Pacific Northwest Active Materials Applications for Contaminated Sediments –

Portland Harbor ROD and Beyond

Pacific Chapter WEDA

October 27, 2017

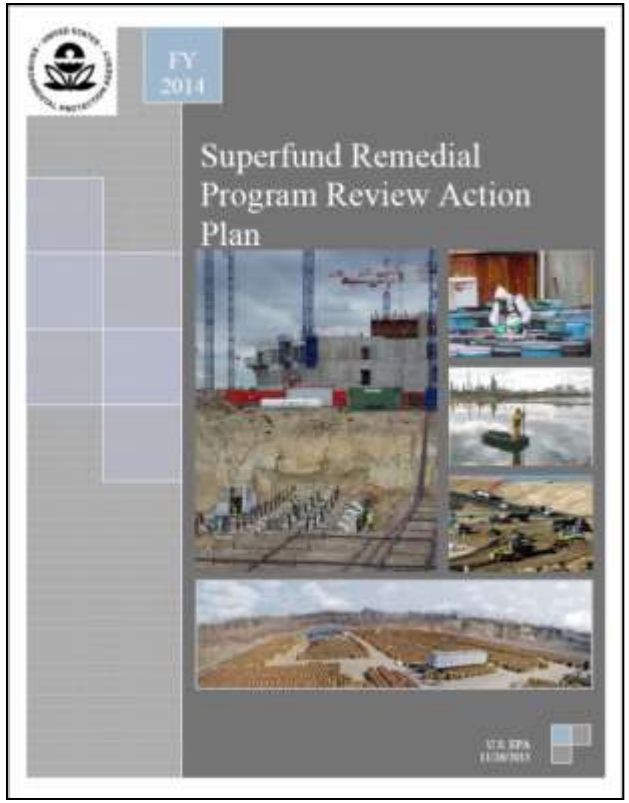
AquaBlok® Composite Particle System

www.aquablok.com

Topics for Discussion

I. Why Amendments – Regulatory Acceptance
II. Portland Harbor ROD – How Does it Fit
III. Activated Carbon Updated Information
IV. Background – AquaBlok Technology Platform
V. Summary of Select Results from Activated Carbon Applications
VI. Summary Discussion

Amendments & Acceptance



"The appropriate use of amendments has much potential to limit exposure to contaminants and, thus, to reduce risks."

- Can reduce dredging impacts
- Focused on contaminant bioavailability
- Shorten recovery time
- Less costly and more expedient

SUPERFUND TASK FORCE RECOMMENDATIONS

Select Objectives:

1. *Reduce Risk*
2. *Increase Speed of Implementation (Use of Early Actions)*
3. *Monitor & Adapt (Use of Adaptive Management)*
4. *Improve Longevity of Remedy*

Accomplishment of Objectives Can Be Enhanced Through Increased Application of Amendments In Sediment Remediation Remedy Design

Portland Harbor ROD

How Do Amendments Fit?

RECORD OF DECISION

Portland Harbor Superfund Site
Portland, Oregon

Conceptual Site Model – Focus on Benthic Community and Ecological Drivers

"Sediment cleanup levels are based on fish and shellfish consumption, which are also *based on benthic risks*. The invertebrate community living in the sediments provides food for fish and other species. The *biologically active zone of the Site ranges from "shallow" sediment (less than 38 cm deep) and up to 10 to 20 cm deep*."

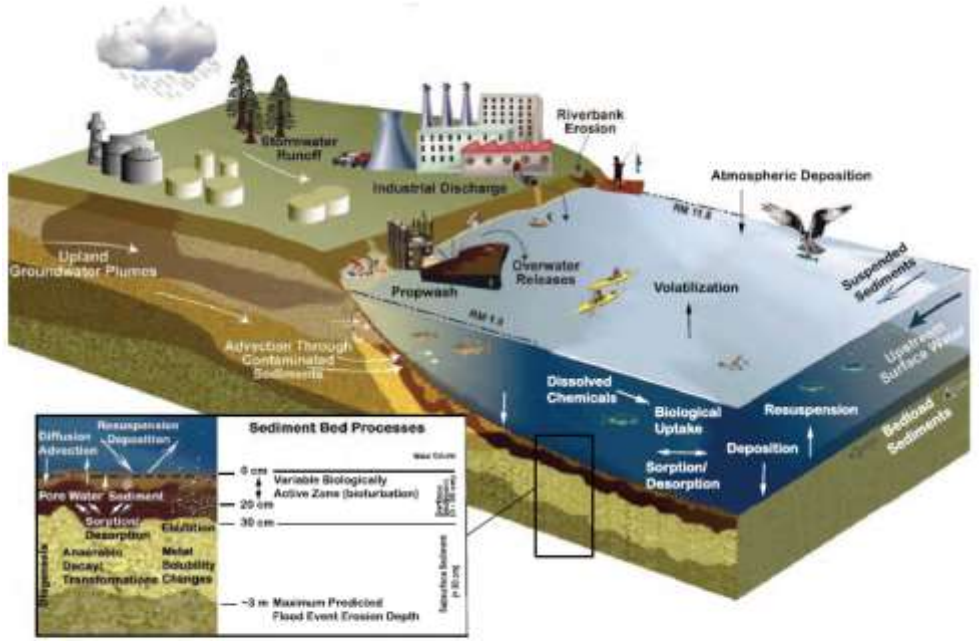


Figure 3. Major Elements of the Portland Harbor CSM

Portland Harbor Superfund Site

RECORD OF DECISION

Portland Harbor Superfund Site
Portland, Oregon

Combination of Remediation Approaches

The Selected Remedy includes:

- MNR - 1,774 acres
- ENR - 28.2 acres
- In Situ Treatment or Amendments - 133 acres
- Dredging & Capping - 365.4 acres of contaminated sediment (approximately 215.2 acres of sediment will be dredged to varying depths – balance will use dredge then cap approach)
- River Bank Excavation - 23,305 lineal feet of river bank (123,000 cy) are assumed to be excavated and covered a reactive cap or a cap
- Dredged material management - (3,017,000 cy of contaminated sediment and 123,000 cy of soil) Sent to off-site disposal facilities.

"The Selected Remedy presents *greater short-term impacts* to the community and habitat than other Alternatives, but achieves *higher post-construction risk reduction* for both humans and ecological receptors compared with current risks from contaminated media."

Amendments Support Dredging Outcomes

Dredge & Cap: The remedy enables caps to be used in dredge areas if RALs are not achieved or if PTW remains based on area-specific analysis. The ROD calls for 3,017,000 cy of dredging with Reactive Caps where appropriate.

Reactive Caps: Includes a 12-inch chemical isolation layer comprised of sand mixed with 5 percent activated carbon (0.12 lbs/ft2/cm)

Residual Management: Residual management layers will be placed following dredging within the prism and surrounding area. In the navigation channel and FMD and intermediate regions, residual layers will consist of sand amended with activated carbon to prevent exposure to residuals above cleanup levels.

Reactive Residual Layer: 12 inches of sand mixed with 5 percent activated carbon (0.12 lbs/ft2/cm)

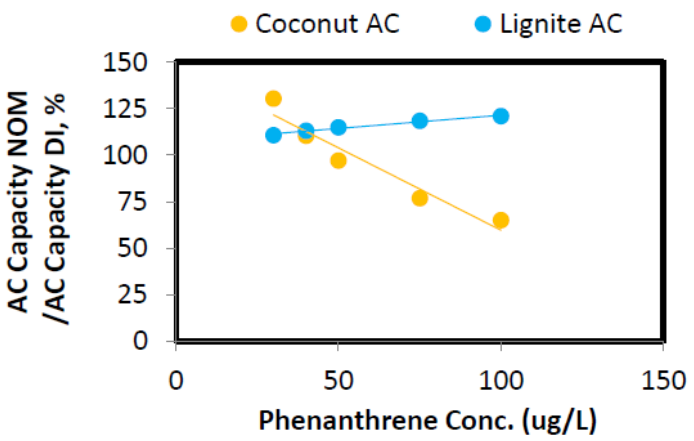
Activated Carbon - Updated Performance Information:

- Type/Form of Carbon
- Kinetics/Capacity
- Comparisons – Performance/Cost
- Risk of Remedy

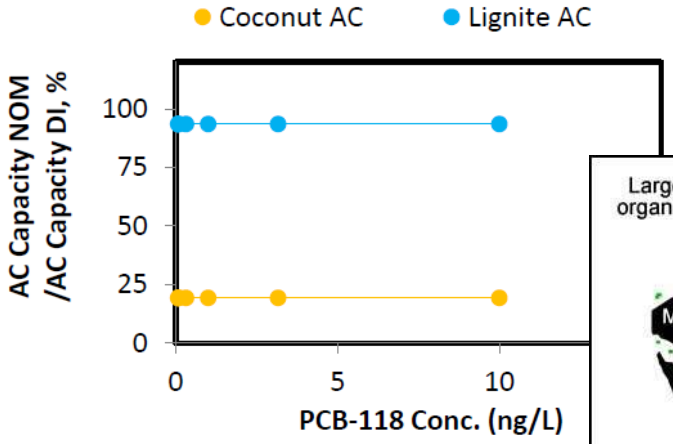
Not all Activated Carbon Performs Equally – Pore Geometry Impacts Performance - NOM

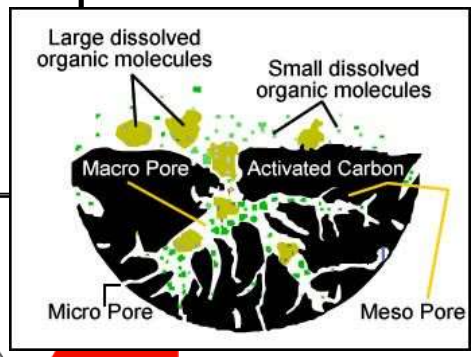
Compared to lignite carbon, coconut shell carbon is more sensitive to NOM impact

PHENANTHRENE



PCB 118





- Meso and macro-pores of lignite carbon minimize NOM impact
- NOM impact on lignite and coconut carbons is consistent with results from potable water and wastewater treatment plants

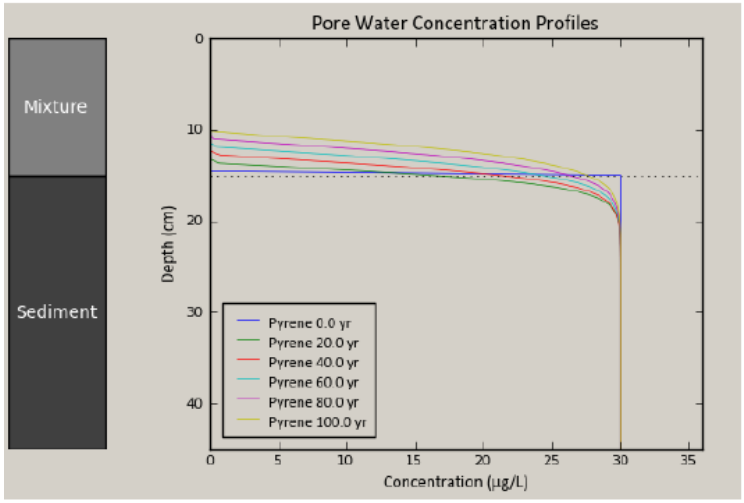
CABOT
NORIT ACTIVATED CARBON

Not all Activated Carbon Performs Equally – Pore Space Size More Important Than Iodine Number

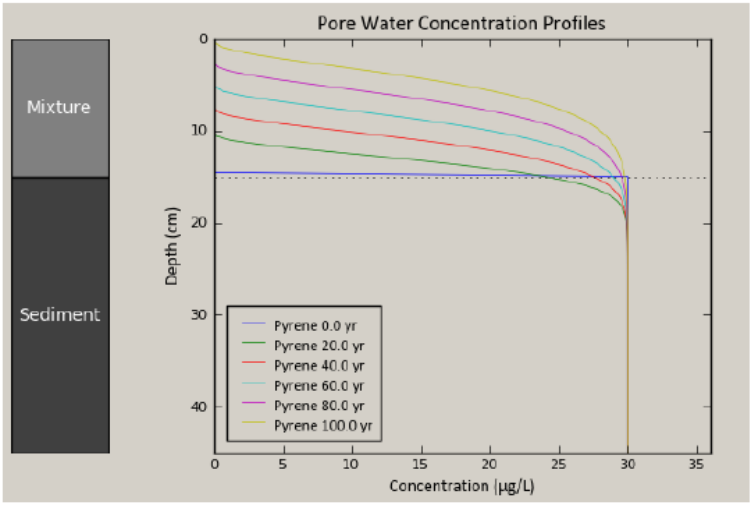
CAPSIM Modeling - Pyrene

Need more bituminous AC to achieve the same performance as lignite AC for high MW PAHs

LIGNITE PAC



BITUMINOUS PAC



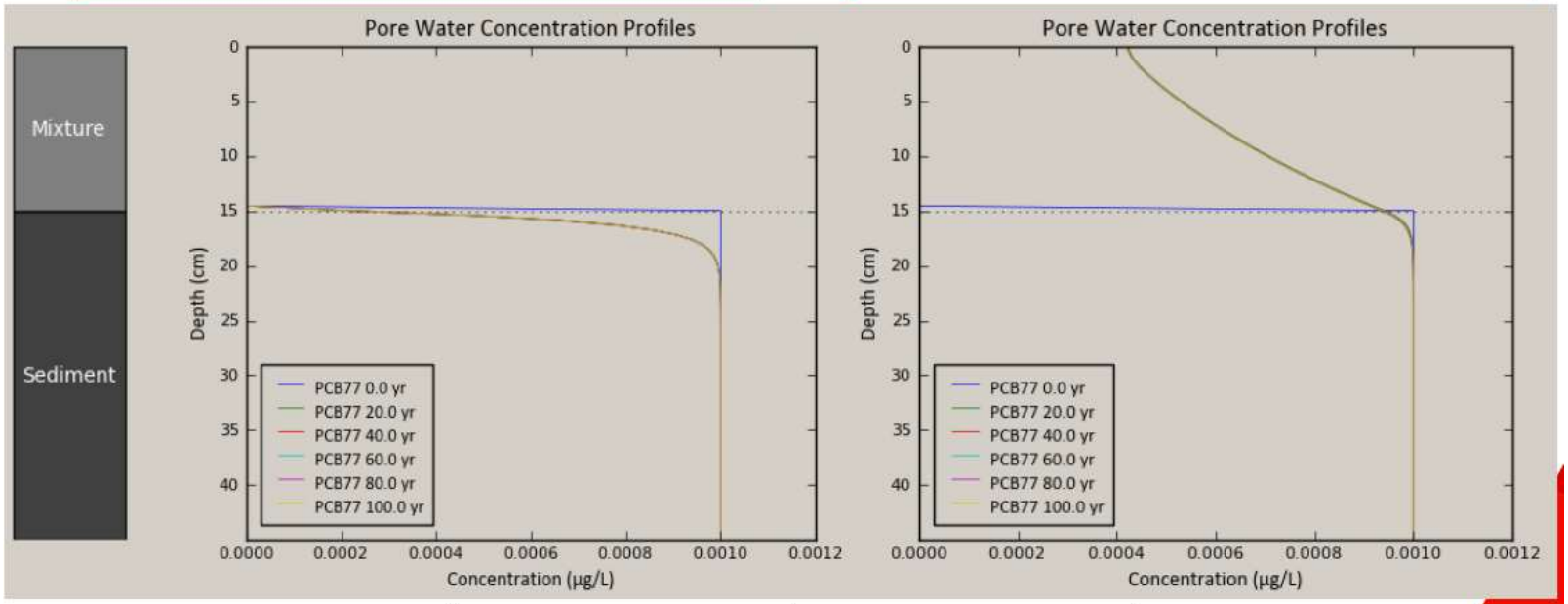
- Conditions: 1% AC, 1 cm/day upwelling rate, no NOM
- When carbon dose is 5%, there is no significant difference between lignite and bituminous carbons

Kinetics is the Key to Thinner Cap Layers

PAC may be better than GAC for PCBs when there is a high upwelling rate

PAC

GAC



Model	CAPSIM
Contaminant	PCB-77 (dioxin-like)
Upwelling rate	3 cm/day
Activated Carbon %	10%
NOM	25 ppm

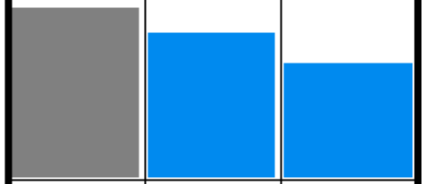
CABOT
NORIT ACTIVATED CARBON

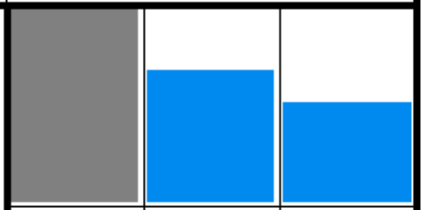
Performance Considerations: Powder vs. Granular Forms of Activated Carbon

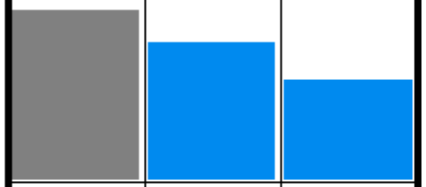
Evaluation of Powdered vs Granular Forms of Amendments for In Situ Sequestration of Sediment Contamination

Matt Vanderkooy, Tom Krug – Geosyntec Consultants
John Hull, John Collins – AquaBlok, Ltd.
Jeff Roberts – SiREM Laboratories

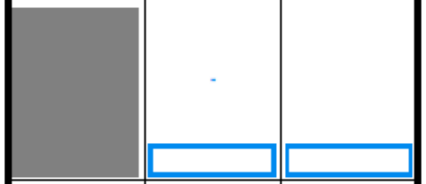
Mass GAC (g)	--	43.1	129.4
Dose GAC (%)	--	5%	15%
Treatment	Control	GAC	

Time	Contact Time - 1 week		
Median PCB Concentration (µg/L)			
	0.27	0.23	0.18

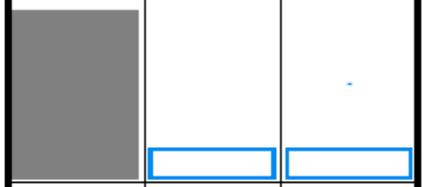
Time	Contact Time - 3 weeks		
Median PCB Concentration (µg/L)			
	0.31	0.21	0.16

Time	Contact Time - 10 weeks		
Median PCB Concentration (µg/L)			
	0.27	0.22	0.16

Mass PAC (g)	--	43.1	129.4
Dose PAC (%)	--	5%	15%
Treatment	Control	PAC	

Time	Contact Time - 1 week		
Median PCB Concentration (µg/L)			
	0.27	<0.05	<0.05

Time	Contact Time - 3 weeks		
Median PCB Concentration (µg/L)			
	0.31	<0.05	<0.05

Time	Contact Time - 10 weeks		
Median PCB Concentration (µg/L)			
	0.27	<0.05	<0.05

Technology Background
&
Summary of Select Results from Activated Carbon Applications

- Puget Sound Naval Shipyard & Intermediate Maintenance Facility, Bremerton, WA
- Hunters Point Naval Shipyard Comparisons – Performance/Cost
- Placement Considerations

AquaBlok Ltd. Technology Background

Uniform Delivery of

High-Value Materials in Low Quantities

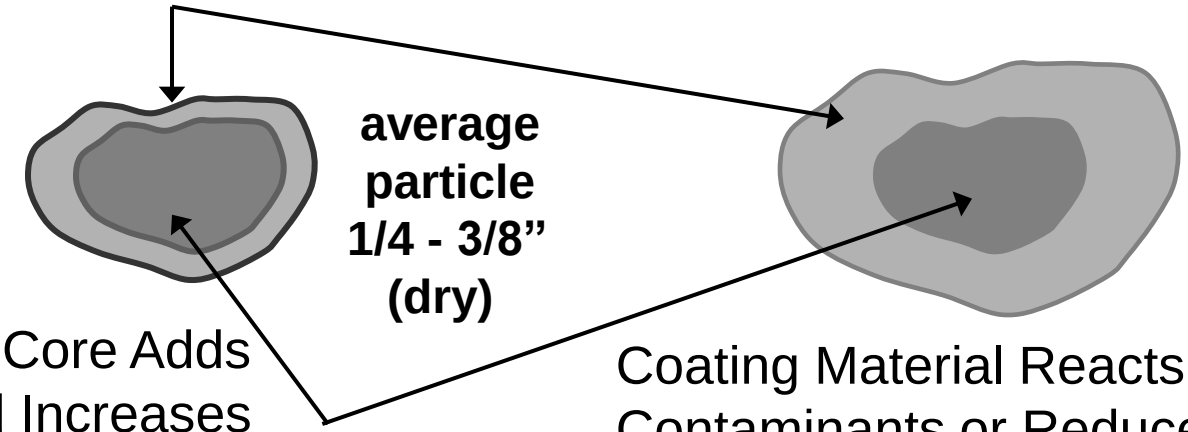
powder coating

+

aggregate core

=

AquaBlok “composite particle”



AquaBlok
www.aquablok.com

Sequestration and/or Treatment

AquaBlok®

- Low Permeability Chemical Isolation Material
- Variable Particle Size & Densities
- High Shear Strength (Erosion Resistance)
- Proven Long-term Performance (Superfund Sites)

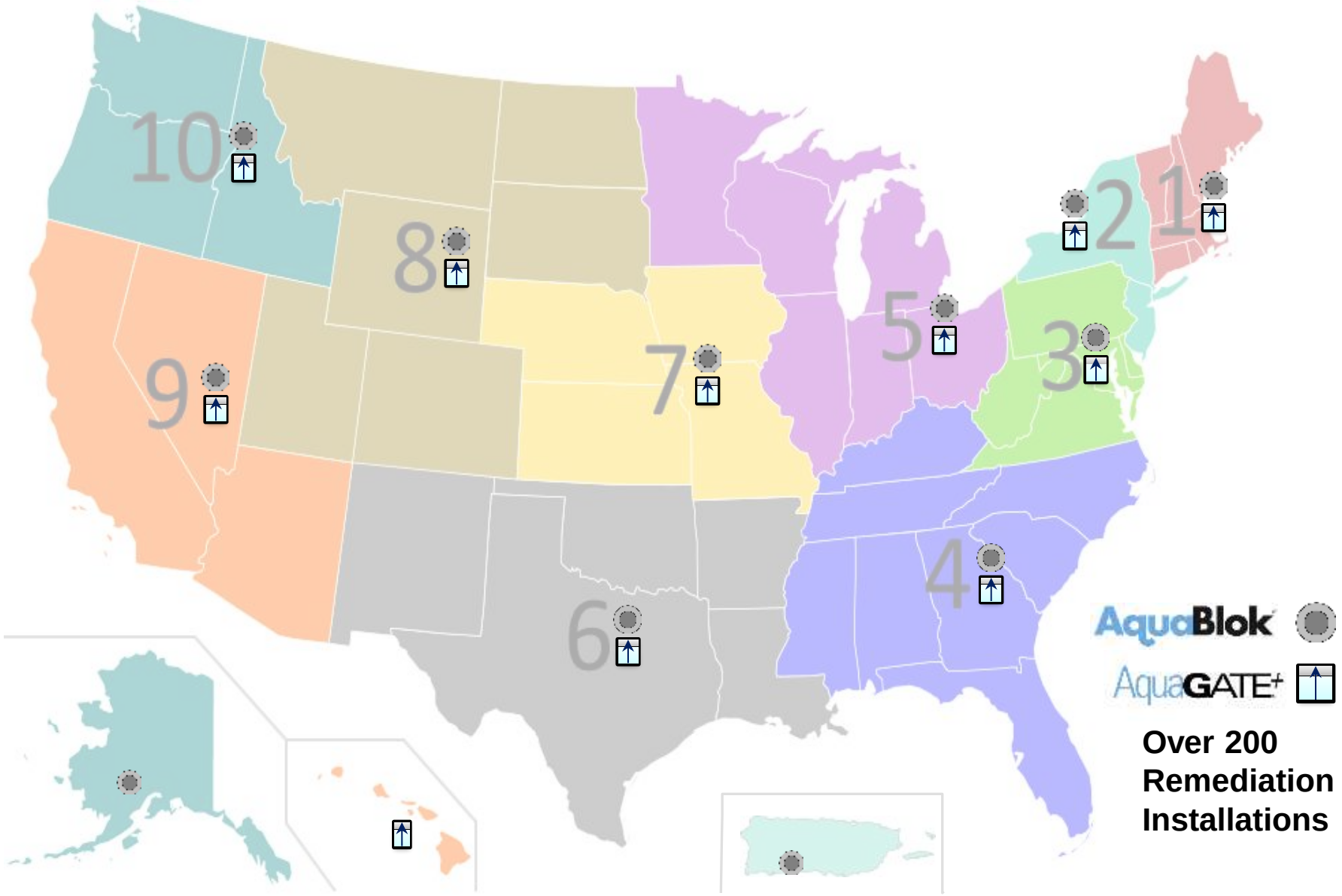
AquaGATE+ PAC/Organoclay/Sorbster/Other

- Permeable (Variable)
- Powdered Treatment Amendments
  - Generally Increased Sorption Rate/Reduced Resident Time
  - Higher Surface area
  - Uniform Distribution at Low Levels
  - Targeted Placement within a Composite Cap

Technical Advantages for AquaGATE+ Amendment Placement

- Allows use of *Powder Materials* – which can provide improved material performance
- High Bulk Density – allows for *placement through deep/moving water*
- *Eliminates Risk of Separation* – compared to mixing bulk materials
- *No Pre-Saturation of Materials Required*
- *Flexible/Rapid Installation* (Low Cost) – using conventional equipment

Product Installations by US EPA Region



Installing an Activated Carbon Sediment Amendment at the Puget Sound Naval Shipyard & Intermediate Maintenance Facility, Bremerton, WA

ESTCP

2016 | Project-of-the-Year Award

ENVIRONMENTAL RESTORATION

Battelle Eighth International Conference on Remediation and Management of Contaminated Sediments

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NAVFAC SPAWAR Systems Center PACIFIC ESTCP ENVIRON

Presentation for Seventh International Conference on Remediation of Contaminated Sediments. February 4-7, 2013, Dallas, TX

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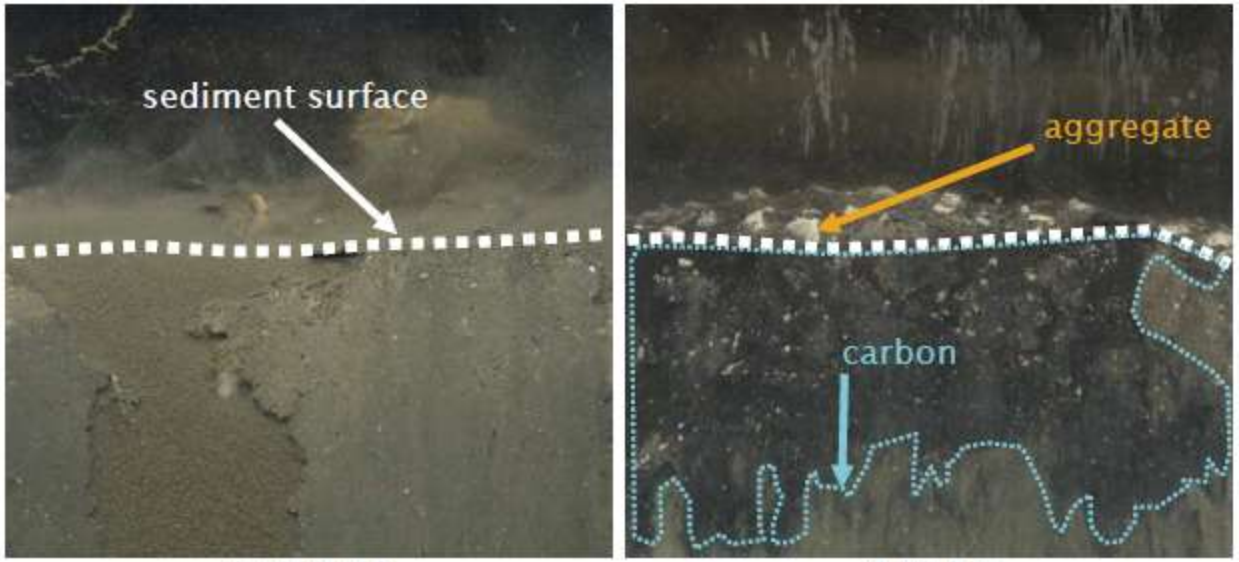
AquaGate + PAC™ Amendment

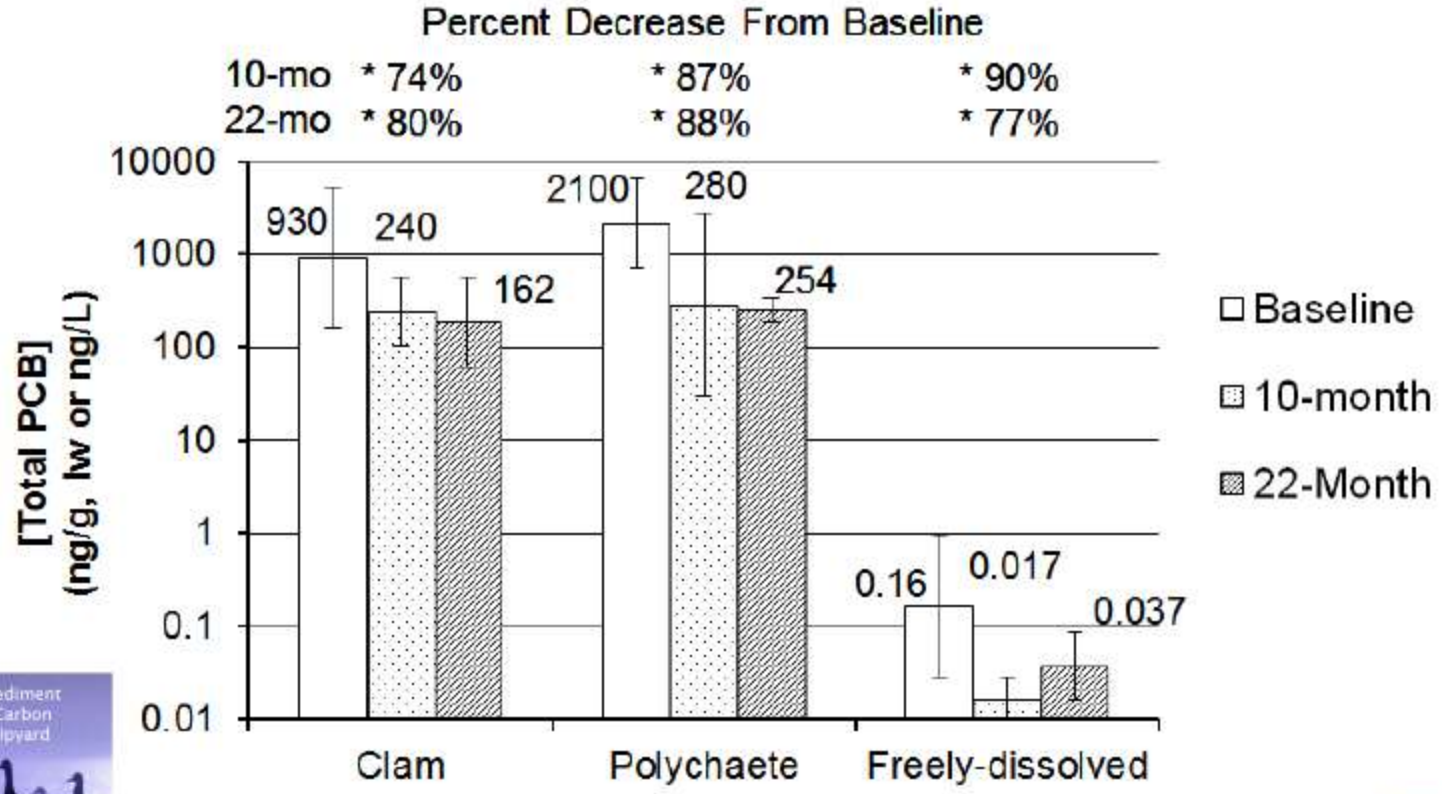
- Targeted 5-cm (2-inch) amendment layer
- Increase in Total Organic Carbon observed in top 10 to 15 cm (measured via analysis of core samples)
  - Baseline = 4%, After amendment = 8%



BEFORE AFTER

Conclusions

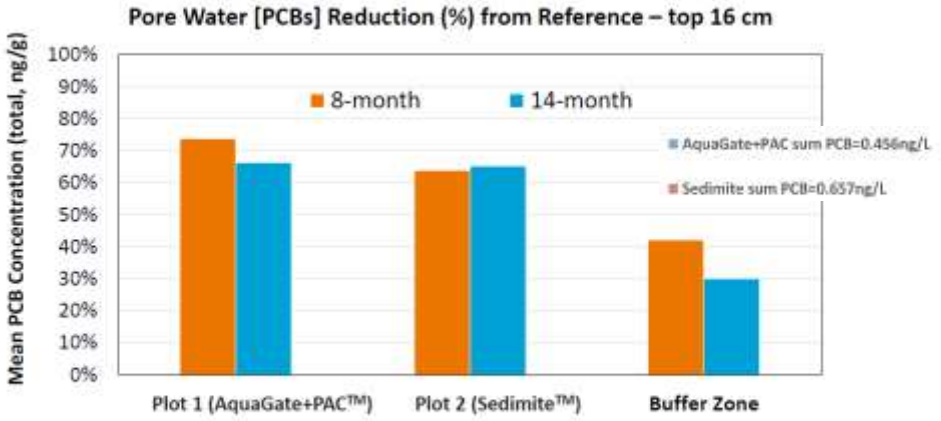
- Activated carbon amendment resulted in a significant reduction in available total PCBs



Asterisk denotes significant difference from baseline to 10-month or 22-month monitoring events (95% CI)

Hunters Point Naval Shipyard - Results

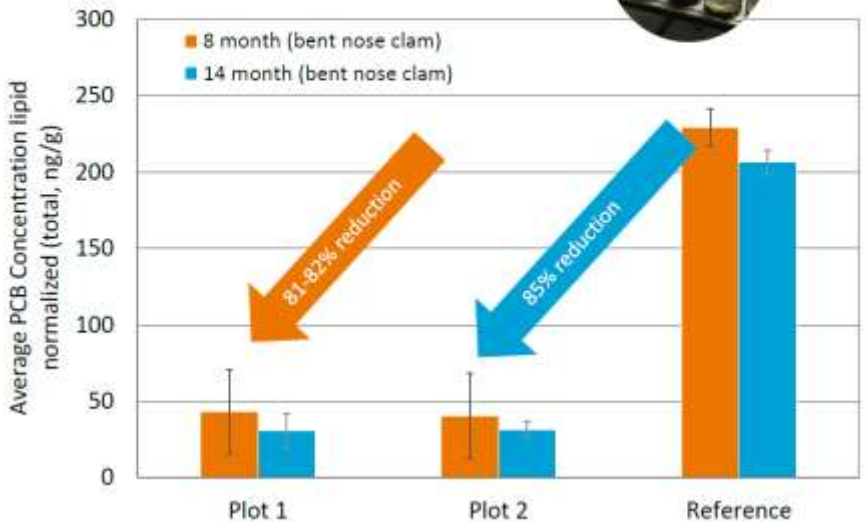
Porewater (SPME)



- Baseline (total PCBs)
  - 2.26 ± 0.2 ng/L
- 8 Month
  - 0.30 – 0.42 ng/L
- 14 Month
  - 0.10 – 0.12 ng/L

Results

Lab Tissue PCBs



South Basin: Pilot Location

Photo from US Navy

Hunters Point Naval Shipyard

Comparison of Materials:

AquaGate+PAC

Carbon %: 10% w/w
Typical Size:
3/8” Minus
(9.5 mm)
Bulk Density:
65-75/cu.ft.

Sedimite™

Carbon %: 40% w/w
Typical Size:
1/4” Minus Diam.
Length Varies
(6.7 mm diam.)
Bulk Density:
45lb/cu.ft.

Summary of Determined Doses			
Amendment Type		**AquaGate+PAC™**	**SediMite™**
Target carbon dose	% by weight	4% – 6%	4% – 6%
Target effective placement thickness	Inches	1.2 – 1.8	0.5 – 0.8
Area treated	Acres	0.41	0.39
	Square feet	17,860	16,800
Total mass amendment applied	Pounds	190,000	53,200
Effective placement thickness	Inches	1.7	0.8
Calculated applied carbon dose	% by weight	5.7%	6.6%

Actual Thickness - at:	65	Lb/CF		1.97
Material Cost at:	0.25	lb		$47,500
Cost / SF				$2.66
Placement Time				2 Days
Target Placement	1.7	inch		
Overplacement - Actual	0.27	inch	15.6%	
Overplacement - Cost / SF	$0.36			

Actual Thickness - at:	45	Lb/CF		0.84
Material Cost at:	1.5	lb (est)		$79,794
Cost / SF				$4.75
Placement Time				2 Days
Target Placement	0.5	inch		
Overplacement - Actual	0.34	inch	68.9%	
Overplacement - Cost / SF	$1.94			

Granular Mixtures vs. AquaGate+

Example Specification – Placement Considerations:

9.8 IN AREAS WHERE THE TYPE 2 SAND AND GRAVEL IS AUGMENTED WITH BULK ORGANOCLAY, THE BULK ORGANOCLAY WILL BE ADDED AT A RATE OF 5% ON A DRY WEIGHT BASIS.

Engineer: ***"We specified 5% because we want to make sure we get a minimum of 2.5% in the cap."***

90 cm Sand/Gravel (90% of thickness)
10 cm AG+OC (10% of thickness)

92 cm Sand/Gravel (92% of thickness)
8 cm GOC (8% of thickness)

Type 2 Sand/Gravel

SIEVE SIZE		% FINER	
INCHES	mm	LOWER BOUND	UPPER BOUND
1	25	85	100
¾	19	70	90
⅜	9.5	55	75
4	4.75	40	60
8	2.36	35	45
16	1.18	15	35
50	0.3	10	25
200	0.075	5	15

1 m3 of Sand/Aggregate = 3,531.5 lb x 90% = 3,178.35 lb
1 m3 of AG+OC = 2,913.46 lb x 10% = 291.35 lb
Total Material (per m3) = 3,469.7 lb/m3

Quantity of OC = 30% x 291.35 = 87.41 lb = 2.52% (per m3)

Say – 300 lb/m3 of AquaGate+OC X 783 m3 of Cap Volume = 117.45 tons

Pricing: AG+OC Based on **120 tons at $1,350/ton** = $162,000
Freight: 6 truckloads @ $6,500/truck =$39,000
Total Delivered Cost = $201,000

1 m3 of Sand/Aggregate = 3,531.5 lb X 5% GOC = 176.57 lb
At 50lb/CF – GOC = Approximate 3-inch Thickness = 7.62 cm

Sand/Aggregate @ 92% = 3,248.95 lb
GOC @5% OC w/w = 176.57 lb
Total Material (per m3) = 3,425.52

Say, 180 lb/m3 X 783 m3 of Cap Volume = 140,940 lb.

Pricing: PM-200 Based on **140,940lb at $2/lb.** = $281,880
Freight: 4 truckloads @ $7,500/truck = $30,000
Total Delivered Cost = $311,880

Benefits of Confirmation of Active Material Design Characteristics: Conclusions

- ***Ability to Confirm material placement assumptions*** such as bulk density (*determines layer thickness*) and loading - which are critical to demonstration that key design parameters are met.
- ***Verification of uniform distribution*** of active-treatment materials is achieved through the thickness of the capping layer.
- Enables ability to perform post-placement confirmation of active-treatment material testing of ***adsorption capacity*** (partition coefficient) that satisfies the specification.
- ***Modeling assumptions can be confirmed*** through comparison of input/assumptions to post-placement physical and material property data.
- Results can be used to ***reduce costs associated with excessive factors of safety*** due to lack of certainty of achievement of a design / specification as well as the ability to provide post-placement verification.

AquaBlok® Composite Particle System

Summary: Amendments Can be Useful in Addressing Contaminated Sediment Issues in the Pacific Northwest

EPA Goals and Objectives are a Good Fit With the Expanded Use and Application of Amendments in Combination with Dredging to Maximize Risk Reduction and Achieve Sustainable Costs in the Pacific Northwest

Innovative Amendment–Based Approaches:

- **Enhanced Back-fill (Thin Amended Layer Capping)**
- **Dredge Residual Management (Thin-layer Treatment)**
- **Addressing Ongoing Sources Via Iterative/Targeted Low-Level Applications**

AquaBlok®
Composite Particle System

On-Site Production

Full-Scale Remote Manufacturing Performed at Multiple Locations