YUCCA MOUNTAIN PROJECT

Studies

Assessment of Engineered Barrier System Performance Issues in TSPA-VA

Presented to:
Nuclear Waste Technical Review Board

Presented by:
Robert W. Andrews
Manager, M&O Performance Assessment
Management and Operating Contractor

June 25-26, 1997

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

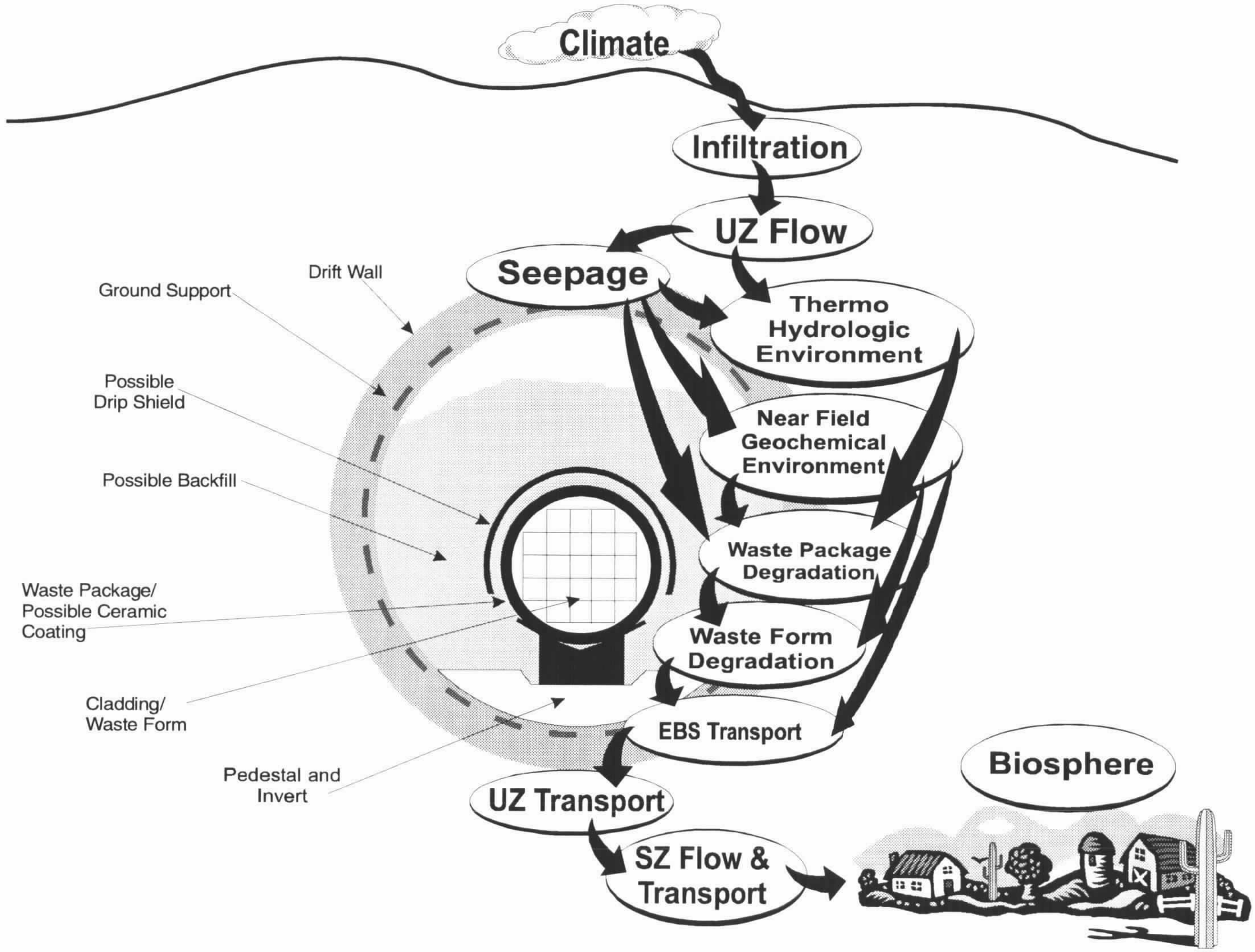
Outline

- Approach to TSPA-VA
- Schematic of Engineered Barrier System (EBS)
- Components of EBS in TSPA-VA
- Key Information Required from EBS Models
- Key Issues Associated with EBS Models
- Methods to Address Key EBS issues
- Conclusions

Approach to TSPA-VA

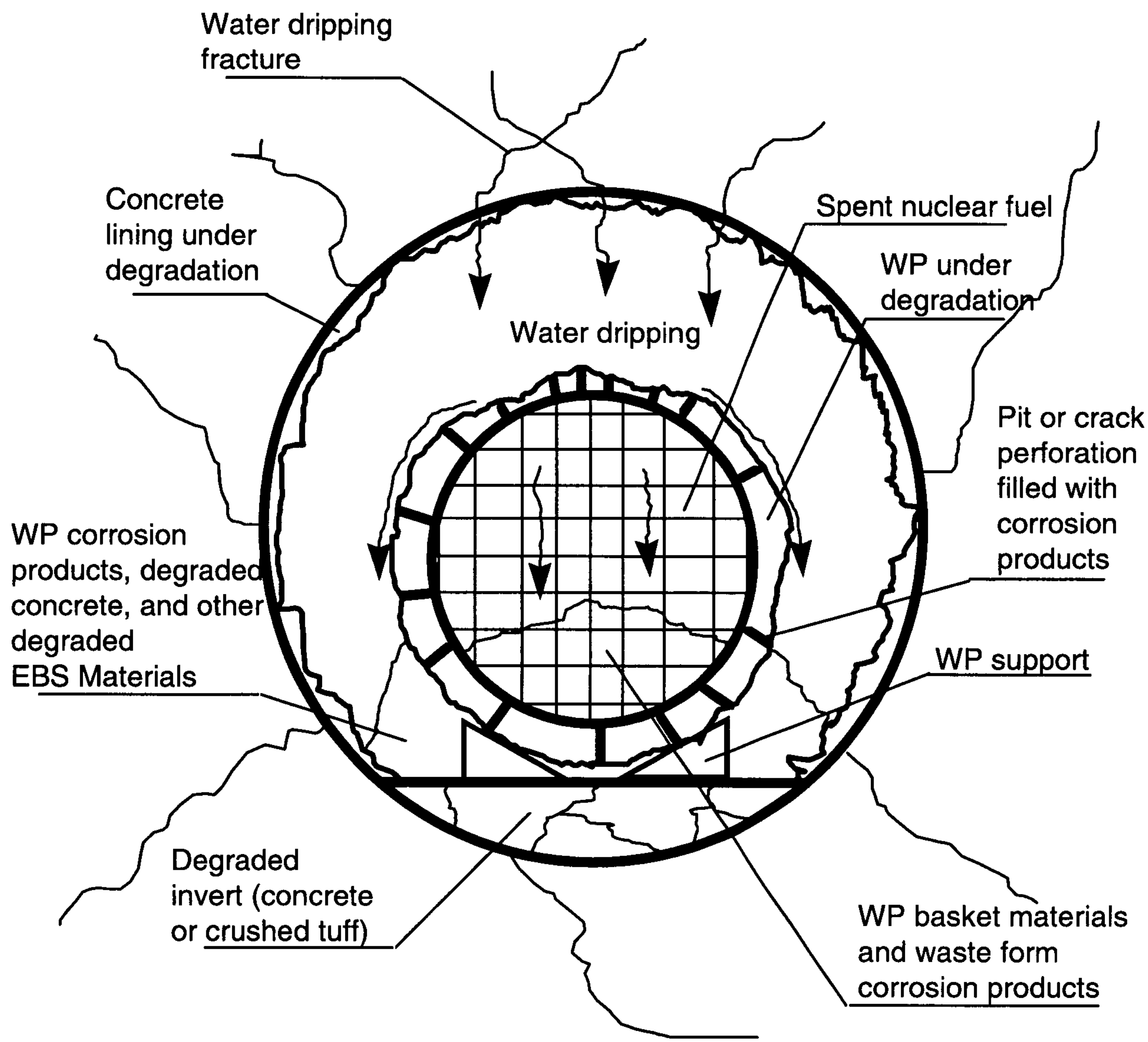
- Integrate site and design information and models to predict potential long-term consequences of radioactive waste disposal at Yucca Mountain
- Evaluate expected performance for the reference design using representative models and parameters
- Evaluate significance (i.e., sensitivity) of alternative models on performance
- Consider reasonable ranges in parameter values in uncertainty analysis (treat variability as stochastic process)
- Evaluate performance benefits of alternative defense-in-depth designs

Models for Total System Performance Assessment



NUKWSTP2.CDR.129.6-6-97

Schematic of Significant EBS Components



Key Engineering Components Affecting Predictions of Long-Term Waste Containment & Isolation

	Significance	KTI	WCIS
• Near-Field Thermohydrology	⬤	✓	✓
• Near-Field Thermochemistry	●	✓	✓
• Possible Drip Shield Integrity	●		
• Waste Package Degradation	⬤	✓	✓
- possible ceramic coating	●		
- corrosion-allowance material	●		
- galvanic protection	⬤		
- corrosion-resistant material	⬤		
• Cladding Degradation	⬤	✓	✓
• Waste Form Degradation	•	✓	✓
• Radionuclide Mobilization	⬤	✓	✓
• EBS Radionuclide Transport	⬤	✓	✓

Key Information Required from EBS Models

Model	Key Information
Near-Field Thermohydrology	Relative humidity (x,y,t) Temperature (x,y,t) Liquid saturation (x,y,t) Liquid flux (x,y,t)
Near-Field Thermochemistry	Key geochemical constituents (x,y,t) (e.g. pH, Eh, pO_2, pCO_2, Cl) – waste package – waste form – backfill/invert
Drip Shield Integrity	Time of return to "ambient" in drift liquid flux (x,y)

Key Information Required from EBS Models

(Continued)

Model	Key Information
Waste Package Degradation	Time of initial "pit" (x,y) Rate of pitting (x,y,t)
Cladding Degradation	Time of initial "pin hole" (x,y) Rate of "unzipping" (x,y,t)
Waste Form Degradation	Waste form surface in contact with water (x,y,t) Degradation rate (x,y,t,env.)
Radionuclide Mobilization	Form of radionuclides released Radionuclide solubility (t,env.)
EBS Transport	Colloid concentration Retardation in EBS (t) Advection/diffusion through EBS (t)

Near-Field Thermohydrologic Model Issues

Issues	Approach to Address
Pre-emplacement hydrogeology	
Percolation flux	Range of reasonable percolation fluxes derived from UZ flow model and expert elicitation
Matrix / fracture properties	Range of reasonable "calibrated" alternative conceptual models considered
Seepage flux	Variability derived by drift-scale models and expert elicitation
Thermal design	Reference VA design is focus, but options carried

Near-Field Thermohydrologic Model Issues
(Continued)

Issues	Approach to Address
Thermal load variability	Analyses for three "representative" thermal outputs – High (18 kW/WP) – Med (10 kW/WP) – Low (2 kW/WP)
Thermohydrologic characteristics of backfill and invert	Use laboratory and literature data with uncertainty
"Validity" of thermohydrolgic model	Range of reasonable models considered (on-going testing to increase confidence)

Near-Field Thermochemical Model Issues

Issues	Approach to Address
Pre-emplacement hydrochemistry	Reasonable range of bulk compositions based on model of water-rock interactions (dominantly J-13)
Perturbed hydrochemistry during thermal phase	Sensitivity study of alteration of aqueous geochemistry
Hydrochemical reaction with liner	Model prediction of range of key geochemical parameters that impact waste package degradation

Near-Field Thermochemical Model Issues

(Continued)

Issues	Approach to Address
Hydrochemical reaction with waste package	Model prediction of range of key geochemical parameters that impact waste form degradation or radionuclide solubility
Hydrochemical reaction with waste form	Model prediction of range of key geochemical parameters that impact radionuclide solubility
Hydrochemical reaction with invert	Model prediction of range of key geochemical parameters that impact radionuclide retardation

Waste Package Degradation Model Issues

Issues	Approach to Address
Waste package design	Reference design is focus, but options carried
Percent of package surface in contact with seep	Dependent on probability of seep and degradation model of dripshield and/or ceramic coating derived from literature and expert elicitation
Degradation rate of corrosion-allowance material	Rate model based on literature, lab data and expert elicitations as a function of key environmental parameters (RH, T, pH, Cl....). Variability treated stochastically

Waste Package Degradation Model Issues
(Continued)

Issues	Approach to Address
Enhanced degradation rate at welds or by MIC	Rate increase from expert elicitation
Galvanic protection of corrosion-resistant material	Variable degrees of galvanic protection (e.g. throwing power) derived from expert elicitation. Variability treated stochastically
Degradation rate of corrosion-resistant material	Rate model a function of environment derived from laboratory and literature data and expert elicitation. Variability treated stochastically

Waste Form Degradation Model Issues

Issues	Approach to Address
Cladding degradation rate	Degradation model tied to mechanistic (lab- and empirical-based) data and industry information
Waste form surface in contact with water film	Derived from cladding degradation and "unzipping," laboratory information on surface area expansion and model results on in-package hydrology (saturation, RH)
Water film thickness	Derived from model results of in-package hydrology
Waste form degradation rate	Functional relationship (dependent on chemistry, temperature, burn-up) derived from laboratory data

Radionuclide Mobilization Model Issues

Issues	Approach to Address
Form of radionuclides released from waste form (including colloids)	Derived from laboratory and literature data
Solubility of radionuclides	Derived from laboratory data with functional relationships

EBS Transport Model Issues

Issues	Approach to Address
Effective diffusion through degraded waste package	Diffusion dependent on lab-derived diffusion coefficients and predicted waste package degradation
Advection through waste package	Use models relating advective flux to in-drift seepage and pit distribution
Radionuclide retardation in degraded waste package/invert materials	Changes in geochemistry used to define change in solubility and sorptive properties derived from laboratory data

EBS Transport Model Issues
(Continued)

Issues	Approach to Address
Diffusion through degraded invert	Use liquid saturation in degraded invert combined with laboratory data on effective diffusion coefficient
Advection through degraded invert	Derived from seepage flux in drift-scale flow model

Conclusions

- Previous TSPA studies have been used to identify significance of key issues in EBS models to predicted performance
- Currently addressing these issues within the TSPA-VA
- Expert elicitation will assist in quantifying uncertainty and variability in some key aspects of the waste package degradation model
- Additional testing and model development and substantiation will occur between VA and LA