YUCCA
MOUNTAIN
PROJECT

Studies

License Application Plan
Viability Assessment - Volume 4

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Carol L. Hanlon
Department of Energy

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

January 26-27, 1999

Purpose of the License Application Plan

(Civilian Radioactive Waste Management Program Plan)

- **To identify remaining scientific investigations and engineering information needed to complete the License Application**
- **To identify costs associated with securing this information**

LONG-TERM GOAL

- **To submit a docketable License Application to the Nuclear Regulatory Commission**

Considerations

- Opportunity to assess adequacy of revised approach to site characterization and design
- Draw on available models and data describing the natural system, repository, and waste package design
- Draw on Total System Performance Assessment
- Draw on strategy for evaluating waste containment and isolation (Repository Safety Strategy)
- Performance confirmation program continuing during construction and operation to further reduce performance uncertainties

Intended Use of the License Application Plan

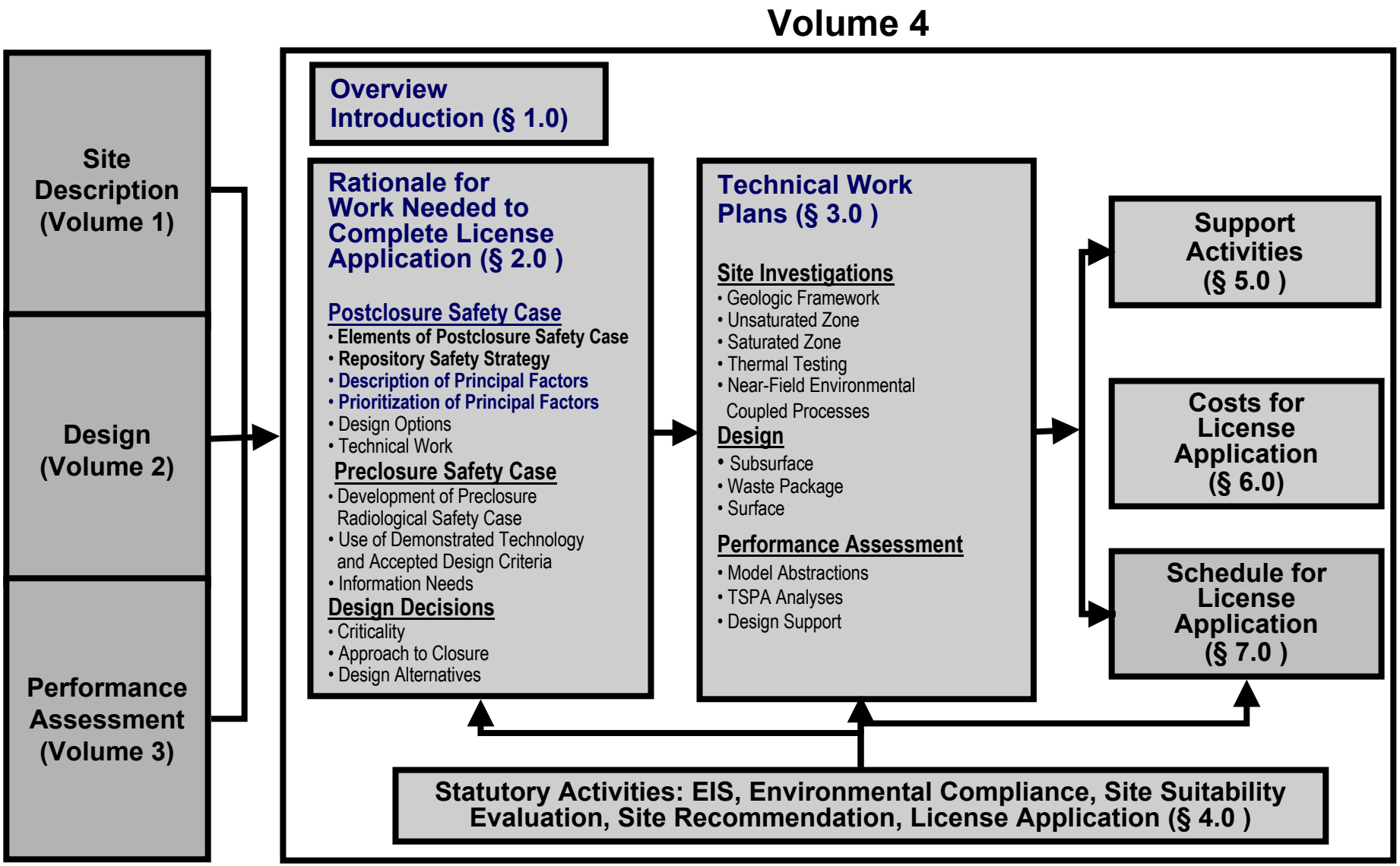
- **Provide understanding of how DOE has identified, prioritized, and described major areas of remaining work to be conducted during next 4 years**
- **Discuss statutory and regulatory activities**
- **Discuss supporting work**
- **Present schedule, costs for work identified**

- **Goal: ability to produce a docketable license application**

License Application Plan NOT Intended to:

- **Provide lower-level detail on work activities identified**
  - **Detailed information on work activities will be provided in Annual Plans and Multi-Year Planning System**
  - **Work plans and procedures will be identified in individual work packages available in the record system**
- **Provide detail on statutory, regulatory, and support activities such as Quality Assurance Program, preparation of Site Recommendation, and License Application**
  - **Details provided in separate management documents specific to each area, i.e., License Application Management Plan, and Quality Assurance Requirement Description**

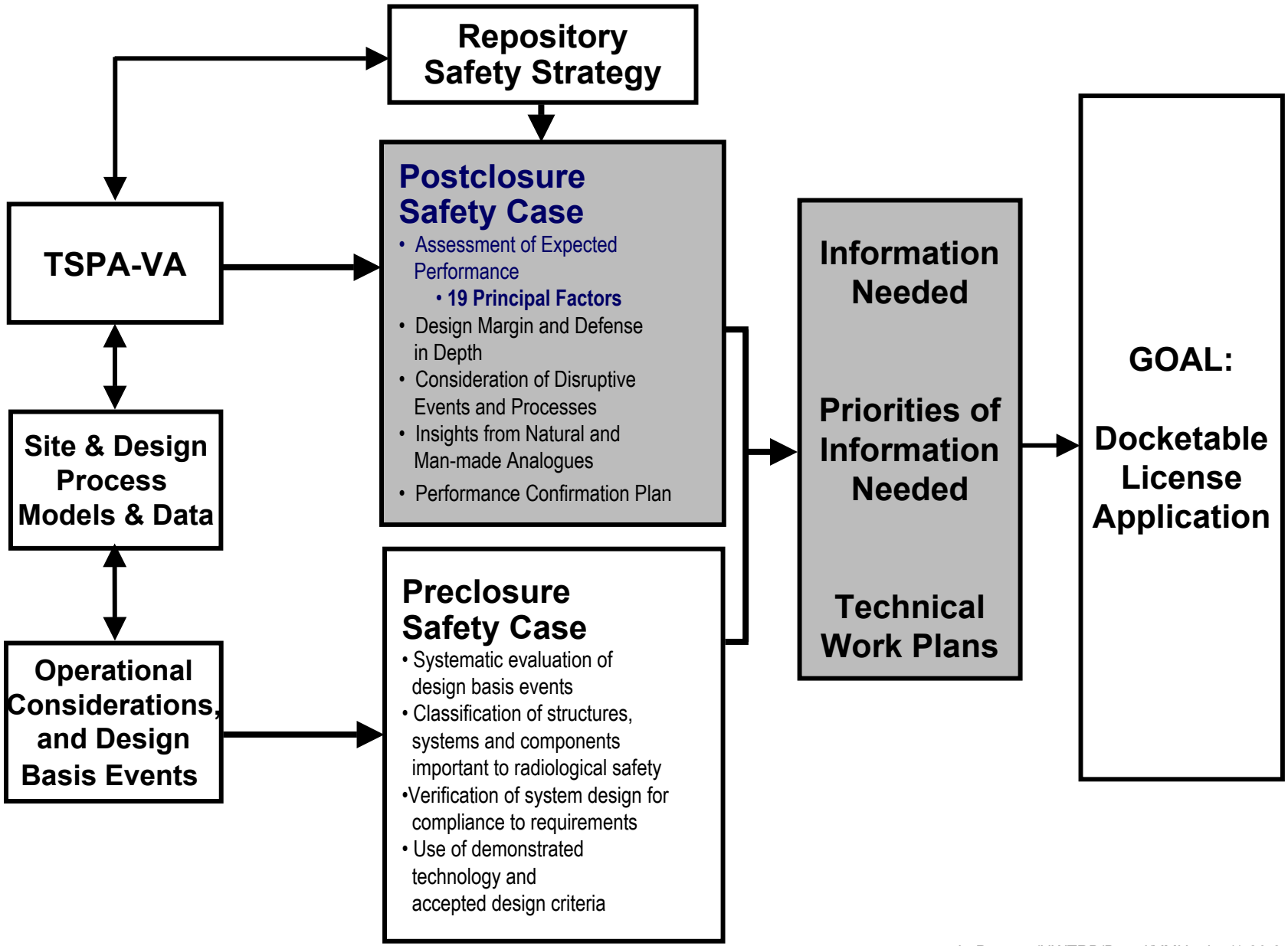
License Application Plan Organization



Areas of Emphasis

- Rationale for Technical Work Needed to Complete the Postclosure Safety Case
- Postclosure Safety Case
- Expected Postclosure Performance
- Principal Factors of Postclosure Performance
- Technical Work Plans

License Application Plan Rationale



Prioritization of Principal Factors

- **19 principal factors were prioritized to identify technical work with best potential to reduce uncertainty in the postclosure safety case**
  - **Consideration to factors to which peak dose rate most sensitive**
  - **This work has consequently received priority funding and resource allocation**

Prioritization of Principal Factors

(Continued)

Prioritization Considerations:

1. Significance of uncertainty to TSPA; effect of uncertainties on peak dose rate calculation: H, M, L
2. Current Confidence (1= Low; 7= High)
   - Is current representation realistic
   - Does current representation capture entire range of conditions important to performance

Prioritization of Principal Factors

(Continued)

3. **Confidence goal (1 = Low; 7 = High)**
   - **Feasible to be accomplished in time for input to Site Recommendation and License Application**
   - **Desirable in significance to TSPA and important to defensibility of technical basis**
4. **Priority = confidence goal - current confidence**

Confidence Goal Assessments

RSS Attributes	Principal Factors	* Signif. of Uncertainty	Current Conf.	Conf. Goal
Limited water contacting waste packages	1. Precipitation and infiltration into the mountain	**M**	**4**	**5**
	2. Percolation to depth	**M**	**3**	**5**
	3. Seepage into drifts	**H**	**2**	**5**
	4A. Effects of heat/excavation on flow (mountain)	**M_b**	**1**	**2**
	4B. Effects of heat/excavation on flow (drift scale)	**M_b**	**2**	**4**
	5. Dripping onto waste package	**M**	**2**	**4**
	6. Humidity and temperature at waste package	**$L_{b,c}$**	**5**	**4**
Long waste package lifetime	7. Chemistry of water on waste package	**M**	**3**	**5**
	8. Integrity of outer carbon steel WP barrier	**M_a**	**4**	**5**
	9. Integrity of inner corrosion–resistant WP barrier	**$H_{a,b}$**	**3**	**6**
Low rates of release for radionulides from breached waste packages	10. Seepage into waste package	**M**	**3**	**3**
	11. Integrity of spent fuel cladding	**H_a**	**3**	**5**
	12. Dissolution of spent fuel & glass waste forms	**$M_{b,c}$**	**4**	**5**
	13. Neptunium solubility	**$M_{b,c}$**	**4**	**5**
	14. Formation & transport of radionuclide-colloids	**$M_{b,c}$**	**2**	**4**
Concentration reduction transport from waste packages	15. Transport through and out of EBS	**$M_{b,c}$**	**3**	**4**
	16. Transport through unsaturated zone	**H_a**	**2**	**5**
	17. Flow and transport in saturated zone	**M**	**2**	**3**
	18. Dilution from pumping	**M**	**5**	**5**
	19. Biosphere transport and uptake	**L**	**5**	**5**

* Subscripts: “a” = 0 to 10 kyr, “b” = 10 to 100 kyr, and “c” = 100 kyr to 1 Myr (no subscript = 0 to 1 Myr)

Prioritization Results

RSS Attributes	Principal Factors [A]	Current Conf.	Conf. Goal	Priority
Limited water contacting waste packages	1. Precipitation and infiltration into the mountain	4	5	1
	2. Percolation to depth	3	5	2
	3. Seepage into drifts	2	5	3
	4A. Effects of heat/excavation on flow (mountain)	1	2	1
	4B. Effects of heat/excavation on flow (drift scale)	2	4	2
	5. Dripping onto waste package	2	4	2
	6. Humidity and temperature at waste package	5	4	0 [B]
Long waste package lifetime	7. Chemistry of water on waste package	3	5	2
	8. Integrity of outer carbon steel WP barrier	4	5	1
	9. Integrity of corrosion–resistant WP barrier	3	6	3
Low rates of release for radionulides from breached waste packages	10. Seepage into waste package	3	3	0
	11. Integrity of spent fuel cladding	3	5	2
	12. Dissolution of spent fuel & glass waste forms	4	5	1
	13. Neptunium solubility	4	5	1
	14. Formation & transport of radionuclide-colloids	2	4	2
Concentration reduction transport from waste packages	15. Transport through and out of EBS	3	4	1
	16. Transport through unsaturated zone	2	5	3
	17. Flow and transport in saturated zone	2	3	1
	18. Dilution from pumping	5	5	0
	19. Biosphere transport and uptake	5	5	0

[A] Emboldened factors discussed in detail. [B] The calculated priority for this factor has the same meaning as zero.

Principal Factors with Relatively High Priority

RSS Attributes	Principal Factors [A]	Current Conf.	Conf. Goal	Priority
Limited water contacting waste packages	1. Precipitation and infiltration into the mountain	4	5	1
	2. Percolation to depth	**3**	**5**	**2**
	3. Seepage into drifts	**2**	**5**	**3**
	4A. Effects of heat/excavation on flow (mountain)	1	2	1
	4B. Effects of heat/excavation on flow (drift scale)	**2**	**4**	**2**
	5. Dripping onto waste package	**2**	**4**	**2**
	6. Humidity and temperature at waste package	5	4	0 [B]
Long waste package lifetime	**7. Chemistry of water on waste package**	**3**	**5**	**2**
	8. Integrity of outer carbon steel WP barrier	4	5	1
	9. Integrity of corrosion–resistant WP barrier	**3**	**6**	**3**
Low rates of release for radionulides from breached waste packages	10. Seepage into waste package	3	3	0
	11. Integrity of spent fuel cladding	**3**	**5**	**2**
	12. Dissolution of spent fuel & glass waste forms	4	5	1
	13. Neptunium solubility	4	5	1
	14. Formation & transport of radionuclide-	**2**	**4**	**2**
Concentration reduction transport from waste packages	15. Transport through and out of EBS	3	4	1
	16. Transport through unsaturated zone	**2**	**5**	**3**
	17. Flow and transport in saturated zone	2	3	1
	18. Dilution from pumping	5	5	0
	19. Biosphere transport and uptake	5	5	0

[A] Emboldened factors discussed in detail. [B] The calculated priority for this factor has the same meaning as zero.

Technical Work Plans

- **Technical Work Identified based upon**
  - **Prioritization effort**
  - **Multi-year planning effort**
- **Technical work organized by functional areas**
  - **Site investigations**
  - **Design**
  - **Performance assessment**

Technical Work Plans

(Continued)

- **Examples of technical work**
  - **Natural analogs**
  - **Corrosion testing**

Technical Work

- **Insights from natural and man-made analogs**
  - **Fourth element of postclosure safety case**
  - **Confirmatory and supporting**
  - **Review and evaluation of existing relevant information**
  - **Studies continued during performance confirmation**

Technical Work

(Continued)

Natural Analogs addressed

Site: - Geologic framework and disruptive events

- Unsaturated zone processes

- Saturated zone processes

- Near-field environment and coupled processes

Design: - Waste package materials testing and modeling

Performance Assessment: - Model abstractions

Components of Analog Studies

Every analog study will include the following:

- **Careful review of available data and understanding of analog system**
- **Comparison of process or system to site-specific characteristics of a Yucca Mountain repository**
- **Assessment of previous modeling studies and their application to Yucca Mountain processes**
- **Qualitative or quantitative application of analog information in process and PA models for improved confidence in predicted Yucca Mountain behavior**

Uses of Natural Analogs for YMP

- **Confidence building in modeling processes for performance assessment**
- **Understanding long-term behavior of waste package and other engineered barrier materials, e.g. metals and cements**
- **Confidence in design – e.g., stability of old mines and other underground workings**
- **Public information and education**

FY99 and FY00 Analog Work

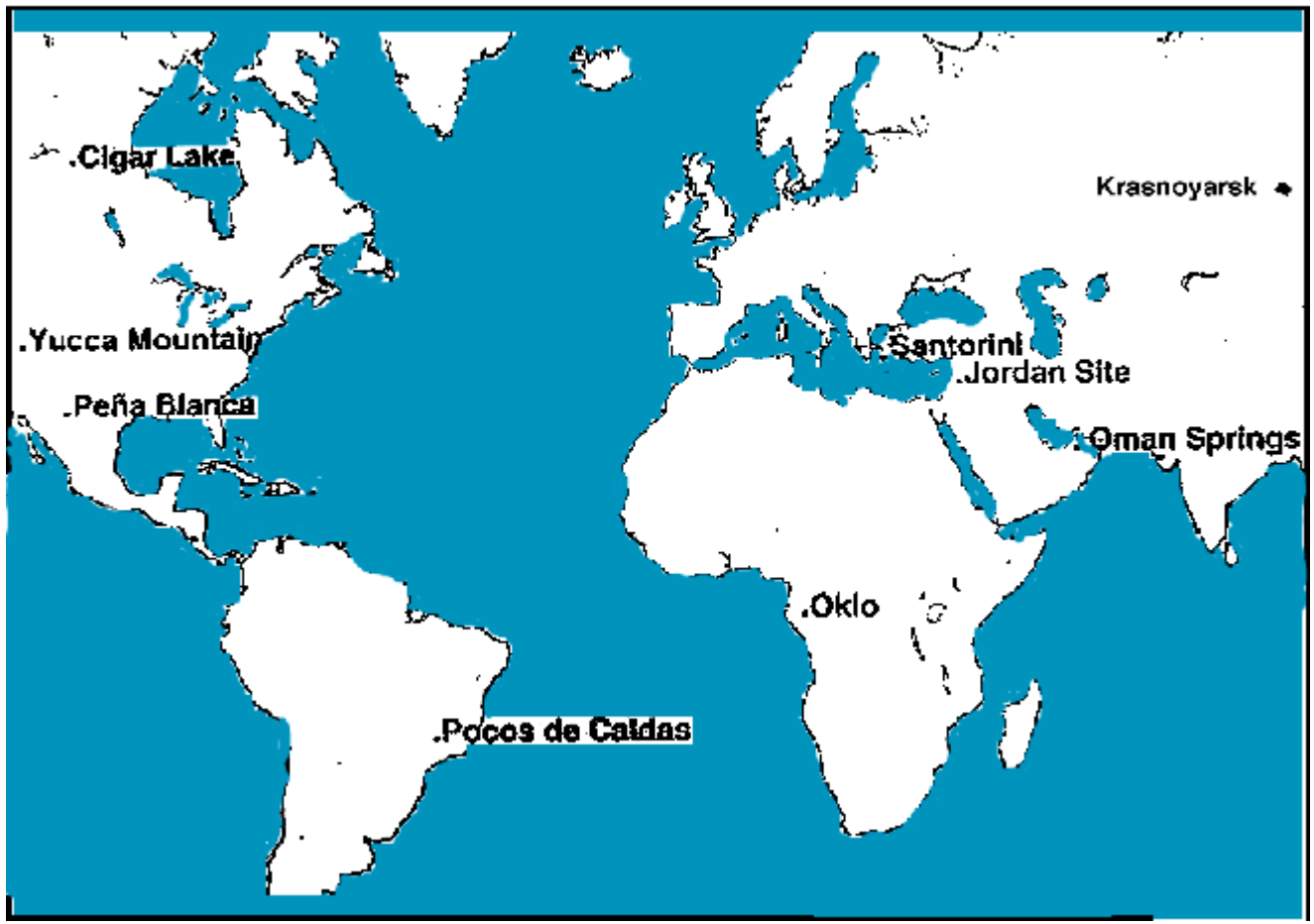
- **Comprehensive review of existing analog information relevant to performance of a Yucca Mountain repository with recommendations for process models and PA:**
  - **seepage into drifts – Rainier Mesa, NV; Hell's Half Acre, ID**
  - **infiltration – Rainier Mesa**
  - **radionuclide solubility and speciation – Oklo, Gabon**
  - **radionuclide transport – Peña Blanca, Mexico; Cigar Lake, Canada**
  - **coupled processes – geothermal fields**
  - **colloidal transport – Nevada Test Site, INEEL**
  - **EBS materials - Maquarin, Jordan; Wairakai, New Zealand**

FY99 and FY00 Analog Work

(Continued)

- **Scoping study of vertical uranium transport in unsaturated ash flow tuff at Peña Blanca, Mexico**
- **Modeling of fracure flow at INEEL and saturated zone dispersion at Hanford analog sites**
- **Study of coupled thermal-mechanical-hydrological-chemical process analogs at Krasnoyarsk, Russia and in geothermal fields worldwide**

Selected Natural Analog Sites



Technical Work

Corrosion

- **Relates to first and second elements of Postclosure Safety Case**
- **Illustrates prioritization of principal factors**
- **At least 6 of highest priority principal factors relate to corrosion:**
  - **Percolation to depth**
  - **Drift seepage**
  - **Dripping onto the waste package**
  - ***Chemistry of the water on waste packages***
  - ***Integrity of inner corrosion-resistant waste package barrier***
  - **Integrity of the spent nuclear fuel cladding**

Technical Work

(Continued)

Corrosion Addressed

Site:	**Geologic framework & disruptive events; unsaturated zone processes**
	Thermal testing
	Near-field environment & coupled processes
Design:	**Surface - waste handling**
	Subsurface design: ventilation, ground control; waste emplacement
	Waste package 3.2.2
	3.2.2.9 waste package testing and modeling
PA:	**Model abstractions**
	Unsaturated zone flow & transport
	Near-field environment
	Waste package

Technical Work

(Continued)

- **Summary of status long-term corrosion studies**

Evolution in Priorities

- **Evolved from effort to develop the knowledge base for Yucca Mountain to confirming the knowledge base and reducing uncertainties in key areas**
- **Evolved from emphasis on scientific investigation to emphasis on design and performance assessment**

Evolution of Priorities

(Continued)

- **DOE has established higher confidence goals for the Engineered System in the License Application Plan than previously**
- **The goals for the Engineered System are as high or higher than goals for the natural system**
- **These goals provide higher priority on several aspects of the engineered system than in the past**
- **Ability to improve our understanding of the natural barriers is diminishing**
- **Our efforts are shifting from the natural system to the engineered system**

Confidence Goal Assessments

RSS Attributes	Principal Factors	* Signif. of Uncertainty	Current Conf.	Conf. Goal
Limited water contacting waste packages	1. Precipitation and infiltration into the mountain	**M**	**4**	**5**
	2. Percolation to depth	**M**	**3**	**5**
	3. Seepage into drifts	**H**	**2**	**5**
	4A. Effects of heat/excavation on flow (mountain)	**M_b**	**1**	**2**
	4B. Effects of heat/excavation on flow (drift scale)	**M_b**	**2**	**4**
	5. Dripping onto waste package	**M**	**2**	**4**
	6. Humidity and temperature at waste package	**$L_{b,c}$**	**5**	**4**
Long waste package lifetime	7. Chemistry of water on waste package	**M**	**3**	**5**
	8. Integrity of outer carbon steel WP barrier	**M_a**	**4**	**5**
	9. Integrity of inner corrosion–resistant WP barrier	**$H_{a,b}$**	**3**	**6**
Low rates of release for radionulides from breached waste packages	10. Seepage into waste package	**M**	**3**	**3**
	11. Integrity of spent fuel cladding	**H_a**	**3**	**5**
	12. Dissolution of spent fuel & glass waste forms	**$M_{b,c}$**	**4**	**5**
	13. Neptunium solubility	**$M_{b,c}$**	**4**	**5**
	14. Formation & transport of radionuclide-colloids	**$M_{b,c}$**	**2**	**4**
Concentration reduction transport from waste packages	15. Transport through and out of EBS	**$M_{b,c}$**	**3**	**4**
	16. Transport through unsaturated zone	**H_a**	**2**	**5**
	17. Flow and transport in saturated zone	**M**	**2**	**3**
	18. Dilution from pumping	**M**	**5**	**5**
	19. Biosphere transport and uptake	**L**	**5**	**5**

* Subscripts: “a” = 0 to 10 kyr, “b” = 10 to 100 kyr, and “c” = 100 kyr to 1 Myr (no subscript = 0 to 1 Myr)

Funding

- DOE has defined a program in the License Application Plan that we believe has fidelity and will lead to a docketable LA
- The License Application Plan established a funding program that will allow DOE to carry out that program
- Short falls in funding will cause slips in schedule
- Some work planned for 1999 has already been carried forward into 2000