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Mixed Anion Exchange Resin Bed Configuration for Multi-Contaminant Groundwater Treatment at Complex Remediation Sites

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U.S. DEPARTMENT OF ENERGY BATTELLE

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Talk Preview

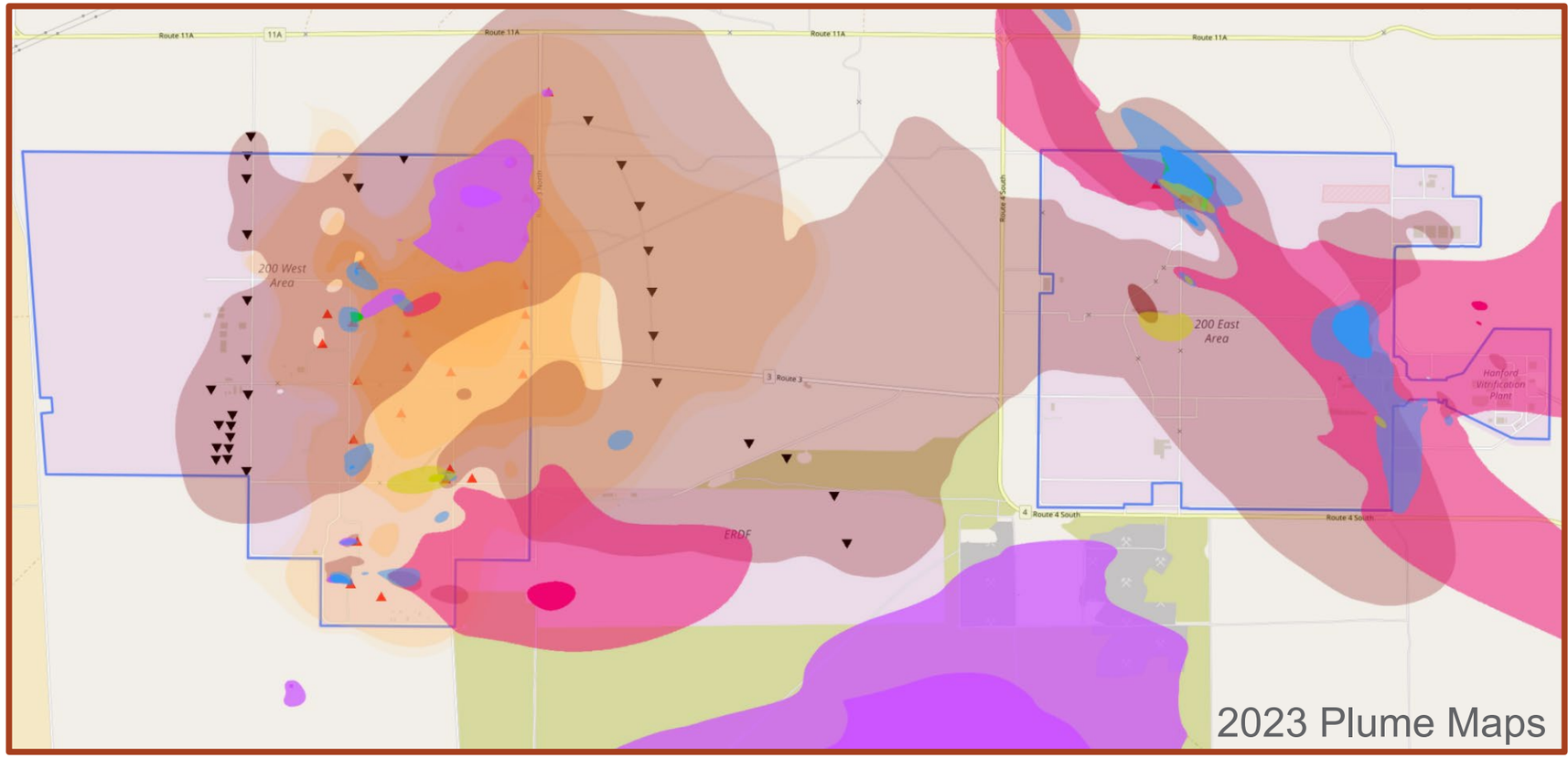
- Evaluate potential for ion exchange (IX) resins already in use at the Hanford Site to treat comingled contaminants (uranium (U), technetium-99 (Tc), and hexavalent chromium (Cr)) in groundwater at the 200 West Area (200W) Pump-and-Treat (P&T) facility via mixed resin treatment train configurations.

- Challenges for P&T at the Hanford Site
  - Co-contaminants Tc, U, and Cr
  - Existing 200W P&T facility operations
- Mixed Resin Treatment Trains
  - Approach
  - Results
  - Future Work

Hanford Site Central Plateau Contaminant Plumes

Significant overlap of groundwater contaminant plumes, including:

- Technetium (Tc)
- Uranium (U)
- Chromium (Cr), including hexavalent chromium
- Iodine-129 (I-129)
- Cyanide (CN)
- Carbon Tetrachloride (CCl_4)
- Nitrate (NO_3)



Plume contours

Tc, I-129, CN, U, CCl_4, Cr, NO_3

200W P&T well infrastructure

Extraction wells

Injection wells

Johnson C.D., et al. 2024. "SOCRATES Software Release 5.0." PNNL-SA-202633.

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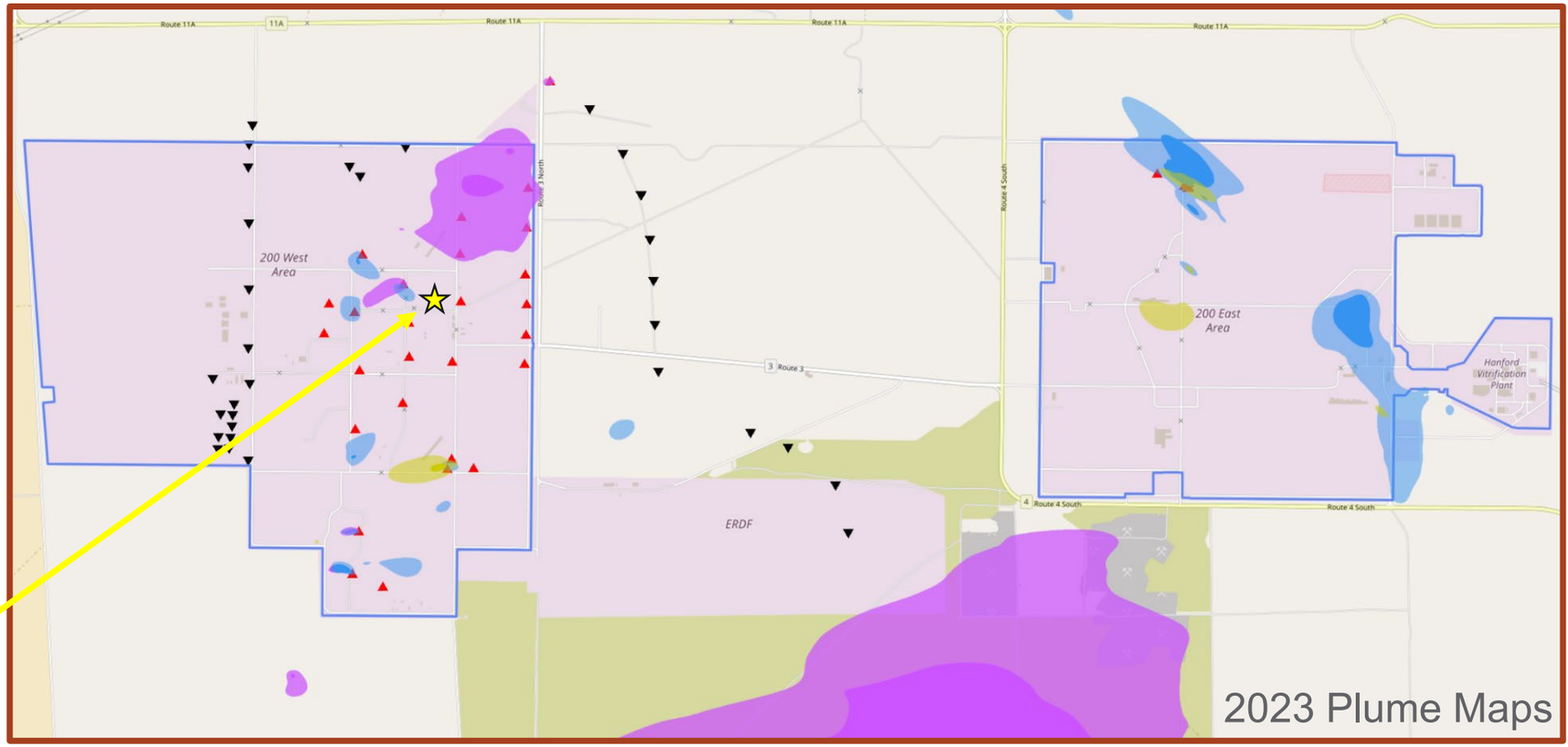
Contaminated groundwater is treated at the 200W pump & treat facility ★



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- **Tc**
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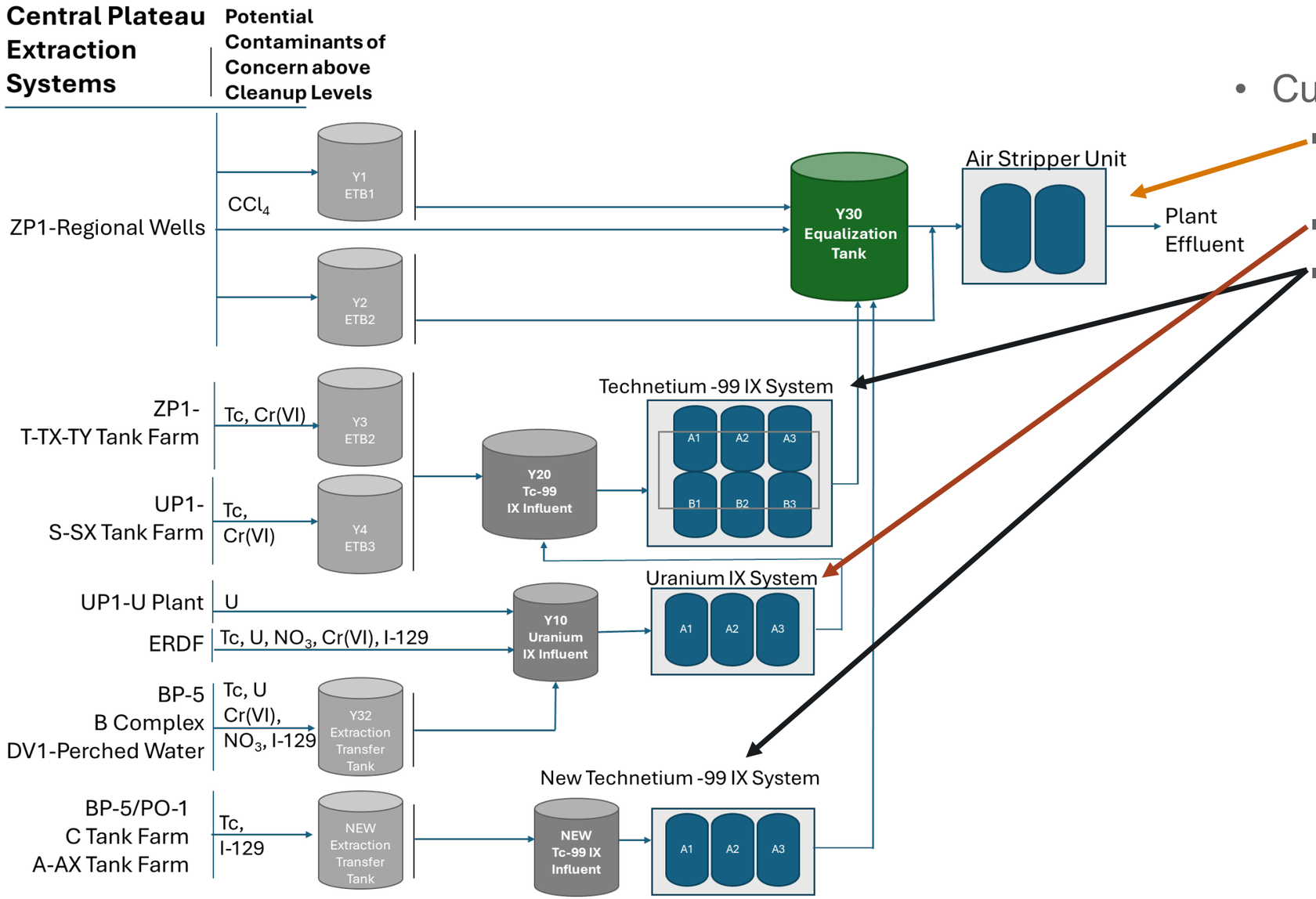
Current 200W P&T Operations on Hanford Site Central Plateau



- Current treatment includes:
  - Air-stripping for volatile organic contaminants
  - **Dowex 21K IX resin for U**
  - **Purolite A532E IX resin for Tc**

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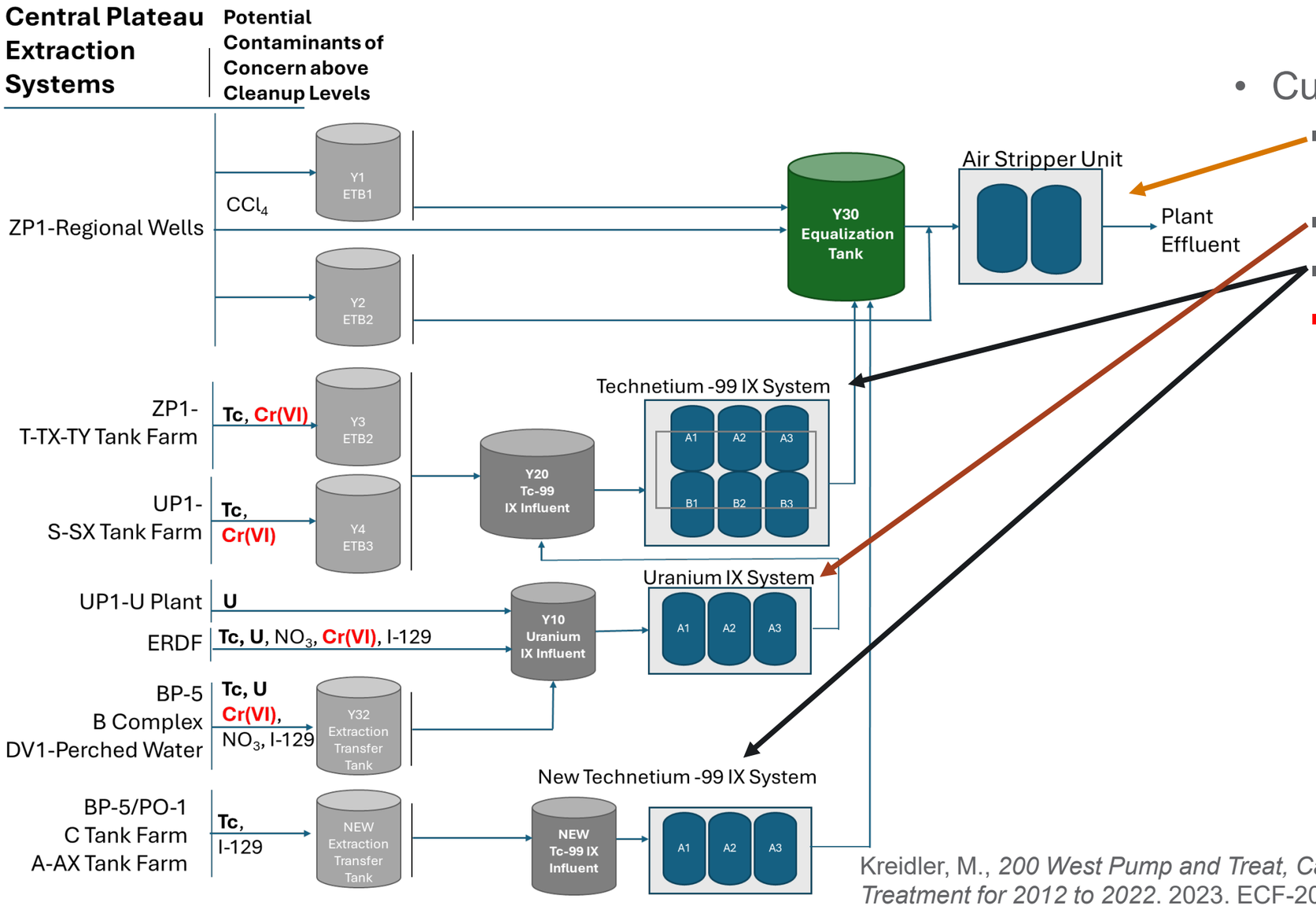

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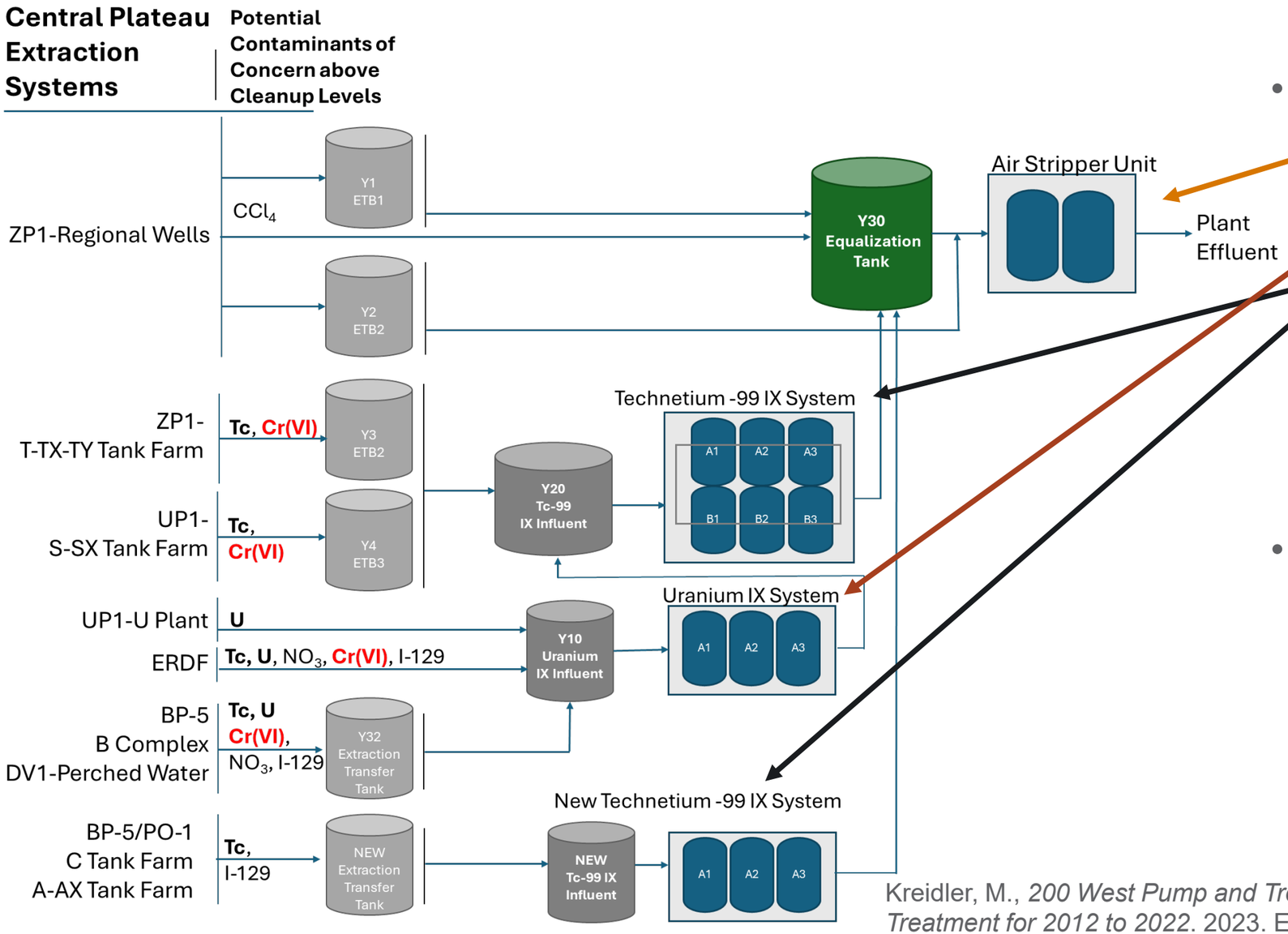

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  - Biological treatment for nitrate, which removed Cr, was suspended in Oct 2019 for an optimization study (Kreidler 2023)
- Any potential changes in Cr regulatory limits and/or influent concentrations may require additional considerations for a Cr treatment pathway.
  - 100 Area P&T facilities currently use ResinTech, Inc. SIR-700-HP resin to treat Cr in groundwater.

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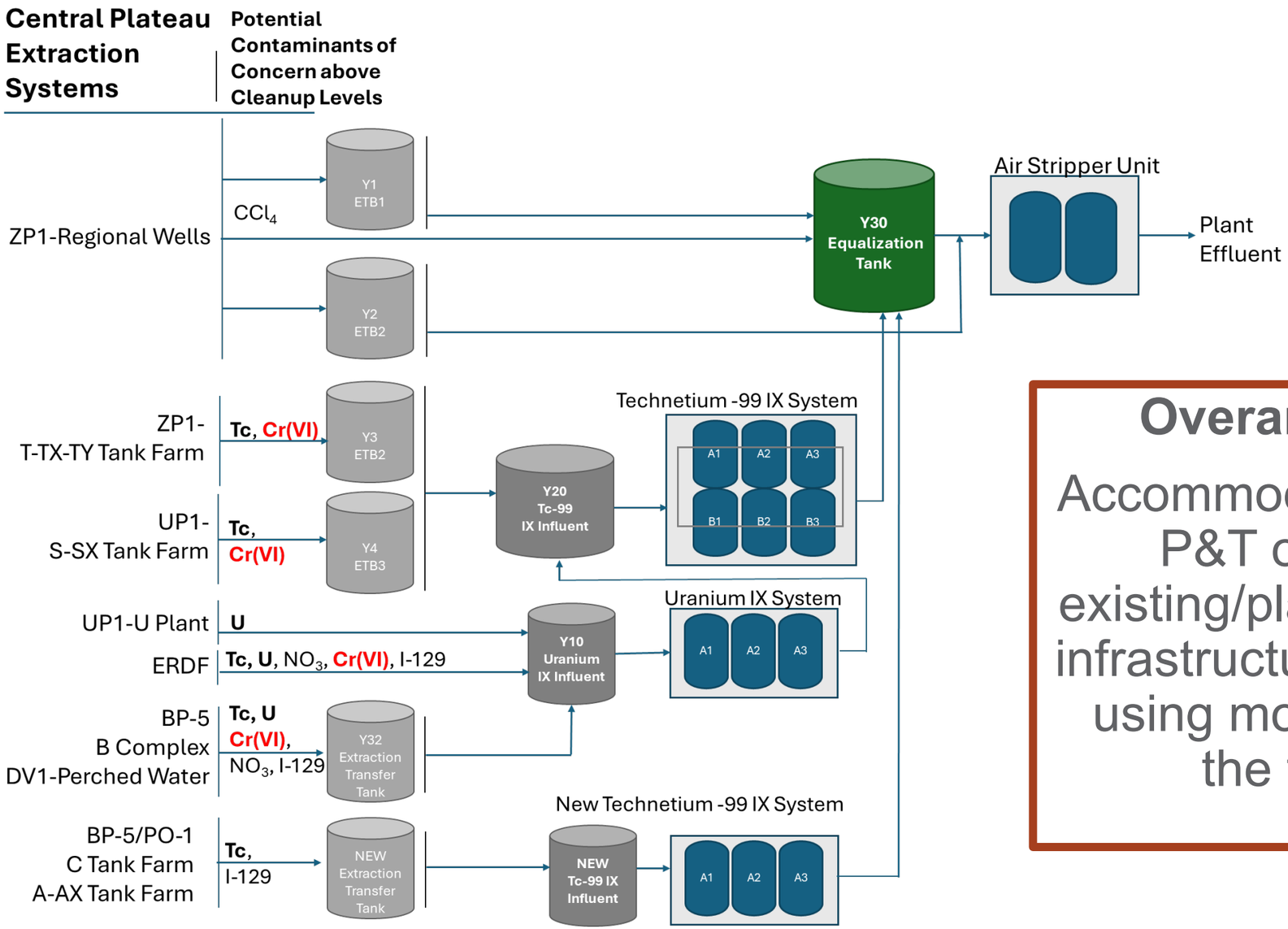


Overarching Project Aim:

Accommodate expansion of 200W P&T operations using the existing/planned IX treatment train infrastructure to treat Tc, U, and Cr using more than one IX resin in the treatment train(s).

Mixed Resin Bed Testing Efforts

Objective: Evaluate IX resin mixed bed configuration(s) for Tc, U, and Cr treatment using IX resins currently used at Hanford:

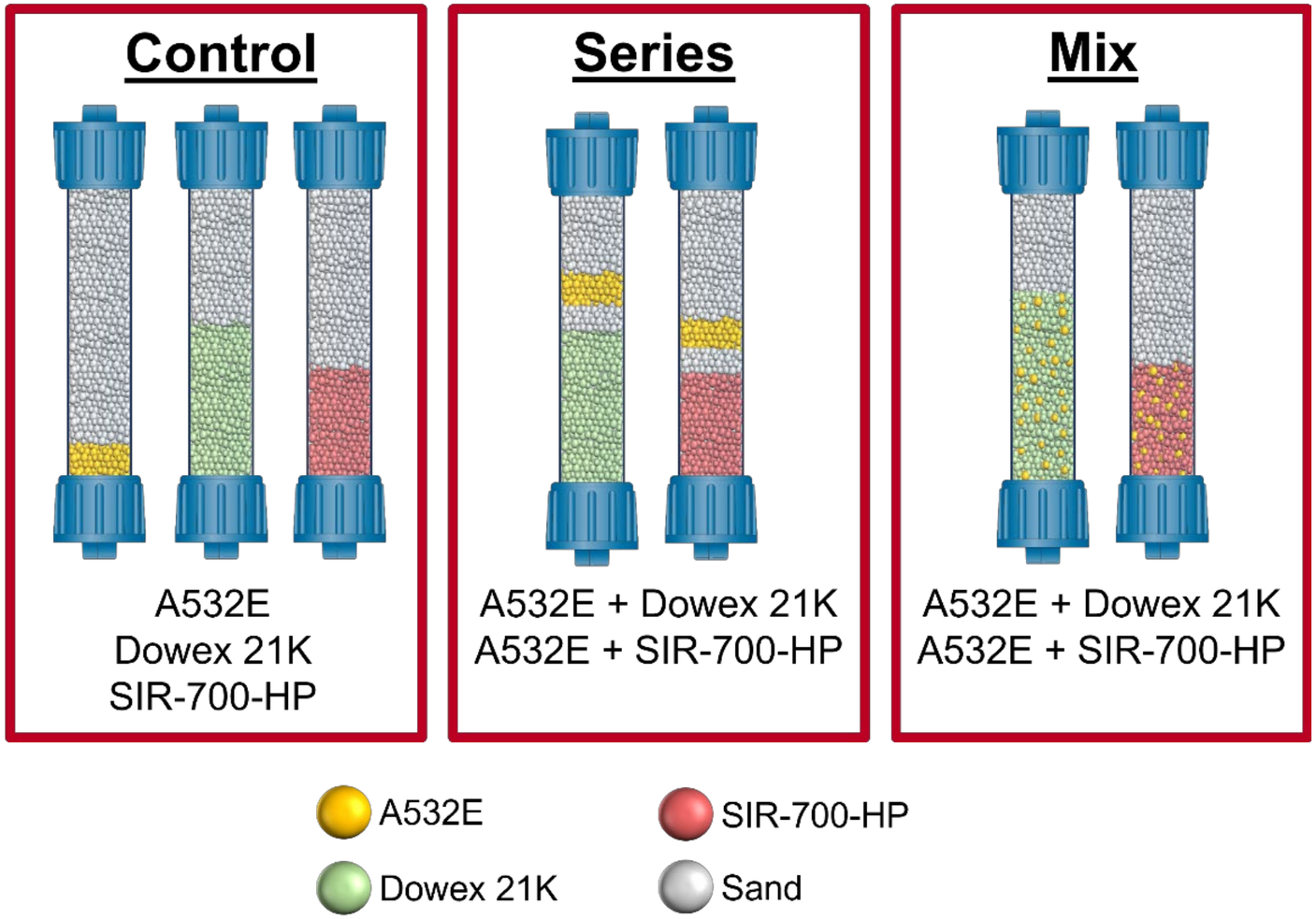
- Purolite A532E (EcoLab) → Tc
- Dowex 21K (DuPont) → U
- SIR-700-HP (ResinTech, Inc. → Cr, U >>Tc

Approach: Identify potential changes in Tc, U, and Cr breakthrough curves from 1D flow columns with different resin configurations.

Simulated groundwater spiked with approx. 0.6 ppm Tc, 1.3 ppm U, and 1.6 ppm Cr.

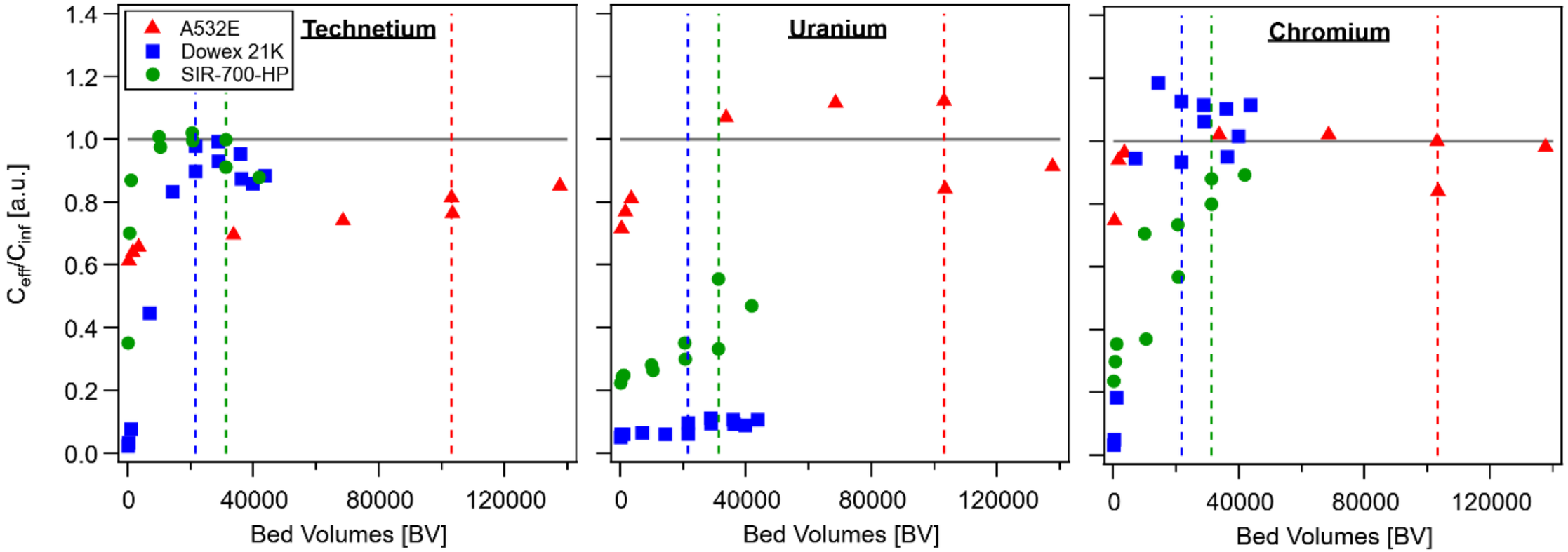
Flow rate: 44 mL/hr

Diagram shows relative amount of IX resins used.



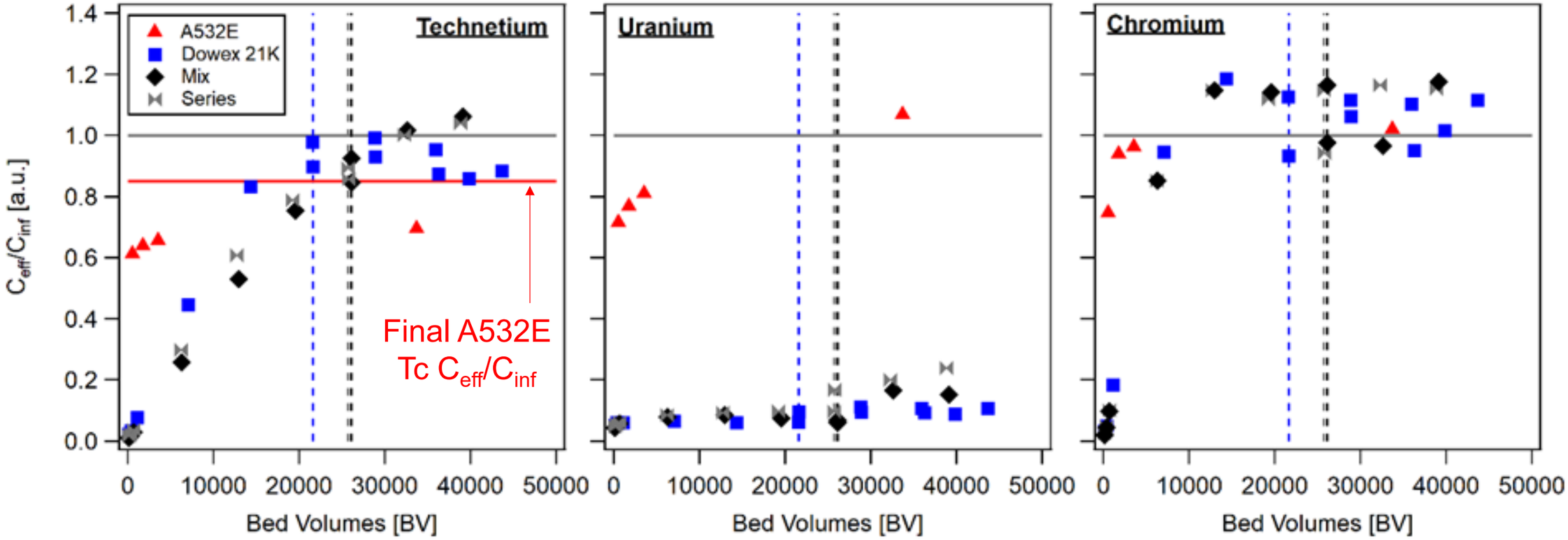
Control Columns Establish Baseline Breakthrough Curves for Tc, U, and Cr

- A532E, Dowex 21K and SIR-700-HP remove the most Tc, U and Cr, respectively, as expected.
  - The short A532E bed height, low residence time, and flow rate all contribute to the unexpected early Tc breakthrough (>60%) for the A532E control column.
- Dashed lines indicate stop flow events.



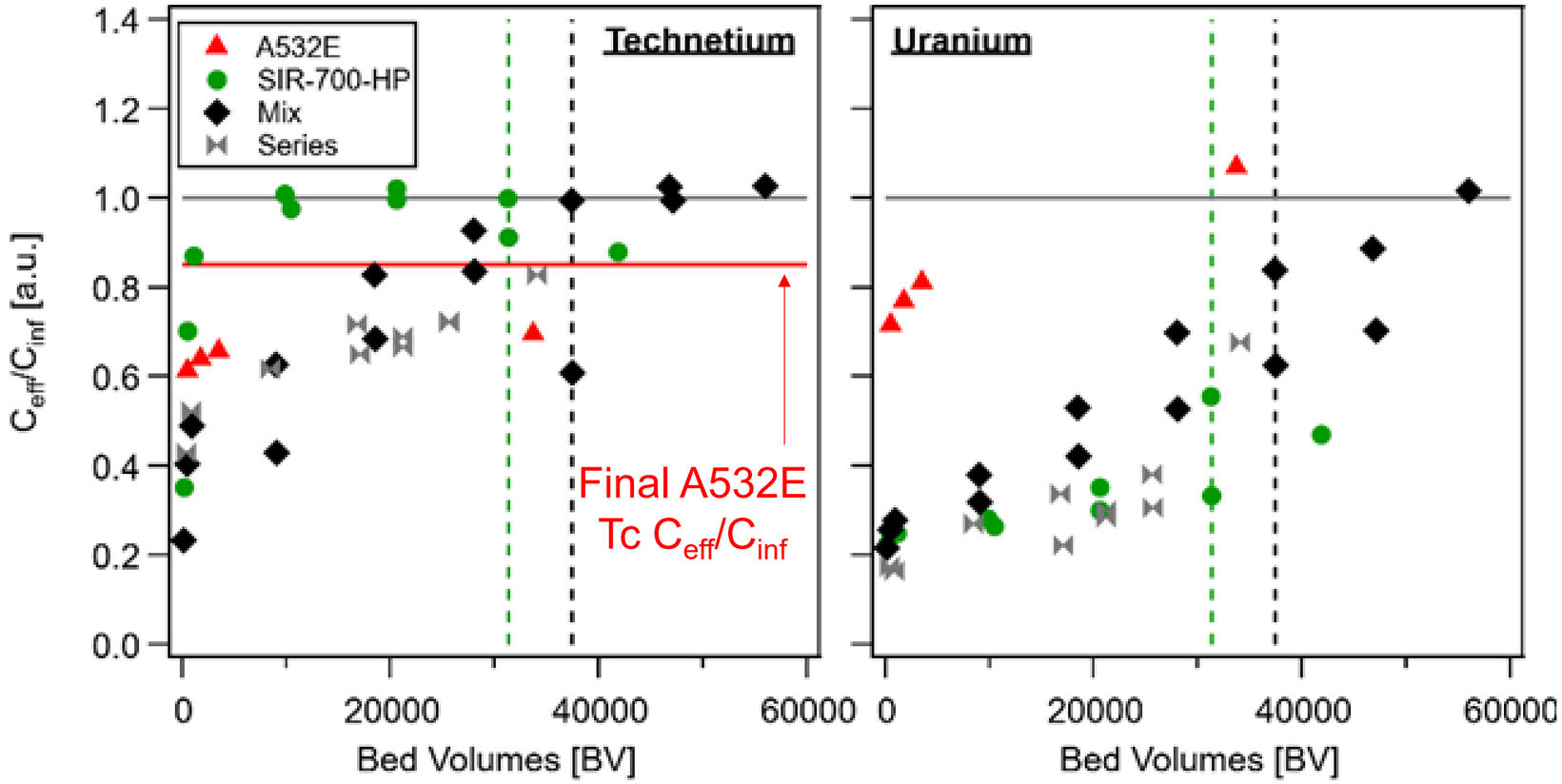
Results: A532E + Dowex 21K

- Most studied IX resins for 200W P&T, offers early insight into the impact of blending resins.
- Combining A532E and Dowex 21K by mixing or in series show shifts to earlier breakthrough for Tc and U compared to the IX resin selective for these contaminants; minimal Cr uptake.
- Existing 200W P&T operations remove the most Tc and U removal, no need to blend resins.



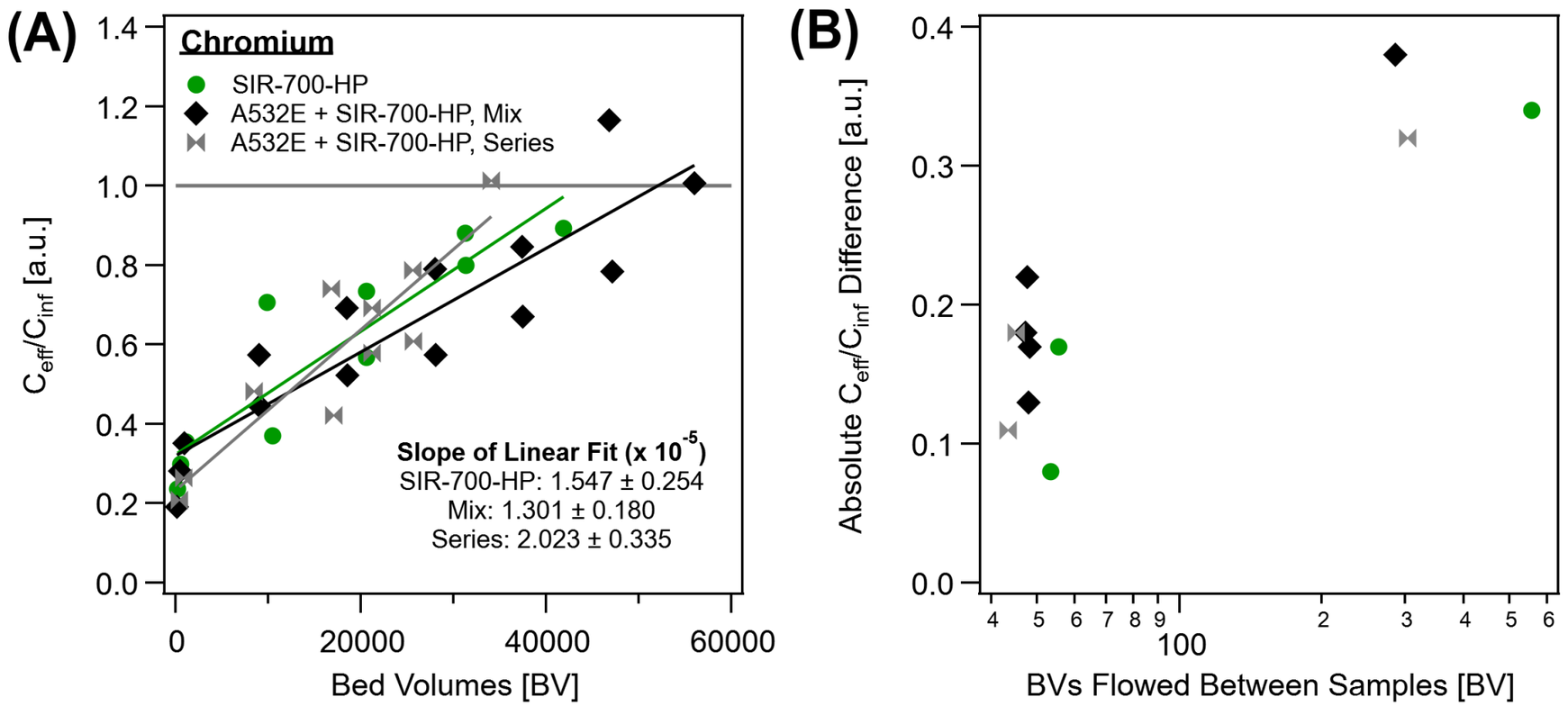
Results: A532E + SIR-700-HP

- Tc breakthrough curves for mixed/series columns are delayed compared to the SIR-700-HP control column, but breakthrough well before the A532E control column.
- U breakthrough occurs earlier for mixed/series columns than SIR-700-HP control column, but some U removal still observed.



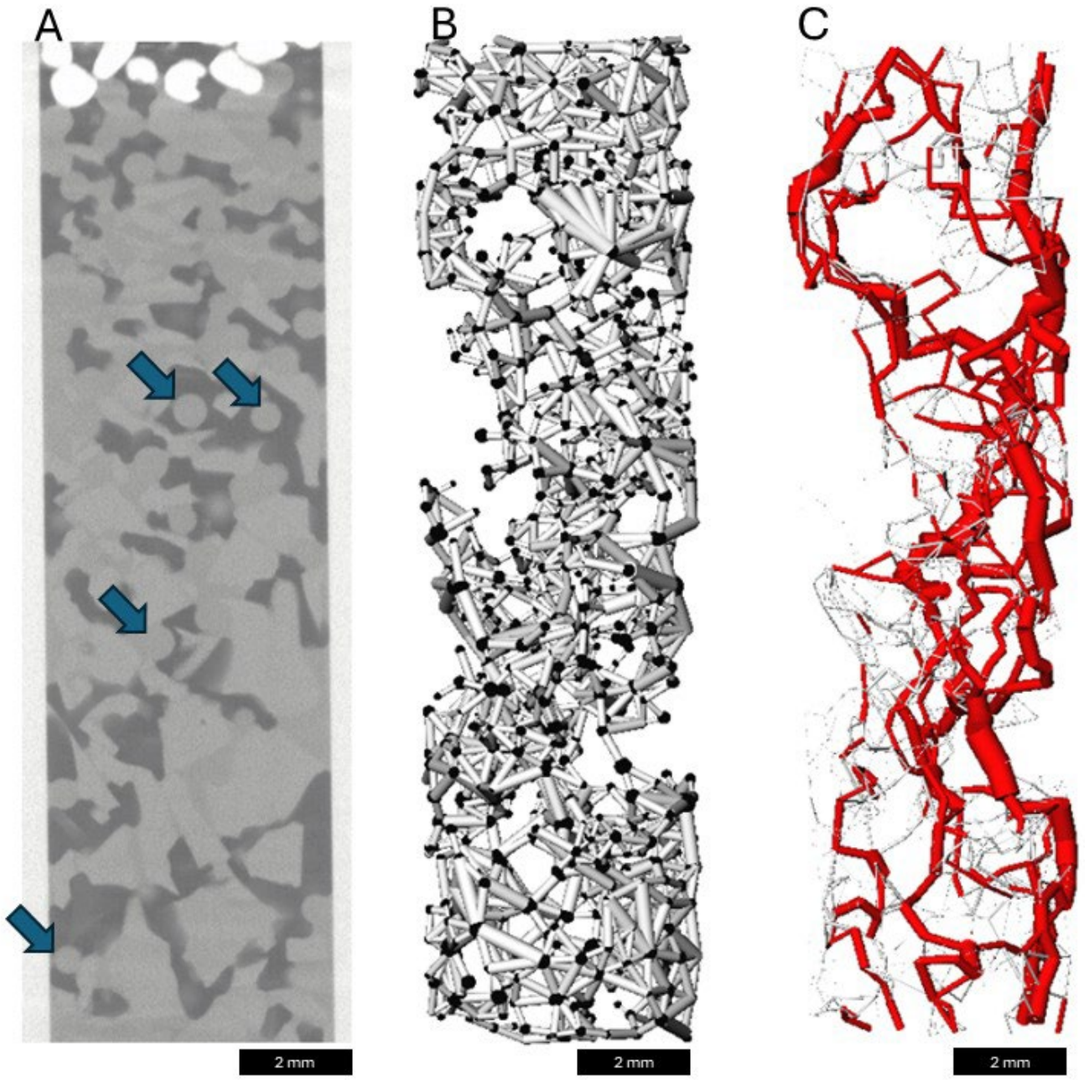
Results: A532E + SIR-700-HP

- Cr breakthrough curve of the mixed A532E and SIR-700-HP column progresses slower than the SIR-700-HP control or series column, based on linear fits to the breakthrough curves.
- Mixing A532E with SIR-700-HP shows an increase in the amount of Cr removed during stop-flow events based on the C_{eff}/C_{inf} difference.



Potential Beneficial Mixing Effects

- Preferential flow paths generated in mixed resin columns potentially increased flow in regions with A532E resin beads (blue arrows) mixed among SIR-700-HP platelets, as shown by X-ray computed tomography (XCT).
  A. XCT image of a mixed A532E and SIR-700-HP column.
  B. Pore connectivity analysis.
  C. Preferential flow paths are shown in red.



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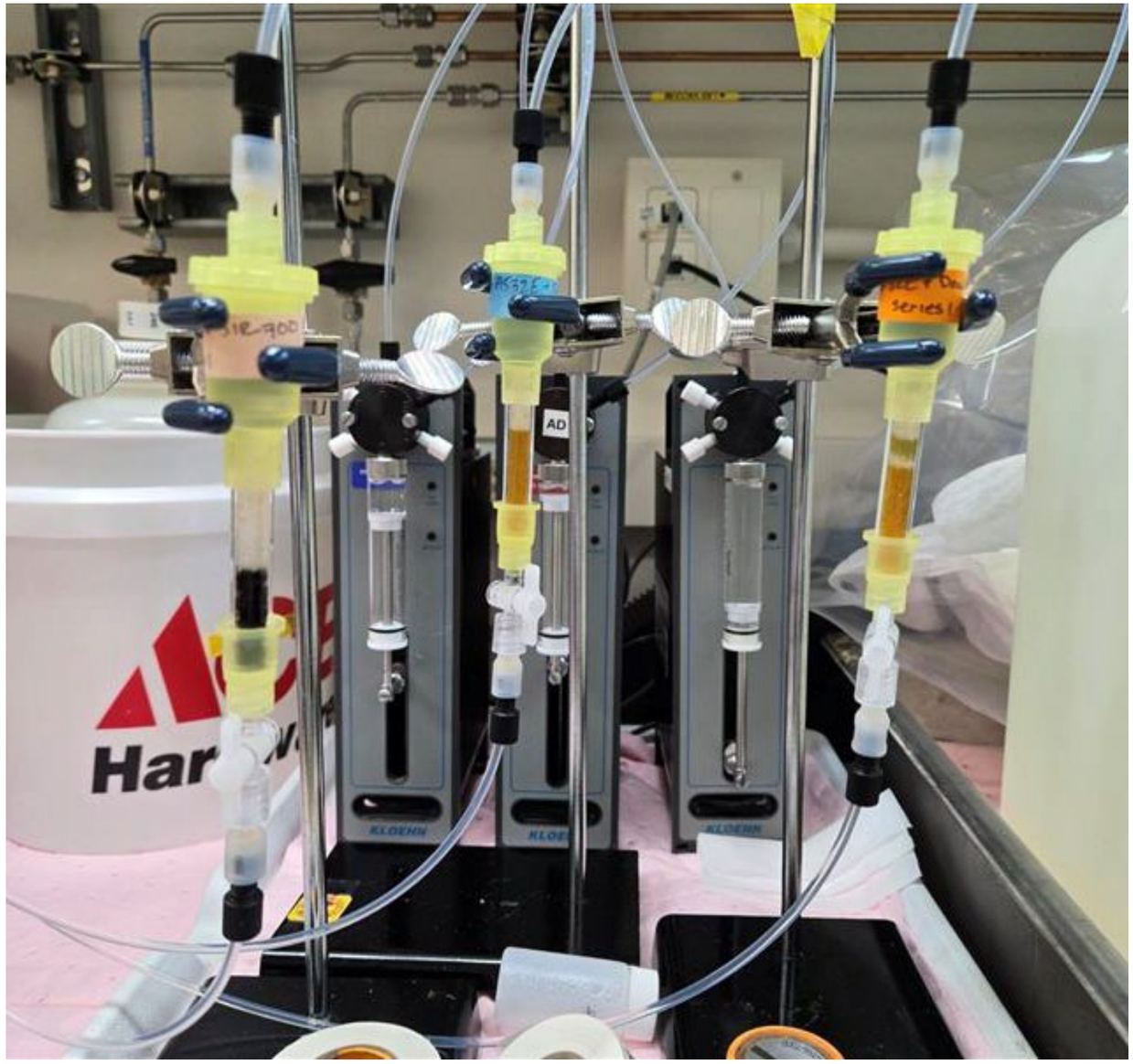
Summary and Future Work

- Mixing A532E and SIR-700-HP could potentially remove Tc and Cr, incidental U.
- U removal by existing Dowex 21K treatment train recommended.
- Potential next step: Run a lab scale “lead, lag, polish” treatment train using mixed bed(s) and column parameters that better match 200W P&T operations, e.g., flow rate, residence time, to demonstrate contaminant removal using mixed bed configuration(s).



Mixed and series columns run during this project.

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Thank you

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