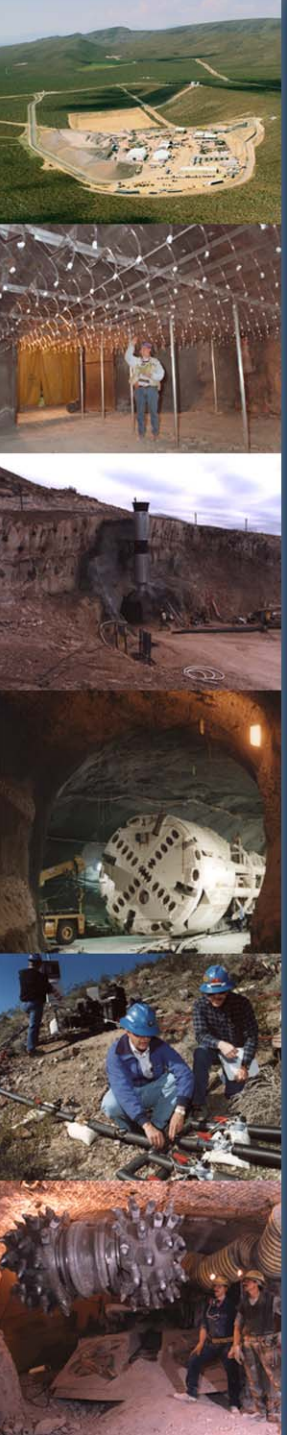


Post Closure Safety Case

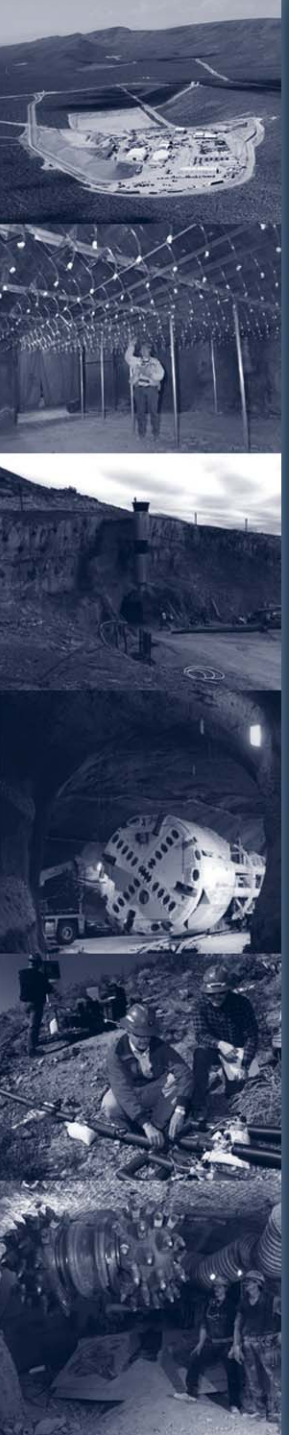
Presented to:
Nuclear Waste Technical Review Board

Presented by:
Jack N. Bailey
Director
Regulatory & Licensing
Management and Operating Contractor

June 24, 1998

License Application Plan

- Progressively improving understanding of the repository system
  - Natural features
  - Engineered features
  - System performance
- VA develops and assesses
  - Natural features
  - Reference design
  - Design options



License Application Plan

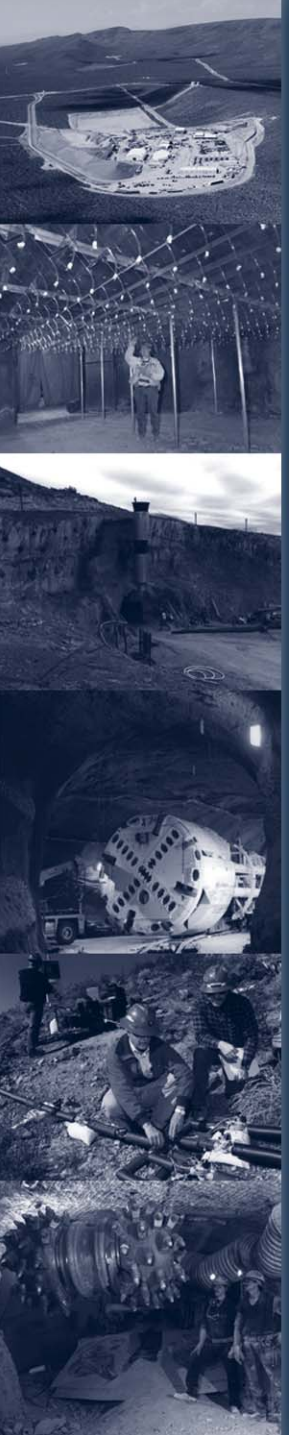
LA Plan Focuses on

- Understanding of the reference design and options
  - Identification and importance of critical elements to overall performance
  - Uncertainties associated with critical elements
  - Consideration of design alternatives and additional design features

License Application Plan
(continued)

- Potential licensing strategies
  - Defense in depth
  - Margin
  - Detail necessary to docket the license application
- Process to select a Licensing Case
  - Understanding of the system
  - Licensing strategies

Performance Allocation Process



Attributes

-
-
-

Hypothesis Testing

-
-
-

Principal Factors

Reference Design

- 19 Principal Factors

Reference Design & Options

- Drip shield
- Ceramic coating
- Backfill
- 21 Principal Factors

- Evaluate Principal Factors

  – Importance to Performance
  – Current Quality of Understanding
  – Projected Quality of understanding

  +

- Consider
  – Performance Margin
  – Defense-in-Depth
    - Redundancy
    - Diversity

- Design Alternatives
  – Low thermal load
  – WP emplacement mode
- Features
  –
  –

Identify Sets Of Principal Factors for Combinations of Design Alternatives & Features

SR/LA Design

Postclosure Safety Case

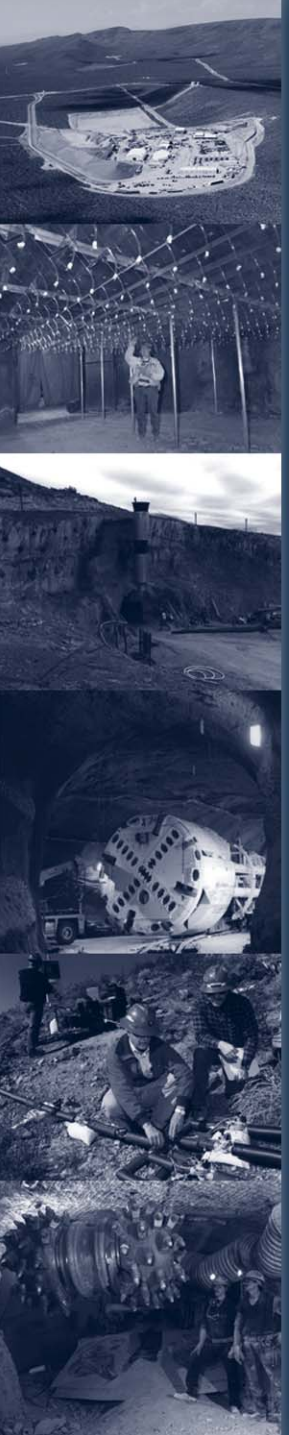
- Focus on elements needed to provide reasonable assurance that public health and safety will be protected
  - Comprehensive understanding of the natural and engineered features of the system
  - Incorporation of design margin and defense in depth to mitigate uncertainties
  - Explicit consideration of disruptive processes and events
  - Supporting information from natural and manmade analogues
  - A performance confirmation plan

Comprehensive Understanding of the Natural and Engineered Features of the System

- Majority of radionuclides in the repository not mobile in Yucca Mountain Environment
  - Insoluble/Sorb strongly
- Remainder could be transported by water movement
- Natural features are favorable for limiting water movement
- Site provides predictable and stable environment for engineering features to further limit water movement

Performance Allocation

- Understand the required performance of the system
- Identify those factors that affect the performance of the system
- Determine Importance of the principal factors with regard to overall system performance
- Determine the current confidence in the understanding and modeling of the principal factors
- Determine the potential confidence in the understanding and modeling of the principal factors
- Determine the performance allocation for LA
- Determine the priority for technical work before LA



Performance Allocation

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance
Limited water contacting waste packages	Precipitation and infiltration into the mountain	M
	Percolation to depth	M
	Seepage into drifts	H
	Effects of heat and excavation on flow	M
	Dripping onto waste package	M
	Humidity and temperature at waste package	M
	Water diversion by drip shield + backfill	H
Long waste package lifetime	Chemistry of water on waste package	M
	Integrity of outer carbon steel waste package barrier	M
	Integrity of inner corrosion-resistant waste package barrier	H
	Ceramic waste package coating	H
Low rate of release of radionuclides from breached waste packages	Seepage into waste package	M
	Integrity of spent fuel cladding	H
	Dissolution of uranium oxide and glass waste forms	M
	Neptunium solubility	M
	Formation of radionuclide-bearing colloids	M
	Transport through and out of waste package	M
Radionuclide concentration reduction during transport from the waste packages	Transport through unsaturated zone	M
	Flow and transport in saturated zone	M
	Dilution from pumping	M
	Biosphere dilution	M

Performance Allocation

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	Potential confidence by LA	Performance allocation (confidence goal for LA)	Current Confidence	Priority For Technical Work Before LA
Limited water contacting waste packages	Precipitation and infiltration into the mountain	M				
	Percolation to depth	M				
	Seepage into drifts	H				
	Effects of heat and excavation on flow	M				
	Dripping onto waste package	M				
	Humidity and temperature at waste package	M				
	Water diversion by drip shield + backfill	H				
Long waste package lifetime	Chemistry of water on waste package	M				
	Integrity of outer carbon steel waste package barrier	M				
	Integrity of inner corrosion-resistant waste package barrier	H				
	Ceramic waste package coating	H				
Low rate of release of radionuclides from breached waste packages	Seepage into waste package	M				
	Integrity of spent fuel cladding	H				
	Dissolution of uranium oxide and glass waste forms	M				
	Neptunium solubility	M				
	Formation of radionuclide-bearing colloids	M				
	Transport through and out of waste package	M				
Radionuclide concentration reduction during transport from the waste packages	Transport through unsaturated zone	M				
	Flow and transport in saturated zone	M				
	Dilution from pumping	M				
	Biosphere dilution	M				

Performance Allocation Development

(continued)

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	**Potential Confidence by LA**	Performance Allocation (Confidence Goal for LA)	**Current Confidence**	**Priority For Technical Work Before LA**
Limited water contacting waste packages	**Precipitation and infiltration into the mountain**	**M**	**M**	**M**	**M**	**L**
	Percolation to depth	M	M	M	M	L
	Seepage into drifts	**H**	**M**	**M**	**M**	**L**
	Effects of heat and excavation on flow	M	M	M	L	M
	Dripping onto waste package	M	M	M	M	L
	Humidity and temperature at waste package	M	H	M	H	L

Priority for Technical Work

- Low Priority

Current Confidence

- In situ measurements have contributed to understanding
- Models consider variations in percolation flux and rock properties
- Moderate current understanding

Potential Confidence

- No significant improvement can be gained

Performance Allocation

- Moderate importance to postclosure performance

Performance Allocation Development

(continued)

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	**Potential Confidence by LA**	Performance Allocation (Confidence Goal for LA)	**Current Confidence**	**Priority For Technical Work Before LA**
Limited water contacting waste packages	**Precipitation and infiltration into the mountain**	**M**	**M**	**M**	**M**	**L**
	Percolation to depth	M	M	M	M	L
	Seepage into drifts	H	M	M	M	L
	Effects of heat and excavation on flow	M	M	M	L	M
	Dripping onto waste package	M	M	M	M	L
	Humidity and temperature at waste package	M	H	M	H	L
	Water diversion by drip shield & backfill	**H**	**H**	**H**	**M**	**H**

Priority for Future Work

- **High Priority**

Current Confidence

- Good information on longevity of ceramics and tuff gravels
- Limited information on flow through backfill
- Feasibility of construction needs improvement
- Moderate current confidence

Potential Confidence

- Testing on flow in backfill will improve modeling
- Proof of principles can be demonstrated as prototype
- High projected confidence

Performance Allocation

- High importance to postclosure performance

Performance Allocation Development

(continued)

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	Potential Confidence by LA	Performance Allocation (Confidence Goal for LA)	Current Confidence	Priority For Technical Work Before LA
Long waste package lifetime	**Chemistry of water on waste package**	**M**	**M**	**M**	**M**	**L**
	Integrity of outer carbon steel waste package barrier	M	H	M	H	L
	Integrity of inner corrosion-resistant waste package barrier	**H**	**H**	**H**	**M**	**H**
	Ceramic waste package coating	H	H	H	M	H

Priority for Future Work

- **High Priority**

Current Confidence

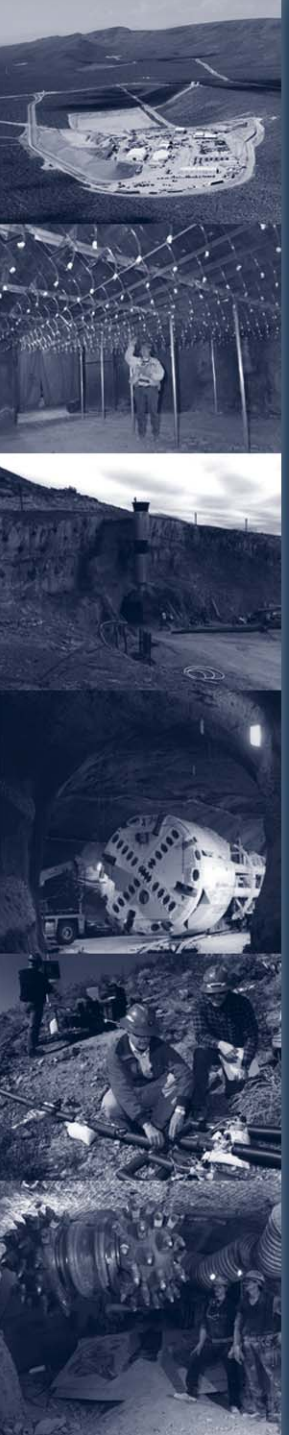
- Limited experience and testing of C-22
- Considered large number of effects
  - dry conditions
  - stress corrosion cracking
  - microbiological effect
  - radiation
  - wetting vs. humid air
- Moderate current confidence

Potential Confidence

- Testing can improve confidence in corrosion rates
- High projected confidence

Performance Allocation

- High importance to postclosure performance



Performance Allocation Development

(continued)

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	Potential Confidence by LA	Performance Allocation (Confidence Goal for LA)	Current Confidence	Priority For Technical Work Before LA
Low rate of release of radionuclides from breached waste packages	**Seepage into waste package**	**H**	**M**	**M**	**M**	**L**
	Integrity of spent fuel cladding	**H**	**M**	**M**	**M**	**L**
	Dissolution of uranium oxide and glass waste forms	M	M	M	M	L
	Neptunium solubility	M	H	M	H	L
	Formation of radionuclide-bearing colloids	M	M	M	L	M
	Transport through and out of waste package	**M**	**L**	**L**	**L**	**L**

Priority for Future Work

- Low Priority

Current Confidence

- Available data on transport through granular and iron materials
- Little data on transport through assemblies or surface of internal components
- Theoretical knowledge of small opening transport
- Low current confidence

Potential Confidence

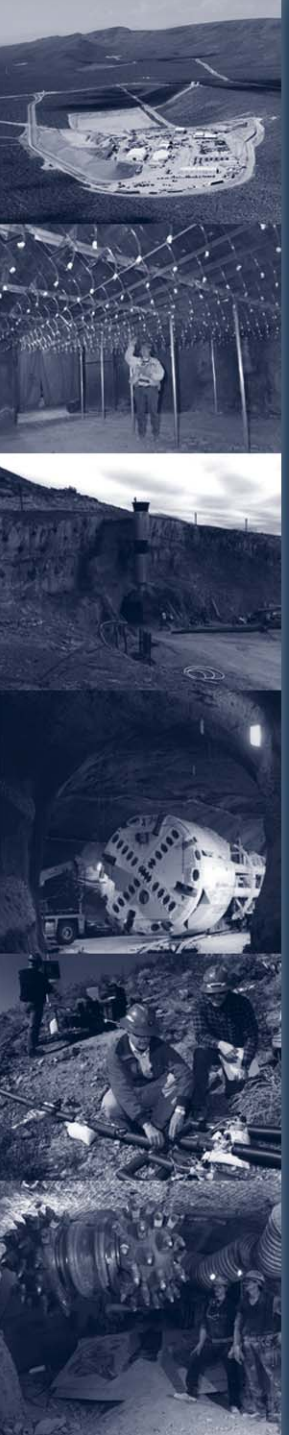
- Testing will not yield full data needs, due to large variations
- Low projected confidence

Performance Allocation

- Low importance to performance

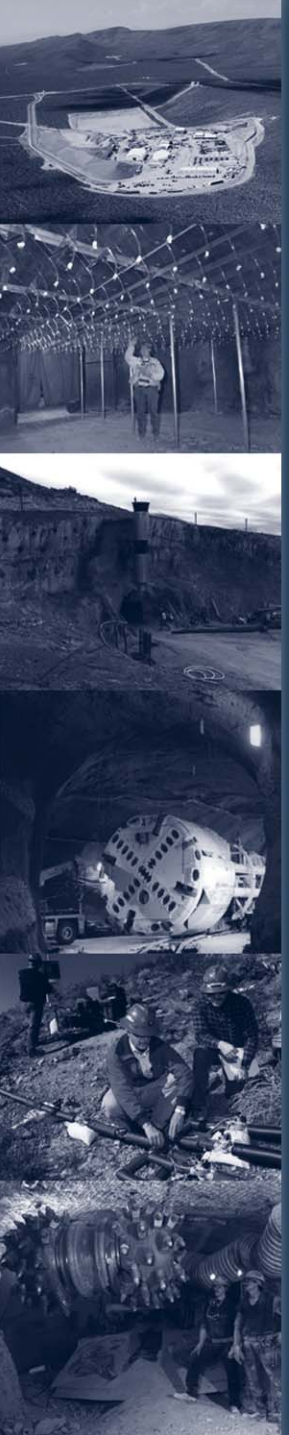
Performance Allocation

Repository System Attributes	Principal Factors and Design Options	Potential Importance to Postclosure Performance	**Potential Confidence by LA**	Performance Allocation (Confidence Goal for LA)	**Current Confidence**	**Priority For Technical Work Before LA**
Limited water contacting waste packages	Precipitation and infiltration into the mountain	M	M	M	M	L
	Percolation to depth	M	M	M	M	L
	Seepage into drifts	H	M	M	M	L
	Effects of heat and excavation on flow	M	M	M	L	M
	Dripping onto waste package	M	M	M	M	L
	Humidity and temperature at waste package	M	H	M	H	L
	Water diversion by drip shield + backfill	H	H	H	M	H
Long waste package lifetime	Chemistry of water on waste package	M	M	M	M	L
	Integrity of outer carbon steel waste package barrier	M	H	M	H	L
	Integrity of inner corrosion-resistant waste package barrier	H	H	H	M	H
	Ceramic waste package coating	H	H	H	M	H
Low rate of release of radionuclides from breached waste packages	Seepage into waste package	M	M	M	M	L
	Integrity of spent fuel cladding	H	M	M	M	L
	Dissolution of uranium oxide and glass waste forms	M	M	M	M	L
	Neptunium solubility	M	H	M	H	L
	Formation of radionuclide-bearing colloids	M	M	M	L	M
	Transport through and out of waste package	M	L	L	L	L
Radionuclide concentration reduction during transport from the waste packages	Transport through unsaturated zone	M	M	M	L	M
	Flow and transport in saturated zone	M	M	M	L	M
	Dilution from pumping	M	H	M	H	L
	Biosphere dilution	M	M	M	M	L



Example Performance Allocations For Design Options

Repository System Attributes	Principal Factors and Design Options	VA Reference Design	VA Reference Design + Drip Shield/Backfill	VA Reference Design + Ceramic WP Coating	VA Reference Design + Drip Shield/Backfill + Ceramic WP Coating
Limited water contacting waste packages	Precipitation and infiltration into the mountain	M	M	M	L
	Percolation to depth	M	M	M	L
	Seepage into drifts	H	M	M	L
	Effects of heat and excavation on flow	M	M	M	L
	Dripping onto waste package	M	M	M	L
	Humidity and temperature at waste package	M	M	M	L
	Diversion by drip shield + backfill	--	H	--	H
Long waste package lifetime	Chemistry on waste package	M	M	L	L
	Integrity of outer carbon steel waste package barrier	M	M	M	L
	Integrity of corrosion-resistant waste package barrier	H	H	H	H
	Integrity of ceramic waste package coating	--	--	H	H
Low rate of release of radionuclides from breached waste packages	Seepage into waste package	M	M	M	L
	Integrity of spent fuel cladding	M	M	M	L
	Dissolution of uranium oxide and glass waste forms	M	M	M	L
	Neptunium solubility	M	M	M	L
	Formation of radionuclide-bearing colloids	M	M	M	L
	Transport through and out of waste package	M	L	L	L
Radionuclide concentration reduction during transport from the waste packages	Transport through the unsaturated zone	M	M	M	L
	Flow and transport in the saturated zone	M	M	M	L
	Dilution from pumping	M	M	M	L
	Biosphere dilution	M	M	M	L



Example Principal Factors for Alternatives

Post Closure Safety Strategy Attributes	Principal Factors for VA Reference Design and Options	Design Features from Alternatives Study
Water Contacting Waste Package	Precipitation and infiltration into the mountain	Surface Modification (Alluvium, Drainage)
	Percolation to depth	
	Seepage into drifts	Metal Lined Drift, Ceramic Lined Emplacement Borehole, Near Field Rock Treatment
	Effects of heat and excavation on flow	Thermal Load
	Dripping onto waste package	
	Humidity and temperature at waste package	Temperature Limits, Waste Package Size/ Spacing, Aging, Blending, Rod Consolidation, Ventilation, Drift Size/ Diameter
	Diversion by Drip Shields or Backfill	Drip Shield, Richards Barrier, Backfill
Waste Package Lifetime	Chemistry on waste package	
	Integrity of outer carbon steel waste package barrier	
	Integrity of inner corrosion-resistant waste package barrier	1 or 2 Corrosion Resistant Materials
	Integrity of Ceramic Waste Package Coatings	Ceramic Coating
Mobilization Rate Of Radionuclides	Seepage into waste package	Additives, Filler
	Integrity of spent fuel cladding	
	Dissolution of uranium oxide and glass waste forms	
	Neptunium solubility	
	Formation of radionuclide-bearing colloids	Diffusive Barrier, Getters
	Transport through and out of waste package	
Concentration Of Radionuclides in Ground Water	Transport through the unsaturated zone	
	Flow and transport in the saturated zone	
	Dilution from pumping	
	Biosphere dilution	