


In Situ Capping of Contaminated Sediments using Active Media

Mid-Atlantic Contaminated Sediment Symposium

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PRESENTED BY:

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CETCO Remediation Technologies

Agenda

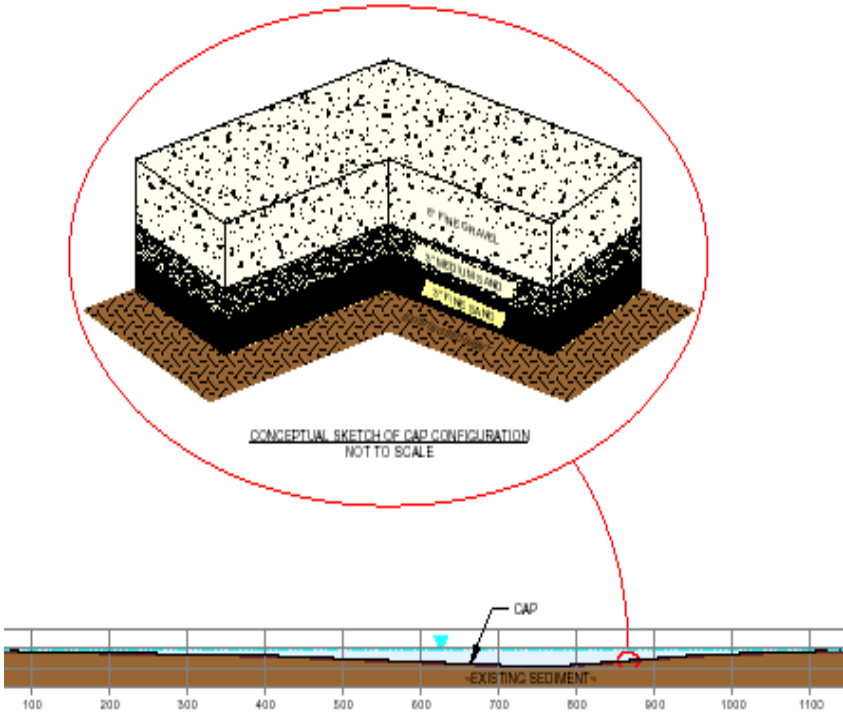
- In-Situ Capping (ISC)
- Active Capping
- Media Selection
- Field Implementation
- Case Studies

Cap Function/Design Objective

Reduce risk by

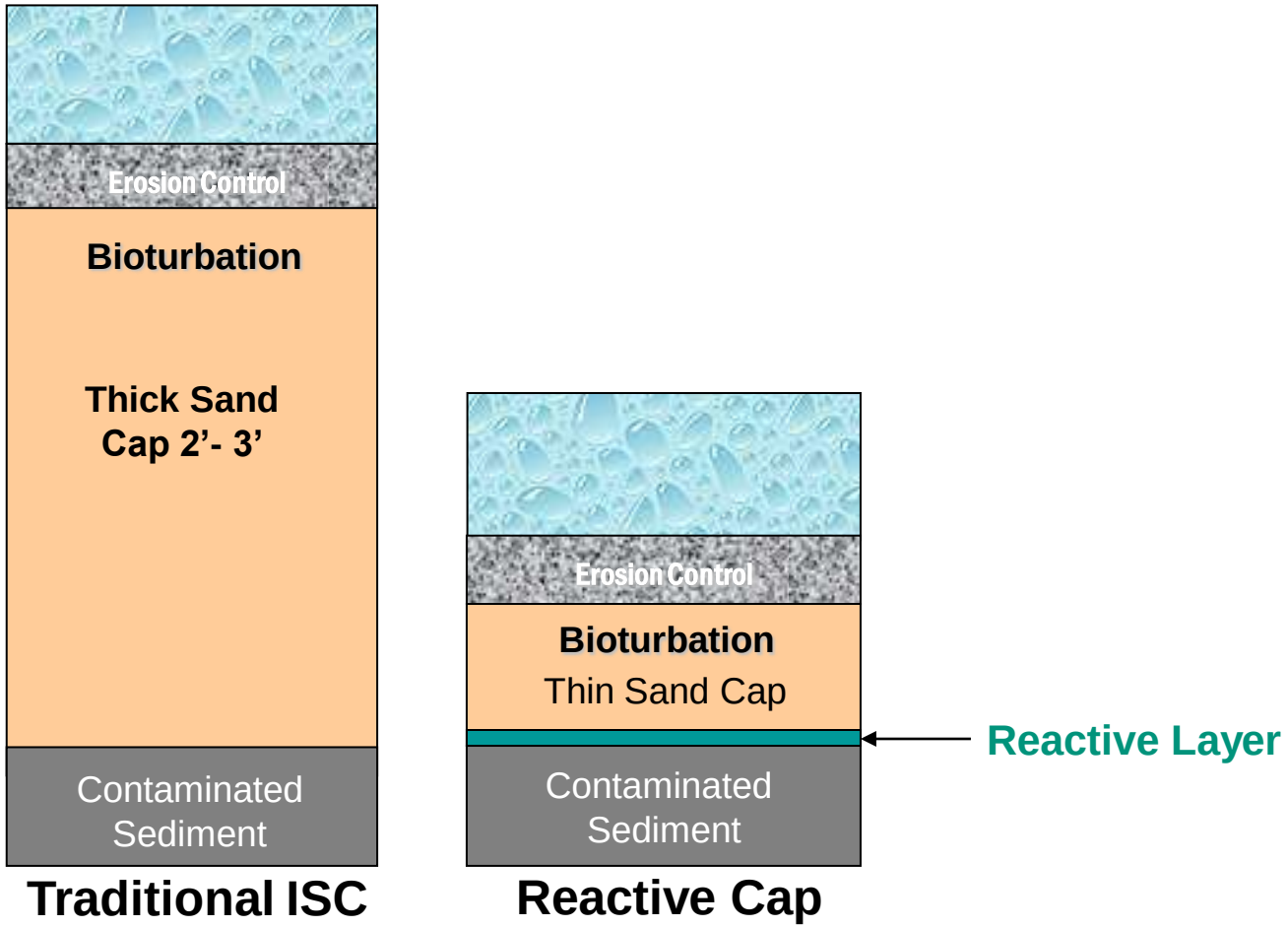
- Stabilizing sediments
- Physically isolating sediment contaminants
- Maintain permeability with groundwater and gas ebullition transport
- Reducing contaminant flux to benthos and water column

Active Capping can enhance chemical isolation



Source: D. Reible, Sediment Remediation – How do you select design options, Portland, OR, 2007

Conceptual Cap Designs



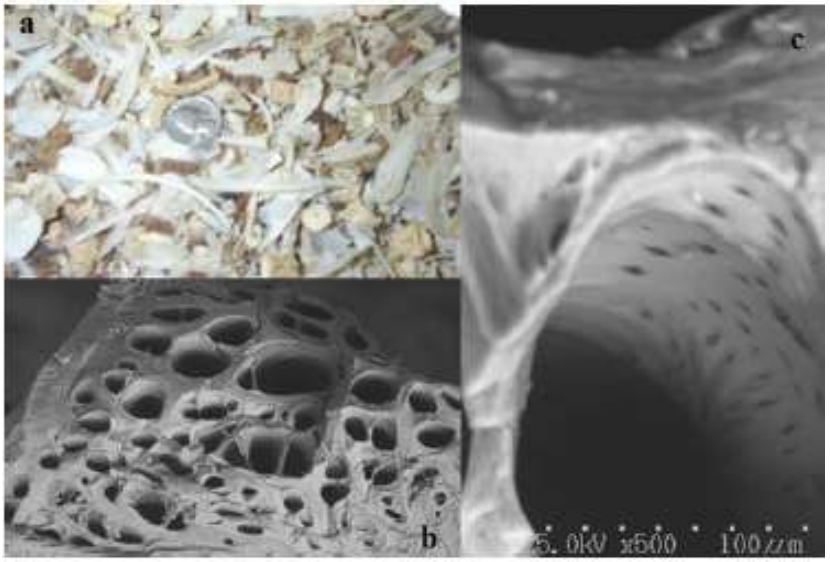
Active Media Used in Capping Sediment

Active Media

- Organoclay® for low soluble organics and NAPL
- Activated carbon soluble organics and some metals
- Apatite for heavy metals
- Combinations of the above

What is Apatite?

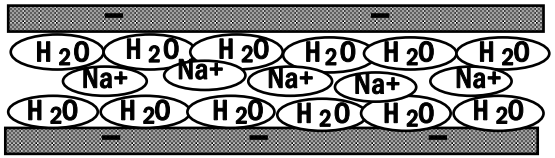
- Apatite is produced either from phosphate rock mineral or from fish bone (Apatite II™).
- Phosfil™, a phosphate mineral used on the Anacostia River, is no longer available from Potash Corp.
- Heavy metals are sequestered, such as, lead reacting with apatite to form pyromorphite.



$$\underset{\text{Apatite II}}{Ca_{10-x}Na_x(PO_4)_{6-x}(CO_3)_x(OH)_2} + 14H^+ \rightarrow (10-x)Ca^{2+} + xNa^+ + (6-x)[H_2(PO_4)]^- + xH_2CO_3 + 2H_2O +$$

$$10Pb^{2+} + 6H_2(PO_4)^- + 2OH^- \rightarrow \underset{\text{pyromorphite}}{Pb_{10}(PO_4)_6(OH)_2} + 12H^+$$

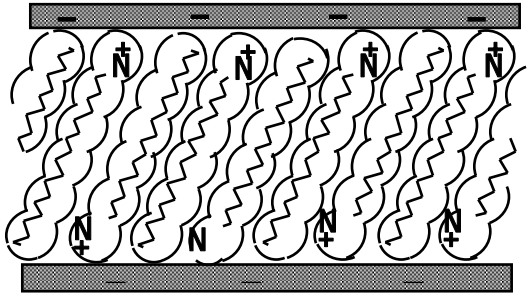
What is Organoclay?



← **Sodium Bentonite clay**

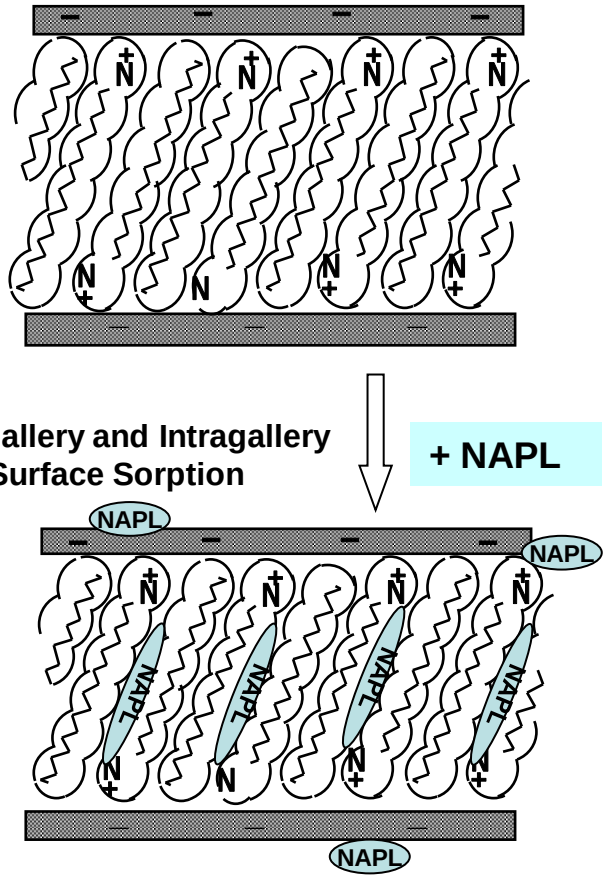
Ion Exchange

Organoclay is obtained by converting a hydrophilic clay to a hydrophobic clay using a surface modification agent through the ion-exchange reaction



← **Organoclay**

NAPL Sorption



← **Organoclay**

Sorption is completed through a partition mechanism. The driving force are the hydrophobic interactions between the long alkyl chains and the organic contaminants. Hydrogen bonding may also occur when the contaminated molecule has oxygen or nitrogen groups since the clay layer edges have abundant hydroxyl groups.

Comparison of Organoclay® to GAC

Organoclay	Granular Activated Carbon
Can adsorb NAPL	NAPL causes fouling
Best at adsorbing low soluble dissolved organics	Can adsorb slightly insoluble dissolved organics
Can adsorb organic-complexed metals (e.g. methyl mercury)	Can adsorb metals
Adsorption is non-competitive	Adsorption is competitive

Organoclay dissolved PAH partition coefficients

PAH Compound	K_d (L/kg)
Naphthalene	3280
Phenanthrene	117,000
Pyrene	286,000
Benzo(a)pyrene	1×10^7

Lampert & Reible Capping Models

- **STEADY-STATE CAP DESIGN MODEL**
- Lampert and Reible (2009)
- Version 4.1; revised 11/22/2011

Active Layer Properties	
Active layer thickness	1cm
Effective Partition Coefficient	117000.0L/kg
Active adsorbent placed loading	3.9kg/m^2/cm

Time to containment breakthrough, $t_{adv/diff}$ ***9.96E+01 yr***

Placement Methods for ISC

- Bulk placement
- Reactive Core Mat
- Marine Mattress

Direct Mechanical Placement

- Materials are handled mechanically in a dry state until released into the water over contaminated sediment
  - Backhoe bucket
  - Clamshell
- Backhoe nearshore
- Barge offshore
- Rely on gravity settling.
- Can confirm settling with 8” acrylic column
- May be limited by depth and current

- Mechanical Placement

Case Study: Port of Portland T4

Organoclay Enhanced Cap for NAPL Source Control

- Near shore cap consisted of Organoclay and aggregate (1:10)
- Capping material was pre-mixed off site and then placed using a barge equipped with a 20 cubic foot bucket
- The final cap thickness was 18” consisting of 85 tons of Organoclay
- Once in place capping material covered with sand and armoring stone

Near Shore Deployment

Reactive Core Mat

- *CETCO Organoclay Reactive Core Mat - 0.8 lb/ft^2 of organoclay between two geotextiles*
- *Geotextiles provide:*
  - *Separation – no intermixing and reduced biointrusion*
  - *Reinforcement – tensile strength*

Reactive Core Mat®

Installation:

- Barge
- Shore
- Gabion mattress

BARGE

SHORE

TRITON MATRESS

Stryker Bay, Duluth, MN

Redevelopment of Former Industrial Site – *In Situ* Sediment Cap:

- Groundwater contaminated by organics threatening nearby fresh water bay
- PAHs primary contaminants of concern
- Remedy involved hybrid design of capping and dredging
- 450,000 ft^2 of activated carbon-sand RCM installed in 1.5 weeks

West Branch Grand Calumet River Reaches 3-5

- Numerous sources
- PAHs, PCBs, metals
- No NAPL
- Sevenson-GC

- Needlepunched GAC RCM installed in dry
- Soft sediment, also used geogrid
- 500,000 ft^2

Case Study: McCormick & Baxter, Portland, OR

Sediment Cap (M&B) – Organoclay RCM placed nearshore

- NAPL from groundwater contaminating beach head and fresh water bay
- Gas releases carried NAPL through water column to water surface
- A re-occurring sheen was developing on the water surface
- Sheen has completely dissipated in capped areas

PRE-REMEDIATION

POST-REMEDIATION

West Pascagoula Creosote Works

West Pascagoula Creosote Works

- Creosote sheen
- RCM Deployed off barge
- Bulk Organoclay near structures
- App. 6 Acres of area successfully capped

Triton® Marine Mattress

Triton Marine Mattress

- 6.5 ft wide
- 20 ft long
- 6 in. thick
- Can attach RCM or line inside w/ geotextile and fill w/ active media

Collins Cove

- Former Manufactured Gas Plant (MGP) site
- Coal tar sheen
- 35,000 ft^2
- Organoclay RCM overlaid with rock filled Triton mattress
- No NAPL breakthrough after 5 years

Island End River

- Former MGP site
- Coal tar sheen
- 130,000 lb bulk organoclay
- 35,000 ft^2 Organoclay RCM attached to rock filled Triton

Summary

- In Situ Capping is a cost effective remedy that can reduce risk
- Cap performance can be enhanced with active media
- Reactive media has been successfully deployed in bulk, mat and gabion mattresses.

Thank You for Joining Us!

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