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Technology Assessment for Radioiodine at the Hanford Site

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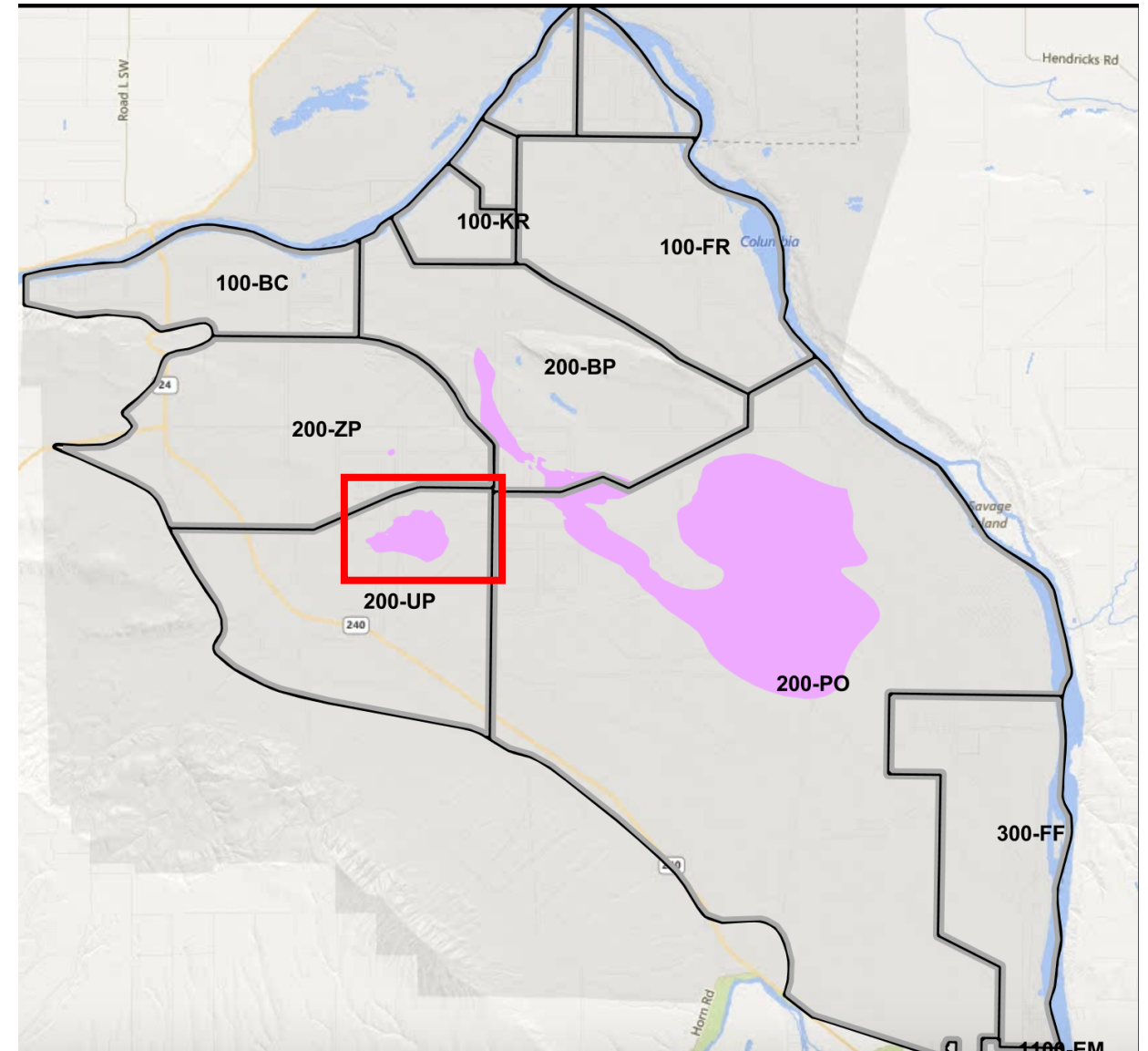
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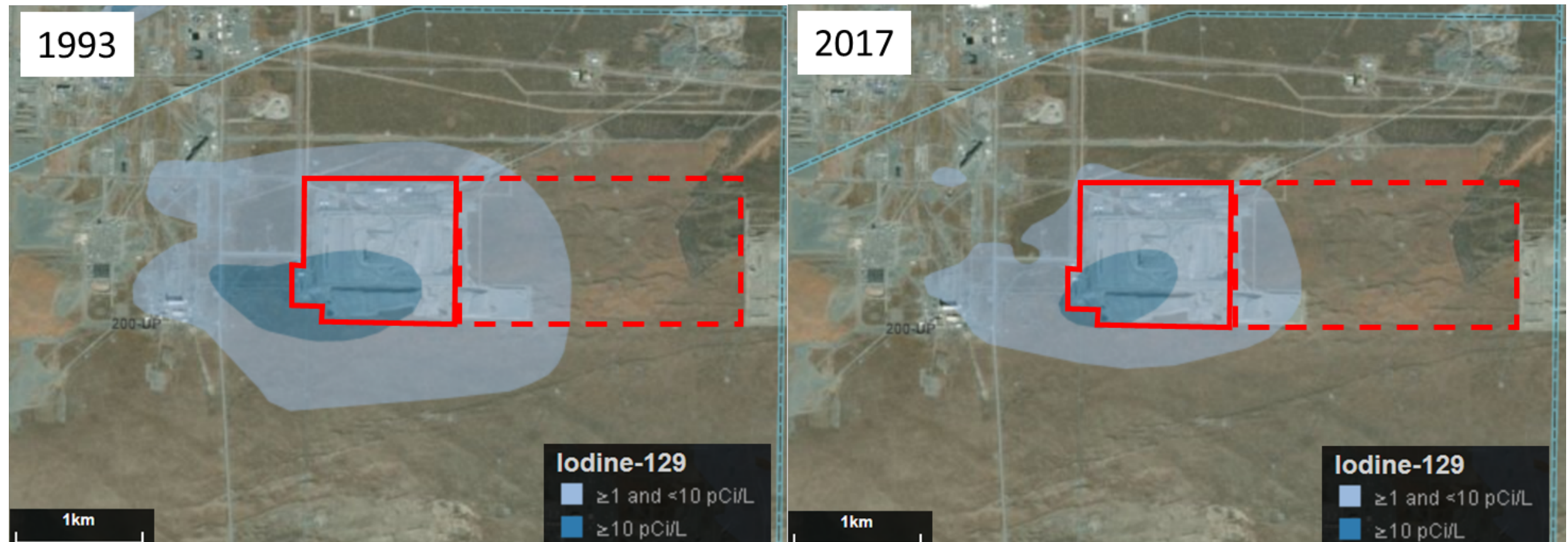
200-UP-1 Interim ROD Context

- Feasibility study for ^{129}I determined no existing treatment technologies to achieve the federal drinking water standard of < 1 pCi/L in the 200-UP-1 Operable Unit at the Hanford Site
 - Current remedy is hydraulic control
 - Current ^{129}I conditions in groundwater are relatively dilute: 1 to ~ 23 pCi/L
- Interim Record of Decision (ROD) dictated three elements be investigated
 - Close conceptual model data gaps for ^{129}I
 - Investigate potential remedies for iodine (in situ and ex situ)
 - Consider whether an Applicable or Relevant and Appropriate Requirements (ARAR) Technical Impracticability (TI) waiver for ^{129}I is appropriate



Plume Location

- Plume core located below the Environmental Restoration Disposal Facility (ERDF)
 - ERDF expansion coincides with plume trajectory
- Plume characteristics
 - Full plume: 3 km² area, 1.2 km wide, 45 m thick

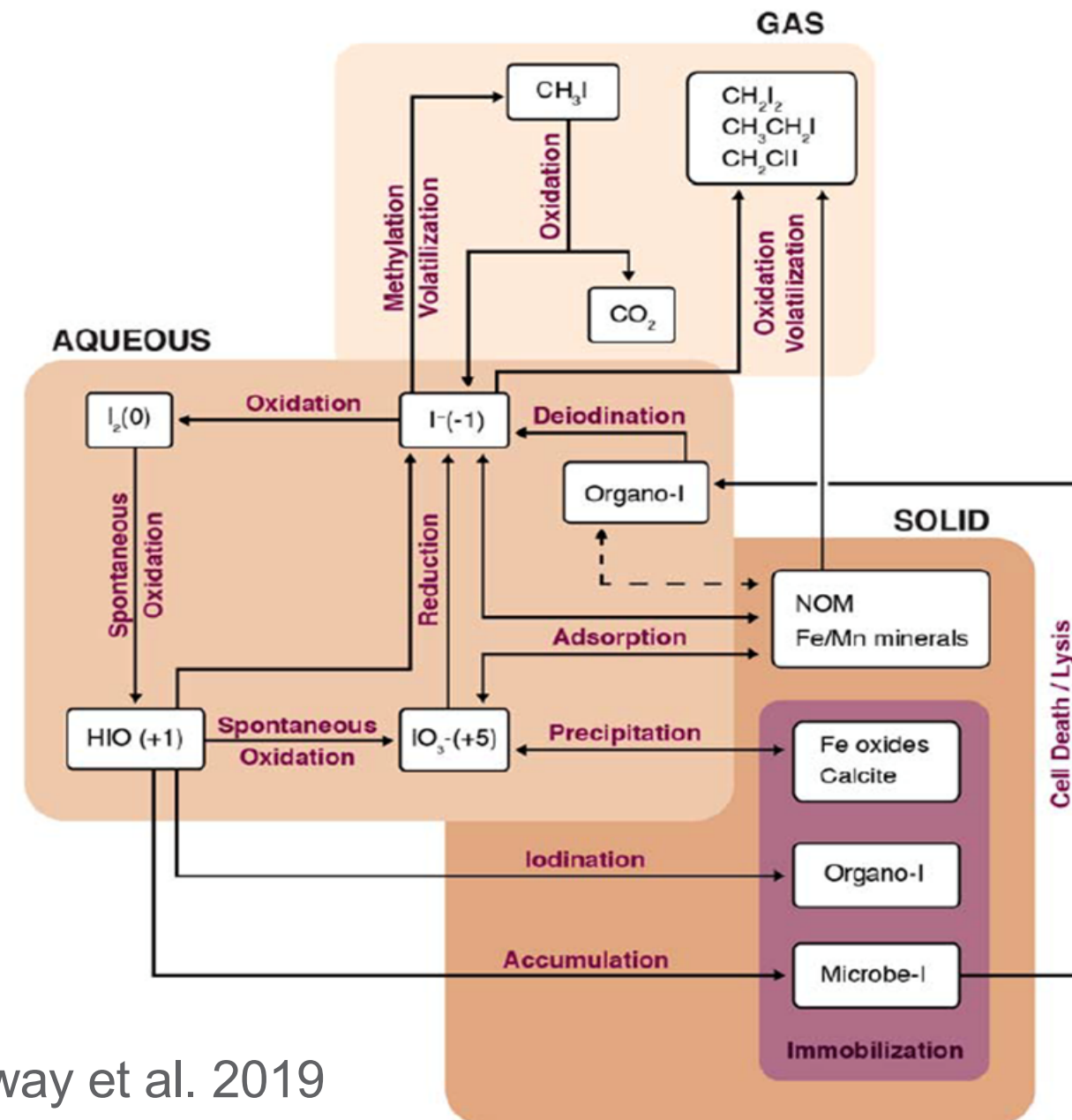


Presence of Stable Iodine (^{127}I)

- Natural stable iodine (^{127}I) is also present in the aquifer at much greater concentrations than ^{129}I
 - Remedies are not specific for a particular iodine isotope
 - Recent resin analysis at pump-and-treat (P&T) facility identified concentrations of ^{127}I : ^{129}I as 1000:1
 - Concentration ratio ($^{127}\text{I} / ^{129}\text{I}$) is not constant within aquifer
- Source of ^{127}I is unknown, but iodine commonly exists as a trace constituent of nitric acid
 - Large volumes of nitric acid used during operations likely contribute to its high concentrations in groundwater
 - Presence of high ^{127}I concentrations must be considered because they exhibit the same geochemical behavior

Iodine Speciation

- Iodate is the predominant species in Hanford groundwater
 - Iodate (IO_3^-) is the prevalent form of iodine, ~70%
 - Iodide (I^-), ~5%
 - Organo-iodine, ~25%
- Predominant species previously thought to be iodide
 - More mobile
 - Consideration for treatment technology



Neeway et al. 2019




Technology Identification

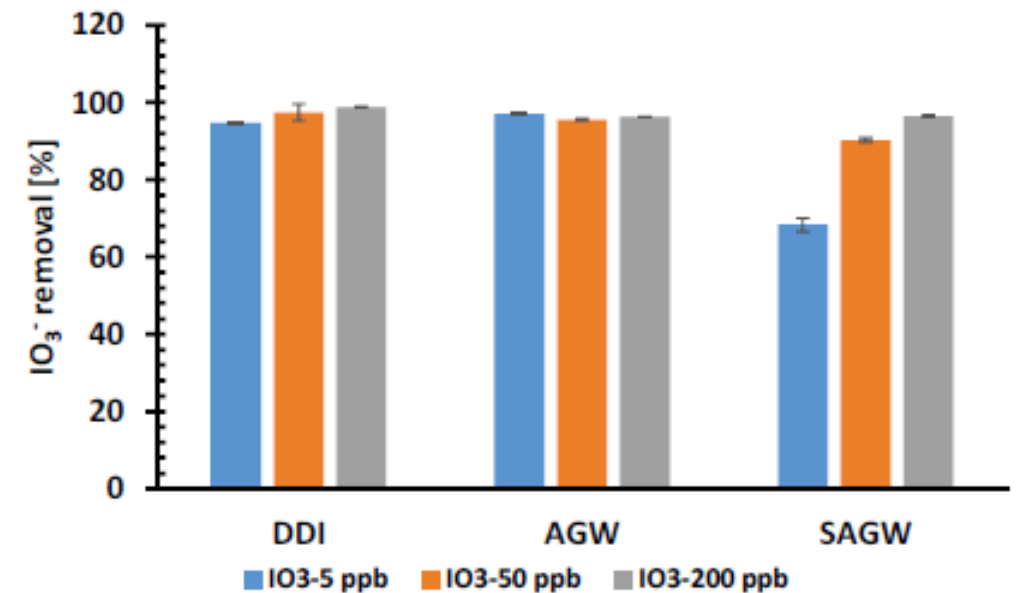
- Literature review to identify promising technologies
- Laboratory scoping tests where further evaluation was needed
- Extended evaluation/scale-up to evaluate whether treatability testing was needed
 - Evaluation based on ability to meet the maximum contaminant level of 1 pCi/L in groundwater

Technology Approaches

- Technologies for further screening organized into three categories
 - **In situ sequestration**
 - ✓ Calcite co-precipitation
 - ✓ Apatite sorption and co-precipitation
 - ✓ Organic sorption (chitin, lignin, humic acid)
 - ✓ Iron oxide sorption and co-precipitation
 - **In situ mobilization to enhance P&T extraction efficiency**
 - ✓ Dithionite
 - **Ex situ extraction within P&T system**
 - ✓ Ferrihydrite, bismuth oxyhydroxide, bismuth-cobalt-aluminum
 - ✓ Commercially available resins
- No microbial-based technologies selected for evaluation
 - Demonstrated to be insignificant process in the conceptual model evaluation
 - Operational difficulties associated with ex situ treatment (P&T)

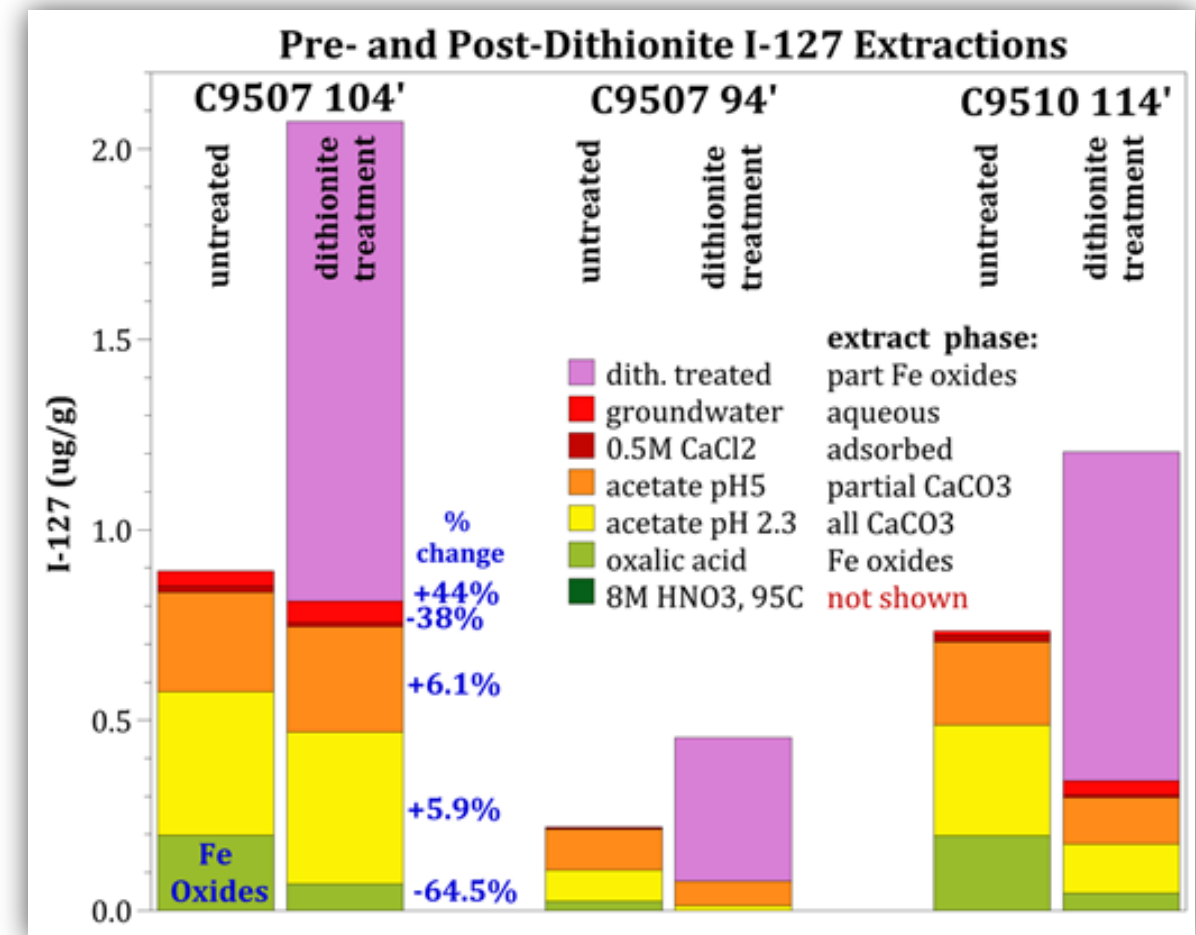
In Situ Sequestration Technology Screening

- Calcite co-precipitation 
 - 70% removal of iodate only
- Apatite sorption/co-precipitation 
 - Minimal removal
- Organic sorption (chitin, lignin, humic acid) 
 - Only chitin effective for iodide
- Iron oxide sorption/co-precipitation
 - ~98% removal of iodate
 - ~70% removal of iodide
 - Iodate sorbs
 - Iodate and iodide can be incorporated during ferrihydrite precipitation
 - **Possible treatability candidate**



Enhanced Pump-and-Treat Technology Screening

- Dithionite
 - Up to 4X more and 3X faster leaching of iodine
- Possible treatability candidate



Ex Situ Treatment Technology Screening

- Non-commercial materials
 - Ferrihydrite, bismuth oxy(hydroxide), and bismuth-cobalt-aluminum
 - High affinity for iodate
 - Effective even in the presence of ^{127}I (1000 times higher than ^{129}I)
 - **Possible treatability candidates**

- Commercial resins
 - CHM-20: Hybrid Type 2 dimethylethanolamine strong base anion resin containing CeO_2 -like phase
 - ASM-10-HP: Hybrid Type 2 dimethylethanolamine strong base anion resin containing ferrihydrite-like phase
 - **Possible treatability candidates**

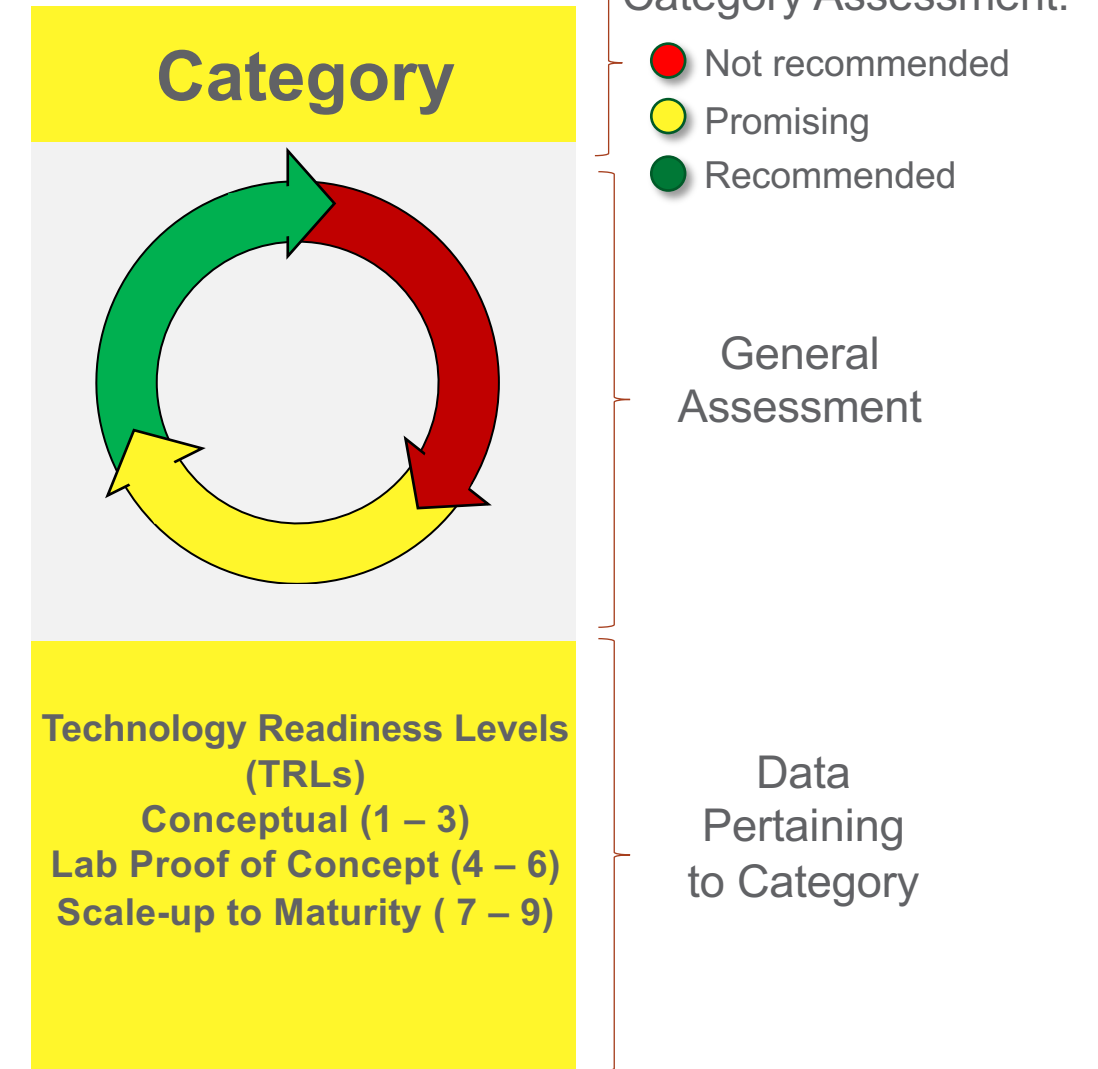
Material Tested	Measured Kd (mL/g)
Ferrihydrite	3230
Bismuth (oxy)hydroxide	200,000
Bi-Co-Al	13,000
12 other compounds tested	zero - 680

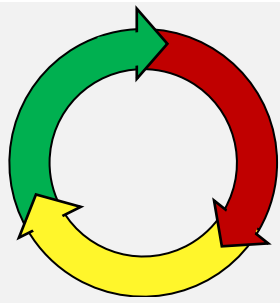
Batch test Kd values measured after 24 hr

Treatability Test Decision Factors

- ROD requirements
 - If one or more **viable** technologies are identified, treatability tests will be conducted for those technologies
- EIC evaluation based on scale-up (e.g., batch to column)
 - **Effectiveness**
 - ✓ Removal from aqueous phase, rate of removal, and stability
 - **Implementability**
 - ✓ Effort type, potential hurdles, similarity to known processes
 - **Cost**
 - ✓ Relative to P&T
 - **Maturity**
 - ✓ Deployment timeline for FS readiness

Evaluation KEY





In Situ: Iron Oxide Precipitation

Potential Viability



TRL 4

- Low/medium readiness
- Performance / deployment uncertainties

FS Viability

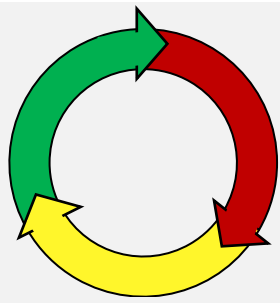


TRL 4

- Performance / deployment uncertainties
- Low TRL

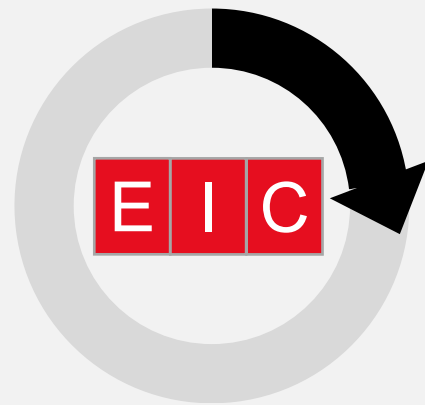
Conclusion

- No demonstrated in situ approach



Enhanced P&T: Dithionite

Potential Viability



TRL 6

- Low/medium readiness
- Deployment uncertainties
- Secondary effects of treatment

FS Viability

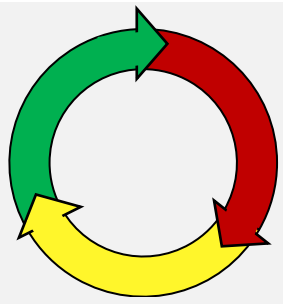


TRL 6

- Low/medium readiness
- Deployment uncertainties
- Secondary effects of treatment

Conclusion

- Poor performance and implementability and no demonstrated in situ approach



Non-Commercial Resins: Ex Situ Pump-and-Treat

Potential Viability



TRL 7

- Good material performance
- Plume core beneath ERDF, hindering implementability
- High cost due to inefficient well network

FS Viability



TRL 7

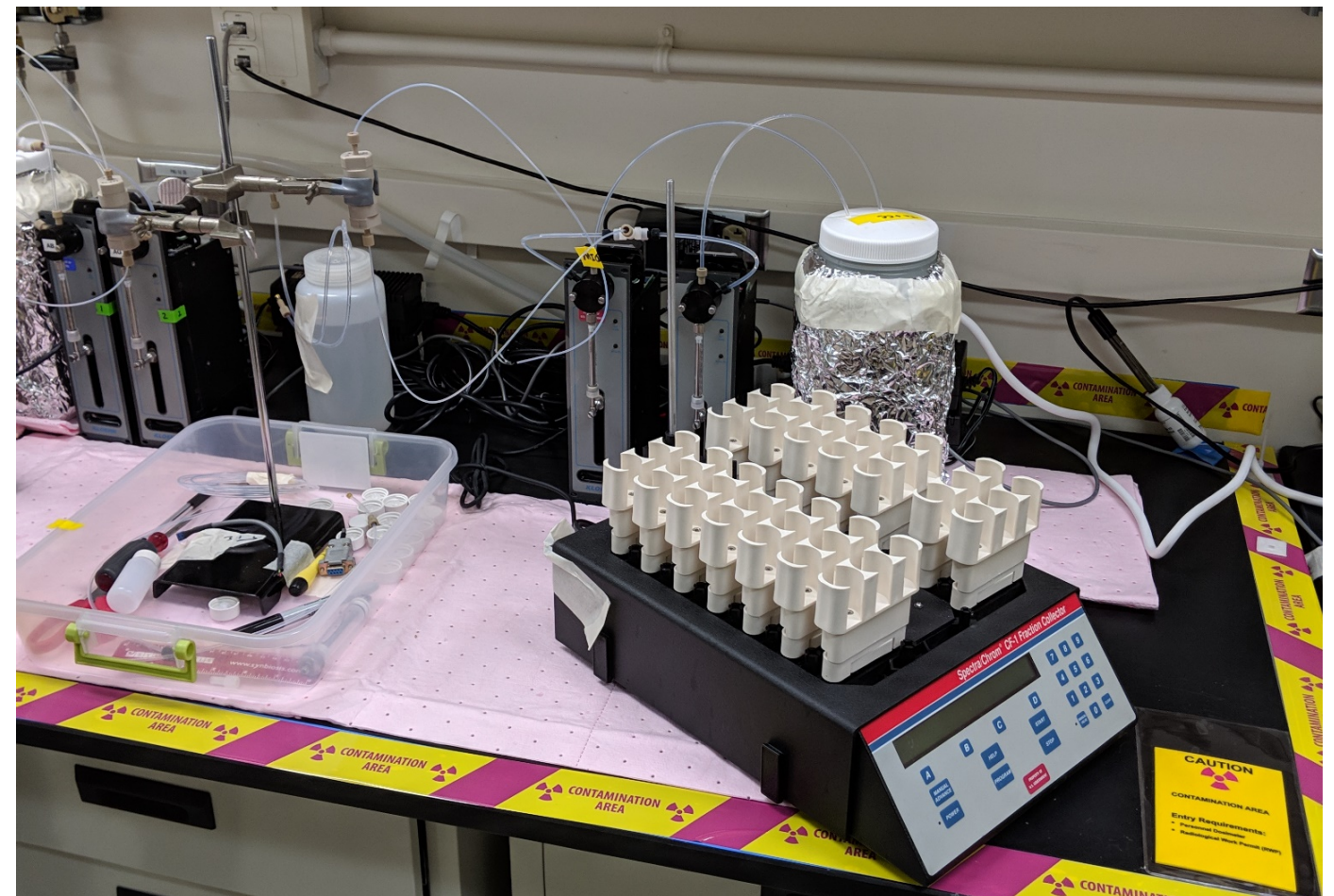
- Resin configuration uncertainties
- Manufacturing timeline uncertain

Conclusion

- Significant uncertainties associated with technology development [poor column performance for custom (PAN) beads]

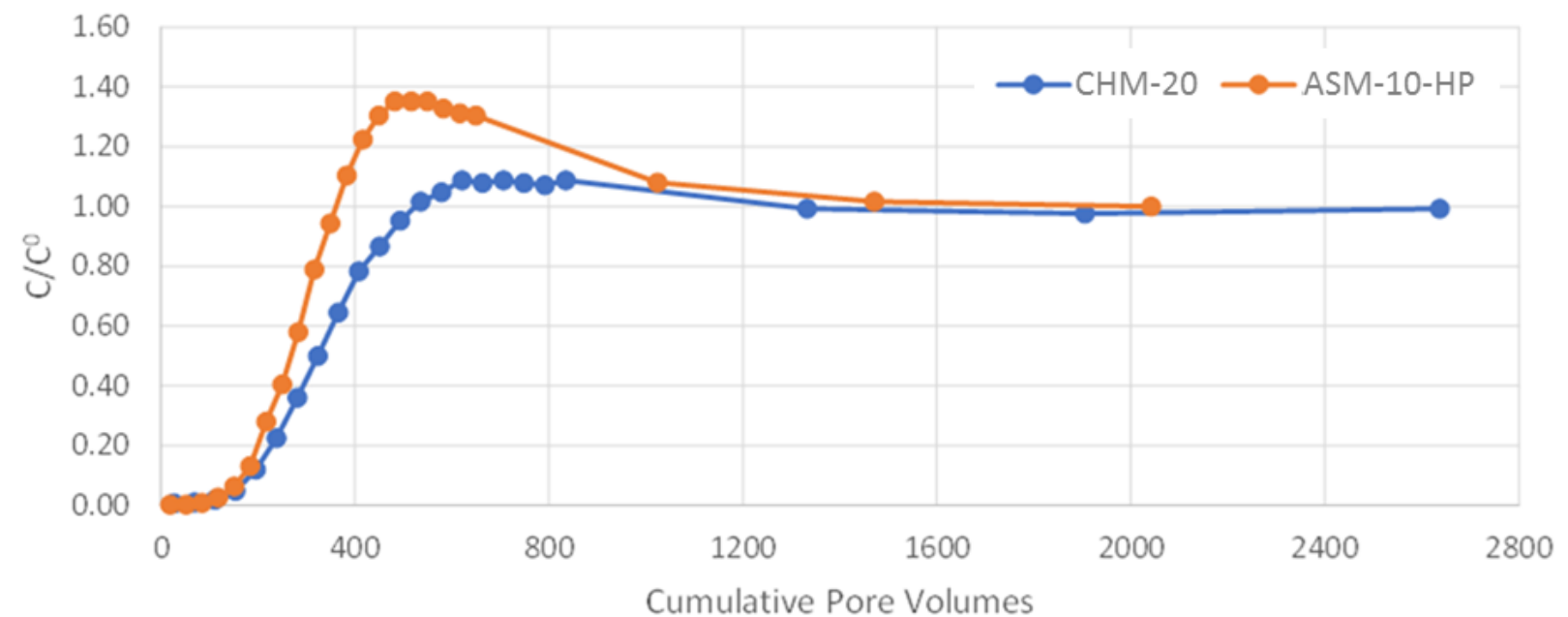
Commercial Resins: CHM-20 and ASM-10-HP

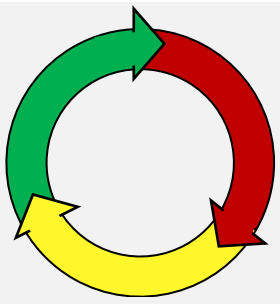
- Column testing scale up
 - 200W groundwater supplemented with iodate (100 ppb) – same order of magnitude as field concentrations of ^{127}I
 - Flow rate = 25 mL/h
- Capacity determined at 3% breakthrough
 - Based on reaching 1 pCi/L standard



Commercial Resin Column Test Results

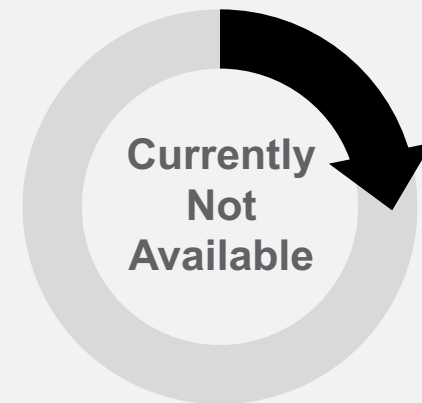
- 3% breakthrough occurred at ~125 pore volumes for both resins
- Pulse of iodate in effluent ($C/C_0 > 1$) shows some likely interaction of the resin and the groundwater constituents (possibly nitrate or carbonate)
- Loading: Column ~10 μg -iodine/g-resin; Batch ~200 μg -iodine/g-resin
- Performance is marginal due to low capacity
 - Iodine: ~1L-treated/g-resin
 - Uranium: ~100L-treated/g-resin
 - ^{99}Tc : ~10,000L-treated/g-resin
- Groundwater constituent interactions would need to be addressed





Commercial Ex-Situ: Pump-and-Treat

FS Viability



TRL 7

- Low capacity
- ERDF interferences
- Relative cost driven high by ERDF interferences and low capacity

Conclusion

- Poor technical practicability
- Resin performance is marginal
 - Low capacity
 - Sensitivity to groundwater constituents
- Plume core beneath ERDF

Technology Evaluation Conclusions

- Practicability of all candidate technologies was low, driven by site and contaminant properties that hinder effectiveness and/or implementability of the technologies
- Effectiveness-Implementability-Cost evaluation included technology maturity
 - CERCLA process requires treatability testing for existing technologies that can be adapted for site-specific needs
- Technology evaluation results can be used to support consideration of a TI waiver

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Thank you

