

Assessment of Flow-Through Media for Reducing PFAS Migration in Surface and Groundwater



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Topics for Discussion

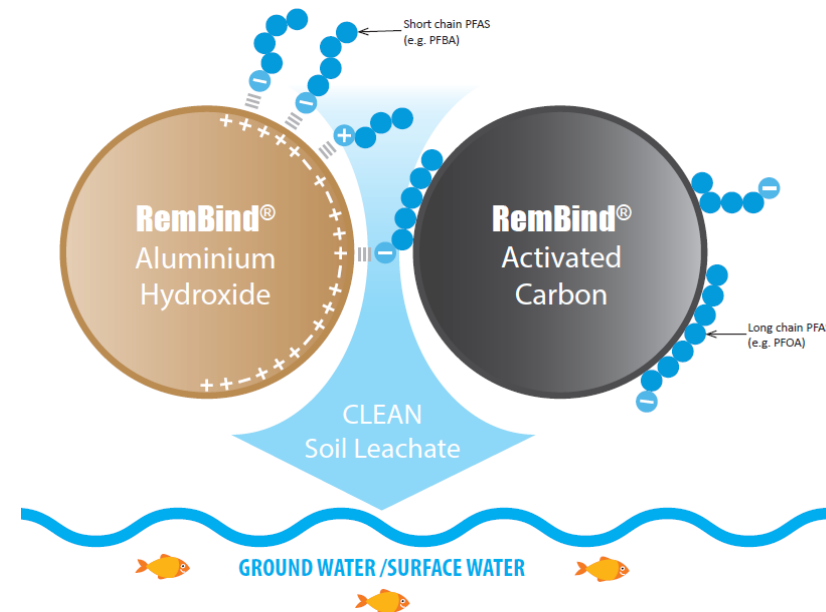
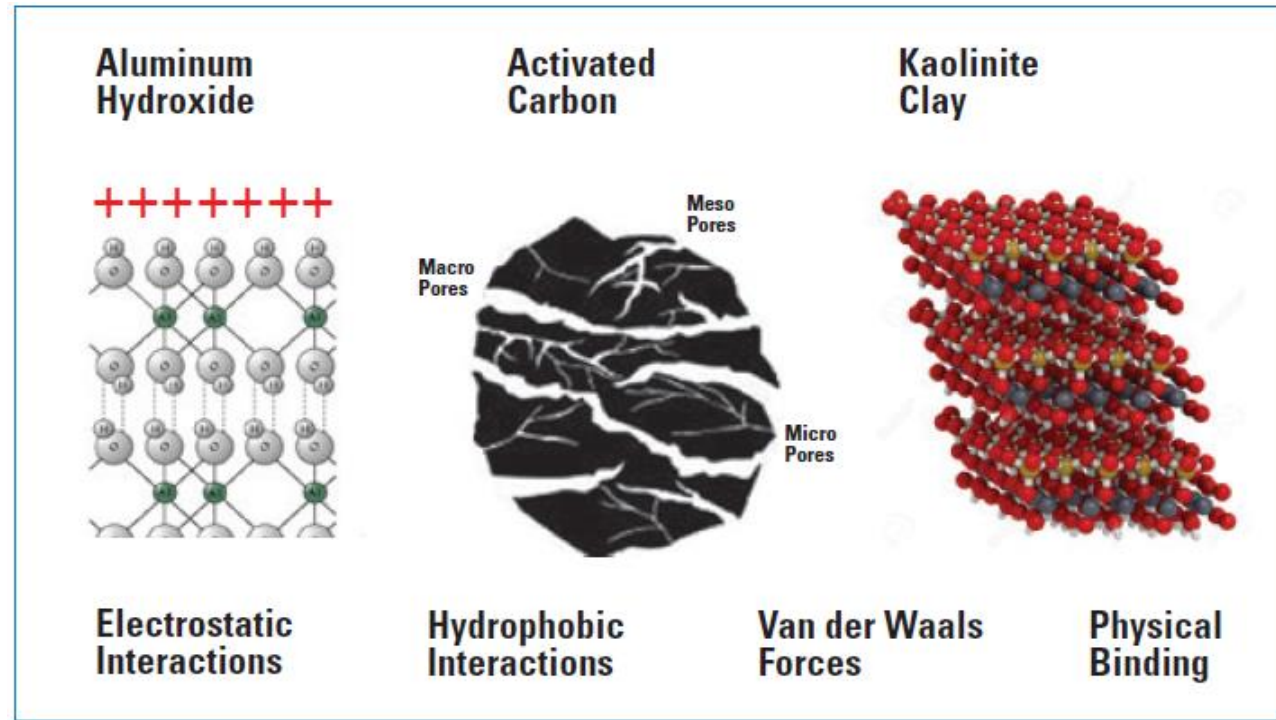
- **Background** – RemBind and AquaBlok Technology/ Experience
- **BECCA Study & Results** –
 - Methodology
 - Jar Tests
 - Column Tests
 - Results
- **Field Application** – Surface Water Application / PRB
- **Other Case Studies**
- **Summary / Questions**

RemBind[®] – Proven PFAS Immobilization Reagent

- A powdered reagent that binds PFAS in soil and water to prevent leaching or transport
- Developed with the Australian Government's leading national R&D organization: Commonwealth Scientific Industrial Research Organization (CSIRO)
- Independently verified by government airport authorities, Defence & industry worldwide
- Applied commercially at full-scale in Australia, Sweden, and the USA



How does RemBind® work?



How effective is RemBind at binding PFAS?

Leachability Characteristics of Per- and Polyfluoroalkyl Substances (PFAS) in 14 Soils from Airport Sites across Australia

Richard Stewart¹ and Ross McFarland²

Site	Soil Type	Product	Product Addition Rate % (w/w)	PFAS Concentrations in Soil Leachates*					Below NSW EPA Landfill Criteria? 50 µg/L **	PFOS Reduction %	Passed USEPA Method 1320?	PFOS/Total PFAS*** %
				Before Treatment			After Treatment					
				PFOS mg/kg	PFOS µg/L	PFOA µg/L	PFOS µg/L	PFOA µg/L				
1	Silty clay loam	RemBind Plus	5.0	0.74	34	0.65	0.29	<0.02	Yes	99.20	Yes	86
2	Silty clay	RemBind Plus	7.5	2.24	376	5.6	0.1	<0.02	Yes	99.97	Yes	67
3	Clay	RemBind Plus	5.0	20.9	695	11	1.5	<0.02	Yes	99.80	nt	99
4	Clayey silt (organic)	RemBind Plus	10.0	3.15	38	1.17	1.9	<0.02	Yes	95.00	Yes	99
5	Sand	RemBind Plus	5.0	1.26	1	1	<0.02	<0.02	Yes	>98.00	nt	99
6	Heavy clay	RemBind Plus	5.0	3.01	87	1.54	<0.02	<0.02	Yes	>99.98	nt	nt
7	Silty sand	RemBind Plus	5.0	7.25	190	0.05	0.05	<0.02	Yes	99.97	Yes	99
8	Clayey loam	RemBind Plus	5.0	1.45	62.5	2.7	<0.02	<0.02	Yes	>99.97	Yes	98
9	Clay/gravel (spill)	RemBind Plus	10.0	184	4,780	222	3.52	0.21	Yes	99.90	Yes	nt
10	Clay/gravel	RemBind Plus	5.0	1.24	72	0.7	0.1	<0.01	Yes	99.90	nt	66
11	Heavy clay	RemBind Plus	5.0	0.67	36	1	0.1	<0.01	Yes	99.70	nt	40
12	Clay	RemBind Plus	5.0	0.78	43	0.6	0.1	<0.01	Yes	99.80	nt	57
13	Silty clay	RemBind Plus	2.5	nt	120	0.51	0.16	<0.02	Yes	99.90	nt	67
14	Silty clay	RemBind Plus	2.5	nt	184	1.84	0.2	<0.02	Yes	99.89	nt	67

* As prepared by TCLP or ASLP at pH 5

** NSW landfill guidelines stipulate a soil leachate criteria of 50 µg/L for PFOS + PFHxS for general solid waste

*** Ratio of total PFOS/total PFAS extended suite (20 analytes) run by Australian Laboratory Services

TCLP = Toxicity Characteristic Leaching Procedure

ASLP = Australian Standard Leaching Procedure

nt = not tested

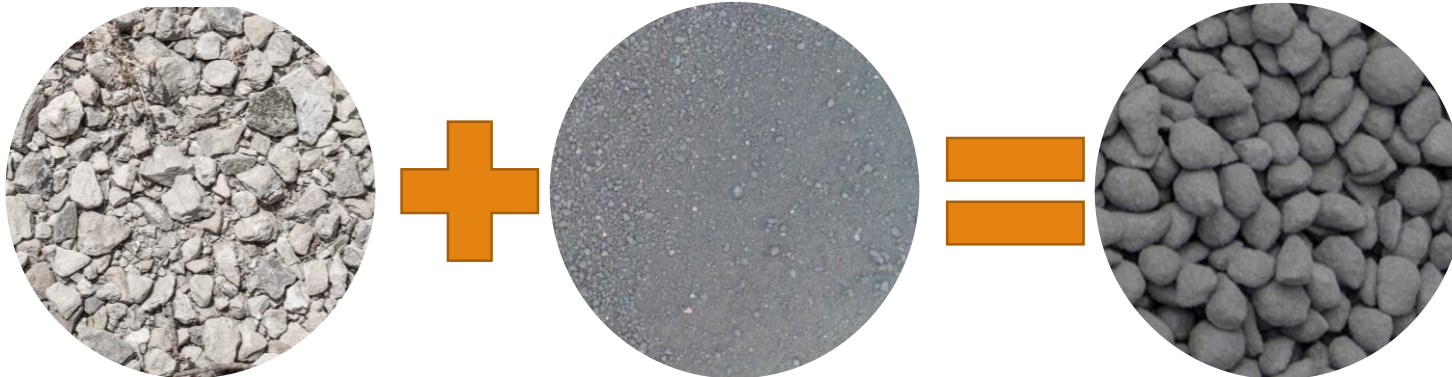
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Adapting RemBind for Surface Water Applications

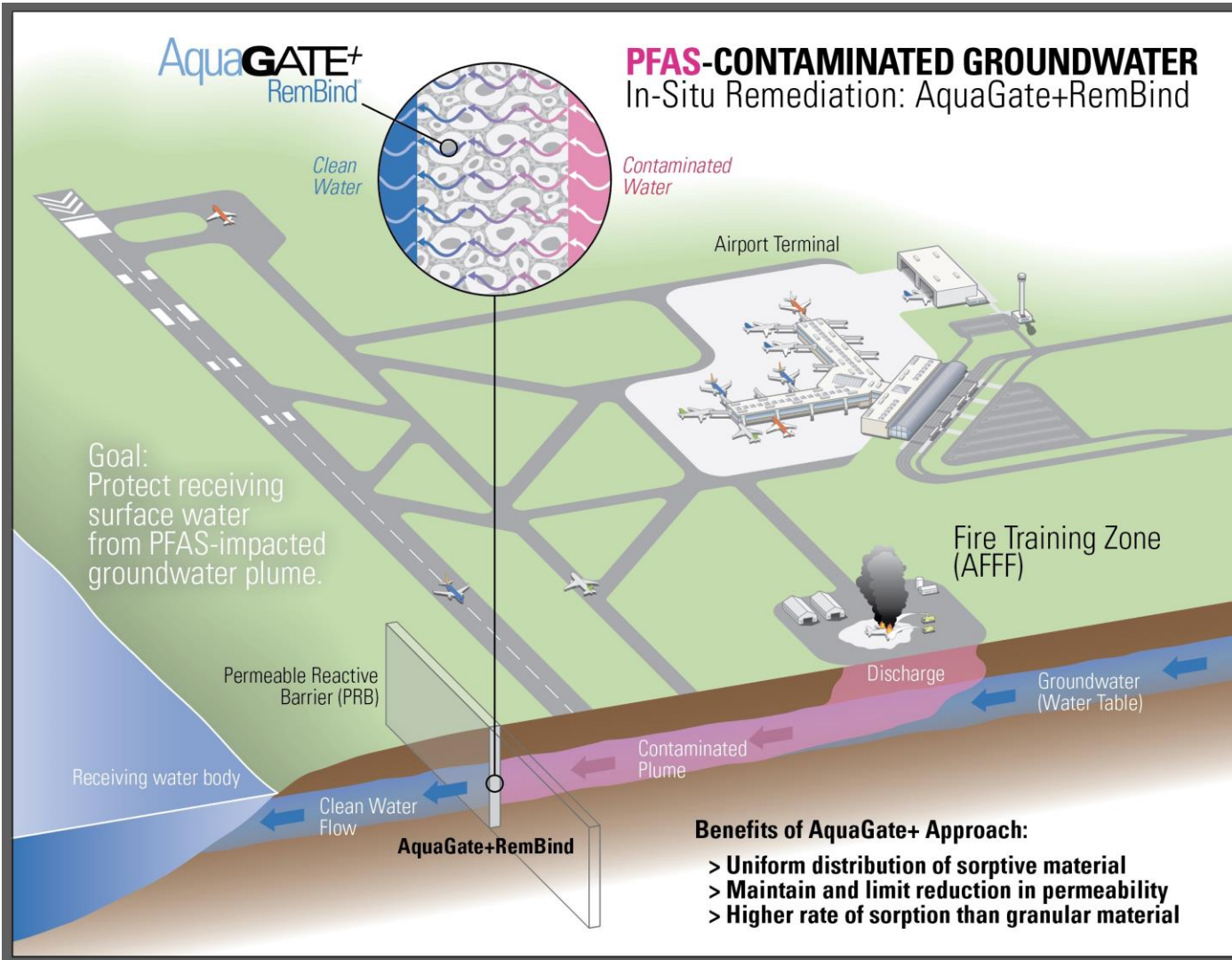
- Australian-sourced aggregate, coated with RemBind® using AquaGate Delivery Technology
- Typical particle diameter = 7-10mm
- Permeability = $3.8 \times 10^{-4} \text{m/s}$, Determined using constant head method as per Australian Standard AS1289.6.7.1

Aggregate +  **RemBind®** 



Surface Water – Context

Need for Passive Removal of PFAS



- **High volume but intermittent**
- **Relatively low concentration compared to wastewater and groundwater at airports**
- **Compared to other migratory paths:**

Wastewater – high co-contaminants (TPH), other products such as fluorine free foams and DCP, low volume

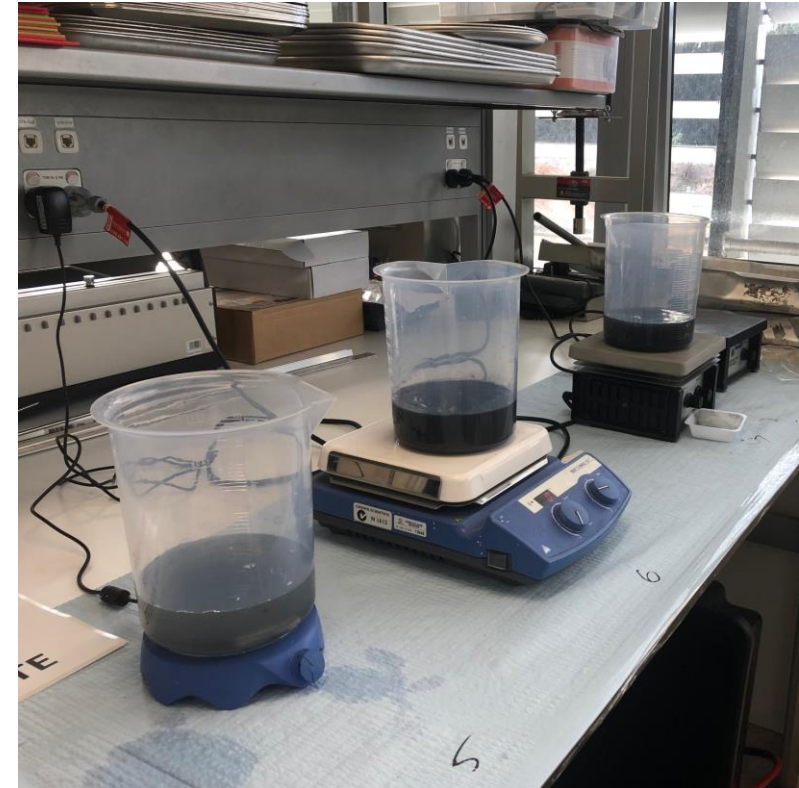
Groundwater – typically higher PFAS contamination levels, different co-contaminants depending on site

Beca Test Methodology - Overview

1. Adsorption Capacity - Jar test to determine the sorption of RemBind®, as a coating material for AquaGate+RemBind material
2. Adsorption Kinetics – Run above tests at different time frames to determine rate or speed of adsorption
3. Scale Up - Perform column tests using Aquagate+RemBind to provide basis for determining breakthrough rates

Beca Jar tests

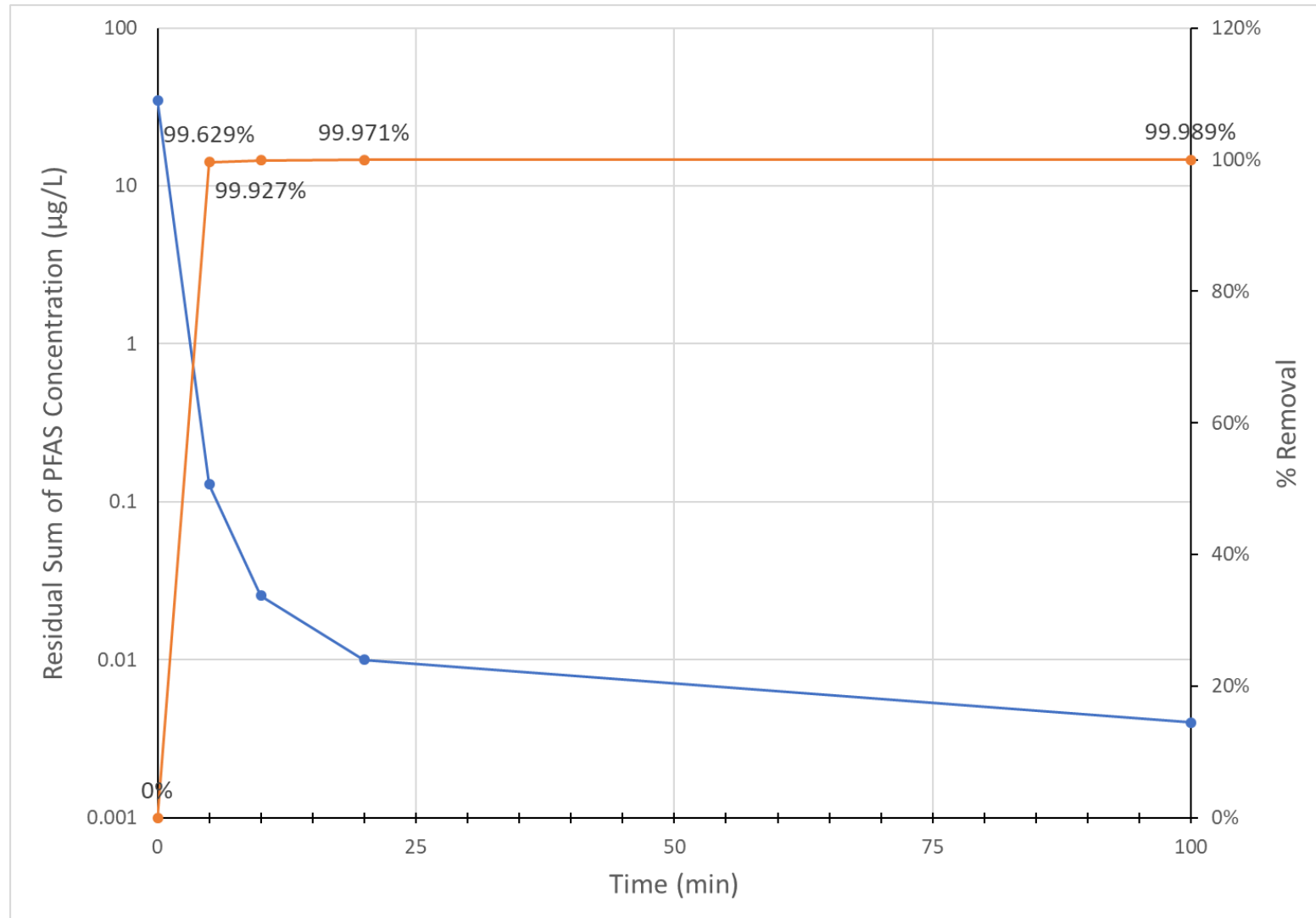
- Jar test method adapted from ASTM D3860-98
- 3 stocks used: PFOS in solution, PFOA in solution, raw stormwater collected from airport
- Stock water aliquots dosed with differing RemBind™ quantities plus product co-ingredients at product spec ratio
- Allowed to stir for 24 hrs
- Solutions targeting around the 50µg/L level





Jar Tests – Adsorption & Rate

- 50 $\mu\text{g/L}$ Starting Concentration
- 99.6% Reduction Completed in First 5 minutes of Contact
- 20min contact time selected for column test





Column tests

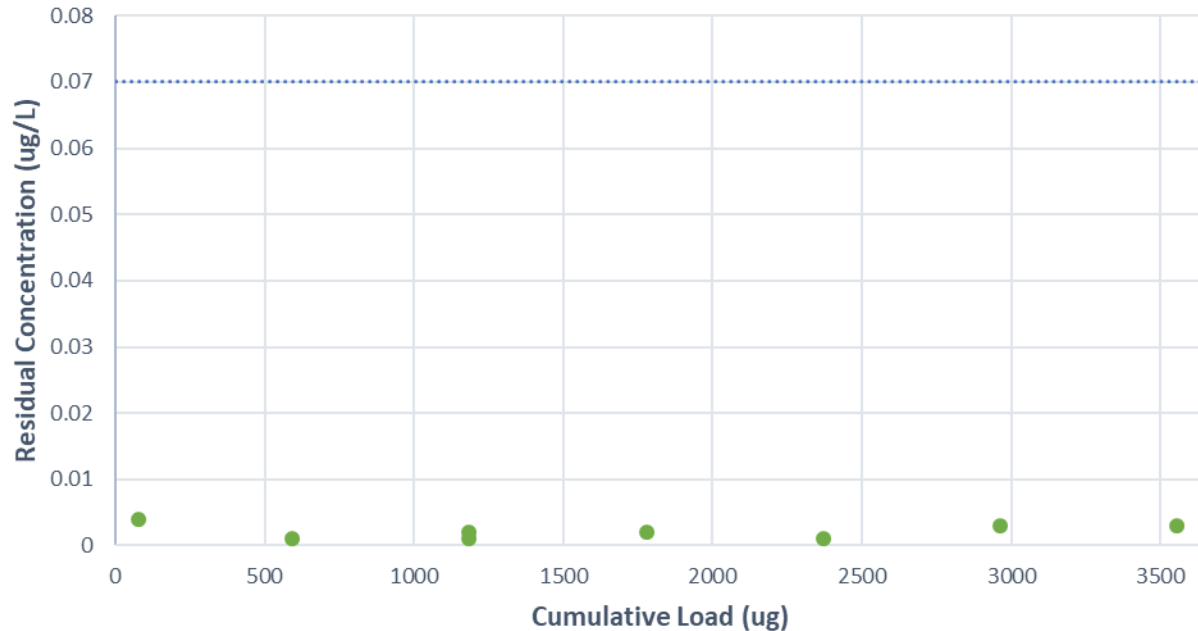
- Apparatus design and methodology adapted from Rapid Small-Scale Column Test (RSSCT)
- Column sizing to achieve scalable proportions and distribution through the column
- Permeability suggested negligible pressure drop
- Limited by volume at lab scale – storage and cost of disposal of residual water



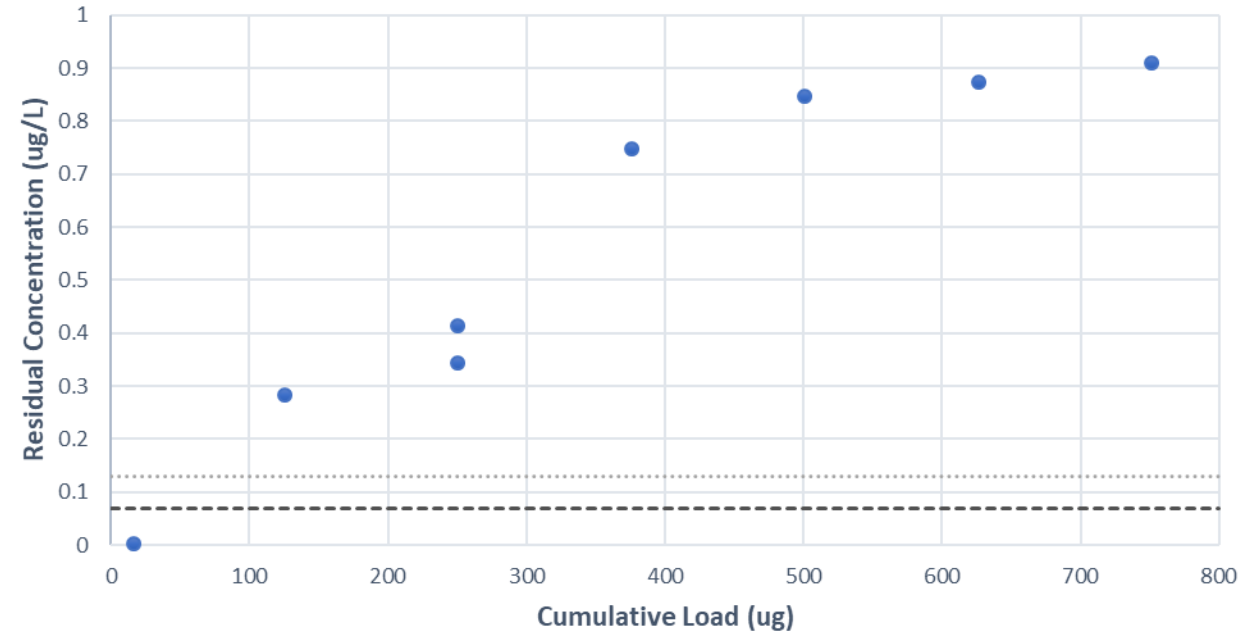


Column Test – PFOS Result

PFOS Residual Concentration (Standard Stock)

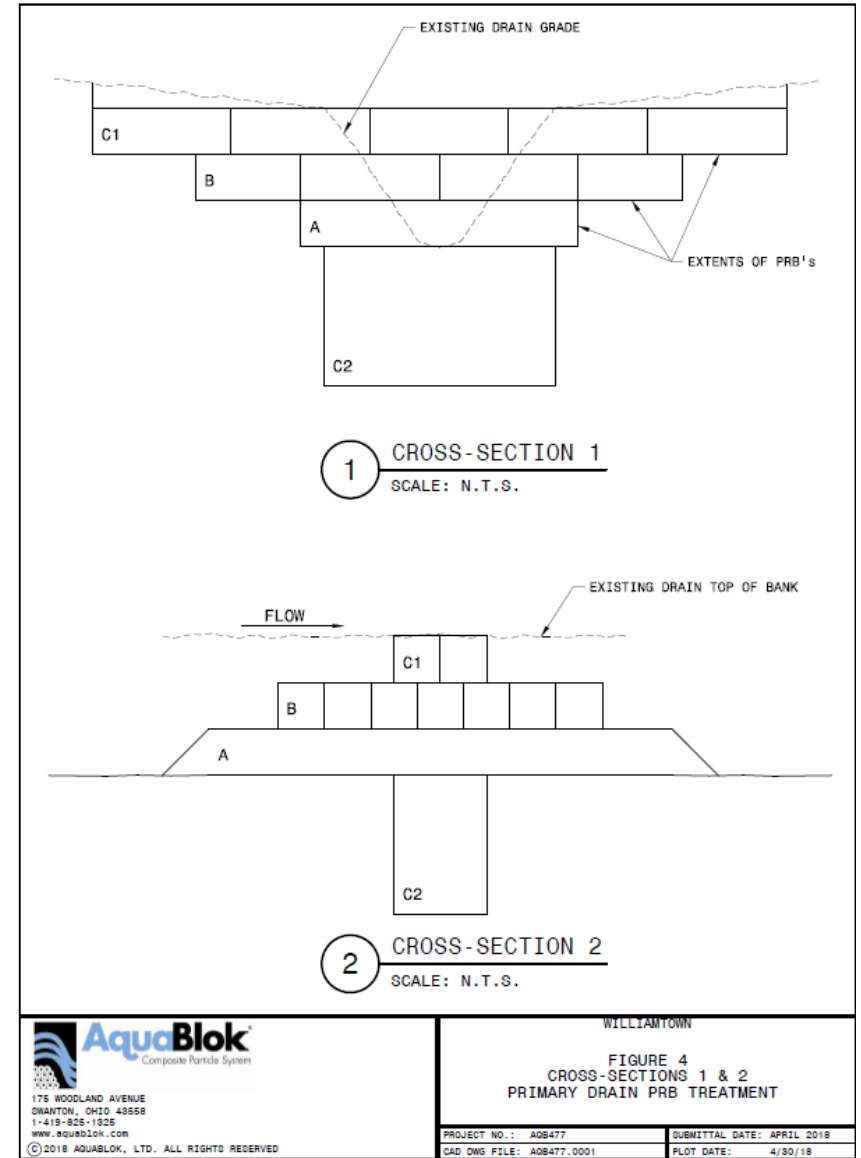
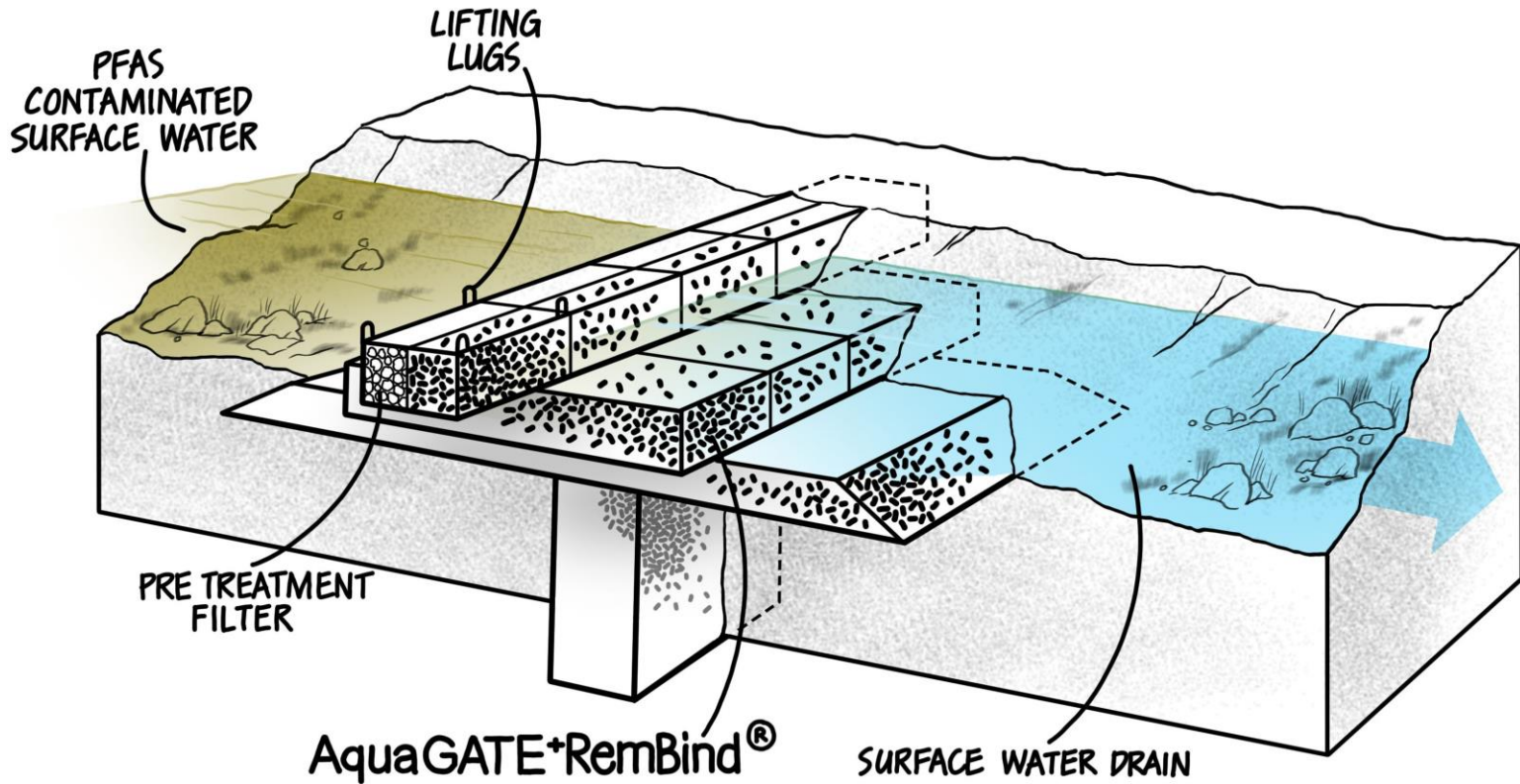


PFOS Residual Concentration (Live Stormwater)



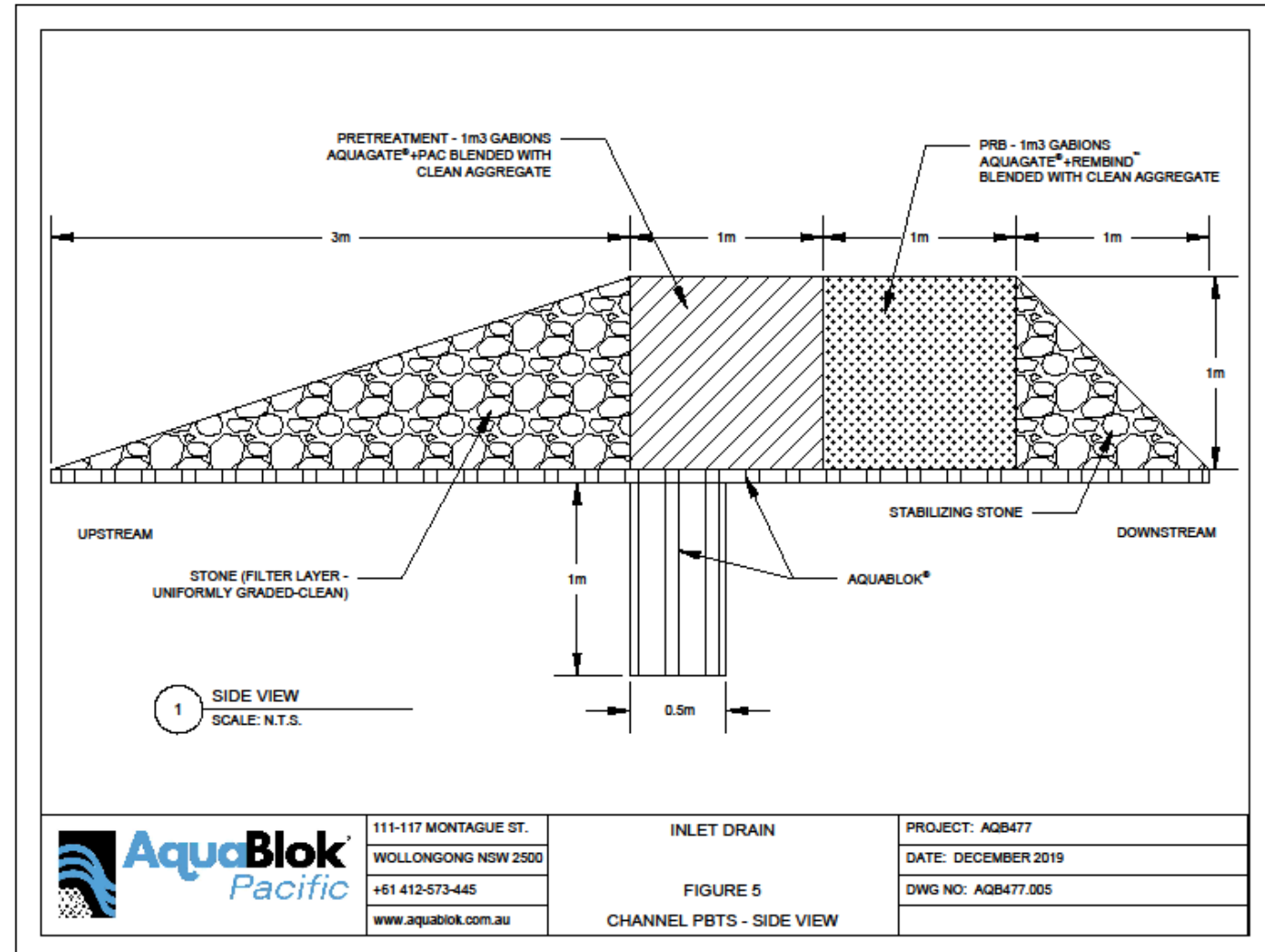
- Standard Stock - Low Residual Maintained for 3,500 μg Load
- Live Stormwater - Maintained below 1 $\mu\text{g/L}$ for Over 800 μg Load – Indicates Impact of TPH Competitive Sorption from Live Stormwater

Application of Passive Flow-Through Design To Surface Water - Drainage Ditch (PRB)



Key Design Parameters – AquaGate+RemBind

- PFAS Adsorption Capacity
 - Approximately 1,000 µg of PFAS per gram of RemBind.
- Treatability based on Contact Time
 - A 5-minute contact time will provide a 99.6% reduction, extrapolated based on independent testing using spiked water with higher PFAS levels than the concentration typically assumed.
- Important Considerations:
 - Adsorption performance of RemBind will vary widely across different scenarios based on physical and chemical factors.

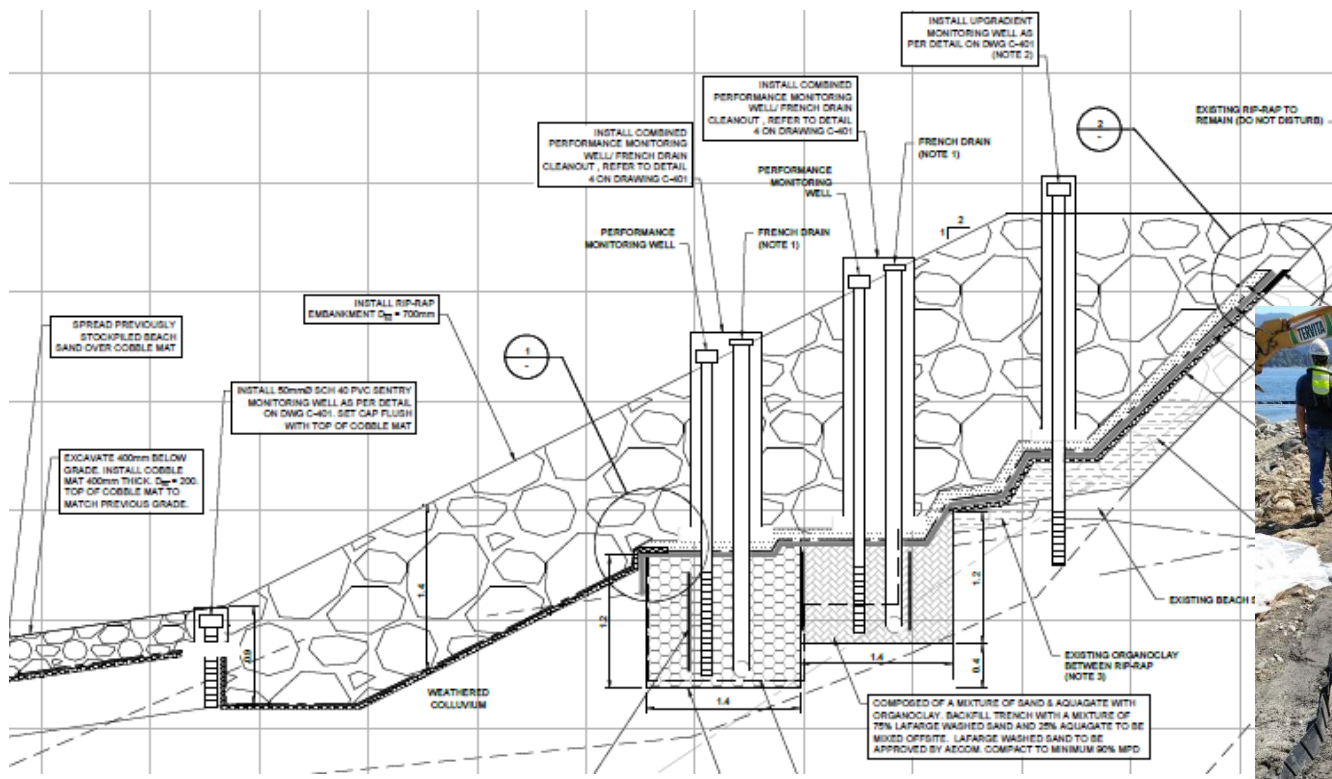


Other Case Studies - Installed Remediation Configurations

- Low-Permeability Sediment Cap
- Cut-off Wall
- Permeable Reactive Barrier (PRB)
- Landfill Cap Repair
- Thin-Layer Post-Dredge Backfill
- In-Situ Sediment Treatment
- Reactive Capping (Water)
- Funnel & Gate
- Upland Seep Zone Treatment



Passive Shoreline Permeable Reactive Barrier (PRB) to Address NAPL & Dissolved-Phase PAHs in Groundwater

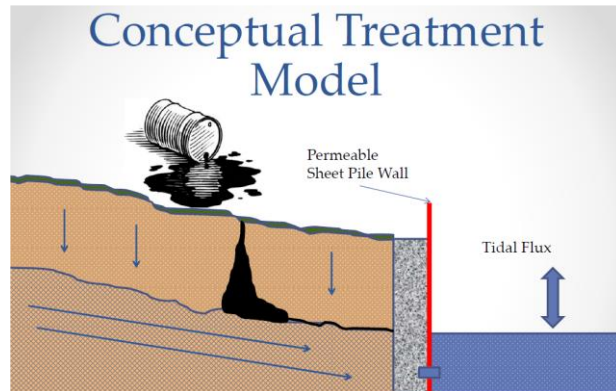


Products Utilized:

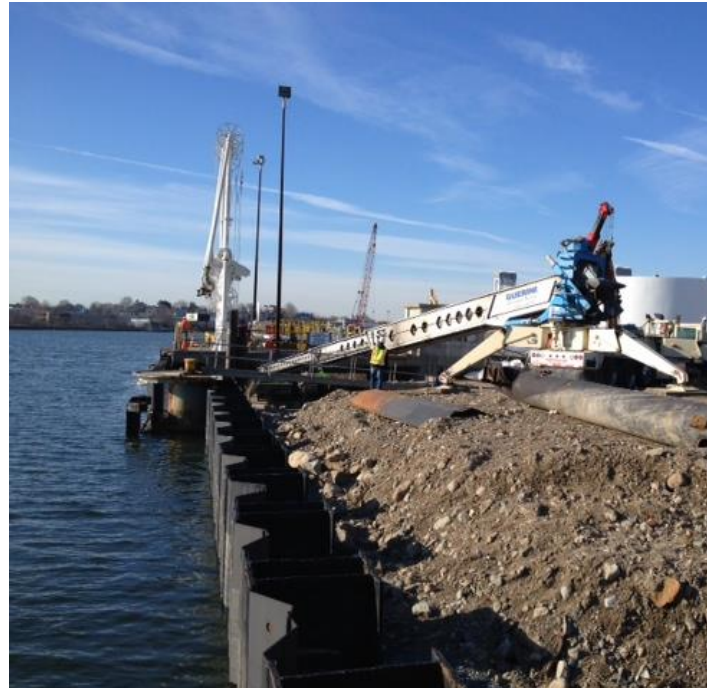
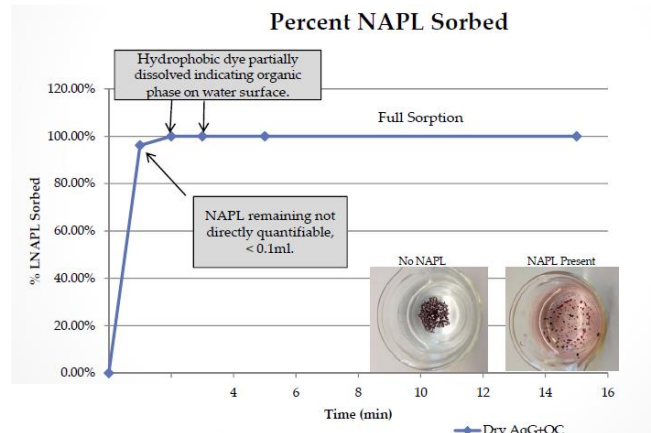
- AquaGate+Organoclay
- AquaGate+PAC
- AquaBlok 2080FW



Permeable Reactive Barrier (PRB) Installation



Contaminated Groundwater Flow AquaGate+ Organoclay PRB Tidal Estuary



Funnel & Gate: Redirect Arsenic Seep to Adsorptive Treatment Materials – Limit Potential Migration to Adjacent River

Site Location: U.S. EPA Region 5
Ohio DOT Project, Toledo, Ohio

- **Contaminant(s) of Concern:** Arsenic from historic accumulation of fill material
- **AquaBlok Design / Site Area:** The approach utilizes a “funnel & gate” treatment design with AquaGate+EHC-M reactive, treatment materials to address a seep zone. A low permeability AquaBlok layer directs the residual seep downward to the base of the slope through the permeable treatment zone. (EHC-M is a proprietary treatment material supplied by FMC Environmental)



Project Status:
Completed September 2012



Use of AquaGate+EHC-M for Treatment of Arsenic Seep Zone



RCRA Metals

	<u>Before</u>	<u>June13'</u>	<u>Aug13'</u>	<u>March14'</u>
Arsenic	60 mg/L	ND mg/L	ND mg/L	ND mg/L
Barium	0.15 mg/L	0.12 mg/L	ND mg/L	0.1mg/L
Cadmium	0.0033 mg/L	ND mg/L	ND mg/L	ND mg/L
Chromium	0.067 mg/L	ND mg/L	ND mg/L	0.043 mg/L
Lead	0.17 mg/L	ND mg/L	ND mg/L	ND mg/L
Selenium	0.81 mg/L	ND mg/L	ND mg/L	ND mg/L
Silver	0.0034 mg/L	ND mg/L	ND mg/L	ND mg/L
Mercury	ND mg/L	ND mg/L	ND mg/L	ND mg/L

Summary – Q&A

AquaBlok® AquaBlok as a Low-Permeability Material to Support Remediation Designs

AquaGATE⁺ Permeable Treatment Material for Flow-Through Remediation Applications

- Permeable Treatment Material for Groundwater & Sediment Remediation Applications
- Rapid Installation – Using Conventional Equipment
- Proven Full-Scale Production – On-Site Manufacturing

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