BrightFields, Inc.
Environmental Services

December 29, 2020

Mr. John Cargill, IV, P.G.
Department of Natural Resources and Environmental Control
Remediation Section
391 Lukens Drive
New Castle, DE 19720

RE: Summary of Environmental Investigation and Remediation - 2020
A-Street Ditch Segment 1 Pilot Study (DE-1525)
Wilmington, Delaware
BrightFields 0985.94.51

Dear Mr. Cargill:

This letter provides a summary of the post-remediation sample collection at the Christina River inlet near A Street performed in 2020.

BACKGROUND

The drainage ditch (A-Street Ditch) that runs parallel to South Walnut Street from Garasches Lane north to the Christina River has been a subject of studies by the Delaware Department of Natural Resources and Environmental Control (DNREC) Watershed Approach to Toxics Assessment and Restoration (WATAR) program. The A-Street Ditch has been divided into six segments (Figure 1). This letter report summarizes the environmental investigation and remediation of Segment 1 of the A-Street Ditch.

BASELINE SAMPLING

On March 14, 2019, University of Maryland, Baltimore Campus (UMBC) and BrightFields collected surface sediment samples and deployed passive samplers at three locations (ASTREET-SED01, ASTREET-SED02, and ASTREET-SED03) in Segment 1 to establish baseline conditions prior to remediation. Sample locations are shown on Figure 2.

BrightFields collected four sediment cores at each location and composited the top four inches from each core into a sample. The sediment samples were transported on ice to the UMBC laboratory and analyzed for activated carbon, Total Organic Carbon (TOC), and polychlorinated biphenyls (PCBs).

BrightFields deployed porewater and surface water passive samplers, prepared by UMBC, with two rectangular sheets of 0.5 gram (g) low density polyethylene (25 μm thick) attached at the bottom of a cinderblock at each of the three sediment sampling locations. The porewater and surface water passive samplers measure the freely dissolved, or bioavailable, concentration of PCBs.

The passive samplers were placed within the top three inches below the sediment-water interface. In the water column at each of these locations, one sheet of 0.5 g passive sampler was suspended in the surface water above the sediment-water interface. The passive samplers were left in place to equilibrate for 2.5 months. They were retrieved on May 30, 2019 and transported to the UMBC laboratory for analysis of dissolved PCBs.

SEDIMITE™ APPLICATION

Prior to performing the remediation, BrightFields cleared the vegetation along the bank to access Segment 1, installed two work platforms, and installed a turbidity curtain across the mouth of the drainage ditch to minimize the tidal effect on the A-Street Ditch.

Segment 1 was divided into a grid for the carbon amendment application. The grid consisted of a total of 87 cells, each measuring 14 foot by 13 foot. On May 30, May 31, June 3, and June 4, 2019, BrightFields applied a total of 15,660 pounds of SediMite™ with a PCB-degrading microorganism amendment to the 87 grid cells.

INITIAL POST-REMEDIATION MONITORING

On October 9, 2019, UMBC and BrightFields performed post-remedy monitoring at the same three locations within Segment 1 (ASTREET-SED01, ASTREET-SED02, and ASTREET-SED03), utilizing the same sampling methods employed during the baseline sampling. Porewater and surface water passive samplers were allowed to equilibrate for two months and were retrieved on December 13, 2019.

INITIAL MONITORING RESULTS

In baseline sediment samples, TOC content of the sediment ranged from 3.3% to 3.7% and the native black carbon content was low at 0.4%. At the time of this report, post-remediation TOC and black carbon results were pending repair of analytical equipment.

The total PCB homolog concentrations in Segment 1 baseline sediment samples SED01 through SED03 were 137 nanograms per gram (ng/g), 118 ng/g, and 177 ng/g, respectively. The post-remediation PCB homolog concentrations were 102 ng/g, 92 ng/g, and 127 ng/g. The average reduction of PCB concentrations was about 25%.

In porewater, pre-remediation dissolved PCB congeners ranged from 0.63 ng/L to 1.2 ng/L. Dissolved PCB congeners in post-remediation porewater ranged from 0.14 ng/L to 0.59 ng/L. Overall percent reductions ranged from 49% to 77%. In surface water, dissolved PCB congeners pre-remediation ranged from 0.62 nanograms per liter (ng/L) to 0.80 ng/L. Dissolved PCB congeners in post-remediation surface water ranged from 0.41 ng/L to 0.56 ng/L. Overall percent reductions were lower in surface water and ranged from 23% to 47%.

Overall, sampling results indicated reduction of PCB mass and bioavailability in sediments five months after application of activated carbon and bioamendments to surface sediments in Segment 1. Detailed results are included in the report prepared by RemBac Environmental, LLC (Attachment 1).

1 YEAR POST-REMEDIATION MONITORING

On June 1, 2020, UMBC and BrightFields performed post-remedy monitoring at the same three locations within Segment 1 (ASTREET-SED01, ASTREET-SED02, and ASTREET-SED03), utilizing the same sampling methods employed during the baseline and initial post-remediation sampling. Porewater and surface water passive samplers were allowed to equilibrate for only one month due to planned construction upstream in the ditch. The passive samplers were retrieved on July 2, 2020 prior to the construction activities in Segment 3 of the A-Street Ditch.

1-YEAR MONITORING RESULTS

In baseline sediment samples, TOC content of the sediment ranged from 3.3% to 3.7% and the native black carbon content was low at 0.4%. At the time of this report, post-remediation TOC and black carbon results for the 2019 and 2020 samples were pending repair of analytical equipment.

The total PCB homolog concentrations in the 1-year monitoring sediment samples SED01 through SED03 were 105 nanograms per gram (ng/g), 96.5 ng/g, and 436 ng/g, respectively. These concentrations were greater than the concentrations in the initial monitoring sediment samples; however, the concentrations in ASTREET-SED01 and ASTREET-SED02 remained significantly lower than the concentrations in the corresponding baseline samples. The increased PCB concentration in the sediment sample closest to the tide gate (ASTREET-SED03) was significantly higher than the concentration in the baseline sample at that location and indicates the potential deposit of additional PCB-impacted material in Segment 1.

The results for the 1-year monitoring sediment samples and the baseline and initial monitoring samples are included in the table below.

Sediment Sample PCB Concentrations (ng/g or ppb)

	Baseline (3/14/2019)	Initial Monitoring (10/9/2019)	1-Year Monitoring (6/1/2020)
ASTREET-SED01	137	102	105
ASTREET-SED02	118	91.9	96.5
ASTREET-SED03	177	127	436

The anomalous sediment sample, ASTREET-SED03, could be the results of various factors, including storm or flooding events and construction activities upgradient in the A-Street Ditch. Two significant rainfall events occurred between December 13, 2019 and June 1, 2020 that resulted in high water in the ditch. These events were January 25, 2020 and April 13, 2020. The receding floodwaters would have flushed through the tide flap gate into Segment 1 of the ditch. These floodwaters could have potentially deposited PCB-impacted sediments from other segments of the ditch and the Christina River.

It is possible that construction activities that occurred between the initial monitoring and the 1-year post-remediation monitoring may have contributed to the increase in total PCB concentrations in surface sediment at ASTREET-SED03. The nearby South Wilmington Wetlands Park (SWWP) construction project included the removal of soil and sediment with elevated PCB concentrations in an area, referred to as Area of Concern 1 (AOC1), adjacent to Segment 3 of the A-Street Ditch.

Segment 3 is upgradient from Segment 1 (Figure 1). The excavation and removal of the elevated soil and sediment occurred from January through March 2020. The excavated area of AOC1 was coated with a layer of activated carbon to mitigate the bioavailability of any remaining PCBs in the soil at the SWWP. All possible efforts, including using appropriate erosion and sediment controls, were made during the excavation activities in AOC1 to minimize impacts on the surrounding areas.

In porewater, 1-year monitoring dissolved PCB congeners ranged from 0.21 ng/L to 0.40 ng/L. Overall percent reductions of dissolved PCBs in porewater ranged from 59% to 80%. In surface water, 1-year monitoring dissolved PCB congeners ranged from 0.23 nanograms per liter (ng/L) to 0.98 ng/L. Reduction of dissolved PCB congeners varied in surface water and ranged from -37% to 63%. The dissolved PCB concentration in surface water at the location where the A-Street Ditch meets the Christina River (ASTREET-SED01) increased significantly during the deployment of the passive sampler in June-July 2020. Previously, the concentration of dissolved PCB congeners in surface water had been significantly reduced during the deployment of the passive sampler in October-December 2019. This increase in dissolved PCB congeners in surface water is likely to be related to the potential deposit of PCB-impacted material near the tide gate at ASTREET-SED03. Concentrations of dissolved PCB congeners in porewater and surface water at ASTREET-SED01 and ASTREET-SED02 remained lower than the baseline concentrations.

The results for the porewater and surface water samples are included in the table below.

Porewater Sample Dissolved PCB Concentrations (ng/L or ppt)

	Baseline (3/14/2019)	Initial Monitoring (10/9/2019)	1-Year Monitoring (6/1/2020)
ASTREET-SED01	1.16	0.59	0.40
ASTREET-SED02	1.03	0.24	0.21
ASTREET-SED03	0.63	0.14	0.26

Surface Water Sample Dissolved PCB Concentrations (ng/L or ppt)

	Baseline (3/14/2019)	Initial Monitoring (10/9/2019)	1-Year Monitoring (6/1/2020)
ASTREET-SED01	0.72	0.56	0.98
ASTREET-SED02	0.80	0.43	0.39
ASTREET-SED03	0.62	0.41	0.23

Overall, sampling results indicated continued reduction of PCB mass and bioavailability in sediments 12 months after application of activated carbon and bioamendments to surface sediments in Segment 1. Detailed results are included in the report prepared by RemBac Environmental, LLC (Attachment 1).

FUTURE SAMPLING SCHEDULE & RECOMMENDATIONS

Additional post remediation monitoring is scheduled for 3 years post-application, which is anticipated to occur in June 2022. Based on the elevated PCB concentration detected in the 1-year monitoring sample at ASTREET-SED03, BrightFields recommends collection of sediment, porewater, and surface water samples at 2 years post-application to evaluate the impact of the

PCBs on the sediment and water in Segment 1.

The next post remediation monitoring sediment, porewater, and surface water samples should assist in evaluating whether additional PCB-impacted sediments were deposited in Segment 1 of the A-Street Ditch after the June 2019 application of bio-amended SediMite™. If it is determined that additional PCB-impacted material was deposited in Segment 1, BrightFields recommends applying additional bio-amended SediMite™ to the area near the tide gate and the ASTREET-SED03 sample location to remediate the additional sediments.

If you have any questions or comments, please contact Jenna Harwanko or me at 302-656-9600.

Sincerely,

BrightFields, Inc.

Kimberly A. Brinson
Technical Manager

Cc: Upal Ghosh, Ph.D., RemBac Environmental, LLC.
Kevin Sowers, Ph.D., RemBac Environmental, LLC.

Attachments:
Figure 1 – Drainage Ditch Segments
Figure 2 – Sample Location Map
Attachment 1 – A-Street Ditch Segment 1 Baseline and Post-application Monitoring (UMBC, October 20, 2020)
Attachment 2 – Photographs

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Figures

Ditch Segments
- Segment 1
- Segment 2
- Segment 3
- Segment 4
- Segment 5
- Segment 6

- Proposed Open Water Elevation -1 and Below
- Proposed Wetland Elevation -1 to 1 (Marsh Plain)
- Proposed Upland Elevation 0' to 17'
- Surveyed Hessler Property Tax Parcels
- Tax Parcels

Source: Delaware FirstMap - 2017 Aerial;
Delaware DataMIL - Tax Parcels;
Proposed Design provided by RK&K April 2018.

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Wilmington, Delaware 19801
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Drainage Ditch Segments
A Street Ditch Remediation
Wilmington, Delaware

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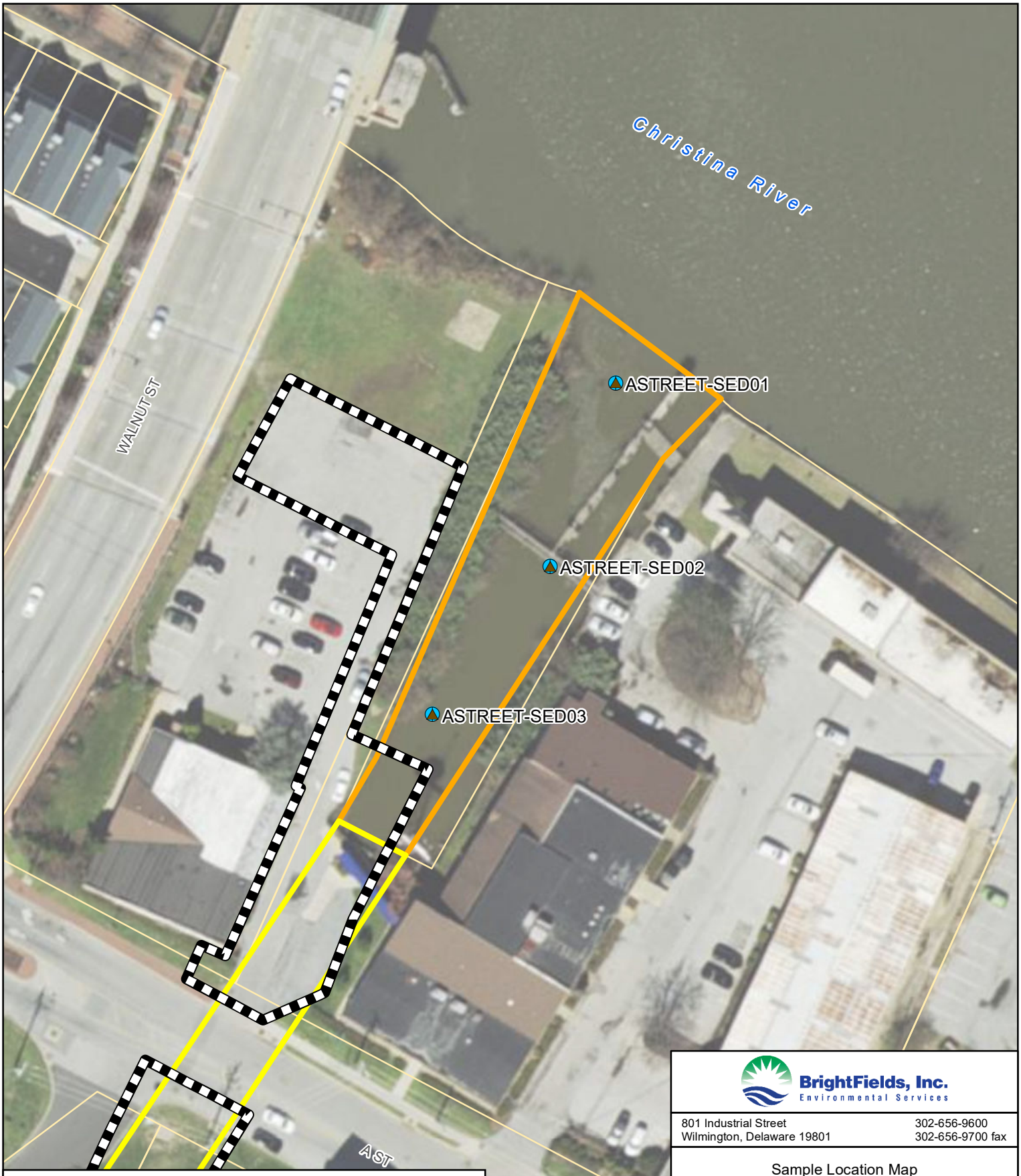

Sediment/Surface Water Sample Locations

South Wilmington Wetlands Park Limit of Construction

Ditch Segments

Segment 1

Segment 2

Tax Parcels

Source:
Delaware FirstMap - 2017 Aerial;
Delaware DataMIL - Tax Parcels.

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Sample Location Map
A Street Ditch Remediation
Wilmington, Delaware

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Attachment 1

A-Street Ditch Segment 1
Baseline and Post-application Monitoring
(UMBC, October 20, 2020)

A-Street Ditch Segment 1 Baseline and Post-application Monitoring

Oindrila Ghosh, Louis Cheung, Upal Ghosh
Department of Chemical, Biochemical, and Environmental Engineering
University of Maryland Baltimore County, Baltimore, MD
October 20, 2020

1. INTRODUCTION.

PCB-impacted sediments in the A Street Ditch in Wilmington, DE were treated with an *in-situ* treatment approach using bioamended activated carbon. The treatment involved amendment of the surface sediments in the ditch with activated carbon and PCB degrading and dechlorinating microorganisms. More details of the in-situ treatment technology are available in Payne et al. (2019). The PCB degraders accelerate the breakdown of the compounds over time while activated carbon amendment enhances the sorption capacity of sediments and reduces the potential for leaching of the PCBs into the overlying water and uptake into benthic organisms. The sorption and degradation processes combined reduce total PCB mass over time and reduce ecological exposure of the PCBs.

This draft report provides results from the baseline sampling performed in Spring 2019 (March 14 – June 3) at the A-Street Ditch immediately prior to the construction of the in-situ remedy followed by monitoring performed post remedy in late Fall 2019 (Oct 9 – Dec 13) and again in Summer 2020 (June1 – July 2). Three monitoring locations were sampled within Segment 1 and were labeled ASTREET-SED01, ASTREET-SED02, and ASTREET-SED03, with location 1 closest to the Christina River as shown in Figure 1.

The following parameters were monitored:

1) Activated Carbon and Total Organic Carbon in surface sediments. This measurement allows the assessment of the placement of activated carbon, persistence of the activated carbon in sediments over time, and evenness of the placement.

2) PCBs in surface sediments. This measurement allows an assessment of the extent of reduction of total PCB concentration achieved after one year of remedy.

3) Freely dissolved PCBs in surface sediment porewater and overlying water using passive sampling. The sediment porewater measurement allows comparison of the net reduction of PCB bioavailability in sediments as a result of the remedy. Comparison of surface water concentration with porewater concentration will allow determination of the extent to which the release of PCBs from sediment to the overlying water has been reduced after the remedy.

Surface sediments were collected by BrightFields (on March 14, October 9, 2019, and June 1, 2020) using a coring device and the top 4” of sediment was homogenized in the field and placed in precleaned glass jars and transported in ice to UMBC. Three locations were sampled from Segment 1 as shown in Figure 1, and at each location, four cores were collected, and the top 4”

from each core composited to prepare one sample (see Figure 2). These composite samples were packed in glass jars and transported to UMBC on ice in a cooler for the analysis of activated carbon and PCBs in sediment.

UMBC prepared passive sampling devices for the measurement of freely dissolved concentrations of PCBs in sediment pore water and surface water. The method used is based on the most recent guidance document for passive sampling (U.S. EPA/SERDP/ESTCP 2017). Prior to deployment all passive samplers were cleaned and loaded with performance reference compounds. At each of the 3 sediment sampling locations, two rectangular sheets of 1 g low density polyethylene (2 mil thick) passive sampler were placed 0-3” below the sediment-water interface attached at the bottom of a cinderblock (Figure 2). In the water column at each of these locations, one sheet of 1 g passive sampler was suspended in the surface water, above the sediment-water interface. Following placement, the passive samplers were allowed to equilibrate for 2-3 months and retrieved for the one baseline and two post-application measurement sampling. The loss of performance reference compounds was used to correct for non-equilibrium.

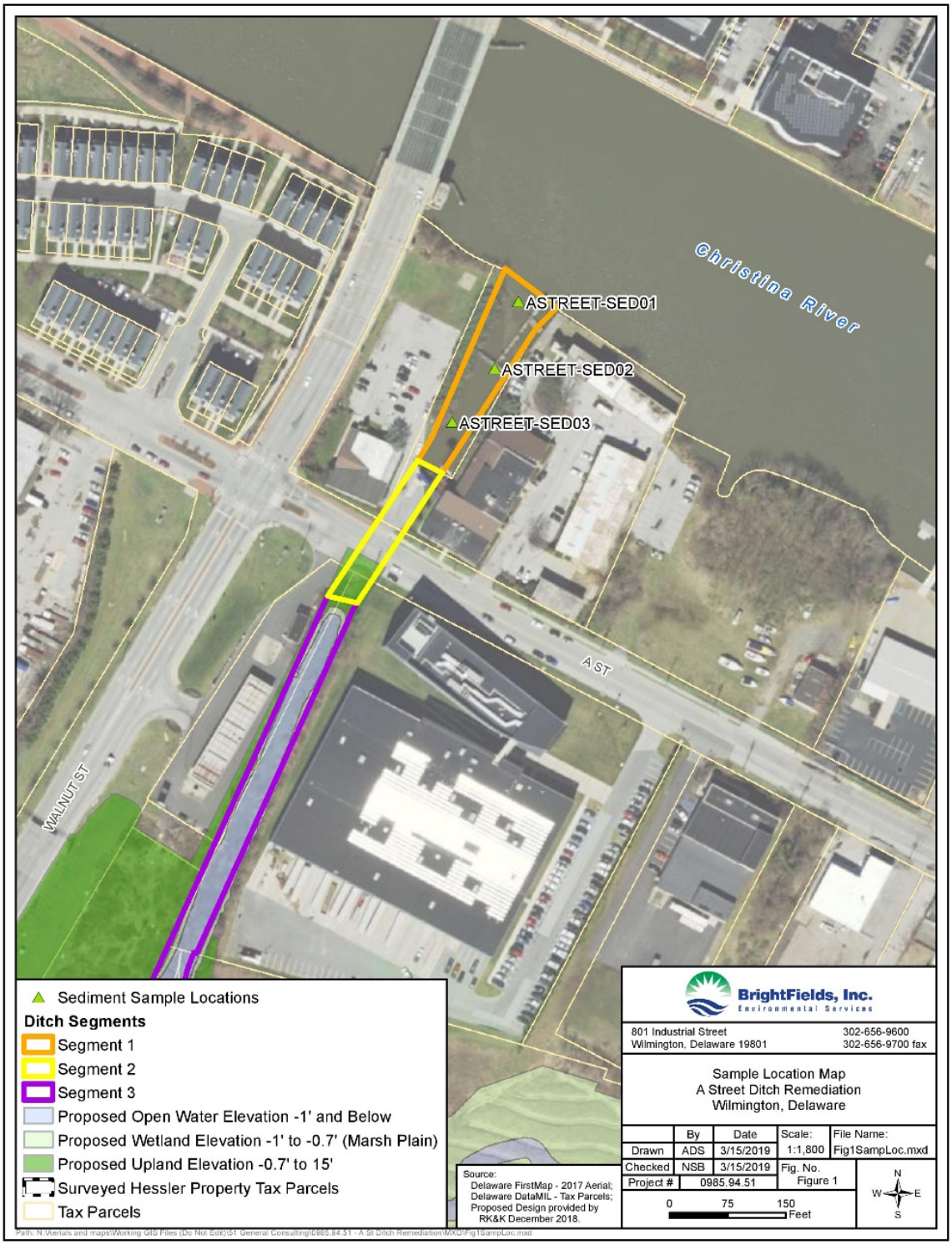


Figure 1. Sampling locations in A-Street Ditch Segment 1

Figure 2a. Left: Sediment cores being collected from Segment 1 of A-Street Ditch. Right: Sediment porewater and surface water passive samplers being placed in Segment 1 of A-Street Ditch (March 14, 2019).

Figure 2b. Bioamended SediMite being applied to Segment 1 of A-Street Ditch.

2. ANALYTICAL METHODS

Total organic carbon and activated carbon in sediments. Sediment samples were homogenized and dried overnight in an oven at 105 °C. For total organic carbon analysis, about 200 mg of the homogenized and dry sediment sample was acidified with HCl to remove inorganic carbon and then analyzed for organic carbon in a Shimadzu TOC-VCPH carbon analyzer. For the activated carbon analysis, about 200 mg of dry sediment was weighed, ground into a powder, and transferred into glass vials for chemical oxidation of the natural organic matter. Detailed oxidation procedure is provided in (Grossman and Ghosh 2009). Briefly, 5 ml of 0.1M $K_2Cr_2O_7$ in concentrated H_2SO_4 was added into oxidation vials in a water bath at 60°C to oxidize the organic matter in the sediment. Chemical oxidation was performed two times to ensure the complete removal of inorganic and natural organic carbons. Only native black carbon and activated carbon are preserved through the chemical oxidation step. The residual sediment containing black carbon and activated carbon was settled to the bottom of the vial by centrifuging and the supernatant acid was removed from the oxidation vial. The black carbon content was measured using s Shimadzu TOC-VCPH carbon analyzer by combustion of the residual sediment sample at 900 °C in pure oxygen and measurement of the CO_2 produced.

PCB extraction from bulk sediment.
Sediment PCBs were extracted following EPA publication SW-846 (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods) method 3550B using three volumes of 40 mL each of acetone-hexane mixture (1:1) and sonicating the slurry for 6 minutes (pulsing for 15 seconds on and 15 seconds off). PCB 14 and 65 were added as surrogate standards to all samples before extraction to check recovery.

PCB extraction from passive samplers.
Passive samplers were extracted for PCBs and PAHs using 30 mL additions of acetone-hexane (1:1). The passive sampler was allowed to extract in the acetone-hexane (1:1) solution, on an orbital shaker, overnight after which the solvent was removed and new solvent was added. This process was repeated three times and following the third extraction all extracts were collected together and evaporated to a smaller volume by nitrogen blowdown. PCB 14 and 65 were added as surrogate standards to all samples before extraction to check recovery.

PCB cleanup and analysis.
PCB cleanup was based on EPA publication SW-846 (Test Methods for Evaluating Solid Waste, Physical/Chemical Methods) methods 3630C (Silica gel cleanup), 3665A (sulfuric acid cleanup) and 3660B (Sulfur removal with copper). The dried and concentrated extracts were passed through a 3% deactivated silica gel column for the removal of organic interferences and to separate the PCBs and PAHs. Silica gel (chromatographic grade, 100-200 mesh, Fisher Scientific, Fair Lawn, NJ) was activated by heating at 130°C for 16 hours, then deactivated by gradually adding 3% by weight deionized water and rotating on a roller at approximately 2 rpm overnight.
PCB analysis was performed on an Aligent 6890N gas chromatograph (Restek, Bellefonte, PA, USA) with an electron capture detector and a fused silica capillary column (Rtx-5MS, 60 m x 0.25 mm i.d, 0.25 μm film thickness). PCB standards for calibration are purchased as hexane

solutions from Ultra Scientific (NorthKingstown, RI, USA). Internal standards, 2,4,6-trichlorobiphenyl (PCB 30) and 2,2',3,4,4',5,6,6'- octachlorobiphenyl (PCB 204) was added to all samples. Most commonly occurring PCB congeners present in typical Aroclor mixes are measured using this method. In some cases peaks coelute which are identified and reported as the sum of congeners. PCB congener 193 was found to co-elute with a possible contaminant that resulted in sporadic high values and was removed from all analyses.

PRC Correction of passive sampler results: PCB concentration in the PE samplers were first calculated and reported in the units of ng/g PE. The loss of PRC estimated was used to generate the fractional correction term using a diffusion -based model in an associated PRC Correction Calculator software (U.S. EPA/SERDP/ESTCP. 2017). The correction term accounts for the non-equilibrium conditions pollutant sampler. The PRC corrected contaminant concentration is reported as µg/L in water. The sum of the concentrations of the congeners in one homolog group is reported as the concentration of the corresponding homolog group.

3. RESULTS

Black Carbon and Total Organic Carbon Analysis

As shown in Table 1 below, the TOC content of the sediment ranged from 3.3 to 3.7% and the native black carbon content was low at 0.4%.

Table 1. Results of Black Carbon and Total Organic Carbon analysis

Sample Name	BC Content (%)	TOC Content (%)
A Street-Sed-01 B	0.4	3.7
A Street-Sed 02 B	0.4	3.3
A Street-Sed 02 B (Dup)	0.3	-
A Street-Sed 03 B	0.4	3.6
Standard 1*	3.6	6.0
Standard 2*	3.4	5.9

*Note: Standard 1 and 3 are laboratory standards prepared with 4% by weight of activated carbon added to a standard sediment and processed alongside the samples. 4% coconut based AC should give 3.8% BC measurement based on Grossman and Ghosh 2009.

BC and TOC results of post application sediment samples are pending.

PCB Concentration in Sediment

Three composite samples of surficial sediments from each of the 3 sampling locations were collected on 3/14/2019 to characterize the initial concentration of PCBs in sediment before the application of bioamendments and SediMite. Duplicate PCB analyses were performed on each of the three sediment samples. The average PCB concentration in Segment 1 of A Street Ditch in the pre application samples A Street Sed-1, Sed-2, and Sed-3 were 137, 118, and 177 ng/g total PCBs respectively as shown in Figure 3a and Table 2. The total PCB concentration was the highest at the upstream location A Street Sed-3 that was close to the tide gate and away from the Christina River. The dominant PCB homologs in sediment were tetra, penta, and hepta chlorobiphenyls. There was also an unusually high abundance of the nona and deca chlorobiphenyls in these sediments, especially in sample A Street-Sed-01, potentially indicating a source of these highly chlorinated congeners from the Christina River. The variability was high for nona and deca homologs in location 1, possibly indicating a heterogeneous distribution of source particles containing this unique homolog signature (see Figure 4a).

PCB concentration in sediment collected from the three sampling locations after the application of AC and bioamendments are shown in Figure 3b. All three sampling locations show lower PCB concentrations in sediment at the first post application sampling compared to the pre application samples. There is an average reduction of PCB concentration in sediments by about 25%. Much of these reductions are observed in the di through octachlorobiphenyls with an apparent increase in the concentrations of the nona and decachloro biphenyls (see Table 2). It is not apparent why the concentrations of nona and deca increases post treatment and could be a result of small-scale spatial variability of these congeners. In the second post application sampling conducted about 1 year after the remedy implementation, the PCB concentrations in sediment at Sed-1 and Sed-2 locations remain the same as post application 1 samples. However for location Sed-3, which was closest to the tide gate, the PCB concentration increases significantly to 436 ng/g. It is possible that this increase is due to disturbance from remedial activities upstream and deposition of new PCB-contaminated sediments at this location. It is also possible that this increase is due to small-scale spatial variability in PCB concentration in sediment. A follow up study can be performed to look at whether there is PCB concentrations variability spatially or with depth at this location.

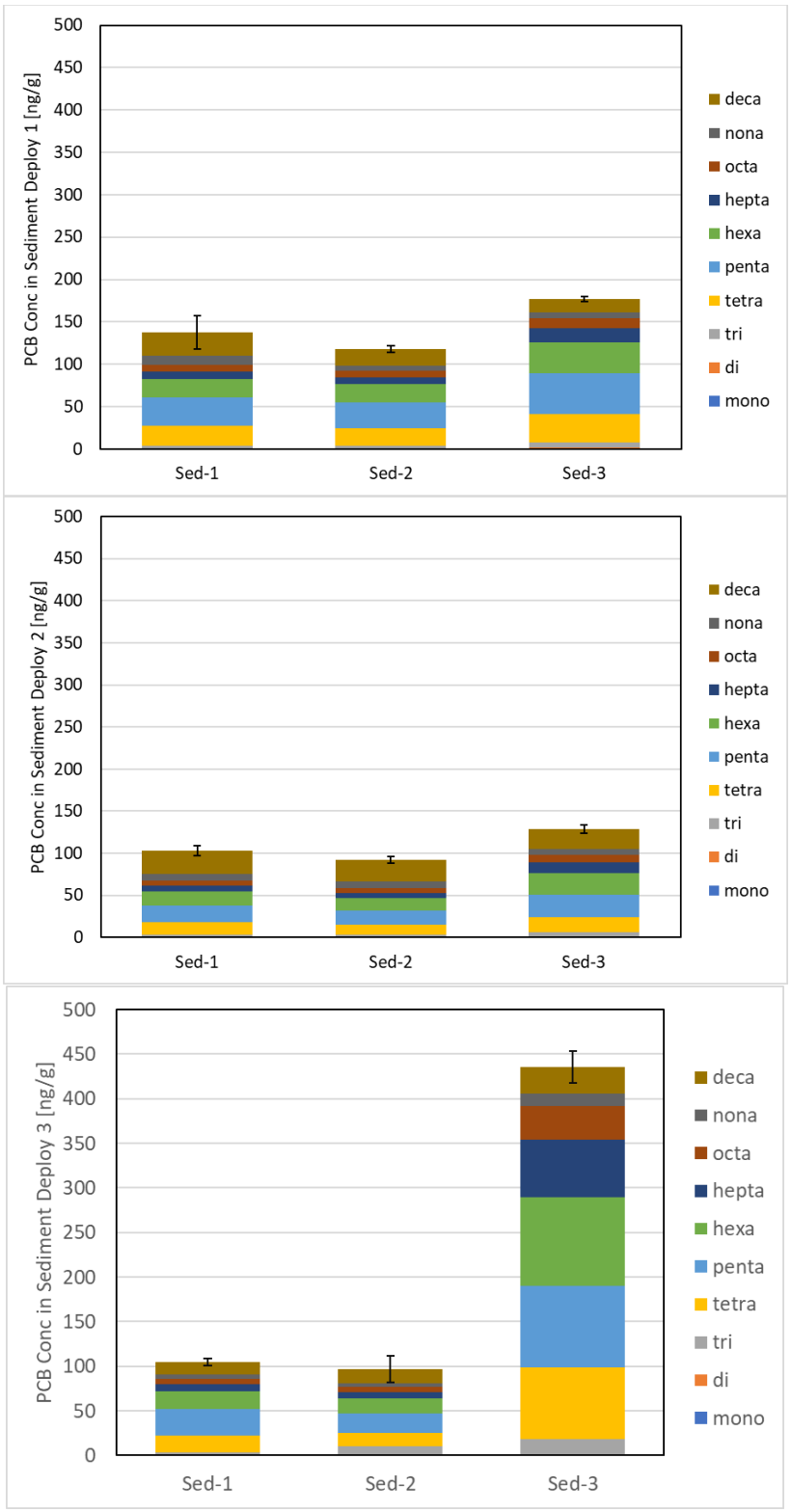
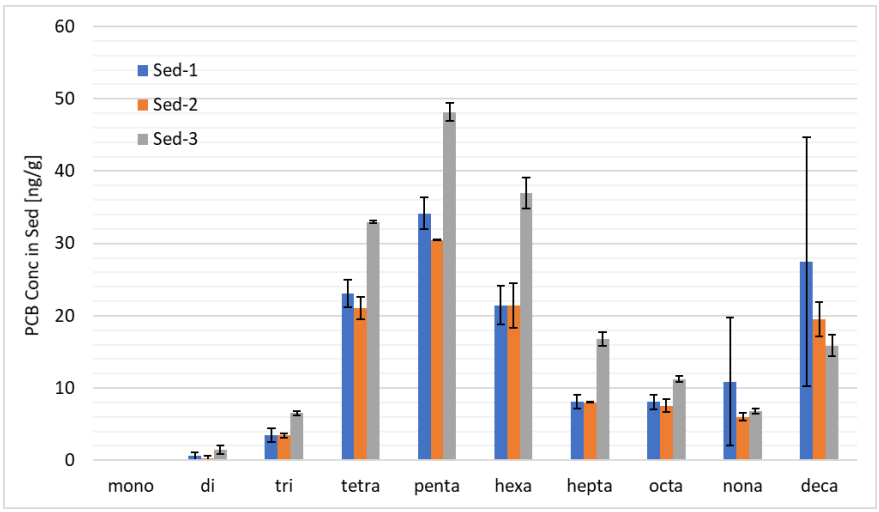
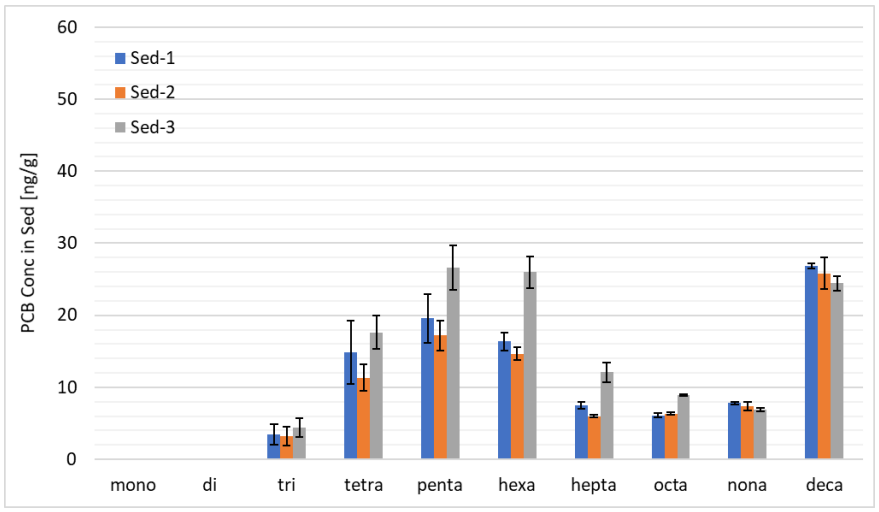


Figure 3. Total and homolog level concentration of PCBs in sediment. Top: baseline sampling on March 14 2019; Middle: post application sampling on October 9, 2019; Bottom: Post application sampling on June 1, 2020.





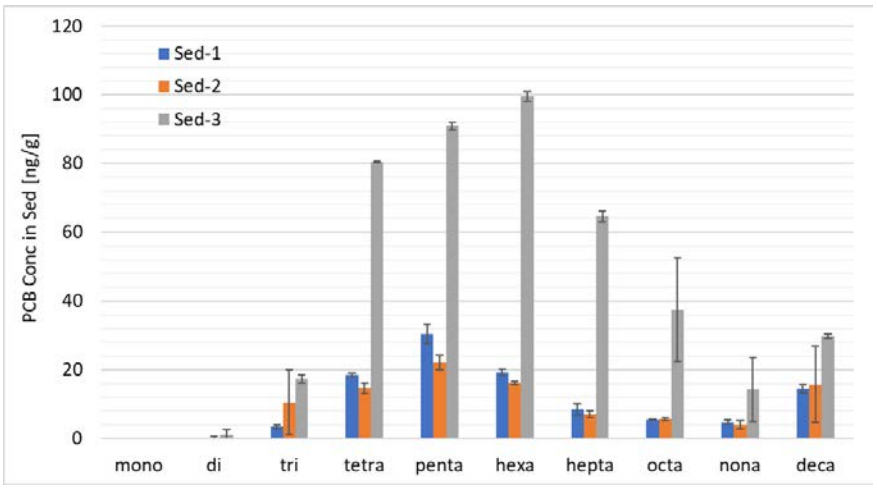


Figure 4. PCB concentration by homolog in sediment. (Top: baseline sampling on March 14 2019; Middle: post application sampling on October 9, 2019; Bottom: Post application sampling on June 1, 2020.

Freely dissolved PCB concentration in sediment porewater and surface water.

The Freely dissolved PCB concentration in sediment porewater and surface water are shown in Figures 5 and 6 respectively. The PCB congeners detected in the freely dissolved phase ranged from the di through hepta chlorobiphenyls. Tetra chlorobiphenyl was the most dominant homolog in the freely dissolved water phase in both sediment porewater and surface water followed by the tri and penta chlorobiphenyls. The pre application freely dissolved total PCB concentration in sediment porewater ranged from 1.2 to 0.63 ng/L. The pre-application surface water PCB concentrations are shown in Figure 6 and range from 0.8 to 0.62 ng/L. These concentrations are close to or above the USEPA Ambient Water Quality Criteria for the protection of human health of 0.64 ng/L. Sites 1 and 2 generally show higher freely dissolved concentration in the sediment compared to the surface water indicating a flux from sediment into the overlying water. For site 3, the concentrations in surface water and sediment porewater are about the same. This could partly be an artifact of how the surface water sampler at this location may have been in greater contact with surface sediments during low tide events, possibly more so than the other two locations.

The first post application samples are generally lower in both the porewater and surface water as shown in Figures 5 and 6. The percent reductions are higher in the porewater of sediments and range from 49% to 77%. The concentration reductions in the surface water are lower and range from 23 – 47%. The surface water is in constant exchange with flows from upstream and from the Christina River due to tidal flow and is expected to demonstrate a smaller change after the sediment remedy. Before treatment, the sediment porewater concentration was generally higher than the surface water concentration indicating a diffusive source of PCBs from the contaminated sediment into the surface water. After the application of the in-situ amendments, the concentration gradient is reversed with a lower concentration of freely dissolved PCBs in the sediment porewater compared to the surface water, indicating that the sediments now act as a sink and not source of PCBs into the water column.

In the second post-application sampling, sediment porewater PCB concentrations in locations 1 and 2 are reduced further with net reductions from baseline of 65% and 80% respectively, however, for locations Sed-3, there is an increase in porewater concentration from post-application 1 sample, but still registering a 59% reduction compared to the baseline sample. The different trend of porewater sample from Sed-3 is likely related to the observed increase in sediment PCB concentrations at this location for post application 2 sample. However, it is remarkable that even with an increase in sediment PCB concentrations at Sed-3, the porewater concentration shows significant reductions from baseline, likely due to the presence of AC in sediments. The surface water PCB concentration in Post application 2 at Sed-2 and Sed-3 decreased further compared to Post application sample 1. However, the surface water PCB concentration in location Sed-1 increased in the post application 2 sample to close to 1 ng/L, which is higher than the pre-application sample at this location, potentially reflecting higher PCB concentrations in the water column being discharged through the creek or in the Cristina River.

Overall, there is indication of reduction of both PCB mass and bioavailability in sediments 5 and 12 months after application of activated carbon and bioamendments to surface sediments in Segment 1 of the A Street Ditch. There is some indication of potential mobilization of PCB impacted new sediments, at least in location Sed-3 that may need to be evaluated further.

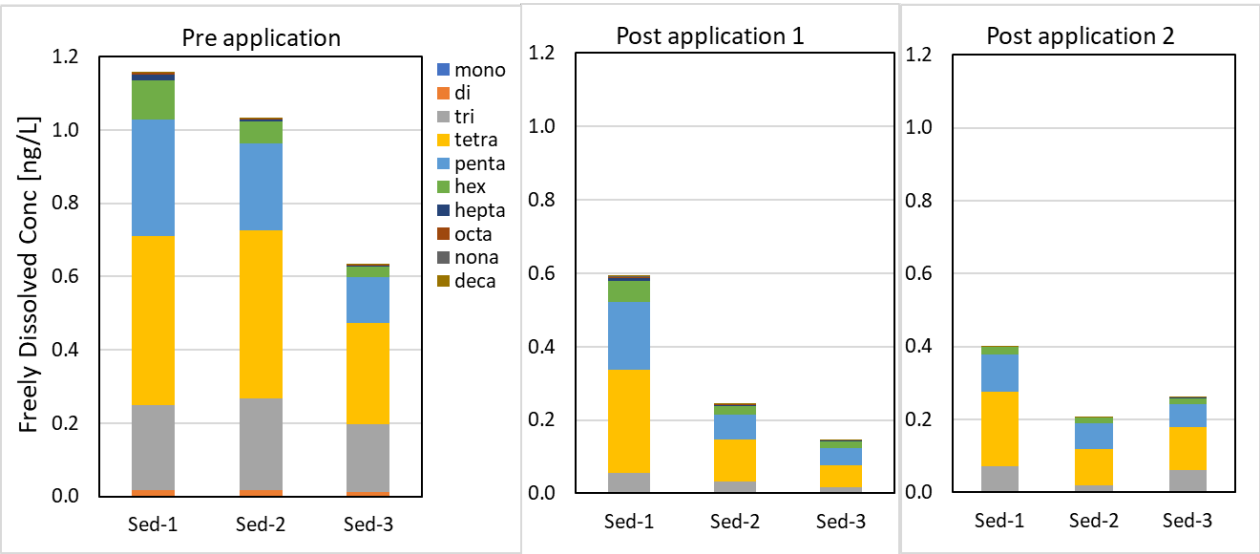


Figure 5. Freely dissolved PCB concentration in sediment porewater for baseline samples (left) and post application samples (right).

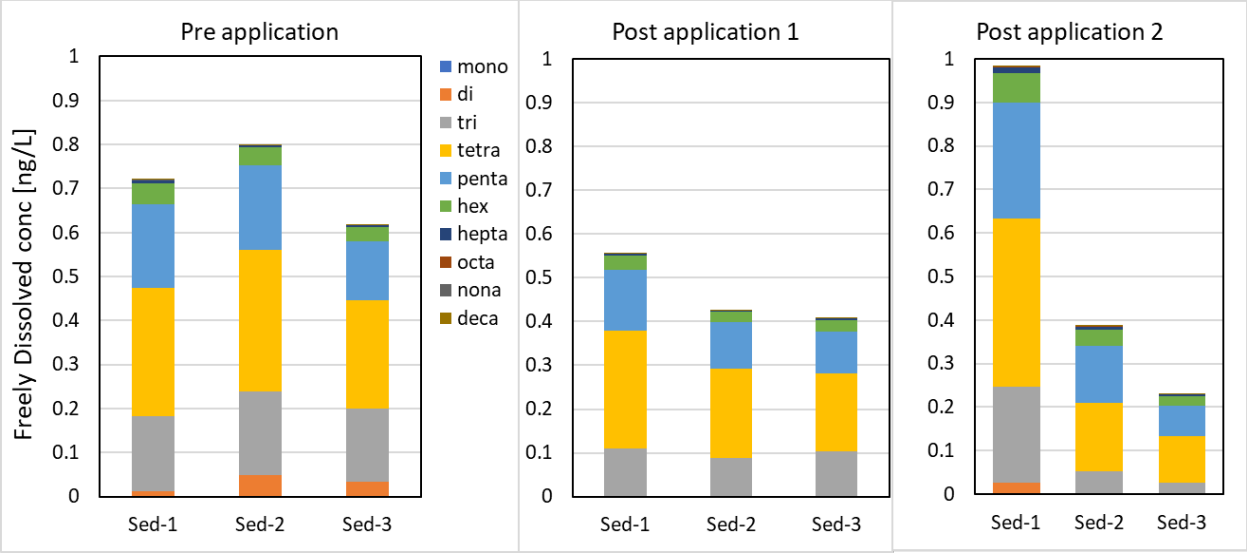


Figure 6. Freely dissolved PCB concentration in surface water for baseline samples (left) and post application samples (right).

Table 2. PCB homolog concentration in sediments (ng/g)

Pre application

Avg Conc

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**Total**
Sed-1	0.0	0.6	3.5	23.1	34.2	21.4	8.1	8.1	10.9	27.5	**137.3**
Sed-2	0.0	0.3	3.5	21.1	30.5	21.4	8.0	7.6	6.0	19.5	**117.8**
Sed-3	0.0	1.5	6.6	33.0	48.2	37.0	16.8	11.3	6.8	15.9	**176.8**

Stdev

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**overall_stdev**
A1	0.0	0.5	0.9	1.9	2.2	2.7	0.9	1.0	8.9	17.3	**19.9**
A2	0.0	0.4	0.3	1.5	0.0	3.1	0.0	0.9	0.5	2.4	**4.3**
A3	0.0	0.5	0.3	0.2	1.3	2.1	1.0	0.5	0.3	1.5	**3.0**

Post application 1

Avg Conc

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**Total**
Sed-1	0.00	0.02	3.40	14.83	19.55	16.35	7.50	6.08	7.84	26.86	**102.4**
Sed-2	0.00	0.00	3.24	11.34	17.18	14.66	5.99	6.32	7.35	25.84	**91.9**
Sed-3	0.00	0.00	4.41	17.63	26.56	26.00	12.08	8.92	6.93	24.43	**127.0**

Stdev

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**overall_stdev**
A1	0.00	0.02	1.43	4.41	3.39	1.25	0.43	0.29	0.18	0.39	**5.9**
A2	0.00	0.00	1.33	1.80	2.04	0.90	0.19	0.17	0.56	2.21	**3.9**
A3	0.00	0.00	1.25	2.33	3.08	2.20	1.38	0.07	0.21	0.97	**4.9**

Post application 2

Avg Conc

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**Total**
Sed-1	0.00	0.0	3.5	18.5	30.4	19.2	8.5	5.6	4.8	14.4	**104.8**
Sed-2	0.00	0.3	10.5	14.7	22.2	16.2	7.1	5.7	4.0	15.8	**96.5**
Sed-3	0.00	1.2	17.5	80.5	90.9	99.5	64.7	37.5	14.2	29.7	**435.5**

Stdev

Site	mono	di	tri	tetra	penta	hexa	hepta	octa	nona	deca	**overall_stdev**
A1		0.03	0.65	0.52	2.85	0.95	1.71	0.14	0.55	1.22	**3.8**
A2		0.29	9.37	1.58	2.14	0.47	0.96	0.47	1.10	11.01	**14.8**
A3		1.52	1.18	0.17	1.04	1.46	1.56	15.03	9.23	0.63	**17.9**

Table 3. PCB Homolog concentrations in sediment porewater

	Deploy 1			Deploy 2			Deploy 3		
Homolog Grp	**Sed-1**	**Sed-2**	**Sed-3**	**Sed-1**	**Sed-2**	**Sed-3**	**Sed-1**	**Sed-2**	**Sed-3**
mono	0.00	0	0	0.00	0.00	0.00	0.00	0.00	0.00
di	0.02	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
tri	0.23	0.25	0.18	0.06	0.03	0.02	0.07	0.02	0.06
tetra	0.46	0.46	0.28	0.28	0.11	0.06	0.20	0.10	0.12
penta	0.32	0.24	0.12	0.18	0.07	0.05	0.10	0.07	0.06
hex	0.11	0.06	0.03	0.06	0.02	0.02	0.02	0.01	0.01
hepta	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
octa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
nona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
deca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**1.16**	**1.03**	**0.63**	**0.59**	**0.24**	**0.14**	**0.40**	**0.21**	**0.26**
% reductions				48.9	76.4	77.1	65.4	80.0	58.8

Table 4. PCB Homolog concentrations in surface water

	Deploy 1			Deploy 2			Deploy 3		
Homolog Grp	**Sed-1**	**Sed-2**	**Sed-3**	**Sed-1**	**Sed-2**	**Sed-3**	**Sed-1**	**Sed-2**	**Sed-3**
mono	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
di	0.01	0.05	0.03	0.00	0.00	0.00	0.03	0.00	0.00
tri	0.17	0.19	0.17	0.11	0.09	0.10	0.22	0.05	0.03
tetra	0.29	0.32	0.25	0.27	0.21	0.18	0.39	0.16	0.11
penta	0.19	0.19	0.13	0.14	0.11	0.09	0.27	0.13	0.07
hex	0.05	0.04	0.03	0.03	0.02	0.03	0.07	0.04	0.02
hepta	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00
octa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
nona	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
deca	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Total	**0.72**	**0.80**	**0.62**	**0.56**	**0.43**	**0.41**	**0.98**	**0.39**	**0.23**
% reductions				22.7	46.7	34.0	-36.7	51.6	62.8

4. REFERENCES

U.S. EPA/SERDP/ESTCP. 2017. Laboratory, Field, and Analytical Procedures for Using Passive Sampling in the Evaluation of Contaminated Sediments: User's Manual. EPA/600/R- 16/357. Office of Research and Development, Washington, DC 20460

Fernandez, L.A., J.K. MacFarlane, A.P. Tcaciuc, and P.M. Gschwend. 2009. Using performance reference compounds in polyethylene passive samplers to deduce sediment porewater concentrations for numerous target chemicals. *Environmental Science and Technology*. 43:8888-8894.

Grossman A, Ghosh U. 2009. Measurement of activated carbon and other black carbons in sediments. *Chemosphere* 75(4):469-475.

Payne, R.B.; Ghosh, U.; May, H.D.; Marshall, C.W.; Sowers, K.R. A Pilot-Scale Field Study: In Situ Treatment of PCB-Impacted Sediments with Bioamended Activated Carbon. *Environmental Science and Technology*., 53, 2626−2634. 2019.

Conflict of interest disclosure:

"Dr. Ghosh is a co-inventor of three patents related to the in-situ remediation technology described in this proposal for which he is entitled to receive royalties upon commercialization. One invention was issued to Stanford University (US Patent # 7,101,115 B2), and the other two to the University of Maryland Baltimore County (UMBC) (U.S. Patent No. 7,824,129; 8,945,906). In addition, Dr. Ghosh is a partner in startup companies (Sediment Solutions and RemBac Environmental) that has licensed the technologies from Stanford and UMBC. Sediment Solutions and RemBak are providing the technology for the implementation of the remediation in A-Street Ditch"

Attachment 2

Photographs

Site Photographs

Photo 1

Collection of baseline sediment samples in March 2019.

Photo 2

On-site preparation of passive samplers by UMBC in March 2019.

Photo 3

Deployment of passive sampler at location ASTREET-SED02 in March 2019.

Photo 4

Passive sampler after deployment at location ASTREET-SED02 in March 2019.

Site Photographs

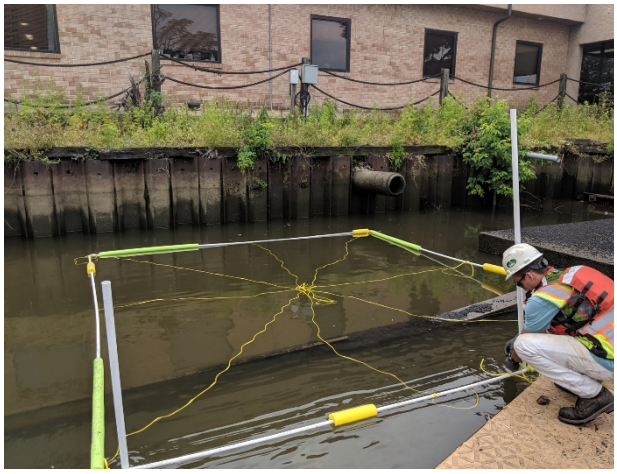
Photo 5

Collecting baseline pore water samples from passive samplers in May 2019.

Photo 6

Turbidity curtain installed at mouth of ditch prior to SediMite™ application.

Photo 7



Preparing grid cells for SediMite™ application.

Photo 8

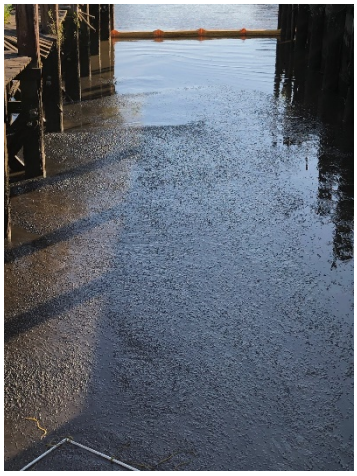
Inoculating SediMite™ with PCB-degrading microorganisms prior to application.

Site Photographs

Photo 9

Application of inoculated SediMite™ to A-Street Ditch Segment 1 sediments.

Photo 10



Inoculated SediMite™ pellets on sediments immediately after application.

Photo 11

UMBC and DNREC preparing passive sampler for deployment in October 2019.

Photo 12

Passive sampler prior to deployment in October 2019.

Site Photographs

Photo 13

Collection of post-remediation sediment samples in October 2019.

Photo 14

Composited sediment collected from each of the three sample locations in October 2019.

Photo 15

Retrieving passive sampler from location ASTREET-SED01 in December 2019.

Photo 16

Retrieval of passive sampler from location ASTREET-SED03 in December 2019.

Site Photographs

Photo 17

Collection of post-remediation sediment samples in June 2020.

Photo 18

Collection of ASTREET-SED03 sediment sample in June 2020.

Photo 19

Deploying passive sampler at location ASTREET-SED02 in June 2020.

Photo 20

Collection of porewater sample from passive sampler in July 2020.