Performance Assessment Demonstration: Source Term Model

Presentation to:
Panel on Risk & Performance Analysis
U.S. Nuclear Waste Technical Review Board

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VERTICAL EMLACEMENT
Location of Radionuclides in Spent Fuel and Potential Releases of C-14
(Apted, el. al., 1989)
Release of Dissolved Radionuclides Depends on:

- Water getting into and out of canister
- Dissolution of fuel
- Solubility of released radionuclides
- Formation of colloids (esp. plutonium)
Release of Dissolved Radionuclides

Rate of $\text{UO}_2$ Dissolution

$$\lambda_L = \frac{QfS_u}{M_{ou}}$$

Low-Solubility Radionuclides

High-Solubility Radionuclides
Significant Parameters for Source Term Model

Waste Package Lifetime

- Non-mechanistic
- Assumed normal distribution
  mean = 550 years,
  0.001 fractile = 100 years
  0.999 fractile = 1000 years

Solubility of Fuel Matrix

- Based on conservative range of data on uranium solubility
- Uniformly distributed
  0.0001 to 0.001 gms/ml
Significant Parameters for Source Term Model (Cont.)

Fraction of water contacting waste

- Exposed cross-section = 0.0008
- Most canisters probably dry
- Diversion of flow to some canisters
- Thermally driven circulation
- Assumed uniform distribution 0.002 to 0.01

Radionuclide Solubilities

- Typical of previous DOE studies of YMP
Performance Assessment Demonstration: Sensitivity and Uncertainty Analyses

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Sensitivity and Uncertainty Analyses

Purpose

Determine sensitivity of model output to parameter variations

Demonstrations of:

Ceteris paribus method - change one variable at a time to see effect on CCDF

Regression method - for the entire sampled space, perform multiple linear regression to determine sensitivity

Average contribution to cumulative EPA release by radionuclide over all vectors

Nexus between NRC subsystem requirements and cumulative EPA release
CCDF for Pluvial Scenario

- Pluvial scenario doubles upper limit of infiltration and shortens distance to water table
- Shows high sensitivity to infiltration and shorter path
- Less relative contribution from column D
## REGRESSION OF YMP RESULTS

### Raw Data Sensitivity Coefficients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Base Case 10,000 yr</th>
<th>Base Case 100,000 yr</th>
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</thead>
<tbody>
<tr>
<td>W.P. Lifetime</td>
<td>-0.045</td>
<td>-0.049</td>
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<tr>
<td>Solubility of UO</td>
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<td>0.13</td>
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<tr>
<td>Infiltration Rate</td>
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<td>0.31</td>
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<tr>
<td>Contact Fraction</td>
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<td>0.18</td>
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<tr>
<td>Mean log ksat TSw</td>
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<tr>
<td>Mean log ksat CHnz</td>
<td>-0.14</td>
<td>-0.22</td>
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<tr>
<td>Rd Plutonium</td>
<td>--</td>
<td>0.23</td>
</tr>
<tr>
<td>Correlation Length</td>
<td>0.11</td>
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</tr>
</tbody>
</table>
AVERAGE IMPORTANCE BY RADIONUCLIDE

- Pu-239 and Pu-240 are largest contributors in general
- C-14, Am-241, and I-129 less important
- Results reflect fracture flow
- C-14, I-129, and Tc-99 may be relatively important for no fracture flow
Relationship between EPA Compliance (40CFR191) and NRC Subsystem Requirements (10CFR60)
Figure 3
Base-Case Liquid Pathway Scenario, 10,000 years Effects of Groundwater Travel Time on EPA release R. Codell 12/10/89
Figure 4
Base-Case Liquid Pathway Scenario, 10,000 years
Effects of Release Rate from Engineered Barrier
R. Codell 12/10/89
Figure 2
Base Case Conditional CCDF
10,000 years
R. Codell, 12/9/89

- All Vectors and $10^{-5}$/yr release
- complies with 1000 yr GWTT
- complies with 500 year W.P.