Initial Field Deployment Results of Gree[n] PCB Removal from Sediment Systems (GPRSS)

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Purpose of Study

- Develop/optimize technology capable of removing PCBs from contaminated sediments
- Develop design for functional GPRSS unit
- Produce and prove functionality of prototype units in a laboratory setting
- Produce fully-functional GPRSS units for testing at a demonstration site in Altavista, VA
- Evaluate efficacy of GPRSS technology for the remediation of PCB-contaminated sediments

Overview of Previous Results

- Various polymers tested for ability to remove PCBs from contaminated sediments (Table 1)

Table 1

Sample ID	% PCB Removal		
	3 Weeks	7 Weeks	17 Weeks
Black Norprene Tubing	5.73%	7.96%	10.63%
White Norprene Tubing	2.15%	4.54%	4.60%
Latex Glove	0.93%	3.14%	4.14%
Thick Nitrile Glove	0.95%	0.31%	1.59%
Abrasion Resistant Gum Rubber (5/8")	1.03%	3.43%	1.86%
Natural Gum Foam	3.04%	14.17%	20.26%
Abrasian Resistant Gum Rubber (1/16")	3.02%	5.42%	8.27%
Weather Resistant Butyl Rubber	3.44%	7.14%	18.46%
Weather Resistant Butyl Rubber	3.85%	9.02%	9.87%
Viton Mat	4.22%	7.30%	6.03%
Black Viton Tubing	1.89%	0.94%	2.76%
White Viton Tubing	0.99%	0.63%	0.91%
Butyl Rubber (glove)	3.99%	3.48%	4.10%
ABS	2.95%	4.71%	3.89%

Table 2

% of PCBs removed by Ethanol-filled Polyethylene (1 month Study)			
	Interior	Within Polymer	Total
Pipet 1	35.4	14.0	49.3
Pipet 2	31.7	11.0	42.7
Pipet 3	35.9	12.0	48.0
Pipet 4	41.9	17.6	59.6

- Butyl Rubber, Norprene, Gum Rubber/Foam showed highest removal capacities
- Interior solvent studies showed marked increase in PCB removal capacity when combined with polymers (Table 2)
- Polymer blanket designed for feasibility studies
- Small-scale demonstration unit produced for testing and physical optimization studies (Figure 1)

Figure 1

Comparison of Sediment Remediation Technologies

Table 3

	GPRSS	Monitored Natural Recovery (MNR)	Dredging/ Removal	Sediment Capping
Environmentally Friendly?	🙂	🙂	☹	🙂
Destroys PCBs?	🙂	☹	🙂	☹
Source Treatment?	🙂	☹	🙂	☹
Reusable?	🙂	😐	☹	☹
Low Cost?	🙂	🙂	☹	😐

Current Research Results (FY13/FY14)

- Current work focused on optimizing GPRSS technology for use in real-world applications.
  - Creation of functional design; production of prototype test units using results from previous studi[es]
  - Commercial vendor produced "spikes" of different polymers (LDPE, HDPE, PP) to allow for testing and evaluation. Figure 2 shows an HDPE spike
  - Testing was performed to determine the "sphere of influence" each individual spike would have. The original prototypes had a 2" spacing between spikes
    - The results of this study (Table 4) showed that a 3" spacing would suffice

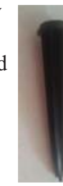

Figure [2]

Table 4

Distance (in.)	% Removal
0.63	30%
1.38	21%
1.88	16%

Table 5

Sample ID	Diffusion Rate (ug/in²/week)
HDPE	12.48
LDPE	13.42
PP	8.20

- Concurrent testing of the mass-produced spikes was conducted to determine the transport rate of the PCBs through the various polymers
  - Results (Table 5) showed that LDPE had the highest transport capabilit[y] PCBs, however physical characteristics of the polymer proved to be unsuitable for real-world use
  - HDPE spikes had nearly as high a diffusion rate as LDPE, and were rig[id] enough for insertion into sediments

- Field deployment was undertaken in a contaminated pond in Altavista, VA in September 2013
  - Two 9ft² treatment zones were cordoned off; pre-treatment concentrations were obtained
  - Each treatment zone was divided into 9 zones which were treated with an individual GPRSS unit. Pre- and post-concentration samples were taken from the locations marked in Figure 3
  - All samples were split for analysis both at KSC and by an independent certified 3rd party laboratory.
  - First samples were taken in early February (~19 weeks), and the ethanol was replaced and the blankets were re-installed for a second treatment. The results of the 3rd party testing are given in Table 6/7. KSC analysis showed even higher removal rates.

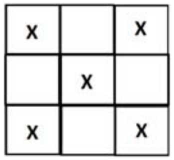

Figure 3

Cross-section of HDPE spik[e]

Table 7 – Box 2

Sample ID	Conc. (ppm)	
	9/24/2013	2/4/2014
NW	74.2	26.8
NE	92.1	26.2
C	85.1	66.9
SW	151	28.3
SE	144	21.4
Overlying water	N/A	2.4 (ppb)

Table 6 – Box 1

Sample ID	Conc. (ppm)	
	9/24/2013	2/4/2014
NW	74.2	26.8
NE	92.1	26.2
C	85.1	66.9
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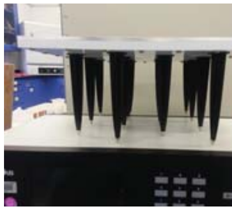
Overlying water	N/A	2.4 (ppb)



Prototype Unit

Altavista Field Deployment

Summary

- Developed and optimized design for GPRSS technology
- Laboratory-scale tests proved functionality of GPRSS design
- Final down-select of polymers were chosen based upon laboratory results
- Produced multiple units for field demonstration at Altavista, VA
- Preliminary results (certified 3rd party lab) show that 70% of sites sampled have been reduced to below EPA action limits for PCBs

Future Directions

- Analyze 2nd sample set (~32 weeks) from Altavista, VA field demonstration
- Analyze GPRSS blankets from Altavista, VA field demonstration to attempt mass-balance of PCBs
- Evaluate re-usability of both blanket and interior solvent
  - Test effectiveness of removal capability of PCBs over multiple removal cycles
  - Test extraction efficiency from polymer blanket
- Evaluate capability of combining polymer blanket with AMTS technology for degradation of PCBs removed /extracted from contaminated sediments