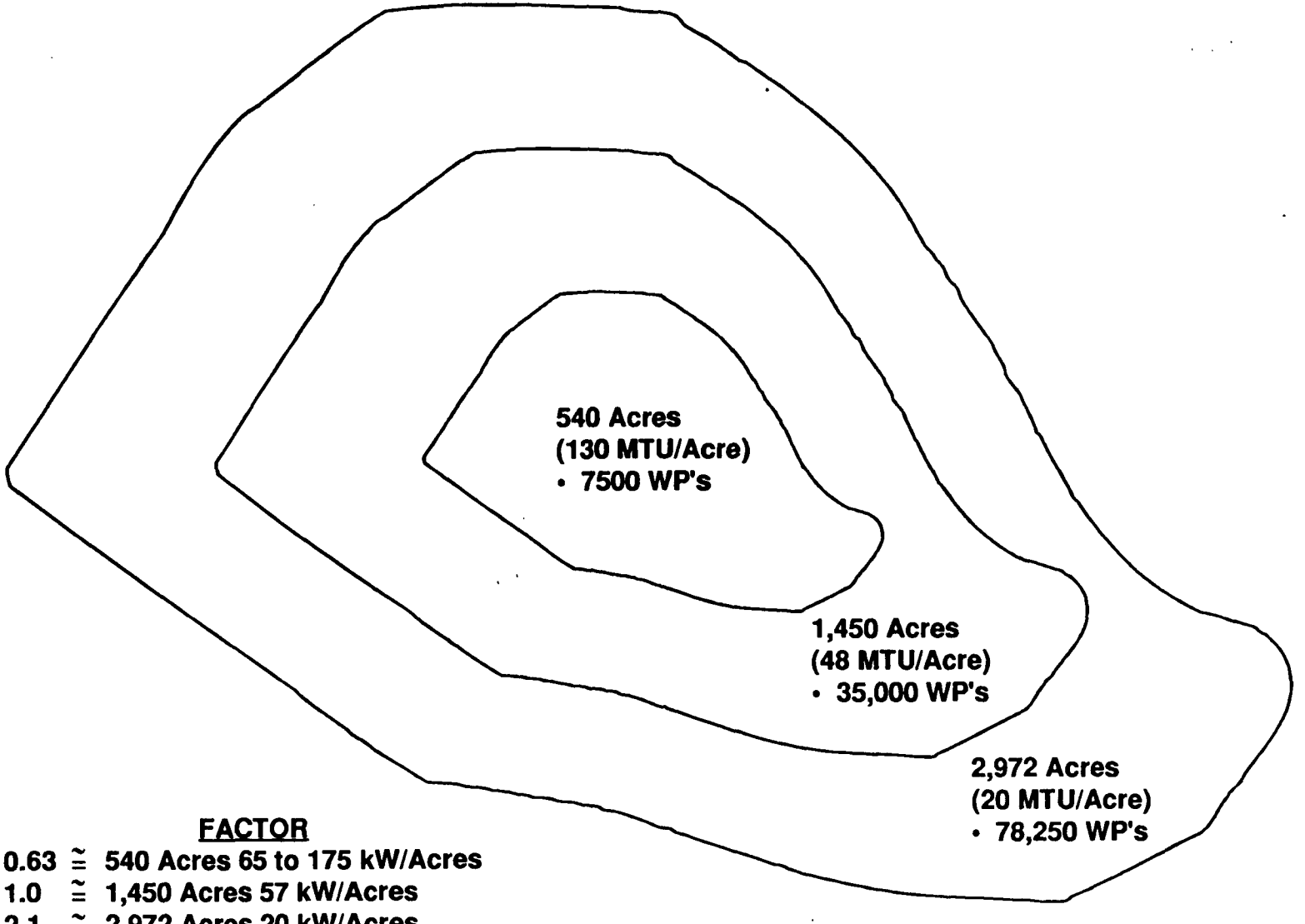
# Drift Emplacement



# Drift Emplacement Alternative

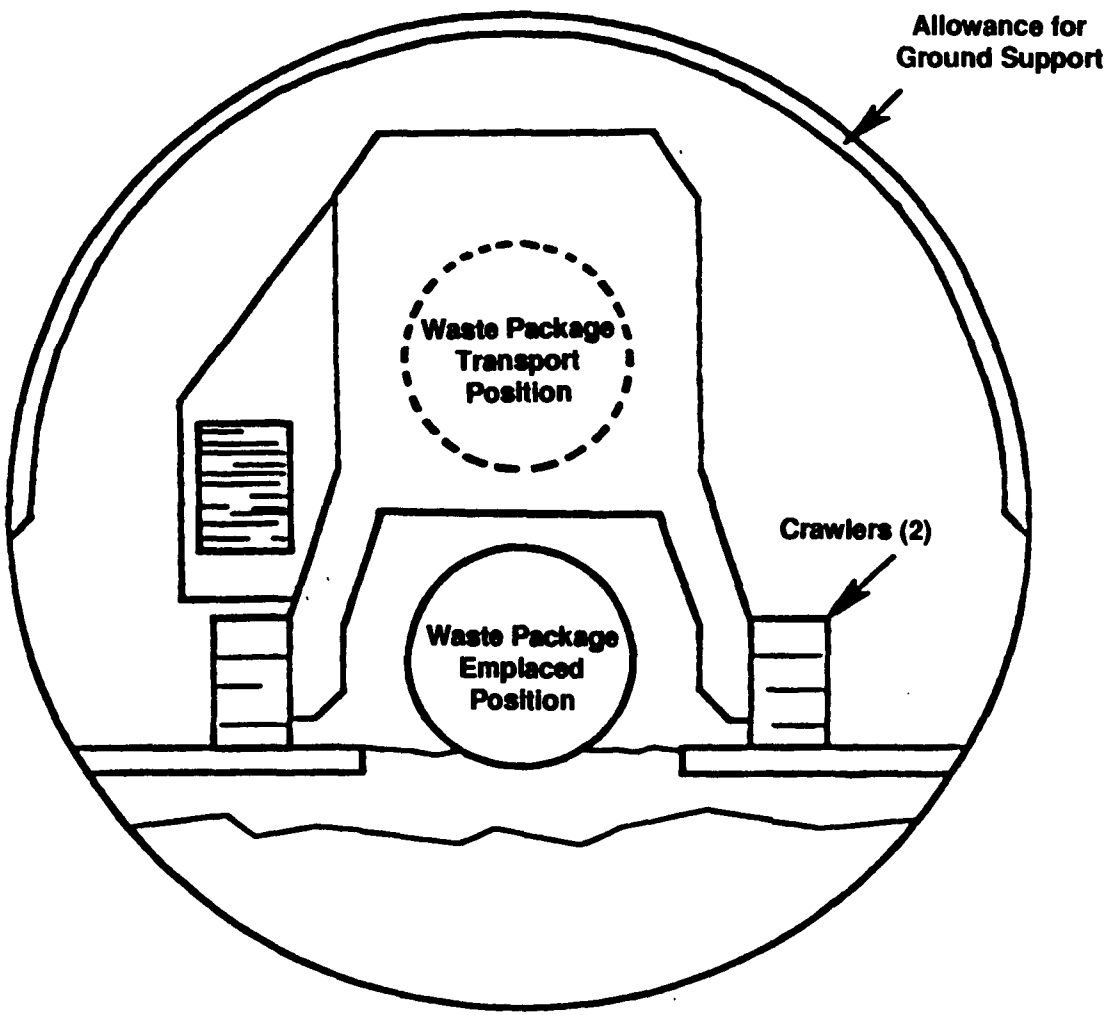
- Improves heat dissipation
- Permits management of thermal loading to increase time waste package will stay dry
- Accommodates larger and heavier waste packages holding more assemblies than SCP design
- Permits easier retrieval
- Should reduce potential for damage from seismic events due to greater freedom of movement
- Robotics will be required unless waste packages are shielded

# Thermal Load Effects on Size of Potential Yucca Mountain Repository




| FACTOR | | |
|---|---|---|
| 0.63 | ≅ | 540 Acres 65 to 175 kW/Acres |
| 1.0 | ≅ | 1,450 Acres 57 kW/Acres |
| 2.1 | ≅ | 2,972 Acres 20 kW/Acres |

# Waste Package Transporter/Emplacement Unit



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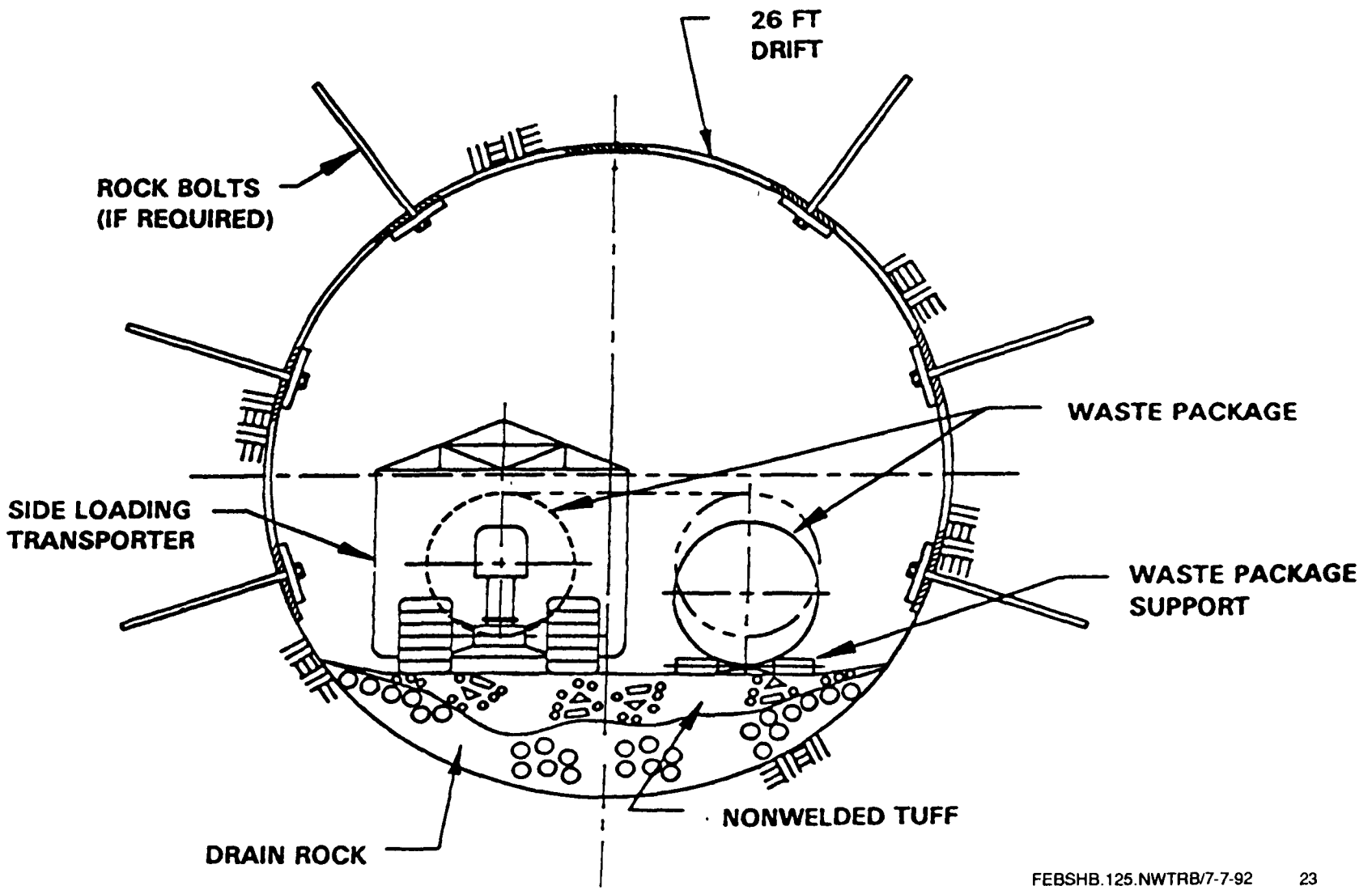

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# Technical Approach for Waste Package Development

| Function of Component | Performance Measure | Degradation Mode | Performance Parameter |
|---|---|---|---|
| • Contain Radionuclides | • Fraction of containers breached | • Metallurgical instability (incl. weld & heat-affected zone) | • Phase transformations |
| | | • Low-temperature oxidation | • Oxidation |
| | | • General aqueous corrosion | • General corrosion rates |
| | | • Microbiologically influenced corrosion (MIC) | • MIC rates |
| | | • Pitting corrosion | • Ecrit for pitting<br>• Eprot for pitting<br>• Ecorr (open circuit)<br>• Pit penetration rates |
| | | • Environmentally assisted cracking | • Crack propagation rates<br>• Threshold stress intensity factors |
| • Limit radionuclide egress after container breach | • Release rate of radionuclides from containers | • Diffusion through corrosion products | • Diffusion coefficients of RNs in corrosion products |
| | | • Transport through cracks | • Diffusion coefficients of RNs in groundwater<br>• Crack geometry |

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# Near-Term Waste Package/EBS Design Activities

- Evaluate and select candidate design concepts for ACD based on preliminary analysis of
  - Containment capability
  - Radionuclide release performance
  - Thermal performance
  - Subcriticality margin
  - Handling and emplacement
  - Retrievability
  - Fabricability and structural integrity
  - Worker exposure
- Initiate detailed evaluation of selected concepts as part of ACD

# Near-Term Container Materials Activities

- Perform degradation mode survey of iron-based corrosion allowance material
- Identify gaps in information for iron-based materials and perform scoping tests
- Restart degradation model development effort
- Identify parametric testing program needed to support model development and initiate testing
- Develop long-term materials test matrix and plan and initiate testing
- Start program to investigate non-metallic materials

# Planning Activities

- **Revise Waste Package Plan**
  - **Including alternates to SCP**
  - **Updating and modifying**
- **Preparing Waste Package Implementation Plan**
- **Start ACD October 1, 1992**