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Characterization Approaches for Radionuclide-Contaminated Subsurface Sites

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Outline

- Conceptual model framework
- Characterization for factors controlling fate and transport and remedy selection
  - Vadose Zone
    - Disposal chemistry affects
    - Transport factors
  - Groundwater
    - Speciation and biogeochemistry
    - Secondary sources
    - Groundwater dynamics
    - Natural attenuation processes
- Conclusions

Conceptual Model Framework

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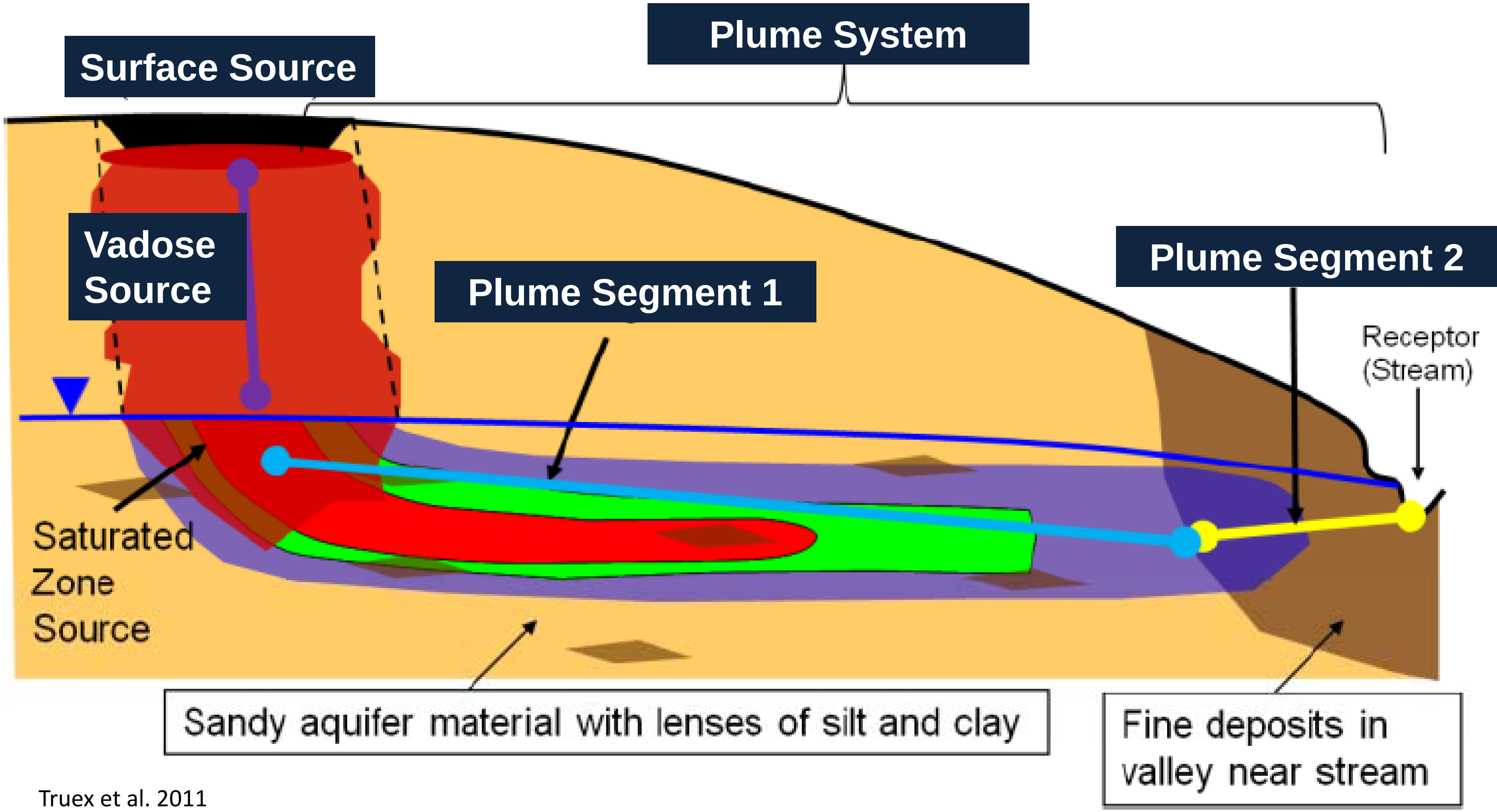
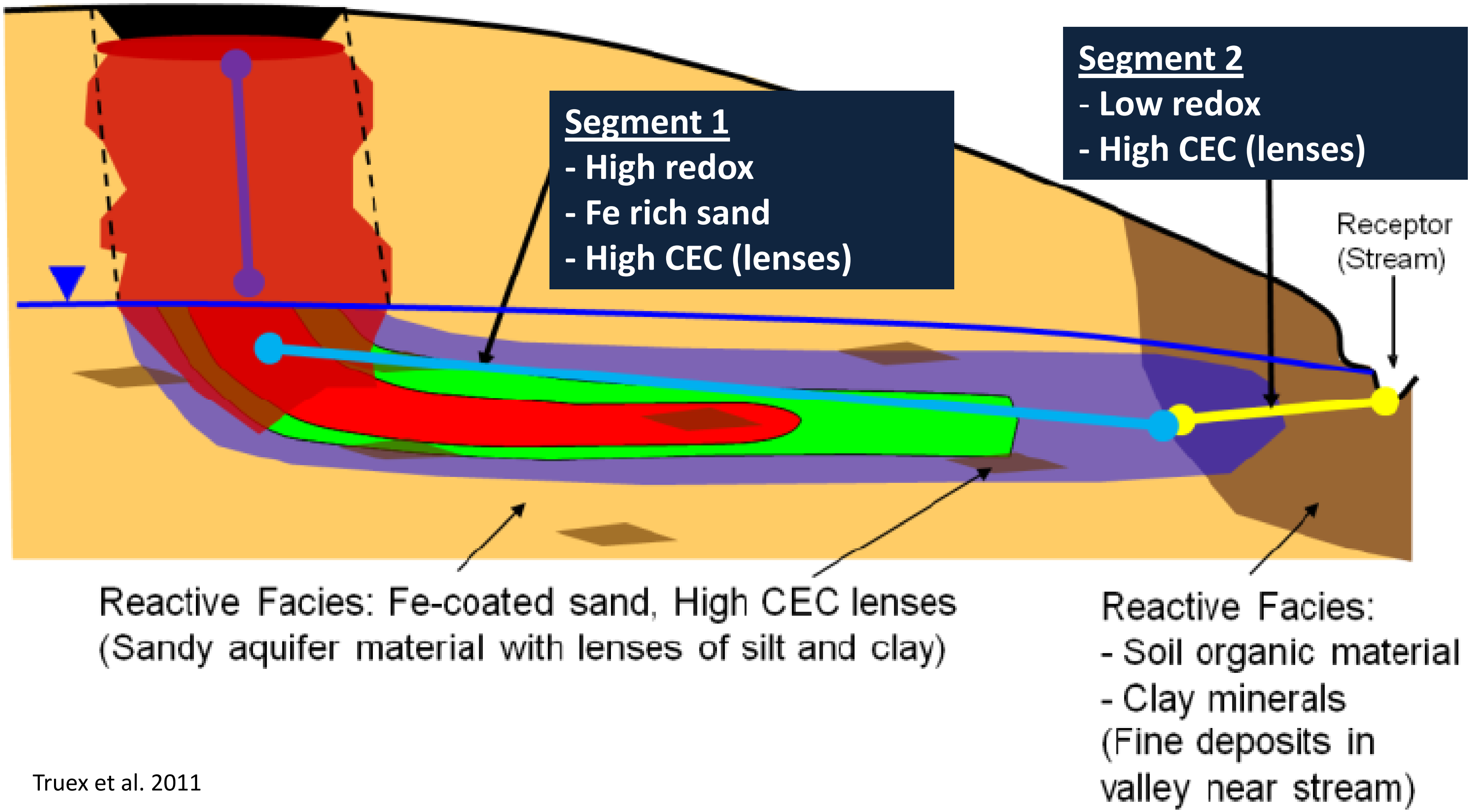


Truex et al. 2011

Conceptual Model Framework



Truex et al. 2011

Vadose Zone Elements

- Disposal Chemistry
  - Co-contaminants and other characteristics of the disposed waste may impact transport for the contaminant of interest. These effects may be most intense near the disposal location (vadose zone).
- Transport Factors
  - For surface waste disposal, transport of contaminants through the vadose zone affects the nature of the source to groundwater.

Disposal Chemistry

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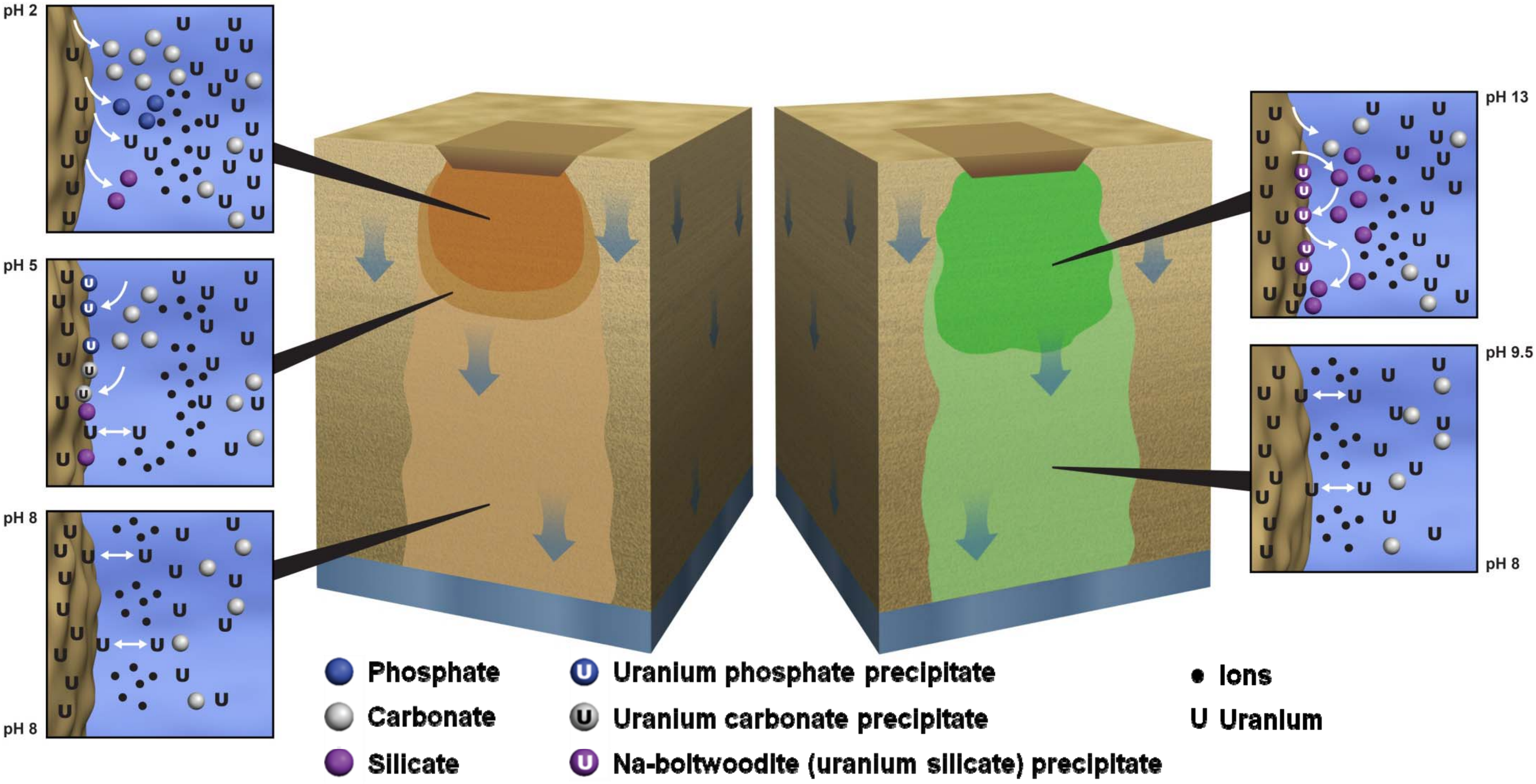

Szecsody et al. 2013
Truex et al. 2014

Disposal Chemistry

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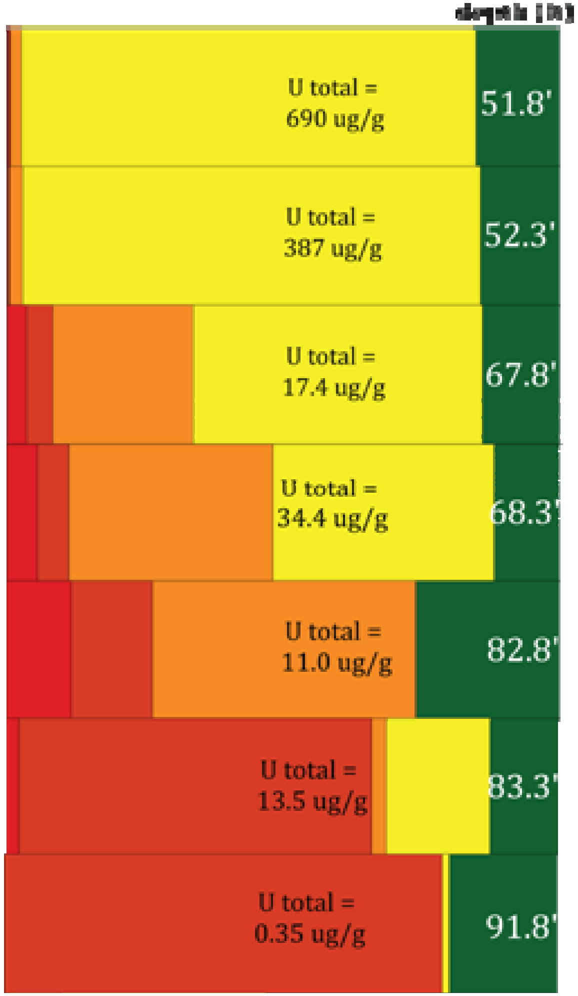
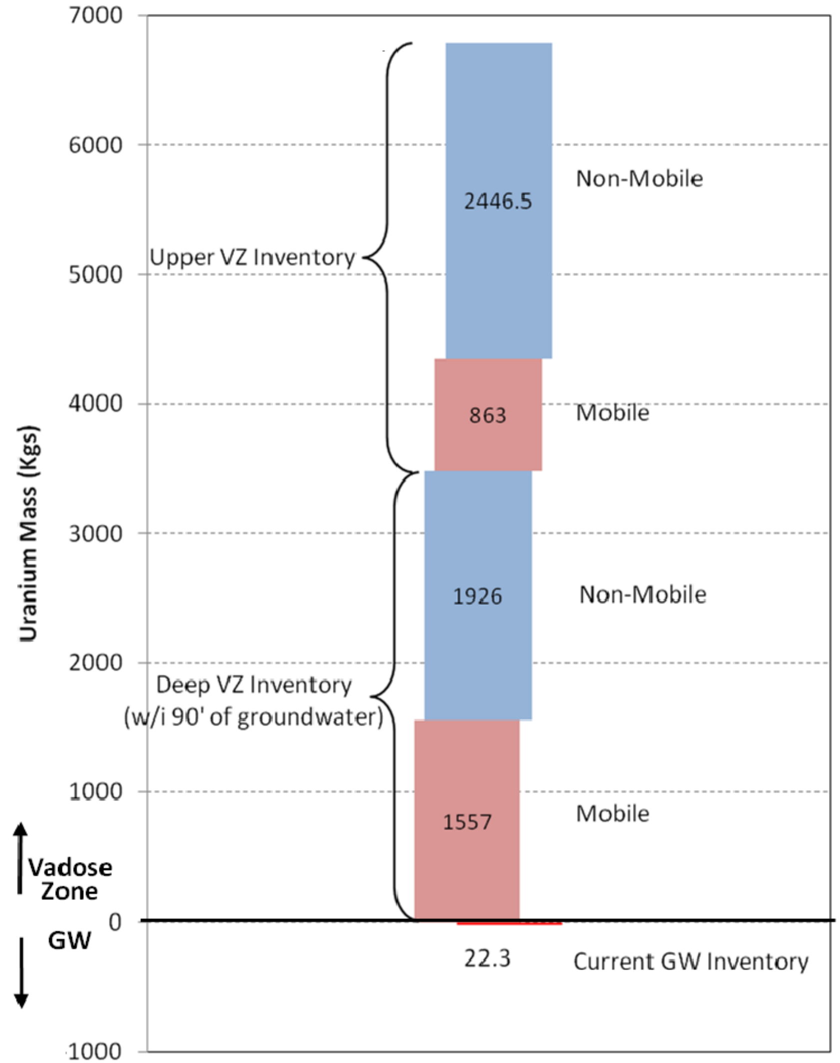
Extraction Solution	Hypothesized targeted sediment components	Interpreted uranium mobility of extracted fraction	Color Code
1. Aqueous: uncontaminated Hanford groundwater	Uranium in pore water and a portion of sorbed uranium	Mobile phase	
2. Ion Exch.: 1M Mg-nitrate	Readily desorbed uranium	Readily mobile through equilibrium partitioning	
3. Acetate pH5: 1 hour in pH 5 sodium acetate solution	Uranium associated with surface exposed carbonate precipitates, including uranium carbonates, or other readily dissolved precipitates	Moderately mobile through rapid dissolution processes	
4. Acetate pH 2.3: 1 week in pH 2.3 acetic acid	Dissolution of most carbonate compounds, including uranium carbonates, and sodium boltwoodite	Slow dissolution processes are associated with uranium release from this fraction such that uranium mobility is low with respect to impacting groundwater	
5. 8M HNO_3: 2 hours in 8M nitric acid at 95°C	Dissolution of most minerals expected to contain uranium, considered to represent total uranium extraction for this study[1]	Very slow dissolution processes are associated with uranium release from this fraction such that uranium mobility is very low with respect to impacting groundwater	

Szecsody et al. 2010, 2012

Disposal Chemistry





Serne et al. 2010

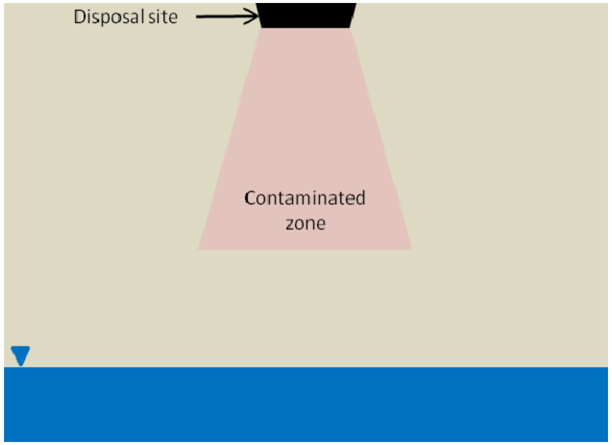
Szecsody et al. 2010

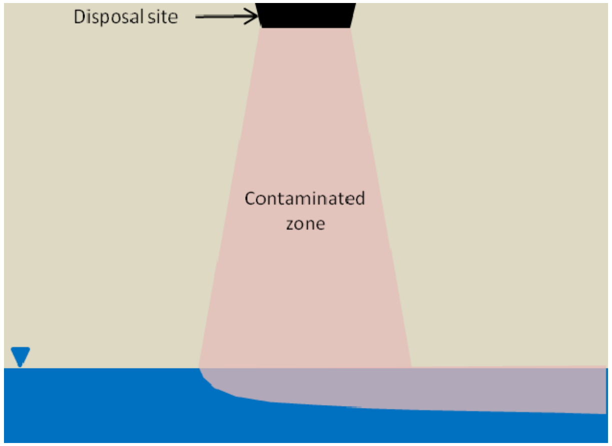
Evaluation of VZ Transport

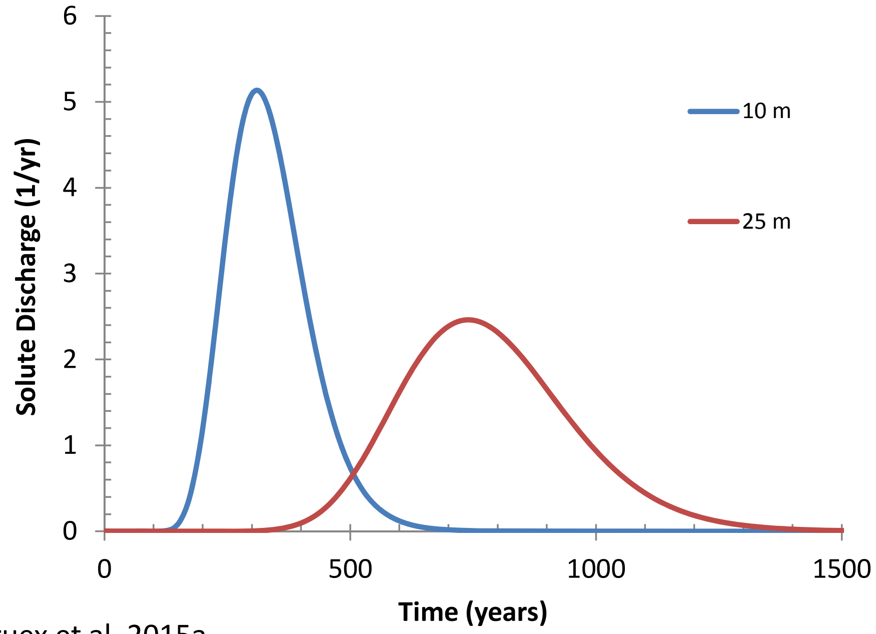
- There are characteristic behaviors that are useful in assessing the nature of contaminant transport from aqueous waste disposal/leaks to the vadose zone.
- There are two primary categories of transport behavior
  - Category I: small volume disposed compared to vadose zone thickness
  - Category II: large volume disposed compared to vadose zone thickness

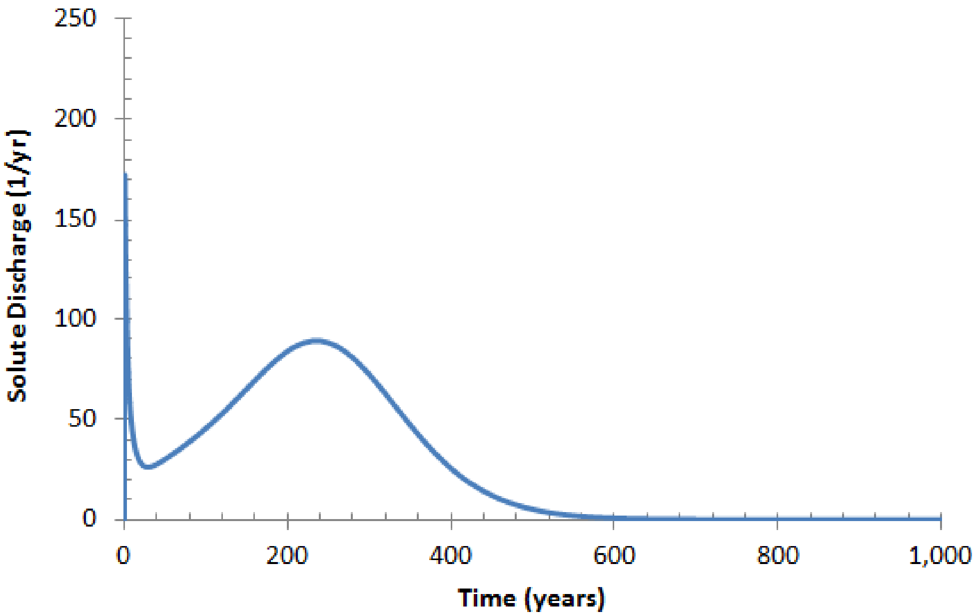
Category I

Category II



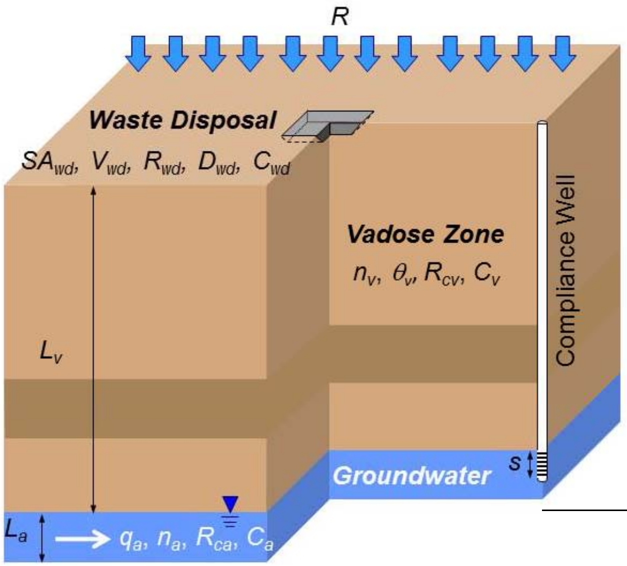






Truex et al. 2015a

Analysis/Characterization Framework

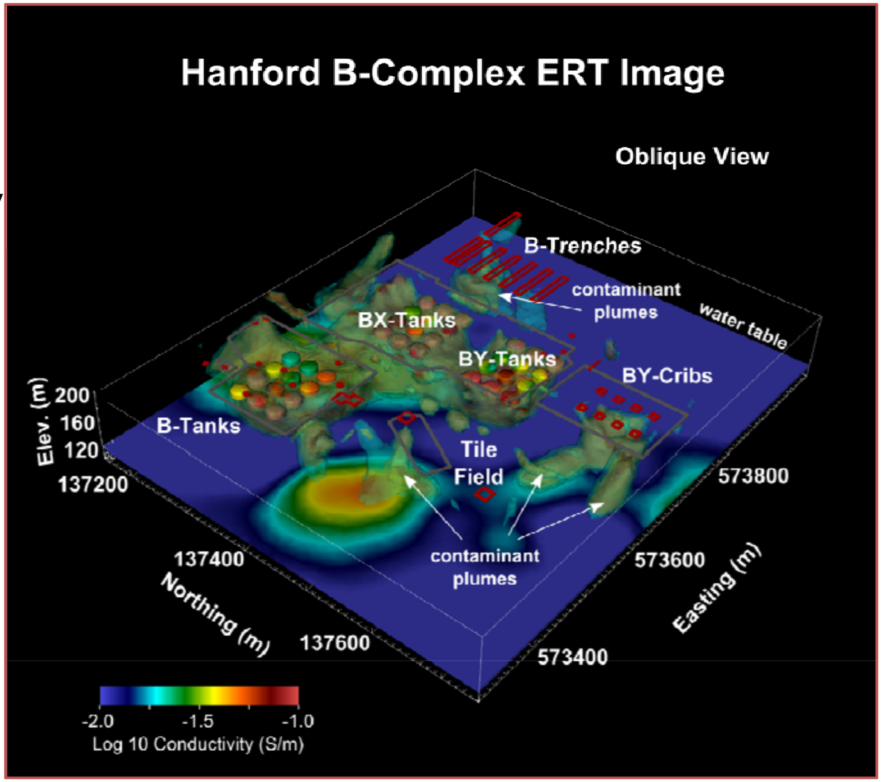


Vadose Zone Parameters	Waste Disposal Parameters	Groundwater Parameters
Thickness (L_v)	Aqueous volume (V_{wd})	Groundwater Darcy flux (q_a)
Recharge rate (historical, current, and estimated future rates) (*R*)	Disposed mass (M_{wd})	Contaminant mixing thickness in aquifer (L_a)
Porosity (n_v)	Rate of waste disposal (R_{wd})	Monitoring well screen length for compliance (*s*)
Contaminant retardation coefficient (R_{cv})	Contaminant concentration (C_{wd})	Porosity (n_a)
Current vertical distribution of contamination	Surface area of aqueous disposal (SA_{wd})	Contaminant retardation coefficient (R_{ca})
Moisture content profile (θ_v)	Acidity or alkalinity of the waste	
	Ionic strength and co-contaminants/species in the waste	
	Timing of waste disposal	

Truex et al. 2015a

Evaluation of VZ Transport

- Contaminant Distribution Characterization Tools
  - Geophysical logging
    - Spectral gamma log
    - Neutron moisture log
  - Borehole sediment samples
  - Geophysics
    - Electrical Resistivity Tomography



Johnson and Wellman 2013

Groundwater Elements

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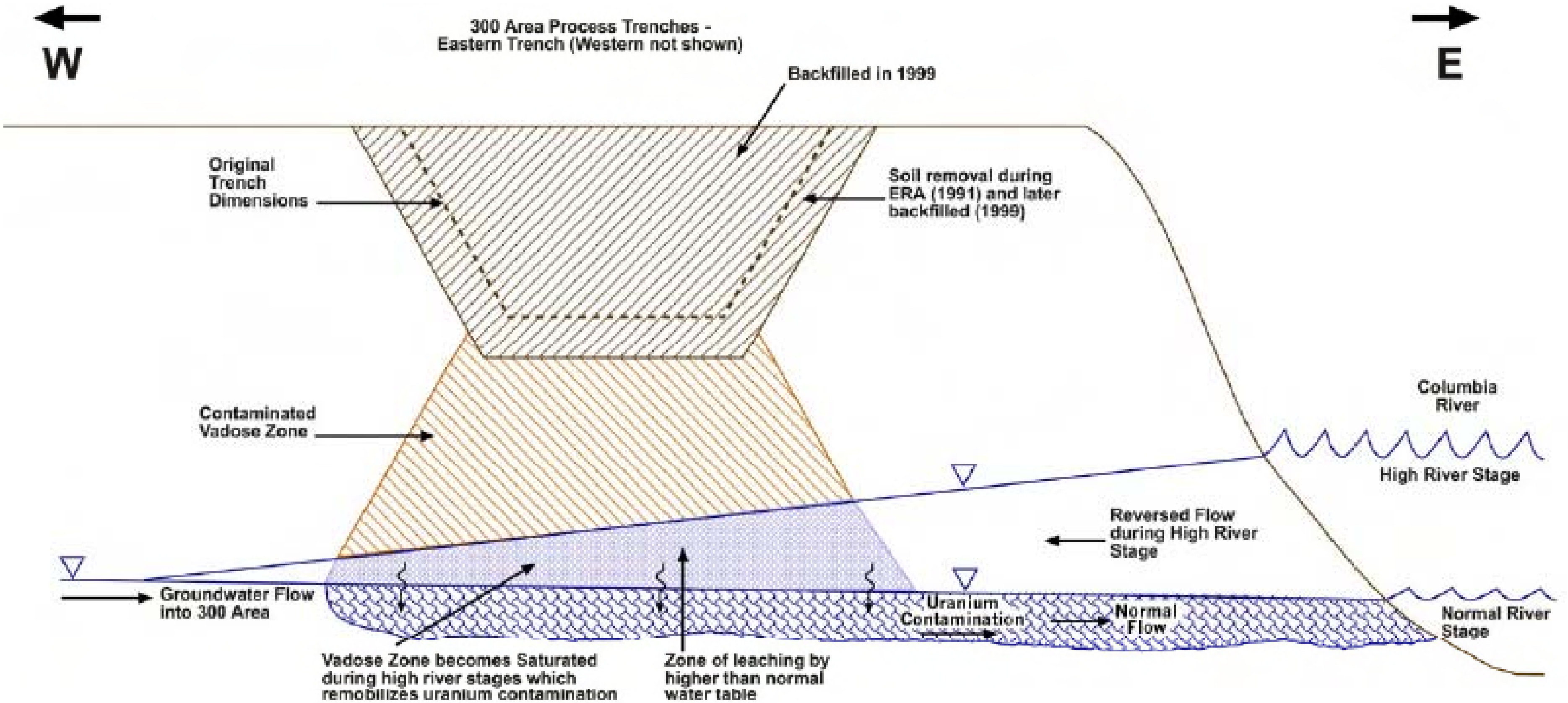
- Speciation and biogeochemistry
  - Characterization of a plume as ^{129}I can be augmented with speciation information to provide insight into mobility
  - Iodide and iodate have different transport characteristics

Composite Sediment [a]	Organic Carbon (%)	Inorganic Carbon (%)	Total Sediment Iodine (µg/g)	Total DOC [b] (µM)	Iodide-spiked K_d [c] (mL/g)	Iodate-spiked K_d [c] (mL/g)
H1	0.12	0.92	4.79	284 ± 33	0.08	1.78
H2	0.04	0.01	0.68	0	0.00	0.83
H3	0.15	0.18	2.10	94 ± 17	3.38	3.94

Xu et al. 2015
Truex et al. 2015b

Groundwater Elements

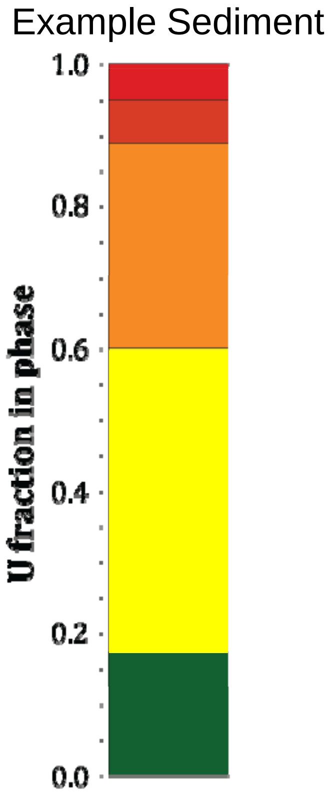
- Secondary sources (leaching)
  - Uranium sources related to periodic rewetting and leaching

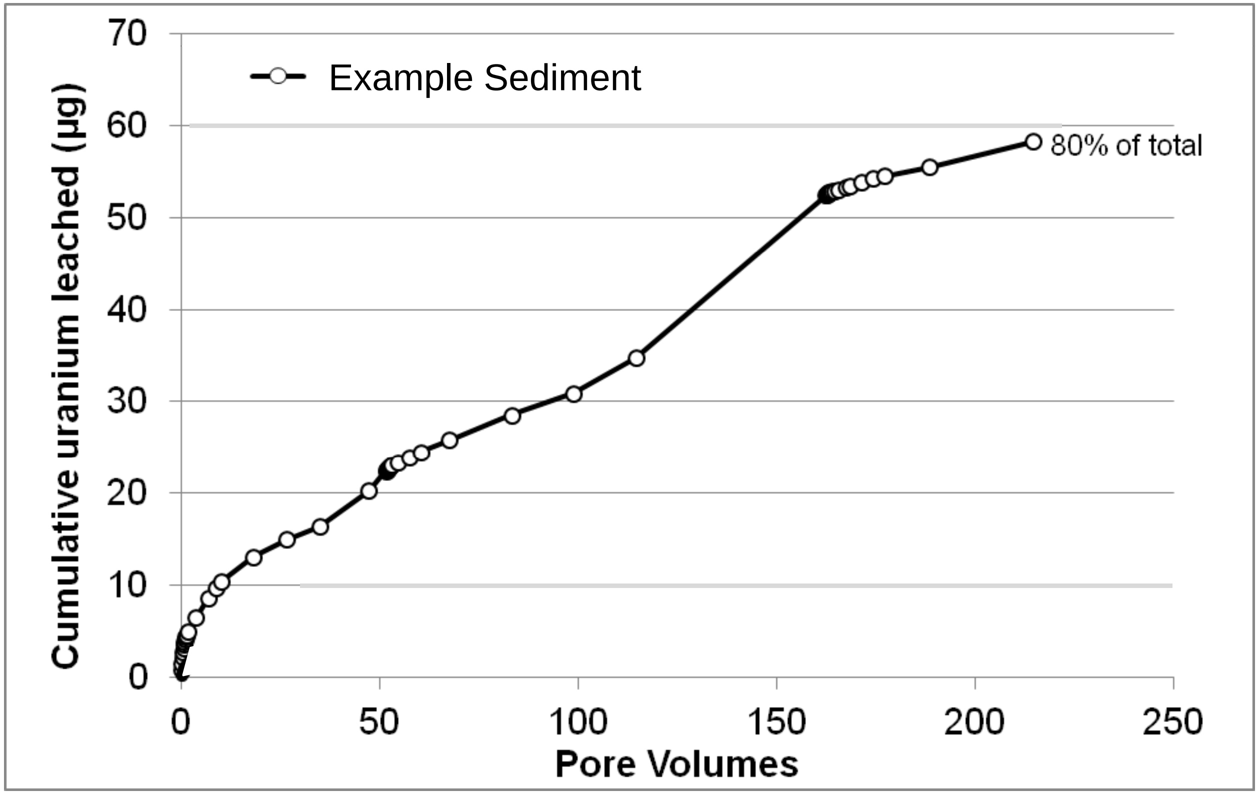


Peterson et al. 2008

Groundwater Elements

- Secondary sources (leaching)
  - Uranium sources related to periodic rewetting and leaching
  - Relevant for other inorganic contaminants (e.g., I, Cr)

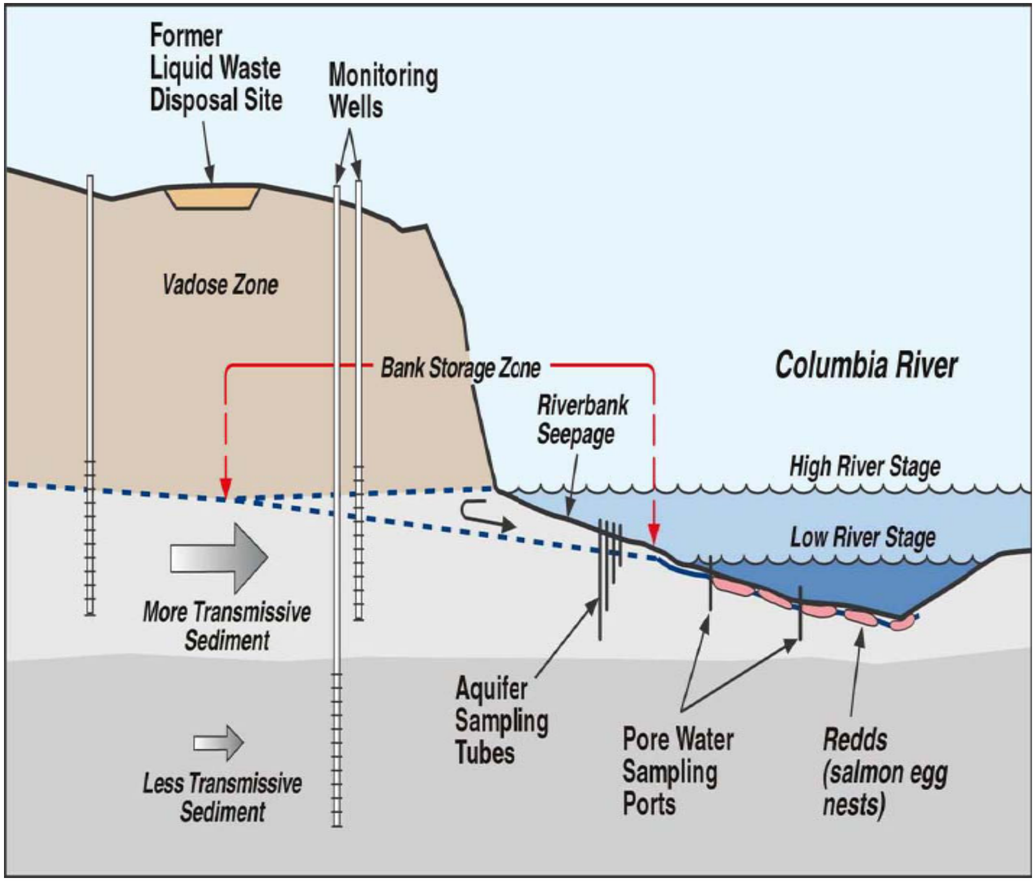




Szecsody et al. 2010, 2012

Groundwater Elements

- Groundwater dynamics
  - Hydrologic information can be augmented with geophysical techniques such as Electrical Resistivity Tomography



Peterson and Connelly 2001

Groundwater Elements

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- Groundwater dynamics
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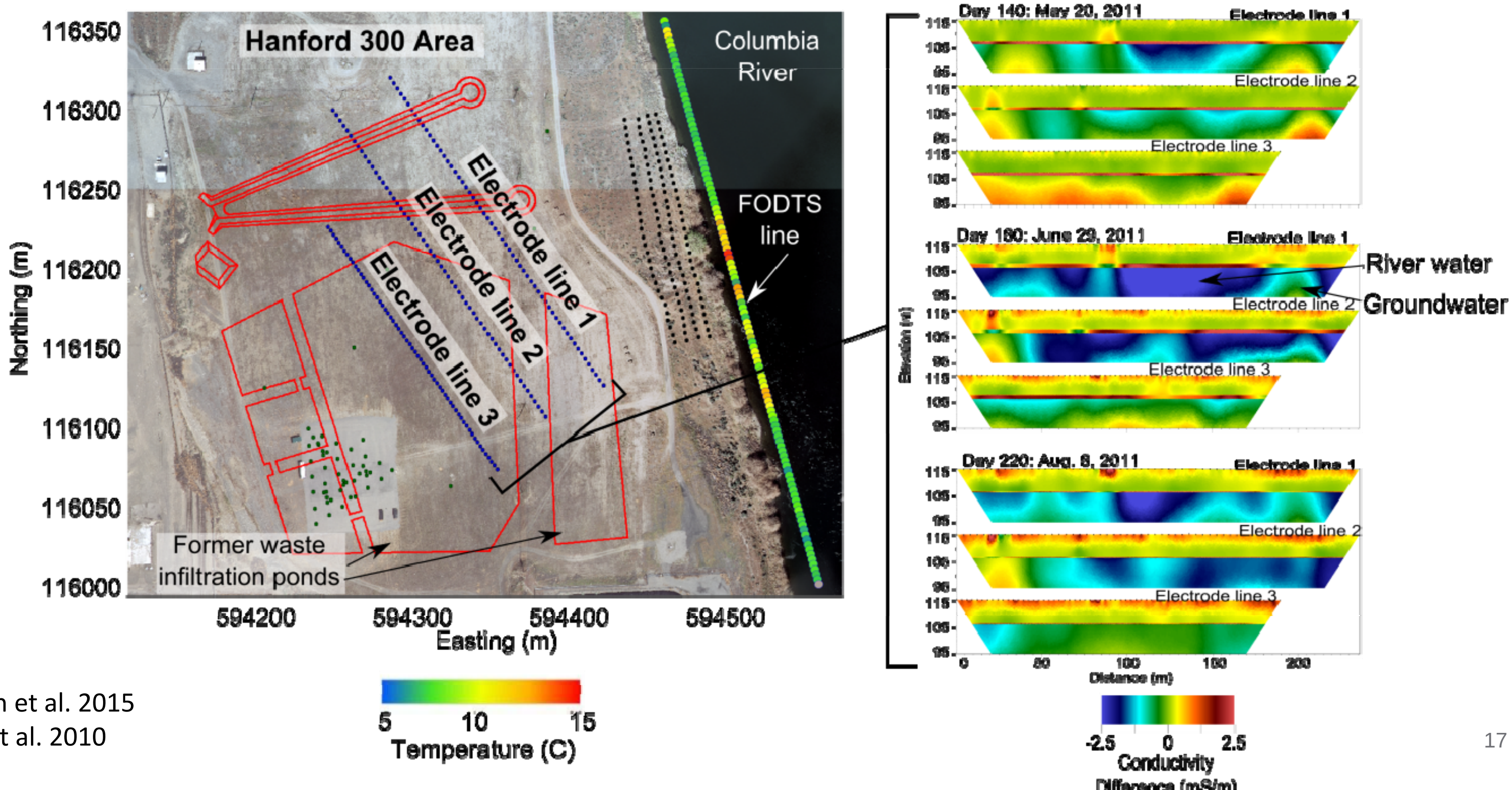
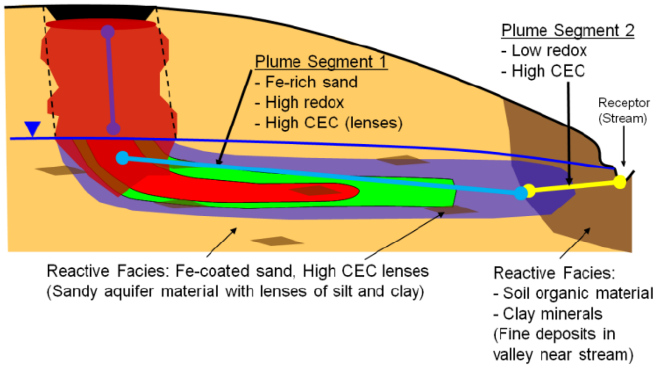


Johnson et al. 2015
Slater et al. 2010

Groundwater Elements

- Natural attenuation processes
  - EPA MNA Technical Protocol
    - "Scenarios" conceptual model document
    - Sediment biogeochemical factors



  - Monitoring data
    - Temporal data provides insights not possible with static data
    - Natural or induced perturbations aid the interpretation of temporal data

Conclusions

- Conceptual model framework
  - Technical basis and organization of efforts
  - Communication
- Assess controlling factors
  - Fate and transport assessment
  - Technical focus
    - Characterization
    - Monitoring
    - Remediation

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