In-situ Dechlorination of Polychlorinated Biphenyls in Sediments Using Zero-Valent Iron

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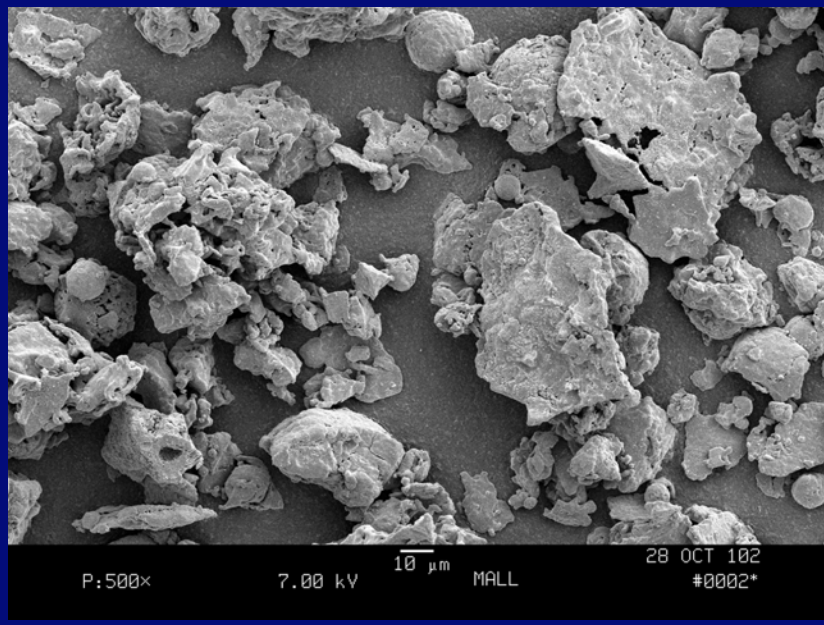
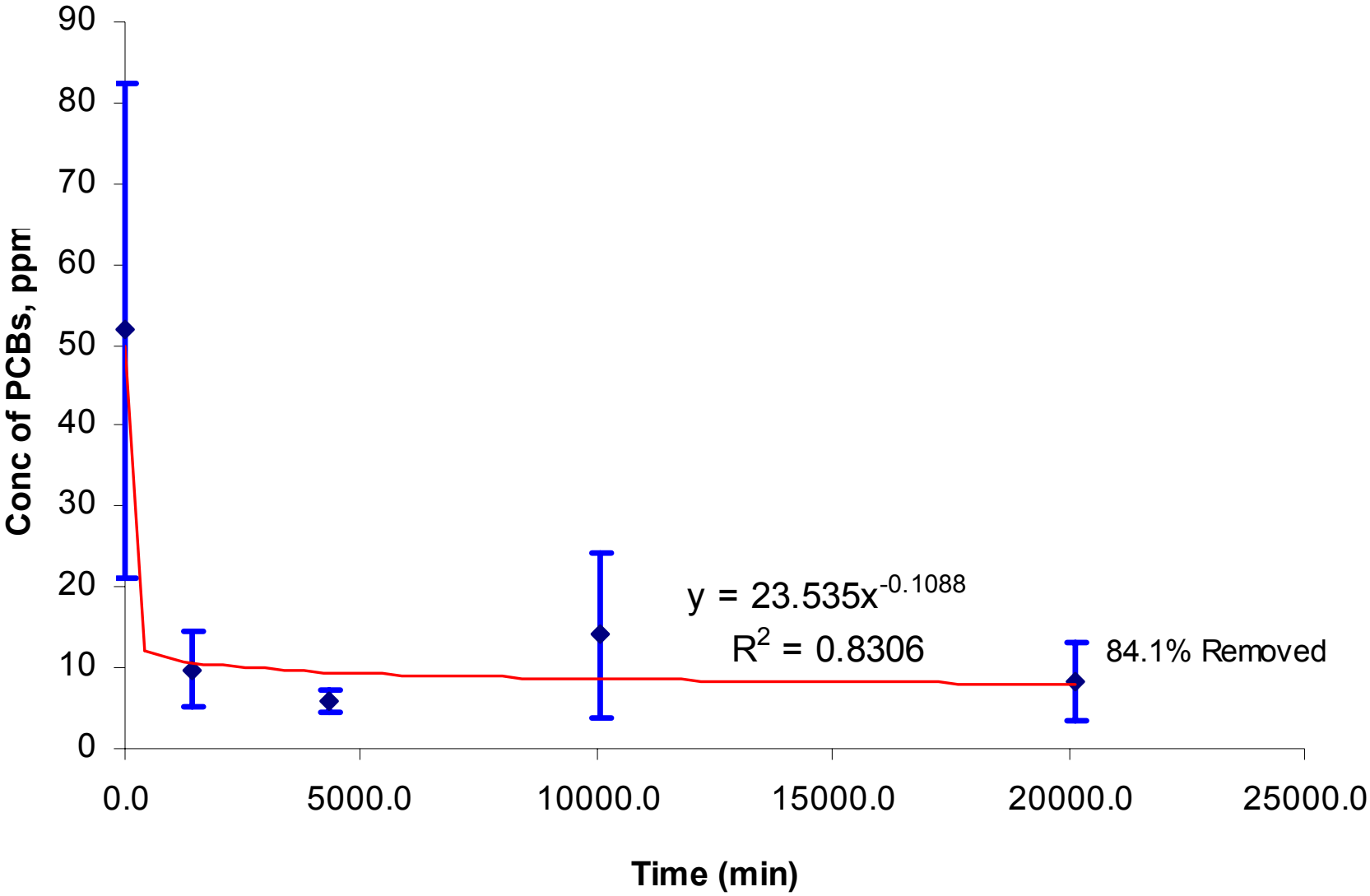


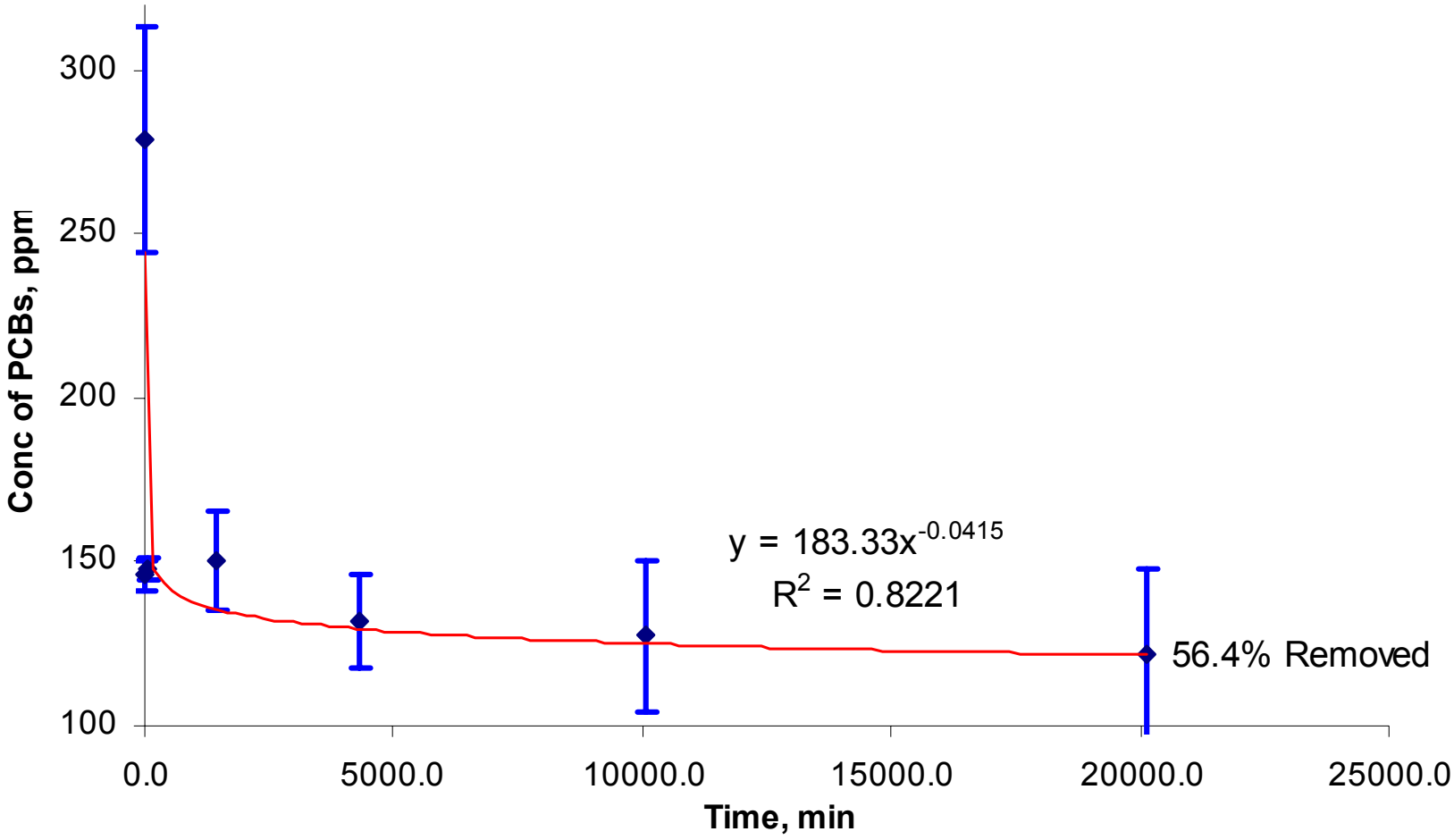
Overview

- ***In situ* remediation** or dredging / offsite treatment.
- Introduction of zero-valent iron (ZVI) – various sizes and manufacturing techniques
- Dechlorination of PCBs in PCB-contaminated sediments
- Relatively fast reaction and an economically viable process

PCB Dechlorination Kinetics with ZVI in Housatonic River Sediment



New Bedford Harbor results



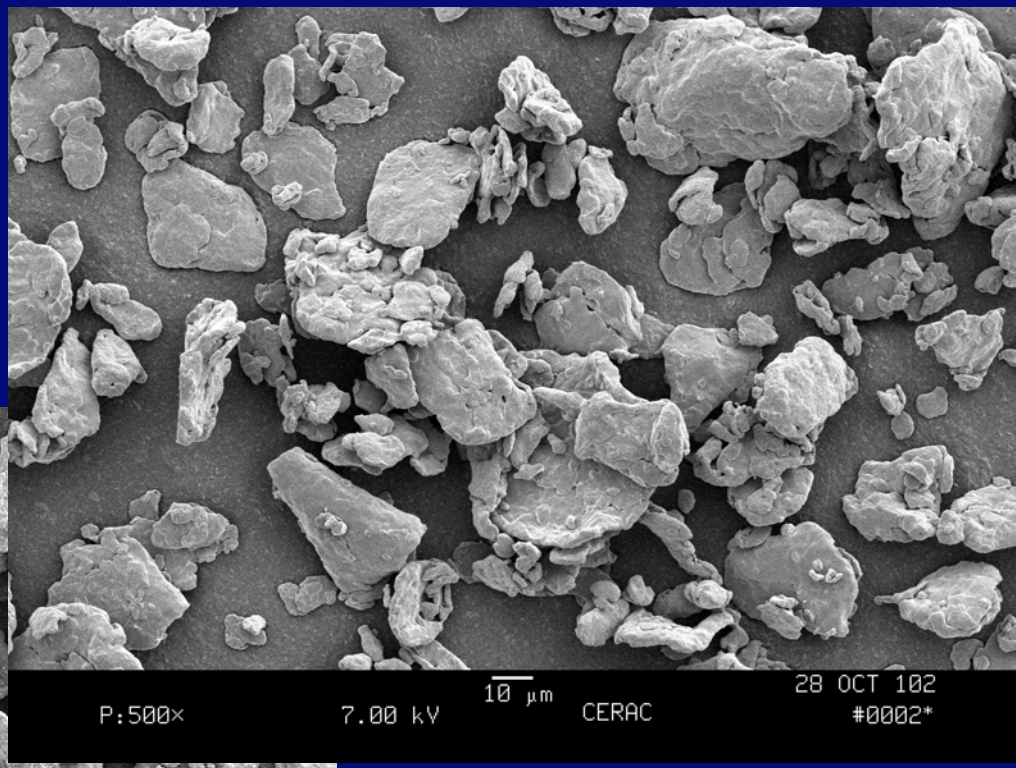
Different Types of ZVI Evaluated

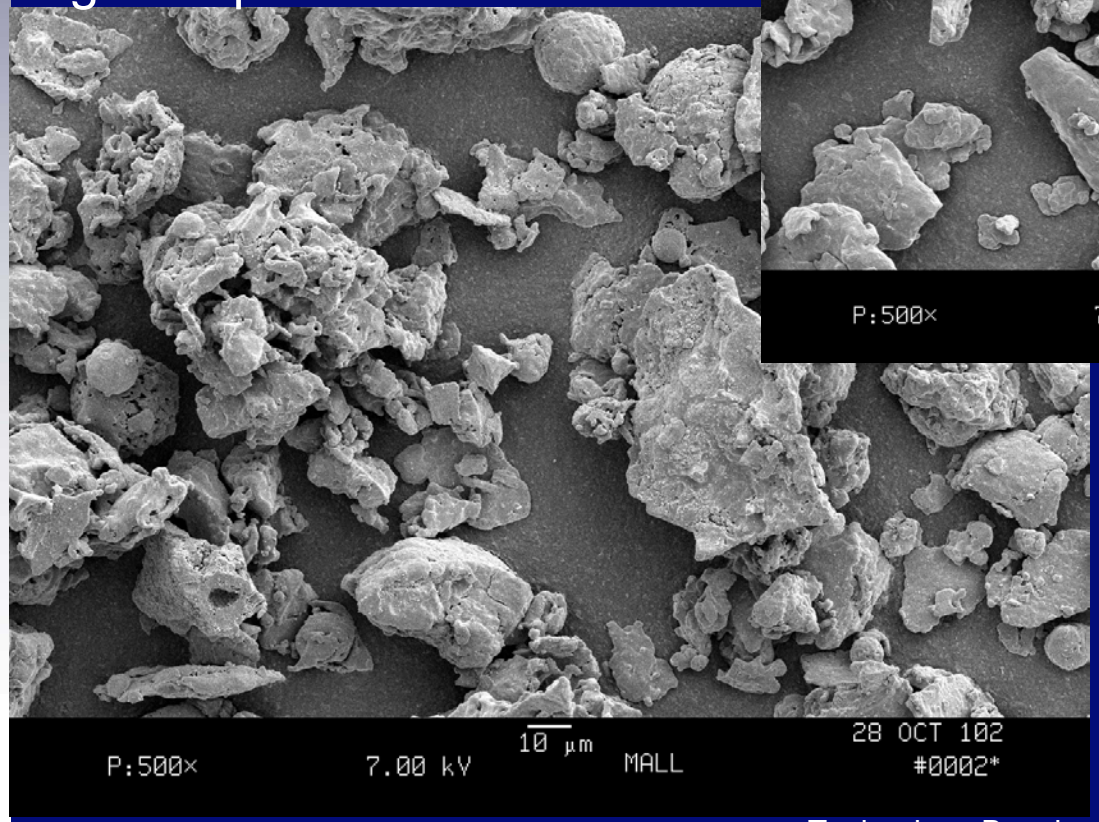
	UNH ZVI*	RNIP	RNIP/Pd	Cerac	Mallinkrodt
Source	lab	Toda America	Toda America	Milwaukee, WI	St. Louis, MO
Cost	$N/A	$9/lb	?	$4.3/lb	$2.39/lb
Size	1-100 nm	30 nm	30nm	50 um	50 um
Water Content	79.9% water	52.5% water	52.5% water	25.0% water	25.5% water
Surface Area	33.5 m2/g	23.6 m2/g	23.6 m2/g	N/A	N/A
Characteristic	suspension	suspension	suspension	dry powder	dry powder

* Wang and Zhang, 1996

50-um iron materials

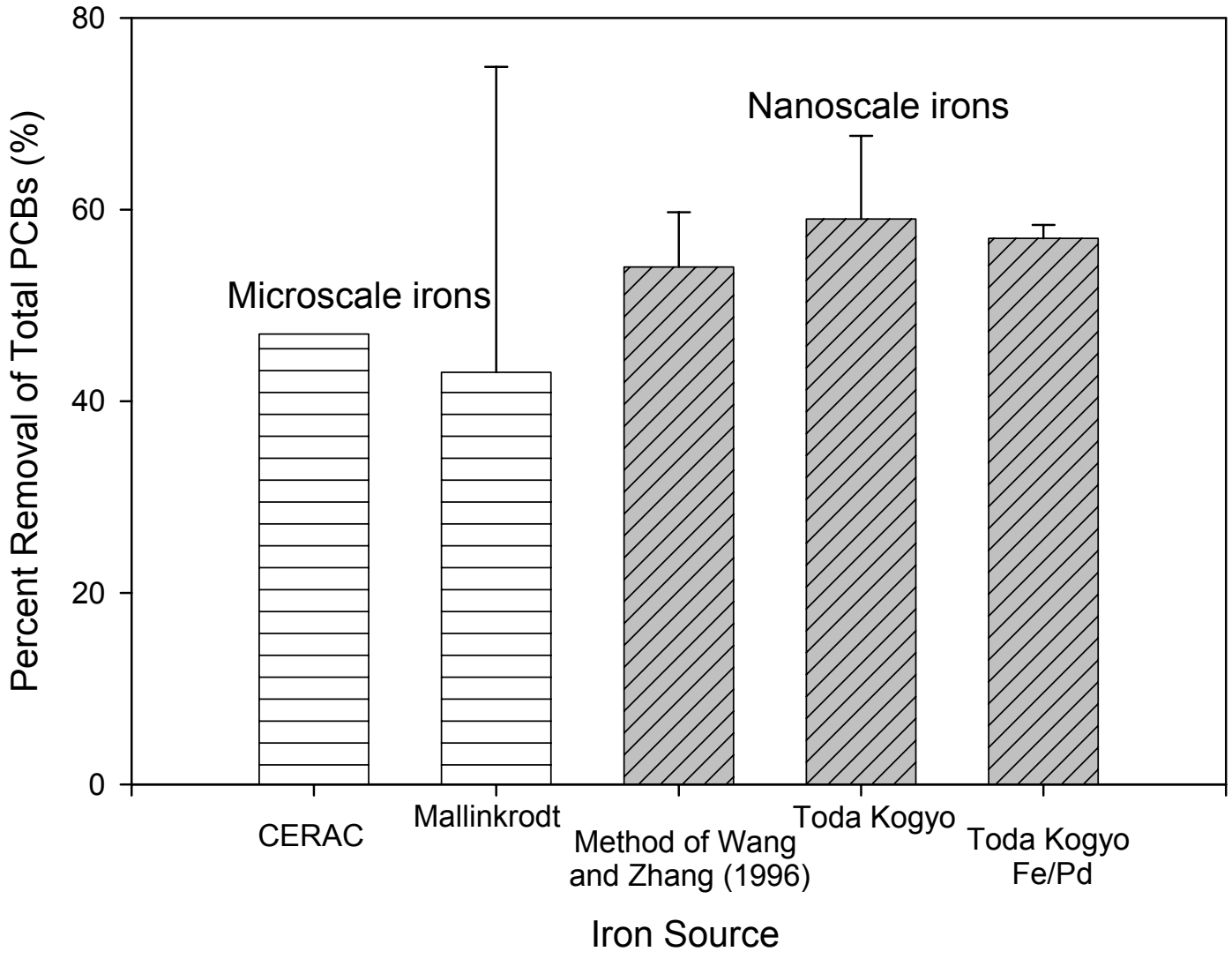
ground iron oxide powder reduced with hydrogen or carbon monoxide at very high temperatures





precipitation of aqueous iron on the anode of an electrochemical cell

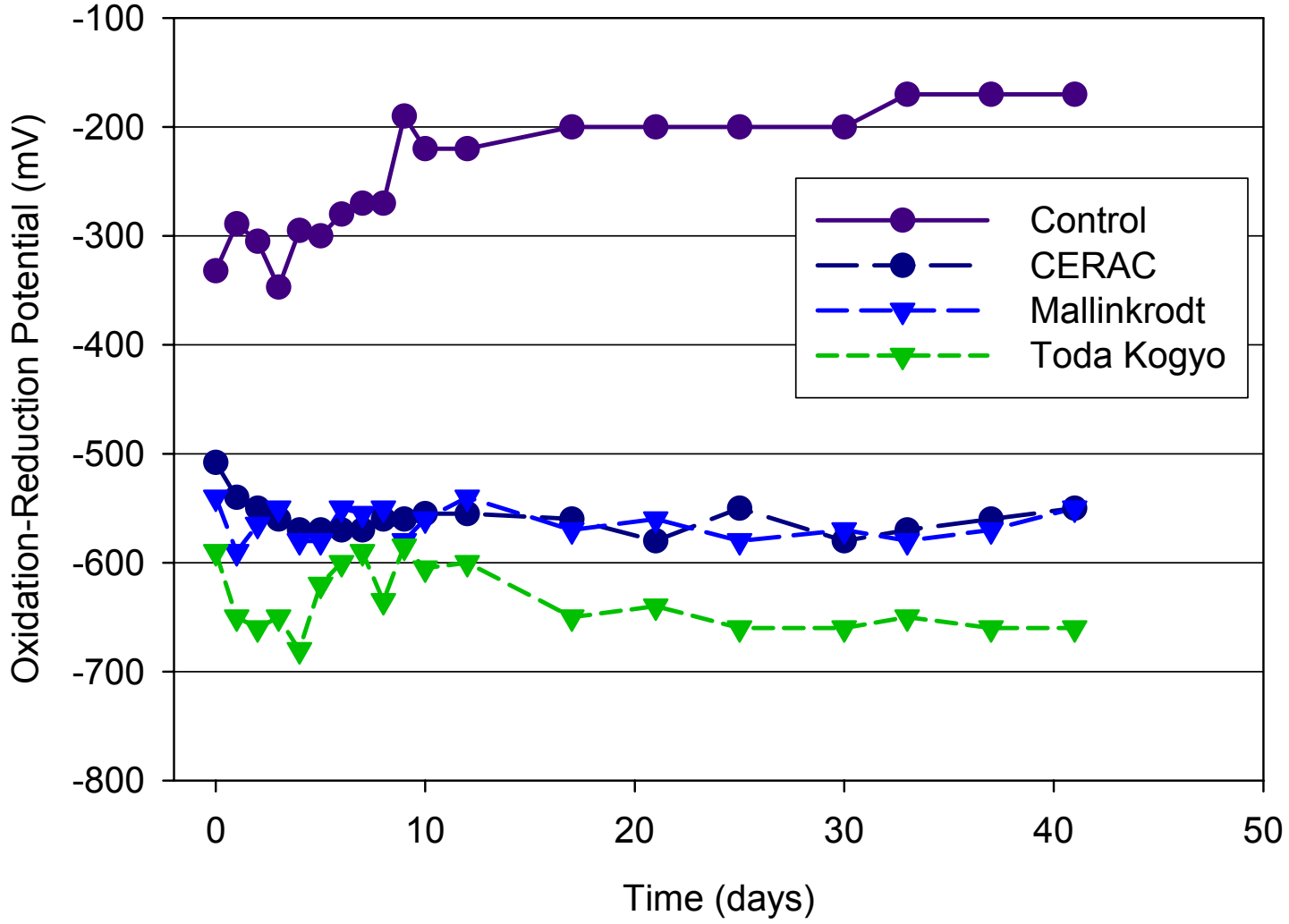
PCB dechlorination with different iron types



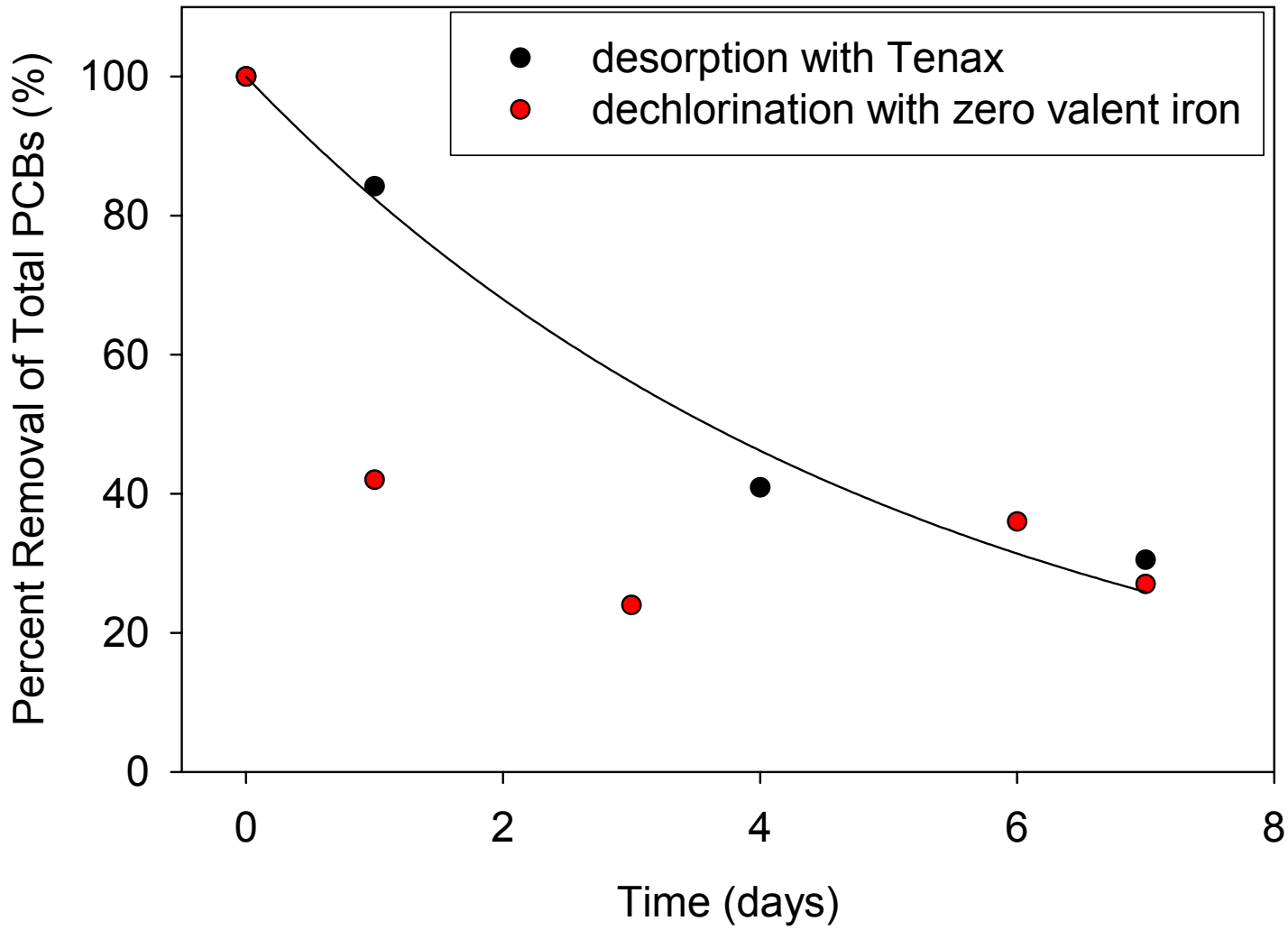
Why does degradation level off?

- Iron degradation faster than PCBs
- Passivation of iron surface
- Desorption of "slow" PCB fraction (unavailable PCBs)

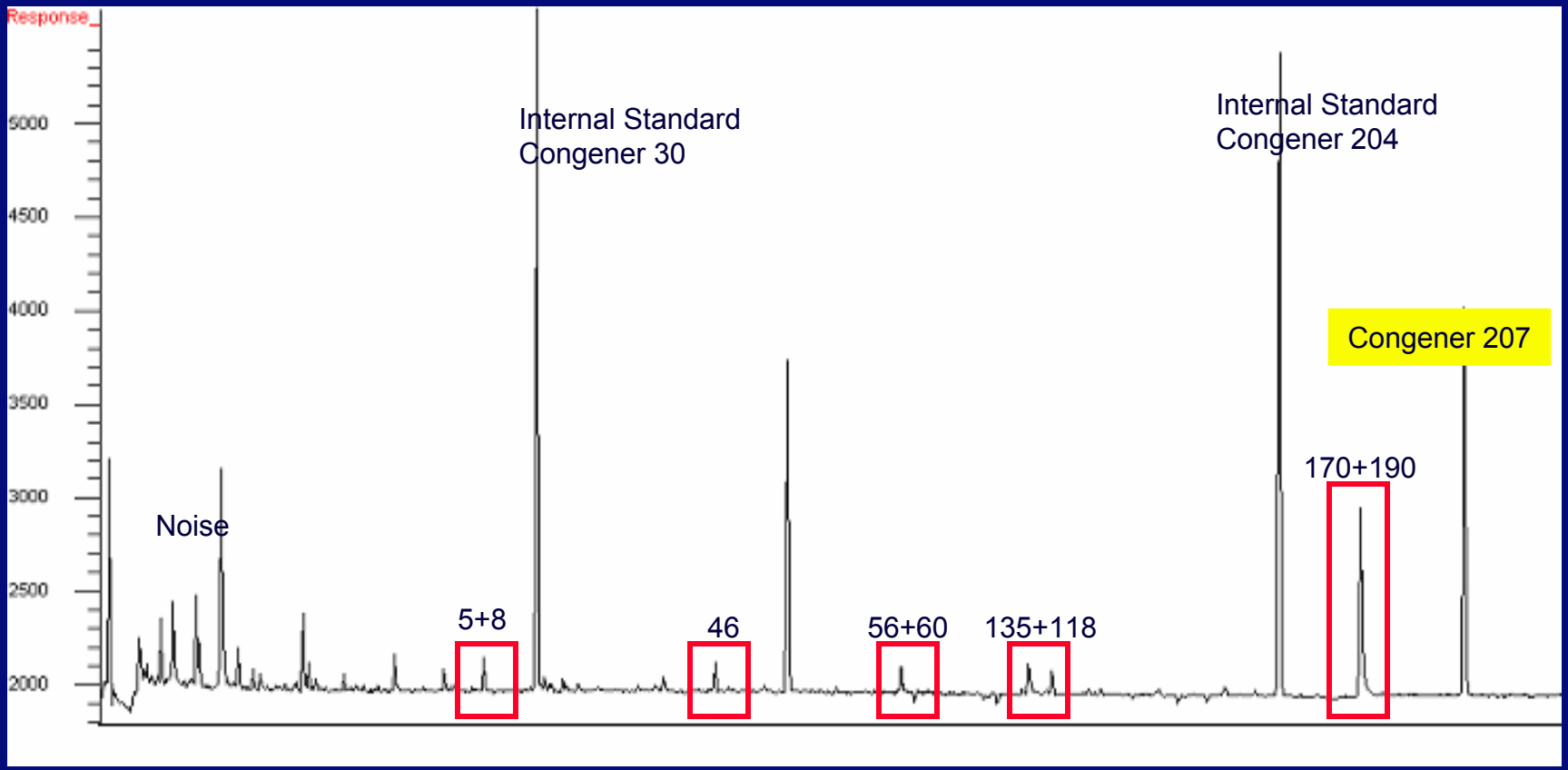
ORP over time



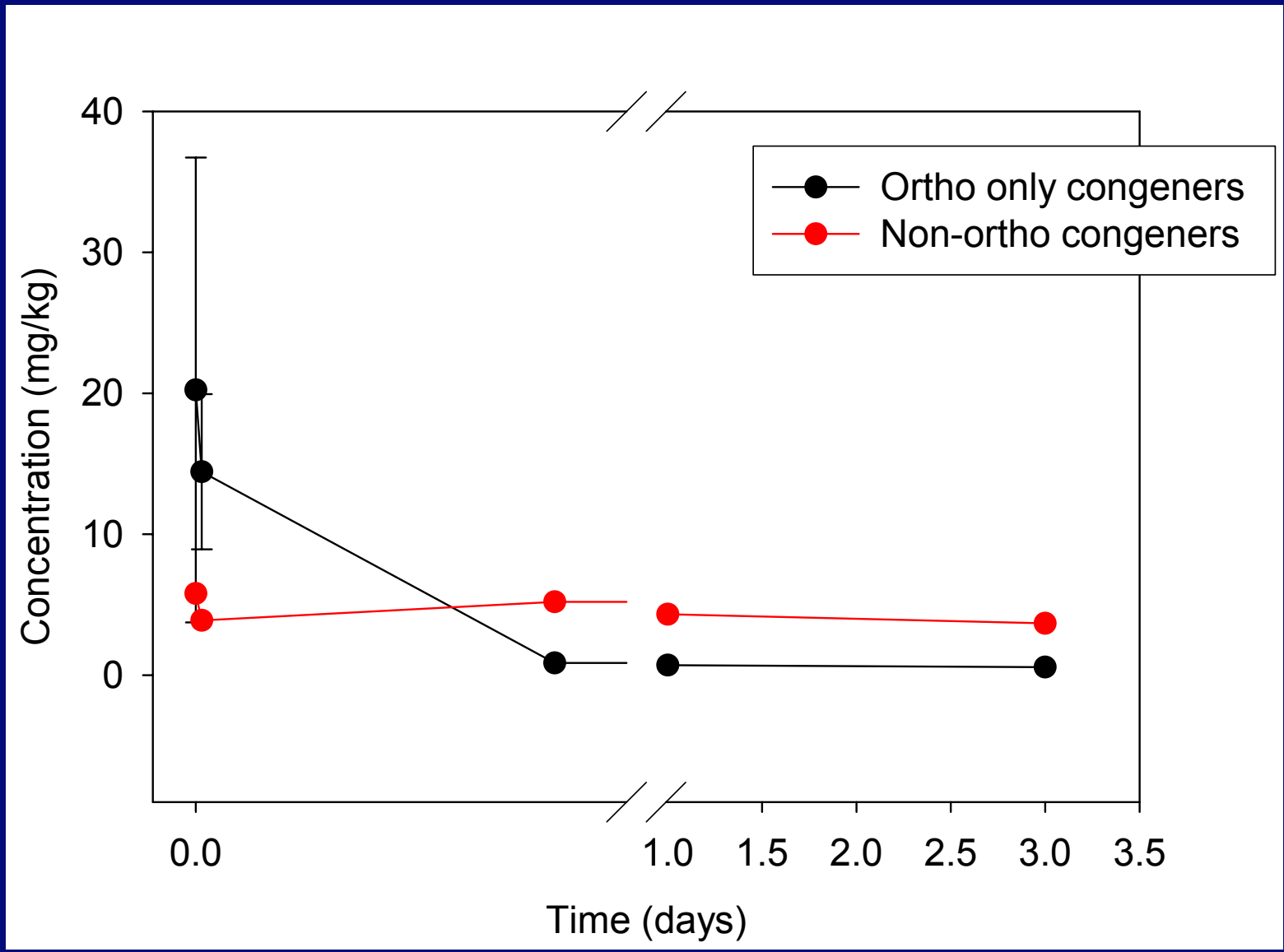
PCB desorption and dechlorination kinetics - NBH sediments



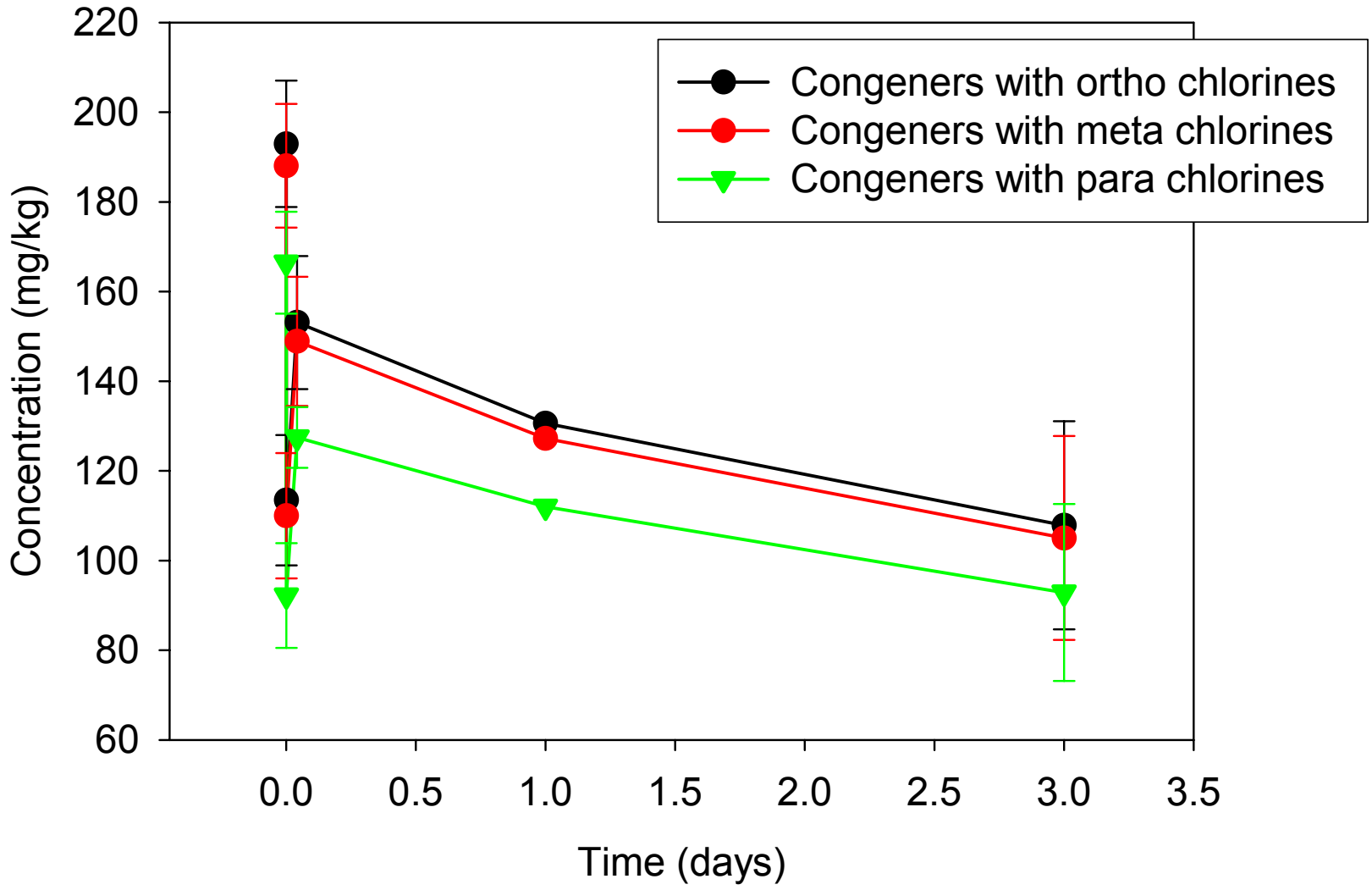
What are the Breakdown Products??
7 Day Breakdown of Congener 207



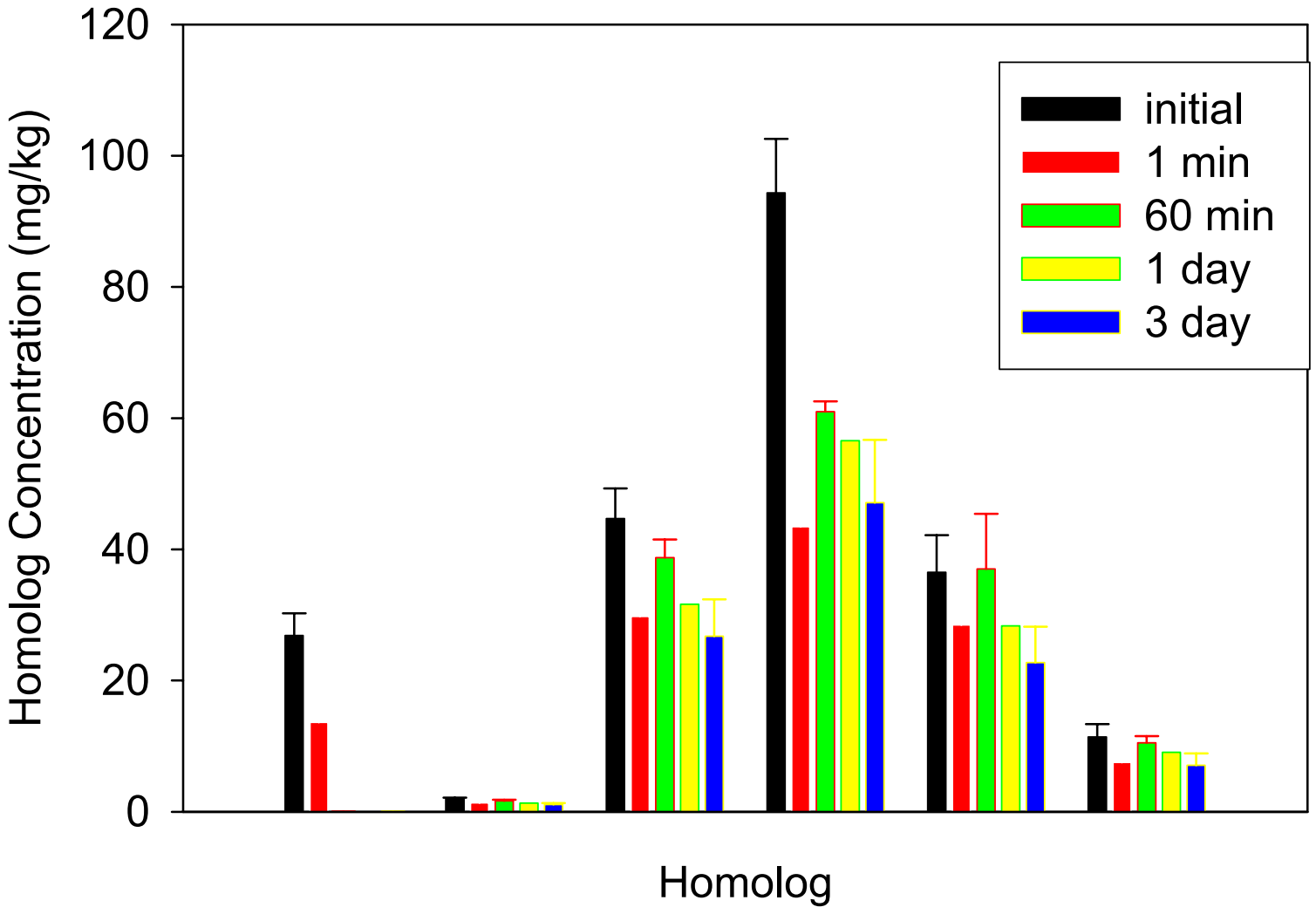
Ortho dechlorination



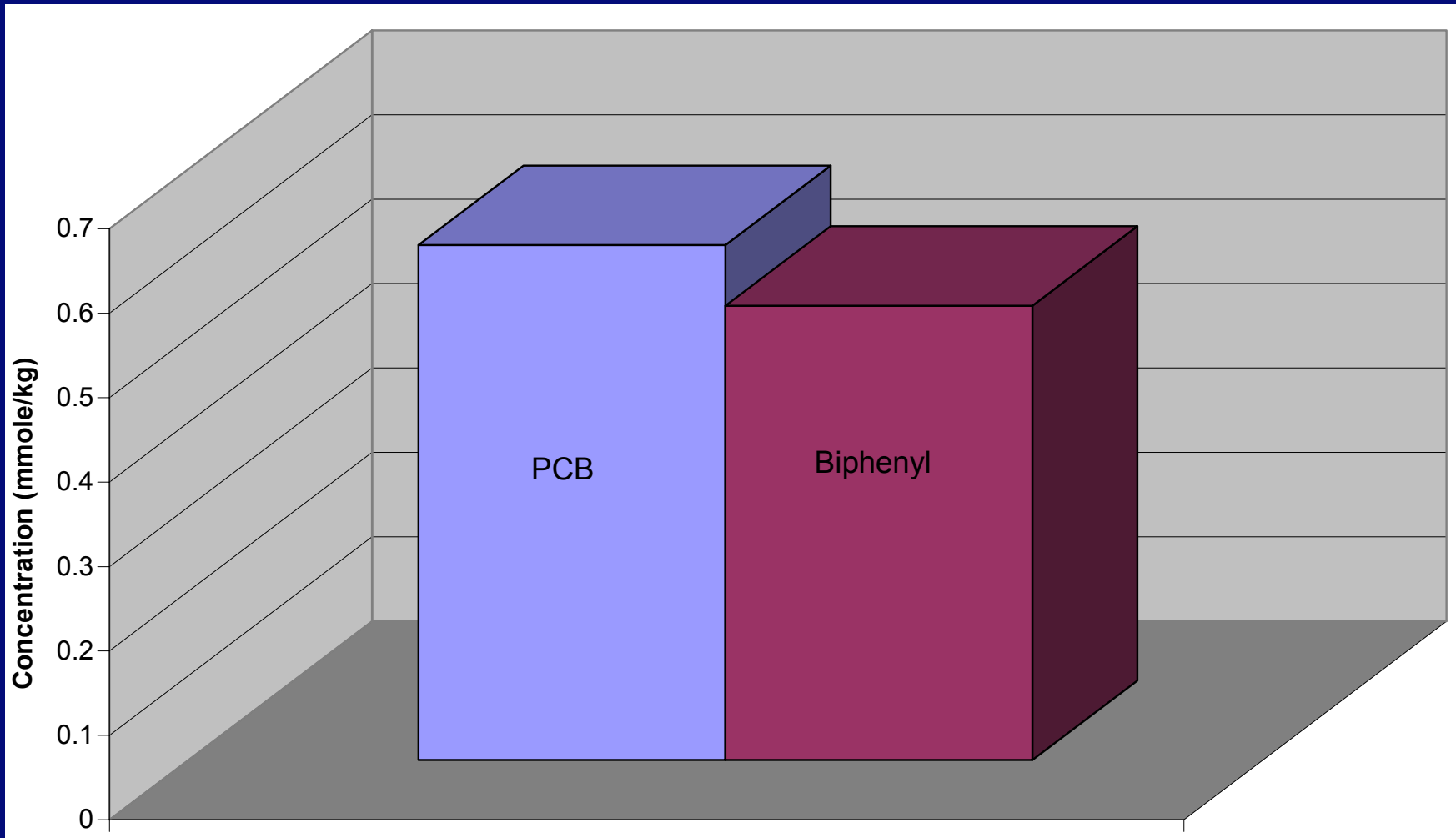
Positional analysis



Homolog-specific dechlorination



Mass Balance

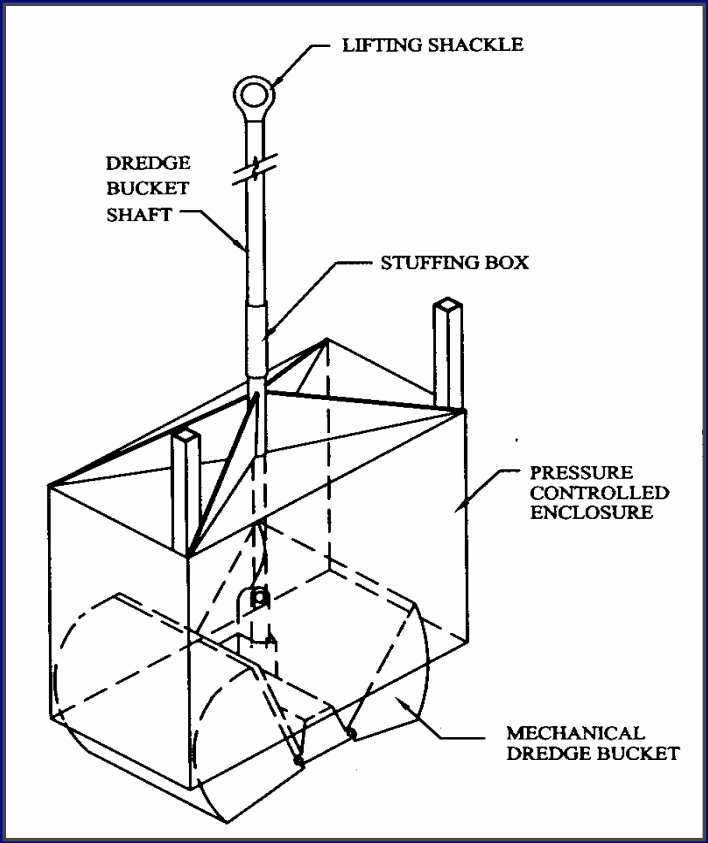


Reagent Delivery – Seaway Environmental Technologies

- Deliver reagent(s) to contaminated subaqueous strata
- Provide adequate mixing of reagent in strata
- Maximize yield – minimize reagent dispersion
- Minimize dispersion of contaminated sediment

Seaway Systems - Field Examples

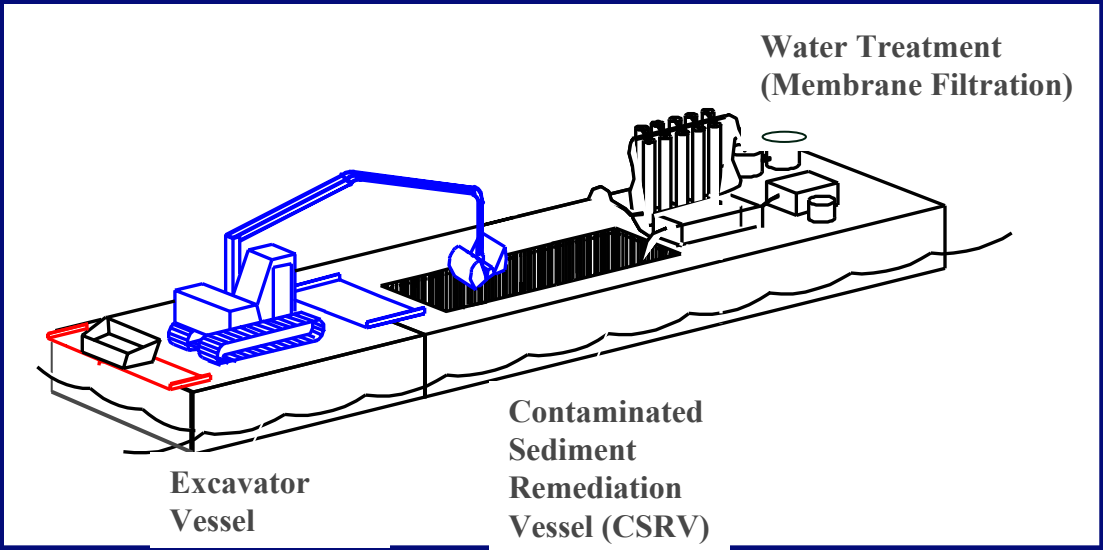
Contaminated Sediment Excavator



- Pressure-controlled housing provides a dry environment around the mechanical bucket or mixing in-situ treatment zone
  - Sediments are prevented from mixing with the water
  - Pressure-controlled subsurface technology permits mixing in dry environment for in-situ treatment
- Vision: barge-mounted, hollow-stem auger encased in pressure-controlled housing

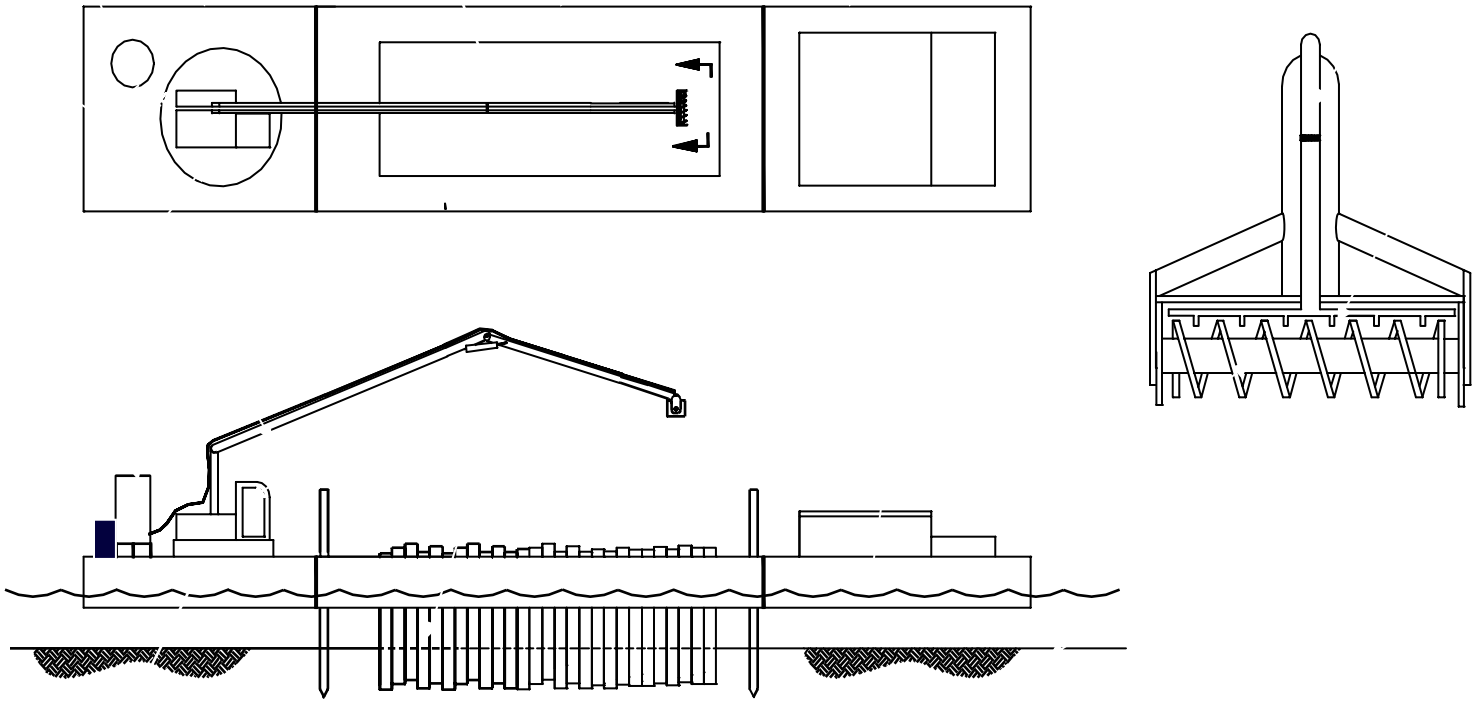
Seaway Systems - Field Examples

Contaminated Sediment Remediation Vessel



- CSRV establishes a containment area within the river
  - Prevents migration of contaminants
  - Operator can work quickly and efficiently
  - Progress can be easily monitored
- Low pressure within containment area prevents water from escaping
- CSRV applicable for in-situ treatment technology

Patent Drawing: In-Situ Treatment of Contaminated Sediments



Deploying shrouds

Current initiatives

- Use of biodegradable, food-grade surfactants to increase availability of PCBs to iron
- Minimization, optimization of iron added
- Use of iron filings
- Influence of iron on microbial consortia
- Large-scale lab. experiments using prototype mixing/delivery device - summer
- Bioavailability/chronic toxicity of treated sediments - summer
- Fundamental investigation of catalysis / reduction mechanisms
- Reactivity of dioxins/furans/PCNs (proposed)

Conclusions

- Cost? ~ $50/cubic yard in materials (for ~2-3% iron addition)
- 50 micrometer size iron works well and may be more cost-effective, easier and safer to handle
- Remediation endpoint – high organic carbon results in slow desorption kinetics
- Implementation
  - mixed into sediment or reactive cap
- Delivery/mixing a key issue for full scale deployment

End