FINAL REPORT

Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment

ESTCP Project ER-0510

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Richard G. Luthy
Yeo-Myoung Cho
Stanford University

Upal Ghosh
University of Maryland Baltimore County

Todd S. Bridges
Alan J. Kennedy
U.S. Army Engineer Research and Development Center

Environmental Security Technology Certification Program

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Luthy, Richard G.
Cho, Yeo-Myoung
Ghosh, Upal
Bridges, Todd S.
Kennedy, Alan J.

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Yang & Yamazaki Environment & Energy Bldg
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14. ABSTRACT

We conducted the first field-scale test of in-situ activated carbon (AC) amendment for contaminated sediment remediation. Using commercial equipment devices, AC was successfully incorporated into the test plots to a nominal 1 ft depth at a dose of 2-3%. In-situ bioassays with Macoma nasuta showed the benefit of AC treatment, though at 18 months post-treatment the in-situ assay results were confounded due to newly deposited sediment. Ex-situ M.nasuta bioassays showed about 50% reduction in PCB biouptake with 2% of AC dose. Field-exposed AC retained a strong stabilization capability to reduce aqueous equilibrium PCB concentrations by as much as 95%, which supports the long-term effectiveness of AC in the field at least up to 18 months. Neither PCB resuspension from the test plots nor adverse impacts to the benthic community were observed. Scaling-up the AC treatment method results in possible total cost savings of 70 to 75% less than sediment dredging and disposal for the Hunters Point South Basin test site. If ongoing contaminant sources are eliminated and freshly deposited sediments are clean, in-situ AC amendment of contaminated sediments can provide a suitable method for reducing contaminant exposure to the water column and biota.

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Activated carbon (AC) amendment, Polychlorinated biphenyls (PCBs), In-situ treatment, Sediment, San Francisco Bay, Field assessments

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Acronyms

AC	activated carbon
AEI	Aquatic Environments, Inc.
BC	black carbon
BDO	Battelle Duxbury Operations
BRAC	Base Realignment and Closure Act
CEI	Compass Environmental, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DDT	dichlorodiphenyltrichloroethane
DoD	Department of Defense
EPA	United States Environmental Protection Agency
ERDC	Engineering Research and Development Center
ESTCP	Environmental Security Technology Certification Program
FS	Feasibility Study
HPS	Hunters Point Shipyard
NPL	National Priorities List
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PED	polyethylene device
QAPP	Quality Assurance Project Plan
RAB	Restoration Advisory Board
RAC	regenerated activated carbon
RPM	Remedial Project Manager
SARA	Superfund Amendments and Reauthorization Act
SERDP	Strategic Environmental Research and Development Program
SPMD	semipermeable membrane devices
TOC	total organic carbon
USACE	United States Army Corps of Engineers
UMBC	University of Maryland Baltimore County

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EXECUTIVE SUMMARY

Prior laboratory studies and a preliminary field pilot-scale study showed that the addition of activated carbon (AC) to sediment contaminated with polychlorinated biphenyls (PCBs) significantly reduced the chemical and biological availability of PCBs. Encouraged by those results, we recently completed a field-scale project (ER-0510) to demonstrate that AC sorbent mixed with sediment is a cost-effective, *in situ*, non-removal, management strategy for reducing risk and the bioavailability of PCBs in offshore sediments at the Hunters Point Shipyard site. In order to achieve these goals, we identified three primary objectives for the scope of this project:

- Demonstrate and compare the effectiveness, in terms of AC application and ease of use, of two available large-scale mixing technologies.
- Demonstrate that AC treatment reduces PCB bioaccumulation in field tests.
- Demonstrate no significant sediment resuspension and PCB release after the large-scale mixing technologies are used.

Using two commercial equipment devices, AC was successfully incorporated into the test plots to a nominal 1 ft depth at a dose of 2 to 3% depending on sampling locations. This was verified by the increases in total organic carbon contents and black carbon contents in AC-amended sediment. *In situ* 28-day semi-permeable membrane device (SPMD) uptake studies showed 50% - 66% reductions in PCB uptakes in AC-amended test plots depending on AC dose. *In situ* bioassays with the bent-nosed clam, *Macoma nasuta* also showed the effectiveness of AC treatment, although the *in situ* bioassay results were sometimes confounded by field conditions resulting from newly deposited sediment, heat stress, and shallow burrowing depth. To overcome these factors, *ex situ* bioassays with *M.nasuta* were conducted with field sediment in the laboratory, which showed about 50% reduction in PCB bioaccumulation with a 2% AC dose.

Field-exposed AC retained a strong stabilization capability to reduce aqueous equilibrium PCB concentrations by as much as 95% depending on AC dose, which supports the long-term effectiveness of AC in the field at least up to 18 months. This was demonstrated also in long-term, SPMD exposure tests lasting more than seven months. The time series test results showed the AC continually reduced SPMD uptake of PCBs, achieving reductions ranging from 76% for tetra-chloro PCBs to 42% for hepta-chloro PCBs. A strong AC-dose response effect was observed both for aqueous equilibrium PCB concentrations and *M.nasuta* PCB bioaccumulations. Neither PCB resuspension from the test plots nor adverse impacts to indigenous amphipods and benthic community were observed during the entire assessment period. Overall, the AC treatment did not impact macro-invertebrate benthic community composition, richness, or diversity.

Cost analysis showed that scaling-up the AC treatment method would result in a total cost savings that may be 70 to 75% less than for dredging and disposal.

This project completes the first field demonstration of sorptive amendment to sediment to reduce PCB exposure and risk. Overall, this study indicates that if ongoing PCB contaminant sources are eliminated and freshly deposited sediments are clean, *in situ* AC amendment to contaminated sediments can provide a suitable, cost-effective method for reducing contaminant exposure to the water column and biota. Additional mixing during or after AC deployment, sequential AC deployment or greater AC dose, or reducing AC particle size will improve overall effectiveness.

1 INTRODUCTION

This final report describes accomplishments and conclusions of a project that received demonstration/validation (DEM/VAL) funding under the U.S. Department of Defense (DoD) Environmental Security Technology Certification Program (ESTCP). The project has been completed for the testing of activated carbon (AC) mixing and *in situ* stabilization of polychlorinated biphenyls (PCBs) in offshore sediments (Parcel F) at Hunters Point Shipyard (HPS) in San Francisco, CA. In addition to validating the effectiveness of the technology, the demonstration project determined probable field-scale implementation costs, and assessed regulatory acceptance. In total, the ESTCP project showed that AC amendment to sediment contaminated with persistent hydrophobic organic compounds is a viable, innovative technology that reduces exposure and risk from organic contaminants and may provide an acceptable alternative to dredging and offsite disposal of contaminated sediments.

1.1 Background

Contaminated sediments pose challenging cleanup and management problems at many DoD sites. In the San Francisco Bay Area, for example, four major Naval Facilities undergoing base closure have contaminated sediments: Hunters Point Naval Shipyard, Alameda Naval Air Station, Moffett Field Naval Air Station, and Mare Island Naval Shipyard[1]. Currently the standard approach to addressing contaminated marine "mud flat" sediments is the expensive *ex situ* process of dredging and disposal. Finding cost-effective *in situ* technologies for contaminated sediment management will significantly reduce expenditures on environmental restoration.

The technology demonstrated in this project is an *in situ* treatment for sediment contaminated with hydrophobic organic contaminants such as PCBs, pesticides, and polycyclic aromatic hydrocarbons (PAHs). Generally, this technology involves the mixing of AC into the contaminated sediment, which strongly adsorbs the hydrophobic organic contaminants in the sediment. This strong sorption stabilizes and reduces the bioavailability of the contaminants in benthic organisms. The goals for this ESTCP project are intended to demonstrate that AC sorbent mixed with sediment is a cost-effective, *in situ*, non-removal, management strategy for reducing the bioavailability of PCBs in offshore sediments at HPS in San Francisco, CA.

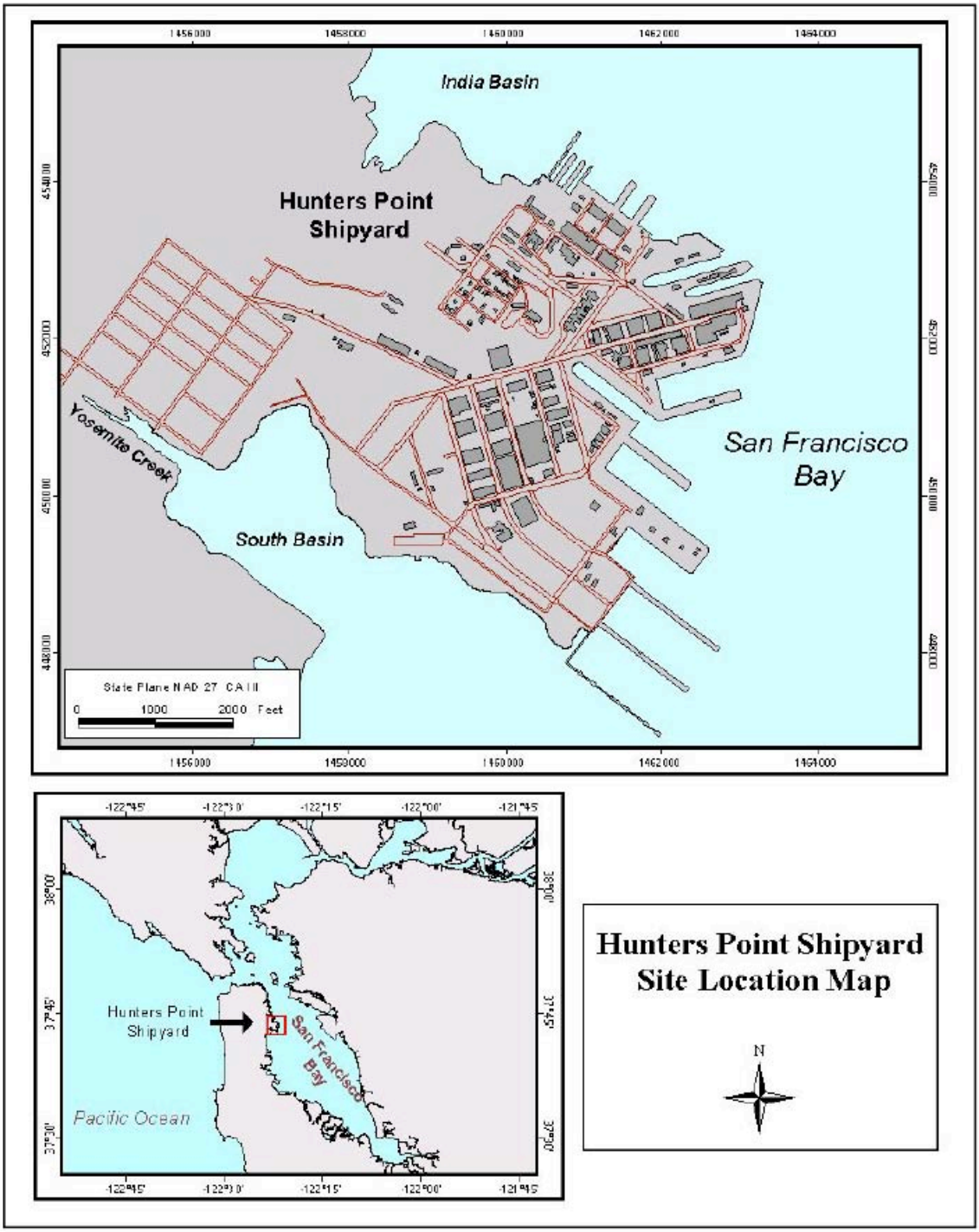


Figure 1-1. Hunters Point Shipyard Site Location Map

Hunters Point Shipyard (HPS) is a former Navy installation located on a peninsula in the southeast corner of San Francisco, CA (Figure 1-1). From 1945 to 1974, the Navy used HPS predominantly for ship repair and maintenance. HPS was deactivated in 1974 and remained relatively unused until 1976, when it was leased to Triple A Machine Shop, a private ship repair

company. In 1986, the Navy resumed occupancy of HPS. Three years later, HPS became a Superfund site as it was placed on the National Priorities List (NPL) in 1989. The Navy then closed the Base in 1991 under the Defense Base Realignment and Closure Act of 1990 (BRAC). The base is in the process of conversion to nonmilitary use. Historically, the area comprising the HPS site consisted of about 928 acres, which have been divided into the six Parcels: A - F. Since Parcel A has been recently transferred to the City of San Francisco, the HPS site now comprises about 853 acres. Parcel F, which contains offshore sediment, comprises approximately 432 acres.

Historical site activities at HPS resulted in the release of chemicals to the environment, including offshore sediments in Parcel F. Environmental restoration activities are being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

1.2 Objective of the Demonstration

This project was a field-scale demonstration of AC-induced *in situ* PCB stabilization in sediment. The demonstration evaluated the use of AC for remediation of PCB contaminated sediment at Parcel F of Hunters Point Naval Shipyard. The project entailed a field pilot-scale operation over a three-year period. The overarching goal of this project was to demonstrate that AC sorbent mixed with sediment was a cost-effective, *in situ*, non-removal, management strategy for reducing the bioavailability of PCBs in offshore sediments at HPS site. In order to achieve this goal, we had identified three primary objectives for the scope of this project:

- Demonstrate and compare the effectiveness, in terms of AC application and ease of use, of two available large-scale mixing technologies.
- Demonstrate that AC treatment reduces PCB bioaccumulation in field tests.
- Demonstrate no significant sediment resuspension and PCB release after the large-scale mixing technologies are used.

These three primary objectives were further sub-divided into the five "primary performance objectives" that are shown in Table 3-1 and further discussed in Section 3.1. "Secondary performance objectives," which support the primary performance objectives, can be also found in Table 3-1 and are further discussed in Section 3.2. The performance objectives were sorted between primary and secondary by applying the following logic: If we were unable to meet the expected performance metric for a particular performance objective and that failure had a significant impact on several other performance objectives, then it was deemed as primary. If these two conditions were not met, then the performance objective was classified as secondary. For example, if neither of the large-scale mixing technologies were able to mix in AC homogeneously down to one foot, this failure in "AC Application" would affect all of the other performance objectives and reduce our chances of achieving our overarching project goal. Thus, the objective of "AC application" was identified as a primary performance objective. As a converse example, if an homogenous AC treatment were found not to reduce PCB bioaccumulation, then it would matter less if it were found that the community structure of the plot was unaffected by the AC treatment. In this way, "Effects of AC treatment on indigenous

benthic community" was identified as secondary to the primary "PCB bioaccumulaion in test or indigenous organisms" performance objective.

In addition to evaluating primary and secondary performance objectives, the demonstration project generated supporting cost and performance data for implementation of the novel sediment remediation technology at DoD sites with conditions similar to those at Hunters Point.

1.3 Regulatory Drivers

Environmental restoration activities at the site are being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).

2 TECHNOLOGY

2.1 Technology Description

We report on the addition of highly-sorbent activated carbon (AC) to the upper sediment layer using available large-scale mixing technologies to manage sediment contamination by hydrophobic organic compounds (HOCs). Conceptually, the approach builds on prior studies by others and us that describe the role of black carbon, e.g., soot, chars, and soot-like materials such as coal, to affect the transport, uptake, and biomagnification of HOCs in sediments.[2] Particle-scale analyses of sediment from the general study area showed that the majority of PCBs were associated with chars and, as such, were not as readily released to water.[3, 4] These observations from field sediments led to the study of AC as an *in situ* amendment in which AC would be mixed into the upper, biologically-active sediment layer to stabilize the PCBs and reduce their availability to the aqueous phase and biota (Figure 2-1). This would enhance significantly a process that was occurring naturally, albeit slowly. Laboratory results with field sediments from this and other sites were promising, and demonstrated that addition of AC to sediment reduced the availability of PCBs, PAHs, and DDT to water and uptake by organisms such as clams, amphipods, polychaetes, and mussels.[5-8]

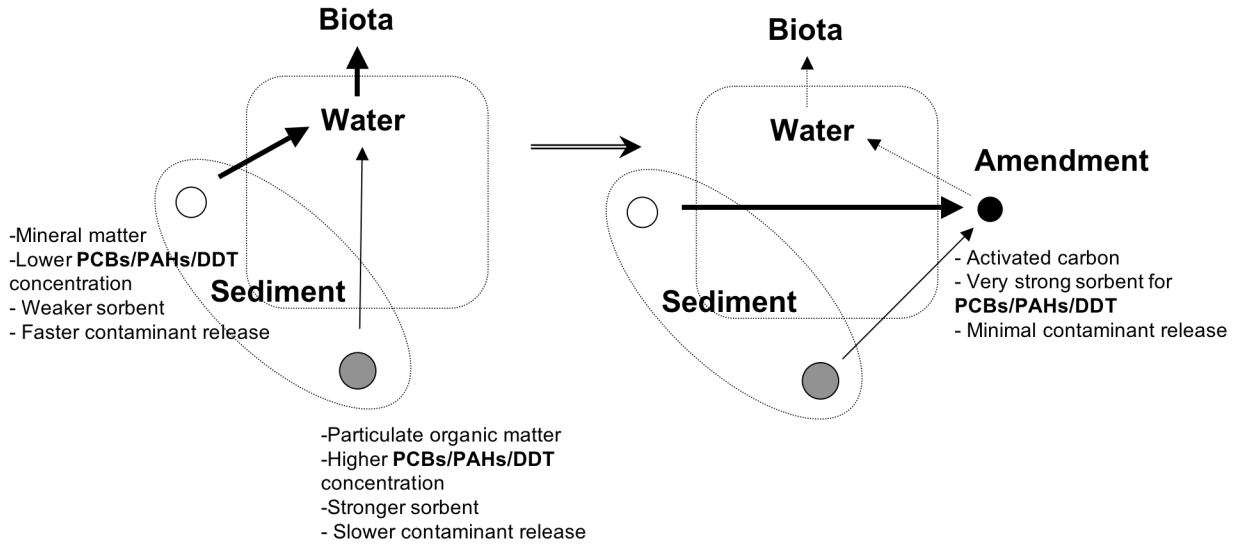


Figure 2-1. Schematic of AC amendment in reducing exposure and environmental risk

2.2 Technology Development

The SERDP-funded laboratory testing phase of this new, *in situ* remediation technology has been completed using contaminated Hunters Point sediment with PCB levels up to 10 mg/kg. This upper limit of 10 ppm was the highest concentration of PCBs that we have observed in any of the sediment samples collected from Area X of Parcel F. Results from the SERDP three-year project were very encouraging and provided a strong basis for technology testing under field conditions. A time line of the development of this technology is shown in Table 2-1. Reductions in total PCB bioaccumulation of 69% to over 80% by *Macoma* clams, 70% by *Leptocheirus* amphipods,

and 82% by *Neanthes* worms were observed in laboratory tests on sediment treated for one month with AC as shown in Figure 2-2.[5] In tests with 6-month contact of AC and sediment, additional reductions in organism PCB uptake were observed (75%, amphipods; 87%, worms), indicating that the benefit to benthic organisms did not diminish and may actually improve with time. In comparison, biomimetic semipermeable membrane devices (SPMD) were used to assess the chemical and biological availability of PCBs and PAHs in sediment and water before and after treatment with activated carbon. AC-treatment for one month reduced SPMD uptake by up to 73% and 83% for PCBs and PAHs, respectively.[9] AC treatment for six months reduced SPMD uptake of PCBs by 77%.

Table 2-1. Technology Development History

Development Phase	Time Frame	Funding Agency	Publications
Discovery of the predominant role of coal and coke on strong sorption of PAHs in sediments	1998-1999	SERDP	6, 7
Discovery of low bioavailability of PAHs sorbed on coal and coke in sediments	1999-2000	SERDP, USACE ERDC	8, 9, 10
Discovery of the predominant role of coal-derived and char particles in the sorption of PCBs in Hunters Point and Milwaukee Harbor sediments	2001-2002	SERDP, Stanford Univ. Graduate Fellowship	3, 11, 12
Demonstration of very low absorption efficiency for a radio-labeled PCB and a PAH on activated carbon in particle-feeding tests with clams	2001-2004	Stanford Univ. Bio-X Research Program	3, 12, 21
Demonstration of reduced PCB aqueous availability from Hunters Point sediment treated with AC	2002-2004	SERDP	3, 4, 12

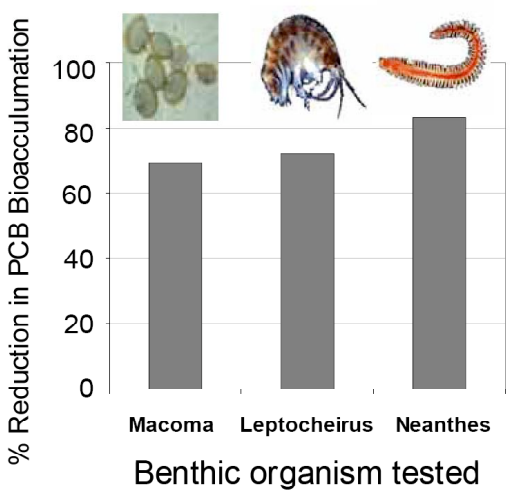


Figure 2-2. Percent reduction of PCB bioaccumulation (28-day exposure after one month AC treatment).

Results from physicochemical tests were similar to those from the biological studies. The total PCB aqueous equilibrium concentrations for sediment mixed with 3.4% by weight AC decreased by 87% and 92% for contact times of one and six months respectively. Adding AC to sediment also reduced aqueous equilibrium PAH concentrations 74% and 84% for one and six month contact periods, respectively.[9]

The effect of AC dose on clam PCB bioaccumulation and aqueous equilibrium PCB concentrations follows a similar trend as shown in Figure 2-3. A carbon dose of about 3 wt. % produced the greatest reductions.

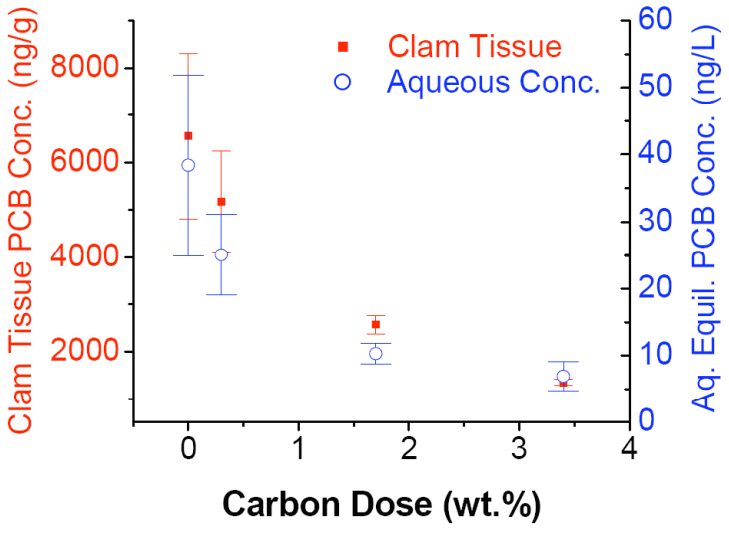


Figure 2-3. *Macoma* clam tissue PCB and aqueous equilibrium PCB concentrations versus AC dose after one-month treatment.

2.3 Advantages and Limitations of the Technology

Technology Advantages: This treatment technology for contaminated sediments is innovative as it is an *in situ* process, which would circumvent the need to do expensive sediment dredging and disposal. Many DoD facilities across the country are challenged with management of sediments contaminated with persistent organic contaminants such as PCBs, PAHs, and DDT. This work addresses the DoD need for cost effective, *in situ* remediation technologies for persistent organic contaminants in sediments. The development of this technology for contaminated sediment management offers the potential to significantly reduce expenditures on environmental restoration, as well as gain acceptance by regulators and communities since it does not involve dredging and habitat destruction. This treatment technology did not show noticeable adverse impacts on the health of the benthic community and did not impact sediment resuspension and PCB release into the water column over the treatment plots. Also the potential of the treatment was retained throughout the project time span.

Technology Limitations: Our laboratory results suggest that we may achieve a factor of 10 or more reduction in the bioavailability (or effective concentration) of PCBs in the field. We define low-range PCB concentrations in sediment as <1 ppm, mid-range as 1-10 ppm, and high-range as >10ppm. Therefore, if the final cleanup goal is to achieve sediments having an effective PCB concentration of <1 ppm, then sediment having a mid-range PCB concentration (1-10 ppm) would be an appropriate target for AC treatment. We recognize that the final cleanup goal for the Hunters Point site is still in development, yet anticipate that the application of this *in situ* technology would most likely be limited to sediment having a low- to mid-range contaminant concentration of total PCBs. In fact, this philosophy is embraced in the Final Feasibility Study for Parcel F sediments, which considers possible AC amendment for PCB stabilization throughout much of South Basin with some targeted removal of higher PCB levels. Dredging and disposal of hot spot areas with high-range contaminant concentrations would be appropriate, as reductions in effective PCB concentration through AC treatment may not be sufficient. The decision to use the AC *in situ* technology would be mediated by final cleanup goals for a particular site. This project revealed that over time, e.g., 18 - 24 months, that newly-deposited, contaminated sediment masked the effectiveness of the underlying AC amendment for benthic organisms that exhibit surficial deposit feeding strategies. If ongoing PCB contaminant sources are eliminated and freshly deposited sediments are clean, then *in situ* AC amendment of contaminated sediments can provide a suitable method for reducing contaminant release to the water column and uptake by biota for exposures resulting from within the sediment bed.

3 PERFORMANCE OBJECTIVES

As already explained in Section 1.2, each performance objective was categorized as either "primary" or "secondary", considering the impact of its success/failure on other objectives. Performance objectives were summarized in Table 3-1.

Table 3-1. Performance Objectives

Performance Objective	Data Requirements	Success Criteria	Results
PRIMARY CRITERIA (Qualitative)			
Ease of use (Comparison of mixing technologies)	Field demonstration experiences	• Two mixing technologies can be compared in terms of mobility, AC delivery, and the effectiveness of AC amendment.	• Rototiller system (Aquamog) showed better performance.
PRIMARY CRITERIA (Quantitative)			
PCB bioaccumulation in test organisms	*M. nasuta* tissue PCB concentrations from *in situ* and *ex situ* 28-day bioassays	• Significantly lower PCB tissue concentrations in test *M.nasuta* tissue that exposed AC-treated plots compared to control plots. • Student t-test or ANOVA for statistical analysis	• 24 months post-treatment *ex situ* bioassay showed significantly reduced PCB biouptake into *M.nasuta* exposed to AC-amended plots (Plots D and F) compared to control plots (Plots C and E) • *In situ* bioassay results were confounded by field-specific conditions from incoming freshly deposited sediment occurring 18-24 months post treatment.
PCB bioaccumulation in indigenous organisms	Indigenous *Corophium spp.* amphipods tissue PCB concentrations at pre- and post-treatment assessments	• Significantly lower PCB tissue concentrations • No impact due to release of PCBs from mixing • Student t-test or ANOVA for statistical analysis	• No significant difference observed • PCB levels in indigenous amphipods responded to overlying water rather than under-lying sediment layer • No enhanced PCB flux due to AC-sediment mixing

Performance Objective	Data Requirements	Success Criteria	Results
PRIMARY CRITERIA (Quantitative)			
AC application	Averaged total organic carbon (TOC) contents of sediment cores from all test plots at pre- and post-treatment assessments	• Averaged TOC should be 3.8 ± 2.5 wt.%, given an initial TOC of 1.0 wt.%. • The standard deviation (SD) was used to make a qualitative statement about the homogeneity of the mixing. • SD = 0.0 – 1.5 wt.%, excellent mixing SD = 1.6 – 2.5 wt.%, good mixing SD = 2.6 – 3.6 wt.%, fair mixing SD > 3.6 wt.%, poor mixing	• Averaged TOC of Plots D and F are 2-3 wt% depending on sampling locations, which were less than the target TOC 3.8% due to over mixing vertically and/or horizontally. • Plot D with rotovator mixing showed excellent mixing. • Plot F with injector mixing showed excellent~good mixing.
PCB resuspension	Aqueous and suspended particulate PCB concentrations above test plots.	• No significant differences in the dissolved PCB concentrations and the particulate-associated PCB concentrations in the water column above Plots D and F after treatment when compared to controls.	• No significant differences spatially (among test plots)
SECONDARY CRITERIA (Qualitative)			
Effects of AC treatment on indigenous benthic community	Aqueous and suspended particulate PCB concentrations above test plots.	• No significant differences exist between metrics of benthic community (e.g., richness, abundance, diversity) in the test plots.	• No significant differences among test plots (richness and diversity) • Effect of AC amendment, if any, was dominated by larger seasonal effects.
Versatility -AEI Mixing Device -CEI Mixing Device	Experience from demonstration operation	• Mixing devices will provide different yet adequate AC mixing into the sediments in Plots D and F.	• Both mixing devices provided adequate AC mixing.
Scale-Up Constraints -throughput -combination of devices	Experience from demonstration operation	• Treatment of 370 ft^2 plots in one day for each mixing device.	• Both mixing devices succeeded in accomplishing AC deployment into the test plots.

Performance Objective	Data Requirements	Success Criteria	Results
SECONDARY CRITERIA (Qualitative)			
Factors Affecting Technology Performance -lab and field mixing differences -ineffective AC homogenization	Comparison of lab and field bioaccumulation reduction results	• No significant changes in the PCB concentrations of tissues assessed for bioaccumulation.	• Sediment deposition occurring 18-24 months post treatment confounded field (*in situ*) biological measurements with *M.nasuta* to assess the effect of AC amendment.
SECONDARY CRITERIA (Quantitative)			
AC/sediment stability	Six-month and eighteen-month averaged TOC values from Plots D and F	• No significant differences between the six-month and eighteen-month TOC values measured in cross sections of sediment cores taken from Plots D and F.	• Not applicable due to heterogeneity of mixing and difference in sampling locations.
PCB uptake into SPMDs	Six-month and eighteen-month PCB uptake into SPMDs	• Significantly lower PCB uptake into SPMDs for those deployed in Plots D and F after treatment compared to controls.	• 50-66 % less PCB uptake into SPMDs were observed in AC-treated plots (Plots D and F) compared to mixing control plot (Plot C).
Aqueous equilibrium PCB concentrations	Sediment core processing and analyses	• Significantly lower aqueous equilibrium PCB concentrations with sediment from Plots D and F after treatment when compared to aqueous equilibrium PCB concentrations with sediment in controls.	• Significantly lower aqueous equilibrium PCB conc.s were observed in AC-treated plots. • The extent of reduction depended on AC dose, with greater than 95% reduction for AC dose =3.65 %. • The AC retained its capacity to sorb PCBs at 6- and 18-months post treatment.
PCB desorption rates	Desorption characteristics of field sediments	• Significantly lower PCB desorption rates with sediment from Plots D and F after treatment when compared to PCB desorption rates with sediment in controls.	• ~50 % reduction in desorption rates were observed with the AC-treated plot samples.

3.1 Primary Objectives

3.1.1 Ease of Use

Based on field demonstration experience, the two mixing technologies were compared to determine which is easier to use in terms of its a) mobilization to a sediment plot, b) movement to another plot, c) delivery of AC to plot, and d) demobilization from sediment plots.

3.1.2 PCB Bioaccumulation in Test Organisms

To show the effectiveness of AC-amendment, we conducted both *in situ* and *ex situ* PCB bioaccumulation studies using test *M.nasuta* clams. The *in situ* PCB bioaccumulation studies were conducted one month before, 6 months after, and 18 months after AC-deployment. *Ex situ* bioassays using sediment samples from the test plots were conducted 24 months after AC-deployment. An *ex situ* PCB bioassay was not originally planned in the demo plan, but it was included in this project to avoid field factors that might have affected *in situ* bioassay performance. Significantly less PCB concentrations in the clam tissues exposed to AC-amended sediment compared to controls were considered as success in meeting this objective.

3.1.3 PCB Bioaccumulation in Indigenous Organisms

PCB concentrations were measured in indigenous amphipods collected from sieved surface sediments taken from all four plots. These amphipods were collected once before and twice after the plot treatments. PCB tissue concentrations between AC-amended plots and controls were statistically compared to determine whether the AC-amendment beneficially or adversely affected the indigenous organisms. Significantly less PCB concentrations in samples in AC-treated plots compared to controls were considered a demonstrable benefit of AC-amendment, while no significant differences were considered as non-adverse impact on the organisms due to release of PCBs from mixing or other factors.

3.1.4 AC Application

The AC profile of sediment cores taken from all four plots were assessed (through TOC measurements) once before and twice after the plot treatments occurred to assess the homogeneity and depth of applied AC. Assuming 100% of AC deployed into a designated depth of nominally 1-ft and area of 370 sq. ft., the target TOC value in AC-amended plots should be close to 3.8 wt% based on 1 wt% of background TOC. The standard deviation (SD) was used to make a qualitative statement about the homogeneity of the mixing: excellent, good, fair, and poor. In addition to TOC measurement, black carbon contents in sediment cores were analyzed to support and validate the results of TOC measurements.

3.1.5 PCB Resuspension

The dissolved PCB concentrations and the particulate-associated PCB concentrations in the water column above the test plots were measured at high tide once before and twice after the plot treatments occurred. No significant differences among test plots were considered as criteria to conclude there was no PCB resuspension, either dissolved or particulate, by AC deployment and/or mechanical mixing. One post treatment-sampling event occurred on the next tidal cycle following treatment.

3.2 Secondary Objectives

3.2.1 AC/Sediment Stability

The TOC values measured for sediment cores from Plots D and F taken at six and eighteen months post-treatment were compared to evaluate if there are any significant differences in the amount of AC in these plots between the two sampling time points.

3.2.2 Effects of AC Treatment on Indigenous Benthic Community

Benthic organisms were sieved from quadrats taken in all four plots once before and twice after the treatments. The benthic community structures that existed in each quadrat were compared to evaluate effects of AC deployment and mixing on benthic recolonization, community structure and organism growth.

3.2.3 PCB Uptake into SPMDs

PCB uptake into SPMDs deployed in all four plots was measured. The SPMD deployments occurred once before and twice after plot treatments. Significantly less PCB uptake into the SPMDs exposed to AC-amended sediment compared to controls was considered as indicative of the benefit of AC-amendment.

3.2.4 Aqueous Equilibrium PCB Concentrations

Sediment subsamples taken from sediment cores were measured for aqueous equilibrium PCB concentrations. Significantly less aqueous PCB concentrations for AC-amended sediment compared to control sediment was considered as indicative of the benefit of AC-amendment.

3.2.5 PCB Desorption Rates

Sediment subsamples taken from sediment cores were measured for PCB desorption characteristics. Significantly less PCB desorption with AC-amended sediment compared to control sediment was considered as indicative of the benefit of AC-amendment.

3.2.6 Factors Affecting Technology Performance

Even if the mixing devices tested in this study achieve good mixing, the observed reductions in PCB bioavailability in the field may occur more slowly than those observed in the laboratory, since the laboratory tests employed AC-amended sediment samples continuously mixed for at least one month. In addition, ineffective homogenization of the AC into the sediment would influence the short- and long-term performance of the technology.

During the project execution, sediment deposition that occurred 18-months and 24-months post treatment was identified as another field factor that affected the performance of the *in situ* biological assessments and further confounded assessments of the performance of AC-amendment. To verify this field factor of sediment deposition, *ex situ* bioassays and surficial sediment characterizations (BC, TOC, aqueous equilibrium PCB conc., and C-13 isotope measurements) were conducted two years after AC-deployment.

3.2.7 Versatility

The *in situ* AC treatment technology can be used at other tidal mudflats or marsh-like locations. Field demonstration experience of the two mixing devices will provide guidance on what site-specific conditions may make one or the other mixing technologies more feasible. Adaptations of the devices are necessary for treating contaminated sediment with overlying water.

3.2.8 Scale-Up Constraints

In order to do full implementation, several mixing devices may be used concurrently to obtain sufficient and satisfactory throughput. In addition, a combination of the best features of the two mixing devices into one mixing system may afford better full implementation. The demonstration will help to identify the best features of each. At South Basin, a coffer dam could be constructed at the narrow inlet so that dewatered sediment behind the cofferdam could be treated effectively in a one- or two-week time period using conventional spreaders and mechanical bulldozer mixers. Also, this would allow for greater flexibility with re-mixing and AC deployment.

4 SITE DESCRIPTION

We selected the test site to be the HPS Parcel F, Area X, tidal mudflat in South Basin for several reasons. First, PCBs have been identified as the major risk driver for HPS Parcel F Area X and most of the sediment in Area X of Parcel F has a mid-range PCB concentration.[10] Second, the combined results of Sedflume experiments[11] on HPS Parcel F sediment and comprehensive hydrodynamic modeling studies[12] indicate that the South Basin area is a net depositional zone and comprised of cohesive sediments not subject to exceeding sediment critical shear stress in most storm events. Third, preliminary field tests indicate that when AC is mixed into the sediment it stays in place due to the cohesive nature of the sediment and the slightly depositional nature of the site. Last, the Navy site managers at Hunters Point have indicated that they hope to use this technology in their final remedial decisions; if they do, technology transfer to other DoD sites should be straightforward. As a result, this technology has been included as an alternative remedial option in the Navy's feasibility study report.[13]

4.1 Site History and Characteristics

HPS is a former Navy installation located on a peninsula in the southeast corner of San Francisco, CA (Figure 1-1), which comprises about 928 acres, with approximately 432 acres of offshore sediment. The Navy used the site for maintaining and repairing ships between 1945 and 1974. The facility was deactivated from 1974 to 1976. A private ship repair company, Triple A Machine Shop, leased the facility for its business in 1976 until the Navy resumed occupancy in 1986. The site was closed in 1991 under the DoD BRAC program and the property is in the process of conversion to nonmilitary use. Historical site activities at HPS resulted in the release of chemicals to the environment, including offshore sediments. The cleanup of the chemicals is required for re-use of the site and cleanup of chemicals from the former landfill and other locations on shore has been completed.

The site was closed in 1991 under the Defense BRAC. Currently, there are no operations in the selected demonstration area. A feasibility study has been completed for the offshore contaminated sediment.[13]

Pictures of the demonstration area are presented in Figure 4-1 and Figure 4-2. The demonstration area is at the HPS tidal mudflat in South Basin. The top four inches of the sediment in the demonstration area is comprised of small gravel, shells, and clay particles. Underneath this top layer, a more homogenous layer of clay, characteristic of bay mud, exists. The bulk density of the surface sediment (top 1 foot) is approximately 1.3 to 1.4 g/cm[14]. The water depths are from 6 feet to less than 2 feet. Tidal currents are very weak. Because PCBs tend to adsorb to fine-grained sediment particles and organic matter, sediment resuspension and deposition are major contaminant transport pathways in South Basin. However, resuspension events due to storm winds are infrequent and only impact the surficial sediments. The basin is a net depositional environment with a net sedimentation rate of about 1 centimeter per year.[11]

Figure 4-1. Demonstration Area

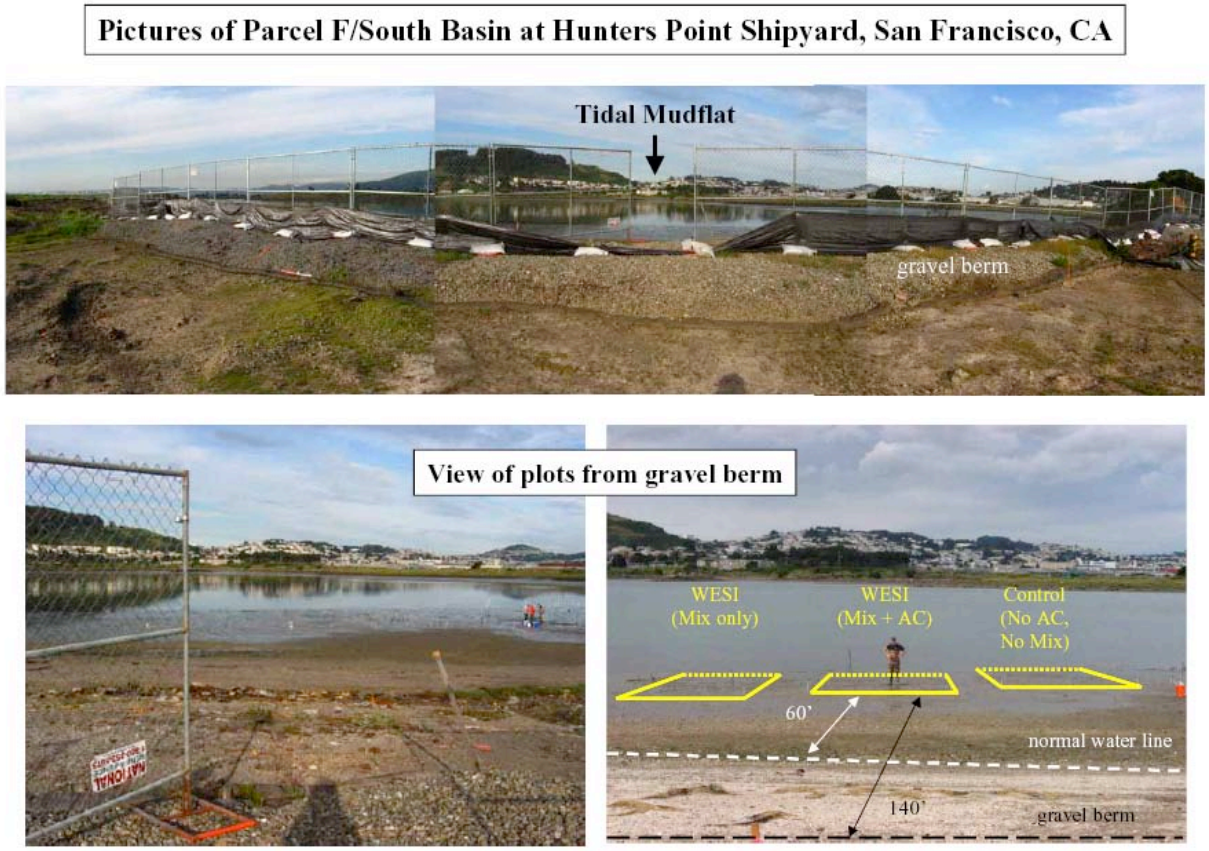


Figure 4-2. Demonstration and Plot Locations

4.2 Contaminant Distribution

The site characterization was conducted in 1991 to evaluate the presence of contaminants in offshore areas of the HPS.[15] The area (Figure 4-1) that has been selected for demonstrating the *in situ* treatment technology has a PCB concentration of approximately 2 ppm for 0-12 inch depth.

To collect baseline PCB distribution data for the test plots, pre-treatment assessments were conducted in December 2005, one month before activated carbon deployments. PCB concentrations for the top 6-inch sediment layer in four test plots were measured using five sediment cores collected from each plot. Sediment PCB concentrations for the test plots were similar to each other in the range of 1 to 2 ppm. Other sediment characteristics (TOC and BC) were also assessed, and further discussed in Section 5.3.

5 TEST DESIGN

The demonstration described in this section was performed in accordance with the demo plan[16] with the exceptions noted in Section 5.1. Points of contact involved in the demonstration are listed in Appendix B. A project organization chart is shown in Figure 5-1.

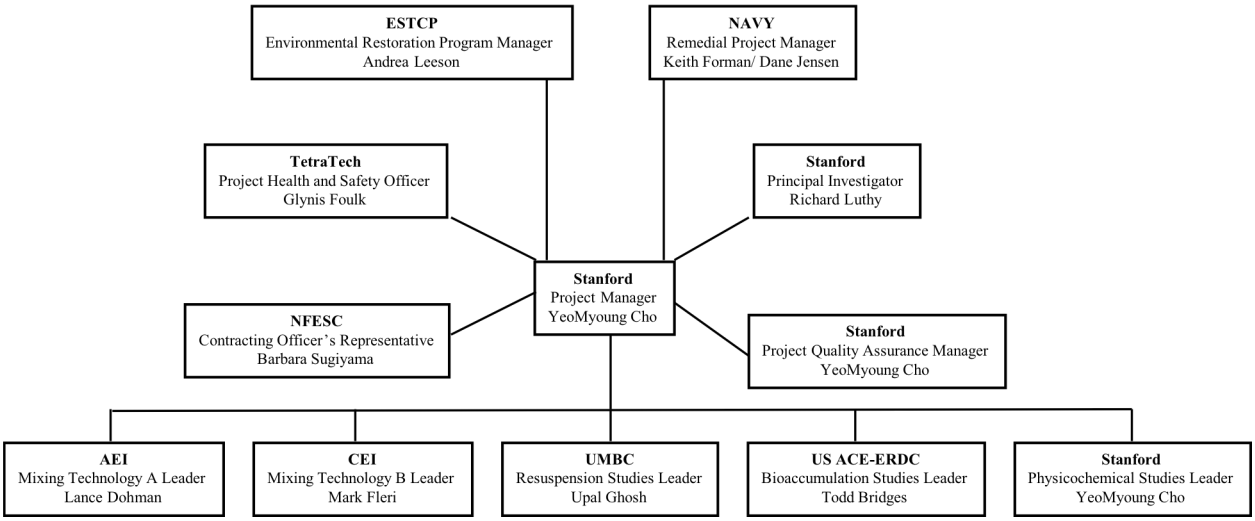


Figure 5-1. Organizational structure for the ESTCP demonstration project. (Current)

5.1 Deviations from the Demonstration Plan

At the end of January 2006, activated carbon treatments to the PCB-contaminated sediment were completed at our field site using equipment from our two subcontractors. We utilized Aquatic Environments' Aquamog and Compass Environmental's Injection System at Hunters Point Naval Shipyard to complete three of the four planned plot treatments: Plot C (Aquamog, Mix Only), Plot D (Aquamog, AC/Mix), and Plot F (Injector, AC/Mix). Unfortunately, we were unable to complete the mixing control for Plot G (Injector, Mix Only), since the sediment surface of this plot was not stable enough to support the excavator's weight. Therefore we assessed four test plots excluding Plot G, and Plot C was considered as a mixing control for both mixing technologies.

In the demo plan, we planned two post-treatment assessments: 6-months and 18-months after AC-deployment. In the actual demonstration, we additionally conducted 24-months post-treatment assessments comprising *ex situ* clam bioassays and characterizations of surficial sediment. The purpose of this additional assessment was to identify field factors occurring over 18- to 24-months that affect AC-amendment performance, and to confirm the benefit of AC-amendment to test organisms.

In the demo plan, we proposed to use same sampling locations for all post-treatment sampling events. However, to avoid altering the sediment layer by prior sampling events, the sampling locations at each post-treatment sampling event were differently selected based on a random sampling plan.

In addition to the analytical assessments proposed in the demo plan, we added two analytical methods to validate our results/findings. These include black carbon (BC) content measurements and C-13 isotope measurements in the treated sediment and the deposited surficial material.

In addition to the 28-day exposure experiments with the SPMDs, a long-term SPMD exposure study was conducted 13 months after AC amendment to investigate long-term exposure and the effectiveness of AC amendment. In these tests the SPMDs were deployed for as long as 7 months in the sediment.

Also, to complement the 28-day exposure experiments with the SPMDs, another passive sampler, polyethylene devices (PEDs), were used to obtain comparable field signals to those from SPMDs.

5.2 Conceptual Experimental Design

This project is designed to compare the effectiveness of two available large-scale mixing technologies, demonstrate that AC treatment reduces PCB release and bioaccumulation in field tests, and demonstrate that no significant sediment resuspension and PCB release occurs after the large-scale mixing technologies are employed. Four test plots of 370 ft^2 area were used in the field study. Two test plots were amended with AC using two different mixing devices respectively, one test plot served as a mixing control, and the other served as a non-mixing control. The four plots were analyzed using a combination of statistical tests, once before and thrice after treatment. The primary performance criteria that were used to demonstrate success of this innovative AC treatment technology are listed in Table 3-1.

5.3 Baseline Characterization

Baseline characterization was conducted one month before mixing the AC into the contaminated sediment. As summarized in Table 5-3, physicochemical and biological background properties of four test plots were assessed. Collectively, all four plots showed similar physicochemical and biological properties. Baseline sediment PCB concentrations in all four plots were similar (~1.1 ppm), and TOC values and BC values in the four plots were similar (~0.5 wt% TOC, ~0.002 g/g BC). Baseline PCB uptake for SPMDs, clam tissue samples, and amphipod tissue samples were similar across the four plots as well.

Each analysis method and results are described further in detail in Section 5 and 6 below.

5.4 Treatability or Laboratory Study Results

The effectiveness of AC amendment to reduce the chemical and biological availability of PCBs in sediment was demonstrated in various laboratory studies[6-9, 17-19] and in a preliminary field study[20]. We concluded from laboratory tests with benthic organisms that the efficacy of treatment depends on factors affecting the rate and extent of mass transfer of PCBs from sediment to the AC, notably: 1) the AC dose, 2) the AC particle size, 3) the extent and duration of AC mixing, and 4) the contact time between AC and sediment.

As a part of this project, laboratory physicochemical (aqueous equilibrium and SPMD) and biological tests on Hunters Point sediment amended with regenerated activated carbon (RAC) were completed to compare RAC's effectiveness (PCB stabilization) and toxicity to that for a virgin activated carbon (VAC) amendment. In all tests, RAC performed as well as, or better, than the VAC (Figure 5-2). Specifically, PCB bioaccumulation for *Neanthes arenaceodentata*

worms were reduced by 99+/-33% (RAC) and 91+/-53% (VAC); aqueous equilibrium PCB concentrations, 93+/-11% (RAC) and 85+/-6% (VAC); and SPMD PCB Uptake, 97+/-27% (RAC) and 66+/-7% (VAC). Survival rates for the *Neanthes* worms were the same for untreated, RAC-treated, and VAC-treated sediments. As expected from previous studies with VAC[5], growth rates for the *Neanthes* were similarly reduced by RAC (32%) and VAC (40%) in comparison to untreated sediment. The RAC sample (ACNS 8x30) used in this study was obtained from US Filter-Westates with an original size range of 600-2400 micron. This RAC sample was then reground and re-sieved at Stanford to obtain a 75-250 micron size range. Although this size range is similar to the 75-300 micron VAC (TOG 50x200) sample that was obtained from Calgon, this small difference in particle size may be one factor affecting the better performance of RAC compared to VAC given that AC performance depends on particle radius. It is also probable that the RAC samples contained on average more fine-sized particles than VAC samples despite the similar size range. Uptake kinetics are strongly dependent on AC particle size. Further research including particle size analysis for AC samples is needed to understand this phenomenon.

Based on the results of this study, we had decided to use RAC instead of VAC in the field treatments to save the treatment cost. The RAC would be purchased from US Filter Westates at a cost of $1.88/pound which includes costs for remilling, resieving, and repackaging their original product (ACNS 8x30 with 600-2400 micron size range, $0.45/pound) to our requested 75-300 micron size range (50x200). In comparison, the cost of virgin activated carbon (TOG 50x200) from Calgon was quoted as $2.49/pound. However, the use of RAC was hampered by a site-specific condition for the test sites at HPS. A concern of possible radiological contamination at the HPS South Basin site banned the addition of any material having a radioactivity signal larger than the site background values measured during a radiation survey, even though the area was eventually determined as uncontaminated. This restriction was unique to this site. For example, the restriction did not allow even the addition of new, clean sand material that has naturally occurring radioactive signal from potassium. One of our RAC samples slightly exceeded the very strict background limit due to naturally occurring material (probably inherent in the parent coal from which the activated carbon was derived), so we could not utilize the RAC.

The concern for background radioactivity was due to atomic weapons testing as part of Operations Crossroads after WW II. Naval vessels exposed to radioactive fallout from the atomic bomb tests in the Bikini Atoll were brought back to the Hunters Point shipyard to evaluate decontamination and the effects of nuclear weapons on Naval vessels. Though no radioactive waste debris has been found at the test site in South Basin, the site and all materials brought to the site continue to be screened for background radioactivity.

If a treatment site does not have this unusual issue, the use of RAC will provide more cost-effective treatment option.

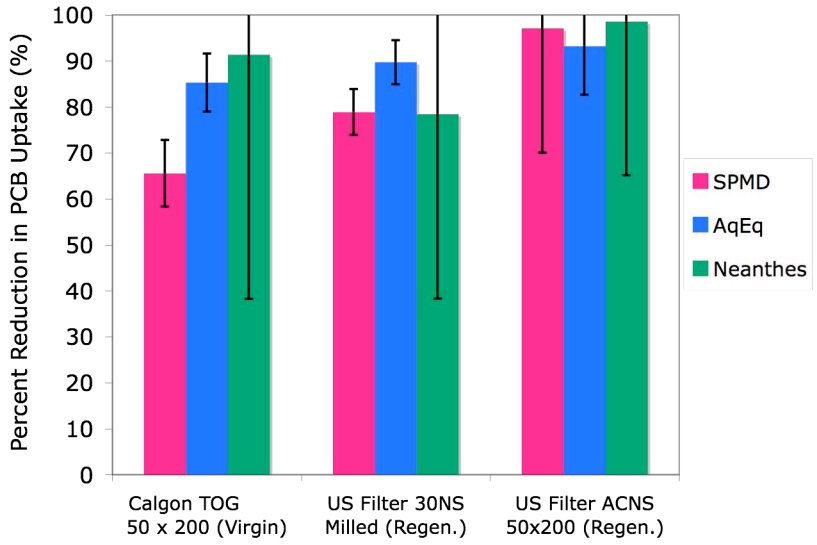


Figure 5-2. Laboratory results comparing virgin AC and regenerated AC treatments.

5.5 Field Testing

5.5.1 Demonstration Set-Up and Start-Up

Two contractors with equipment that can be used to deploy and mix AC into sediments in the field scale worked on this demonstration project. The equipment was used in three of the four plots as indicated in Figure 5-3. The AEI Aquamog was located on the western side of Plots C and D; while the CEI injector was located on the shore east of Plot F. The shapes of the plots were selected based on the mechanical movements of the mixing arms on each piece of equipment. As shown in Figure 5-3, the Aquamog has an arm that can mix a 6-foot swath and move in a radial fashion for Plots C and D; whereas the CEI injector arm can mix an 8-foot swath but can only move forward and backward on Plot F. The four plots have been located along a tide contour line in an attempt to ensure that the benthic communities that exist in these plots are similar. Preliminary sediment cores taken from the four plots indicated that the sediment has a similar texture across all four plots.

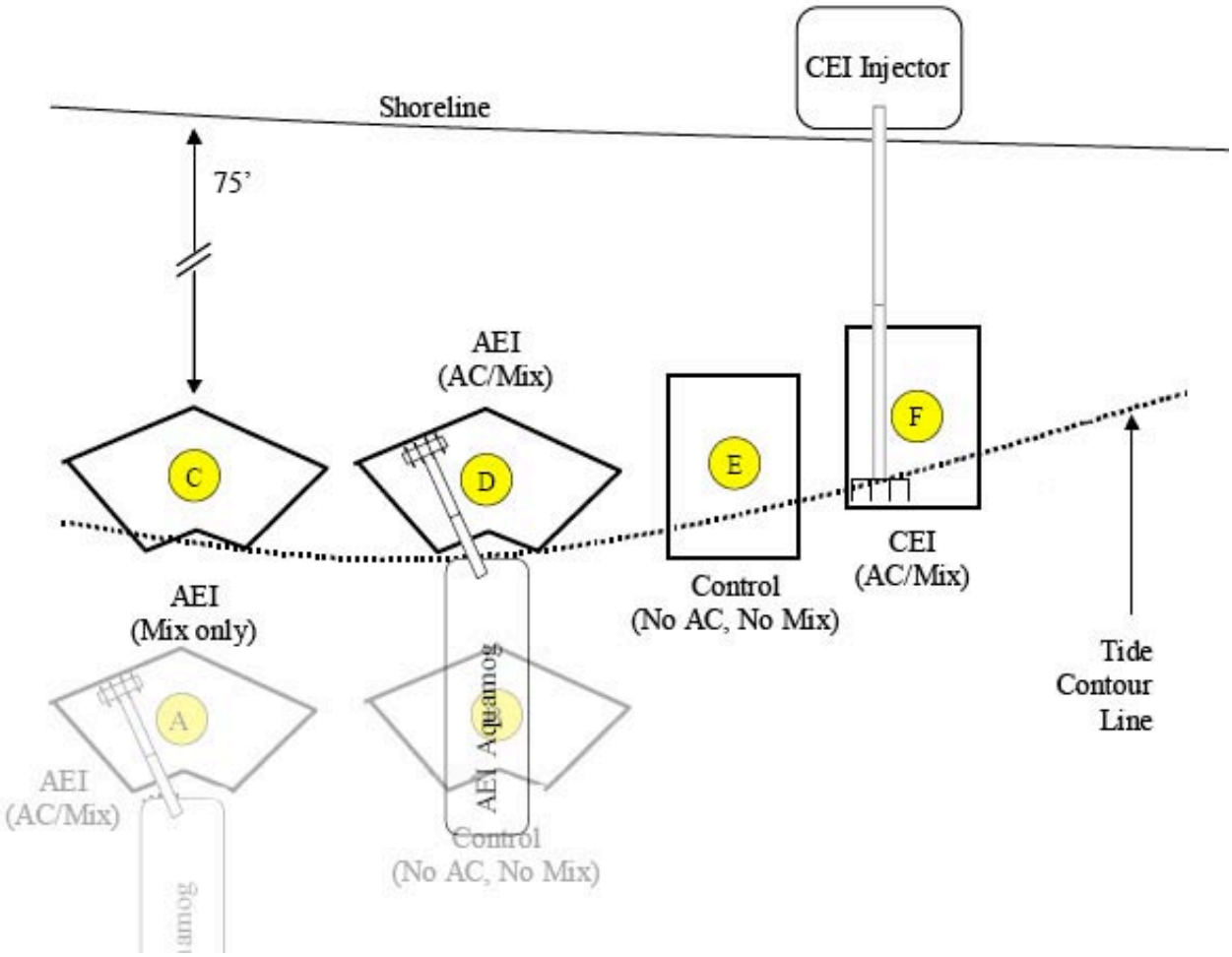


Figure 5-3. Schematic of ESTCP plots and mixing equipments

The first contractor, Aquatic Environments, Inc. (AEI), has a barge-like machine (called an Aquamog, Figure 5-4) with a rotovator attachment that is typically used to disrupt weed growth in marshy areas. In the field demonstration, AEI was responsible for the mobilization, storage, operation, and demobilization of the Aquamog to the Hunters Point Naval Shipyard field site in January 2006. The Aquamog was deployed on the water during high tide and allowed to settle onto the sediment surface at low tide to do treatments on Plots C and D. AEI supplied an ARGO amphibious support vehicle and any auxiliary equipment to the demonstration site that was necessary to complete the treatments. Before mobilization of the Aquamog, AC was manually deployed on the test plot. Besides delivering AC to the sediment surface, the Aquamog has a rotovator attachment that was used to mix transferred AC into sediments in Plot D to an approximate depth of one foot. The depth of the mixing was controlled by the speed and downward pressure of the rotovator. The rotovator attachment also was used to mix (only) the sediments in Plot C to a depth of one foot. Employees of AEI were responsible for the safe operation of all equipment. Operation of all equipment occurred under the supervision of a field project manager and/or AEI senior management.

Figure 5-4. AEI "Aquamog" with rotovator arm

The second contractor, Compass Environmental, Inc. (CEI) (formerly Williams Environmental Services, Inc.), owns an injection system used traditionally for sediment solidification with cement mortar (Figure 5-5). CEI provided its patented rake injector and other equipment necessary to support the treatments of Plots F. This equipment was located on the shore with the injector arm reaching out to Plot F. Via a slurry, AC was injected and mixed into the upper one foot of tidal zone sediments for Plot F. CEI provided the data necessary to demonstrate that the requisite carbon mass has been added to Plot F. CEI recorded data such as slurry flow rate, slurry density, pump time, and slurry volume pumped into each test plot. Employees of CEI were responsible for the safe operation of all equipment. Operation of all equipment occurred under the supervision of a field project manager and/or CEI senior management.

Both AEI and CEI provided their own Health and Safety Plans that was related to their work. Other personnel present at the site and involved in this specific project followed the Health and Safety Plan in Appendix C.

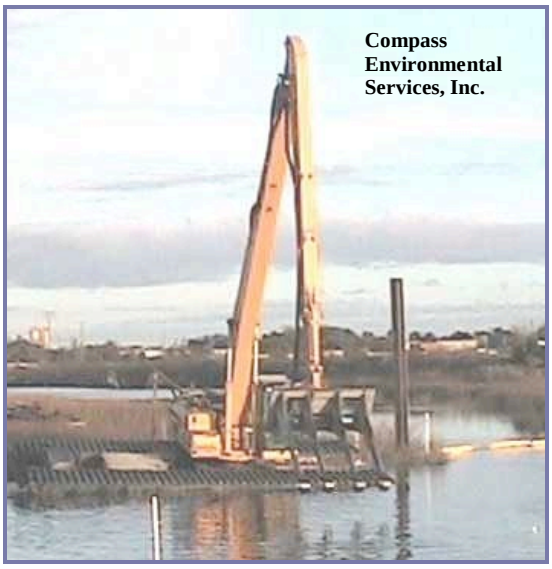


Figure 5-5. CEI Slurry injection system

5.5.2 Period of Operation

The demonstration was a three-year project. The schedule of milestones is provided in Table 5-2 in Section 5.5.8. The field activities started in December 2005 as planned. A detailed schedule of dates for the occurrence of the plot treatments and sampling events has been included in Appendix A.

5.5.3 Amount/Treatment Rate of Material to be Treated

The PCB contaminated sediments in Plots D and F were treated by applying approximately 3.4 wt.% dose of AC and mixing it into the sediment with the AEI Aquamog and CEI slurry injector system, respectively. The AC dose was applied to an approximate depth of one foot, a nominal depth containing the biologically active zone. Each plot is about 370 cubic feet in volume and required approximately 1250 pounds of AC. Therefore, a total of 2500 pounds of AC was required for this field study.

The dose of 3.4 wt.% activated carbon for the field demonstration was chosen based on the laboratory data presented in Figure 2-2. Though we have not tested greater doses in the laboratory, the trends in Figure 2-2 indicate that the effect of the activated carbon dose on clam tissue PCBs and aqueous equilibrium PCBs begins to level off at 3 to 4 wt.% AC dose. This AC dose-response has been tested in the sediment with low/mid PCB contamination (1-10 ppm) and varied natural TOC levels (0.5-5 %), showing similar responses with weak correlation to PCB level or TOC contents. Therefore, since we wished to maximize the effectiveness of the AC dose and minimize the costs of the AC, we believe that a 3.4 wt.% dose achieved this balance.

This AC dose was acceptable to regulators, as the laboratory tests at this dose showed reduced PCB uptake with no detrimental effects to test organisms.

5.5.4 Residual Handling

There are no residual handling issues for applying AC into the site sediment. The sediment and tissue samples from the demonstration activities were handled and disposed of by the selected analytical laboratories.

5.5.5 Operating Parameters for the Technology

The operating parameters for the AC treatment technology under field condition requires:

- a one-time treatment of AC into sediment with large-scale mixing equipment
- one skilled and experienced operator is needed to operate each large-scale mixing equipment, with another two people involved in support activities

The monitoring for the AC treatment technology consisted of the following sampling events:

- one pre-treatment sampling event at t = -1 month
- three post-treatment sampling events at t = 6 months, 18 months, and 24 months

Sampling and analyses were conducted before and after AC application in a set schedule as presented in Table 5-1 in Section 5.5.6. Dr. Richard G. Luthy (Principal Investigator) of Stanford provided the primary technical oversight to the project. Ms. Yeo-Myoung Cho (Project Manager) coordinated activities of the project between the project teams. AEI and CEI were responsible for their respective sediment and AC mixing tasks. Stanford, United States Army Corp of Engineers - Engineer Research and Development Center (USACE-ERDC), and University of Maryland Baltimore County (UMBC) were responsible for field sampling from the test plots. Ms. Yeo-Myoung Cho served as Project Quality Assurance Manager and coordinated field activities and laboratory analyses for Stanford.

5.5.6 Sampling Plan

The schedule of plot sampling and analysis is summarized in Table 5-1. A detailed schedule of dates for the occurrence of the plot treatments and sampling events is shown in the Appendix A.

Table 5-1. Schedule of plot sampling and analysis

Months Since Treatment (t)	Sampling Description
	Pre-Treatment Sampling
t = -1.5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide. • Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC and sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = -0.5	• Remove clams for PCB congener analysis. • Remove SPMDs for PCB congener analysis.
	Mixing and AC Treatments
t = 0	• Apply various treatments to three of the four plots.
	Post-Treatment Samplings
t = 0.05	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.
t = 5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.

Months Since Treatment (t)	Sampling Description (continued)
	Post-Treatment Samplings
t = 5.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 6.5	• Remove clams for PCB congener analysis. • Remove SPMDs for PCB congener analysis.
t = 17.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 18.5	• Remove clams for PCB congener analysis. • Remove SPMDs for PCB congener analysis.
t = 24	• Take five, six-inch diameter six-inch length sediment core samples in the four plots for *ex situ* clam bioassay and analysis of TOC, BC, C-13, sediment PCB concentrations, and aqueous equilibrium PCB concentrations. • Take five top 5 mm (1/8 inch) sediment samples for analysis of TOC, BC, C-13, sediment PCB concentrations, and aqueous equilibrium PCB concentrations.

5.5.7 Demobilization

AEI and CEI were responsible for demobilizing their respective mixing devices after the treatments occurred. Stanford, ERDC, and UMBC were responsible for removing any sampling equipment that was used in the test plots. All equipment and sampling devices used in the contaminated sediments were subjected to a radiation screen prior to decontamination. Decontamination of mixing devices and sampling equipment occurred on site at decontamination pads that have been installed by the Navy.

5.5.8 Demonstration Schedule

The key tasks and the proposed timeline are shown in Table 5-2. Development of a draft Demonstration Plan was done in cooperation with NAVFAC in April and May 2005, as we did in Fall 2004 for the Treatability Study Work Plan for Hunters Point Shipyard Parcel F.[14] The draft Demonstration Plan was submitted in July 2005 to ESTCP for first review. At the end of August 2005, the Demonstration Plan was revised based on ESTCP comments and resubmitted for ESTCP's second review. The Demonstration Plan went out in early September 2005 for review by area regulatory agencies such as the Environmental Protection Agency (EPA) Region 9, California Department of Toxic Substances Control (DTSC), San Francisco Regional Water Quality Control Board (SFRWQCB), San Francisco Public Utilities Commission and Department of Public Health, and National Oceanic and Atmospheric Administration (NOAA). The regulatory agencies' comments were addressed and the Demonstration Plan was sent to ESTCP for final review and approval at December 2005. Pre-AC treatment sampling took place in December 2005, with plot treatments occurring in January 2006.

In addition to the Demonstration Plan document, monthly financial and quarterly progress reports to ESTCP were prepared. All data analyses for pre- and post-treatment samples have been completed in September 2008, drafts of the Final Report and Cost & Performance Report were prepared for a December 2008 submission. Review and approval of these reports should be complete by January 2009.

Table 5-2. Demonstration Schedule (updated from the demo plan)

TASK		2005			2006				2007				2008				2009
	Quarter (1=Jan-Mar, 2=Apr-Jun, etc.)	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1
1	Preparation of draft Demonstration Plan	■	■														
2	Review and approval of final Demonstration Plan		■	■													
3	Deployment of carbon treatments in the field				■												
4	Assessment of sediment and PCB resuspension			■	■						■						
5	Biological monitoring of treatment units			■							■		■				
6	Physicochemical monitoring of treatment units			■							■		■				
7	Financial and Progress reporting to ESTCP	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
8	Technology cost assessment and transition pentia														■	■	
9	Preparation of draft Final Report and Cost & Perfomance Report														■	■	
10	Review and approval of final FR and C&P Report																■

5.6 Sampling Methods

This project was designed to compare the effectiveness of two available large-scale mixing technologies, demonstrate that AC treatment reduces PCB release to pore water and PCB bioaccumulation in field tests, and evaluate sediment resuspension and PCB release to overlying water. To achieve these objectives, four test plots of 370 ft^2 area were used in the field study and analyzed once before and thrice after treatments were applied. Various treatments were applied to three of the four plots as shown in Figure 5-3, leaving one plot (Plot E) to serve as a reference plot (a non-mixed control). Plot C was treated by mixing the sediment with the Aquamog rotovator, but without applying AC. Plots D and F were treated by applying a approximately 3.4 wt.% AC and mixing it into the sediment with the Aquamog and CEI slurry injector system, respectively. The AC dose was applied to an approximate depth of one foot, corresponding to a nominal depth including the biologically active zone. A variety of samples were taken once before and thrice after treatments were applied, as outlined in the schedule in Table 5-1 in Section 5.5.6. The pre-treatment samples were used to obtain baseline data.

In each of the four plots, five sampling locations had been selected using a stratified random sampling strategy. This sampling strategy ensures that the sampling locations are more evenly dispersed within each plot (that is, as opposed to spatially aggregated, which could occur if simple random sampling was used), and meet the criterion of random sampling so that statistical tests can be applied during data analysis. To obtain the five stratified random sampling locations for a given plot, each plot was divided into five equal sub-areas containing the same number of possible sampling locations. The outside 3-foot edge of the plots was not included in the selection process to ensure that the sampling locations are located within the actual treatment area. In each sub-area, a random sampling location was selected. The resulting sampling locations are shown in Figure 5-6 for each plot. Sampling locations at each post-treatment sampling event were differently selected to avoid sampling in obviously disturbed locations. The total number and types of samples obtained from each plot at each sampling time point is listed in Table 5-3and Table 5-4 and illustrated in Figure 5-7 and Figure 5-8.

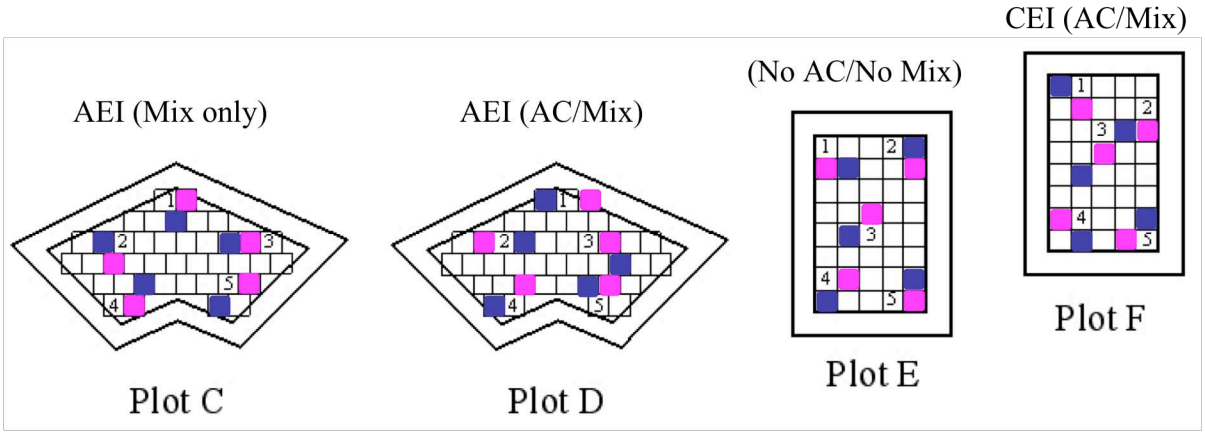


Figure 5-6. Schematic of the five sampling locations in each plot at each sampling event. These locations were selected through stratified random sampling in both plot shapes. The outside edge of the plots was not included in the selection process to ensure that sampling locations are located within the actual treatment area. Each block has area of 2 feet by 2 feet. Numbered blocks: sampling locations at t = -1, and 6 months. Blocks in pink: sampling locations at t = 18 months. Blocks in navy: sampling locations at t = 24 months. Plot C is a control plot and Plot E is a reference plot.

Table 5-3. Number of Samples Obtained from Each Plot at Sampling Time Points t = -1, 6, and 18 Months.

Field Sample Type	Sample Analyses	Sample Amount	Number
Clam Tissue	PCB concentration	composite of 6-7 clams	5 (each composite will be split between ERDC and BDO)
Amphipod	PCB concentration	minimum 200 mg composite	5 (each composite will be split between ERDC and BDO)
SPMD	PCB uptake	Each	5
Sieved Quadrat	Benthic Community	Each	5
Sediment Core	TOC	1 g	30
Sediment Core	Sediment PCB concentration	5 g	5
Sediment Core	Aqueous Equilibrium PCBs	30 g	5
Sediment Core	PCB desorption characteristics	100 g	2
Sediment Core	BC	1 g	2
Overlying Water[1]	Dissolved PCBs	XAD column	2
Overlying Water[1]	Particulate PCBs	Filter	2

[1]Overlying water samples were collected at t=-1 month, and immediately after treatment on the next tidal cycle, and at t=6 months.

Table 5-4. Number of Samples Obtained from Each Plot at Sampling Time Points t=24 Months.

Field Sample Type	Sample Analyses	Sample Amount	Number
Sediment Composite	*Ex situ* PCB bioaccumulation in clam tissues	composite of 6-7 clams	5 (each composite will be split between ERDC and BDO)
Sediment Composite	TOC	1 g	3 (analytical replicate)
Sediment Composite	Sediment PCB concentration	5 g	3 (analytical replicate)
Sediment Composite	Aqueous equilibrium PCBs	30 g	3 (analytical replicate)
Sediment Composite	BC	1 g	3 (analytical replicate)
Sediment Composite	C-13 isotope	1 g	3 (analytical replicate)
Surficial Sediment	TOC	1 g	5
Surficial Sediment	BC	1 g	5
Surficial Sediment	Sediment PCB concentration	5 g	3 (analytical replicate)
Surficial Sediment	Aqueous equilibrium PCBs	30 g	3 (analytical replicate)
Surficial Sediment	C-13 isotope	1 g	3 (analytical replicate)

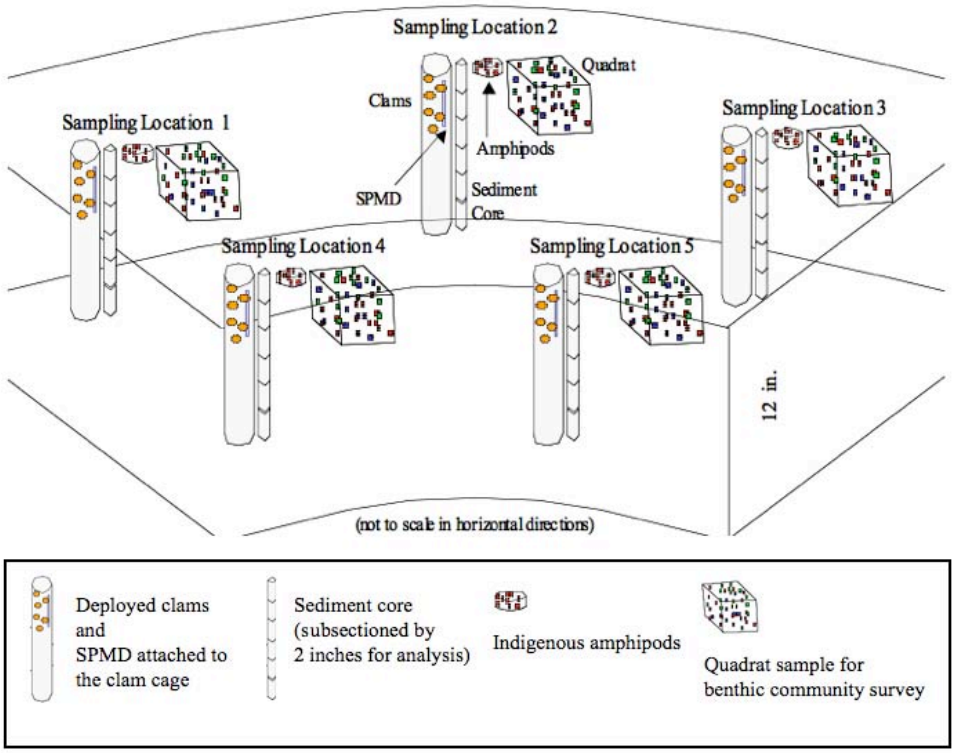


Figure 5-7. Schematic of Samples to be Taken From Each Plot at Sampling Time Points t = -1-Month Pretreatment, and 6- and 18-Months Post-treatment.

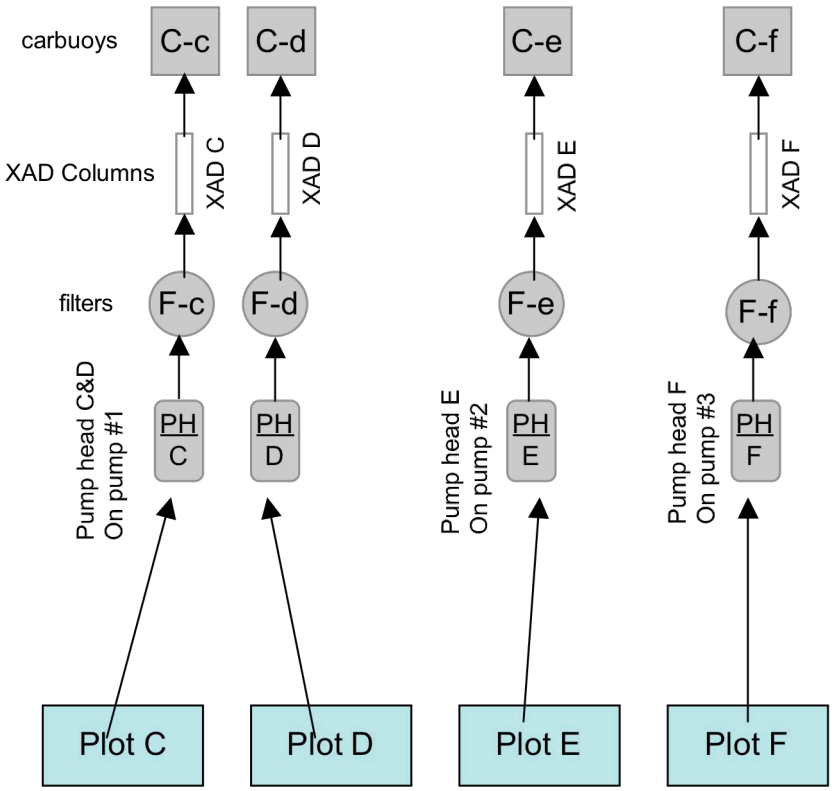


Figure 5-8. Schematic of Sampling of Overlying Water Samples from Each Plot. Duplicate Samples Were Collected from Each Plot in Sequence at Each Sampling Time Point.

Figure 5-9. Field Samples. A) Clams, B) Amphipods, C) Sediment cores, D) Overlying water, E) SPMDs, and F) Quadrats

***In situ Macoma nasuta* studies.** To measure *in situ* PCB bioaccumulation in the field, six to seven *Macoma nasuta* clams with shell length between 1.00 and 1.25 inches were deployed into each of mesh-covered 6-inch diameter PVC tubes deployed in four test plots (Figure 5-10 and Figure 5-9 a). Clams were deployed at three field assessment events: pre-treatment, and 6-months and 18-months after AC amendment. *Macoma nasuta*, a native bivalve to San Francisco Bay, was obtained from Dillon Beach, CA (Aquatic Research Organisms, Hampton, NH, USA). Clams were placed on the top of the sediment, inside the cages, and allowed to burrow. After 24 hours, unburrowed clams were replaced. After a 28-day exposure, clams were retrieved by scooping out the sediment in the cages, separating from the sediment and rinsing with site water, and then placed in polyethylene containers and carried to the laboratory for tissue preparation. The clams were purged in clean sediment (Palo Alto Baylands Nature Preserve sediment, Palo Alto, CA) for 48 hours and then in synthetic seawater (Red Sea Salt, Red Sea, Houston, TX) with salinity of 30 ‰ for 24 hours at 15 °C before sacrificing. Each clam was shucked, and the resulting whole tissue was placed in separate scintillation glass vials and frozen at -80 °C before homogenization.

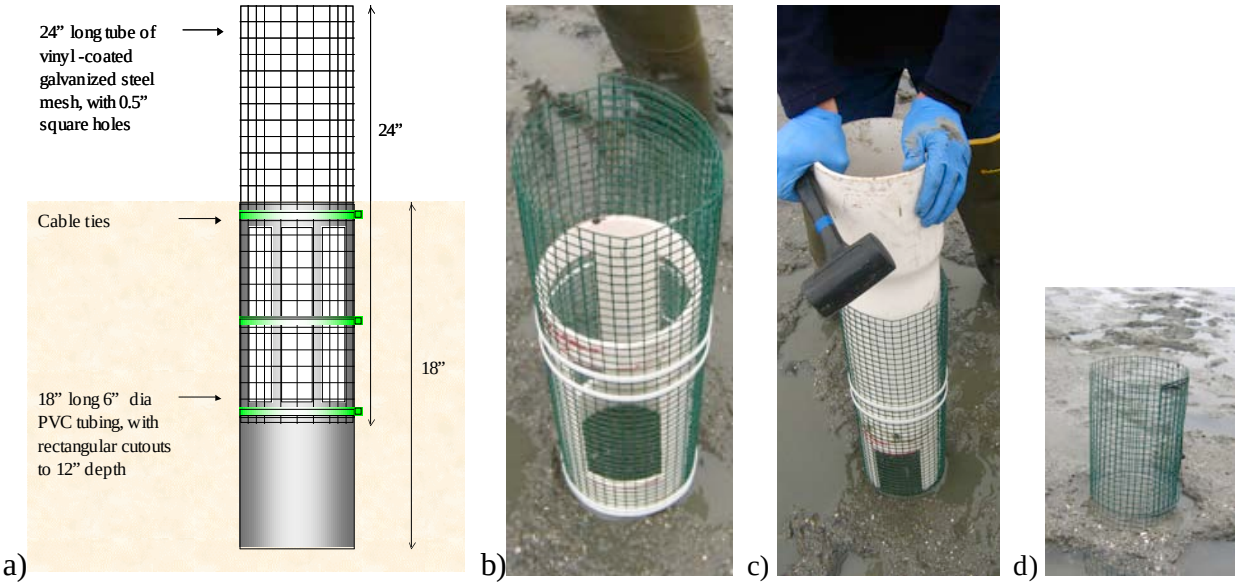


Figure 5-10. a) Schematic of Clam Tube, and b-d) Pounding Clam Tube in Sediment

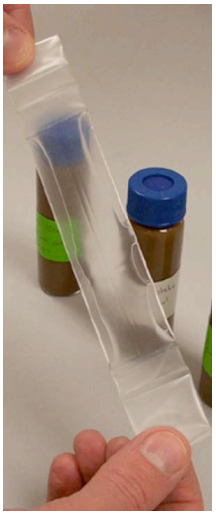
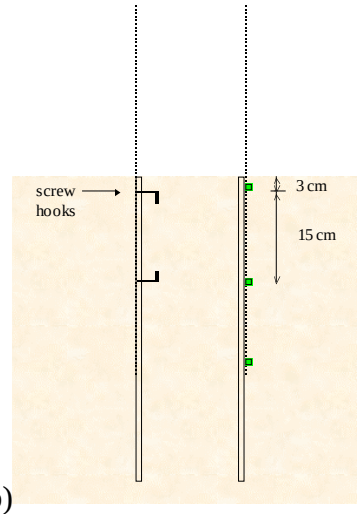
***Ex situ Macoma nasuta* studies (24-month post-treatment assessment).** Sediment samples were collected 24 months after AC-treatment from each test plot at five randomly selected sampling locations (0.5 ft^2). Sediment was collected using a stainless steel shovel to a depth of 6-inches. Five sediment samples from each plot were composited and sieved with 4 mm stainless steel mesh screen (OSH, Mountain View, CA) on-site to remove large shells and coarse sand material. The sediment composite was transferred to clean 5-gallon buckets and stored at 4 °C until further processing. *Macoma nasuta*, obtained as previously described, were received 72-hours prior to test initiation and acclimated to laboratory conditions in 20-gallon aquaria containing collection site sediment and aerated in 30 ‰ Instant Ocean Seawater (Aquarium Systems, Mentor, OH). Sediment from each field plot was homogenized with an impellor mixer (Lightnin, ND-1A 115V, Rochester, NY) for five minutes to consistent texture. Homogenized sediments were layered into each of five replicate, five-gallon aquaria (> 4 cm depth) for each test plot (t = 4, n = 5) and overlying water (30 ‰) was gently added using a turbulence reducer and allowed to equilibrate overnight. The remaining sediment was used for chemical assessments. Ten clams were added to each test chamber; clams that failed to burrow after 24-h were replaced. The exposure was conducted for 28-days at 15 ± 1 °C with monitoring of water quality parameters (temperature, pH, D.O., salinity, and ammonia) and 70% water exchanges three times per week. Following the 28-day exposure, the clams were removed from the test sediments and allowed to purge their guts by placing each individual into 250 ml beakers containing 200 ml reference sediment (obtained from the site of clam collection) for a 48-hour period, followed by transfer to clean seawater in aquaria for an additional 24-hour period. Clams from each replicate were counted for overall survival, shucked, rinsed in deionized water and frozen at -80 °C for further processing. Following homogenization, the tissue was analyzed for PCBs, lipid, and moisture content. Clams failing to burrow during the gut-purging period were not included in the analysis.

***In situ* amphipod residues.** Five replicate samples of amphipod tissue were collected from each field test plot at three field assessment events: pre-treatment, and 6-months and 18-months after AC amendment (Figure 5-9 b). Surficial sediments (approximately top 3 cm) were collected

using a stainless steel trawl within the quadrant, stored in plastic sealable containers and transported to the laboratory in a cooler. Seawater was then added to the sediment and swirled vigorously, inducing amphipods to swim to the surface, where they were collected into small fish nets or sieves. *Corophium* spp and *Grandidierella japonica* were visually separated from other macroinvertebrates and transferred to clean, aerated 30 ‰ seawater for 24-h to allow gut purging at 15 ± 1 °C. Amphipods were then removed from the seawater to blotting paper and approximately 80 – 120 mg of amphipod tissue was transferred to 20 ml glass scintillation vials with Teflon lids, and frozen for analysis of tissue residues.

***In situ* SPMD/PED uptake.** Semipermeable membrane devices (SPMDs) are bio-mimetic passive samplers and were used to obtain a supporting *in situ* PCB uptake signal to compare with *M. nasuta*. Custom-made 10 cm-long SPMDs containing 0.1 g triolein, with two outer loops (EST, St. Joseph, MO) were attached vertically on two metal hooks located on the inside of the clam cages before clam cage deployment and then deployed with the clam cages (Figure 5-11 and Figure 5-9 e). Five SPMDs, one SPMD per clam cage, were deployed in each plot at each assessment point at a vertical depth spanning 1 - 5 inches. After 28 days exposure, SPMDs were retrieved, rinsed with DI water, and transferred into pre-cleaned glass jars and shipped to the laboratory and stored at 4°C. For the time series deployment, six SPMDs were attached to a 10x30 cm rectangular frame made of stainless steel tubing and deployed into Plots C and D within a 6-inch depth. Two SPMDs from each sampling frame were retrieved 97, 140, and 224 days later.

Polyethylene devices (PEDs) are recently introduced alternative passive samplers to SPMDs. The uptake of PCBs by PEDs is analogous to passive uptake by SPMDs, as PEDs are simply SPMDs without the inner lipid layer. PEDs are advantageous due to their simplicity and that they may come to equilibrium faster than SPMDs[21]. PEDs were deployed in the four plots (C, D, E, and F) at five randomly assigned locations for 28-day studies. For the deployment at pretreatment and 6 months post-treatment assessment, PEDs were constructed by cutting pre-cleaned PE into 14.5 cm^2 circles and attaching the PE to circular frames made of coated wire. The PEDs were placed horizontally in the sediment at depth of 15 cm. For sampling 18 months after amendment, pre-cleaned PE strips were impregnated with performance reference compounds (PRCs), PCB 29 and PCB 69, at levels measured by field blanks. PEDs were constructed by horizontally attaching one PRC-spiked PE strip (3.8 cm wide) to a stainless steel frame (10 cm by 30 cm). The frames were placed at a depth of 5-15 cm. Upon retrieval, the PE strips were cut in half before extraction, creating a total of ten replicates per plot. Use of PEDs and performance reference compounds are described in Tomaszewski and Luthy [21].

a)  b) 

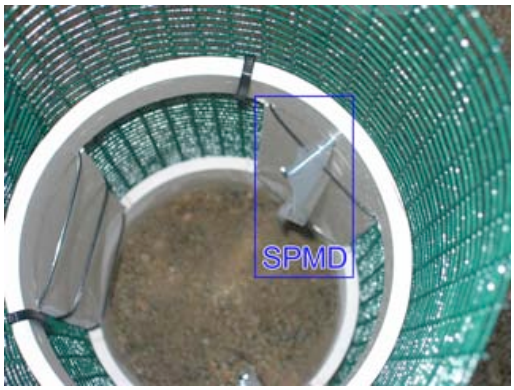
c) 

Figure 5-11. SPMDs (a) were mounted onto screw hooks (b & c) inside of clam tubes.

Sediment core sampling. To assess physicochemical conditions, five sediment cores with a minimum depth of 1 ft were taken from each test plot using 2-inch-diameter, 3-ft-long cellulose acetate butyrate core liners (Wildlife Supply Company, Buffalo, NY, USA) (Figure 5-9 c). After sampling, capped sediment core liners were stored at 4 °C until further processing.

Sediment core processing (Figure 5-12**).** One-foot long sediment core samples were divided into six cross sections of 2-inch lengths. Each cross section was homogenized by stirring manually with a stainless-steel spatula. Approximately 1 g of sediment was then sub-sampled for total organic carbon (TOC) analysis. After TOC samples were collected, the remainder of the top three cross sections from each core was recombined and homogenized and a 10-g sub-sample taken for sediment PCB concentration measurement, a 30-g sub-sample for aqueous equilibrium PCB concentration measurement, and 100-g sub-sample for PCB desorption tests. For the desorption test, a total of five 100-g sub-samples from each plot were combined and homogenized to give one composite sample per plot. The composite sample was also used to determine black carbon (BC) content.

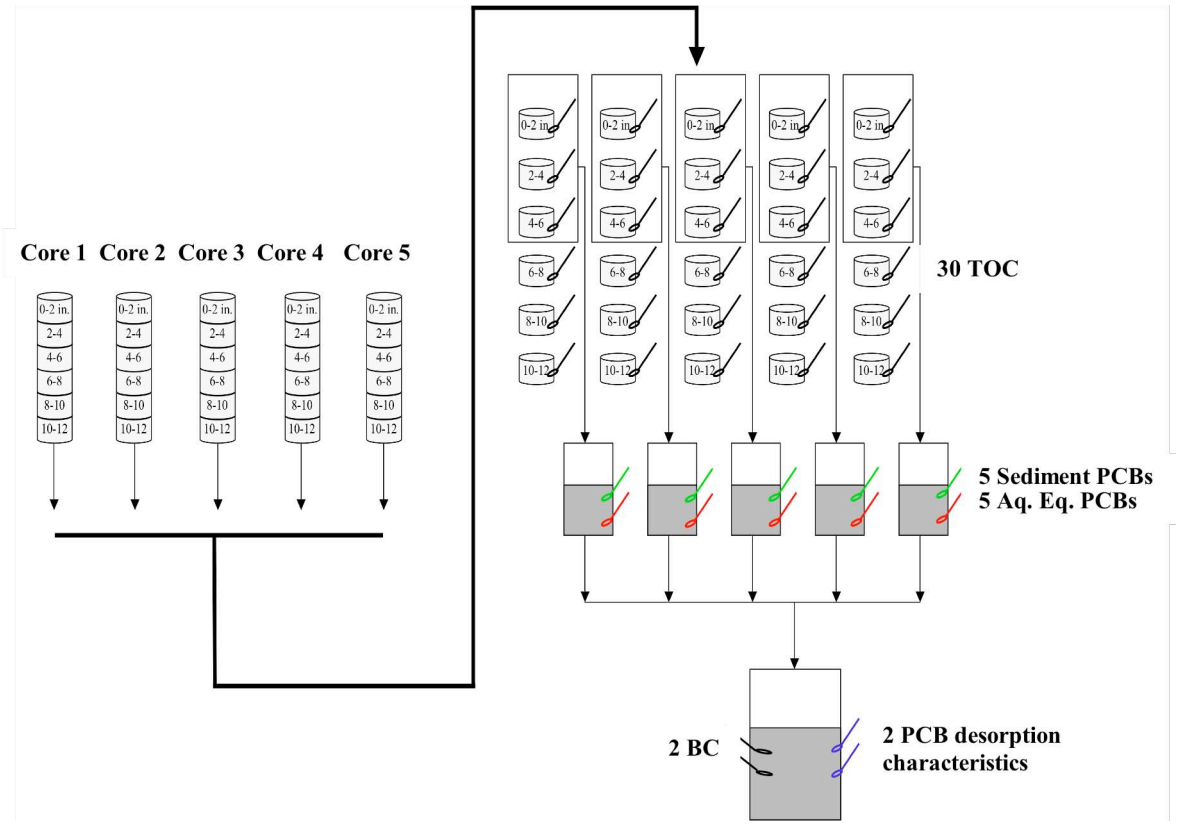


Figure 5-12. Schematic of Core Sampling in Each Plot.

Benthic community assessment. Benthic macroinvertebrates were collected by extracting 0.15 m diameter by 0.15 m deep cores using PVC tubing (Figure 5-9 f). Five replicate cores were sampled from each plot at each sampling event. Each core was vertically sectioned in intervals of 0-0.05 m, 0.05-0.10 m and 0.10-0.15 m. Samples were sieved over a 500 μm sieve using site water; the material retained on the sieve was fixed in 4% formalin containing Rose Bengal stain. After shipping, samples were then transferred to 70% ethanol for longer-term storage. The 0 – 0.05 m depth samples were sorted and enumerated to the lowest practical taxonomic designation using dissecting microscopes according to available keys [22, 23]. Samples from 18-month post-treatment were subsampled (quartered) using a Folsom Plankton Splitter (1831-F10, Wildco, Buffalo, NY, USA) following sorting due to the large number of macroinvertebrates present in the samples.

Sediment assessments (24-month post-treatment assessment). The composite sediment for the *ex situ* tests was analyzed for total organic carbon (TOC), black carbon (BC), carbon-13, aqueous equilibrium PCB concentration, and sediment PCB concentration. From the homogenate, three analytical replicates for each analysis were sampled. To investigate the possible deposition of newly-introduced materials on the test plot surface, surficial sediment was collected from the top 1/8 inch at each test plot. Twenty-four months after AC treatment, surface sediment was carefully scraped by a stainless steel sampling blade at five randomly selected sampling locations from each test plot, and transferred in to pre-cleaned glass jars. The sediment was dried and homogenized by mortar and pestle, and approximately 2-g portions of dry sediment were removed for determination of TOC, BC, and C-13 isotope content. The five

sediment samples were combined into one composite sample for triplicate PCB measurements and aqueous equilibrium measurements. TOC, BC, aqueous PCB, and sediment PCB analytical procedures are described in Cho et al.[20] Carbon-13 isotope signals were measured simultaneously with TOC using an element analyzer coupled with an isotope ratio mass spectrometer (Thermo Finnigan Delta Plus continuous flow stable isotope ratio mass spectrometer, Carlo Erba NA-1500 elemental analyzer).

Statistical analysis. Two-sided Student's t-tests were performed to determine statistically significant differences between two data sets for clam PCB tissue residues, SPMD uptake, TOC, BC, C-13 isotope content, aqueous equilibrium PCB concentration, and sediment PCB concentration using R software (available at http://www.r-project.org/). Statistically significant differences among multiple factors (i.e., sampling dates and treatment plots) for amphipod PCB tissue residues and benthic indices were conducted by two-way analysis of variance (ANOVA) and multiple comparisons were conducted by the Tukey test (SigmaStat, SSPS, Chicago, IL). Univariate metrics of the community data involved measurement of single parameters including total abundance (total numeration of all macroinvertebrates), total taxa richness (total number of different types of macroinvertebrate taxa), relative abundance, and Shannon Index of Diversity (diversity considering species number and evenness of species). Community species composition was analyzed by multivariate statistical methods including Hierarchical clustering, Non-Metric Dimensional Scaling (NMDS) and Multivariate Dispersion (MVDSP) and analysis of similarity (ANOSIM). Clustering and ordination were performed on transformed ($\log_{(10)}$ +1) data using the Bray Curtis similarity index. All techniques were preformed using PRIMER statistical software following interpretive guidance found in Clarke and Warwick [24].

Water column sampling. To investigate possible PCB release into the overlying water column by either AC amendment or mechanical mixing, overlying water above the four plots was sampled simultaneously before treatment and soon as the high tide began to cover the plots after the mixing or treatment with AC (Figure 5-9 d). The procedure was adapted from the surface water sampling method used in the EPA Lake Michigan Mass Balance Study [25] as described by Cho. et al. [20] The inlet of the sampling tube was anchored 0.5 ft above the sediment surface in the center of the test plot and submerged under water during high tide. The method involves pumping the water through a pre-combusted glass fiber filter paper with a nominal pore size of 0.7 microns to capture suspended particles, followed by passing the filtered water through a pre-cleaned XAD-2 resin adsorbent column to trap dissolved PCBs. Up to 40 L of water was taken per sample from the field for duplicate analysis. The filters and resins were stored at 4 °C until analysis.

Total organic carbon (TOC) analysis. TOC sediment samples were dried and ground into fine powder using an agate mortar and pestle. Duplicate samples with approximately 4 mg of weight were taken from those samples and weighed into a silver sample capsule. 100 µl of 6% sulfurous acid was added twice into the capsule to remove carbonate phases [26]. Each sediment sample was dried at 50 °C overnight and submitted to element analysis for TOC contents using a Carlo Erba NA-1500 elemental analyzer. Carbon analysis errors were <0.5% based on an acetanilide standard (71.1 wt.% C). AC dose was calculated using a relationship between sample TOC and that for AC (TOC = 86.1 %) [20, 27]:

$$AC = (TOC - TOC_0) / (86.1\text{-}TOC) \quad (1)$$

Where AC is the amount of added AC (g/g), TOC is the measured TOC values after AC addition, TOC_0 is the measured TOC values for Plot C (control).

Black carbon (BC) analysis. Black carbon (BC) measurement of sediment samples was performed by a wet chemical oxidation method using a solution of sulfuric acid and potassium dichromate [28] in which organic carbon derived from plant and biological matter is oxidized to carbon dioxide while BC is preserved. The carbon remaining in the sample is measured by the amount of carbon dioxide produced when the sample then is combusted in oxygen at 900 ^{o}C. To derive AC values from the BC measurement, a sediment sample with no AC (Site C top 6 inch) was spiked with 0%, 2.5% and 5% AC. BC isolation and measurement was then performed on the standard samples. A calibration curve was generated from the data (R^2=0.9992, p<0.0001) and used to convert BC measurements to corresponding values of AC in the sample (Figure 5-13).

$$AC = (BC - 0.0022) / 0.7128 \quad (2)$$

where AC is the amount of added AC (g/g dry sediment), and BC is the measured BC (g/g dry sediment), and 0.0022 is the background BC content in the test plot.

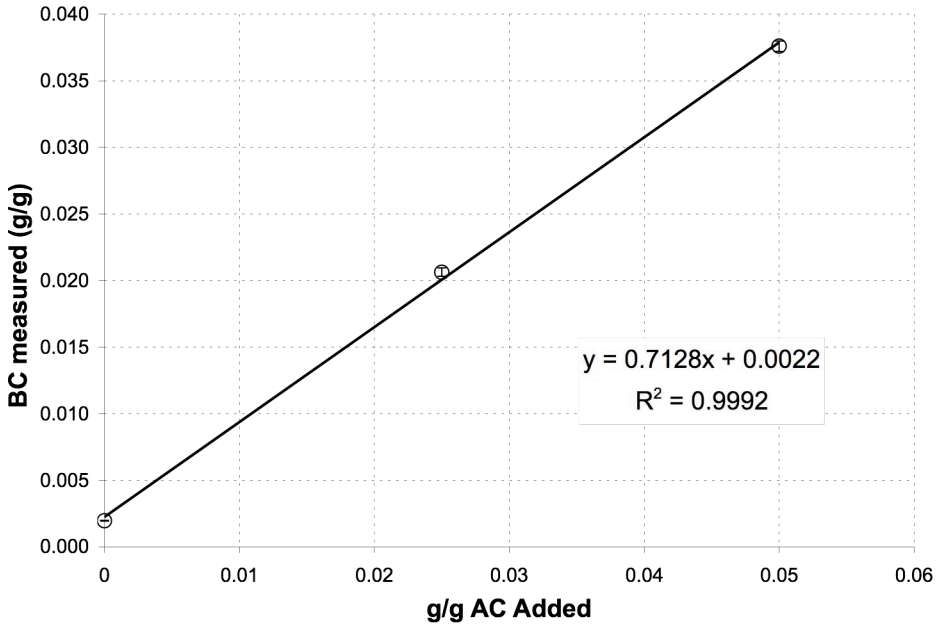


Figure 5-13. Calibration of AC versus BC measurement.

Sediment extraction. Sediment sub-samples were dried and ground into fine powder. Approximately 3-g of dry sediment were weighed into a 50 ml beaker. Surrogate PCB standards, PCB-14 and PCB-65 were spiked into the sediment. Sediment samples were extracted three times with sonication in a 50% acetone and 50% hexane mixture, following a procedure based on EPA Method 3550A. The solvent phase was exchanged into 100% hexane, and concentrated before clean up.

SPMD/PED extraction. SPMDs with end loops removed were cleansed by rinsing with deionized water; swirling for 30 s in 1 M hydrochloric acid; rinsing first with deionized water,

then acetone, and finally isopropyl alcohol; and air-drying for 30s. The SPMDs were next submerged in 125 ml of hexane and dialyzed at room temperature for 24 h. The dialysate was removed, and dialysis with 125 ml of fresh hexane was repeated for 8 h. Dialysates were combined, the total volume recorded, and aliquots taken for cleanup. The PED extraction procedure and surrogate recovery is described in Tomaszewski and Luthy [21].

Aqueous equilibrium. Equilibrium distribution of PCBs between sediment and aqueous phases was measured by placing approximately 30 g of activated carbon-treated or untreated wet sediment in 780 mL glass bottles with 31 ‰ seawater and 1 g/L sodium azide (Extra Pure, EMD) to inhibit microbiological growth. The bottles were capped with Teflon-lined caps, shaken, and rotated at approximately 2 rpm on a roller for 14 d, after which the sediment/water mixture was allowed to settle and the supernatant cleared of any floating particles with a Pasteur pipette. Colloids were removed using a flocculation procedure described previously [3]. PCBs were extracted from the aqueous phase three times with 40 mL of hexane. The extract was combined with rinses, and concentrated by a nitrogen blowdown apparatus.

Desorption. PCB desorption characteristics of subsamples from a homogenate of sediment cores from each plot followed previously published methods [4].

PCB congener analysis. Frozen clam tissues from *in situ* and *ex situ* bioassays were combined per each sampling location or replicate. Each set of clams was thawed and combined into a stainless steel mortar set in a bath of liquid nitrogen. Using a pestle, the combined tissue sample was pulverized and homogenized until ground into a fine powder. A 0.5-g aliquot was removed for dry weight determination and a 0.1-g aliquot was removed for lipid weight determination. The remaining portion was used for PCB congener analysis following U.S. EPA SW846 methodology and extracted according to method 3545 using accelerated solvent extraction with an Agilent 5890 gas chromatograph and electron capture detection. Tissue residues of indigenous amphipods were analyzed as described in Millward et al. [5] and Jones et al. [29] Lipid analysis was modified from Van Handel [30], as described in Millward et al [5]. Total 134 congeners or congener groups can be identified and quantified using this protocol. Co-eluting PCB congener peaks were calibrated as a sum of congeners. Only congeners with all data replicates above MDL were analyzed and summed to give a total PCB level.

The extract from physicochemical analyses (sediment PCB, aqueous equilibrium PCB, desorption, resuspension, SPMD, and PED uptake) was cleaned following a two-step cleanup procedure. First, sulfur interferences were removed by contacting with activated copper following EPA SW846 Method 3660A. Second, organic interferences were removed using a deactivated silica gel (3% moisture) column following EPA Method 3630C. PCB congener specific analysis was performed using a modified EPA Method 8082. An Agilent gas chromatograph (model 6890) with a fused silica capillary column (HP-5, 60 m x 0.25 mm ID) and a micro electron capture detector were used for analysis. A 5-level PCB calibration table was prepared using a known PCB mixture containing 250 µg/L of Aroclor 1232, 180 µg/L of Aroclor 1248 and 180 µg/L of Aroclor 1262 yielding a total PCB concentration of 610 µg/L. The PCB calibration mixture was obtained from the EPA's National Health and Environmental Effects Research Laboratory in Grosse Ile, Michigan. Concentrations of individual PCB congeners in this mixture had been obtained from Mullin [31]. Two internal standards were used: PCB-30 (2,4,6-trichlorobiphenyl) and PCB-204 (2,2',3,4,4',5,6,6'-octachloro biphenyl), which are not present in commercial Aroclor mixtures. Using this protocol, 92 PCB congeners or congener groups can be identified and quantified. Co-eluting PCB congener peaks were

calibrated as a sum of congeners. Only congeners with all data replicates above the MDL were analyzed and summed to give a total PCB level.

Congener lists with MDLs are provided in Appendix A.

5.7 Sampling Results

Please note that this section is combined with Section 6 “Performance Assessment” for more efficient presentation of data and results.

6 PERFORMANCE ASSESSMENT

6.1 Primary Objectives

6.1.1 Ease of Use

We utilized two types of mechanical mixing devices, as shown in Figure 6-1 and Figure 6-2, for AC deployment and incorporation into sediment. The first device, a barge-like machine with a rotovator attachment (called an Aquamog, Figure 6-1), was owned by Aquatic Environments, Inc. (AEI, Alamo, CA). This device is typically used to disrupt weed growth in marshy areas. AC was manually deployed on the surface of the plot, then the Aquamog with its rotovator mixed the AC into the sediment. The second device was provided from Compass Environmental, Inc. (CEI, Stone Mountain, GA). It is an injection system, which is used traditionally for sediment solidification with cement mortar (Figure 6-2). It comprises of a rake injector and a slurry maker. AC was injected as a slurry form into the sediment, and mixed with the rake injector mixer.

6.1.1.1 AEI Aguamog with Rotovator Arm

Figure 6-1 shows the mobilization/AC delivery/AC-sediment mixing with AEI's Aquamog. The Aquamog was launched from a dock at Hunters Point near the test site, approached the test plot (Plot D) at high tide, and settled onto the sediment surface at low tide (Figure 6-1 A and B). AC was manually deployed on the surface of the plot at low tide (Figure 6-1 C). Then, AC was mixed into sediment by the rotovator arm for about half an hour total over the plot (Figure 6-1 D).

The overall operation by Aquamog was very successful where AC-sediment mixing was visually confirmed immediately. However, its treatable sediment area was limited to one test plot at one tidal cycle, because its mobility was limited at low tide. For full-scale application, enhanced mobility at low tide would be desired. Also, a more efficient AC delivery is needed to amend larger sediment volume. Although the barge-mounted Aquamog can give a good accessibility to inter-tidal areas like our test site, it is also true that this mixing technology is only applicable at low tide and on uncovered sediment. For AC application on sub-tidal areas or underwater areas, different mixing strategies should be considered. A pilot-scale field project has been conducted by our colleagues to address this issue using an underwater rototiller box.[32] At South Basin, a cofferdam could be constructed at the narrow inlet[13] so that dewatered sediment including the inter-tidal area and the sub-tidal area behind the cofferdam could be treated effectively in a one- or two-week time period using conventional spreaders and mechanical bulldozer mixers. Also, this would allow for greater flexibility with re-mixing and AC deployment.

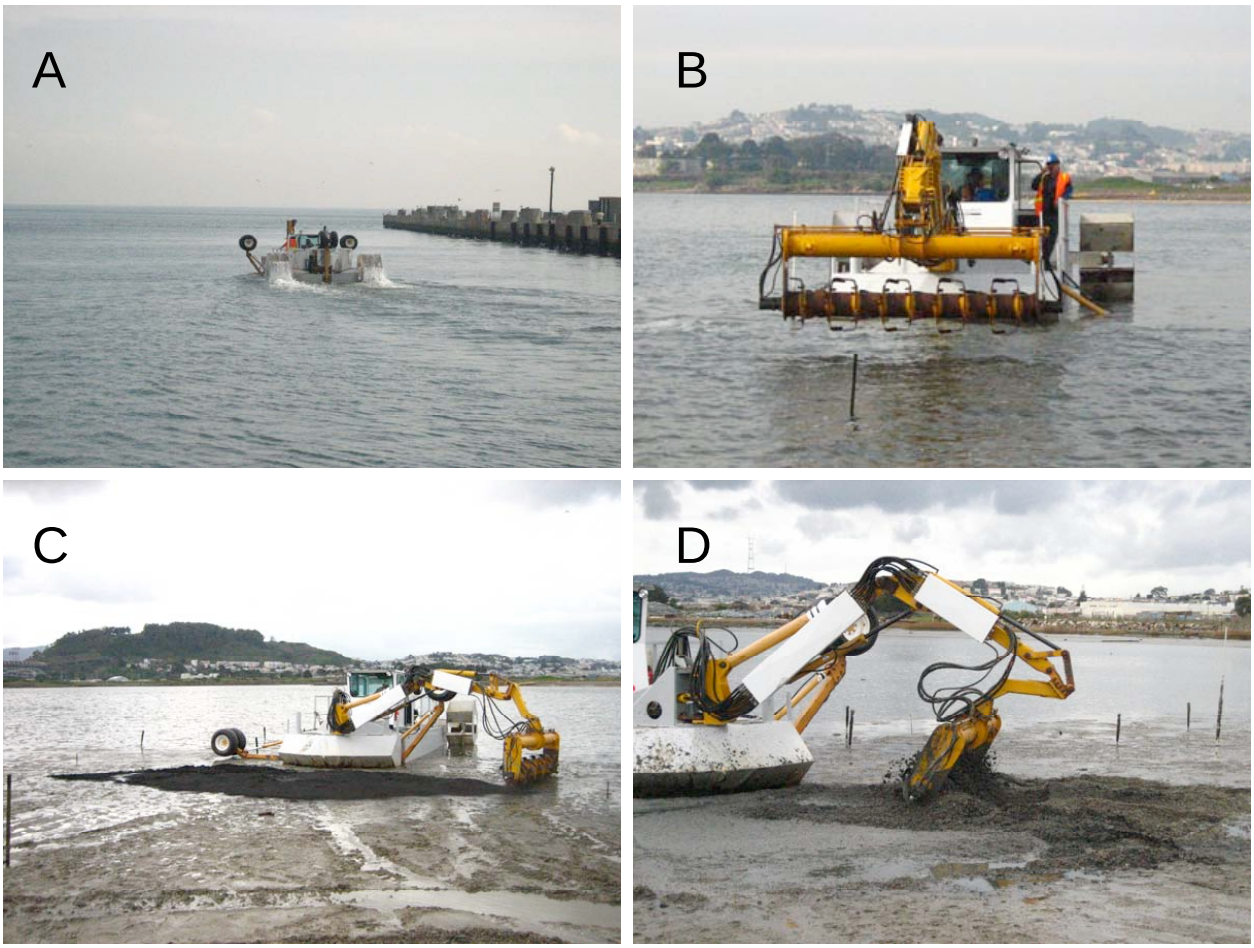


Figure 6-1. AEI Aguamog with rototiller arm. A) Mobilization of Aquamog; B) Positioning on the test plot at hight tide; C) Manually deployed AC on the top of the test plot; D) AC-sediment mixing

6.1.1.2 CEI Injector System

As shown in Figure 6-2, the CEI injector system approached from shore to the designated test plot. The device was mobilized and demobilized at low tide. AC was delivered into the test plot as a slurry form. The slurry maker and pump were located on the shore and connected to the injector device by a pipe. Because of its better mobility at low tide compared to AEI's Aquamog, this device could have mixed two plots (AC-mixed plot F and mix only control plot G) in one tidal cycle. However, unfortunately, we were unable to complete the mixing control for Plot G (Injector, Mix Only) since the sediment surface of this plot was not stable enough to support the device's weight. As noted above, at South Basin a coffer dam could be constructed at the narrow inlet so that dewatered sediment behind the cofferdam could be treated effectively in a one- or two-week time period using conventional spreaders and mechanical bulldozer mixers. This would allow for greater flexibility with equipment choice and AC re-mixing and AC deployment.

Figure 6-2. CEI Injector system. A) Mobilization of the injector device; B) AC-sediment mixing; C) AC slurry tank; D) Tip of injector showing slurry discharge port.

6.1.2 PCB Bioaccumulation in Test Organisms

6.1.2.1 *In situ Macoma nasuta* PCB Bioaccumulation

Data in Figure 6-3 show *M. nasuta* lipid normalized PCB concentrations for 28-day exposures conducted at different times during the study. The *in situ* assessment of pre-treatment, baseline lipid normalized PCB tissue residues in *M. nasuta* indicated no statistically significant differences among the field test plots prior to the addition of AC. Clams deployed six-months post-AC treatment in Plots D and F indicated a trend of lower PCB residues relative to the mixed (Plot C) and unmixed reference control (Plot E) plots. The largest difference in the PCB residues at the six-month post-treatment assessment existed between Plots C and D. Clams deployed in the rotovator-mixed control plot (Plot C) showed 388 ± 69 µg/kg and clams deployed in the rotovator-mixed AC amended plot (Plot D) showed 262 ± 58 µg/kg PCBs on a lipid normalized basis, representing a 32% reduction (t-test, p=0.02) at an average AC dose of 3.2% among the five sampling locations. The injector-mixed AC amended plot (Plot F) showed a 13% reduction compared to the mixing control plot (Plot C) at an average AC dose of 2.0%, although the p value is not less than the 0.05 alpha level (p=0.13). The smaller reduction compared to Plot C is probably due in part to the inherent heterogeneity of PCBs in Plot F with locally higher sediment

PCB levels. Overall, the reduction in tissue PCB residues at the 6 month assessment were notably less than reductions reported in previous laboratory *ex situ* studies of almost 90% for *M. balthica* [6], *Leptocheirus plumulosus,* and *Neanthes arenaceodentata* [5]. This difference is likely a consequence of AC dose and extent of mixing in the field versus the laboratory. In the previous laboratory studies, the sediments were treated continuously with 3.4% AC in a roller for 30-days, allowing more effective sediment contact with a larger AC dose and thus greater reduction in bioavailability. The current study involved a one time mixing of 30 minutes for the entire test plot giving a variable AC content of about 2 to 3 % depending on sampling locations.

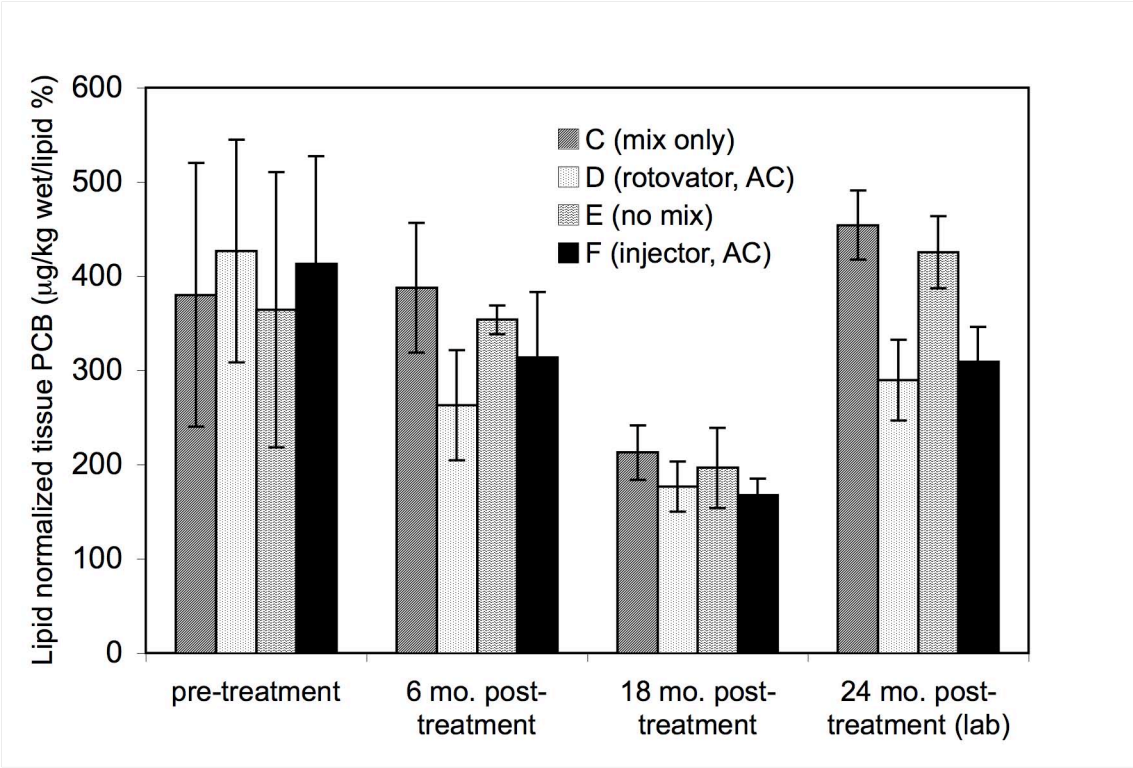


Figure 6-3. Comparison of PCB bioaccumulation for *M. nasuta* exposed for 28 days (n=3-5). Data are expressed on a wet weight basis and normalized by total lipid-content for tissue PCB concentrations for *M. nasuta* exposed to the test plots. Total PCB concentrations were obtained by summation of 134 PCB congeners or congener groups. Each column and error bar represents the mean and one standard deviation (n = 3-5). The 18 month post-treatment response of clams to AC amendment and PCB-uptake is confounded by the deposition of fresh, incoming PCB-containing sediment.

At the 18-month assessment, further reductions in tissue PCB residues were not exhibited as expected; instead, the results suggested that there were no statistically significant differences in the PCB tissue residues among all four plots (t-test). To account this unexpected result, we conducted further sampling and an extensive set of additional laboratory tests. Through the tests, we found that the answer to this complex question lay in one particularly confounding field-related factor of fresh sediment deposition.

When the samples were collected for the 18-month assessment, the field team noticed that the surface of all the test plots exhibited the same surface features and texture and suspected that new sediment had been deposited onto the surface of the plots. In fact prior radioisotope analysis of sediment cores from South Basin had suggested that new sediment might be deposited at a of 0.5 – 0.9 cm/yr [13], but none was not evident during the first six months of the study. However, by 18 months post-treatment it was visually apparent that deposition had occurred. Also, when clam tubes were left as deposition markers in the sediment after the 18-month sampling, sediment deposition was evident subsequently 6- and 12-months later at a rate consistent with an estimate of about 0.5 - 1 cm/yr of fresh deposit on the field plots. Since *M. nasuta* selectively surface deposit-feed by particle size at the mantle cavity and organic carbon enrichment [33-35], the freshly deposited material altered exposure and PCB accumulation. Consequently the clam tissue concentrations based on lipid-normalization were more uniform across the four test plots. As will be discussed in greater detail later, the surficial deposit material was contaminated with PCBs, contained much less black carbon, and exhibited a different carbon-13 isotope signature compared to the underlying treated sediment.

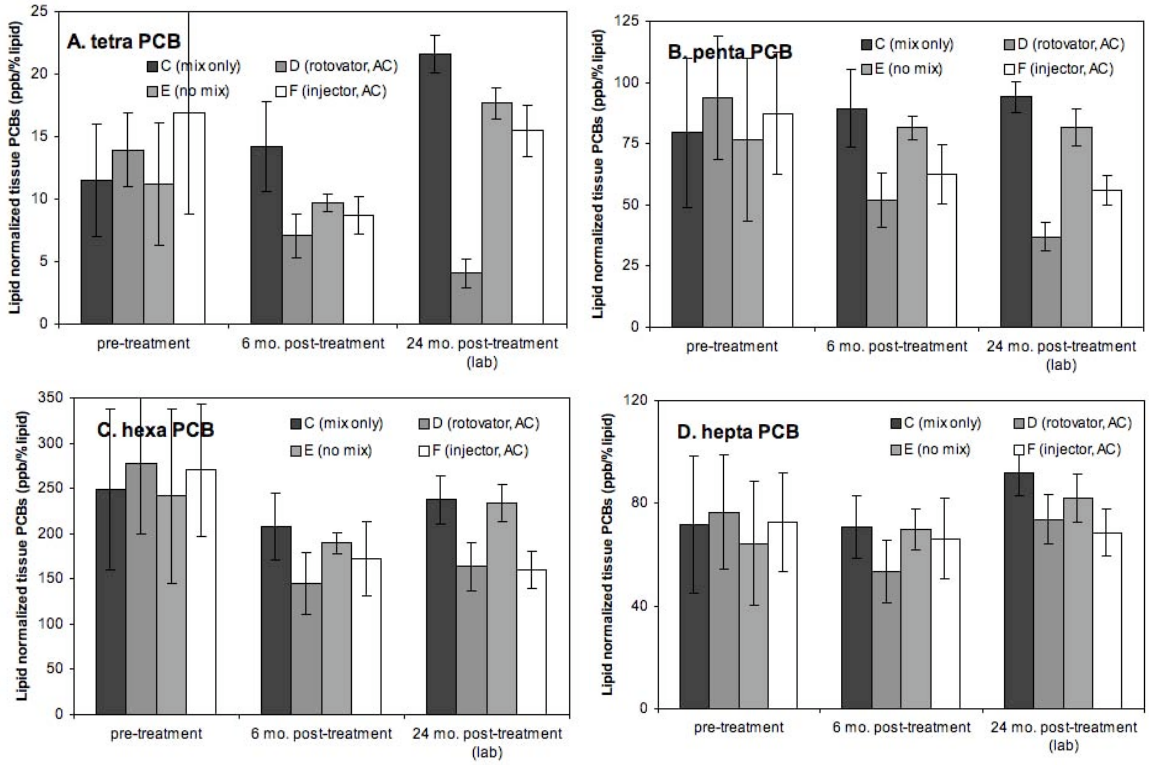


Figure 6-4. Comparison of PCB homologue specific bioaccumulation for field-deployed *M. nasuta* for 28 days at 6 months post-treatment and 24 months post-treatment. Each column and error bar represents the mean and one standard deviation (n = 3-5). A) tetra, B) penta, C) hexa, and D) hepta PCB homologue group.

Figure 6-4 showed PCB homologue-specific uptake values at pretreatment, 6 months and 24 months post-treatment (18 months data were not included in the figure, because they did not show significant differences among the test plots due to field confounding factors). Homologue-

specific data also showed similar reductions with greater benefit of AC amendment evident for less chlorinated PCB homologues. For example, clams deployed in the rotovator-mixed AC-amended plot D at 6 months post-treatment accumulated 50% (t-test, p=0.01), 42% (t-test, p<0.01), 30% (t-test, p=0.03), and 24% (t-test, p=0.07) less PCB homologues (tetra, penta, hexa, and hepta PCB homologues respectively) compared to the rotovator-mixed control plot C. 24 months post-treatment *ex situ* study data also showed the similar trend.

6.1.2.2 *Ex situ Macoma nasuta* PCB Bioaccumulation

In the 24-month post-treatment *ex situ, M. nasuta* bioaccumulation tests, the confounding factor of newly deposited sediment was removed because composite sediment samples were collected from the plots, coarse-sieved to achieve predominantly fine-grained test material, and homogenized briefly for five minutes prior to laboratory testing. When exposed in the laboratory for 28-days, *M. nasuta* survival was high (> 82%) and further PCB tissue residues reductions were observed in comparison to the 6-month assessments. Again, the largest difference in the PCB tissue residues existed between Plots C and D. The PCB tissue uptake in Plot D was 36 % lower than that found in Plot C (Figure 6-3) with 2% AC dose in the sample composite (t-test, p <0.001). In Plot F, 32 % lower PCB tissue uptake was observed (t-test, p<0.001).

6.1.2.3 Difficulties of Field Bioassays

When comparing the laboratory and field bioaccumulation studies, the fieldwork was more problematic for several reasons related to unexpected and inevitable field conditions. First, we observed during all field sampling events that the clams burrowed to shallower depths (1-2 inch) than was observed in a previous pilot-scale study (2-3 inch).[20] This shallower burrowing depth is possibly due to the coarser sediment texture (i.e., shells) of the test plots, which were located about 8 m shore-ward from that of Cho et al.[20] Coarser sediment is not favored by *M. nasuta*[36] and the burrowing problem was believed to increase mortality of field-deployed clams. Second, we experienced a record-breaking heat wave in the San Francisco Bay Area at the time of the 6-month post-treatment assessment sampling[37], which stressed the deployed clams and diminished the survival rate (< 80%, Table 6-1). Third, as mentioned previously, the deposition of incoming surface materials modified conditions at the field site and made it difficult to resolve the effects of the remedial action. This newly deposited material contained PCBs and likely masked the effect of AC amendment on the underlying sediment.

Table 6-1. *Macoma nasuta* survival (%) from the *in situ* assessments.

	C	D	E	F	Avg.
Pre-treatment	100	100	97	94	98
6 mo. post-treatment	86	74	70	60	72
18 mo. post-treatment	79	68	91	70	77
24 mo. post-treatment (lab)	82	83	85	83	83

To confirm that the surficial sediment was indeed newly deposited and different from the underlying sediment, we assessed surface sediment 24-months after AC treatment for black

carbon (BC), TOC, carbon-13 isotopes, total and aqueous equilibrium PCBs, and compared these data with that for 6-inch core composites collected at the same time. As shown in Figure 6-5 and Figure 6-12, the BC content and the TOC content of the top surface sediment layers did not show a significant difference among the four plots, while composite 6-inch sediment core samples show a clear AC signature for the AC-amended plots (Plots D and F). Total sediment PCB levels among the four plots ranged from 1.1 to 1.4 mg PCBs/kg dry sediment with no statistically significant differences between plots; the surficial sediment PCB levels were within the range of the sediment PCB levels of the test plots (1 to 2 ppm). Additionally, carbon-13 isotope data showed that the origin and/or biological age of the surface sediment was clearly different from that of the 6-inch core composite samples (Figure 6-7). Finally, no difference in aqueous equilibrium PCBs concentration with surface sediment was observed in the two AC-treated plots (Figure 6-8), as compared to the 6-inch core composite samples that gave about 56-75% reductions compared to the control samples (t-test, $p<0.001$).

Even with the strong evidence of sediment deposition, there could be a concern about possible sediment winnowing and consequent AC loss at the surficial sediment layer, which might also result in the decrease in BC contents in AC-treated plots. However, several arguments rule out this possibility as a major factor at this test site. First, Zimmerman et al. showed that AC-sediment mixing does not significantly affect the stability of surface sediments, as measured by sediment erosion rate and critical shear stress for incipient motion using sediment samples collected from South Basin.[11] From sediment stability tests and hydrodynamic modeling, they concluded that mixing AC with cohesive sediment at the South Basin will not reduce surface sediment stability nor result in significant erosion of treated sediments.[11] Second, if the winnowing of AC was significant, the winnowing of other lighter sediment particles (e.g., black carbon particles other than AC) should have occurred as well, which would have resulted in significantly reduced BC contents of surficial sediment material even from the non-AC treated plots (C and E). For the non-AC treated plots (C and E), we did not observe any difference in the BC contents between surficial materials and sediment composite samples. This finding indicates that the winnowing phenomenon, if any, has not been very significant during our project time span. In conclusion, sediment winnowing probably minimally impacted the performance of the AC-sediment amendment, where the sediment is cohesive and the site is not subjected to frequent high-energy events. However, in this regard, for high-energy environments, the stability of AC amendment should be thoroughly tested and evaluated before AC application.

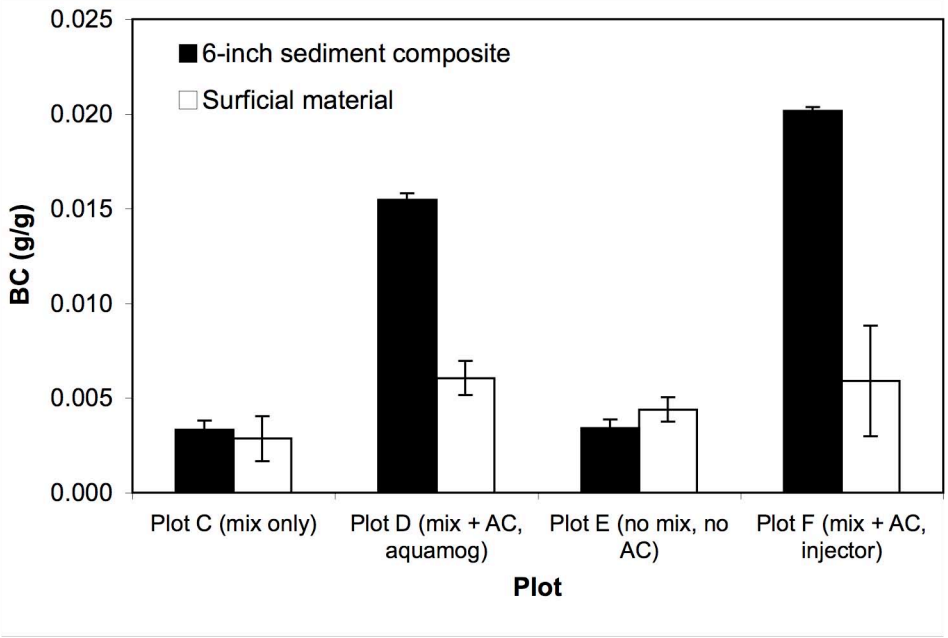


Figure 6-5. Black carbon (BC) content for 6-inch sediment composite compared to the top 1/8 inch surface sediment samples in the four test plots 24 months after treatment. These data show that the fresh surface deposit contains about the same amount of BC as the untreated sediment and comprises significantly less BC than the treated sediment. Each column and error bar represents the mean and one standard deviation (n=3-5).

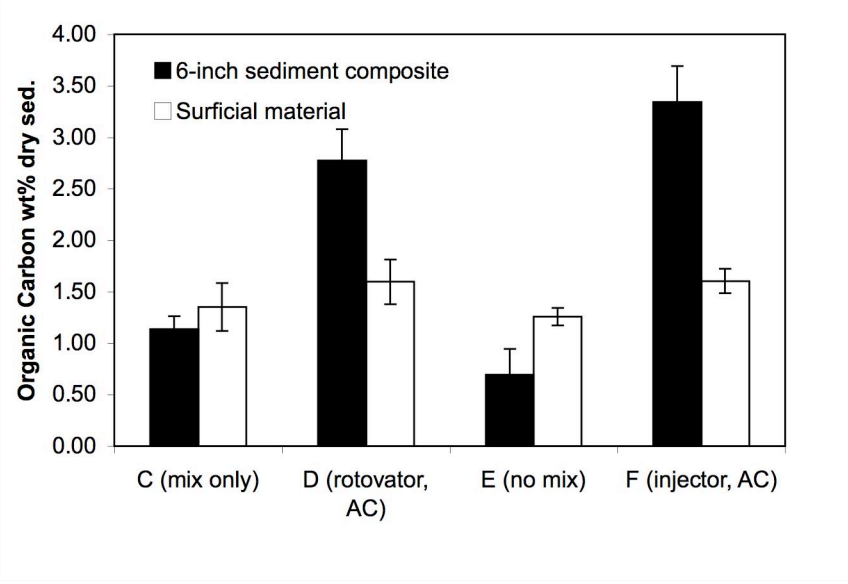


Figure 6-6. Total organic carbon content for 6-inch sediment composite compared to the top 1/8 inch surface sediment samples in the four test plots 24 months after treatment. These data show that the surface deposit contains about the same amount of TOC as the untreated sediment and comprises significantly less OC than the treated sediment (t-test, $p<0.05$). Each column and error bar represents the mean and one standard deviation (n=3-5).

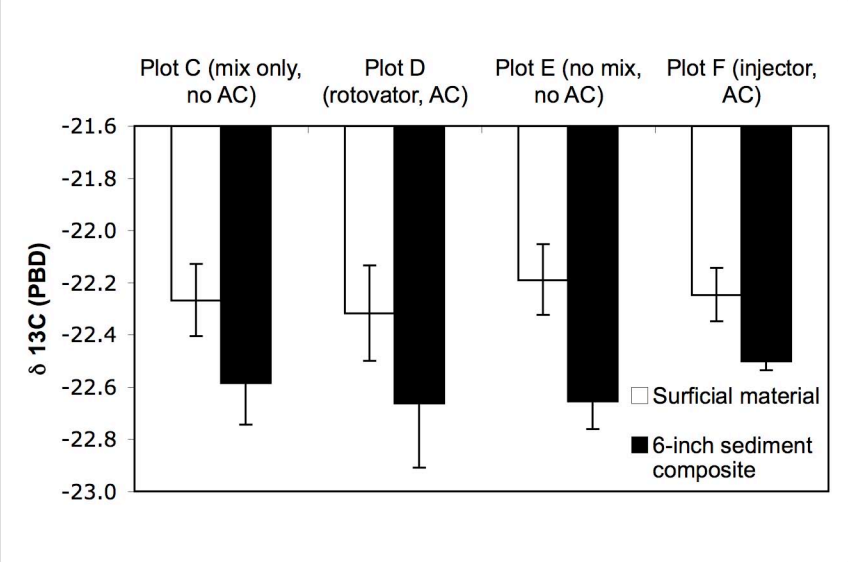


Figure 6-7. C-13 isotope data for 6-inch sediment composite and 1/8 inch surface sediment samples in test plots in the four test plots 24 months after treatment. These data show that the surface deposit has different C-13 isotope signature from the 6-inch composite indicating the surficial materials have a different origin and/or biological age (t-test, $p<0.05$). Each column and error bar represents the mean and one standard deviation (n=3-5).

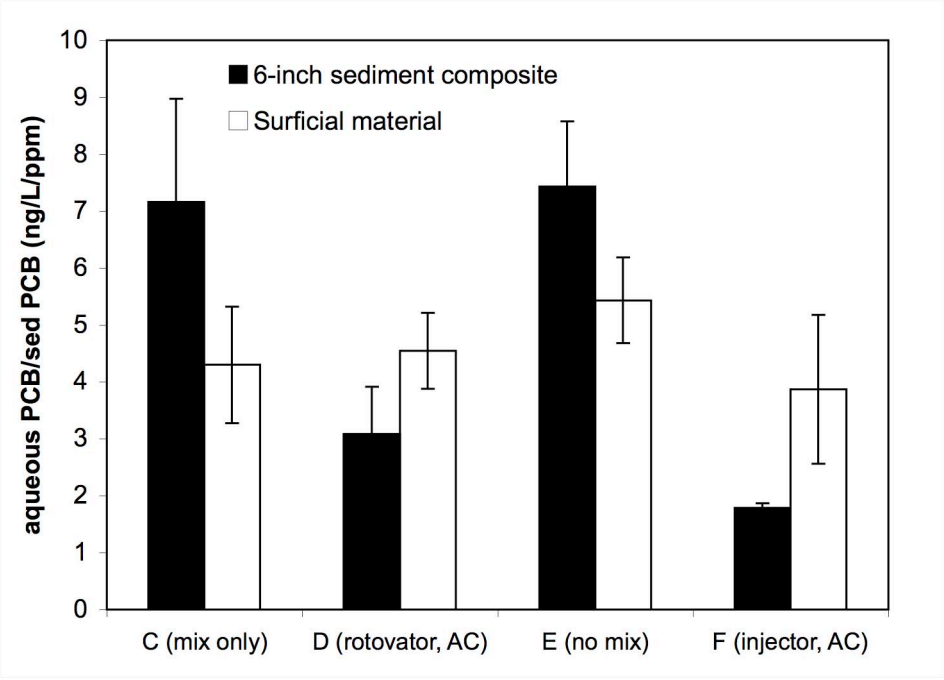


Figure 6-8. Sediment normalized aqueous equilibrium PCB concentrations for 6-inch composite sediment and 1/8-inch surface sediment samples in test plots. Total PCB concentrations were obtained by summation of 92 PCB congeners or congener groups. The freshly-deposited surficial material does not show the effect of the AC treatment compared to the 6-inch sediment core composites. The treated sediments show 57 to 75% reduction in aqueous PCBs compared to the controls. Each column and error bar represents the mean and one standard deviation (n=3).

6.1.2.4 PCB Bioaccumulation and AC Dose.

The AC dose in sediment has a pronounced affect on PCB bioavailabilty and uptake. As shown in Figure 6-9 for Hunters Point sediment, McLeod et al. reported a significant dose-response relationship for clam bioaccumulation and AC doses ranging from 0.4 to 3.4% [6]. This dose-response relationship is compared with our field studies for the rotovator-mixed Plot D at 6-months post treatment, and in the laboratory for plot D at 24-months post treatment. The AC dose in these field samples vary from 2 to 3% depending on sampling locations. Also shown in Figure 4 are field data from Cho et al. [20] for rotovator mixed AC in a test plot located about 8 m further in the mudflat from the current test plots. Collectively, these data show a consistent dose-response relationship with increasing reductions in PCB uptake with increasing AC dose in the sediment. The data show that one-month mixing in the laboratory, or field sampling and briefly homogenizing, results in greater reductions compared to a single, short mixing event. In the field studies, the duration of mechanical mixing was not more than 30 minutes total for the whole test plot. After such mixing, PCB contact with AC relies principally on diffusion-limited processes, requiring much longer times to realize the benefit of the AC in reducing contaminant availability [38, 39].

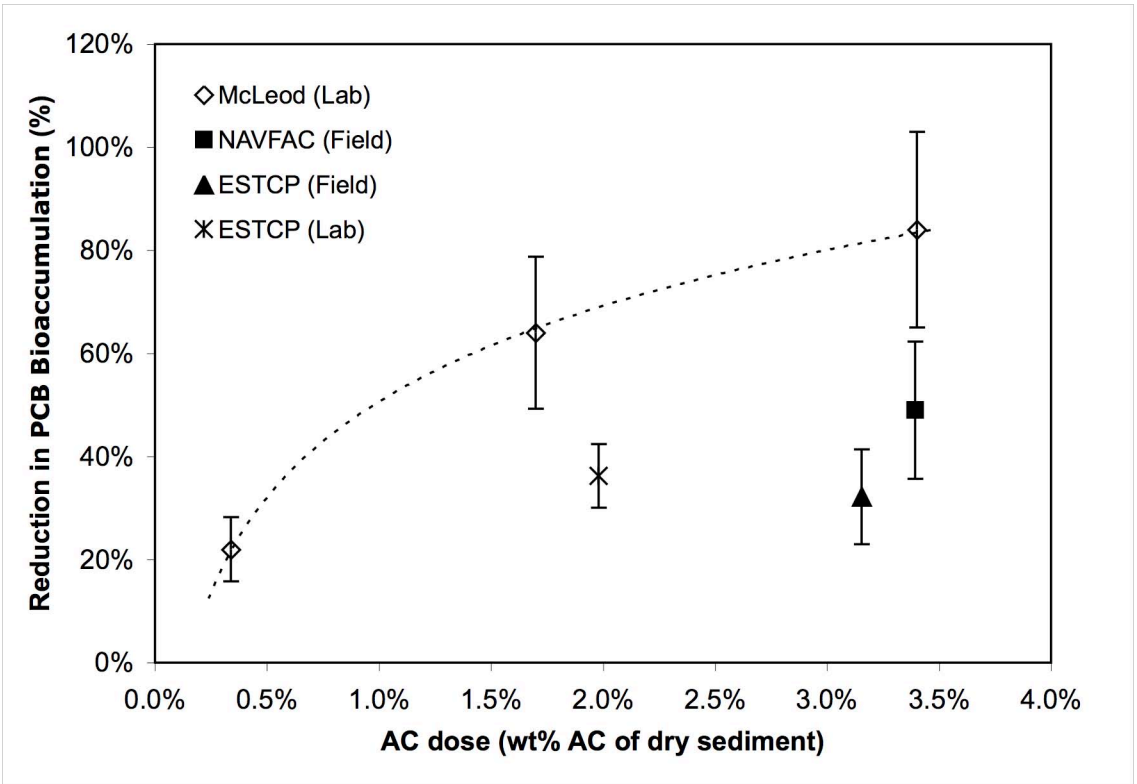


Figure 6-9. Activated carbon dose-response relationship for clam PCB bioaccumulation. ◇ McLeod et al.[6] laboratory studies that employed AC-sediment contact on a roller for 1 month (n= 3-4). ■ Prior NAVFAC field study [20] and rotovator mixing for about half an hour total on the test plot (% difference of lipid normalized BAF compared to control plot) (n=3). ▲This ESTCP field study with rotovator mixing for about half an hour total on the test plot (% difference of

lipid normalized tissue PCB residue compared to the mixing control plot) (n=3-5). ∗ This ESTCP study based on rotovator mixing of field sediment and laboratory bioassay with additional mixing of collected field samples through sieving and 5-minute homogenizing (% difference of lipid normalized PCB tissue residue compared to the mixing control plot (n=5). Each point and error bar represents the mean and one standard deviation.

6.1.3 PCB Bioaccumulation in Indigenous Organisms

Amphipods are sensitive to a suite of contaminants and are commonly used in *ex situ* toxicity assessments of marine sediments [40-42]. To our knowledge, few previous marine assessments of organic contaminant tissue residues have been conducted for field-collected [43, 44] or laboratory exposed amphipods [40, 45, 46], possibly due to low tissue yields (e.g., 0.001 g per individual) in relation to analytical requirements (at least 3 – 5 g). We analyzed PCBs in field-collected amphipods by a micro-analytical technique [29]. Assessments prior to AC treatment indicated no significant differences in residues among the four test plots (t-test). Each post treatment assessment (6 and 18 months) also showed no significant differences in lipid normalized PCB tissue residues among test plots (Figure 6-10). Temporal comparison among pretreatment and two-time post-treatment assessments was not applicable here, because amphipod burdens responds to various field factors (e.g., temperature, salinity, or deposited surficial materials) that could not be controlled for all assessments. No spatial differences among test plots throughout the entire project time span indicates that mixing itself did not increase PCB exposure to resident amphipods. Since these amphipods dwell and deposit feed from surficial sediments, they responded more to the newly deposited sediment that was mentioned earlier than to the subsurface sediment layer. Notably, similar AC contents were found in surface sediment (where amphipods reside) from the four test plots (Figure 6-5) at eighteen months.

In addition to the similar amounts of BC in each plots' surface sediment, amphipod mobility may partially explain the similar PCB residues between plots as *Corophium spp.* are mobile [47-50]. *Corophium spp.* can swim vertically for several seconds into tidal currents and passively shift in position depending on flow[51], suggesting the possibility that some individuals collected from the treated plots could have been exposed to that sediments from other portions of the site. Additionally, the *Corophium spp.* and *G. japonica* sampled are tube-builders, and more likely exposed to pore water diluted by overlying water [45, 46], and have been shown to accumulate less organic pollutant than the non-tube building *Eohaustorius estarius* [46]. In a previous laboratory study, we found that AC treatment significantly reduced the available PCBs for the non-tube building amphipod, *L. plumulosus* [20].

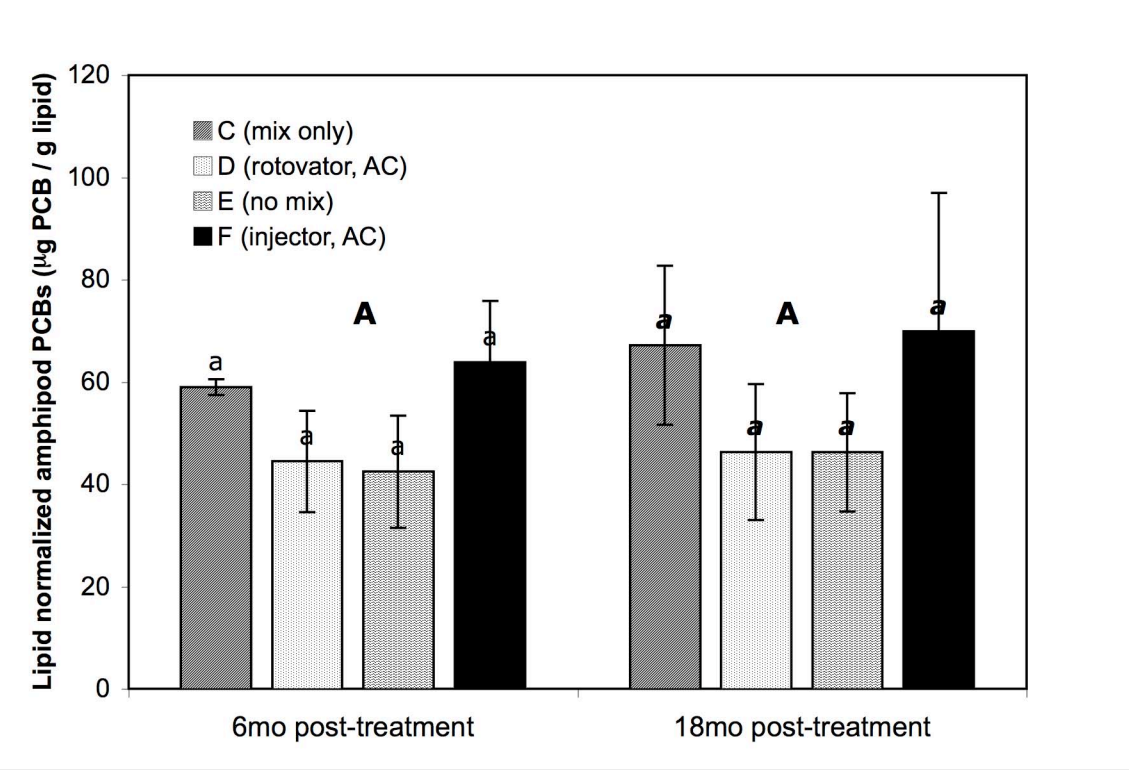


Figure 6-10. *In situ* amphipod PCB bioaccumulation normalized by lipid contents (n=3-5). Total PCB concentrations were obtained by summation of 134 PCB congeners or congener groups. Compared to controls, these data show that the mixing of sediment did not in itself increase PCB exposure to organisms that dwell and feed on the sediment surface. Each column and error bar represents the mean and one standard deviation. Bars with same letter designations were not statistically different each other. Pre-treatment lipid-normalized amphipod bioaccumulation was not reported here due to the lack of lipid content data.

6.1.4 AC Application

As described in section 6.1.1, activated carbon was applied to PCB-contaminated sediment at the field site using two, large-scale mechanical mixing devices (see Figure 6-1 and Figure 6-2) for AC deployment and incorporation into sediment. Three treatment plots were completed: Plot C (Aquamog, Mix Only), Plot D (Aquamog, AC/Mix), and Plot F (Injector, AC/Mix).

Sediment PCB, TOC, and BC in the top 6-inch sediment sections of the four test plots are shown in Table 6-2. Sediment concentrations were corrected by the percent recovery of PCB 65 surrogate to account for the limited extractability for AC-amended sediments from Plots D and F [52]. The total PCB levels among the plots were in the range of 1 to 2 ppm before and after treatment, except for Plot F after treatment. After mixing and AC treatment, Plot F showed highly variable sediment PCB levels while the other three plots showed less variable values. This suggests that sediment properties of Plot F may have been inherently more heterogeneous than the other three plots, and mixing may have dispersed a region of higher PCB concentration within the sediment of Plot F.

Table 6-2. Sediment properties of the four test plots: sediment PCB levels (mg PCB/kg dry sed, total PCBs), total organic content (% OC/dry sed), black carbon content (g BC/g dry sed). Two sets of estimated activated carbon dose are presented using TOC and BC data. Each data entry represents the mean and one standard deviation.

Plot	C Mix only, Control	D Rotovator, AC	E Reference	F Injector, AC
	Sediment PCB level	(mg PCB /kg dry sed)		
pre-treatment (n=5)	1.35 ± 0.40	1.60 ± 0.72	1.62 ± 1.01	1.46 ± 0.37
6 mo. post-treat. (n=5)	1.88 ± 0.34	1.78 ± 1.07	1.92 ± 0.83	3.43 ± 1.81
18 mo. post-treat (n=5)	2.32 ± 0.82	1.91 ± 1.10	2.04 ± 0.81	10.45 ± 16.94
	Total organic content	(% OC/dry sed)		
pre-treatment (n=5)	0.44 ± 0.05	0.36 ± 0.06	0.47 ± 0.08	0.45 ± 0.20
6 mo. post-treat. (n=5)	0.77± 0.16	3.38 ± 0.74	0.48 ± 0.05	2.47 ± 1.20
18 mo. post-treat (n=5)	0.63 ± 0.15	2.42 ± 0.59	0.57 ± 0.12	3.31 ± 1.62
	Activated Carbon (calculated from TOC)		(g AC/g dry sed)	
6 mo. post-treat. (n=5)		0.032 ± 0.010		0.020 ± 0.011
18 mo. post-treat (n=5)		0.021 ± 0.007		0.032 ± 0.018
	Black carbon content	(g BC/g dry sed)		
pre-treatment (n=1-2*)	0.0014	0.00075 ± 0.00001	0.00077 ± 0.0001	0.0019 ± 0.001
6 mo. post-treat. (n=1-2*)	0.0015	0.025 ± 0.0002	0.0015 ± 0.0002	0.010 ± 0.0004
18 mo. post-treat (n=1-2*)	0.0019 ± 0.00002	0.017 ± 0.0001	0.0026	0.023
	Activated Carbon (calculated from BC)		(g AC/g dry sed)	
6 mo. post-treat. (n=1-2*)		0.033 ± 0.0003		0.011 ± 0.0006
18 mo. post-treat (n=1-2*)		0.020 ± 0.0002		0.029

* analytical replicates from composite sample

After AC amendment, Plots D and F showed significant enhancement of TOC and BC values in the upper 6-inch sediment layer, which confirms successful AC incorporation into the designated plots (Figure 6-11). Post-application assessments at 6-months and 18-months after treatment were performed at different randomly selected sites on the test plots. The data in Table 6-2 and Figure 6-11 show heterogeneous distribution of the AC by measurement of either BC or TOC for the two AC-treated plots (Plots D and F) between the two post-treatment assessments. The amount of deployed AC in the two plots was calculated from averaged post-treatment BC values, giving 0.026 g/g dry sediment and 0.020 g/g dry sediment for Plots D and F respectively. The AC dose values for Plots D and F are close to but less than the target AC dose of 0.034 g/g dry sediment. The difference is likely due to some over-mixing in the vertical (e.g., ~15 inches) and horizontal dimensions with the large mechanical devices and the relatively small dimensions of the test plots. The amount of AC dose estimated from 6-inch averaged TOC data for cores taken at six months and 18 months post treatment gave similar values as that estimated from BC data (0.026 g/g for both Plots D and F).

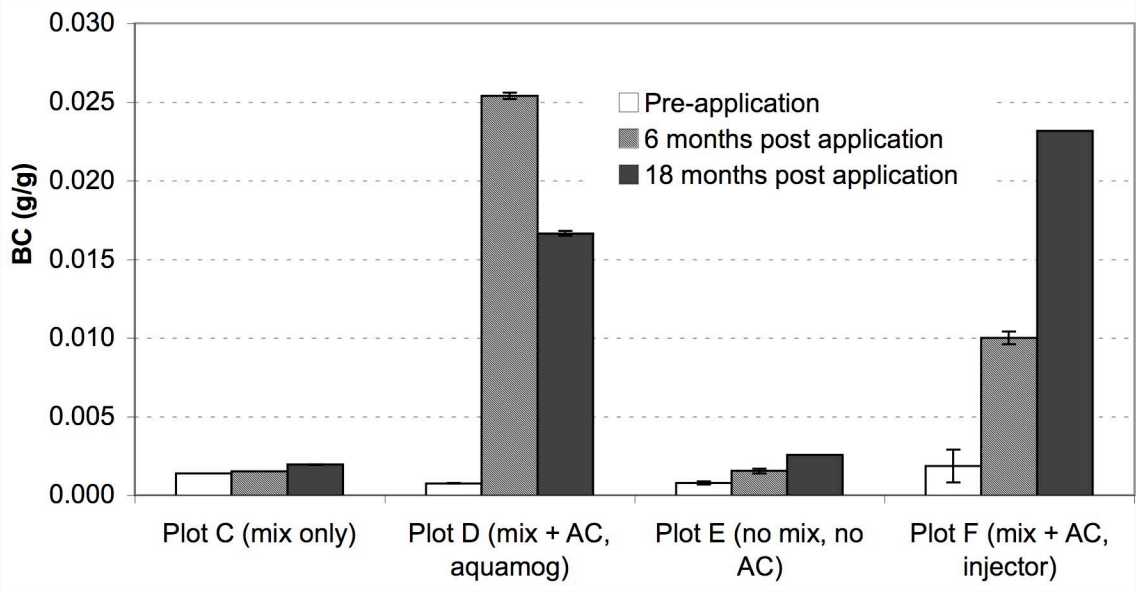


Figure 6-11. Black carbon (BC) measurement of the top 6-inch composite sediment samples (n=1-2, analytical replicates).

Figure 6-12 shows a visual representation of TOC data for 2-inch core sections down to 1 ft depth in Plot D before and 6 months after AC treatment. These data show that the mixing of AC into the plot via the rotovator resulted in variable distribution of the AC. The values ranged from no increase in TOC for some 2-inch sections to over 5 fold increase above background TOC for some cores. While almost all of the core sections show an increase in TOC, the largest values of AC dose are indicated for cores taken closest to the barge and TOC values decrease farther from the barge. The rotovator was moved radially in a back and forth motion and this resulted in greater homogeneity and larger TOC values closer to the barge. Similarly, Plot F showed enhanced TOC levels in most 2-inch sections. TOC values of Plots D and F for top 6-inch sediment after treatment are 2.90 ± 1.21 and 2.89 ± 1.94 respectively. The larger standard deviation of TOC values in Plot F indicates that AC-mixing via the slurry injection device on Plot F was less homogeneous than the rotovator device employed at Plot D.

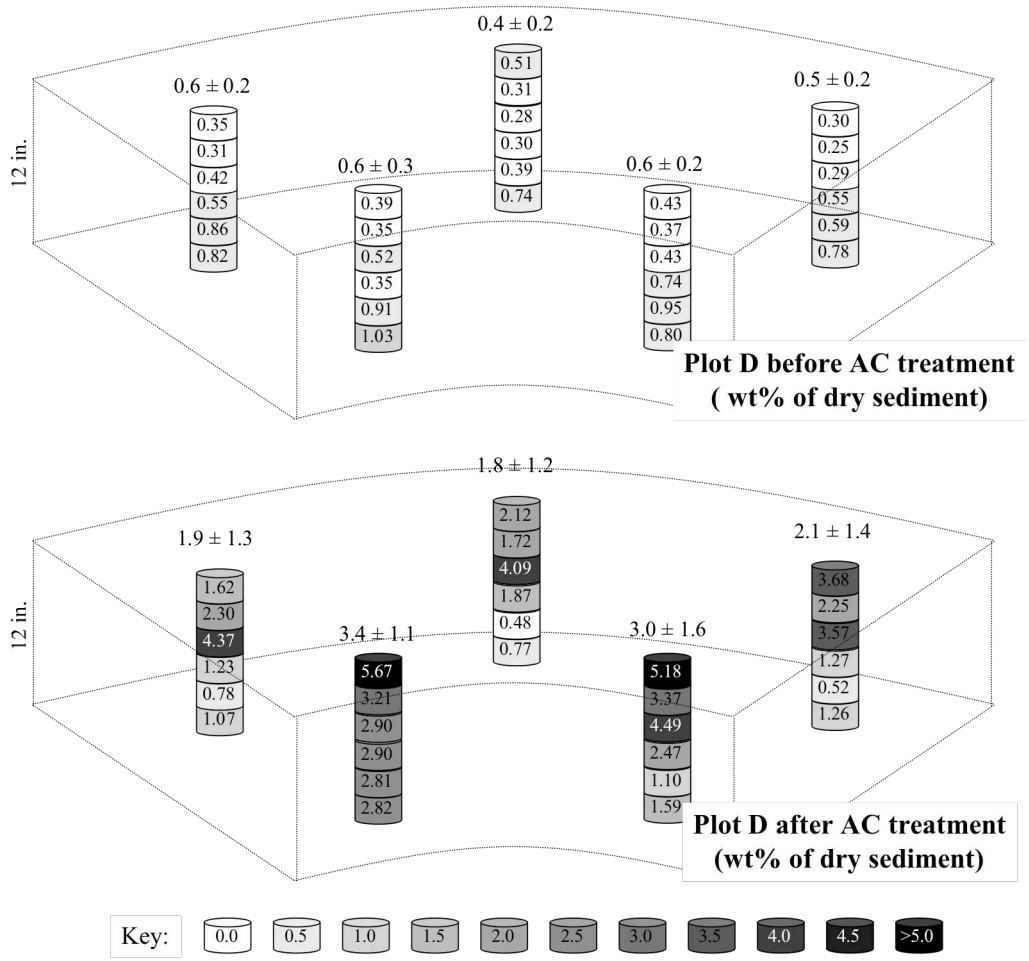


Figure 6-12. Comparison of TOC values from sediment cores taken before and 6 months after treatment in Plot D.

6.1.5 PCB Resuspension

Dissolved PCBs in the water column above each test plot before (Figure 3a) and one-day after AC treatment (Figure 3b) were dominated by congeners with 3-6 chlorines. There was no significant difference in aqueous PCBs over the treatment and control plots before treatment and ranged from 1.77 ± 0.77 ng/L to 2.21 ± 0.76 ng/L total PCBs. One day after treatment, the dissolved PCBs above each treatment plot were close to that before treatment and were not significantly different from each other, ranging from 2.12 ± 0.11 ng/L to 2.46 ± 0.44 ng/L. Particle associated PCBs above the test plots (Figure 3c and 3d) also showed no spatial variance among the four plots, while a uniform increase in particle load by a factor of three over each of the plots was observed. This increase is attributed to wind-induced turbulence, as was observed in a previous pilot-scale test [20]. Average wind speed during the sampling times was calculated based on available surface weather observation data from the nearest National Oceanic and Atmospheric Administration (NOAA) monitoring station at San Francisco International Airport. The average wind speed during the sampling period at one day after AC treatment was 2.5 m/s, while there was no measurable wind during the pre-treatment assessment sampling. Overall, these results suggest that wind speed and direction have a greater impact on resuspension of

particle-associated PCBs than the immediate effect of mechanical mixing of AC with sediment. The observed wind induced effects are likely representative of more basin-wide phenomena than that localized over the relatively small test plots.

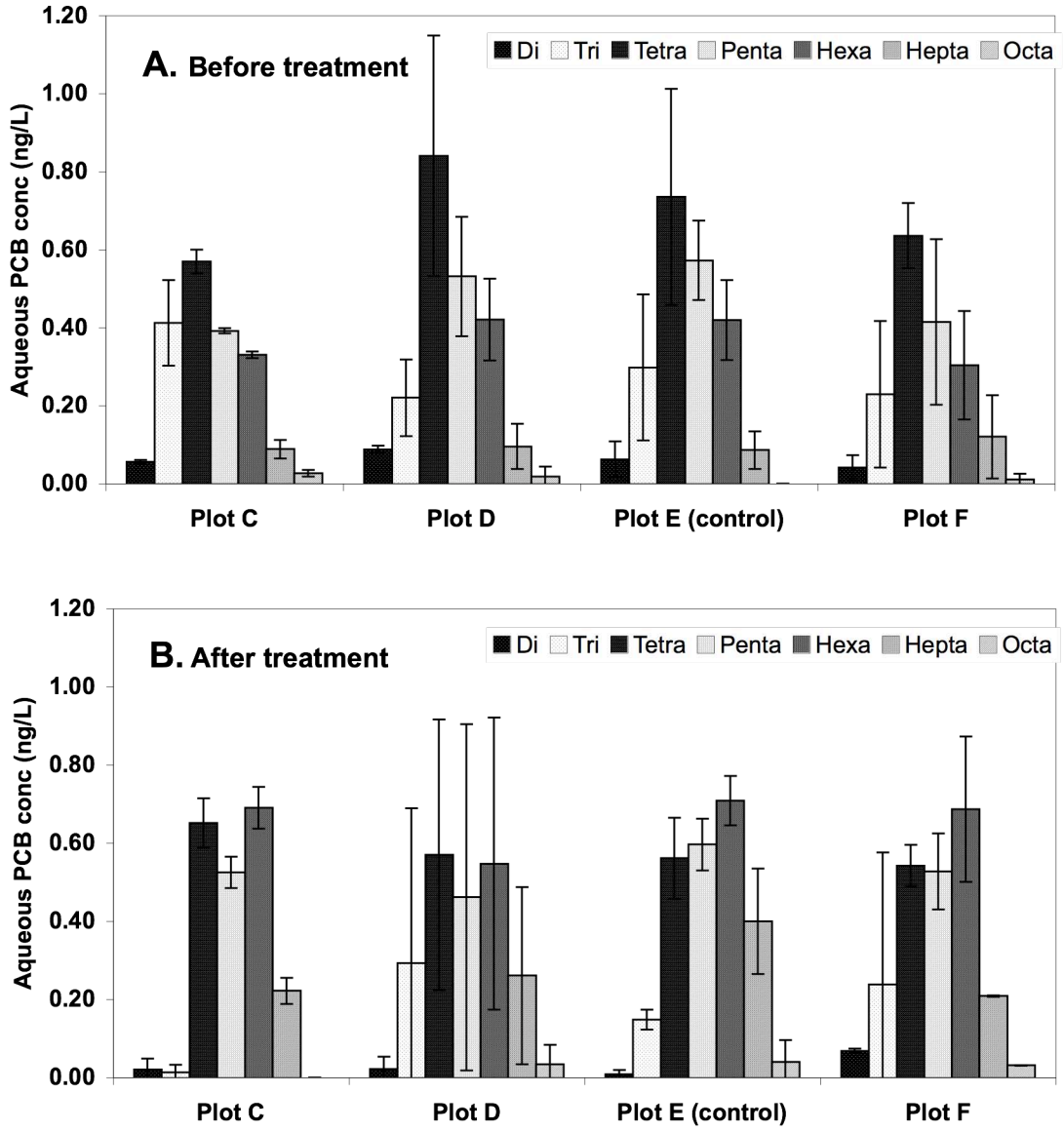


Figure 6-13. Comparison of (a, b) aqueous PCB concentration and (c, d) particle-associated PCB concentrations sampled above the test plots during high tide one day before and immediately after AC treatment. Each column and error bar represents the mean and one standard deviation (n = 2).

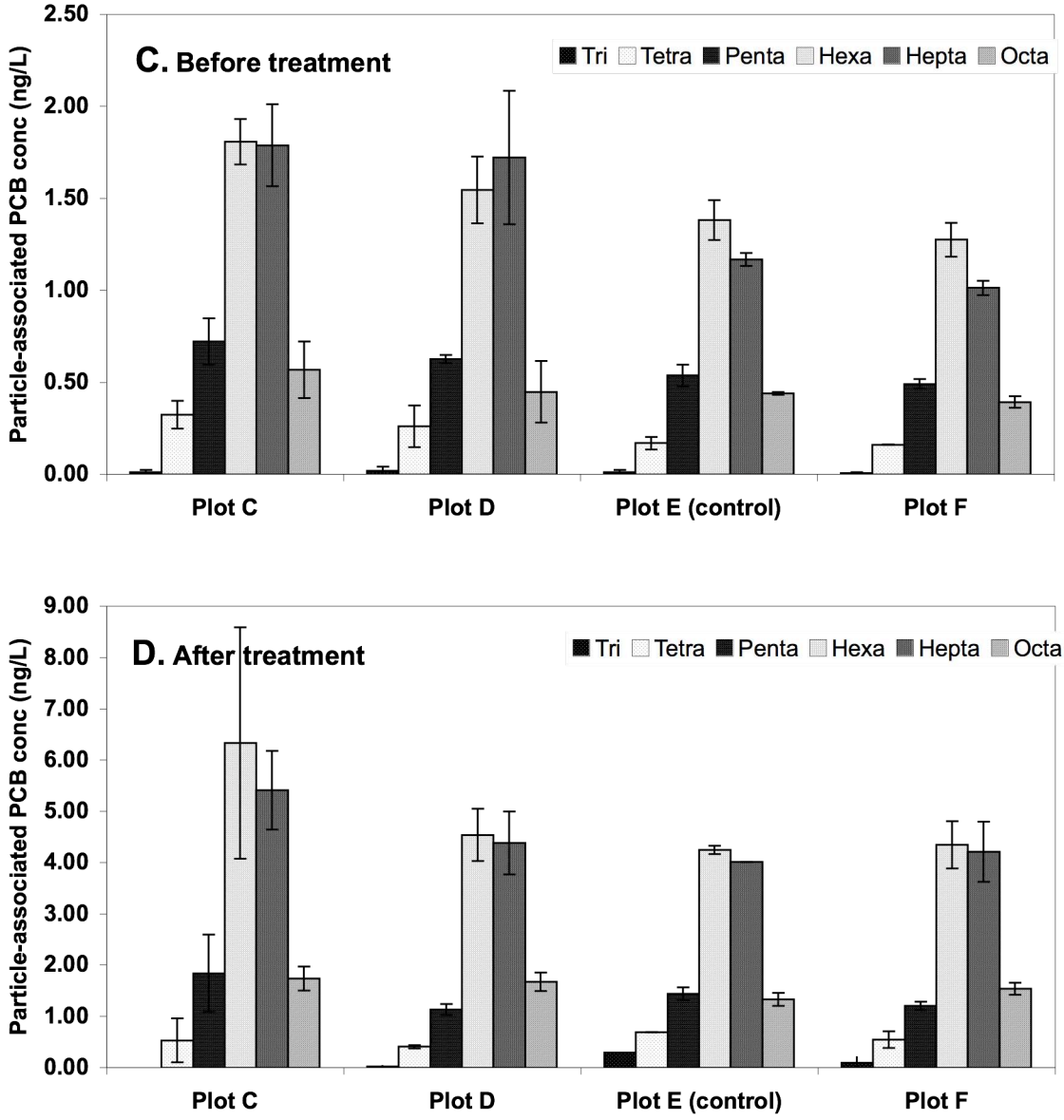


Figure 6-14 (Continued). Comparison of (a, b) aqueous PCB concentration and (c, d) particle-associated PCB concentration sampled above test plots during high tide one day before and immediately after AC treatment. Each column and error bar represents the mean and one standard deviation (n = 2).

6.2 Secondary Objectives

6.2.1 AC/Sediment Stability

We hypothesized that total organic carbon contents would not change significantly between two post-treatment assessments assuming no loss of deployed activated carbon from the sediment. As seen in Table 6-2, after AC amendment, Plots D and F showed significant enhancement of TOC and BC values in the upper 15-cm sediment layer, which confirms successful AC

incorporation into the designated plots in the range of 2 to 3.2% g AC/g dry sediment. Because the two post-treatment assessments utilized different sampling locations, the AC-treated plots showed variable TOC values between the two assessments although the differences are not statistically significant for both plots (Student t-test, $p>0.05$). TOC data for 5-cm core sections down to 30-cm depth show that the mixing of AC into the plot resulted in variable distribution of the AC (Figure 6-12). This uneven AC distribution was possibly induced by the uni-directional mixing motion of the mixing devices as well as by insufficient mixing time. In terms of variability, Plot F showed higher variability than Plot D (coefficient of variation), indicating that AC-mixing via the slurry injection device on Plot F was less homogeneous than the rotovator device employed at Plot D. As expected, the unmixed reference Plot E retained similar TOC values throughout the assessment events. The mixing-control Plot C showed an increase of TOC after mixing, which implies an effect of mixing on TOC redistribution within the top 15-cm sediment layer.

We found that the surficial sediment of the two AC-treated plots contained less BC/TOC contents 24 months after treatment. There are several possible explanations for this observation: sediment deposition or sediment winnowing. As discussed earlier (section 6.1.2.3), there was strong evidence for sediment deposition 24 months after treatment, while the data suggest sediment winnowing was not evident during the project time span. We conclude that sediment deposition was occurring based on the totality of measurements and observations.

6.2.2 Effects of AC Treatment on Indigenous Benthic Community

Benthic macroinvertebrates are useful indicators of chemical and physical sediment perturbations. Such organisms comprise pollution sensitive (e.g., amphipods), pollution tolerant (e.g., *Capitella capitella, Gemma gemma, Streblosbio benedicti*), and rapid colonizing (e.g., *S. benedicti, G. gemma*) taxa [53]. The taxa and their densities in the current study (Table 6-3 and Table 6-4) were relatable to previously reported marine assemblage taxa and densities (mean: 39,000; range: 500–3,500,000 m^2) in San Francisco Bay [54]. Univariate (Table 6-4) and multivariate (Figure 6-15) analyses (two-way ANOVA and ANOSIM) indicated sampling time (Dec. 2005, Jul. 2006, and Jul. 2007; ANOSIM: R=0.89-0.91, p=0.001) was more important in determining assemblage structure than differences between plots (ANOSIM: R=0.14-0.34, $p<0.05$). Taxa richness and diversity between plots were not significantly different, indicating similar species composition between control, mixed and AC treatments.

Table 6-3. Taxa list of benthic macroinvertebrates from benthic community surveys.

Phylum	Taxon
Annelida	*Goniadidae*
	Exogene lourei
	Brania brevipharyngea
	Polynoidae
	Eteone californica
	Nereis succinea
	Capitella
	Heteromastus filiformis
	Pseudo / polydora
	Streblospio benedicti
	Terebellidae
	Cirriformia spirobrancha
	Tubificoides
Platyhelminthes	Platyhelminthes
Arthropoda	*Ostracoda*
	Balanus amphitrite
	Unknown Aphipod
	Corophium
	Grandidierella japonica

Phylum	Taxon
Arthropoda	*Ampelisca*
	Cirolana
	Paranthura elegans
	Cumacea
	Maxillopoda
Protista	*Foraminifera*
Cnideria	*Antrozoa*
Mollusca	*Macoma*
	Gemma gemma
	Prothaca staminea
	Venerupis philippinarum
	Pomatocorbula amurensis
	Mytilidae
	Musculista senhousia
	Mytilus edulis
	Bulla
Nematoda	Nematoda
Nemertea	Nemertea

Table 6-4. Summary of means for univariate benthic macroinvertebrate assemblage metrics (one standard deviation from the mean provided in parentheses). Values with different letter designations within each individual sampling event were statistically significantly different.

Metric	Pre-treatment (December 2005)				6-month post treatment (July 2006)				18-month post treatment (July 2007)			
	C	D	E	F	C	D	E	F	C	D	E	F
Total abundance (No. / m^{-2})	46,927 (14,552) A	48,490 (7,560) A	30,854 (9,728) A	58,988 (21,046) A	45,601 (9,859) a	57,782 (61,541) a	56,620 (15,695) a	46,281 (15,865) a	258,748 (107,716) AB	160,474 (25,432) B	328,766 (85,380) A	219,462 (88,396) AB
Taxa richness	16.8 (3.9) A	18.5 (2.9) A	16.2 (2.0) A	17.8 (1.5) A	17.4 (2.7) a	17.4 (2.9) a	18.2 (1.9) a	19.8 (1.6) a	12.8 (3.6) A	14.6 (2.7) A	13.3 (1.0) A	12.6 (4.2) A
Shannon diversity	1.62 (0.62) A	1.89 (0.19) A	1.87 (0.04) A	1.79 (0.17) A	1.68 (0.36) a	1.88 (0.34) a	1.60 (0.32) a	1.86 (0.05) a	1.42 (0.25) A	1.18 (0.26) A	1.13 (0.23) A	0.83 (0.21) A
Amphipod abundance (No. / m^{-2})	29,286 (10,056) A	21,929 (6,115) A	8,618 (3,245) B	9,309 (3,391) B	24,198 (10,662) a	37,695 (37,788) a	30,481 (8,832) a	24,615 (7,940) a	157,141 (82,094) A	97,056 (27,506) A	220,493 (89,200) A	155,124 (69,254) A
Relative amphipod abundance (%)	66.4% (23.9) A	44.9% (7.4) A	27.3% (4.6) B	16.6% (7.3) B	52.4% (16.7) a	66.8% (17.5) a	53.8% (7.0) a	53.8% (6.3) a	58.4% (9.0) A	60.4% (13.1) A	65.3% (9.3) A	69.5% (5.7) A
Gemma gemma abundance	833 (1,035) A	726 (406) A	329 (315) A	1,809 (937) A	2,664 (2,935) a	230 (255) a	1,294 (841) a	1,502 (692) a	50,085 (36,988) A	18,771 (14,912) B	5,373 (3,892) B	965 (572) B
Annelid abundance	7,993 (6,490) B	14,459 (3,393) AB	11,589 (5,460) B	29,242 (12,887) A	11,041 (3,118) a	10,054 (9,437) a	8,980 (3,889) a	7,127 (3,041) a	28,244 (4,273) B	25,832 (2,478) B	47,695 (5,689) A	43,287 (19,509) A
Dispersion	1.457	0.357	0.375	0.435	0.986	1.519	0.995	0.703	1.356	1.471	1.088	1.037

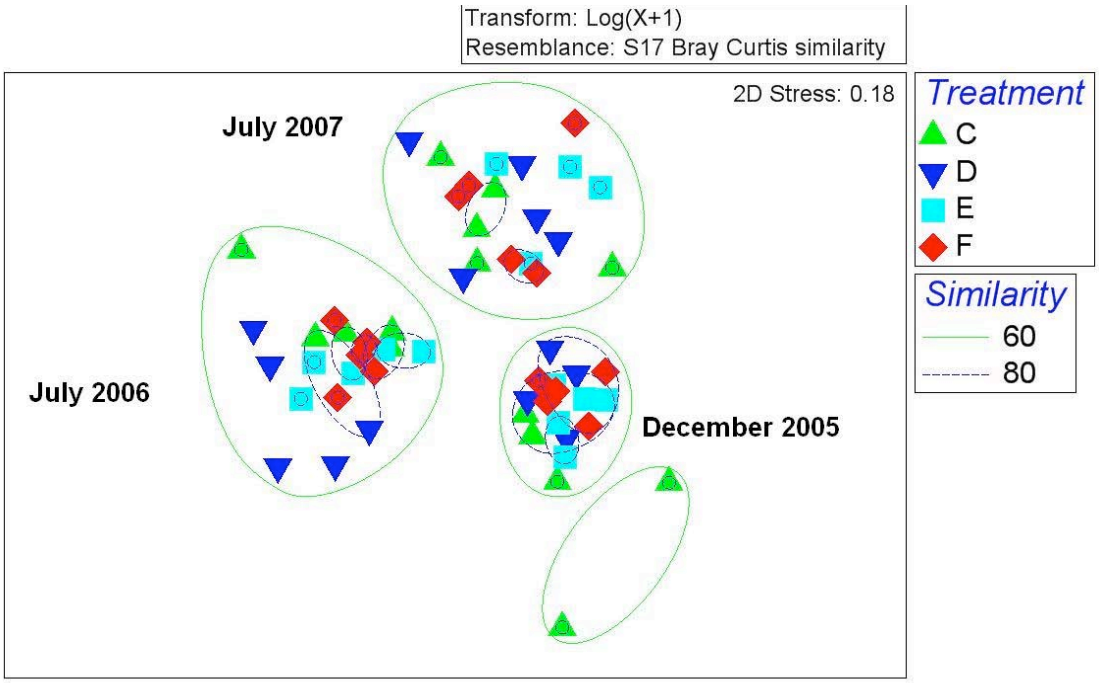


Figure 6-15. Combined multi-dimensional scaling and clustering results for all benthic community data (2005-2007). The relative positioning between data points represents their degree of similarity, with the most distant points being more dissimilar. The replicate points are clearly clustered by sampling event (as least 60% similarity), suggesting seasonality as the most important determining factor for the community. December 2005 data plots were closely clustered, indicating greater similarity (mostly 80%) compared to July 2006 and 2007 data (60% similarity). The undisturbed control plot (E) replicates were consistently the most similar to one another relative to the other plots while Plot D was more dispersed.

Total abundance was significantly higher in July 2007 [18-months post treatment] relative to previous sampling (independent of plot). Abundance in July 2006 [6-months post treatment] was likely suppressed relative to July 2007 due to low salinity (10‰), which was less than the typical central SF Bay range (25 – 30‰; 2000-2008; http://sfbay.wr.usgs.gov/access/wqdata/index.html) and the reported lower threshold (18 ‰) for marine assemblages [54]. For pre-treatment and six-month post-treatment sampling, total abundance was not statistically different between plots. However, at 18-months post-treatment, significantly lower abundance was found in Plot D relative to Plot E. This reduction corresponded with lower amphipod abundance in Plot D (Table 6-4). As in Thompson et al. [54], *Corophium* amphipods were the predominant taxon (> 40% of all invertebrates present). The relative abundance of amphipods was not significantly different between plots, indicating they were not disproportionately affected relative to the community. Shifts in amphipod abundance may have resulted from natural abiotic effects [53] and amphipod numbers increased significantly in Plots E and F from pre-treatment levels. The distance between replicate data points (i.e., dispersion) in MVDSP and NMDS analysis (Figure 6-15) is representative of variability in community composition within each plot and is generally considered a sensitive indicator of disturbance [24]. Pre-treatment dispersion was lower than post-treatment, and the relative dispersion within Plot D increased from pre- (0.357) to post-treatment (1.519, 1.471), indicating greater heterogeneity relative to consistently lower dispersion (0.375 –

1.088) in the unaltered Plot (E) (Figure 6-15 and Table 6-4). Significantly more *G. gemma* clams were found in Plot C (and substantially more in Plot D) relative to Plots E and F, corresponding with the rotorvator mixing method and comparatively softer substrate. Overall, post-treatment differences between the plots were minor relative to natural seasonal fluctuations between sampling events and inter-plot differences were not consistent between 6-month and 18-month post-treatment. The benthic communities on the plots are similar to what would be expected to occur in similar habitats throughout the Bay.

6.2.3 PCB Uptake into SPMDs

6.2.3.1 28-day *In situ* Uptake Experiments

In situ SPMD uptake experiments were conducted to obtain another indicator of the effect of AC amendment in the field in parallel with *in situ* clam bioaccumulation studies. At the 6-months post-treatment assessment, there were 66% and 62% reductions in PCB uptake into SPMDs in the AC-treated plots, Plots D and F respectively (Figure 6-16), compared to the mixing control plot (t test, $p < 0.05$ for both). At the 18-months post-treatment assessment, there were 52% and 46% reduction in SPMD uptakes for Plots D and F, respectively (t test, $p < 0.05$ for both). The differences between the two assessment time points are possibly due to the spatial variances of sediment AC dose, e.g., for Plot D the AC content varied from 2 to 3% [55]. As shown in Table 6.2 and Figure 6-17 the 18-month post-treatment sampling locations for Plot D contained an average smaller dose of AC compared to the 6-month post-treatment sampling locations. Also we observed that mixing might enhance SPMD-sediment by redistributing fine particles through the sampling region.

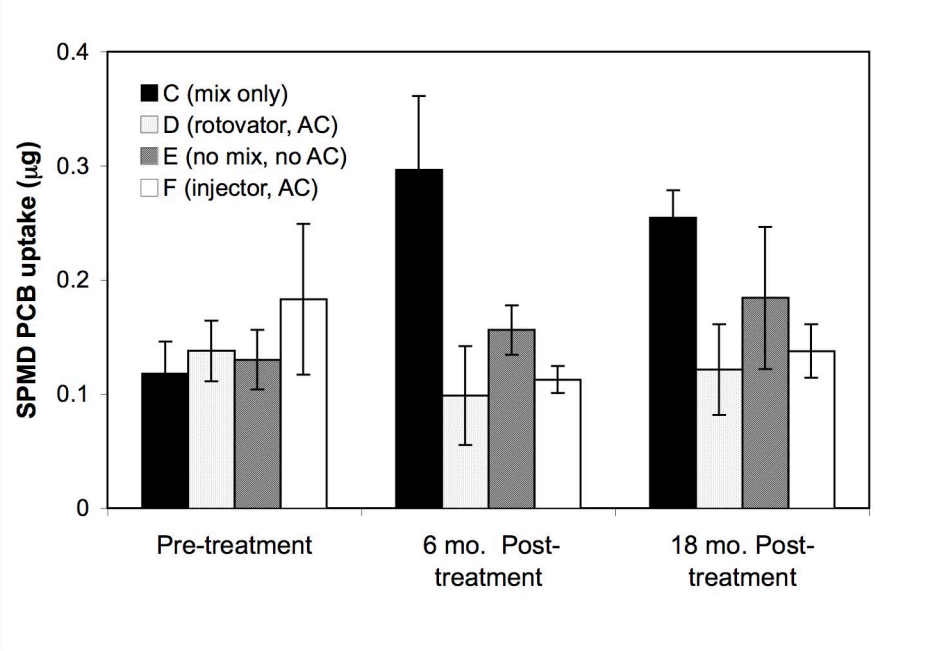


Figure 6-16. PCB uptake into field deployed SPMDs. Total PCB concentrations were obtained by summation of 92 PCB congeners or congener groups. Each column and error bar represents the mean and one standard deviation (n = 3-5).

SPMDs are useful bio-mimetic passive samplers, and correlations between uptake in SPMDs and biological indicators (e.g., fish, mussels) have been reported in the literature [56]. However, the use of passive membrane samplers placed within sediment is relatively new [21] and here we find a correlation between clam bioaccumulation and SPMD uptake (Figure 6-17), although the correlation was relatively weak ($R^2 = 0.49$, $p = 0.01$). As discussed in the previous section, there were many uncertainties that possibly masked the *in situ* biological signals. The burial depth of SPMDs (spanning 1-5 inches) was deeper than that of clams (1-2 inches), implying that the SPMDs could respond better to AC treatment and attain better contact with finer-grained sediments. We found a good correlation between pore-water PCB concentrations and SPMD-PCB uptakes [55].

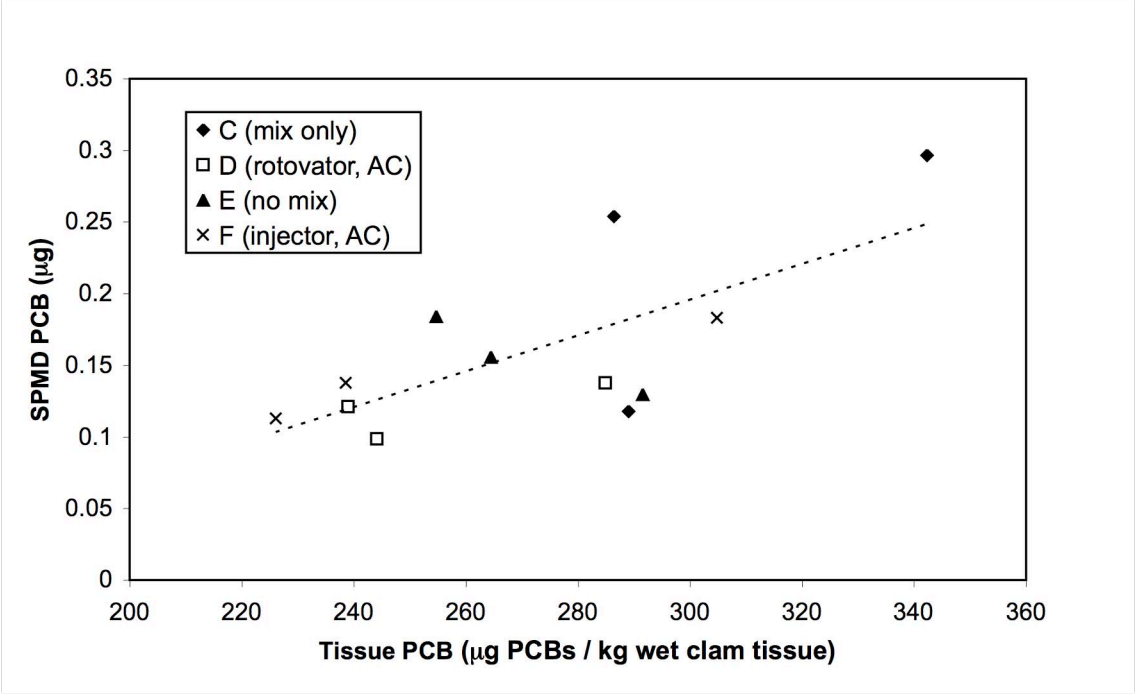


Figure 6-17. Correlation between *in situ* clam PCB bioaccumulation and *in situ* PCB uptake into SPMD in three assessment events (pre-treatment, 6-month post-treatment, and 18-month post-treatment assessments). Each point represents average tissue PCBs (x-axis), and average SPMD uptake (y-axis) for each plot and each assessment (n=3-5). The dotted line represents the trend line with $R^2 = 0.49$ ($p=0.01$). Total SPMD uptakes and tissue PCB levels were measured by summation of PCB congener/congener groups (92 for SPMD and 134 for clam tissue).

6.2.3.2 Correlation Between PCB Uptakes into SPMDs and Porewater PCB Conc.

In addition to SPMDs, we utilized another kind of passive samplers, polyethylene devices (PEDs) to study the effect of AC-amendment. The study of PCB uptake into PEDs is the part of our related SERDP project number 1552 on measurement and modeling of ecosystem risk and recovery for *in situ* treatment of contaminated sediments. The uptake of PCBs by PEDs is analogous to passive uptake by SPMDs, as PEDs are simply SPMDs without the inner lipid layer. PEDs are advantageous due to their simplicity and that they may come to equilibrium faster than

SPMDs [21]. Sediment pore water concentrations were estimated from field-deployed PEDs using impregnated reference compounds to estimate the sampling rate [21]. Until now, there has been no direct comparison between these two passive sampling techniques. Here, the relationship between PEDs and SPMDs is shown in Figure 6-19 where the mass of PCB uptake into SPMDs in the four test plots are well correlated with the estimated pore-water concentrations by PEDs. The good correlation between the two passive samplers (SPMDs and PEDs) provides mutual validation, and confirms the effectiveness of AC-amendment by either less PCB uptake into samplers or by lower pore-water PCB levels in the AC-treated plots as estimated from PEDs placed in the sediment.

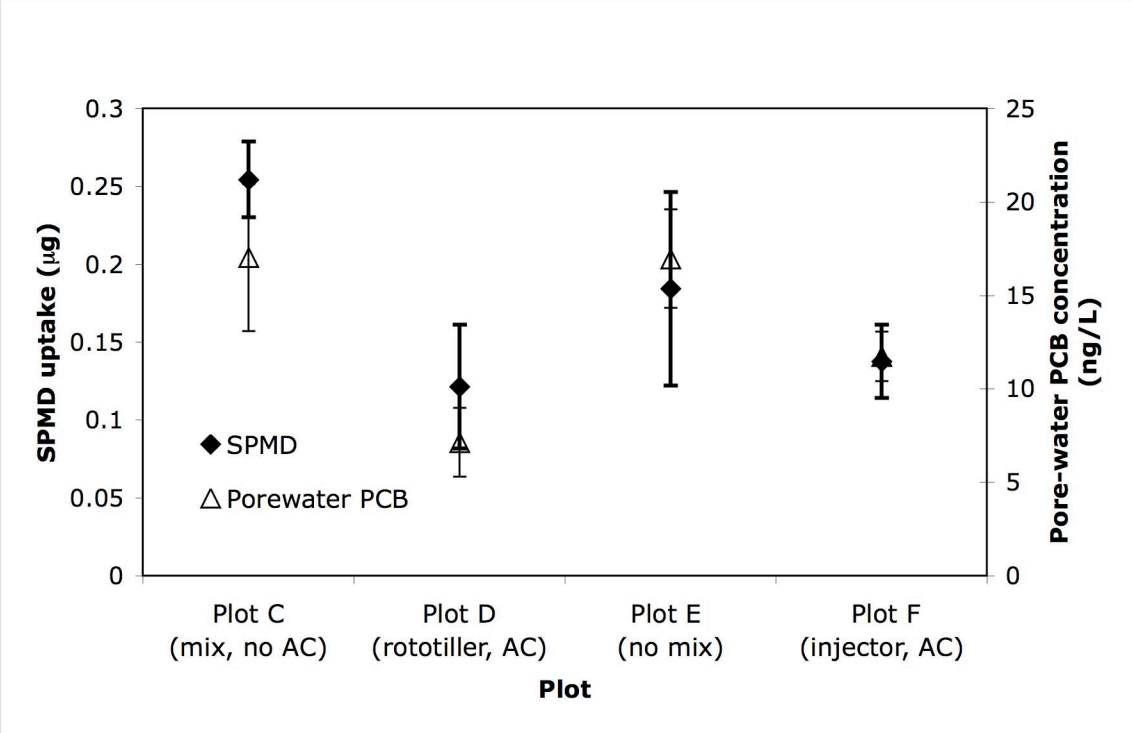


Figure 6-18. SPMD uptake (n=5) versus pore-water concentration estimated from PEDs (n = 10). Total PCB concentrations/uptakes were obtained by summation of 92 PCB congeners or congener groups.

6.2.3.3 *In situ* Long-term SPMD Uptake Experiments

To investigate the effect of AC treatment during longer exposure periods, a time series measurement of SPMD uptake was conducted in the AC-treated plot (Plot D) and mixing control plot (Plot C) thirteen months after treatment. These two plots were selected for longer-exposure PCB uptake assessments because the two plots underwent the same mixing regime by the rotovator system. Figure 6-19 shows SPMD uptake of PCBs by homolog groups for exposure times ranging more than 7 months. For SPMDs exposed to the sediment for 94-days, the AC-treated Plot D showed 50% reduced total PCB uptake compared to the untreated Plot C. This reduction was evident even after 7-months of continuous exposure, indicating AC treatment efficacy was retained for a 7-month contact time. The PCB reduction ranged from 76 % for tetra-chloro PCBs to 42% for hepta-chloro PCBs. The aqueous equilibrium experiment showed greater than 70% reduction in PCB concentrations for all homologues for AC-treated Plot D

compared to Plot C with 2.42 - 3.38 wt % TOC. The difference between aqueous equilibrium PCB concentration and SPMD uptake is possibly due to the limited mass transfer conditions in the field (quiescent system) and the heterogeneous nature of the AC distribution. Aqueous equilibrium PCB concentration measurements were performed in the laboratory and included a 14-day mixing period to equilibrate the sample, so these measurements entailed much greater contact between AC and sediment. The field deployed SPMDs experienced a static, heterogeneous AC-sediment mixture that received no mechanical mixing beyond the initial mixing of less than half an hour. Under static conditions for the field sediment, the stabilizing action by AC particles is limited to a localized parcel of sediment and is dependent on pore water diffusion perhaps with some small advective transport [38].

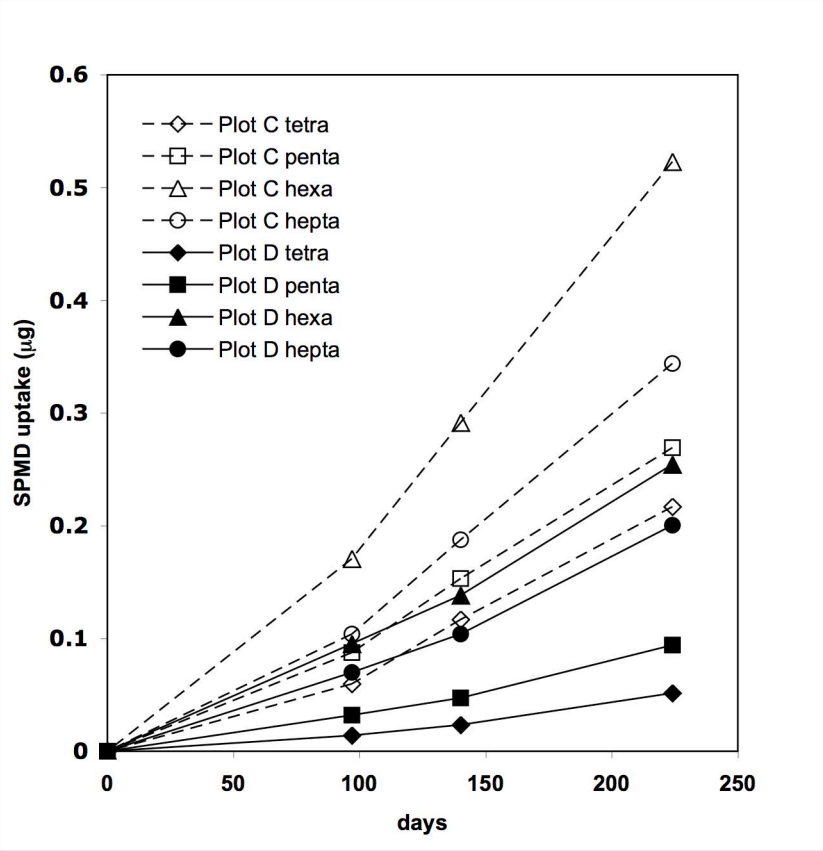
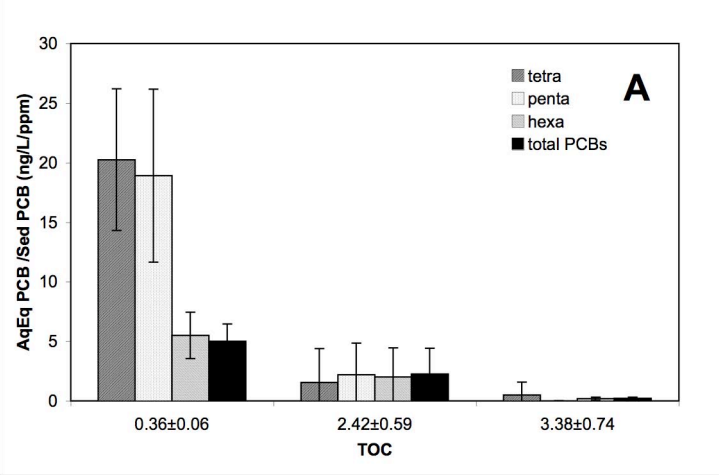


Figure 6-19. Time series PCB uptakes into SPMDs from Plots C (mixing control) and D (AC mix, rotovator) (n = 1-2). The time series began 13 months after AC treatment.

6.2.4 **Aqueous Equilibrium PCB Concentrations**

Figure 6-20 a and b show PCB aqueous equilibrium concentrations and corresponding TOC contents in the sediment for Plots D and F. The data represent sampling at five different locations on each test plot at time 6- and 18-months post treatment. Aqueous equilibrium concentrations were normalized by PCB sediment concentrations to account for the variability of sediment levels. Our assessments show that the dominating factor affecting PCB aqueous equilibrium is the average AC dose. Increasing TOC by adding activated carbon, whether by the rotovator in Plot D or the injector device in Plot F, correlated with decreasing aqueous

equilibrium PCB concentrations. In Plot D, more than 95 % reduction in equilibrium aqueous PCB concentration was obtained with an approximate 3% increase of TOC. The effect of reducing aqueous concentration was greater for tetra- and penta-chlorinated PCB homologues than for hexa-chlorinated PCBs, which is likely a consequence of slower mass transfer uptake of PCBs by AC for the higher homologues. Plot F showed a similar trend, but the dose-response relationship is not as clear as that for Plot D. This is attributed to the greater heterogeneous sediment properties of Plot F than Plot D in terms of both PCB and AC distributions. This dose-response relationship correlates very well with the relationship found in a laboratory study with sediment from South Basin in which mixing with AC reduced aqueous equilibrium PCBs level from 44 to 87% as dose was increased from 0.34 to 3.4% [18]. Field-deployed AC particles retained their potential to stabilize PCB contaminated sediment for at least up to 18 months after the initial field deployment event. Laboratory studies with sediment have shown similar long-term effectiveness with AC for 18 months of continuous mixing with sediment [57].



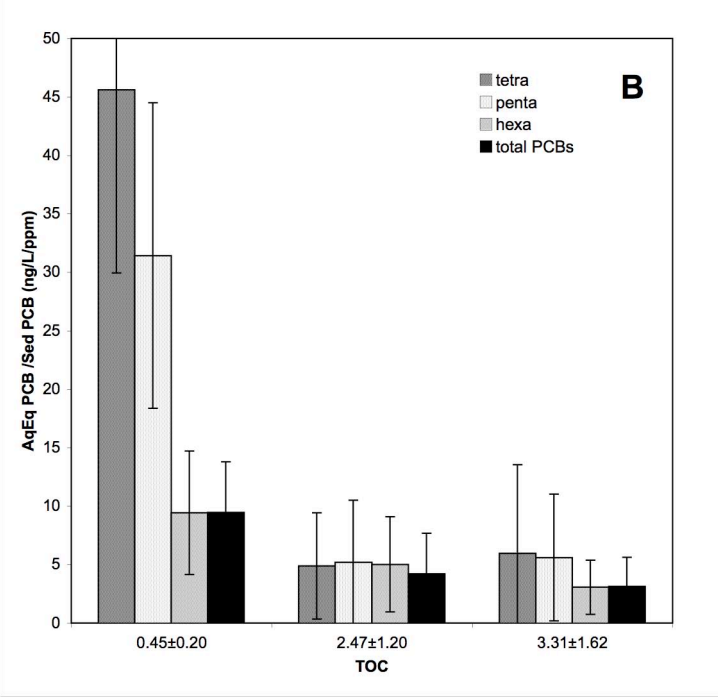


Figure 6-20. AC dose-response relationship for aqueous equilibrium PCB concentrations normalized by sediment concentrations. (a) Plot D and (b) Plot F. Each column and error bar represents the mean and one standard deviation (n=5). Total PCB concentrations were obtained by summation of 92 PCB congeners or congener groups.

6.2.5 PCB Desorption Rates

Results of PCB desorption kinetics of sediment obtained before and 6- to 18-months after AC application are shown in Figure 6-21. The results are presented as fraction PCB desorbed at different times for different doses of AC achieved in the field as BC contents. The two AC-treated plots (Plot D and F, Figure 6-21a and b) show decreases in fraction of PCB desorbed with increasing dose of AC. Unlike aqueous equilibrium tests that used five field replicate sediment samples per each plot, these PCB desorption tests were conducted with one composite sample from each plot, so the greater heterogeneity of Plot F did not affect the results in this case. For the untreated plot C (Figure 6-21c), there is no significant change in fraction PCB desorbed before and after treatment. However, for the untreated plot E (Figure 6-21d), at 18 months after treatment there is a marked increase in PCB desorbed compared to the before and 6-month after treatment samples. This large increase in desorbed fraction in the untreated plot E is likely related to the higher PCB concentration observed in sediment samples obtained from this plot 18 months after treatment and a weaker binding of PCBs associated with the high concentration material. The desorption studies support the findings from the other measurements that PCB availability is reduced after AC application in the field.

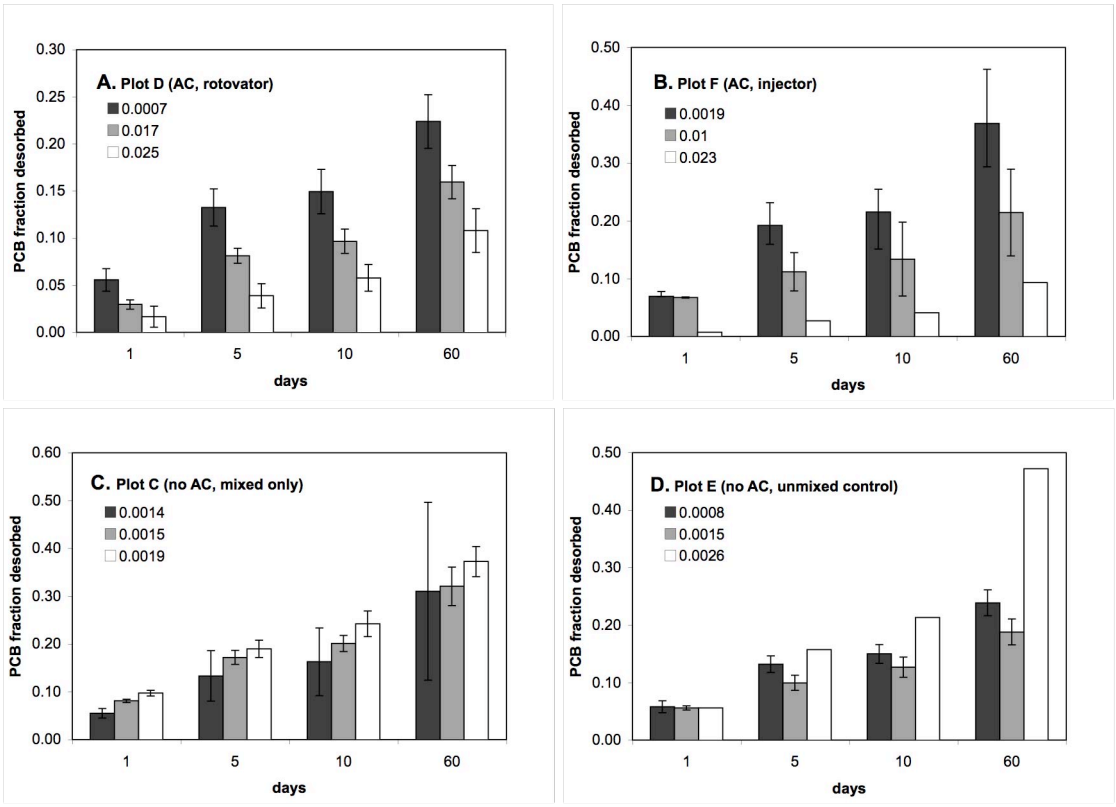


Figure 6-21. PCB desorption kinetics of sediment samples from four treatment plots obtained before, and 6- and 18-months after, AC application in the field. The bar graphs show the fraction of PCBs desorbed for samples with different black carbon (BC) contents. Each column and error bar represents the mean and one standard deviation (n=1-2, analytical replicates). The dark bars correspond to pre-treatment samples, and the gray and white bars correspond to 6- and 18-month post-treatment samples, respectively. Total PCB concentrations/uptakes were obtained by summation of 92 PCB congeners or congener groups.

6.2.6 Factors Affecting Technology Performance

We identified two field conditions as major factors affecting our AC-amendment performance. First, as described in section 6.1.2.3, deposition of fresh, in-coming PCB-contaminated sediment on the test plots confounded the results of *in situ* bioassays, because the biological indicator in our project, *Macoma nasuta*, relies on feeding of surficial sediment material. However this factor did not affect other performance measurements: *ex situ* bioassays, passive sampler uptake experiments (SPMDs and PEDs), aqueous equilibrium experiments, and desorption experiments with sediment samples. Therefore, this illustrates for success at full-scale, contaminant source control and management of incoming contaminated sediment from surrounding areas are necessary to reduce exposure and risk. In the case of technology demonstrations at small-scale, adequate performance assessments should be selected and conducted in ways that assess the effectiveness of AC-amendment to the underlying treated sediment layer independent of confounding effects of sediment deposition. As shown here, this is a concern for small test plots located within a larger contaminated region subject to deposition of fresh, in-coming contaminated sediment.

Second, slow, diffusion-limited PCB mass transfer under field conditions retards the beneficial effect of the AC amendment (section 6.1.2.4). This retardation results in differences between performance assessments such as bioaccumulation experiments and physicochemical tests with well-mixed samples in the laboratory versus minimally mixed sediment in the field. These differences were apparent within the 3-year project time frame of this demonstration project. These differences would be diminished with long-term monitoring and point to the need for predictive models to assess long-term performance and risk reduction.[39]

Although sediment winnowing was not evident in this study, there could be a concern about possible sediment winnowing and consequent AC loss in the surficial sediment layer in some higher-energy environments. Therefore, the stability of AC amendment should be thoroughly tested before the application of this AC amendment technique to another sites.

6.2.7 Versatility

As described in section 3.1.4, calculations from BC data showed 2.0 and 2.6 wt% of AC was incorporated into the top 6-inch sediment layer of Plots D and F respectively. From TOC data, it was estimated that on average both plots contained approximately the same amount of AC (2.6 wt%). These values are less than the intended amount of AC addition (3.4 wt%). This is probably due to the relatively small test area and vertical (e.g., ~15 vs. 12 inches) and/or horizontal over-mixing. Based on our experience and data, we conclude that both mixing devices could provide similar and adequate AC-mixing performance. At full scale, a cofferdam may be constructed across the inlet of South Basin. Work could then commence behind the cofferdam unimpeded by tidal action. This would greatly speed up AC addition as well as allow consideration of other devices for spreading and mixing the AC.

6.2.8 Scale-Up Constraints

Both mixing devices from AEI and CEI succeeded in mixing AC into test plots in a day. It took less than 30 min for AC-mixing by both mixing devices. Most of the operational time was spent for mobilization/demobilization of devices. As noted above, a cofferdam may be constructed across the inlet of South Basin. Work could then commence behind the cofferdam unimpeded by tidal action. This would greatly speed up AC addition and allow consideration of other devices for spreading and mixing the AC.

6.3 Conclusions

This three-year project successfully demonstrated that the top layer of sediments in a PCB-contaminated tidal mudflat could be amended with activated carbon using large-scale commercial equipment. This is the first field demonstration anywhere of *in situ* sorptive sequestration of PCBs in contaminated sediments. We showed that the field-scale AC-amendment reduced the availability of PCBs to water and biota without adversely impacting the natural benthic community of macroinvertebrates nor releasing PCBs into overlying water. We also identified two field factors that affected performance of the AC-amendment: the deposition of fresh, in-coming contaminated sediment, and slow, diffusion-limited PCB mass transfer under quiescent field conditions. Further we demonstrated that the sequestration potential of AC was evident during the entire project period.

Using a one-time, approximate 30-minute mixing event, AC amendment was able to reduce PCB bioaccumulation in marine clams (*M.nasuta*) by 30-50%, reduce available PCB in sediment pore water by 50 to 70% for continuous passive sampler exposures lasting seven months, and reduce PCB desorption rates from sediment. With additional mixing in the laboratory, AC-amended field sediment showed more than 95% reduced partitioning into the aqueous phase depending on AC dose, which confirms that the potency of AC was retained.

Furthermore, we demonstrated the strong effects of AC dose and mixing regime on reductions in PCB bioaccumulation through the comparison of data collected for sediment-AC contact under well-mixed, homogeneous conditions in the laboratory and data collected for sediment-AC contact under a one-time, brief mixing event in the field. The lower reductions in PCB bioaccumulation observed in the field calls for predictive models to assess long-term trends in changes in PCB-pore water concentrations under field conditions with slow mass transfer and heterogeneous distribution of AC. We expect that comprehensive understandings of PCB mass transfer under field conditions will provide a foundation for performance modeling and allow improved predictive assessments for this *in situ* remediation technology.

To enhance the immediate effect of AC amendment in the field and maximize the overall treatment effect by AC, improvements of AC-sediment contact will be essential. Additional mechanical mixing, sequential deployment of AC, increasing AC dose, or adjusting AC particle sizes are possible solutions for this issue. If ongoing sources are eliminated and freshly deposited sediments are clean, AC amendment to contaminated sediments can provide a suitable *in situ* method for reducing risk and contaminant exposures to the water column and biota for those contaminants originating from within the sediment.

6.4 Publication of Results

6.4.1 Peer Reviewed Journal

Cho, Y.-M.; Ghosh, U.; Kennedy, A. J.; Grossman, A.; Ray, G.; Tomaszewski, J. E.; Smithenry, D. W.; Bridges, T. S.; Luthy, R. G., Field Application of Activated Carbon Amendment for *In situ* Stabilization of Polychlorinated Biphenyls in Marine Sediment. *Environ. Sci. Technol.* **2009,** ASAP, available from the *ES&T* web site.

Zimmerman, J. R.; Bricker, J. D.; Jones, C.; Dacunto, P. J.; Street, R. L.; Luthy, R. G., The stability of marine sediments at a tidal basin in San Francisco Bay amended with activated carbon for sequestration of organic contaminants. *Water Research* **2008,** 42, (15), 4133-4145.

Cho, Y.-M.; Smithenry, D. W.; Ghosh, U.; Kennedy, A. J.; Millward, R. N.; Bridges, T. S.; Luthy, R. G., Field methods for amending marine sediment with activated carbon and assessing treatment effectiveness. *Marine Environmental Research* **2007,** 64, 541-555.

6.4.2 Conference Proceedings

Cho, Y.-M.; Luthy, R. G.; Ghosh, U.; Kennedy, A. J.; Bridges, T. S. *Field Testing of Activated Carbon Mixing and In situ Stabilization of PCBs in Sediment,* Partners in Environmental Technology Technical Symposium & Workshop, Washington D.C., 2008.

Cho, Y.-M.; Tomaszewski, J. E.; Luthy, R. G.; Ghosh, U.; Kennedy, A. J.; Bridges, T. S. *Field Testing of Activated Carbon Mixing and In situ Stabilization of PCBs in Sediment,* Partners in Environmental Technology Technical Symposium & Workshop, Washington D.C., 2007.

Cho, Y.-M.; Smithenry, D. W.; Ghosh, U.; Kennedy, A. J.; Millward, R. N.; Bridges, T. S.; Luthy, R. G. *Field Testing of Activated Carbon Mixing and In situ Stabilization of PCBs in Sediment,* Partners in Environmental Technology Technical Symposium & Workshop, Washington D.C., 2006.

Cho, Y.-M.; Smithenry, D. W.; Ghosh, U.; Kennedy, A. J.; Millward, R. N.; Bridges, T. S.; Luthy, R. G. *Application of Activated Carbon Amendment for In situ Stabilization of PCBs in Sediment: Field-Scale Studies*, CALFED Bay-Delta Program Science Conference, Sacramento, CA, 2006; Sacramento

7 COST ASSESSMENT

7.1 Cost Model

Table 7-1. Cost Model for In Situ Stabilization by Activated Carbon Mixing

Cost Element	Data Tracked During the Demonstration	Costs	
Treatability study	• Detailed assessment required • Personnel required and associated labor • Materials • Analytical laboratory costs	Lab technician, 80 h	$2,000
		Materials	$3,000
		Analytical laboratory	$7,200
Baseline characterization	• For 20 monitoring locations • Detailed field/laboratory assessments required • Field assessment costs • Analytical laboratory costs • Personnel required and associated labor • Materials	Field technician, 5*20 h Lab technician, 3*160 h	$2,500 $12,000
		Materials	$18,000
		Analytical laboratory	$26,400
Site preparation	• No cost tracking	NA	
Activated carbon amendment	• For 700 ft^2 treatment by one of mixing options • Activated carbon • Mobilization/demobilization of AEI Aquamog • Mobilization/demobilization of CEI Injector system • Personnel required and associated labor	Field technician, 5*20 h	$2,500
		Materials	$3,000
		Activated carbon (TOG), 350 lb / 100 ft^2	$ 7000
		AEI Aquamog Labor & Rental, 2 days	$10,000
		CEI Injector Labor & Rental, 2 days	$10,000
Operation and maintenance costs (periodic monitoring)	• For 20 monitoring locations • Detailed field/laboratory assessments required • Field assessment costs • Analytical laboratory costs • Personnel required and associated labor • Materials	Field technician, 5*20 h Lab technician, 3*320 h	$2,500 $24,000
		Materials	$18,000
		Analytical laboratory	$26,400
		Reporting (per year)	$10,000
Decontamination and residual waste management	• Standard practice, no cost tracking	NA	
Public education program	• No cost tracking	NA	
Operation and maintenance costs	• No unique requirements recorded	NA	
Long-term monitoring	• No cost tracking	NA	

7.1.1 Treatability Study

Laboratory treatability studies should be conducted before a field application to assure the benefit of activated carbon to treat contaminants of concern. The use of regenerated carbon can be also tested in this study. The cost was based on the gross expenditure for the preliminary regenerated AC carbon study in this project.

7.1.2 Baseline characterization

Baseline characterization would include sediment core sampling, water sampling, benthic community survey, and biological assessments (either *in-situ* or *ex-situ)*. This cost model is based on the gross expenditure of the pretreatment assessment with a total of 20 sampling locations (4 locations for water sampling). It should be noted that the intensive monitoring activities were conducted in a relatively small area (5 monitoring/sampling locations per approximately 370 ft^2 in this project. For full-scale application, the monitoring would be sparser than for this project, which reduces the unit cost for baseline characterization.

7.1.3 Site preparation

The site preparation cost comprises the cost to optimize the site for AC application and mixing. For example, installation of silt curtain, installation of cofferdam, and dewatering would be included in this cost component. These operations are typical for sediment remediation.

7.1.4 Activated carbon amendment

This component would include operation/labor for selected mixing devices. The cost would be variable depending on the applicable mixing devices. In this cost model, the cost for the two proposed mixing devices (AEI Aquamog and CEI Injector system) is provided based on this project. The cost for activated carbon is based on the TOG carbon that was utilized in this project ($2.9 /lb), which also would be variable depending on available carbon types. The costs were based on the case of treatment of 700 ft^2 with the AC dose of 4 wt%. Other types of activated carbon would be much cheaper in bulk orders, e.g., Calgon Carbsorb at about $1/lb, and regenerated activated carbon is even less costly.

7.1.5 Operation and maintenance costs (periodic monitoring)

To assure the effectiveness of the remediation, periodic post-treatment assessment should be conducted. The monitoring would be similar to the baseline characterization, so the cost model takes the same cost. Annual reports also would be included.

7.1.6 Decontamination and residual waste management

This cost components is typical and standardized. It would be similar to the cost for conventional dredging/excavation technique.

7.1.7 Public education program

Because this *in-situ* treatment technology has been recently developed and uses a different strategy compared to the conventional treatment options of dredging or capping, public education would be needed to enhance public acceptance.

7.1.8 Long-term monitoring

Long-term effectiveness of the AC amendment technology is expected, but long-term monitoring is necessary. This cost components is typical and standardized.

7.2 Cost Drivers

The primary cost driver for this *in-situ* AC amendment is the capital cost of AC amendment and site preparation. As discussed earlier (6.1.1), although the two large-scale mixing devices

showed adequate performance to the relatively small test area, their full-scale application and/or sub-tidal area application would be questioned due to their minimal mobility and production rate. Therefore an engineering task is to develop a better mixing technology. Appropriate site preparation (e.g., dewatering) would facilitate the application of AC amendment for the sub-tidal area, for example by installing a coffer dam and using conventional soil tilling and mixing equipment.

The cost of activated carbon is also the cost driver. For the cost model from this study, the cost of AC was set as $2.9/lb, but this can be significantly lowered using regenerated carbon instead of virgin carbon. In a preliminary treatability test (Section 5.4), we demonstrated that regenerated carbon showed equal or even better performance than virgin carbon. Also, bulk delivery of other types of virgin activated carbon may be in range of about $1/lb, e.g., Calgon Carbsorb at about $1/lb, and regenerated activated carbon is even less costly.

The experience of performing the pilot-scale study through the ESTCP effort and analyzing the Feasibility Study report shows that more effort is needed to explore efficient engineering options for the delivery and mixing of activated carbon into sediments for a full-scale application. An example of more efficient activated carbon delivery and mixing is discussed below in section 7.3.2.

7.3 Cost Analysis

A comparison of remedial alternatives and cost estimates are presented in the 2008 Final Feasibility study report for Parcel F at Hunters Point Navy Shipyard (Appendix D).[13] In this section, the results from the cost analysis presented in the Feasibility Study are summarized along with modified cost estimates for an alternate remediation option.

7.3.1 Remedial Alternatives for Cost Analysis

Seven remedial alternatives were analyzed in detail in the Feasibility Study report and are briefly described below:

Alternative 2: Excavation/Backfill and Off-Site Disposal. ($31.6M) This alternative involves enclosing the South Basin area with cofferdams, draining the area, dredging and disposing of the sediment, and backfilling with clean material. A total of 150,520 cubic yards of sediment would be excavated in this process.

Alternative 3: Activated Carbon *In situ* Stabilization and Institutional Controls. ($14.4M) In this approach, PCB contaminated sediment area will be amended with 3.4% by weight of activated carbon in the top 1 ft of sediment. The application will be a direct scale up of the pilot-testing conducted under the present ESTCP project using the Aquamog in its current form and will not involve dewatering the application area.

Alternative 4: Monitored Natural Attenuation. ($2.1M) This alternative does not involve any active sediment remediation and relies on natural recovery of the site through clean material deposition and biodegradation processes. The costs are associated with monitoring and institutional controls.

Alternative 5: Focused Removal, Backfill and Monitored Natural Attenuation. ($16.6M) The South Basin area is dewatered after installing cofferdams as in Alternative 2. After a focused

removal of 57,850 cubic yards of PCB contaminated sediments, the excavated area is backfilled with clean material. The non-excavated area will undergo monitored natural attenuation.

Alternative 5A: Focused Removal, Backfill with Activated Carbon Amended Material, and Monitored Natural Attenuation. ($21.7M) This alternative is similar to Alternative 5 with the exception that the backfill material is amended with activated carbon.

Alternative 6: Focused Removal, Modified Shoreline Removal, Backfill, Monitored Natural Attenuation. ($16.9M) This is similar to Alternative 5, with additional removal of sediment along the shoreline.

Alternative 6A: Focused Removal, Modified Shoreline Removal, Activated Carbon Backfill, Monitored Natural Attenuation. ($22.4M) This is similar to Alternative 5A, with additional removal of sediment along the shoreline.

The present value cost estimates for each of these alternatives are presented in Figure 7-1 and range from $2-30 million. Based on the cost calculations presented in the Feasibility Study, scaling up of the activated carbon application method used in the present ESTCP study (using an Aquamog) would result in a total cost that is about half of the cost of dredging and disposal. The other alternatives of focused dredging and activated carbon amendment have costs that are higher than activated carbon amendment alone, but less than dredging.

A careful review of the detailed remedial plans and cost calculations presented in the Feasibility Study indicate potential areas of improvement. Based on the experience of performing the pilot-scale study through the ESTCP effort and analyzing the Feasibility Study report, it appears that more effort is needed to explore efficient engineering options for the delivery and mixing of activated carbon into sediments for a full-scale application. The Aquamog equipment has limited mobility and reach, and may not be suitable for full-scale application in its current form. The production rate using the Aquamog is too low (an estimate of 5,000 sq ft/d was used in the FS calculations) requiring a long period of operation (291 days) and associated operating costs. A more cost effective approach of application over a large area may be achieved by installing a cofferdam and dewatering the South Basin like Alternative 5 and using standard earth moving and landscaping equipment to apply and amend the carbon as described below.

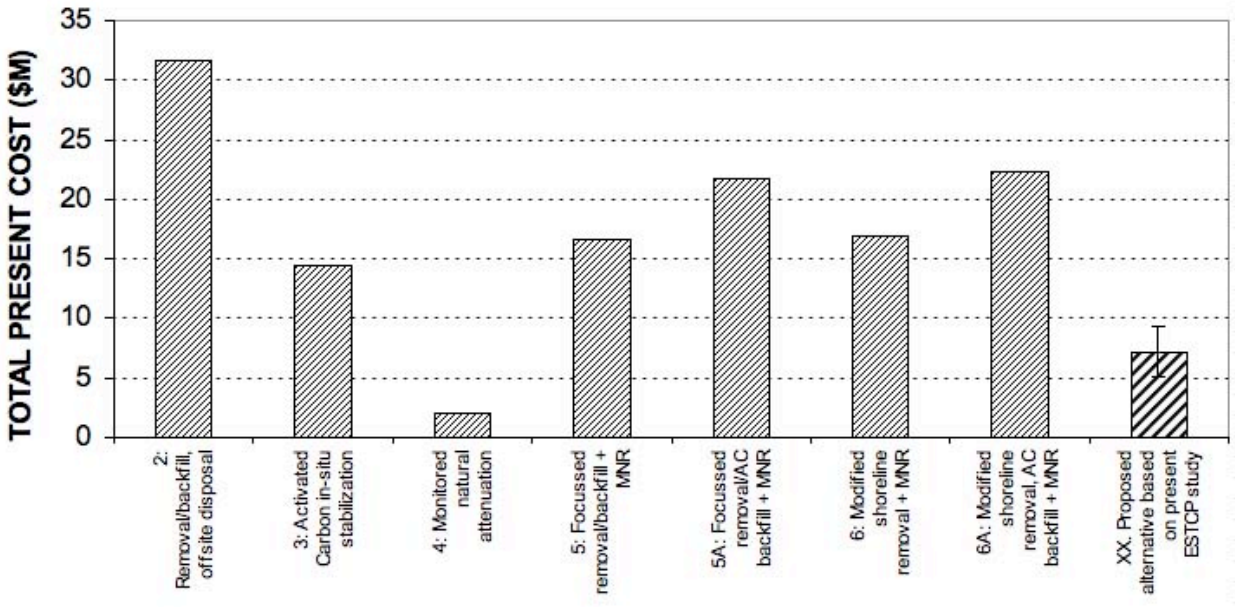


Figure 7-1. Present value cost comparison of different remedial alternatives for Hunters Point Navy Shipyard South Basin area (Area IX/X). Source: 2008 Final Feasibility Study Report for Parcel F.[13]

7.3.2 Proposed Application of Activated Carbon into Sediment After Dewatering South Basin.

This proposed application is similar to Alternative 5A described in the Feasibility Study with two main differences: 1) Sediments are not dredged and disposed before application of activated carbon, and 2) Activated carbon is mixed into the top 1 ft of native sediment and not mixed in with clean backfill material brought from off site. The application and mixing of the carbon is performed in two increments to allow a more homogeneous application. In this proposed approach, the South Basin area will be closed off with cofferdams followed by dewatering the region. Activated carbon will be applied over the PCB contaminated sediment area using a tractor spreader similar to Alternative 5A. The carbon will be mixed into the top 1 ft of native sediment using a bulldozer with tiller attachment similar to that described in Alternative 5A.

The dose of activated carbon required is estimated to be 4% by dry weight. This is based on the observation that the average dose of activated carbon in Plots D and F in the present ESTCP study ranged from 2-2.6% by dry weight, and the need to provide a safety factor to overcome effects of spatial heterogeneity of application and potential losses from deeper mixing. The cost of activated carbon is based on a quote received from Calgon Corporation for the Grasse River Activated Carbon Pilot study for the delivery of 15,000 lb of activated carbon (Carbsorb 50x200) at $1.04/lb. (Note: the Feasibility Study uses a cost of carbon of $2.9/lb). As described in Table 7-2, the cost of activated carbon application into sediment after dewatering the South Basin area is $9.1M which is 30% of the cost of Alternative 2 (dredging/disposal). Activated carbon material cost is about half of the total remediation cost. Significant cost reduction is possible (about 25%) by using a less expensive regenerated activated carbon, which is half as expensive as virgin activated carbon. The cost estimate assumptions were summarized below (quoted or rephrased from the Final Feasibility Study Report for Parcel F[13]).

- The remediation area is accessible, and no specialized equipment or services (aside from those described in this report) would be necessary to gain access to the site.
- All activities would be performed using modified EPA Level D personal protective equipment.
- The cost for decontamination facilities, residual waste management and dewatering facilities are similar to Alternative 2 (Excavation/Backfill and Off-Site Disposal, Please refer to the detailed cost estimations in the Feasibility Study Final Report, Appendix D[13]).
- Engineering (design, permitting, and manifesting) and professional management costs are calculated as a percent of the total direct labor cost (12%).
- Sediment contaminated with PCBs would be stabilized by addition of 4 percent activated carbon to the top 1 foot of sediments.
- The area would be dewatered using cofferdams and centrifugal pumps before the treatment.
- Approximately 57,850 cubic yards would be treated, requiring approximately 1,610,000 lb of activated carbon.
- The cost of activated carbon is $1.04/lb, which is based on the quote for Calgon Carbsorb 50x200 for the Grasse River, NY, study.
- Activated carbon would be applied over the PCB contaminated sediment area using a tractor spreader similar to Alternative 5A (Focused Removal and Activated Backfill).
- Ten crane mats would be on site for loading the carbon onto the bulldozer.
- The carbon will be mixed into the top 1 ft of native sediment using a bulldozer with tiller attachment similar to that described in Alternative 5A (Focused Removal and Activated Backfill).
- The application and mixing of the carbon is performed in two increments to allow a more homogeneous application.
- Annual monitoring would be conducted for the same parameters for the first five years, followed by monitoring every 5 years for years 25 through 30, and reported in 5-year review documents.

The estimated costs follow the cost estimate for full-scale application that was presented in the Final Report of the preceding SERDP-funded study (CU-1207) but with consideration of greater volume of sediment for treatment and a higher activated carbon dose. Shown in Table 7-3 are the same cost calculations after accounting for the larger treatment volume of 57,850 cubic yards delineated in the Feasibility Study and a higher dose (4%) of activated carbon. The revised cost based on the larger sediment volume is $7.5M, which is close to the estimate provided in Table 7-2 for application after installing a cofferdam and draining South Basin.

Based on the cost comparisons presented above, a recommendation from the present ESTCP study is to explore the application of activated carbon into the top 1 ft of native sediment without sediment removal after installing a cofferdam across the narrow inlet and draining

South Basin. An activated carbon dose of about 4% is recommended to overcome effects of spatial heterogeneity of application and potential losses from deeper mixing.

Table 7-2. Application of activated carbon into native sediment after installing a cofferdam and dewatering South Basin at HPS

(cost calculations are based on the detailed cost table provided in the Feasibility Study for Alternative 5A with several modifications: no dredging and disposal, no clean backfill, lower labor and design costs)

Coffer Dam installation and pumping (South Basin; 2000 ft)		343,272
Coffer Dam installation and pumping (Yosemeti Creek; 150 ft)		57,488
Thin layer backfill of AC only, no excavation, with tiller mixing		4,694,777
Activated carbon cost	*$4,670,300*	
Broadcast carbon twice using tractor spreader (2x 33 acre; $105/acre)	*6968*	
Soil tilling twice using D3 doser with tiller attachment (2x 40 hr @ $200/hr)	*15960*	
Decontamination	*1100*	
Spare bulldoser with tiller	*449*	
Confirmation sampling		29,540
Residual waste management		22,250
Professional labor management (@ 33% of capital costs; similar to Alt 5A)		1,681,527
Design cost (@ 12% of capital costs; similar to Alt 5A)		611,464
LONG TERM MONITORING		
Annual monitoring first four years		543,402
Monitoring every 5 years and 5-year review for years 5-30		1,088,770
TOTAL		**9,072,491**

Table 7-3. Cost calculation for activated carbon addition to sediment at Hunters Point South Basin

(Cost estimate presented earlier in the final report of CU-1207 using typical cost of dredging operations)
(Revised sediment volume of 57,850 cu ya based on 2007 Feasibility Study)

SEDIMENT HANDLING COSTS	
Capital costs	
Site Preparation	$20,000
Mobilization - Equipment and silt curtain	$285,000
Cost of fresh carbon (at $2.2/kg)	$4,670,300
Carbon application and mixing	$525,840
(approximation using typical cost for auger dredging; no disposal cost)	
Water quality monitoring during operations	$50,000
Site restoration	$5,000
Direct Capital	$5,556,140
Engineering, Procurement & Construction Management (12% of direct capital)	$666,737
Contractor Overhead/Profit (15%)	$833,421
Total capital cost	$7,056,298
INSTITUTIONAL CONTROLS	
Capital Items:	
Public Education Program	$50,000
O&M Plans	$10,000
Deed Restrictions	$2,500
Engineering, Procurement and Construction Management (12% of direct capital)	$7,500
Present worth of Longer Term Operating Costs (assuming interest rate of 8%)	
Long Term Monitoring (40 years at $10k/year)	119246
Public Education Program (40 years at $15k/year)	178869
Maintaining O&M Plans (40 years at $400/year)	4770
Reporting (40 years at $10k/year)	119246
TOTAL COST (using fresh GAC)	**$7,548,429**
TOTAL COST (using regenerated GAC)	$5,000,992

Material Handling And Cost Assumptions:	
Sediment volume to be treated in cubic yards from Parcel F FS report	57,850
Volume of sediment to be treated in cubic meters (top 1 foot)	44,226
Weight of dry sediment in kg (assuming dry bulk density of sediment = 1200kg/cum)	53,071,590
Weight of carbon needed in kg (4% of sediment dry weight; 2.5% + safety factor of 1.5%)	2,122,864
Cost of carbon (assuming $2.2/kg for fresh GAC)	4,670,300
Cost of carbon (assuming $1.0/kg for regenerated carbon)	2,122,864

Sediment handling costs are based on costs reported for sediment dredging using a horizontal auger dredge (Basis for Preliminary Cost Estimates: Sediment Remediation, Fox River, Wisconsin, Little Lake Butte Des Morts, Wisconsin DNR). The cost of mobilizing and operating a horizontal auger dredge is assumed to be similar to a sediment mixing equipment we may use for carbon mixing. Mobilization cost was kept the same. All other operational costs including site preparation, sediment mixing, water quality monitoring, and site restoration was assumed to be one tenth of the costs estimated at the Fox River site which had a 5 times larger volume of sediments to be treated compared to the sediment volume that will be handled at Hunters Point. The cost of institutional controls is assumed to be half that of the Fox River estimate.

8 IMPLEMENTATION ISSUES

8.1 Environmental Checklist

The potential regulations that may apply to the demonstration are CERCLA and SARA. No hazardous emissions and residuals were produced by this *in situ* treatment technology during the demonstration.

8.2 Other Regulatory Issues

The regulatory agencies for this demonstration project are area regulatory agencies such as EPA Region 9, California Department of Toxic Substances Control (DTSC), San Francisco Regional Water Quality Control Board (SFRWQCB), San Francisco Public Utility Commission and Department of Public Health, and National Oceanic and Atmospheric Administration (NOAA). The demonstration plan was reviewed by these and other regulatory agencies before implementation.

The PI and the team attended the Bayview Hunters Point Restoration Advisory Board (RAB) meeting. A presentation about the technology was given to the RAB group on two occasions. A presentation was also given to the EPA Biological Technical Assistant Group (BTAG), and to a national meeting of EPA Regional Risk Assessors.

The Hunters Point site offers the opportunity to assess several strategies for activated carbon deployment, including mixing activated carbon with sediment or focused sediment removal and activated carbon-amended backfill.

8.3 End-User Issues

The Navy site managers at Hunters Point have indicated that they hope to use the technology in their final remedial decisions; if they do, technology transfer to other DoD sites should be straightforward. We have discussed this work with the Hunters Point Base Closure Team on several occasions and received favorable comments. Consequently, this AC-amendment technology and modified treatment method were included as alternatives in the Navy's Final Feasibility Study Report.[13] Knowledge gained from this field demonstration project will be disseminated to Navy Remedial Project Managers, DoD personnel, and other interested parties through the Navy's Sediments Subgroup of the Risk Assessment Workgroup (RAW), the Navy's Alternative Restoration Technology Team (ARTT) committee, the Interstate Technology Regulatory Cooperation (ITRC) Sediments Workgroup, the Remediation Technology Development Forum (RTDF) Sediments Action Team, and the Tri-Service Environmental Centers Coordinating Committee and Symposium. Since this project represents the first demonstration anywhere of *in situ* treatment for sorptive stabilization of PCBs in sediment, the project technical papers published in the peer-reviewed literature should command considerable attention.

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FINAL

QUALITY ASSURANCE PROJECT PLAN including SAMPLING AND ANALYSIS PLAN

Appendix A
HUNTERS POINT SHIPYARD PARCEL F
ESTCP FINAL REPORT

Prepared for:

ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM
1155 Herdon Parkway, Suite 900
Herndon, VA 20170

Prepared by:

STANFORD UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
YANG & YAMAZAKI ENVIRONMENTAL & ENERGY BLDG
STANFORD, CA 94305-4020

(Modified from original QAPP/SAP of ESTCP Demonstration Plan)

May, 2009

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FINAL

QUALITY ASSURANCE PROJECT PLAN including SAMPLING AND ANALYSIS PLAN

Appendix A HUNTERS POINT SHIPYARD PARCEL F ESTCP FINAL REPORT

Prepared by:

STANFORD UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
YANG & YAMAZAKI ENVIRONMENT & ENERGY BLDG
STANFORD, CA 94305-4020

May, 2009

REVIEW AND APPROVALS (for Demonstration Plan)

Project QA Manager, Stanford Yeo-Myoung Cho	Yeo Myoung Cho Name	Date: 11/14/05
Project Manager, Stanford Dennis Smithenry	Dennis W. Smithenry Name	Date: 11/16/05

DISTRIBUTION LIST

This document will be distributed to the following project participants once all approval signatures have been received:

Ryan Ahlersmeyer
Todd Bridges
Yeo-Myoung Cho
Scott Dockum
Lance Dohman
Mark Fleri
Glynis Foulk
Upal Ghosh
Katie Houff
Andrea Leeson
Richard Luthy
Carole-Sue Peven
Dennis Smithenry
Barbara Sugiyama

Hunters Point Shipyard Parcel F ESTCP Demonstration Plan

U.S. EPA QA/R-5 QAPP ELEMENTS

U.S. EPA QA/R-5 QAPP ELEMENT	ESTCP Demonstration Plan QAPP/SAP
A1 Title and Approval Sheet	Title and Approval Sheet
A2 Table of Contents	Table of Contents
A3 Distribution List	Distribution List
A4 Project/Task Organization	A.2.1 Project and Task Organizations
A5 Problem Definition/Background	A.2.2 Problem Definition/Background A.2.3 Site Description
A6 Project/Task Description	A.2.4 Project/Task Description
A7 Quality Objectives and Criteria	A.2.5 Quality Objectives and Criteria
A8 Special Training/Certification	A.2.6 Special Training/Certification
A9 Documents and Records	A.2.7 Documentation and Records
B1 Sampling Process Design	A.3.1 Sampling Process Design (Experimental Design)
B2 Sampling Methods	A.3.2 Field Sampling Methods
B3 Sample Handling and Custody	A.3.3 Sample Processing, Handling, and Custody
B4 Analytical Methods	A.3.4 Analytical Laboratory Methods
B5 Quality Control	A.3.5 Quality Control Requirements
B6 Instrument/Equipment Testing, Inspection, and Maintenance	A.3.6 Instrumentation/Equipment Testing, Inspection, and Maintenance
B7 Instrument/Equipment Calibration and Frequency	A.3.7 Instrument/Equipment Calibration and Frequency
B8 Inspection/Acceptance of Supplies and Consumables	A.3.8 Inspection/Acceptance of Supplies and Consumables
B9 Nondirect Measurements	A.3.9 Nondirect Measurements
B10 Data Management	A.3.10 Data Management
C1 Assessment and Response Actions	A.4.1 Assessment and Response Actions
C2 Reports to Management	A.4.2 Reports to Management
D1 Data Review, Verification, and Validation	A.5.1 Data Review, Validation, and Oversight
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ACRONYMS AND ABBREVIATIONS

AC	–	activated carbon
AEI	–	Aquatic Environments, Inc.
ASCII	–	American Standard Code for Information Interchange
ASTM	–	American Society for Testing and Materials
BC	–	Black Carbon
BDO	–	Battelle Duxbury Operations
BRAC	–	Base Realignment and Closure (Act)
CD	–	compact disc
CEI	–	Compass Environmental, Inc.
CERCLA	–	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	–	Code of Federal Regulations
COC	–	chain of custody
DGPS	–	differential global positioning system
DoD	–	Department of Defense
DP	–	demonstration plan
DQA	–	data quality assessment
DQO	–	data quality objective
EB	–	equipment blank
EDD	–	electronic data deliverable
ELAP	–	Environmental Laboratory Accreditation Program
ERDC	–	Engineering Research and Development Center
EST	–	Environmental Sampling Technologies
ESTCP	–	Environmental Security Technology Certification Program
FR	–	final report
FS	–	feasibility study
FSP	–	field sampling plan
GC	–	gas chromatography
GC/ECD	–	gas chromatograph/electron capture detector
GC/MS	–	gas chromatography/mass spectroscopy
GPS	–	global positioning system
HASP	–	Health and Safety Plan
HAZWOPER	–	Hazardous Waste Operations and Emergency Response
HPS	–	Hunters Point Shipyard
HSO	–	Site Health and Safety Officer
ID	–	identification
LCS	–	laboratory control sample
LCSD	–	laboratory control sample duplicate
LIMS	–	laboratory information management system
LM	–	Laboratory Manager

MB	–	method or procedural blank
MDL	–	method detection limit
mL	–	milliliter
MLLW	–	mean lower low water
MQO	–	Management Quality Objective
MS	–	matrix spike
MSD	–	matrix spike duplicate
NA	–	not available
NEDTS	–	Navy Environmental Data Transfer Standards
NELAC	–	National Environmental Laboratory Accreditation Conference
NFESC	–	Naval Facilities Engineering Service Center
NIST	–	National Institute of Standards and Technology
NOAA	–	National Oceanic and Atmospheric Administration
NPL	–	National Priorities List
NS&T	–	National Status and Trends
PED	–	polyethylene device
PC	–	personal computer
PCB	–	polychlorinated biphenyl
QA	–	quality assurance
QAPP	–	quality assurance project plan
QC	–	quality control
QSM	–	quality systems manual
RIS	–	recovery internal standard
RL	–	reporting limit
RPD	–	relative percent difference
RPM	–	Remedial Project Manager
RSD	–	relative standard deviation
RSO	–	Radiation Safety Officer
SA	–	selective availability
SAP	–	sampling and analysis plan
SARA	–	Superfund Amendments and Reauthorization Act
SDG	–	sample delivery group or analytical batch
SERDP	–	Strategic Environmental Research Development Program
SIS	–	surrogate internal standard
SOP	–	standard operating procedure
SPMD	–	semi-permeable membrane device
SWDIV	–	Southwest Division Naval Facilities Engineering Command
SWG	–	Sediment Work Group
TOC	–	total organic carbon
UMBC	–	University of Maryland Baltimore County
U.S. EPA	–	U.S. Environmental Protection Agency

A.1.0 INTRODUCTION

This Quality Assurance Project Plan (QAPP), which contains the Sampling and Analysis Plan (SAP), has been developed for the Environmental Security Technology Certification Program (ESTCP) Demonstration Plan (DP) prepared by Stanford. The original proposal to ESTCP was titled *Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment.* The ESTCP DP will be completed at Hunters Point Shipyard (HPS) Parcel F (offshore sediment) in San Francisco, California.

In recent Strategic Environmental Research Development Program (SERDP)-funded work with sediment from Hunters Point, San Francisco Bay, Dr. Richard G. Luthy's research group at Stanford found that the polychlorinated biphenyls (PCBs) in the sediment tend to preferentially accumulate in coal-derived and char particles where the compounds may be strongly bound (Ghosh et al., 2003a; Luthy et al., 2004 Zimmerman et al., 2004). In addition, the Stanford team, along with researchers at the United States Army Corps of Engineers Engineering Research Development Center (USACE-ERDC), demonstrated in laboratory experiments that large reductions in PCB aqueous concentrations and PCB bioaccumulation (clams, polychaetes, and crustaceans) occurred in Hunters Point sediment treated with activated carbon (AC) (Ghosh et al., 2003b; Luthy et al., 2004; Millward et al., 2004; Zimmerman et al., 2004). These observations suggest that mixing AC into sediment may provide a new technology for contaminated sediment management.

This QAPP describes the ESTCP DP that will be conducted during FY2005-2008. The overall purpose of this project is to demonstrate that AC sorbent mixed with sediment is a cost-effective, in situ, non-removal, management strategy for reducing the bioavailability of PCBs in offshore sediments at HPS site. The scope of the ESTCP DP is to:

1) Demonstrate and compare the effectiveness, in terms of AC application and ease of use, of two available large-scale mixing technologies,
2) Demonstrate that AC treatment reduces PCB bioaccumulation results in field tests, and
3) Demonstrate no significant sediment resuspension and PCB release after the large-scale mixing technologies are used.

This QAPP documents the policies, the project organization, quality assurance (QA) requirements, and quality control (QC) procedures to be implemented for the ESTCP DP to ensure that the data are valid for use. The QAPP is incorporated as Appendix A to the ESTCP Demonstration Plan, and is not an independent document. This QAPP addresses all U.S. Environmental Protection Agency (U.S. EPA) requirements for a quality assurance project plan (QAPP) (U.S. EPA, 2001) with the elements of a field sampling and analysis plan (SAP) so that field and laboratory activities are described in one document. It defines the QA/QC methods that must be implemented to ensure that data meets the requirements of the Data Quality Objectives (DQO). The Health and Safety Plan in Appendix B, which is issued as a separate document, defines the preventative and prophylactic procedures that will be implemented during the field survey to ensure the safety of the field team.

The Navy has indicated that the AC treatment technology is being considered as an alternative for detailed analysis in an upcoming Feasibility Study (FS). Any data that the Navy may use to make a decision about assessing the AC treatment technology in the FS must be generated by a Navy-certified lab. Since the laboratories at Stanford, University of Maryland Baltimore County (UMBC), and USACE-ERDC that are involved in this ESTCP DP are not Navy-certified laboratories, The Navy Remedial Project Manager (RPM) of the HPS Parcel F site has requested that an archive of sample splits be created for the clams and amphipods that are collected to assess the AC treatment effects on PCB bioaccumulation. These samples splits will be analyzed by Battelle Duxbury Operations (BDO), a Navy-certified laboratory. The resulting PCB bioaccumulation data from BDO has been identified by the Navy

as "critical data" that must be of known and sufficient quality for decision making. The decision to analyze this archive will be made by the Navy RPM as part of the FS.

A.2.0 PROJECT MANAGEMENT

A.2.1 Project and Task Organization

Figure A-1 presents the initial organizational structure of the ESTCP DP project.

Dr. Andrea Leeson is the Environmental Restoration Program Manager at the ESTCP office. She is responsible for approval of the Demonstration Plan and executing Environmental Restoration contracts with Stanford and ERDC.

Mr. Ryan Ahlersmeyer is the Navy Remedial Project Manager (RPM) at Hunters Point Shipyard Parcel F. He is responsible for reviewing the Demonstration Plan to ensure that it meets Navy requirements for the site. He will also provide support for the field activities that occur at HPS Parcel F. Mr. Ahlersmeyer will decide if critical data for the HPS FS is to be obtained from the samples splits that are archived in this ESTCP Demonstration.

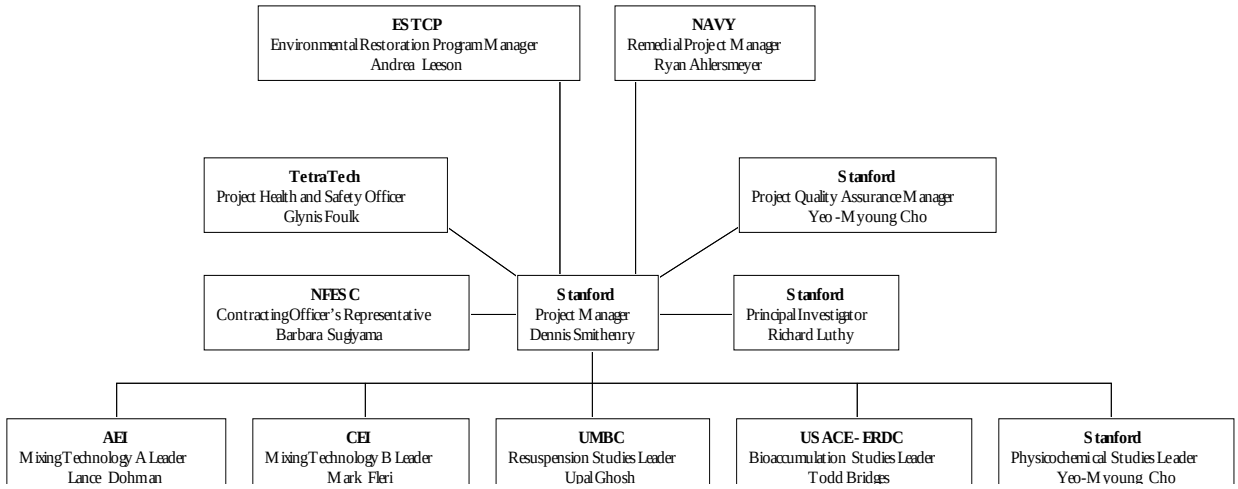

Figure A-1. Organizational Structure for the ESTCP DP

Dr. Richard G. Luthy is the Principal Investigator (PI) for the ESTCP DP. He is a professor at Stanford University whose lab studies support the in situ technology of applying AC to PCB-contaminated sediment. He will provide expertise and guidance to the Project Manager in the development and implementation of the QAPP. His team at Stanford (Dr. Luthy, Ms. Cho, and Dr. Smithenry) is responsible for assessment of proposed carbon application by AEI and CEI, deployment of semi-permeable membrane devices (SPMDs), analysis of sediment PCB concentrations, and analysis of aqueous equilibrium PCB concentrations.

Dr. Dennis W. Smithenry is the Project Manager. Dr. Smithenry, a postdoctoral researcher at Stanford University, is responsible for coordinating field efforts outlined in the QAPP between the various groups involved in the project. He is responsible for overall preparation and coordination of the study planning documents: the demonstration plan, QAPP, and supporting documents. He coordinates technical activities as a liaison between the ESTCP Environmental Restoration Manager, Navy RPM, Stanford PI, Project

Health and Safety Officer, Project QA Manager, and NFESC DoD Contracting Officer's Representative. He is responsible for ensuring that communication of all decisions, which impact field or laboratory activities, are dispatched in real time. He is responsible for responding to QA reports and either implementing or requiring corrective action to address systematic problems. He communicates directly with the ESTCP Environmental Restoration Program Manager and the Navy RPM to coordinate activities and enforce schedules and deadlines.

Ms. Glynis Foulk of Tetra Tech is the Project Health and Safety Officer (HSO). She is responsible for reviewing the project Health and Safety Plan (HASP), ensuring that the field personnel have received appropriate health and safety training for work at the study site, and that the training is documented. She may also conduct inspections during field operations. She reports issues and concerns directly to the Project Manager and has the authority to stop work.

Ms. Yeo-Myoung Cho is the Project QA Manager. She is responsible for reviewing the QAPP to ensure that all elements are addressed in adequate detail and must approve the final version. She ensures that project reviews are conducted frequently enough to ensure that the work is being conducted according to the QAPP and SOPs, and that corrective action plans are implemented to address any deficiencies identified. She reports the results of these oversight activities to the Project Manager. She is authorized to stop work if data quality or staff safety is threatened. She ensures that all SOPs cited in the QAPP are approved and available, and that appropriate training is documented for team members. She verifies that adequate forms and labels are designed for the sampling and analysis effort. She reviews chain of custody (COC) forms to verify that custody is maintained, and conducts field and laboratory inspections as appropriate to ensure that the QAPP is implemented. She prepares reports of inspections and audits, and communicates findings to the Project Manager. Ms. Cho will also serve as Physicochemical Studies Leader. In this role, she will be responsible for assessment of proposed carbon application by AEI and CEI, deployment of semi-permeable membrane devices (SPMDs), analysis of sediment PCB concentrations, and analysis of aqueous equilibrium PCB concentrations.

Dr. Upal Ghosh, an Assistant Professor at University of Maryland Baltimore County, will serve as Resuspension Studies Leader. He is responsible for carrying out field water quality tests that will assess if PCB resuspension occurs as a result of mixing the AC into the sediment. He will also conduct laboratory tests that assess the change in PCB availability for desorption to the aqueous phase after treatment. He will implement these tests in coordination with the Project Manager. Dr. Ghosh will be present to assist with and oversee the proper deployment of the two remediation technologies that will be tested at Hunters Point. Dr. Ghosh will assist with the evaluation of the technologies. Dr. Ghosh and his team at UMBC will also assist with technology scale-up and cost estimation for full-scale application. Dr. Ghosh will assist in preparing the ESTCP Cost and Performance Report, ESTCP Final Technical Report, and will be available to make presentations to the user community, regulatory community, and industry.

Dr. Todd S. Bridges will represent USACE-ERDC and serve as Bioaccumulation Studies Leader. He is responsible for carrying out field clam bioaccumulation tests that will assess whether the bioavailability of PCBs is reduced by the mixing AC into sediments. He will coordinate and implement these tests in coordination with the Project Manager.

Ms. Barbara Sugiyama will serve as DoD Contracting Officer's Representative to help prepare the full proposal and Phase II briefing. Ms. Sugiyama will take care of contract issues between Stanford and the ESTCP office.

Mr. Lance Dohman will represent Aquatic Environments, Inc. (AEI) and serve as Mixing Technology A Leader. He will be responsible for the mobilization, storage, and demobilization of the Aquamog, an ARGO amphibious support vehicle, and auxiliary equipment to the demonstration site.

He will supervise and be responsible for the safe operation of equipment provided and used by Aquatic Environments, Inc. employees. He will provide technical assistance in using the Aquamog to distribute and mix AC and sediment through rotovation onto the demonstration plot.

Mr. Mark Fleri will represent Compass Environmental, Inc. (CEI) and serve as Mixing Technology B Leader. H will be responsible for the mobilization, storage, operation, and demobilization of its patented rake injector and other equipment necessary to support the injection of a dose of carbon in the upper one foot of tidal zone sediments at Hunters Point. He will supervise and be responsible for the safe operation of equipment provided and used by CEI's employees.

Ms. Sarah Brennan is the Database Manager at BDO should the decision be made to analyze the archived sample splits. She is responsible for ensuring that the database construction and output meet the needs of the ESTCP DP for analysis and report preparation. She is responsible for overseeing accurate and complete loading of data to the database, sample tracking, and providing sample identification codes. She provides database exports to the Navy contractor validation firm for data validation upon request.

Dr. Carole-Sue Peven is the Chemistry Laboratory Leader at BDO should the decision be made to analyze the archived sample splits. She is responsible for ensuring that appropriate and comparable technical procedures for sample analysis are used by BDO. She will coordinate with the Project Manager and appropriate labs to ensure that holding times are met and that reporting schedules are not compromised for the archived sample splits. Ms. Peven ensures that the status of laboratory analyses and potential problems are reported to the Project Manager. She is responsible for performing a management review of analytical data reports produced.

The field sampling crew is responsible for conducting all field activities according to the QAPP and for communicating problems to the Project Manager.

All critical data from the archived sample splits that may be used in the HPS FS will be generated by BDO. BDO is responsible for conducting all analytical activities according to Naval Facilities Engineering Service Center (NFESC, 1999), the Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories (DoD, 2002), and the QAPP.

A.2.2 Problem Definition/Background

Contaminated sediments pose challenging cleanup and management problems. Hydrophobic organic compounds such as PCBs associate with fine-grained, organic-rich, sediment material. This serves as a contaminant reservoir in shallow estuarine and coastal regions from which fish and bottom-dwelling organisms accumulate toxic compounds that may be passed up the food chain. However, work at Stanford University and elsewhere proposes that hydrophobic organic contaminants in sediment may be of more or less concern depending on how weakly or strongly they are sorbed to sediment organic matter (e.g., Bucheli and Gustafsson, 2001).

Portions of the offshore sediment at HPS have elevated concentrations of PCBs that could pose a potential human health and ecological risk. Currently the standard approach to addressing contaminated marine "mud flat" sediments is the expensive ex situ process of dredging and disposal. Previous laboratory experiments (Ghosh et al., 2003b; Luthy et al., 2004; Millward et al., 2004; Zimmerman et al., 2004) have shown that large reductions in PCB aqueous concentrations and PCB bioaccumulation (clams, polychaetes, and crustaceans) occurred in HPS sediment treated with AC. Based on these observations, this project will entail mixing AC into sediment as a new technology for contaminated sediment management.

A.2.3 Site Description

HPS is situated on a peninsula in the southeast corner of San Francisco, CA. The peninsula is bounded on the north, east, and south by San Francisco Bay and on the west by the Bayview Hunters Point district. HPS comprises about 928 acres, with approximately 400 acres of offshore sediments. From 1945 to 1974, the Navy used HPS predominantly for ship repair and maintenance. HPS was deactivated in 1974 and remained relatively unused until 1976, when it was leased to Triple A Machine Shop, a private ship repair company. In 1986, the Navy resumed occupancy of HPS, but closed the Base in 1991.

Historical site activities at HPS resulted in the release of chemicals to the environment, including offshore sediments. Environmental restoration activities are conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). The facility was closed under the Defense Base Realignment and Closure Act of 1990 (BRAC) and is in the process of conversion to nonmilitary use.

Four plots, as shown in Figure A-2 (excluding Plot G), having areas of 370 ft^2 will be used as the test plots for the ESTCP DP. The plots will be located within the tidal flat region of Hunters Point South Basin, in the southeast portion of the cove; this location is accessible from the shore and away from possible impacts of any potential on-going PCB releases on the north side of the cove (Battelle, 2003) as shown in Figure A-2.

A.2.4 Project/Task Description

The scope of the ESTCP DP is to compare the effectiveness of two available large-scale mixing technologies, demonstrate that AC treatment reduces the aqueous PCB availability and PCB bioaccumulation results in field tests, and evaluate sediment resuspension and PCB release.

There are primary quantitative performance criteria that have been identified to measure the success of the AC treatment technology demonstration:
1) PCB bioaccumulation in test organisms (clams),
2) PCB bioaccumulation in indigenous organisms (amphipods),
3) Homogeneity of AC application, and
4) PCB Resuspension.

The procedures developed to implement the scope of the ESTCP DP are described below in Sections A.2.4.1 through A.2.4.3. The schedule of sampling and analysis related to these procedures is summarized in Table A-1.

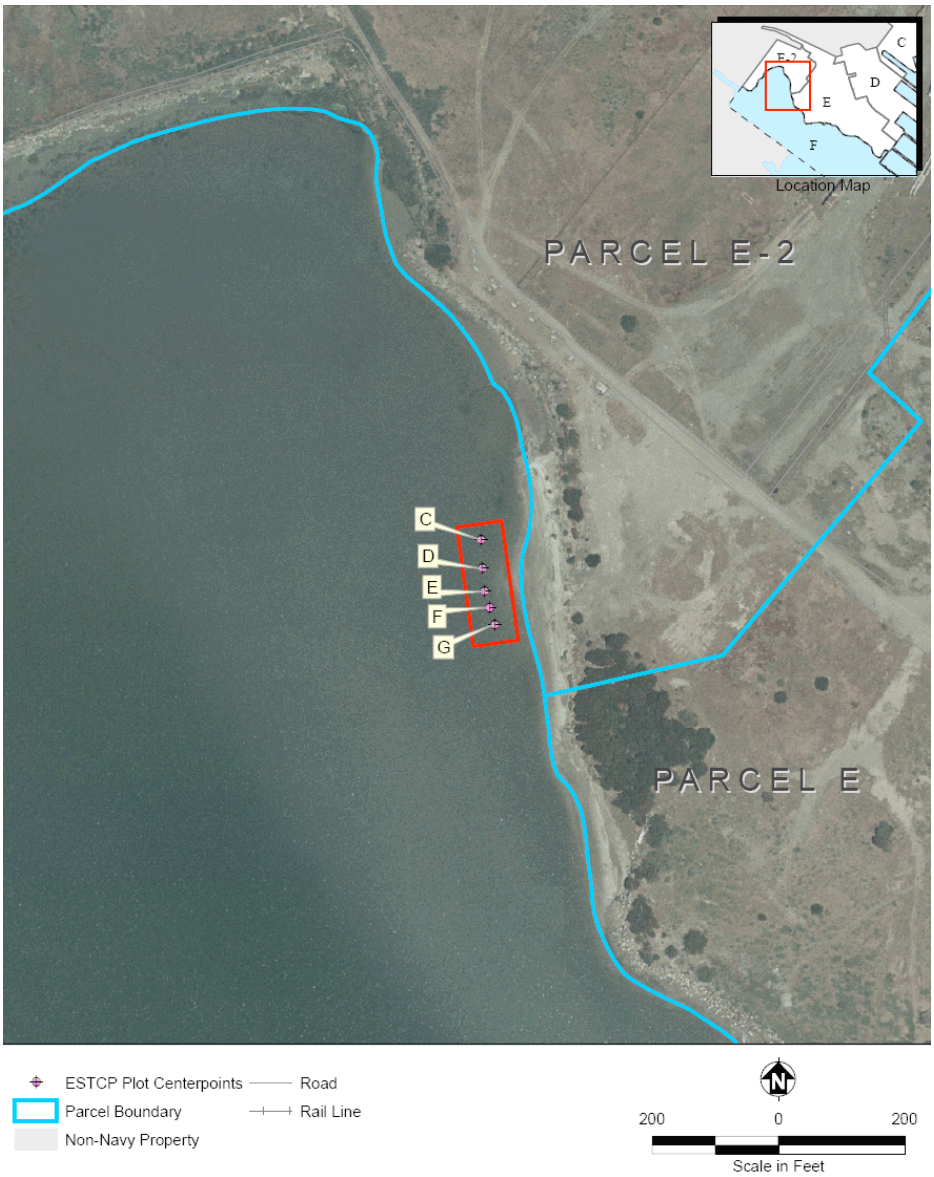

Figure A-2. Proposed Demonstration Area (Plot G was not utilized in this project)

A.2.4.1 Application of Activated Carbon

The first contractor, Aquatic Environments, Inc. (AEI), has a barge-like machine (called an Aquamog, Figure A-3) with a rotovator attachment that is typically used to disrupt weed growth in marshy areas. In the field demonstration, AEI will be responsible for the mobilization, storage, operation, and demobilization of the Aquamog to the Hunters Point Naval Shipyard field site in January 2006. In the field demonstration, the Aquamog will be deployed on the water during high tide and allowed to settle onto the sediment surface at low tide to do treatments on Plots C and D as shown in Figure A-2. AEI will supply an ARGO amphibious support vehicle and any auxiliary equipment to the demonstration site that will be necessary to complete the treatments. Before mobilization of the Aquamog, AEI is also responsible for the design, development, and testing of a delivery system for transferring AC from the deck of the Aquamog to the plot surface. Besides delivering AC to the sediment surface, the Aquamog has a rotovator attachment that will be used to mix transferred AC into sediments into Plot D to an

approximate depth of one foot. The depth of the mixing can be controlled by the speed and downward pressure of the rotovator. The rotovator attachment will also be used to mix (only) the sediments in Plot C to a depth of one foot.

The second contractor, Compass Environmental, Inc. (CEI) [formerly Williams Environmental Services, Inc. (WESI)], owns an injection system used traditionally for sediment solidification with cement mortar (Figure A-4). In Jan. 2006, CEI will provide its patented rake injector and other equipment necessary to support the treatments of Plot F. This equipment will be located on the shore with the injector arm reaching out to Plot F. Via a slurry, AC will be injected and mixed into the upper one foot of tidal zone sediments for Plot F. CEI will provide the data necessary to demonstrate that the requisite carbon mass has been added to Plot F. CEI will record data such as slurry flow rate, slurry density, pump time, and slurry volume pumped into each test plot.

The field sampling and analysis methods that will be used to assess the depth and homogeneity of the AC application are provided in Section A.3.2 through A.3.5.

Figure A-3. "Aquamog" with Rotovator Arm

Figure A-4. CEI System with Injector Arm

A.2.4.2 Assessment of Reductions in Aqueous PCB Availability and PCB Bioaccumulation

To determine that the AC treatments lead to a reduction in aqueous PCB availability and PCB bioaccumulation, the following assessments will be completed during the course of the ESTCP DP project:

a) PCB bioaccumulation in test clams and indigenous amphipods retrieved from plots (ERDC),
b) AC treatment effects on indigenous benthic community structure (ERDC), and
c) in situ PCB stabilization using physicochemical tests of PCB availability (Stanford/UMBC).

Further details of these field sampling and analysis methods associated with the above assessments are provided in Sections A.3.2 through A.3.5.

A.2.4.3 Assessment of Resuspension Potential

The overlying water above the four plots will be sampled during high tide once before and thrice after treatments to evaluate possible sediment and PCB resuspension and measure suspended and dissolved PCB concentrations. The sampling and analysis methods associated with this assessment are provided in Sections A.3.2 through A.3.5.

A.2.5 Quality Objectives and Criteria

A.2.5.1 Data Quality Objectives

The development of the DQOs for the ESTCP DP followed U.S. EPA's Guidance for the Data Quality Objectives Process (U.S. EPA QA/G-4, 2000b). The DQOs have been divided into two categories that relate to those defined in the ESTCP DP. The DQOs for primary quantitative performance criteria are defined in Table A-2; the DQOs for secondary performance criteria are defined in Table A-3. Table A-4 defines the measurements that will be completed to assess the primary performance criteria and secondary performance for the ESTCP DP. Measurements that will be done by BDO on the archived sample splits and will produce critical data for the Navy are identified Table A-4.

A.2.5.2 Measurement Quality Objectives

Measurement quality objectives for critical analyses conducted for this study can be expressed in terms of accuracy, precision, completeness, and sensitivity goals. Accuracy and precision are monitored through the analysis of QC samples (Section A.3.5). Completeness is a calculated value. Sensitivity is monitored through instrument calibration (Section A.3.7) and the determination of method detection limits (MDLs) and reporting limits (Section A.2.5.2). Qualitative quality objectives, expressed in terms of comparability and representativeness, are addressed as part of the sampling design.

> **Accuracy** is defined as the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components that are due to sampling and analytical operations.
>
> **Precision** is defined as degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. Precision is usually expressed as standard deviation, variance, or range, in either absolute or relative terms.
>
> **Completeness** is the amount of data collected as compared to the amount needed to ensure that the uncertainty or error is within acceptable limits. The goal for data completeness is 100%.

However, the project will not be compromised if 90% of the samples collected are analyzed with acceptable quality.

Comparability is a measure of the confidence with which one data set can be compared to another. This is a qualitative assessment and is addressed primarily in sampling design through use of comparable sampling procedures or, for monitoring programs, through accurate resampling of stations over time. In the laboratory, comparability is ensured through the use of comparable analytical procedures and ensuring that project staff are trained in the proper application of the procedures. Within-study comparability will be assessed through analytical performance (QC samples).

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population. This is a qualitative assessment and is addressed primarily in the sample design, through the selection of sampling sites and procedures that reflect the project goals and environment being sampled. It is ensured in the laboratory through (1) the proper handling, homogenizing, compositing, and storage of samples and (2) analysis within the specified holding times so that the material analyzed reflects the material collected as accurately as possible.

Sensitivity is the capability of a test method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. Sensitivity is addressed primarily through the selection of appropriate analytical methods, equipment, and instrumentation. The methods selected for this study were chosen to provide the sensitivity required for the end-use of the data. This is a quantitative assessment and is monitored through the instrument calibrations and calibration verification samples and the analysis of procedural blanks with every analytical batch.

Method Detection Limits for PCB congeners in tissues are determined by spiking clean, low-lipid tissue (e.g., white meat fillet from a non-bottom-feeding fish species) with all parameters of interest and processing them according to the methods defined Section A.3.4. MDLs for Gas chromatography/electron-capture detector (GC/ECD) analysis are determined on the primary column. (MDLs for PCBs must also be determined on a confirmation column if data from confirmatory analyses will be reported. In these instances, the MDLs determined from confirmation column analysis must be less than those determined from the primary column. Quantification on confirmation columns is not, however, anticipated for this investigation.)

Reporting Limits (RLs) for PCB congeners are empirical values based on a low calibration standard (≤0.005 µg/mL), instrument sensitivity, and day-to-day operations. Sample-specific reporting limits will be calculated and reported with the final data. For PCB congeners, the RL is calculated as

RL = (Low Standard Concentration) (Preinjection Volume) (Dilution Factors) (1/ Sample Size)

The DoD Quality Systems Manual (DoD, 2002) includes the following note: *There may be numbers reported to the client that are below the reporting limit. These numbers must be flagged appropriately. When the analysis demonstrates a non-detect at the MDL, the data shall be flagged with a "U." The value reported to the client is the MDL, adjusted by any dilution factor used in the analysis. When an analyte is detected between the lower quantitation limit and the MDL, the data shall be flagged with a "J." The value reported is an estimate.*

A.2.6 Special Training/Certification

A.2.6.1 Training Requirements

Documented training is required for each individual performing activities in support of environmental data collection or analysis. In order to ensure that field personnel are trained in the study sampling procedures, pre-deployment practice sessions will be conducted to ensure that clam, amphipod, water, and sediment samples can be deployed and/or collected as specified in the standard operating procedures. Each BDO laboratory technician and analyst must complete an initial demonstration of capability before processing or analyzing samples for this project. At least annually, technicians and analysts must demonstrate continued proficiency for the analyses that they are performing. The procedures used to ensure that staff training is current and documented is defined in laboratory SOPs. The laboratory manager is responsible for determining specific training and certification needs, and for ensuring that any required training is documented.

Individuals implementing this QAPP must receive, at a minimum, orientation to the project's purpose, scope, and methods of implementation. This orientation is the responsibility of the Project Manager or designee. Field and data management personnel must have documented experience or direct training in the procedures that they will be performing for this project, including any applicable SOPs.

A.2.6.2 Special Training

Special training and certification required for this study include the following:

- Any field team member involved in the operation of either large-scale mixing device will have been trained by AEI or CEI in the proper and safe operation of all equipment associated with the mixing device.
- Any field team members involved with sample collection or handling must be supervised by a Health and Safety Officer who has received certification of training in hazardous waste operations and emergency response (HAZWOPER – 29 CFR 1910.120). This is a 40-hour course.
- The Health and Safety Officer must complete an additional 8-hour supervisor training course (HAZWOPER – 29 CFR 1910.120).
- Any other safety-related training defined in the project HASP.
- Vessel operators will be experienced and have demonstrable experience in small boat handling under the conditions expected at the site.

Radioactive contamination may be present at the site. The sediment samples will be scanned for radioactivity by Tetra Tech ECI field personnel (under a separate contract to the Navy) who have been trained to perform this task.

The Project Manager is responsible for identifying worker certification needs for the field unit and ensuring that all team members are adequately trained. A field orientation must be conducted to establish guidelines for field observations between crews to ensure repeatability within the limits of this qualitative approach. This orientation is the responsibility of the Project Manager.

A.2.6.3 Navy Evaluation

Only laboratories that the Navy has evaluated and approved within the previous 18 months may perform the critical analyses of the archived sample splits described in this QAPP. Critical analyses are those upon which future decisions regarding the suitability of AC application as a remedial alternative may be based. For the ESTCP DP, critical parameters are defined as PCB congeners in the *M. nasuta* tissue and *Corophium spp.* amphipod samples that will be collected and archived in December 2005 (t = -1 months), August 2006 (t = 6 months), and August 2007 (t = 18 months) as shown in Table A-1.

Battelle Duxbury Operations (BDO) in Duxbury, MA will perform critical data analyses. The BDO laboratory has obtained general NFESC approval for the use of these methods for the BRAC program.

A.2.6.4 State of California Environmental Laboratory Approval Program

Laboratory certification through the State of California Environmental Laboratory Accreditation Program (ELAP) is required for any certifiable methods. ELAP does not certify the low-level methods required for the BDO's critical analyses that will be used for the ESTCP DP. Therefore, certification is not required for these measurements.

A.2.7 Documentation and Records

A.2.7.1 Document Control

It is critical that project personnel have the most recent versions of the QAPP and SOPs. Version control is maintained by defining the version number and date on each of these documents. A distribution list is maintained for each controlled document. When a new version is approved, it is distributed and the old versions must be marked as "Obsolete." Requests for SOPs should be submitted to the QA Officer at the authoring laboratory. Field and laboratory logbooks are controlled documents and must be permanently bound and prenumbered, dated, and distinctly labeled.

A.2.7.2 Documentation Standards

Each organization performing activities in support of environmental data collection that will be used for decision making at Hunters Point must have written procedures for the methods and procedures related to the collection, processing, analysis, reporting, and tracking of environmental data. This documentation must be in either the organization's QA Manual or in SOPs. Written procedures must describe how analytical methods are implemented, and must be readily available to personnel. SOPs are controlled documents and, as such, must be approved by management and dated. The laboratory must maintain a master list of SOPs in accordance with DoD QSM (2002) requirements. All SOPs that are used for environmental data collection activities must be reviewed annually and updated as needed. The QAPP defines procedures by reference to the SOP number or another appropriate citation.

All critical data (BDO measurements of PCB congeners in *M. nasuta* and *Corophium spp.* tissues) and supporting data (field data) generated during the course of this project must be able to withstand challenges to their validity, accuracy, and legibility. To meet this objective, data are recorded in standardized formats and in accordance with prescribed procedures. The documentation of all environmental data collection activities must meet the following minimum requirements. Other specific documentation requirements are discussed throughout this QAPP and the associated SOPs:

- Data must be entered directly, promptly, and legibly. All reported data must be uniquely traceable to the raw data. All data reduction formulas must be documented.

- Handwritten data must be recorded in ink. All original data records include, as appropriate, a description of the data collected, units of measurement, unique sample identification (ID) and station or location ID (if applicable), name (signature or initials) of the person collecting the data, and date of data collection.

- Any changes to the original (raw data) entry must not obscure the original entry. The reason for the change must be documented, and the change must be initialed and dated by the person making the change.

- The use of pencil, correction fluid, and erasable pen is prohibited.

Any changes to raw data must be documented and approved. Changes that are anticipated up to 12 hours prior to the intended field or laboratory activities must be documented and submitted to the Project Manager for approval prior to implementation of the changes.

A.2.7.2.1 Changes and Deviations

During the conduct of this study, it may be necessary to modify the planned activities. Modifications that are anticipated prior to field or laboratory work will be reported to the Project Manager, who will assess the potential impact (e.g., those that would impact the study objectives, design, or data quality). All changes to the QAPP must be communicated to the Project QA Manager. All QAPP changes must receive the written approval of the Project QA Manager. All modifications will be described in the final report. The Project Manager and Project QA Manager will determine whether modifications are significant enough to either update the QAPP or prepare an addendum to the document.

Changes that are not anticipated prior to the planned activities are deviations and must be communicated to the Project Manager as soon as possible, documented, and submitted for approval to the Project Manager. Documentation should include an assessment of any impact that the deviation has on data quality and the corrective action. Minor deviations (e.g., those that would not impact the study objectives, design, or data quality) will be reported to and approved by the Project Manager. Major deviations (e.g., those that could impact the study objectives, design, or data quality) will additionally be reported to the Project Manager and the Project QA Manager. A discussion of major deviations and potential impact on the project objectives will be included in the final report.

A.2.7.2.2 Definition of Raw Data

Raw data are defined as any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments. If exact copies of raw data have been prepared (and verified accurate by signature) then the exact copy or exact transcript may be substituted National Environmental Laboratory Accreditation Conference (NELAC) Chapter 1 Glossary (June 2000). Raw data will be archived at each participating laboratory for 10 years from the date of the final report; reference Section A.2.7.8 for further disposition requirements.

A.2.7.3 Field Documentation and Forms

This section defines the specific records and data that must be maintained for each field activity to ensure that samples and data are traceable and defensible. Field records will be documented in bound, paginated field logbooks to provide a secure record of field activities, observations, and measurements during

sampling. All field records and documentation must comply with the documentation requirements defined in this section. Copies of all field data collection forms are provided in Attachment 1.

Field data and observations will be recorded in real time on activity-specific data forms that are bound into the logbooks. Completion of a sample collection form for each sample is the responsibility of the appropriate Research Studies Leader. The information recorded for each sample includes, as appropriate:

- Unique sample ID number and description
- Date and time of collection
- Identification of person who collected the sample
- Identification of person recording field data (if different than the collector)
- Sample location (Lat/Long or State Plane)
- Sampler type
- Sampling procedures, sample volume and receiving container
- Storage conditions from sampling to aliquotting or shipment.

A.2.7.4 Laboratory Documentation

Documentation of all laboratory activities is critical for tracking data and evaluating the success of any activity. It is expected that each laboratory maintains written policies that define documentation requirements and procedures. Laboratory documentation requirements at BDO are defined in the laboratory QA Manual and SOPs. Required documentation includes, but is not limited to, the following:

- Calibration and maintenance records for all instruments and equipment involved in the collection of environmental data.

- Preparation of calibration standards, spiking solutions, and dosing solutions such that each unique preparation can be tracked to the original (neat) material.

- Lot numbers for all standards, stock solutions, reagents, and solvents.

- All sample processing or preparation for testing such that it is traceable to sample receipt records.

- All sample analyses and results of analyses. All rejected data are accompanied by explanations of the failure and the corrective action.

- All data reduction formulas such that reported data can be reproduced from the raw data.

A.2.7.5 Contents of Data Packages

Laboratories at Stanford, UMBC, and ERDC will generate full data packages for 20% of the samples analyzed and summary data packages for 80% of the sample analyzed. BDO laboratory will generate a full data package for 100% of the samples analyzed. The full data package contains all information required for validation (Section A.5.0 discusses data validation requirements). The full data packages must contain any of the following elements that are applicable to the analysis because the data will be validated:

- Title page;
- Table of contents;
- Data package narrative (contents defined in the DoD QSM [2002] and this QAPP);

- Copies of SOPs for all analyses not performed in accordance with strict U.S. EPA methods (once);
- Final data report tables (see Section A.2.7.7 for contents);
- Analytical records:
  - Instrument tuning (GC/ECD methods);
  - Retention times (GC methods);
  - Calibration data;
  - Calibration verifications;
  - Surrogate recoveries (GC/ECD and GC methods);
  - Internal standard response and retention times;
  - All QC data required by the analytical method or the QAPP (blanks, laboratory control samples [LCS]/LCS duplicates [LCSD], matrix spike samples [MS])/MS duplicates [MSD], duplicates);
- Required supporting information:
  - Entire package of sample custody documentation, including sample receipt form;
  - Sample processing and spiking records;
  - Copies of standard preparation logs for each standard used in sample preparation and instrument calibration;
  - Run logs (see DoD QSM [2002] requirements);
  - Raw data associated with field and QC data;
  - Chromatograms;
  - Instrument calibration records and calibration results;
  - Results of all QC samples required by the QAPP; matrix spike solution compounds in concentration units;
  - Sources of control limits for surrogates and LCS; and
  - Source of LCS;
- Summary of internal standard retention times and response;
- Description of manual integration procedures; and,
- List of current MDLs for the preparation and analysis methods used for sample processing.

Summary data packages will include sample results and a QA/QC summary report. Section A.3.10 describes the data reporting requirements for this project.

A.2.7.6 Electronic Data Deliverable

All analytical data and the associated field data produced by Stanford, UMBC, ERDC, and BDO will be submitted to the Stanford database manager. Standard data reporting formats have been designed and described in project-specific SOPs such that data will be submitted in a uniform manner that meets the ESTCP DP database requirements. This process is described in Section A.3.10. Because the ESTCP DP database will be used to facilitate analytical data validation, the laboratory will be required to include QC data in the data submission. Project-specific SOPs will be provided to the lab and field team that are submitting data. If applicable, the electronic submission should include QC results. All electronic data deliverables (EDDs) must conform to Navy Environmental Data Transfer Standards (NEDTS) by being Excel 97 or Excel 2000 for Windows compatible, or as a tab-delimited text (ASCII) file.

A.2.7.7 Reports

- The ESTCP reports (Cost and Performance, Final Technical, and Verified Fact Sheet) will be prepared by the combined efforts of Stanford University, UMBC, and ERDC.
- BDO laboratory data reports must contain the following:
  - The concentration, units, MDL, RL, and data qualifier for critical data;
  - The sample collection date, extraction date (if applicable), and analysis date;
  - The Field Sample ID, Laboratory Sample ID, and the sample delivery group or analytical batch (SDG) number.
  - All required QC data including detected concentrations, spike amounts (or concentrations), percent recoveries and the appropriate calculation of precision (relative percent difference [RPD], relative standard deviation [RSD]).

A.2.7.8 Storage and Disposal

Stanford's database will be maintained in electronic and hardcopy format for 10 years following the submission of required ESTCP reports.

If critical data is obtained from the archived sample splits, BDO is responsible for maintaining electronic and hardcopy raw data, data packages, and final data that it generates for this project for 10 years after data submission. If raw data will be stored on tape or CD, then the magnetic tape storage device or other similar storage device must be capable of recording data for long-term, off-line storage. At the end of the 10-year period, BDO will contact the Navy RPM or a representative to determine if the Navy wants to take possession of the data. If directed to do so, BDO will transfer the data and electronic records associated with this investigation to the Navy. The Navy is then responsible for maintaining that data in accordance with the prescribed time requirements. The Stanford project manager will provide BDO with a complete photocopy of all field records associated with samples analyzed by BDO. BDO will archive these records as part of the project files.

Sample archiving and disposal is discussed in Section A.2.2.8.

A.3.0 STUDY DESIGN, DATA GENERATION AND ACQUISITION

This section describes the method requirements for all aspects of data measurement and acquisition: collection, handling, and analysis of samples; QC procedures and requirements; and data management. The overall purpose of this project is to demonstrate that AC sorbent mixed with sediment is a cost-effective, in situ, non-removal, management strategy for reducing the bioavailability of PCBs in offshore sediments at HPS site.

A.3.1 Sampling Process Design (Experimental Design)

The field data will be obtained by collecting samples according to the Sampling Design shown in Table A-1. Table A-4 defines the measurements associated with the primary and secondary performance criteria, respective lab samples, and laboratories responsible for analyses. Table A-5 defines the total number of samples that will be collected during the entire ESTCP DP and the intended analyses.

This project is designed to compare the effectiveness of two available large-scale mixing technologies, demonstrate that AC treatment reduces aqueous PCB availability and PCB bioaccumulation in field tests, and evaluate sediment resuspension and PCB release. To achieve these objectives, four test plots of 370 ft^2 area will be used in the field study and analyzed once before and thrice after treatments occurs as shown in Table A-1. As discussed in Section 2.4.1, various treatments will be applied to three of the four plots, leaving one plot (Plot E) to serve as a non-mixing control. A schematic of these four plots, labeled with respective treatments, is shown in Figure A-5. Plot C will be treated by mixing the sediment with the Aquamog rotovator, but without applying AC. Plots D and F will be treated by applying a 3.4 wt.% AC and mixing it into the sediment with the Aquamog and CEI slurry injector system, respectively. Plot G was not utilized in this project (Attachment 3). The AC dose will be applied to an approximate depth of one foot, corresponding to the biologically active zone. The shapes of the Plots C and D were made to fit the radial design of the Aquamog's rotovator arm. The shapes of Plots F was chosen to fit the design of CEI's equipment. All of the plots were made to follow the contour line of the tides so that similar benthic communities would exist in each of the plots at the beginning of the study.

In each of the four plots, there will be five sampling locations, as shown in Figure A-5. These five sampling locations in each plot at each post-treatment sampling event have been selected using a stratified random sampling strategy. This sampling strategy ensures that the sampling locations are spatially distributed, and meet the criterion of random sampling so that statistical tests can be applied during data analysis. To obtain the five stratified random sampling locations for a given plot, each plot was divided into five equal sub-areas containing the same number of possible sampling locations. The outside 3-foot edge of the plots was not included in the selection process to ensure that the sampling locations are located within the actual treatment area. In each sub-area, a random sampling location was selected. The resulting randomly-selected sampling locations are shown in Figure 3-6 for each plot. To avoid altering the sediment layer by prior sampling events, the sampling locations at each post-treatment sampling event were differently selected based on a random sampling plan.

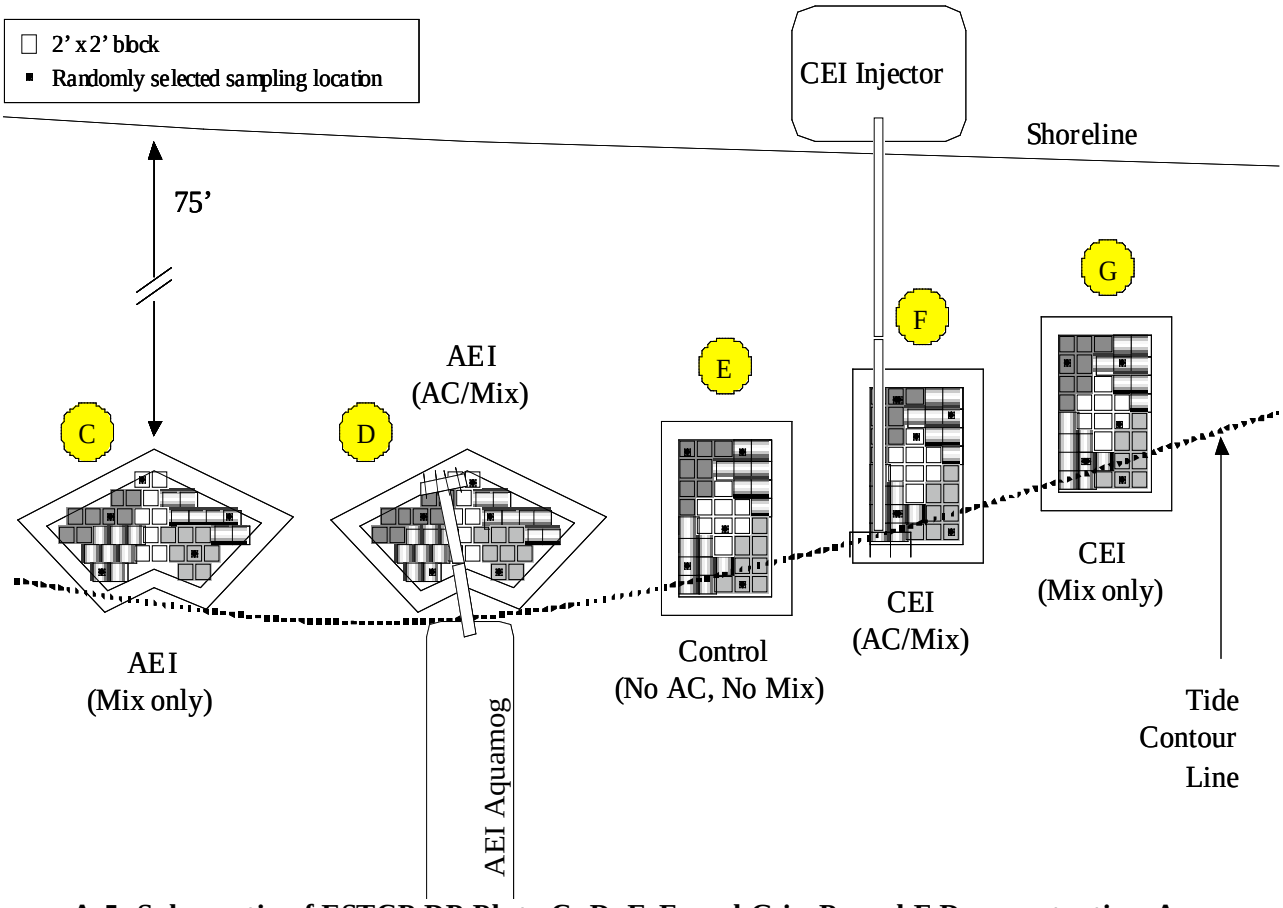

Figure A-5. Schematic of ESTCP DP Plots C, D, E, F, and G in Parcel F Demonstration Area (Plot G was not utilized.)

A.3.2 Field Sampling Methods

To perform analytical tests, field samples must be collected according to standard protocols. This section defines the field sampling methods that apply to this ESTCP DP. These protocols describe appropriate procedures to collect field samples for the purpose of (1) determining physical characteristics and (2) measuring chemical constituents. The field protocols for this study were selected to ensure that sampling procedures meet the requirements for the intended use of the data. Field sampling activities will be led by Dr. Dennis Smithenry. All general field information, including field location, field activities, type of equipment, and weather, will be recorded on the Field Daily Log Form, and maintained in a paginated and bound field logbook (see Section A.2.7.3). Field SOPs can be found in Attachment 2.

The sampling area will be scanned for radioactivity by Tetra Tech ECI field personnel prior to the survey. This scanning will be conducted at HPS due to the historical disposal of radium dials in the landfill in Parcel E. The scanners will notify the HSO, and Radiation Safety Officer (RSO) of any samples with greater than two sigma background readings. The HASP describes the procedures for sample segregation and disposal, decontamination, and the procedures for the release of materials for unrestricted use. The Tetra Tech ECI project HASP details the scanning procedures.

A.3.2.1 Plot Locations

GPS coordinates will be recorded in the field using a handheld GPS unit (Garmin Geko™ 201) with WAAS-enabled accuracy of ±3 m. The exact GPS coordinates will be defined with the latitude and longitude in terms of degrees and decimal minutes using WGS 84 datum. The dimensions of the plot are on a similar scale to that of the unit's accuracy, so only the center of each plot will be defined with GPS coordinates. The locations of clam tube/SPMD/PED deployments and core samples will be marked on a scale map (with magnetic North identified) in relation to the center and corners of each plot. GPS coordinates will be recorded for water column samples taken over the plot areas. The exact GPS coordinates will define the latitude and longitude in terms of decimal degrees or degrees and decimal minutes.

A.3.2.2 Testing Material Deployment and Sampling of Environmental Media for Chemical Analysis

A.3.2.2.1 SPMD Deployment and Retrieval

As shown in Table A-1, biomimetic SPMDs will be deployed in the sediment once before and twice after AC treatment to simulate the in situ availability of PCBs to biota. The SPMDs used in this study will be 10 cm long and will contain the nonpolar lipid triolein. One SPMD will be vertically suspended inside each clam tube onto two hooks mounted on the inner wall. Each end of the SPMD has a 3-cm-long loop. These loops will be slipped onto the hooks that are 16 cm apart. The top loop of the SPMD will be located 3 cm below the sediment surface. This design will allow the SPMD to be suspended and stretched vertically, keeping it away from the clam tube wall. A total of 75 SPMDs will be deployed during the entire project. Following field collection, the SPMDs will be sent to Stanford University for PCBs analysis.

For the time series deployment, six SPMDs will be attached to a 10x30 cm rectangular frame made of stainless steel tubing and deployed into Plots C and D within a 6-inch depth. Two SPMDs from each sampling frame will be retrieved 97, 140, and 224 days later.

A.3.2.2.2 M. nasuta *Tube Deployment and Retrieval*

PCB bioaccumulation in test clams will be measured using particle-feeding *M. nasuta* clams native to San Francisco Bay. The work shall use small organisms (6-g "whole clam with shell" weight, to reduce the slow internal equilibration kinetics associated with larger organisms) of standard size (to minimize size-related accumulation effects). These clams will be placed in mesh-covered PVC tubes sunk into the four plots once before and twice after AC treatment at each of the five sampling locations, according to the schedule shown in Table A-1. The clam tube will be 1.5 feet long and have a diameter of 6 inches. The five clam tubes in each plot are considered experimental replicates. The six clams will be placed per clam tube onto the sediment surface within the tube's diameter and allowed to burrow. A total of 60 clam tubes will be deployed during the entire project. After a 28-day exposure, the clams will be removed by carefully scooping out the sediment in the clam tubes. The clams then will be separated from the sediment, rinsed with site water, and placed in polyethylene containers. The organisms shall be depurated in clean sediment for 24 hours and then in seawater for 48 hours at ambient temperatures before sacrificing clams. Each clam will be shucked, and the resulting whole tissue will be placed in a separate scintillation glass vial. At ERDC each set of six (or total number surviving) clams that came from a given clam tube will be homogenized and split. Half will be shipped to BDO for archiving and while the other half will be analyzed at ERDC. The in situ tests will conform to work of others employing planktonic crustaceans, amphipods, shrimp, and oligochaete worms (e.g., Chappie and Burton, 1997).

A.3.2.2.3 Indigenous Amphipod Sample Collection

According to the schedule in Table A-1, five separate surface (0-2 cm) sediment samples shall be collected at the sampling locations in each plot as shown in Figure A-5 and placed into a separate wide-mouthed polyethylene jar with a vented lid. These jars shall be maintained at <18 °C in a cooler, and transferred to laboratory conditions within 2h of collection where they will be sieved for *Corophium* spp.amphipods. Each sieved sediment sample shall provide at least 200 mg wet weight of amphipods.

A.3.2.2.4 Quadrat Surface Sediment Collection and Sieving

At each of the sampling locations shown in Figure A-5, surface sediment (0-10 cm) will collected from 0.25-m quadrats once before and twice after plot treatments as shown in Table A-1 and placed in separate, labeled plastic buckets prior to processing. The benthic organisms existing in these quadrat sediment samples will be sieved using a 500µm sieve, preserved in 10% formaldehyde solution in the field, and transferred to the laboratory in 500mL polyethylene jars. A total of 60 quadrats will be sieved during the entire study producing 60 benthic community samples. By comparing the macrofaunal composition that exists in the benthic community samples collected before and after treatments, the AC treatment effects upon benthic recolonization, community structure and organism growth can be determined.

A.3.2.2.5 Surface Water Sample Collection

Overlying water above the all four plots will be sampled simultaneously soon after the high tide recovers the plots before and after treatment with AC, as indicated in Table A-1. This sampling event for the four plots will be repeated after the first set of samples is obtained. A total of 32 water samples will be collected for analysis. The method is similar to the surface water sampling method used in the EPA Lake Michigan Mass Balance Study (http://www.epa.gov/glnpo/lmmb/methods/field96.pdf). The inlet of the sampling tube will be positioned and anchored 0.5 ft above the sediment surface and submerged under water during high tide. The method involves sampling up to 50 L of water per sample from the field, pumping the water through a pre-combusted glass fiber filter paper with a nominal pore size of 0.7 microns, and passing the filtered water through a pre-cleaned XAD-2 resin adsorbent column. The filter paper containing the suspended particulates and the XAD-2 resin columns containing trapped dissolved PCBs will be shipped in a cooler to the UMBC laboratory for extraction and PCB analysis.

A.3.2.2.6 Sediment Core Sample Collection

According to the schedule in Table A-1, sediment core samples will be collected to evaluate the depth and homogeneity of the treatments in the sediment and the sediment PCB concentrations. At each of the sampling locations shown in Figure A-5, 2.0-inch-diameter sediment core samples will be taken once before and twice after AC treatment for a total of 60 core samples during the entire project. Samples will be collected, capped, and returned to Stanford for processing.

A.3.2.2.7 PED Deployment and Retrieval

As shown in Table A-1, polyethylene devices (PEDs) will be deployed in the sediment once before and twice after AC treatment for 28-day exposure studies. For the deployment six months after AC amendment, PEDs were constructed by cutting pre-cleaned PE into 14.5 cm^2 circles and attaching the PE to circular frames made of coated wire. The PEDs were placed horizontally in the sediment at depth of 15 cm. For sampling 18 months after amendment, pre-cleaned PE strips were impregnated with performance reference compounds (PRCs) PCB 29 and PCB 69, at levels measured by field blanks. PEDs were constructed by horizontally attaching one PRC-spiked PE strip (3.8 cm wide) to a stainless steel frame (10 cm by 30 cm). The frames were placed at a depth of 5-15 cm. Upon retrieval, the PE strips were cut in half before extraction, creating a total of ten replicates per plot.

A.3.2.2.8 Surface Sediment Sample Collection

According to the schedule in Table A-1, surface sediment samples will be collected to verify sediment deposition phenomena by measuring BC, TOC, sediment PCB concentrations, aqueous PCB concentrations, and 13C. At each of the sampling locations, top 5 mm sediment samples will be taken two years after AC treatment for a total of 20 sediment samples. Samples will be collected, and returned to Stanford for processing.

A.3.2.2.9 Collection of Sediment Sample for Ex-situ Clam Bioassay

According to the schedule in Table A-1, sediment samples for ex-situ clam bioassay at 2-year post-treatment assessment will be collected. These sediment samples will be also analyzed to measure sediment PCB concentrations, TOC, BC, aqueous equilibrium PCB concentrations, and 13C. At each test plot, five 6-inch deep sediment samples will be taken, and sieved/combined into one composite sediment sample on site. Samples will be shipped to ERDC for further processing.

A.3.2.2.10 Equipment Decontamination

Throughout sample collection activities, care will be taken to avoid sample contamination. This will be accomplished through rigorous decontamination procedures and careful sample handling procedures (Section A.3.3).

- To the extent possible, non-contaminating materials (glass, stainless steel, Teflon™) will be used for sample collection.
- Sampling equipment will be cleaned prior to use and between samples.
- All sources of contamination (airborne sources, fingers, unclean equipment) should be avoided.

To avoid cross-contamination in core samples collected for TOC and PCB analysis, a separate pre-cleaned core liner will be used to collect and contain each sample. The core sample will be capped at both ends to seal in the sediment, which will not be removed from the liner until it is opened for processing under controlled laboratory conditions (described in Section A.3.3.3.4).

A.3.2.2.11 Management and Disposal of Investigation-Derived Waste

Field sampling and sample preparation activities will be conducted such as to minimize generation of waste materials. In the field, sediment and rinse water from sampling equipment will be washed back to Parcel F. Solvent waste will not be generated in the field. All solid waste (gloves, paper towels, etc.) will be bagged or otherwise contained prior to disposal in standard refuse containers (dumpsters). In the laboratory, solvent waste will be contained in appropriately labeled containers and disposed of in compliance with state and federal waste handling regulations. Solid waste and wastewater generated during sample preparation of sediment samples at each laboratory will be managed in compliance with the organization's requirements. Sediment analytical results can be used to characterize the waste, identify the waste stream, and determine whether or not excess sediment requires management as hazardous waste. Excess sediment and archived sediment samples will be held as long as they are analytically viable (up to one year); when the samples are no longer of use to the project they will be handled as waste.

A.3.3 Sample Processing, Handling, and Custody

A.3.3.1 Sample Processing

Minimal sample processing will be conducted in the field. Sample processing will be conducted at facilities that have the appropriate clean laboratory space, experienced staff, secure sample storage, decontamination facilities, and shipping/receiving service for processing and subsampling cores. All other samples will be processed at the laboratory that will perform the analysis. Table A-6 defines the container types, sample volumes, preservation methods, laboratory addresses and contacts, and holding times.

A.3.3.2 Field Sample Containers and Labeling

Sample containers will be labeled with waterproof, adhesive-back labels. Sample labels must provide sufficient detail to uniquely identify each sediment sample and allow tracking to field activities. Sample identification numbers will be in the format:

EAE-001

Where E is the year 2005 (F-2006, G-2007, H-2008)
AE is the Survey Number
001 is a unique, sequential number

Sample labels must include a unique sample identification number (EAE-XXX), sample type (core, clams, SPMD, filter, or XAD column), collection date, sample collector's name, container number and total number of containers (e.g., 1 of 2, 2 of 2). An example is provided below.

ESTCP DP Project
Unique Sample ID: EAE-_____
Location ID_____
Sample Type (circle one)
Core / Clams / Amphipods / Quadrat / SPMD /filter / XAD/
Date: _____ **Time:** _____
Sample Collector:_____
Container_____of_____

A.3.3.3 Sample Handling

During sample collection and handling, field personnel will wear polyethylene or latex gloves gloves during all sampling collection activities that involve sediment. Gloves should be changed often.

Sample holding conditions and holding times are detailed in Table A-6. Holding times are calculated from the time of sample collection. Documentation must be sufficient to track sample holding, processing, and analysis times to ensure that holding times are met. Documentation of sample collection must include both date and time. The following sample handling requirements must be met for all samples:

- Samples must be held in a controlled area with limited access; and,

- Deviations from the defined storage requirements must be documented and reported with the data.

A.3.3.3.1 SPMD Sample Handling

SPMDs will be rinsed gently with site water to remove sediments attached to the outer surface, taking care not to puncture the surface. The SPMD will be placed in a glass container with a Teflon™-lined lid. SPMDs will be stored at 4°C until analysis at Stanford.

A.3.3.3.2 **M. nasuta** *Sample Handling*

Living clams shall be removed from tubes and transferred to a vented polyethylene jar that contains clean water. The clams will be transported to Stanford University and allowed to depurate in clean water for 48 hours at ambient temperatures. After depuration, each surviving clam will be shucked and each resulting clam tissue will be placed into a separate pre-cleaned 20 mL scintillation vial. The vials containing a single clam tissue will be immediately placed in a -10°C freezer. Once frozen, the samples will be shipped overnight (on dry ice in a cooler) to ERDC. At ERDC each set of six (or total number surviving) clams that came from a given clam tube will be homogenized and split. Half will be shipped to BDO for archival at -10°C; while the other half will be analyzed at ERDC. If the survival is less than three clams per clam tube, a conference call between BDO, Stanford, and ERDC will be conducted to determine the best distribution of available clam tissue.

A.3.3.3.3 Indigenous Amphipod Sample Handling

In the laboratory, the amphipods shall be removed from the sediment using a 500µm sieve and rinsed with clean artificial seawater. Amphipods shall be depurated for 24 h using San Francisco Bay seawater receiving trickle flow aeration in a cold room facility at 15 °C. Following depuration, amphipods from each sampling location shall be removed and weighed by placing them into tarred and pre-cleaned 20 mL scintillation vials. Samples will be immediately frozen. Once frozen, samples will be shipped on dry ice to ERDC for homogenization and splitting. Half of the resulting homogenate sample will be analyzed by ERDC, while the other half will be shipped on dry ice to BDO for archival at -10°C. Analysis of the PCB concentrations in these amphipod samples will assess the AC treatment effects upon PCB bioaccumulation in a resident benthic population.

A.3.3.3.4 Benthic Community Sample Handling

Benthic community samples collected from sieved quadrats will be preserved in a 10% formaldehyde solution, stored at 4 °C temporarily , and then shipped overnight to ERDC in coolers maintained at 4 °C. Once at ERDC, these samples will be subjected to benthic community structure analyses.

A.3.3.3.5 Surface Water Sample Handling

Sampling of the water column will produce a filter paper sample and a XAD-2 resin column sample. The filter paper sample will be transferred to a glass container with a Teflon™-lined lid. The XAD-2 resin column will be tightly capped. The filter paper containing the suspended particulates and the XAD-2 resin columns containing trapped dissolved PCBs will be shipped in a cooler to the UMBC laboratory for extraction and PCB analysis.

A.3.3.3.6 PED Sample Handling

PED sample handling will be the same with SPMD sample handling.

A.3.3.3.7 Sediment Core Processing and Sample Handling

Sediment cores for chemical analysis will be capped upon collection with no further field processing. These cores will be transferred in a cooler to Stanford University at the end of each collection day. Sediment cores will be subsampled at Stanford according to the following guidelines:

- Place the core on a non-contaminating surface and remove the end caps;
- Using a core plunger, slowly push out the core onto the non-contaminating surface and take a picture of the core;
- Every two inches, gently pass a clean stainless steel knife through the core and place cross sections into pre-cleaned beakers;
- Homogenize each cross section and remove a 1-g subsample for TOC measurement. The TOC subsample will be placed into a small pre-cleaned and labeled glass vial;
- Recombine and homogenize the top three cross sections (0-6 inches) in a large glass container with a Teflon™-lined lid. From this homogenate, a) remove a 5-g subsample for sediment PCB concentration measurement and place it into a pre-cleaned and labeled beaker, b) remove a 30-g subsample for aqueous equilibrium PCB concentration measurement and place it into a pre-cleaned and labeled 4 oz. glass jar, and c) remove a 100-g subsample for PCB desorption tests and place it into a pre-cleaned and labeled 500 mL beaker. [Note: This 500 mL beaker should be used to collect all five 100-g subsamples that are taken from the five homogenized sediments cores that come from one given plot. Homogenize the resulting 500-g sample and remove two 100-g subsamples for the desorption tests. These two 100-g subsamples should be placed into separate pre-cleaned and labeled 4 oz. glass jars.]
- The remainder of the core will be archived;
- Document sediment subsamples by recording the following information: Date sediments were subsampled, ID code or number for each subsample, and sample allocation information (analyses performed).

At the conclusion of the project, sediment waste will be classified as potential hazardous waste and disposed of through procedures outlined by Stanford's Environmental Health and Safety program.

A.3.3.3.8 Surface Sediment Sample Handling

Surface sediment samples will be transferred into a pre-cleaned and labeled 4 oz. glass jar with a Teflon™-lined lid. Samples will be stored at 4°C until analysis at Stanford.

A.3.3.3.9 Composite Sediment Processing and Sample Handling

Five sediment samples (0-6inch) in each plot will be placed into clean 2-gal plastic buckets. The five sediment samples will be sieved with a 4 mm stainless steel mesh screen to remove shell and coarse sand material and combined into a large plastic bucket. The composite sediment sample will be transferred into two 5-gal plastic buckets, and wait to settle. Excessive seawater will be removed. The buckets will be placed into a cooler and shipped on dry ice to ERDC for homogenization and splitting.

A.3.3.3.10 Sample Homogenization

Sample homogenization is a critical activity and must be conducted to ensure that the homogenate and aliquots are representative of the field material. For sediment samples, the sample homogenization referenced in Section A.3.3.3.6 will be accomplished by placing the wet sediment in a clean, glass container and mixed thoroughly by hand until a homogeneous color and texture is achieved. The composite sediment samples referenced in Section A.3.3.3.8 will be thoroughly homogenized with an impellor mixer for five minutes to consistent texture. Homogenization of tissue samples is described in Sections A.3.4.2.1 and A.3.4.4.3.

A.3.3.4 Field Sample Preservation, Packaging, and Shipment

During the sampling day, samples collected for the ESTCP DP will be preserved by placing the containers in coolers immediately after collection. At the end of the sampling day, all field samples that are to be shipped overnight will be packaged in coolers and shipped with the appropriate chain-of-custody (COC) forms as described in Section A.3.3.5. Each of these coolers will also contain a temperature cooler blank so that the receiving laboratory may verify sample temperature upon receipt. Sediment cores will be stored upright.

A.3.3.5 Chain-of-Custody Records

Sample custody records are the administrative records associated with the physical possession and/or storage history of each individual sample from the purchase and preparation of each sample container and sampling apparatus to the final analytical result and sample disposal.

Sample custody will be documented throughout collection, shipping, analysis, and disposal of the sample. Samples will not be left unattended unless properly secured. The sample custody form provides a record of the samples collected and analyses requested. If more than one cooler is sent in one shipment to the laboratory, then each cooler will contain a separate custody record for the samples in that cooler. In addition, the outside of the coolers will be marked to indicate the number of coolers in the shipment (e.g., 1 of 2, 2 of 2). All coolers must be shipped under a bill of lading that identifies the total number of coolers in the shipment. Separate tracking numbers will be assigned to each cooler. Specifically for sample archives sent to BDO, sample custody procedures will be in accordance with the BDO SOPs 6-010, *Sample Receipt, Custody, and Handling*.

Each analytical laboratory must have a formal, documented system designed to provide sufficient information to reconstruct the history of each sample, including preparation of sampling containers, sample collection and shipment, receipt, distribution, analysis, storage or disposal, and data reporting within the laboratory. Laboratory documentation must provide a record of custody for each sample (versus a sample batch) throughout processing, analysis, and disposal.

The custody form summarizes the samples collected and analyses requested. The custody form tracks sample release from the field to the initial receiving laboratory. Each sample custody form will be signed by the person relinquishing samples once that person has verified that the custody form is accurate; i.e., that all samples present in the shipping container are listed on the form, and that the sample descriptions, requested analytical methods, and sampling dates are accurate. The original sample custody forms accompany the samples; the shipper will keep a copy. Upon receipt at the sample destination, sample custody forms will be signed by the person receiving the samples once that person has verified that all samples identified on the custody forms are present in the shipping container. Any discrepancies will be noted on the form (in addition to any internal laboratory documentation policy) and the sample receiver will immediately contact the Project Manager to report missing, broken, or compromised samples.

Samples are considered to be in a person's custody if:

- The samples are in a person's actual possession;
- The samples are in a person's view after being in that person's possession;
- The samples were in a person's possession and then were locked or sealed up to prevent tampering; or,
- The samples are in a secure area.

A.3.3.6 Sample Receipt

Immediately upon receipt by a laboratory, the condition of samples must be assessed and documented. The contents of the shipping container must be checked against the information on the custody form for anomalies. If any discrepancies are noted, or if laboratory acceptance criteria or project-specific criteria are not met, the laboratory must contact the Project Manager for resolution of the problem. The discrepancy, its resolution, and the identity of the person contacted must be documented in the project file. The following conditions may cause sample data to be unusable and must be communicated to the laboratory team leader:

- The integrity of the samples is compromised (e.g., leaks, cracks, grossly contaminated container exteriors or shipping cooler interiors, obvious odors, etc.);
- The identity of the container cannot be verified;
- The proper preservation of the container cannot be established;
- Incomplete sample custody forms (e.g., the sample collector is not documented or the custody forms are not signed and dated by the person who relinquished the samples);
- The sample collector did not relinquish the samples; and,
- Required sample temperatures were not maintained during transport.

The custodian must verify that sample conditions, amounts, and containers meet the requirements for the sample and matrix (Table A-6). A unique sample identifier must be assigned to each sample container received at the laboratory, including multiple containers of the same sample.

A.3.4 Analytical Laboratory Methods

The information in this section includes the analytical methods that will be used to assess the primary and secondary performance criteria listed in Table A-4. This section is divided into four parts so that the analytical methods are grouped according to the laboratory that is responsible. To summarize briefly, the following labs are responsible for the identified analyses:

- Stanford University Laboratory (Stanford, CA): PCBs in SPMD samples and PED samples, total PCB in sediments, aqueous equilibrium PCBs, and total organic carbon (TOC) in sediment cores.
- USACE-ERDC Laboratory (Vicksburg, MS): PCBs in clam tissue samples, PCBs in amphipod samples, and benthic community structure analyses.

- UMBC Laboratory (Baltimore, MD): PCBs associated with surface water sampling, sediment PCB desorption characteristics, and black carbon (BC) in sediment cores.

- BDO Laboratory (Duxbury, MA): PCBs in archived clam tissue samples split and PCBs in archived amphipod sample splits.

A.3.4.1 Analytical/Testing Methods for Stanford

A.3.4.1.1. PCB Uptake in SPMDs

The biomimetic SPMDs will be custom-made by Environmental Sampling Technologies to be 10 cm long and contain 0.1 g triolein, a component of fish lipid. (inner length is 10 cm and outer length including loops is approximately 16 cm) Upon retrieval, the SPMDs will be gently washed with site water to remove sediment from the surfaces, rinsed with deionized water, placed into a glass jar, and returned to Stanford for storage in a 4 ºC cold room until they are processed. The loops of SPMDs will be cut and removed. SPMDs will be cleaned by rinsing with deionized water, swirling for 30 s in 1 M hydrochloric acid, rinsing with the series of deionized water, acetone, and isopropyl alcohol, and air-drying for approximately 30s. The SPMDs will be then submerged in about 125 ml volume of hexane and dialyzed at room temperature for 24 h. The dialysate will be removed, and dialysis with 125 ml of fresh hexane will be repeated for 8 h. Dialysates will be combined with hexane rinse, the total volume will be recorded, and aliquots will be taken for cleanup. The cleanup procedure will include two steps. First, sulfur interferences will be removed by contacting with activated copper following EPA SW846 Method 3660A. Second, organic interferences will be removed using a deactivated silica gel (3% moisture) column following EPA Method 3630C. The PCB analysis of the resulting SPMD extracts will be performed according to Section A.3.4.1.3.

A.3.4.1.2. PCB Uptake in PEDs

Low-density polyethylene (PE) with no additives and a thickness of 51 µm was obtained from Brentwood Plastics (St. Louis, MO). The PE was pre-cleaned with a series of solvents (hexane, methanol, deionized water) then allowed to dry at 60 ^{o}C for 4 hours. Impregnation of PRCs was completed using a method described previously (Booij et al. 2002). Two PRCs, 2,4,5-trichlorobiphenyl (PCB 29) and 2,3',4,6-tetrachlorobiphenyl (PCB 69), were employed as their log K_{OW} values (5.60 and 6.04) suggest boundary layer-controlled kinetics and measurable loss over 28-day deployment periods. PCB congeners with log K_{OW} values less than 5.60 were not significantly measured in laboratory (<0.9% total concentration) or field-deployed PEDs (<0.2% total concentration). PCB concentrations in the PEDs used in this study were measured by cutting the deployed PE from frames, rinsing with deionzed water, wiping dry with a Kimwipe, and extracting in 40 mL hexane. After 24 hours of extraction with rotation at 2 rpm, the PE was removed from hexane, rinsed with solvent, and allowed to dry for weight determination. The cleanup procedure and PCB analysis are the same with SPMDs.

A.3.4.1.3 Sediment Core Processing and Analyses

The two-inch diameter core samples with lengths of 12-14 inches will be collected, capped, returned to Stanford, and stored in a 4ºC cold room until they are processed. As discussed in Section 3.3.3.6, each core sample will be divided into two-inch-long core cross sections. After TOC subsamples are removed from each cross section, the remainder of the top three cross sections (0-6 inches) from each core will be combined. From each resulting core homogenate, three portions will be removed for further analyses. The first 5-gram portion will be used to measure sediment PCB concentrations (Stanford). The second 30-gram portion will be used to measure aqueous equilibrium PCB concentrations (Stanford). The third 100-gram portion will be used to measure PCB desorption rates (UMBC)—see Section A.3.3.3.6 for complete details on how to obtain the PCB desorption subsamples.

TOC of Sediment
To assess the depth and homogeneity of the mixed AC in the sediment, the total organic carbon (TOC) of each cross section will be measured by elemental analysis, as it has been found to be an effective indicator for the amount of AC added in the sediment. Each cross section will be homogenized by stirring manually with a stainless steel spatula, and then approximately 1 g of sediment will be subsampled for elemental analysis. These subsamples will be dried and ground using an agate mortar and pestle. Duplicate subsamples of approximately 4 mg each will be weighed into silver boats. Weighed samples will be then acidified twice in situ with 6% sulfurous acid to remove carbonate phases. These sediment samples will be analyzed for total organic carbon (TOC) using a Carlo Erba NA1500 elemental analyzer at Stanford University. For well-mixed sediment in Plots D and F, we expect an average TOC of 3.8 wt.% (original sediment TOC = 1.0 wt.%) with a small standard deviation among samples within a plot.

Sediment PCB Concentrations
Sediment samples will be extracted three times with sonication in a 50% acetone and 50% hexane mixture, following a procedure based on EPA Method 3550A. The acetone portion will be removed and exchanged with hexane by a nitrogen blowdown apparatus. Then, the extract will be concentrated using a nitrogen blowdown apparatus and cleaned using the same two-step procedure mentioned previously for the SPMD extracts. The PCB analysis of the resulting sediment extracts will be performed according to Section A.3.4.1.3.

Aqueous Equilibrium PCB Concentrations
Equilibrium distribution of PCBs between sediment and aqueous phases will be measured by placing approximately 30 g of activated carbon-treated or untreated wet sediment in 780 mL glass bottles with 31 ppt seawater and 1 g/L sodium azide (practical grade, Mallinckrodt, Paris, KY) to inhibit microbiological growth. The bottles will be capped with Teflon-lined caps, shaken, and rotated at approximately 2 rpm on a roller for 14 d, after which the sediment/water mixture will be allowed to settle and the supernatant cleared of any floating particles with a Pasteur pipette. Colloids will be removed using a flocculation procedure described previously (Ghosh et al. 2000). PCBs will be extracted from the aqueous phase with hexane. The extract will be concentrated by a rotary evaporator and followed by a nitrogen blowdown apparatus. Extract cleanup will follow the same procedures mentioned previously for the SPMD extracts. The PCB analysis of the resulting extracts will be performed according to Section A.3.4.1.3.

C13 of Sediment
Carbon-13 isotope signals will be measured simultaneously with TOC using an element analyzer coupled with an isotope ratio mass spectrometer (Thermo Finnigan Delta Plus continuous flow stable isotope ratio mass spectrometer, Carlo Erba NA-1500 elemental analyzer).

A.3.4.1.4 Stanford PCB Congener Analysis

PCB congener specific analysis will be performed using a modified EPA Method 8082. An Agilent gas chromatograph (model 6890) with a fused silica capillary column (HP-5, 60 m x 0.25 mm ID) and a micro electron capture detector will be used for analysis. A 5-level PCB calibration table will be prepared using a known PCB mixture containing 250 µg/L of Aroclor 1232, 180 µg/L of Aroclor 1248 and 180 µg/L of Aroclor 1262 yielding a total PCB concentration of 610 µg/L. The known PCB calibration mixture has been already obtained from the EPA's National Health and Environmental Effects Research Laboratory in Grosse Ile, Michigan. Concentrations of individual PCB congeners in this mixture have been obtained from Mullin. Two internal standards will be used: PCB-30 (2,4,6-trichlorobiphenyl) and PCB-204 (2,2',3,4,4',5,6,6'-octachloro biphenyl), which are not present in commercial Aroclor mixtures.

Using this protocol, 92 PCB congeners or congener groups can be identified and quantified. With this analytical method, there are some coeluting PCB peaks in the analysis. Where this occurs, coeluting peaks will be calibrated as a sum of congeners.

A.3.4.2 Analytical/Testing Methods for ERDC

A.3.4.2.1 Ex-situ Laboratory Clam PCB Bioaccumulation Studies

Macoma nasuta, will be received 72-hours prior to test initiation and acclimated to laboratory conditions in 20-gallon aquaria containing collection site sediment and aerated in 30 ‰ Instant Ocean Seawater (Aquarium Systems, Mentor, OH). Homogenized sediments from each plot will be layered into each of five replicate, five-gallon aquaria (> 4 cm depth) for each test plot (t = 4, n = 5) and overlying water (30 ‰) will be gently added using a turbulence reducer and allowed to equilibrate overnight. The remaining sediment will be used for chemical assessments. Ten clams will be added to each test chamber; clams that failed to burrow after 24-h will be replaced. The exposure will be conducted for 28-days at 15 ± 1 °C with monitoring of water quality parameters (temperature, pH, D.O., salinity, and ammonia) and 70% water exchanges three times per week. Following the 28-day exposure, the clams will be removed from the test sediments and allowed to purge their guts by placing each individual into 250 ml beakers containing 200 ml reference sediment (obtained from the site of clam collection) for a 48-hour period, followed by transfer to clean seawater in aquaria for an additional 24-hour period. Clams from each replicate will be counted for overall survival, shucked, rinsed in deionized water and frozen at -80 °C for further processing. Following homogenization, the tissue will be analyzed for PCBs, lipid, and moisture content. Clams failing to burrow during the gut-purging period will not be included in the analysis.

A.3.4.2.2 Extraction of PCBs in Clam and Amphipod Samples

Sample jars containing whole *M. nasuta* clam tissues will be received frozen from Stanford with no prior homogenization. Each sample jar will contain one whole clam tissue (1-2g). These clam tissues will be grouped in sets of six (or less based on survival rate) according to the clam tubes from which they were retrieved in the field. Each set of six clams will be thawed and combined (6-12 g) into a stainless steel mortar that is set in a bath of liquid nitrogen. Using a pestle, the combined tissue sample will be thoroughly pulverized and homogenized until the tissue has the consistency of a powder. After homogenization, there should be no chunks visible or pieces of whole tissue left. At this point, a 1-g aliquot will be removed for dry weight determination and a 1-g aliquot will be removed for lipid weight determination. After removing these aliquots, the resulting homogenate (4-10g) from each sample will be split into two equal parts (2-5g). One split will be analyzed by ERDC, while the other will be immediately frozen and later shipped on dry ice to BDO for archival.

If there is 4-5g of total tissue mass in the ERDC split, ERDC may further divide their split into two parts so that they have backup sample of their own. The extraction procedure will begin by weighing 2-3g aliquots of each ERDC split into 60mL vials. 0.1mL of surrogate will be added to each sample, including QC samples, and 0.1mL of spike will be added to the appropriate samples. 1g of hydromatrix will be added and stirred into each sample. 50mL of hexane will be added to each vial with sample. The vials will be shaken to ensure sample is free flowing and has not clumped together. Vials will be placed in ultrasonic bath and sonicated overnight.

The extracted samples will be filtered through a funnel containing sodium sulfate into TurboVap tubes. The vials and funnels will be rinsed several times with hexane. The TurboVap tubes will be placed in the TurboVap and the extracts will be evaporated to approximately 1mL before subsequent cleanup.

Extract cleanup will follow EPA Method 3630C (US EPA, 1996). Solvent-rinsed chromatography columns (15 x 250 mm, Kimble/Kontes, Vineland, NJ) will be packed with a plug of glass wool, followed

by 3 g deactivated silica gel (3.3 % moisture) and topped with a small amount of sodium sulfate. Columns will be pre-rinsed with 20 mL hexane. Following addition of sample extracts, columns will be eluted with 80 mL of hexane. Samples will then be concentrated on a Zymark TurboVap II to approximately 2 mL. Extracts will be transferred to clear 12 mL vials, 2 mL of concentrated sulfuric acid will be added, and the mixture will be vortexed for 30 s. The hexane layer will be transferred to another 12 mL vial and the remaining acid rinsed with a small amount of hexane that will be combined with the primary extract. Approximately 1mL of water saturated with sodium bicarbonate will be added to the vial with the extract to neutralize any traces of acid. The vial will be shaken for several seconds, and then the water will be carefully removed from the extract. A small amount of sodium sulfate will be added to remove any remaining water. The extract will be concentrated under a stream of nitrogen to less than 1mL and then transferred to a 2mL chromatography vial. The 12mL vial will be rinsed with 0.5mL of hexane which will be also added to the 2mL vial. The extract will be given a final nitrogen concentration to less than 1mL. Internal standard will be added and the extract will be adjusted to 1mL.The PCB analysis of the resulting extracts will be performed according to Section A.3.4.2.3.

Aliquots of wet homogenized amphipod tissue (100 mg) will be weighed into certified pre-cleaned 20 mL vials. A surrogate, 2,4,5,6-tetrachloro-m-xylene, will be added to each sample to monitor method efficiency. Hexane (10 mL) will be added and each sample extracted twice for a total of 6 minutes using a Fisher Scientific Model 550 Sonic Dismembrator with microtip probe. Combined solvent layers will be transferred to a prepared silica gel column and cleaned up following EPA Method 3630C (US EPA, 1996).

A.3.4.2.3 Community Structure Analysis of Benthic Organisms from Surface Sediment Quadrats

To isolate treatment effects upon benthic recolonization, community structure, and organism growth, the benthic community samples shall be analyzed for macrofaunal composition, using a suite of appropriate univariate and/or multivariate techniques to address both spatial and temporal differences in community structure (US EPA 1992).

A.3.4.2.4 ERDC PCB Congener Analysis

Following cleanup, extracts will be transferred to solvent-rinsed 2 mL vials, internal standards pentachloronitrobenzene and 4,4'-dibromobiphenyl (Restek, Bellafonte, PA), will be added at a final concentration of 50 ng/mL, and the final volume adjusted to 1 mL. Extracts will be analyzed following EPA Method 8082 (US EPA, 1996) using a Hewlett-Packard 5890 series II gas chromatograph equipped with electron capture detectors and dual columns using 2µl injection volume. Agilent (Wilmington, DE) DB-5MS and Supelco (Bellefonte, PA) SPB-octyl columns, both 30 m, 0.25 mm ID, 0.25-µm-film thickness, will be used to achieve separation. Initial oven temperature will be 130 ºC (2 minute hold time), ramped to 255 ºC at 1.4 ºC/minute. The temperature will be then raised to 265 ºC at a rate of 18º/minute and held for 9 minutes resulting in a total run time of 100.8 minutes. Injector and detector temperatures will be 255 and 305 ºC, respectively. The carrier gas mix will be helium (1.35 mL/minute) and 5% methane in argon (65 mL/min) gas. Data for co-eluting peaks will be presented as a sum of congeners. Only congeners with all data replicates above MDL will be included.

A.3.4.3 Analytical/Testing Methods for UMBC

A.3.4.3.1 Measurement of Aqueous and Suspended Particulate PCB Concentrations in Field Water

The XAD-2 resin and the glass fiber filters will be extracted in a soxhlet extraction system with a 50% acetone and 50% hexane. The soxhlet extraction procedure will follow EPA SW846 method 3540C. The extract will be concentrated in a Kuderna Danish evaporator and a N_2 blowdown apparatus. The PCB sample will be cleaned up from organic interferences using a deactivated silica gel column following EPA

SW846 method 3630C. Sulfur interferences will be removed by contacting with activated copper following EPA SW846 method 3660B. The PCB analysis of the resulting extracts will be performed according to Section A.3.4.3.2.

A.3.4.3.2 PCB Desorption Characteristics of Field Sediments

PCB desorption characteristics of subsamples from a homogenate of sediment cores from each plot will be evaluated. The desorption tests will follow previously published methods (Ghosh et al. 2003a).

A.3.4.3.3 Black Carbon Analysis

Black carbon (BC) measurement of sediment samples will be performed by a wet chemical oxidation method using a solution of sulfuric acid and potassium dichromate (Grossman & Ghosh 2008) in which organic carbon derived from plant and biological matter is oxidized to carbon dioxide while BC is preserved. The carbon remaining in the sample is measured by the amount of carbon dioxide produced when the sample then is combusted in oxygen at 900 ºC. To derive AC values from the BC measurement, a sediment sample with no AC (Plot C top 6 inch) will be spiked with 0%, 2.5% and 5% AC. BC isolation and measurement will be then performed on the standard samples. A calibration curve will be generated from the data and used to convert BC measurements to corresponding values of AC in the sample.

A.3.4.3.4 UMBC PCB Congener Analysis

PCB congener specific analysis will be performed using a modified EPA SW846 Method 8082. An Agilent gas chromatograph (model 6890) with a fused silica capillary column (HP-5, 60 m x 0.25 mm ID) and a micro electron capture detector will be used for analysis. A 5-level PCB calibration table is prepared using a known PCB mixture containing 250 µg/L of Aroclor 1232, 180 µg/L of Aroclor 1248 and 180 µg/L of Aroclor 1262 yielding a total PCB concentration of 610 µg/L. The known PCB calibration mixture has been already obtained from the EPA's National Health and Environmental Effects Research Laboratory in Grosse Ile, Michigan. Concentrations of individual PCB congeners in this mixture have been obtained from Mullin (1994). Two internal standards are used: PCB 30 (2,4,6-trichlorobiphenyl) and PCB 204 (2,2',3,4,4',5,6,6'-octachloro biphenyl), which are not present in commercial Aroclor mixtures. Using this protocol, 92 PCB congeners or congener groups could be identified and quantified. With this analytical method, there are some coeluting PCB peaks in the analysis. Where this occurs, coeluting peaks are calibrated as sum of congeners.

A.3.4.4 Analytical/Testing Methods for BDO

The analytical method chosen for BDO measurements was selected to meet the ecological benchmark and is based on the National Oceanic and Atmospheric Administration (NOAA) National Status and Trends (NS&T) program. The critical data compound list of PCB congeners in Table A-7, with required reporting limits and detection limits, will be used if the archived sample splits are analyzed. Table A-8 provides a list of applicable laboratory SOPs.

A.3.4.4.1 Analysis of PCB Congeners in Archived Sample Splits

If it is determined that critical data is to be obtained from the archived tissue sample splits, BDO will perform the analysis of PCBs congeners according to low-level methods developed for the NOAA Status and Trends Program (Lauenstein and Cantillo, 1993). These procedures are detailed in BDO SOPs 5-190 and 5-128. Ideally, 30 g of sample tissue is homogenized by macerating the tissue using a tissuemizer and 75 mL of dichloromethane until a uniform slurry is attained with no visible non-uniform "chunks." This procedure is repeated once and the extracts decanted between tissumizing steps. A third extract is accomplished by adding 50 mL of dichloromethane to the tissue in the extraction vessel and shaking for

0.5 hours. The extract is purified and concentrated under nitrogen to a pre-injection volume of approximately 1.0 mL. Extracts for PCB congener analysis are solvent exchanged into hexane prior to analysis. Masses of tissue as low as 1 g can be extracted using this procedure; if less than 30 g is available then the entire sample will be extracted and the detection limits adjusted accordingly.

Laboratory analyses must be performed using instruments and columns that are capable of achieving the sensitivity and separation to achieve the reporting limits defined for PCB congeners.

- Samples are quantified using the method of internal standards.
- PCB compounds are analyzed by using a GC/ECD with a confirmatory column to qualitatively verify peak identification.
- Only PCB peaks confirmed on both columns will be considered "hits."
- Sample data will not be surrogate corrected.
- No data will be blank-corrected.

Manual integrations are also a key element of low-level organic compounds analyses and are implemented routinely for low-level GC/ECD data to separate data system baseline integration features from peaks that can be distinguished at greater than 3:1 signal:noise ratio. Manual integration:

- Will not be used preferentially for QC samples and must not be used to satisfy QC criteria requirements;
- Must be identified, and must be signed and dated by the analyst; and,
- Must be justified in each data package and in the case narratives. Due to constraints of the software acquisition software, each manually integrated value is not flagged.

Sample cleanup is a critical component of low-level organic compounds analyses; therefore, a variety of cleanup options may be employed to purify the sample extracts. Sample cleanup options are incorporated into the sample processing SOPs; all sample cleanup procedures will be documented. Sample cleanup procedures will be implemented on a batch-wide basis to ensure comparability of results and to assess cleanup effects on QC samples.

A.3.4.4.2 Tissue Lipids

If archived tissue sample splits will be analyzed, lipid concentrations will be determined for each sample. The lipid concentration of each tissue sample will be determined from the dichloromethane sample extract prepared during the PCB compounds extraction according to BDO SOP 5-190. A 10-mL aliquot of unconcentrated extract is air-dried to determine the DCM extractable lipid concentration.

A.3.4.4.3 Percent Moisture

If archived tissue sample splits will be analyzed, *percent moisture* will be determined by BDO to determine the amount of water present in sample aliquots. Percent moisture is determined by drying a well-homogenized aliquot of tissue sample. Percent moisture will be determined as the percent ratio of wet to dry weight for each analytical aliquot and applied to the data generated at each laboratory. Dry weights at BDO are performed using dry heat.

A.3.4.5 General Requirements

Each laboratory performing analyses for the ESTCP DP must comply with the training requirements defined in Sections A.2.6.1 and A.2.6.2. The BDO laboratory must also comply with the specific certification requirements defined in Sections A.2.6.3 and A.2.6.4.

A laboratory batch is defined as a group of ≤20 field samples of a similar matrix that is processed as a unit with the same reagents and solvents, simultaneously with the required QC samples, and analyzed in the same method sequence. A procedural blank must be analyzed in each analytical sequence. For the purposes of this study, all sediments are considered a "similar" matrix. Critical data will not be surrogate-corrected and no data will be blank-corrected.

Analytical failures must be assessed and corrected. In most cases an analytical failure will stop the flow of work until it is reviewed, the root cause is identified, and corrective action is implemented. Most analytical failures are associated with QC results or instrument performance. Corrective action for these areas is addressed in Section A.4.1. Any deviations from the approved methods must be documented and discussed in the report narrative.

Spent samples, solvent, and acid waste will be discarded in the appropriate waste stream according to SOPs and the sample custody requirements defined in Section A.3.3.5.

A.3.5 Quality Control Requirements

A.3.5.1 Field Quality Control

This section describes the use of cooler blanks and field duplicates in this study.

Cooler Blanks. A cooler (temperature) blank will be placed in a cooler so that the temperature of each cooler can be measured accurately upon receipt at the laboratory without compromising sample integrity. Thus, the cooler blank is a surrogate sample: the cooler blank for water samples is deionized water, and the cooler blank for sediment samples is a solid matrix (e.g., soil, sodium sulfate). The container type for the cooler blank is not critical, but should be approximately the same size as the sample containers. Cooler blanks lids should be clearly labeled so that laboratory sample custodians will recognize and use them to measure temperatures upon receipt. Cooler blanks are <u>not</u> assigned a unique field sample identification number.

Field Duplicates. No field duplicates will be collected for this study. The samples collected within each plot are considered study replicates.

A.3.5.2 Analytical Laboratory Quality Control

The study design and QC samples are intended to assess the major components of total study error, which facilitates the final evaluation of whether environmental data are of sufficient quality to support the related decisions. The QC sample requirements are designed to provide measurement error information that can be used to initiate corrective actions with the goal of limiting the total measurement error.

QC samples and frequency applicable to analytical chemistry laboratories at Stanford, ERDC, UMBC, and BDO are detailed in Table A-9. The laboratory duplicate and matrix spike samples must be an authentic field sample, not one of the field duplicates. If there is insufficient tissue mass (or field sample) for a matrix spike or matrix spike duplicate, a laboratory control sample duplicate will be prepared to assess laboratory precision. Table A-10 defines the general required accuracy and precision for QC samples, along with corrective actions that must be implemented if QC criteria are not met.

All QC sample failures and associated corrective actions will be documented. If data must be reported with failing QC results, then data qualifiers will be assigned to the QC sample data. Table A-11 defines data qualifiers that will be applied by the laboratories.

A.3.5.3 Control Charts

Laboratory control charts are used to track the results of quality control on an ongoing basis. Criteria for monitoring control charts, for detecting warning or control limits, and for verifying that results fall within the acceptable limits are specified in the control chart SOPs or specific analytical procedures. Control criteria are defined in Table A-10.

Control charts for PCB congener analysis are established and maintained at BDO Duxbury using the percent recovery results of the LCS. The control chart average, warning (2σ), and control limits (3σ) must be based on at least 20 individual percent recovery values generated within a calendar year vs. a "true value" calculation using representative congeners of interest for each method (i.e., the same SOP).

A.3.6 Instrumentation/Equipment Testing, Inspection, and Maintenance

A.3.6.1 Field Equipment

Stanford University, its subcontractors, and ERDC will provide all field equipment required for the field survey, including the global positioning system (GPS), coring devices, and all supplies and consumables for the field-sampling program.

A.3.6.2 Laboratory Equipment

All analytical instruments and equipment are to be maintained according to SOPs and the manufacturers' instructions. Equipment and instrument maintenance is defined in laboratory SOPs. All routine maintenance and nonroutine repairs are to be documented in a bound logbook. The information recorded should include analyst initials, date maintenance was performed, a description of the maintenance activity, and (if the maintenance was performed in response to a specific instrument performance problem) the result of retesting to demonstrate that the instrument performance had been returned to acceptable standards prior to reuse. The return to analytical control is demonstrated by successful calibration.

A.3.7 Instrument/Equipment Calibration and Frequency

Laboratory and field equipment will be calibrated in accordance with U.S. EPA guidance or the manufacturers' recommendations. Field equipment refers to articles used for on-site monitoring and testing, whereas laboratory equipment refers to articles used in the laboratory in support of data collection (e.g., refrigerators). Laboratory instruments are units used for sample analysis (e.g., GC/ECD). Calibration procedures and frequencies are provided in this section.

A.3.7.1 Field Equipment

The location of the four plots is an important measurement for the ESTCP DP. GPS coordinates will be recorded in the field using a handheld GPS unit (Garmin Geko™ 201) with WAAS-enabled accuracy of ±3 m. The exact GPS coordinates will be defined with the latitude and longitude in terms of degrees and decimal minutes using WGS 84 datum. The dimensions of the plot are on a similar scale to that of the unit's accuracy, so only the center of each plot will be defined with GPS coordinates. The five sampling locations of each plot will be marked on a scale map (with magnetic North identified) in relation to the plot center, plot corners, and an external permanent marker. GPS coordinates will be recorded for water column samples taken over the plot areas.

The GPS unit will be calibrated by conducting a comparison measurement of a known reference position at a specific location versus the position location that is acquired by the GPS unit. The reference position is Benchmark SUAA0000-CORS established by the National Geodetic Survey, defined as 37° 25.614' Longitude (N) and 122° 10.396' Latitude (W). This position is identified with a marker that is a bolt in a metal plate. The marker is mounted on a 2 meter metal tower fixed to the roof of the Durand Building on the Stanford University campus. The calibration will be done each day prior to use. If the GPS unit fails to attain a reading within 10 m of the known reference position, then the unit will be recalibrated to this position.

Calibration information will be recorded in the field logbook. In addition, a label specifying the scheduled date of the next calibration will be attached to each piece of field equipment. If this identification is not feasible, then calibration records for the equipment will be readily available for reference.

Should any of the field equipment become inoperable, it will be removed from service and tagged to indicate that repair, recalibration, or replacement is needed. The Technology Leaders and Research Studies Leaders will be notified so that prompt service or substitute equipment can be obtained. Backup systems will be available for each instrument in use and will be calibrated prior to use in the field.

A.3.7.2 Laboratory Equipment and Instruments

Laboratory equipment and instrument calibration procedures will be completed in accordance with the laboratory SOPs. Specific DoD requirements for general laboratory equipment are defined in Table A-12. Calibration of the GC/ECD that will be used for PCB congener analysis by all laboratories (Stanford, ERDC, UMBC, and BDO) is summarized below.

Certified calibration standards used for instrument calibration will be obtained from commercial vendors for PCB congeners. Where possible, standards will be traceable to the National Institute of Standards and Technology (NIST). Stock solutions for spiking solutions will be made from reagent-grade chemicals or as specified in the SOPs. Stock standards may also be used to make intermediate standards from which calibration standards are prepared. All analytical stock solutions will be prepared using Class-A volumetric ware. Documentation relating to the receipt, mixing, and use of standards is recorded in the laboratory logbooks or on data sheets. Specific handling and documentation requirements for the use of standards are provided in laboratory SOPs. All new calibration or spiking solutions are analyzed against a previously accepted standard to verify that the concentrations of each parameter are within 15% of the verified stock.

- Prior to analysis, a five- or six-point quadratic calibration curve that spans the expected concentration range will be generated by GC/ECD to quantify the individual PCB congeners. The correlation coefficient for the initial calibration must be $r \geq 0.995$.

- A mid-level calibration standard will be re-analyzed every 24 hours (typically 10-12 samples). The calibration check standard concentration must be ≤25% from true check standard concentration. If this calibration check fails corrective action will be performed. Affected samples will be reanalyzed according to the criteria and procedures defined in the SOP.

- Sample quantification is performed by the method of internal standards using the recovery internal standard (RIS) compounds as the quantification internal standards. Surrogate compound recoveries are determined for the surrogate internal standard (SIS) compounds. For tissue samples, target analyte concentrations are reported on a wet weight basis.

A.3.8 Inspection/Acceptance of Supplies and Consumables

Prior to use, supplies and consumables will be inspected and tested to ensure that they conform to the required level of quality. Any defective material will be replaced before the sampling event or before analysis begins. Each laboratory must maintain an inventory of all chemicals, reagents, purchased standards solutions, and solvents. All reagents and solutions must be reagent grade or better.

Certified clean containers (I-Chem or equivalent) will be used as sample containers in the field. Prior to use in the field, the containers will be inspected. Any defective material will be replaced before the sampling event begins. Certificates of analysis provided with the containers will be retained by the laboratory or field sample custodian, depending upon whether containers are shipped from the lab or drop-shipped directly to the field by the supplier. Appropriate materials, bubble wrap, plastic bags, tape, and supplies will be available for packing samples to avoid breakage during transport.

In the laboratory, tissue samples will be homogenized and transferred to certified, clean I-Chem or equivalent glass jars (PCB congeners). Prior to use, the containers will be inspected. Any defective material will be replaced before homogenization and aliquotting begins. The laboratory sample custodian will retain certificates of analysis provided with the containers. Appropriate materials, bubble wrap, plastic bags, tape, and supplies will be available for packing samples to avoid breakage during transport.

A.3.9 Nondirect Measurements

Any critical data generated from the archived tissue sample splits will be incorporated into the body of data that have been collected at HPS in support of the FS.

A.3.10 Data Management

Data generated in support of the ESTCP DP will be tracked and reviewed by the appropriate Research Leader. Critical data generated by BDO in support of the ESTCP DP are tracked and reviewed by the BDO Chemistry Laboratory Leader. After review and validation of the field and laboratory data reports, critical data will be entered into the regional database system in place at BDO. The database will provide data for the preparation of reports and graphics. The data management process for the study has been designed to minimize loss and human error. Data flow will be automated to the extent practical.

Data management (e.g., paper flow; data tracking, data entry, etc.) and data assessment (e.g., verification, validation, and data quality assessment [DQA]) activities require adequate QC procedures to ensure that the SOPs are being followed and result in records/reports that are accurate and appropriate. QC procedures include peer review of each step and management review of a certain percentage of the data. Each laboratory must document its data management procedures in an SOP. Data verification and review is described in Section A.5.0.

A.3.10.1 Field Data

Preprinted labels (Section A.3.3.2) that include a unique sample identification number and prompt for required sample-specific information will be provided to the field team. A separate label is attached to each sample container and the sample ID recorded on the field log. This provides a unique link between the field records and each sample.

Sample collection information is hand-recorded in bound, prepaginated logbooks, then keyed into spreadsheets or project-specific applications. Data entry into the electronic format follows the sampling efforts. In addition to sample collection information, which describes where and how samples were collected, the

field team may also record other information associated with the collection of a sample. Sample custody forms document the transfer of each collected sample from the field to the laboratory, and from the processing laboratory to the analytical laboratory.

A.3.10.2 Laboratory Data

Data management at the laboratory begins with the receipt of samples. Samples are logged in and assigned unique identification numbers that are used to identify samples throughout storage, processing, analysis, and reporting. Laboratory data will be reported by analytical batch (20 samples) with a unique batch ID that is clearly and directly related to the unique quality control samples that were processed and analyzed with the batch. Required QC sample type and frequency are defined in Tables A-9 and A-10. QC samples should not be reported across batches.

For critical data analysis by BDO, a Laboratory Information Management System (LIMS) houses all data for samples from the arrival of the sample in the laboratory to the final delivery of data to the client. This system is used to track samples from arrival through analysis to reporting. The LIMS software is a two-fold system. SQL Server 2000 is used as the back end of the system; all data is stored in a SQL Server 2000 database. Data is entered and manipulated on the end user level with an application developed in Microsoft® Access 2000. With the exception of the database administrator and the database developer, all access to the database is accomplished using Microsoft® Access 2000. All data and derived products will be stored on the laboratory server and burned onto compact discs (CDs).

A.3.10.3 Electronic Data Deliverables

Electronic data files are named uniquely and systematically, enabling tracking and retrieval. All instruments use the same software versions. Electronic data reside on specified servers, not individual personal computers (PCs). Raw and final data files are saved to CDs in read-only format and are stored in locked cabinets.

All laboratories generating data that will be entered into the Stanford database are required to submit data to the data manager in EDD format. The EDD must be formatted as an ASCII-ii file or a spreadsheet of the laboratory data in the SOP-specified format. Section A.2.7.6 discusses the EDD.

All critical chemical concentration data collected by BDO for the study will be entered into the BDO database and the Stanford database (PCB congeners and related field data). The EDD for BDO analytical laboratories is detailed in BDO HPS SOP 003. The EDD file is validated for format and content and imported into the databases. If an EDD is not correctly structured, as described in the SOP, then the laboratory will be required to resubmit the data file in the correct format in a timely manner. All EDDs produced by BDO will conform to the requirements of the NEDTS and SWDIV EWI #6 (U.S. Navy, 2001).

A.4.0 ASSESSMENTS/OVERSIGHT

This section presents the internal and external checks (assessments) that will be used to ensure that

- Elements of this QAPP have been correctly implemented as prescribed for all investigations conducted under the ESTCP DP;
- The quality of the data generated is adequate and satisfies the DQOs identified in QAPP; and,
- Corrective actions, when needed, are implemented in a timely manner and their effectiveness is confirmed.

Assessment activities will include inspection, peer review, data audits, and DQA.

A.4.1 Assessment and Response Actions

The following subsections identify planned assessment and oversight activities to ensure that the objectives identified above are attained for field and laboratory operations. The Navy QA Officer, Project QA Manager, and/or the Project Manager may also identify additional assessment activities to be performed during the course of the study, based upon findings of the planned assessment activities described below. These individuals are authorized to stop work for cause if data quality or staff safety is threatened.

A.4.1.1 Assessment Actions

An audit evaluates the capability and performance of a measurement system or its components and identifies problems warranting correction and is performed by a person independent of the activities audited. The Project QA Manager and the QA managers at each analytical laboratory are responsible for assigning audit activities. Technical expertise and experience in auditing will be considered in selecting an auditor or audit team.

A.4.1.1.1 Assessment of Field Activities

A field audit involves an on-site visit by an auditor or audit team. A field audit is not planned for the HPS ESTCP DP.

A.4.1.1.2 Assessment of Laboratory Operations

A laboratory performance audit has been conducted by NFESC at BDO analytical laboratory. The purpose of a performance audit is to ensure that the laboratory is capable of producing data of known and acceptable quality. The laboratory audit included reviewing the laboratory's written procedures, evaluating the laboratory's historical performance, and verifying that the laboratory procedures comply with Navy QA requirements. The performance audit also includes analysis of blind performance evaluation samples provided by the Navy to measure the laboratory's performance. Navy evaluation of BDO analytical laboratory for the analysis of PCB congeners has been completed.

BDO has an internal audit program to monitor the degree of adherence to its policies, procedures, and standards. The internal audit program includes systems audits, performance evaluations, data audits, and spot assessments. Internal audits are conducted by the laboratory QA officer, who is independent of the area(s) being evaluated. The internal QA program is defined in a QA manual. QA audit assessment procedures are defined in SOPs.

The Project Manager will communicate with each analytical laboratory on a regular basis while the project samples are being analyzed. This will allow assessment of progress in meeting DQOs and Management Quality Objectives (MQOs), and the identification of any problems requiring corrective actions early in the investigative process. The Project Manager will review any identified problems and provide for the swift implementation of any outstanding corrective actions.

A.4.1.2 Response Actions

An effective QA program requires prompt and thorough correction of nonconformance conditions that can affect quality. Rapid and effective corrective action minimizes the possibility of questionable data or documentation.

Two types of corrective actions exist: immediate and long term. Immediate corrective actions include correction of documentation deficiencies or errors, repair of inaccurate instrumentation, or correction of inadequate procedures. Often, the source of the problem is obvious and can be corrected at the time it is observed. Long-term corrective actions are designed to eliminate the sources of problems. Examples of long-term corrective actions are correction of systematic errors in sampling or analysis and correction of procedures producing questionable results. Corrections can be made through additional personnel training, instrument replacement, or procedural improvements. One or more corrections may be necessary.

QA problems and corrective actions will be documented to provide a complete record of QA activities and to help identify needed long-term corrective actions. Defined responsibilities are required for scheduling, implementing, documenting, and ensuring the effectiveness of the corrective action.

A.4.1.2.1 Field Corrective Actions

Field nonconformance conditions are defined as occurrences or measurements that are either unexpected or that do not meet established acceptance criteria and which will affect data quality if corrective action is not implemented. Some examples of nonconformance conditions include incorrect use of field equipment; improper sample collection, preservation, storage, or shipment procedures; incomplete field documentation, including custody records; incorrect decontamination procedures; incorrect collection of QC samples; and unsafe field practices.

Corrective action procedures will depend on the severity of the nonconformance condition. In cases in which immediate and complete corrective action is implemented by field personnel, the corrective action will be recorded in the field log notebook. Nonconformance conditions which have a substantial impact on data quality require completion of a corrective action request form (however named). This form may be filled out by an auditor or by an individual who suspects that any aspect of data integrity is being affected by a field nonconformance issue. Each form is limited to a single nonconformance issue; if additional problems are identified, multiple forms must be used for documentation.

Copies of the corrective action request form will be distributed, as appropriate, to the Project Manager, the Project QA Manager, and the project file. The problem resolution will follow the steps listed below:

- Determine when and how the problem developed;
- Assign responsibility for problem investigation and documentation;
- Determine corrective actions to eliminate the problem;
- Design a schedule for completion of the corrective action;
- Assign responsibility for implementing the corrective action; and,
- Document and verify that the corrective action has eliminated the problem.

The report will also list completion dates for each phase of the corrective action procedure and the due date for the Project QA Manager to review and check the effectiveness of the solution. If warranted, a follow-up audit will be conducted to check that the problem has not reappeared. The follow-up review is conducted to ensure that the solution has adequately and permanently corrected the problem. The Project QA Manager can require field activities to be limited or discontinued until the corrective action is complete and the nonconformance issue has been eliminated.

A.4.1.2.2 Laboratory Corrective Action

The internal laboratory corrective action procedures and a description of nonconformance situations requiring corrective action are contained in the laboratory QA plan and SOPs.

Specifically to BDO, at a minimum, corrective action and/or notification of the Chemistry Laboratory Manager will be implemented when any of the following three conditions occurs: (1) control chart warning or control limits are exceeded, (2) method QC requirements are not met, and (3) sample holding times are exceeded. Nonconformance situations will be reported to the appropriate laboratory manager within two working days after they are identified. In addition, a corrective action report, signed by the laboratory manager and the laboratory QA Manager, will be provided to the Chemistry Laboratory Manager and the Project Manager. Corrective actions will be implemented where possible, as specified in laboratory SOPs. Where corrective action is not feasible, appropriate qualifiers will be added to data.

A.4.2 Reports to Management

When the ESTCP DP is complete, the results will be incorporated into the ESTCP DP Reports (Cost and Performance, Final Technical, and Verified Fact Sheet) that will be prepared by Stanford University, UMBC, and ERDC.

A.4.2.1 Project Progress Report

The monthly and quarterly reports for this project are the responsibility of Stanford University.

A.4.2.2 Quality Control Summary Report

A data QC summary report will be prepared by BDO and submitted with the final study report if the RPM directs BDO to remove the samples from archival and analyze them. The report will describe, for each type of analysis,

- A summary of the QC procedures used to assess data accuracy, precision, and completeness;
- A detailed report of analytical data accuracy, precision, and completeness;
- The results of performance and systems audits; and,
- The corrective actions that have occurred over the period of the report.

Particular emphasis will be placed on determining whether project quality criteria were met and whether data are of sufficient quality to support required decisions. The duration and location of storage for the complete data packages also will be defined in this report.

A.5.0 DATA VALIDATION AND USABILITY

This section of the QAPP provides a description of the data review activities that will occur after the data collection phase of the project is completed. The requirements and methods for data review, verification, and validation, as well as the process for reconciling data generated with the DQOs are described. Implementation of these methods will determine whether or not the data conform to the specified primary and secondary performance criteria, thus satisfying the project objectives**.**

A.5.1 Data Review, Validation, and Oversight

Data review includes data verification, validation, and oversight, as well as reconciliation of the data quality with user requirements. The data verification process includes the initial review of the data packages to ensure that the analyses requested have been provided. Data validation is the process of reviewing data and accepting, qualifying, or rejecting data on the basis of sound criteria using established U.S. EPA guidelines. Final technical data review of analytical data occurs after independent data validation has been completed. It provides an indication of overall trends in data quality and usability. These procedures are detailed below.

A.5.1.1 Data Verification

The analytical data generated during field investigations will be assembled in packages by sample delivery group, processing batch, or analytical batch. The contents of a data package are defined in Section A.2.7.5. The analytical chemistry data packages generated by BDO will contain supporting QC data for the associated field samples and will be validated by an independent data validator (Section A.5.1.2).

Each analytical laboratory is responsible for reviewing each data package prior to release for validation. At a minimum, the following reviews must be performed:

- Peer review of the data by a qualified analyst;
- Review of the reported data and deviations by a technical supervisor or data coordinator; and,
- QA office review of 10% of the data.

Implementation of these procedures is defined in laboratory SOPs. Reviews must ensure the following:

- All data for project samples are reported accurately and completely;
- Sample analysis was conducted in accordance with required laboratory procedures and analytical methods specified in the QAPP;
- Criteria for data quality have been met or deviations are documented in the package narrative and data flags have been appropriately applied;
- Each data set is appropriately reviewed; and,
- All project requirements have been met.

A.5.1.2 Data Validation

Data validation is conducted to assess the compliance of chemistry data with the DQOs defined in the QAPP. Data are assessed for completeness and compliance with the requirements of the analytical methods. Validation is conducted on each data package to determine the adequacy of the data to meet the DQOs.

The Navy requests that any of the critical PCB congener data produced by BDO be validated through an outside data validation firm. Laboratory Data Consultants (Carlsbad, CA) is proposed as the data validation firm.

The PCB congener data that may generated by BDO uses low-level (NOAA NS&T or U.S. EPA) analytical methods that are appropriate for the assessment of ecological risk. There are no formal validation guidelines for the validation of these methods. Therefore, validation will emulate U.S. EPA guidelines (U.S. EPA, 1994a, 1994b, and 1994c), although specific validation criteria for data generated according to these methods may not exist. The U.S. EPA validation *guidelines* will be used in data validation, and the method-specific data assessment criteria defined in the laboratory SOPs and the QAPP will be used as the basis of validation.

Since HPS is a National Priorities List (NPL) site, the BDO data must be subject to a data validation strategy that involves 20% Level-IV and 80% Level-III data validation. These levels of data validation are described in Sections A.5.1.2.1 and A.5.1.2.2.

Stanford, ERDC, and UMBC laboratories will use a similar data validation strategy that will be conducted internally.

A.5.1.2.1 Level-III Data Validation

Level-III data validation assumes that reported data values are correct as reported. Data quality is assessed by verifying that the criteria defined in the QAPP (Table A-13) for critical data have been achieved.

A.5.1.2.2 Level-IV Data Validation

Level-IV data validation is based on the assessment of raw data packages, which include all data required for a full review and assessment of compound selection, integration, interference assessment, and re-quantification (e.g., spectra and chromatograms). Supporting records are also included in the package (e.g., calibration standard, instrument sequence files, and dilution factors).

Level-IV data validation includes requantification of reported QC and field sample values using the raw data files. In addition, instrument performance, calibration methods, and calibration standards are reviewed to ensure that the detection limits and data values are accurate and appropriate.

A.5.1.2.3 Results of Data Validation

During data validation, the laboratory performance is assessed against prescriptive requirements and subjective requirements. Evaluation of laboratory performance against prescriptive requirements is assessed through compliance with the method requirements and the acceptability of QC sample results that are independent of sample matrix (e.g., instrument performance checks, calibration criteria). An assessment of the subjective requirements involves identification of potential matrix effects, and consists of an evaluation of the analytical results and the results of the testing blank, duplicate, and matrix spike samples. The validator then assesses how, if at all, the matrix effect impacted the usability of the data. Best professional judgment in any area not specifically addressed by U.S. EPA guidelines will be utilized as necessary and will be described in the usability assessment portion of the data validation report.

The data validation report will include a comprehensive narrative detailing all QC exceedances and explaining qualifications of data results. Data qualification “flags” will be applied by the laboratory for data that do not meet quality criteria (Table A-10). These data qualifiers are listed and defined in Table A-11. Validation qualifiers will be applied directly to the EDD by the validator, as appropriate.

A.5.2 Data Quality Assessment Reconciliation with Planning Objectives

DQA is a data analysis and interpretation process involving scientific and statistical evaluation of data sets to determine if they are sufficient to support specific decisions. To implement the DQA process, the analyst will work closely with a multidisciplinary team, potentially including the Principal Investigator, Project Manager, Research Studies Leaders, and statistician. The overall assessment of the ESTCP DP is the responsibility of the Stanford University Principal Investigator.

Upon receipt of the laboratory analytical chemistry data, the data analyst shall assemble the data set, including field information such as sample coordinates and descriptions and associated field measurements, and review any additional reports (e.g., survey and validation reports). The DQA shall begin with exploratory data analysis, including a significant graphical component. Standard data assessment tools will be used, such as histograms, q-q plots, cumulative frequency distributions, and box plots. Because the DQA process evaluates individual data points within the context of entire data sets, it will identify both "suspect" data (probable outliers to the actual data distribution) and critical observations that could affect decisions based on these data. As necessary, "suspect" data will be submitted for "focused validation" to determine whether the "suspect" data resulted from errors in the data generation process. "Suspect" and other unusual observations will be reviewed by experts on the natural environment and the measurement process to determine if there are scientific explanations and if data can be corrected or need to be rejected. If observations are not corrected or rejected by the above process and are therefore determined to represent variability inherent in the measurement process or the environment, these data shall be retained within the data set. Any changes made to the data set shall be fully documented.

The DQA process addresses the questions "Did we get what we asked for?" and "Did we ask for what we need?" The standards which will be used to evaluate the adequacy of the study findings from the actual data received are the original DQO specifications for the HPS ESTCP DP survey design, which will be reviewed for continued relevance to the ecological risk decisions being made. To assess the adequacy of this sampling design to support the study questions, the data analyst must work with other members of the project team to determine if the number, type, and quality of samples as specified in the Demonstration Plan and QAPP and as actually collected, were appropriate. This includes: determining if the correct number and location of samples were taken; determining if the appropriate media were sampled; judging the adequacy of the sample number and locations, given the updated understanding of the problem; and determining if the understanding of the problem changed since the QAPP was prepared because of observations made by the field team.

For critical data, the BDO project manager will implement the DQA process as described in U.S. EPA guidance (U.S. EPA QA/G-9, 2000a) to determine adequacy of the critical data to support a decision. The ESTCP DP will generate data to support evaluation of remedial alternatives in the HPS Parcel F FS, as described in the DQOs. The DQA will start by determining if these critical assumptions held true, and whether the sampling design provided data of adequate quality to support the decision. The ESTCP DP Demonstration Plan describes data analysis procedures.

Assuming that the sampling design was adequate to support the decision, the evaluation of data adequacy to support that decision may terminate after the initial exploratory analysis, and the site should move forward in the decision-making process. This determination will be made based on the observed chemistry, the variability of these measurements, and a determination of the uncertainty associated with the types of comparisons that are being made with the data.

If an adequate level of confidence was achieved with the chemical constituent concentrations actually observed, this observation supports the case that data are sufficient to be incorporated into the FS.

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Table A-1. Schedule of Plot Sampling and Analysis

Months Since Treatment (t)	Sampling Description
	Pre-Treatment Sampling
t = -1.5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide. • Deploy clams, five replicate enclosures in the five plots. • Deploy SPMDs/PEDs, five replicates in the five plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC and sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = -0.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
	Mixing and AC Treatments
t = 0	• Apply various treatments to three of the four plots.
	Post-Treatment Samplings
t = 0.05	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.
t = 5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.
t = 5.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs/PEDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 6.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
t = 17.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs/PEDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 18.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
t = 24	• Take five, six-inch diameter six-inch length sediment core samples in the four plots for ex-situ clam bioassay and analysis of TOC, BC, C-13, sediment PCB concentrations, and aqueous equilibrium PCB concentrations. • Take five top 5 mm (1/8 inch) sediment samples for analysis of TOC, BC, C-13, sediment PCB concentrations, aqueous equilibrium PCB concentrations.
Months Since Treatment (t)	Sampling Description
	Pre-Treatment Sampling
t = -1.5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide. • Deploy clams, five replicate enclosures in the five plots. • Deploy SPMDs/PEDs, five replicates in the five plots.

	• Take five, two-inch diameter core samples in the four plots for analysis of TOC and sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = -0.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
	Mixing and AC Treatments
t = 0	• Apply various treatments to three of the four plots.
	Post-Treatment Samplings
t = 0.05	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.
t = 5	• Collect duplicate water samples in the four plots to measure aqueous and suspended particulate PCB concentrations in the water column during high tide.
t = 5.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs/PEDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 6.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
t = 17.5	• Deploy clams, five replicate enclosures in the four plots. • Deploy SPMDs/PEDs, five replicates in the four plots. • Take five, two-inch diameter core samples in the four plots for analysis of TOC, BC, sediment PCB concentrations, aqueous equilibrium PCB concentrations, and PCB desorption rates. • Sieve surface sediment quadrats to collect benthic community samples • Sieve surface sediment samples to collect amphipod samples.
t = 18.5	• Remove clams for PCB congener analysis. • Remove SPMDs/PEDs for PCB congener analysis.
t = 24	• Take five, six-inch diameter six-inch length sediment core samples in the four plots for ex-situ clam bioassay and analysis of TOC, BC, C-13, sediment PCB concentrations, and aqueous equilibrium PCB concentrations. • Take five top 5 mm (1/8 inch) sediment samples for analysis of TOC, BC, C-13, sediment PCB concentrations, aqueous equilibrium PCB concentrations.

Table A-2. Data Quality Objectives for Primary Quantitative Performance Criteria of ESTCP DP

STEP 1: State the Problem

Sediment in HPS South Basin Parcel F (Area IX-X) is contaminated with PCBs and may pose an unacceptable risk to human health and the environment. The standard approach to addressing contaminated marine "mud flat" sediments is dredging and disposal. Mixing AC into sediments to reduce the bioavailability of PCBs is potentially an effective in situ remediation strategy. Laboratory studies have demonstrated that PCBs in sediment tend to preferentially accumulate in coal-derived and char particles where the compounds may be strongly bound (Ghosh et al., 2003a; Luthy et al., 2002; Zimmerman et al., 2004). Laboratory studies also show that mixing AC with sediment reduces PCBs concentrations in the tissue of benthic organisms (Luthy et al. 2004). A field study is required to a) compare the effectiveness, in terms of homogeneity and depth of AC application, of two available large-scale mixing technologies, b) demonstrate that AC treatment of sediment reduces PCB bioaccumulation in the field, and c) evaluate sediment resuspension and PCB release.

STEP 2: Identify the Decision

PRIMARY DECISION

1. Will AC treatment of PCB-contaminated sediment reduce PCB bioaccumulation in the field?
2. Will large-scale field application of carbon via AEI or CEI mixing equipment adequately mix the sediments and AC?
3. Will PCB resuspension occur as a result of mixing AC into sediment?

STEP 3: Identify Inputs to the Decision

1. PCB concentrations in sediment-dwelling *M. nasuta* clams (native to San Francisco Bay) from in-situ one-month exposures (in clam tubes sunk in plots once before and twice after plot treatments) and ex-situ bioassay once after plot treatments.
2. PCB concentrations in indigenous *Corophium spp.* amphipods collected from plots once before and twice after plot treatments.
3. Total Organic Carbon (TOC) measurements in cross-sections of core samples taken from test plots once before and twice after plot treatments.
4. Dissolved and particulate PCBs in water column above test plots once before and thrice after plot treatments.

STEP 4: Define the Study Boundaries

- The study area is approximately 100 ft offshore in Area X off the mid-eastern South Basin shoreline. Four 370 ft^2 test plots will be located in the study area, all equidistant from the shoreline.
- The vertical limit of the study area will be a depth of 1.5 ft.
- The plot treatments and field sampling schedule are constrained by the low tide schedule.

STEP 5: Develop a Decision Rule

PRIMARY DECISION RULE (Sampling design quantitatively focuses on this decision rule)

1. If the PCB tissue concentrations for AC-treated (Plots D and F) are significantly lower when compared to control plots (Plots C and/or E) using an appropriate statistical method, then these results indicate that AC treatment reduces PCB bioaccumulation in the field.
2. The average of the TOC values of all the sediment core cross sections analyzed from one plot (after a homogenous 3.4 wt.% AC dose in either Plots D or F) should be 3.8 wt.%, given an initial TOC of 1.0 wt.%. If the average of the TOC values of all the sediment core cross sections analyzed from one plot is 3.8 ± 2.5 wt.% (given an initial TOC of 1.0 wt.%), then the mixing afforded by the AC application was "good." Qualitative statements about the AC mixing will be based on the magnitude of the standard deviation (SD) as follows: SD = 0.0 – 1.5 wt.%, excellent mixing; SD = 1.6 – 2.5 wt.%, good mixing; SD = 2.6 – 3.6 wt.%, fair mixing; SD > 3.6 wt.%, poor mixing.
3. If there are no significant differences in the water column PCB concentrations before and after AC treatment, then sediment-bound PCBs are not resuspended due to AC application.

STEP 6: Evaluate Decision Errors

Insufficient PCB bioaccumulation data could result in incorrect conclusions being drawn concerning the efficacy of AC treatment. An insufficient number of TOC samples could result in a large standard deviation across sediment cores in a given test plot, which in turn would suggest that the AC application was not homogeneous. Uncertainty in the water column PCB concentrations before and after plot treatments could result in an over- or under-estimation of the resuspension of PCBs due to treatments of the sediment. Duplicate samples during slack tide will be taken to minimize this error.

Table A-2. Data Quality Objectives for Primary Quantitative Performance Criteria of ESTCP DP (continued)

STEP 7: Optimize the Design for Obtaining Data

In-situ PCB Bioaccumulation in Test Clams
PCB bioaccumulation will be measured using *Macoma nasuta* clams that are particle-feeding organisms native to San Francisco Bay. Six clams will be deployed into each of the five mesh-covered clam tubes that are sunk into the five random sampling locations of each plot as shown in Figure A-5. At three intervals during the study (1 month pre-treatment, 6 months post-treatment, and 18 months post-treatment), we will deploy clams and characterize their survival and 28-day PCB bioaccumulation. To measure PCB bioaccumulation, living clams shall be removed from tubes and transferred to a vented polyethylene jar that contains clean water. The clams will be transported to Stanford University and allowed to depurate in clean water for 48 hours at ambient temperatures. After depuration, each surviving clam will be shucked and each resulting clam tissue will be placed into a separate pre-cleaned 20 mL scintillation vial. The vials containing a single clam tissue will be immediately placed in a -10°C freezer. Once frozen, the samples will be shipped overnight (on dry ice in a cooler) to ERDC. At ERDC each set of six (or total number surviving) clams that came from a given clam tube will be homogenized and split. Half will be shipped to BDO for archival at -10°C; while the other half will be analyzed at ERDC. the clams will be removed from the field after exposure and depurated in clean sediment for 48 hr. The clams will then be subjected to PCB congener, moisture and lipid analyses.

Ex-situ Laboratory Clam PCB Bioaccumulation Studies
Ex-situ PCB bioaccumulation will be measured using *Macoma nasuta* clams that are particle-feeding organisms native to San Francisco Bay and composite sediment samples from each plot. Homogenized sediments from each plot will be layered into each of five replicate, five-gallon aquaria (> 4 cm depth) for each test plot (t = 4, n = 5) and overlying water (30 ‰) will be gently added using a turbulence reducer and allowed to equilibrate overnight. The remaining sediment will be used for chemical assessments. Ten clams will be added to each test chamber; clams that failed to burrow after 24-h will be replaced. The exposure will be conducted for 28-days at 15 ± 1 °C with monitoring of water quality parameters (temperature, pH, D.O., salinity, and ammonia) and 70% water exchanges three times per week. Following the 28-day exposure, the clams will be removed from the test sediments and allowed to purge their guts by placing each individual into 250 ml beakers containing 200 ml reference sediment (obtained from the site of clam collection) for a 48-hour period, followed by transfer to clean seawater in aquaria for an additional 24-hour period. Clams from each replicate will be counted for overall survival, shucked, rinsed in deionized water and frozen at -80 °C for further processing. Following homogenization, the tissue will be analyzed for PCBs, lipid, and moisture content. Clams failing to burrow during the gut-purging period will not be included in the analysis.

PCB Bioaccumulation in Indigenous Amphipods
PCB bioaccumulation will be measured in indigenous benthic biota. At each the three sampling time points, five separate surface (0-2 cm) sediment samples shall be collected at the five random sampling locations in each plot as shown in Figure A-5, and placed into a separate wide-mouthed polyethylene jar with a vented lid. These jars shall be maintained at <18 °C in a cooler, and transferred to laboratory conditions within 2h of collection where they will be sieved for *Corophium* spp.amphipods. Each sieved sediment sample shall provide at least 200 mg wet weight of amphipods. In the laboratory, the amphipods shall be removed from the sediment using a 500µm sieve and rinsed with clean artificial seawater. Amphipods shall be depurated for 24 h using San Francisco Bay seawater receiving trickle flow aeration in a cold room facility at 15 °C. Following depuration, amphipods from each sampling location shall be removed and weighed by placing them into tarred and pre-cleaned 20 mL scintillation vials. Samples will be immediately frozen. Once frozen, samples will be shipped on dry ice to ERDC for homogenization and splitting. Half of the resulting homogenate sample will be analyzed by ERDC, while the other half will be shipped on dry ice to BDO for archival at -10 °C. Analysis of the PCB concentrations in these amphipod samples will assess the AC treatment effects upon PCB bioaccumulation in a resident benthic population.

Depth and Homogeneity of the Mixed AC
In each plot, 2.0-inch-diameter sediment core samples will be collected at five randomly distributed sampling

locations once before and twice after plot treatments. Each of the core samples collected will be one foot in length (minimum) and divided into 2-inch-long core cross sections. A direct correlation exists between measured TOC and the amount of AC added in sediment, so TOC analysis will be performed on a subsample of each core section to evaluate the degree of AC mixing into sediment.

Resuspension of PCBs

Duplicate samples of the overlying water above the four plots during high tide once before and thrice after plot treatments will take place to measure the dissolved and particulate PCB concentrations. A total of 32 water samples will be collected 0.5 foot above the sediment surface at each assessment event. Sample collection involves pumping water through a pre-combusted glass fiber filter with a nominal pore size of 0.7 microns in a stainless steel filter holder to trap suspended particles; this will be followed by passing the filtered water through a XAD-2 resin trap in a glass column.

Table A-3. Data Quality Objectives for Secondary Quant. Performance Criteria of ESTCP DP

STEP 1: State the Problem

Experiments that add additional support to the primary quantitative data quality objectives/performance criteria listed in Table A-2 are required to fully assess the AC treatment technology. These experiments are needed to:
1) validate that the AC treatment reduces aqueous PCB availability in the field (biomimetic semi-permeable membrane devices (SPMDs), aqueous equilibrium studies, and desorption studies),
2) assess AC treatment effects on benthic recolonization, community structure, and organism growth, and
3) assess the stability of the AC/sediment mix.

STEP 2: Identify the Decision

PRIMARY DECISION

1. Will AC treatment reduce aqueous PCB availability in field sediment?
2. Will AC treatment affect the indigenous benthic community?
3. Will the AC/sediment mix remain stable over time?

STEP 3: Identify Inputs to the Decision

1. a. Aqueous PCB measurements in equilibrium with sediment subsamples taken from plot cores once before and twice after plot treatments.
   b. PCB desorption rates for sediment subsamples taken from plot cores once before and twice after plot treatments.
   c. PCB uptake into SPMDs placed into plots once before and twice after plot treatments.
   d. PCB congeners in a homogenate of the entire sediment core taken from test plots before and after AC treatment.
2. Community structure analyses of benthic organisms found in each of the sieved quadrats taken once before and twice after plot treatments.
3. Total Organic Carbon (TOC) values measured for sediment cores from Plots D and F taken after six and eighteen months will compared to evaluate if there are any significant differences in the amount of AC in these plots between the two sampling time points.

STEP 4: Define the Study Boundaries

1. The study area is approximately 100 ft offshore in Area X off the mid-eastern South Basin shoreline. Four 370 ft^2 test plots will be located in the study area, all equidistant from the shoreline.
2. The vertical limit of the study area will be a depth of 1.5 ft.
3. The plot treatments and field sampling schedule are constrained by the low tide schedule.

STEP 5: Develop a Decision Rule

PRIMARY DECISION RULE (Sampling design quantitatively focuses on this decision rule)

1. a. If the aqueous equilibrium PCB concentrations for the AC-treated plots (Plots D and F) are significantly lower when compared to control plots (Plots C and E) using an appropriate statistical method, then these results indicate that AC treatment reduces aqueous PCB availability in field sediment.
   b. If the PCB desorption rates for the AC-treated plots (Plots D and F) are significantly lower when compared to control plots (Plots C and E) using an appropriate statistical method, then these results indicate that AC treatment reduces the PCB desorption rate from field sediments.
   c. If the SPMD PCB uptake data for AC-treated plots (Plots D and F) are significantly lower when compared to control plots (Plots C and E) using an appropriate statistical method, then these results indicate that AC treatment reduces PCB uptake into a biomimetic device.
2. If metrics of benthic community structure (e.g., total taxa richness, total abundance, relative amphipod abundance, and various multi-metric indices) of AC-treated plots (Plots D and F) are not statistically significantly reduced compared to that of the control plots (Plots C and E then the AC application does not affect the benthic community structure. However, if a statistically significant difference (increase or decrease) does exist between treated and control plots in any metric of biological integrity, then the analysis of the community structure will be used to calculate the treatment effects on benthic recolonization. Determination of statistical differences in measures of biological integrity will be performed by one-way analysis of variance.
3. If there are no significant differences (by appropriate statistical test) between the six-month and eighteen-month TOC values measured in cross sections of sediment cores taken from Plots D and F, then the AC/sediment mix is stable in the timeframe of the study.

Table A-3. Data Quality Objectives for Secondary Quant. Performance Criteria of ESTCP DP (continued)

STEP 6: Evaluate Decision Errors

Just the mixing of sediments in Plots C, D, and F will have a large impact on the community structure. Quadrats to assess community structure will be taken six and eighteen months after the treatments occur to give the benthic community time to reestablish itself. If this time period is insufficient, then it will be difficult to decide if it was the mixing or actual AC that affected the community structures.

STEP 7: Optimize the Design for Obtaining Data

Sediment PCB and Aqueous Equilibrium PCB Concentrations

Subsamples from the total of 60 cores will be analyzed for total PCB sediment concentrations and aqueous equilibrium concentration of PCBs.

Sediment PCBs Desorption Characteristics

Subsamples from two sediment cores per plot (taken once before and twice after treatments) will be analyzed to evaluate PCB desorption characteristics. The desorption tests on the sediment core subsamples will follow previously published methods (Ghosh et al., 2000) These analyses will allow us to assess the change in PCB availability for desorption to the aqueous phase after treatment.

Benthic Community Structure Analyses

Surface sediment (0-10 cm) will collected from five randomly selected 0.25-m quadrats per plot once before and twice after plot treatments. The benthic organisms existing in these quadrat sediment samples will be sieved using a 500µm sieve, preserved in 10% formaldehyde solution in the field, and transferred to the laboratory in 500mL polyethylene jars. A total of 60 quadrats will be sieved during the entire study producing 60 benthic community samples. By comparing the macrofaunal composition that exists in the benthic community samples collected before and after treatments, the AC treatment effects upon benthic recolonization, community structure and organism growth can be determined.

PCB Uptake into SPMDs

Five semi-permeable membrane devices (SPMDs) will be deployed inside of the clam tubes in each plot once before and twice after plot treatments. A total of 60 SPMDs will be deployed during the entire project. Measurement of PCB uptake into these devices will simulate the in situ bioavailability of PCBs to biota. The SPMDs will be vertically oriented 3 cm below the sediment surface inside each clam tube. The SPMDs will be contacted with sediment for one month before removal, processing, and analysis.

Depth and Homogeneity of the Mixed AC

In each plot, 2.0-inch-diameter sediment core samples will be collected at five randomly distributed sampling locations once before and twice after plot treatments. Each of the core samples collected will be one foot in length (minimum) and divided into 2-inch-long core cross sections. A direct correlation exists between measured TOC and the amount of AC added in sediment, so TOC analysis will be performed on a subsample of each core section to evaluate the degree of AC mixing into sediment.

Stability of AC/Sediment Mix

Total Organic Carbon (TOC) values measured for sediment cores from Plots D and F taken after six and eighteen months will compared to evaluate if there are any significant differences in the amount of AC in these plots between the two sampling time points.

Table A-4. Primary and Secondary Quantitative Performance Criteria Measurements for the ESTCP DP

Performance Criteria	Primary/ Secondary	Associated Lab Sample	Lab Analysis	Lab Responsible for Analysis
PCB bioaccumulation in test organisms	Primary	Clam tissue	Low-level PCB congeners, lipids, dry weight	ERDC/BDO[1]
PCB bioaccumulation in indigenous organisms	Primary	Amphipod tissue	Low-level PCB congeners, lipids, dry weight	ERDC/BDO[1]
AC application	Primary	Sediment	TOC	Stanford
PCB Resuspension	Primary	XAD column, filter	PCB congener	UMBC
AC/Sediment Stability	Secondary	Sediment	TOC	Stanford
Effects of AC treatment on indigenous benthic community	Secondary	Benthic community	Benthic community structure	ERDC
PCB Uptake into SPMDs	Secondary	SPMD	PCB congener	Stanford
Aqueous equilibrium PCB concentrations	Secondary	Water	PCB congener	Stanford
PCB Desorption Rates	Secondary	Sediment	PCB congener	UMBC

[1]Only data generated by a Navy-certified laboratory (BDO) on archived tissue sample splits can be used for decision-making at Hunters Point.

Table A-5. Total Number of Samples and Intended Analyses for the ESTCP DP

Field Sample Type	Sample Analyses	Sample Amount	Total Number Collected During Entire Project
Clam Tissue (In-situ Bioassay)	PCB concentration	composite of 6 clams	60 (each composite will be split between ERDC and BDO)
Clam Tissue (Ex-situ Bioassay)	PCB concentration	composite of 6 clams	20
Amphipod	PCB concentration	mininum 200 mg composite	60 (each composite will be split between ERDC and BDO)
SPMD	PCB uptake	Each	60
Sieved Quadrat	Benthic Community	Each	60
Sediment Core	TOC	1 g	360
Sediment Core	Sediment PCB concentration	5 g	60
Sediment Core	Aqueous Equilibrium PCBs	30 g	60
Sediment Core	PCB desorption characteristics	100 g	24
Sediment Core	BC	2 g	24
Surface Sediment	TOC	1 g	20
Surface Sediment	BC	2 g	20
Surface Sediment	Aqueous Equilibrium PCBs	30 g	12
Surface Sediment	Sediment PCB concentration	5 g	12
Surface Sediment	13C	1 g	12
Composite Sed.	TOC	1 g	12
Composite Sed.	BC	2 g	12
Composite Sed.	Aqueous Equilibrium PCBs	30 g	12
Composite Sed.	Sediment PCB concentration	5 g	12
Composite Sed.	13C	1 g	12
Overlying Water	Dissolved PCBs	XAD column	32
Overlying Water	Particulate PCBs	Filter	32

Table A-6. Container, Sample Size, Preservation, and Shipping Information for the ESTCP DP

Sample Type	Sample Container Number, Type, Size	Min. Sample Size	Sample Preser-vation	Holding Time[a]	Receiving Laboratory and Sample Custodian
Clams	500 mL vented polyethylene jar	One clam	In cooler with ice, but no direct ice-clam contact.	24 h from collection to depuration	Stanford University Dept. Civil & Environmental Engineering, B-55 Stanford, CA 94305 Attn: Dennis Smithenry (650) 723-8574
Depurated Shucked Whole Clam Tissues for Splitting and Analysis	20 mL pre-cleaned scintillation vial	One whole clam tissue	Frozen (-10°C)	1 yr/40 d	U.S. Army Engineer Research and Development Center (ERDC) 3909 Halls Ferry Rd. Vicksburg, MS 39180-6199 Attn: Todd Bridges (601) 634-3626
Depurated Shucked Whole Clam Tissues for Archive	20 mL pre-cleaned scintillation vial	2 g homo-genate	Frozen (-10°C)	1 yr/40 d	Battelle 397 Washington Street Duxbury, MA 02332 Attn: Carole P-McCarthy (781) 952-5232
SPMDs	Original sample containers from supplier or 4 oz. pre-cleaned wide mouth glass	1	4°±2°C	1 yr/40 d (once ampoule is open)[b]	Stanford University
Sediment Cores	2-inch diameter butyrate core tube (1.5 ft. long)	12 inches	4°±2°C	TOC/BC (1 yr) PCBs (1 yr/40d)	Stanford University
Surface Sediment	4 oz. pre-cleaned wide mouth glass	30 g	4°±2°C	TOC/BC (1 yr) C13 (30 d) PCBs (1yr/40d)	Stanford University
Composite Sediment	32 oz. pre-cleaned wide mouth glass	> 500 g	4°±2°C	TOC/BC (1 yr) C13 (30 d) PCBs (1yr/40d)	Stanford University
Benthic Community Samples	in 4% formaldehye solution in 500 mL polyethylene jars	N/A	4°±2°C	3 yr/(N/A)	ERDC
Amphipod Sample for Splitting and Analysis	20 mL pre-cleaned scintillation vial	200 mg	Frozen (-10°C)	1 yr/40 d	ERDC
Amphipod Sample for Archive	20 mL pre-cleaned scintillation vial	100 mg homo-genate	Frozen (-10°C)	1 yr/40 d	Battelle
Surface Water Samples—Filter Papers	8 oz. pre-cleaned wide mouth glass	One	4°±2°C	1 yr/40 d	University of Maryland Baltimore County 1000 Hilltop Circle Baltimore, MD 21250 Attn: Upal Ghosh 410-455-8665

Surface Water Samples—XAD Resin Columns	50mm x 300mm Glass Column Capped after Collection	400 mL XAD	4°±2°C	1 yr/40 d	University of Maryland

(a) Holding time: yr = year; d = day; h = hour; x/y = days from collection to extraction/days from extraction to analysis.

(b) SPMD samples can be stored for an undetermined period of time. Once SPMDs have undergone dialysis, the hexane extracts sealed in ampoules can also be stored under refrigeration for an undetermined period of time. (Personal communication, Terri Spencer, EST Laboratory, 2004).

Table A-7. PCB Congeners, Detection Limits, Reporting Limits, and Benchmarks for *M. nasuta* and *Corophium spp*. (All concentrations are ng/g wet weight.)

PCB Congeners	Method Detection Limit	Reporting Limit	Benchmark
Cl2(8)	0.32	0.22	NA
Cl3(18)	0.03	0.22	NA
Cl3(28)	0.04	0.22	NA
Cl4(44)	0.03	0.22	NA
Cl4(52)	0.02	0.22	NA
Cl4(66)	0.03	0.22	NA
Cl5(101)	0.02	0.22	NA
Cl5(105)	0.04	0.22	NA
Cl5(118)	0.04	0.22	NA
Cl6(128)	0.09	0.22	NA
Cl6(138)	0.04	0.22	NA
Cl6(153)	0.07	0.22	NA
Cl7(170)	0.04	0.22	NA
Cl7(180)	0.04	0.22	NA
Cl7(187)	0.04	0.22	NA
Cl8(195)	0.04	0.22	NA
Cl9(206)	0.03	0.22	NA
Cl10(209)	0.04	0.22	NA
Total PCBs	NA	NA	13.8[(a)]

(a) Battelle developed reference threshold concentrations for PCBs in San Francisco Bay as part of the validation study (Battelle, 2003). The 90th percentile value for total PCBs was approximately 69 µg/kg dry wt. This value represents a "background" concentration for PCBs in invertebrate tissues in the bay. This value is converted to wet weight using the conversion factor of 80% moisture for clam tissue and used as the benchmark for the ESTCP DP.

NA = not available.

Table A-8. BDO Standard Operating Procedures for the Critical Data Collection from Archived Tissue Sample Splits

Battelle Duxbury Operations	
3-116	Operation and Maintenance of Gas Chromatographs
5-128	Identification and Quantification of Polychlorinated Biphenyls (By Congener and Aroclor) and Chlorinated Pesticides by Gas Chromatography/Electron Capture Detection
5-190	Tissue Extraction for Trace Level Semi-Volatile Organic Contaminant Analysis
BDO HPS SOP 003	Navy Program Electronic Data Interchange Standards For Analytical Laboratories

Table A-9. Definitions, Requirements, and Frequency for Quality Control Samples

QC Sample	Definition	Frequency
FIELD QUALITY CONTROL		
Equipment Blank (EB)	An equipment blank is a sample of contaminant-free medium (typically reagent-grade water) that has been passed through or over the sampling equipment used to collect field samples.	None
LABORATORY QUALITY CONTROL (on any sample with the exception of a field duplicate)		
Method or Procedural Blank (MB)	A combination of solvents, surrogates, and all reagents used during sample processing, processed concurrently with the field samples. Monitors purity of reagents and laboratory contamination. Matrices: Water (MilliQ); soil or sediment (sodium sulfate). A processing batch MB must be analyzed with each sequence.	1/sample batch[(a)]
Laboratory Control Sample (LCS)	A LCS sample is a matrix-specific sample that is prepared with each processing batch. It is spiked with the analytes of interest and processed identically to the field samples. Matrices are the same as those used for the procedural blank.	1/sample batch
Laboratory Control Sample Duplicate (LCSD)	A second laboratory control sample prepared as described above if there is insufficient tissue mass to perform a matrix spike duplicate.	1/sample batch *if no MSD.*
Matrix Spike (MS)	A field sample spiked with the analytes of interest at 10X the MDL, processed concurrently with the field samples; monitors effectiveness of method on sample matrix; performed in duplicate for sediments.	1/sample batch *if sufficient tissue mass.*
Matrix Spike Duplicate (MSD)	Second aliquot of a field sample processed and analyzed to monitor precision; each sample set should contain a duplicate. The duplicate may be a second matrix spike sample.	1/sample batch *if sufficient tissue mass.*
Surrogate Internal Standards (SIS)	All field and QC samples are spiked with a known amount of surrogates just prior to extraction; recoveries are calculated to quantify extraction efficiency.	Each organic compounds sample
Reagent or Solvent Purity Checks	All reagents are lot-checked prior to use.	Per lot purchase

(a) A batch is defined as 20 field samples processed simultaneously and sharing the same QC samples.

Table A-10. Measurement Quality Criteria for Measurements of PCB Congeners

QC Parameter	Acceptance Criteria	Corrective Action
Accuracy		
Field(Equipment) Blank	<RL	Review data and assess results for evidence of field-related contamination. Flag all data that are >RL.
Instrument Solvent Blank	< lowest calibration standard	Review data and analysis for possible sources of contamination. Reanalyze and/or document corrective action. Data must be flagged.
Method (Procedural) Blank	<RL	Evaluate batch for corrective action if Blank > RL and sample concentration < 5 times the detected blank. Perform corrective action as above and re-process (extract, digest) sample batch. If batch cannot be re-processed; "B" flag all data that are < 5 times the blank.
•*Matrix Spike*	40 - 120% recovery **Concentration in spike must be >5 × background levels to be used for data quality assessment**	Review data to assess impact of matrix. If other QC data are acceptable and no spiking error occurred, then flag associated data. If QC data are not affected by matrix failure or spiking errors occurred, then re-process MS. If not possible, then notify client and flag associated data.
•*Surrogate Spike (SIS)*	40 - 120% recovery	Review data. Discuss with Laboratory Manager (LM). Reanalyze, re-extract, and/or document corrective action and deviations.
•*Laboratory Control Sample (LCS)*	40 - 120% recovery	Perform corrective action. Re-analyze and/or re-process sample batch. Batch data associated with failed LCS (LCS data outside control limits) cannot be reported. If batch cannot be re-processed: notify client, flag data, discuss impact in report narrative.
Precision: *MS/MSD*	<30% RPD **Concentration detected must be >5 times RL to be used for data quality assessment**.	Review data to assess impact of matrix. If other QC data are acceptable, then flag associated data. If QC data are not affected by matrix failure, then re-process duplicate. If not possible, then notify client and flag associated data.

Table A-11. Navy Environmental Data Transfer Standard (NEDTS) Data Qualifiers for PCB Congener Analysis

Data Qualifiers	
B	Blank contamination: The analyte was detected above the reporting limit in an associated blank. For this study, blank contamination indicates that the analyte was found in both a sample and the associated blank. The "B" will be reported on the result associated with the field samples, not the blank.
D	Dilution run. Initial run outside linear calibration range of instrument
E	Estimate, result outside linear calibration range of instrument.
J	Estimated value (Compared to the sample-specific reporting limit)
R	Rejected
U	The value was less than the or the analyte was not detected (The sample-specific MDL is inserted)
X	Indicates manual modification of result or U.S. EPA qualifier
Quality Control Qualifiers	
N	Spiked sample recovery not within control limits
*	Duplicate analysis not within control limits

Table A-12. Calibration Procedures for Laboratory Equipment [(a)]

Equipment	Frequency of Check	Acceptance Criteria	Reference
Chemistry Laboratory Equipment			
Balance calibration check	Daily or before use with two weights that bracket target weight(s) and Annual calibration with NIST standards by certified technician	1% performance criterion to top-loading balances, and 0.1% to analytical balances. (Expanded criteria from 0.1 to 1% for top-loaders, for no standard existed for this balance type.)	ASTM E 898, Standard Practice for the Evaluation of Single-Pan Mechanical Balances, E 319, Standard Practice for the valuation of Single-Pan Mechanical Balances, and D 5522, Standard Specification for Minimum Requirements for Laboratories Engaged in Chemical Analysis of Soil, Rock, and Contained Fluid
Refrigerator/ Freezer temperature Monitoring	Daily	Refrigerators: 4 ± 2 °C, Freezers: -10 to -20°C (This ASTM standard does not address freezers, but SW-846 has noted this freezer range in some methods)	ASTM D 5522, Standard Specification for Minimum Requirements for Laboratories Engaged in Chemical Analysis of Soil, Rock, and Contained Fluid
Thermometer calibration check	Mercury - annually Electronic, spirit, or other glass thermometers - quarterly at two temperatures that bracket target temperature(s) against an NIST traceable thermometer	Appropriate correction factors applied	ASTM Methods E 77, Standard Test Method for Inspection and Verification of Thermometers, and D 5522, Standard Specification for Minimum Requirements for Laboratories Engaged in Chemical Analysis of Soil, Rock, and Contained Fluid
Variable volume pipettes (i.e., Eppendorf)	Monthly	3% of known of true value.	ASTM E 542, Standard Practice for Calibration o f Volumetric Apparatus, and E 969, Standard Specification for Volumetric (Transfer) Pipettes.
Nonvolumetric glassware/ labware verification (Applicable only when used for measuring volumes)	By lot at the time of purchase	3% of known or true value. (Standard tolerance does not exist – Class B volumetric flasks criteria vary between 0.8 to 0.05% for 5 mL to 2,000 mL, respectively – set at 3% to maintain consistency with pipette tolerance designation)	ASTM E 542, Standard Practice for Calibration of Volumetric Ware
Drying ovens	Before and after use	Compliance with method-specific requirements	ASTM D 5522, Standard Specification for Minimum Requirements for Laboratories Engaged in Chemical Analysis of Soil, Rock, and Contained Fluid

(a) Summary of Navy IRCDQM Equipment Calibration Requirements and related references. Toxicology information is defined by the laboratory and is not covered in the IRCDQM.

ASTM = American Society for Testing and Materials.

Table A-13. Level III Data Validation Assessment Parameters

Criteria	PCBs (GC)
Holding times	X
Instrument tunes	
Initial and continuing calibrations	X
Blanks	X (5X/10X rule)
LCS/ Laboratory set limits	
Surrogates	X
MS/MSD	X
Duplicates	
Internal standard area performance	
Target compound retention times	X
Instrument performance	X
Interference with compound quantification	X

ATTACHMENT 1 to QAPP
FIELD DATA COLLECTION FORMS

FIELD LOGBOOK (#/6)

HUNTERS POINT SHIPYARD PARCEL F

ESTCP DEMONSTRATION STUDY

Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment

Prepared for

Environmental Security Technology Certification Program

Project Number ESTCP ER-0510

Version 1.0

IF THIS LOGBOOK IS LOST AND YOU FIND IT, PLEASE CONTACT

Dr. Dennis Smithenry
Stanford University
Terman Engineering Center, B55
Stanford, CA 94305

650-723-8574 (office)
650-814-1832 (cell)
smithnry@stanford.edu

Contact List

NAME	ROLE/Institution	TELEPHONE	e-MAIL
STANFORD UNIVERSITY			
Dennis Smithenry	Project Manager	650-723-8574 (w) 650-814-1832 (cell)	smithnry@stanford.edu
Yeo-Myoung Cho	Project QA Manager & Physicochemical Studies Leader	650-804-6825 (cell)	daybreak@stanford.edu
Richard Luthy	Principal Investigator	650-723-3921 (w)	luthy@stanford.edu
NAVY			
Ryan Ahlersmeyer	Parcel F RPM	619-532-0960 (w) 858-232-2619 (cell)	ryan.ahlersmeyer@navy.mil
ERDC			
Todd S. Bridges	Bioaccumulation Studies Leader A	601-634-3626 (w)	Todd.S.Bridges@erdc.usace.army.mil
Al Kennedy	Bioaccumulation Studies Leader B	601-634-3344 (w) 601-415-5314 (cell)	Alan.J.Kennedy@erdc.usace.army.mil
UMBC			
Upal Ghosh	Resuspension Studies Leader	410-455-8665 (w) 443-629-2136 (cell)	wwilliams@ttfwi.com
AEI			
Lance Dohman	Mixing Technology Leader A	925-521-0400 (w) 650-868-8240 (cell)	ldohman@aquamog.com
CEI			
Mark Fleri	Mixing Technology Leader B	770-879-4075 (w)	mfleri@compassenvironmental.com
OTHER			
Rod Millward	Weston Solutions	415-435-7486 (w)	Rod.Millward@WestonSolutions.com
Chuck Bartholmew	TetraTech	415-671-1990 (w)	cbartholmew@ttfwi.com
Ray Bienert	TetraTech EMI	415-222-8296 (w)	Ray.Bienert@ttemi.com
Yip Chun	TetraTech EMI	415-222-8377 (w)	yip.chun@ttemi.com
Glynis Foulk	TetraTech EMI	916-853-4561 (w)	glynis.foulk@ttemi.com
Andrew Gorman	TetraTech	415-671-1990	agorman@ttfwi.como
Keith Jones	US Filter/Westates	510-639-7274	jonesk2@usfilter.como
Leslie Lundgren	TetraTech EMI	415-222-8205 (w) 415-407-3433 (cell)	leslie.lundgren@ttemi.com
Bill William	TetraTech	415-216-2733 (w) 415-671-1990 (gen. w)	wwilliams@ttfwi.com

Emergency Telephone Numbers

Ambulance	911
Police	911
Hospital	911
Fire Department	(415) 822-6779
HPS Base Security	(415) 330-0500
HPS Base Police	(415) 330-0565
HPS Base Contact	(415) 811-1613
California Office of Emergency Services	(800) 852-7550
City of San Francisco CIH (Ed Ochi)	(415) 671-3171
EPA Region 9, Environmental Emergencies	(415) 744-2000
OSHA Region 9	(415) 744-6670
RCRA Hotline	(800) 424-9346
U.S. Department of Transportation	(415) 744-3115
EPA National Response Center	(800) 424-8802
Poison Control Center	(800) 876-4766
Office of Emergency Services	(800) 852-7550 (916) 262-1621
City of San Francisco CIH (Ed Ochi)	(415) 671-3171
California DTSC	(916) 255-2002
California EPA	(916) 445-3846
TOXLINE	(301) 496-1131
CHEMTREC	(800) 424-9300
San Francisco General Hospital Emergency Room	(415) 206-8111
General Information	(415) 206-8000
Medical Center	(415) 206-8492
Alternate Hospital (St. Luke's Hospital)	(415) 641-6625
Tetra Tech Health and Safety Officer—Glynis Foulk	(916) 853-4561
Field Project Manager – Dennis Smithenry (Office)	(650)723-8574
(Cellular)	(650)814-1832
San Francisco General Hospital – Emergency	911
California OSHA	(213) 736-3041
California Department of Fish and Game	(310) 590-5132
BCO Radiation Safety Officer (RSO) - Craig Jensen(Office)	(614) 424-5170
(Cellular)	(614) 402-5386
BCO Assistant RSO - Leonard Davis (Office)	(614) 424-4368
(Pager)	(614) 786-3419

Hospital Information

San Francisco General Hospital
1001 Potrero Avenue
San Francisco, California 94110
(415) 206-8376

DIRECTIONS TO SAN FRANCISCO GENERAL HOSPITAL (3.0 miles):

- Exit HPS main gate on Innes Avenue and proceed 0.5 miles west to Hunter Point Boulevard, which becomes Evans Avenue. Proceed 1.5 miles west on Evans Avenue, passing Third Street and Highway 280, to Cesar Chavez (Army) Street.
- Left onto Cesar Chavez (Army) Street, and proceed 0.5 miles west, passing Highway 101, to Potrero Avenue.
- Right onto Potrero Avenue, proceed 0.25 miles north into the hospital entrance.
- A route map to the hospital is shown in Appendix A.

St. Luke's Hospital
3555 Cesar Chavez (Army) Street
San Francisco, California 94110
(415) 647-8600

DIRECTIONS TO ST. LUKE'S HOSPITAL (3.4 miles):

- Exit HPS main gate on Innes Avenue and proceed 0.5 miles west to Hunter Point Boulevard, which becomes Evans Avenue. Proceed 1.5 miles west on Evans Avenue to Cesar Chavez (Army) Street, passing Third Street and Highway 280.
- Left onto Cesar Chavez (Army) Street, proceed 1 mile west, passing Highway 101 and Potrero Avenue, and into the Hospital entrance at the intersection of Cesar Chavez/Valencia.

A route map to each hospital is shown in the following figures.

Map to San Francisco General Hospital (shown as "B") from Hunters Point (shown as "A")

Map to St. Luke's Hospital (shown as "B") from Hunters Point (shown as "A")

Reviewed by _____ Date (mm/dd/yy) _____

SITE-SPECIFIC HEALTH AND SAFETY PLAN (S-HASP)
TRAINING RECORD

S-HASP Title/Revision No. Site-Specific Health and Safety Plan for Hunters Point

_____ _____
Site Health and Safety Officer Project Number

I have read the S-HASP presented herein and fully understand the material covered. I understand that I am responsible for compliance with the requirements of this HASP and I agree to abide by the same. I also had the opportunity to discuss the information presented in the HASP, and to ask any questions about the information that I want clarified. I understand that this record will become a permanent part of my employee health and safety training file.

Date	Print Name	Signature

Reviewed by _____ Date (mm/dd/yy) _____

TAILGATE SAFETY MEETING RECORD FORM

DAILY TAILGATE SAFETY MEETING FORM

Date: _____ Time: _____

Project Number: _____

Project Name: ESTCP Demonstration Study

Specific Location: Hunters Point Shipyard, San Francisco, CA

Type of Work: _____

Chemicals Present: PCBs and other halogenated organics, metals, and possible radiation.

SAFETY TOPICS DISCUSSED

Protective Clothing/Equipment: HAZWOPER Level D: standard work clothes, boots, long pants, waders, long-sleeved shirt, safety vest, eye protection, hardhat, latex gloves (change often), dust masks

Hazards of Chemicals Present: Limited, primarily associated with incidental ingestion of contaminated sediment.

Physical Hazards: Tripping, slipping, getting stuck in the sediments. Exposure to cold/heat. Biting/stinging insects.

Special Hazards: Feral dogs, human trespassers/transients. Radium dial disposal area onshore.

Other Topics: Buddy system, Good hygiene, Drinking Water, Sunscreen

ATTENDEES

Name (printed)	Signature

Reviewed by _____ Date (mm/dd/yy) _____

GPS CALIBRATION

Check GPS at Established Benchmark at Survey start, prior to sample collection.

Established Benchmark Name (PID AI4505 / SUAA0000-CORS) Est. by National Geodetic Survey.

Benchmark Location

Units and Datum	Northing / Latitude	Easting / Longitude
Lat Long NAD 83 (Deg:min.min)	37° 25.614	122° 10.396

Comments – Marker is a bolt in metal plate. This marker mounted on a 2 meter metal tower fixed to the roof of the Durand Building on the Stanford Campus.

GPS Reference Check Point Name: MW44A (Monitoring Well 44A) on Parcel E at HPS.

Reference Checkpoint 1 Location

Units and Datum	Northing / Latitude	Easting / Longitude
Lat Long NAD 83 (Deg:min.min)	37°	122°

Date/Time: _____ INITIAL:_____

Unit Maker/Model: Garmin Geko 201 Handheld GPS Unit

Benchmark or Reference Checkpoint (circle one) Name _____

Established coordinates from table: 37°_____/ 122° _____

Measured coordinates: 37°_____/ 122° _____

Difference _____ meters (0.001 minutes ~ 2m) Within 100 meters? Yes / No

If no, check operation, re-measure, or replace unit and repeat calibration check.

Date/Time: _____ INITIAL:_____

Unit Maker/Model: Garmin Geko 201 Handheld GPS Unit

Benchmark or Reference Checkpoint (circle one) Name _____

Established coordinates from table: 37°_____/ 122° _____

Measured coordinates: 37°_____/ 122° _____

Difference _____ meters (0.001 minutes ~ 2m) Within 100 meters? Yes/No

If no, check operation, re-measure, or replace unit and repeat calibration check.

Reviewed by _____ Date (mm/dd/yy) _____

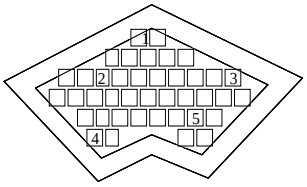
CORE SAMPLING DATA SHEET

UNIQUE SAMPLE ID ____AE-_____ INITIALS _____

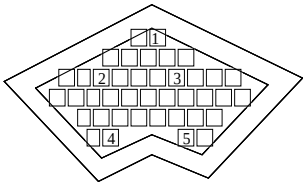
DATE (mm/dd/yy) _____ STANFORD SAMPLE ID Core-_____

ON STATION (time) _____ SAMPLER USED Push Core (2.0 inch diameter)

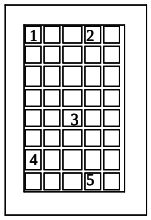
Sampling Location (mark one) Shore



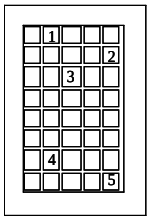
Plot C



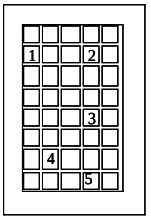
Plot D



Plot E



Plot F



Plot G

PENETRATION DEPTH _____ in SAMPLE RETAINED _____ in

CORE DIAMETER 2.0 inch RECEIVING CONTAINER Cooler STORAGE CONDITIONS FROM SAMPLING TO SHIPMENT Cooler

SEDIMENT COLOR Brownish Dark Gray SEDIMENT ODOR None Slight Moderate Strong Overwhelming H_2S Petroleum Other:

SEDIMENT TYPE Sand Shells and Mud

Target core length for HPS cores is 12-14 inches; Minimum acceptable core length is 12 inches.

Reviewed by _____ Date (mm/dd/yy) _____

CORE PROCESSING DATA SHEET

Original Sample ID:		Stanford Sample ID: Core -
Logged By:	Date:	Time:

TOC Subsamples

Depth Below Water Surface (in)	New Cross Section Sample ID for TOC	TOC Stanford Sampling ID	Sediment Texture	Sediment Odor	Sediment Color	Comments
0-2	___AE-_____	Section-				
2-4	___AE-_____	Section-				
4-6	___AE-_____	Section-				
6-8	___AE-_____	Section-				
8-10	___AE-_____	Section-				
10-12	___AE-_____	Section-				

TOC Subsampling Procedure: Description of cross-section procedures: 1) Place the core on a non-contaminating surface and remove the end caps. 2) Using a core plunger, slowly push out the core onto the surface. 3) Take a picure of the core. 4) Every two inches, gently pass a clean stainless steel knife through the core and place cross sections into pre-cleaned beackers. 5) Homogenize each cross section and remove a 1-g subsample for TOC measurement. The TOC subsample will be placed in to a small pre-cleaned ans labeled glass vial. 6) Recombine and homogenize core sections in a large glass container with a Teflon lined lid.

Receiving container for TOC sample: Glass vials (2.0 ml)

Storage conditions from sampling to cross-sectioning: 250 ml beaker, Room temperature

Storage conditions from cross sectioning to TOC analysis: 60'C oven for drying (TOC)

Reviewed by _____ Date (mm/dd/yy) _____

SEDIMENT PCB COMPOSITE SUBSAMPLING DATA SHEET (1)

FOR ARCHIVE, AQUEOUS EQUILIBRIUM and SEDIMENT PCB LEVEL

NEW COMPOSITE SAMPLE ID _____AE-_____

DATE OF COMPOSITING CORE CROSS SECTIONS (mm/dd/yy) _____

TIME OF COMPOSITING CORE CROSS SECTIONS _____

INITIALS _____ STANFORD SAMPLE ID Composite-_____

DESCRIPTION OF COMPOSITING PROCEDURES Recombine and homogenize core sections in a large glass container with a Teflon lined lid.

COMPOSITE TEXTURE _____ COMPOSITE ODOR _____ COMPOSITE COLOR _____

RECEIVING CONTAINTER FOR SEDIMENT PCB COMPOSITE SAMPLE 1L pre-cleaned glass jar with wide mouth

STORAGE CONDITIONS FROM CROSS-SECTIONING TO COMPOSITING Room Temperature

STORAGE CONDITIONS FROM COMPOSITING TO ANALYSIS 4°C Cold Room

ORIGINIAL CROSS SECTION SAMPLE IDs	UNIQUE SAMPLE ID	STANFORD SAMPLE ID
0 – 2 inches	_____AE-_____	Section-
2 – 4 inches	_____AE-_____	Section-
4 – 6 inches	_____AE-_____	Section-

Further Subsamples from Sediment Core Homogenate

Subsample Measurement	Subsample New ID	Stanford Sampling ID	Approximate Mass	Sample Container Type	Comments
Sediment PCBs	___AE-_____	Sed -	5 g	100 mL beaker	
Aqueous Equilibrium PCBs	___AE-_____	AqEq -	30 g	4 oz. glass jar	

Reviewed by _____ Date (mm/dd/yy) _____

SEDIMENT PCB COMPOSITE SUBSAMPLING DATA SHEET (2)
FOR PCB DESORPTION TEST

NEW COMPOSITE SAMPLE ID _____AE-_____ / _____AE-_____

DATE OF COMPOSITING COMPOSITES OF A PLOT (mm/dd/yy)

TIME OF COMPOSITING COMPOSITES OF A PLOT

INITIALS _____ STANFORD SAMPLE ID Desorption - 1-_____ / Desorption - 2-_____

DESCRIPTION OF COMPOSITING PROCEDURES Recombine and homogenize composites of one plot in a pre-cleaned beaker and take two 100g of subsamples.

COMPOSITE TEXTURE _____ COMPOSITE ODOR _____ COMPOSITE COLOR _____

RECEIVING CONTAINTER FOR SEDIMENT PCB COMPOSITE SAMPLE Pre-cleaned glass jar with wide mouth

STORAGE CONDITIONS FROM CROSS-SECTIONING TO COMPOSITING Room Temperature

STORAGE CONDITIONS FROM COMPOSITING TO ANALYSIS 4°C Cold Room

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

ORIGINIAL COMPOSITE SAMPLE IDs	UNIQUE SAMPLE ID	STANFORD SAMPLE ID
Station 1	_____AE-_____	Composite-
Station 2	_____AE-_____	Composite-
Station 3	_____AE-_____	Composite-
Station 4	_____AE-_____	Composite-
Station 5	_____AE-_____	Composite-

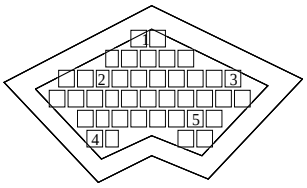
Reviewed by _____ Date (mm/dd/yy) _____

SEMIPERMEABLE MEMBRANE DEVICE (SPMD) DATA SHEET

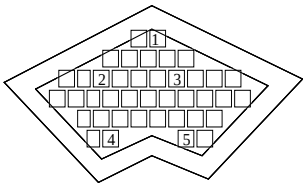
UNIQUE SAMPLE ID ____AE-_____

STANFORD SAMPLE ID SPMD-

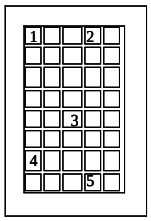
Sampling Location (mark one) Shore



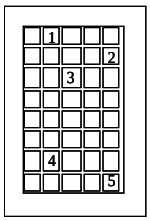
Plot C



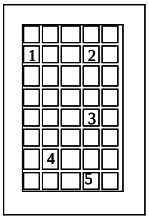
Plot D



Plot E



Plot F



Plot G

DEPLOYMENT

DATE SPMD DEPLOYED (mm/dd/yy) _____ INITIALS _____ ON STATION (time) _____

SPMD LENGTH (inner) 10 cm SPMD LENGTH (outer) 16 cm

RETRIEVAL

DATE SPMD RETRIEVED (mm/dd/yy) _____ INITIALS _____ ON STATION (time) _____

SPMD LENGTH (inner) 10 cm SPMD LENGTH (outer) 16 cm

RECEIVING CONTAINER pre-cleaned glass jar with wide mouth STORAGE CONDITIONS FROM SAMPLING TO SHIPMENT Cooler

Reviewed by _____ Date (mm/dd/yy) _____

Macoma CLAM SIZING DATA SHEET

DATE *Macoma* Sized (mm/dd/yy) _____ INITIALS _____ Time _____

Size (Mass (g) or Length (mm))		***Total***
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		
-		

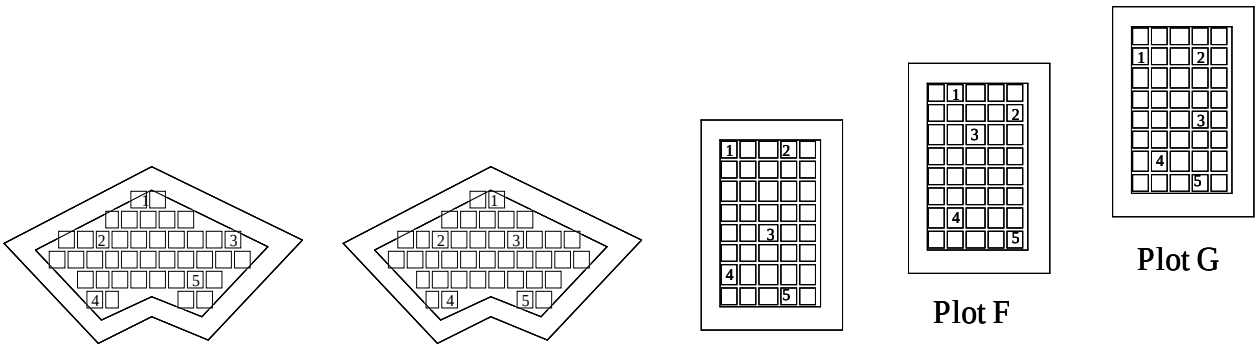
Reviewed by _____ Date (mm/dd/yy) _____

Macoma CLAM DATA SHEET

UNIQUE SAMPLE ID ____AE-_____

STANFORD SAMPLE ID Clam-

Sampling Location (mark one) Shore



DEPLOYMENT

DATE *Macoma* DEPLOYED (mm/dd/yy) _____ INITIALS _____ ON STATION (time) _____

NUMBER of *Macoma* DEPLOYED _____ NUMBER of *Macoma* BURROWED BEFORE HIGH TIDE _____

NUMBER of *Macoma* RE-DEPLOYED _____ NUMBER of *Macoma* BURROWED NEXT DAY BEFORE HIGH TIDE _____

RETRIEVAL

DATE *Macoma* RETRIEVED (mm/dd/yy) _____ INITIALS _____ ON STATION (time) _____

NUMBER of *Macoma* RETRIEVED (live) _____ NUMBER of *Macoma* RETRIEVED (dead) _____ Survival rate (%) _____

RECEIVING CONTAINER PP container STORAGE CONDITIONS FROM SAMPLING TO SHIPMENT Cooler / ice bag

DEPTH (inch)	NUMBER of *Macoma* RETRIEVED (live/dead)

Reviewed by _____ Date (mm/dd/yy) _____

Macoma CLAM SACRIFICING DATA SHEET

DATE *Macoma* Sacrificed (mm/dd/yy) ______________ INITIALS ______________ Time ______________

___AE-______	Clam #	Whole Clam Mass (g)	Whole Wet Tissue Mass (g)	Container
Clam-	1			_______of _______
	2			_______of _______
	3			_______of _______
	4			_______of _______
	5			_______of _______
	6			_______of _______

___AE-______	Clam #	Whole Clam Mass (g)	Whole Wet Tissue Mass (g)	Container
Clam-	1			_______of _______
	2			_______of _______
	3			_______of _______
	4			_______of _______
	5			_______of _______
	6			_______of _______

___AE-______	Clam #	Whole Clam Mass (g)	Whole Wet Tissue Mass (g)	Container
Clam-	1			_______of _______
	2			_______of _______
	3			_______of _______
	4			_______of _______
	5			_______of _______
	6			_______of _______

___AE-______	Clam #	Whole Clam Mass (g)	Whole Wet Tissue Mass (g)	Container
Clam-	1			_______of _______
	2			_______of _______
	3			_______of _______
	4			_______of _______
	5			_______of _______
	6			_______of _______

___AE-______	Clam #	Whole Clam Mass (g)	Whole Wet Tissue Mass (g)	Container
Clam-	1			_______of _______
	2			_______of _______
	3			_______of _______
	4			_______of _______
	5			_______of _______
	6			_______of _______

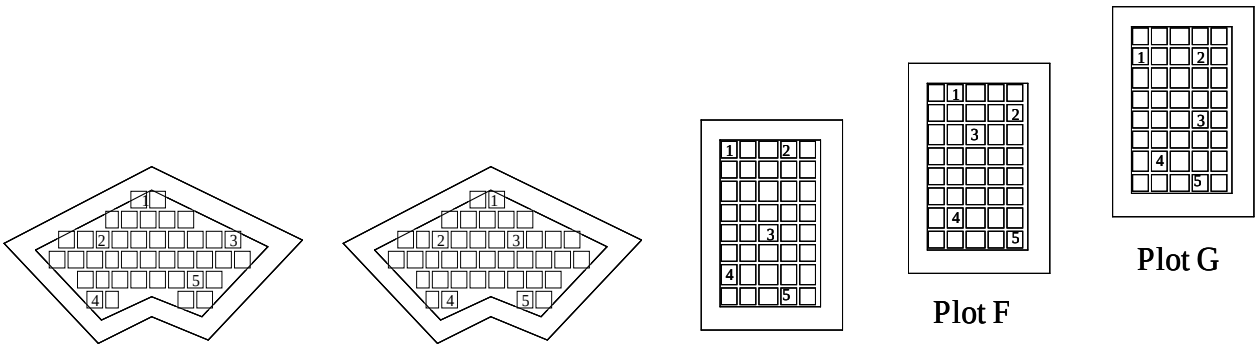
Reviewed by ______________________ Date (mm/dd/yy) _______________

COROPHIUM AMPHIPOD DATA SHEET

UNIQUE SAMPLE ID ____AE-_____

STANFORD SAMPLE ID Amphipod-

Sampling Location (mark one) Shore



RETRIEVAL

DATE Amphipod Samples RETRIEVED _____ INITIALS _____ ON STATION (time) _____

Surface Sediment Depth (cm) _____ (Sieved through 500 micron sieve)

RECEIVING CONTAINER PE container STORAGE CONDITIONS FROM SAMPLING TO SHIPMENT Cooler / ice bag

The mass of amphipod samples should be more than 500mg.

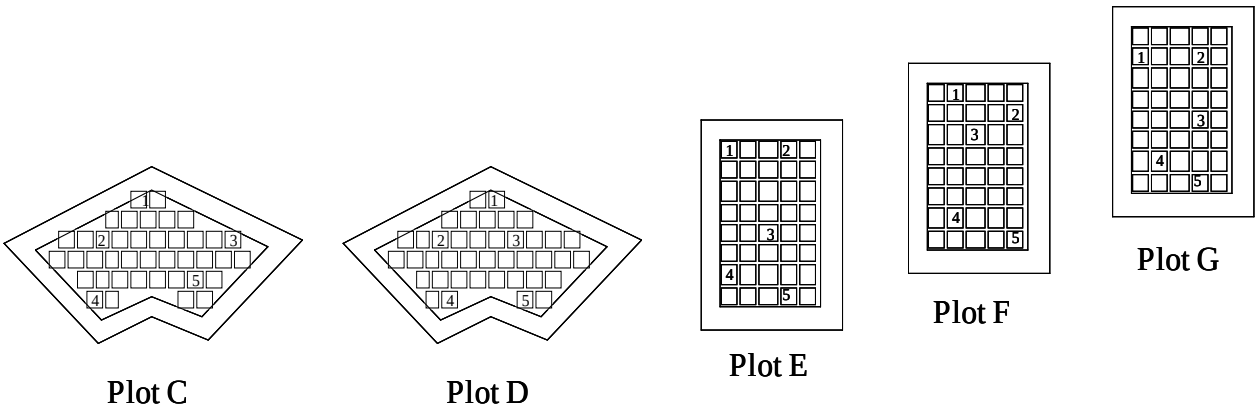
Reviewed by _____ Date (mm/dd/yy) _____

QUADRAT SIEVING FOR BENTHIC COMMUNITY SAMPLES

UNIQUE SAMPLE ID ____AE-_____ / ____AE-_____

STANFORD SAMPLE ID Benthic- Upper - / Benthic-Lower-

Sampling Location (mark one) Shore



BENTHIC COMMUNITY SAMPLE (BCS) FROM QUADRAT SIEVING

DATE BCS Sieved (mm/dd/yy) _____ INITIALS _____ ON STATION (time) _____

Surface Sediment Depth (cm) (Upper part) 0 - _____ Surface Sediment Depth (cm) (Lower part) _____ -

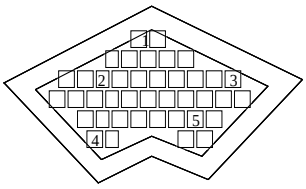
Preserved in-- 4% formaldehyde solution Sieve size 500 µm Quadrat Dimension (cm×cm) 25×25

RECEIVING CONTAINER PE container STORAGE CONDITIONS FROM SAMPLING TO SHIPMENT Cooler / ice bag

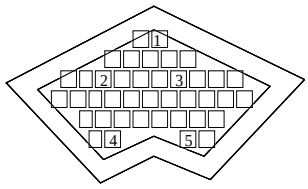
Reviewed by _____ Date (mm/dd/yy) _____

FIELD WATER SAMPLING DATA SHEET (XAD/FILTERS)

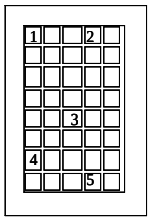
INITIALS _____ DATE (mm/dd/yy) _____



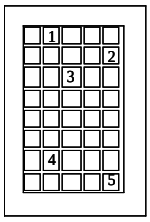
Plot C



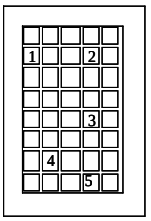
Plot D



Plot E



Plot F



Plot G

* circle one of the plots

SAMPLING START TIME _____ SAMPLING END TIME _____

Volume of water sampled _____

XAD-2 Column

UNIQUE SAMPLE ID ____AE-_____ UMBC SAMPLE ID _____

STANFORD SAMPLE ID XAD - XAD Column ID _____

Filters

UNIQUE SAMPLE ID ____AE-_____ UMBC SAMPLE ID _____

STANFORD SAMPLE ID Filters - Number of filters _____

Coments

Reviewed by _____ Date (mm/dd/yy) _____

FIELD DAILY LOG FORM

		Log Entry	
INITALS		**Starting Time of Activities**	**Ending Time of Activities**
Date (mm/dd/yy)		**: am/pm**	**: am/pm**
Field Location		***Hunters Point Shipyard***	
ESTCP Plots Sampled (circle)		**C D E F G**	
Field Activities		**1.**	
		2.	
		3.	
		4.	
		5.	
		6.	
		7.	
		8.	
		9.	
		10.	
Weather (at Start of Activities)		**Temperature (°C):**	
		Wind Speed	
		Other--	
Weather (at End of Activities)		**Temperature (°C):**	
		Wind Speed	
		Other--	

Weather information will be obtained from the National Weather Service Website.
http://www.wrh.noaa.gov/total_forecast/index.php?zone=caz006&county=cac075&wfo=mtr&dgtl=1&lat=37.73118&lon=-122.38259

Reviewed by _____ Date (mm/dd/yy) _____

SPMD EXTRACTION DATA SHEET

DATE (mm/dd/yy) _____ INITIALS _____ Time _____

Volume of Surrogate Spike (µL) _____ Volume of Extract for Clean-up (mL) _____

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	SPMD-	SPMD-	SPMD-	SPMD-	SPMD-
Volume of Extract (mL)					

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	SPMD-	SPMD-	SPMD-	SPMD-	SPMD-
Volume of Extract (mL)					

Reviewed by _____ Date (mm/dd/yy) _____

SEDIMENT EXTRACTION DATA SHEET

DATE (mm/dd/yy) _____ INITIALS _____ Time _____

Volume of Surrogate Spike (µL) _____ Volume of Extract for Clean-up (mL) _____

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	Sed-	Sed-	Sed-	Sed-	Sed-
Volume of Extract (mL)					

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	Sed-	Sed-	Sed-	Sed-	Sed-
Volume of Extract (mL)					

Reviewed by _____ Date (mm/dd/yy) _____

AQUEOUS EQUILIBRIUM EXTRACTION DATA SHEET

DATE (mm/dd/yy) _____ INITIALS _____ Time _____

Volume of Surrogate Spike (µL) _____ Volume of Extract for Clean-up (mL) _____

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	AqEq-	AqEq-	AqEq-	AqEq-	AqEq-
Volume of Extract (mL)					

LOCATION (circle one):	Plot C	Plot D	Plot E	Plot F	Plot G

UNIQUE SAMPLE ID	__AE-_____	__AE-_____	__AE-_____	__AE-_____	__AE-_____
STANFORD ID	AqEq-	AqEq-	AqEq-	AqEq-	AqEq-
Volume of Extract (mL)					

Reviewed by _____ Date (mm/dd/yy) _____

DEVIATION DOCUMENTATION

INITIALs: _____ Date / Time: _____
A deviation from Protocol, Demo Plan or QAPP/SAP (circle one)

Description:

Impact on project:

APPROVED BY: _____ _____
Dennis Smithenry, Project Manager **Date**

Reviewed by _____ Date (mm/dd/yy) _____

MISCELLANEOUS DOCUMENTATION

INITIALs: _____ Date / Time: _____

Reviewed by _____ Date (mm/dd/yy) _____

ATTACHMENT 2 to QAPP
FIELD STANDARD OPERATING PROCEDURES

HUNTERS POINT SHIPYARD PARCEL F

ESTCP DEMONSTRATION STUDY

Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment

Prepared for

Environmental Security Technology Certification Program

Project Number ESTCP ER-0510

Version 1.1

Clam/SPMD Deployment and Retrieval Field SOP

Macoma*/SPMD Deployment*

We will measure PCB bioaccumulation using particle-feeding *Macoma nasuta* clams native to San Francisco Bay. The work shall use small organisms (approximately 6-gram "whole clam with shell" wet weight, to reduce the slow internal equilibration kinetics associated with larger organisms) of standard size (to minimize size-related accumulation effects).

1. Prior to receiving clams, set up four large 10 gallon aquarium each with 8 gallon of water, replicating SF Bay temperature (± 2ºC) and interstitial salinity (± 1‰). No sediment required. Aeration of water will begin at least one day prior to receiving clams.
2. 450 *Macoma nasuta* clams will be ordered and shipped from Aquatic Research Organisms (ARO, POC: Stan. 1-800-927-1650, Hampton, NH) to Dennis Smithenry at Stanford less than four days prior to deployment. ARO will be instructed to provide small animals with shell lengths in the range of 1 to 1.25 inches. These orders shall arrive without water, either on moist paper towels or in a plastic bag.
3. On receipt, the bags will be opened. The *Macoma* will be grouped according to size, and a small size class (approximately 175 organisms) selected for the deployment based on small size and number available. Length and mass of whole clams will be recorded. Selected animals shall be marked with a marker pen to aid identification on recovery.
4. The selected clams shall be allowed to gradually acclimate to aquarium conditions (over 2-3h) by suspending them in the plastic bag in the aquarium, and gradually introducing aquarium water. Once they are at equilibrium with the aquarium, they can be placed on the bottom of the aquarium. Aeration should be maximized at this time, the clams shall not be fed, and 50% water can be exchanged every 2d.
5. From the remaining clams, an additional thirty *Macoma* will be selected and sacrificed. These clams will be used to analyze background PCBs. These clams should be sacrificed using the following procedure:
   a. Open *Macoma*
   b. Remove wet tissue, wash if necessary (if sediment is on gills), dry by draining or dabbing with a KimWipe, and store each whole clam tissue in a separate, labeled 20 mL scintillation vial
   c. Record wet weight
   d. Immediately place jars in -10 ºC freezer.
   e. These thirty individual whole clam samples will be shipped to ERDC on dry ice for homogenization and splitting. Half of the homogenate will be analyzed by ERDC, while the other half will be shipped on dry ice to BDO for archival at -10 ºC.
6. The *Macoma* will be inspected at least every 24h, and dead animals removed. Damaged animals shall be discarded.
7. One day prior to deployment, the 20 clam tubes, with SPMDs attached on the inside, shall be placed at Hunters Point. The clam tubes shall be placed in the five sampling locations in each plot as defined in Figure A-5 of the QAPP.
8. On the day of deployment, *Macoma* shall be transferred from Stanford to Hunters Point within 2h of removal from aquaria. For transportation, *Macoma* shall be placed in a cooler. The cooler shall have wet ice at the base, with sufficient paper toweling above to protect them from burning. 120 clams (20 tubes, 6 clams per tube) will be placed into the tubes and allowed to burrow into the sediment. After one hour, *Macoma* will be checked to ensure that they have burrowed. Any animals still on the surface shall be replaced.
9. One day after deployment, all *Macoma* will be checked to ensure that they have buried. Any animals still on the surface shall be replaced.

Macoma *Retrieval*

1. Clams shall be retrieved for PCB congener analysis after one month of contact with field sediment.
2. For clam retrieval, the sediment shall be dug out carefully by hand, at approximately 1" intervals. Record survival. The depth penetration of each recovered clam shall be recorded.
3. Place clams from each tube in a separate, labeled and vented polyethylene storage jar. Place jar on top of wet paper towels, above wet ice on the base of a cooler. Transport to Stanford environmental chambers within 2h. SPMDs will be removed from the inside of the clam tubes, gently rinsed with bay water to remove attached sediment, and placed in a pre-cleaned glass jar with Teflon-lined lid. These glass jars will be placed into a cooler containing wet ice and transported to Stanford within 2h.

Clam/SPMD Deployment and Retrieval Field SOP (continued)

4. *Depuration*.
   a. Clams shall be depurated in clean sediment for 24h and then in seawater for 48h prior to sacrifice.
   b. Prior to depuration, *Macoma* shall be removed briefly from their polyethylene storage jar while a clean reference sediment is introduced. Then the clams will be placed into the top of this sediment and allowed to burrow. Once a majority of the clams have burrowed, the jars containing both the sediment and clams may then be immersed into the aquaria used in the initial equilibration stage. A conference call will be arranged between BDO, Stanford, and ERDC if survival rate is lower than 3 out of 6 deployed clams per tube, to discuss new splitting procedures if necessary.
   c. After 48h of depuration, *Macoma* shall be removed and processed.
5. After clams and SPMDs are removed, the tubes shall be pulled from the sediment.

Macoma *Sample Processing*

1. After depuration, each surviving clam will be shucked and each resulting clam tissue will be placed into a separate pre-cleaned 20 mL scintillation vial
2. *Macoma* shall be shucked by ERDC or Stanford personnel. These clams should be sacrificed using the following procedure:
   a. Open *Macoma*
   b. Remove wet tissue, wash if necessary (if sediment is on gills), dry by draining or dabbing with a KimWipe, and store each whole clam tissue in a separate, labeled 20 mL scintillation vial
   c. Record wet weight
   d. Immediately place jars in -10℃ freezer.
3. Assuming no mortality, we expect that each *Macoma* collection period would yield 120 clams (6 clams from 20 tubes).
4. Once frozen, the clam tissue samples will be shipped overnight (on dry ice in a cooler) to ERDC.
5. At ERDC each set of six (or total number surviving) clams that came from a given clam tube will be homogenized and split.
6. Half of each homogenate will be analyzed by ERDC, while the other half will be shipped on dry ice to BDO for archival at -10℃.

Core Sampling Field SOP

Two-inch-diameter sediment core samples will be taken at each sampling time point at the five randomly-selected sampling locations in each plot as defined in Figure A-5 of the QAPP. A total of 60 core samples will be taken during the entire project. An acceptable core length will be between 12-14 inches.

To take a core sample:

1. Position a clean butyrate core liner (pre-labeled) on and perpendicular to the sediment surface.
2. Slowly tap the liner down into the sediment using a hammer until the corer is twelve to fourteen inches below the sediment surface.
3. Place a liner cap onto the top of core liner to form a seal and slowly pull core directly upward out of sediments.
4. Turn core liner on its side (in the air) and place a liner cap on the bottom.
5. Record the core length. If the length is not 12-14 inches long, reject the core and return to Step 1.
6. Clean the outside walls of the core liner with paper towels and place upright in cooler.
7. Transport cores to laboratory within 8 hours and then place in 4°C refrigerated cooler for future processing.

To avoid cross-contamination in core samples collected for TOC and PCB analysis, a separate pre-cleaned core liner will be used to collect and contain each sample. The core sample will be capped at both ends to seal in the sediment, which will not be removed from the liner until it is opened for processing under controlled laboratory conditions.

Amphipod Retrieval Field SOP

1. Five replicate amphipod samples shall be collected at each sampling time point at the five randomly-selected sampling locations in each plot as defined in Figure A-5 of the QAPP
2. All samples will be obtained from areas of similar habitat / hydrology (i.e., based upon contours of the tide)
3. For each replicate sample:
   a. Surface samples (0 – 2 cm) shall be collected using a trowel
   b. Each replicate sample shall be placed into a separate wide-mouthed polyethylene jar with a vented lid.
   c. Collected amphipods shall be maintained in a cooler at <18 ℃ and transferred to laboratory conditions within 2h of collection
   d. In the laboratory, the amphipods shall be removed from the sediment using a 500 µm sieve. Material will be passed through the sieve(s) using San Francisco Bay water.
   e. Each replicate shall include sufficient tissue for analysis of PCBs in native amphipods.
   f. Where possible, c. 200 mg wet weight will be collected per sample (i.e., c. 200 - 300 amphipods will be collected per replicate).
   g. Amphipods shall be depurated for 24 h using San Francisco Bay seawater receiving trickle flow aeration in a cold room facility at 15 °C.
4. Following depuration, amphipods from each sampling location shall be removed and weighed by placing them into tarred and pre-cleaned 20 mL scintillation vials. Samples will be immediately frozen.
5. Additional amphipods shall be collected and archived for later species identification, if necessary.
6. Once frozen, samples will be shipped on dry ice to ERDC for homogenization and splitting. Half of the resulting homogenate sample will be analyzed by ERDC, while the other half will be shipped on dry ice to BDO for archival at -10 ℃.

Quadrat Sieving For Benthic Community Samples Field SOP

1. Five replicate benthic community samples shall be taken at each sampling time point at the five randomly-selected sampling locations in each plot as defined in Figure A-5 of the QAPP. These samples will be collected using methods based on those for previous W-EMAP sampling strategies for Bay area benthic communities, including Hunters Point.
2. Surface sediment (0 - 10 cm) will be collected using a corer (25 cm by 25 cm) from each randomly selected quadrant, and samples shall be placed in separate, labeled plastic buckets prior to processing.
3. Samples will be sieved at Weston Solutions laboratories, at Stanford, or in the field as follows:
   a. Manageable aliquots of each sediment sample will be passed through a 500 µm sieve. If course materials are present in the samples, a 1000 or 2000 µm sieve will be stacked upon the 500 µm sieve. Material will be passed through the sieve(s) using San Francisco Bay water, and gentle shaking/spraying. Materials retained in the 500 µm sieve will be backwashed into storage containers. The 1000 or 2000 µm sieve will be thoroughly inspected for the presence of larger invertebrates. Coarse materials will be preserved separately.
   b. Removed benthic organisms will be stored in wide-mouth containers, after removing any debris and excess sediment, as necessary.
   c. Samples will be preserved in 10% formaldehyde, and shipped to ERDC Vicksburg for identification.
4. Once at ERDC, samples will be further sieved, if necessary, to better separate organisms from sediment particles.
5. If deemed necessary to facilitate sample sorting, vital stains (e.g., Rose Bengal) and / or floatation (e.g., sugar) will be employed.
6. Samples will be placed into white pans for sorting by backwashing sieves. Sieves will be examined to ensure all invertebrates are removed.
7. Samples will be immersed in water and invertebrates will be removed using soft-touch forceps.
8. Similar invertebrates (i.e., a rough taxon) will be grouped and placed into labeled vials containing 70% ethanol; this will be repeated for each group of invertebrates with a similar bauplan.
9. Vials from each replicate will be placed in a labeled plastic zipper bag and stored until required for classification
10. Remaining sample materials will be saved and 10% of samples will be re-sorted by another technician for QC purposes.
11. Organisms will be identified using a dissecting microscope to the lowest practical taxonomic designation according to standard keys (e.g., Smith and Carlton, 1975; Kozloff, 1987; or similar)
12. Organisms within each taxon will be enumerated and biological metrics of population (e.g., relative abundance and biotic-integrity-type assessments) and community (e.g., richness, diversity) levels of organization will be determined for each replicate sample
13. An integrated suite of univariate and multivariate analyses will be conducted to analyze effects of treatment, time, and plot on benthic community structure
14. Sorted organisms shall be archived for the duration of the project, to ensure temporal taxonomic standardization.

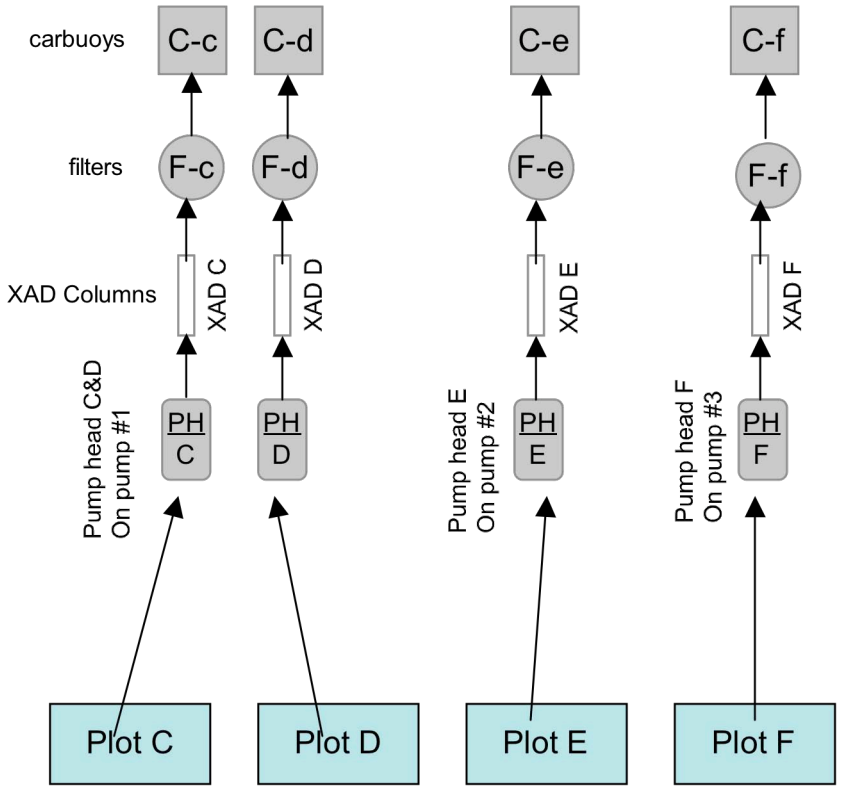
Surface Water Collection Field SOP

Overlying water above all four plots will be sampled simultaneously soon after the high tide recovers the plots. This sampling event for the five plots will be repeated after the first set of samples is obtained. The inlet of the sampling tube will be positioned and anchored 0.5 ft above the sediment surface and submerged under water during high tide. The method involves sampling nearly 20 L of water per sample from the field, pumping the water through a pre-combusted glass fiber filter paper with a nominal pore size of 0.7 microns, and passing the filtered water through a pre-cleaned XAD-2 resin adsorbent column. The filter paper samples will be transferred to a glass container with a Teflon™-lined lid. The XAD-2 resin column will be tightly capped. The filter paper containing the suspended particulates and the XAD-2 resin columns containing trapped dissolved PCBs will be shipped in a cooler to the UMBC laboratory for extraction and PCB analysis. The surface water sampling involves the following steps:

1. Check clean XAD-2 resin columns stored in the refrigerator and place in a cooler for transport to the field. There should be two XAD-2 resin columns for sampling at each treatment plot and one extra for the field sampling effort at each time.
2. Check the pre-combusted glass fiber filter papers and transfer to a container for transport to the field. There should be at least five filter papers for each water sample (forty for duplicate sampling in four treatment plots).
3. Make sure that the lead-acid batteries for the field water-pumps are fully charged.
4. Ensure that the following checklist of major equipment and supplies are carried to the field for water sampling:
   a. Three water pumps with two pump heads on each pump.
   b. Three + 1 spare pump batteries.
   c. Four 142 mm stainless steel pressure filters.
   d. ¼ inch Teflon tubing of adequate length to cover the sampling distances involved.
   e. XAD-2 resin columns.
   f. Pre-combusted filter papers.
   g. Wrenches to open and close the stainless steel pressure filters.
   h. Four graduated plastic carbuoys to hold and measure the volume of water sampled.
   i. Eight glass jars with Teflon-lined caps to hold the used filter papers .
   j. Field sampling data sheet and logbook to enter field notes.
   k. Stakes and ties to position the sampling tubes.
   l. A pack of medium size disposable nitrile gloves.
   m. Roll of tissue paper.
   n. Two 1-gallon jugs of distilled water.
   o. Three folding tables to keep the sampling equipment in the field.
5. Reach sampling site 1 hr before lowest tide point and setup the sampling equipment as described in the steps below and illustrated in the schematic on the next page.
6. At low tide, when the treatment plots are exposed, position the stakes and tie down four sampling tubes such that the sampling end of the tubes are at the center of each treatment plot and are 6” above the sediment surface.
7. Connect the other end of the Teflon sampling tubes to the inlet of the pump tubing.
8. Attach the inlet of each pressure filter to the outlet of each pump head.
9. Attach the inlet end of each XAD-2 resin column to the outlet of the pressure filter.

Surface Water Collection Field SOP (continued)

10. Attach tubing to the outlet end of the XAD-2 resin column to collect the effluent water in a labeled and graduated carbuoy.
11. Have an assistant double-check to make sure that the connections are made correctly to the matching set of sampling equipment.
12. Start the pump once the sampling tube is submerged in water with the rising tide. Purge the pump and tubing with 2L of water before starting sample collection.
13. Replace filter papers as soon as clogging is evident from reduced flow rates. Typically, filters will need to be changed after each 5 liters of water sampling.
14. Collect used filters from each filter holder separately in labeled glass jars.
15. Based on our preliminary study at Hunters Point, 20 L of sampled water will provide adequate PCB sample in the XAD-2 columns and filters for quantitative PCB analysis.
16. At the conclusion of the first 20 L sample, collect another 20 L at each plot for a duplicate measurement.
17. At the conclusion of the duplicate sample collection, dismantle the setup, retrieve sample tubes, ensure all filter collection bottles and XAD-2 resin columns are correctly labeled and packed in a cooler.
18. Clean filter holders and pump heads with distilled water to prevent corrosion from salt water. Also, wipe the outside of the pumps and battery to remove any deposits of salt water.



Surface Sediment Collection Field SOP

Surface sediment samples will be taken at 24-month post-treatment assessment event at the five randomly-selected sampling locations in each plot as defined in Figure A-5 of the QAPP.

To take a surface sample sample:

1. Surface sediment samples (0-5mm) shall be collected using a clean stainless steel blade.
2. Each replicate sample shall be placed into placed in a pre-cleaned glass jar with Teflon-lined lid. These glass jars will be placed into a cooler containing wet ice and transported to Stanford within 2 hour.
3. Place in 4℃ refrigerated cooler for future processing.

Sediment Collection for Ex-situ Bioassay Field SOP

Sediment samples will be taken at 24-month post-treatment assessment event at the five randomly-selected sampling locations in each plot as defined in Figure A-5 of the QAPP.

To take a sediment sample:

1. Sediment samples (0-6inch) shall be collected using a shovel at the five sampling locations with an area of 2 ft by 2 ft in each plot and placed into clean 2-gal plastic buckets.
2. The five sediment samples in each plot shall be sieved with a 4 mm stainless steel wire mesh screen to remove shell and coarse sand material and combined into a large plastic bucket.
3. Minimum amount of site seawater shall be used to help the sieving process.
4. The composite sediment sample shall be transferred into two 5-gal plastic buckets, and wait to settle.
5. Excessive supernatant will be removed.
6. The buckets shall be placed into a cooler and shipped on dry ice to ERDC for homogenization and splitting.

Schedule for ESTCP Plot Treatments and Sampling Events

Hunters Point Naval Shipyard Parcel F
2005-2008

Date – [t= months since treatment]	Field Work Description	Time of Field Work	Low Tide Time	Low Tide (ft)	Sun-rise	Sun-set
Pre-Treatment Sampling						
12/12/05 (M) [t = -1.5]	Collect Sediment Cores, Quadrats, and Amphipods	13:00 – 18:00	16:01	-0.7	7:15	16:51
12/13/05 (Tu)	Deploy Clams and SPMDs, Water Sampling	14:00 – 22:00	16:45	-1.0	7:16	16:51
1/10/06 (Tu) [t = -0.5]	Retrieve Clams and SPMDs (Day 1)	13:00 – 18:00	15:49	-0.6	7:25	17:10
1/11/06 (W)	Retrieve Clams and SPMDs (Day 2)	14:00 – 18:00	16:34	-0.8	7:24	17:11
Treatments						
1/25/06 (W) [t = 0]	Mixing and AC treatments (Day 1)	7:00 – 18:00	15:00	-0.3	7:18	17:26
1/26/06 (Th)	Mixing and AC treatments (Day 2)	7:00 – 18:00	15:49	-0.9	7:18	17:27
1/27/06 (F) if needed	Mixing and AC treatments (Day 3)	8:00 – 18:00	16:36	-1.4	7:17	17:28
1/28/06 (Sa) if needed	Mixing and AC treatments (Day 4)	14:00 – 20:00	17:21	-1.6	7:16	17:29
Post-Treatment Samplings						
1/29/06 (Su) [t = 0.05]	Water Sampling	16:00 – 22:00	18:04	-1.7	7:15	17:30
6/30/06 (F) [t = 5]	Water Sampling	8:00 – 14:00	9:47	-0.1	5:50	20:35
7/13/06 (Th) [t = 5.5]	Collect Sediment Cores, Quadrats, and Amphipods	6:00 – 12:00	8:29	-1.6	5:58	20:31
7/14/06 (F)	Deploy Clams and SPMDs	6:00 – 12:00	9:10	-1.2	5:58	20:31
8/11/06 (F) [t = 6.5]	Retrieve Clams and SPMDs (Day 1)	6:00 – 12:00	8:02	-0.9	6:21	20:06
8/12/06 (Sa)	Retrieve Clams and SPMDs (Day 2)	6:00 – 12:00	8:41	-0.3	6:22	20:05
6/29/07 (F) [t = 17]	Water Sampling	6:00 – 11:00	6:19	-1.0	5:50	20:35
7/16/07 (M) [t = 17.5]	Collect Sediment Cores, Quadrats, and Amphipods	6:00 – 12:00	8:10	-1.1	6:00	20:30
7/17/07 (Tu)	Deploy Clams and SPMDs	6:00 – 12:00	8:45	-0.7	6:00	20:29
8/13/07 (M) [t = 18.5]	Retrieve Clams and SPMDs (Day 1)	6:00 – 12:00	7:07	-0.6	6:23	20:04
8/14/07 (Tu)	Retrieve Clams and SPMDs (Day 2)	6:00 – 12:00	7:38	-0.2	6:23	20:03
1/22/08 (Tu) [t = 24]	Collect Surficial Sediment and Composite Sediment Samples	15:00 – 18:00	18:07	-1.3	7:21	17:21
1/23/08 (W)	Suspended Solids Sampling	15:30 – 18:00	18:46	-1.0	7:21	17:33

ATTACHMENT 3 to QAPP
DEVIATIONS AND ADD-ONS

HUNTERS POINT SHIPYARD PARCEL F

ESTCP DEMONSTRATION STUDY

Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment

Prepared for

Environmental Security Technology Certification Program

Project Number ESTCP ER-0510

Deviations and Add-ons from the Demonstration Plan

- At the end of January 2006, activated carbon treatments to the PCB-contaminated sediment were completed at our field site using equipment from our two subcontractors. We utilized Aquatic Environments' Aquamog and Compass Environmental's Injection System at Hunters Point Naval Shipyard to complete three of the four planned plot treatments: Plot C (Aquamog, Mix Only), Plot D (Aquamog, AC/Mix), and Plot F (Injector, AC/Mix). Unfortunately, we were unable to complete the mixing control for Plot G (Injector, Mix Only), since the sediment surface of this plot was not stable enough to support the excavator's weight. Therefore we assessed four test plots excluding Plot G, and Plot C was considered as a mixing control for both mixing technologies.
- In the demo plan, we planned two post-treatment assessments: 6-months and 18-months after AC-deployment. In the actual demonstration, we additionally conducted 24-months post-treatment assessments comprising ex-situ clam bioassays and characterizations of surficial sediment. The purpose of this additional assessment was to identify field factors occurring over 18- to 24-months that affect AC-amendment performance, and to confirm the benefit of AC-amendment to test organisms.
- In the demo plan, we proposed to use same sampling locations for all post-treatment sampling events. However, to avoid altering the sediment layer by prior sampling events, the sampling locations at each post-treatment sampling event were differently selected based on a random sampling plan.
- In addition to the analytical assessments proposed in the demo plan, we added two analytical methods to validate our results/findings. These include black carbon (BC) contents measurement and C-13 isotope measurement in the treated sediment and the deposited surficial material.
- In addition to 28-day exposure experiment of SPMD, long-term SPMD exposure study was conducted 13 months after AC amendment to investigate long-term effectiveness of AC amendment.
- In addition to 28-day exposure experiment of SPMD, we utilized another passive sampler, polyethylene devices (PEDs) that can give comparable field signals to those from SPMDs.

ATTACHMENT 4 to QAPP
METHOD DETECTION LIMITS AND REPORTING LIMITS FOR PCB ANALYSES

HUNTERS POINT SHIPYARD PARCEL F

ESTCP DEMONSTRATION STUDY

Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment

Prepared for

Environmental Security Technology Certification Program

Project Number ESTCP ER-0510

PCB congeners	MDL (Sed)	MDL (SPMD)	40L sample (water sample)	780mL sample (aq.eq.)
	mg/kg	ng	ng/L	ng/L
1	0.27	0.80	0.004	1.03
3	0.53	1.58	0.058	2.02
4 + 10	0.11	0.33	0.013	0.42
7 + 9	0.05	0.16	0.002	0.20
6	0.11	0.32	0.013	0.40
8 + 5	0.07	0.22	0.028	0.28
12 + 13	0.07	0.20	0.003	0.25
18	0.07	0.21	0.002	0.27
15 + 17	0.11	0.32	0.005	0.40
24 + 27	0.03	0.10	0.002	0.13
16 + 32	0.08	0.24	0.011	0.30
26	0.05	0.16	0.002	0.20
25	0.04	0.12	0.003	0.15
31	0.06	0.17	0.006	0.22
28	0.04	0.13	0.001	0.16
21 + 33	0.06	0.18	0.013	0.23
53	0.05	0.14	0.016	0.18
51	0.03	0.10	0.001	0.13
22	0.07	0.21	0.006	0.27
45	0.05	0.14	0.006	0.18
46	0.05	0.15	0.004	0.19
52+49	0.07	0.20	0.005	0.26
43	0.04	0.11	0.001	0.14
47	0.03	0.10	0.001	0.13
48	0.04	0.12	0.003	0.15
44	0.05	0.15	0.001	0.19
37 + 42	0.06	0.17	0.005	0.22
41 + 71	0.08	0.25	0.004	0.32
64	0.02	0.07	0.001	0.08
40	0.04	0.11	0.005	0.15
100	0.03	0.09	0.001	0.11
63	0.04	0.11	0.004	0.13
74	0.03	0.10	0.004	0.13
70 + 76	0.03	0.10	0.002	0.12
66	0.05	0.16	0.002	0.20

PCB congeners	MDL (Sed)	MDL (SPMD)	40L sample (water sample)	780mL sample (aq.eq.)
	mg/kg	ng	ng/L	ng/L
95	0.05	0.16	0.002	0.20
91	0.07	0.21	0.001	0.27
56 + 60	0.16	0.49	0.004	0.63
92 + 84 + 89	0.05	0.15	0.003	0.20
101	0.06	0.18	0.002	0.23
99	0.05	0.14	0.001	0.18
119	0.02	0.07		0.09
83	0.04	0.13	0.002	0.17
97	0.04	0.11	0.002	0.14
81 + 87	0.04	0.13	0.002	0.17
85	0.05	0.14	0.002	0.19
136	0.07	0.22	0.002	0.28
77 + 110	0.05	0.16	0.004	0.20
82	0.03	0.08	0.002	0.10
151	0.03	0.10	0.002	0.12
135 + 144 + 147 + 124	0.03	0.10	0.002	0.13
107	0.03	0.08		0.10
123 + 149	0.03	0.10	0.003	0.12
118	0.03	0.09	0.004	0.11
134	0.02	0.06	0.001	0.08
114 + 131	0.03	0.09	0.001	0.12
146	0.03	0.09	0.005	0.11
153	0.03	0.08	0.002	0.10
105	0.01	0.02	0.001	0.02
132	0.02	0.05	0.001	0.06
141	0.03	0.10	0.003	0.13
137 + 176 + 130	0.02	0.06	0.001	0.07
163 + 138	0.03	0.10	0.001	0.12
158	0.03	0.08	0.001	0.10
178	0.04	0.12	0.005	0.15
187 + 182	0.03	0.08	0.002	0.10
183	0.03	0.09	0.001	0.11
128	0.02	0.05	0.004	0.06
185	0.02	0.05	0.002	0.07

PCB congeners	MDL (Sed)	MDL (SPMD)	40L sample (water sample)	780mL sample (aq.eq.)
	mg/kg	ng	ng/L	ng/L
174	0.03	0.08	0.005	0.11
177	0.03	0.09	0.002	0.12
202 + 171 + 156	0.03	0.10	0.003	0.12
157 + 200	0.02	0.07	0.005	0.09
172	0.03	0.09	0.001	0.12
197	0.02	0.07	0.001	0.10
180	0.02	0.07	0.001	0.09
193	0.03	0.08	0.002	0.11
191	0.03	0.09	0.001	0.12
199	0.02	0.07	0.002	0.09
170 + 190	0.02	0.06	0.002	0.07
198	0.02	0.05	0.001	0.06
201	0.04	0.12	0.002	0.16
203 + 196	0.04	0.12	0.001	0.15
189	0.02	0.07		0.09
208 + 195	0.02	0.06	0.001	0.07
207	0.02	0.05	0.001	0.06
194	0.02	0.06	0.001	0.08
205	0.02	0.07	0.001	0.09
206	0.02	0.07	0.002	0.09
209	0.01	0.04	0.001	0.06

Organism	Sampling event	Sample ID	Rep	RL (µg/kg)	DL (µg/kg)
Macoma	2005 (t = 0)	C	1	0.66	0.2200
Macoma	2005 (t = 0)	C	2	1.8	0.6000
Macoma	2005 (t = 0)	C	3	1.1	0.3667
Macoma	2005 (t = 0)	C	4	1.5	0.5000
Macoma	2005 (t = 0)	D	1	1.1	0.3667
Macoma	2005 (t = 0)	D	2	0.76	0.2533
Macoma	2005 (t = 0)	D	3	1.0	0.3333
Macoma	2005 (t = 0)	D	4	1.1	0.3667
Macoma	2005 (t = 0)	D	5	1.1	0.3667
Macoma	2005 (t = 0)	E	1	1.3	0.4333
Macoma	2005 (t = 0)	E	2	1.4	0.4667
Macoma	2005 (t = 0)	E	3	1.4	0.4600
Macoma	2005 (t = 0)	E	4	2.1	0.6867
Macoma	2005 (t = 0)	E	5	1.5	0.4833
Macoma	2005 (t = 0)	F	1	0.9	0.3033
Macoma	2005 (t = 0)	F	2	1.6	0.5333
Macoma	2005 (t = 0)	F	3	1.0	0.3233
Macoma	2005 (t = 0)	F	4	1.5	0.5000
Macoma	2005 (t = 0)	F	5	1.0	0.3333
Macoma	2005 (t = 0)	G	1	1.7	0.5567
Macoma	2005 (t = 0)	G	2	1.6	0.5333
Macoma	2005 (t = 0)	G	3	2.1	0.7000
Macoma	2005 (t = 0)	G	4	1.3	0.4333
Macoma	2006 (t = 6)	C	1	0.33	0.1100
Macoma	2006 (t = 6)	C	2	0.33	0.1100
Macoma	2006 (t = 6)	C	3	0.34	0.1133
Macoma	2006 (t = 6)	C	4	0.33	0.1100
Macoma	2006 (t = 6)	C	5	0.33	0.1100
Macoma	2006 (t = 6)	D	1	0.33	0.1100
Macoma	2006 (t = 6)	D	2	0.36	0.1200
Macoma	2006 (t = 6)	D	3	0.39	0.1300
Macoma	2006 (t = 6)	D	4	0.33	0.1100
Macoma	2006 (t = 6)	D	5	0.33	0.1100
Macoma	2006 (t = 6)	E	1	0.81	0.2700
Macoma	2006 (t = 6)	E	2	0.31	0.1033
Macoma	2006 (t = 6)	E	3	0.33	0.1100
Macoma	2006 (t = 6)	E	4	0.35	0.1167
Macoma	2006 (t = 6)	E	5	0.33	0.1100
Macoma	2006 (t = 6)	F	1	0.34	0.1133
Macoma	2006 (t = 6)	F	2	0.34	0.1133
Macoma	2006 (t = 6)	F	3	0.4	0.1333
Macoma	2006 (t = 6)	F	4	0.32	0.1067
Macoma	2006 (t = 6)	F	5	0.33	0.1100
Macoma	2006 (t = 6)	BKGD	1	0.33	0.1100
Macoma	2006 (t = 6)	BKGD	2	0.33	0.1100
Macoma	2006 (t = 6)	BKGD	4	0.3	0.1000

Organism	Sampling event	Sample ID	Rep	RL (µg/kg)	DL (µg/kg)
Macoma	2007 (t = 18)	C	1	0.31	0.1033
Macoma	2007 (t = 18)	C	2	0.34	0.1133
Macoma	2007 (t = 18)	C	3	0.32	0.1067
Macoma	2007 (t = 18)	C	4	0.32	0.1067
Macoma	2007 (t = 18)	C	5	0.32	0.1067
Macoma	2007 (t = 18)	D	1	0.34	0.1133
Macoma	2007 (t = 18)	D	2	0.32	0.1067
Macoma	2007 (t = 18)	D	3	0.52	0.1733
Macoma	2007 (t = 18)	D	4	0.33	0.1100
Macoma	2007 (t = 18)	D	5	0.33	0.1100
Macoma	2007 (t = 18)	E	1	0.33	0.1100
Macoma	2007 (t = 18)	E	2	0.33	0.1100
Macoma	2007 (t = 18)	E	3	0.31	0.1033
Macoma	2007 (t = 18)	E	4	0.33	0.1100
Macoma	2007 (t = 18)	E	5	0.33	0.1100
Macoma	2007 (t = 18)	F	1	0.33	0.1100
Macoma	2007 (t = 18)	F	2	0.32	0.1067
Macoma	2007 (t = 18)	F	3	0.31	0.1033
Macoma	2007 (t = 18)	F	4	0.33	0.1100
Macoma	2007 (t = 18)	F	5	0.40	0.1333
Macoma	2007 (t = 18)	BKGD	1	0.32	0.1067
Macoma	2007 (t = 18)	BKGD	2	0.20	0.0667
Macoma	2007 (t = 18)	BKGD	3	0.29	0.0967
Macoma	2007 (t = 18)	BKGD	4	0.34	0.1133
Macoma	2007 (t = 18)	BKGD	5	0.33	0.1100
Macoma	2008 (ex situ)	C	1	0.22	0.0733
Macoma	2008 (ex situ)	C	2	0.24	0.0800
Macoma	2008 (ex situ)	C	3	0.24	0.0800
Macoma	2008 (ex situ)	C	4	0.25	0.0833
Macoma	2008 (ex situ)	C	5	0.21	0.0700
Macoma	2008 (ex situ)	D	1	0.22	0.0733
Macoma	2008 (ex situ)	D	2	0.23	0.0767
Macoma	2008 (ex situ)	D	3	0.25	0.0833
Macoma	2008 (ex situ)	D	4	0.24	0.0800
Macoma	2008 (ex situ)	D	5	0.26	0.0867
Macoma	2008 (ex situ)	E	1	0.24	0.0800
Macoma	2008 (ex situ)	E	2	0.2	0.0667
Macoma	2008 (ex situ)	E	3	0.21	0.0700
Macoma	2008 (ex situ)	E	4	0.23	0.0767
Macoma	2008 (ex situ)	E	5	0.19	0.0633
Macoma	2008 (ex situ)	F	1	0.25	0.0833
Macoma	2008 (ex situ)	F	2	0.2	0.0667
Macoma	2008 (ex situ)	F	3	0.27	0.0900
Macoma	2008 (ex situ)	F	4	0.23	0.0767
Macoma	2008 (ex situ)	F	5	0.19	0.0633

Organism	Sampling event	Sample ID	Rep	RL (µg/kg)	DL (µg/kg)
Macoma	2008 (ex situ)	BKGD	1	0.27	0.0900
Macoma	2008 (ex situ)	BKGD	2	0.27	0.0900
Macoma	2008 (ex situ)	BKGD	3	0.2	0.0667
Macoma	2008 (ex situ)	BKGD	4	0.18	0.0600
Macoma	2008 (ex situ)	BKGD	5	0.24	0.0800
Amphipods	2005 (t = 0)	C	1	1.3	0.4333
Amphipods	2005 (t = 0)	C	2	3.6	1.2000
Amphipods	2005 (t = 0)	C	3	2.2	0.7333
Amphipods	2005 (t = 0)	C	4	3	1.0000
Amphipods	2005 (t = 0)	D	1	2.2	0.7333
Amphipods	2005 (t = 0)	D	2	1.5	0.5000
Amphipods	2005 (t = 0)	D	3	2.0	0.6667
Amphipods	2005 (t = 0)	D	4	2.2	0.7333
Amphipods	2005 (t = 0)	D	5	2.2	0.7333
Amphipods	2005 (t = 0)	E	1	2.6	0.8667
Amphipods	2005 (t = 0)	E	2	2.8	0.9333
Amphipods	2005 (t = 0)	E	3	2.8	0.9200
Amphipods	2005 (t = 0)	E	4	4.1	1.3733
Amphipods	2005 (t = 0)	E	5	2.9	0.9667
Amphipods	2005 (t = 0)	F	1	1.8	0.6033
Amphipods	2005 (t = 0)	F	2	3.1	1.0300
Amphipods	2005 (t = 0)	F	3	1.9	0.6433
Amphipods	2005 (t = 0)	F	4	3.1	1.0167
Amphipods	2005 (t = 0)	F	5	2.1	0.6933
Amphipods	2005 (t = 0)	G	1	1.7	0.5567
Amphipods	2005 (t = 0)	G	2	3.3	1.0900
Amphipods	2005 (t = 0)	G	3	4.1	1.3667
Amphipods	2005 (t = 0)	G	4	2.5	0.8433
Amphipods	2006 (t = 6)	C	1	1.1	0.3667
Amphipods	2006 (t = 6)	C	2	0.96	0.3200
Amphipods	2006 (t = 6)	C	3	1.1	0.3667
Amphipods	2006 (t = 6)	C	4	0.7	0.2333
Amphipods	2006 (t = 6)	C	5	1	0.3333
Amphipods	2006 (t = 6)	D	1	1.4	0.4667
Amphipods	2006 (t = 6)	D	2	1.1	0.3667
Amphipods	2006 (t = 6)	D	3	1.1	0.3667
Amphipods	2006 (t = 6)	D	4	0.66	0.2200
Amphipods	2006 (t = 6)	D	5	1.1	0.3667
Amphipods	2006 (t = 6)	E	1	1	0.3333
Amphipods	2006 (t = 6)	E	2	0.84	0.2800
Amphipods	2006 (t = 6)	E	3	1.2	0.4000
Amphipods	2006 (t = 6)	E	4	1	0.3333
Amphipods	2006 (t = 6)	E	5	0.76	0.2533
Amphipods	2006 (t = 6)	F	1	1	0.3333
Amphipods	2006 (t = 6)	F	2	1.1	0.3667

Organism	Sampling event	Sample ID	Rep	RL (µg/kg)	DL (µg/kg)
Amphipods	2006 (t = 6)	F	3	0.82	0.2733
Amphipods	2006 (t = 6)	F	4	0.97	0.3233
Amphipods	2006 (t = 6)	F	5	0.6	0.2000
Amphipods	2007 (t = 18)	C	1	1.4	0.4667
Amphipods	2007 (t = 18)	C	2	1	0.3333
Amphipods	2007 (t = 18)	C	3	0.57	0.1900
Amphipods	2007 (t = 18)	C	4	1.1	0.3667
Amphipods	2007 (t = 18)	C	5	0.9	0.3000
Amphipods	2007 (t = 18)	D	1	0.7	0.2333
Amphipods	2007 (t = 18)	D	2	0.94	0.3133
Amphipods	2007 (t = 18)	D	3	0.95	0.3167
Amphipods	2007 (t = 18)	D	4	1	0.3333
Amphipods	2007 (t = 18)	D	5	0.86	0.2867
Amphipods	2007 (t = 18)	E	1	1	0.3333
Amphipods	2007 (t = 18)	E	2	0.97	0.3233
Amphipods	2007 (t = 18)	E	3	0.48	0.1600
Amphipods	2007 (t = 18)	E	4	0.75	0.2500
Amphipods	2007 (t = 18)	E	5	1.1	0.3667
Amphipods	2007 (t = 18)	F	1	0.8	0.2667
Amphipods	2007 (t = 18)	F	2	0.74	0.2467
Amphipods	2007 (t = 18)	F	3	0.97	0.3233
Amphipods	2007 (t = 18)	F	4	0.57	0.1900
Amphipods	2007 (t = 18)	F	5	0.77	0.2567

Appendix B: Points of Contact

POINT OF CONTACT Name	ORGANIZATION Name Address	Phone Fax E-mail	Role in Project
Dr. Todd Bridges	U.S. Army Engineering Research and Development Ctr. 3909 Halls Ferry Rd. Vicksburg, MS 39180	Phone: 601-634-3626 Fax: 601-634-3713 E-mail: Todd.S.Bridges@erdc.usace.army.mil	Bioaccumulation Studies Leader
YeoMyoung Cho	Stanford University Yang & Yamazaki Environment & Energy Building, Room M03, 473 Via Ortega, Stanford CA 94305-4020	Phone: 650-725-3025 Fax:650-725-3162 E-mail:daybreak@stanford.edu	Project Manager, Project QA Manager, and Physicochemical Studies Leader
Lance Dohman	Aquatic Environments, Inc.	Phone: 925-521-0400 Fax: 925-521-0403 E-mail: ldohman@aquamog.com	Mixing Technology A Leader
Mark A. Fleri	Compass Environmental, Inc.	Phone: 770-879-4075 Fax: 770-879-4831 E-mail: mfleri@compassenvironmental.com	Mixing Technology B Leader
Keith Forman	Base Realignment and Closure 1455 Frazee Road, Suite 900, San Diego, CA 92108-4310	Phone: 619-532-0913 Fax: 619-532-0955 E-mail: keith.s.forman@navy.mil	BRAC Environmental Coordinator, Hunters Point Shipyard
Glynis Foulk	Tetra Tech EM, Inc.	Phone : 916-853-4561 E-mail: glynis.foulk@ttemi.com	Health and Safety Officer
Dr. Upal Ghosh	University of Maryland Baltimore County, Technology Research Center Room 184 5200 Westland Blvd Baltimore, MD 21227	Phone: 410-455-8665 Fax: 410-544-6500 E-mail: ughosh@umbc.edu	Resuspension Studies Leader
Dane C. Jensen	Base Realignment and Closure 1455 Frazee Rd., Suite 900 San Diego, CA 92108-4310	Phone: 619-532-0789 E-mail: dane.c.jensen@navy.mil	Parcel F Remedial Project Manager
Dr. Andrea Lesson	Environmental Security Technology Certification Program	Phone: 703-696-2118 Fax: 703-696-2114 E-mail: andrea.leeson@osd.mil	Environmental Restoration Program Manager
Dr. Richard G. Luthy	Stanford University Yang & Yamazaki Environment & Energy Building, Room M313B, 473 Via Ortega, Stanford CA 94305-4020	Phone: 650-723-3921 Fax: 650-725-8662 E-mail: luthy@stanford.edu	Principal Investigator

Barbara Sugiyama	NFESC, Port Hueneme	Phone: 805-982-1668 E-mail: barbara.sugiyama@navy.mil	Contracting Officer's Representative

FINAL

SITE-SPECIFIC HEALTH AND SAFETY PLAN

Appendix C
HUNTERS POINT SHIPYARD PARCEL F
ESTCP FINAL REPORT

Prepared for:

ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM
1155 Herdon Parkway, Suite 900
Herndon, VA 20170

Prepared by:

STANFORD UNIVERSITY
Department of Civil and Environmental Engineering
Terman Engineering Center
Stanford, CA 94305-4020

December 5, 2005

(Adapted from original HASP from the Final Hunters Point Shipyard Parcel F Treatability Study Work Plan prepared for SOUTHWEST DIVISION NAVAL FACILITIES ENGINEERING COMMAND located at San Diego, CA for Project No. G477702 under Contract No. N68711-01-F-6102. The original HASP was prepared by Battelle in Duxbury, MA and Stanford University and distributed on August 1, 2004.)

SITE-SPECIFIC HEALTH AND SAFETY PLAN

Field Sampling Activities at Hunters Point Shipyard in San Francisco, California

Principal Investigator:	Richard Luthy (Stanford)
Project Managers:	Dennis Smithenry (Stanford)
Health and Safety Officer:	Glynis Foulk, CIH (Tetra Tech EM, Inc.)
RSO (ARSO)	Charles Stanfield (Tetra Tech EM, Inc.)
Site Radiation Safety Specialist:	Charles Stanfield (Tetra Tech EM, Inc.)
Date of Issue:	December 5, 2005

Authorization: Glynis Foulk — Safety and Health Representative — 11/16/05 — Date

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ACRONYMS AND ABBREVIATIONS

AC	activated carbon
ACGIH	American Conference of Governmental Industrial Hygienists
AEI	Aquatic Environments, Inc.
APR	Air Purifying Respirator
ARSO	Assistant Radiation Safety Officer
BBP	blood-borne pathogens
BTEX	benzene, toluene, ethylbenzene, and xylene
Cal-OSHA	California Occupational Safety and Health Administration
CCR	California Code of Regulations
CEI	Compass Environmental, Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CNS	central nervous system
COPEC	chemical of potential ecological concern
CPR	cardiopulmonary resuscitation
DP	demonstration plan
ESTCP	Environmental Security Technology Certification Program
FS	Feasibility Study
FSP	Field Sampling Plan
GI	gastrointestinal
HAZWOPER	Hazardous Waste Operations and Emergency Response
HSO	Site Health and Safety Officer
IR	Installation Restoration
IRP	Installation Restoration Program
MSDS	Material Safety Data Sheet
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEL	permissible exposure limit
PPE	personal protective equipment
ppm	parts per million
RSO	Radiation Safety Officer
RWQCB	Regional Water Quality Control Board
RCP	Radiological Control Plan
S-HASP	Site-Specific Health and Safety Plan
SPMDs	semipermeable membrane devices

STEL	short-term exposure limit
TLV	threshold limit value
TPH	total petroleum hydrocarbons
TTECI	Tetra Tech EC, Inc.
TtFW	Tetra Tech FW, Inc.
TWA	time-weighted average
UV	ultraviolet
WESI	Williams Environmental Services, Inc.

1.0 INTRODUCTION

This Site-Specific Health and Safety Plan (S-HASP) delineates the basic safety requirements for field activities to be performed at Hunters Point Shipyard (HPS) from November 2005 through June 2008. These activities will be conducted to support an Environmental Security Technology Certification Program (ESTCP) Demonstration Plan (DP). This S-HASP was prepared in compliance with the requirements of the California Occupational Safety and Health Administration (Cal-OSHA) standard for Hazardous Waste Operations and Emergency Response (Title 8 CCR, GISO 5192). This S-HASP should be used in conjunction with the ESTCP DP.

The provisions set forth in this S-HASP apply to all contractors and subcontractors (field personnel). Subcontractors may elect to modify these provisions, but only to upgrade or increase safety activities. This S-HASP may not thoroughly address all hazards associated with any specialized subcontractor operations; in this situation, subcontractors shall be responsible for developing their own Health and Safety Plans and procedures to adequately address their scope of operations at this site.

This S-HASP addresses the potential hazards that may be encountered for this project. If unanticipated changes in site or working conditions occur which are not addressed by this plan, addenda shall be provided.

1.1 Site Location and Background

HPS is situated on a peninsula in the southeast corner of San Francisco, CA. The peninsula is bounded on the north, east, and south by San Francisco Bay and on the west by the Bayview Hunters Point district. HPS comprises about 955 acres, with approximately 400 acres of offshore sediments. From 1945 to 1974, the Navy used HPS predominantly for ship repair and maintenance. HPS was deactivated in 1974 and remained relatively unused until 1976, when it was leased to Triple A Machine Shop, a private ship repair company. In 1986, the Navy resumed occupancy of HPS, but closed the Base in 1991.

Historical site activities at HPS resulted in the release of chemicals to the environment, including offshore sediments. Environmental restoration activities are conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Super-fund Amendments and Reauthorization Act of 1986 (SARA). The facility was closed under the Defense Base Realignment and Closure Act of 1990 (BRAC) and is in the process of conversion to nonmilitary use.

1.2 Scope of Work

The overall purpose of ESTCP DP project is to demonstrate that activated carbon (AC) sorbent mixed with sediment is a cost-effective, in situ, non-removal, management strategy for reducing the bioavailability of PCBs in offshore sediments at HPS site. The scope of the ESTCP DP is to:

1) Demonstrate and compare the effectiveness, in terms of homogeneity and depth of AC application, of two available large-scale mixing technologies,
2) Demonstrate and validate that AC treatment reduces the aqueous PCB availability and PCB bioaccumulation results in field tests, and
3) Evaluate sediment resuspension and PCB release.

Specific details regarding data collection activities are provided in the Quality Assurance Project Plan (QAPP) for the ESTCP DP. Detailed DQOs for the primary and secondary performance criteria are

provided in Tables A-2 and A-3 of the ESTCP DP. DQOs were developed following the guidelines presented in the United States Environmental Protection Agency's seven-step DQO process (U.S. EPA, 2000).

Five test plots (labeled C-G) of 370 ft^2 area will be used in the field study and analyzed in a "before and after treatment" experimental design. After pre-treatments samples are taken, two subcontractors to Stanford will apply treatments to four of the five plots, leaving one plot to serve as a control.

The first contractor, Aquatic Environments, Inc. (AEI), has a barge-like machine (called an Aquamog, Figure A-3) with a rotovator attachment that is typically used to disrupt weed growth in marshy areas. In the field demonstration, AEI will be responsible for the mobilization, storage, operation, and demobilization of the Aquamog to the Hunters Point Naval Shipyard field site in January 2006. In the field demonstration, the Aquamog will be deployed on the water during high tide and allowed to settle onto the sediment surface at low tide to do treatments on Plots C and D as shown in Figure A-2 of the QAPP. AEI will supply an ARGO amphibious support vehicle and any auxiliary equipment to the demonstration site that will be necessary to complete the treatments. Before mobilization of the Aquamog, AEI is also responsible for the design, development, and testing of a delivery system for transferring AC from the deck of the Aquamog to the plot surface. Besides delivering AC to the sediment surface, the Aquamog has a rotovator attachment that will be used to mix transferred AC into sediments into Plot D to an approximate depth of one foot. The depth of the mixing can be controlled by the speed and downward pressure of the rotovator. The rotovator attachment will also be used to mix (only) the sediments in Plot C to a depth of one foot. Plot E will receive no treatment as serve as the control plot.

The second contractor, Compass Environmental, Inc. (CEI) [formerly Williams Environmental Services, Inc. (WESI)], owns an injection system used traditionally for sediment solidification with cement mortar (Figure A-4). In Jan. 2006, CEI will provide its patented rake injector and other equipment necessary to support the treatments of Plots F and G. This equipment will be located on the shore with the injector arm reaching out to Plots F and G. Via a slurry, AC will be injected and mixed into the upper one foot of tidal zone sediments for Plot F. For Plot G, the sediments will be mixed using the rake injector mixers with no application of a AC slurry. CEI will provide the data necessary to demonstrate that the requisite carbon mass has been added to Plot F. CEI will record data such as slurry flow rate, slurry density, pump time, and slurry volume pumped into each test plot.

Because transportation, mobilization and operation of the equipment for these two subcontractors require specially trained personnel performing non-standard field operations, AEI and CEI shall be responsible for developing their own Health and Safety Plans and procedures to adequately address their scope of operations at this site. This S-HASP covers the hazards associated with field sampling activities.

The schedule of sampling and analysis that will occur before and after plot treatments is summarized in Table A-1 of the QAPP. Several types of field sampling activities will be performed for the ESTCP DP (most one-month before and 6- and 18-months after treatments occur):

- One-month deployments of test clams in PVC tubes sunk in plots
- Collection of indigenous amphipods in plots
- One-month deployments of semipermeable membrane devices (SPMDs) in plots
- Collection of benthic community samples from quadrats taken in plots
- Collection of push sediment core samples from plots
- Sampling of water column above plots at high tide

2.0 PROJECT SAFETY AUTHORITY

Personnel responsible for project safety are the Project Manager and the Site Health and Safety Officer (HSO) or his/her designee.

The Project Manager is responsible for the provisions and submittal of this plan, and for advising the HSO on health and safety matters. The Project Manager has the authority to provide for the auditing of compliance with the provisions of this plan, suspension or modification of work practices, and administration of disciplinary actions for individuals whose conduct does not meet the requirements set forth herein. The Project Manager may elect to give the HSO authority to administer disciplinary actions for individuals whose conduct does not meet the requirements set forth herein.

The HSO is responsible for the dissemination of the information contained in this plan to all personnel assigned to the project, and to the responsible representative of each Navy subcontractor firm working on the project. The senior field team member may also be designated as the HSO. As such, he or she is responsible for maintaining, performing or providing the following as necessary:

- Verification of that field team members are supervised by a HSO or designee that has completed the medical surveillance program examinations, and 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) training.
- Daily tailgate discussion of the site safety plan. Documentation of tailgate safety meetings in field notebook.
- Documentation of all accidents or S-HASP violations.
- Emergency contacts as needed.
- Implementation of Decontamination/Contamination Reduction Procedures (see Section 9.0).

The HSO or his/her designee has the authority to suspend work any time he or she determines that the health and safety practices at the site are inadequate. In such cases, the HSO also shall inform the Project Manager of individuals whose conduct is not consistent with the requirements of the plan.

The HSO has the responsibility to check in with the field Project Manager each day before commencing field operations. The HSO will disseminate any new information provided to the field team during tailgate safety meetings.

3.0 MEDICAL SURVEILLANCE

Any field personnel engaged in project operations that expose them to hazardous wastes, hazardous substances, or any combination of hazardous wastes or hazardous substances shall be participants in a Medical Surveillance program. These persons must be medically evaluated and cleared for use of respiratory protection devices and protective clothing for working with hazardous materials by the examining physician(s). The medical clearance shall be current within one year through at least the last day of field operations. The applicable requirements under the Cal-OSHA standards for HAZWOPER (Title 8 CCR, GISO 5192) and the Respiratory Protection Program (Title 8 CCR, GISO 5144) will be observed.

All field personnel shall bring proof of medical clearance from an approved source to the job site for inspection before beginning work. The HSO will be responsible for reviewing the proof of medical

clearance in accordance with the requirements described above and documenting this review in the field notes before those persons can commence work.

4.0 SAFETY/ORIENTATION TRAINING

This section presents the general and site-specific training requirements for this project in accordance with regulatory and client requirements. All field personnel shall bring proof of required training to the job site for inspection before beginning work. Training shall be provided by a qualified person and must cover certain content requirements. The HSO will be responsible for reviewing the proof of training in accordance with the requirements described below and documenting this review in the field notes before those persons may begin work.

4.1 General Training Requirements

General training requirements that apply to field personnel on this project are described below. The majority of the field staff meet or exceed the minimum requirements as defined below and are 40 hour HAZWOPER trained.

4.1.1 HAZWOPER

Field personnel engaged in project operations that potentially expose them to hazardous wastes, hazardous substances, or any combination of hazardous wastes or hazardous substances shall be supervised by the HSO who has satisfied the following training requirements. These requirements must be satisfied in accordance with the CAL OSHA standard for HAZWOPER (Title 8 CCR, GISO 5192):

- Initial 40-hour HAZWOPER training; and,
- Annual 8-hour HAZWOPER refresher training current within one year.
- One-time only 8-hour HAZWOPER Supervisor training in addition to initial 40-hour HAZWOPER and 8- hour HAZWOPER training.

4.1.2 First Aid

At least one team member shall have current first aid training including adult cardiopulmonary resuscitation (CPR) and blood-borne pathogens (BBP) training. Current training for the purposes of this S-HASP is as follows: (1) first aid training current within three years, (2) adult CPR current within one year, and (3) BBP training current within one year. In addition, the HSO is CPR/First Aid/BBP trained as well.

4.1.3 Respirator Training and Fit-Testing

It is not reasonably anticipated that employees on site will be exposed at or above the action levels or permissible exposure limits for chemical hazards present at the site due to the fact that samples collected are wet sediment samples, leaving little potential for significant exposures via inhalation of dusts or vapors. Therefore respirator training or fit testing will not be required for the HPS sediment sampling activities. In the event that conditions change and it is determined that respiratory protection is warranted, team members shall be provided appropriate Air Purifying Respirator (APRs) and appropriate fit-testing current within one year. Fit testing shall be performed on the make, model, and size of the full-face APR to be worn for any required task.

4.2 Site-Specific Training

All potential field personnel will review this S-HASP before commencing work as part of the site-specific safety training for this project. The HSO will review the S-HASP before field operations begin and will conduct daily tailgate safety meetings to bring up appropriate health and safety concerns and discuss any changes in field conditions. Field personnel will certify their review by signing a HASP training record form (Appendix A) or signing the field notebook after the tailgate safety meeting. The Project Manager is responsible for distributing this S-HASP to appropriate personnel and verifying review by obtaining signed review forms or copies of field notes. Signed review forms or copies of field notes will be placed in project files and in field personnel medical files.

Whenever a change of conditions on-site occurs that may affect safety, the HSO or his/her designee will conduct a tailgate safety meeting if appropriate. Changing site conditions that may affect safety include the following:

- Change of field personnel;
- Change in work activity;
- Change in weather conditions; and,
- Visitors on site.

All training sessions, safety meetings, and safety briefings will be documented by the HSO or his/her designee in the field notebook, or on Tailgate Safety Meeting Record forms (Appendix B). Documentation will include a brief description of topics addressed and the signatures of all training attendees.

4.3 Navy Subcontractor Documentation

Navy subcontractor employees shall maintain proof of qualification and completion of all required training onsite. This information can be satisfied by either: (1) an employer's certification statement including a summary report of all required training and medical surveillance completion dates for each individual, or (2) individual training certificates and medical clearance reports for each individual.

5.0 HAZARD ASSESSMENT

This section discusses the identification of general, task, or activity-specific and site-specific hazards associated with planned field activities for this project. Physical, chemical, and biological hazards are addressed separately. The job hazard analysis identifies the potential hazards associated with near-water safety and includes a description of the control measures to be implemented, a list of equipment with any applicable inspection, and training requirements.

5.1 Physical Hazards

General physical hazards present during field sampling activities could include the following:

- Tripping over hoses, pipes, tools, equipment or uneven terrain;
- Slipping on wet or oily surfaces;
- Injury due to lifting heavy sediment samples or equipment;
- Working over or near water
- Entanglement or injury from rotating or energized parts of mixing equipment;
- Exposure to noise generated by motors and pumps;

- Insufficient or faulty protective equipment; and
- Insufficient or faulty operations, equipment, or tools.

Other site-specific physical hazards may include any of the following:

- Hypothermia from exposure to potentially cool air temperatures and windy conditions;
- Sunburn, windburn;
- Damage to eyes from sun exposure (ultraviolet [UV] radiation); and
- Bites from snakes or stinging insects.

Safety precautions for general and site-specific hazards are addressed in Table 5-1 and Section 7.0 of this S-HASP.

5.2 Chemical Hazards

Chemicals that have been detected in shoreline areas and are therefore potentially present in sediments include metals, low- and high-molecular-weight PAHs, benzene, toluene, ethylbenzene, and xylene (BTEX), total petroleum hydrocarbons (TPH), organotins, polychlorinated biphenyls (PCBs), and radium dials/radioactive contamination. For ease of reference, the potential physical and chemical hazards expected and protective measures used to promote worker safety are provided together in Table 5-1. A list of historical chemicals or constituents occurring at the site along with their toxicological properties is presented in Table 5-2. More details regarding specific chemicals expected to be present are provided in the following sections.

Table 5-1. Hazards and Protective Measures for Hunters Point Sampling Activities

Potential Hazards	Methods to Ensure Worker Safety
Physical Hazards	
Injuries Caused by Tripping or Slipping	Regular job site reconnaissance will be conducted to identify, and eliminate if practicable the hazards. Sturdy steel-toed rubber or neoprene boots with non-slip soles should be worn when working on or around vessels and docks. Long pants shall be worn to prevent abrasion in the event of a slip, trip or fall.
Lifting, Manual Labor	The HSO or designee will identify ergonomic factors and will develop measures to prevent injury. Proper lifting techniques and warm-up will be used before strenuous tasks. Special hand protection will be required where indicated.
Working near water	Coordination with facility personnel, establishment of communications, and implementation of water safety requirements/measures will be used to ensure worker safety. Work will always be performed by a team of at least two persons, never one person working alone. Personnel working in water above waist height will be required to use a Personal Flotation Device
Heavy Mixing Equipment	Workers will wear hardhats while mixing equipment is in operation. Work will always be performed by a team of at least two persons, never one person working alone. Wearing loose clothing around operating machinery (i.e., engines, etc.) will be prohibited; loose hair shall be appropriately secured
Noise	Personnel will wear hearing protection (ear plugs or ear muffs) when working around noisy equipment, such as motors and pumps/
Solar Radiation	Protective clothing, eyewear, and sun block will be worn.
Weather	If lightning or thunder is seen or heard, then all personnel will cease sampling and seek shelter until the threat of lightning strikes passes.
Cold Stress/ Hypothermia	Appropriate foul weather gear will be worn when necessary. This includes waterproof or resistant boots, insulated leather gloves and rain gear. Training as appropriate
Snakes and	The HSO will identify areas where workers could contact snakes and/or stinging insects and

Potential Hazards	Methods to Ensure Worker Safety
Stinging Insects such as Spiders, Wasps and Bees	will determine actions needed to rectify the problem. Workers will not be allowed to work near insects where an unreasonable risk is present. Identify workers with allergies and ensure that appropriate emergency treatment is available.
Chemical Hazards	
Skin and Eye Irritation from Contact with Chemicals	Workers will wear appropriate chemically compatible personal protective equipment (PPE) dependent on the task (see Section 8.0), especially when collecting sediments. Good hygienic practices will be employed including frequent washing of the hands forearms and face, especially prior to eating or drinking. Eating or drinking is not permitted where samples have been handled or stored.
Radium Dials/ Radioactive Contamination	All samples will be handled with gloves and decontaminated in accordance with the approved protocols (TtFW 2004). Any samples found to be contaminated by radiation will be segregated and held for evaluation/disposal.
Biohazard or Infectious Materials	Gloves are to be worn when handling materials that are biohazard or infectious. Wash hands thoroughly after handling these materials and prior to eating or drinking. Do not eat or drink in areas where these materials are handled or stored. Disinfect work surfaces to prevent spread of contamination. Disinfect any wounds or cuts and prevent recontamination by using appropriate PPE. Seek medical attention as needed.

Table 5-2. Toxicological Properties of Chemical Compounds Potentially Present in Hunters Point Sediments

Class/Compounds (examples)	Principal Routes of Entry	Acute Exposure Effects/Symptoms	Chronic Exposure Effects/Symptoms
ORGANIC COMPOUNDS			
Aromatic Hydrocarbons			
Benzene	Inh, Ing, Skin	Central nervous system (CNS) depression; skin, eyes and upper respiratory tract irritation	Carcinogen, blood change leukemogenic
Ethylbenzene	Inh, Ing, Skin	Skin, eyes, nose and throat irritation	Skin rash
N-hexane	Inh, Ing, Skin	CNS depression; eyes and nose irritation	Skin irritation peripheral neuropathy
Toluene	Inh, Ing, Skin	CNS depression; skin, eyes, and respiratory tract irritation	Dermatitis
Xylene	Inh, Ing, Skin	Dizziness; nose, throat, skin, and eye irritation; olfactory changes; irritant; poison; distortion; hallucination; CNS effects	Cardiac arrhythmia
Petroleum Distillates			
Gasoline, Diesel	Inh, Skin, Ing	Anesthesia, dizziness, headache, nausea, vomiting, sleepiness, fatigue, disorientation, depression, unconsciousness, respiratory tract irritation, sore throat, cough	Dermatitis, headache, mood shifts, CNS effects, fatigue
Semivolatile Organic Compounds			
Polychlorinated biphenyls (PCB)	Skin, Inh, Ing	Irritatant to eyes; chloracne	Liver damage; reproductive effects; [potential occupational carcinogen]
Polycyclic Aromatic Hydrocarbons (as PAHs)	Skin, Inh, Ing	Irritant to skin, vomiting, photosensitization, headache	As a class overall, can be considered mutagenic and tumorigenic with several compounds known carcinogens; also causes liver damage
Organic Metals			
Organotins	Skin, Inh, Ing	Irritation eyes, skin, respiratory system; headache, dizziness; psycho-neurologic disturbance; sore throat, cough; abdominal pain, vomiting;	Urine retention; paresis, focal anesthesia; skin burns, pruritus; in animals: hemolysis; hepatic necrosis; kidney damage
INORGANIC COMPOUNDS			
Metals			
Chromium (VI)	Skin, Inh, Ing	Skin, respiratory tract irritation, dermatitis, skin ulceration	Carcinogen, lung and skin effects, nasal septum perforation
Chromium	Skin, Inh, Ing	Skin, respiratory tract irritation	Lung disease
Lead	Inh, Ing	GI distress, kidney failure	Neuropathy, CNS anemia
Mercury	Ihl, Skin, Ing	Skin irritant. Inhalation of vapors may cause pneumonitis. May affect CNS and kidneys. Effect may be delayed.	Affects central nervous system and kidneys, resulting in irritability, emotional instability, tremor, mental and memory disturbances, speech disorders. May cause inflammation and discoloration of the gums.

Class/Compounds (examples)	Principal Routes of Entry	Acute Exposure Effects/Symptoms	Chronic Exposure Effects/Symptoms
Nickel	Skin, Inh, Ing	Skin, nasal irritation, respiratory tract irritation	Carcinogen, lung, GI system disease
Zinc	Inh, Ing	Metal fume fever, skin irritation	GI system effects, dermatitis

GI = gastrointestinal.
Ing = ingestion.
Inh = inhalation.
Skin = skin absorption.

5.2.1 Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are present in coal tar, petroleum hydrocarbons, and other sources and are used in a variety of industrial products. Some PAHs are recognized human carcinogens. Exposure by any route to PAHs and other recognized human carcinogens shall be maintained at the absolute practicable minimum level. Sampling will involve the collection of wet sediments using a grab sampler; therefore, the exposure to PAHs should be minimal. Sediment samples collected previously at HPS indicated that PAH concentrations were generally below or equal to ambient levels in San Francisco Bay. The primary route of exposure is anticipated to be via dermal exposure and ingestion. These hazards will be controlled by proper use of PPE and personal hygiene practices including frequent and thorough hand washing as well as the designation of a clean area for eating and drinking.

5.2.2 Polychlorinated Biphenyls

PCBs, also referred to as Aroclors, are synthetic industrial products that have been commonly used as cooling fluids and electrical insulators. PCBs are common contaminants of oily-type waste and are found around railroad tracks and in industrial areas and dumps. PCBs are recognized environmental pollutants and human carcinogens. Work involving contact with PCBs exceeding 100 µg/g (specify dermal or inhalation) (i.e., parts per million [ppm]) may require special medical evaluation and approval of the HSO. Historical concentrations of PCBs found in Hunters Point sediments were considerably below this concentration.

PCBs are skin absorbable and appropriate precautions shall be implemented. Handling of samples that may be contaminated with PCBs shall be performed wearing appropriate chemically compatible PPE (gloves, safety glasses, and face shield where warranted.). Sampling will involve the collection of wet sediments using a grab sampler; therefore, the exposure to PCBs should be minimal.

In addition, precautions should be implemented to prevent inhalation of dusts that may be contaminated with PCB's. Process samples that are suspected to contain PCBs are to be stored and handled in well-ventilated areas and hands, forearms and face are to be washed with soap and water after sample processing.

Although OSHA has not set standards for each specific PCB, occupational exposures for chlorodiphenyl 42% chlorine and 54% chlorine are defined in 29 CFR 1910.1000, Table Z-1. Limits for these air contaminants are 1 mg/m^3 and 0.5 mg/m^3 respectively.

5.2.3 Petroleum Hydrocarbons

Petroleum hydrocarbons such as gasoline and diesel fuel may include a wide range of substances, some of which may pose substantive human health hazards. The aromatic volatile petroleum hydrocarbons including BTEX compounds are generally of greater concern, in part because they are more likely to exist in the worker's breathing zone. In moderate exposures, BTEX compounds all produce similar acute effects including headache, narcosis, and anesthesia. Table 5-2 summarizes the exposure criteria and health effects of BTEX. Among the aromatic volatile petroleum hydrocarbons, benzene is the primary substance of concern because of its status as a known carcinogen and association with leukemia and aplastic anemia in chronic exposure situations.

The permissible exposure limits (PELs) set by the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists' (ACGIH) threshold limit values (TLVs)-2004 for airborne exposure are provided in Table 5-3 for BTEX. Even high concentrations (ppm to percent level) of volatile organic compounds are not reasonably expected to present airborne concentrations at or approaching OSHA PELs or ACGIH TLVs considering the volume of sediments to be sampled and processed during field activities. Furthermore, all work will be conducted in open-air conditions. Considering the relative volatility of each compound and the open working conditions, these compounds are not reasonably expected to present inhalation exposures of concern to worker health and safety. Sampling will involve the collection of wet sediments using a grab sampler; therefore, the exposure to volatile organic compounds should be minimal.

TABLE 5-3. OSHA PELS AND ACGIH TLVS FOR SELECTED VOLATILE ORGANIC COMPOUNDS

Compound	OSHA PELs		ACGIH TLVs	
	TWA[(a)] (ppm)	STEL[(b)] (ppm)	TWA[(a)] (ppm)	STEL[(b)] (ppm)
Benzene	1.0	5.0	0.5	2.5
Toluene	200	300	50	–
Ethylbenzene	100	-	100	125
Xylene (*o*-, *m*-, *p*- isomers)	100	-	100	150

(a) **TWA**: Time-weighted average is the employee's average airborne exposure in any 8-hour work shift of a 40-hour workweek, which shall not be exceeded.

(b) **STEL**: Short-term exposure limit is the employee's 15-minute TWA airborne exposure, which shall not be exceeded at any time during a workday.

Petroleum hydrocarbons can also be absorbed through the skin if contact with highly contaminated sediments is made. Dermal exposures will be controlled through the use of PPE as described in Section 8.0.

5.2.4 Explosion and Fire

The types of hydrocarbons potentially expected to be present (gasoline and diesel fuel) are not expected to generate vapors at explosive concentrations during any of the tasks to be performed. All work will be conducted in open-air conditions. Therefore, the potential for vapors to reach explosive concentrations is minimal and vapor monitoring will not be necessary.

5.2.5 Heavy Metals and Organotins

A variety of heavy metals may be encountered as contaminants in sediments. Some metals are highly toxic; others are also recognized human carcinogens. As these materials are not volatile unless heated to extremely high temperatures, control by proper use of PPE and personal hygiene practices will prevent significant exposure. Sampling will involve the collection of wet sediments using grab samplers under ambient temperatures; therefore, the exposure to volatile metals or airborne particulate should be negligible.

5.2.6 Radioactive Contamination

Historically, radium dials were disposed of in the Parcel E landfill adjacent to the study area. Therefore, all sediment samples collected as part of the Treatability Study will be scanned for radioactivity by Tetra Tech EC, Inc. (TTECI) field personnel according to the Radiological Control Plan, attached as Appendix C. It should be noted that the Radiological Control Plan (RCP) was developed by Tetra Tech Foster Wheeler (TtFW), which is now called TTECI, in 2004 for onshore survey and removal activities conducted for the Navy in Parcel E and, therefore, not all elements and language of the plan are pertinent to the Parcel F Treatability Study. For example, although the RCP includes descriptions of procedures for personnel radiation surveys, radiation screening for the Treatability Study will be limited only to the on-site screening of collected sediment samples. The RCP sections pertinent to the Treatability Study are: Section 4.0 (Instrumentation and Procedures), Section 5.0 (Detection Sensitivity), Section 7.1 and 7.2 (Survey and Decontamination Procedures).

Table 5-4 provides acceptable levels of contamination based on the NRC Reg. Guide 1.86 limits. Should levels of contamination exceeding those listed in Table 5-4 be encountered during the surveys, appropriate decontamination methods in accordance with Section 7.2 of the TtFW Radiological Control Plan will be implemented.

TABLE 5-4. RADIATION CONTAMINATION LIMITS

Radionuclide	Fixed (dpm/100 cm^2)	Loose (dpm/100 cm^2)	Total (dpm/100 cm^2)
Alpha	100 α	20 α	120 α
Beta (Strontium-90)	1,000 β^-	200 β^-	1,200 β^-
Beta / Gamma	5,000 β^-, γ	1,000 β^-,γ	6,000 β^-,γ

Notes:

Types of radiation: α - alpha, γ - gamma, β^- - beta
cm^2 – square centimeters
dpm – disintegrations per minute

The TTECI RSO (or ARSO) will determine if decontamination is required and direct the field team leader on the process. In addition, the sampler and any other contaminated equipment will be decontaminated. All operations involving radioactive contamination will be carried out in conformance with the procedures described in the TtFW RCP in Appendix C (TtFW 2004).

5.2.7 Unidentified Chemicals

Chemicals not previously identified or considered may be present in Hunters Point sediments. Exposure to unidentified chemicals by any route shall be maintained at the absolute practicable minimum level to prevent casual contact with chemicals. Control by proper use of PPE and personal hygiene practices will prevent significant exposure.

Considering the small volume of sampling media to be disturbed, the type of media (wet sediments), the historical concentrations in shoreline areas of the site and the open working conditions of all field operations, significant inhalation exposures at or approaching OSHA or ACGIH exposure limits are not reasonably expected. However, skin or dermal absorption of the contaminants potentially present in sediments is considered a potential route of entry and will be controlled through the use of PPE (i.e., chemical-resistant gloves, wet suits, and booties) as described in Section 8.0 of this S-HASP. Ingestion is not considered a significant route of entry for these chemicals on this project. However, the use of PPE and standard safety procedures (no eating or drinking in operations areas) will minimize the potential for ingestion of sediment-associated contaminants.

5.3 Biological Hazards

Multiple biological hazards may be present at the Hunters Point site and are identified in Table 5-1 along with control measures to be implemented. Field personnel shall carefully review this section.

Work in shallow bayous may expose personnel to a variety of aquatic hazards. Project personnel shall not wade barefoot while performing project work. Appropriate footwear includes boots or waders. Free swimming is prohibited (see also Section 5.4.1).

Samples that are retrieved as part of the sample acquisition process may contain organic materials that contain biohazard/infectious materials (such as partially decomposed animal or vegetative materials, or parasites). Gloves shall be worn when handling these materials. Additionally, any open wound or punctures should be covered to prevent infection. All areas should be disinfected as needed to prevent the spread of potentially hazardous materials and to prevent the contamination of samples. In the event that someone receives a cut, puncture, or abrasion, appropriate first aid should be administered to prevent infection.

5.4 Task-Specific Hazards

The following tasks have specific hazards and control measures that are described below.

5.4.1 Work Near Water

When working over or near water, there is a potential for personnel to fall in and the danger of drowning exists. Work within 15 feet of unobstructed access to water shall be performed in accordance with the requirements given below.

- Personnel will use the buddy system at all times.
- Personnel working in water above waist height will be required to use a Personal Flotation Device
- Swimming shall be prohibited for personnel, unless necessary to prevent injury or loss of life.

5.4.2 Noise

Working near a motors and pumps can subject workers to noise exposures in excess of allowable limits. The use of ear plugs or ear muffs is mandatory when noise prevents conversation in a normal voice at a distance of 3 feet. This "rule of thumb" is an indication that noise levels may exceed the OSHA action level of 85 decibels. All personnel required to wear hearing protection, as provided by this section, shall be in a hearing conservation program in compliance with 29 CFR Section 1910.95 and 8 CCR Section 5096.

6.0 AIR MONITORING AND CONTROL MEASURES

No area air monitoring is planned because inhalation exposures of concern are not reasonably anticipated for any of the project activities to be performed (see Section 5.2 of this S-HASP). In the event that conditions change and it is determined that respiratory protection is warranted, team members shall be provided appropriate Air Purifying Respirator (APRs) and appropriate fit-testing current within one year. Fit testing shall be performed on the make, model, and size of the full-face APR to be worn for any required task.

7.0 GENERAL PROJECT SAFETY REQUIREMENTS

7.1 General Safety Precautions

The project operations shall be conducted with the following minimum safety requirements employed:

- Sample radiation scanning will be required.
- Smoking will not be permitted on project property.
- Eating and drinking will be restricted to areas that are designated.
- Wearing loose clothing around operating machinery (i.e., engines, etc.) will be prohibited; loose hair shall be appropriately secured.
- Work boots with steel toe and shank shall be worn during all field work activities.
- Hard hats, long-sleeve shirts, long pants and sunscreen will be worn as appropriate to prevent sunburn/windburn.
- Layers of clothing are recommended to prevent hypothermia.
- In warm weather, regular work breaks will be made to afford consumption of drinking water and to limit the possibility of hyperthermia.
- All personnel shall be required to thoroughly wash hands, forearms and face before eating or drinking. Personnel shall only eat or drink in areas designated for the purpose.
- Gross decontamination and removal or disposal of all personal protective equipment shall be performed prior to exiting the process area.

- The HSO and all field employees will be responsible to identify and alert other field team members to physical hazards present at the site.

Additional safety precautions for specific operations are described in Section 8.0 of this S-HASP.

7.2 Symptoms of Chemical Exposure

Field operations personnel shall inform each other of non-visual symptoms that may indicate chemical exposure such as:

- Headaches;
- Dizziness;
- Difficulty breathing;
- Nausea;
- Vomiting;
- Blurred vision;
- Cramps;
- Irritation of eyes, skin, or respiratory tract;
- Changes in complexion or skin discoloration;
- Changes in apparent motor coordination;
- Changes in personality or demeanor;
- Excessive salivation or changes in papillary response; and,
- Changes in speech ability or pattern.

7.3 Cold Stress

Adverse climate conditions such as cold weather are important considerations in planning and conducting site operations. The largest danger regarding cold stress is hypothermia, which occurs when the body's core temperature drops below 96.8°F. Conditions that could induce such a drop are immersion in low-temperature water and exposure to extremely cold ambient temperatures. Work warming regimens will be instituted as necessary as determined by the HSO. Signs and symptoms of a low body core temperature are shivering, a lower mental alertness, less ability to make rational decisions, and loss of consciousness.

When working in cold environments, specific steps should be taken to lessen the chances of cold-related injuries. These include the following:

- Protecting of exposed skin surfaces with appropriate clothing (such as face masks, handwear, and footwear) that insulates, stays dry, and blocks wind
- Shielding the work area with windbreaks to reduce the cooling effects of wind
- Providing equipment for keeping workers' hands warm by including warm air jets and radiant heaters in addition to insulated gloves
- Using adequate insulating clothing to maintain a body core temperature of above 96.8°F
- Providing extra insulating clothing on site

Clinical signs of cold stress are listed in Table 7-1.

Table 7-1. Cold Stress Clinical Signs

Core Temperature	Clinical Signs
98.6°F	Normal oral temperature
96.8°F	Metabolic rate increases in an attempt to compensate for heat loss
95.0°F	Maximum shivering
93.2°F	Victim conscious and responsive, with a normal blood pressure
91.4°F	Severe hypothermia below this temperature
89.6-87.8°F	Consciousness clouded; blood pressure becomes difficult to obtain; pupils dilated but react to light
86.0°F – 84.2°F	Progressive loss of consciousness; muscular rigidity increases; pulse and blood pressure difficult to obtain; respiratory rate decreases

7.4 Hypothermia

A potential for hypothermia from exposure to potentially cool air temperatures, windy conditions, and low water temperatures exists. The signs of hypothermia include shivering, numbness, glassy stare, reduction of rational decision-making, apathy, weakness, impaired judgment, or a loss of consciousness. To care for workers that have hypothermia, the following steps should be taken:

- Gently move the person to a warm place.
- Remove any wet clothing from the person and dry the person.
- Warm the person SLOWLY by wrapping them in blankets or by putting dry clothing on the person.
- Hot water bottles and chemical hot packs may be used when the person is first wrapped in a towel or blanket. Focus on warming the trunk or core of the body first (e.g. place warm water bottles under arms.)
- DO NOT WARM PERSON TOO QUICKLY, such as immersing him or her in warm water. Rapid warming can cause dangerous heart rhythms.

7.5 Heat Stress

Due to the time of year a portion of this project will be conducted during, it is possible heat related illness is a concern. All personnel will be briefed on the signs and symptoms of heat related illnesses and treatments. Factors which increase the risk of heat induced problems are as follows:

- High physical exertion.
- Being unaccustomed to working in heat.
- Wearing protective clothing that traps body heat
- Age- Older people may have less body water and lower sweat gland efficiency.
- Being overweight- which makes the body work harder to perform tasks.
- Medications that can interfere with normal body reactions to heat.

When working in hot environments, specific steps should be taken to lessen the chances of heat-related illnesses. These include the following:

- Ensuring that all employees drink plenty of fluids (Gatorade® or its equivalent)
- Ensuring that frequent breaks are scheduled so overheating does not occur
- Revising work schedules, when necessary, to take advantage of the cooler parts of the day (such as working from 5:00 a.m. to 11:00 a.m. and 6:00 p.m. to nightfall).

TABLE 7-2. SIGNS AND SYMPTOMS OF HEAT RELATED ILLNESSES AND TREATMENTS

HEAT INDUCED PROBLEMS			
Problem	**Body Response**	**Signs and Symptoms**	**Treatment**
Heat Cramps	• The body loses too much salt from heavy exertion in heat.	• Painful spasms of muscles used during work.	• Increase fluid intake with electrolytes (Unless otherwise indicated by a doctor). • Take frequent breaks, preferably in a cool area.
Heat Exhaustion	• The body can't replace fluids and/or salt lost in sweating. • Perspiration in heat is important because it cools the body as it evaporates.	• Weakness, dizziness, nausea. • Pale or flushed appearance. • Sweating, moist and clammy skin.	• Move to a cool place. • Loosen clothes and apply cool compresses. • Drink water slowly. • Elevate feet 8-12 inches.
Heat Stroke	• The body no longer sweats and holds so much heat that body temperature reaches dangerous levels. • **Heat stroke is a medical EMERGENCY and can lead to delirium, convulsions, unconsciousness, or death.**	• DRY, hot reddish skin, and LACK OF SWEATING! • High body temperature and strong, rapid pulse. • Chills • Confusion	• **Treat as a MEDICAL EMERGENCY!** • Call for EMS or a doctor immediately! • Move to a cool area immediately. • Use cool water to soak person's clothes and body. • Fan the body. • Don't give fluids if victim is unconscious.

EMS = Emergency Medical Services

8.0 PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

PPE consists of standard safety equipment required on the site and special safety equipment required for specific tasks or activities. Navy contractors and subcontractors (field personnel) will provide their own PPE. All field personnel are expected to come to work with proper safety equipment as specified in this S-HASP; equipment will be supplied by their respective employers. In addition, all field personnel entering the site shall comply with any task-specific safety requirements.

The level of equipment required at the site will depend on the activities being performed. This level may be revised as conditions change as determined by the HSO. The PPE selection will be determined based on its potential use, and the manufacturer's permeation and degradation properties for the contaminants

being worked with. A description of the proposed initial PPE for all fieldwork at this site and for sample collection activities is presented below.

The minimum required protective clothing for all fieldwork at Hunters Point consists of the following:

- Safety glasses;
- Leather work boots with steel toe and shank;
- Long pants;
- Short-sleeved shirt or short-sleeved T-shirt;
- Hard hat (as required for coring or mixing equipment operations);
- Personal flotation device when working in water greater than waist deep;
- Protective gloves-leather and chemical resistant;
- Ear plugs (as required); and
- Rubber over-the-sock boot with steel toe and shank (optional).

9.0 DECONTAMINATION/CONTAMINATION REDUCTION PROCEDURES

Boots, clothing, gloves, and other equipment can become contaminated by direct exposure to potentially contaminated sediments. Decontamination of PPE will consist of washing PPE with soap and water to remove sediment. A decontamination station will be designated, configured, and secured at the site if appropriate. Contaminated disposable PPE or clothing will be placed in appropriate storage or disposal receptacles and removed from the site within 90 days to a proper disposal facility. All decontamination fluids and solids will be controlled and contained in appropriate containers and removed from the site within 90 days to a proper disposal facility. Decontamination zones or areas will be established in the process areas. These zones/areas will be sufficiently large to allow separation of decontamination/processing support from the radiation monitoring areas.

Radioactive contamination may be present at the site and samples will be scanned onsite for radioactivity by trained TTECI personnel. Procedures for performing radioactive contamination surveys and decontaminating equipment and materials are provided in Section 7.2 of the TtFW Radiation Control Plan (TtFW 2004) (see Appendix C).

10.0 EMERGENCY RESPONSE PROCEDURES

Project personnel shall carefully review the aforementioned procedures. This section describes emergency equipment to be taken into the field and site-specific procedures to be followed in case of an emergency.

10.1 Emergency Equipment

First aid and BBP kits will be taken into the field each day during sampling and related field activities. To assure immediate access to first aid and BBP supplies, kits will be provided for each field team if these teams will be working in separate locations. Portable fire extinguishers shall be available in all areas where gas powered pumps or engines will be used.

10.2 General Emergency Procedures

In the event of a fire, explosion, physical injury or illness due to physical or chemical exposure, the appropriate parties should be contacted using the phone numbers listed at the end of this section. In addi-

tion to notifying the Hunters Point Contact, the HSO or designee shall notify the Stanford Project Manager (Dennis W. Smithenry) as soon as possible after appropriate emergency services have been notified and appropriate measures taken to protect people, environment, and property. Weather radios, two-way radios, and/or cell phones shall be in working condition and available for all field activities.

10.3 BBP Control Plan

All personnel should be aware of the potential to transmit disease from contact with body fluids. Personnel should assume that all bodily fluids are potentially infectious and use appropriate precautions. Controls to be considered are as follows:

- Use of the victim's hand to control initial bleeding;
- Use of available protective gear (Tyvek®, gloves, safety glasses) to prevent contact;
- Wash promptly after contact with body fluids;
- Use barrier mask while giving CPR;
- Decontaminate any area contaminated with bodily fluids with a 10:1 solution of water to bleach as soon as possible.

10.4 Medical Emergency Procedures

For injuries or illness other than very minor cuts or scrapes, a physician's attention is required. **For treatment of potentially life-threatening injury or illness, call 911 for assistance**.

For treatment of minor injuries or illness, personnel should be transported to San Francisco General Hospital (or the alternative, St. Luke's Hospital). Directions to these hospitals from the site are indicated on a map provided in Appendix D.

11.0 REFERENCES

Stanford. 2005. *Draft ESTCP Demonstration Plan for Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment at Hunters Point Shipyard Parcel F.* Prepared by Stanford University, Stanford, CA. July.

Tetra Tech FW, Inc. 2004. *Final Characterization Work Plan*. Metal Debris Reef and Metal Slag Areas, Parcel E, Hunters Point Shipyard, San Francisco, California. Appendix D: Final Radiation Control Plan. June 18.

Emergency Telephone Numbers

Ambulance		911
Police		911
Hospital		911
Fire Department		(415) 822-6779
HPS Base Security		(415) 330-0500
HPS Base Police		(415) 330-0565
HPS Base Contact		(415) 811-1613
California Office of Emergency Services		(800) 852-7550
City of San Francisco CIH (Ed Ochi)		(415) 671-3171
EPA Region 9, Environmental Emergencies		(415) 744-2000
OSHA Region 9		(415) 744-6670
RCRA Hotline		(800) 424-9346
U.S. Department of Transportation		(415) 744-3115
EPA National Response Center		(800) 424-8802
Poison Control Center		(800) 876-4766
Office of Emergency Services		(800) 852-7550 (916) 262-1621
City of San Francisco CIH (Ed Ochi)		(415) 671-3171
California DTSC		(916) 255-2002
California EPA		(916) 445-3846
TOXLINE		(301) 496-1131
CHEMTREC		(800) 424-9300
San Francisco General Hospital Emergency Room		(415) 206-8111
General Information		(415) 206-8000
Medical Center		(415) 206-8492
Alternate Hospital (St. Luke's Hospital)		(415) 641-6625
Tetra Tech Health and Safety Officer—Glynis Foulk		(916) 853-4561
Field Project Manager – Dennis Smithenry	(Office)	(650)723-8574
	(Cellular)	(650)814-1832
San Francisco General Hospital – Emergency		911
California OSHA		(213) 736-3041
California Department of Fish and Game		(310) 590-5132
BCO Radiation Safety Officer (RSO) - Craig Jensen	(Office)	(614) 424-5170
	(Cellular)	(614) 402-5386
BCO Assistant RSO - Leonard Davis	(Office)	(614) 424-4368
	(Pager)	(614) 786-3419

APPENDIX A

Site-Specific Health and Safety Training Record Forms

SITE-SPECIFIC HEALTH AND SAFETY PLAN (S-HASP)
TRAINING RECORD

S-HASP Title/Revision No. Site-Specific Health and Safety Plan for Hunters Point

Site Health and Safety Officer _____ Project Number _____

I have read the S-HASP presented herein and fully understand the material covered. I understand that I am responsible for compliance with the requirements of this HASP and I agree to abide by the same. I also had the opportunity to discuss the information presented in the HASP, and to ask any questions about the information that I want clarified. I understand that this record will become a permanent part of my employee health and safety training file.

Date	Print Name	Signature

APPENDIX B

Tailgate Safety Meeting Record Forms

TAILGATE SAFETY MEETING RECORD FORM

DAILY TAILGATE SAFETY MEETING FORM

Date:_____ Time:_____

Project Number:_____

Project Name: _____

Specific Location: _____

Type of Work:_____

_____

Chemicals Present:_____

SAFETY TOPICS DISCUSSED

Protective Clothing/Equipment: _____

_____

Hazards of Chemicals Present: _____

_____

Physical Hazards: _____

_____

Special Hazards: _____

_____

Other Topics: _____

_____

ATTENDEES

Name (printed)	Signature

APPENDIX C

TtFW FINAL
RADIOLOGICAL CONTROL PLAN
(SURVEY AND SAMPLING PLAN)
REVISION 0
JUNE 18, 2004

Southwest Division
Naval Facilities Engineering Command
Contracts Department
1220 Pacific Highway, Building 127, Room 112
San Diego, California 92132-5190

Contract No. N68711-98-D-5713
CTO No. 0072

FINAL

RADIOLOGICAL CONTROL PLAN
(Survey and Sampling Plan)
Revision 0
June 18, 2004

METAL DEBRIS REEF AND METAL SLAG AREAS
PARCEL E, HUNTERS POINT SHIPYARD
SAN FRANCISCO, CALIFORNIA

DCN: FWSD-RAC-04-1970

Prepared by

TETRA TECH FW, INC.

1230 Columbia Street, Suite 500
San Diego, CA 92101

and

New World Technology
448 Commerce Way
Livermore, CA 94551

Daryl Delong	Abid Loan, P.E.
NWT Project Manager	TtFW Project Manager

ABBREVIATIONS AND ACRONYMS

α	alpha
β	beta
γ	gamma
µCi/mL	microcurie per milliliter (activity)
µR/hr	microroentgens per hour
AHA	Activity Hazard Analysis
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
BHASP	Building Health and Safety Plan
cm	centimeters
cm^2	square centimeters
cpm	counts per minute
Cs-137	Cesium 137
DAC	derived airborne concentration
DON	Department of the Navy
dpm	disintegrations per minute
EPA	U.S. Environmental Protection Agency
HPS	Hunters Point Shipyard
keV	kiloelection volt
LLRW	Low-level Radioactive Waste
MeV	megaelectron volt
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
m/s	meters per second
NaI	sodium iodide
NRC	Nuclear Regulatory Commission
NWT	New World Technology
pCi/g	picocurie per gram
PPE	personal protective equipment
PRG	Preliminary Remediation Goal
RASO	Radiological Affairs Support Office
RCP	Radiological Control Plan
RCT	Radiological Control Technician

ABBREVIATIONS AND ACRONYMS
(Continued)

RSOR	Radiation Safety Office Representative
RWP	radiation work permit
SHSP	Site-Specific Health and Safety Plan
SHSS	Site Health and Safety Specialist
SOP	STANDARD OPERATING PROCEDURE
TCRA	time critical removal action
TLD	thermo-luminescent dosimeter
TTECI	Tetra Tech EC, Inc.
TtFW	Tetra Tech FW, Inc.

INTRODUCTION

This Radiological Control Plan (RCP), supplemented with guidance provided in the Site-Specific Health and Safety Plan (SHSP), New World Technology (NWT) Field Operating Procedures, and the Radiological Health Program, details radiological controls to be performed in support of the site characterization that will be conducted to support a time-critical removal action (TCRA) for removing metal debris and radioactive sources and/or contamination from the metal debris reef and the metal slag areas within Parcel E, located at Hunters Point Shipyard (HPS), San Francisco, California. The Department of the Navy (DON) has determined upon review of the site's operational history and site-specific investigative data that metal debris reef and metal slag areas contain radioactive devices, thus requiring a response action. Prior to a removal action in these two areas, additional site characterization of the sediments is necessary and is discussed herein. A separate Work Plan and RCP will be prepared for the removal action.

The RCP will be used as a control document by all field personnel engaged in the implementation of the Work Plan. Included in this RCP are field surveillance procedures, sampling procedures, decontamination procedures, release requirements, and data gathering methods that will be used during the implementation of this RCP.

Tetra Tech EC, Inc. (TTECI) personnel will conduct the hands-on work while NWT personnel will perform the radiological control and oversight for the work being conducted. All personnel performing work will be trained in general radiation safety practices. Specific radiation work permits (RWPs) will be used during performance of all work associated with the implementation of this Work Plan.

OBJECTIVES

The specific objectives for this RCP are as follows:

- Address the radiological survey procedures to be implemented during the implementation of the Work Plan.
- Address survey and sampling procedures.
- Address decontamination procedures.
- Identify radiological controls used during the performance of this Work Plan.
- Identify the release levels for equipment and personnel.

BACKGROUND

Site location and background are detailed in Section 2.0 of the Characterization Work Plan for Metal Debris Reef and Metal Slag Areas (Characterization Work Plan) (TtFW, 2004).

PREREQUISITES

Prerequisites for the initiation of activities described within this document include completion of a Building Health and Safety Plan (BHASP), Activity Hazard Analyses (AHA), required notifications, as well as the procurement of services, equipment, and materials necessary to perform the work. Additional activities will include a pre-work radiological evaluation of the designated work areas.

RADIOLOGICAL HEALTH AND SAFETY

The NWT *Radiological Health Program Manual* (NWT, 2002), supplemented with field-related Standard Operating Procedures (SOPs), is utilized to address controls necessary for radiologically safe and correct operations. Critical requirements resulting from each of the aforementioned documents include the presence of a Site Health and Safety Specialist (SHSS) at active work locations to ensure implementation of SHSP and BHASP driven criteria. Additionally, an American National Standards Institute (ANSI)-qualified Radiological Control Technician (RCT) will be present at active work areas to ensure implementation of required RWP criteria. Air monitoring, including initial baseline sampling to determine radiological background conditions, will be performed as necessary during boring activities. Personal protective equipment (PPE) levels, dictated by radiological considerations, will be assigned or modified, according to the approved RWP. For additional details relevant to radiological issues, reference can be made to the *Radiological Health Program Manual* (NWT, 2002).

ALARA

The basic concept in radiation protection specifies that exposures to ionizing radiation and releases of radioactive material should be managed to reduce collective doses to workers and the public as low as reasonably achievable (ALARA). It is the intent of this RCP to take into consideration the concepts of ALARA during the course of the work carried out by the Characterization Work Plan (TtFW) for the metal reef and metal slag areas.

TRAINING

All personnel conducting fieldwork under the Characterization Work Plan will be provided with general awareness training for radiation. General awareness training provides the worker with a basic knowledge of the hazards, health concerns and protective practices related to radiation and radioactive materials. Training will be documented on the appropriate NWT form. A copy will be kept in the project field office while the original will be maintained at the NWT corporate headquarters in Livermore, California.

DOSIMETRY

All personnel conducting fieldwork under the Characterization Work Plan will be issued and required to wear a thermal luminescent dosimeter (TLD) to monitor and track occupational exposure. All personnel issued a TLD will complete the Nuclear Regulatory Commission (NRC) Form 4 for occupational exposure. Each completed Form 4 will be maintained by NWT at the Livermore office with a copy kept on site.

RADIATION WORK PERMITS

A RWP shall be prepared and will specify the activities to be performed and all radiological safety requirements for the work. All personnel assigned to site work will be required to read, understand the requirements, and sign the RWP prior to beginning work.

Project Task Management

All radiological surveys, RWPs, air sampling, and documentation required to be completed, will be performed in accordance with the applicable NWT SOP. The following sections identify how the tasks will be managed with the utilization of the RWP.

Purpose of the Radiation Work Permit

RWPs provide guidelines specifying the appropriate personnel protective measures within the scope of the work based upon the radiological conditions in the area. The RWP will also provide a complete document addressing existing radiological conditions, work scope and limitations, radiological limitations, PPE requirements, dosimetry requirements, ALARA considerations, and specific instructions to Health Physics Technicians and radiation workers. An RWP should not be used unless a radiological survey has been performed in the work area within the last 24 hours or there is reasonable assurance that conditions have not changed as determined by the Health Physics Supervisor or his/her designee.

Development of the Radiation Work Permit

The Health Physics Supervisor shall perform, or assign a Health Physics Technician to perform a survey of the work area. Prior to performing a work area survey, the surveyor shall be as knowledgeable as possible about the nature of the work to be performed (surface or sub-surface surveying, drilling, sample collection, equipment repair, decontamination, jack hammering, etc.), the specific component or equipment to be worked on, the positions the workers may take to perform the work (kneeling on the ground, leaning against one component to work on another, etc.), and the possibility of the presence of highly radioactive debris.
All surveys used to assess work conditions in preparation for a job shall clearly describe all the radiological hazards present in the work area. The following guidelines should be considered when performing a work area survey:

- What are the contamination, radiation, and airborne radioactivity levels at the position(s) where the individual is to work?
- Where are designated radiation, high radiation, contaminated area boundaries?
- Are there any special radiological hazards or hot spots to avoid?
- Is the area currently wet or greasy or will it become wet or greasy from the work?
- If work on a specific component is required, what are the contact and 30 cm dose rates for the component?
- Is there or could there be any highly radioactive debris present?
- What additional safety hazards may be encountered at the jobsite?

Upon completion of the radiological survey, the survey shall be reviewed/approved by the Health Physics Supervisor. A clear description of the work activity is very important. Information regarding the exact location and scope of work is essential to adequately establish the current and anticipated radiological conditions in the area.
The Health Physics Technician shall complete the RWP, entering all existing radiological conditions, source of survey information, and the survey number.

Review and Approval of the Radiation Work Permit

The Health Physics Supervisor or his/her designee shall review Section I through Section V for accuracy and correctness as necessary. Upon completion of the review, the Health Physics Supervisor or his/her designee shall sign and approve the RWP for use unless there are industrial hygiene/safety aspects which could impact upon the safe completion of the work of the RWP. In this case, the Industrial

Hygiene/Safety Technician shall review the RWP and ascertain that the proposed work description is acceptably safe and is accordance with the provisions of the SHSP.
The Health Physics Supervisor or his/her designee will then submit the RWP to the Radiation Safety Office Representative (RSOR) for review and approval.

Management of the Radiation Work Permit

In the event of conditions or scope of the work changes that do not justify the generation of a new RWP, two modifications or extensions of the RWP may be made by the Health Physics Supervisor. Appropriate radiological surveys will be performed in the work area at the end of each day or if there is reasonable assurance that conditions may have changed. This is to ensure that the RWP is adequate for the field conditions encountered. Upon termination of an RWP, the original RWP will be retained in the permanent project file. All other copies will be kept at an NWT designated office.

Implementation of the Radiation Work Permit

Prior to the initial use of any RWP, the user(s) shall read, and sign Section VI (Personnel Authorized to Perform Work & Acceptance of Responsibility) of the RWP to indicate that he/she understands the requirements of the RWP. Any questions shall be answered by the Health Physics Supervisor. Prior to the initial use of the RWP, the Health Physics Supervisor or his/her designee shall conduct a pre-job briefing with the work crew members. Pre-job briefings shall be documented on Forms NWT-025 (Industrial Hygiene/Safety) or NWT-026 (Health Physics) and accompanied by a NWT-027 Training Record. A copy of the RWP will be kept at the work area location at all times.
Upon completion of the modification or extension of the RWP and prior to use, the approval/review signatories of the original RWP shall initial and note agreement with the modification by placing "R-1/initials" or "R-2/initials" and the date in the block for RWP approval by position. The Health Physics Supervisor shall communicate all changes made to the RWP to the affected work crew and work crew supervisors prior to the commencement of work covered under the RWP.

RADIATION DETECTION INSTRUMENTATION

During the performance of this RCP, different instrumentation will have to be used to detect the various forms of radioactive material that may be present. Table D.4-1 identifies the instrumentation that may be used for the RCP objectives. Each instrument is explained in further detail in the following sections.

TABLE D.4-1

INSTRUMENTATION FOR RADIOLOGICAL SURVEYS

Measurement/ Technique	Type of Instrumentation		Typical Background	Typical Efficiency (%)	Detection Sensitivity
	Detector	Meter			
Surface gamma scans	NaI 2-inch x 2-inch Scintillation Ludlum Model 44-10	Ludlum Model-2350-1 Data Logger	100 to 12,000 cpm; varies with calibration γ	N/A	150-1500 cpm γ.
Static alpha/beta	Large-area scintillation, Ludlum Model 43-89 (100 cm^2)	Count rate meter Ludlum Model-2360 Data Logger	100-200 cpm β 5-10 cpm α	~6 β total efficiency ~12 α total efficiency	~ 110 dpm/100 cm^2 β ~ 20 dpm/100 cm^2 α
Direct Measurement Static gamma	NaI 2-inch x 2-inch Scintillation Ludlum Model 44-10	Ludlum Model-2350-1 Data Logger	100 to 12,000 cpm; varies with calibration γ	N/A	200 cpm-2000 cpm γ. Varies with Calibration.
Exposure Rates	NaI Scintillation Micro R Meter Ludlum Model-19	(Same as detector)	7-8 μR/hr	N/A	2 μR/hr
Gross alpha/beta on smears (Swipes)	Protean Low Background Gas Flow Proportional Counter IPC9025		1-5 cpm β 0-0.5 cpm α	~62 β ~27 α	4-10 dpm/100 cm^2 β 5-10 dpm/100 cm^2 α

Notes:

α – alpha cpm – counts per minute
β – beta dpm – disintegrations per minute
γ – gamma N/A – not applicable
μR/hr – microRoentgens per hour NaI – sodium iodide
cm^2 – square centimeters

INSTRUMENT FOR ALPHA/BETA SURVEYS

Surveys for alpha/beta radiation will be performed using a Ludlum Model 2360 Scaler/Ratemeter Data Logger equipped with a logging command device as well as a Ludlum Model 43-89 probe. The

instrumentation measures alpha and beta radiation levels and presents data in a scaler (digital display) or rate meter (analog display) mode. Static measurements for particulate radiations are instantaneously recorded by the rate meter after positioning the detector, a scintillation probe, directly over a designated surveillance surface and recording "scan" ranges or collecting "static" measurements. Measurements are obtained by traversing an area at a maximum speed (scan rate) of approximately 0.5 meters per second (m/s) and slowly sweeping the detector assembly serpentine (snakelike, "S"-shaped) pattern, while maintaining the detector approximately 0.25 inches (6 millimeters) above the area surveyed. Once the actual background levels are established, the static time requirement will be calculated.

INSTRUMENT FOR GAMMA SURVEYS

Surveys for gamma (photon) radiation will be performed using a Ludlum Model 2350-1 Data Logger equipped with a command device and a Ludlum Model 44-10 scintillation detector, which utilizes a 2-inch by 2-inch sodium iodide (NaI) crystal. Capable of detecting gamma photon energies ranging from 60 kiloelectron volts (keV) to 3 megaelectron volts (MeV), the instrument is programmed to respond to the full spectrum of gamma photon energies. Static photon measurements require positioning the detector assembly approximately 4 inches (10 cm) above the designated surveillance surface and completing a stationary 60-second survey. Scan measurements are obtained by traversing a path at a maximum speed (scan rate) of approximately 0.5 m/s and slowly sweeping the detector assembly in a serpentine (snakelike, S-shaped) pattern, while maintaining the detector 2.5 to 4 inches (6 to 10 cm) above the area surveyed. NaI scintillation detectors are very sensitive to gamma radiation and are ideal for locating elevated radiation levels above background. The instruments will be utilized with the detection discriminator set to full open.

INSTRUMENT FOR EXPOSURE RATE SURVEYS

Exposure rate surveys, obtained approximately 1 meter from contact with area surfaces, are conducted with use of a Ludlum Model 19 MicroR meter. Compatible with anticipated exposure rates, the instrument is equipped with an internally mounted 1-inch by 1-inch NaI scintillation detector that is integral to the meter housing. The MicroR meter provides optimum performance in measuring low-level gamma photon radiation readings, which are readily provided on the meter face in units of microRoentgens per hour (μR/hr). Readings will be obtained after allowing the instrument to stabilize for approximately 1 minute.

INSTRUMENT FOR SWIPE SAMPLES

Standard swipe samples will be collected for the analysis of removable contaminants. Swipe samples, also referred to as smears, will be obtained at discrete points from equipment and materials. All samples will be processed using a Protean IPC 9025 counter. The Protean IPC 9025 is a gas flow proportional alpha/beta radiation counter, which features a low background counting chamber. A microprocessor allows for data processing, and the unit provides a full range of simultaneous alpha and beta analysis at levels required for environmental release surveillance. Data is reported in units of disintegrations per minute (dpm) per 100 cm^2.

DETECTION SENSITIVITY –
MINIMUM DETECTABLE CONCENTRATION

STATIC MDC

The static minimum detectable concentration (MDC) represents the level of radioactivity, on a surface, that is practically achievable by the overall measurement process. The conventional equation is used to calculate instrument MDC in units of dpm per 100 cm^2.

EQUATION 1

$$MDC = \frac{3 + 4.65\sqrt{C_B}}{\varepsilon_i \varepsilon_s \frac{W_A}{100\,cm^2} T_B}$$

where:

C_B = Background counts in time T_B (min)
T_B = Background counting time (min)
ε_ι = the instrument efficiency (count per particle)
ε_s = the contaminated surface efficiency (particle per disintegration)
W_A = the area of the detector window (cm^2)

SCAN MDC

The scan MDC is derived from the minimum detectable count rate (MDCR) by applying conversion factors that account for detector and surface characteristics and surveyor efficiency. The MDCR accounts for the background level, performance criteria (d^1), and observation interval. The observation interval during scanning is the actual time that the detector can respond to the contamination source. This interval depends on the scan speed, detector size in the direction of the scan, and area of elevated activity.
The scan MDC for structure surfaces is calculated using Equation 2.

EQUATION 2

Scan

$$MDC = \frac{MDCR}{\sqrt{P} * \varepsilon_i * \varepsilon_s \frac{W_A}{100\,cm^2}}$$

where:

MDCR = as discussed in Section 5.2.1
ε_ι = the instrument efficiency (count per particle)
ε_s = the contaminated surface efficiency (particles per disintegration)
W_A = the area of the detector window (cm^2)
P = surveyor efficiency

SCANNING MINIMAL DETECTABLE COUNT RATE, GAMMA

MDCR is the minimum detectable number of net source counts in the scan interval, for an ideal observer, that can be arrived at by multiplying the square root of the number of background counts (in the scan interval) by the detectability value associated with the desired performance (as reflected in d^1) as shown in Equation 3.

EQUATION 3

$$MDCR = d^1 \sqrt{b_i \times 60/i}$$

where:

d^1 = index of sensitivity (α and β error)
b_i = number of background counts in scan time interval (count)
i = scan or observation interval (s)

RADIOLOGICAL CONTROL PROCEDURES

Radiological control procedures will be implemented to support bore sampling activities at the metal debris reef and metal slag areas. These procedures are intended to protect the health and safety of workers and general public, comply with the NWT radioactive material license requirements under which the work is to be performed, and to minimize the liability of TTECI and the DON to risks associated with radioactive materials.

Radiological control procedures are required for the following work phases and activities:

- Equipment and material surveys
- Operational checks and use of calibrated radiological survey instruments
- Radiological surveys and calibration documentation (Note: Only survey instruments that have been calibrated within the last 12 months by a facility authorized by an agreement state or the NRC will be used. Calibration documentation will be maintained on site.)
- Radiological postings
- Sampling activities
- RWPs
- Documentation and notifications

SURVEY PROCEDURES

The following protocol will be used for conducting radiological surveys, supplemented with any additional requirements listed in the NWT Radioactive Material License and SOPs. Oversight will be provided by the on-site TTECI Radiation Safety Officer and NWT Radiation Safety Office Representative (RSOR).

GENERAL SURVEY PROCEDURES

At a minimum, the following steps will be used in conducting all radiological surveys associated with the performance of the Characterization Work Plan. Additional steps are included in subsequent portions of this RCP. NWT SOPs will be used in conjunction with this RCP. All surveys will be performed by a qualified RCT.

1. Perform routine instrument operational checks by visually inspecting the equipment for damage, confirmation of current calibration by inspecting the attached calibration sticker, battery check, and response check.
2. The average background will be determined by performing at least 10 measurements at different locations within the designated background reference area. The reference area, once selected, will be identified using site maps or global positioning system (GPS) as appropriate. The detector probe should be held approximately 4 inches from the surface area for beta/gamma and 0.25 inches from the surface area for alpha radiation. The detector should be allowed to stabilize for at least 30 seconds before a background count is taken. The average of all of the counts taken will be the background. Background scan ranges will also be collected for reference data.
3. The 3-sigma value, lower limit of detection and MDC will be calculated using the results of the average background and recorded in the radiological logbook and on the appropriate NWT form.
4. All daily instrument check and background measurements shall be documented on the appropriate forms referenced in the NWT operating procedures. (Note: All NWT forms will be kept on file in the field office. Copies will be submitted to others when required.)
5. Personnel performing the surveys will typically wear Level D PPE (hard hat, steel-toed boots, reflective vest, eye protection, and gloves).
6. The entire surface area of the equipment or material shall be surveyed with the instrument used to perform the background measurements. Technicians should move slowly (less than 1.5 feet per second) over the surface area, keeping the detector probe approximately 4 inches from the surface area for beta/gamma and 0.25 inches from the surface area for alpha radiation.
7. In addition to the generation of field surveillance documentation, as required by NWT SOPs, survey results will be documented in the radiological field logbook. Personnel performing the surveys will manually enter results in the radiological logbook.
8. Qualified personnel shall survey, in a pre-designated low background area, their hands, feet, and clothing before leaving the work area. Personnel that are not qualified to self-survey will be surveyed by a qualified technician. Any contaminated clothing

will be removed and placed into a waste bag and stored with the other waste pending further characterization. Surveys will be performed using a calibrated alpha/beta scintillation detector and in accordance with NWT SOPs.

Incoming Equipment Surveys

In addition to the general procedures set forth in this document, incoming equipment and materials will be subject to the following guidelines.

1. Table D.7-1 provides acceptable levels of contamination based on the NRC Reg. Guide 1.86 limits. Should levels of contamination exceeding those listed in Table D.7-1 be encountered during the surveys, appropriate decontamination methods in accordance with NWT SOPs will be implemented.

TABLE D.7-1

RADIATION CONTAMINATION LIMITS

Radionuclide	Fixed (dpm/100 cm^2)	Loose (dpm/100 cm^2)
Alpha	100 α	20 α
Beta (Strontium-90)	1,000 β^-	200 β^-
Beta / Gamma	5,000 β^-, γ	1000 β^-,γ

Notes:

Types of radiation: α - alpha, γ - gamma, β^- - beta
cm^2 – square centimeters
dpm – disintegrations per minute

2. Equipment will be surveyed for existing contamination levels prior to being placed into service.
3. Surveys will consist of 100 percent scan for alpha/beta contamination. Swipes will be taken to ensure that there is no removable contamination present. Should the levels exceed those listed in Table D.7-1, the equipment will not be permitted to be placed into service and will be requested to be returned to the source.

Boring Surveys

In addition to the general procedures set forth in this document, the following guidelines will be used prior to placing equipment and materials at the borehole location.

1. Once a borehole location has been identified, a survey for gamma radiation will be conducted at the immediate area where the sample is to be collected. Additional surveys will be conducted in a 5-foot radius to document existing radiation levels and help keep personnel exposure ALARA.
2. Surveys will consist of 100 percent scan for gamma radiation and a 1-minute static count at the boring location. Should the static measurement exceed 1½ times background, a new location will be selected for boring.

3. In order to control occupational and environmental exposures, monitoring and trending for airborne radioactive material will be conducted during any evolution that disturbs the surface. Controls (i.e., misting with water, use of HEPA vacuum cleaners or filtration units or use of work area containments) will be implemented to ensure that airborne concentrations well below 10 percent of the applicable derived airborne concentration (DAC) value for workers and the public.

   If airborne concentrations exceed the established levels, all work will stop until engineering controls are put into place that will maintain the airborne concentrations below the established DAC values. If engineering controls cannot be put into place or the airborne concentrations cannot be maintained below the established DAC, all work will stop and notifications will be made. Table D.7-2 identifies the DAC for potential radionuclides that may be encountered.

TABLE D.7-2

DERIVED AIRBORNE CONCENTRATION

Radionuclide	Public		Worker	
	DAC (µCi/mL)	10% DAC (µCi/mL)	DAC (µCi/mL)	10% DAC (µCi/mL)
Radium (Ra)-226	9.0E-13	9.0E-14	3.0E-10	3.0E-11
Uranium (U)-235	6.0E-14	6.0E-15	2.0E-11	2.0E-12
Cesium (Cs)-137	2.0E-10	2.0E-11	6.0E-8	6.0E-9
Plutonium (Pu)-239	2.0E-14	2.0E-15	7.0E-12	7.0E-13
Strontium (Sr)-90	3.0E-11	3.0E-12	8.0E-9	8.0E-10

Notes:

µCi/mL – microcurie per milliliter (activity)
DAC - derived airborne concentration
Ref 10 Code of Federal Regulations 20, App B

Sampling Activities

1. Bore samples will be analyzed using gamma spectroscopy analysis. The focus of the analysis will be the photons emitted from radionuclides identified in Table A.8-2 of the Sampling and Analysis Plan (TtFW, 2004; Appendix A). A region of interest around the appropriate energy ranges will allow quantification of the nuclides and daughter products.

2. The comparison of sample activity results with the limiting levels is to be based on a gamma spectral analysis of each sample. The lower detection limit will be set *a priori* to a level no greater than .5 of the cleanup levels specified in Table D.7-3. The guidance values are directly related to the risk posed by the nuclides in equilibrium with daughter products through defined exposure pathways.

TABLE D.7-3

EPA PRELIMINARY REMEDIATION GOALS

Radionuclide	Industrial Reuse – Soil[a] (pCi/g)
Americium (Am)-241	7.8[b]
Plutonium (Pu)-239	14.3
Radium (Ra)-226	1 > background, not to exceed 2
Uranium (U)-235	0.57[b]
Cesium (Cs)-137	0.13[b]
Sr-90	10.7 [b]

Notes:

[a] U.S. Environmental Protection Agency Preliminary Remediation Goals (PRGs) for soil for outdoor worker (EPA, 2002)

[b] Decay-corrected PRG for industrial reuse provided by EPA Region IX.

pCi/g – picocuries per gram

3. All samples obtained will be monitored using field instrumentation to determine the potential presence of external loose surface contamination and dose rates. Any sample with a dose rate exceeding 150 percent of the established background level will not be submitted for gamma spectral analysis. If surface contamination is indicated on the sample container, decontaminate the container prior to submission for analysis.
4. Samples will be obtained at a rate of three per borehole (a total of 90 samples). Each will be analyzed on site in the NWT laboratory by gamma spectroscopy. Ten percent of the samples will be forwarded for additional analysis to include, gamma spectroscopy, gross alpha, gross beta, isotopic Pu, isotopic U, and Strontium (Sr)-90, at an accredited laboratory for quality assurance cross check. The laboratory shall be accredited under the National Voluntary Laboratory Accreditation Program. Additional samples may be obtained and analyzed based on field survey results of the cores. Any core area that exceeds background readings by a factor of 3 sigma should be submitted for analysis.
5. All samples will be logged by survey unit, assigned a distinct identification number and shipped for analysis under sample chain-of-custody forms.
6. The samples should be of sufficient quantity, approximately 500 grams, to support the minimum detection level requirement.
7. The original samples will be maintained and stored until the results of the analysis are made available and reviewed and it has been verified that the sample does not exceed the action level. Samples will be archived until released for disposal by Radiological Affairs Support Office.

Personnel Surveys

Personnel conducting fieldwork shall have a whole body survey ("frisk"), by a qualified technician, in a pre-designated low background area, before leaving the work area. Any contaminated clothing will be removed and placed into a waste bag and stored with the other waste pending further characterization. A qualified technician, in a pre-designated low background area will also survey tools, materials, and equipment before being removed from the work area each day. Surveys will be performed using a calibrated alpha/beta scintillator.

Outgoing Equipment Surveys

In addition to the general procedures set forth in this document, outgoing equipment and materials will be subject to the additional guidelines.

1. A release survey will be performed prior to the equipment and/or materials leaving HPS. All surveys will be documented on the appropriate NWT form and given a unique survey number.
2. Surveys will consist of a 100 percent scan for alpha/beta contamination. Swipes will be taken to ensure that there is no removable contamination present per SOP. Should the levels exceed those listed in Table D.7-1, the equipment will not be permitted to leave the site, and appropriate decontamination methods will be taken.

DECONTAMINATION PROCEDURES

Surveillance results may at times dictate the gross decontamination of equipment and materials. In such instances, to prevent the uncontrolled spread of loose contaminants, any materials or equipment initially identified as radiologically contaminated will be immediately secured. The assigned RCT will also ensure that the NWT RSOR is promptly informed of the situation. Prior to transport of such materials or equipment to a designated decontamination pad, such processes will first be evaluated for radiological impact. Instructions unique to such transfer, including the actual decontamination process, will be outlined in a separate job-specific RWP with pre-job brief requirements per applicable NWT SOPs.

POST-WORK AREA SURVEILLANCE

At the daily conclusion of the boring operations, areas where work was performed will be surveyed for contaminants. Survey results will be compared to data defining pre-work conditions to determine if further remedial actions or additional controls are necessary.

POINT SOURCE AND CONTAMINATED MATERIAL REMOVAL PROCEDURE

Should surveys identify a discrete point source on the surface or in a core sample or levels of contamination are found to be present that exceed those specified in Table D.7-1, the source or material will be removed per the procedure detailed below.

1. Removal and storage of any point sources and/or contaminated materials will be performed under the supervision of a qualified RCT.
2. Personnel performing removal of point sources and/or contaminated materials will wear modified Level D PPE (Tyvek coveralls and booties, gloves, hard hats, and eye protection).
3. When a point source has been identified, the source will be removed and placed into an appropriately sized clear plastic bag. The source will be given a unique identification number and recorded in the radiological logbook. All point sources will be stored in a separate steel drum from other contaminated materials found and removed during the surveys.

4. For the core samples, any sediment surrounding a discrete source in the core sample will also be removed to a distance of 1 foot in each direction and placed into a lined 55-gallon drum.

5. In the case of radiologically contaminated materials or debris not associated with a point source, such materials will be removed and placed into a lined 55-gallon drum.

6. All bags and drums will be marked with a unique identification number that will be assigned and recorded in the radiological logbook.

7. Any filled 55-gallon steel drum(s) generated during this process will be placed in storage until the material can be characterized for total activity and isotopes.

8. A description and photographic detail of any point sources or contaminated objects, related activity (in counts per minute) and disposition shall be entered in the radiological field logbook.

9. Drums of radioactive material, as well as any materials or equipment used to perform contamination removal, shall be surveyed prior to being removed from the work area. A handheld Ludlum Model 2360 survey meter equipped with a Ludlum Model 43-89 scintillation detector shall be used by a qualified RCT to perform all release surveys. Follow-up swipes will be taken on all drums, materials and equipment and analyzed using the Protean gas proportional detector prior to leaving the work area. The release limits are presented in Table D.7-1.

10. Any drums and/or equipment, which do not meet the release criteria of Table D.7-1 will be decontaminated using damp rags. Rags used to decontaminate equipment will be bagged and placed in a waste drum. Equipment that cannot be decontaminated by using only damp rags will be bagged and stored with the waste until such time it can be decontaminated at a dedicated decontamination area.

11. Qualified personnel shall survey, in a pre-designated low background area, their hands, feet, and clothing before leaving the work area. Personnel that are not qualified to self-survey will be surveyed by a qualified RCT. Any contaminated clothing will be removed and placed into a waste bag and stored with the other waste pending further characterization. Surveys will be performed using a calibrated alpha/beta scintillation detector.

12. Radioactive material generated during this project will be stored in Building 406. Material from this project will be segregated from other radioactive materials, currently stored in Building 406, which were generated from other projects.

REFERENCES

New World Technology (NWT). 2002. *Radiological Health Program Manual*. July.

Tetra Tech FW, Inc. (TtFW). 2004. *Draft Characterization Work Plan for Metal Debris Reef and Metal Slab Areas. Parcel E, Hunters Point Shipyard, San Francisco, California.* April.

U.S. Environmental Protection Agency (EPA). 2002. *Region 9 Preliminary Remediation Goals 2002*. San Francisco, California.

APPENDIX D

Hospital Information and Location Map

Hospital Information

San Francisco General Hospital
1001 Potrero Avenue
San Francisco, California 94110
(415) 206-8376

DIRECTIONS TO SAN FRANCISCO GENERAL HOSPITAL (3.0 miles):

- Exit HPS main gate on Innes Avenue and proceed 0.5 miles west to Hunter Point Boulevard, which becomes Evans Avenue. Proceed 1.5 miles west on Evans Avenue, passing Third Street and Highway 280, to Cesar Chavez (Army) Street.
- Left onto Cesar Chavez (Army) Street, and proceed 0.5 miles west, passing Highway 101, to Potrero Avenue.
- Right onto Potrero Avenue, proceed 0.25 miles north into the hospital entrance.
- A route map to the hospital is shown in Appendix A.

St. Luke's Hospital
3555 Cesar Chavez (Army) Street
San Francisco, California 94110
(415) 647-8600

DIRECTIONS TO ST. LUKE'S HOSPITAL (3.4 miles):

- Exit HPS main gate on Innes Avenue and proceed 0.5 miles west to Hunter Point Boulevard, which becomes Evans Avenue. Proceed 1.5 miles west on Evans Avenue to Cesar Chavez (Army) Street, passing Third Street and Highway 280.
- Left onto Cesar Chavez (Army) Street, proceed 1 mile west, passing Highway 101 and Potrero Avenue, and into the Hospital entrance at the intersection of Cesar Chavez/Valencia.

A route map to each hospital is shown in the following figures.

Map to San Francisco General Hospital (shown as "B") from Hunters Point (shown as "A")

Map to St. Luke's Hospital (shown as "B") from Hunters Point (shown as "A")

FINAL

ELECTRONIC DATA DELIVERABLE

Appendix D
HUNTERS POINT SHIPYARD PARCEL F
ESTCP FINAL REPORT

Prepared for:

ENVIRONMENTAL SECURITY TECHNOLOGY CERTIFICATION PROGRAM
1155 Herdon Parkway, Suite 900
Herndon, VA 20170

Prepared by:

STANFORD UNIVERSITY
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
YANG & YAMAZAKI ENVIRONMENTAL & ENERGY BLDG
STANFORD, CA 94305-4020

(Modified from original QAPP/SAP of ESTCP Demonstration Plan)

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	N/A	RAC-SPMD-Control-1	Regenerated AC Study	SPMD uptake	PCBs (reported as total	13.0	µg	114.3	74.2
ER-0510	N/A	RAC-SPMD-Control-2	Regenerated AC Study	SPMD uptake	PCBs (reported as total	14.1	µg	87.5	76.3
ER-0510	N/A	RAC-SPMD-Control-3	Regenerated AC Study	SPMD uptake	PCBs (reported as total	14.1	µg	117.7	84.4
ER-0510	N/A	RAC-SPMD-TOG-1	Regenerated AC Study	SPMD uptake	PCBs (reported as total	4.6	µg	90.0	94.5
ER-0510	N/A	RAC-SPMD-TOG-2	Regenerated AC Study	SPMD uptake	PCBs (reported as total	5.3	µg	97.1	107.1
ER-0510	N/A	RAC-SPMD-TOG-3	Regenerated AC Study	SPMD uptake	PCBs (reported as total	4.4	µg	82.6	90.4
ER-0510	N/A	RAC-SPMD-30NS-1	Regenerated AC Study	SPMD uptake	PCBs (reported as total	3.0	µg	92.9	94.8
ER-0510	N/A	RAC-SPMD-30NS-2	Regenerated AC Study	SPMD uptake	PCBs (reported as total	2.8	µg	85.6	91.8
ER-0510	N/A	RAC-SPMD-30NS-3	Regenerated AC Study	SPMD uptake	PCBs (reported as total	2.9	µg	91.4	97.3
ER-0510	N/A	RAC-SPMD-ACNS-1	Regenerated AC Study	SPMD uptake	PCBs (reported as total	0.5	µg	92.9	91.4
ER-0510	N/A	RAC-SPMD-ACNS-2	Regenerated AC Study	SPMD uptake	PCBs (reported as total	0.3	µg	90.6	89.1
ER-0510	N/A	RAC-SPMD-ACNS-3	Regenerated AC Study	SPMD uptake	PCBs (reported as total	0.3	µg	97.4	96.8
ER-0510	N/A	RAC-AQEQ-Control-1	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	105.3	ng/L	70.1	69.4
ER-0510	N/A	RAC-AQEQ-Control-2	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	109.7	ng/L	75.5	77.2
ER-0510	N/A	RAC-AQEQ-Control-3	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	101.1	ng/L	54.6	80.6
ER-0510	N/A	RAC-AQEQ-TOG-1	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	16.5	ng/L	95.0	83.1
ER-0510	N/A	RAC-AQEQ-TOG-2	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	14.6	ng/L	87.6	84.7
ER-0510	N/A	RAC-AQEQ-TOG-3	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	15.4	ng/L	83.3	82.6
ER-0510	N/A	RAC-AQEQ-30NS-1	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	11.2	ng/L	91.5	83.4
ER-0510	N/A	RAC-AQEQ-30NS-2	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	10.7	ng/L	91.2	83.7
ER-0510	N/A	RAC-AQEQ-30NS-3	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	10.6	ng/L	67.8	77.1
ER-0510	N/A	RAC-AQEQ-ACNS-1	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	7.5	ng/L	34.5	54.5
ER-0510	N/A	RAC-AQEQ-ACNS-2	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	6.2	ng/L	95.6	83.9
ER-0510	N/A	RAC-AQEQ-ACNS-3	Regenerated AC Study	Aqueous Equilibirun	PCBs (reported as total	7.3	ng/L	78.3	78.6

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	EAE-231	Section-0-C-1-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.36025668	wt%	N/A	N/A
ER-0510	EAE-232	Section-0-C-1-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.37280615	wt%	N/A	N/A
ER-0510	EAE-233	Section-0-C-1-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.55107884	wt%	N/A	N/A
ER-0510	EAE-234	Section-0-C-1-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.37180234	wt%	N/A	N/A
ER-0510	EAE-235	Section-0-C-1-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.02515336	wt%	N/A	N/A
ER-0510	EAE-236	Section-0-C-1-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.46527867	wt%	N/A	N/A
ER-0510	EAE-238	Section-0-C-2-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.41740697	wt%	N/A	N/A
ER-0510	EAE-239	Section-0-C-2-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.4595391	wt%	N/A	N/A
ER-0510	EAE-240	Section-0-C-2-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.40266143	wt%	N/A	N/A
ER-0510	EAE-241	Section-0-C-2-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.38174856	wt%	N/A	N/A
ER-0510	EAE-242	Section-0-C-2-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.12820119	wt%	N/A	N/A
ER-0510	EAE-243	Section-0-C-2-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.05203716	wt%	N/A	N/A
ER-0510	EAE-245	Section-0-C-3-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.4546877	wt%	N/A	N/A
ER-0510	EAE-246	Section-0-C-3-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.28477144	wt%	N/A	N/A
ER-0510	EAE-247	Section-0-C-3-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.36263357	wt%	N/A	N/A
ER-0510	EAE-248	Section-0-C-3-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.52590241	wt%	N/A	N/A
ER-0510	EAE-249	Section-0-C-3-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.34957502	wt%	N/A	N/A
ER-0510	EAE-250	Section-0-C-3-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.93757032	wt%	N/A	N/A
ER-0510	EAE-252	Section-0-C-4-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.56225883	wt%	N/A	N/A
ER-0510	EAE-253	Section-0-C-4-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.62048642	wt%	N/A	N/A
ER-0510	EAE-254	Section-0-C-4-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.35581991	wt%	N/A	N/A
ER-0510	EAE-255	Section-0-C-4-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.55117293	wt%	N/A	N/A
ER-0510	EAE-256	Section-0-C-4-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.1501351	wt%	N/A	N/A
ER-0510	EAE-257	Section-0-C-4-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.08942145	wt%	N/A	N/A
ER-0510	EAE-259	Section-0-C-5-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.40225303	wt%	N/A	N/A
ER-0510	EAE-260	Section-0-C-5-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.35957394	wt%	N/A	N/A
ER-0510	EAE-261	Section-0-C-5-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.65205151	wt%	N/A	N/A
ER-0510	EAE-262	Section-0-C-5-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.48908005	wt%	N/A	N/A
ER-0510	EAE-263	Section-0-C-5-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.58439421	wt%	N/A	N/A
ER-0510	EAE-264	Section-0-C-5-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	Unavailable	wt%	N/A	N/A
ER-0510	EAE-266	Section-0-D-1-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.50483856	wt%	N/A	N/A
ER-0510	EAE-267	Section-0-D-1-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.30725706	wt%	N/A	N/A
ER-0510	EAE-268	Section-0-D-1-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.27445435	wt%	N/A	N/A
ER-0510	EAE-269	Section-0-D-1-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.30162679	wt%	N/A	N/A
ER-0510	EAE-270	Section-0-D-1-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.39093829	wt%	N/A	N/A
ER-0510	EAE-271	Section-0-D-1-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.73803905	wt%	N/A	N/A
ER-0510	EAE-273	Section-0-D-2-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.34399831	wt%	N/A	N/A
ER-0510	EAE-274	Section-0-D-2-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.30358652	wt%	N/A	N/A
ER-0510	EAE-275	Section-0-D-2-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.4130711	wt%	N/A	N/A
ER-0510	EAE-276	Section-0-D-2-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.54606346	wt%	N/A	N/A
ER-0510	EAE-277	Section-0-D-2-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.85335598	wt%	N/A	N/A
ER-0510	EAE-278	Section-0-D-2-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.81959987	wt%	N/A	N/A
ER-0510	EAE-280	Section-0-D-3-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.29365382	wt%	N/A	N/A
ER-0510	EAE-281	Section-0-D-3-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.2458076	wt%	N/A	N/A
ER-0510	EAE-282	Section-0-D-3-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.28471094	wt%	N/A	N/A
ER-0510	EAE-283	Section-0-D-3-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.54481201	wt%	N/A	N/A
ER-0510	EAE-284	Section-0-D-3-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.58687482	wt%	N/A	N/A
ER-0510	EAE-285	Section-0-D-3-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.775694	wt%	N/A	N/A
ER-0510	EAE-287	Section-0-D-4-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.39062202	wt%	N/A	N/A
ER-0510	EAE-288	Section-0-D-4-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.34381979	wt%	N/A	N/A
ER-0510	EAE-289	Section-0-D-4-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.52270991	wt%	N/A	N/A
ER-0510	EAE-290	Section-0-D-4-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.34462434	wt%	N/A	N/A
ER-0510	EAE-291	Section-0-D-4-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.90920002	wt%	N/A	N/A
ER-0510	EAE-292	Section-0-D-4-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.03111323	wt%	N/A	N/A
ER-0510	EAE-294	Section-0-D-5-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.4282951	wt%	N/A	N/A
ER-0510	EAE-295	Section-0-D-5-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.36896176	wt%	N/A	N/A
ER-0510	EAE-296	Section-0-D-5-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.43237049	wt%	N/A	N/A
ER-0510	EAE-297	Section-0-D-5-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.73827315	wt%	N/A	N/A
ER-0510	EAE-298	Section-0-D-5-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.94646299	wt%	N/A	N/A
ER-0510	EAE-299	Section-0-D-5-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.79537865	wt%	N/A	N/A
ER-0510	EAE-301	Section-0-E-1-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.45308445	wt%	N/A	N/A
ER-0510	EAE-302	Section-0-E-1-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.44721879	wt%	N/A	N/A
ER-0510	EAE-303	Section-0-E-1-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.34053972	wt%	N/A	N/A
ER-0510	EAE-304	Section-0-E-1-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.63931423	wt%	N/A	N/A
ER-0510	EAE-305	Section-0-E-1-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.41452065	wt%	N/A	N/A
ER-0510	EAE-306	Section-0-E-1-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.51067335	wt%	N/A	N/A
ER-0510	EAE-308	Section-0-F-2-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.60630374	wt%	N/A	N/A
ER-0510	EAE-309	Section-0-E-2-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.57108309	wt%	N/A	N/A
ER-0510	EAE-310	Section-0-E-2-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.49188674	wt%	N/A	N/A
ER-0510	EAE-311	Section-0-E-2-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.61775781	wt%	N/A	N/A
ER-0510	EAE-312	Section-0-E-2-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.70627807	wt%	N/A	N/A
ER-0510	EAE-313	Section-0-E-2-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	Unavailable	wt%	N/A	N/A
ER-0510	EAE-315	Section-0-E-3-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.38955387	wt%	N/A	N/A
ER-0510	EAE-316	Section-0-E-3-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.31089646	wt%	N/A	N/A
ER-0510	EAE-317	Section-0-E-3-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.41262731	wt%	N/A	N/A
ER-0510	EAE-318	Section-0-E-3-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.47295841	wt%	N/A	N/A
ER-0510	EAE-319	Section-0-E-3-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.79347313	wt%	N/A	N/A
ER-0510	EAE-320	Section-0-E-3-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	Unavailable	wt%	N/A	N/A

ER-0510	EAE-322	Section-0-E-4-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.36493864	wt%	N/A	N/A
ER-0510	EAE-323	Section-0-E-4-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.60390641	wt%	N/A	N/A
ER-0510	EAE-324	Section-0-E-4-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.67990693	wt%	N/A	N/A
ER-0510	EAE-325	Section-0-E-4-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.6340235	wt%	N/A	N/A
ER-0510	EAE-326	Section-0-E-4-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.85942461	wt%	N/A	N/A
ER-0510	EAE-327	Section-0-E-4-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.88206974	wt%	N/A	N/A
ER-0510	EAE-329	Section-0-E-5-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.38973051	wt%	N/A	N/A
ER-0510	EAE-330	Section-0-E-5-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.49275529	wt%	N/A	N/A
ER-0510	EAE-331	Section-0-E-5-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.50194596	wt%	N/A	N/A
ER-0510	EAE-332	Section-0-E-5-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.91555396	wt%	N/A	N/A
ER-0510	EAE-333	Section-0-E-5-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.85239508	wt%	N/A	N/A
ER-0510	EAE-334	Section-0-E-5-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.10209634	wt%	N/A	N/A
ER-0510	EAE-336	Section-0-F-1-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.33507578	wt%	N/A	N/A
ER-0510	EAE-337	Section-0-F-1-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.23769652	wt%	N/A	N/A
ER-0510	EAE-338	Section-0-F-1-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.26283199	wt%	N/A	N/A
ER-0510	EAE-339	Section-0-F-1-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.33036872	wt%	N/A	N/A
ER-0510	EAE-340	Section-0-F-1-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.77028021	wt%	N/A	N/A
ER-0510	EAE-341	Section-0-F-1-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.80258484	wt%	N/A	N/A
ER-0510	EAE-343	Section-0-F-2-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.30488185	wt%	N/A	N/A
ER-0510	EAE-344	Section-0-F-2-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.27837705	wt%	N/A	N/A
ER-0510	EAE-345	Section-0-F-2-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.26358736	wt%	N/A	N/A
ER-0510	EAE-346	Section-0-F-2-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.27109803	wt%	N/A	N/A
ER-0510	EAE-347	Section-0-F-2-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.58871194	wt%	N/A	N/A
ER-0510	EAE-348	Section-0-F-2-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.94781029	wt%	N/A	N/A
ER-0510	EAE-350	Section-0-F-3-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.4012933	wt%	N/A	N/A
ER-0510	EAE-351	Section-0-F-3-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.28760806	wt%	N/A	N/A
ER-0510	EAE-352	Section-0-F-3-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.41103598	wt%	N/A	N/A
ER-0510	EAE-353	Section-0-F-3-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.40605432	wt%	N/A	N/A
ER-0510	EAE-354	Section-0-F-3-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.92456235	wt%	N/A	N/A
ER-0510	EAE-355	Section-0-F-3-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.92203649	wt%	N/A	N/A
ER-0510	EAE-357	Section-0-F-4-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.53422653	wt%	N/A	N/A
ER-0510	EAE-358	Section-0-F-4-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.65135588	wt%	N/A	N/A
ER-0510	EAE-359	Section-0-F-4-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.98028871	wt%	N/A	N/A
ER-0510	EAE-360	Section-0-F-4-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.45547534	wt%	N/A	N/A
ER-0510	EAE-361	Section-0-F-4-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.84159745	wt%	N/A	N/A
ER-0510	EAE-362	Section-0-F-4-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.77792557	wt%	N/A	N/A
ER-0510	EAE-364	Section-0-F-5-1	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.56440073	wt%	N/A	N/A
ER-0510	EAE-365	Section-0-F-5-2	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.53209423	wt%	N/A	N/A
ER-0510	EAE-366	Section-0-F-5-3	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.74680123	wt%	N/A	N/A
ER-0510	EAE-367	Section-0-F-5-4	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.43118918	wt%	N/A	N/A
ER-0510	EAE-368	Section-0-F-5-5	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.98072362	wt%	N/A	N/A
ER-0510	EAE-369	Section-0-F-5-6	Pretreatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.14370129	wt%	N/A	N/A
ER-0510	EAE-416	Sed-0-C-1	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.18	mg PCBs / kg	82.5	88.4
ER-0510	EAE-418	Sed-0-C-2	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.49	mg PCBs / kg	74.5	76.2
ER-0510	EAE-420	Sed-0-C-3	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	0.98	mg PCBs / kg	76.9	83.1
ER-0510	EAE-422	Sed-0-C-4	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.99	mg PCBs / kg	24.5	57.6
ER-0510	EAE-424	Sed-0-C-5	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.12	mg PCBs / kg	74.2	75.8
ER-0510	EAE-426	Sed-0-D-1	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.38	mg PCBs / kg	70.2	75.1
ER-0510	EAE-428	Sed-0-D-2	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.04	mg PCBs / kg	75.9	78.8
ER-0510	EAE-430	Sed-0-D-3	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.01	mg PCBs / kg	74.3	75.6
ER-0510	EAE-432	Sed-0-D-4	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.76	mg PCBs / kg	63.9	69.0
ER-0510	EAE-434	Sed-0-D-5	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.79	mg PCBs / kg	74.3	79.5
ER-0510	EAE-436	Sed-0-E-1	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.08	mg PCBs / kg	74.9	82.2
ER-0510	EAE-438	Sed-0-E-2	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	3.40	mg PCBs / kg	58.0	61.1
ER-0510	EAE-440	Sed-0-E-3	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	0.90	mg PCBs / kg	70.2	74.3
ER-0510	EAE-442	Sed-0-E-4	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.34	mg PCBs / kg	70.3	74.0
ER-0510	EAE-444	Sed-0-E-5	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.39	mg PCBs / kg	76.3	81.3
ER-0510	EAE-446	Sed-0-F-1	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.54	mg PCBs / kg	67.3	72.0
ER-0510	EAE-448	Sed-0-F-2	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.13	mg PCBs / kg	75.9	79.1
ER-0510	EAE-450	Sed-0-F-3	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.03	mg PCBs / kg	71.0	78.8
ER-0510	EAE-452	Sed-0-F-4	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.66	mg PCBs / kg	71.8	77.3
ER-0510	EAE-454	Sed-0-F-5	Pretreatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.92	mg PCBs / kg	64.7	69.2
ER-0510	EAE-417	AqEq-0-C-1	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	10.3	ng PCBs / L	85.0426969	86.9660407
ER-0510	EAE-419	AqEq-0-C-2	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	13.7	ng PCBs / L	86.0536562	82.3683348
ER-0510	EAE-421	AqEq-0-C-3	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	6.5	ng PCBs / L	81.9392659	84.1502069
ER-0510	EAE-423	AqEq-0-C-4	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	7.1	ng PCBs / L	84.9710674	84.6209428
ER-0510	EAE-425	AqEq-0-C-5	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	16.8	ng PCBs / L	84.3052012	84.475694
ER-0510	EAE-427	AqEq-0-D-1	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)		ng PCBs / L	41.1273922	69.1122876
ER-0510	EAE-429	AqEq-0-D-2	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)		ng PCBs / L	17.7486516	47.7390577
ER-0510	EAE-431	AqEq-0-D-3	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)		ng PCBs / L	11.3251091	42.1786965
ER-0510	EAE-433	AqEq-0-D-4	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	11.1	ng PCBs / L	84.8410781	84.8434481
ER-0510	EAE-435	AqEq-0-D-5	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	12.4	ng PCBs / L	85.5249934	85.5946293
ER-0510	EAE-437	AqEq-0-E-1	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	9.1	ng PCBs / L	82.2453673	84.5071348
ER-0510	EAE-439	AqEq-0-E-2	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	9.3	ng PCBs / L	87.8473272	88.7521086
ER-0510	EAE-441	AqEq-0-E-3	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	6.7	ng PCBs / L	82.5896897	83.9207752
ER-0510	EAE-443	AqEq-0-E-4	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	8.1	ng PCBs / L	83.5177786	83.7572141
ER-0510	EAE-445	AqEq-0-E-5	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	11.9	ng PCBs / L	89.1517829	89.4358391
ER-0510	EAE-447	AqEq-0-F-1	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	11.3	ng PCBs / L	90.3446286	89.0358275
ER-0510	EAE-449	AqEq-0-F-2	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	5.5	ng PCBs / L	81.3153598	85.0286871

ER-0510	EAE-451	AqEq-0-F-3	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	16.4	ng PCBs / L		77.6310734	81.1707574
ER-0510	EAE-453	AqEq-0-F-4	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	12.9	ng PCBs / L		72.5414252	74.8972067
ER-0510	EAE-455	AqEq-0-F-5	Pretreatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	22.0	ng PCBs / L		70.7915851	72.8230802
ER-0510	EAE-026	SPMD-0-C-1	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.160	µg		94	98
ER-0510	EAE-027	SPMD-0-C-2	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.095	µg		93	93
ER-0510	EAE-028	SPMD-0-C-3	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.105	µg		95	97
ER-0510	EAE-029	SPMD-0-C-4	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.098	µg		94	97
ER-0510	EAE-030	SPMD-0-C-5	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.132	µg		97	100
ER-0510	EAE-031	SPMD-0-D-1	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.125	µg		103	103
ER-0510	EAE-032	SPMD-0-D-2	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.104	µg		98	98
ER-0510	EAE-033	SPMD-0-D-3	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.169	µg		94	97
ER-0510	EAE-034	SPMD-0-D-4	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.131	µg		100	101
ER-0510	EAE-035	SPMD-0-D-5	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.160	µg		97	100
ER-0510	EAE-036	SPMD-0-E-1	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.100	µg		95	96
ER-0510	EAE-037	SPMD-0-E-2	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.106	µg		99	102
ER-0510	EAE-038	SPMD-0-E-3	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.159	µg		94	97
ER-0510	EAE-039	SPMD-0-E-4	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.137	µg		97	98
ER-0510	EAE-040	SPMD-0-E-5	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.149	µg		99	101
ER-0510	EAE-041	SPMD-0-F-1	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.139	µg		103	102
ER-0510	EAE-042	SPMD-0-F-2	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.138	µg		96	103
ER-0510	EAE-043	SPMD-0-F-3	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.140	µg		96	96
ER-0510	EAE-044	SPMD-0-F-4	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.211	µg		96	100
ER-0510	EAE-045	SPMD-0-F-5	Pretreatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.288	µg		97	100
ER-0510	EAE-151	Clam-0-C-1	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	243.668	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-152	Clam-0-C-2	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	221.719	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-153	Clam-0-C-3	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	296.077	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-154	Clam-0-C-4	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	369.48	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-155	Clam-0-C-5	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	314.314	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-156	Clam-0-D-1	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	247.483	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-157	Clam-0-D-2	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	285.029	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-158	Clam-0-D-3	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	326.615	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-159	Clam-0-D-4	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	243.517	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-160	Clam-0-D-5	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	321.888	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-161	Clam-0-E-1	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	228.972	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-162	Clam-0-E-2	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	301.878	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-163	Clam-0-E-3	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	254.303	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-164	Clam-0-E-4	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	308.111	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-165	Clam-0-E-5	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	364.62	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-166	Clam-0-F-1	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	271.588	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-167	Clam-0-F-2	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	266.381	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-168	Clam-0-F-3	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	326.139	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-169	Clam-0-F-4	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	347.742	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-170	Clam-0-F-5	Pretreatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	312.023	µg PCBs/ kg wet clam tissue			
ER-0510	EAE-151	Clam-0-C-1	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-152	Clam-0-C-2	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue			
ER-0510	EAE-153	Clam-0-C-3	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	1.1%	% of wet clam tissue			
ER-0510	EAE-154	Clam-0-C-4	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.6%	% of wet clam tissue			
ER-0510	EAE-155	Clam-0-C-5	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-156	Clam-0-D-1	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue			
ER-0510	EAE-157	Clam-0-D-2	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.6%	% of wet clam tissue			
ER-0510	EAE-158	Clam-0-D-3	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.5%	% of wet clam tissue			
ER-0510	EAE-159	Clam-0-D-4	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-160	Clam-0-D-5	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue			
ER-0510	EAE-161	Clam-0-E-1	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue			
ER-0510	EAE-162	Clam-0-E-2	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue			
ER-0510	EAE-163	Clam-0-E-3	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue			
ER-0510	EAE-164	Clam-0-E-4	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-165	Clam-0-E-5	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-166	Clam-0-F-1	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue			
ER-0510	EAE-167	Clam-0-F-2	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue			
ER-0510	EAE-168	Clam-0-F-3	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue			
ER-0510	EAE-169	Clam-0-F-4	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue			
ER-0510	EAE-170	Clam-0-F-5	Pretreatment Assessment	Clam PCB Bioaccumulation	lipid content	0.6%	% of wet clam tissue			
ER-0510	EAE-051	Amphipod-0-C-1	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	589.042	µg PCBs/ kg wet tissue			
ER-0510	EAE-052	Amphipod-0-C-2	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	690.794	µg PCBs/ kg wet tissue			
ER-0510	EAE-053	Amphipod-0-C-3	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	767.597	µg PCBs/ kg wet tissue			
ER-0510	EAE-054	Amphipod-0-C-4	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	569.355	µg PCBs/ kg wet tissue			
ER-0510	EAE-055	Amphipod-0-C-5	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)		µg PCBs/ kg wet tissue			
ER-0510	EAE-056	Amphipod-0-D-1	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	598.697	µg PCBs/ kg wet tissue			
ER-0510	EAE-057	Amphipod-0-D-2	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	780.619	µg PCBs/ kg wet tissue			
ER-0510	EAE-058	Amphipod-0-D-3	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	639.997	µg PCBs/ kg wet tissue			
ER-0510	EAE-059	Amphipod-0-D-4	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	695.98	µg PCBs/ kg wet tissue			
ER-0510	EAE-060	Amphipod-0-D-5	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	788.289	µg PCBs/ kg wet tissue			
ER-0510	EAE-061	Amphipod-0-E-1	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	804.853	µg PCBs/ kg wet tissue			
ER-0510	EAE-062	Amphipod-0-E-2	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	604.349	µg PCBs/ kg wet tissue			
ER-0510	EAE-063	Amphipod-0-E-3	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	608.86	µg PCBs/ kg wet tissue			

ER-0510	EAE-064	Amphipod-0-E-4	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	997.404	µg PCBs/ kg wet tissue			
ER-0510	EAE-065	Amphipod-0-E-5	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	755.79	µg PCBs/ kg wet tissue			
ER-0510	EAE-066	Amphipod-0-F-1	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	620.081	µg PCBs/ kg wet tissue			
ER-0510	EAE-067	Amphipod-0-F-2	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	570.892	µg PCBs/ kg wet tissue			
ER-0510	EAE-068	Amphipod-0-F-3	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	618.95	µg PCBs/ kg wet tissue			
ER-0510	EAE-069	Amphipod-0-F-4	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	839.116	µg PCBs/ kg wet tissue			
ER-0510	EAE-070	Amphipod-0-F-5	Pretreatment Assessment	Indigenous Amphipod PCB Bioacc	PCBs (reported as total PCBs)	1093.811	µg PCBs/ kg wet tissue			
ER-0510	EAE-406,407	Desorption-0-C-0.08d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-1d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.06	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-2d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.08	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-5d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.13	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-10d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.16	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-35d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.25	fraction of PCB desorbed			
ER-0510	EAE-406,407	Desorption-0-C-60d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.31	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-0.08d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-1d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.06	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-2d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.07	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-5d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.13	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-10d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.15	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-35d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.20	fraction of PCB desorbed			
ER-0510	EAE-408,409	Desorption-0-D-60d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.22	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-0.08d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-1d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.06	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-2d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.09	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-5d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.13	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-10d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.15	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-35d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.21	fraction of PCB desorbed			
ER-0510	EAE-410,411	Desorption-0-E-60d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.24	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-0.08d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.03	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-1d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.07	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-2d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.11	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-5d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.19	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-10d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.22	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-35d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.32	fraction of PCB desorbed			
ER-0510	EAE-412,413	Desorption-0-F-60d	Pretreatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.37	fraction of PCB desorbed			
ER-0510	N/A	BC-0-C	Pretreatment Assessment	Composite Sediment BC	Black Carbon Contents	0.00139	g BC / g dry S	N/A	N/A	
ER-0510	N/A	BC-0-D	Pretreatment Assessment	Composite Sediment BC	Black Carbon Contents	0.000752	g BC / g dry S	N/A	N/A	
ER-0510	N/A	BC-0-E	Pretreatment Assessment	Composite Sediment BC	Black Carbon Contents	0.00077	g BC / g dry S	N/A	N/A	
ER-0510	N/A	BC-0-F	Pretreatment Assessment	Composite Sediment BC	Black Carbon Contents	0.001854	g BC / g dry S	N/A	N/A	
ER-0510	EAE-206	XAD-0-C-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	1.99	ng PCBs / L	96		64
ER-0510	EAE-208	XAD-0-C-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	1.76	ng PCBs / L	102		82
ER-0510	EAE-210	XAD-0-D-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	2.75	ng PCBs / L	85		93
ER-0510	EAE-212	XAD-0-D-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	1.68	ng PCBs / L	76		84
ER-0510	EAE-214	XAD-0-E-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	2.45	ng PCBs / L	75		100
ER-0510	EAE-216	XAD-0-E-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	1.90	ng PCBs / L	71		87
ER-0510	EAE-218	XAD-0-F-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	1.23	ng PCBs / L	76		63
ER-0510	EAE-220	XAD-0-F-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	2.31	ng PCBs / L	72		107
ER-0510	EAE-207	Filter-0-C-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	5.59	ng PCBs / L	106		104
ER-0510	EAE-209	Filter-0-C-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	4.84	ng PCBs / L	127		106
ER-0510	EAE-211	Filter-0-D-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	4.53	ng PCBs / L	112		105
ER-0510	EAE-213	Filter-0-D-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	4.71	ng PCBs / L	95		95
ER-0510	EAE-215	Filter-0-E-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.52	ng PCBs / L	114		101
ER-0510	EAE-217	Filter-0-E-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.88	ng PCBs / L	89		95
ER-0510	EAE-219	Filter-0-F-1	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.23	ng PCBs / L	90		95
ER-0510	EAE-221	Filter-0-F-2	Pretreatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.43	ng PCBs / L	158		87

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	FAE-001	XAD-1-C-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.20	ng PCBs / L	85	70
ER-0510	FAE-011	XAD-1-C-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.04	ng PCBs / L	100	61
ER-0510	FAE-003	XAD-1-D-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	0.87	ng PCBs / L	53	80
ER-0510	FAE-013	XAD-1-D-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	3.51	ng PCBs / L	89	71
ER-0510	FAE-005	XAD-1-E-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.15	ng PCBs / L	93	60
ER-0510	FAE-015	XAD-1-E-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.77	ng PCBs / L	81	60
ER-0510	FAE-007	XAD-1-F-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.30	ng PCBs / L	85	69
ER-0510	FAE-017	XAD-1-F-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	2.30	ng PCBs / L	75	65
ER-0510	FAE-002	Filter-1-C-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	12.69	ng PCBs / L	86	76
ER-0510	FAE-012	Filter-1-C-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	18.97	ng PCBs / L	112	69
ER-0510	FAE-004	Filter-1-D-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	11.08	ng PCBs / L	100	68
ER-0510	FAE-014	Filter-1-D-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	13.17	ng PCBs / L	74	65
ER-0510	FAE-006	Filter-1-E-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	12.23	ng PCBs / L	66	67
ER-0510	FAE-016	Filter-1-E-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	11.76	ng PCBs / L	66	67
ER-0510	FAE-008	Filter-1-F-1	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	12.48	ng PCBs / L	80	68
ER-0510	FAE-018	Filter-1-F-2	1 d post-treatment asses	Water Column PCB	PCBs (reported as total	11.70	ng PCBs / L	62	64

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	FAE-181	Section-1-C-1-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.355892613	wt%	N/A	N/A
ER-0510	FAE-182	Section-1-C-1-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.733286294	wt%	N/A	N/A
ER-0510	FAE-183	Section-1-C-1-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.031910424	wt%	N/A	N/A
ER-0510	FAE-184	Section-1-C-1-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.133847683	wt%	N/A	N/A
ER-0510	FAE-185	Section-1-C-1-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.435363877	wt%	N/A	N/A
ER-0510	FAE-186	Section-1-C-1-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.955168811	wt%	N/A	N/A
ER-0510	FAE-187	Section-1-C-2-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.692826391	wt%	N/A	N/A
ER-0510	FAE-188	Section-1-C-2-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.671861811	wt%	N/A	N/A
ER-0510	FAE-189	Section-1-C-2-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.81427687	wt%	N/A	N/A
ER-0510	FAE-190	Section-1-C-2-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.818814574	wt%	N/A	N/A
ER-0510	FAE-191	Section-1-C-2-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.634234139	wt%	N/A	N/A
ER-0510	FAE-192	Section-1-C-2-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.703700381	wt%	N/A	N/A
ER-0510	FAE-193	Section-1-C-3-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.674126005	wt%	N/A	N/A
ER-0510	FAE-194	Section-1-C-3-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.390646316	wt%	N/A	N/A
ER-0510	FAE-195	Section-1-C-3-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.771636174	wt%	N/A	N/A
ER-0510	FAE-196	Section-1-C-3-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.444988672	wt%	N/A	N/A
ER-0510	FAE-197	Section-1-C-3-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.922953599	wt%	N/A	N/A
ER-0510	FAE-198	Section-1-C-3-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.886132577	wt%	N/A	N/A
ER-0510	FAE-199	Section-1-C-4-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.825470485	wt%	N/A	N/A
ER-0510	FAE-200	Section-1-C-4-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.85259874	wt%	N/A	N/A
ER-0510	FAE-201	Section-1-C-4-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.624736553	wt%	N/A	N/A
ER-0510	FAE-202	Section-1-C-4-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.677279192	wt%	N/A	N/A
ER-0510	FAE-203	Section-1-C-4-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.928330677	wt%	N/A	N/A
ER-0510	FAE-204	Section-1-C-4-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.853111885	wt%	N/A	N/A
ER-0510	FAE-205	Section-1-C-5-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.67015847	wt%	N/A	N/A
ER-0510	FAE-206	Section-1-C-5-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.731739744	wt%	N/A	N/A
ER-0510	FAE-207	Section-1-C-5-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.731762244	wt%	N/A	N/A
ER-0510	FAE-208	Section-1-C-5-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.345952153	wt%	N/A	N/A
ER-0510	FAE-209	Section-1-C-5-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.987074429	wt%	N/A	N/A
ER-0510	FAE-210	Section-1-C-5-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.77812789	wt%	N/A	N/A
ER-0510	FAE-211	Section-1-D-1-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.121834471	wt%	N/A	N/A
ER-0510	FAE-212	Section-1-D-1-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.717651509	wt%	N/A	N/A
ER-0510	FAE-213	Section-1-D-1-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	4.091096068	wt%	N/A	N/A
ER-0510	FAE-214	Section-1-D-1-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.865109997	wt%	N/A	N/A
ER-0510	FAE-215	Section-1-D-1-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.481115813	wt%	N/A	N/A
ER-0510	FAE-216	Section-1-D-1-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.76724618	wt%	N/A	N/A
ER-0510	FAE-217	Section-1-D-2-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.616095482	wt%	N/A	N/A
ER-0510	FAE-218	Section-1-D-2-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.295236908	wt%	N/A	N/A
ER-0510	FAE-219	Section-1-D-2-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	4.370725788	wt%	N/A	N/A
ER-0510	FAE-220	Section-1-D-2-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.297417986	wt%	N/A	N/A
ER-0510	FAE-221	Section-1-D-2-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.782982034	wt%	N/A	N/A
ER-0510	FAE-222	Section-1-D-2-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.067395314	wt%	N/A	N/A
ER-0510	FAE-223	Section-1-D-3-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.876620671	wt%	N/A	N/A
ER-0510	FAE-224	Section-1-D-3-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.245656364	wt%	N/A	N/A
ER-0510	FAE-225	Section-1-D-3-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.570230534	wt%	N/A	N/A
ER-0510	FAE-226	Section-1-D-3-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.269457067	wt%	N/A	N/A
ER-0510	FAE-227	Section-1-D-3-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.516274988	wt%	N/A	N/A
ER-0510	FAE-228	Section-1-D-3-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.259057803	wt%	N/A	N/A
ER-0510	FAE-229	Section-1-D-4-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	5.668031343	wt%	N/A	N/A
ER-0510	FAE-230	Section-1-D-4-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.206162149	wt%	N/A	N/A
ER-0510	FAE-231	Section-1-D-4-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.904959799	wt%	N/A	N/A
ER-0510	FAE-232	Section-1-D-4-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.895348076	wt%	N/A	N/A
ER-0510	FAE-233	Section-1-D-4-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.805142989	wt%	N/A	N/A
ER-0510	FAE-234	Section-1-D-4-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.824500236	wt%	N/A	N/A
ER-0510	FAE-235	Section-1-D-5-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	5.183997689	wt%	N/A	N/A
ER-0510	FAE-236	Section-1-D-5-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.369027636	wt%	N/A	N/A
ER-0510	FAE-237	Section-1-D-5-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	4.488341855	wt%	N/A	N/A
ER-0510	FAE-238	Section-1-D-5-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.474435112	wt%	N/A	N/A
ER-0510	FAE-239	Section-1-D-5-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.100165912	wt%	N/A	N/A
ER-0510	FAE-240	Section-1-D-5-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.585544123	wt%	N/A	N/A
ER-0510	FAE-241	Section-1-E-1-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.519625078	wt%	N/A	N/A
ER-0510	FAE-242	Section-1-E-1-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.369317995	wt%	N/A	N/A
ER-0510	FAE-243	Section-1-E-1-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.374892078	wt%	N/A	N/A
ER-0510	FAE-244	Section-1-E-1-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.477820069	wt%	N/A	N/A
ER-0510	FAE-245	Section-1-E-1-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.481113761	wt%	N/A	N/A
ER-0510	FAE-246	Section-1-E-1-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.575548906	wt%	N/A	N/A
ER-0510	FAE-247	Section-1-E-2-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.855575502	wt%	N/A	N/A
ER-0510	FAE-248	Section-1-E-2-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.531427234	wt%	N/A	N/A
ER-0510	FAE-249	Section-1-E-2-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.209771584	wt%	N/A	N/A
ER-0510	FAE-250	Section-1-E-2-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.412191786	wt%	N/A	N/A
ER-0510	FAE-251	Section-1-E-2-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.465548063	wt%	N/A	N/A
ER-0510	FAE-252	Section-1-E-2-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.599178606	wt%	N/A	N/A
ER-0510	FAE-253	Section-1-E-3-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.516799527	wt%	N/A	N/A
ER-0510	FAE-254	Section-1-E-3-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.25700641	wt%	N/A	N/A
ER-0510	FAE-255	Section-1-E-3-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.822299089	wt%	N/A	N/A
ER-0510	FAE-256	Section-1-E-3-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.661514079	wt%	N/A	N/A
ER-0510	FAE-257	Section-1-E-3-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.674021052	wt%	N/A	N/A
ER-0510	FAE-258	Section-1-E-3-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.845169611	wt%	N/A	N/A

FR-0510	FAE-259	Section-1-F-4-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.537728031	wt%	N/A	N/A	
ER-0510	FAE-260	Section-1-E-4-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.341407776	wt%	N/A	N/A	
ER-0510	FAE-261	Section-1-E-4-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.45209591	wt%	N/A	N/A	
ER-0510	FAE-262	Section-1-E-4-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.588434494	wt%	N/A	N/A	
ER-0510	FAE-263	Section-1-E-4-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.613492532	wt%	N/A	N/A	
ER-0510	FAE-264	Section-1-E-4-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.898628961	wt%	N/A	N/A	
ER-0510	FAE-265	Section-1-E-5-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.456239424	wt%	N/A	N/A	
ER-0510	FAE-266	Section-1-E-5-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.519946016	wt%	N/A	N/A	
ER-0510	FAE-267	Section-1-E-5-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.449116757	wt%	N/A	N/A	
ER-0510	FAE-268	Section-1-E-5-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.922079433	wt%	N/A	N/A	
ER-0510	FAE-269	Section-1-E-5-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.975710091	wt%	N/A	N/A	
ER-0510	FAE-270	Section-1-E-5-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.759003963	wt%	N/A	N/A	
ER-0510	FAE-271	Section-1-F-1-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.996665531	wt%	N/A	N/A	
ER-0510	FAE-272	Section-1-F-1-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.719664377	wt%	N/A	N/A	
ER-0510	FAE-273	Section-1-F-1-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.417935759	wt%	N/A	N/A	
ER-0510	FAE-274	Section-1-F-1-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.534515648	wt%	N/A	N/A	
ER-0510	FAE-275	Section-1-F-1-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.48561297	wt%	N/A	N/A	
ER-0510	FAE-276	Section-1-F-1-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.988757856	wt%	N/A	N/A	
ER-0510	FAE-277	Section-1-F-2-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	8.369534359	wt%	N/A	N/A	
ER-0510	FAE-278	Section-1-F-2-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.625591261	wt%	N/A	N/A	
ER-0510	FAE-279	Section-1-F-2-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.173752831	wt%	N/A	N/A	
ER-0510	FAE-280	Section-1-F-2-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.609923572	wt%	N/A	N/A	
ER-0510	FAE-281	Section-1-F-2-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.607309462	wt%	N/A	N/A	
ER-0510	FAE-282	Section-1-F-2-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.944904661	wt%	N/A	N/A	
ER-0510	FAE-283	Section-1-F-3-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.785385075	wt%	N/A	N/A	
ER-0510	FAE-284	Section-1-F-3-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.641297754	wt%	N/A	N/A	
ER-0510	FAE-285	Section-1-F-3-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.350637041	wt%	N/A	N/A	
ER-0510	FAE-286	Section-1-F-3-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.626752937	wt%	N/A	N/A	
ER-0510	FAE-287	Section-1-F-3-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.902138268	wt%	N/A	N/A	
ER-0510	FAE-288	Section-1-F-3-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.703776246	wt%	N/A	N/A	
ER-0510	FAE-289	Section-1-F-4-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	4.270974816	wt%	N/A	N/A	
ER-0510	FAE-290	Section-1-F-4-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.698588187	wt%	N/A	N/A	
ER-0510	FAE-291	Section-1-F-4-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.613732373	wt%	N/A	N/A	
ER-0510	FAE-292	Section-1-F-4-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	1.846083422	wt%	N/A	N/A	
FR-0510	FAE-293	Section-1-F-4-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.643888969	wt%	N/A	N/A	
ER-0510	FAE-294	Section-1-F-4-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	0.715205553	wt%	N/A	N/A	
ER-0510	FAE-295	Section-1-F-5-1	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	3.957381174	wt%	N/A	N/A	
ER-0510	FAE-296	Section-1-F-5-2	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.001104477	wt%	N/A	N/A	
ER-0510	FAE-297	Section-1-F-5-3	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.413767267	wt%	N/A	N/A	
ER-0510	FAE-298	Section-1-F-5-4	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.087053162	wt%	N/A	N/A	
ER-0510	FAE-299	Section-1-F-5-5	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	2.886234798	wt%	N/A	N/A	
ER-0510	FAE-300	Section-1-F-5-6	6 mo. post-treatment Assessment	2 inch Sediment Core TOC	Total organic carbon content	4.231936293	wt%	N/A	N/A	
ER-0510	FAE-321	Sed-1-C-1	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.935855813	mg PCBs / kg c	56	60	
ER-0510	FAE-322	Sed-1-C-2	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.161050518	mg PCBs / kg c	64	64	
ER-0510	FAE-323	Sed-1-C-3	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.298964373	mg PCBs / kg c	71	74	
ER-0510	FAE-324	Sed-1-C-4	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.038675599	mg PCBs / kg c	73	73	
ER-0510	FAE-325	Sed-1-C-5	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.949133039	mg PCBs / kg c	56	66	
ER-0510	FAE-326	Sed-1-D-1	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	0.945391779	mg PCBs / kg c	10	64	
ER-0510	FAE-327	Sed-1-D-2	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	0.681296647	mg PCBs / kg c	6	63	
ER-0510	FAE-328	Sed-1-D-3	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.458454435	mg PCBs / kg c	14	63	
ER-0510	FAE-329	Sed-1-D-4	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.721003623	mg PCBs / kg c	13	58	
ER-0510	FAE-330	Sed-1-D-5	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	3.093309401	mg PCBs / kg c	8	56	
ER-0510	FAE-331	Sed-1-E-1	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	0.95334766	mg PCBs / kg c	66	68	
ER-0510	FAE-332	Sed-1-E-2	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	3.055613882	mg PCBs / kg c	72	75	
ER-0510	FAE-333	Sed-1-E-3	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.026334895	mg PCBs / kg c	78	80	
ER-0510	FAE-334	Sed-1-E-4	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.269487307	mg PCBs / kg c	75	81	
ER-0510	FAE-335	Sed-1-E-5	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.277493511	mg PCBs / kg c	71	74	
ER-0510	FAE-336	Sed-1-F-1	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	1.670037098	mg PCBs / kg c	61	82	
ER-0510	FAE-337	Sed-1-F-2	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.926214071	mg PCBs / kg c	21	71	
ER-0510	FAE-338	Sed-1-F-3	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	2.497837225	mg PCBs / kg c	24	78	
ER-0510	FAE-339	Sed-1-F-4	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	6.399451884	mg PCBs / kg c	39	72	
ER-0510	FAE-340	Sed-1-F-5	6 mo. post-treatment Assessment	Sediment PCB level	PCBs (reported as total PCBs)	3.680095528	mg PCBs / kg c	20	68	
ER-0510	FAE-341	AqEq-1-C-1	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	11.10759943	ng PCBs / L	79	76	
ER-0510	FAE-342	AqEq-1-C-2	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	8.924423637	ng PCBs / L	80	77	
ER-0510	FAE-343	AqEq-1-C-3	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	8.968899617	ng PCBs / L	78	77	
ER-0510	FAE-344	AqEq-1-C-4	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	14.54099087	ng PCBs / L	77	74	
ER-0510	FAE-345	AqEq-1-C-5	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	13.07366047	ng PCBs / L	78	76	
ER-0510	FAE-346	AqEq-1-D-1	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	0.19454655	ng PCBs / L	81	78	
FR-0510	FAE-347	AqEq-1-D-2	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	0.149388318	ng PCBs / L	85	84	
ER-0510	FAE-348	AqEq-1-D-3	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	0.328423146	ng PCBs / L	86	85	
ER-0510	FAE-349	AqEq-1-D-4	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	0.96643793	ng PCBs / L	69	65	
ER-0510	FAE-350	AqEq-1-D-5	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	0.10	ng PCBs / L	77	74	
ER-0510	FAE-351	AqEq-1-E-1	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	5.89728224	ng PCBs / L	75	76	
ER-0510	FAE-352	AqEq-1-E-2	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	3.94360186	ng PCBs / L	77	72	
ER-0510	FAE-353	AqEq-1-E-3	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	10.27932988	ng PCBs / L	80	75	
ER-0510	FAE-354	AqEq-1-E-4	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	5.315857457	ng PCBs / L	88	85	
ER-0510	FAE-355	AqEq-1-E-5	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	7.039368955	ng PCBs / L	84	84	
ER-0510	FAE-356	AqEq-1-F-1	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	2.168369792	ng PCBs / L	87	89	
ER-0510	FAE-357	AqEq-1-F-2	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	11.08830601	ng PCBs / L	75	74	

ER-0510	FAE-358	AqEq-1-F-3	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	2.113711479	ng PCBs / L	86	87
ER-0510	FAE-359	AqEq-1-F-4	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	58.89975626	ng PCBs / L	81	76
ER-0510	FAE-360	AqEq-1-F-5	6 mo. post-treatment Assessment	Aqueous Equilibirum	PCBs (reported as total PCBs)	21.87964628	ng PCBs / L	69	70
ER-0510	FAE-021	SPMD-1-C-1	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.31166717	µg	95	100
ER-0510	FAE-022	SPMD-1-C-2	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.236920657	µg	94	96
ER-0510	FAE-023	SPMD-1-C-3	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.243644908	µg	98	98
ER-0510	FAE-024	SPMD-1-C-4	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.294539698	µg	102	96
ER-0510	FAE-025	SPMD-1-C-5	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.39635124	µg	98	97
ER-0510	FAE-026	SPMD-1-D-1	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.063311644	µg	92	90
ER-0510	FAE-027	SPMD-1-D-2	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.067601479	µg	91	96
ER-0510	FAE-028	SPMD-1-D-3	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.091310655	µg	93	95
ER-0510	FAE-029	SPMD-1-D-4	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.100030644	µg	98	95
ER-0510	FAE-030	SPMD-1-D-5	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.170950787	µg	96	94
ER-0510	FAE-031	SPMD-1-E-1	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.185122544	µg	89	94
ER-0510	FAE-032	SPMD-1-E-2	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.132288366	µg	93	95
ER-0510	FAE-033	SPMD-1-E-3	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.141852653	µg	90	90
ER-0510	FAE-034	SPMD-1-E-4	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.171558964	µg	96	98
ER-0510	FAE-035	SPMD-1-E-5	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.149325014	µg	93	96
ER-0510	FAE-036	SPMD-1-F-1	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.115544348	µg	94	96
ER-0510	FAE-037	SPMD-1-F-2	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.10992927	µg	94	97
ER-0510	FAE-038	SPMD-1-F-3	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.100413666	µg	92	95
ER-0510	FAE-039	SPMD-1-F-4	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.105930465	µg	92	95
ER-0510	FAE-040	SPMD-1-F-5	6 mo. post-treatment Assessment	SPMD uptake	PCBs (reported as total PCBs)	0.131478079	µg	97	99
ER-0510	FAE-121	Clam-1-C-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	394.364	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-122	Clam-1-C-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	341.481	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-123	Clam-1-C-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	320.142	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-124	Clam-1-C-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	300.514	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-125	Clam-1-C-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	354.645	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-126	Clam-1-D-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	263.549	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-127	Clam-1-D-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	216.365	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-128	Clam-1-D-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	218.633	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-129	Clam-1-D-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	288.976	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-130	Clam-1-D-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	232.829	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-131	Clam-1-E-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)		µg PCBs/ kg wet clam tissue		
ER-0510	FAE-132	Clam-1-E-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	206.381	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-133	Clam-1-E-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	249.46	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-134	Clam-1-E-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	327.038	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-135	Clam-1-E-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	274.93	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-136	Clam-1-F-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	249.86	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-137	Clam-1-F-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	193.446	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-138	Clam-1-F-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	272.262	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-139	Clam-1-F-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	185.288	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-140	Clam-1-F-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	229.445	µg PCBs/ kg wet clam tissue		
ER-0510	FAE-121	Clam-1-C-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-122	Clam-1-C-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	1.2%	% of wet clam tissue		
ER-0510	FAE-123	Clam-1-C-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue		
ER-0510	FAE-124	Clam-1-C-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-125	Clam-1-C-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-126	Clam-1-D-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue		
ER-0510	FAE-127	Clam-1-D-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue		
ER-0510	FAE-128	Clam-1-D-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue		
ER-0510	FAE-129	Clam-1-D-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-130	Clam-1-D-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content		% of wet clam tissue		
ER-0510	FAE-131	Clam-1-E-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content		% of wet clam tissue		
ER-0510	FAE-132	Clam-1-E-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content		% of wet clam tissue		
ER-0510	FAE-133	Clam-1-E-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue		
ER-0510	FAE-134	Clam-1-E-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue		
ER-0510	FAE-135	Clam-1-E-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-136	Clam-1-F-1	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue		
ER-0510	FAE-137	Clam-1-F-2	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue		
ER-0510	FAE-138	Clam-1-F-3	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.7%	% of wet clam tissue		
ER-0510	FAE-139	Clam-1-F-4	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.6%	% of wet clam tissue		
ER-0510	FAE-140	Clam-1-F-5	6 mo. post-treatment Assessment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue		
ER-0510	FAE-041	Amphipod-1-C-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)		µg PCBs/ kg wet tissue		
ER-0510	FAE-042	Amphipod-1-C-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1041.057	µg PCBs/ kg wet tissue		
ER-0510	FAE-043	Amphipod-1-C-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1009.072	µg PCBs/ kg wet tissue		
ER-0510	FAE-044	Amphipod-1-C-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1389.012	µg PCBs/ kg wet tissue		
ER-0510	FAE-045	Amphipod-1-C-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	983.527	µg PCBs/ kg wet tissue		
ER-0510	FAE-046	Amphipod-1-D-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	733.95	µg PCBs/ kg wet tissue		
ER-0510	FAE-047	Amphipod-1-D-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	828.521	µg PCBs/ kg wet tissue		
ER-0510	FAE-048	Amphipod-1-D-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	974.122	µg PCBs/ kg wet tissue		
ER-0510	FAE-049	Amphipod-1-D-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1212.111	µg PCBs/ kg wet tissue		
ER-0510	FAE-050	Amphipod-1-D-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	845.904	µg PCBs/ kg wet tissue		
ER-0510	FAE-051	Amphipod-1-E-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1014.314	µg PCBs/ kg wet tissue		
ER-0510	FAE-052	Amphipod-1-E-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	851.317	µg PCBs/ kg wet tissue		
ER-0510	FAE-053	Amphipod-1-E-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	698.723	µg PCBs/ kg wet tissue		

ER-0510	FAE-054	Amphipod-1-E-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	851.399	µg PCBs/ kg wet tissue				
ER-0510	FAE-055	Amphipod-1-E-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	953.609	µg PCBs/ kg wet tissue				
ER-0510	FAE-056	Amphipod-1-F-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1441.003	µg PCBs/ kg wet tissue				
ER-0510	FAE-057	Amphipod-1-F-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1080.484	µg PCBs/ kg wet tissue				
ER-0510	FAE-058	Amphipod-1-F-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1052.584	µg PCBs/ kg wet tissue				
ER-0510	FAE-059	Amphipod-1-F-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	867.07	µg PCBs/ kg wet tissue				
ER-0510	FAE-060	Amphipod-1-F-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	PCBs (reported as total PCBs)	1307.995	µg PCBs/ kg wet tissue				
ER-0510	FAE-041	Amphipod-1-C-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.9%	% of wet tissue				
ER-0510	FAE-042	Amphipod-1-C-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.8%	% of wet tissue				
ER-0510	FAE-043	Amphipod-1-C-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.8%	% of wet tissue				
ER-0510	FAE-044	Amphipod-1-C-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content		% of wet tissue				
ER-0510	FAE-045	Amphipod-1-C-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.6%	% of wet tissue				
ER-0510	FAE-046	Amphipod-1-D-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.1%	% of wet tissue				
ER-0510	FAE-047	Amphipod-1-D-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.5%	% of wet tissue				
ER-0510	FAE-048	Amphipod-1-D-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.4%	% of wet tissue				
ER-0510	FAE-049	Amphipod-1-D-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.2%	% of wet tissue				
ER-0510	FAE-050	Amphipod-1-D-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.3%	% of wet tissue				
ER-0510	FAE-051	Amphipod-1-E-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.1%	% of wet tissue				
ER-0510	FAE-052	Amphipod-1-E-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.9%	% of wet tissue				
ER-0510	FAE-053	Amphipod-1-E-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.5%	% of wet tissue				
ER-0510	FAE-054	Amphipod-1-E-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.3%	% of wet tissue				
ER-0510	FAE-055	Amphipod-1-E-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.7%	% of wet tissue				
ER-0510	FAE-056	Amphipod-1-F-1	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.5%	% of wet tissue				
ER-0510	FAE-057	Amphipod-1-F-2	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.8%	% of wet tissue				
ER-0510	FAE-058	Amphipod-1-F-3	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	2.1%	% of wet tissue				
ER-0510	FAE-059	Amphipod-1-F-4	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.1%	% of wet tissue				
ER-0510	FAE-060	Amphipod-1-F-5	6 mo. post-treatment Assessment	Indigenous Amphipod PCB Bio	lipid content	1.9%	% of wet tissue				
ER-0510	FAE-361,362	Desorption-1-C-0.08d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-1d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.10	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-2d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.14	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-5d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.19	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-11d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.24	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-31d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.32	fraction of PCB desorbed				
ER-0510	FAE-361,362	Desorption-1-C-60d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.37	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-0.08d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.00	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-1d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-2d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-5d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.04	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-11d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.06	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-31d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.09	fraction of PCB desorbed				
ER-0510	FAE-363,364	Desorption-1-D-60d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.11	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-0.08d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.02	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-1d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.06	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-2d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.08	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-5d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.10	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-11d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.13	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-31d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.16	fraction of PCB desorbed				
ER-0510	FAE-365,366	Desorption-1-E-60d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.19	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-0.08d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.01	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-1d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.07	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-2d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.09	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-5d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.11	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-11d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.13	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-31d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.18	fraction of PCB desorbed				
ER-0510	FAE-367,368	Desorption-1-F-60d	6 mo. post-treatment Assessment	Sediment PCB Desorption	PCBs (reported as total PCBs)	0.21	fraction of PCB desorbed				
ER-0510	N/A	BC-1-C	6 mo. post-treatment Assessment	Composite Sediment BC	Black Carbon Contents	0.0015	g BC / g dry Se	N/A	N/A		
ER-0510	N/A	BC-1-D	6 mo. post-treatment Assessment	Composite Sediment BC	Black Carbon Contents	0.0254	g BC / g dry Se	N/A	N/A		
ER-0510	N/A	BC-1-E	6 mo. post-treatment Assessment	Composite Sediment BC	Black Carbon Contents	0.00154	g BC / g dry Se	N/A	N/A		
ER-0510	N/A	BC-1-F	6 mo. post-treatment Assessment	Composite Sediment BC	Black Carbon Contents	0.01001	g BC / g dry Se	N/A	N/A		
ER-0510	FAE-141	XAD-2-C-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.34	ng PCBs / L		101		92
ER-0510	FAE-142	XAD-2-C-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.48	ng PCBs / L		96		87
ER-0510	FAE-143	XAD-2-D-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	Fail to Measure	ng PCBs / L	N/A	N/A		
ER-0510	FAE-144	XAD-2-D-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	Fail to Measure	ng PCBs / L	N/A	N/A		
ER-0510	FAE-145	XAD-2-E-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.62	ng PCBs / L		95		83
ER-0510	FAE-146	XAD-2-E-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.23	ng PCBs / L		116		79
ER-0510	FAE-147	XAD-2-F-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.18	ng PCBs / L		104		84
ER-0510	FAE-148	XAD-2-F-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	3.16	ng PCBs / L		122		90
ER-0510	FAE-149	Filter-2-C-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	16.43	ng PCBs / L		96		96
ER-0510	FAE-150	Filter-2-C-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	17.96	ng PCBs / L		79		75
ER-0510	FAE-151	Filter-2-D-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	Fail to Measure	ng PCBs / L	N/A	N/A		
ER-0510	FAE-152	Filter-2-D-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	Fail to Measure	ng PCBs / L	N/A	N/A		
ER-0510	FAE-153	Filter-2-E-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	25.29	ng PCBs / L		64		101
ER-0510	FAE-154	Filter-2-E-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	16.89	ng PCBs / L		87		89
ER-0510	FAE-155	Filter-2-F-1	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	23.69	ng PCBs / L		83		84
ER-0510	FAE-156	Filter-2-F-2	6 mo. post-treatment Assessment	Water Column PCB	PCBs (reported as total PCBs)	21.02	ng PCBs / L		87		90

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	FAE-141	XAD-1-C-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	0.99	ng PCBs / L	81	97
ER-0510	FAE-142	XAD-1-C-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	0.33	ng PCBs / L	79	88
ER-0510	FAE-143	XAD-1-D-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	1.00	ng PCBs / L	79	98
ER-0510	FAE-144	XAD-1-D-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	1.83	ng PCBs / L	64	95
ER-0510	FAE-145	XAD-1-E-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	1.76	ng PCBs / L	80	98
ER-0510	FAE-146	XAD-1-E-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	uncollected	ng PCBs / L	N/A	N/A
ER-0510	FAE-147	XAD-1-F-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	1.29	ng PCBs / L	82	92
ER-0510	FAE-148	XAD-1-F-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	1.53	ng PCBs / L	100	99
ER-0510	FAE-149	Filter-1-C-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	3.43	ng PCBs / L	100	94
ER-0510	FAE-150	Filter-1-C-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	10.25	ng PCBs / L	109	96
ER-0510	FAE-151	Filter-1-D-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	2.98	ng PCBs / L	110	102
ER-0510	FAE-152	Filter-1-D-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	7.98	ng PCBs / L	116	95
ER-0510	FAE-153	Filter-1-E-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	uncollected	ng PCBs / L	N/A	N/A
ER-0510	FAE-154	Filter-1-E-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	5.96	ng PCBs / L	115	85
ER-0510	FAE-155	Filter-1-F-1	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	8.47	ng PCBs / L	126	83
ER-0510	FAE-156	Filter-1-F-2	12 mo. Post-treatment a	Water Column PCB	PCBs (reported as total PCBs)	5.13	ng PCBs / L	103	89

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Rec	Surrogate Recovery (PCB 65)
ER-0510	GAE-217	Section-2-C-1-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.63446389	wt%	N/A	N/A
ER-0510	GAE-218	Section-2-C-1-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.27834673	wt%	N/A	N/A
ER-0510	GAE-219	Section-2-C-1-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.60362715	wt%	N/A	N/A
ER-0510	GAE-220	Section-2-C-1-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.45283498	wt%	N/A	N/A
ER-0510	GAE-221	Section-2-C-1-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.49047132	wt%	N/A	N/A
ER-0510	GAE-222	Section-2-C-1-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.71186966	wt%	N/A	N/A
ER-0510	GAE-223	Section-2-C-2-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.73355646	wt%	N/A	N/A
ER-0510	GAE-224	Section-2-C-2-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.50648658	wt%	N/A	N/A
ER-0510	GAE-225	Section-2-C-2-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.64313468	wt%	N/A	N/A
ER-0510	GAE-226	Section-2-C-2-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.4915808	wt%	N/A	N/A
ER-0510	GAE-227	Section-2-C-2-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.72140544	wt%	N/A	N/A
ER-0510	GAE-228	Section-2-C-2-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.61563387	wt%	N/A	N/A
ER-0510	GAE-229	Section-2-C-3-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.88891629	wt%	N/A	N/A
ER-0510	GAE-230	Section-2-C-3-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.3470144	wt%	N/A	N/A
ER-0510	GAE-231	Section-2-C-3-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.39134226	wt%	N/A	N/A
ER-0510	GAE-232	Section-2-C-3-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.42950009	wt%	N/A	N/A
ER-0510	GAE-233	Section-2-C-3-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.470382	wt%	N/A	N/A
ER-0510	GAE-234	Section-2-C-3-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.52698526	wt%	N/A	N/A
ER-0510	GAE-235	Section-2-C-4-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.06704048	wt%	N/A	N/A
ER-0510	GAE-236	Section-2-C-4-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.89813861	wt%	N/A	N/A
ER-0510	GAE-237	Section-2-C-4-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.71051946	wt%	N/A	N/A
ER-0510	GAE-238	Section-2-C-4-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.88966502	wt%	N/A	N/A
ER-0510	GAE-239	Section-2-C-4-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.60456522	wt%	N/A	N/A
ER-0510	GAE-240	Section-2-C-4-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.81569435	wt%	N/A	N/A
ER-0510	GAE-241	Section-2-C-5-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.04347078	wt%	N/A	N/A
ER-0510	GAE-242	Section-2-C-5-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.33273092	wt%	N/A	N/A
ER-0510	GAE-243	Section-2-C-5-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.39990834	wt%	N/A	N/A
ER-0510	GAE-244	Section-2-C-5-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.42329716	wt%	N/A	N/A
ER-0510	GAE-245	Section-2-C-5-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.80771297	wt%	N/A	N/A
ER-0510	GAE-246	Section-2-C-5-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.87887472	wt%	N/A	N/A
ER-0510	GAE-247	Section-2-D-1-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.9989379	wt%	N/A	N/A
ER-0510	GAE-248	Section-2-D-1-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.49352292	wt%	N/A	N/A
ER-0510	GAE-249	Section-2-D-1-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.03166682	wt%	N/A	N/A
ER-0510	GAE-250	Section-2-D-1-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.07308904	wt%	N/A	N/A
ER-0510	GAE-251	Section-2-D-1-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.41967079	wt%	N/A	N/A
ER-0510	GAE-252	Section-2-D-1-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.55100799	wt%	N/A	N/A
ER-0510	GAE-253	Section-2-D-2-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.08590426	wt%	N/A	N/A
ER-0510	GAE-254	Section-2-D-2-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.66338895	wt%	N/A	N/A
ER-0510	GAE-255	Section-2-D-2-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.5469575	wt%	N/A	N/A
ER-0510	GAE-256	Section-2-D-2-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.37679051	wt%	N/A	N/A
ER-0510	GAE-257	Section-2-D-2-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.07562305	wt%	N/A	N/A
ER-0510	GAE-258	Section-2-D-2-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.14295728	wt%	N/A	N/A
ER-0510	GAE-259	Section-2-D-3-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.29050349	wt%	N/A	N/A
ER-0510	GAE-260	Section-2-D-3-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.40130449	wt%	N/A	N/A
ER-0510	GAE-261	Section-2-D-3-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.32775776	wt%	N/A	N/A
ER-0510	GAE-262	Section-2-D-3-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.18337789	wt%	N/A	N/A
ER-0510	GAE-263	Section-2-D-3-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.19768248	wt%	N/A	N/A
ER-0510	GAE-264	Section-2-D-3-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.04681325	wt%	N/A	N/A
ER-0510	GAE-265	Section-2-D-4-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.17209411	wt%	N/A	N/A
ER-0510	GAE-266	Section-2-D-4-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.90488216	wt%	N/A	N/A
ER-0510	GAE-267	Section-2-D-4-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	4.27196405	wt%	N/A	N/A
ER-0510	GAE-268	Section-2-D-4-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.31886181	wt%	N/A	N/A
ER-0510	GAE-269	Section-2-D-4-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.76405514	wt%	N/A	N/A
ER-0510	GAE-270	Section-2-D-4-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.12334394	wt%	N/A	N/A
ER-0510	GAE-271	Section-2-D-5-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	4.31601582	wt%	N/A	N/A
ER-0510	GAE-272	Section-2-D-5-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.66989183	wt%	N/A	N/A
ER-0510	GAE-273	Section-2-D-5-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.09363022	wt%	N/A	N/A
ER-0510	GAE-274	Section-2-D-5-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.40554168	wt%	N/A	N/A

ER-0510	GAE-275	Section-2-D-5-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.74363846	wt%	N/A	N/A
ER-0510	GAE-276	Section-2-D-5-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.95055215	wt%	N/A	N/A
ER-0510	GAE-277	Section-2-E-1-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.10273998	wt%	N/A	N/A
ER-0510	GAE-278	Section-2-E-1-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.36834957	wt%	N/A	N/A
ER-0510	GAE-279	Section-2-E-1-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.19833768	wt%	N/A	N/A
ER-0510	GAE-280	Section-2-E-1-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.32871892	wt%	N/A	N/A
ER-0510	GAE-281	Section-2-E-1-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.43343332	wt%	N/A	N/A
ER-0510	GAE-282	Section-2-E-1-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.38290068	wt%	N/A	N/A
ER-0510	GAE-283	Section-2-E-2-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.75622053	wt%	N/A	N/A
ER-0510	GAE-284	Section-2-E-2-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.32663147	wt%	N/A	N/A
ER-0510	GAE-285	Section-2-E-2-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.21038739	wt%	N/A	N/A
ER-0510	GAE-286	Section-2-E-2-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.43060713	wt%	N/A	N/A
ER-0510	GAE-287	Section-2-E-2-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.36679567	wt%	N/A	N/A
ER-0510	GAE-288	Section-2-E-2-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.47550109	wt%	N/A	N/A
ER-0510	GAE-289	Section-2-E-3-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.83273495	wt%	N/A	N/A
ER-0510	GAE-290	Section-2-E-3-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.39982143	wt%	N/A	N/A
ER-0510	GAE-291	Section-2-E-3-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.19880137	wt%	N/A	N/A
ER-0510	GAE-292	Section-2-E-3-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.51495471	wt%	N/A	N/A
ER-0510	GAE-293	Section-2-E-3-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.62534528	wt%	N/A	N/A
ER-0510	GAE-294	Section-2-E-3-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.30090479	wt%	N/A	N/A
ER-0510	GAE-295	Section-2-E-4-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.16986093	wt%	N/A	N/A
ER-0510	GAE-296	Section-2-E-4-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.37421423	wt%	N/A	N/A
ER-0510	GAE-297	Section-2-E-4-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.46726721	wt%	N/A	N/A
ER-0510	GAE-298	Section-2-E-4-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.65288045	wt%	N/A	N/A
ER-0510	GAE-299	Section-2-E-4-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.4879653	wt%	N/A	N/A
ER-0510	GAE-300	Section-2-E-4-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	Unavailable	wt%	N/A	N/A
ER-0510	GAE-301	Section-2-E-5-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.30517032	wt%	N/A	N/A
ER-0510	GAE-302	Section-2-E-5-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.43136069	wt%	N/A	N/A
ER-0510	GAE-303	Section-2-E-5-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.42576727	wt%	N/A	N/A
ER-0510	GAE-304	Section-2-E-5-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.47880483	wt%	N/A	N/A
ER-0510	GAE-305	Section-2-E-5-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.67712037	wt%	N/A	N/A
ER-0510	GAE-306	Section-2-E-5-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.47334368	wt%	N/A	N/A
ER-0510	GAE-307	Section-2-F-1-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	7.79122202	wt%	N/A	N/A
ER-0510	GAE-308	Section-2-F-1-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	6.1681902	wt%	N/A	N/A
ER-0510	GAE-309	Section-2-F-1-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.69993523	wt%	N/A	N/A
ER-0510	GAE-310	Section-2-F-1-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.01793683	wt%	N/A	N/A
ER-0510	GAE-311	Section-2-F-1-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.52295371	wt%	N/A	N/A
ER-0510	GAE-312	Section-2-F-1-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.73615245	wt%	N/A	N/A
ER-0510	GAE-313	Section-2-F-2-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.00516669	wt%	N/A	N/A
ER-0510	GAE-314	Section-2-F-2-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.57838639	wt%	N/A	N/A
ER-0510	GAE-315	Section-2-F-2-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	0.9700433	wt%	N/A	N/A
ER-0510	GAE-316	Section-2-F-2-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.591743	wt%	N/A	N/A
ER-0510	GAE-317	Section-2-F-2-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.28067423	wt%	N/A	N/A
ER-0510	GAE-318	Section-2-F-2-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.52396512	wt%	N/A	N/A
ER-0510	GAE-319	Section-2-F-3-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.32633057	wt%	N/A	N/A
ER-0510	GAE-320	Section-2-F-3-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.56033275	wt%	N/A	N/A
ER-0510	GAE-321	Section-2-F-3-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.51031278	wt%	N/A	N/A
ER-0510	GAE-322	Section-2-F-3-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.7098023	wt%	N/A	N/A
ER-0510	GAE-323	Section-2-F-3-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.8861254	wt%	N/A	N/A
ER-0510	GAE-324	Section-2-F-3-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.2011044	wt%	N/A	N/A
ER-0510	GAE-325	Section-2-F-4-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.96609285	wt%	N/A	N/A
ER-0510	GAE-326	Section-2-F-4-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.01140724	wt%	N/A	N/A
ER-0510	GAE-327	Section-2-F-4-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.61629001	wt%	N/A	N/A
ER-0510	GAE-328	Section-2-F-4-4	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.81302327	wt%	N/A	N/A
ER-0510	GAE-329	Section-2-F-4-5	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	1.32182879	wt%	N/A	N/A
ER-0510	GAE-330	Section-2-F-4-6	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.56043492	wt%	N/A	N/A
ER-0510	GAE-331	Section-2-F-5-1	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	3.99158438	wt%	N/A	N/A
ER-0510	GAE-332	Section-2-F-5-2	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	4.71849698	wt%	N/A	N/A
ER-0510	GAE-333	Section-2-F-5-3	18 mo. post-treatment A	2 inch Sediment Core TOC	Total organic carbon content	2.73377532	wt%	N/A	N/A

ER-0510	GAE-334	Section-2-F-5-4	18 mo. post-treatment A:	2 inch Sediment Core TOC	Total organic carbon content	2.43028683	wt%	N/A	N/A	
ER-0510	GAE-335	Section-2-F-5-5	18 mo. post-treatment A:	2 inch Sediment Core TOC	Total organic carbon content	1.62966516	wt%	N/A	N/A	
ER-0510	GAE-336	Section-2-F-5-6	18 mo. post-treatment A:	2 inch Sediment Core TOC	Total organic carbon content	2.28824881	wt%	N/A	N/A	
ER-0510	GAE-173	Sed-2-C-1	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.07356641	mg PCBs / kg		75	74
ER-0510	GAE-174	Sed-2-C-2	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	2.09085333	mg PCBs / kg		72	73
ER-0510	GAE-175	Sed-2-C-3	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	2.56168831	mg PCBs / kg		70	70
ER-0510	GAE-176	Sed-2-C-4	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.2980135	mg PCBs / kg		68	68
ER-0510	GAE-177	Sed-2-C-5	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	2.57508542	mg PCBs / kg		66	69
ER-0510	GAE-178	Sed-2-D-1	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	0.84428626	mg PCBs / kg		20	68
ER-0510	GAE-179	Sed-2-D-2	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.55359837	mg PCBs / kg		30	66
ER-0510	GAE-180	Sed-2-D-3	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.5072598	mg PCBs / kg		24	69
ER-0510	GAE-181	Sed-2-D-4	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.11745523	mg PCBs / kg		19	68
ER-0510	GAE-182	Sed-2-D-5	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	2.54792433	mg PCBs / kg		12	53
ER-0510	GAE-183	Sed-2-E-1	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.66742505	mg PCBs / kg		60	63
ER-0510	GAE-184	Sed-2-E-2	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.38639724	mg PCBs / kg		66	64
ER-0510	GAE-185	Sed-2-E-3	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.33241499	mg PCBs / kg		75	76
ER-0510	GAE-186	Sed-2-E-4	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	2.79952443	mg PCBs / kg		69	74
ER-0510	GAE-187	Sed-2-E-5	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.03191552	mg PCBs / kg		73	75
ER-0510	GAE-188	Sed-2-F-1	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	40.7341102	mg PCBs / kg		52	72
ER-0510	GAE-189	Sed-2-F-2	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.09895896	mg PCBs / kg		16	54
ER-0510	GAE-190	Sed-2-F-3	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.15175085	mg PCBs / kg		28	70
ER-0510	GAE-191	Sed-2-F-4	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	1.81964444	mg PCBs / kg		20	59
ER-0510	GAE-192	Sed-2-F-5	18 mo. post-treatment A:	Sediment PCB level	PCBs (reported as total PCBs	3.43085427	mg PCBs / kg		20	60
ER-0510	GAE-193	AqEq-2-C-1	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	22.2550962	ng PCBs / L		77	77
ER-0510	GAE-194	AqEq-2-C-2	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	24.5309146	ng PCBs / L		73	73
ER-0510	GAE-195	AqEq-2-C-3	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	23.5426473	ng PCBs / L		81	79
ER-0510	GAE-196	AqEq-2-C-4	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	21.5533402	ng PCBs / L		84	83
ER-0510	GAE-197	AqEq-2-C-5	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	31.2725654	ng PCBs / L		89	85
ER-0510	GAE-198	AqEq-2-D-1	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	0.32845722	ng PCBs / L		81	74
ER-0510	GAE-199	AqEq-2-D-2	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	9.08394533	ng PCBs / L		76	76
ER-0510	GAE-200	AqEq-2-D-3	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	3.66419244	ng PCBs / L		80	78
ER-0510	GAE-201	AqEq-2-D-4	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	2.9553967	ng PCBs / L		4	6
ER-0510	GAE-202	AqEq-2-D-5	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	3.31595176	ng PCBs / L		85	83
ER-0510	GAE-203	AqEq-2-E-1	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	15.5500208	ng PCBs / L		80	81
ER-0510	GAE-204	AqEq-2-E-2	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	24.7805403	ng PCBs / L		80	80
ER-0510	GAE-205	AqEq-2-E-3	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	9.330352	ng PCBs / L		80	81
ER-0510	GAE-206	AqEq-2-E-4	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	19.5963336	ng PCBs / L		81	82
ER-0510	GAE-207	AqEq-2-E-5	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	23.8575096	ng PCBs / L		97	93
ER-0510	GAE-208	AqEq-2-F-1	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	8.49768637	ng PCBs / L		81	78
ER-0510	GAE-209	AqEq-2-F-2	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	19.9609161	ng PCBs / L		78	77
ER-0510	GAE-210	AqEq-2-F-3	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	7.36197409	ng PCBs / L		79	80
ER-0510	GAE-211	AqEq-2-F-4	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	8.83117332	ng PCBs / L		85	82
ER-0510	GAE-212	AqEq-2-F-5	18 mo. post-treatment A:	Aqueous Equilibirum	PCBs (reported as total PCBs	6.49743196	ng PCBs / L		82	78
ER-0510	GAE-069	SPMD-2-C-1	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.23562599	µg		82	73
ER-0510	GAE-070	SPMD-2-C-2	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.28018393	µg		80	79
ER-0510	GAE-071	SPMD-2-C-3	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs)		µg			
ER-0510	GAE-072	SPMD-2-C-4	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.23156009	µg		75	73
ER-0510	GAE-073	SPMD-2-C-5	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.26969982	µg		83	79
ER-0510	GAE-074	SPMD-2-D-1	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs)		µg			
ER-0510	GAE-075	SPMD-2-D-2	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.09070988	µg		75	70
ER-0510	GAE-076	SPMD-2-D-3	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.08660435	µg		82	80
ER-0510	GAE-077	SPMD-2-D-4	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.13840192	µg		80	77
ER-0510	GAE-078	SPMD-2-D-5	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.16931971	µg		84	78
ER-0510	GAE-079	SPMD-2-E-1	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.27398724	µg		88	91
ER-0510	GAE-080	SPMD-2-E-2	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.13087505	µg		84	83
ER-0510	GAE-081	SPMD-2-E-3	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs)		µg			
ER-0510	GAE-082	SPMD-2-E-4	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.16137142	µg		81	84
ER-0510	GAE-083	SPMD-2-E-5	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.17075756	µg		88	89

ER-0510	GAE-084	SPMD-2-F-1	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.13406141	µg		72	68
ER-0510	GAE-085	SPMD-2-F-2	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.16250875	µg		79	78
ER-0510	GAE-086	SPMD-2-F-3	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs)		µg			
ER-0510	GAE-087	SPMD-2-F-4	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs	0.11604234	µg		71	71
ER-0510	GAE-088	SPMD-2-F-5	18 mo. post-treatment A:	SPMD uptake	PCBs (reported as total PCBs)		µg			
ER-0510	GAE-129	Clam-2-C-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	251.211	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-130	Clam-2-C-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	315.165	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-131	Clam-2-C-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	283.886	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-132	Clam-2-C-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	275.224	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-133	Clam-2-C-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	306.305	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-134	Clam-2-D-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	239.539	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-135	Clam-2-D-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	227.851	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-136	Clam-2-D-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	283.935	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-137	Clam-2-D-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	228.462	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-138	Clam-2-D-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	215.084	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-139	Clam-2-E-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	205.79	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-140	Clam-2-E-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	272.42	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-141	Clam-2-E-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	332.293	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-142	Clam-2-E-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	231.108	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-143	Clam-2-E-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	231.749	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-144	Clam-2-F-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	238.801	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-145	Clam-2-F-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	261.55	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-146	Clam-2-F-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	215.909	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-147	Clam-2-F-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	243.292	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-148	Clam-2-F-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	PCBs (reported as total PCBs	233.252	µg	PCBs/ kg wet clam tissue		
ER-0510	GAE-129	Clam-2-C-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.4%	%	of wet clam tissue		
ER-0510	GAE-130	Clam-2-C-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-131	Clam-2-C-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.4%	%	of wet clam tissue		
ER-0510	GAE-132	Clam-2-C-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.3%	%	of wet clam tissue		
ER-0510	GAE-133	Clam-2-C-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.5%	%	of wet clam tissue		
ER-0510	GAE-134	Clam-2-D-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-135	Clam-2-D-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-136	Clam-2-D-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.5%	%	of wet clam tissue		
ER-0510	GAE-137	Clam-2-D-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.7%	%	of wet clam tissue		
ER-0510	GAE-138	Clam-2-D-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-139	Clam-2-E-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-140	Clam-2-E-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-141	Clam-2-E-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.3%	%	of wet clam tissue		
ER-0510	GAE-142	Clam-2-E-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.3%	%	of wet clam tissue		
ER-0510	GAE-143	Clam-2-E-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.5%	%	of wet clam tissue		
ER-0510	GAE-144	Clam-2-F-1	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.3%	%	of wet clam tissue		
ER-0510	GAE-145	Clam-2-F-2	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.7%	%	of wet clam tissue		
ER-0510	GAE-146	Clam-2-F-3	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.3%	%	of wet clam tissue		
ER-0510	GAE-147	Clam-2-F-4	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.6%	%	of wet clam tissue		
ER-0510	GAE-148	Clam-2-F-5	18 mo. post-treatment A:	Clam PCB Bioaccumulation	lipid content	1.2%	%	of wet clam tissue		
ER-0510	GAE-089	Amphipod-2-C-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1320.273	µg	PCBs/ kg wet tissue		
ER-0510	GAE-090	Amphipod-2-C-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1332.472	µg	PCBs/ kg wet tissue		
ER-0510	GAE-091	Amphipod-2-C-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1167.652	µg	PCBs/ kg wet tissue		
ER-0510	GAE-092	Amphipod-2-C-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1311.875	µg	PCBs/ kg wet tissue		
ER-0510	GAE-093	Amphipod-2-C-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1576.454	µg	PCBs/ kg wet tissue		
ER-0510	GAE-094	Amphipod-2-D-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1098.199	µg	PCBs/ kg wet tissue		
ER-0510	GAE-095	Amphipod-2-D-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1214.044	µg	PCBs/ kg wet tissue		
ER-0510	GAE-096	Amphipod-2-D-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1601.768	µg	PCBs/ kg wet tissue		
ER-0510	GAE-097	Amphipod-2-D-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1524.622	µg	PCBs/ kg wet tissue		
ER-0510	GAE-098	Amphipod-2-D-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1601.394	µg	PCBs/ kg wet tissue		
ER-0510	GAE-099	Amphipod-2-E-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs)		µg	PCBs/ kg wet tissue		
ER-0510	GAE-100	Amphipod-2-E-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs)		µg	PCBs/ kg wet tissue		

ER-0510	GAE-101	Amphipod-2-E-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1549.129	µg PCBs/ kg wet tissue			
ER-0510	GAE-102	Amphipod-2-E-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1541.732	µg PCBs/ kg wet tissue			
ER-0510	GAE-103	Amphipod-2-E-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	2014.53	µg PCBs/ kg wet tissue			
ER-0510	GAE-104	Amphipod-2-F-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1792.847	µg PCBs/ kg wet tissue			
ER-0510	GAE-105	Amphipod-2-F-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1264.864	µg PCBs/ kg wet tissue			
ER-0510	GAE-106	Amphipod-2-F-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	1406.164	µg PCBs/ kg wet tissue			
ER-0510	GAE-107	Amphipod-2-F-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs	3602.825	µg PCBs/ kg wet tissue			
ER-0510	GAE-108	Amphipod-2-F-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	PCBs (reported as total PCBs)		µg PCBs/ kg wet tissue			
ER-0510	GAE-089	Amphipod-2-C-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.9%	% of wet tissue			
ER-0510	GAE-090	Amphipod-2-C-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.0%	% of wet tissue			
ER-0510	GAE-091	Amphipod-2-C-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	1.5%	% of wet tissue			
ER-0510	GAE-092	Amphipod-2-C-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	1.6%	% of wet tissue			
ER-0510	GAE-093	Amphipod-2-C-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content		% of wet tissue			
ER-0510	GAE-094	Amphipod-2-D-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	1.8%	% of wet tissue			
ER-0510	GAE-095	Amphipod-2-D-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.9%	% of wet tissue			
ER-0510	GAE-096	Amphipod-2-D-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	3.6%	% of wet tissue			
ER-0510	GAE-097	Amphipod-2-D-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.6%	% of wet tissue			
ER-0510	GAE-098	Amphipod-2-D-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	5.9%	% of wet tissue			
ER-0510	GAE-099	Amphipod-2-E-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content		% of wet tissue			
ER-0510	GAE-100	Amphipod-2-E-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content		% of wet tissue			
ER-0510	GAE-101	Amphipod-2-E-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	3.8%	% of wet tissue			
ER-0510	GAE-102	Amphipod-2-E-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	4.0%	% of wet tissue			
ER-0510	GAE-103	Amphipod-2-E-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	3.4%	% of wet tissue			
ER-0510	GAE-104	Amphipod-2-F-1	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	3.0%	% of wet tissue			
ER-0510	GAE-105	Amphipod-2-F-2	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.4%	% of wet tissue			
ER-0510	GAE-106	Amphipod-2-F-3	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	2.5%	% of wet tissue			
ER-0510	GAE-107	Amphipod-2-F-4	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content	3.3%	% of wet tissue			
ER-0510	GAE-108	Amphipod-2-F-5	18 mo. post-treatment A:	Indigenous Amphipod PCB Bi	lipid content		% of wet tissue			
ER-0510	GAE-213	Desorption-2-C-0.08d	18 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.04	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-1d	19 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.08	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-2d	20 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.12	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-5d	21 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.17	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-10d	22 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.20	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-30d	23 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.27	fraction of PCB desorbed			
ER-0510	GAE-213	Desorption-2-C-60d	24 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.32	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-0.08d	25 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.01	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-1d	26 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.03	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-2d	27 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.05	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-5d	28 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.08	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-10d	29 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.10	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-30d	30 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.13	fraction of PCB desorbed			
ER-0510	GAE-214	Desorption-2-D-60d	31 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.16	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-0.08d	32 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.03	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-1d	33 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.06	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-2d	34 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.10	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-5d	35 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.16	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-10d	36 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.21	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-30d	37 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.33	fraction of PCB desorbed			
ER-0510	GAE-215	Desorption-2-E-60d	38 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.47	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-0.08d	39 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.00	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-1d	40 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.01	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-2d	41 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.01	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-5d	42 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.03	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-10d	43 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.04	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-30d	44 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.07	fraction of PCB desorbed			
ER-0510	GAE-216	Desorption-2-F-60d	45 mo. post-treatment A:	Sediment PCB Desorption	PCBs (reported as total PCBs	0.09	fraction of PCB desorbed			
ER-0510	N/A	BC-2-C	18 mo. post-treatment A:	Composite Sediment BC	Black Carbon Contents	0.0019	g BC / g dry S	N/A		N/A
ER-0510	N/A	BC-2-D	18 mo. post-treatment A:	Composite Sediment BC	Black Carbon Contents	0.0166	g BC / g dry S	N/A		N/A

ER-0510	N/A	BC-2-E	18 mo. post-treatment A:	Composite Sediment BC	Black Carbon Contents	0.0026	g BC / g dry S	N/A	N/A
ER-0510	N/A	BC-2-F	18 mo. post-treatment A:	Composite Sediment BC	Black Carbon Contents	0.0232	g BC / g dry S	N/A	N/A
ER-0510	N/A	PED-2-C-1	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	13.10	ng PCBs		
ER-0510	N/A	PED-2-C-2	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	15.86	ng PCBs		
ER-0510	N/A	PED-2-C-3	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	17.56	ng PCBs		
ER-0510	N/A	PED-2-C-4	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	23.84	ng PCBs		
ER-0510	N/A	PED-2-C-5	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	17.67	ng PCBs		
ER-0510	N/A	PED-2-C-6	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	18.91	ng PCBs		
ER-0510	N/A	PED-2-C-7	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	16.87	ng PCBs		
ER-0510	N/A	PED-2-C-8	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	21.47	ng PCBs		
ER-0510	N/A	PED-2-C-9	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	14.73	ng PCBs		
ER-0510	N/A	PED-2-C-10	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	10.21	ng PCBs		
ER-0510	N/A	PED-2-D-1	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	7.71	ng PCBs		
ER-0510	N/A	PED-2-D-2	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	7.97	ng PCBs		
ER-0510	N/A	PED-2-D-3	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	42.56	ng PCBs		
ER-0510	N/A	PED-2-D-4	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	3.63	ng PCBs		
ER-0510	N/A	PED-2-D-5	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	9.21	ng PCBs		
ER-0510	N/A	PED-2-D-6	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	9.25	ng PCBs		
ER-0510	N/A	PED-2-D-7	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	5.93	ng PCBs		
ER-0510	N/A	PED-2-D-8	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	6.81	ng PCBs		
ER-0510	N/A	PED-2-D-9	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	6.57	ng PCBs		
ER-0510	N/A	PED-2-D-10	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	13.26	ng PCBs		
ER-0510	N/A	PED-2-E-1	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	15.34	ng PCBs		
ER-0510	N/A	PED-2-E-2	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	20.31	ng PCBs		
ER-0510	N/A	PED-2-E-3	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	15.71	ng PCBs		
ER-0510	N/A	PED-2-E-4	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	21.37	ng PCBs		
ER-0510	N/A	PED-2-E-5	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	14.07	ng PCBs		
ER-0510	N/A	PED-2-E-6	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	14.07	ng PCBs		
ER-0510	N/A	PED-2-E-7	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	14.82	ng PCBs		
ER-0510	N/A	PED-2-E-8	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	17.83	ng PCBs		
ER-0510	N/A	PED-2-E-9	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	19.40	ng PCBs		
ER-0510	N/A	PED-2-E-10	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	16.69	ng PCBs		
ER-0510	N/A	PED-2-F-1	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	12.85	ng PCBs		
ER-0510	N/A	PED-2-F-2	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	11.12	ng PCBs		
ER-0510	N/A	PED-2-F-3	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	12.24	ng PCBs		
ER-0510	N/A	PED-2-F-4	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	14.03	ng PCBs		
ER-0510	N/A	PED-2-F-5	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	11.09	ng PCBs		
ER-0510	N/A	PED-2-F-6	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	9.52	ng PCBs		
ER-0510	N/A	PED-2-F-7	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	11.61	ng PCBs		
ER-0510	N/A	PED-2-F-8	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	12.36	ng PCBs		
ER-0510	N/A	PED-2-F-9	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	5.54	ng PCBs		
ER-0510	N/A	PED-2-F-10	18 mo. post-treatment A:	PED uptake	PCBs (reported as total PCBs	10.71	ng PCBs		
ER-0510	N/A	SPMD-C-97d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.4299269	µg	83	85
ER-0510	N/A	SPMD-C-97d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.44929387	µg	81	83
ER-0510	N/A	SPMD-C-140d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.73588307	µg	83	85
ER-0510	N/A	SPMD-C-140d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.83144364	µg	85	91
ER-0510	N/A	SPMD-C-224d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	1.42924121	µg	105	86
ER-0510	N/A	SPMD-C-224d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	1.41916956	µg	95	83
ER-0510	N/A	SPMD-D-97d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.2410739	µg	89	84
ER-0510	N/A	SPMD-D-97d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.20275258	µg	83	84
ER-0510	N/A	SPMD-D-140d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.33402159	µg	81	78
ER-0510	N/A	SPMD-D-140d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.33151909	µg	84	84
ER-0510	N/A	SPMD-D-224d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs)		µg		
ER-0510	N/A	SPMD-D-224d	13-18 mo. post-treatmen	SPMD long term uptake	PCBs (reported as total PCBs	0.64313573	µg	83	85

Header ID	Unique Sample ID	Location ID	Project	Analysis	Analyte	Result	Unit	Surrogate Re	Surrogate Recovery (PCB 65)
ER-0510	HAE-001	Sed-Comp-C-1	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.072001253	mg PCBs / kg	52	50
ER-0510	HAE-002	Sed-Comp-C-2	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.670134778	mg PCBs / kg	53	54
ER-0510	HAE-003	Sed-Comp-C-3	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.032147065	mg PCBs / kg	52	51
ER-0510	HAE-004	Sed-Comp-D-1	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.604071427	mg PCBs / kg	23	50
ER-0510	HAE-005	Sed-Comp-D-2	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.879795821	mg PCBs / kg	23	47
ER-0510	HAE-006	Sed-Comp-D-3	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.803063112	mg PCBs / kg	11	41
ER-0510	HAE-007	Sed-Comp-E-1	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.951446998	mg PCBs / kg	50	51
ER-0510	HAE-008	Sed-Comp-E-2	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.923298596	mg PCBs / kg	56	53
ER-0510	HAE-009	Sed-Comp-E-3	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	0.678128203	mg PCBs / kg	49	47
ER-0510	HAE-010	Sed-Comp-F-1	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.457493083	mg PCBs / kg	8	41
ER-0510	HAE-011	Sed-Comp-F-2	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.694091969	mg PCBs / kg	22	44
ER-0510	HAE-012	Sed-Comp-F-3	24 mo. post-treatment	Top 6 inch Sediment PCB level	PCBs (reported as total PCBs)	1.681843004	mg PCBs / kg	12	45
ER-0510	HAE-013	Sed-Surf-C-1	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.621259514	mg PCBs / kg	70	64
ER-0510	HAE-014	Sed-Surf-C-2	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.019893605	mg PCBs / kg	57	61
ER-0510	HAE-015	Sed-Surf-C-3	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.130953873	mg PCBs / kg	60	62
ER-0510	HAE-016	Sed-Surf-D-1	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.162971742	mg PCBs / kg	60	65
ER-0510	HAE-017	Sed-Surf-D-2	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.166964108	mg PCBs / kg	55	60
ER-0510	HAE-018	Sed-Surf-D-3	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.377680539	mg PCBs / kg	58	62
ER-0510	HAE-019	Sed-Surf-E-1	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.144217189	mg PCBs / kg	58	62
ER-0510	HAE-020	Sed-Surf-E-2	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.014287363	mg PCBs / kg	57	64
ER-0510	HAE-021	Sed-Surf-E-3	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.091019219	mg PCBs / kg	58	60
ER-0510	HAE-022	Sed-Surf-F-1	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.185646922	mg PCBs / kg	58	64
ER-0510	HAE-023	Sed-Surf-F-2	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.824504696	mg PCBs / kg	56	61
ER-0510	HAE-024	Sed-Surf-F-3	24 mo. post-treatment	Top 5mm Sediment PCB level	PCBs (reported as total PCBs)	1.257479105	mg PCBs / kg	55	60
ER-0510	HAE-049	TOC-Surface-C-1	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.28	wt%	N/A	N/A
ER-0510	HAE-050	TOC-Surface-C-2	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.18	wt%	N/A	N/A
ER-0510	HAE-051	TOC-Surface-C-3	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.38	wt%	N/A	N/A
ER-0510	HAE-052	TOC-Surface-C-4	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.39	wt%	N/A	N/A
ER-0510	HAE-053	TOC-Surface-C-5	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.52	wt%	N/A	N/A
ER-0510	HAE-054	TOC-Surface-D-1	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.21	wt%	N/A	N/A
ER-0510	HAE-055	TOC-Surface-D-2	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.63	wt%	N/A	N/A
ER-0510	HAE-056	TOC-Surface-D-3	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.39	wt%	N/A	N/A
ER-0510	HAE-057	TOC-Surface-D-4	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.76	wt%	N/A	N/A
ER-0510	HAE-058	TOC-Surface-D-5	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.98	wt%	N/A	N/A
ER-0510	HAE-059	TOC-Surface-E-1	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.05	wt%	N/A	N/A
ER-0510	HAE-060	TOC-Surface-E-2	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.16	wt%	N/A	N/A
ER-0510	HAE-061	TOC-Surface-E-3	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.08	wt%	N/A	N/A
ER-0510	HAE-062	TOC-Surface-E-4	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.66	wt%	N/A	N/A
ER-0510	HAE-063	TOC-Surface-E-5	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.33	wt%	N/A	N/A
ER-0510	HAE-064	TOC-Surface-F-1	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.25	wt%	N/A	N/A
ER-0510	HAE-065	TOC-Surface-F-2	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	2.16	wt%	N/A	N/A
ER-0510	HAE-066	TOC-Surface-F-3	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.59	wt%	N/A	N/A
ER-0510	HAE-067	TOC-Surface-F-4	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.39	wt%	N/A	N/A
ER-0510	HAE-068	TOC-Surface-F-5	24 mo. post-treatment	Top 5mm TOC-Surface sediment	Total organic carbon content	1.62	wt%	N/A	N/A
ER-0510	HAE-069	TOC-Comp-C-1	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	1.40	wt%	N/A	N/A
ER-0510	HAE-070	TOC-Comp-C-2	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	1.02	wt%	N/A	N/A
ER-0510	HAE-071	TOC-Comp-C-3	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	0.98	wt%	N/A	N/A
ER-0510	HAE-072	TOC-Comp-D-1	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	2.75	wt%	N/A	N/A
ER-0510	HAE-073	TOC-Comp-D-2	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	2.57	wt%	N/A	N/A
ER-0510	HAE-074	TOC-Comp-D-3	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	3.01	wt%	N/A	N/A
ER-0510	HAE-075	TOC-Comp-E-1	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	0.79	wt%	N/A	N/A
ER-0510	HAE-076	TOC-Comp-E-2	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	0.62	wt%	N/A	N/A
ER-0510	HAE-077	TOC-Comp-E-3	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	0.67	wt%	N/A	N/A
ER-0510	HAE-078	TOC-Comp-F-1	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	3.41	wt%	N/A	N/A
ER-0510	HAE-079	TOC-Comp-F-2	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	3.41	wt%	N/A	N/A
ER-0510	HAE-080	TOC-Comp-F-3	24 mo. post-treatment	Top 6 inch TOC-Composite sediment	Total organic carbon content	3.21	wt%	N/A	N/A
ER-0510	HAE-025	AqEq-Comp-C-1	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	18.45259648	ng PCBs / L	75	77
ER-0510	HAE-026	AqEq-Comp-C-2	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	15.59336032	ng PCBs / L	71	76
ER-0510	HAE-027	AqEq-Comp-C-3	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	17.93572534	ng PCBs / L	84	88
ER-0510	HAE-028	AqEq-Comp-D-1	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	5.283474261	ng PCBs / L	74	72
ER-0510	HAE-029	AqEq-Comp-D-2	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	4.622167583	ng PCBs / L	73	72
ER-0510	HAE-030	AqEq-Comp-D-3	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	5.666605598	ng PCBs / L	80	81
ER-0510	HAE-031	AqEq-Comp-E-1	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	13.59398416	ng PCBs / L	71	74
ER-0510	HAE-032	AqEq-Comp-E-2	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	11.66863893	ng PCBs / L	67	72
ER-0510	HAE-033	AqEq-Comp-E-3	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	12.2566254	ng PCBs / L	73	77
ER-0510	HAE-034	AqEq-Comp-F-1	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	6.532182255	ng PCBs / L	69	70

ER-0510	HAE-035	AqEq-Comp-F-2	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	6.517670155	ng PCBs / L	71	71
ER-0510	HAE-036	AqEq-Comp-F-3	24 mo. post-treatment	Top 6 inch Aqueous Equilbrium	PCBs (reported as total PCBs)	6.724933815	ng PCBs / L	76	78
ER-0510	HAE-037	AqEq-Surf-C-1	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.026553253	ng PCBs / L	71	73
ER-0510	HAE-038	AqEq-Surf-C-2	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	9.191056429	ng PCBs / L	79	80
ER-0510	HAE-039	AqEq-Surf-C-3	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.729096558	ng PCBs / L	75	77
ER-0510	HAE-040	AqEq-Surf-D-1	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.489358961	ng PCBs / L	73	76
ER-0510	HAE-041	AqEq-Surf-D-2	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	10.03190445	ng PCBs / L	77	80
ER-0510	HAE-042	AqEq-Surf-D-3	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.471701687	ng PCBs / L	73	75
ER-0510	HAE-043	AqEq-Surf-E-1	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.878141745	ng PCBs / L	72	74
ER-0510	HAE-044	AqEq-Surf-E-2	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	8.82501053	ng PCBs / L	79	80
ER-0510	HAE-045	AqEq-Surf-E-3	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	10.73858839	ng PCBs / L	76	81
ER-0510	HAE-046	AqEq-Surf-F-1	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	11.20932944	ng PCBs / L	81	83
ER-0510	HAE-047	AqEq-Surf-F-2	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	7.875190409	ng PCBs / L	74	77
ER-0510	HAE-048	AqEq-Surf-F-3	24 mo. post-treatment	Top 5 mm Aqueous Equilbrium	PCBs (reported as total PCBs)	7.688844158	ng PCBs / L	81	83
ER-0510	HAE-081	13C-Surface-C-1	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.42	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-082	13C-Surface-C-2	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.07	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-083	13C-Surface-C-3	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.36	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-084	13C-Surface-C-4	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.18	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-085	13C-Surface-C-5	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.30	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-086	13C-Surface-D-1	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.38	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-087	13C-Surface-D-2	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.28	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-088	13C-Surface-D-3	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.51	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-089	13C-Surface-D-4	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.39	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-090	13C-Surface-D-5	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.02	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-091	13C-Surface-E-1	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.24	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-092	13C-Surface-E-2	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.31	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-093	13C-Surface-E-3	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.11	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-094	13C-Surface-E-4	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.29	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-095	13C-Surface-E-5	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-21.99	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-096	13C-Surface-F-1	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.11	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-097	13C-Surface-F-2	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.23	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-098	13C-Surface-F-3	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.21	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-099	13C-Surface-F-4	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.28	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-100	13C-Surface-F-5	24 mo. post-treatment	Top 5mm Sediment 13C	Carbon isotope 13	-22.39	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-101	13C-Comp-C-1	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.46	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-102	13C-Comp-C-2	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.77	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-103	13C-Comp-C-3	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.52	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-104	13C-Comp-D-1	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.50	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-105	13C-Comp-D-2	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.54	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-106	13C-Comp-D-3	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.95	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-107	13C-Comp-E-1	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.67	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-108	13C-Comp-E-2	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.75	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-109	13C-Comp-E-3	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.54	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-110	13C-Comp-F-1	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.54	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-111	13C-Comp-F-2	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.47	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-112	13C-Comp-F-3	24 mo. post-treatment	Top 6inch Sediment 13 C	Carbon isotope 13	-22.49	δ 13 C (PBD,‰	N/A	N/A
ER-0510	HAE-113	BC-Surface-C-1	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.003500984	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-114	BC-Surface-C-2	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.002367934	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-115	BC-Surface-C-3	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.004627193	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-116	BC-Surface-C-4	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.001857073	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-117	BC-Surface-C-5	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.001945339	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-118	BC-Surface-D-1	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.005369013	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-119	BC-Surface-D-2	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.005021962	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-120	BC-Surface-D-3	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.00634681	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-121	BC-Surface-D-4	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.006198511	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-122	BC-Surface-D-5	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.007306745	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-123	BC-Surface-E-1	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.004179413	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-124	BC-Surface-E-2	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.00365188	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-125	BC-Surface-E-3	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.004771007	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-126	BC-Surface-E-4	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.004030464	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-127	BC-Surface-E-5	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.005285227	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-128	BC-Surface-F-1	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.00581	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-129	BC-Surface-F-2	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.01081854	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-130	BC-Surface-F-3	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.003457267	g BC / g dry Sı	N/A	N/A
ER-0510	HAE-131	BC-Surface-F-4	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.004035853	g BC / g dry Sı	N/A	N/A

ER-0510	HAE-132	BC-Surface-F-5	24 mo. post-treatment	Top 5mm BC-Surface sediment	Black carbon content	0.005366454	g BC / g dry S	N/A N/A
ER-0510	HAE-133	BC-Comp-C-1	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.003301934	g BC / g dry S	N/A N/A
ER-0510	HAE-134	BC-Comp-C-2	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.003805019	g BC / g dry S	N/A N/A
ER-0510	HAE-135	BC-Comp-C-3	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.002856931	g BC / g dry S	N/A N/A
ER-0510	HAE-136	BC-Comp-D-1	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.01511846	g BC / g dry S	N/A N/A
ER-0510	HAE-137	BC-Comp-D-2	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.015456766	g BC / g dry S	N/A N/A
ER-0510	HAE-138	BC-Comp-D-3	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.01579689	g BC / g dry S	N/A N/A
ER-0510	HAE-139	BC-Comp-E-1	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.003776812	g BC / g dry S	N/A N/A
ER-0510	HAE-140	BC-Comp-E-2	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.003555825	g BC / g dry S	N/A N/A
ER-0510	HAE-141	BC-Comp-E-3	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.002927124	g BC / g dry S	N/A N/A
ER-0510	HAE-142	BC-Comp-F-1	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.020379562	g BC / g dry S	N/A N/A
ER-0510	HAE-143	BC-Comp-F-2	24 mo. post-treatment	Top 6 inch BC-Composite sediment	Black carbon content	0.020048193	g BC / g dry S	N/A N/A
ER-0510	HAE-144	BC-Comp-F-3	24 mo. post-treatment	Top 6 inch composite sediment	Black carbon content	0.02006816	g BC / g dry S	N/A N/A
ER-0510	HAE-145	Clam-3-C-1	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	369.809	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-146	Clam-3-C-2	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	423.614	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-147	Clam-3-C-3	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	440.437	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-148	Clam-3-C-4	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	503.742	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-149	Clam-3-C-5	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	397.949	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-150	Clam-3-D-1	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	219.603	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-151	Clam-3-D-2	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	201.432	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-152	Clam-3-D-3	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	302.706	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-153	Clam-3-D-4	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	241.295	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-154	Clam-3-D-5	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	278.226	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-155	Clam-3-E-1	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	497.12	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-156	Clam-3-E-2	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	376.237	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-157	Clam-3-E-3	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	428.549	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-158	Clam-3-E-4	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	453.84	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-159	Clam-3-E-5	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	336.953	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-160	Clam-3-F-1	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	294.516	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-161	Clam-3-F-2	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	326.465	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-162	Clam-3-F-3	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	326.37	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-163	Clam-3-F-4	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	370.595	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-164	Clam-3-F-5	24 mo. post-treatment	Clam PCB Bioaccumulation	PCBs (reported as total PCBs)	331.181	µg PCBs/ kg wet clam tissue	
ER-0510	HAE-145	Clam-3-C-1	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue	
ER-0510	HAE-146	Clam-3-C-2	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue	
ER-0510	HAE-147	Clam-3-C-3	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue	
ER-0510	HAE-148	Clam-3-C-4	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.1%	% of wet clam tissue	
ER-0510	HAE-149	Clam-3-C-5	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue	
ER-0510	HAE-150	Clam-3-D-1	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue	
ER-0510	HAE-151	Clam-3-D-2	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue	
ER-0510	HAE-152	Clam-3-D-3	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue	
ER-0510	HAE-153	Clam-3-D-4	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.8%	% of wet clam tissue	
ER-0510	HAE-154	Clam-3-D-5	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.2%	% of wet clam tissue	
ER-0510	HAE-155	Clam-3-E-1	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.2%	% of wet clam tissue	
ER-0510	HAE-156	Clam-3-E-2	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue	
ER-0510	HAE-157	Clam-3-E-3	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue	
ER-0510	HAE-158	Clam-3-E-4	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue	
ER-0510	HAE-159	Clam-3-E-5	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue	
ER-0510	HAE-160	Clam-3-F-1	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	0.9%	% of wet clam tissue	
ER-0510	HAE-161	Clam-3-F-2	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.3%	% of wet clam tissue	
ER-0510	HAE-162	Clam-3-F-3	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.0%	% of wet clam tissue	
ER-0510	HAE-163	Clam-3-F-4	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.1%	% of wet clam tissue	
ER-0510	HAE-164	Clam-3-F-5	24 mo. post-treatment	Clam PCB Bioaccumulation	lipid content	1.2%	% of wet clam tissue	