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**Evaluation of Dredged Material  
Proposed for Ocean Disposal  
from Arthur Kill Project Area,  
New York**

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January 1997

Prepared for the  
U.S. Army Corps of Engineers - New York District  
under a Related Services Agreement  
with the U.S. Department of Energy  
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Pacific Northwest National Laboratory  
Operated for the U.S. Department of Energy  
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**EVALUATION OF DREDGED MATERIAL  
PROPOSED FOR OCEAN DISPOSAL  
FROM ARTHUR KILL PROJECT AREA,  
NEW YORK**

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Richland, Washington 99352**

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## Summary

The objective of the bioassay reevaluation of Arthur Kill Federal Project was to reperform toxicity testing on proposed dredged material following current ammonia reduction protocols. Arthur Kill was one of four waterways that the U. S. Army Corps of Engineers-New York District (USACE-NYD) requested the Battelle Marine Sciences Laboratory (MSL) to sample and to evaluate for dredging and disposal in April 1993. Sediment samples were re-collected from the Arthur Kill Project areas in August 1995.

Tests and analyses were conducted according to the manual developed by the USACE and the U.S. Environmental Protection Agency (EPA), *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual)*, commonly referred to as the "Green Book," and the regional manual developed by the USACE-NYD and EPA Region II, *Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters*.

The re-evaluation of proposed dredged material from the Arthur Kill project areas consisted of benthic acute toxicity tests. Thirty-three individual sediment core samples were collected from the Arthur Kill project area. Three composite sediments, representing each reach of the area proposed for dredging, was used in benthic acute toxicity testing. Benthic acute toxicity tests were performed with the amphipod *Ampelisca abdita* and the mysid *Mysidopsis bahia*. The amphipod and mysid benthic toxicity test procedures followed EPA guidance for reduction of total ammonia concentrations in test systems prior to test initiation.

Statistically significant acute toxicity was found in all Arthur Kill composites in the static renewal tests with *A. abdita*, but not in the static tests with *M. bahia*. Statistically significant acute toxicity and a greater than 20% increase in mortality over the reference sediment was found in the static renewal tests with *A. abdita*. *M. bahia* did not show statistically significant acute toxicity or a greater than 10% increase in mortality over reference sediment in static tests.

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## 1.0 Introduction

### 1.1 Project Objectives

The objective of the Arthur Kill Project reevaluation was to retest proposed dredged material from the Arthur Kill Project area, following current ammonia reduction protocols, to determine the acute toxicity of each sediment compared with the sediment from the Mud Dump Site. Tests for Mud Dump disposal were conducted on Arthur Kill sediment core samples according to the manual developed by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA), *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual)* (EPA/USACE 1991), commonly referred to as the "Green Book," and the regional manual developed by the USACE-New York District (USACE-NYD) and EPA Region II, *Guidance for Performing Tests on Dredged Material to be Disposed of in Ocean Waters* (USACE-NYD/EPA Region II 1992), hereinafter referred to as the "Regional Guidance Manual." The Regional Guidance Manual provides specifications for the use of local or appropriate test species in biological tests and identifies chemical contaminants of concern.

Three composite sediments, representing each reach proposed for dredging, were used in benthic acute toxicity tests. Benthic acute toxicity tests were performed on the amphipod *Ampelisca abdita* and the mysid *Mysidopsis bahia*.

### 1.2 Project Background

The proposed Arthur Kill project area was located along the western shore of Staten Island, New York (Figure 1.1). The project requires dredging and disposal of an estimated 566,000 cu yd of sediment. Project depth of the channel is 35 ft plus 2 ft overdepth (37 ft). Arthur Kill was one of two waterways that the USACE-NYD requested the Battelle Marine Sciences Laboratory (MSL) to evaluate in a series of dredged material projects that became known as the New York/New Jersey Federal Projects 6 program. The projects evaluated under the Federal Projects 6 program were the Arthur Kill, New York/New Jersey and Hackensack River, New Jersey Federal Projects. Sediment samples from four reaches in these waterways were collected during a survey that took place from July 31 through August 4, 1995. Combining sample collection and evaluation of multiple dredged material projects was more cost-effective for the USACE-NYD, because the expense of sediment sampling, reference site testing, and quality control analyses could be shared among projects.

## **1.3 Organization of this Report**

Following this introduction, Section 2 presents the materials and methods used for sample collection, sample processing, toxicity testing, statistical data analysis, and quality assurance. Results of the bioassays are presented in Section 3. A discussion of the results and conclusions is provided in Section 4. Section 5 lists the literature cited in this report. Appendix A contains raw data associated with benthic acute toxicity tests: water quality measurements, test animal survival data, and reference toxicant test results.



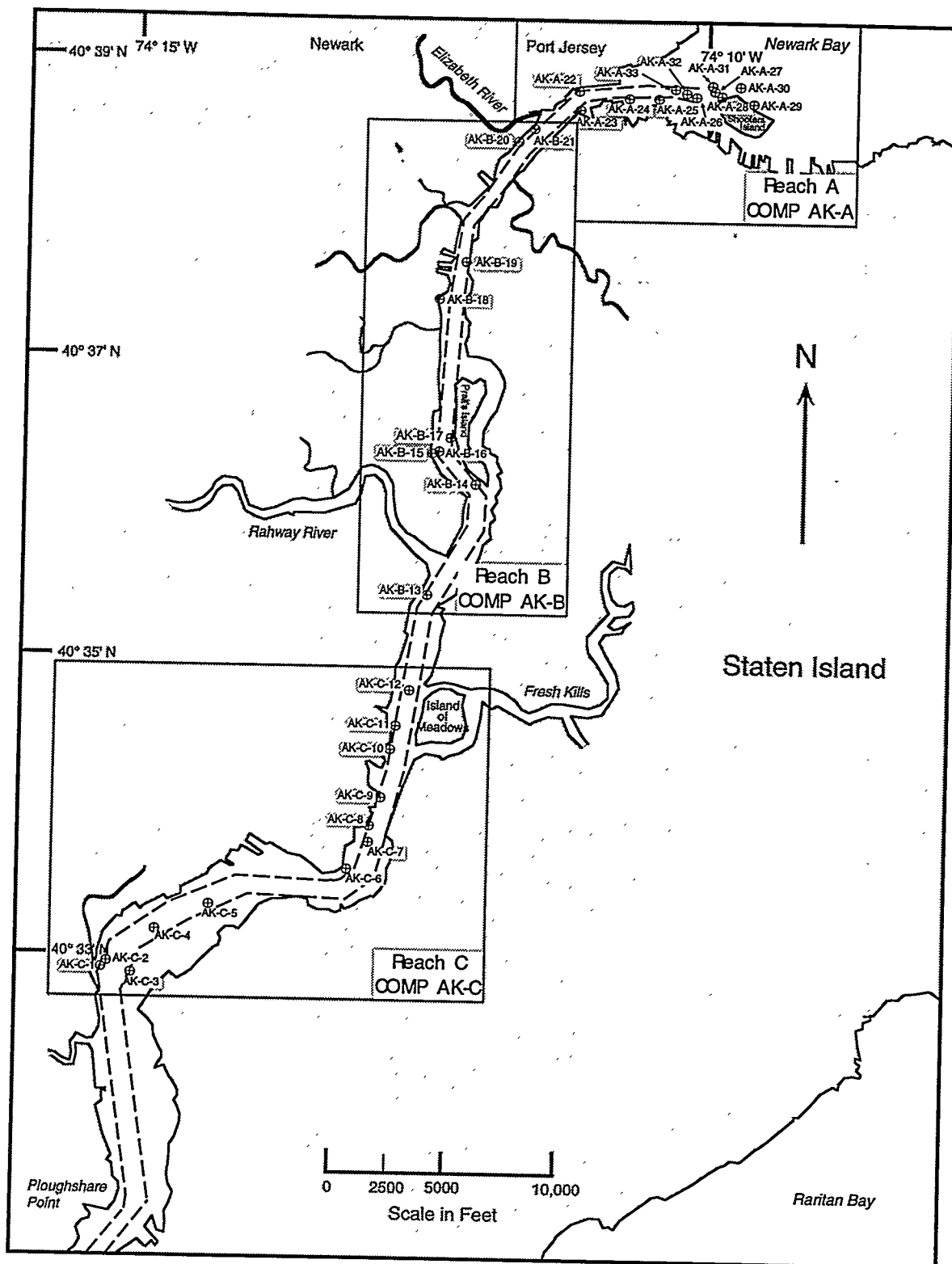


FIGURE 1.1. Location of Arthur Kill Project Area and Sample Collection Stations

## 2.0 Materials and Methods

### 2.1 Sediment Collection

Sediment samples were collected from 33 stations within the Arthur Kill project area. Sampling locations were selected by the USACE-NYD based on recent bathymetric surveys. The locations, their coordinates, and water and core sampling depths are presented with the sampling results in Section 3.0. Reference sediment was collected from the Mud Dump Reference Site aboard the M/V *Gelberman*. All Arthur Kill samples were collected aboard the M/V *Hayward*. Both vessels are owned and operated by USACE-NYD and located at Caven Point, New Jersey.

#### 2.1.1 Test Sediment Sampling

The approximate core sampling locations were first determined with the aid of reference to landmarks, such as shoreline features or buoys, as well as by water depth. Then, the vessel's onboard Differential Global Positioning System (dGPS) was used to identify and record (within 5 m) each sampling station. The vessel's LORAN was available as a backup system. Water depth at the time of sampling was measured by lead line and confirmed with a fathometer on the boat. The actual water depth was converted to mean lower water (MLW) depth by correcting to the tide height at the time the depth was recorded. The difference between the MLW depth and the project depth, plus 2 ft overdepth, yields the amount of core required.

Core samples were collected aboard the *Hayward* using an Ocean Surveys, Inc. vibracore sampler. The vibracore sampler consisted of a 4-in. outer diameter, steel core barrel attached to an pneumatic vibratory hammer. The vibratory hammer could be fitted to steel core barrels of various lengths, depending on the length of core needed. To collect a core sample, the core barrel was fitted with a 3.125-in. interior diameter, steam-cleaned, Lexan polycarbonate tube. The vibracore was then suspended by the ship's crane. Once the coring apparatus was directly above the sampling station, the core was lowered through the water to the sediment surface. At this point, the station coordinates were recorded from the vessel's dGPS, and water depth was recorded by lead line. The vibratory hammer was switched on until the corer penetrated through the sediment to the desired project depth. Adequate penetration was determined relative to marks on the outside of the core barrel and on the cable suspending the vibracore from the crane. The vibracore apparatus was then pulled out of the sediment and lowered onto the ship's deck. A cutter-head and core-catcher assembly prevented loss of the sediment through the bottom of the

core liner. After each core was brought on board, the liner was pulled from the barrel and the length of cored sediment was measured from the mudline to determine whether the project depth plus 2 ft overdepth had been reached. If the sediment core length was at least project depth plus 2 ft overdepth, it was capped, sealed with tape, and labeled. If the sediment core length was not to project depth the sediment sample was discarded and another sample was taken at the same location (within ~20 ft), until project depth was reached or it was determined that the substrate prevented further penetration of the coring device. While on board the sampling vessel, cores were kept cool (~4°C) in a freezer on the deck of the boat. If necessary, cores were cut into shorter sections to fit in the freezer.

A log book was maintained containing records of each sample collected, consisting of station designation, coordinates, replicate number, date, sampling time, water depth, core length, and number of sections per core. At the end of each sampling day, when the *Hayward* returned to Caven Point, all sediment cores were loaded into a locked refrigerated van, thermostatically controlled to maintain temperature at ~4°C. Sample identification numbers were logged on chain-of-custody forms daily.

At the conclusion of the sample collection survey, sediment cores were shipped by refrigerated van from Caven Point, New Jersey, to the MSL in Sequim, Washington. The shipment departed from Caven Point on August 4, 1995, and arrived at the MSL on August 9, 1995.

### **2.1.2 Reference and Control Sediment Sampling**

Reference sediments for acute toxicity tests were collected from the Mud Dump Reference Site. Three, 5-gal containers of surficial sediment were collected at the reference site using a van Veen grab sampler. After recovery, water was drained from the sampler, and the sediments were transferred to epoxy-coated steel buckets. The buckets were covered, labeled, and kept cool (~4°C) in a freezer on deck while aboard the boat. Records for collected reference sediment included coordinates, replicate number, date, sampling time, and water depth. Reference sediment samples were loaded into the refrigerated van at the staging area upon return to port, and sample identification numbers were logged on chain-of-custody forms.

Control sediments were used in each toxicity and bioaccumulation test to validate test procedures. Control sediment used in *M. bahia* tests was collected from Sequim Bay, Washington, using a van Veen grab sampler deployed from an MSL research vessel. Native control sediment for *A. abdita* was supplied with the test organisms by the respective supplier.

## 2.2 Test Organism Collection

Two species of test organisms were used to evaluate sediment samples from the Arthur Kill project area:

- *Ampelisca abdita*, a tube-dwelling, surface detrital-feeding amphipod
- *Mysidopsis bahia*, a juvenile mysid shrimp.

*Ampelisca abdita* were wild-captured animals, collected by the commercial supplier, East Coast Amphipod, Kingston, Rhode Island. *A. abdita* and its native sediment were collected from Narragansett Bay, Rhode Island, by dragging a large dipnet along the sediment surface. Test organisms were carefully removed from their tubes for counting, and then placed in clean, native sediment for overnight transport to the MSL. *Mysidopsis bahia* were purchased from Aquatic Biosystems, Fort Collins, Colorado. Mysids that were less than 24-h old were shipped via overnight delivery in plastic bags containing oxygen-supersaturated seawater maintained at approximately 15°C with "blue ice."

All organisms were shipped or transported either in native sediment or under other conditions designed to ensure their viability. After their arrival at the MSL, the test organisms were gradually acclimated to test conditions. Animals with abnormal behavior or appearance were not used in toxicological tests. All acclimation and animal care records are part of the raw data files for these projects.

## 2.3 Sediment Sample Preparation

Sediment sample preparation consists of all steps performed in the laboratory between receipt of the samples at the MSL and the preparation of samples for biological testing. Sediment samples for archiving and biological analysis were prepared from individual core samples, composites of a number of core samples, reference sediment, and control sediment. All sediment samples were assigned random, unique code numbers to ensure that samples were handled without bias by staff in the biology laboratory.

Sediment for biological testing was used within the 6-week holding period specified in the Green Book. During this holding time, the sediment samples were received at the MSL; inventoried against chain-of-custody forms; processed and used for benthic toxicity tests, and subsampled for archiving. This section describes procedures followed for equipment preparation, compositing strategy, and preparation of sediments for biological testing and archiving.

### 2.3.1 Laboratory Preparation and Safety Considerations

All glassware, stainless-steel or titanium utensils, Nalgene, Teflon, and other laboratory containers and equipment underwent stringent cleaning procedures to avoid contamination of samples. Glassware (e.g., test containers, aquaria, sediment transfer dishes) was washed with hot water and detergent, rinsed with deionized water, then soaked in a 10% solution of reagent grade nitric acid for a minimum of 4 h and rinsed again with deionized water before it was allowed to air dry. Polyvinyl chloride (PVC), Nalgene, and Teflon tools were then rinsed with methylene chloride and allowed to dry under a fume hood. Stainless-steel bowls, spoons, spatulas, and other utensils were washed with hot water and detergent, rinsed with deionized water, and allowed to air dry. They were then solvent-rinsed with methylene chloride and allowed to dry under a fume hood.

Neoprene stoppers and polyethylene sheets or other porous materials were washed with hot water and detergent and rinsed with deionized water. These items were then "seasoned" by continuous soaking in 0.45- $\mu$ m filtered seawater for at least 2 days prior to use. Large pieces of laboratory equipment, such as the epoxy-coated sediment mixer, were washed with a dilute solution of detergent, and thoroughly rinsed with tap water followed by deionized water or filtered seawater.

Equipment used for determining water quality, including the meters for pH, dissolved oxygen (DO), temperature, ammonia and salinity, were calibrated according to the manufacturers' specifications and internal MSL standard operating procedures (SOPs).

Because the potential toxicity of the Arthur Kill sediment was unknown, sediment processing and testing were segregated from other laboratory activities. Specific areas at the MSL were established for sample storage and for core-cutting, sediment mixing, and sediment sieving. Work areas were covered with plastic sheeting to contain any waste sediment. Wastewater generated during all operations was retained in 55-gal barrels and periodically pumped through activated charcoal filters and into the MSL's wastewater treatment system. These procedures minimized any potential for cross-contamination of sediment samples and any potential accidental release to the environment.

Laboratory staff members were protected by personal safety equipment such as eyewear, Tyvek suits, plastic aprons, and rubber gloves. Those who were likely to have the most exposure to the potential volatile compounds in the bulk sediment (i.e., those responsible for opening, homogenizing, and compositing core samples) were also provided with half-mask respirators.

### 2.3.2 Preparation of Sediment for Benthic Testing

Each Lexan core liner was opened by scoring the core longitudinally with a circular saw, then finishing the cut and opening the core with a clean, solvent-rinsed linoleum knife to expose the sediment. As each sediment core sample was opened, it was examined for physical characteristics (e.g., sediment type and consistency, color, odor). In particular, the presence of any strata in the cores was noted. All core observations were recorded in the sediment preparation log book. The sediment between the mudline and project depth was then transferred from the core liner to a clean, stainless-steel bowl by scooping the sediment from the core liner with a spoon or spatula. The sediment was mixed by hand with stainless-steel utensils until the color and consistency appeared homogenous, creating a sample representative of the individual sampling station. Sieving was not necessary because organisms that may interfere with test results were not observed in the sediment samples.

Aliquots of the homogenized sediment were then transferred to the appropriate sample jar(s) for an archive sample. The remainder of the sediment from the individual core stations was combined in an epoxy-coated cement mixer to create one of the three composite samples representing the Arthur Kill project area, designated COMP AK-A, COMP AK-B, and COMP AK-C. The AK-A composite contained sediments from Stations AK-A-22 through AK-A-33. The AK-B composite contained sediments from Stations AK-B-13 through AK-B-21. The AK-C composite contained sediments from Stations AK-C-1 through AK-C-12. The composited reach sediment was used for solid-phase toxicity as required by USACE-NYD. Aliquots of homogenized composite sediment were transferred to the archive sample jar(s). The remainder was stored in labeled epoxy-coated pails, tightly covered, at  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$  until use for benthic toxicity.

The Mud Dump Reference Site sediment *A. abdita*, and *M. bahia* native control sediment were also homogenized in the large, stainless-steel bowls, and prior to mixing, reference sediment was pressed through a 1-mm mesh sieve to remove live organisms that might affect the outcome of toxicity tests. After mixing, aliquots for archiving were removed. Native control sediment for *A. abdita* and *M. bahia* was pressed through a 0.5-mm mesh sieve to remove live organisms and mixed in stainless-steel bowls after sieving. All reference and control sediments were stored at  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$  until used in benthic toxicity tests.

## 2.4 Benthic Acute Toxicity Test Procedures

Deposited sediment effects of open-water dredged material disposal were evaluated by benthic acute toxicity tests with the marine amphipod *A. abdita* and the mysid *M. bahia*.

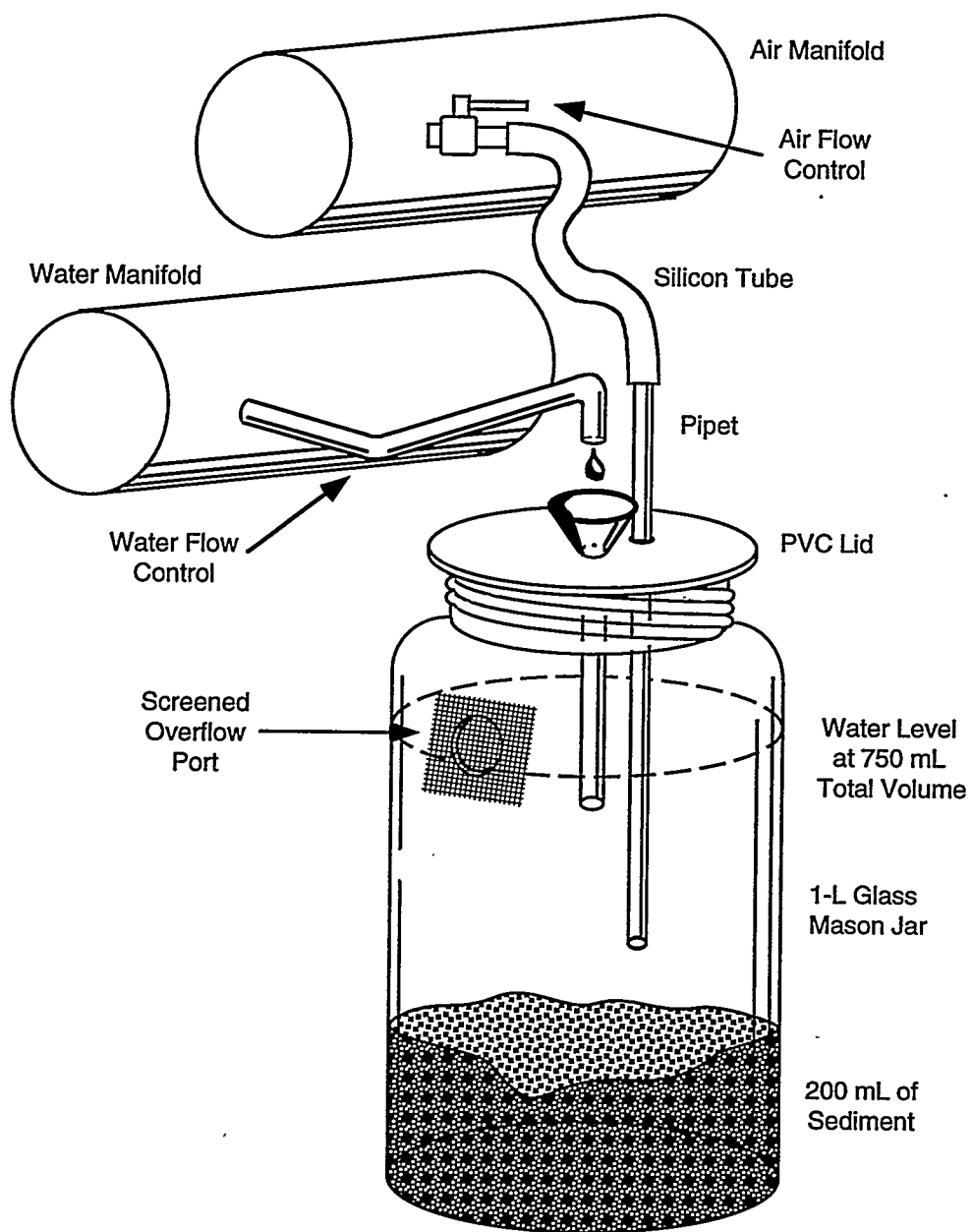
### 2.4.1 Static Renewal Test with *Ampelisca abdita*

Upon receipt, *A. abdita* were placed in a tub of clean sediment from their collection area and gradually acclimated to laboratory conditions with unfiltered flowing Sequim Bay seawater. *A. abdita* were received at approximately 12°C and acclimated to 20°C±2°C over 5 days. The *A. abdita* were not fed prior to testing.

All amphipod static-renewal tests were performed in 1-L glass jars modified for use as flow-through test chambers. The test chambers were fitted with lids equipped with funnels and screened overflow ports (Figure 2.1). To prepare each test container, 200 mL of clean seawater was placed in each jar. Sediment was added until water was displaced to a volume of 400 mL, then seawater was added to a total volume of 750 mL. Five replicates of each Arthur Kill composite sediment, Mud Dump Reference Site sediment, and native test animal control treatments were tested.

Concentrations of ammonia have been encountered in the porewater of sediment core samples from New York/New Jersey waterways at levels high enough to affect survival of amphipods in benthic toxicity tests (Barrows et al. 1996). Therefore, the amphipod tests were conducted according to the ammonia protocols issued by EPA and the USACE (EPA/USACE 1993). This guidance requires postponing test initiation (exposure of test animals) until pore water total ammonia concentrations are reduced to <20 mg/L by overlying water replacement for *A. abdita*. During this "purging" period, test chambers were maintained under test conditions, and the flow-through system was turned on periodically to deliver the seawater at a rate of two exchanges per day. Pore water ammonia measurements were made on "dummy" containers that were set up and maintained in the same manner as the actual test containers but without animals added to them. The pore water was obtained by siphoning off the overlying water in the dummy jar and centrifuging the sediment in a Teflon jar for at least 20 min at approximately 3000 rpm. Salinity, temperature, and pH were also determined in the pore water samples. Once the test was initiated, overlying water was renewed at a rate of two chamber exchanges per day throughout the 10-day tests.

The amphipod benthic toxicity tests were initiated by the addition of 20 organisms to each test chamber for a test population of 100 amphipods per sediment treatment. Amphipods were gently sieved from their native sediment in holding tanks and transferred to shallow baking dishes.



**FIGURE 2.1.** Testing Containers for Static Renewal Benthic Toxicity Tests



For each test chamber, five animals were counted and transferred by pipet into each of four small, plastic cups containing a small amount of filtered seawater. The animals in each transfer cup were recounted by a second analyst. The animals were placed in the test chamber by pouring the contents of each of four cups into the test chamber.

Salinity, temperature, DO, and pH were measured in overlying water in all replicates prior to test initiation, in at least one replicate per treatment daily, and in all replicates at test termination. Measurements of total ammonia levels in the overlying water and porewater also continued during testing. Overlying water ammonia was measured in all replicates prior to test initiation (Day 0), in at least one replicate per treatment daily, and in all replicates at test termination (Day 10). Pore water ammonia was measured on Day 0 and Day 10 in the "dummy" containers. The following were the acceptable ranges for water quality parameters during the amphipod tests:

Temperature	20°C±2°C
DO	>60% saturation
pH	7.8±0.5
Salinity	30‰±2‰
Ammonia	20 mg/L in porewater
Renewal Rate	2 volume exchanges/day.

Gentle aeration was provided throughout the test, and the amphipods were not fed during testing. At the end of the 10-day period, the contents of each chamber were gently sieved through 0.5-mm mesh, and the number of live, dead, and missing amphipods was recorded on termination forms. An animal was considered dead if it did not respond to gentle probing. As a quality control check, a second observer confirmed surviving test organisms on at least 10% of the termination counts.

Reference toxicant tests with cadmium chloride were performed concurrently with the *A. abdita* solid-phase exposure. The reference toxicant tests were 96-h, water-only exposures that were otherwise conducted following the same procedures as for the static tests with sediment. *A. abdita* were exposed to nominal concentrations of 0, 0.19, 0.38, 0.75, and 1.50 mg/L Cd.

#### **2.4.2 Static Renewal Test with *Mysidopsis bahia***

Upon receipt at the laboratory, *M. bahia* were placed in 10-gal aquaria and gradually acclimated from 25‰ seawater to 30‰ with Sequim Bay seawater over a 3-day period. *M. bahia* were received and held for 3 days at 20°C±2°C until testing and were fed concentrated brine shrimp nauplii twice daily prior to testing. Mortality of *M. bahia* during holding was less than 1%.

The 10-day static benthic acute toxicity test with *M. bahia* was performed in 1 L glass jars modified for use as flow-through test chambers. The test chambers were fitted with funneled lids and screened overflow ports (Figure 2.1). To prepare each test container, 200 mL of clean

seawater was placed in each jar. Sediment was added until water was displaced to a volume of 400 mL, then seawater was added to the total volume of 750 mL. Five replicates of each Hackensack River sediment composite, and Mud Dump Reference Site sediment were tested.

Concentrations of ammonia have been encountered in the pore water of sediment core samples from New York/New Jersey waterways at levels high enough to affect overlying water ammonia levels and survival of mysids in benthic toxicity tests (Barrows et al. 1996). Therefore, the mysid tests were conducted according to the ammonia protocols issued by EPA and USACE (EPA/USACE 1993). This guidance requires postponing test initiation (exposure of test animals) until overlying water total ammonia concentrations are reduced to <20 mg/L by overlying water replacement for *M. bahia*. During this "purging" period, test chambers were maintained under test conditions, and the flow-through system was turned on periodically, to deliver the seawater at a rate of two exchanges per day. Overlying water ammonia measurements were made on test containers. Salinity, temperature, and pH were also determined in the overlying water samples. Once the test was initiated, overlying water was not renewed and the 10-day test was conducted in static conditions.

The *M. bahia* benthic toxicity test was initiated by the addition of 20 organisms to each test chamber for a test population of 100 mysids per sediment treatment. *M. bahia* were transferred from holding tanks to shallow glass dishes. For each test chamber, five animals were counted and transferred by pipet into each of four small, plastic cups. The animals in each transfer cup were recounted by a second analyst. The animals were placed in the test chamber by dipping the cup below the surface of the water to release the animals.

Salinity, temperature, DO, pH, and total ammonia in overlying water were measured in all replicates prior to test initiation, in at least one replicate per treatment daily, and in all replicates at test termination. The following were the acceptable ranges for water quality parameters during the mysid benthic test:

Temperature	20°C±2°C
DO	>40% saturation
pH	7.8±0.5
Salinity	30‰±2‰
Ammonia	20 mg/L in overlying water.

Gentle aeration was provided to all test chambers during the test to maintain consistency in DO concentration among test chambers. At the end of the 10-day period, the contents of each chamber were gently sieved through 0.5-mm mesh, and the number of live and dead or missing *M. bahia* was recorded on termination forms. An animal was considered dead if it did not respond to gentle prodding. As a quality control check, a second observer confirmed surviving test organisms on at least 10% of the termination counts.

Reference toxicant tests with copper were performed concurrently with the *M. bahia* solid-phase exposure. The reference toxicant tests were 96-h, water-only exposures that were otherwise conducted following the same procedures as for the static tests with sediment. *M. bahia* were exposed to nominal concentrations of 0, 0.15, 0.2, 0.3, and 0.4 mg/L Cu.

## **2.5 Data Analysis and Interpretation Procedures**

Statistical analyses were conducted to determine the magnitude and significance of toxicity and bioaccumulation in test treatments relative to the reference treatment. Each statistical test was based on a completely random design that allowed unbiased comparison among treatments.

### **2.5.1 Randomization**

All water-column and benthic toxicity tests were designed as completely random tests. Organisms were randomly allocated to treatments, and treatments were randomly positioned on water tables. To determine randomization, a random-number table was generated for each test using the discrete random-number generator in Microsoft's *Excel* spreadsheet software.

### **2.5.2 Statistical Analysis of Benthic Toxicity Tests**

Benthic toxicity of all sediment treatments was compared with a single reference treatment using Dunnett's test (Dunnett 1964). The arcsin square root of the proportion of organisms surviving the test was used to stabilize the within-class variances. As recommended by the Green Book, an experiment-wise error  $\alpha=0.05$  was used.

## **2.6 Quality Assurance/Quality Control Procedures**

The quality assurance/quality control (QA/QC) procedures for the Arthur Kill Project were consistent with the Regional Guidance Manual and the Green Book, and were documented in the Work/Quality Assurance Project Plan, *Evaluation of Dredged Material Proposed for Ocean Disposal from Federal Projects in New York (Part 2)*, prepared by the MSL and submitted to the USACE-NYD for this program. This document describes all QA/QC procedures that were followed for sample collection, sample tracking and storage, and physical/chemical analyses. A member of Pacific Northwest National Laboratory's quality engineering staff was present

throughout all phases of this program to observe procedures, review and audit data, and ensure that accepted protocols were followed. Laboratory notebooks or data accumulation notebooks were assigned to each portion of these studies and served as records of day-to-day project activities.

## 3.0 Results

This section presents results of sample collection and processing, and physical and chemical analyses conducted on sediment samples collected from the proposed Arthur Kill dredging area.

### 3.1 Sample Collection and Processing

Sediment core samples were collected from the Arthur Kill project area on July 31 through August 2, 1995 (Figure 1.1). Table 3.1 lists each sampling station within the Arthur Kill project area, sampling coordinates, collection date, length of core required for testing (including 2 ft of overdepth), and length of core actually collected. All samples were collected aboard the *Hayward*. Thirty-three core samples were collected from the Arthur Kill channel, and all were collected to project depth (-35 ft MLW). All but four core samples were collected to project depth plus overdepth (-37 ft MLW) as shown in Table 3.1.

Upon delivery of the sediment core samples to the MSL on August 9, 1995, samples were composited according to the procedures described in Section 2. Individual sediment core samples were sub-sampled for archiving and then combined with other core samples to create three composited sediments. Three composited sediment samples representing each reach of the Arthur Kill project area (COMP AK-A, COMP AK-B, and COMP AK-C) were used in benthic testing and sub-sampled for archiving. COMP AK-A consisted of stations AK-A-22 through AK-A-33. COMP AK-B consisted of stations AK-B-13 through AK-B-21. COMP AK-C consisted of stations AK-C-1 through AK-C-12.

### 3.2 Benthic Toxicity Testing

Benthic tests were performed on the Arthur Kill sediment composite. Benthic acute toxicity tests were performed with the infaunal amphipod *A. abdita* and the mysid *M. bahia*. This section discusses the results of all sediment and reference toxicant testing. Complete test results, water quality measurements, and the results of the reference toxicant tests are presented in Appendix A. Throughout this section, the term "significant difference" is used to express statistically significant differences at  $\alpha=0.05$  only. Tests for statistical significance between test

**TABLE 3.1. Summary of Sediment Sample Data for Arthur Kill Project Area**

Station	Collection	dGPS Station Coordinates		Core Length Required (ft)	Core Length Collected (ft)	Depth (ft)
	Date	Latitude N	Longitude W			
<u>Reach A</u>						
AK-A-33	7/31/95	40°38.82'	74°10.30'	1.5	2.0	35.5
AK-A-32	7/31/95	40°30.80'	74°10.18'	2.7	4.0	34.3
AK-A-31	7/31/95	40°38.83'	74°09.90'	2.2	3.0	34.8
AK-A-30	7/31/95	40°38.83'	74°09.68'	7.4	6.1	29.6
AK-A-29	7/31/95	40°38.75'	74°09.60'	7.7	7.9	29.3
AK-A-28	7/31/95	40°38.77'	74°09.85'	6.9	7.0	30.1
AK-A-27	7/31/95	40°38.77'	74°09.95'	7.8	8.0	29.2
AK-A-26	7/31/95	40°38.78'	74°10.17'	3.5	3.5	33.5
AK-A-25	8/02/95	40°38.75'	74°10.43'	6.7	7.0	30.3
AK-A-24	8/02/95	40°38.75'	74°10.58'	6.2	6.5	30.8
AK-A-23	8/02/95	40°38.68'	74°11.08'	7.4	7.5	29.6
AK-A-22	8/02/95	40°38.78'	74°11.08'	9.0	8.9	28.0
<u>Reach B</u>						
AK-B-21	8/02/95	40°38.53'	74°11.52'	5.9	6.5	31.1
AK-B-20	8/02/95	40°38.45'	74°11.62'	8.2	8.3	28.8
AK-B-19	8/02/95	40°37.63'	74°12.10'	3.3	3.5	33.7
AK-B-18	8/02/95	40°37.37'	74°12.27'	6.6	5.8	30.4
AK-B-17	8/02/95	40°36.45'	74°12.20'	6.3	6.8	30.7
AK-B-16	8/02/95	40°36.37'	74°12.32'	8.3	8.3	28.7
AK-B-15	8/01/95	40°36.33'	74°12.28'	9.1	9.0	27.9
AK-B-14	8/01/95	40°36.10'	74°11.97'	5.6	5.0	31.4
AK-B-13	8/01/95	40°35.38'	74°12.45'	4.1	4.3	32.9
<u>Reach C</u>						
AK-C-12	8/01/95	40°34.75'	74°12.50'	3.4	3.5	33.6
AK-C-11	8/01/95	40°34.53'	74°12.67'	4.6	5.0	32.4
AK-C-10	8/01/95	40°34.37'	74°12.70'	4.3	4.3	32.7
AK-C-9	8/01/95	40°34.12'	74°12.77'	2.8	3.5	34.2
AK-C-8	8/01/95	40°33.90'	74°12.08'	6.2	6.3	30.8
AK-C-7	8/01/95	40°33.75'	74°12.90'	4.9	5.0	32.1
AK-C-6	8/01/95	40°33.60'	74°13.07'	6.5	6.5	30.5
AK-C-5	8/01/95	40°33.37'	74°14.22'	3.9	4.0	33.1
AK-C-4	8/01/95	40°33.20'	74°14.65'	5.2	5.5	31.8
AK-C-3	8/01/95	40°32.95'	74°14.97'	4.0	4.0	33.0
AK-C-2	8/01/95	40°32.88'	74°15.30'	3.6	4.0	33.4
AK-C-1	8/01/95	40°32.80'	74°15.22'	7.3	9.0	29.7
<u>Grab Samples</u>						
MDRS(a)	8/02/95	40°20.22'	73°52.18'	—(b)	—	ND(c)

(a) MDRS Mud Dump Reference Site.

(b) — Not applicable.

(c) ND No data collected.

**TABLE 3.2.** Summary of Benthic Tests Performed with Arthur Kill Sediment Composites

<u>Test Organism and Composite</u>	<u>Mean % Survival</u>	<u>Significantly Different Than MDRS(a)</u>	<u>20% Difference from MDRS</u>	<u>10% Difference from MDRS</u>
<i>A. abdita</i> (AK-A)	41%	Yes	Yes	--(b)
<i>A. abdita</i> (AK-B)	19%	Yes	Yes	--
<i>A. abdita</i> (AK-C)	62%	Yes	Yes	--
<i>A. abdita</i> (MDRS)	93%	--	--	--
<i>A. abdita</i> (Control)	95%	--	--	--
<i>M. bahia</i> (AK-A)	90%	No	--	No
<i>M. bahia</i> (AK-B)	85%	No	--	No
<i>M. bahia</i> (AK-C)	89%	No	--	No
<i>M. bahia</i> (MDRS)	91%	--	--	--
<i>M. bahia</i> (Control)	95%	--	--	--

(a) MDRS Mud Dump Reference Site.

(b) -- Not applicable.

treatments and control or reference treatments were performed following methods outlined in Section 2.6.

### **3.2.1 *Ampelisca abdita* Benthic Acute Toxicity Test**

Results of the benthic acute toxicity test with *A. abdita* are summarized in Table 3.2. Complete test results and water quality data are presented in Appendix A, Tables A.1 through A.4. Survival in the *A. abdita* control sediment was 95%. Amphipod survival was 41% for the AK-A composite, 19% for the AK-B composite, 62% for the AK-C composite, and 93% in the Mud Dump reference. *A. abdita* survival in all the Arthur Kill composites was significantly different than in the Mud Dump reference, and 20% different.

Water quality parameters were within acceptable ranges throughout the test. Prior to ammonia reduction, the porewater ammonia concentrations were 150 mg/L in COMP AK-A, 142 mg/L in COMP AK-B, and 140 mg/L in COMP AK-C. Overlying water in test containers was renewed twice daily for 12 days until porewater ammonia was 20.5 mg/L in COMP AK-A, 24.6 mg/L in COMP AK-B, and 12.6 mg/L in COMP AK-C. Renewal of overlying water was continued twice daily during the 10-day test. Concentrations of ammonia in the overlying water were <1.0 mg/L during the test. Concentrations of ammonia in porewater on day 10 were 13.7 mg/L in COMP AK-A, 12.7 mg/L in COMP AK-B, and 9.34 mg/L in COMP AK-C. The Cd reference toxicant test produced an LC<sub>50</sub> of 0.61 mg/L Cd, within the control range established at the MSL (0.5 mg/L to 1.4 mg/L Cd).

### 3.2.2 *Mysidopsis bahia* Benthic-Static Acute Toxicity Test

Results of the benthic acute toxicity test with *M. bahia* are summarized in Table 3.2. Complete test results and water quality data are presented in Appendix A, Tables A.5 through A.8. Survival in the *M. bahia* control sediment was 95%. Mysid survival was 90% for the AK-A composite, 85% for the AK-B composite, 89% for the AK-C composite, and 91% in the Mud Dump reference. *M. bahia* survival in all the Arthur Kill composites was not significantly different than in the Mud Dump reference, and was not 10% different.

All water quality parameters were within acceptable ranges throughout the test, except for minor deviations in pH measurements rising to 8.45 units in the control. Prior to ammonia reduction, the porewater ammonia concentrations were 150 mg/L in COMP AK-A, 142 mg/L in COMP AK-B, and 140 mg/L in COMP AK-C. Overlying water in test containers was renewed once; overlying water ammonia was 3.58 mg/L in COMP AK-A, 5.51 mg/L in COMP AK-B, 3.73 mg/L in COMP AK-C; porewater ammonia was 49.0 mg/L in COMP AK-A, 53.6 mg/L in COMP AK-B, and 42.1 mg/L in COMP AK-C. Renewal of overlying water was discontinued once the test was initiated, and the test was run static. Concentrations of ammonia in the overlying water ranged from <1.0 mg/L to 12.5 mg/L during the test. The Cu reference toxicant test produced an LC<sub>50</sub> of 190 µg/L Cu, which was within the control range established at the MSL (116 µg/L to 229 µg/L Cu).



## 4.0 Discussion and Conclusions

In this section, physical and chemical analyses, and bioassays performed on the Arthur Kill sediment composites are evaluated relative to the Mud Dump Reference Site sediment by the guidelines of the Green Book Tier III. Tier III evaluations include water-column toxicity tests, benthic toxicity tests, and whole-sediment bioaccumulation studies. Tier III evaluations assess the impact of contaminants in the dredged material on marine organisms to determine whether there is potential for the material to have an unacceptable environmental effect during ocean disposal.

The Green Book provides the following guidance for determining whether the proposed dredged material is unacceptable for ocean disposal based on the Tier III benthic acute toxicity test:

The proposed dredged material does not meet the limiting permissible concentration (LPC) for benthic toxicity when organism survival in the test sediment and the reference site sediment is statistically significantly different, and the decrease in survival exceeds 20% for *A. abdita*, or 10% for *M. bahia*.

In comparison with the Mud Dump Reference Site, statistically significant acute toxicity and greater than 20% increase in mortality was found with all the Arthur Kill composites in the static renewal test with *A. abdita*. In comparison with the Mud Dump Reference Site, no statistically significant acute toxicity nor greater than 10% increase in mortality was found with the Arthur Kill composites in the static test with *M. bahia*. The increase in *A. abdita* mortality was not related to ammonia concentrations. The Arthur Kill sediment composite did not meet the LPC for benthic toxicity to the test organism *A. abdita*, but the LPC was met for the test organism *M. bahia*.

## 5.0 References

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**Appendix A.**

**Benthic Acute Toxicity Test Data  
for Arthur Kill Project**

**Table A.1.** Results for 10-Day, Static Renewal, Benthic Acute Toxicity Test with *A. abdita*, Arthur Kill

Sediment Treatment	Replicate	Live <sup>(a)</sup>	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
<u>Reach A</u>						
COMP AK-A	1	4	16	0.20	0.41	0.13
COMP AK-A	2	8	12	0.40		
COMP AK-A	3	9	11	0.45		
COMP AK-A	4	9	11	0.45		
COMP AK-A	5	11	9	0.55		
<u>Reach B</u>						
COMP AK-B	1	4	16	0.20	0.19	0.09
COMP AK-B	2	2	18	0.10		
COMP AK-B	3	2	18	0.10		
COMP AK-B	4	6	14	0.30		
COMP AK-B	5	5	15	0.25		
<u>Reach C</u>						
COMP AK-C	1	13	7	0.65	0.62	0.12
COMP AK-C	2	16	4	0.80		
COMP AK-C	3	10	10	0.50		
COMP AK-C	4	11	9	0.55		
COMP AK-C	5	12	8	0.60		
<u>Reference</u>						
MDRS <sup>(b)</sup>	1	17	3	0.85	0.93	0.07
MDRS	2	20	0	1.00		
MDRS	3	18	2	0.90		
MDRS	4	18	2	0.90		
MDRS	5	20	0	1.00		
Ampelisca Control	1	18	2	0.90	0.95	0.04
Ampelisca Control	2	19	1	0.95		
Ampelisca Control	3	19	1	0.95		
Ampelisca Control	4	20	0	1.00		
Ampelisca Control	5	19	1	0.95		

(a) Survival based on initial exposure of 20 organisms per replicate.

(b) MDRS Mud Dump Reference Site.

**Table A.2. Water Quality Summary for 10-Day Static Renewal, Benthic Acute Toxicity Test with *A. abdita*, Arthur Kill**

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (‰)		Total Ammonia <sup>(a)</sup> (mg/L)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Acceptable Range:	18.0	22.0	7.30	8.30	4.6	NA <sup>(a)</sup>	28.0	32.0	NA	20.0
<u>Reach A</u>										
COMP AK-A	19.3	20.5	7.92	8.18	6.0	6.9	30.5	31.5	<1.0	<1.0
<u>Reach B</u>										
COMP AK-B	19.2	20.3	7.87	8.16	6.2	6.9	30.5	32.0	<1.0	<1.0
<u>Reach C</u>										
COMP AK-C	19.3	20.3	7.85	8.28	6.2	7.0	30.5	31.5	<1.0	<1.0
<u>Reference</u>										
MDRS <sup>(b)</sup>	19.2	20.3	7.89	8.09	6.5	7.0	30.5	32.0	<1.0	<1.0
<i>Ampelisca</i> Control	19.4	20.4	7.93	8.30	6.4	7.0	31.0	32.0	<1.0	<1.0

(a) Overlying water measurement.

(b) NA Not applicable.

(c) MDRS Mud Dump Reference Site.

Table A.3. Results of 96-Hour, Cadmium Reference Toxicant Test with  
with *A. abdita*, Arthur Kill

Cadmium Conc. mg/L	Replicate	Live <sup>(a)</sup>	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
0.00	1	19	1	0.95	.	
0.00	2	20	0	1.00	0.98	0.03
0.00	3	20	0	1.00		
0.19	1	18	2	0.90		
0.19	2	19	1	0.95	0.92	0.03
0.19	3	18	2	0.90		
0.38	1	15	5	0.75		
0.38	2	17	3	0.85	0.82	0.06
0.38	3	17	3	0.85		
0.75	1	6	14	0.30		
0.75	2	8	12	0.40	0.35	0.05
0.75	3	7	13	0.35		
1.50	1	0	20	0.00		
1.50	2	0	20	0.00	0.00	0.00
1.50	3	0	20	0.00		

(a) Survival based on initial exposure of 20 organisms per replicate.

Table A.4. Water Quality Summary for 96-Hour *A. abdita* Cadmium Reference Toxicant Test, Arthur Kill

Cadmium Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (‰)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Acceptable Range:	18.0	22.0	7.30	8.30	4.6	NA <sup>(a)</sup>	28.0	32.0
0.00	19.3	19.8	8.11	8.14	6.8	7.2	31.0	32.0
0.19	19.3	19.7	8.10	8.13	7.0	7.2	31.0	32.0
0.38	19.4	19.8	8.07	8.12	6.9	7.2	31.0	32.0
0.75	19.4	19.8	8.04	8.12	6.9	7.3	31.0	32.0
1.50	19.4	19.7	7.83	8.08	6.7	7.3	31.0	32.0

(a) NA Not applicable.

**Table A.5.** Results of 10-day, Static Renewal, Benthic Acute Toxicity Test with *M. bahia*, Arthur Kill

Sediment Treatment	Replicate	Live <sup>(a)</sup>	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
<u>Reach A</u>						
COMP AK-A	1	18	2	0.90	0.90	0.07
COMP AK-A	2	18	2	0.90		
COMP AK-A	3	18	2	0.90		
COMP AK-A	4	20	0	1.00		
COMP AK-A	5	16	4	0.80		
<u>Reach B</u>						
COMP AK-B	1	18	2	0.90	0.85	0.07
COMP AK-B	2	18	2	0.90		
COMP AK-B	3	15	5	0.75		
COMP AK-B	4	16	4	0.80		
COMP AK-B	5	18	2	0.90		
<u>Reach C</u>						
COMP AK-C	1	18	2	0.90	0.89	0.02
COMP AK-C	2	18	2	0.90		
COMP AK-C	3	18	2	0.90		
COMP AK-C	4	18	2	0.90		
COMP AK-C	5	17	3	0.85		
<u>Reference</u>						
MDRS <sup>(b)</sup>	1	17	3	0.85	0.91	0.04
MDRS	2	19	1	0.95		
MDRS	3	18	2	0.90		
MDRS	4	19	1	0.95		
MDRS	5	18	2	0.90		
<i>Mysidopsis</i> Control	1	18	2	0.90	0.95	0.05
<i>Mysidopsis</i> Control	2	20	0	1.00		
<i>Mysidopsis</i> Control	3	19	1	0.95		
<i>Mysidopsis</i> Control	4	18	2	0.90		
<i>Mysidopsis</i> Control	5	20	0	1.00		

(a) Survival based on initial exposure of 20 organisms per replicate.

(b) MDRS Mud Dump Reference Site.



**Table A.6. Water Quality Summary for 10-Day, Static Renewal, Benthic Acute Toxicity Test with *M. bahia*, Arthur Kill**

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (‰)		Total Ammonia <sup>(a)</sup> (mg/L)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Acceptable Range:	18.0	22.0	7.30	8.30	3.0	NA <sup>(b)</sup>	28.0	32.0	NA	15.0
<u>Reach A</u>										
COMP AK-A	19.2	20.3	7.75	8.02	5.9	7.1	30.5	32.0	<1.0	12.5
<u>Reach B</u>										
COMP AK-B	19.4	20.2	7.76	8.01	5.7	7.1	30.5	32.0	1.3	10.6
<u>Reach C</u>										
COMP AK-C	19.5	20.3	7.66	8.04	5.7	7.0	30.5	32.0	<1.0	12.5
<u>Reference</u>										
MDRS <sup>(c)</sup>	19.7	20.3	7.70	8.01	5.9	7.1	30.5	32.0	<1.0	<1.0
<i>Mysidopsis</i> control	19.7	20.3	7.79	8.45 <sup>(d)</sup>	5.8	7.0	30.5	32.0	<1.0	<1.0

(a) Overlying water measurement.

(b) NA Not applicable.

(c) MDRS Mud Dump Reference Site.

(d) Data point out of range.

Table A.7. Results of 96-Hour, Copper Reference Toxicant Test with  
*M. bahia*, Arthur Kill

Copper Conc. mg/L	Replicate	Live <sup>(a)</sup>	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
0.0	1	10	0	1.00	0.97	0.06
0.0	2	10	0	1.00		
0.0	3	9	1	0.90		
0.15	1	8	2	0.80	0.90	0.10
0.15	2	10	0	1.00		
0.15	3	9	1	0.90		
0.2	1	4	6	0.40	0.37	0.06
0.2	2	4	6	0.40		
0.2	3	3	7	0.30		
0.3	1	0	10	0.00	0.03	0.06
0.3	2	1	9	0.10		
0.3	3	0	10	0.00		
0.4	1	0	10	0.00	0.00	0.00
0.4	2	0	10	0.00		
0.4	3	0	10	0.00		

(a) Survival based on initial exposure of 10 organisms per replicate.

**Table A.8.** Water Quality Summary for 96-Hour, Copper Reference Toxicant Test with *M. bahia*, for Benthic Acute Toxicity Test, Arthur Kill

Copper Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (‰)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Acceptable Range:	18.0	22.0	7.30	8.30	3.0	NA <sup>(a)</sup>	28.0	32.0
0.0	19.0	19.6	7.89	8.03	6.4	7.2	31.0	32.0
0.15	19.0	19.6	7.82	8.00	6.6	7.3	31.0	31.5
0.2	19.1	19.7	7.80	8.10	6.7	7.2	31.0	32.0
0.3	19.1	19.5	7.78	8.05	6.5	7.3	31.0	32.0
0.4	19.1	19.5	7.74	8.09	6.8	7.3	31.0	31.5

(a) NA Not applicable.