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Contaminant Release from Cementitious Materials: Savannah River Practice

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Salt Lake City

Performance Assessment Community of Practice Technical Exchange Meeting

Modeling the Performance of Engineered Systems for Closure and Near-Surface Disposal

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Overview of Typical Savannah River PA Practice

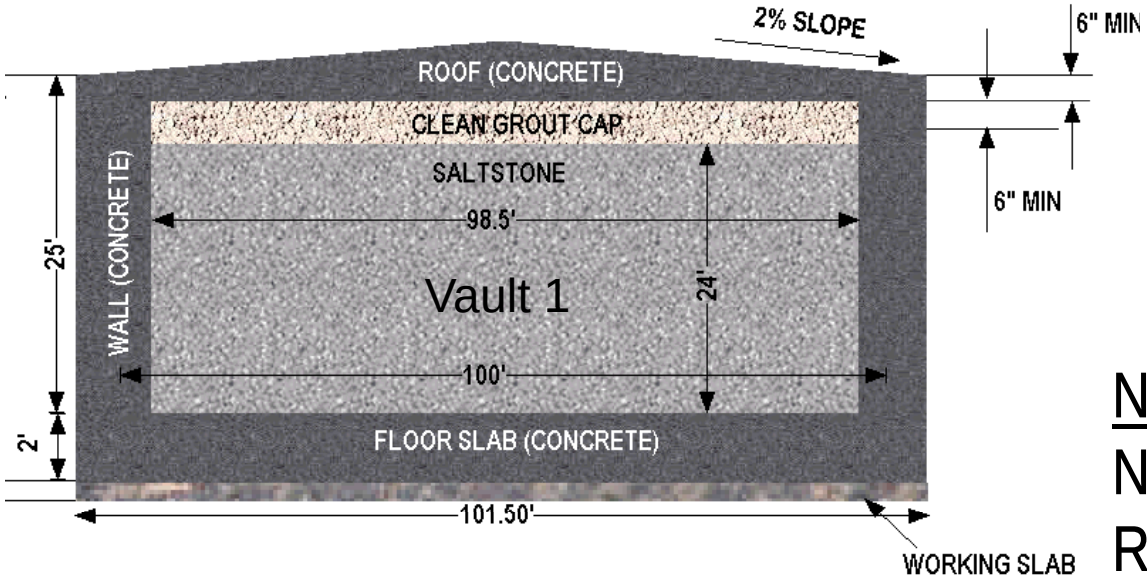
- Chemical equilibrium batch analysis of bulk dissolved species and solid minerals, e.g. The GeoChemist's Workbench
- Key pH and Eh transitions defined in terms of pore volumes flushed
- Timing of transitions defined by flow simulation
- System-level transport simulation using simple Kd / solubility
- Kd and solubility values defined by pH / Eh regime, e.g.
  - Region II versus III in parlance of Bradbury and Sarott (1995)
  - Oxidizing versus reducing conditions

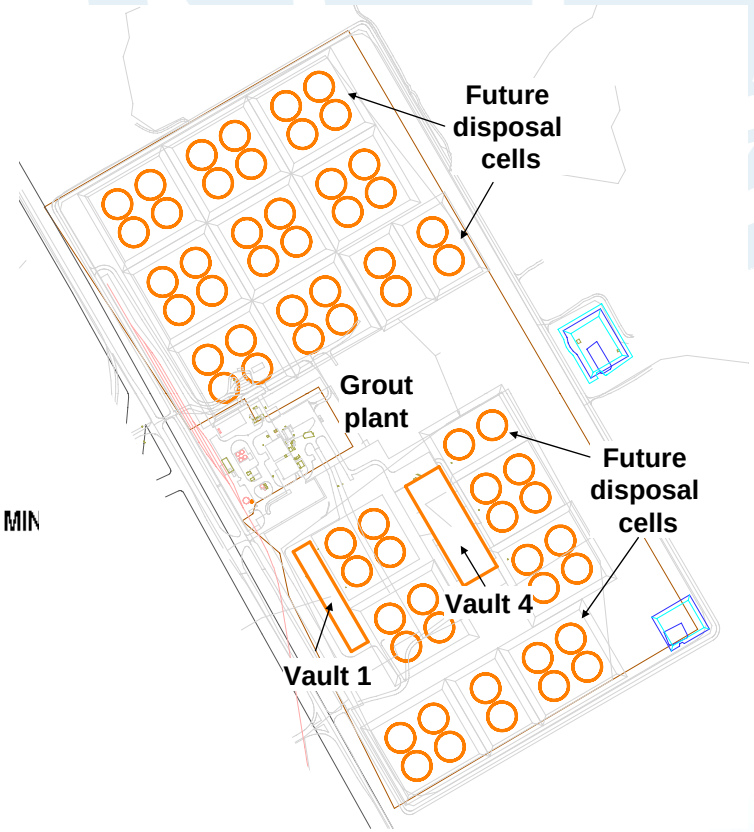
Saltstone Disposal Facility Example

- From 2009 Saltstone PA (draft)
- Contaminant release, except Tc-99
  - from Saltstone grout
  - through vault concrete
- Technetium release
  - shrinking core model of slag reduction capacity

Saltstone Disposal Facility

- Salt liquid waste mixed with dry grout to form "Saltstone"
- Blast furnace slag in Saltstone grout and vault concrete to create reducing conditions





Notable species

Nitrate, Tc-99, I-129 and Ra-226 ingrowth from Th-230

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Saltstone Formulation

Ingredient	Quantity (wt%)
Salt solution (average 28% by weight salts)	47
Blast furnace slag (grade 100 or 120)	25
Fly ash (Class F)	25
Cement (ASTM C 150 Type II) or lime	3

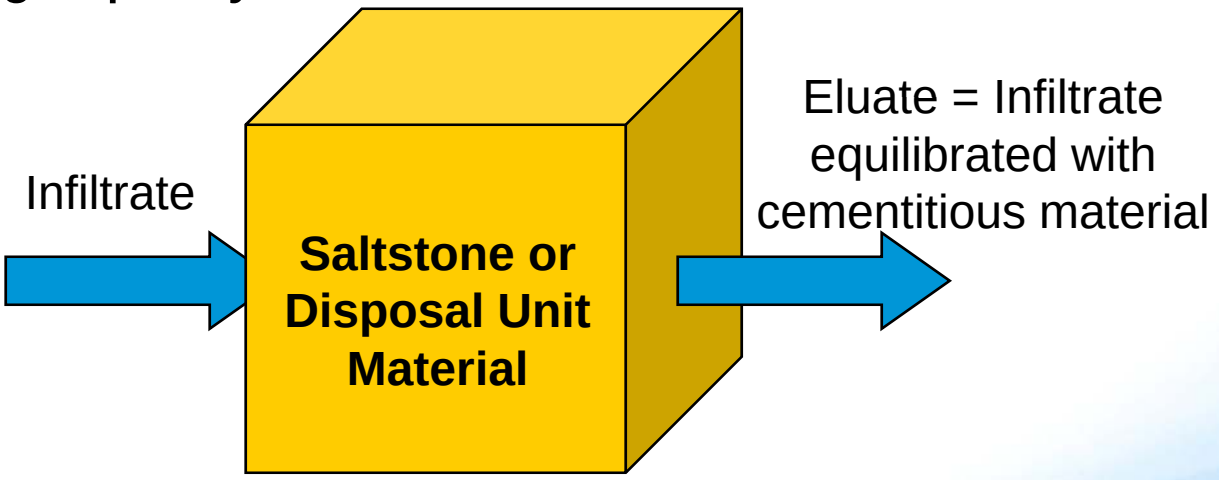
Concrete Formulation - Future Disposal Cells

Ingredient	Quantity (lbs/cu yd)
Type V cement (Lehigh T-V #2 ; ASTM C 150)	213
Grade 100 Blast furnace slag (Holcim Grade 100 Slag; ASTM C 989)	284
Silica Fume (W. R. Grace Silica Fume; ASTM C 1240)	47.3
Type F Fly ash (SEFA Class "F" Fly Ash; ASTM C 618)	165.7
sand (Rinker Aggregates Company - Augusta Sand - Natural Washed Sand); ASTM C 33)	911
aggregate (Rinker Aggregates Company - Dogwood Quarry - #67 Granite; ASTM C 33)	1850
Water (maximum)	269.8
Water (maximum; gal/ cu yd)	32.3
Maximum water to cementitious material ratio	0.38
Grace WRDA 35 (oz/cwt c+p)	5
Grace Darex II (oz/cwt c+p)	0.4 to 0.5
Grace Adva 380 (oz/cwt c+p)	3 to 4
Minimum compressive strength of at 28 days	5000 psig
Slump range/target of before Super-P	1 – 3 inches / 2 inches
Slump range/target of after Super-P	6 – 8 inches / 7 inches

Contaminant Release - except Tc-99

Approach (Miles Denham, SRNL):

- Calculate chemical analysis of saltstone from cementitious components
- Calculate normative mineralogy from chemical analysis and measured reducing capacity
- Use measured porosity
- Use various influent water chemistries



Volume of Infiltrate = Volume of Eluate for Each Step

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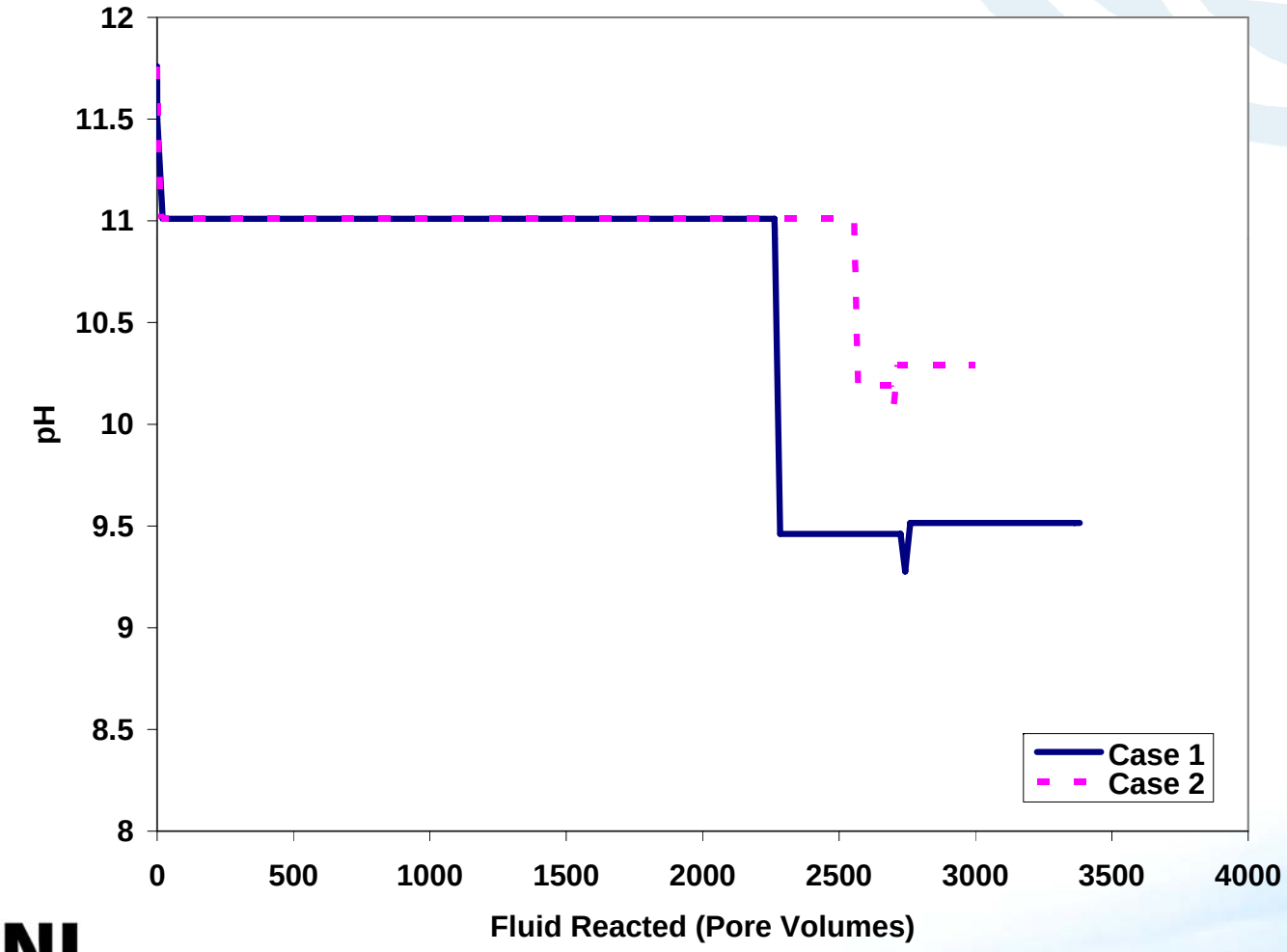
Contaminant Release - except Tc-99

Influent chemistry cases:

- Case 1 – groundwater
  - groundwater has no contact with or is unaffected by vault concrete
- Case 2 – groundwater equilibrated with calcite
  - groundwater flows through highly aged (Bradbury and Sarott Region III) vault concrete
- Case 3 – groundwater equilibrated with CSH
  - Groundwater flows through moderately aged (Bradbury and Sarott Region II) vault concrete

Contaminant Release - except Tc-99

pH results:



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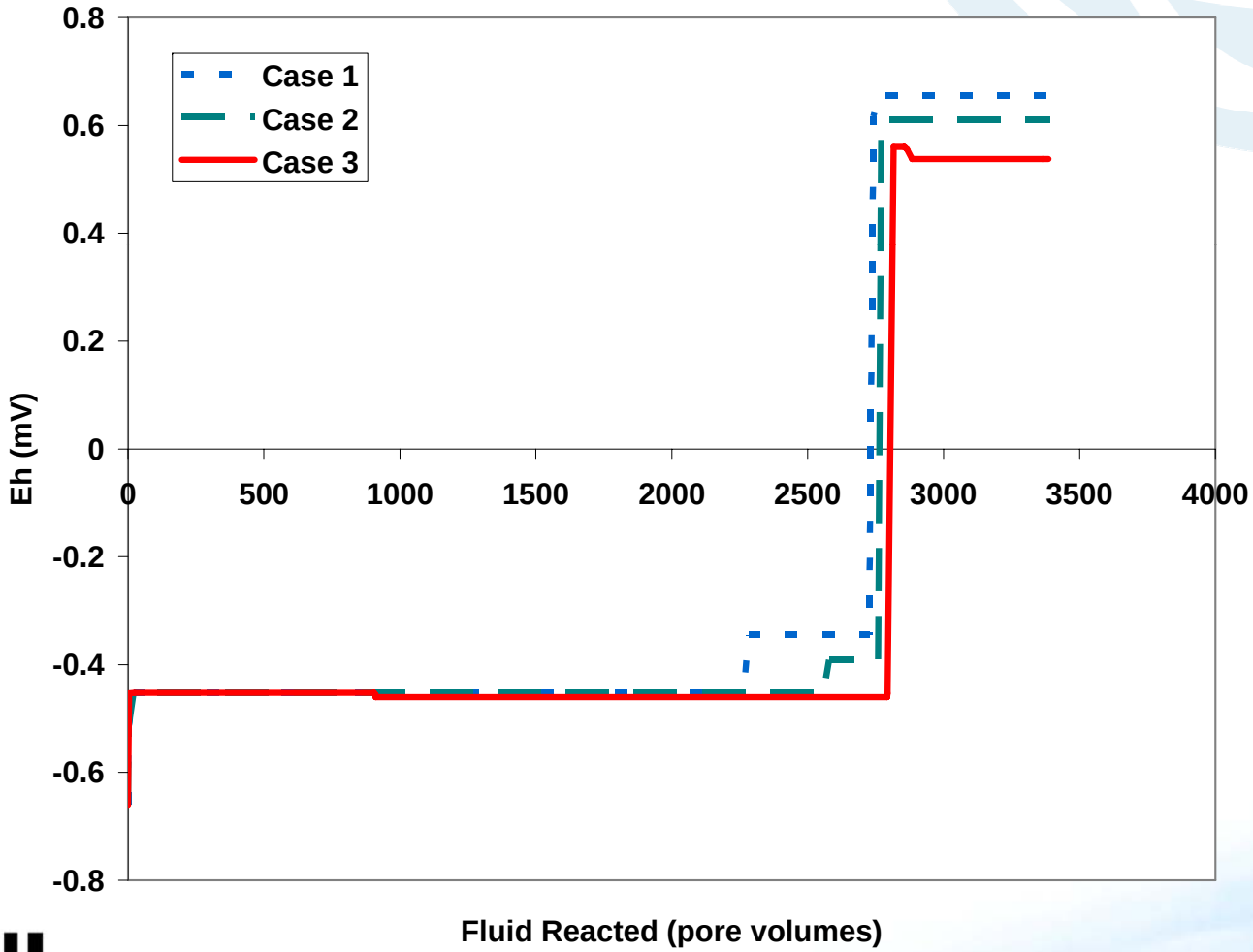
Contaminant Release - except Tc-99

Eh results:



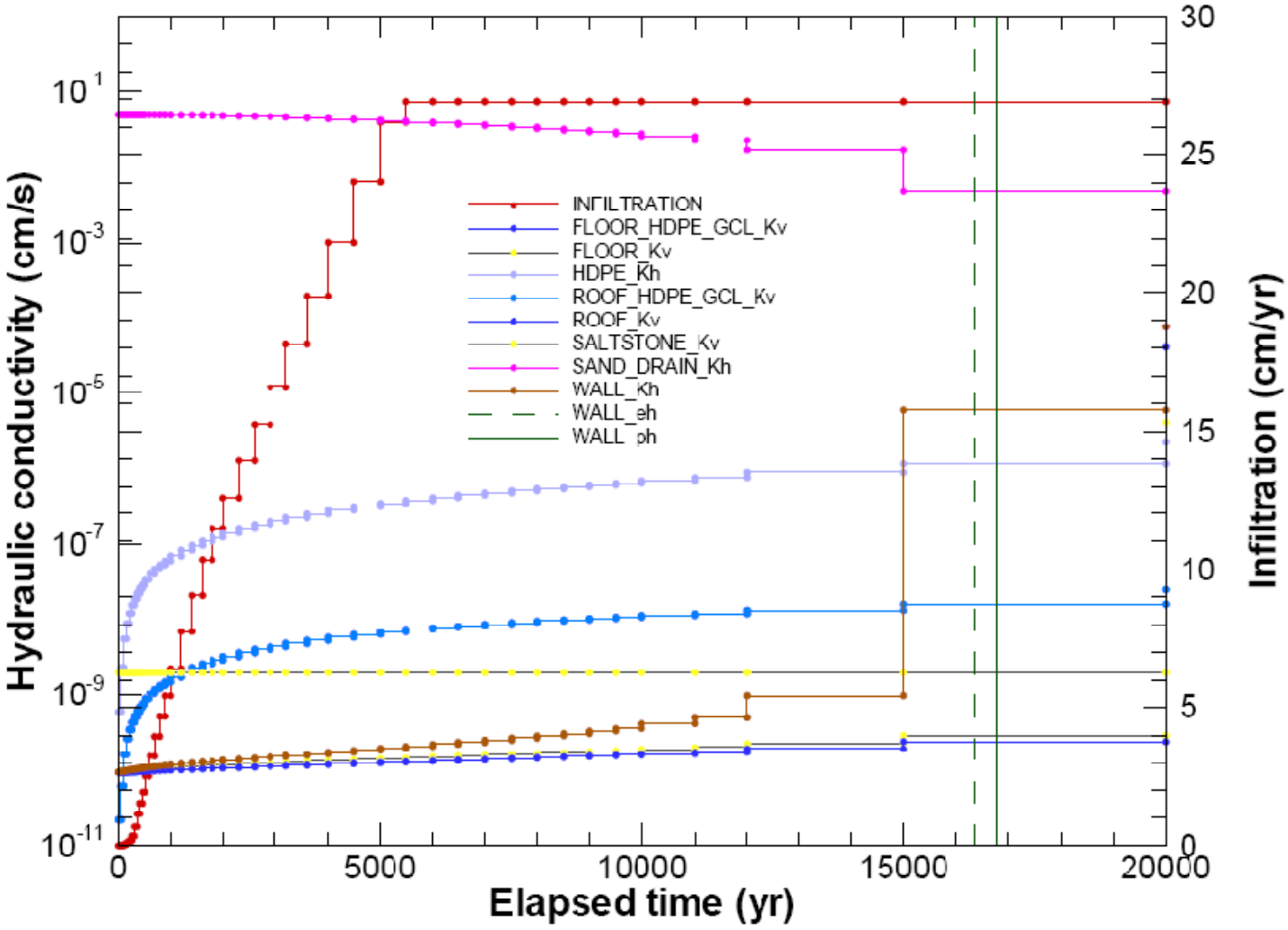
Contaminant Release - except Tc-99

Pore volumes summary:

	Eh Transition		pH Transition	
Case	Pore Volume (unitless)	Value Range	Pore Volume (unitless)	Value Range
Saltstone/fluid=GW (no fluid contact with vault)	2734	-0.45 to +0.66	2274	11.0 to 9.5
Saltstone/fluid=GW+calcite (vault oxidized Region III)	2775	-0.45 to +0.61	2558	11.0 to 10.3
Saltstone/fluid=CW+CSH (vault oxidized (Region II)	2806	-0.45 to +0.56	10422 (extrapolated)	11.0 to ?
Vault 2/fluid=GW	3230	-0.46 to +0.57	4206 (extrapolated)	11.0 to ?

Contaminant Release - except Tc-99

Timing:



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Contaminant Release - Tc-99

Shrinking core model with three species:

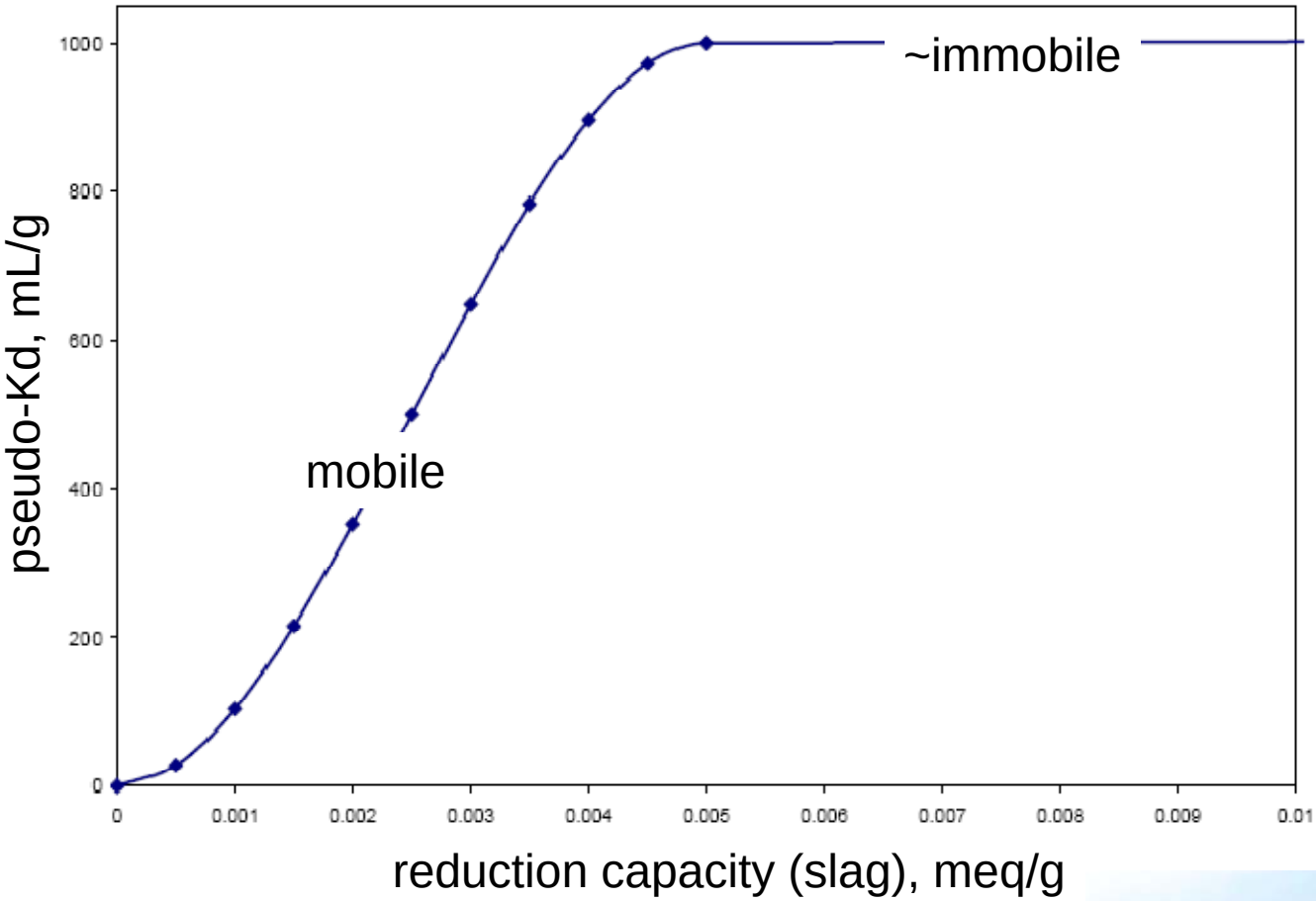
- Slag (solid phase)
- Oxygen (liquid phase)
- Tc-99 (liquid phase)

Reduction and oxidation capacities:

- Saltstone grout = 0.82 meq/g
- Vault concrete = 0.24 meq/g
- Dissolved oxygen concentration = 1.06 meq/L

Contaminant Release - Tc-99

Tc-99 mobility controlled by pseudo-Kd function:



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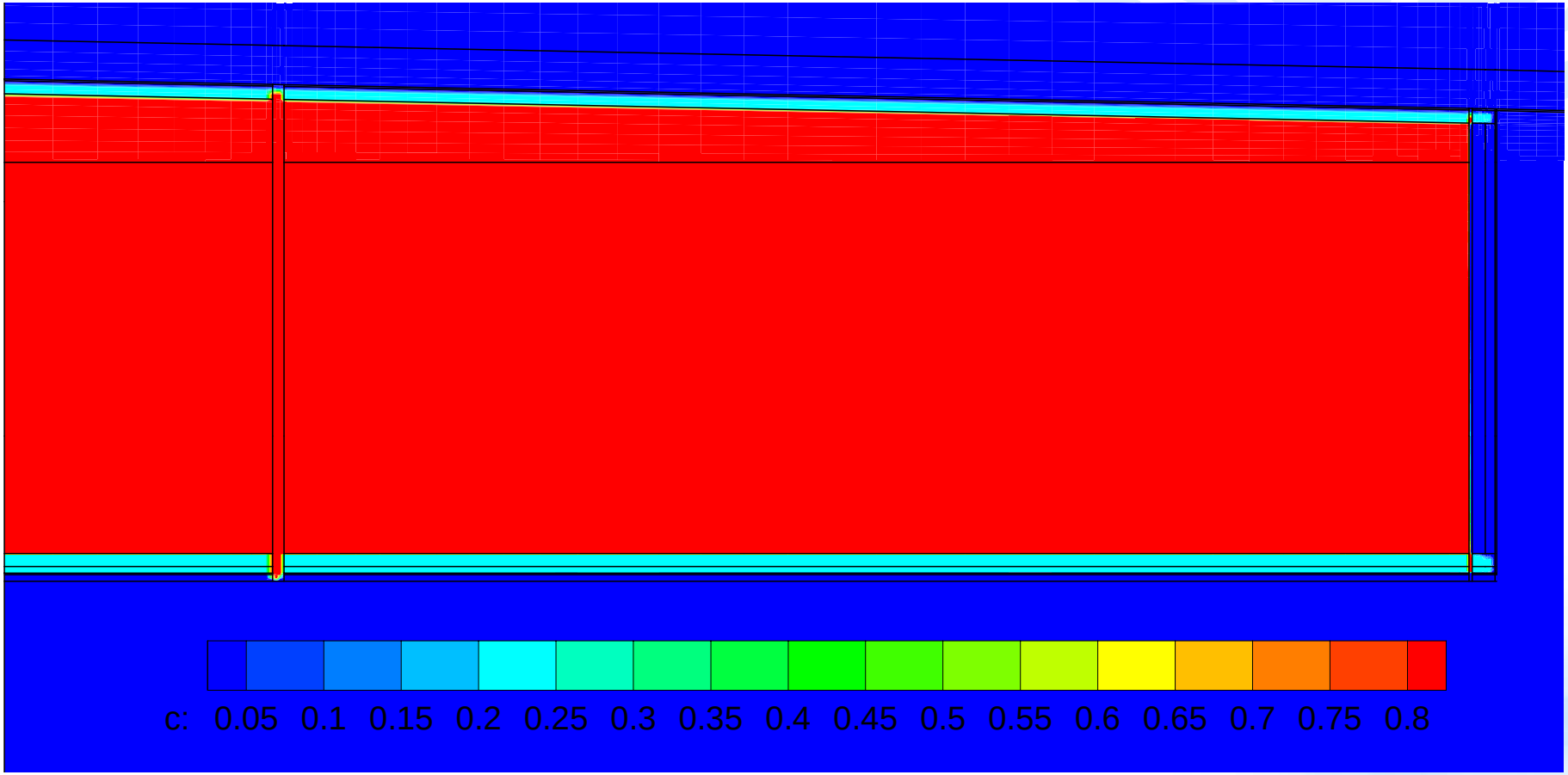
Contaminant Release - Tc-99

Shrinking core model:

Reduction capacity at 20k years



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Opportunities for Improvement?