Treatment of PFAS-Contaminated Water

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Challenges

Chemical properties

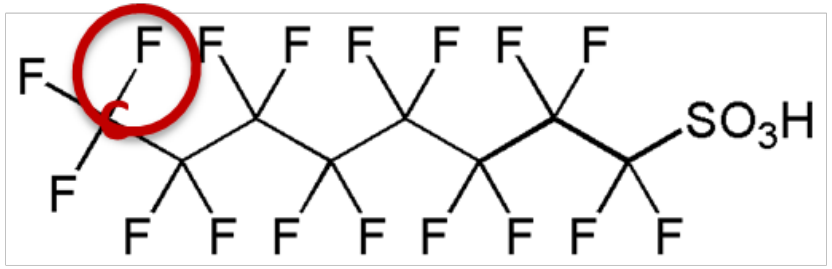
Mixtures

- Can't detect/quantify some PFAS
- Range of properties

Precursors → Compounds of concern

- Many can undergo transformation

PFOS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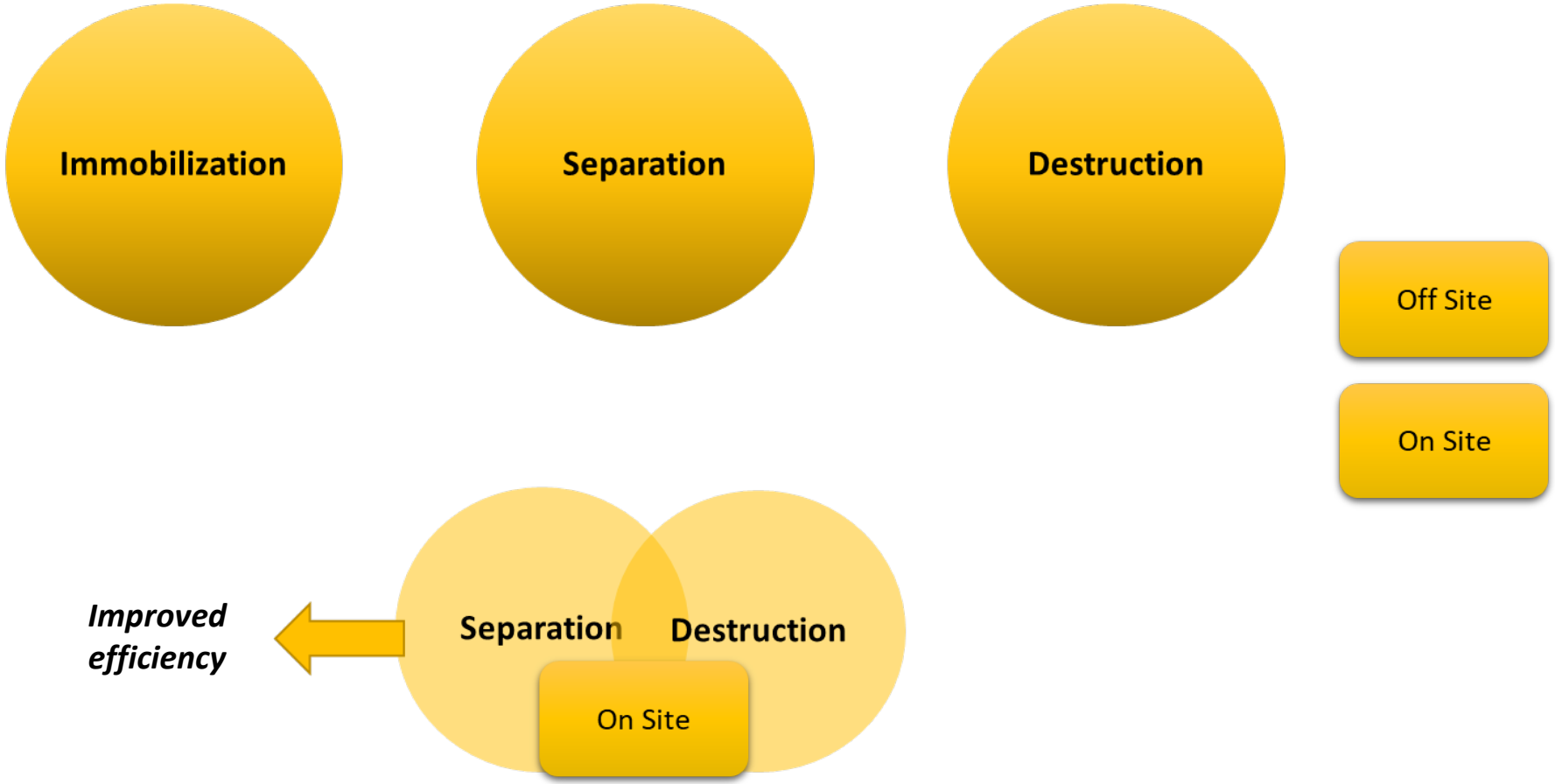
Treatment Options



Carbon-Based Sorption

ex situ pump-and-treat, *in situ* injectable

Large installations and point-of-entry or point-of-use

Granular or powdered activated carbon

Clays, blends, Synthetics

Treatability testing essential

Co-contaminants and precursors compete

Less effective for small-chain compounds

Hemi-micelle and micelle formation

GAC fate and reuse

Note: GAC = granular activated carbon

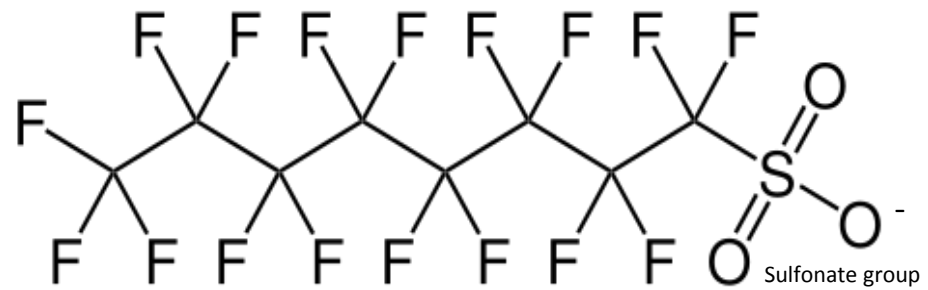
Carbon-based sorption is effective, but challenging to predict

Ion Exchange (IX) - Sorption

PFOS – Perfluorooctane Sulfonate

Hydrophobic "Tail"

Ionized "Head"



Selective IX Resins

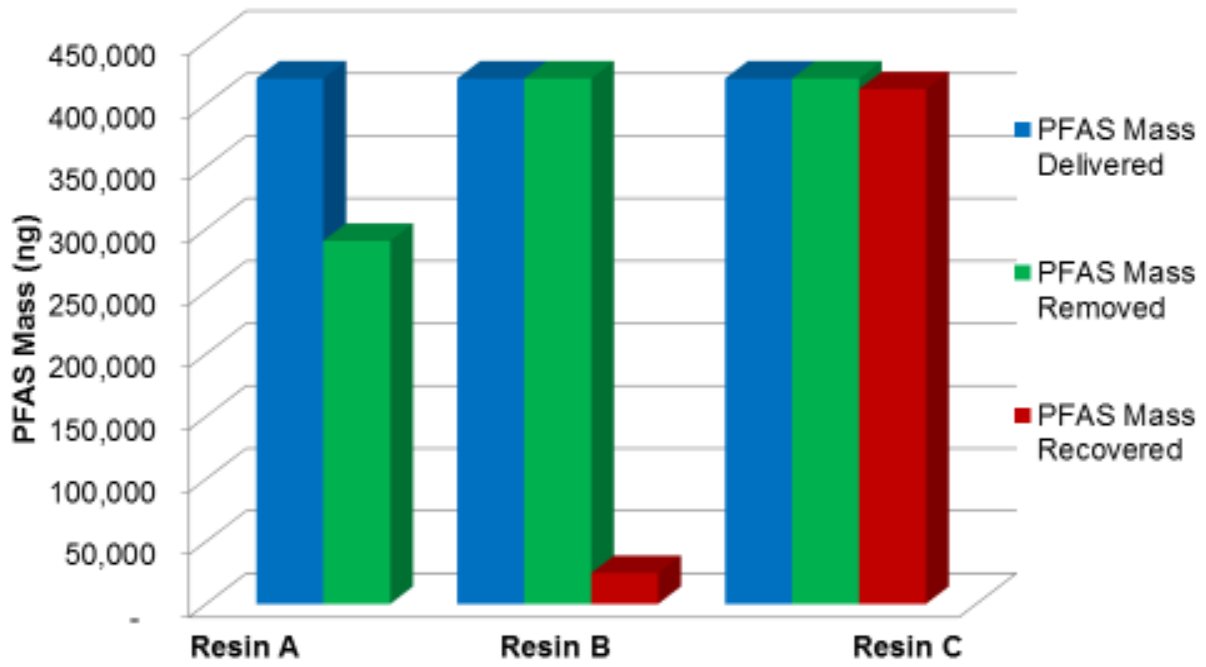
removes by both <u>ion exchange</u> and <u>adsorption</u> using both "Head" & "Tail"

Incineration or other disposal alternative

Short Contact Time ~3 mins

Graphic used with permission, Stew Abrams, Langan/Adapted from Purolite
Photo used with permission, Francis Boodoo, Purolite

Ion Exchange - Sorption



- Treatability testing essential
- Co-contaminants and precursors compete
- Less effective for small-chain compounds
- Resin fate and reuse

Reverse Osmosis (RO) - Separation

Membrane Processes

Effective for PFAS

- High pressure and therefore high energy
- Reject water disposal needed
- Not all membranes are the same
- Typically used on lower flow rates
- (i.e., residential point of entry/point of use)
- Removes multiple pollutants

Removes beneficial constituents

- Including hardness, minerals, nutrients

Photo used with permission, Bill DiGuiseppi, Jacobs

Source: ITRC PFAS training, used with permission

Redox Manipulation

Plasma

Sonolysis

Activated Persulfate

Electrochemical

Chemical Reduction

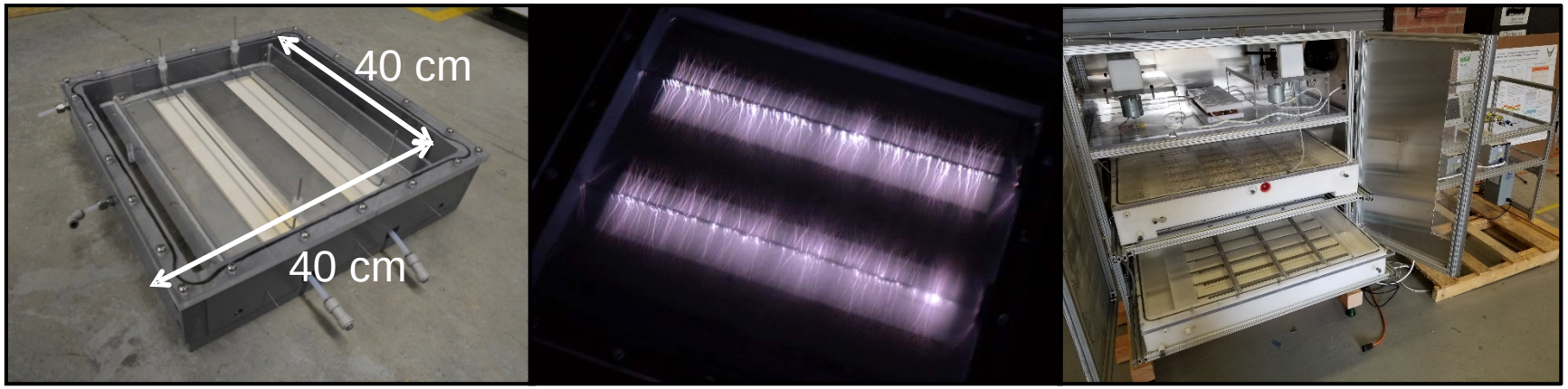
Combinations

Details: Nzeribe, B. N., et al. (2019). *Critical Reviews in ES&T*, 49(10), 866-915.

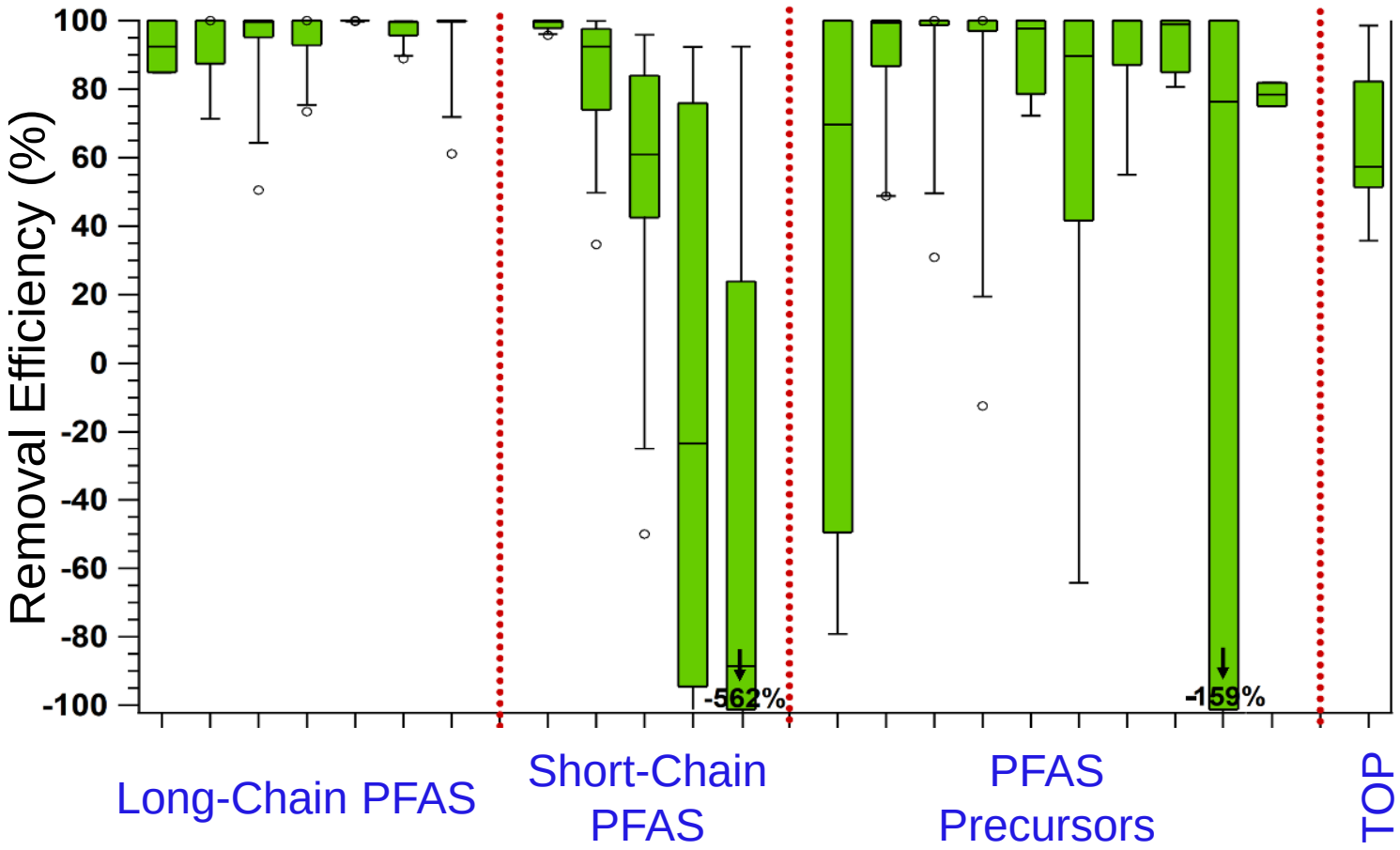
Plasma

Uses electricity to convert water into mixture of highly reactive species

- $OH\bullet$, O, $H\bullet$, $HO_2\bullet$, $O_2\bullet^-$, H_2, O_2, H_2O_2 and aqueous electrons (e^-_{aq})

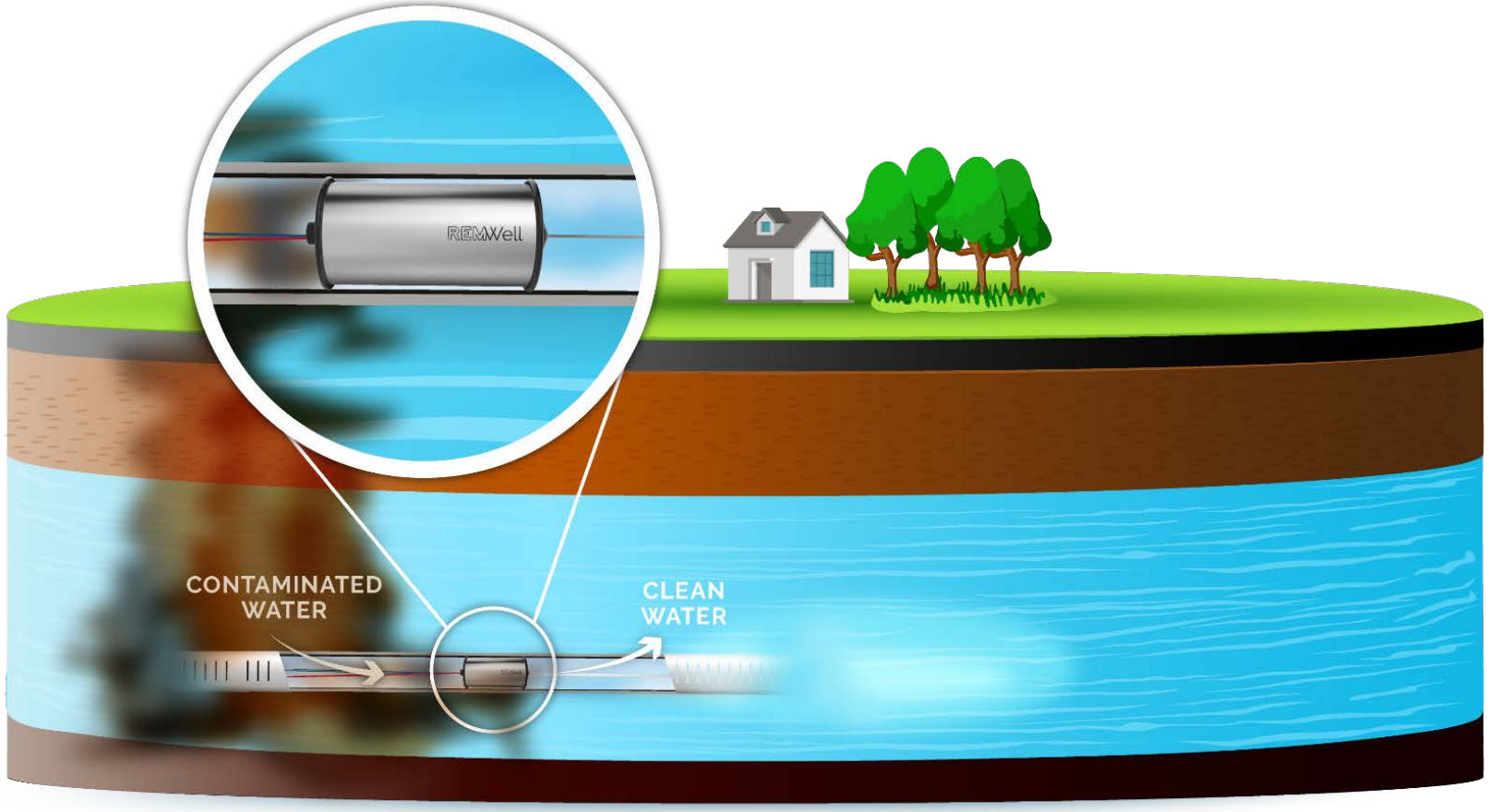


Plasma



Plasma treats PFAS rapidly, proceeding through short-chain intermediates

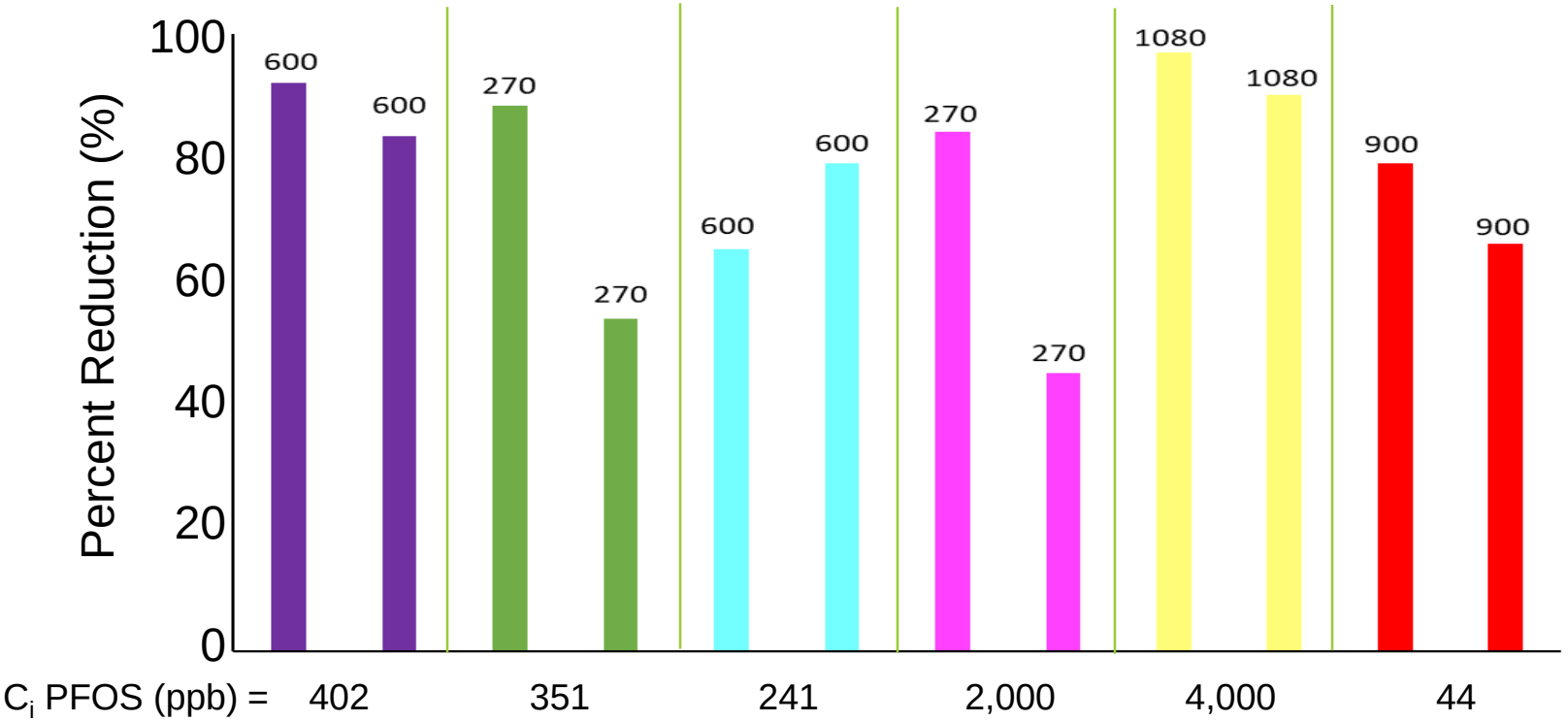
Sonolysis: *In Situ Reactor for PFAS Treatment*



Contaminated water → Clean water

Sonolysis: *In Situ Reactor for PFAS Treatment*

Values above bars: Treatment Time (minutes)



Notes: Each color represents a different contaminated field site with PFOA on left and PFOS on right.

Sonolysis effectively treats PFAS, with potential for *in situ* application

Challenges and Limitations

Mixtures, precursors, co-contaminants

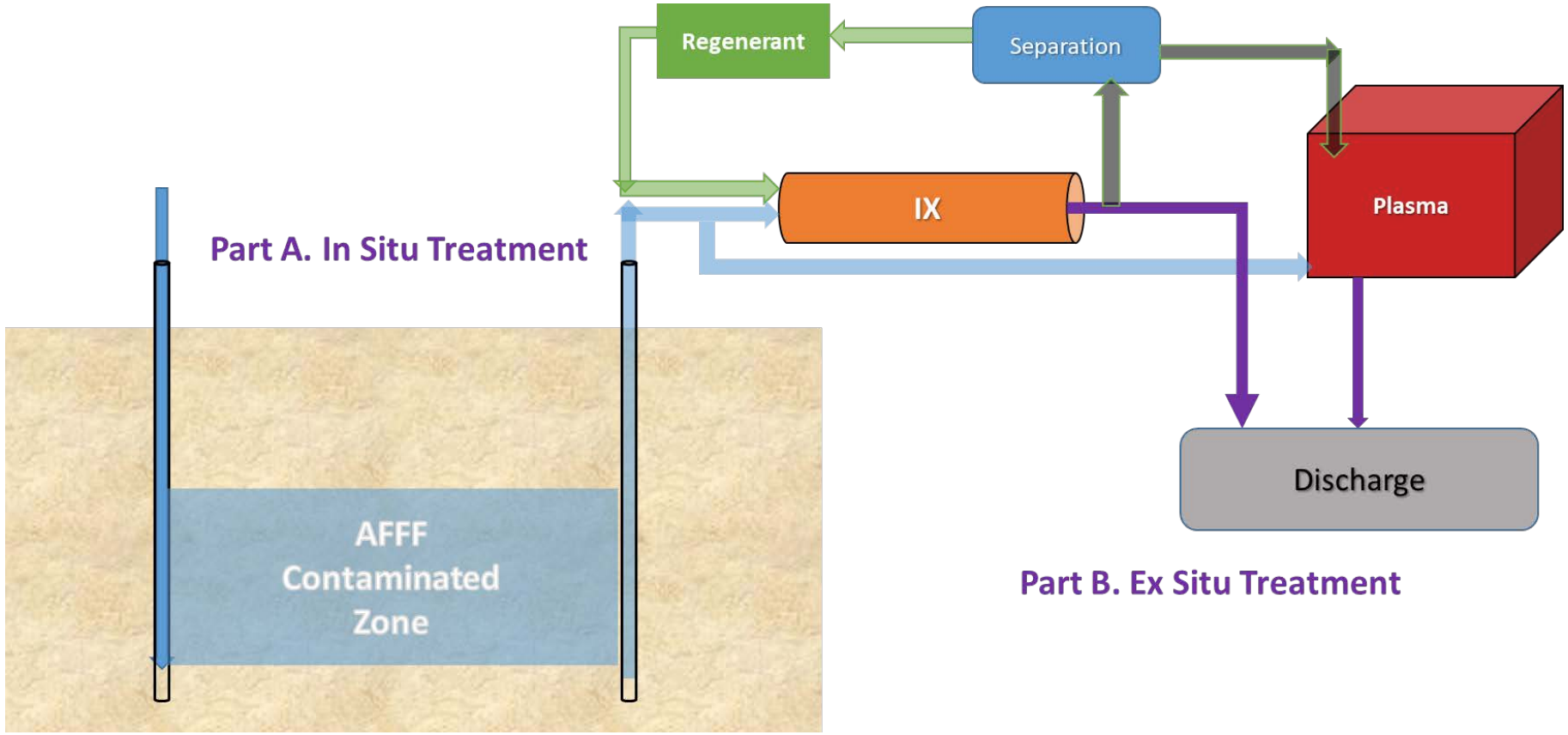
Managing materials

Incomplete mineralization

Energy intensity

Limited field-scale examples

Treatment Trains



Treatment trains can improve treatment efficiency