YUCCA
MOUNTAIN
PROJECT

Studies

Performance Allocation and Identification of Needed Information--The Path Forward to the Postclosure Safety Case

Presented to:
NRC/DOE Technical Exchange
License Application Plan

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Office of Civilian Radioactive
Waste Management

Performance Allocation

- Performance allocation is
  - Determination of the relative reliance placed on the principal factors of the system
  - Part of design evaluation and, when the LA design is selected, specification of requirements for that design
  - Central to the safety case that will be presented in the License Application

General Performance Allocation Process

- Understand the required performance of the system
- Identify the principal factors of the system important to that performance
- Determine relative importance to total system performance of these principal factors
- Estimate the level of confidence in the representation of those principal factors
- Allocate performance to the principal factors

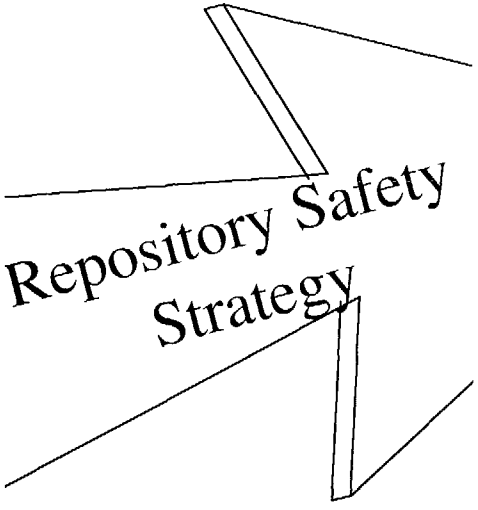
A Form of Performance Allocation Has Been Used in Planning

- Planning identifies principal factors based upon
  - Current information
  - Current confidence in those factors
- Planning also estimates potential confidence in the representation of the factors
- Planning further identifies information needed to support evaluation of design alternatives and additional design features
- This approach has been used throughout site characterization to identify and prioritize information needed for the postclosure safety case

Evolution of Performance Allocation During Site Characterization

Site Characterization Plan

- Principal elements relied on
  - Unsaturated rock units
  - Saturated rock below the unsaturated rock
  - Engineered-barrier system
- Performance allocation used to prioritize information needs to characterize these elements

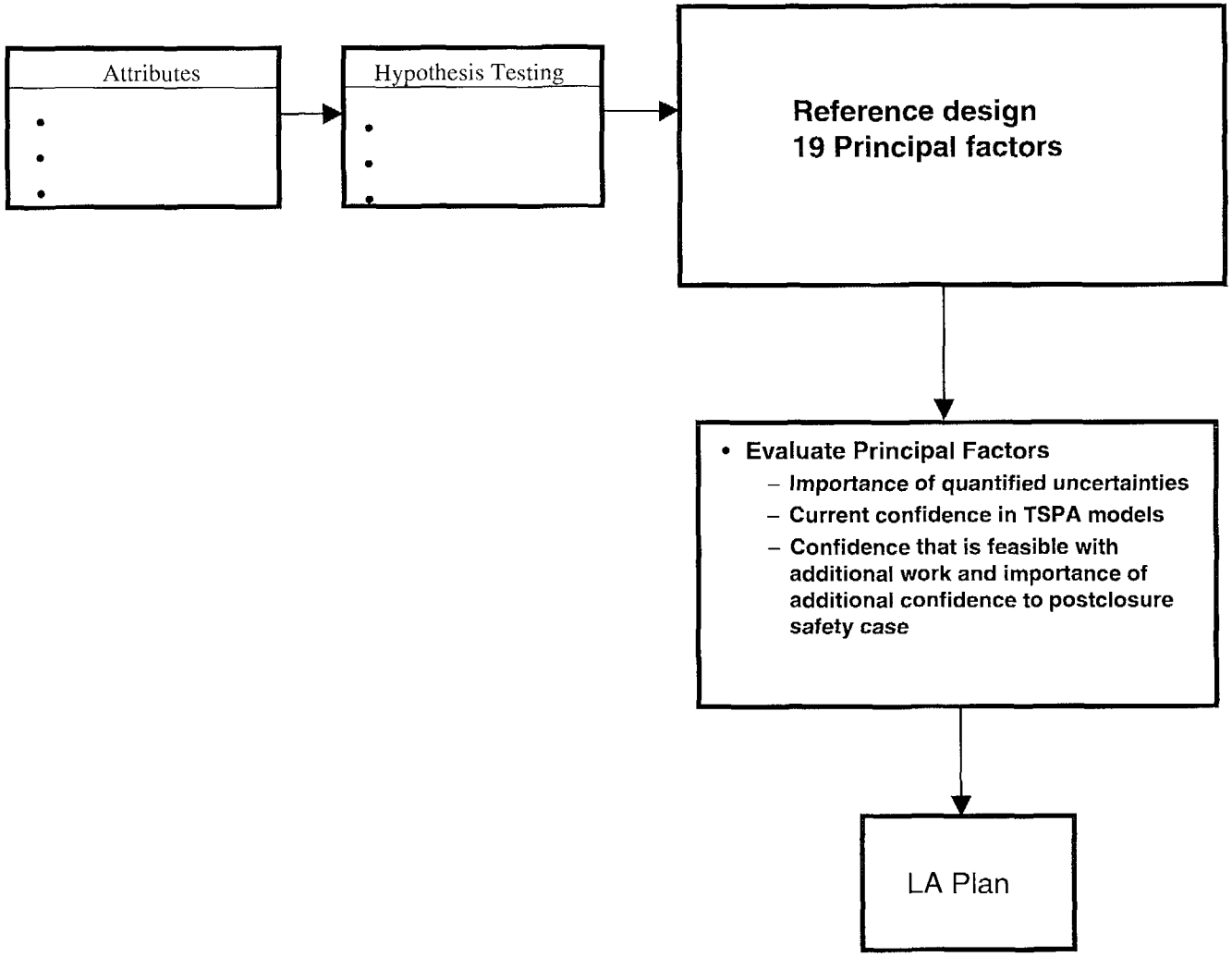


Repository Safety Strategy (Rev 2 Draft)
Viability Assessment

- 19 Principal Factors grouped according to the key attributes of the system
- Performance allocation used to prioritize information needed to address uncertainties in these factors

Postclosure Safety Case

Performance Allocation For the VA



Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components	Principal Factors	Significance of Uncertainties to TSPA	Current Confidence	Confidence Goal	Priority for SR/LA
Limited water contacting waste packages	Unsaturated Zone Flow	Precipitation and infiltration into the mountain	M	4	5	1
		Percolation to depth	M	3	5	2
		Seepage into drifts	II	2	5	3
	Thermal Hydrology	Effects of heat and excavation on flow: A. Mountain scale B. Drift scale	 M_b M_b	 1 2	 2 4	 1 2
		Dripping onto waste packages	M	2	4	2
		Humidity and temperature at waste packages	$L_{b,c}$	5	4	0
Long waste package lifetime	Near-Field Geochemical Environment	Chemistry of water on waste packages	M	3	5	2
	Waste Package Degradation	Integrity of outer carbon steel waste package barrier	M_a	4	5	1
		Integrity of inner corrosion-resistant waste package barrier	$H_{a,b}$	3	6	3
		Seepage into waste packages	M	3	3	0
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization	Integrity of spent nuclear fuel cladding	H_a	3	5	2
		Dissolution of spent nuclear fuel and glass waste forms	$M_{b,c}$	4	5	1
		Neptunium solubility	$M_{b,c}$	4	5	1
		Formation and transport of Radionuclide-bearing colloids	$M_{b,c}$	2	4	2
		Transport through and out of the engineered Barrier system	$M_{b,c}$	3	4	1
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport	Transport through the unsaturated zone	H_a	2	5	3
	Saturated Zone Flow and Transport	Flow and transport in the saturated zone	M	2	3	1
		Dilution from pumping	M	5	5	0
	Biosphere Transport	Biosphere transport and uptake	L	5	5	0

Performance Allocation in the VA

Attributes of the Repository Safety Strategy
Limited water contacting waste packages
Long waste package lifetime
Low Rate of release of radionuclides from breached waste packages
Radionuclide concentration reduction during transport from the waste packages

Understand the attributes of the system

Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components
Limited water contacting waste packages	Unsaturated Zone Flow
	Thermal Hydrology
Long waste package lifetime	Near-Field Geochemical Environment
	Waste Package Degradation
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport
	Saturated Zone Flow and Transport
	Biosphere Transport

Represent the key elements and processes of the system

Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components	Principal Factors
Limited water contacting waste packages	Unsaturated Zone Flow	Precipitation and infiltration into the mountain
		Percolation to depth
		Seepage into drifts
	Thermal Hydrology	Effects of heat and excavation on flow: A. Mountain scale B. Drift scale
		Dripping onto waste packages
		Humidity and temperature at waste packages
Long waste package lifetime	Near-Field Geochemical Environment	Chemistry of water on waste packages
	Waste Package Degradation	Integrity of outer carbon steel waste package barrier
		Integrity of inner corrosion-resistant waste package barrier
		Seepage into waste packages
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization	Integrity of spent nuclear fuel cladding
		Dissolution of spent nuclear fuel and glass waste forms
		Neptunium solubility
		Formation and transport of Radionuclide-bearing colloids
		Transport through and out of the engineered Barrier system
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport	Transport through the unsaturated zone
	Saturated Zone Flow and Transport	Flow and transport in the saturated zone
		Dilution from pumping
	Biosphere Transport	Biosphere transport and uptake

Understand the principal factors important to performance

Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components	Principal Factors	Significance of Uncertainties to TSPA
Limited water contacting waste packages	Unsaturated Zone Flow	Precipitation and infiltration into the mountain	M
		Percolation to depth	M
		Seepage into drifts	H
	Thermal Hydrology	Effects of heat and excavation on flow: A. Mountain scale B. Drift scale	 M_b M_b
		Dripping onto waste packages	M
		Humidity and temperature at waste packages	$L_{b,c}$
Long waste package lifetime	Near-Field Geochemical Environment	Chemistry of water on waste packages	M
	Waste Package Degradation	Integrity of outer carbon steel waste package barrier	M_a
		Integrity of inner corrosion-resistant waste package barrier	$H_{a,b}$
		Seepage into waste packages	M
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization	Integrity of spent nuclear fuel cladding	H_a
		Dissolution of spent nuclear fuel and glass waste forms	$M_{b,c}$
		Neptunium solubility	$M_{b,c}$
		Formation and transport of Radionuclide-bearing colloids	$M_{b,c}$
		Transport through and out of the engineered Barrier system	$M_{b,c}$
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport	Transport through the unsaturated zone	H_a
	Saturated Zone Flow and Transport	Flow and transport in the saturated zone	M
		Dilution from pumping	M
	Biosphere Transport	Biosphere transport and uptake	L

Assess significance of quantifiable uncertainties on TSPA estimates of performance

Significance of Uncertainties to TSPA

L if possible variations change estimates by less than factor of 5

M if possible variations change estimates by less than factor of 50

H if possible variations change estimates by more than factor of 50

Applicable Period

a 0-10,000 years

b 10,000-100,000 years

c 100,000-1,000,000 years

Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components	Principal Factors	Significance of Uncertainties to TSPA	Current Confidence
Limited water contacting waste packages	Unsaturated Zone Flow	Precipitation and infiltration into the mountain	M	4
		Percolation to depth	M	3
		Seepage into drifts	H	2
	Thermal Hydrology	Effects of heat and excavation on flow: A. Mountain scale B. Drift scale	 M_b M_b	 1 2
		Dripping onto waste packages	M	2
		Humidity and temperature at waste packages	$L_{b,c}$	5
Long waste package lifetime	Near-Field Geochemical Environment	Chemistry of water on waste packages	M	3
	Waste Package Degradation	Integrity of outer carbon steel waste package barrier	M_a	4
		Integrity of inner corrosion-resistant waste package barrier	$H_{a,b}$	3
		Seepage into waste packages	M	3
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization	Integrity of spent nuclear fuel cladding	H_a	3
		Dissolution of spent nuclear fuel and glass waste forms	$M_{b,c}$	4
		Neptunium solubility	$M_{b,c}$	4
		Formation and transport of Radionuclide-bearing colloids	$M_{b,c}$	2
		Transport through and out of the engineered Barrier system	$M_{b,c}$	3
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport	Transport through the unsaturated zone	H_a	2
	Saturated Zone Flow and Transport	Flow and transport in the saturated zone	M	2
		Dilution from pumping	M	5
	Biosphere Transport	Biosphere transport and uptake	L	5

Assess current confidence in TSPA representations of the principal factors

Estimates of current confidence based on best judgement
Confidence scale goes from 1 to 7

Performance Allocation in the VA

Attributes of the Repository Safety Strategy	TSPA Model Components	Principal Factors	Significance of *Uncertainties* to TSPA	Current Confidence	Confidence Goal
Limited water contacting waste packages	Unsaturated Zone Flow	Precipitation and infiltration into the mountain	M	4	5
		Percolation to depth	M	3	5
		Seepage into drifts	II	2	5
	Thermal Hydrology	Effects of heat and excavation on flow: A. Mountain scale B. Drift scale	 M_b M_b	 1 2	 2 4
		Dripping onto waste packages	M	2	4
		Humidity and temperature at waste packages	$L_{b,c}$	5	4
Long waste package *lifetime*	Near-Field Geochemical *Environment*	Chemistry of water on waste packages	M	3	5
	Waste Package Degradation	Integrity of outer carbon steel waste package barrier	M_a	4	5
		Integrity of inner corrosion-resistant waste package barrier	$II_{a,b}$	3	6
		Seepage into waste packages	M	3	3
Low Rate of release of radionuclides from breached waste packages	Waste Form Alteration and Mobilization	*Integrity of spent nuclear fuel cladding*	II_a	3	5
		Dissolution of spent nuclear fuel and glass waste forms	$M_{b,c}$	4	5
		Neptunium solubility	$M_{b,c}$	4	5
		Formation and transport of Radionuclide-bearing colloids	$M_{b,c}$	2	4
		Transport through and out of the engineered Barrier system	$M_{b,c}$	3	4
Radionuclide concentration reduction during transport from the waste packages	Unsaturated Zone Transport	Transport through the unsaturated zone	H_a	2	5
	Saturated Zone Flow and Transport	Flow and transport in the saturated zone	M	2	3
		Dilution from pumping	M	5	5
	Biosphere Transport	Biosphere transport and uptake	L	5	5

Assess feasibility and desirability of increased confidence in next 18 months

Performance Allocation in the VA

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	Biosphere Transport	Biosphere transport and uptake	L	5	5	0

Assess priority of work to address uncertainties in current estimates

Example--Seepage in Emplacement Drifts

- Significance to TSPA estimates of performance
  - Seepage is principal source of water that may drip onto waste packages, contributing to waste package corrosion and mobilization of radionuclides
  - Some of percolation flux may be diverted around drifts, limiting seepage
  - Seepage expected to be highly variable throughout repository
  - TSPA sensitivity studies indicate that variations can lead to variations in peak dose rate of more than a factor of 50
- High (H) significance to TSPA

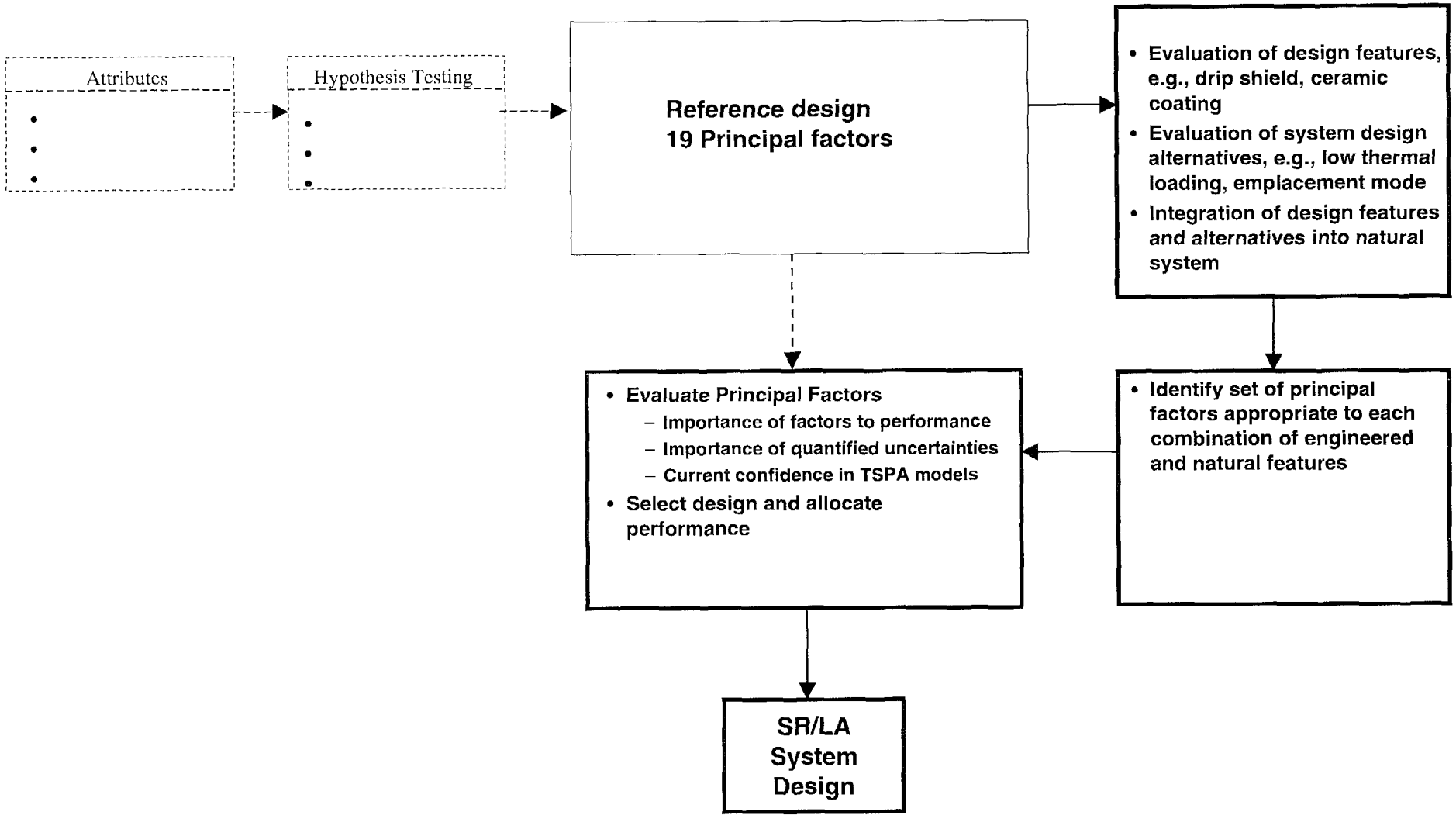
Example--Seepage in Emplacement Drifts

- Current Confidence
  - Current estimates based on limited in situ measurements and modeling calibrated to these measurements
  - Considerable spatial and temporal variability in properties not yet captured in models
  - Modeling is idealized (undisturbed, circular drifts)
  - Data so far from just two niches
- Current confidence estimated to be "2"

Example--Seepage in Emplacement Drifts

- Confidence Goal
  - Estimates of spatial variability in percolation flux can be improved by additional ESF and niche studies
  - Seepage can be measured in extended niche studies, including those in different tuff units, sites near a fault, and a site below tuff interface
  - Information will be expanded from studies in Cross Drift
  - Extensive information from injection studies at Cross-Drift/ESF crossover point
- Achievable confidence estimated to be "5"
- Priority of work estimated to be "3"

Performance Allocation For the SR/LA



Performance Allocation and the Licensing Case

- Until now performance allocation has served principally to prioritize work
- Performance allocation for the SR/LA system design will be a key aspect of the licensing case presented in the license application

Framework for the License Application Plan

- Analysis of the reference system design
  - Identification of principal factors
  - Understanding of uncertainties associated with those factors
- Elements of the licensing case
  - Postclosure safety case
  - Preclosure safety case
  - Operational requirements

Postclosure Safety Case

- Quantitative estimates of expected postclosure performance
- Incorporation of design margin and defense in depth to address uncertainties
- Explicit consideration of disruptive processes and events
- Supporting information from natural and manmade analogues
- A performance confirmation plan

Preclosure Safety Case

- Systematic identification of design basis events
- Safety classification of structures, systems, and components
- Verification of system design for compliance to requirements
- Use of demonstrated technology and accepted design criteria

Operational Requirements

- Retreivability
- Emplacement mode

Summary

- Performance allocation for postclosure safety considerations to set priorities for work to support the license application developments
- Other considerations for postclosure safety, preclosure safety, and operational requirements contribute to the work necessary to support license application development