SIGNIFICANCE OF RADIONUCLIDE TRANSPORT PROCESSES TO PERFORMANCE ASSESSMENT:

The Affect of Time and Alternate Thermal Management Strategies

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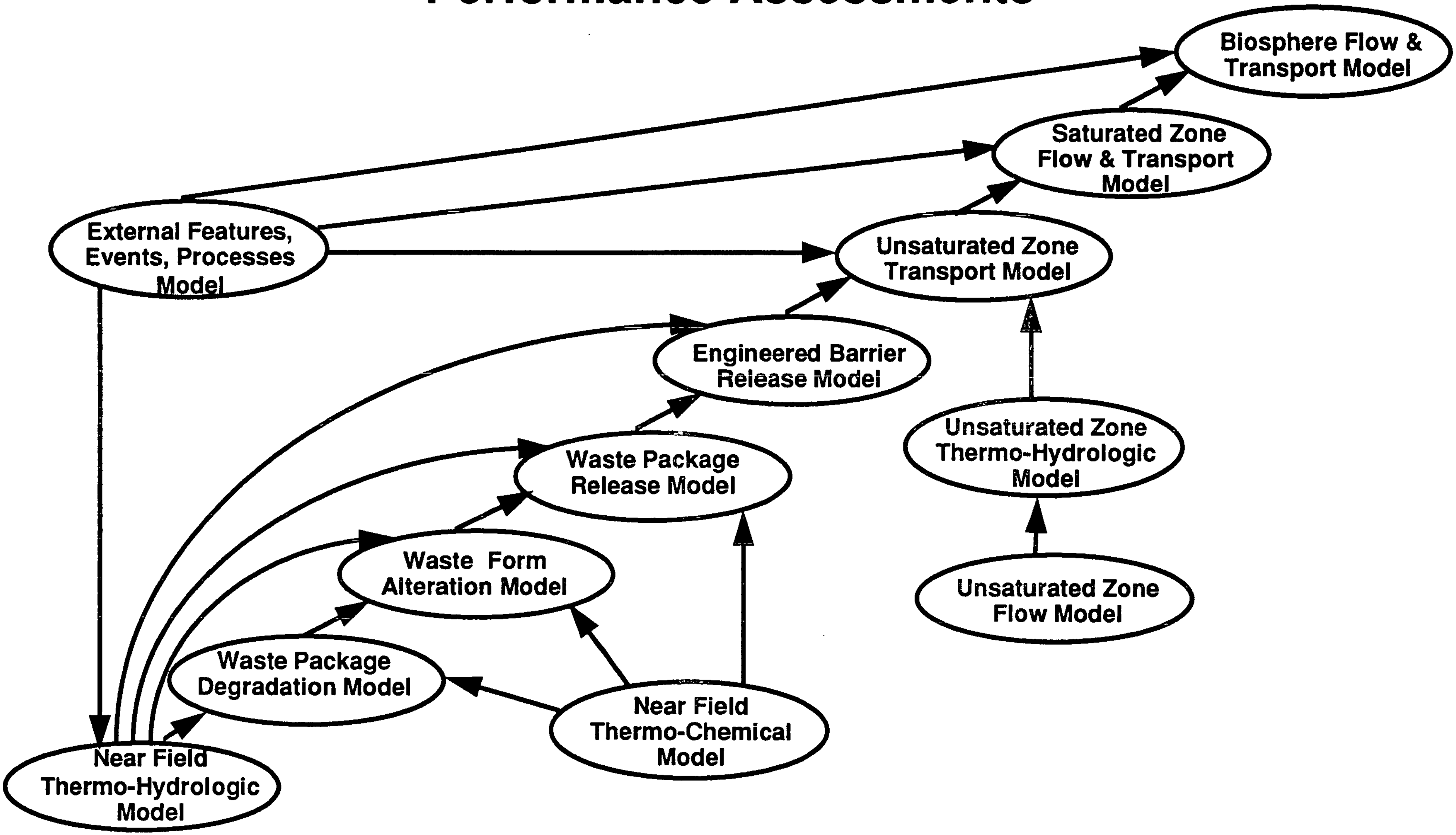
Outline

- Relevant radionuclide transport domains and processes at Yucca Mountain
- Relative significance of radionuclide transport processes over different time periods and alternate measures of performance
- Possible effects of increased temperatures on radionuclide transport processes
- Relative significance of thermal management strategy on radionuclide transport processes

Influence Diagram for Integrated Total System Performance Assessments



Relevant Radionuclide Transport Domains and Processes

Processes	Waste Package/ EBS	UZ Gaseous	UZ Aqueous	SZ Aqueous	Biosphere
	Domains				
Waste form dissolution	✔				
Solubility limits	✔				
Diffusion	✔				
Advection	✔	✔	✔	✔	✔
Retardation	✔	✔	✔	✔	✔
Dispersion			✔	✔	
Matrix diffusion			✔	✔	

Relative Significance of Radionuclide Transport Processes from RIP TSPA-1993

- **Function of:**
  - time period considered
  - performance measure considered
    - » integrated cumulative release
    - » peak dose or concentration
- **Depends on fundamental assumptions used in analyses, e.g.:**
  - definition of waste package “failure”
  - water contact mode or percent of waste form surface exposed and wetted
  - fracture-matrix interaction
  - “minimum” Kd strategy

Relative Significance of Radionuclide Transport Processes Over Different Time Periods: Cumulative Release

	10,000 years		100,000 years	1,000,000 years
	Gaseous	Aqueous		
Dominant Radionuclides	C-14	Tc-99	C-14 Tc-99	C-14 Tc-99 Np-237
Key Transport Processes	WP "failure" SF dissolution	WP "failure" SF dissolution UZ aqueous flux UZ dispersion Matrix imbibition/ diffusion	WP "failure" SF dissolution EBS diffusion	SF dissolution Np solubility
Less Significant Processes	Gas transport		UZ aqueous flux	EBS diffusion UZ aqueous flux Np retardation
Insignificant Processes	UZ aqueous flux EBS diffusion		UZ dispersion	UZ dispersion Matrix imbibition/ diffusion

Relative Significance of Radionuclide Transport Processes Over Different Time Periods: Peak Individual Dose

	10,000 years	100,000 years	1,000,000 years
Dominant Radionuclides	Insignificant (μ rem/yr)	Tc-99 I-129	Tc-99 I-129 Np-237
Key Transport Processes	WP "failure" SF dissolution EBS diffusion	SF dissolution EBS diffusion UZ aqueous flux Np retardation	SF dissolution Np solubility
Less Significant Processes	UZ aqueous flux UZ dispersion Matrix imbibition/ diffusion		EBS diffusion UZ aqueous flux Np retardation
Insignificant Processes	"Minimum" Kd	WP "failure" UZ dispersion Matrix imbibition/ diffusion	WP "failure" UZ dispersion Matrix imbibition/ diffusion

Possible Effects of Increased Temperatures on Radionuclide Transport Processes

- **Modifications in source term**
  - delays initiation of aqueous corrosion
    - » function of humidity/temperature
    - » above ca. 300 C increase oxidation rate of mild steel
  - once aqueous corrosion is initiated (ca. 95 C), increased temperature:
    - » increases corrosion rate (factor 2 to 3)
    - » increases dissolution rate (factor 2 to 3)
    - » increases/decreases nuclide solubility (factor 2 to 5)
    - » increases $^{14}CO_2$ release

Possible Effects of Increased Temperatures on Radionuclide Transport Processes

- Modifications in transport through waste package/EBS
  - decreases average advective flux towards/through repository (?heterogeneity effects)
  - decreases water saturation and diffusive transport through capillary barrier
- Modifications in gas transport in geosphere
  - increases gas phase advective flux
  - increases gaseous component of carbon (i.e., CO_2 versus HCO_3)
- Modifications in aqueous transport in geosphere
  - initially, drive moisture (liquid and vapor) away from repository
  - with time, moisture (liquid and vapor) return to repository
  - possibility of refluxed water causing local saturated conditions and therefore potential for fracture flow
  - enhance sorptive capacity
  - modify liquid saturation and effective transport porosity

Thermo-Hydrologic Perturbations Included in RIP TSPA-1993

- Delay initiation of aqueous corrosion processes
- Modify aqueous corrosion rates for mild steel and Alloy 825
- Modify spent fuel and glass alteration rates
- Modify radionuclide solubilities
- Modify water content and diffusion coefficient in EBS
- Modify gas-phase velocities and $^{14}CO_2$ retardation and travel times

- Did *not* include modified aqueous geosphere flux

Consequences of Thermo-Hydrologic Perturbations on RIP TSPA-1993 Results

- Higher temperatures delay corrosion initiation by several thousand years (depending on location)
- If waste packages are contacted by moisture and temperatures are below boiling but at higher end of temperature regime (ca. 95 C), corrosion rates are about 2-3 times higher and "failure" times are shorter
- If waste packages have "failed" at these temperatures,
  - dissolution rate is higher and waste package releases are higher for dissolution-limited nuclides
  - solubility limits are higher or lower and waste package releases are higher, lower or unchanged depending on the controlling radionuclide
- EBS diffusion not significantly reduced from ambient due to assumed rock-backfill hydrologic equilibrium

Relative Significance of Thermal Management Strategy on Radionuclide Transport Processes Over Different Time Periods

	10,000 years	100,000 years	1,000,000 years
Key Thermal Effects	Initiation of aqueous corrosion Oxidation rate Corrosion rate EBS water content (diffusion)	EBS water content (diffusion) UZ aqueous flux	
Less Significant Thermal Effects	SF dissolution rate UZ aqueous flux	Corrosion rate SF dissolution rate	
Insignificant Thermal Effects	Rn solubility	Initiation of aqueous corrosion Rn solubility	All

Conclusions

- Results from Performance Assessment help identify relative significance of radionuclide transport processes
- Relative significance depends on:
  - time period of concern
  - performance measure of concern
  - fundamental assumptions (conceptual and parameter) used in analyses
- Relative significance of transport processes is affected by thermal management strategy