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Remedy Selection and Implementation for Radionuclides in Soil and Ground Water

MICHAEL TRUEX

Pacific Northwest National Laboratory

Outline

- Radionuclide characteristics related to remediation
- Considering end states and attenuation in remedy decisions
- Remedy selection and implementation

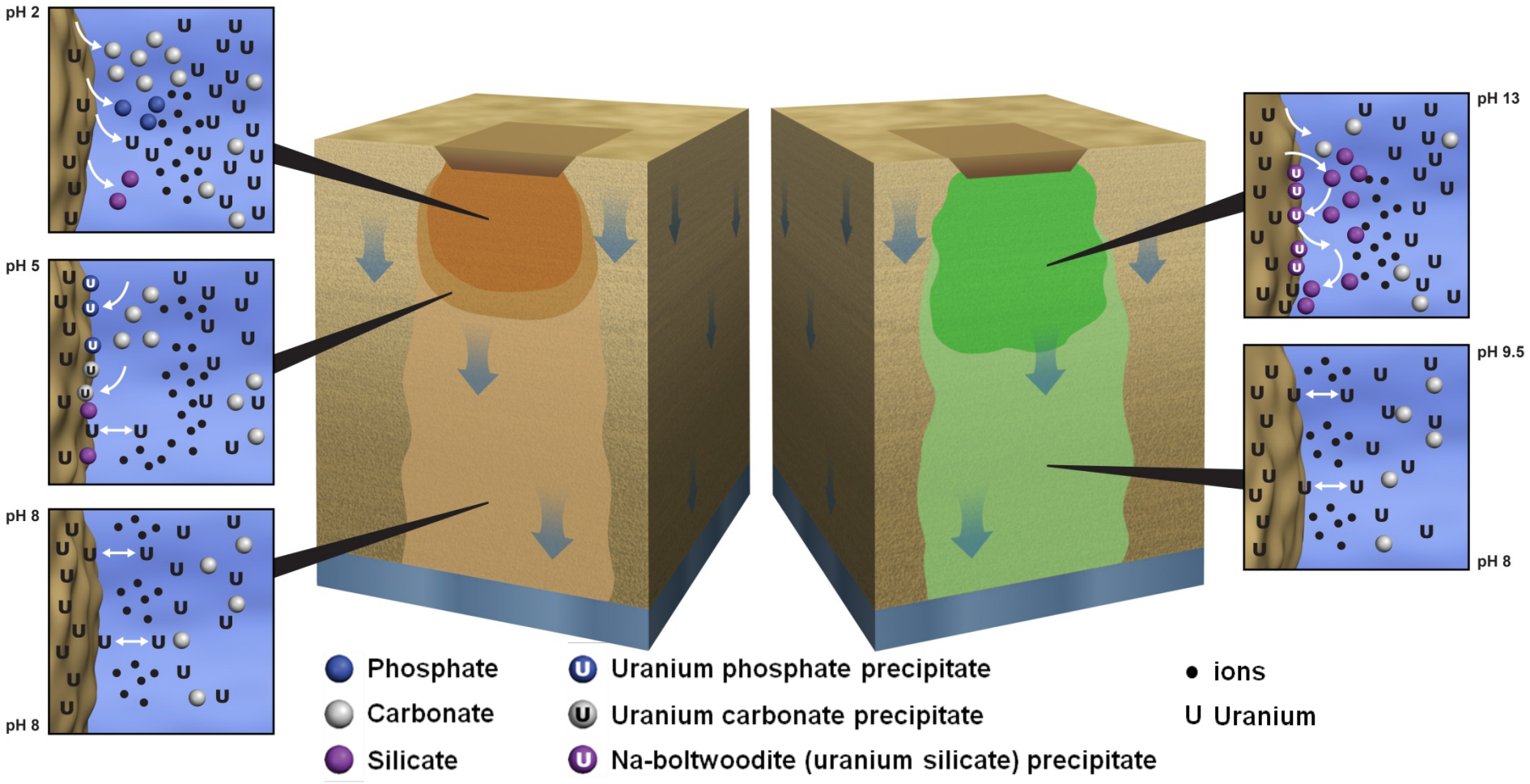
Radionuclide Characteristics (Friend or Foe)

- Half-life
  - Shorter is better (when exposure is controlled)
    - Sr-90 or tritium compared to uranium, I-129, or Tc-99
- Mobility (sorption)
  - Very low mobility generally good
  - Medium or high mobility - depends on the situation
    - Attenuated transport can be helpful (vadose zone contamination) or problematic (P&T)
    - Secondary sources are problematic unless balanced by attenuation

Radionuclide Characteristics (Friend or Foe)

- Biogeochemical interactions
  - Helpful
    - Uranium and Sr-90 interactions with phosphate
    - Uranium silicate precipitates
  - Mixed
    - Uranium and I-129 (and Cr) interactions with carbonate
      - Depends on location/extent
    - I-129 species transformation
      - Depends on change in mobility and potential for attenuation/ sequestration
    - Uranium and Tc-99 redox
      - Depends on setting and role in a remedy
  - No interactions
    - tritium

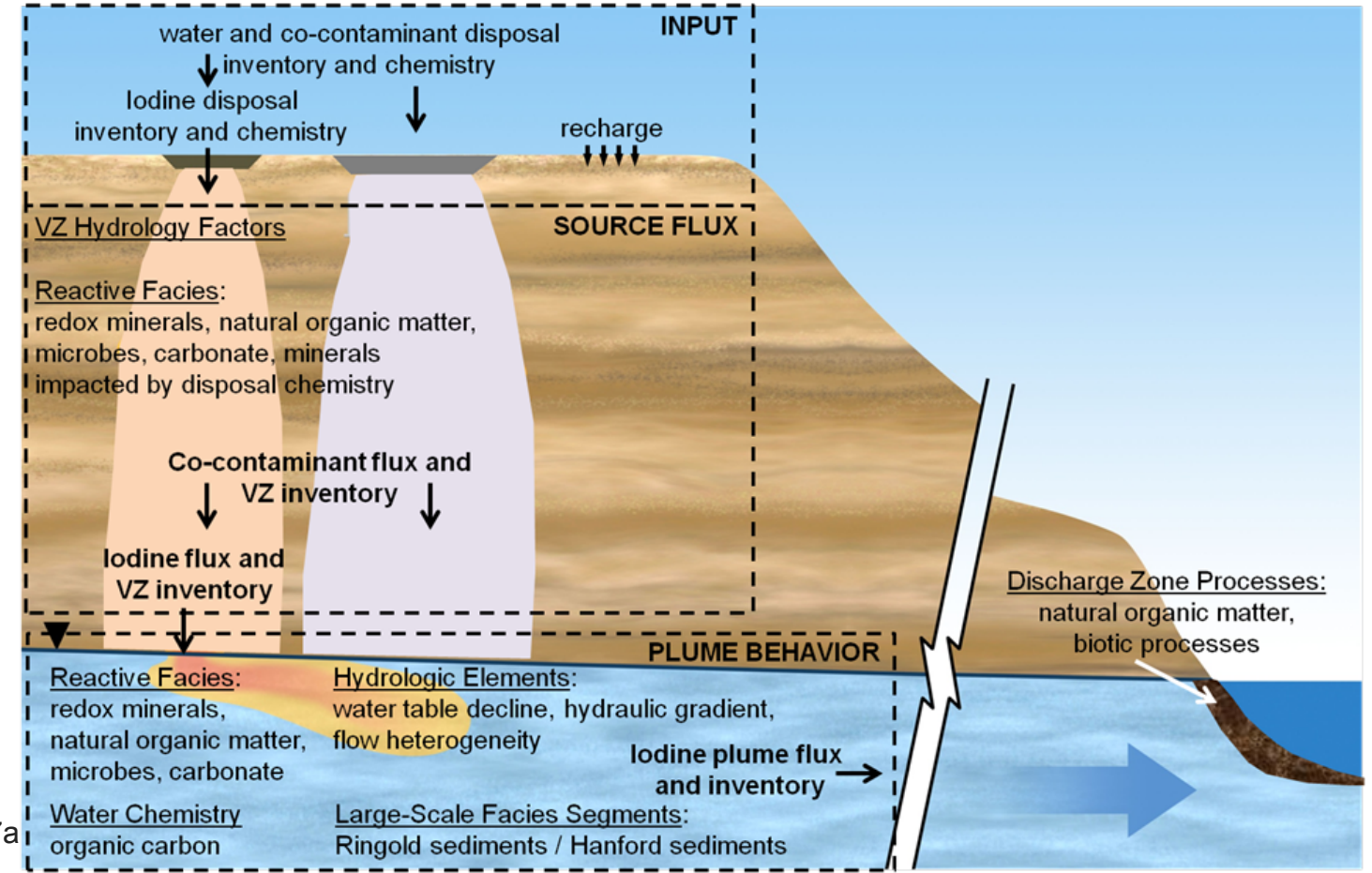
Disposal Chemistry



Szecsody et al. 2013
Truex et al. 2014

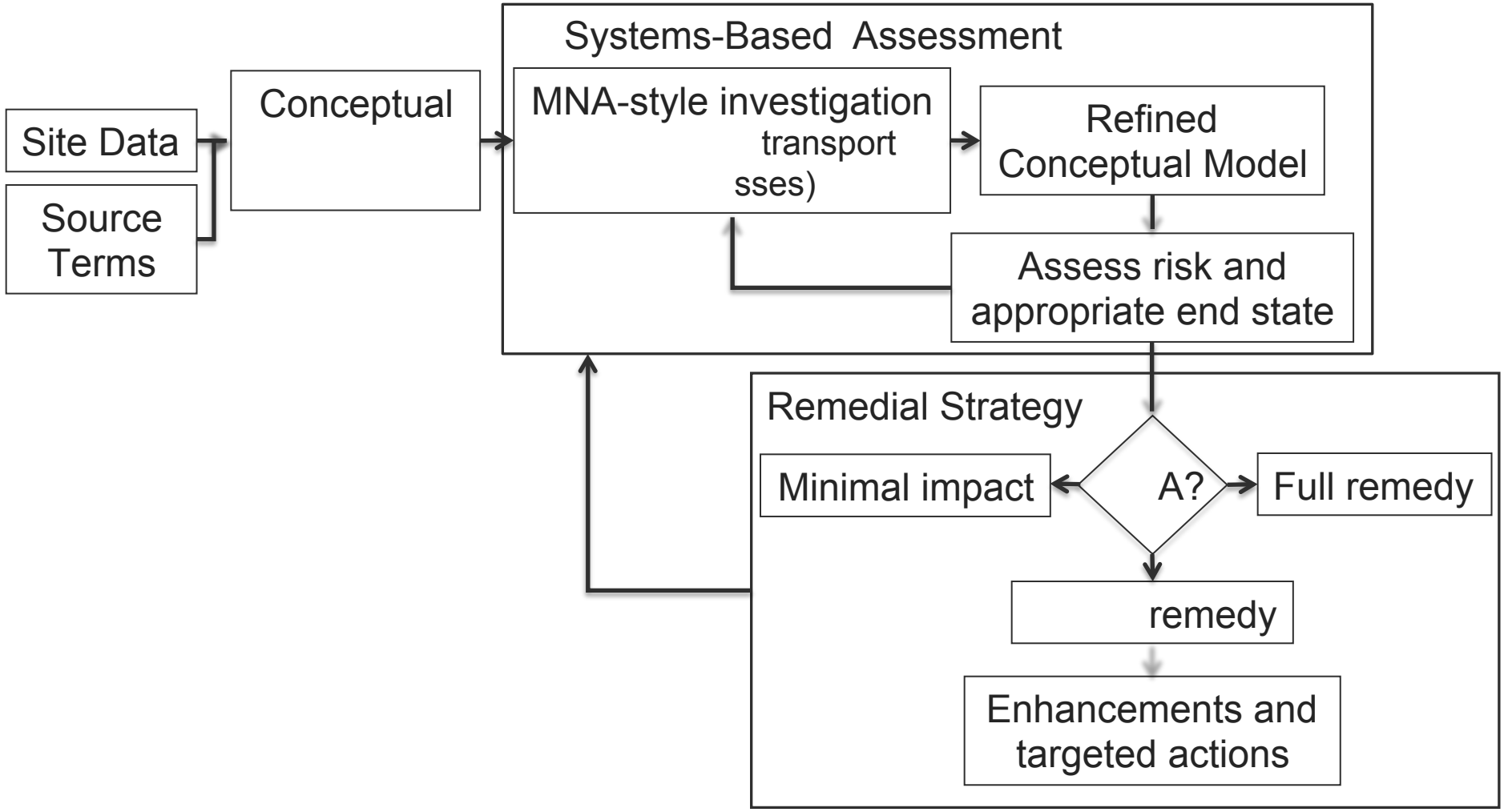
Radionuclide Characteristics (Friend or Foe)

- The Conceptual Site Model helps us decide:
  - Friend or foe for risk and transport
  - Friend or foe for remediation



Truex et al. 2017a

Considering End States and Attenuation in Remedy Selection



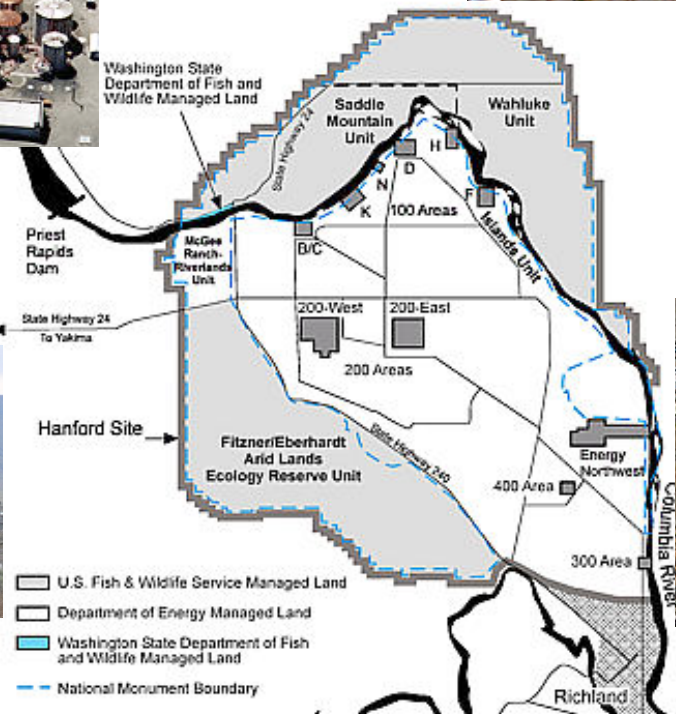
Remedy Selection

- Attenuation and transport processes are important to consider for remediation decisions in the vadose zone and groundwater
  - important for both remedy selection and remedy implementation
- Remedy technology decisions consider the intersection of
  - radionuclide characteristics
  - the target problem
  - remedy functionality
  - remediation objective

Hanford Background

Irradiate Fuel Elements

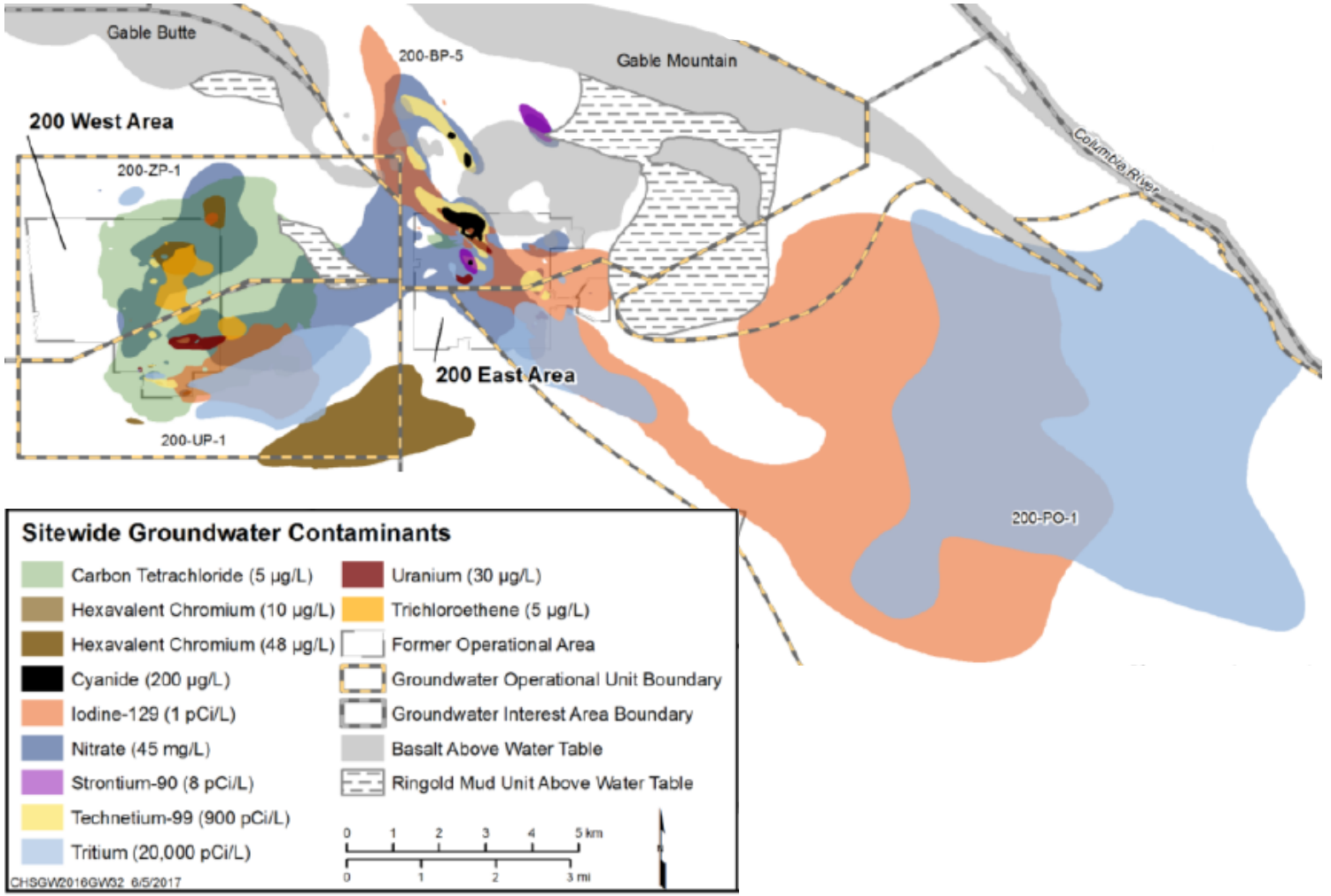
Chemical Separations



Plutonium Finishing

Manufacture Fuel Elements

Hanford Background



DOE 2017

Central Plateau: Deep Vadose Zone Sites

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Tc-99: ~40 Ci discharged; Groundwater @ ~ 100 X standard

Tc-99: 110 Ci discharged; ~5-20 Ci remain in deep vadose zone

Uranium: 10,000 kgs discharged; ~20 Kgs in groundwater @ 150 X standard; ~2,000 Kgs in mobile state and remain in deep vadose zone

BY Cribs

B-BX-BY Tank Farms

Key Contaminants
Tc-99
Uranium
I-129
Chromium

T Tank Farm

U Cribs

S-SX Tank Farms

Inner Area
25 Km^2

PUREX Cribs

Uranium: 75,000 Kgs discharged; Minimal breakthrough to groundwater; Unknown mobility and presence in deep vadose zone

BC Cribs & Trenches

Tc-99: ~40 Ci discharged; Groundwater @ ~ 100 X standard

Uranium: 36,000 Kgs discharged; Minimal breakthrough to groundwater; Unknown mobility and presence in deep vadose zone

Tc-99: 410 Ci discharged; No breakthrough to groundwater; Most mass between 30 - 50 meters below surface

Hanford Background

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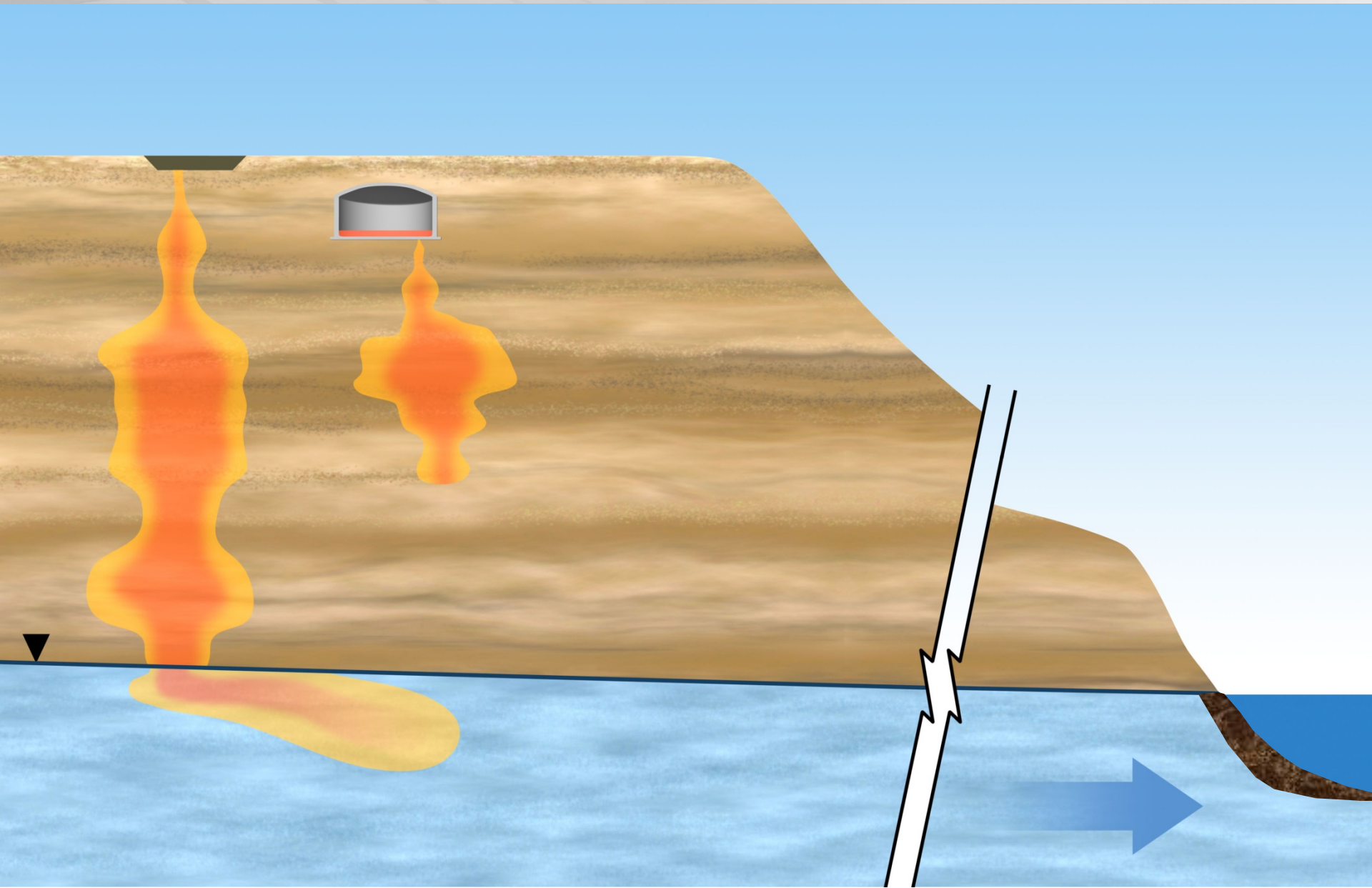
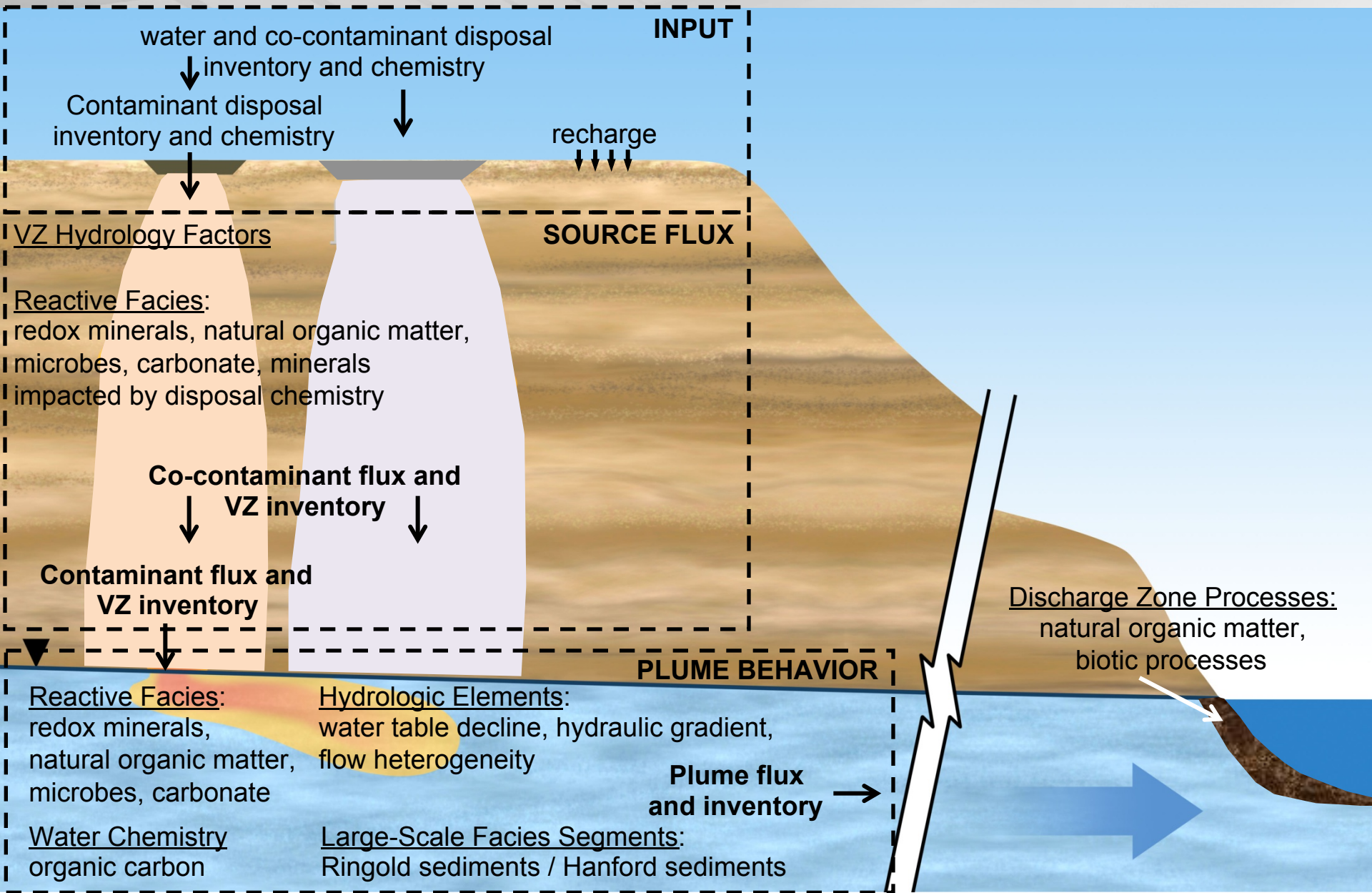
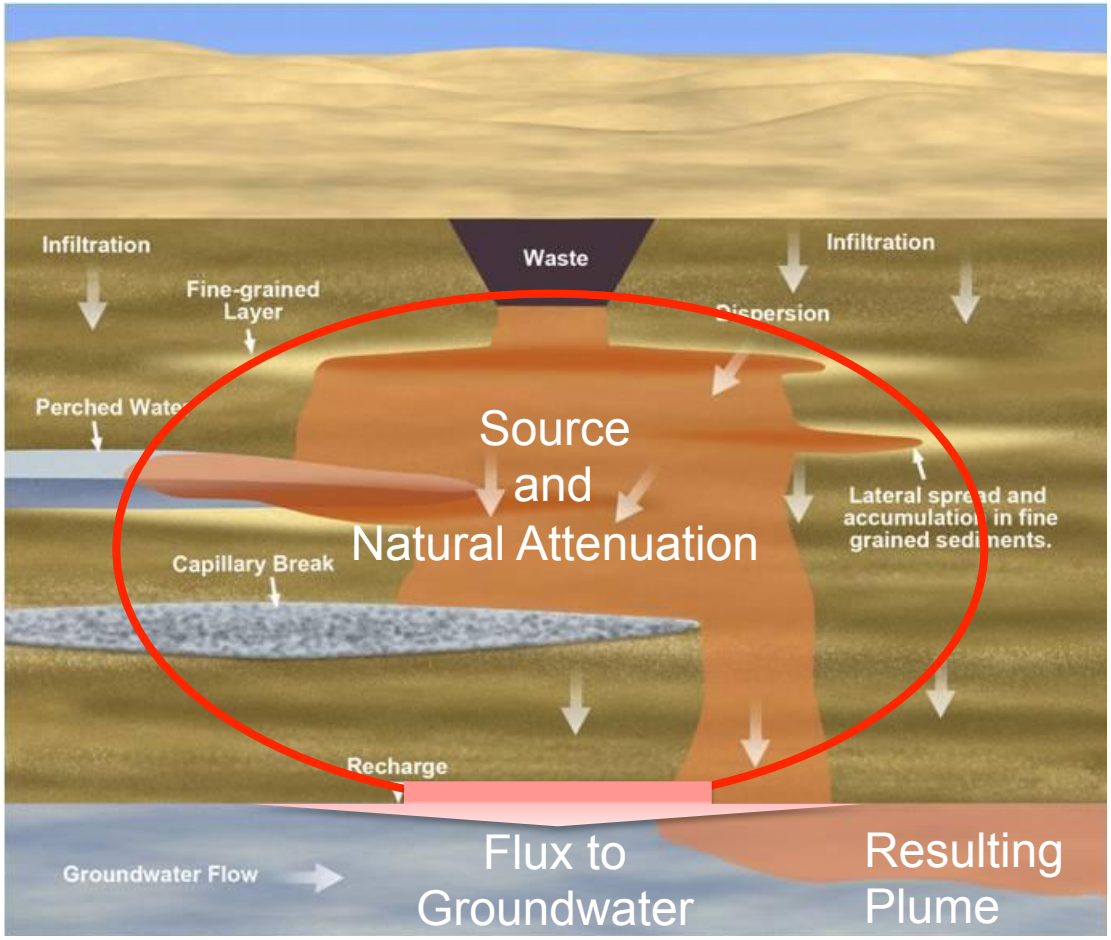


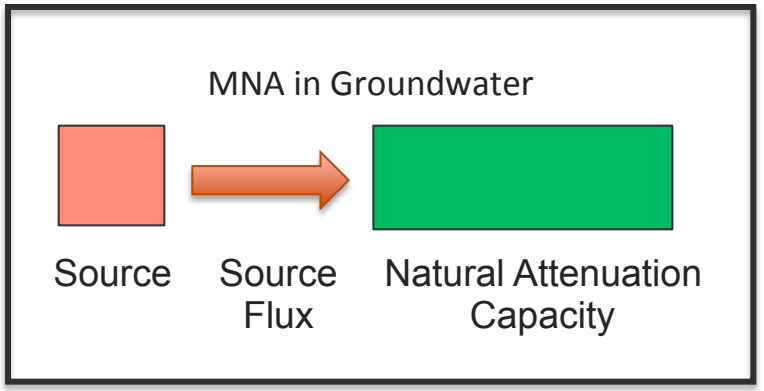
Hanford Background

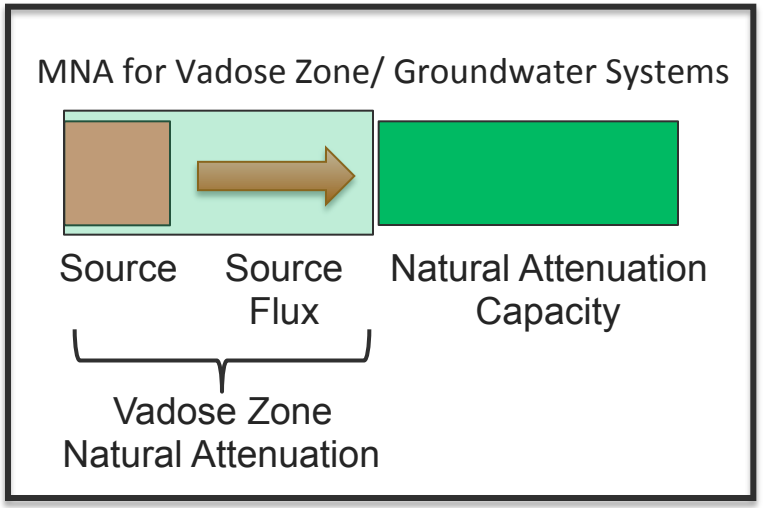


Attenuation



Adapted from Dresel et al. 2011



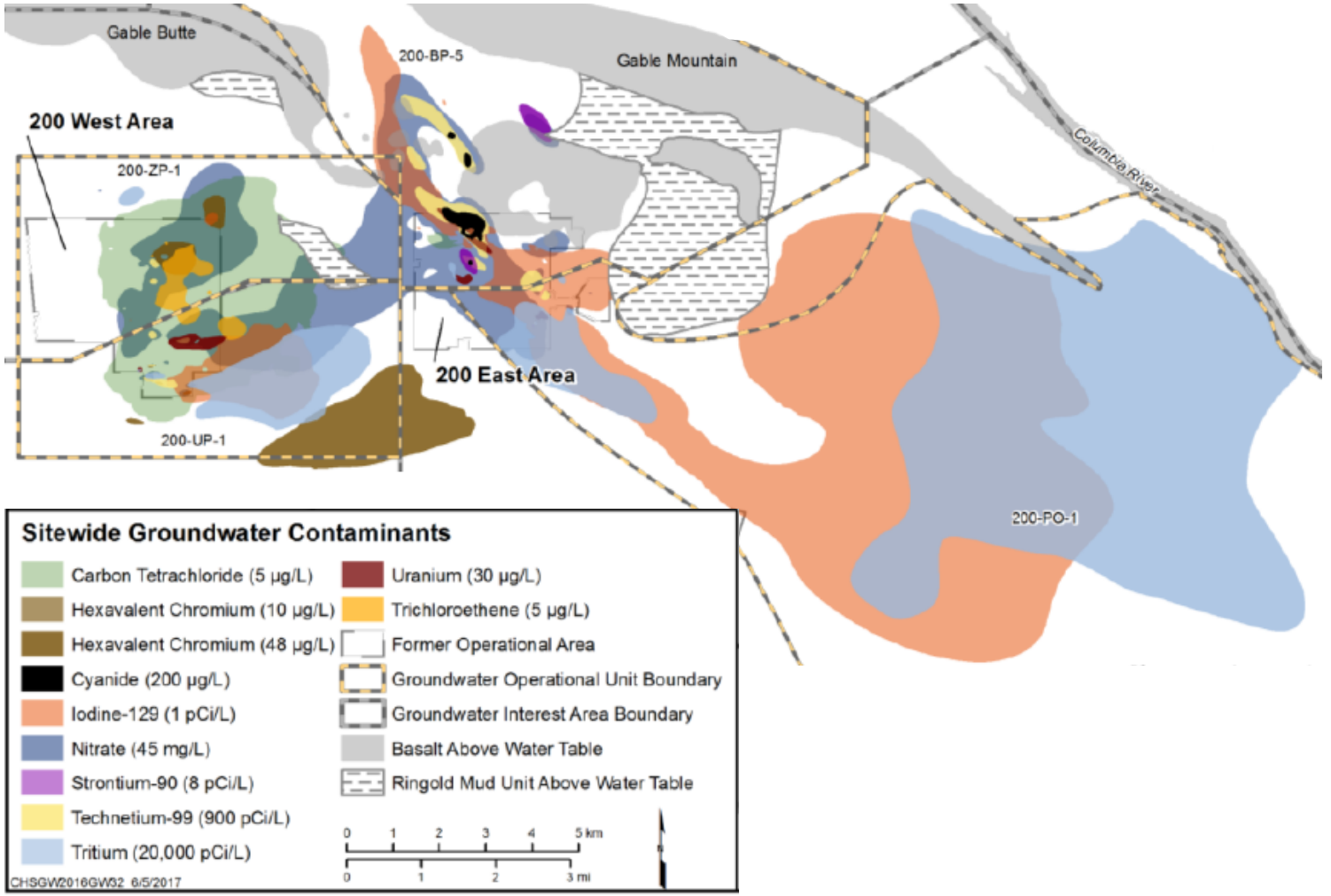


Truex and Carroll 2013
Truex et. al 2015a
Oostrom et al., 2016

Attenuation and transport processes

- What do we need to know?
  - Vadose Zone
    - Quantify vadose zone contaminant flux to groundwater
    - Determine where and what type of mitigation is needed
  - Groundwater
    - Quantify plume dynamics and secondary source characteristics
    - Exit strategy for P&T
      - Transition to MNA
  - Coupled System
    - Assess continuing and long-term sources not related to current plumes

Hanford Background



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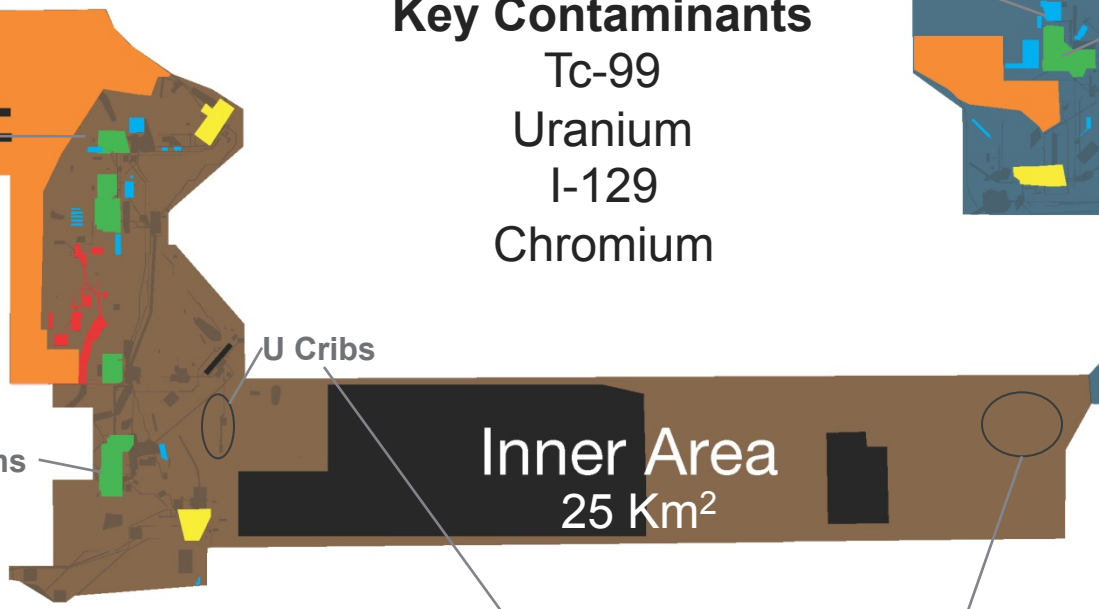

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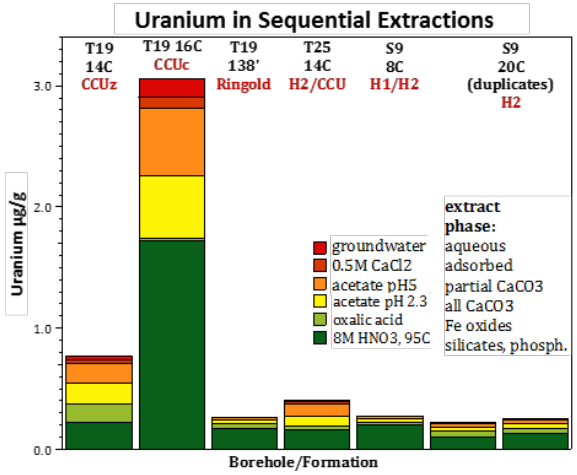
Attenuation and transport processes

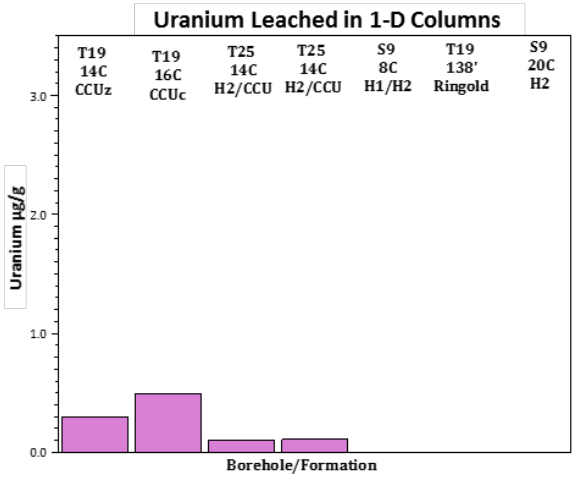
- Processes
  - Hydraulic attenuation
  - Adsorption
  - Transformation
  - Sequestration
- Ramifications
  - Temporal profile of source flux and concentrations
  - Inventory of mobile contaminants
  - Spatial distribution information
  - Plume dynamics

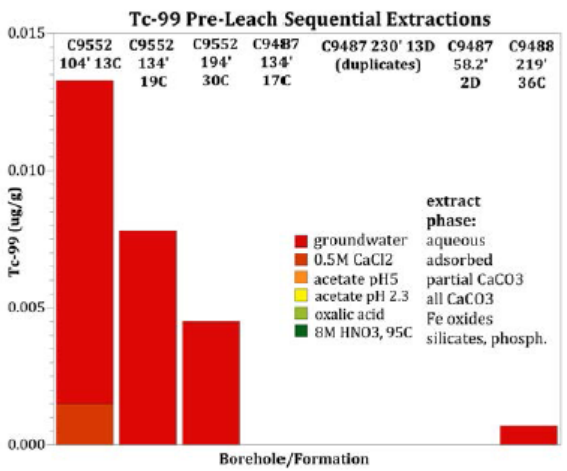
Attenuation and transport processes

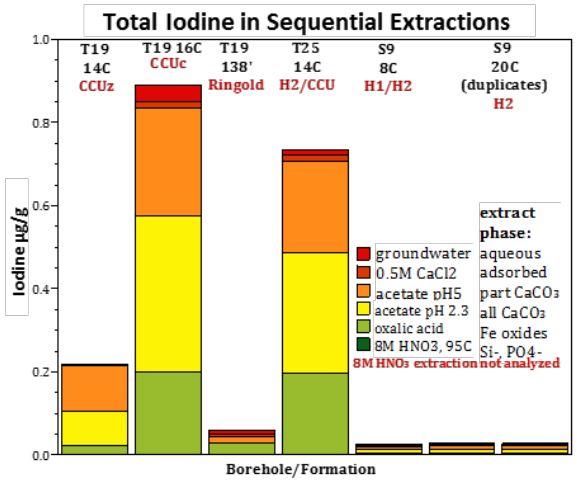
- Vadose zone attenuation/transport SAP
  - Target sampling and analysis for
    - Important hydrologic units
    - Representative contaminant discharges
    - Problematic waste sites
  - Define analyses based on national guidance for attenuation tailored to site needs
    - COC and primary biogeochemistry
    - Sequential extractions and other indicator diagnostics
    - Leaching or batch Kd studies to support estimating transport parameters
    - Hydraulic/physical properties where needed to support model configuration

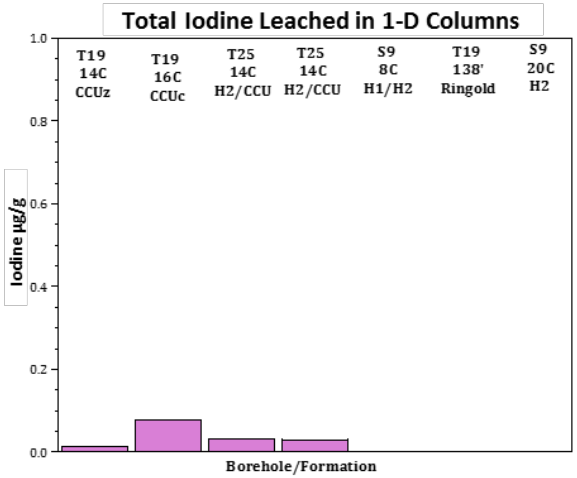
Reaction and Mobility – Vadose Zone





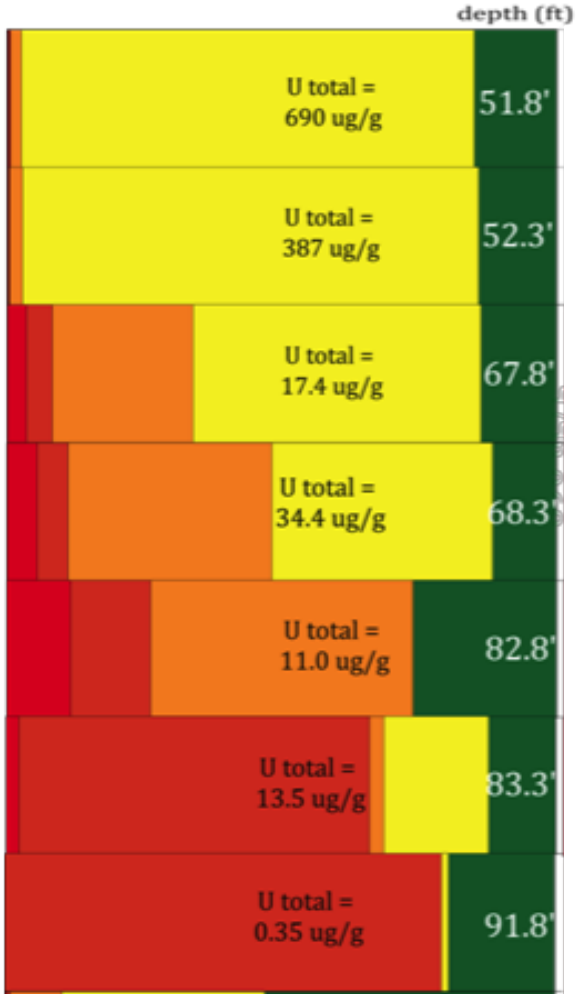




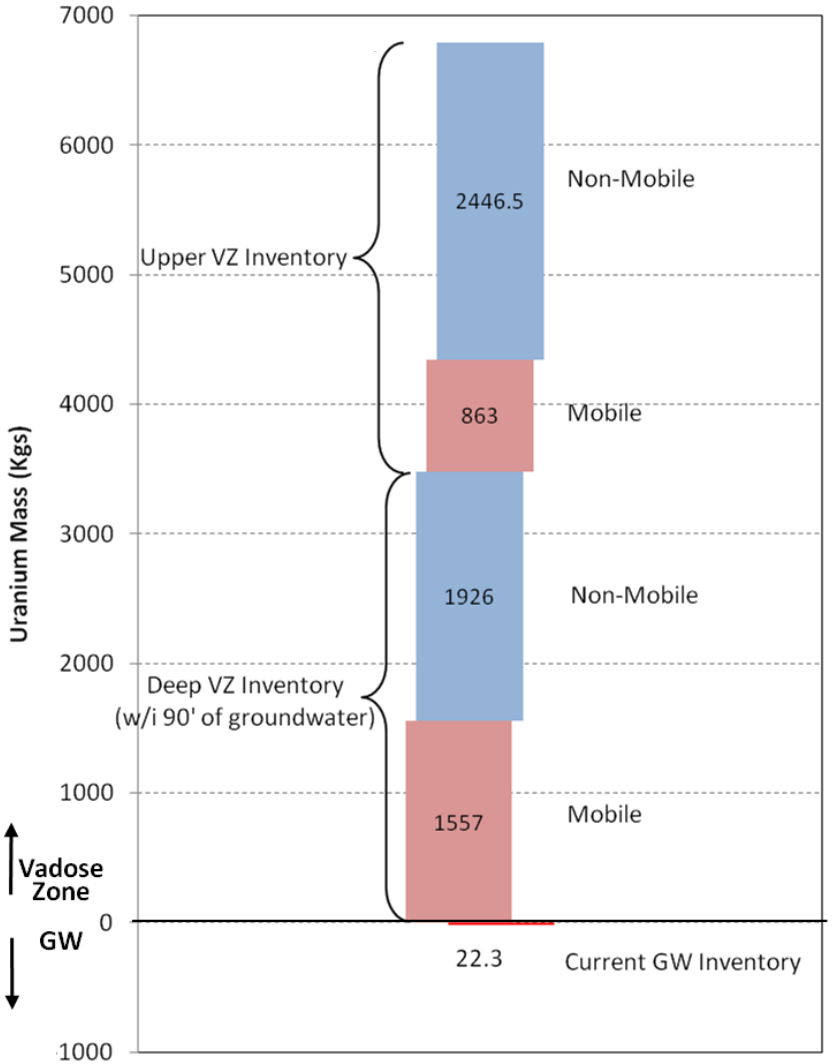


Truex et al. 2017b
Szecsody et al. 2017

Distribution and Mobility



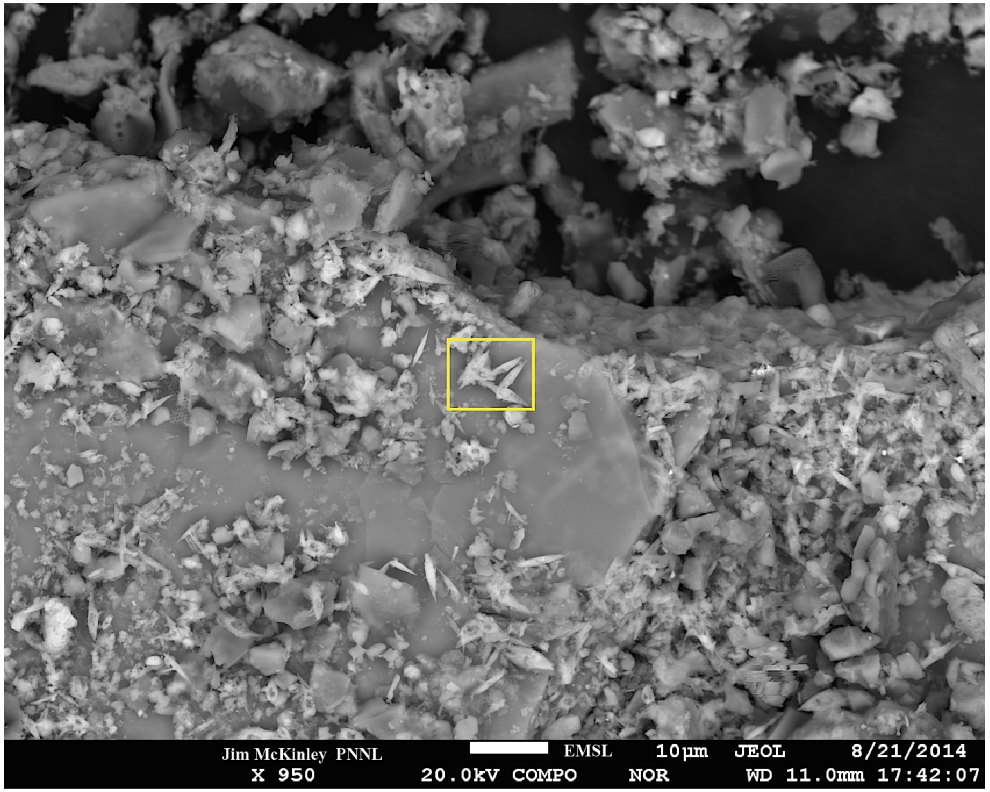
Szecsody et al. 2010



Serne et al. 2010

Carbonate interactions

- Uranium, iodate, and chromate co-precipitates with calcite



Cr-calcite observed in a Hanford field sediment

Truex et al. 2015b

Source characteristics (location/flux)

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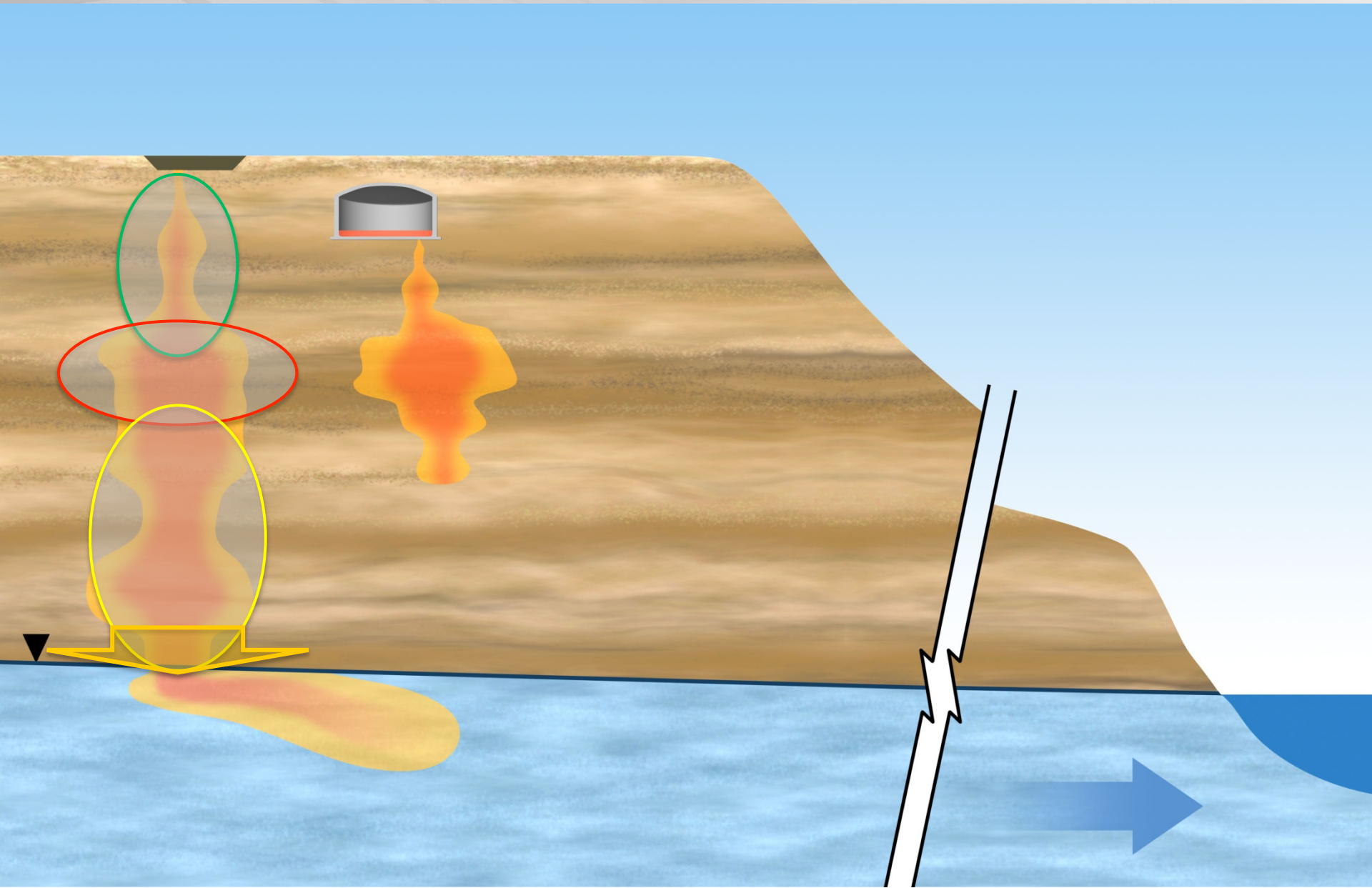
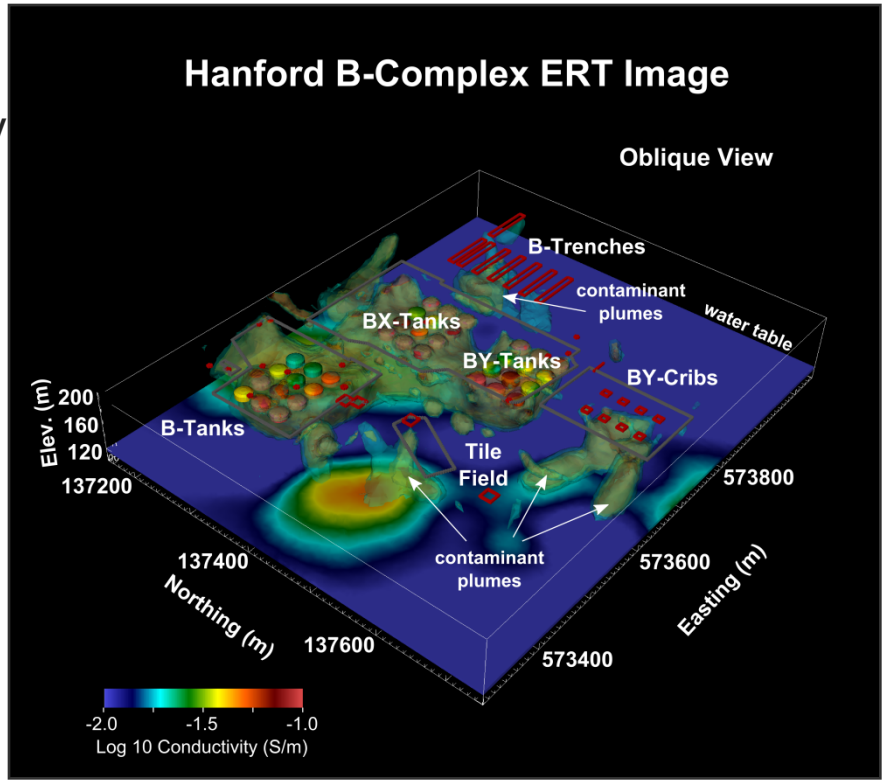


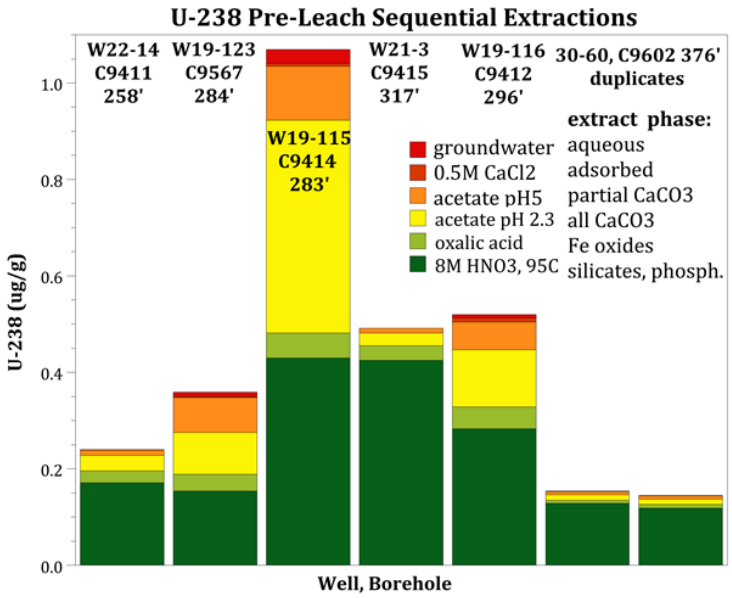
Evaluation of VZ Transport

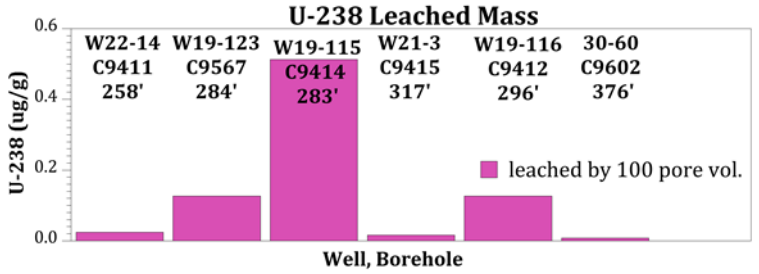
- Contaminant Distribution
  - Geophysical logging
    - Spectral gamma log
    - Neutron moisture log
  - Geophysics
    - Electrical Resistivity Tomography



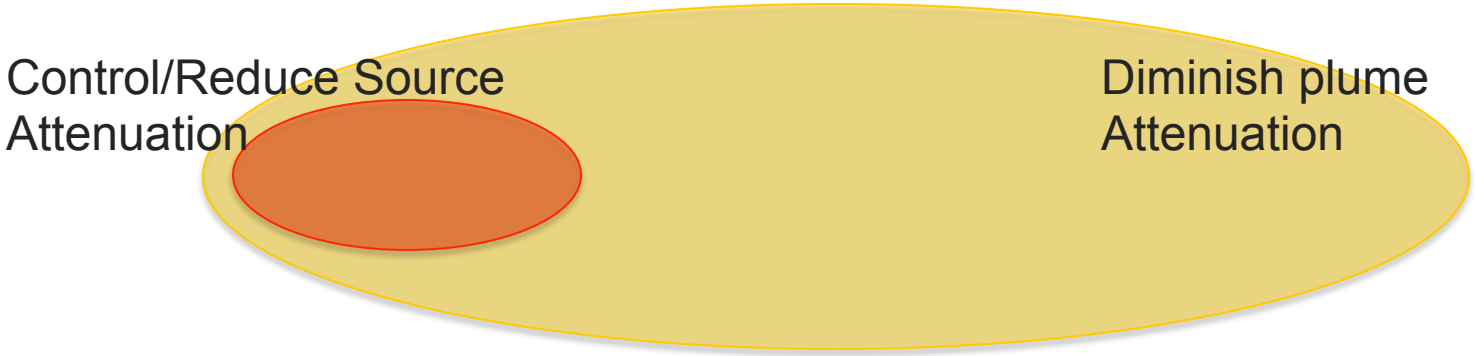
Johnson and Wellman 2013; https://e4d.pnnl.gov/

Reaction and Mobility - Groundwater



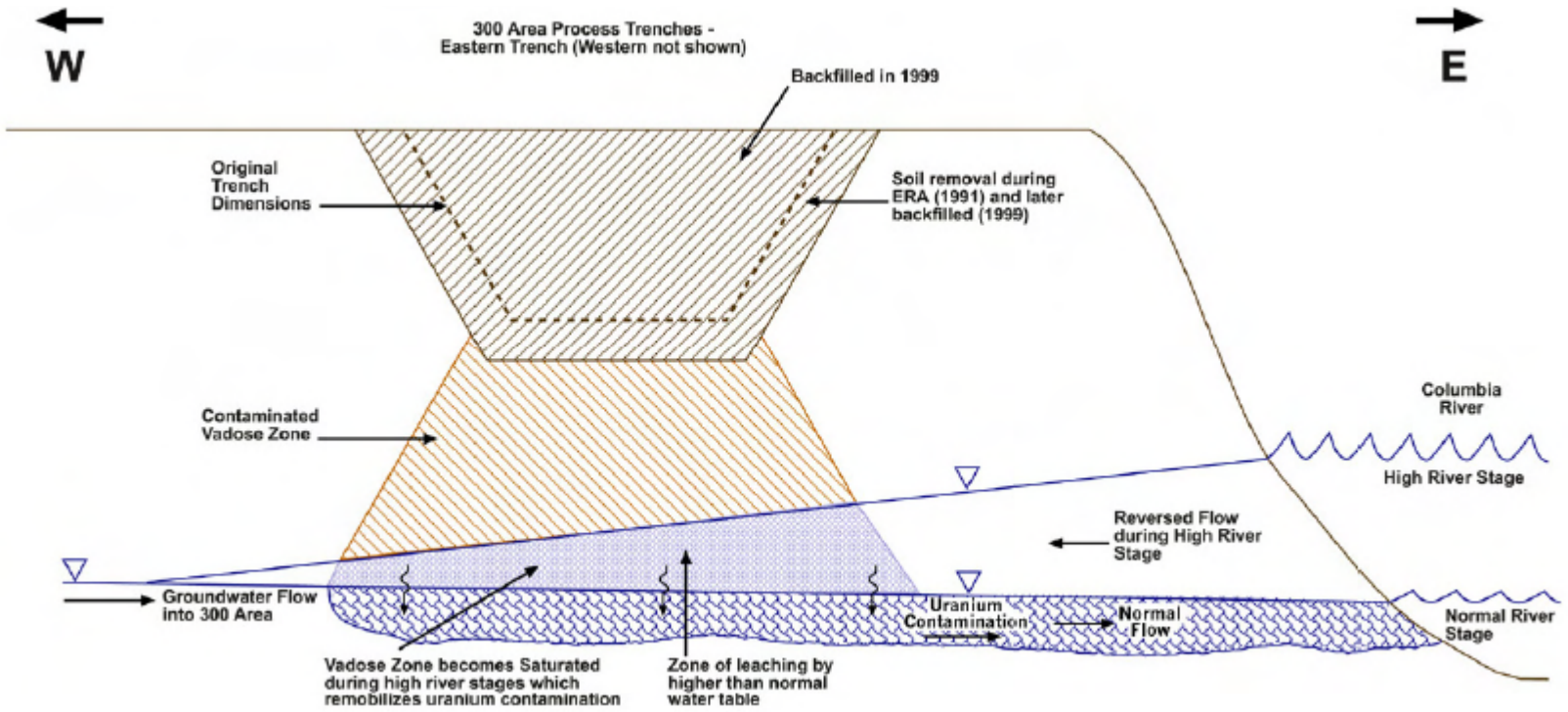


Lee et al. 2017



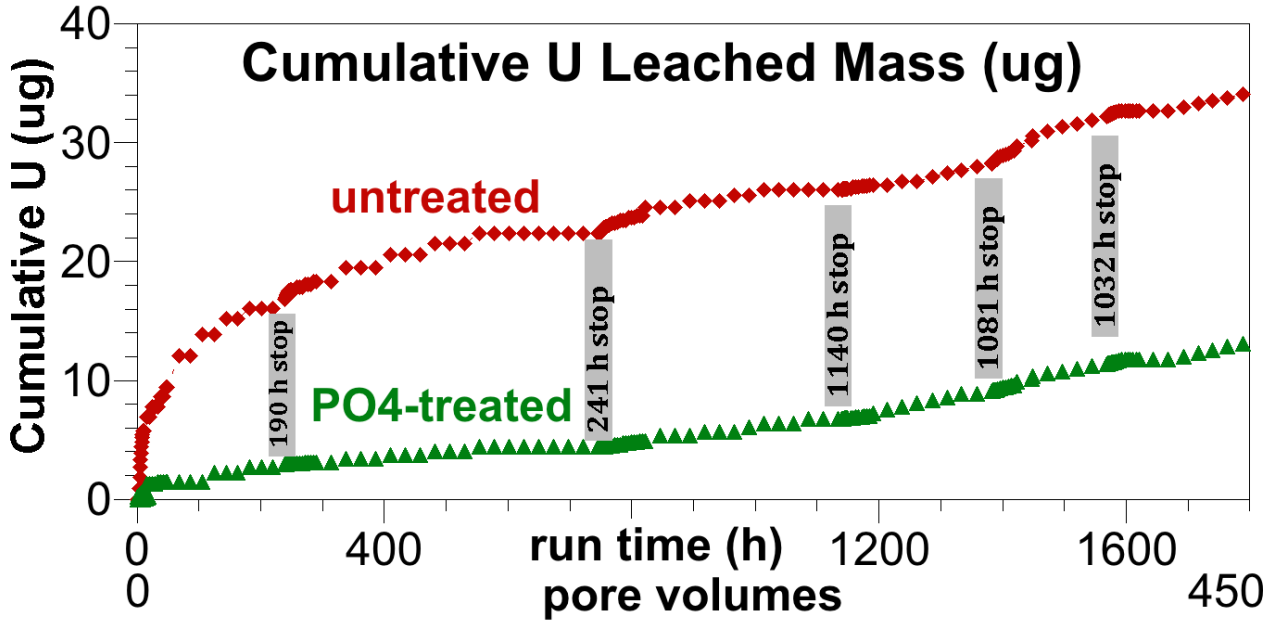
Uranium source zone

- Periodically rewetted zone



Geochemical stabilization – periodically rewetted zone

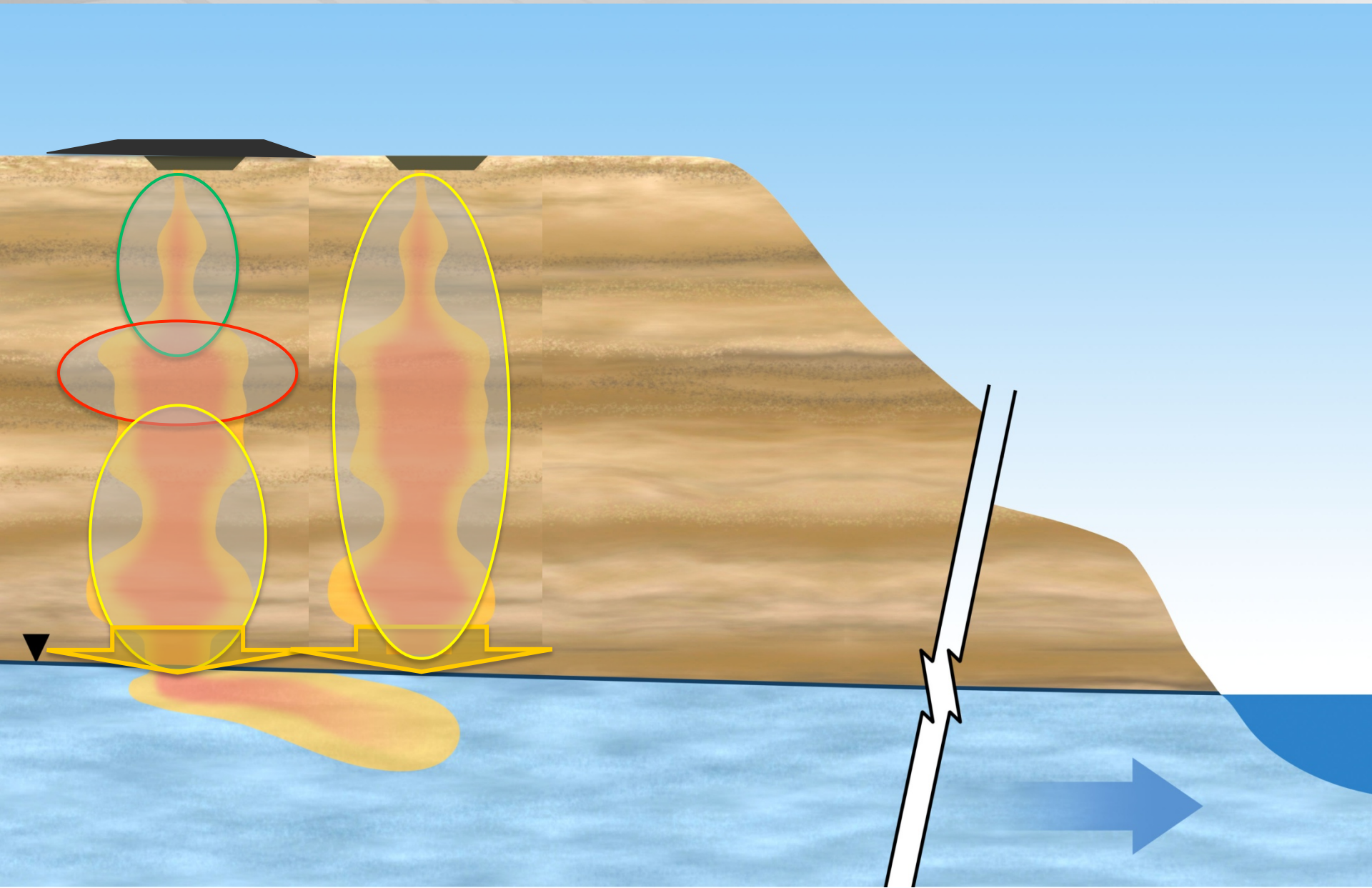
- Phosphate treatment for uranium



Technology evaluation

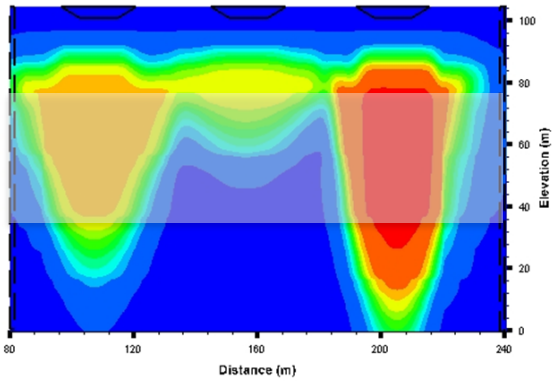
- Treatability tests and assessments
  - Determine technology in relation to
    - radionuclide characteristics
    - the target problem
    - remedy functionality
    - remediation objectives
- Examples
  - Soil flushing
  - Surface barriers/desiccation
  - Uranium sequestration

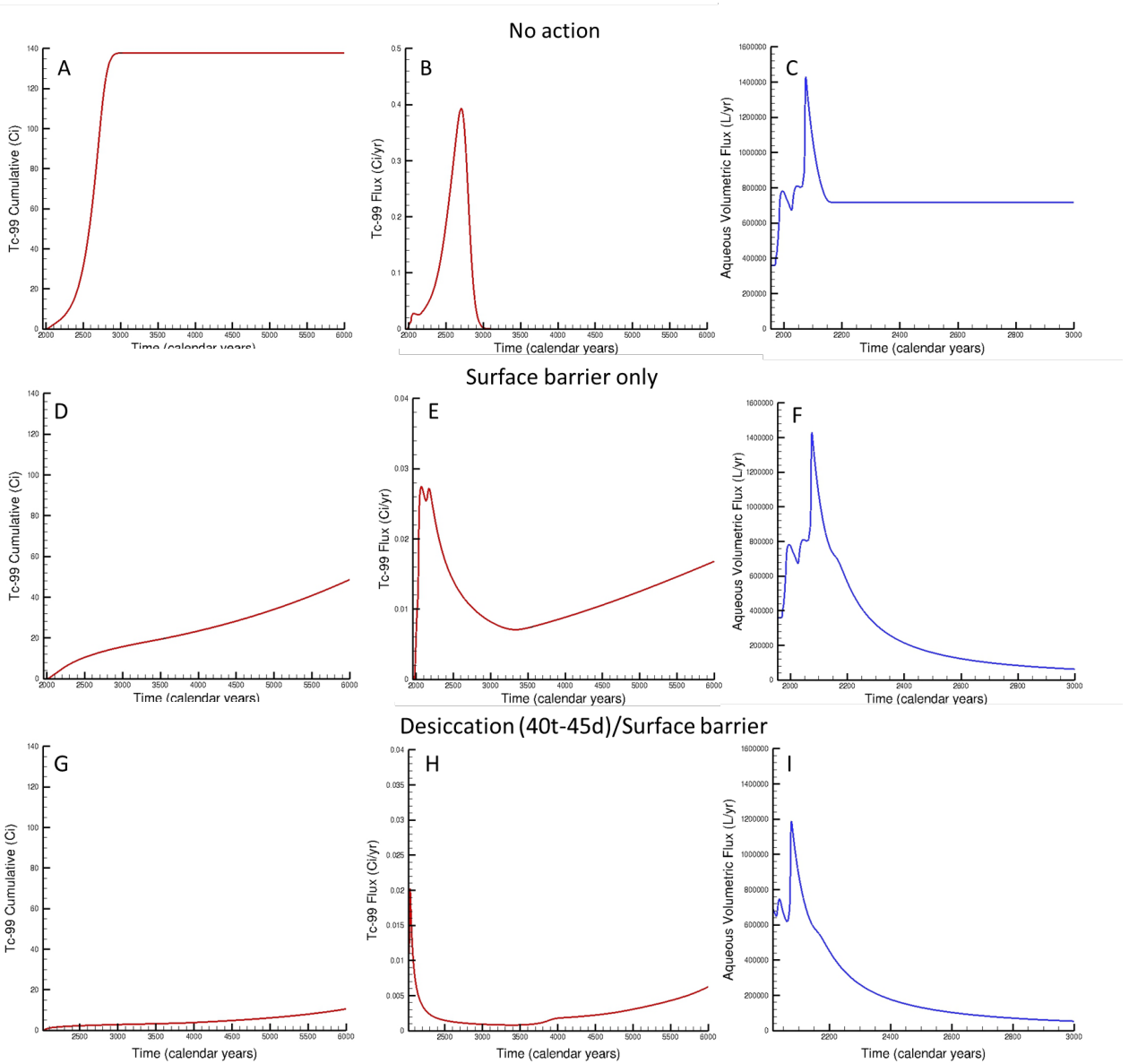
Source characteristics (location/flux)



Surface Barrier and desiccation

- Effect of drainage

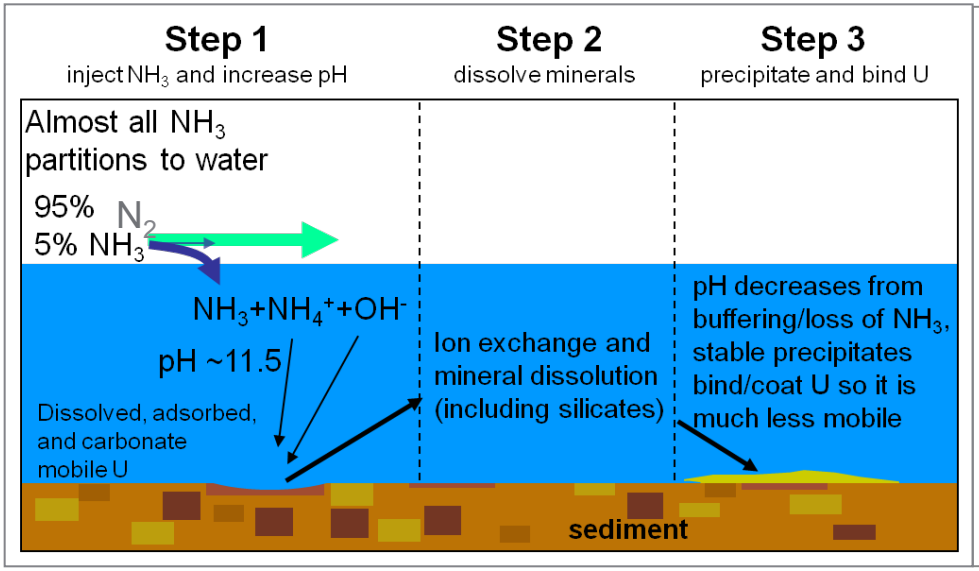


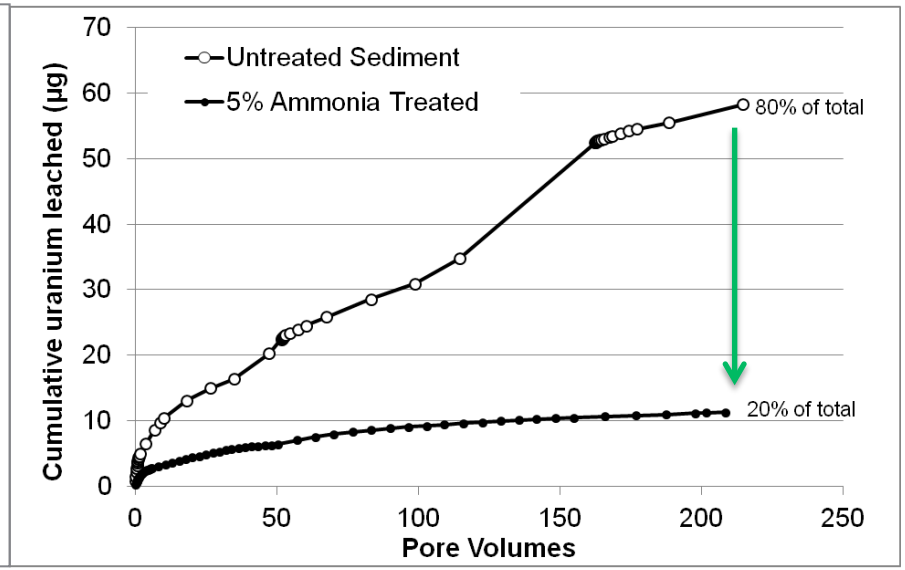


Truex et al. 2017c

Geochemical stabilization – vadose zone

- Ammonia gas for uranium sequestration





Szecsody et al. 2012

Remedy Implementation

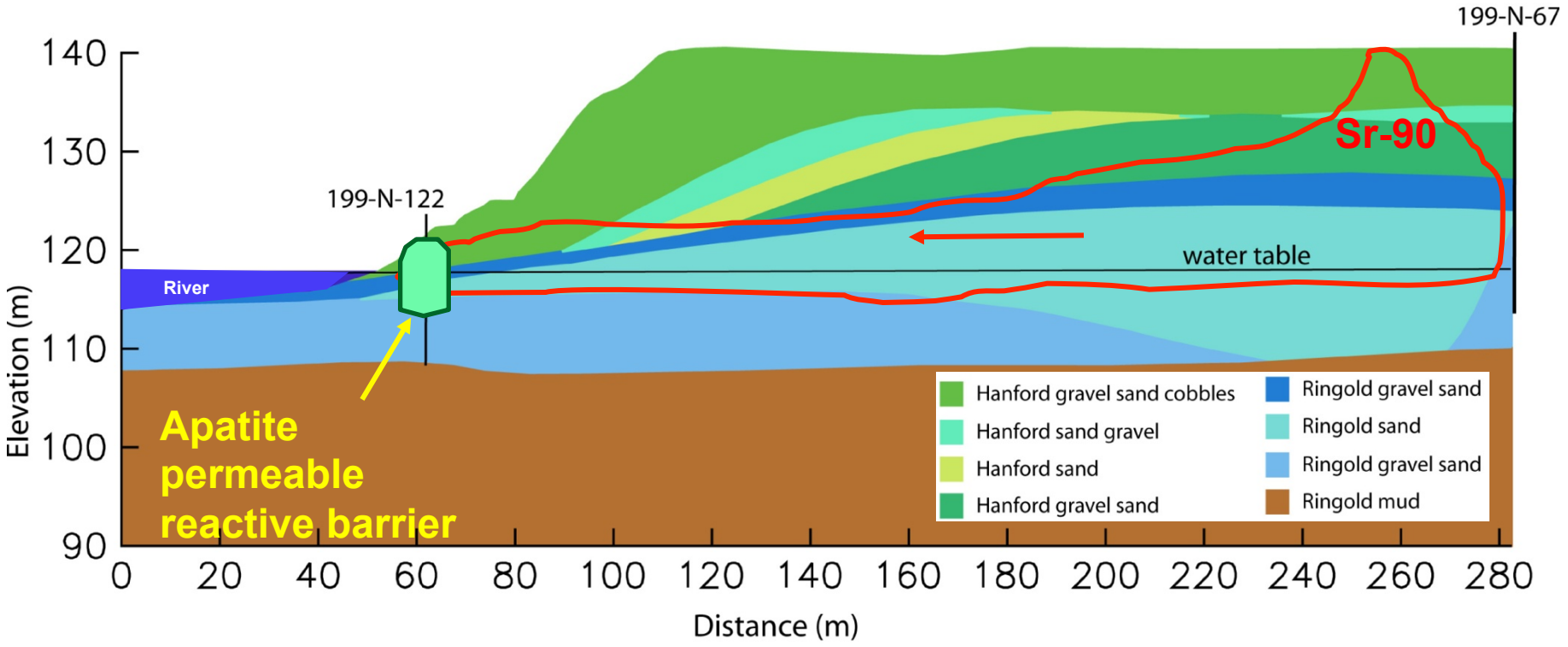
- Vadose zone remediation target
  - Where
  - What chemical form
  - How much flux reduction
- Diminishing plumes
  - How much is needed
  - Secondary or continuing sources
- Transition to MNA
- Current plumes versus long-term sources

Remedy Implementation

- Adaptive Site Management
  - National Research Council
  - ITRC
    - Remediation Management of Complex Sites
    - http://rmcs-1.itrcweb.org/
- Exit Strategies (P&T)
  - http://bioprocess.pnnl.gov/Pump-and-Treat.htm
  - Truex et al. (2015c, 2017d)
- Monitoring
  - Objectives based
  - Performance metrics
  - Transition for long-term

Hanford 100-N Area Sr-90

- Only near-river strontium is a risk to the river
- Monitoring linked to remedy approach



Conclusions

- Attenuation and transport processes are important in remedy selection and implementation
- Remedy technology decisions consider the intersection of
  - radionuclide characteristics
  - the target problem
  - remedy functionality
  - remediation objective
- Remedy implementation should consider
  - Adaptive site management
  - Exit strategies
  - Monitoring strategies

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