Multiple Tracer Testing Approaches for Improved Groundwater Flow and Reactive Transport Modeling Input Parameters

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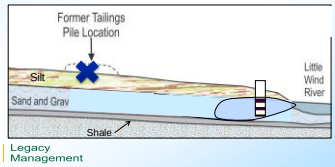
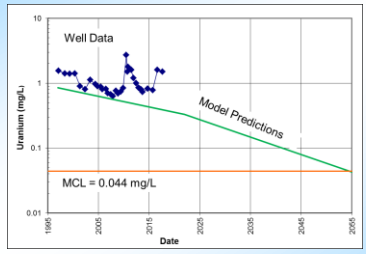
Uranium Ore-Processing Sites Past Modeling of Natural Flushing

- Tailings have been removed, assumed source removed
- Contaminant plume in alluvial sands and gravels, assumed limited attenuation (uranium moving only slightly slower than groundwater flow rates)
- Examples: Rifle, Riverton, Grand Junction, Naturita, etc.

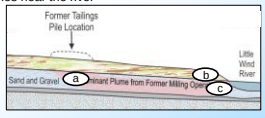


Actual Data Compared to Model Predictions

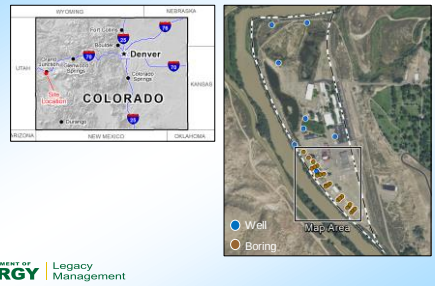


New Data (20+ Years of Hindsight)

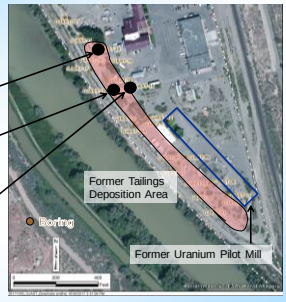
- Natural flushing not occurring as previously modeled
  - Persistent secondary sources
- Solid-phase uranium sources that were not accounted for in prior modeling, related to:
  a) Precipitates with associated uranium below the former tailings
  b) Evaporites above the water table due to plume wicking into the silt
  c) Organic zones near the river



Grand Junction, Colorado, Site



Three Areas for Tracer Testing



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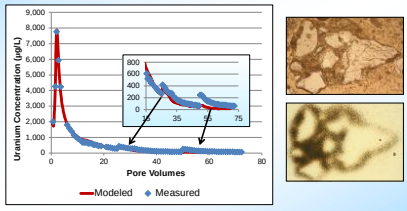
Column Test Results and Modeling

- Key processes: dual porosity, sorption, and mineral dissolution



Stop-flow U increase and fission-track radiography indicates the need to consider dual porosity

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Tracer Testing Objectives

- Evaluation of tracer testing methods to better understand contaminant release and transport processes at the field scale related to plume persistence
- Provide data for revising site conceptual models and estimating reactive transport modeling parameters
- Compare field-scale uranium release and transport process parameters with those derived from existing column tests
- Ultimate goal: improved predictions of contaminant transport (especially uranium)
- Approach is applicable at other sites, but first use Grand Junction site as a demonstration

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Tracer Testing Methods and Derived Data

- Borehole dilution
  - Groundwater flow velocity and direction, vertical stratification
- Saturated zone push-pull test (single well injection and extraction)
  - Dispersion, dual porosity, adsorption/desorption
- Saturated zone cross-hole test (inject in one well and extract from another well)
  - Same as push-pull test plus mineral precipitation/dissolution
- Unsaturated zone infiltration with saturated zone cross-hole test
  - Adds data on unsaturated zone release rates/processes

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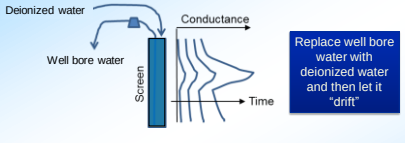
Borehole Dilution



Replace well bore water with deionized water and then let it "drift"

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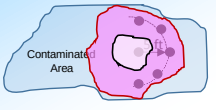
Push-Pull



"Push" river water with tracers, followed by river water without tracers, could allow for some "drift" time. Then "pull" it all back.

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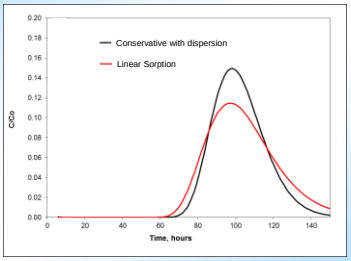
Dispersion and Sorption Influence

- Five-hour injection, 45-hour chase, two-hour drift



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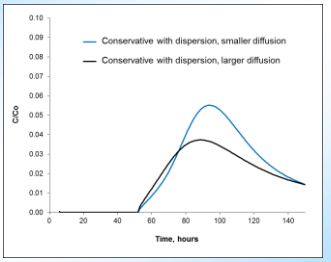
Dual Porosity Influence

- Five-hour injection, 45-hour chase, two-hour drift



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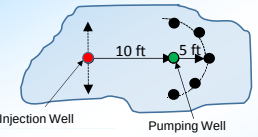
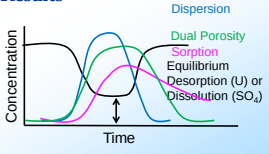
Cross Hole

Use borehole dilution results to align injection well with groundwater flow direction



Theoretical Results

With pumping longer than injection



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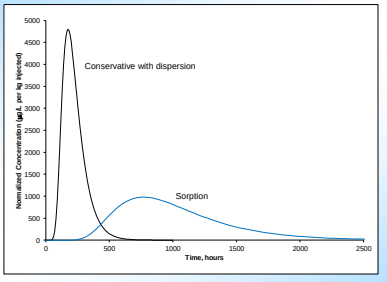
Dispersion and Sorption Influence



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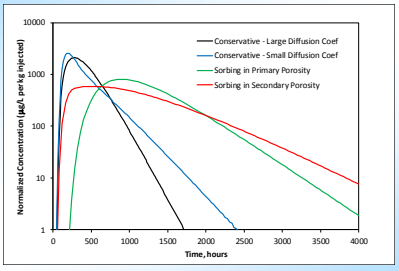
Dual Porosity and Sorption Influence



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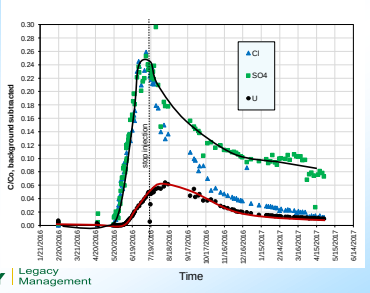
Example Data (Injecting Cl, SO_4, and U)



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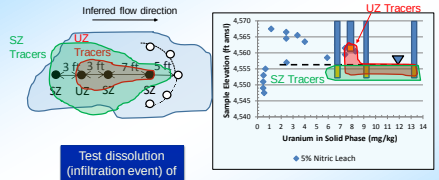
Evaporite Site with Unsaturated Zone (UZ) and Saturated Zone (SZ) Tracer Test



Test dissolution (infiltration event) of evaporites that have greater uranium concentration

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Summary and Conclusions

- Goal: improved predictions of contaminant transport
- Need to revise past conceptual and numerical models with new information
- Column testing and modeling indicates need for dual porosity, sorption, and mineral dissolution processes
- Multiple tracer testing approaches are proposed to test multiple processes at the field scale
- Tracer testing results will be used to revise or develop new input parameters for predictions (reactive transport modeling)
- Stay tuned for Grand Junction site results next year

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