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Advances in Sediment Remediation: Case Studies and Challenges

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25 YEARS OF ESTCP
SYMPOSIUM
2019 | Enhancing DoD's Mission Effectiveness

Introduction

- The range of available in situ sediment remediation technologies and monitoring tools has expanded over the past ~10-15 years
- Dredging remains an important option; methods have improved
- Every site is different; we need a big tool box
- As more sites are remediated, we need to share long-term monitoring data to identify and address remaining challenges

https://www.darrp.noaa.gov/hazardous-waste/epa-finalizes-plan-cleanup-passaic-river

Case Studies – Technology Focus

1. Enhanced Natural Recovery (ENR) – effectiveness
2. Amended Thin-Layer Cap – construction and monitoring
3. In situ Treatment with Activated Carbon – long-term performance

Other case studies: Sediment Remedy Effectiveness Retrospective Workshop, June 2019
Workshop objective: to collaboratively review robust sediment cleanup remedy effectiveness case studies to more broadly develop knowledge to inform future sediment cleanup remedies. Presentations available at http://www.smwg.org/presentations

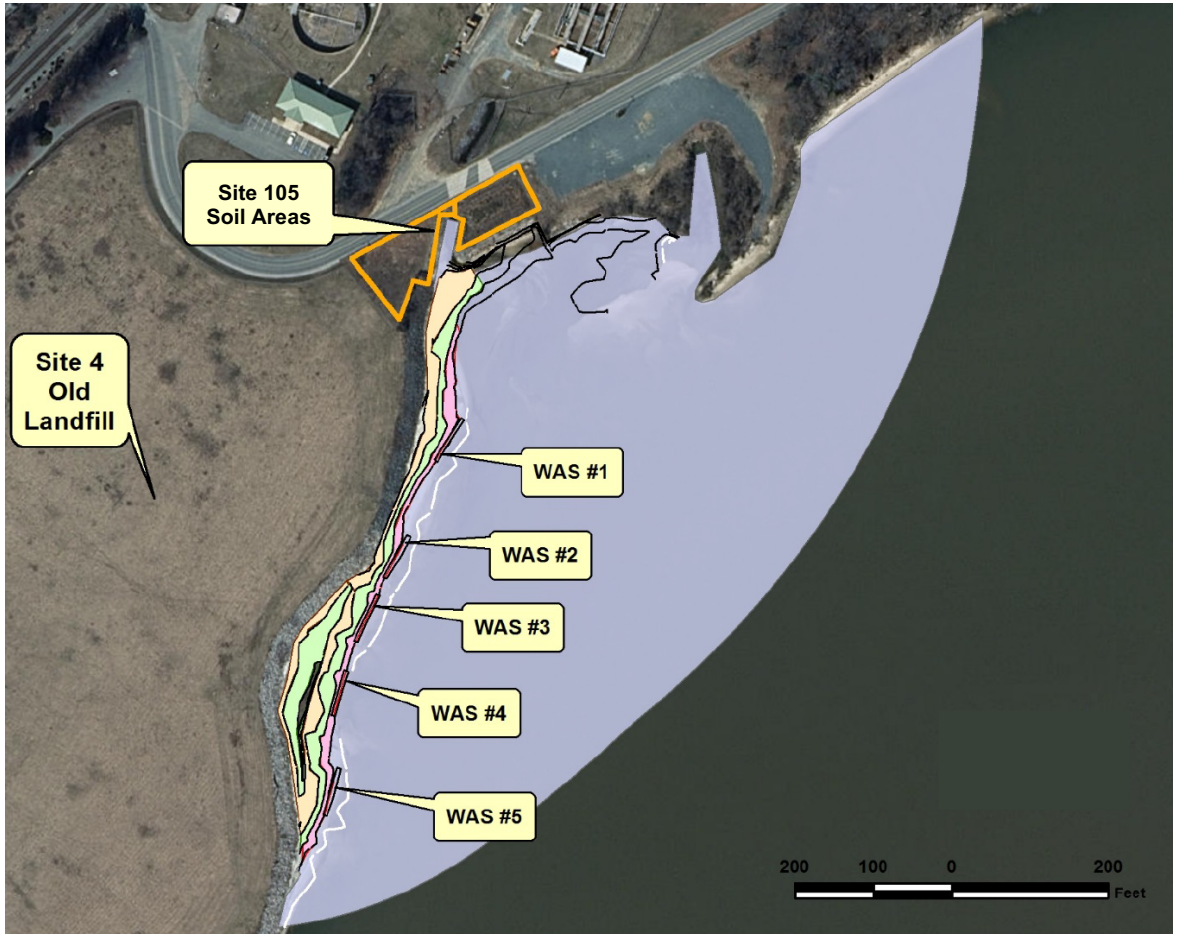
ENR - Site Setting and Remedy

- Shallow tidal embayment, moderate levels of DDx contamination
- Risk to piscivorous birds
- Habitat enhancement cap (HEC)
  - Facilitate natural recovery
  - Reduce exposure of aquatic biota to contaminants
  - Vegetation increases stability and enhances habitat quality
  - Some physical and biological mixing with underlying sediment is expected

Photo By: Mike DiCicco

ENR – Construction

- 10.9 acre HEC installed in 2014
  - 9 to 12 inches of clean sand placed (6-inch design thickness)
  - Shoreline planted with low marsh, high marsh, and transitional vegetation
  - Five wave attenuation structures installed in 2015 to protect low marsh
- ESTCP Project ER-201368: post-placement monitoring for 2 years
- Annual long-term monitoring (LTM)
- Land use controls



Legend:

- Low Marsh (0-1ft msl)
- High Marsh (1-2ft msl)
- Upper Transitional (2-3ft msl)
- Subtidal Area

Modified from Battelle and Neptune and Co., 2019

ENR – Stability and Mixing

- ER-201368: sediment cores, sediment physical and chemical analysis, bathymetry, SPI, SED-FSP, sediment traps
- LTM: visual inspections, SPI, topo/bathy after major storm events

Battelle and Neptune and Co., 2019

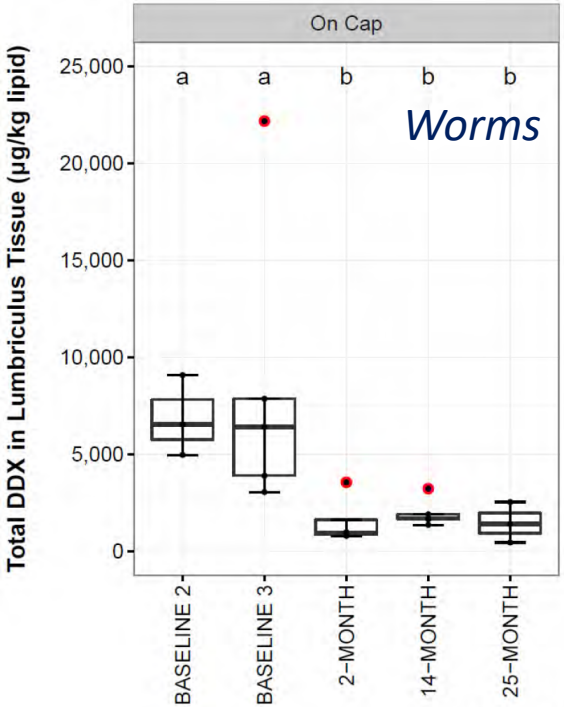
Target thickness maintained (average ~10" in 2018); some sand redistribution

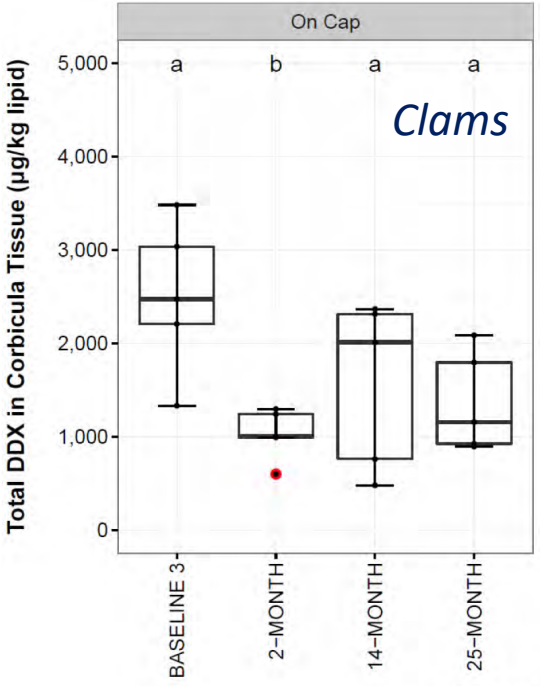
Battelle and Neptune and Co., 2019

New sediment deposition on cap; widespread top-down mixing but limited bottom-up mixing

ENR – Bioaccumulation

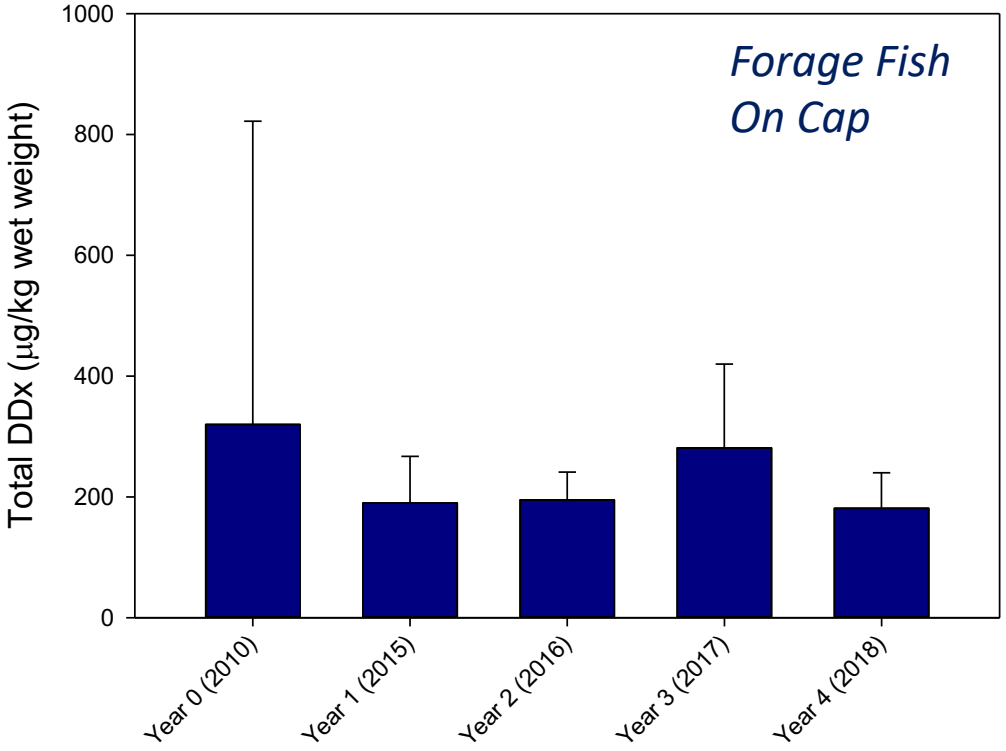
- ER-201368: sediment sampling, in situ bioaccumulation testing, passive sampling
- LTM: forage fish/porewater-seep sampling





Kirtay et al., 2017

Reductions in DDx concentrations in worm and clam tissue up to 2 years post-placement



Data from Battelle and Neptune and Co., 2019

Average forage fish tissue DDX concentrations have declined after HEC placement

ENR - Summary

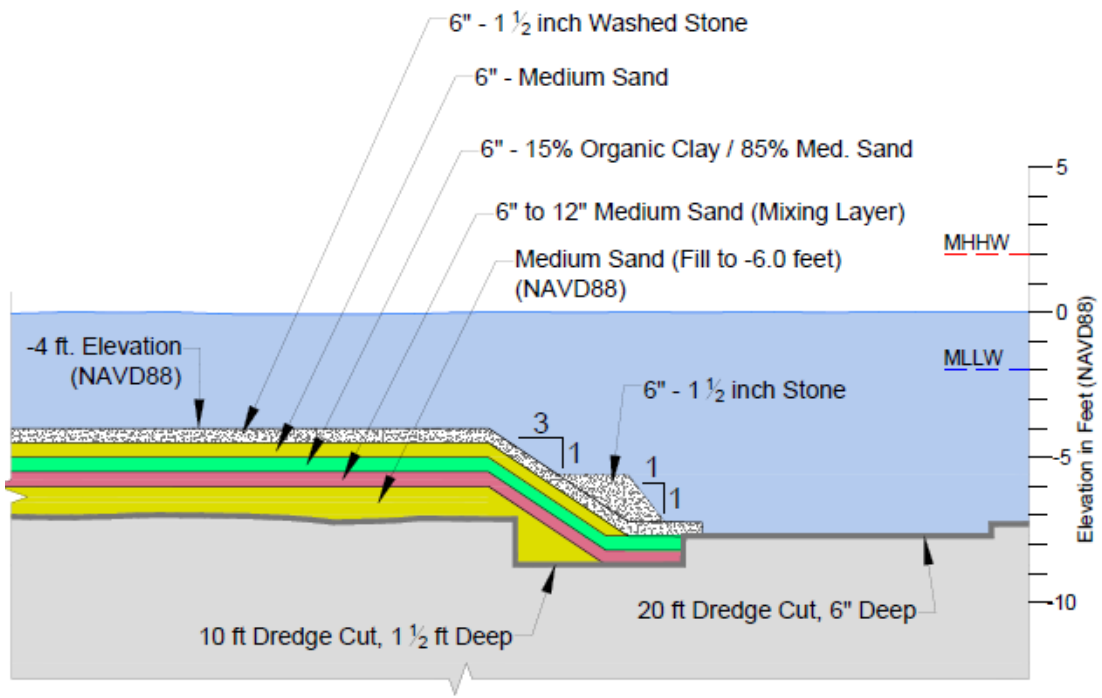
- ENR is more likely to be effective if certain site conditions are met (relatively stable, new sediment deposition is relatively clean, bottom-up mixing is limited, advection is not significant)
- The ENR layer should be carefully placed to minimize mixing with underlying sediment and achieve target thickness
- ENR can be effective in reducing contaminant concentrations in surface sediment and bioavailability to aquatic organisms

Amended Cap – Site Setting and Remedy

- Shallow estuary
- Dredging remedy in progress for PCB-contaminated sediments
- Interim cap installed while upland source control measures are developed and implemented
  - Isolate underlying sediment
  - Prevent erosion/resuspension
  - Prevent dissolved-phase transport through cap

Amended Cap - Construction

Shoreline and subtidal cap constructed 2018-2019



Cap design (Jacobs, 2019)

Capping barge inside silt curtain

Telebelt delivery of capping material to barge

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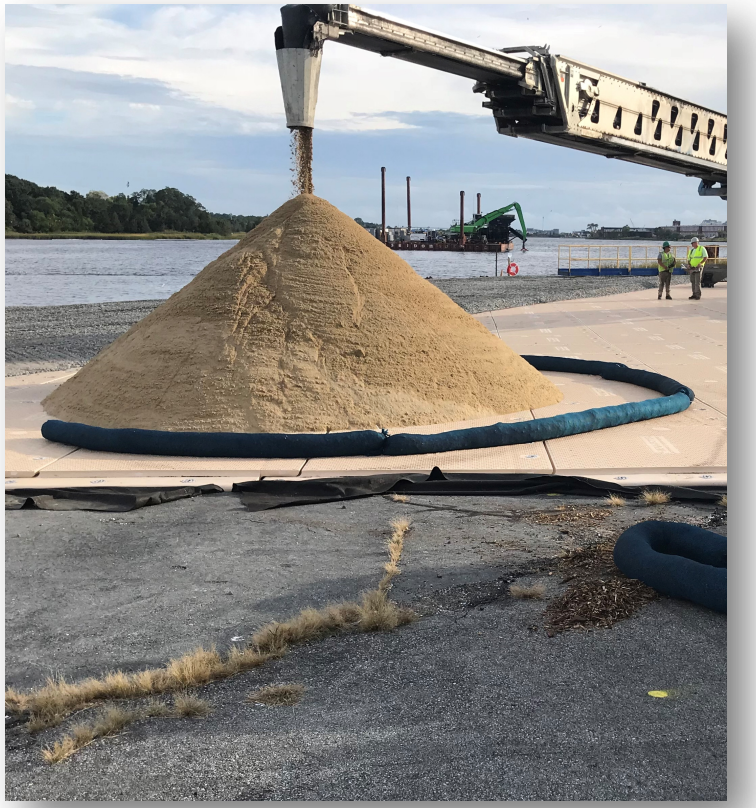
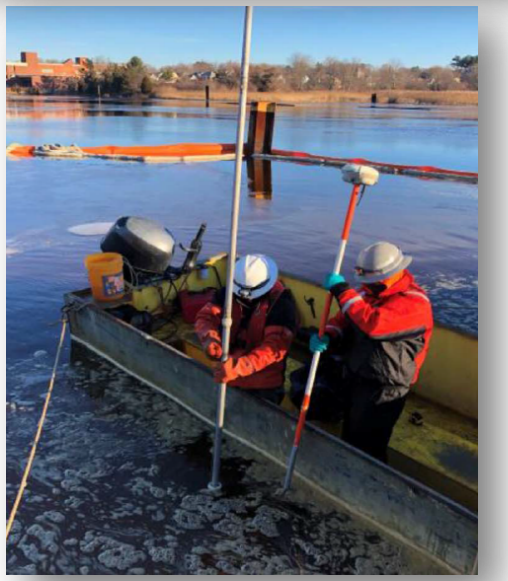
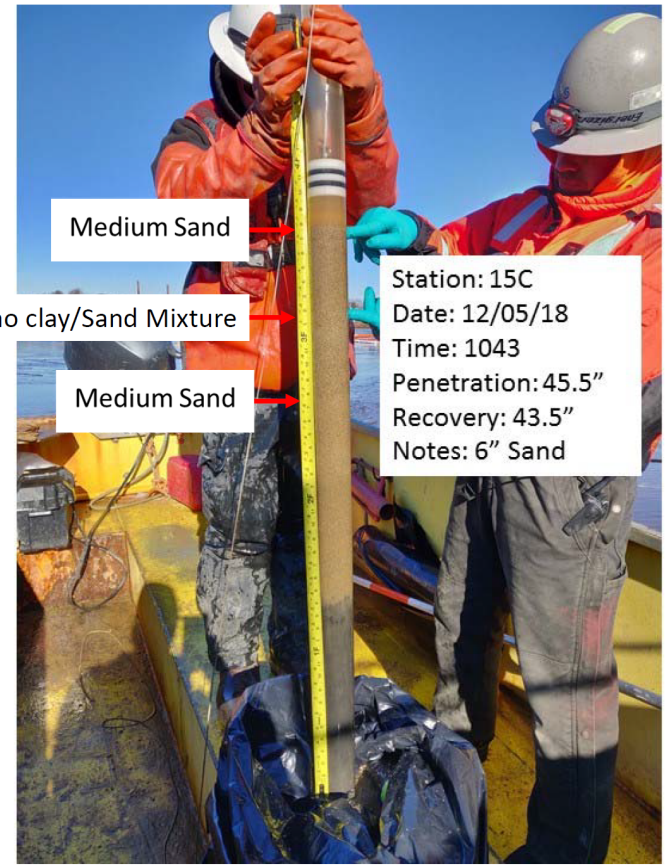
Amended Cap – Construction Monitoring



Raw materials and sand/OC mix – visual inspection and analytical testing



Bathymetry: RTK GPS shots and single-beam surveys



Cap layer thickness - push cores

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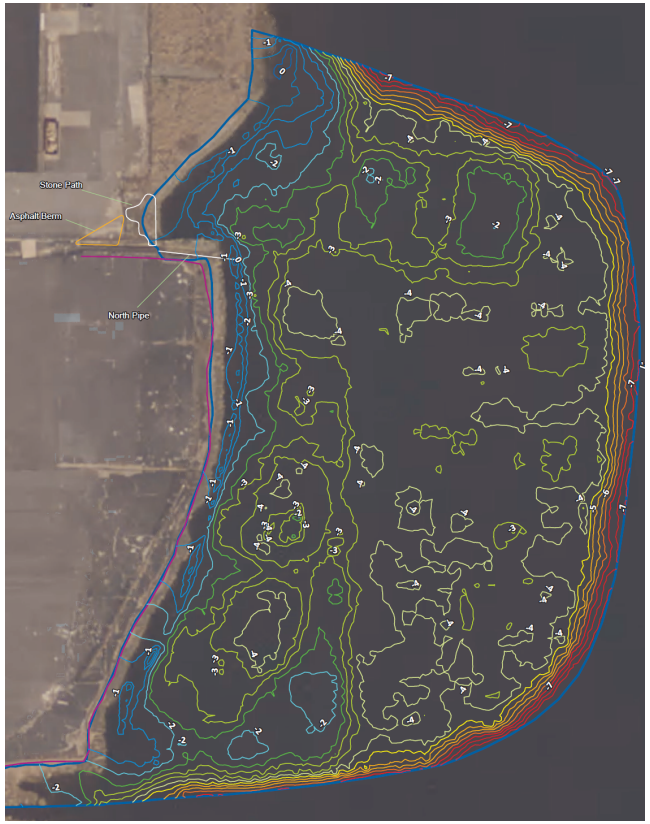
Amended Cap – Performance Monitoring



Settlement monitoring: periodic bathymetric surveys and settlement plate elevation measurements

Photo by Battelle

Passive sampling to measure dissolved-phase transport through cap

Amended Cap - Summary

- Placing thin layers that meet minimum thickness requirements without over-placement requires practice and experience
- Design thicknesses can approach the uncertainty of measurement technologies
  - Use multiple lines of evidence for monitoring
  - Consistency is important
  - Design QC program to minimize construction downtime
- Develop a response plan for adverse weather conditions

Onshore bucket test

Activated Carbon Treatment – Site Setting and Remedy

- Freshwater river, ~500 ft wide and ~20 ft deep; relatively low velocities
- Sediment deposition rate ~2 cm/year
- Human health and ecological risks from exposure to PCBs
- 2006 Activated Carbon Pilot Study
- 2013 Record of Decision

https://www.epa.gov/sites/production/files/2017-03/documents/grasseriverphotos.pdf

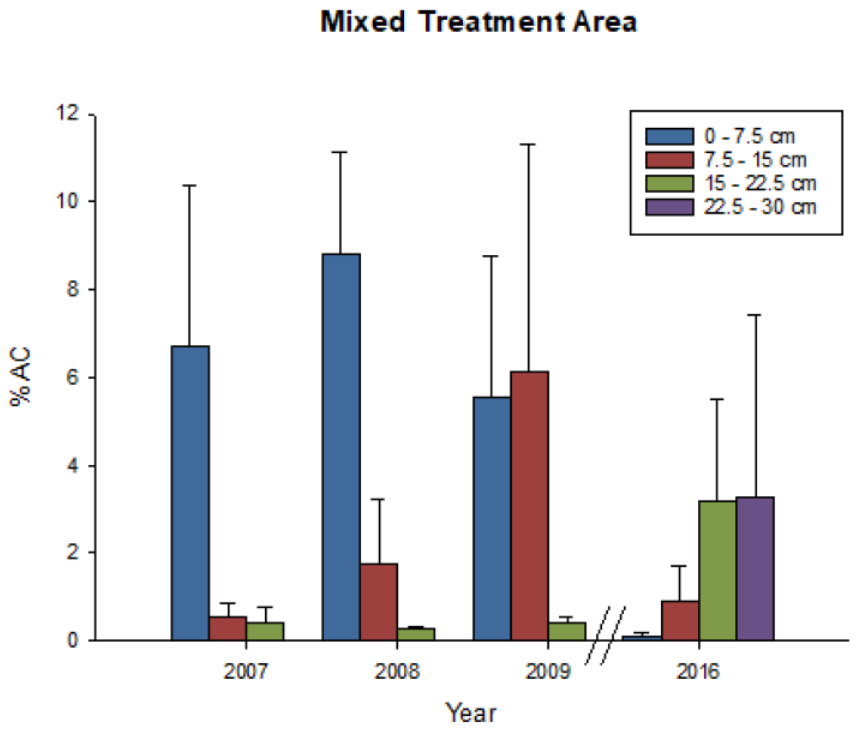
Activated Carbon Treatment - Construction

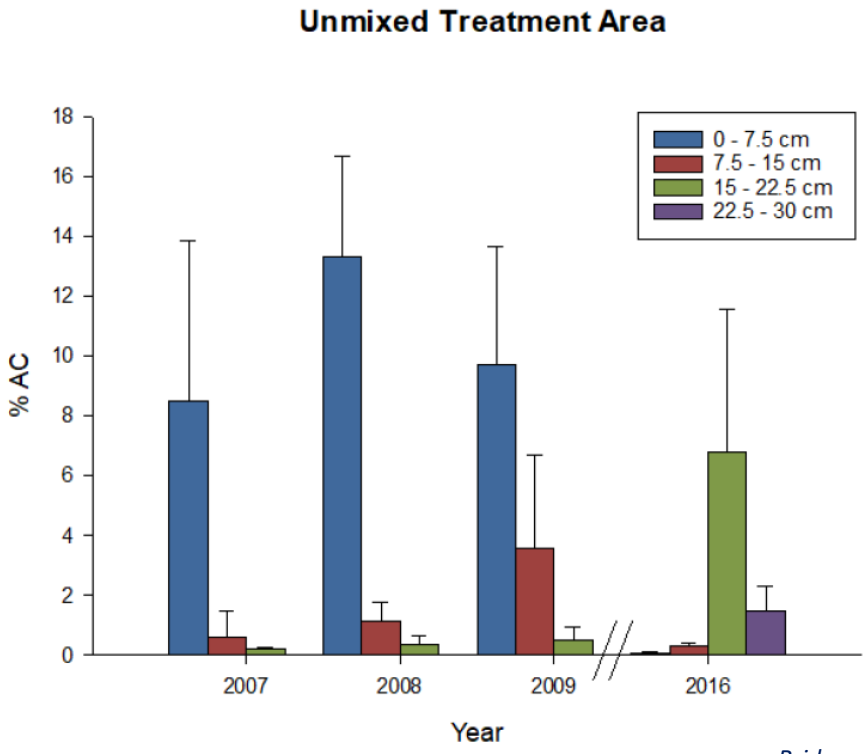
- 0.5 acre pilot test area
- Target dose 2.5% granular activated carbon (GAC) by weight in the top 6 inches
- AC placed as a slurry on the sediment bed
- Test plots with and without mechanical mixing of AC into the bed
- Baseline and 3 years of LTM
- Long-term efficacy evaluated in ESTCP project ER-201580 (10 years post-treatment)

http://www.thegrasseriver.com/activated_carbon_photo.html

Activated Carbon Treatment – Long-Term Stability

- Sediment core profiles of black carbon concentrations (PCB data not shown)



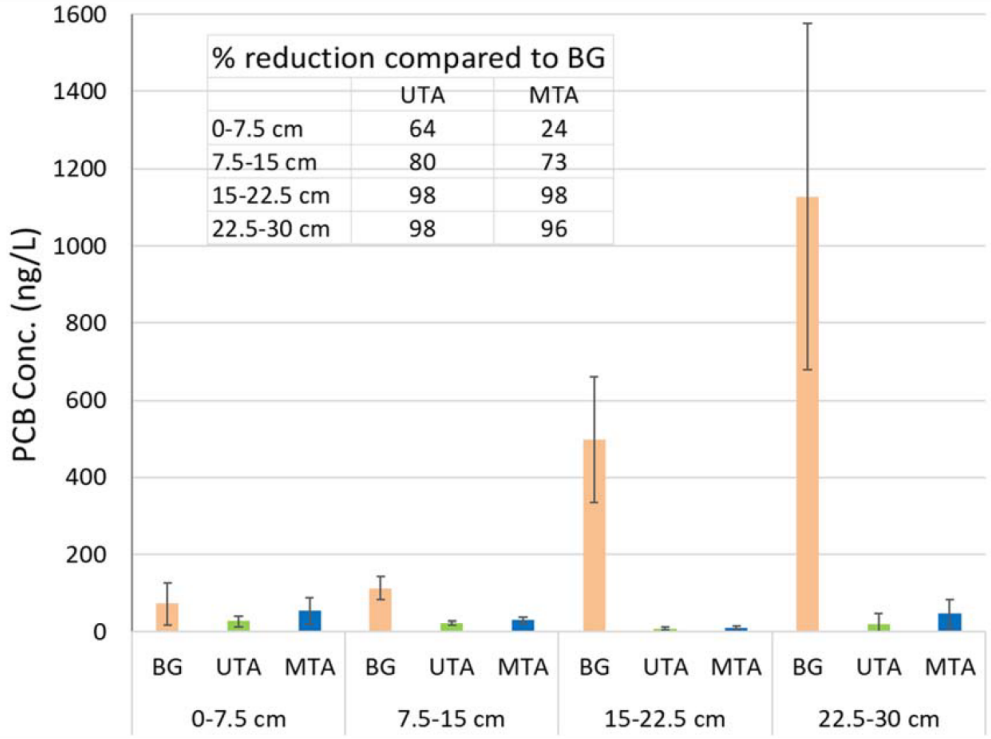


Bridges et al., 2019

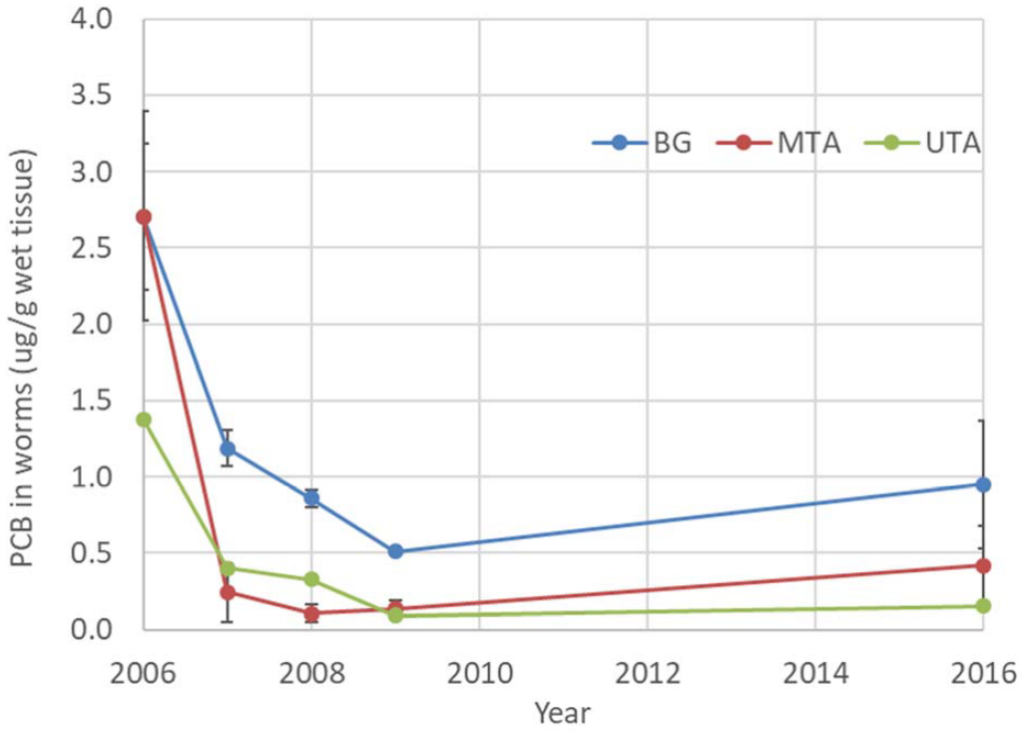
After 10 years, the highest AC concentrations were found in the deeper sample intervals due to progressive burial by new sediment; depth of AC penetration was greater in the mixed treatment area.

Activated Carbon Treatment – Long-Term Bioavailability

- Porewater testing with passive samplers and ex situ bioaccumulation testing



After 10 years, porewater PCB concentrations in AC-treated sample intervals are lower than those in the background area.



After 10 years, PCB concentrations in worm tissue from the AC-treated cores are lower than those from the background area (top 15 cm of newly-deposited sediment removed prior to testing).

Activated Carbon Treatment - Summary

- AC-treated layer was stable in the slow-flowing river system
- AC-treated layer has been buried by new, relatively cleaner sediment
- AC-treated layer has continued reducing porewater PCB concentrations
- Bioavailability reductions apparent even after 10 years in the field
- Initial mechanical mixing resulted in a more diffuse AC layer over time

Ongoing Sediment Remediation Challenges

- Assessing source control status and preventing recontamination
- For dredging remedies, developing more disposal and beneficial use options
- Increasing regulatory acceptance of in situ remedies and onsite disposal options
- Assessing long-term effectiveness in reducing contaminant concentrations in fish tissue

https://www.epa.gov/choose-fish-and-shellfish-wisely/fish-and-shellfish-advisories-and-safe-eating-guidelines

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