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Ecological Evaluation of Proposed Dredged Material from Richmond Harbor Deepening Project and the Intensive Study of the Turning Basin

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June 1995

Battelle/Marine Sciences Laboratory
Sequim, Washington

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SUMMARY

Richmond Harbor is located on the eastern shoreline of central San Francisco Bay in Richmond, California. The Richmond Harbor access channels and several of the shipping berths are no longer wide or deep enough to accommodate modern deeper-draft vessels. The Water Resources Development Act of 1986 (Public Law 99-662) authorized the U.S. Army Corps of Engineers (USACE), San Francisco District to deepen and widen the navigation channels in Richmond Harbor. Several options for disposal of the material from this dredging project are under consideration by USACE, as follows: disposal within San Francisco Bay, at open-ocean disposal sites, or at uplands disposal sites.

The purpose of this study was to conduct comprehensive evaluations, including chemical, biological, and bioaccumulation testing of sediments in the selected areas of Richmond Harbor. This information was required by the Environmental Protection Agency (EPA) and the USACE in order to evaluate the suitability of sediments in these areas for unconfined aquatic disposal.

Battelle/Marine Sciences Laboratory (MSL) collected 20 core samples, both 4-in. and 12-in., to a project depth of -40 ft mean lower low water (MLLW) (-38 ft MLLW plus 2 ft of overdepth) using a vibratory-hammer core. These 20 field samples were combined in the laboratory to form five test composites plus an older bay mud (OBM) composite that were analyzed for physical/chemical parameters, biological toxicity, and tissue chemistry parameters following the EPA/USACE guidelines called *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* Solid-phase tests were conducted with the amphipod, *Rhepoxynius abronius*; the clam, *Macoma nasuta*; and the polychaete worm, *Nephtys caecoides.* Suspended-particulate-phase (SPP) tests were conducted with the sanddab, *Citharichthys stigmaeus*; the mysid, *Holmesimysis costata*; and the bivalve, *Mytilus galloprovincialis.* Bioaccumulation of contaminants was measured in tissues of *Macoma nasuta* and *Nereis virens.*

Sediments from one ocean reference sediment, the Deep Off-Shelf Reference Area (R-OS), and two in-bay reference sediments, the Bay Farm Borrow Area (R-BF) and the Alcatraz Environs Reference Area (R-AM), were tested concurrently. Results from analysis of the five test treatments were statistically compared with the reference sediment R-OS in the first five sections of this report. Appendixes Q and R contain the comparisons of the test treatments with reference sediments R-BF and R-AM, respectively.

The solid-phase tests for Richmond Harbor sediments show acute toxicity to *R. abronius* exposed to test treatment TB Lower COMP when compared with effects from the reference sediment R-OS. Test treatments SF COMP, SFW COMP, and OBM COMP were acutely toxic to *N. caecoides* relative to the reference sediment R-OS. The Richmond Harbor test treatments UIH COMP and TB Upper COMP were not acutely toxic to any of the solid-phase test species.

The results of the *C. stigmaeus* and *H. costata* SPP tests showed no statistically significant difference between the 0% and 100% SPP for any test treatment. The results of the *M. galloprovincialis* SPP test showed no statistically significant difference (as defined by embryo survival) between the 0% and 100% SPP for test treatments SFW COMP and TB Upper COMP. None of the survival results for *M. galloprovincialis* was below 50%; therefore, LC_{50} values could not be calculated. Analysis of normal larval development for *M. galloprovincialis* showed statistically significant toxicity in the 100% SPP of test treatments SFW COMP, UIH COMP, TB Upper COMP, and TB Lower COMP relative to the 0% SPP. The EC_{50} values that were below 100% SPP were as follows: 80% SPP for SFW COMP, 57.6% SPP for UIH COMP, 74.8% SPP for TB Upper COMP, and 69.7% SPP for TB Lower COMP. Inhibition of normal larval development could have been largely attributed to ammonia released from the sediment into the SPP of the SFW COMP, UIH COMP, and the TB Lower COMP. The mean percentage of normal larvae for these composites is within the range of expected effects caused by ammonia. This is not the case for TB Lower COMP; the EC_{50} value is below the 95% confidence interval for ammonia, suggesting that contaminants other than ammonia could have been responsible for the reduction in the percentage of normal larvae present in the 100% SPP of this composite.

M. nasuta and *N. virens* tissue contaminant concentrations were one to five orders of magnitude below the Food and Drug Administration action limits for fish and shellfish after exposure to Richmond Harbor sediments. However, specific contaminants in tissues exposed to the test treatments were statistically significantly elevated when compared with the concentrations in the tissues exposed to the reference treatment R-OS.

Nine high molecular weight polyaromatic hydrocarbons (HPAHs), at least one pesticide (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin), and one metal (lead) showed statistically significant bioaccumulation in *M. nasuta* tissues exposed to SF COMP, SFW COMP, UIH COMP, and TB Upper COMP relative to that in tissues exposed to R-OS. The pesticides found in *M. nasuta* tissues exposed to SF COMP, SFW COMP, and UIH COMP were elevated at levels ranging from <2 to 470 times those in the *M. nasuta* tissues exposed to reference treatment R-OS. *M. nasuta* tissues exposed to three test composites, SF COMP, SFW COMP, and UIH COMP, had HPAH concentrations that were elevated to levels greater than 10 times and up to 78 times higher than those found in the tissues exposed to R-OS.

Similarly, in *N. virens* tissues, the same groups of compounds bioaccumulated with statistically significant elevations relative to those exposed to R-OS. The HPAHs and at least one pesticide (4,4'-DDT, 4,4'-DDD, 4,4'-DDE, and dieldrin or aldrin) were the most prevalent contaminants in *N. virens* tissues exposed to SF COMP, SFW COMP, and UIH COMP, relative

to those in tissues exposed to the reference treatment R-OS. In tests using these three composites, 4,4'-DDD was elevated in *N. virens* tissues to levels greater than 10 times and up to 110 times higher than those in *N. virens* tissues exposed to R-OS.

The results from the 10-day acute toxicity test with *R. abronius* showed acute toxicity to sediments from TB Lower COMP. A review of the sediment chemistry data showed that most of the contaminants were associated with station TB-4. Because the Turning Basin represents a large quantity of dredged material, approximately 333,500 cubic yards of sediment, the USACE and EPA decided that more definitive testing was necessary to characterize the extent of contamination in this area. This testing will be referred to throughout the report as the Intensive Study of the Turning Basin. MSL staff collected nine cores from the Turning Basin; these nine cores consist of the seven stations originally tested plus two additional stations, TB-8 and TB-9, located to the northeast and southwest of station TB-4. For comparison purposes, sediment was also collected and tested from the three reference areas (R-OS, R-BF, and R-AM) and two control areas (C-WB and C-SB).

Solid-phase toxicity tests were conducted with the amphipod *R. abronius* in three separate experiments: a standard 10-day test, an ammonia reduction to <20 mg/L test, and an ammonia reduction to <15 mg/L test. The results from the standard 10-day test showed that six test treatments were acutely toxic to *R. abronius* relative to R-OS. These test treatments are TB-2 Lower, TB-3 Lower, TB-5 Lower, TB-7 Lower, TB-8 Lower, and TB-9 Lower. The results for the ammonia reduction to <20 mg/L tested showed only one test treatment, TB-3 Lower, was acutely toxic to *R. abronius* when compared with R-OS. The results of the ammonia reduction to <15 mg/L showed that TB-3 Lower, TB-7 Lower, TB-8 Lower, and TB-9 Lower were not acutely toxic to *R. abronius* when compared with R-OS. Once the ammonia was reduced to <20 mg/L or <15 mg/L in all test treatments, no acute toxicity to *R. abronius* was observed when compared with the effects to *R. abronius* exposed to R-OS. These results suggest that ammonia could have contributed to the observed toxicity of the test sediments. Ammonia is considered to be a nonpersistent compound and is not a chemical of concern for evaluation of sediment for disposal at R-OS. If the results of all three experiments are used to evaluate suitability of Turning Basin sediments, then none of the Turning Basin stations are acutely toxic to *R. abronius* relative to R-OS.

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1.0 INTRODUCTION

Richmond Harbor, a major West Coast port for shipping and petroleum refining, is located on the eastern shoreline of central San Francisco Bay near San Francisco, California (Figure 1.1). Improvements are required in Richmond Harbor (Figure 1.2) and its access channels to accommodate modern deeper-draft vessels. The Water Resources Development Act of 1986 (Public Law 99-662) authorized the U.S. Army Corps of Engineers (USACE), San Francisco District, to deepen and widen the navigation channels to -40 ft mean lower low water (MLLW) (-38 ft MLLW plus 2 ft of overdraft) in Richmond Harbor. Several options for disposal of the material from this dredging project are under consideration by USACE as follows: disposal within San Francisco Bay, at open-ocean sites, or at upland disposal sites. The deepening and widening of areas of Richmond Harbor evaluated in this report will remove an estimated 602,000 cubic yards of dredged material.

Section 103 of the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA), Public Law 92-532, specifies that all proposed disposal of dredged material into open water be evaluated to determine the potential environmental impacts of these activities. Potential impacts to ocean waters are determined by evaluation of dredged material through the 40 CFR 227 guidelines. Similarly, disposal of dredged material into waters of the United States must be evaluated for potential environmental impacts through guidelines (40 CFR 230) developed under Section 404 of the Federal Water Pollution Control Act Amendments of 1972, also called the CWA. The testing reported in this report complies with requirements of the MPRSA and CWA in determining suitability of dredged material for open water disposal.

Battelle/Marine Sciences Laboratory (MSL)[a], operating under contract to USACE, conducted earlier evaluations of the Richmond Harbor Channels (*Ecological Evaluation of Proposed Dredged Material from Richmond Harbor* [Pinza et al. 1992] and *Environmental Evaluations for Deepening of Richmond Harbor and Santa Fe Channels* [Brown et al. 1990]).

As a follow-up to these evaluations, more intensive sampling and analyses were planned for the Richmond Harbor Deepening Project. The study area for the Richmond Harbor Deepening Project includes 20 stations: 5 in the Upper Inner Harbor (UIH), 4 in the Santa Fe Channel (SF), 4 in the National Gypsum-GATX berth area called Santa Fe widening stations (SFW), and 7 in the Turning Circle that were separated into upper and lower sections to produce TB Upper and TB Lower composites. Sediments from these stations were collected with a vibratory-hammer corer to a depth of -42 ft MLLW and then separated into two segments, mudline to -40 ft MLLW, and -40 ft MLLW to -42 ft MLLW. The sediments from mudline to the project depth of -40 ft MLLW

(a) The Battelle/Marine Sciences Laboratory is part of the Pacific Northwest Laboratory, which is operated for the U.S. Department of Energy by Battelle Memorial Institute.

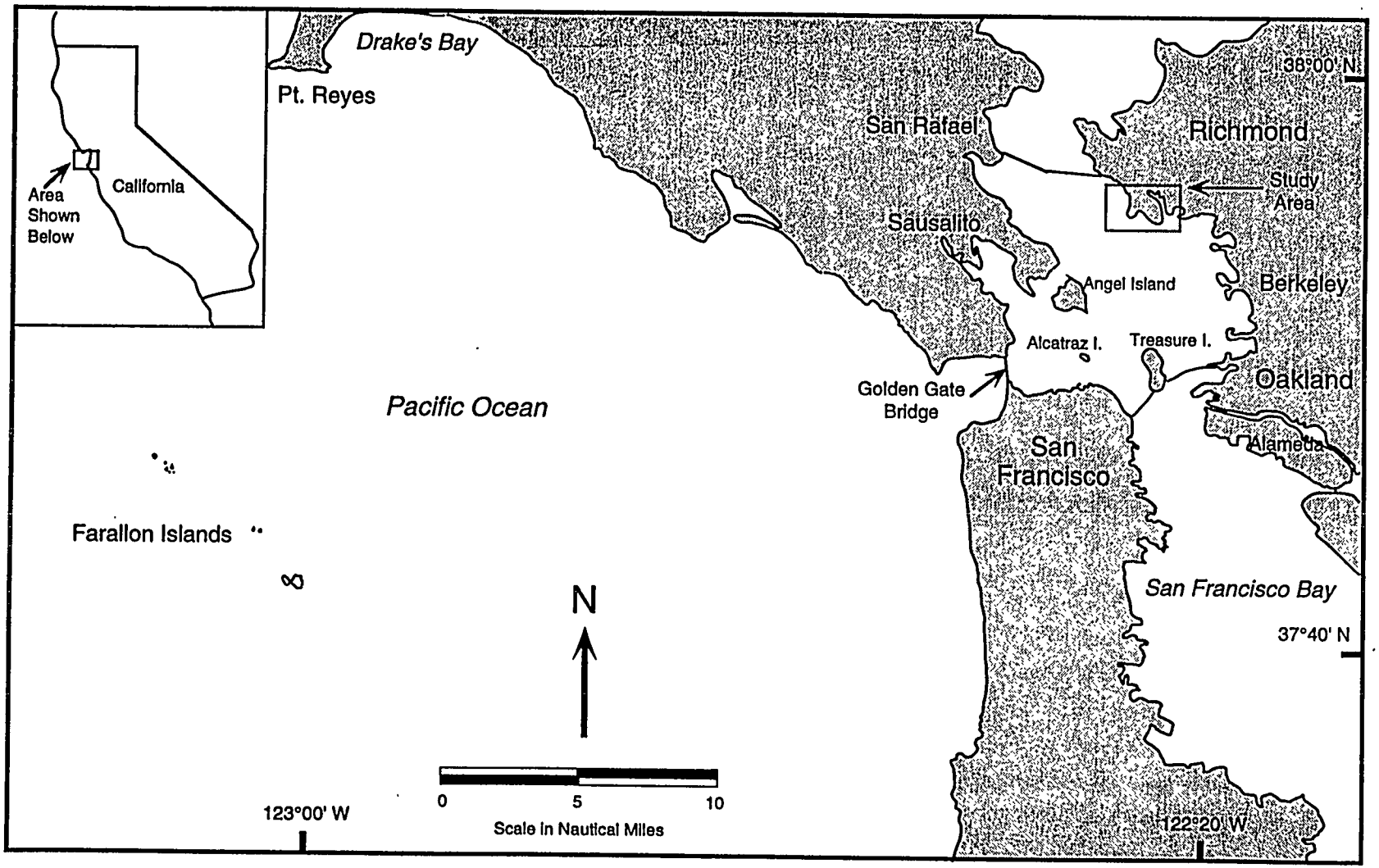


FIGURE 1.1. Site Location Map

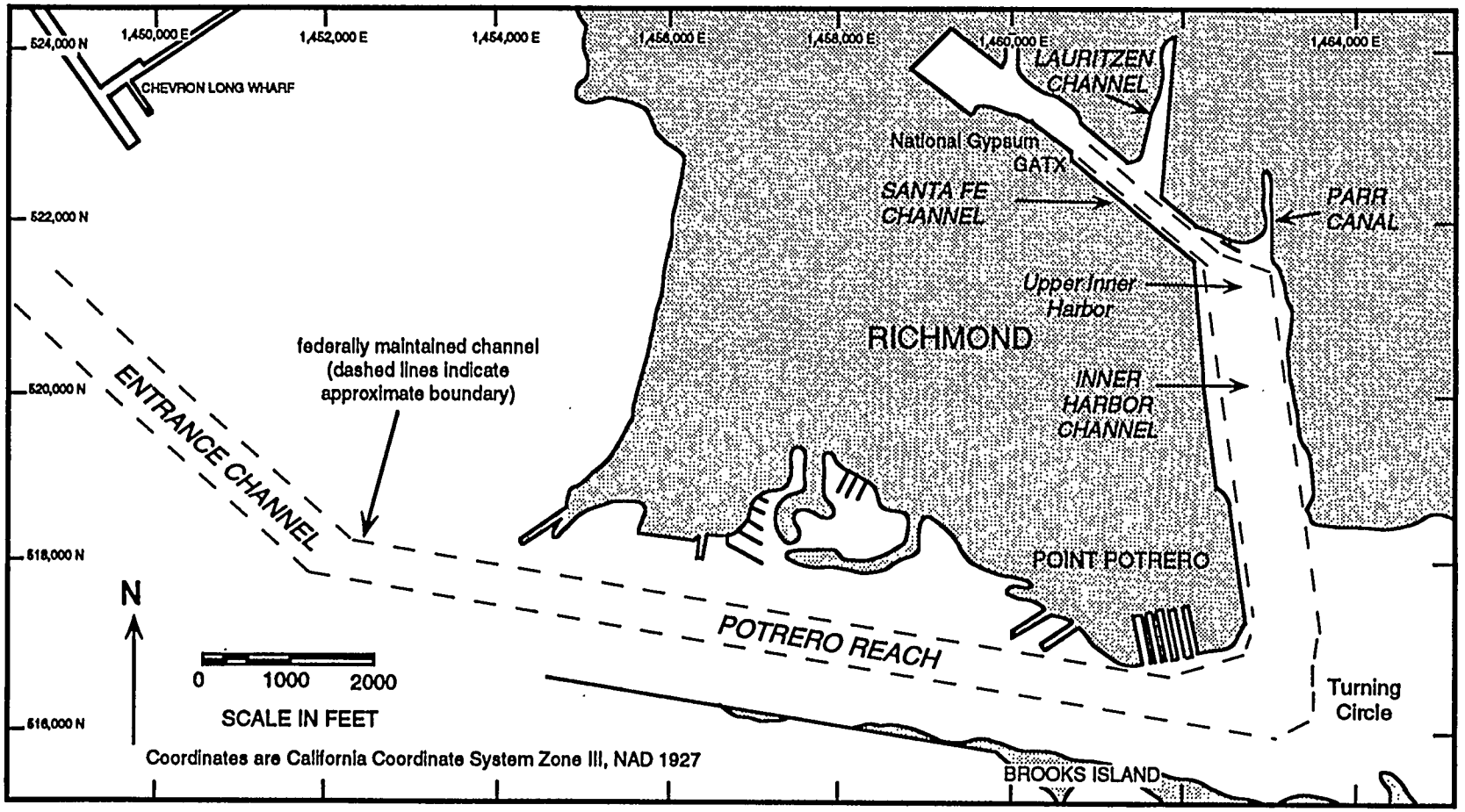


Figure 1.2 Map of Richmond Harbor

were used to form five test composites. If old bay mud (OBM) was present in any of the field stations from -40 ft MLLW to -42 ft MLLW, it was combined to make an OBM composite (COMP). The 4-in. core samples collected at each of the 20 field stations were subjected to geologic analysis and subsampled for physical/chemical parameters.

The five test composites and the OBM composite were subjected to chemical analysis, biological testing, and tissue chemistry analysis following the guidelines in the *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual)* (EPA/USACE 1991), hereinafter referred to as the *1991 Implementation Manual*. The guidelines require that reference and control sediment samples be evaluated in the same manner as the test sediments. The purpose of the reference sediment is to compare the biological responses and contaminant levels of a proposed dredged sediment sample with those of a potential disposal area that is "...substantially free of contaminants and which...reflects conditions that would exist in the vicinity of the disposal site had no dredged-material disposal ever occurred...." The control sediment allows validation of test results through evaluation of the health and normal response of test organisms.

In August 1993, the Environmental Protection Agency (EPA) released the Final Environmental Impact Statement (EIS) for Designation of a Deep Water Ocean Dredged Material Disposal Site off San Francisco, California. The preferred alternative site (Alternative Site 5) is located off the continental shelf, approximately 50 nautical miles from the Golden Gate in 2500 to 3000 m of water. The EPA/Corps Deep Water Ocean Reference Site (R-OS) is located approximately 16 miles south of Site 5.

The focus of this report is the comparison of the five test composites from the Richmond Harbor Study Area and the OBM COMP with the sediment from the Deep Off-Shelf Reference Area (R-OS). These test composites are also compared with sediment from two in-bay reference sites, the Bay Farm Borrow Area and the Alcatraz Environs Reference Area. The latter two comparisons are presented in Appendixes Q and R, respectively.

Geologic examination of the 20 Richmond Harbor field samples included descriptions of sediment layers and other notable features of the sediment. Chemical analyses were performed on sediment from the individual stations plus the composites and includes measurements of conventional parameters (grain size, total organic carbon [TOC], total volatile solids [TVS], oil and grease, and total petroleum hydrocarbons [TPH]), EPA priority pollutant organics (polynuclear aromatic hydrocarbons [PAHs], phthalate esters, polychlorinated biphenyls [PCBs], and chlorinated pesticides), metals, and butyltins. The five Richmond Harbor test composites (SF COMP, SFW COMP, UIH COMP, TB Upper COMP, and TB Lower COMP) were analyzed using the California Waste Extraction Test (WET), using Method 8080 for the soluble

threshold limit concentrations (STLC) of selected chlorinated pesticides, and PCBs. The 17 California Assessment Metals (CAM17) and hexavalent Cr were also analyzed using WET.

Biological toxicity tests included controlled laboratory exposures of sensitive marine organisms to the solid phase and suspended-particulate phase (SPP) of the dredged material. Solid-phase acute toxicity and bioaccumulation tests compare the effects of the dredged sediment on sensitive benthic organisms with those of a reference sediment representing a potential disposal site. Four species were used for the solid-phase tests: the amphipod, *Rhepoxynius abronius*; the bentnose clam, *Macoma nasuta*; and the polychaetes, *Nephtys caecoides* and *Nereis virens*. The SPP toxicity tests are designed to test for acute toxicity or sublethal effects of dissolved contaminants and those associated with the suspended particulates in the water column. Evaluations of SPP effects are then made, after allowing for initial mixing of the dredged material. Three species were exposed to the various concentrations of SPP: the juvenile speckled sanddab, *Citharichthys stigmaeus*; the mysid, *Holmesimysis costata*; and larvae of the bay mussel, *Mytilus galloprovincialis*.

Potential for bioaccumulation of contaminants from sediment is determined after a 28-day exposure of *M. nasuta* and *N. virens* to the solid-phase of the proposed dredged material, followed by chemical analyses of the tissues for the EPA priority pollutant organics, metals, and butyltins. Contaminant levels in the tissues of the organisms exposed to the test treatments were statistically compared with the contaminant levels in the tissues exposed to the reference treatments and to U.S. Food and Drug Administration (FDA) limits. The purpose of these analyses is to provide data to address potential mobility of contaminants from sediment proposed for ocean disposal.

The results in Section 3 of this report show that the TB Lower COMP was acutely toxic to *R. abronius*. Because the Turning Basin represents approximately 333,500 cubic yards of dredged material, the USACE and EPA decided that further investigations of this area were necessary to more clearly define the nature and extent of sediment contamination and acute toxicity in the Turning Basin. Sediment was collected from nine stations in the Turning Basin. These stations consist of the seven stations sampled during the January 1994 field effort, plus two new stations located to the northeast and southwest of station TB-4.

The Turning Basin sediments were collected to -40 ft MLLW using the 4-in. vibratory hammer core. The core from each station, with the exception of TB-4, was then split into two samples: one sample consisted of sediment from mudline to 5 ft below mudline and the other sample consisted of sediment from 5 ft below mudline to -40 ft MLLW. In the core from station TB-4, sediment from -33.4 ft to -38.8 ft MLLW, representing the middle section of the core, was composited separately from the upper and lower segments because of its disrupted appearance and hydrocarbon odor. The sediment from mudline to 5 ft below mudline from each core was

archived in a 1-L glass container in the event that further analysis would be required. The sediment from 5 ft below mudline to -40 ft MLLW and the TB-4 Middle section were thoroughly mixed, subsampled for chemistry, and used in three separate 10-day *R. abronius* tests. Three reference sediments (R-OS, R-BF, and R-AM) and control sediments (C-WB and C-SB) were also collected for this study and used for comparison purposes and to validate the test results.

The methods used for the Intensive Study of the Turning Basin were the same as those used in the January 1994 study and are described in Section 2 and 4 of this report. The Intensive Study of the Turning Basin results compared to the reference R-OS are located in Section 4 of this report. The results of these test treatments were also compared with those from testing sediment from two in-bay reference sites, the Bay Farm Borrow Area and the Alcatraz Environs Reference Area. Those two comparisons are presented in Appendixes Q and R, respectively.

The results of the January 1994 study also showed that OBM COMP was acutely toxic to *N. caecoides*. The sediment chemistry results for that composite showed that no contaminants of concern were elevated above reference levels. Discussions among MSL, USACE, and EPA staff concluded that this composite should be tested again to determine the reason for the acute toxicity. Four sampling stations, UIH-2, UIH-4, SFW-1 and SFW-3, were resampled, and the sediment was composited into one OBM COMP that was chemically analyzed and used in a 10-day *N. caecoides* feeding study. The results from that study are presented in a separate report, *The Older Bay Mud Study* (a).

This report is divided into five sections. Section 1.0 is the introduction containing a brief overview. Section 2.0 describes the methods and materials used for sample collection and processing, biological testing, physical and chemical analyses of sediments and tissues, data analysis, and quality assurance requirements. Section 3.0 presents the results of geologic descriptions, biological testing, and physical and chemical analyses. Section 4.0 presents the results of the Intensive Study of the Turning Basin. Section 5.0 is the discussion and conclusions. Section 6 lists the literature cited in support of this document. A series of appendixes contain detailed data listings for the following areas:

Appendix A	Materials and Methods Used for the Description of Sediment Cores
Appendix B	Core Data Logs
Appendix C-D	Sediment Chemistry and Quality Control Data
Appendix E-N	Toxicity Test Data
Appendix O-P	Tissue Chemistry and Quality Assurance Data

(a) 1995 draft report, Pacific Northwest Laboratory, Richland, Washington.

Appendix Q	Potential Effects of Disposal of Richmond Harbor Sediments and the Intensive Study of the Turning Basin Sediments at the Bay Farm Borrow Area
Appendix R	Potential Effects of Disposal of Richmond Harbor Deepening and Turning Basin Sediments at Alcatraz Island Disposal Site and at Alcatraz Environs Reference Area.

2.0 MATERIALS AND METHODS

2.1 SEDIMENT AND TEST ORGANISM COLLECTION

Sediment core samples were collected using either a 4-in. or 12-in. vibratory-hammer corer at 20 stations in Richmond Harbor. The sediment samples were collected to -42 ft MLLW (project depth -40 ft plus 2 ft for potential OBM composite). Specific locations of sediment sampling stations are presented with the sampling results in Section 3.1. Four-inch core samples were collected at each station and used for geologic description and sediment chemistry. Twelve-inch core samples were also taken at each of the 20 stations and combined to form 6 sediment COMPs. These six sediment composites were submitted for chemical analyses and used for biological testing of the sediments. In addition to the sediment composites, sediments from three reference areas were also collected and consisted of sediment from four stations at the Bay Farm Borrow Area, eight stations at the Alcatraz Environs Reference Area, and one station at the Deep Off-Shelf Reference Area; henceforth, these reference sediments will be called R-BF, R-AM, and R-OS, respectively. Sediment was also collected from the four control stations and was used to validate the toxicity tests. Biological testing required the collection of seven species of marine organisms; four of the species were collected in California (*N. caecoides*, *C. stigmaeus*, *H. costata* and *M. galloprovincialis*), two species were collected in western Washington (*R. abronius*, *M. nasuta*), and one species *(N. virens)* was collected from Maine.

2.1.1 Richmond Harbor Core Samples

Navigation support for locating the sampling stations in Richmond Harbor was provided by Towill, Inc., of Concord, California, and included a survey vessel and operator. The surveyors used a laser/range azimuth positioning system (EDM-Geodimeter AGA-120, Wild T-2 1-s theodolite). Towill provided corrected water depths at each station by measuring the actual depth with a recording fathometer (DE719-E), measuring the water surface elevation, and calculating the difference between the water surface elevation and 0 ft MLLW. All stations were sampled to -42 ft MLLW (-40 ft project depth and 2 ft for OBM COMP) using a 12-in. vibratory-hammer split corer and a 4-in. vibratory-hammer corer. Both samplers were designed by the MSL and Manson Construction (Figure 2.1). The 12-in. corer was used to collect the large volume of sediment needed for biological testing and chemical characterization, while minimizing contamination caused by contact with core tool or excessive sample handling. The 4-in. cores were used to collect sediment for geologic descriptions and chemical characterizations at each station. The 4-in. cores were collected and stored in noncontaminating Lexan polycarbonate tubes, which maintain the stratigraphic integrity of sediments and allow a geologist to describe the vertical stratigraphy and types of sediment present at each station.

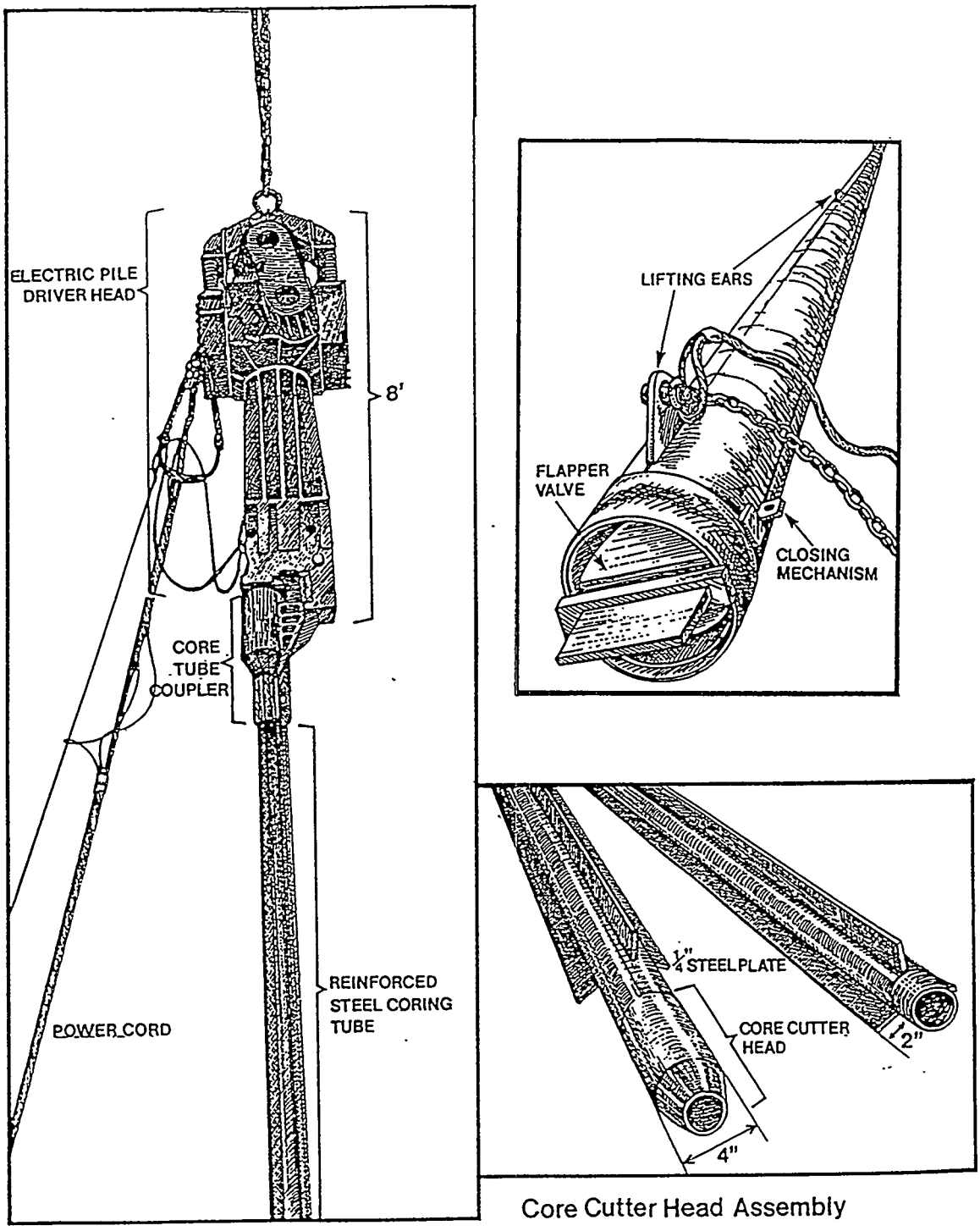


FIGURE 2.1. Components of the 4-in. and 12-in. Vibratory-Hammer Coring Devices

Both the 12-in.- and 4-in.- core samplers were deployed from Manson Construction's derrick barge, *Hagar*. The two sizes of cores were collected in a similar manner, but the sediment samples were handled differently. For both sizes of core, the coring apparatus was attached to an electric vibratory hammer. The corer and the vibratory hammer were suspended by the crane on the derrick barge. When the coring apparatus was directly above the sampling station, the core was lowered through the water to the sediment surface. Then, for harder-packed sediments, the vibratory hammer was started and the corer penetrated down through the sediment to a project depth of -40 ft MLLW, as indicated by the water surface level relative to marks on the outside of the core barrel. For soft sediment, the weight of the coring apparatus often caused penetration through the sediment without vibration; once harder material was reached, the hammer was turned on and the corer was allowed to penetrate to project depth. The coring apparatus was then pulled from the sediment, detached from the vibratory hammer, and lowered onto the barge deck.

As each 12- in. core was brought on board the barge platform, the hinged door of the core barrel was opened and the sediment was measured from the mudline downward to ensure that appropriate depth was reached. If the required core length was not achieved, the sediment in the core barrel was emptied and rinsed with seawater to prepare for a second core attempt. Once the required core length was achieved, the sediment was marked at -42 ft MLLW.

After the core segments were measured, the appropriate amount of sediment (calculation of volume to be removed was based on the amount of sediment needed for chemical and biological analyses) was transferred, using a stainless steel spade, from the core barrel to an epoxy-coated 5-gal bucket. Each sample container was labeled with the project name, station or composite designation, contributing station(s), and the sampling date(s). The containers were sealed and kept cool (~4°C) in a freezer on board the sampling vessel until loaded into a refrigerated van at the end of the sampling day.

Sediment was also collected to -42 ft MLLW using the 4-in.-diameter vibratory-hammer corer sampler; one core was collected per station. The core barrel was lined with a 3.125-in. (inner diameter) steam-cleaned Lexan core liner. When each core was brought on board, the liner was pulled from the barrel and the sediment measured from the mudline downward to determine whether appropriate depth was reached. If not, the liner was replaced, and another core sample was taken until project depth was reached. Then the Lexan liner was carefully carried to the cutting stand where it was capped, sealed, labeled, and if necessary, cut into shorter sections to fit in the freezer. Each core label included an arrow pointing to the top of the core, the station designation, core section indicator (e.g., Section 1 of 2 and Section 2 of 2), length interval from the mudline (e.g., 0-3 ft), and sampling date. When each 4-in. core was labeled and sealed, it was kept in a freezer on board the sampling vessel at ~4°C.

Detailed sampling records were maintained at each station and consisted of the following: station name, date, type of core (12- in. or 4-in.), replicate number, uncorrected water depth, tide height, corrected water depth, required core length, sampling time, total core collected, and comments. At the end of each sampling day, cores were off-loaded from the barge and stored in a refrigerated van at the staging area. When sampling was completed, the inventory of the samples was confirmed and recorded on the MSL chain-of-custody forms. The custody forms were signed by the field leader, who kept one copy and sealed the others with the core samples. The interior of the refrigerated van was maintained at 4°C while the core samples were transported to the MSL in Sequim, Washington.

Richmond Harbor site water was also collected using a peristaltic pump and 25 ft on noncontaminating Lexan C-flex tubing. Water was pumped from approximately 15 ft below the surface into solvent-rinsed 5-gal polypropylene carboys. This site water was used to prepare the SPP (Section 2.2.4).

2.1.2 Reference and Control Samples

Reference sediment samples R-AM, R-BF and R-OS were collected using a pipe dredge deployed from the *FV Cobra*, a charter boat owned and operated by Bob Smith Sportfishing. Sampling locations were determined by LORAN C and variable fix and range radar systems aboard the vessel and by a Raytheon Global Positioning System (GPS). The vessel navigation systems were verified at known fixed locations, such as the Golden Gate channel pilot buoy. Reference sampling records were maintained in a log book, and consisted of station position, date, time, replicate, water depth, sediment type, and comments. All reference samples were kept in labeled coolers on board the sampling vessel until they were off-loaded to the refrigerated van.

The control sediment sampling stations were located in Sequim Bay, Washington (C-SB); West Beach, Whidbey Island, Washington (C-WB); Dillon Beach/Tomales Bay, California (C-NE); and Newcastle, Maine (C-NV). The control sediment from Sequim Bay was collected with a modified van Veen grab sampler (0.1 m^2) deployed from an MSL research vessel. West Beach sediment was collected with a small, MSL-designed, anchor-dredge sampler that also obtains sufficient quantities of *Rhepoxynius abronius* for test purposes. The dredge was deployed from the MSL's 17-ft Boston Whaler in approximately 15 ft of water at the sampling location as determined by reference to shoreline features. The control sediment, C-NE, was collected by Brezina and Associates, using a shovel, and was collected concurrently with the test organisms *N. caecoides* and *C. stigmaeus*. This control sediment and the test organisms were shipped overnight to the MSL. The sediment was stored at 4°C±2°C and the test organisms were maintained at proper holding conditions. The New England sediment was collected concurrently with the test organism, *N. virens,* by Aquatic Research Organisms, Newcastle.

2.1.3 Test Organism Collection

Seven species of marine organisms were used in Richmond Harbor toxicity tests:

- bentnose clam, *Macoma nasuta*
- polychaete, *Nephtys caecoides*
- polychaete, *Nereis virens*
- phoxocephalid amphipod, *Rhepoxynius abronius*
- juvenile flatfish speckled (sanddab), *Citharichthys stigmaeus*
- juvenile mysid shrimp, *Holmesimysis costata*
- larvae of bay mussel, *Mytilus galloprovincialis.*

All of the organisms were wild-captured individuals collected either by a commercial supplier or by the MSL. *M. nasuta* were collected from intertidal zones in Discovery Bay near Gardiner, Washington, by a commercial supplier, using a shovel, sieve, and bucket. In the field, clams were kept cool in large containers filled with sediment and seawater from the collection station. *R. abronius* were collected by the MSL off West Beach, Whidbey Island, using the specially designed anchor dredge deployed from a 17-ft Boston Whaler. Sediment brought up with the dredge was sieved through a 2-mm mesh screen to remove large debris and predatory species. During sampling, the amphipods were kept in coolers partially filled with their native sediment and seawater until delivery to a holding tank at the MSL.

Brezina and Associates (Dillon Beach, California) supplied *N. caecoides*, *C. stigmaeus*, and *H. costata* individuals for toxicity testing. *N. caecoides* were collected from mud flats in Tomales Bay using a shovel, bucket, and sieve. *N. caecoides* were placed into clean coolers containing sediment and seawater from the collection station. Prior to overnight shipment to the MSL, the seawater in each cooler was supersaturated with oxygen (22 ppm). The *C. stigmaeus* were collected from Tomales Bay in 12 ft to 15 ft of water. *C. stigmaeus* were captured with a small trawl with a 0.25-in. mesh net. The trawl was held close to the work boat so a dip net could be used to transfer *C. stigmaeus* into double plastic bags containing oxygen-saturated seawater. *H. costata* were collected with a plankton dip net and transferred to a holding container aboard the work boat, where they were sorted by appropriate age and size class and then shipped to the MSL in bags containing oxygen-saturated water. Adult bay mussels (*M. galloprovincialis*) were obtained from the intertidal zones of Long Beach, California, by Marinus Incorporated. *N. virens* were collected from intertidal regions of Newcastle using a bucket and shovel, and were transported via overnight mail in moist mats of seaweed packed in coolers.

2.2 SEDIMENT SAMPLE PREPARATION

According to the *1991 Implementation Manual*, sediment must be initiated into biological tests within 6-weeks of sample collection, although 2 weeks is the recommended holding time. In the 6-week holding period the core samples were received at the MSL and inventoried against the chain of custody, processed for solid-phase and SPP testing, and initiated into the appropriate biological tests. The following sections describe equipment preparation, geologic descriptions of core samples, and preparation of sediment for solid-phase and SPP tests.

2.2.1 Laboratory Glassware and Equipment Preparation

The cleaning of glassware, stainless steel utensils, plastic, laboratory containers and equipment was done according to stringent procedures to avoid contamination of sediment samples. Glassware, including test containers, aquaria, and sediment transfer equipment, was washed with warm, soapy water, rinsed five times with deionized water, then soaked in a 5% reagent- grade nitric acid bath for a minimum of 4 h. After soaking, glassware was rinsed with deionized water five times and allowed to dry. Titanium tools, polyvinyl chloride (PVC), Nalgene, and other plastic items, such as funnels, were washed and soaked in acid baths in the same manner as glassware.

Stainless steel bowls, spoons, spatulas, and other utensils were washed with warm, soapy water, rinsed five times with deionized water, and allowed to air dry. They were then rinsed with methylene chloride under a fume hood and the methylene chloride was allowed to evaporate under the hood before use.

Rubber stoppers and other porous materials were washed with warm, soapy water and rinsed five times with deionized water. These items were then "seasoned" by continuous soaking in 0.45-µm-filtered seawater for at least 2 days prior to use.

Large pieces of laboratory equipment, such as the epoxy-coated (TNEMEC Epoxy converter 83-83B) mixer used to mix sediment and epoxy-coated boards used to hold cores for geologic descriptions, were washed with mild soap solution and thoroughly rinsed with tap water followed by deionized water.

Equipment used to measure water quality, such as pH, dissolved oxygen (DO), temperature, ammonia, and salinity, were calibrated according to manufactures' guidelines or as specified in MSL standard operating procedures (SOPs).

2.2.2 Geologic Description of Cores

A geologic characterization of each Richmond Harbor sampling station was conducted by an MSL geologist. The description was performed on each 4-in. core. All core sections from one station were removed from storage and scored longitudinally with a circular saw. A linoleum knife

was used to split the core open to expose the sediment stratigraphy. The geologist measured and described the core from top to bottom, recording data on a core data log. The geologic characterization protocol (Appendix A) was consistent with the American Society of Testing and Materials (ASTM) Method D2488-84 (ASTM 1984).

2.3 SEDIMENT AND TISSUE CHEMISTRY PROCEDURES

Richmond Harbor sediment treatments were analyzed for conventional and chemical parameters. Conventional parameters consisted of the following: grain size, TOC, TVS, oil and grease, TPH, and percentage of solids. Chemical parameters consisted of PAHs, chlorinated pesticides, PCBs, phthalate esters, metals, and butyltins. Metals, pesticides, and PCBs were also analyzed using WET. Table 2.1 lists the parameters for which the Richmond Harbor sediment treatments were analyzed and shows the quality assurance ranges and detection limits for each parameter. Richmond Harbor tissues of *N. virens* and *M. nasuta* were analyzed for the set of PAHs, chlorinated pesticides, PCBs, phthalate esters, metals, and butyltins (Table 2.2).

The following sections briefly describe the methods used for analysis of sediments and tissues for the required physical and chemical parameters. Analyses followed established procedures where applicable. Quality control samples when appropriate, included method blanks, matrix spike (MS) analyses, standard reference materials (SRMs), and analytical replicates. The MS and SRM were used as a measurement of analytical accuracy. The analytical replicates were used to evaluate analytical precision.

Prior to subsampling for chemistry, all sediment composites were thoroughly homogenized (Section 2.3.7) to provide a uniform consistency. Sample aliquots for chemical analyses were placed in cleaned and labeled containers appropriate for the parameters to be measured. Sediment treatments not used immediately were returned to the labeled, epoxy-coated metal buckets and stored at 4°C.

2.3.1 Conventional Sediment Measurements

Grain size analysis was conducted by Soil Technology, Inc., of Bainbridge Island, Washington. Sixteen grain size fractions were determined by a combination of sieve and pipette techniques from the Puget Sound Estuary Program (PSEP) *Protocols for Measuring Selected Environmental Variables in Puget Sound* (PSEP 1986). These methods are consistent with ASTM D2217 (ASTM 1985) and D422 (ASTM 1972) (with the substitution of a No. 100 sieve for a No. 140 sieve). An additional measurement for salt content was performed, and each grain size fraction was corrected for this salt measurement. Table 2.3 presents the fractions measured.

TABLE 2.1. Analytical Chemistry Requirements for Richmond Harbor Sediment Treatments

Parameters	Detection Limits (a) (mg/kg dry wt)	Number of Samples	Range of Recovery (%)	Relative Precision (%)
Sediment Conventional Parameters				
TOC	0.1%	36	NA (b)	10
Oil and Grease	20	36	50 - 150	20
TPH	20	36	50 - 150	20
Grain Size	1.0 %	36	NA	20
Total Solids	1.0 %	36	NA	20
TVS	0.1%	36	NA	20
Metals				
Silver (Ag)	0.1	36	75 - 125	20
Arsenic (As)	2.5	36	NA	20
Cadmium (Cd)	0.1	36	75 - 125	20
Chromium (Cr)	33	36	NA	20
Copper (Cu)	5.5	36	NA	20
Mercury (Hg)	0.02	36	75 - 125	20
Nickel (Ni)	7.5	36	NA	20
Lead (Pb)	6.2	36	NA	20
Selenium (Se)	0.1	36	75 - 125	20
Zinc (Zn)	7.8	36	NA	20
Organic Compounds				
Butyltins	0.001	36	40 - 120	30
PCBs(c)	0.02	36	40 - 120	30
PAHs(d)	0.02	37	40 - 120	30
Pesticides(e)	0.002 - 0.03	36	40 - 120	30
Phthalate Esters	0.02	36	40 - 120	30

(a) Target detection limits; all efforts were made to reach lowest practical detection limits.
(b) Not applicable. Spiking for specific method is not feasible.
(c) Reported as Aroclor equivalents 1242, 1248, 1254, and 1260 and total PCB. Analyzed using EPA Method 8080.
(d All compounds on EPA Method 610 list. Analyzed using Method 8270 in selected ion mode.
(e) All compounds on EPA Method 608 list. Analyzed using Method 8080.

TABLE 2.2. Analytical Chemistry Requirements for Richmond Harbor Tissue Samples

Parameters	Detection Limits [a] (mg/kg wet wt)	Number of Samples	Range of Recovery (%)	Relative Precision (%)
Metals				
Ag	0.1	90	75 - 125	20
As	2.0	90	NA[b]	20
Cd	0.1	90	75 - 125	20
Cr	1.0	90	75 - 125	20
Cu	4.3	90	NA	20
Hg	0.02	90	75 - 125	20
Ni	1.0	90	75 - 125	20
Pb	1.0	90	75 - 115	20
Se	1.0	90	NA	20
Zn	35	90	NA	20
Organic Compounds				
Butyltins	0.001	90	40 - 120	30
PCBs [c]	0.02	90	40 - 120	30
PAHs [d]	0.02	90	40 - 120	30
Pesticides[e]	0.003	90	40 - 120	30
Phthalate Esters	0.02	90	NA	NA

(a) Target detection limits; all efforts were made to reach lowest practical detection limits.
(b) Not applicable, Spiking for XRF analysis not feasible.
(c) Reported as Aroclor equivalents 1242, 1248, 1254, and 1260 and total PCB, EPA Method 8080.
(d) All compounds on EPA Method 610 list. Analyzed using Method 8270 in SIM.
(e) All compounds on EPA Method 608 list. Analyzed using Method 8080.

TABLE 2.3. Grain Size Fractions Measured

Grain Size (µm)	Phi	Screen Number
3350	-2	6
2000	-1	10
1000	0	18
250	2	60
125	3	120
62.5	4	230
48	4.5	NA[a]
31.2	5	NA
23	5.5	NA
15.6	6	NA
7.8	7	NA
3.9	8	NA
1.9	9	NA
0.9	10	NA
<0.4	11	NA

(a) Not applicable.

Approximately 25 g of each sediment sample was analyzed for total solids, and another 10-g to 100-g aliquot was weighed for grain size analysis. To separate the coarser sand and gravel fraction from the silt/clay fraction, sediment was washed with distilled water through a 63.5-μm (4.0 phi) sieve into a 1-L graduated cylinder. The coarse fraction was dried, weighed, and shaken through a nest of sieves to yield the required seven coarse subfractions. Any material still passing through the final 63.5-μm sieve was added to the previous fines in the 1-L graduated cylinder. The silt/clay fraction was then subdivided by a pipette technique based on Stoke's Law of differential settling velocities for different sized particles. The silt/clay fraction was disassociated by adding a dispersant (sodium hexametaphosphate) to distilled water contained in a 1-L graduated cylinder. At specified time intervals and specified depths below the surface, 20-mL aliquots were withdrawn from the graduated cylinder, delivered to a preweighed container, and dried at 90°C±2°C to a constant weight. Triplicate analysis of three samples was performed as a quality control measure. Other quality control measures, such as spikes, SRMs, or minimum detection limits, do not apply to grain size analysis.

Analysis of total volatile solids was performed at Analytical Resources Inc. (ARI) in Seattle, Washington. Total volatile solids are a measure of the fraction of total solids that are lost on ignition. The TVS measurements are used as an estimate for the amount of organic matter in the total solids. Operationally, TVS are defined by the combustion temperature and do not always represent the organic content of a sample because some of the more volatile organic material may be lost during drying and some inorganic material may be lost during combustion. To perform TVS analysis, ARI follows PSEP (1986), which first oven dries the sample to constant weight , and then the sample is removed and combusted at 550°C. The sample was cooled in a desiccator and then reweighed. The amount of sample lost during ignition was then defined as the *volatile solids fraction.* Quality control measures included one method blank and three sets of triplicate analysis.

Analysis of TOC was performed by Global Geochem, in Canoga Park, California. The TOC is the amount of nonvolatile, partially volatile, volatile, and particulate organic carbon compounds in a sample. Each sediment treatment was dried and ball milled to a fine powder. Before combustion, inorganic carbon in the sample was removed by acidification. The TOC in sediment was then determined by measuring the quantity of carbon dioxide released during combustion of the sample (EPA 1986a) and reporting the release as percentage of dry weight. Quality control measures included six method blanks and one triplicate analysis per batch.

Total oil and grease and TPH were performed by ARI. Total oil and grease includes vegetable oils, animal fats, soaps, waxes, and any other carbon-hydrogen material extractable by the solvent Freon. The TPH comprises the nonpolar mineral fraction of total oil and grease that is not removed by silica gel absorption. Infrared spectrophotometry (IR) was used to determine

concentrations of oil and grease (Method 413.2, EPA 1979) and petroleum hydrocarbons (Method 418.1, EPA 1979). A 20-g aliquot of sample was dried with anhydrous sodium sulfate, then extracted with Freon. For total oil and grease, sample extracts were scanned from 4000 to 600 cm^{-1} on an infrared spectrophotometer, and the peak height was measured at 2930 cm^{-1}. Since this wavelength represents the $-CH_2$ configurations of hydrocarbons, it was the standard used to determine oil and grease. For TPH, silica gel was added to the extract to remove the more polar animal- and vegetable-based oils. The extract was then shaken and allowed to settle. An aliquot was then removed and scanned the same way as was the oil and grease sample. The relationship of peak height to oil concentration was determined by regressing the peak height versus a known concentration of fuel oil and vegetable oil for TPH and oil and grease, respectively. Quality control measures include one blank, a matrix spike, and one analytical triplicate per batch.

2.3.2. Semivolatile Organic Compounds

Analyses for semivolatile organic compounds (PAHs and phthalate esters) in the Richmond Harbor sediment treatments and *M. nasuta* and *N. virens* tissues were performed by the MSL in Sequim, Washington. The semivolatile organic compounds analyzed in sediments were the 16 PAHs listed in EPA Method 610. These compounds were extracted by the National Oceanic Atmospheric Administration (NOAA) status and trends method (Krahn et al. 1988), which involves multiple extractions on an ambient roller using methylene chloride as the extraction solvent. A portion of the extract was used for PAH and phthalate ester analysis by gas chromatography/mass spectroscopy (GC/MS) in the selective ion mode (SIM) following EPA SW-846 Method 8270 (EPA 1986b). Tissue extracts were run through gel permeation chromatography (GPC) prior to analysis to remove any additional interferences.

Quality control measures included at least one method blank per batch. A matrix spike solution consisting of all 16 PAH compounds was added to each sample of both sediment and tissue to assess the accuracy of the measurement. One matrix spike was performed for each batch. National Institute of Science and Technology (NIST) SRM 1941 was used to assess the accuracy of the sediment measurement and NIST SRM 1974 was used to assess the accuracy of the tissue measurement. One sample in each batch was analyzed in triplicate to assess precision.

2.3.3 Chlorinated Pesticides and PCBs

Pesticide and PCB analyses for Richmond Harbor sediments and *M. nasuta* and *N. virens* tissue samples were performed by the MSL. Chlorinated pesticides and PCBs in sediments and tissues were quantified by gas chromatography/electron capture detection (GC/ECD) following EPA SW-846 Method 8080 (EPA 1986b).

Chlorinated pesticides and PCBs were extracted simultaneously with the PAH compounds, using the ambient roller technique described for PAHs. The procedure involved multiple methylene chloride extractions. A portion of the methylene chloride extract was solvent-exchanged to hexane, and interferences were removed by passing the extract through a column packed with deactivated alumina and silica by the NOAA status and trends method (Krahn et al. 1988). The samples then require an additional cleanup treatment using HPLC to remove other interferences. Analytical quantification was performed using GC/ECD analysis. Surrogates were added to each sample before extraction to assess extraction efficiency.

Quality control measures included a method blank with each batch. A matrix spiking solution, consisting of either a subset of pesticides or one Aroclor, was also added to the appropriate samples before extraction. The matrix spike analyses were conducted with each batch to assess accuracy of the measurements. One sample in each batch was analyzed in triplicate to assess precision.

2.3.4 Metals

Sediment and tissue metals analyses were performed by Pacific Northwest Laboratory (PNL). Ten metals were measured in sediments and tissues: silver (Ag), arsenic (As), Cd, chromium (Cr), Cu, mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn). Samples of sediment, *M. nasuta* tissue, and *N. virens* tissue were analyzed using a combination of four different methods: 1) energy-diffusive x-ray fluorescence (XRF), following a PNL standard operating procedure; 2) Zeeman graphite-furnace atomic absorption spectroscopy (GFAA), following modified EPA 200.9 (EPA 1991); 3) cold-vapor atomic absorption spectroscopy (CVAA), according to the method of Bloom and Crecelius (1983); and 4) inductively coupled plasma mass spectrometry (ICP/MS), following modified EPA 200.8 (EPA 1991). The analytical methods for each sample matrix and corresponding metals for which each method was used are presented in Table 2.4.

TABLE 2.4. Analytical Method and Corresponding Metal for Each Sample Matrix

Sediment				*N. virens* Tissue			*M. nasuta* Tissue		
XRF	GFAA	CVAA	ICP/MS	XRF	CVAA	ICP-MS	XRF	CVAA	ICP-MS
As	Ag	Hg	Cd	As	Hg	Cr	As	Hg	Cr
Cr	Se			Cu		Ag	Cu		Ag
Cu				Se		Cd	Se		Cd
Ni				Zn		Pb	Zn		Pb
Pb						Ni			Ni
Zn									

To prepare sediment and tissues for analysis, samples were freeze-dried, then blended in a Spex mixer-mill. Approximately 5 g of this mixed sample was then ground in a ceramic ball mill. The XRF analysis was performed on a 0.5-g aliquot of dried, ground material pressed into a pellet with a diameter of 2 cm. For GFAA, CVAA, and ICP/MS analyses, 0.2-g aliquots of dried homogenous sample went through an acid digestion process to separate and isolate the metals from the matrix.

Quality control measures for metals analyses included analysis of blanks (not applicable to XRF technique), matrix spike, and triplicate analyses for each batch of up to 20 samples, and analysis of at least 1 SRM sample per 20 samples. The SRMs for sediment were SRM 1646, obtained from NIST, and BEST-1 obtained from the National Research Council of Canada (NRCC). The tissue SRM consisted of an oyster tissue, 1566a, obtained from NRCC.

2.3.5 Butyltins

Butyltins in sediment and *M. nasuta* and *N. virens* tissue were analyzed at the MSL. Butyltin compounds in sediment and tissues were analyzed using gas chromatography/ flame photometric detection (GC/FPD) following the methods of Unger et al. (1986).

Wet samples were extracted with methylene chloride and tropolone. Tripentyltin was added before extraction as a surrogate compound to assess extraction efficiency. The mono-, di-, and tributyltin compounds extracted from the sediment and tissues were derivatized to a less volatile, more thermally stable form (nonionic n-hexyl/or n-pentyl derivatives). The extracts were passed through a Florisil liquid chromatography column for cleanup, and the butyltins were quantified by GC/FPD. Concentrations were reported in µg/kg dry weight of mono-, di-, and tributyltin species as tin. The recently certified reference material for butyltins, NRCC SRM PACS-1, was analyzed with the sediment. Selected sediment and tissue samples were spiked with di- and tributyltins prior to extraction to assess the accuracy of the procedure. Method blanks, three sets of matrix spikes and three sets of triplicates were analyzed as quality control measures.

2.3.6 California Waste Extraction Test (WET), Soluble Threshold Limit Concentration (STLC), Metals, Hexavalent Chromium and STLC, Pesticides, and PCBs

California State Title 22 WET and subsequent analyses for soluble threshold limit concentration (STLC) of metals, pesticides, and PCBs were conducted by Clayton Environmental Consultants of Pleasanton, California. The WET extracts (membrane-filtered liquid portion of sediment sample) were measured for metals by either EPA Method 6010 (inductively-coupled plasma [ICP]) or by atomic absorption (AA). Extracts were prepared and measured for pesticides and PCBs following EPA Methods 3510 and 8080. Two surrogate internal standards were added prior to extraction: decachlorobiphenyl and tetrachloro-m-xylene. Quality control

samples for both metals and organics analyses included a method blank, matrix spike, and matrix spike duplicate.

2.3.7 Preparation of Solid-Phase Samples

Solid phase, also called bulk sediment or whole sediment, refers to the sediment itself, as opposed to suspended or dissolved phases. In biological tests, the solid phase of sediments can be from the test sediment (represents dredged material once it has settled at an aquatic disposal site), the reference sediment (the existing environment of a disposal site without dredged material), or the control sediment (environment of a benthic test organism).

All of the Richmond Harbor sediment used for biological testing came from stations that were combined to yield the six sediment composites. The compositing scheme was provided by USACE prior to field sampling. Individual stations were sampled with the 12-in. vibratory-hammer corer, and specific and appropriate volumes from each station were removed and placed in a corresponding labeled bucket. The labeled buckets with the appropriate composite name were then sent back to the MSL for processing. The procedure for homogenizing Richmond Harbor test sediment composites involved placing the sediment in a mixer coated with a epoxy paint and mixing the sediment with minimal amounts of 0.45-µm-filtered seawater to achieve a homogeneous consistency. Once a sediment composite was thoroughly homogenized, it was referred to as a *sediment treatment*, indicating that all the necessary sample processing was completed and the sediment could be used in testing. The term *sediment treatment* will be used to describe all three sediment types, test, reference and control prepared in this manner.

The reference and control sediment sample processing involved sieving prior to compositing. To perform the sieving process, sediments were placed on screens having mesh diameters of 0.5 or 1.0 mm, depending on sediment type, and press sieved into clean epoxy-coated buckets. Depending on the sediment consistency, minimal amounts of 0.45-µm filtered seawater was added to ensure thorough mixing. Any sediment or organism remaining on the 0.5 mm sieve was removed and discarded. After sieving the sediment treatments were stored at approximately 4°C until needed for testing. Between sieving of different reference sediments, all equipment was thoroughly rinsed with 0.45-µm-filtered seawater to avoid potential cross-contamination of samples.

2.3.8 Preparation of Suspended-Particulate-Phase Samples

The SPP of sediment composites was used to evaluate water column effects of open-water dredged material disposal. The SPP is the liquid supernatant that remains after mixing sediment with seawater and allowing heavier particles to settle to the bottom. Because SPP preparation does not involve filtration, this phase contains suspended particles as well as

dissolved constituents. The SPP tests evaluate effects caused by both the physical presence of the suspended particles and the chemical toxicity of contaminants associated with the particles or dissolved fractions. The process is intended to approximate exposure conditions created as a result of material discharged through the water column during dredge-disposal operations.

The first step of SPP preparation was creating a 4:1 (volume:volume) water to sediment slurry in 1-L glass jars with Teflon-lined lids. The jars were marked at 200 mL and 400 mL and filled to the 200-mL mark with brine-adjusted Richmond Harbor site water. The brine was prepared by freezing and thawing filtered Sequim Bay seawater, and decanting the liquid to reach a salinity of 100%. Homogenized sediment was added until the water was displaced to the 400-mL mark. The jar was shaken vigorously by hand and then filled to 1 L with the brine-adjusted Richmond Harbor seawater. Twelve jars of sediment and water were placed on a shaker table and agitated for 30 min at a shaking rate of 120 to 150 cycles/min. After shaking, the slurry was poured into 500-mL Teflon containers with tightly-fitted lids. These containers were placed in a centrifuge and spun for 10 to 15 min at a g-force of 777 (equivalent to a 24-h settling period). The 10-min centrifugation was necessary to ensure that test organisms would be visible at the first observation after exposure to SPP test treatments. After centrifugation, the supernatant was poured into clean 10-gal aquaria; and the sediment remaining in the Teflon jar was discarded. If SPP was not used immediately, it was stored at 4°C. The Teflon jars were rinsed after each use, and the above process was continued until an adequate amount of SPP was produced for each test treatment. Between sediment SPP preparations, all glass and Teflon containers were appropriately cleaned according to procedures described in Section 2.2.1.

For each SPP treatment, there were five replicates of each of the four SPP concentrations: 0% (MSL filtered seawater), 10%, 50%, and 100% SPP. The brine-adjusted Richmond Harbor sitewater was used to prepare the SPP, as noted above, and 0.45-µm filtered Sequim Bay seawater was used to prepare the dilution series.

2.4 TOXICOLOGICAL TESTING PROCEDURES

Biological tests including solid-phase, and bioaccumulation were performed at the MSL. The solid-phase tests were used to assess the acute toxicity potential of dredged material after it had settled at an aquatic disposal site. Three species of marine organisms were exposed to the test treatments from Richmond Harbor, reference area sediment, and control sediment.

Two acute toxicity tests were conducted: 1) a 10-day solid-phase static test using the burrowing amphipod, *R. abronius*, and 2) a 10-day solid-phase flow-through acute toxicity test exposure using the polychaete, *N. caecoides* and the clam, *M. nasuta*.

The SPP tests evaluate effects caused by the physical presence of suspended particles and the toxicity of chemical contaminants associated with the particles or dissolved into the water after disposal. Three marine species were used in these tests: juvenile sanddabs (*C. stigmaeus*), mysids (*H. costata*), and larvae of the bay mussel (*M. galloprovincialis*). The SPP treatments were prepared as described in Section 2.2.4.

The bioaccumulation test was a 28-day exposure of *M. nasuta* and *N. virens*, tested in separate test containers. The purpose of the bioaccumulation test was to assess the potential for bioaccumulation of contaminants from the sediment into the tissues of the organisms. The sediment treatments and procedures were similar to those of the 10-day test, except they involved a longer exposure period, larger test population, larger species of polychaete, and depuration process for surviving *M. nasuta* and *N. virens*.

The MSL facilities provided the required conditions for flow-through solid-phase tests, static solid-phase tests, and static SPP tests. Laboratory equipment providing these testing conditions included a controlled-temperature environment, flow-through filtered seawater supply, lighting control, and air supply.

2.4.1 10-Day Solid-Phase Static Test with *R. abronius*

The amphipods were kept in a large holding tank containing their native sediment with flowing 15°C seawater. Organisms were not fed during the holding period, which was less than 2 weeks before test initiation.

The *R. abronius* test was conducted in 1-L glass jars (Figure 2.2) placed in random positions on a water table maintained at 15°C. Prior to test initiation, test sediment was added to the jars to a depth of 2 cm, and then 0.45-µm-filtered seawater was added to a volume of 750 mL. The jars were aerated and placed on the water table overnight to stabilize temperature to test conditions. After settling, initial water quality parameters were measured in each container and recorded on water quality forms.

The amphipods were gently sieved from the holding tank into clean seawater and counted into small transfer containers. The number of organisms was then confirmed by a second observer before the amphipods were transferred into the test container. Initiation of testing began by adding 20 *R. abronius* to each test container. The date and time of initiation were recorded on data forms. *R. abronius* were observed daily during the test, and the number of organisms floating on the surface, swimming in the jar, or on the sediment surface was recorded on observation forms. Amphipods that were floating on the surface were gently pushed below the water surface with a pipette tip and observed as they either buried or did not rebury into the sediment. Two replicates of each sediment treatment in *dummy jars* were also prepared in the same manner as the test containers, with the exception that no organisms were added. These

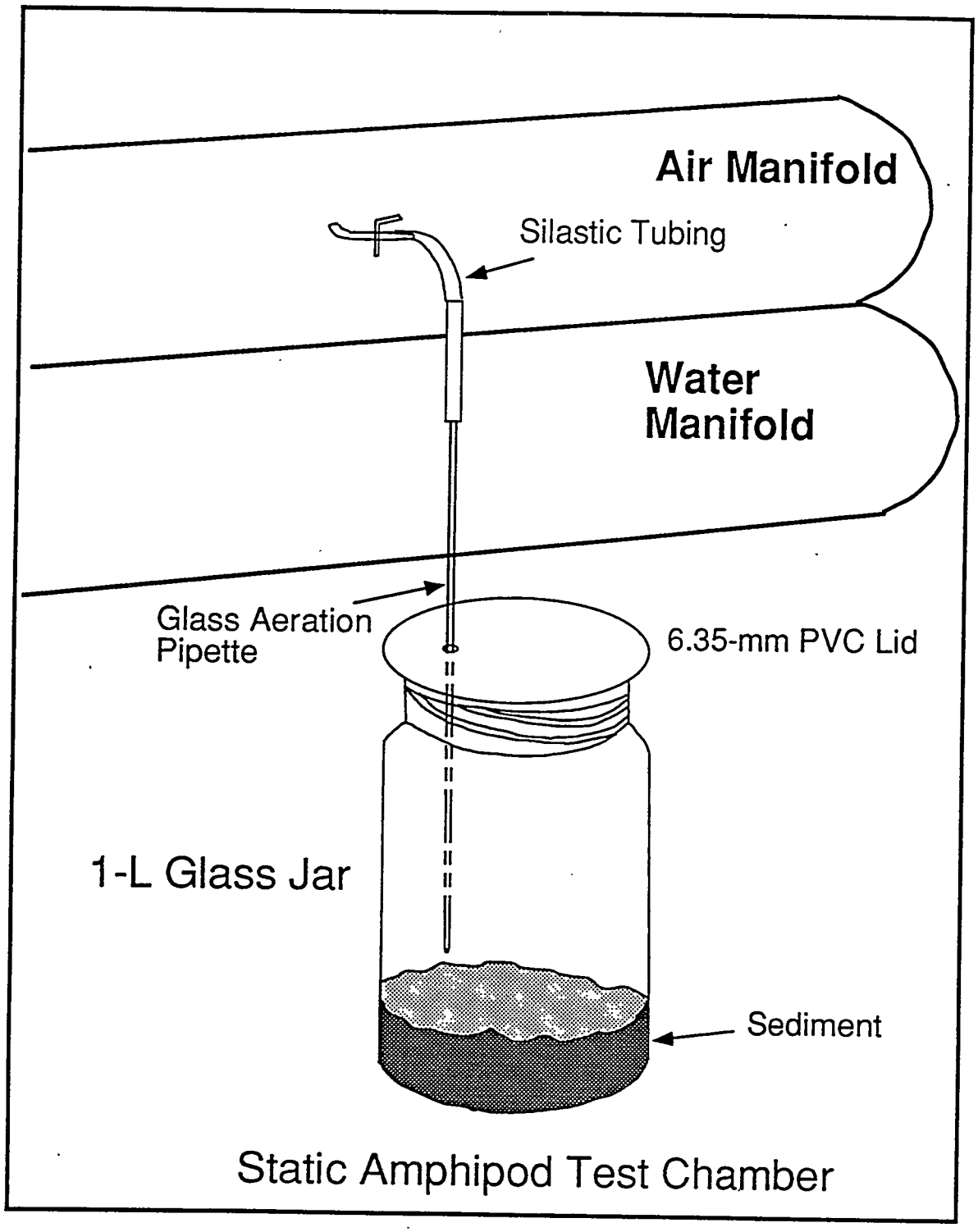


FIGURE 2.2. Static Mason Jar for *R. abronius* Toxicity Test

dummy jars were used to measure the interstitial porewater ammonia of the sediment treatments prior to initiation of the organisms and on Day 10 (termination).

Water temperature, salinity, pH, and DO were measured daily in one replicate of each sediment treatment, and in all containers at initiation and termination of the bioassay. Ammonia in the overlying water was measured on Days 0, 1, 3, 7, and 10. Porewater ammonia was measured in dummy jars on Days 0 and 10. Acceptable ranges for water quality parameters during the experiment were as follows:

DO	≥6.0 mg/L
pH	7.30 to 8.30
Salinity	30 ±2.0‰
Temperature	15.0°C ±2.0°C
Ammonia (porewater)	≤30 mg/L.

At the end of the test (Day 10), the contents of each jar were sieved through a 0.5-mm Nytex screen to collect the *R. abronius*. The organisms were placed in clean seawater in a glass dish labeled with the sediment treatment and replicate number. The number of live and dead organisms was counted and examined under a dissecting microscope. The presence or absence of body parts recovered at the end of the test was also noted. If an individual organism did not respond to gentle probing it was considered dead. At least 10% of the mortality counts were confirmed by a second observer.

A 96-h reference toxicant test with cadmium chloride was conducted to have a basis for comparison with the health and expected response of the test organisms to a known toxicant. The reference toxicant test was conducted in the same manner as the 10-day solid-phase test. *R. abronius* were exposed to a seawater control plus four concentrations of cadmium chloride (0.38, 0.75, 1.5 and 3.0 mg/L as cadmium [Cd]). There were three replicates of each concentration.

2.4.2 10-Day Solid-Phase Flow-Through Test with *N. caecoides and M. nasuta*

Prior to testing, *N. caecoides* were held in their native sediment in shallow trays covered with well-aerated 15°C seawater from a gravity-fed flow-through system. *M. nasuta* were held in large water tables or holding tanks containing clean sediment with flow-through 15°C seawater. Temperature, pH, DO, and salinity of water in each holding tank were monitored daily. The organisms were not fed during the holding period.

The flow-through tests with *M. nasuta* and *N. caecoides* were conducted in a 10-gal aquaria placed in random positions on water tables. Figure 2.3 shows the system used for flow-through tests. Approximately 8 L of sand-filtered seawater was added to each aquarium via the flow-through system. Then, sediment was added to a depth of 3 cm, by measuring the required amount (3870 mL) into a glass container and pouring it into the aquarium while washing it with

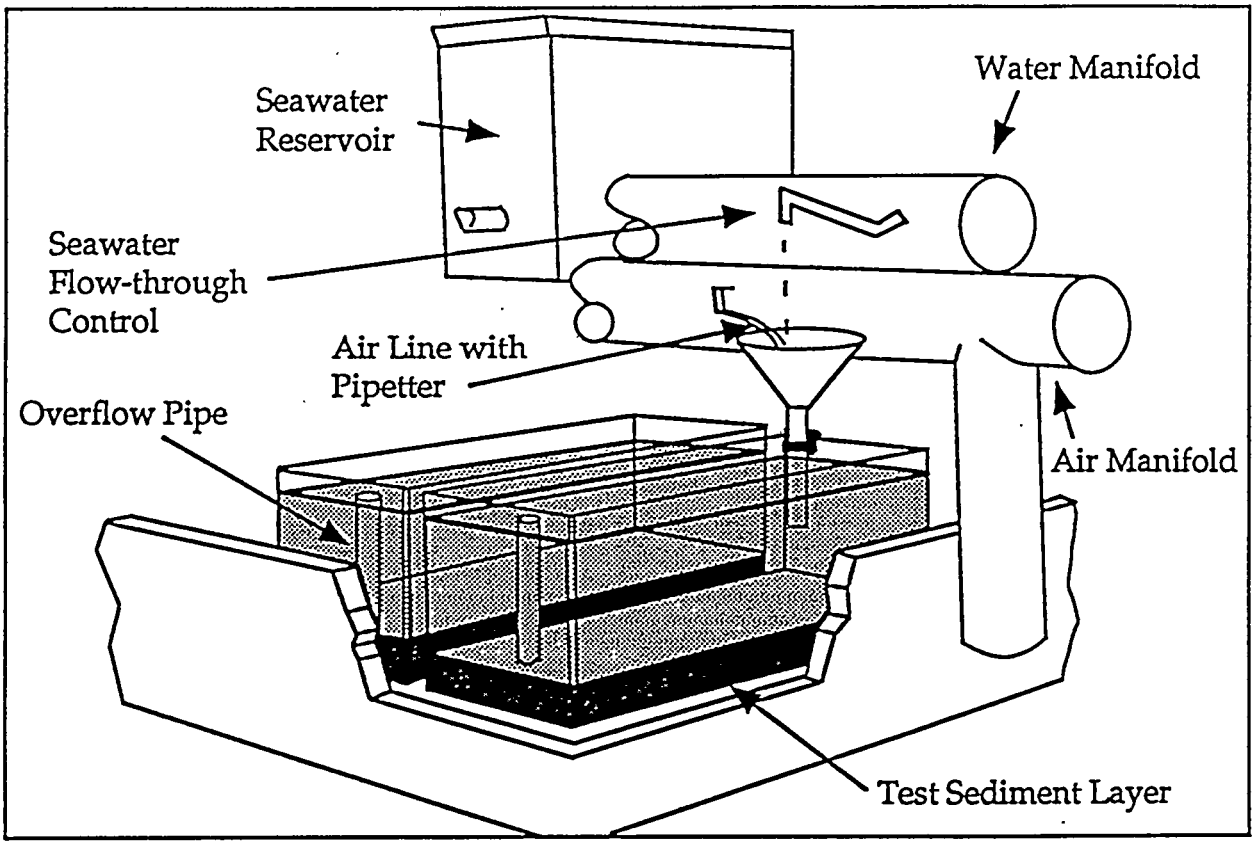


FIGURE 2.3. Flow-through Aquaria for 10-Day *M. nasuta/N. caecoides* Toxicity Test and 28-Day *M. nasuta* and *N. virens* Tests

seawater to help distribute the sediment evenly over the bottom. The flow-through system was initiated, and aquaria were allowed to fill to a total volume of approximately 36 L. For 4 h, the sediments in the aquaria were allowed to settle in the absence of flowing seawater. Then the flow-through system was adjusted and calibrated to deliver 125±10 mL/min of seawater flow to each aquarium. The system was allowed to operate overnight before the addition of test organisms.

To initiate the test, 20 or 25 *M. nasuta* and 20 *N. caecoides* were collected from the holding tanks and placed in each aquarium. Each test aquarium was labeled with initiation time/date and the initials of the examiner who placed the organisms in each chamber. Water quality parameters (below) were measured daily in at least one replicate of each sediment treatment and recorded on water quality data sheets. A replicate of each sediment treatment dummy jar was used to measure the interstitial porewater ammonia of the sediment treatments prior to initiation and termination of the test organisms. (Water quality data are provided in Appendix E). The water quality parameters and ranges established for the tests were as follows:

DO	≥6.0 mg/L
pH	7.30 to 8.30
Salinity	30 ±2.0‰
Temperature	15.0°C ±2.0°C
Flow Rates	125 ±10 mL/min
Ammonia	measured but presently not established.

Daily observations of test organism behavior were made and recorded on data forms. The number of *M. nasuta* on the sediment surface and the number of those with their siphons exposed were noted, as well as the number of *N. caecoides* on the sediment surface and the number of those with only their heads exposed. In addition, the number of dead organisms in each aquarium was recorded on daily observation forms. Dead organisms were removed from the aquaria and incinerated; no replacement of dead organisms occurred during testing. If a dead *N. caecoides* was removed, it was identified as a whole animal, a head, or a tail portion.

At the end of the 10-day test, water quality measurements were performed in all replicates and the contents of each aquarium were gently passed through a 1.0-mm Nytex screen to recover the *N. caecoides* and *M. nasuta*. The organisms were placed in glass dishes and labeled with the sediment treatment number. At this time, the number of dead and live organisms of each species was counted. Death was determined by observing whether the *N. caecoides* reacted to gentle probing; if there was no movement, the organism was considered dead. Death of *M. nasuta* was determined by the presence of gaping shells. The mortality data were recorded on the termination forms. At least 10% of the mortality counts were confirmed by a second observer.

2.4.3 28-Day Solid-Phase Flow-Through Test with *N. virens* and *M. nasuta*

The procedure for conducting the 28-day solid-phase flow-through test with *N. virens* and *M. nasuta* was identical to that of the 10-day test, with five exceptions: 1) the number of organisms in each aquarium was 25 *M. nasuta* and 25 *N. virens* because more individuals were needed to produce enough tissue for chemical analysis; 2) *N. virens* replaced *N. caecoides* because it is a much larger species and can provide a greater quantity of tissue for chemical analysis; 3) the exposure period was increased from 10 to 28 days; 4) the surviving test organisms were depurated, and tissues were sampled for chemical analysis; and 5) the *M. nasuta* and *N. virens* were tested separately. The ranges for water quality parameters, as well as the test conditions, such as temperature and flow rate, were the same for the 28-day test as for the 10-day test. Water quality parameters were measured, and mortality of the test organisms monitored at the same frequency for both tests.

When the 28-day test was terminated, the living *M. nasuta* and *N. virens* were collected for chemical evaluation of bioaccumulation. To ensure that tissue chemistry results would not be biased by contaminants associated with sediment grains in the digestive tract, the test organisms were allowed to depurate, or void the digestive tract, for 48 h following the 28-day exposure. The surviving *N. virens* from one test aquarium were placed in another flow-through 10-gal aquarium with flowing seawater and no sediment. The animals were not fed during the depuration period. The surviving *M. nasuta* were contained in a glass baking dish (without sediment), and placed in an aquarium with flowing seawater. After 48 h of depuration, the *M. nasuta* shells were cleaned with a scrub brush prior to the removal of tissues using titanium knives. The tissues were placed into clean jars and submitted for chemical analysis. The *N. virens* were gently washed in clean seawater to remove external sediment grains and put in containers for chemical analyses.

2.4.4 96-Hour Suspended-Particulate-Phase Test with *C. stigmaeus*

The test chambers for the SPP test with *C. stigmaeus* were 10-gal static aquaria randomly positioned on the water tables, with 20 to 24 aquaria per table. Test temperature was maintained by a circulating water bath on the water table. Aeration was provided through a glass pipette connected by silastic tubing to an overhead air manifold. Aquaria were labeled with a sediment treatment code, concentration, and replicate number. The volume of test material in each aquarium was 10 L. To obtain the 100% SPP treatment, 10 L of 100% SPP was added directly to the aquarium; the 0% SPP treatment consisted of 10 L of Sequim Bay filled seawater. To prepare the 10% and 50%, SPP concentrations appropriate volumes of 100% SPP and 0.45 µm-filtered Sequim Bay dilution water were mixed directly in a test aquarium.

After SPP preparation and placement of containers on the water table, aeration was started and initial water quality parameters were measured in all replicates. Ten *C. stigmaeus*

were removed from the holding tanks, using a net, and added to each test container. The test population for each concentration was 50 individuals (200 individuals per SPP treatment). Initiation time and date were documented on test containers and data forms.

C. stigmaeus were not fed during the 96-h exposure. After initiation, DO, pH, salinity, and temperature were measured daily in at least one replicate. Ammonia was measured in at least one replicate of the 100% SPP prior to the introduction of test organisms and at the end of the 96-h test. Acceptable ranges for the water quality parameters during the experiment were as follows:

DO	≥6.0 mg/L
pH	7.30 to 8.30
Salinity	30 ±2.0‰
Temperature	15.0°C±2.0°C
Ammonia	measured but presently not established.

Observations of *C. stigmaeus* activity and behavior in each test container were made at test initiation and at 4, 24, 48, and 72 h. An organism was considered dead if it did not respond to gentle probing.

Before termination of the test at 96 h, water quality parameters were measured in all replicates. At 96 h, the number of live and dead organisms was counted in each test container. As a quality control check, a second observer confirmed at least 10% of the mortality counts.

A 96-h Cu reference toxicant test was also conducted to establish the health and expected response of the test organisms. The reference toxicant test was conducted in the same manner as the SPP tests. *C. stigmaeus* were exposed to a seawater control plus four concentrations of copper sulfate (0.5, 1.0, 1.5, and 2.0 mg/L as Cu). There were three replicates of each treatment.

A 96-h ammonia reference toxicant test was conducted to establish the expected response of the test organisms to ammonia. The ammonia reference toxicant test was conducted in the same manner as the SPP tests. *C. stigmaeus* were exposed to a seawater control plus four concentrations of ammonia (15, 20, 25, and 30 mg/L as ammonium chloride). The actual concentrations of ammonia were measured in this experiment and are reported in Section 3.0 of this report. There were three replicates of each concentration.

2.4.5 96-Hour Suspended-Particulate-Phase Test with *H. costata*

Prior to testing, *H. costata* were held for at least 48 h in flow-through aquaria maintained at test temperature (15°C). In the holding tanks, *H. costata* were fed brine shrimp twice a day, and water quality parameters were monitored daily.

The test containers for the *H. costata* test were 400-mL glass jars placed in random positions on water tables. Test temperature was maintained by immersing these containers in a circulating water bath. Aeration was provided through a pipette connected by silastic tubing to an overhead air manifold. Appropriate volumes of 100% SPP and 0.45-µm-filtered Sequim Bay dilution water were added to 1-gal jars to make 0%, 10%, 50%, and 100% SPP concentrations for the *H. costata* test. A total of 1500 mL was prepared for each dilution to provide the test volume of 300 mL in each of five replicates. The test containers were labeled with a sediment treatment code, concentration, and replicate number.

After the SPP concentrations were prepared and placed on the water table, gentle aeration was started and water quality was measured in all replicates. *H. costata* were then removed from the holding tanks, using a wide-bore pipette. To initiate the test, 10 individuals were added to each container to produce a test population of 50 individuals per concentration (200 individuals per treatment). The test initiation time and date were documented on data forms. After test initiation, water quality parameters were measured in one replicate. Ammonia was measured in at least one replicate of the 100% SPP prior to initiation of the organisms and at the end of the 96-h test. The parameters for this test were as follows:

DO	≥6.0 mg/L
pH	7.30 to 8.30
Salinity	30 ±2.0‰
Temperature	15.0°C ±2.0°C
Ammonia	measured but presently not established.

Observations of test organisms were made at test initiation and at 4, 24, 48, and 72 h, using a light table to enhance visibility of the *H. costata*. During the 96-h exposure, *H. costata* were fed brine shrimp daily. Excess food was removed with a small pipette before daily observations, using extra caution not to disturb test animals. Molted exoskeletons and any particulates that had settled from the SPP solution were also removed.

Prior to test termination, water quality parameters were measured in all replicates. At 96 h, the number of live and dead animals was counted in each test container. An organism was considered dead if it did not respond to gentle probing. As a quality control check, a second observer confirmed surviving test organisms in at least 10% of the mortality counts.

A 96-h Cu reference toxicant test was conducted to establish the health and expected response of the test organisms. The reference toxicant test was conducted in the same manner as the SPP tests. *H. costata* were exposed to a seawater control plus four concentrations of copper sulfate (50, 100, 150 and 200 µg/L as Cu). There were three replicates of each treatment.

A 96-h ammonia reference toxicant test was also conducted to establish the expected response of the test organisms to concentrations of ammonia. The ammonia reference toxicant

test was conducted in the same manner as the SPP tests. *H. costata* were exposed to a seawater control plus 11 concentrations of ammonia (0.25, 0.5, 1, 2, 5, 10, 20, 40, 60, 80, and 100 mg/L as ammonium chloride). Actual ammonia measurements were determined for this experiment and are reported in Section 3.0 of this report. There were three replicates of each concentration.

2.4.6 48-Hour Suspended-Particulate-Phase Test with Larval *M. galloprovincialis*

Mussels were held in flowing, unfiltered Sequim Bay seawater at ambient temperatures for approximately five days. Chambers for the bivalve-larvae test were 500-mL glass jars, labeled with sediment treatment code, concentration, position number, and replicate number. Dilutions of SPP (0%, 10%, 50%, and 100%) were prepared with Sequim Bay seawater in a 2,000-mL graduated cylinder, then 300 mL of test solution was poured directly into each of five replicate test chambers. After all chambers reached testing temperatures (16°C±2°C), initial water quality parameters were measured in all replicates. Test chambers were placed in random positions on a water table and provided with gentle aeration.

Spawning was induced by placing adult *M. galloprovincialis* into 15°C, filtered Sequim Bay seawater and then rapidly raising the holding water temperature to 20°C. Spawning generally occurred within 1 h of temperature elevation. Spawning males and females were isolated in individual jars with filtered Sequim Bay seawater and allowed to shed gametes for approximately 45 min. Eggs from each female were then filtered into separate jars through a 75 µm Nytex screen to remove feces, detritus, and byssal fibers. Sperm from at least three males were pooled and 10 mL of sperm solution was then added to the individual egg stocks. Egg-sperm solutions were mixed every 10 min with a perforated plunger. Fertilization proceeded for 1 h, then the fertilization rate (percentage fertilized) was determined by removing a subsample and observing the number of multi-cell stage embryos. Fertilization was considered successful if greater than 90% of the embryos were in the multi-cell stage. To prevent polyspermy, egg stocks with greater than 90% fertilization were rinsed on a 20µm Nytex screen to remove excess sperm. Embryo stock-solution density was estimated by removing a 0.1 mL subsample and counting all multi-cell embryos, then multiplying by 10 to yield embryo density (embryos/mL). Stock solution was diluted or concentrated to yield 7500 to 9000 embryos/mL. The test was initiated by introducing 1 mL of stock solution into each test chamber to produce embryo densities of 25 to 30 embryos/mL. Test initiation date and time were recorded on data sheets. Following initiation, 10 mL stocking density subsamples were removed from each container and preserved in 10% formaldehyde to determine actual stocking density. Water quality parameters were measured in one replicate per treatment daily throughout the test. Acceptable ranges for water quality parameters were as follows:

DO	≥ 4.0 mg/L
Temperature	16°C ±2°C
pH	7.30 to 8.30
Salinity	30 ±2.0%
Ammonia	measured but presently not established.

The bivalve test was terminated after 48 h, when greater than 90% of the larvae in the controls had reached the D-cell stage (prodissoconch I). Final water quality parameters were recorded for all replicates. In addition, ammonia concentrations were measured in one replicate of all 0% SPP and 100% SPP treatments.

Each chamber was then homogenized with a perforated plunger, and a 10-mL subsample was removed and placed into 20-mL scintillation vial. The subsample was then fixed with 1 mL of 50% formaldehyde in seawater. Samples were scored for the appearance of normal D-shaped larvae (prodissoconch I), abnormal prodissoconch I larvae, developmentally delayed/developmentally delayed-abnormal larvae (categorized as "other" in Appendix J), and total number of larvae. At least 10% of the counts were confirmed by a second observer.

A 48-h Cu reference toxicant test was conducted with each batch of test larvae to establish the health and expected response of the test organisms. The reference toxicant test was set up and conducted in the same manner as the SPP tests. *M. galloprovincialis* larvae were exposed to a filtered Sequim Bay seawater control plus copper sulfate concentrations of 1 µg/L, 4 µg/L, 16 µg/L, and 64 µg/L as Cu, with three replicates per concentration. Because not all treatments could be tested concurrently, a separate reference test was performed with each round of tests to compare gamete sensitivity to a known toxicant.

A 48-h ammonia reference toxicant test was also conducted to establish the sensitivity of test organisms to ammonia. The ammonia reference toxicant test was conducted in the same manner as the SPP tests. *M. galloprovincialis* were exposed to a seawater control plus four concentrations of ammonia (1, 10, 20, 40, 80, and 100 mg/L as ammonium chloride). Actual ammonia concentrations were measured for this experiment and are reported in Section 3.0 of this report. There were three replicates of each concentration.

2.5 DATA ANALYSIS AND INTERPRETATION

The geologic characteristics, sediment chemistry, acute toxicity, and bioaccumulation potential of Richmond Harbor dredged material samples were compared with data from the analysis of the reference sediment R-OS. The geologic evaluations and sediment chemistry data are not analyzed statistically, but are presented in both graphical and tabular formats to assist with interpretation. These portray the differences in physical and chemical characteristics between the dredged material and the reference sediment R-OS.

2.5.1 Randomization

All solid-phase and SPP toxicity tests were designed as completely random tests using the discrete uniform random number generator in LOTUS 123 spreadsheet. Organisms were randomly allocated to treatments, and treatments were randomly positioned on water tables. Special care was taken with *C. stigmaeus* individuals in order to eliminate bias caused by variable mobility of the fish (otherwise, easily caught fish would be used earlier than more mobile fish).

2.5.2 Statistical Analysis of Solid-Phase Tests

Solid-phase acute toxicity data are compared only with data for one reference treatment, using a one-tailed Dunnett's test (Dunnett 1964) with an experiment-wise error rate α=0.05. This test identifies, with 95% confidence, test treatments with greater acute toxicity (mortality) than the reference. The Dunnett's test is the recommended statistical method to apply to assessment of dredged material for open-water disposal (EPA/USACE 1991). Dunnett's test approach is environmentally more conservative because it results in the identification of potentially a greater number of stations that are unacceptable for unconfined aquatic disposal. However, when Dunnett's test is applied to nonindependent data sets, there is increased probability of Type II statistical error (a chance that a difference between treatment and reference means will be identified as statistically significant when it is not). Dunnett's test results are used in conjunction with the criterion that mortality between test and reference treatments must be greater than 20% for a sediment to be considered acutely toxic.

2.5.3 Statistical Analysis of Suspended-Particulate-Phase Tests

Two statistical tests are presented in the *1991 Implementation Manual* for the interpretation of SPP tests. The first test is a one-sided t-test between survival in control replicates and survival in the 100% SPP replicates. This test is performed only when survival in the 100% SPP is less than control (0% SPP) survival and when control survival is greater than 90% (indicating test validity). Prior to conducting the t-test, angular transformation (arcsine of the square root) of the proportion surviving in test replicates is performed to reduce possible heterogeneity of variance between control and 100% SPP mean survivals. The second test required by the *1991 Implementation Manual* is an LC_{50} calculation, the concentration of SPP that is lethal to 50% of the individuals tested. The LC_{50} values for these tests were calculated using the Trimmed Spearman-Karber Method (Finney 1971). The Spearman Karber estimator is appropriate only if there is increasing mortality with increasing concentration and if 50% or greater mortality is observed in test solutions when normalized to control survival. If 50% mortality does not occur in the 100% SPP dilutions for any treatments, then LC_{50} values are reported as >100% SPP. The same method was used to calculate EC_{50} values (the concentration at which 50% of

the test individuals show a developmental effect) for the bivalve SPP test and LC_{50} values for all reference toxicant tests.

2.5.4 Statistical Analysis of Bioaccumulation

Before statistical analysis of *M. nasuta* and *N. virens* tissue concentrations, a visual inspection of the tissue chemistry data was performed. If visual inspection showed that a compound was undetected in the replicate samples in test treatments, or that the mean tissue concentration in the reference treatments was greater than that in the test treatments, no further analysis was performed. If the detected concentration of a compound for at least one replicate exceeded that of any reference treatment, statistical analysis was performed. In all cases, detection limits were used in numerical calculations when a compound was undetected.

Contaminant levels in tissues of *M. nasuta* and *N. virens* exposed to potential dredged material test treatments were compared with those exposed to sediment from the Deep Off-Shelf reference area. Like the solid-phase toxicity data, bioaccumulation data were statistically analyzed using Dunnett's test ($\alpha = 0.05$). In contrast to a multiple comparison test, the result of using the Dunnett's test is the identification of Type II errors, which detect a greater number of statistically significant differences between treatment and reference. Any statistically significant bioaccumulation was reported along with the magnitude of the difference between mean contaminant concentrations found in the test treatment tissues and the mean concentration found in the tissues exposed to the reference sediment R-OS.

2.6 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

The quality assurance/quality control (QA/QC) procedures followed for these studies were consistent with the *1991 Implementation Manual* and the EPA protocols (PSEP 1986). The procedures were documented by the PNL Quality Engineering Division in a QA plan (QAP). Data accumulation notebooks were assigned to each portion of the study and served as records of day-to-day activities during the research. All entries in the notebooks were signed, dated, and reviewed by both the project manager and the quality assurance engineer. The following discussion summarizes QA/QC procedures followed for the three main portions of this study: sediment sampling, biological testing, and chemical testing.

2.6.1 Sample Tracking and Storage

All sediment samples were accompanied by chain-of-custody forms from the time of collection to receipt at the MSL. After sample collection and compositing, a new set of custody forms was initiated for the sediment subsamples requiring chemical analyses. These accompanied the samples to the appropriate laboratory where the forms were signed and returned to the MSL project manager. Custody forms were also initiated for all tissue samples

upon completion of the biological testing. These forms accompanied the samples to the appropriate laboratory for chemical analyses.

All sediment collected for these studies was stored in glass, cellulose acetate butyrate containers, or steel drums lined with 9-C-4-A-phenolic epoxy, a noncontaminating coating. Sediment cores and grab samples were stored at 4°C prior to biological testing. Subsamples for chemical analyses were obtained prior to biological testing. These subsamples were stored frozen (except those for grain size analysis, which were held at 4°C) until chemical analyses were performed. Samples for organic analyses were stored frozen for up to 2 months (PSEP 1986). Samples for metals were freeze-dried upon receipt at the laboratory and held for up to 6 months (EPA/USACE 1991; PSEP 1986).

Tissue samples were frozen immediately upon completion of the bioaccumulation tests. Samples for organic analyses and metals were stored in precleaned glass jars with Teflon-lined lids and samples for metals analyses were stored in precleaned plastic jars. Prior to analyses, samples for organic analyses were held for up to 2 months.

2.6.2 Sediment and Tissue Chemistry Quality Control Procedures

Chemical testing procedures require that specific QA/QC protocols be followed. The QA/QC guidelines specific to this project are provided in the PNL Quality Assurance Division as a QAP. These guidelines include the following:

- analysis of a method blank with each batch of samples
- replicate analysis on at least 5% of the samples (triplicate analyses where possible) to assess analytical precision
- analysis of matrix spikes on 5% of the samples (where applicable) with appropriate compounds to assess accuracy
- analysis of SRMs at a frequency of 5%, if available for the analytes of interest and sample matrix
- archiving of all instrument printouts (e.g., raw data and chromatograms from AA and GC analyses) for future review.

In actual practice, some of the specific guidelines listed in the QAP for analytical precision and accuracy were modified to apply to the most current methods employed by laboratories. The guidelines for detection limits, range of recovery, and relative precision are listed in Table 2.1 for sediments and in Table 2.2 for tissues.

Measurements of accuracy can be determined by analyzing matrix spikes of known concentrations, as well as SRMs that have been certified for the presence of specific parameters. Matrix spikes were analyzed for organic parameters, including oil and grease, TPH, PAHs, pesticides, PCBs, metals, and butyltins. Spikes generally are made up of a subset of the

analytes of interest. Spike recoveries were calculated based on the difference between the amount spiked and the amount recovered in the sample, taking into account the amounts already present in the spiked sample. Spikes for organic compounds and metals were analyzed at a frequency of 5%. Surrogate compounds were added in known amounts to samples analyzed for PAHs, pesticides, PCBs, and butyltins. Surrogate compounds are added to samples prior to extraction, and their recoveries are a measurement of the efficiency or procedural accuracy of the analysis. Sediment SRMs were analyzed for metals and for organic compounds and metals. Tissue SRMs were analyzed for PAHs and metals. The SRMs for pesticide and PCBs in tissue were not available for this study. The SRMs are not associated with analysis of TOC, oil and grease, TPH, TVS, or grain size.

Measurements of precision were obtained through replicate analysis of selected sediment treatments. Analysis of replicates shows the precision or repeatability of the results. The measurement of precision is the industrial statistic "I," relative percentage of difference (RPD) for duplicate analyses, and the relative standard deviation (RSD) for triplicate analyses. The "I" statistic is defined as the absolute value of the difference between duplicate measurements, divided by the sum of the duplicates. The RPD is defined as the absolute value of the difference between two duplicate measurements, divided by the mean of the duplicates, multiplied by 100. The RSD is defined as the sample standard deviation divided by the mean, multiplied by 100. All instrument printouts and other raw data generated using the MSL's analytical instruments are filed at the MSL for future reference. Raw data generated by offsite analytical facilities are retained at those facilities, but can be made available for inspection.

2.6.3 Toxicological Testing Quality Control Procedures

Test organisms were handled carefully during collection and transfer to test containers. Organisms shipped to the MSL were gradually equilibrated to test conditions, and kept in their native sediment whenever possible. Animals were fed, if necessary, before biological testing. Information on the collecting and handling of each test species is included in Section 2.1.3.

Selection of species was consistent with the *1991 Implementation Manual* and involved the use of juvenile forms, burrowing invertebrates, deposit-feeding organisms, and a larval (planktonic) form. Representatives of all test organisms were taxonomically identified by qualified experts at the MSL before use in bioassays.

Water quality parameters were measured to ensure that acceptable experimental conditions were maintained during testing. Conditions consisted of a stable temperature (±2.0°C), minimum DO of 4.0 mg/L, and 16 h of light per day. Salinity and pH could vary within each test container using the following ranges: salinity ±2.0‰, and pH ±0.5 units. These limits and values are consistent with those outlined in the *1991 Implementation Manual*. Water quality instruments were calibrated according to the manufacturers' specification or PNL protocols.

3.0 RESULTS

3.1 SEDIMENT COLLECTION AND SAMPLE PREPARATION

Sediment samples were collected between January 28 and February 2, 1994, from selected field locations in Richmond Harbor. The reference sediment from Bay Farm Borrow Area, Alcatraz Environs Reference Area, and Deep Off-Shelf Reference Area were collected between January 24 and 26, 1994. Control sediment from Sequim Bay, West Beach, Tomales Bay, and New England were collected between February 1 and February 18, 1994. All sediment samples were stored in noncontaminating containers, epoxy-lined 5-gal buckets or seasoned coolers at approximately 4°C until ready for processing at the MSL. Richmond Harbor and reference sediment samples were shipped via refrigerated van to the MSL upon completion of the sampling effort. Core samples were geologically described at the laboratory before being homogenized into samples for sediment chemistry. Composites of the test, reference and control treatments were homogenized for sediment chemistry and biological toxicity testing. The SPP of each sediment composite was also prepared for biological testing.

3.1.1 Richmond Harbor Deepening Project Core Sampling

Sediment core samples were collected to -42 ft MLLW (-38 ft MLLW project depth plus 2 ft overdepth plus up to 2 ft of OBM) from a total of 20 stations in Richmond Harbor: 5 in the Upper Inner Harbor (UIH COMP), 4 in the Santa Fe Channel (SF COMP), 4 in the National Gypsum-GATX berths called Santa Fe Widening stations (SFW COMP), and 7 in the Turning Circle that were separated into upper and lower stations (TB Upper and TB Lower COMP). Stations containing OBM from -40 ft to -42 ft MLLW were subsampled to make an OBM composite. One 4-in. core and one 12-in. core were collected at each station as described in Section 2.1.1. Sampling information for 4-in.- and 12-in.- core samples is listed in Table 3.1. Station locations and compositing information are shown in Figure 3.1.

3.1.2 Reference and Control Sediment Sampling

Sampling information for reference and control sediment collection is presented in Table 3.2. The Deep Off-Shelf Reference Area is located approximately 50 nautical miles southwest of the Golden Gate Bridge (Figure 3.2), off the continental shelf, in about 3000 m of water. Sediment samples from this area were collected using a pipe dredge deployed from the *FV Cobra* as described in Section 2.1.2. The R-BF and R-AM sediments were also collected using the *FV Cobra*. The Bay Farm Borrow Area, located in San Francisco Bay (Figure 3.3), was sampled at four locations and the sediments were combined to form one R-BF composite, representative of this area.

TABLE 3.1. Sampling Information for Sediment Composites, Richmond Harbor Deepening Project (one 4-in. and one 12-in. core were collected at each station)

Station	California State Plane Coordinates (Zone III) North	East	Latitude (N)	Longitude (W)	Top of Core (-ft MLLW)	Core Required to -40 ft (ft)	Volume Contribution to COMP (gal)	
SF-1	521,738.32	1,462,203.74	37° 55' 05.618"	122° 21' 51.913"	38.5	1.5	5	to SF COMP
SF-2	522,057.12	1,461,809.50	37° 55' 08.691"	122° 21' 56.912"	37.8	2.2	7	to SF COMP
SF-3	522,387.11	1,461,406.62	37° 55' 11.874"	122° 22' 02.021"	37.0	3.0	9	to SF COMP
SF-4	522,712.99	1,461,015.29	37° 55' 15.018"	122° 22' 06.985"	35.9	4.1	13	to SF COMP
SFW-1	522,099.85	1,461,571.48	37° 55' 09.067"	122° 21' 59.892"	32.9	7.1	5	to SFW COMP
SFW-2	521,903.55	1,461,795.44	37° 55' 07.171"	122° 21' 57.049"	34.1	5.9	4	to SFW COMP
SFW-3	521,710.62	1,462,018.23	37° 55' 05.307"	122° 21' 54.221"	28.0	12.0	8	to SFW COMP
SFW-4	521,523.35	1,462,256.88	37° 55' 03.503"	122° 21' 51.197"	30.8	9.2	7	to SFW COMP
UIH-1	520,784.24	1,462,517.29	37° 54' 56.249"	122° 21' 47.764"	36.9	3.1	6	to UIH COMP
UIH-2	521,007.25	1,463,021.53	37° 54' 58.552"	122° 21' 41.528"	35.3	4.7	8.5	to UIH COMP
UIH-3	521,065.41	1,462,701.82	37° 54' 59.064"	122° 21' 45.532"	37.3	2.7	5	to UIH COMP
UIH-4	521,265.09	1,462,446.79	37° 55' 00.988"	122° 21' 48.763"	34.4	5.6	10	to UIH COMP
UIH-5	521,289.00	1,462,695.23	37° 55' 01.273"	122° 21' 45.669"	36.0	4.0	7	to UIH COMP
TB-1	515,998.97	1,463,059.03	37° 54' 09.054"	122° 21' 39.817"	30.2	5.0(a)	5	to Upper COMP
TB-2	515,872.52	1,463,413.44	37° 54' 07.873"	122° 21' 35.365"	5.2	5.0	5	to Upper COMP
TB-3	516,138.25	1,463,701.22	37° 54' 10.557"	122° 21' 31.841"	4.6	5.0	5	to Upper COMP
TB-4	516,410.09	1,463,489.51	37° 54' 13.202"	122° 21' 34.549"	28.3	5.0	5	to Upper COMP
TB-5	516,618.50	1,463,878.13	37° 54' 15.338"	122° 21' 29.753"	6.3	5.0	5	to Upper COMP
TB-6	516,685.17	1,463,510.37	37° 54' 15.925"	122° 21' 34.357"	30.9	5.0	5	to Upper COMP
TB-7	516,872.49	1,463,674.47	37° 54' 17.809"	122° 21' 32.357"	8.6	5.0	5	to Upper COMP
TB-1	515,998.97	1,463,059.03	37° 54' 09.054"	122° 21' 39.817"	35.2	4.2	3	to Lower COMP
TB-2	515,872.52	1,463,413.44	37° 54' 07.873"	122° 21' 85.365"	10.2	29.8	15	to Lower COMP
TB-3	516,138.25	1,463,701.22	37° 54' 10.557"	122° 21' 31.841"	9.6	30.4	15	to Lower COMP
TB-4	516,410.09	1,463,489.51	37° 54' 13.202"	122° 21' 34.549"	33.3	6.7	4	to Lower COMP
TB-5	516,618.50	1,463,878.13	37° 54' 15.338"	122° 21' 29.753"	11.3	28.7	14	to Lower COMP
TB-6	516,685.17	1,463,510.37	37° 54' 15.925"	122° 21' 34.357"	35.9	4.1	2	to Lower COMP
TB-7	516,872.49	1,463,674.47	37° 54' 17.809"	122° 21' 32.357"	13.6	26.4	13	to Lower COMP

(a) TB Upper COMP was representative of TB stations from mudline to 5 ft below mudline.

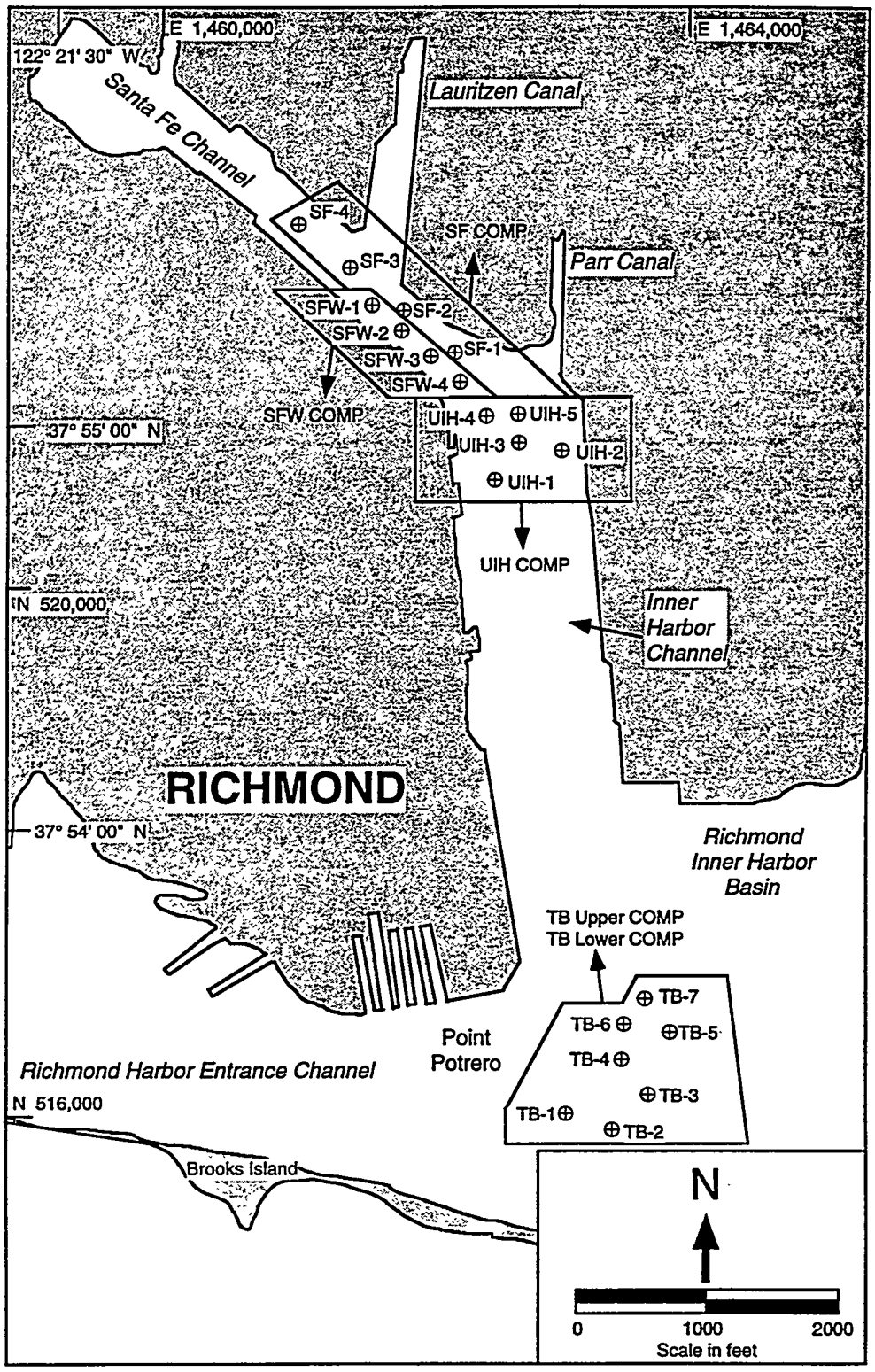


FIGURE 3.1. Sampling Stations and Compositing Scheme for the Richmond Harbor Deepening Project

TABLE 3.2. Reference and Control Sediment Sampling Data

Reference Area	Station	Station Location		Depth (ft)	Volume (gal)
		Latitude (N)	Longitude (W)		
Bay Farm	R-BF 2	37°44.60'	122°16.75'	20	10
	R-BF 3	37°44.34'	122°16.75'	31	10
	R-BF 4	37°44.38'	122°16.60'	31	10
	R-BF 5	37°44.50'	122°16.60'	32	10
	TOTAL R-BF				40
Alcatraz Environs	R-AM A	37°49.75'	122°25.88'	65	5
	R-AM B	37°49.75'	122°25.57'	71	5
	R-AM C	37°49.75'	122°24.90'	58	5
	R-AM D	37°49.27'	122°25.88'	61	5
	R-AM F	37°49.27'	122°24.90'	85	5
	R-AM G	37°48.83'	122°25.88'	59	5
	R-AM H	37°48.83'	122°25.57'	46	5
	R-AM I	37°48.78'	122°24.95'	50	5
	TOTAL R-AM				40
Deep Off-Shelf Area	R-OS	37°24.71'	123°14.74'	4000	40
Sequim Bay Control	C-SB	48°03.70'	123°01.50'	25-30	50
Tomales Bay Control	C-NE	38°13.83'	122°57.67'	intertidal	40
West Beach Control	C-WB	48°23.83'	122°40.00'	15-20	10
New England Control	C-NV	ND(a)	ND	ND	5

(a) ND Not Determined.

The Alcatraz Environs Reference Area surrounding Alcatraz Island (Figure 3.4) consisted of eight field locations that were individually sampled for sediment chemistry parameters and then composited to form one R-AM test treatment, representative of the area. This composite was also sampled for sediment chemistry. Four control sediments for use in solid-phase toxicity tests were collected from Sequim Bay (Figure 3.5), West Beach (Figure 3.6), Tomales Bay (Figure 3.7), and New England, as described in Section 2.1.2. Sequim Bay sediment (C-SB) was used in all solid-phase tests as an experimental control as well as for the native control for the clam, *M. nasuta*. West Beach control sediment (C-WB) was used as the native control for the amphipod, *R. abronius*. Tomales Bay is the source of native sediment for the polychaete, *N. caecoides*, and was used in the 10-day toxicity test. Native sediment for the polychaete, *N. virens*, was collected from a site in Maine for use in the *N. virens* 28-day bioaccumulation test.

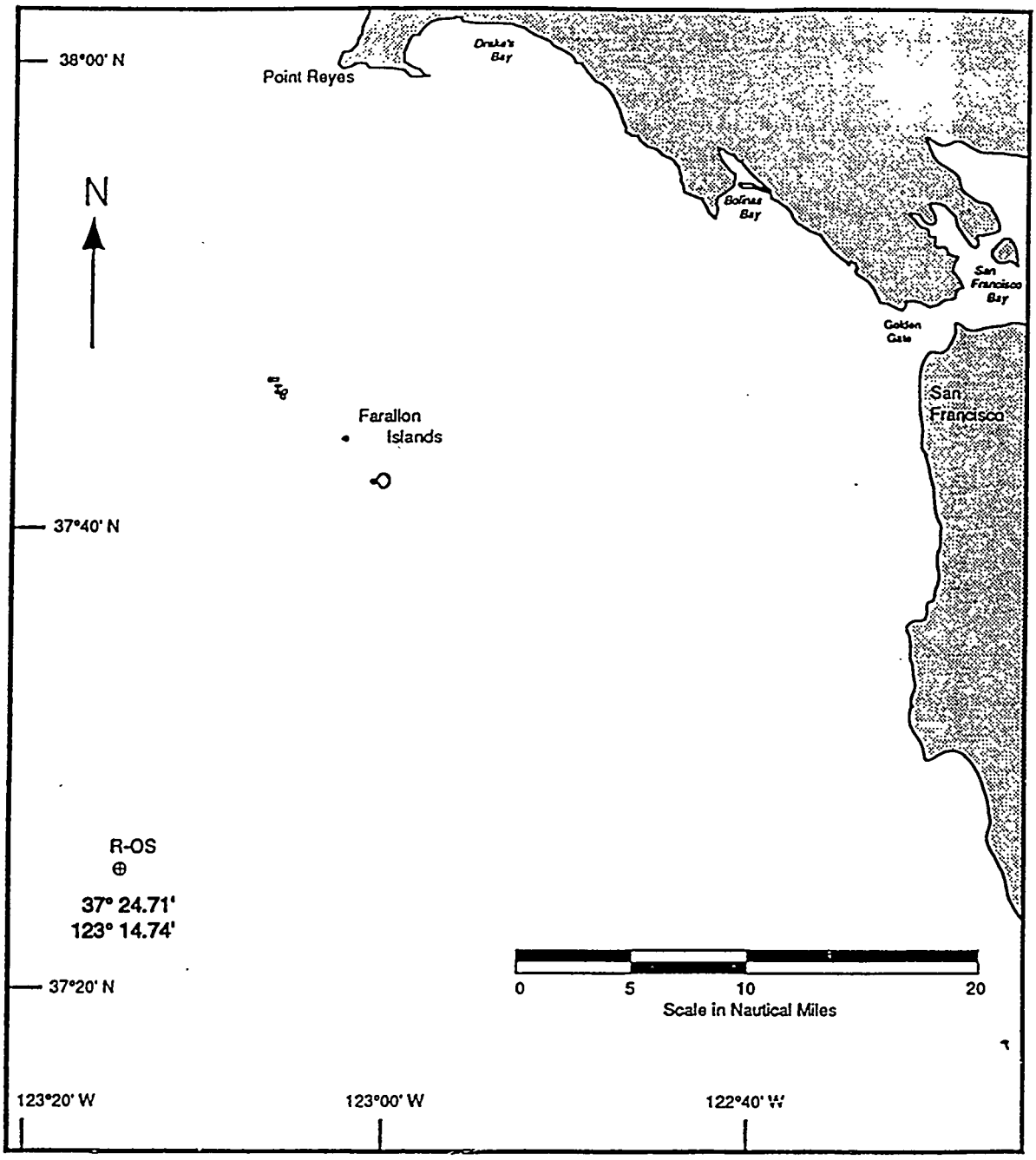


FIGURE 3.2. Location of Deep Off-Shelf Reference Area (R-OS)

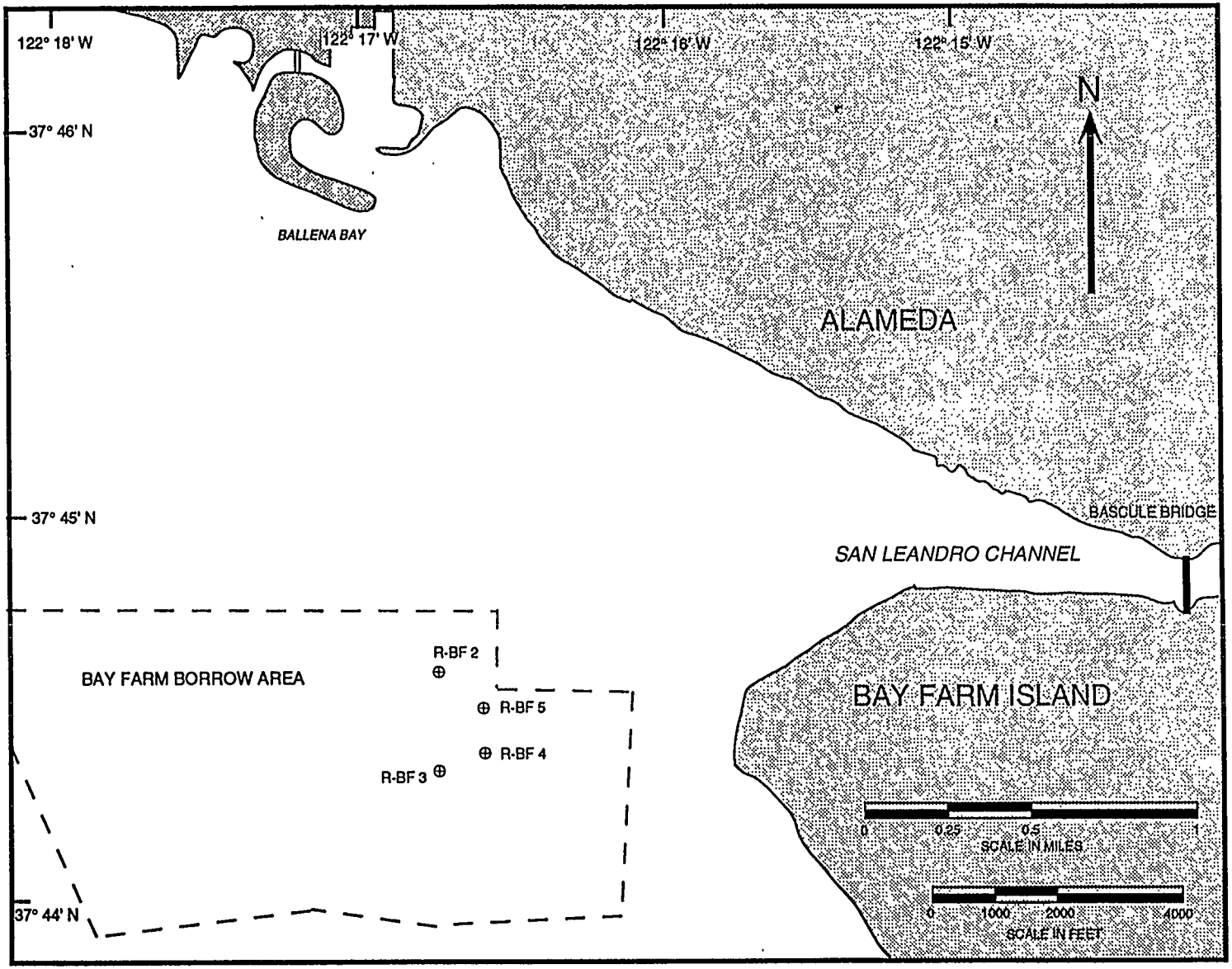


FIGURE 3.3. Location of Bay Farm Reference Area (R-BF)

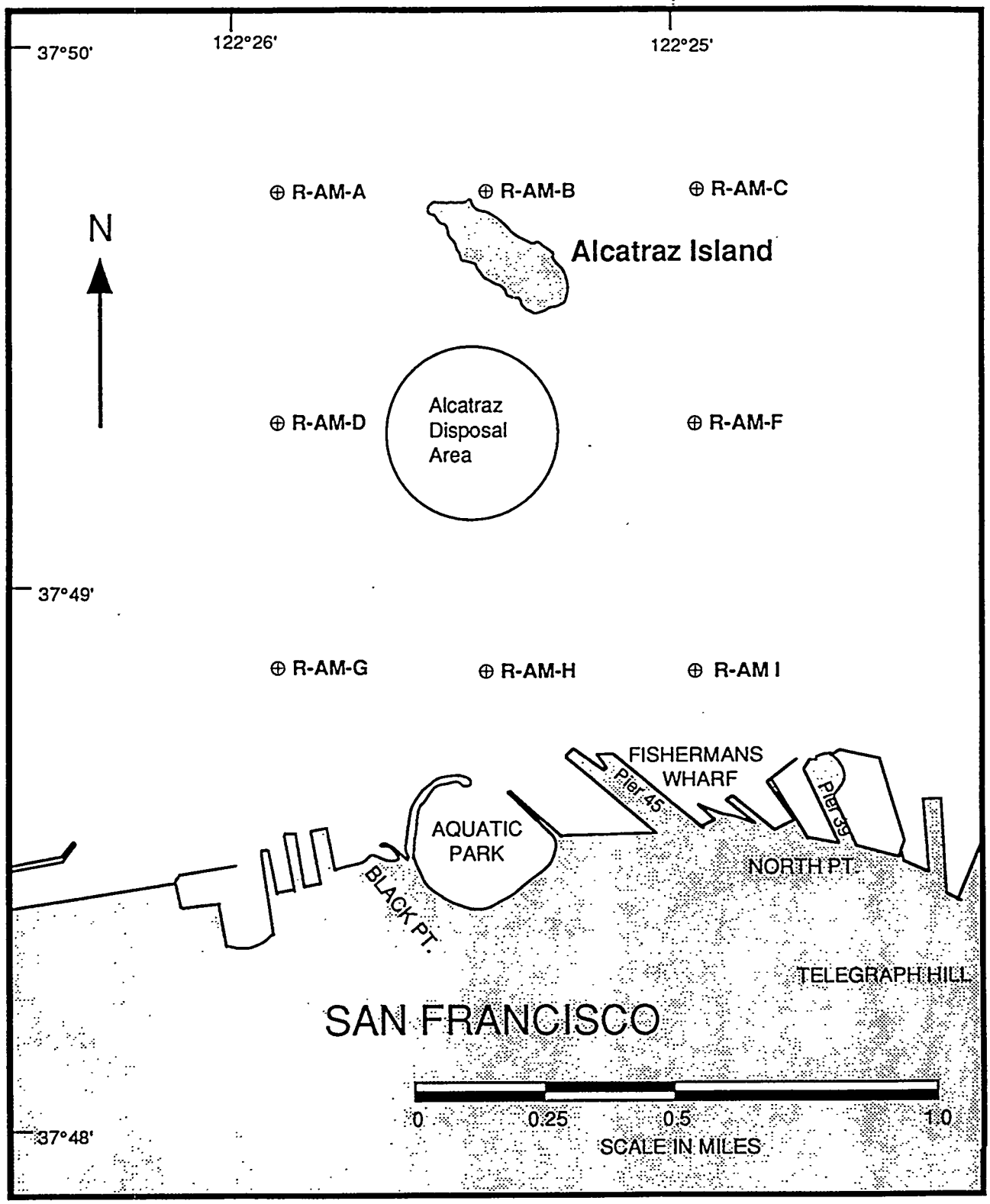


FIGURE 3.4. Location of Alcatraz Environs Reference Area (R-AM)

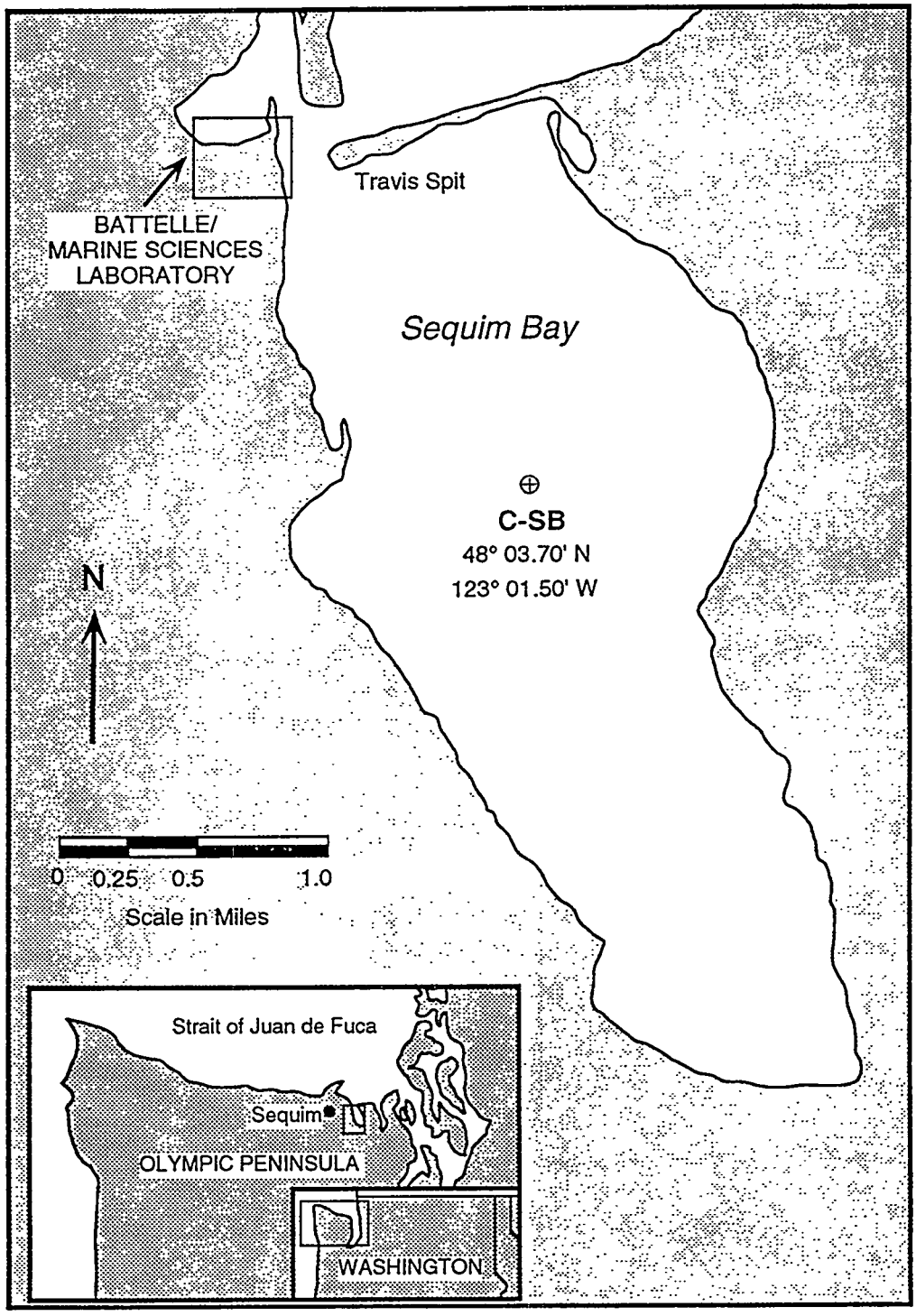


FIGURE 3.5. Location of *M. nasuta* Control (C-SB), Sequim Bay, Washington

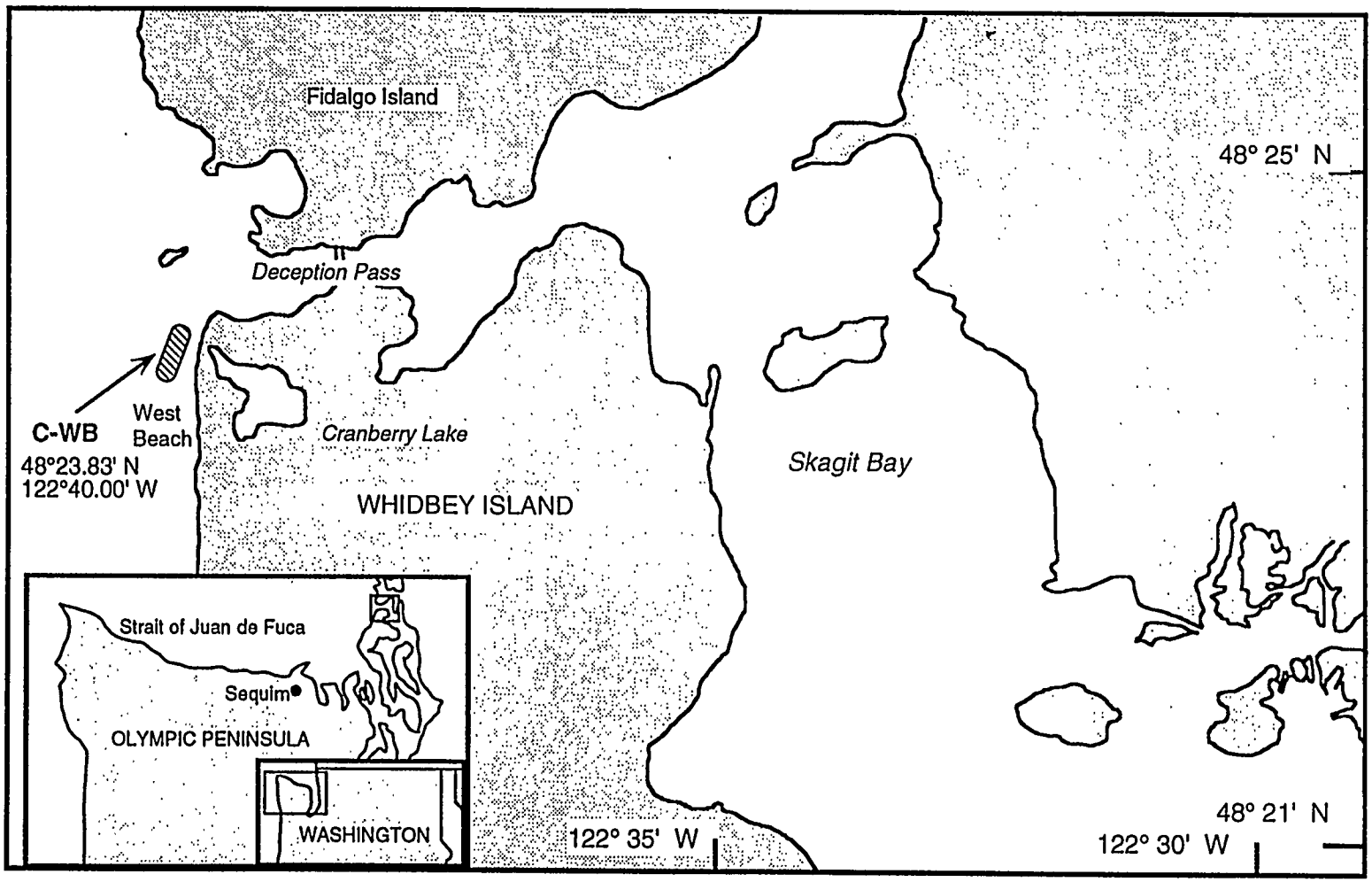


FIGURE 3.6. Location of *R. abronius* Control (C-WB), West Beach, Whidbey Island, Washington

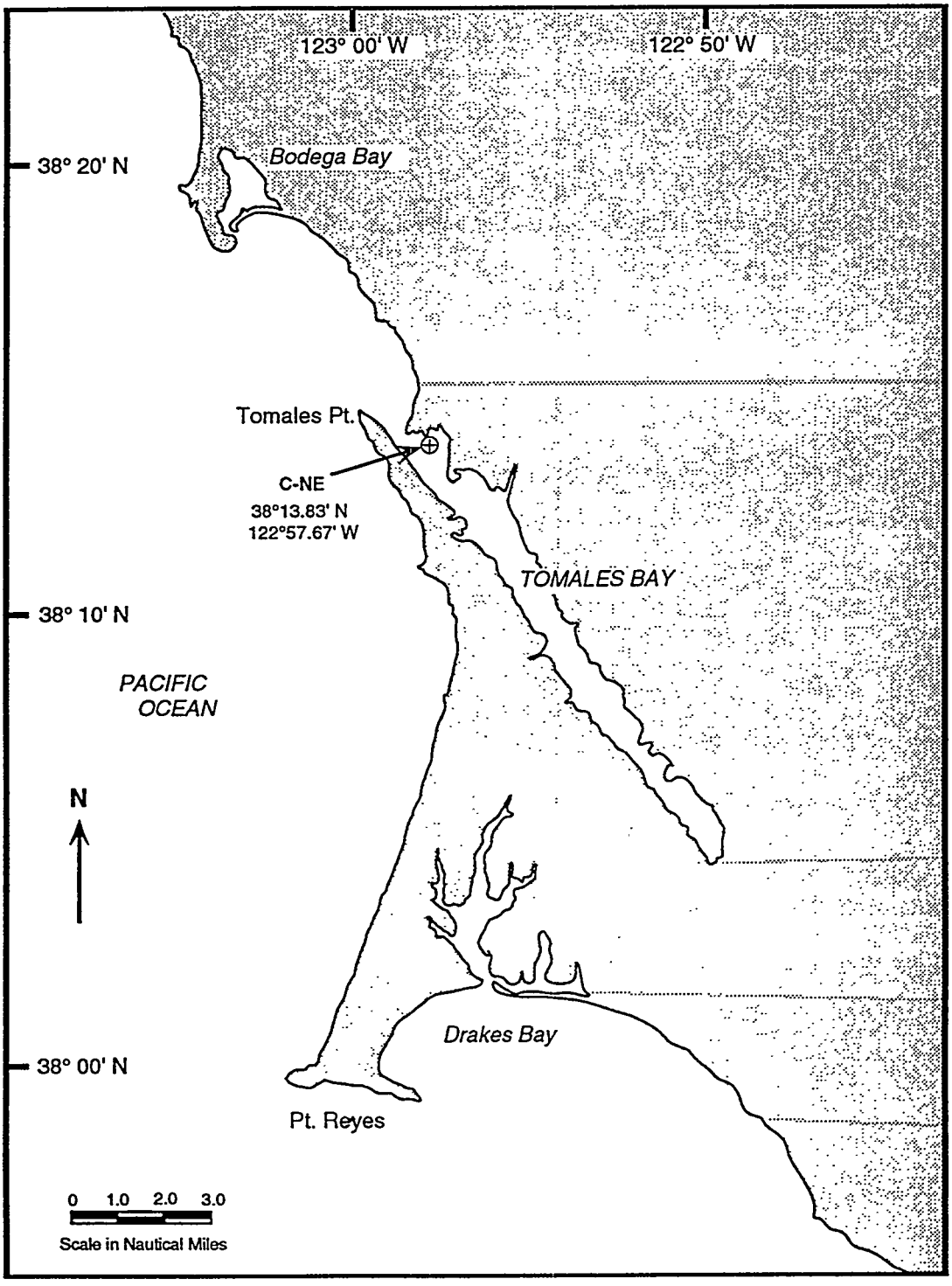


FIGURE 3.7. Location of *N. caecoides* Control (C-NE), Tomales Bay, California

3.1.3 Sample Preparation

Richmond Harbor sediment composites, 4-in. cores, reference sediments, and control sediments were processed as soon as they were received at the MSL. The composites, consisting of the material between the mudline and -40 ft MLLW from each contributing station for a total of approximately 30 gal of sediment, were thoroughly homogenized before biological and chemical testing. The 4-in. cores were described by a geologist (Section 2.2.2) before the sediment between the mudline and -40 ft MLLW was removed and homogenized for sediment chemistry. Reference and control sediments were press-sieved through 0.5- or 1.0-mm mesh to remove organisms, and then were thoroughly homogenized before testing. Table 3.3 summarizes the chemical and biological testing strategy for all Richmond Harbor samples.

3.2 GEOLOGIC DESCRIPTION

In this section, the characteristics of the marine sediments in Richmond Harbor are described based on the 4-in. cores collected during the field study. The cores were logged according to ASTM Procedure D2488-84 (ASTM 1984). Sediment characteristics described are dilatancy of silt/clay, toughness of silt/clay, plasticity of silt/clay, sediment type (i.e. engineering classification), color, consistency (i.e. firmness), cementation, sedimentary structure, reaction with hydrochloric acid, maximum particle size and odor. In addition, other features such as root traces, mollusk shells, or other detritus were noted. A detailed description of the materials and methods used for describing the cores is provided in Appendix A.

Marine sediment throughout Inner Richmond Harbor consists of two geologic units: the younger bay mud (YBM) and the underlying OBM (Goldman 1969). The YBM is typically composed of black or dark gray, very soft to soft clay, silt, and fine-grained sand with a high water content. The YBM has been accumulating in an estuarine environment since the last retreat of glacial ice (from about 15,000 to 18,000 years ago). The YBM is up to 130 ft thick in San Francisco Bay (Goldman 1969). The underlying OBM consists of relatively dry, firm to hard silts and clays with variable amounts of sand. The marine portions of the OBM are finer-grained and generally olive or gray in color. It is believed that the OBM was deposited in shallow marine and terrestrial environments during the interglacial epoch immediately preceding the formation of the Wisconsin ice sheet, and was exposed and subjected to erosion during the first Wisconsonian glacial advance (Goldman 1969). While exposed, the OBM sediments desiccated and consolidated. The OBM is up to 200 ft thick, and appears to be about 50 ft thick in the Richmond area. The OBM in Richmond Harbor is underlain by interbedded sandstone and shale bedrock of the Franciscan Formation, which outcrops at Point Potrero (Helley and Lajoie 1979).

TABLE 3.3. Sediment Samples and Testing Strategy, Richmond Harbor Deepening Project

Sediment Treatment	Core Size (in.)	Vertical Segment	Mudline (-ft MLLW)	Sediment Chemistry	SPP Testing	Solid-Phase Testing	Bioaccumulation Testing
SF COMP	**12**	**Mudline to -40 ft MLLW[a]**	**NA[b]**	**YES**	**YES**	**YES**	**YES**
SF-1	4	Mudline to -40 ft MLLW	38.5	YES	NO	NO	NO
SF-2	4	Mudline to -40 ft MLLW	37.8	YES	NO	NO	NO
SF-3	4	Mudline to -40 ft MLLW	37.0	YES	NO	NO	NO
SF-4	4	Mudline to -40 ft MLLW	35.9	YES	NO	NO	NO
SFW COMP	**12**	**Mudline to -40 ft MLLW**	**NA**	**YES**	**YES**	**YES**	**YES**
SFW-1	4	Mudline to -40 ft MLLW	32.9	YES	NO	NO	NO
SFW-2	4	Mudline to -40 ft MLLW	34.1	YES	NO	NO	NO
SFW-3	4	Mudline to -40 ft MLLW	28.0	YES	NO	NO	NO
SFW-4	4	Mudline to -40 ft MLLW	30.8	YES	NO	NO	NO
UIH COMP	**12**	**Mudline to -40 ft MLLW**	**NA**	**YES**	**YES**	**YES**	**YES**
UIH-1	4	Mudline to -40 ft MLLW	36.9	YES	NO	NO	NO
UIH-2	4	Mudline to -40 ft MLLW	35.3	YES	NO	NO	NO
UIH-3	4	Mudline to -40 ft MLLW	37.3	YES	NO	NO	NO
UIH-4	4	Mudline to -40 ft MLLW	34.4	YES	NO	NO	NO
UIH-5	4	Mudline to -40 ft MLLW	36.0	YES	NO	NO	NO
TB Upper COMP	**12**	**Mudline to 5 ft below mudline**	**NA**	**YES**	**YES**	**YES**	**YES**
TB-1 Upper	4	Mudline to 5 ft below mudline	30.2	YES	NO	NO	NO
TB-2 Upper	4	Mudline to 5 ft below mudline	5.2	YES	NO	NO	NO
TB-3 Upper	4	Mudline to 5 ft below mudline	4.6	YES	NO	NO	NO
TB-4 Upper	4	Mudline to 5 ft below mudline	28.3	YES	NO	NO	NO
TB-5 Upper	4	Mudline to 5 ft below mudline	6.3	YES	NO	NO	NO
TB-6 Upper	4	Mudline to 5 ft below mudline	29.5	YES	NO	NO	NO
TB-7 Upper	4	Mudline to 5 ft below mudline	8.6	YES	NO	NO	NO
TB Lower COMP	**12**	**5 ft below mudline to -40 ft MLLW**	**NA**	**YES**	**YES**	**YES**	**YES**
TB-1 Lower	4	35.2 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-2 Lower	4	10.2 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-3 Lower	4	9.6 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-4 Lower	4	33.3 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-5 Lower	4	11.3 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-6 Lower	4	35.9 ft to -40 ft MLLW	NA	YES	NO	NO	NO
TB-7 Lower	4	13.6 ft to -40 ft MLLW	NA	YES	NO	NO	NO
OBM COMP	**12**	**-40 ft to -42 ft MLLW**	**NA**	**YES**	**YES**	**YES**	**YES**
R-OS	grab	NA	NA	YES	NO	YES	YES
R-BF	grab	NA	NA	YES	NO	YES	YES
R-AM	grab	NA	NA	YES	NO	YES	YES
C-SB	grab	NA	NA	NO	NO	YES	YES
C-NE	grab	NA	NA	NO	NO	YES	YES
C-WB	grab	NA	NA	NO	NO	YES	NO

(a) Composited samples consisted of equal percentages of core (i.e. 20% of core volume) from mudline to -40 ft MLLW.
(b) NA Not applicable.

The Santa Fe and Inner Harbor Channels have been dredged to a maintenance depth of -35 ft MLLW. The proposed turning basin east of Point Potrero has never been dredged. The characteristics of the YBM and OBM in the Santa Fe Channel, upper Inner Harbor Channel, and proposed turning basin are described below.

3.2.1 Santa Fe and Inner Harbor Channels

Eight cores were collected from the Santa Fe Channel: four from the center (SF-1 through SF-4), and four along the southern edge of the channel (SFW-1 through SFW-4). Five cores were collected from the Inner Harbor Channel (UIH-1 through UIH-5). Core locations are shown in Figure 3.1. Geologic cross-sections of the Santa Fe Channel and Upper Inner Harbor Channel are presented in Figure 3.8. The elevation of the YBM/OBM contact was approximately -40 ft MLLW in the center of the channels, and as shallow as -35.2 ft MLLW along the southern edge of the Santa Fe Channel (SFW-3). The contact probably represents the dredged surface of the OBM, and the YBM in the channels has accumulated since dredging began. The YBM ranged in thickness from 0.7 ft (SF-1) to 7.2 ft (SFW-3). The YBM consisted of very dark gray to black, very soft to soft silty clay with few mussel shells and wood fibers. The OBM was olive gray or brown where present above -40 ft MLLW (Stations SFW-1, SFW-3, and SFW-4). A 2-ft thick layer of well-graded, very coarse sand was present at the top of the OBM at SFW-1.

3.2.2 Proposed Turning Basin

Seven cores were collected in the proposed turning basin east of Point Potrero (TB-1 through TB-7). Core locations are shown in Figure 3.1. Geologic cross-sections of the turning basin are presented in Figure 3.9. The YBM was much thicker in the proposed turning basin than in the Richmond Harbor channels, ranging from 2.2 ft to greater than 35.5 ft. The OBM was encountered at only one station in the turning basin (TB-1). The YBM was composed primarily of dark gray, very soft to soft clay. The clay commonly contained whole and fragmented clam shells (*Macoma sp.*). Gas holes and a sulfur smell were common in the sediment, probably as a result of decomposing organic matter. A layer of shell hash 2 ft thick was found from about 4 ft to 6 ft below the mudline at stations TB-2 and TB-3. A layer of clayey sand with rounded pebbles was found approximately 25 ft below the mudline at stations TB-2, TB-3, TB-5, and TB-7. Vertical root traces were found in the uppermost 3 ft of YBM at Station TB-6. Because this area has never been dredged, some of these sediments may have been deposited in preindustrial times.

The OBM at Station TB-1 consisted of firm to hard interbedded clayey gravel and silt. The OBM sediments were olive gray, olive, or olive brown in color. The pebbles in the gravel were well-rounded and up to 1.5 in.

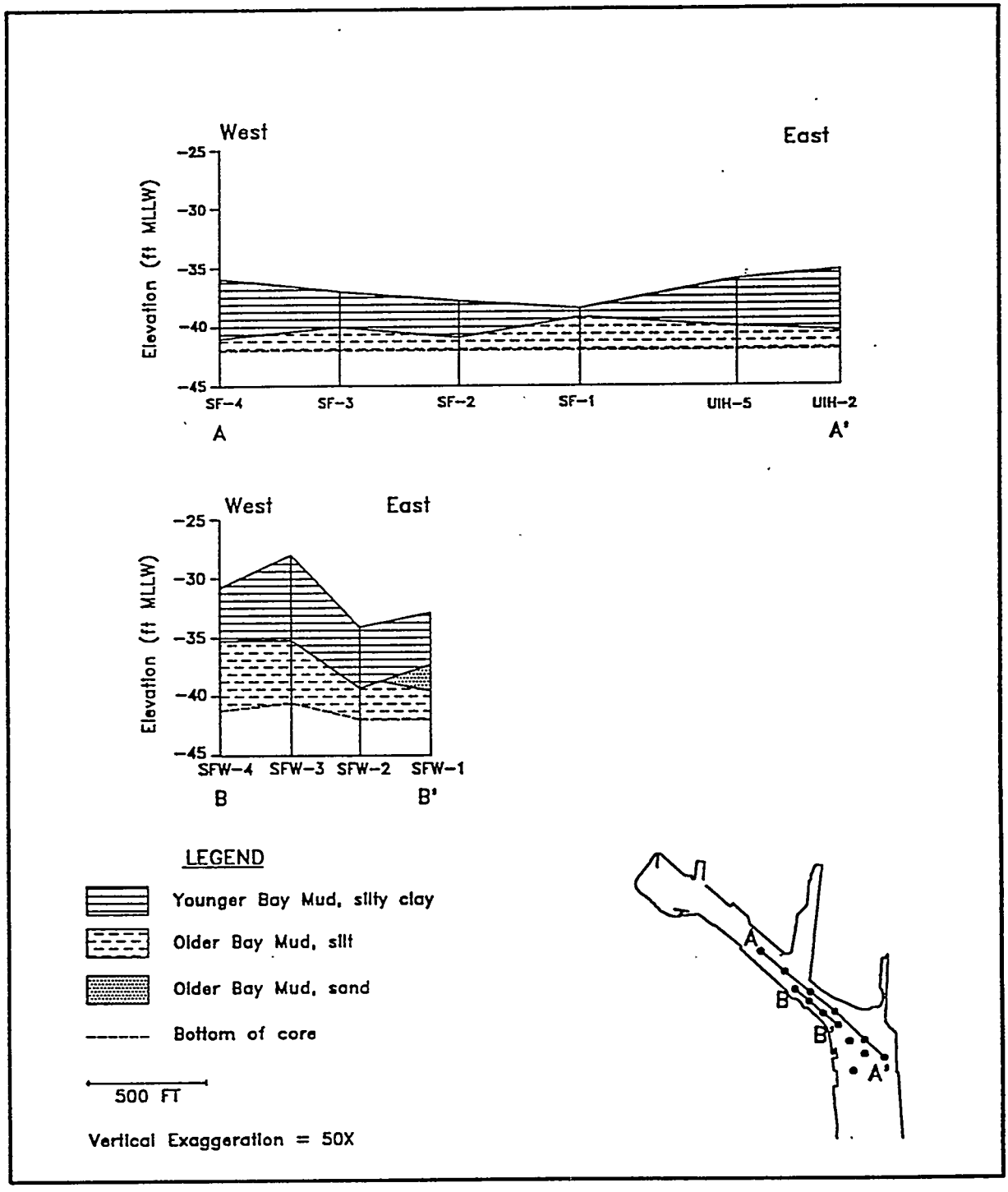


FIGURE 3.8. Geologic Cross-Sections of the Santa Fe Channel and Upper Inner Harbor Channel of Richmond Harbor

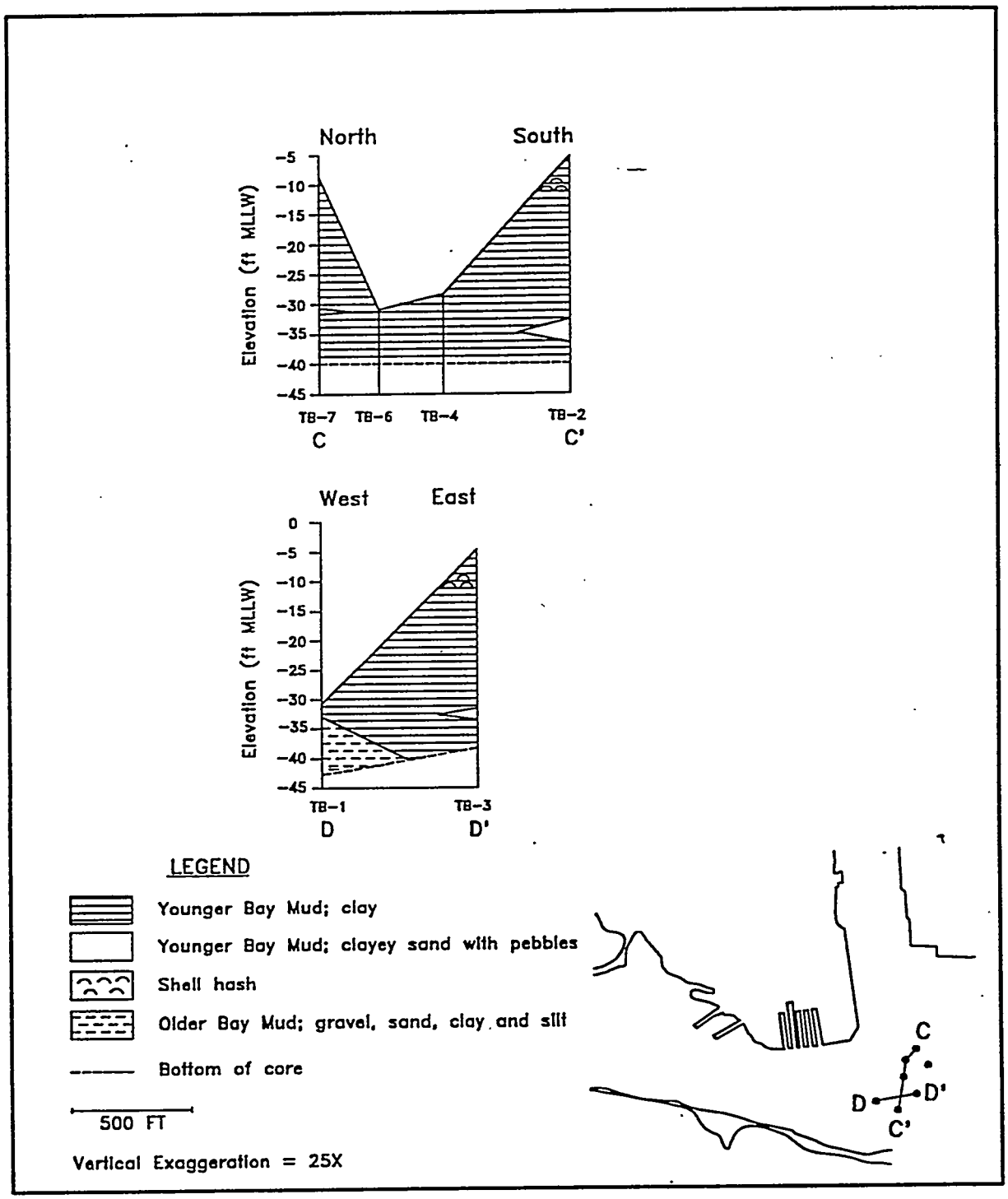


FIGURE 3.9. Geologic Cross-Sections of the Turning Basin in Richmond Harbor

3.3 SEDIMENT CHEMISTRY

3.3.1 Sediment Conventional Measurements

Sediment conventional measurements are grain size,TOC, TVS, oil and grease, and TPH. Grain size, TOC, and TVS are expressed as percentage of dry weight of the sample. Oil and grease and TPH concentrations are expressed as mg/kg dry weight. A summary of the Richmond Harbor Deepening Project conventional measurements is presented in Table 3.4. The complete results, including quality assurance/quality control summaries and results, are presented in Appendix C, Tables C.1 through C.7. The conventional parameters are also depicted graphically for all sediment treatments in Figures 3.10 to 3.14. The OBM COMP was analyzed for PAHs, pesticides, PCBs and butyltins. The results of these analyses are reported in the appropriate sections.

The Richmond Harbor test treatments were predominantly fine-grained, with 45% to 98% of the sediment in the silt and clay categories. Only two treatments, TB-1 Upper and TB-1 Lower, had greater percentage of gravel and sand. The reference sediment R-OS was also fine-grained (66% silt and clay).

Percentages of TOC in the test treatments ranged from 0.05% in TB-1 Lower to 1.37% in SF-4. Typically, the reference sediment R-OS (1.35%) and R-BF (1.24%) had among the highest percentages of TOC of any sediments analyzed during this project. Only the sediment from SF-4 (1.37%) had a higher TOC content than that of R-OS. The higher percentages of TOC were associated with the fine-grained sediments. All sediment treatments with TOC percentages ≥1.0% were predominantly silt and clay. The percentages of TVS ranged from 1.73% in TB-1 Lower to 3.25% to TB-2 Upper in the test treatments. Thirteen of the test sediments had TVS values greater than that of R-OS (2.49%).

Oil and grease concentrations were detected in most test treatments and ranged from 27 mg/kg in SFW-4 to 232 mg/kg in SFW COMP. The concentrations in 18 of the test treatments were higher than in R-OS sediments (39 mg/kg). The detected TPH concentrations ranged from 32 mg/kg in TB-6 Upper to 104 mg/kg in SFW COMP. The TPH concentration was undetected in R-OS sediments. The TPH concentrations followed a pattern similar to that of the oil and grease concentrations. Those stations with the higher oil and grease values also had the highest TPH values. The fractional percentage of TPH to the oil and grease total ranged from 34% to 87%, indicating that most of the oil and grease present in these sediments can be attributed to petroleum sources. Sediment from stations in the Santa Fe channel (SF-3, SF-4, SFW-2, SFW-3, and SFW COMP) and Upper Inner Harbor (UIH COMP, UIH-4, and UIH-5) contain relatively more TPH than predicted based on the concentrations of oil and grease in the samples. This relationship is illustrated in Figure 3.15.

TABLE 3.4. Conventional Sediment Measurement Results for the Richmond Harbor Deepening Project Sediment Treatments

Sediment Treatment	Percent Dry Weight: Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	mg/kg Dry Weight: Oil and Grease	TPH
R-OS	0	34	45	21	1.35	2.49	39	29 U[a]
SF COMP	1	29	35	35	0.71	2.32	29 U	29 U
SF-1	1	29	42	28	0.33	2.27	36	23 U
SF-2	6	18	34	42	0.98	2.62	66	34
SF-3	0	9	32	59	1.27[b]	2.67	136	67
SF-4	0	5	32	63	1.37	2.70	98	57
SFW COMP	5	23	37	35	0.76[b]	2.26	102 [b]	68 [b]
SFW COMP[c]	NA[d]	NA	NA	NA	NA	NA	232	104
SFW-1	13	35	21	31	1.00	2.21	44	35
SFW-2	8	15	35	42	1.09	2.84	79	69
SFW-3	2	18	47	33	0.49	2.32	117	84
SFW-4	3	27	45	25	0.32	2.01	27	22 U
UIH COMP	0	6	33	61	1.23	2.69	91	65
UIH-1	0	5	35	60	1.17	2.80	204	75
UIH-2	0	2	33	65	1.20	2.73	97	38 U
UIH-3	0	7	35	58	1.12	2.81	80	34 U
UIH-4	1	13	35	51	0.87	2.83	142	72
UIH-5	0	7	39	54	0.97	2.74	139	70
TB Upper COMP	8	14	45	33	0.85	2.48	47	30 U
TB-1 Upper	22	33	24	21	0.50	2.45	36	23 U
TB-2 Upper	5	20	41	34	0.73	3.25	36	25 U
TB-3 Upper	1	13	48	38	0.78	2.47	28 U	28 U
TB-4 Upper	0	3	46	51	1.09	2.63	169	57
TB-5 Upper	1	7	58	34	0.79	2.44	26 U	26 U
TB-6 Upper	0	3	49	48	0.66	2.43	83	32
TB-7 Upper	0	5	66	29	0.63	2.38	29 [b]	25 U[b]
TB-7 Upper[c]	NA	NA	NA	NA	NA	NA	20 U	20 U
TB Lower COMP	3[b]	15[b]	46[b]	36[b]	0.69	2.15	35	26 U
TB-1 Lower	9	53	23	15	0.05	1.73	19 U	19 U
TB-2 Lower	1	23	43	33	0.62	2.08	29	24 U
TB-3 Lower	0[b]	13[b]	52[b]	36[b]	0.70	2.21	30	25 U
TB-4 Lower	0	4	47	49	0.93	2.88	58	30 U
TB-5 Lower	0	12	55	33	0.70	2.27	25 U	25 U
TB-6 Lower	0[b]	7[b]	50[b]	43[b]	0.55	2.27	26 U	26 U
TB-7 Lower	1	3	55	41	0.72	2.43	26 U	26 U

(a) U Undetected at or above the detection limit.
(b) Value is mean of replicate analysis.
(c) Sample reanalyzed approximately one month after original oil and grease and TPH analysis to provide appropriate matrix spike data.
(d) NA Not applicable.

FIGURE 3.10. Grain Size Distribution in Sediment Treatments

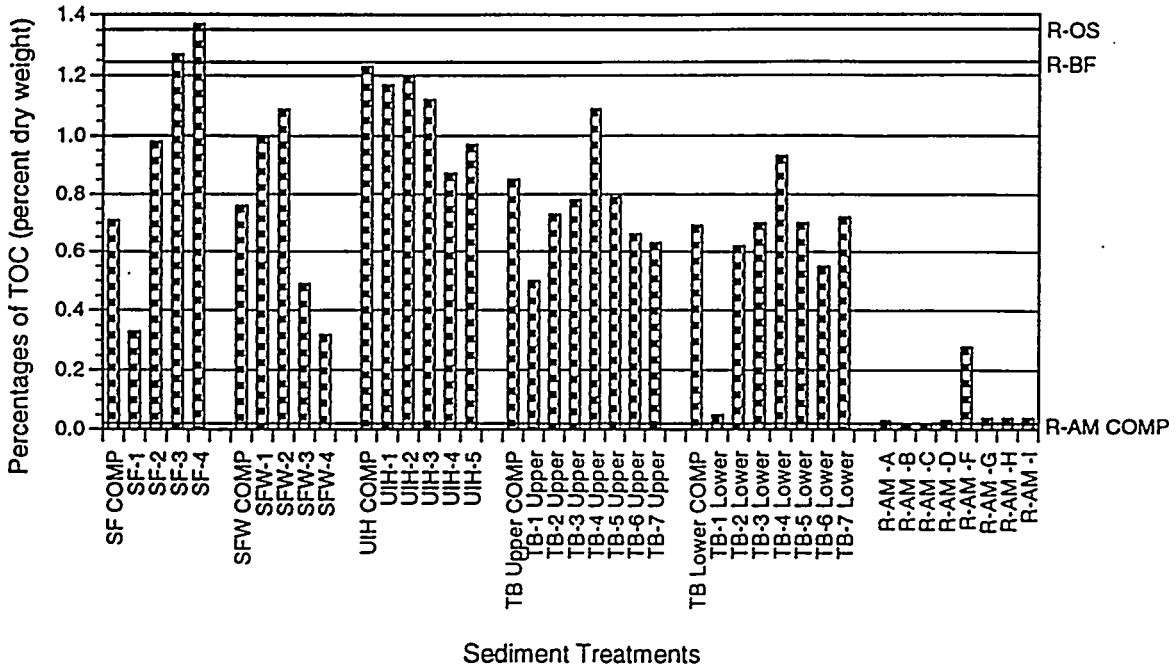


FIGURE 3.11. Percentages of TOC in Sediment Treatments

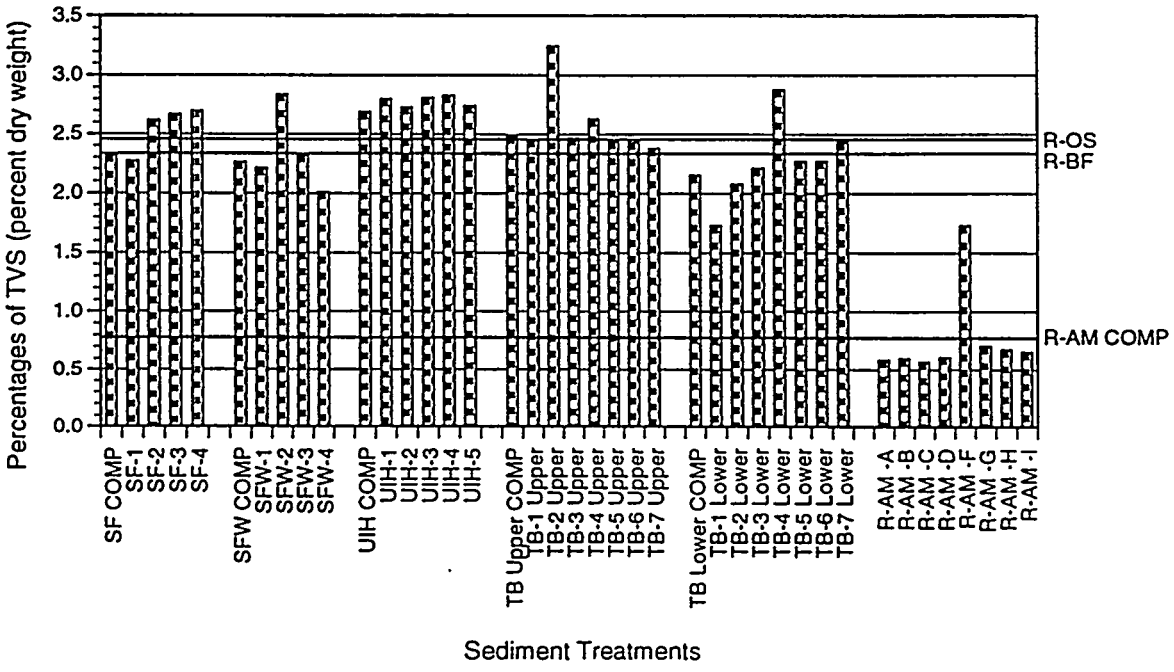


FIGURE 3.12. Percentages of TVS in Sediment Treatments

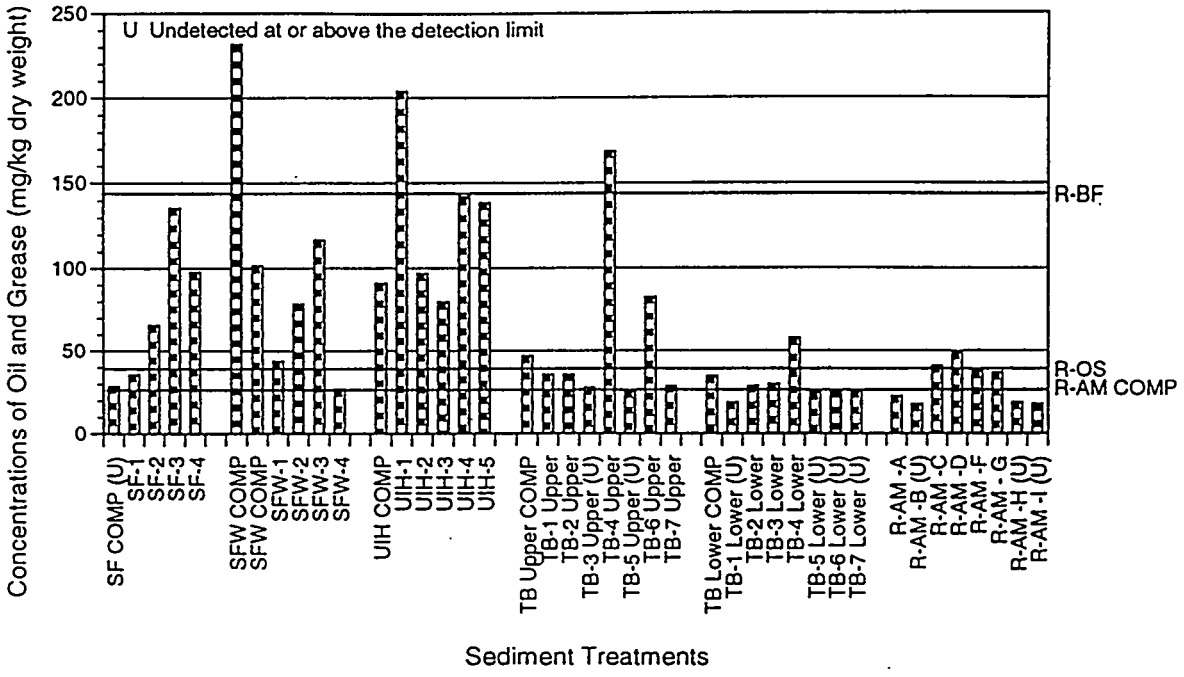


FIGURE 3.13. Concentrations of Oil and Grease in Sediment Treatments

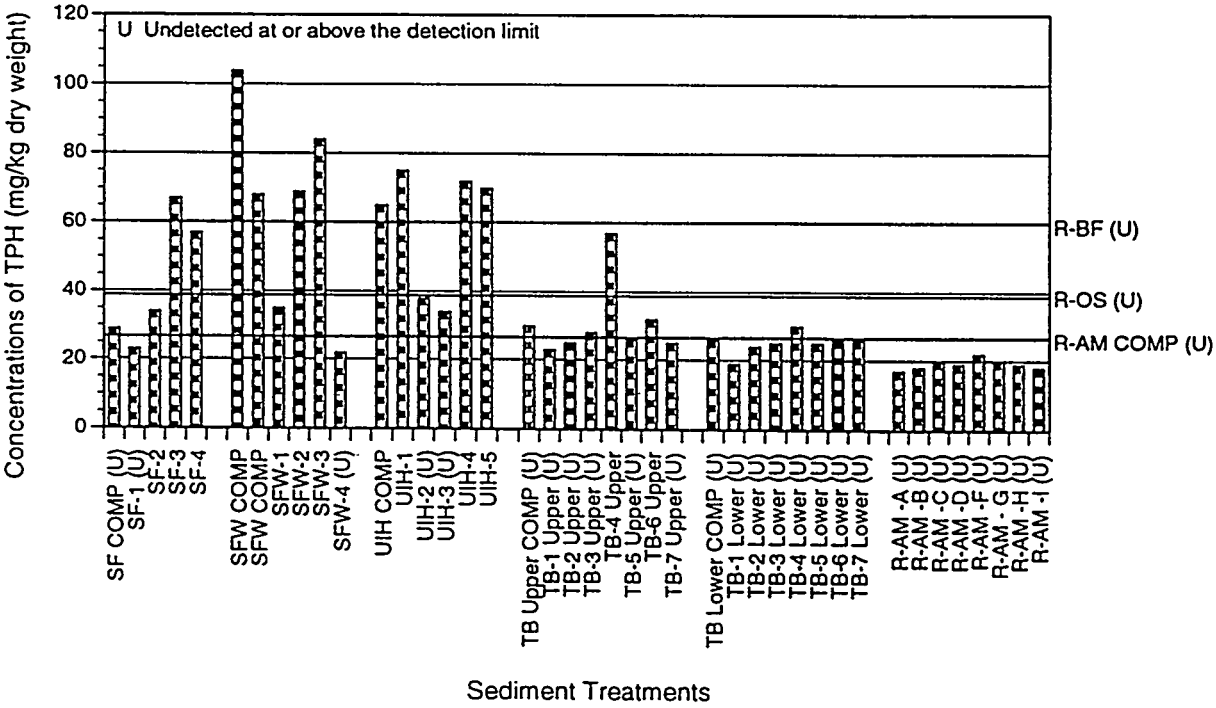


FIGURE 3.14. Concentrations of TPH Sediment Treatments

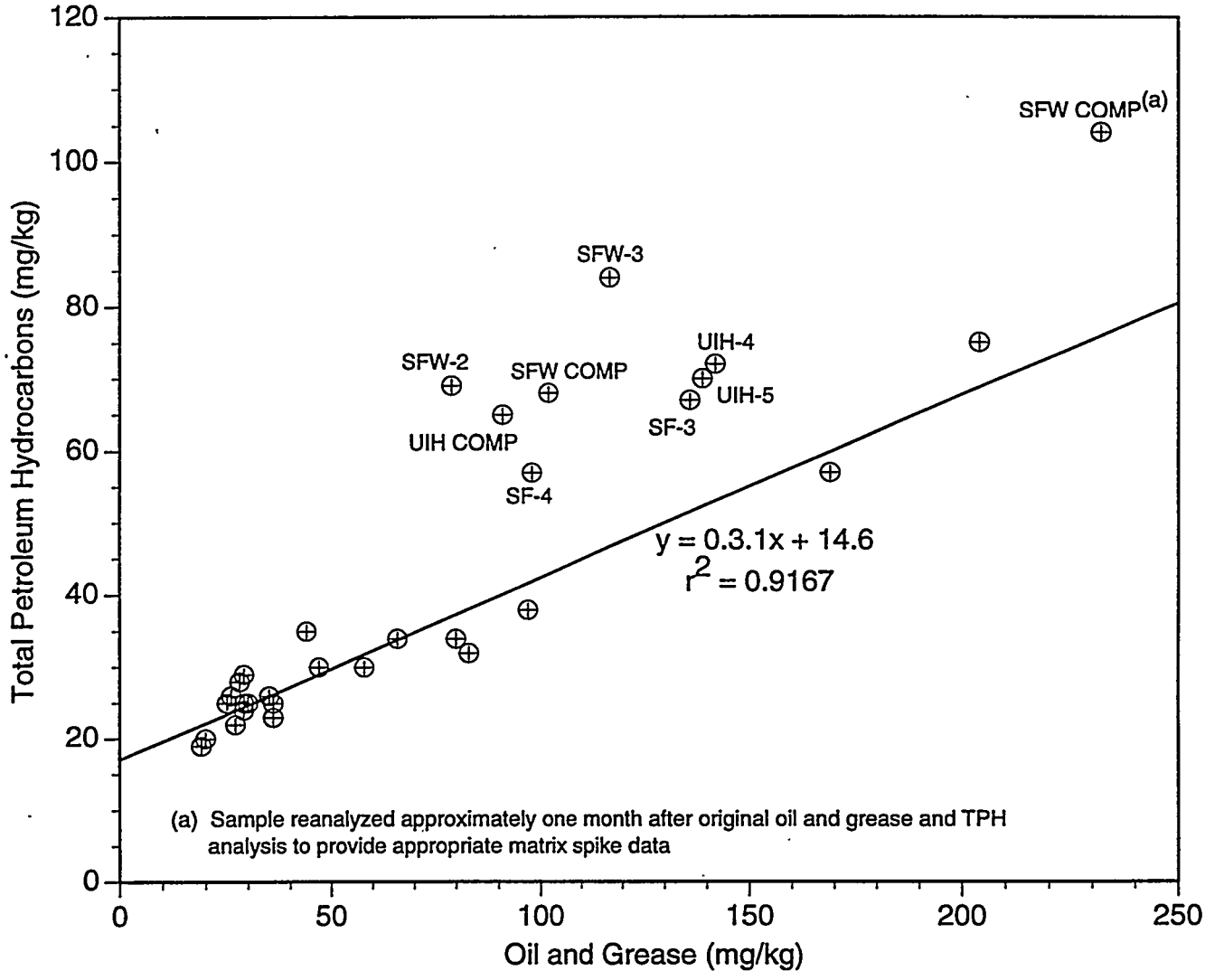


FIGURE 3.15. Concentration of Oil and Grease vs. TPH

3.3.2 Polynuclear Aromatic Hydrocarbons and Phthalate Esters

The Richmond Harbor sediment treatments were analyzed for the 16 priority pollutant PAHs listed in the *1991 Implementation Manual*. The complete results of PAH and phthalate esters analysis, including QC data and QA/QC summaries, are presented in Appendix C, Tables C.8 through C.15. Table 3.5 is a summary of total PAHs, pesticides, and PCB concentrations for the test treatments and the reference treatment R-OS. The test treatments with higher organic concentrations relative to the reference R-OS were delineated by shading the test treatment values.

Concentrations of low-molecular-weight PAHs (LPAHs) in the test treatments ranged from undetected in TB-1 Lower to 3897 µg/kg in SFW COMP. The concentrations of high-molecular-weight PAH (HPAH) ranged from 2 µg/kg in TB-1 Lower to 3390 µg/kg in SFW-2. The five test treatments with the highest overall total PAH concentrations were SFW COMP, SFW-2, SFW-3, SF-3, and SF-4, with concentrations of 5703 µg/kg, 3776 µg/kg, 3293 µg/kg, 3745 µg/kg, and 3763 µg/kg, respectively. Twenty-four test treatments had levels of total PAHs (TPAH) that were higher than those of the reference treatment R-OS (Figure 3.16). Naphthalene was found in the highest concentration in SFW COMP and SFW-3, and pyrene and benzo(b)fluoranthene were found in the highest concentrations in SFW-2 and SF-4. The LPAH compounds were much higher in concentration than HPAH at SFW COMP and SFW-3 representing approximately 67% of the TPAH.

Six phthalate esters were analyzed in the Richmond Harbor sediment treatments. The results of the phthalate esters are presented in Appendix C, Tables C.13 and C.14. One compound, bis(2-ethylhexyl)phthalate ester was detected in 20 of the test treatments, ranging from 104 µg/kg in SFW-3 to 473 µg/kg in SF-4. The only other detected phthalate ester was butyl benzyl found in UIH-5 at 58 µg/kg. The reference treatment R-OS had no detectable levels of any phthalate ester.

3.3.3 Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs)

The Richmond Harbor sediment treatments were analyzed for 18 chlorinated pesticides and 4 PCBs. Eight pesticides were detected in the sediment of at least one test treatment. The compound DDT and its chemical analogues, as well as dieldrin and aldrin, were prevalent in a majority of the test treatments and are summarized in Table 3.5 The compound 4,4'-DDD, was found in the sediments at the highest concentrations ranging from 0.75 µg/kg in TB-5 Upper to 288 D µg/kg (D indicates that the sample required dilution in order to remain within the calibration level of the GC) in SF-4. One compound, 4,4'-DDE, was detected in the sediment from R-OS at a concentration of 0.94 µg/kg. All of the detected pesticides (except 4,4'-DDE) were found at higher levels in the test treatments relative to the sediment from R-OS (Figures 3.17 to 3.21).

TABLE 3.5. Detected PAHs, Pesticides, and PCBs in Richmond Harbor Deepening Project Sediment Treatments (shading indicates detected values greater than the Deep Off-Shelf reference sediment [R-OS]; values in µg/kg dry weight)

Sediment Treatment	Total LPAH	Total HPAH	Aldrin	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
R-OS	48	68	0.06 U[a]	0.18 U	0.94	0.51 U	0.38 U	20 U
SF COMP	228	1345	2.31	203 D[b]	34.2	14.0 D	14.0	10.7
SF-1	79	690	1.02	82.8 D	1.16	23.3	5.51	33.6
SF-2	273	1876	3.46	285 D	65.2	78.7 D	25.8	17.7
SF-3[c]	471	3274	3.59	283 D	36.1 D	55.8	24.1	18.3
SF-4	489	3274	3.98	288 D	66.5	137 D	22.8	19.8
SFW COMP	3897	1806	3.37	267 D	82.3 D	81.7 D	46.2	14.5
SFW-1	248	1735	1.67	191 D	31.1	11.2 D	12.9	10.8
SFW-2	386	3390	2.29	184 D	57.2	87.4 D	17.1	20 U
SFW-3	2188	1105	1.64	127 D	31.8 D	56.3 D	17.5	39.4
SFW-4	71	396	0.76	88.4 D	18.7	38.4	6.26	20 U
UIH COMP[c]	425	2372	2.80	110 D	18.8 D	53.2 D	9.17	9.3
UIH-1	253	1596	0.07 U	76.1 D	13.1	49.2	6.48	72.0
UIH-2	278	1987	1.09	75.8 D	14.0	48.8	7.24	92.3
UIH-3	245	1709	3.10	157 D	24.3	85.2	10.8	15.7
UIH-4	227	1712	1.40	70.5 D	14.2	44.2	5.47	67.5
UIH-5	283	1843	2.53	178 D	40.4	60.5 D	16.8	140
TB Upper COMP	115	820	1.26	1.99	0.08 U	0.73	1.08	20 U
TB-1 Upper	48	368	0.05 U	1.83	0.06 U	1.24	0.32 U	8.51 J[d]
TB-2 Upper[c]	172	1213	0.06 U	2.11	0.39	2.00	0.57	20 U
TB-3 Upper	161	1322	0.06 U	1.01	0.07 U	0.50 U	0.85	4.68 J
TB-4 Upper	216	1622	1.08	17.0	5.16	4.74	2.05	46.8
TB-5 Upper	91	383	0.06 U	0.75	0.07 U	6.87	0.62	20 U
TB-6 Upper	13	18	0.06 U	0.17 U	0.07 U	0.48 U	0.36 U	20 U
TB-7 Upper	26	26	0.05 U	0.16 U	0.07 U	0.46 U	0.34 U	20 U

TABLE 3.5. (contd)

Sediment Treatment	Total LPAH	Total HPAH	Aldrin	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
TB Lower COMP	31	94	0.12	0.97	0.07 U	0.47 U	0.36 U	20 U
TB-1 Lower	ND(e)	2	0.04 U	0.12 U	0.05 U	0.36 U	0.27 U	20 U
TB-2 Lower	13	17	0.05 U	0.14 U	0.06 U	0.40 U	0.30 U	20 U
TB-3 Lower	16	26	0.05 U	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-4 Lower	260	2023	0.07 U	2.19	0.08 U	12.8	1.86	59.3
TB-5 Lower	19	25	0.05 U	0.15 U	0.06 U	0.43 U	0.32 U	20 U
TB-6 Lower	14	20	0.05 U	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-7 Lower	28	27	0.05 U	0.16 U	0.07 U	0.45 U	0.34 U	20 U
OBM COMP	8	4	0.05 U	0.13 U	0.06 U	0.38 U	0.28 U	20 U

(a) U Undetected at or above the detection limit.
(b) D Diluted sample.
(c) Pesticide and PCB values are a mean of replicate samples.
(d) J Dectected below the method detection limit but above the instrument detection limit.
(e) ND Not detected.

FIGURE 3.16. Concentrations of Total PAH in Sediment Treatments

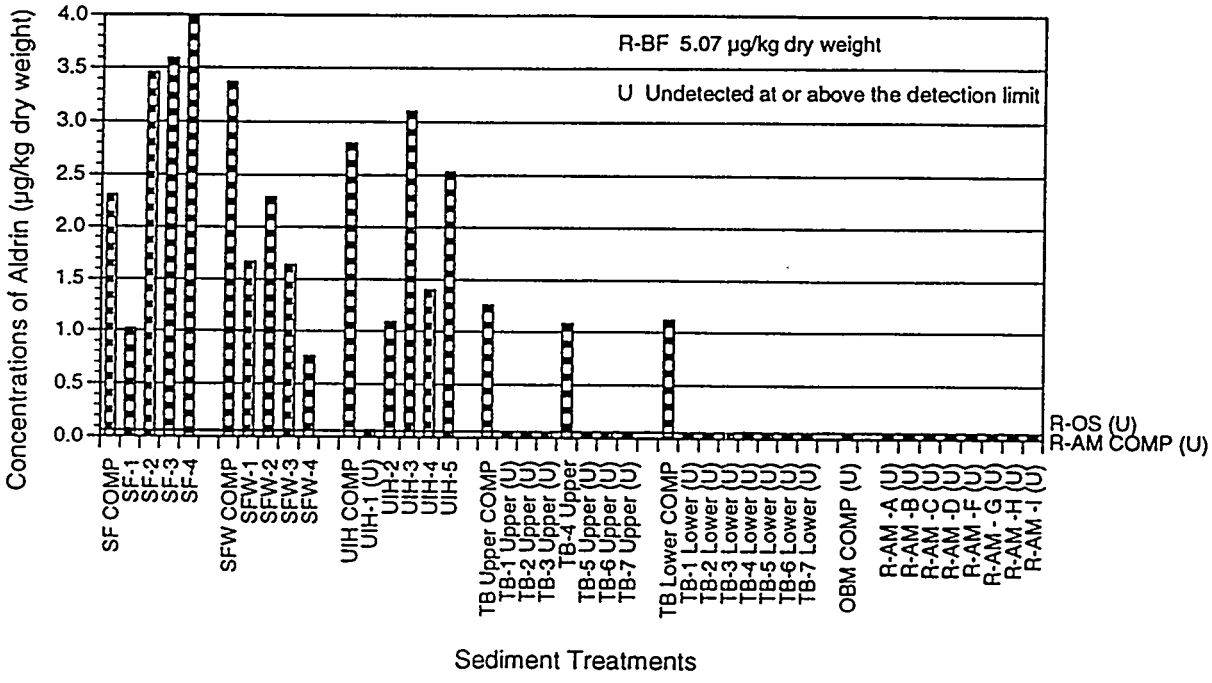


FIGURE 3.17. Concentrations of Aldrin in Sediment Treatments

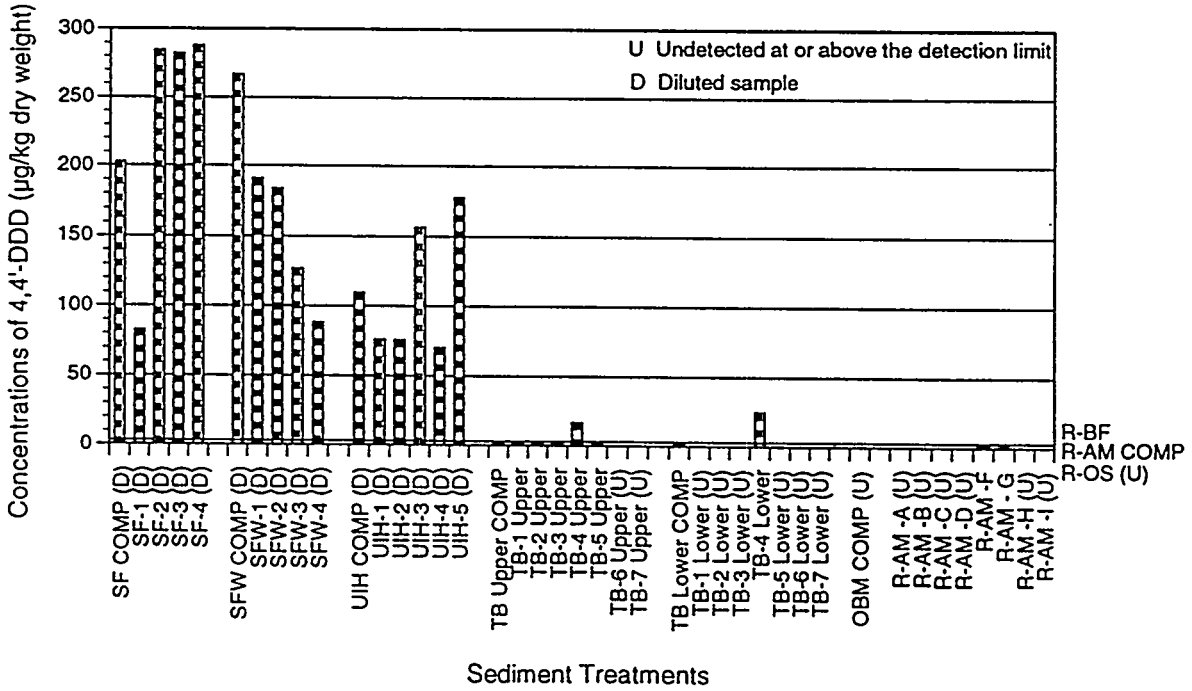


FIGURE 3.18. Concentrations of 4,4'-DDD in Sediment Treatments

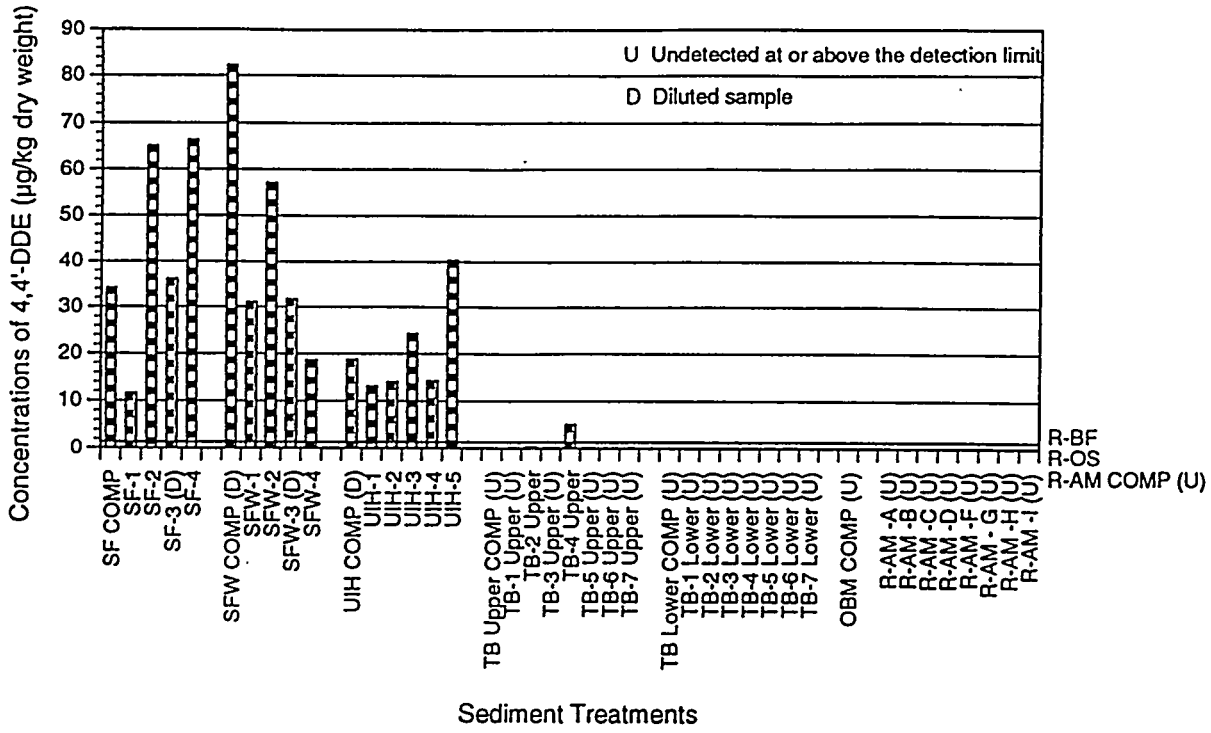


FIGURE 3.19. Concentrations of 4,4'-DDE in Sediment Treatments

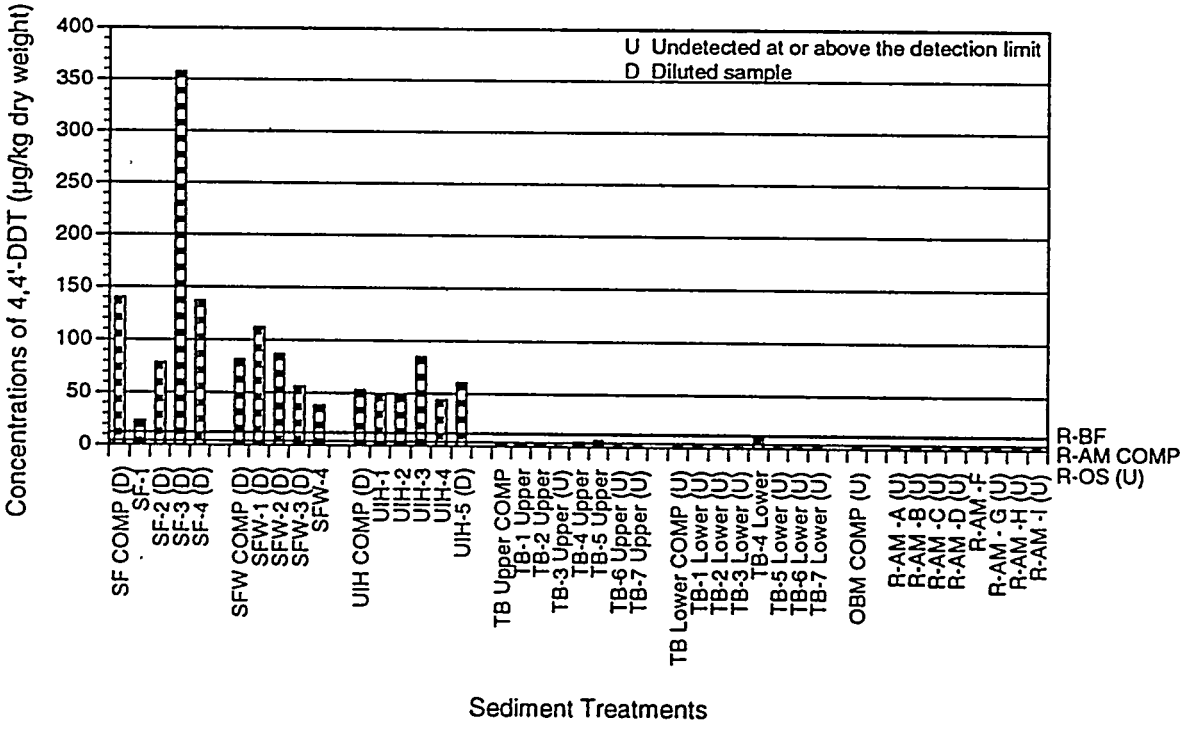


FIGURE 3.20. Concentrations of 4,4'-DDT in Sediment Treatments

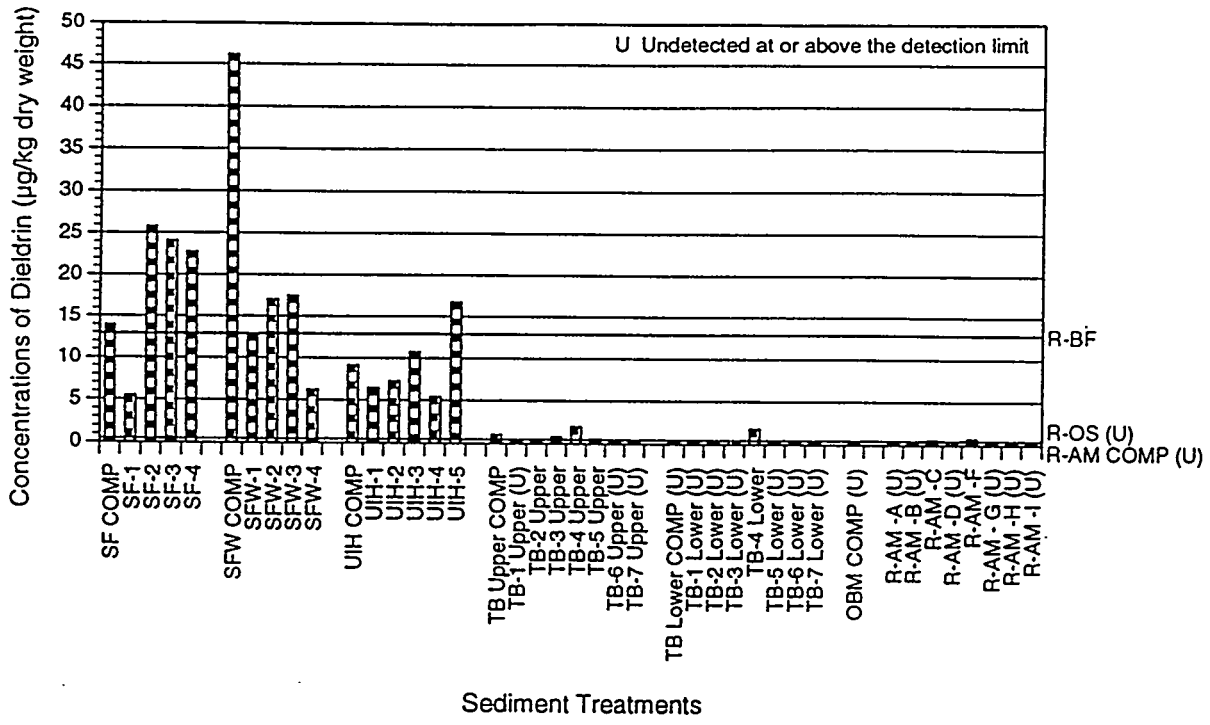


FIGURE 3.21. Concentrations of Dieldrin in Sediment Treatments

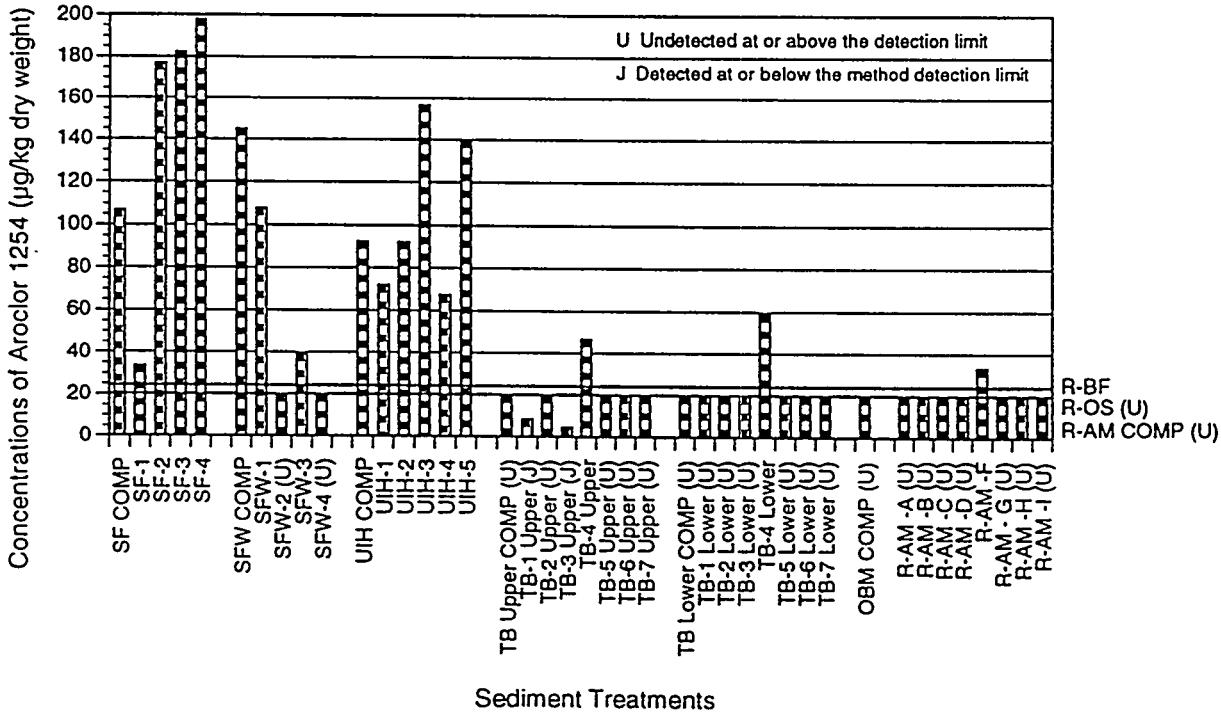


FIGURE 3.22. Concentrations of Aroclor-1254 in Sediment Treatments

Aroclor 1254 was the only PCB found in the majority of the test treatments ranging from 4.68 J µg/kg (J indicates detected below the method detection limit, but above the instrument detection limit) in TB-3 Upper to 198 µg/kg in SF-4. The reference sediment R-OS had no detectable levels of any of the Aroclor compounds (Figure 3.22).

3.3.4 Metals

Ten metals were analyzed in the Richmond Harbor sediment treatments. Table 3.6 shows shaded values for those test treatments with higher concentrations of metals than were found in R-OS. Seven metals, As, Cr, Cu, Hg, Ni, Pb, and Zn, were found at higher levels in the majority of the test treatments relative to R-OS. Selenium concentrations were higher in R-OS (1.25 mg/kg) than in all of the test treatments. The remaining two metals, Ag and Cd, had elevated concentrations in less than half of the test treatments relative to the reference treatment. Sediments from test treatment SF-4, had the greatest number of metals (Cr, Cu, Pb, and Zn) at the highest concentrations among all test treatments. Test treatment TB-1 Lower had five metals (Cd, Cu, Ni, Pb, and Zn) at the lowest concentrations of any test treatment.

Sediments from the Santa Fe Channel and the Upper Inner Harbor area appear to have the greatest concentration of metals, whereas sediment from the Turning Basin appears to be less enriched with metals (Figures 3.23 to 3.32).

3.3.5 Butyltins

Three organotins (mono-, di-, and tributyltin) were measured in the Richmond Harbor sediment treatments. A summary of the dibutyltin (DBT) and tributyltin (TBT) analyses are shown in Table 3.6 and Figures 3.33 and 3.34. The TBT concentrations were detected in 18 test treatments and ranged from 1.05 µg/kg in SFW-4 to 30.6 µg/kg in SF-3. Eighteen of the test treatments had detectable values of DBT. The DBT concentrations in the test treatments ranged from 1.13 µg/kg in TB-1 Upper to 33.1 µg/kg in SF-4. The reference sediment R-OS had concentrations of TBT and DBT that were detected below the method detection limit.

3.3.6 California Waste Extraction Test (WET) and Soluble Threshold Limit Concentrations (STLC) for 17 California Assessment Metals (CAM), Hexavalent Chromium and Selected Pesticides and PCBs by Method 8080

Five Richmond Harbor test treatments were analyzed for 17 metals, hexavalent chromium, and selected pesticides and PCBs using the WET. The detection limits set forth for analysis were approximately one-tenth of the STLC values listed in Title 22 of the California Code of Regulations (Health and Safety Code §25205.7).

TABLE 3.6. Metal and Butyltin Conentrations in Richmond Harbor Deepening Project Sediment Treatments (shading indicates values greater than the Deep Off-Shelf reference sediment [R-OS]; metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-OS	0.556	2.19 J[a]	0.489	171	23.5	0.084	68.1	10.8	1.25	84.3	0.40 U[b]	0.65 U
SF COMP	0.391	9.4	0.511	189	55.0	0.360	80.3	35.2	0.235	130	8.52	7.48
SF-1	0.303	7.0	0.922	178	35.6	0.115	71.0	18.9	0.128 U	83.5	1.67	1.59
SF-2	0.566	14.2	0.654	202	71.7	0.490	93.5	48.6	0.418	176	6.78	9.05
SF-3	0.626	13.4	0.474	214	92.9	0.628	111	56.5	0.336	204	30.6	18.2
SF-4	0.694	14	0.564	215	107	0.689	109	64.8	0.412	208	27.0	33.1
SFW COMP	0.603	12.4	0.890	192	65.3	0.943	92.5	45.8	0.522	157	2.85	5.73
SFW-1	0.438	14.4	0.482	169	68.5	0.377	82.8	55.8	0.235	175	5.76	9.88
SFW-2	0.615	4.48	0.855	158	34.3	0.857	67.6	20.1	0.421	86.7	4.79	8.46
SFW-3	0.537	9.6	0.782	166	55.6	0.465	86.6	30.4	0.796	119	0.40 U	0.65 U
SFW-4	0.268	13.1	0.628	183	59.6	0.158	85.1	44.3	0.243	153	1.05	2.01
UIH COMP	0.639	13.6	0.513	203	81.2	0.508	112	52.5	0.334	192	8.59	8.38
UIH-1	0.599	14.2	0.484	192	75.6	0.607	115	53.6	0.507	180	5.38	7.95
UIH-2	0.670	13.6	0.465	193	83.9	0.618	117	53.0	0.434	183	6.67	9.87
UIH-3	0.713	14.8	0.596	189	85.7	0.644	111	59.5	0.331	190	4.66	6.68
UIH-4	0.491	10.9	0.733	168	68.0	0.311	101	37.3	0.150	164	7.12	6.02
UIH-5	0.663	15.4	0.570	202	82.1	0.516	114	58.2	0.413	192	8.11	7.04
TB Upper COMP	0.223	10.3	0.249	166	40.5	0.234	86.9	17.4	0.240	100	1.87	0.65 U
TB-1 Upper	0.163	11.0	0.159	210	33.6	0.201	71.7	14.7	0.128 U	73.4	0.40 U	1.13
TB-2 Upper	0.214	12.1	0.300	173	42.6	0.373	78.8	21.2	0.240	96.3	1.35	0.65 U
TB-3 Upper	0.275	12.0	0.306	169	46.3	0.532	91.5	27.2	0.337	117	0.40 U	0.65 U
TB-4 Upper	0.501	14.5	0.352	164	68.3	0.401	105	36.6	0.420	151	2.18	2.38
TB-5 Upper	0.145	9.6	0.299	171	34.0	0.175	84.4	13.8	0.426	90.6	0.40 U	0.65 U
TB-6 Upper	0.135	9.9	0.224	184	47.1	0.109	108	10.3	0.340	97.2	0.40 U	0.65 U
TB-7 Upper	0.102	9.2	0.288	212	26.0	0.066	74.1	9.4	0.243	85.0	0.40 U	0.65 U

TABLE 3.6. (contd)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
TB Lower COMP	0.158	11.6	0.252	180	39.4	0.140	90.3	9.4	0.128 U	91.8	0.40 U	0.65 U
TB-1 Lower	0.128	6.7	0.100	206	17.2	0.077	47.5	8.2	0.128 U	42.4	0.40 U	0.65 U
TB-2 Lower	0.106	11.4	0.250	201	33.5	0.073	91.5	13.7	0.346	81.0	0.40 U	0.65 U
TB-3 Lower	0.114	8.3	0.269	203	44.2	0.078	91.8	13.8	0.330	87.0	0.40 U	0.65 U
TB-4 Lower	0.501	13.8	0.549	181	65.0	0.642	98.2	40.2	0.413	155	0.40 U	1.20
TB-5 Lower	0.115	10.3	0.281	201	33.6	0.062	85.8	10.4	0.333	84.4	0.40 U	0.65 U
TB-6 Lower	0.143	10.7	0.217	205	47.6	0.088	101	12.7	0.240	87.1	0.40 U	0.65 U
TB-7 Lower	0.140	10.8	0.284	193	44.7	0.078	105	10.4	0.273	94.5	0.40 U	0.65 U
OBM COMP	NA(c)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.40 U	0.65 U

(a) J Detected below the method detection limit but above the instrument detection limit.
(b) U Undetected at or above the detection limit.
(c) NA Not applicable.

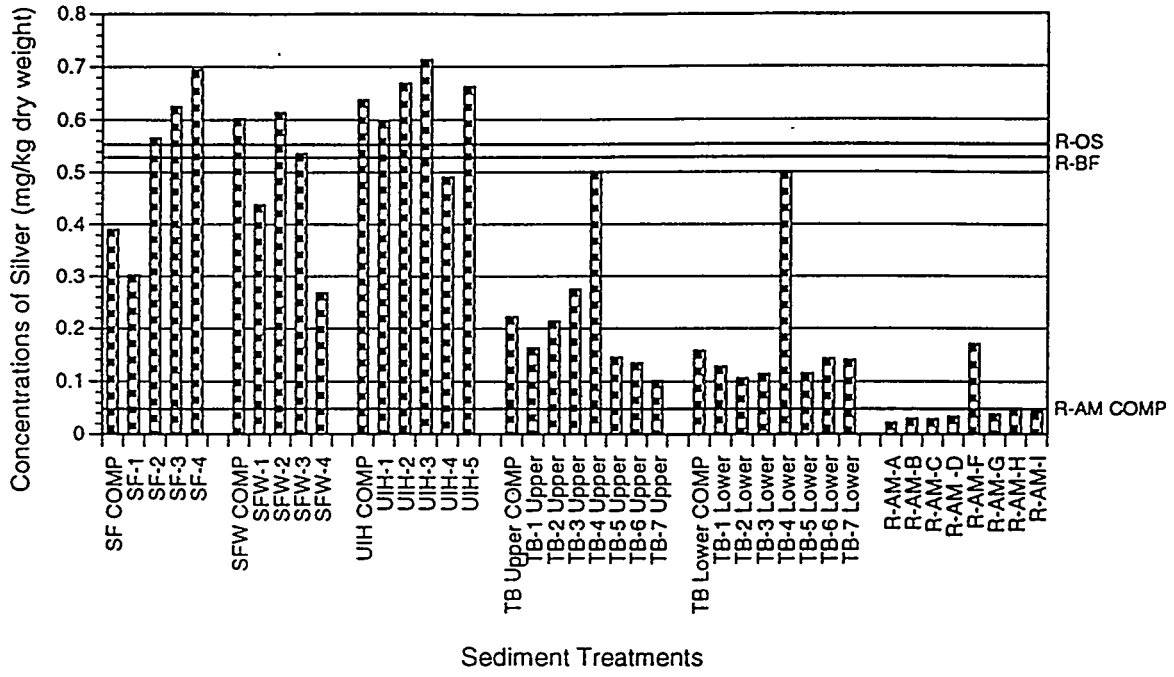


FIGURE 3.23 Concentrations of Silver in Sediment Treatments

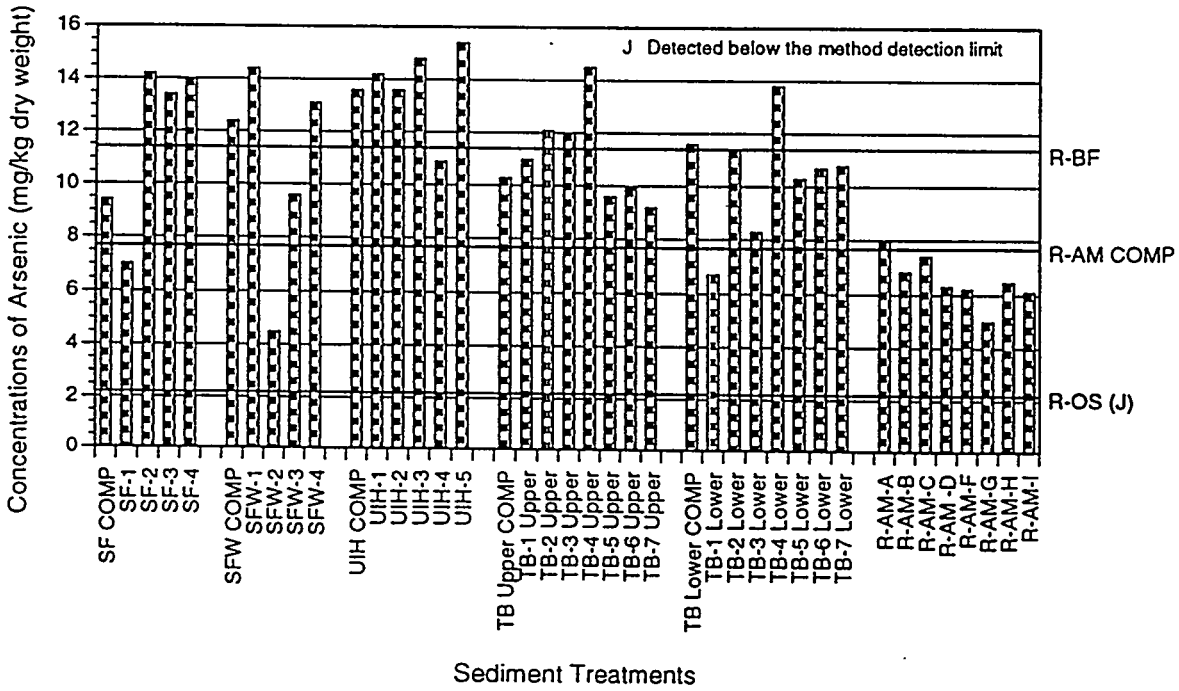


FIGURE 3.24. Concentrations of Arsenic in Sediment Treatments

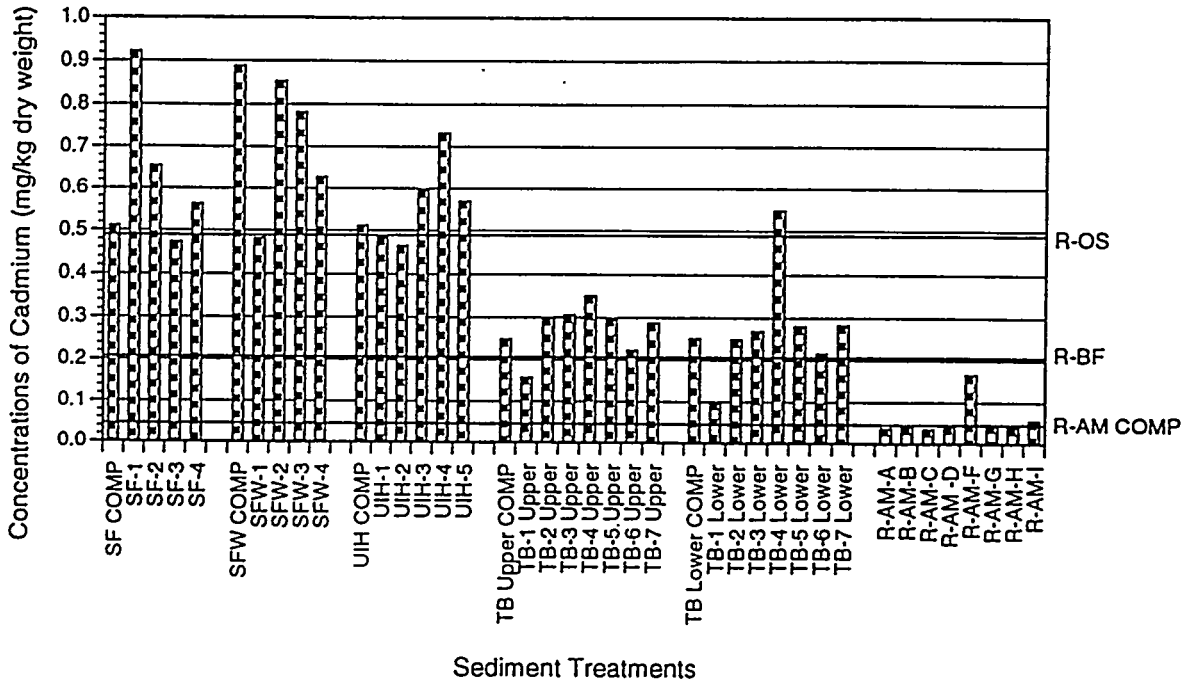


FIGURE 3.25. Concentrations of Cadmium in Sediment Treatments

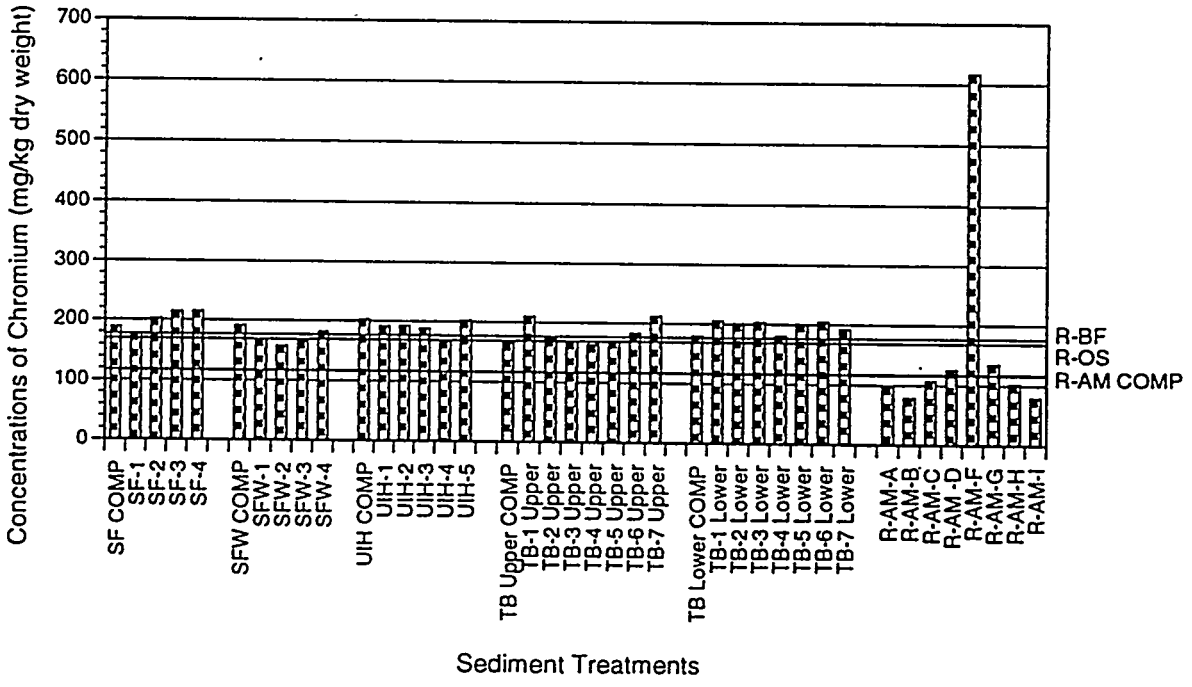


FIGURE 3.26. Concentrations of Chromium in Sediment Treatments

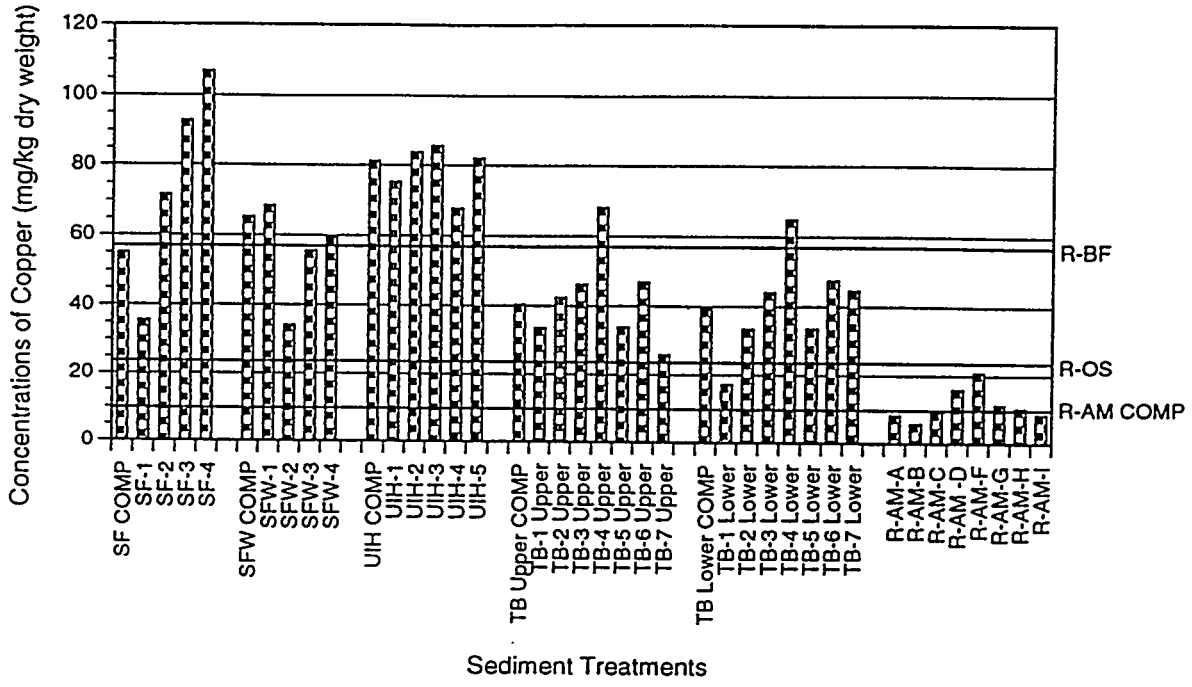


FIGURE 3.27. Concentrations of Copper in Sediment Treatments

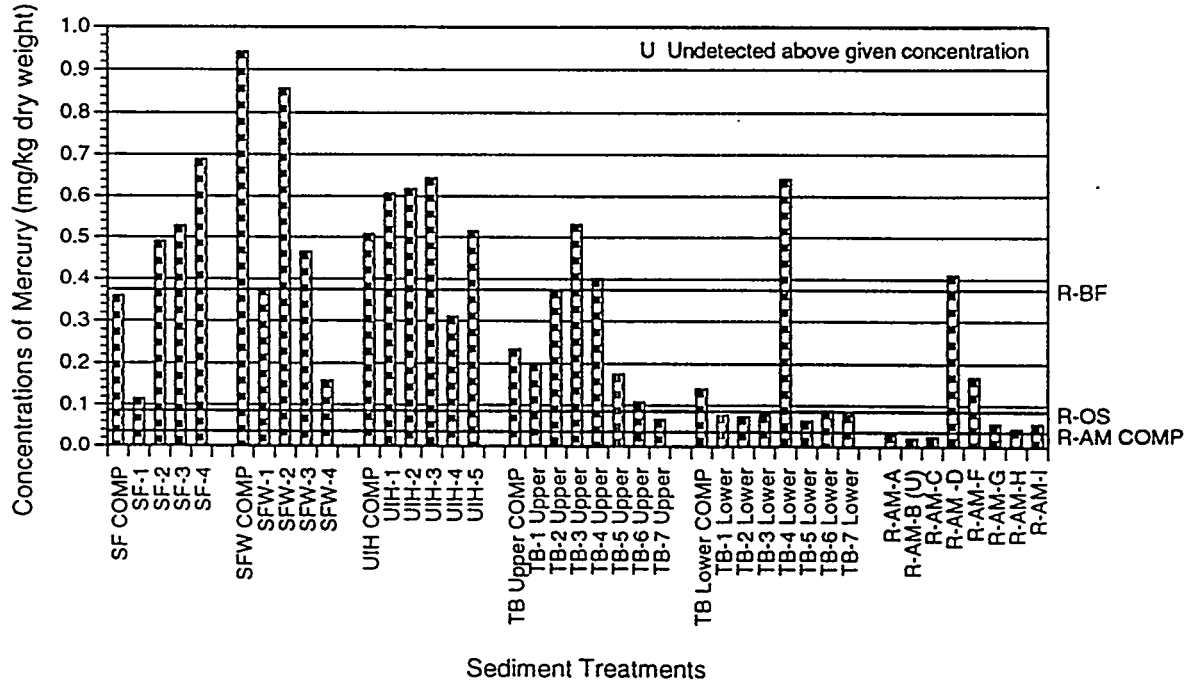


FIGURE 3.28. Concentrations of Mercury in Sediment Treatments

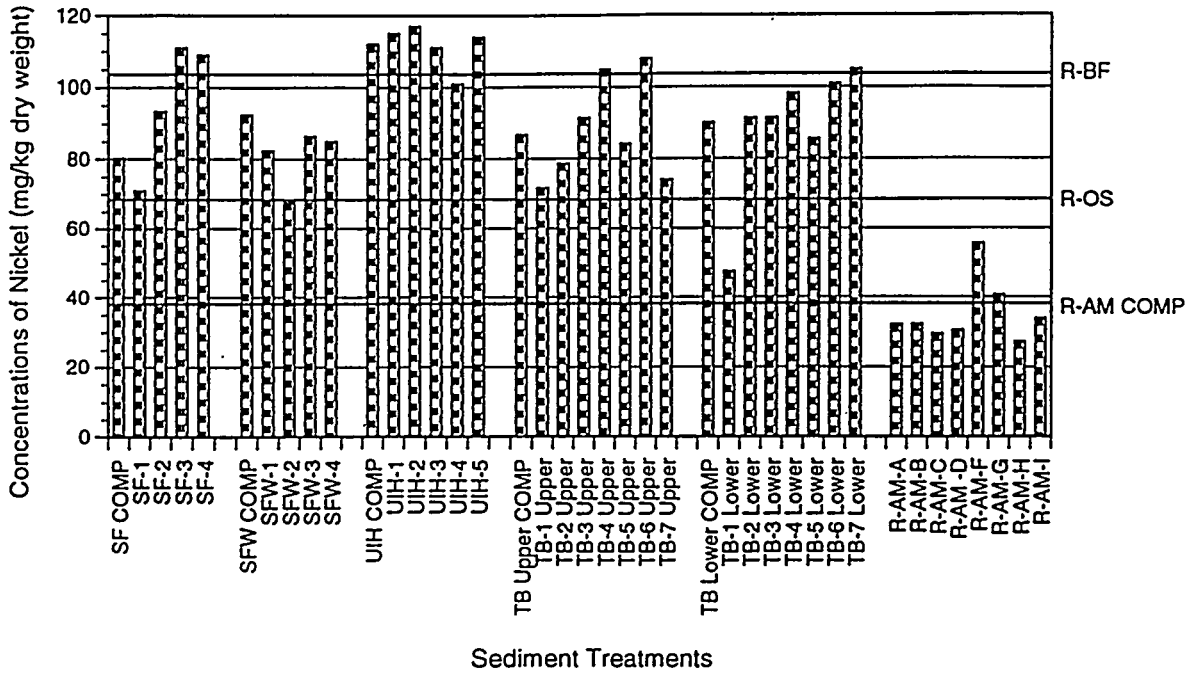


FIGURE 3.29. Concentrations of Nickel in Sediment Treatments

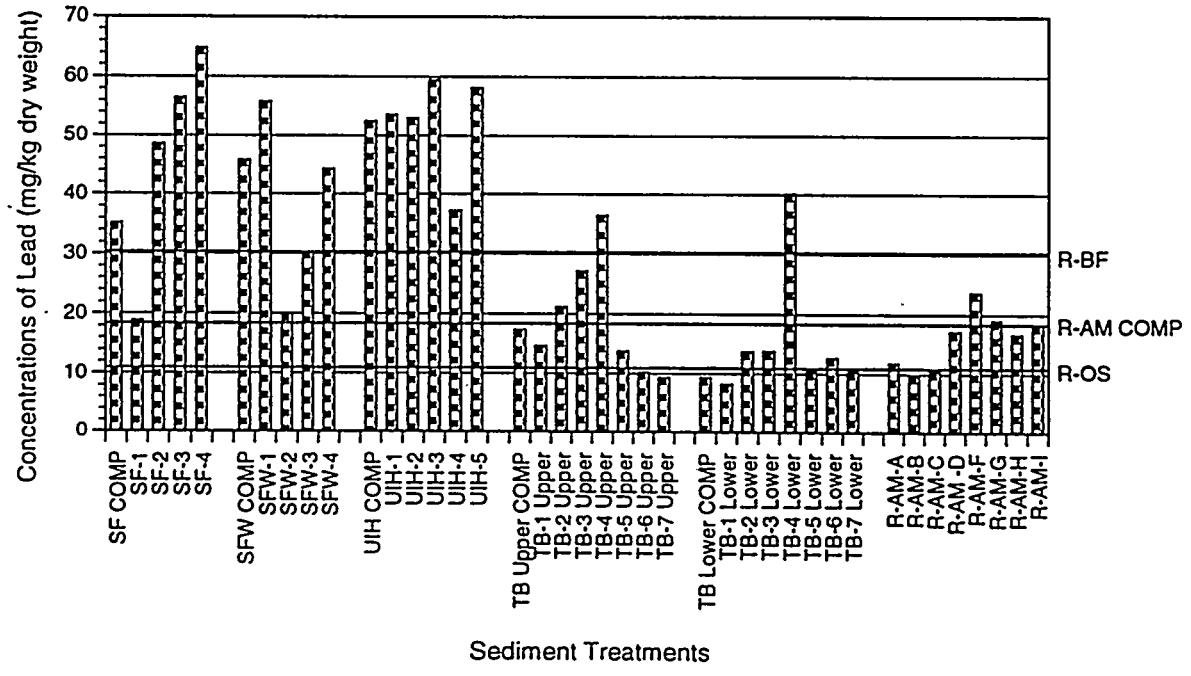


FIGURE 3.30. Concentrations of Lead in Sediment Treatments

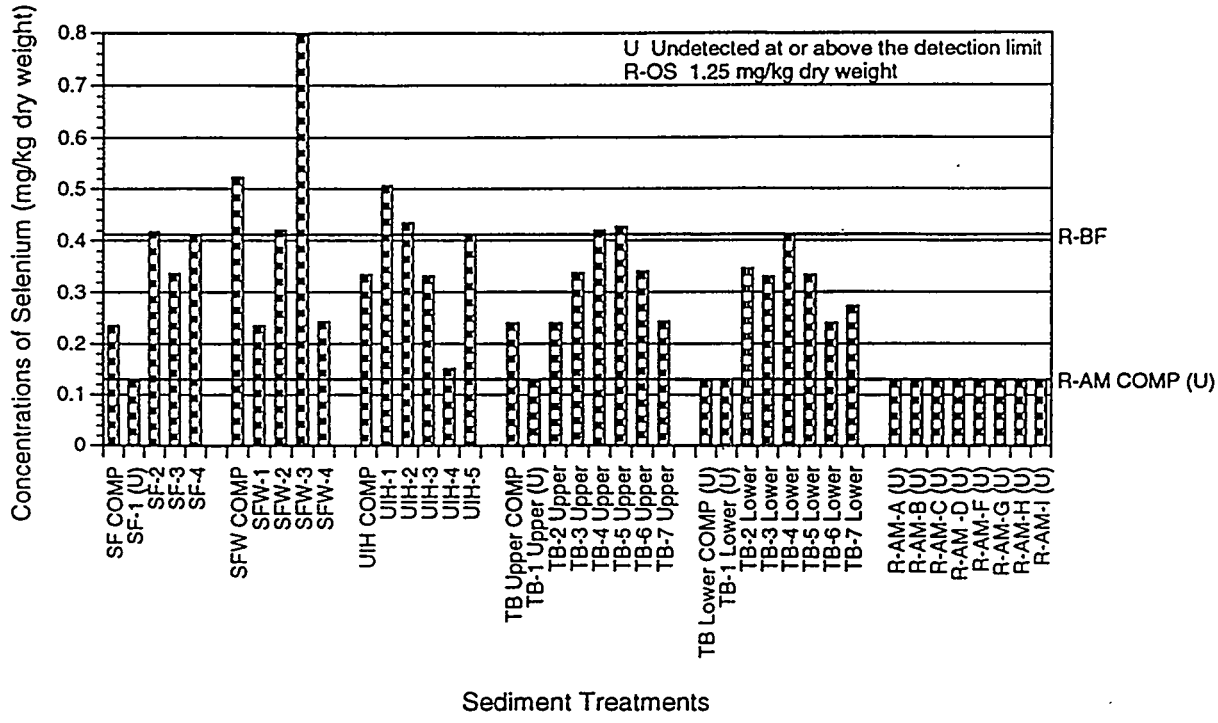


FIGURE 3.31. Concentrations of Selenium in Sediment Treatments

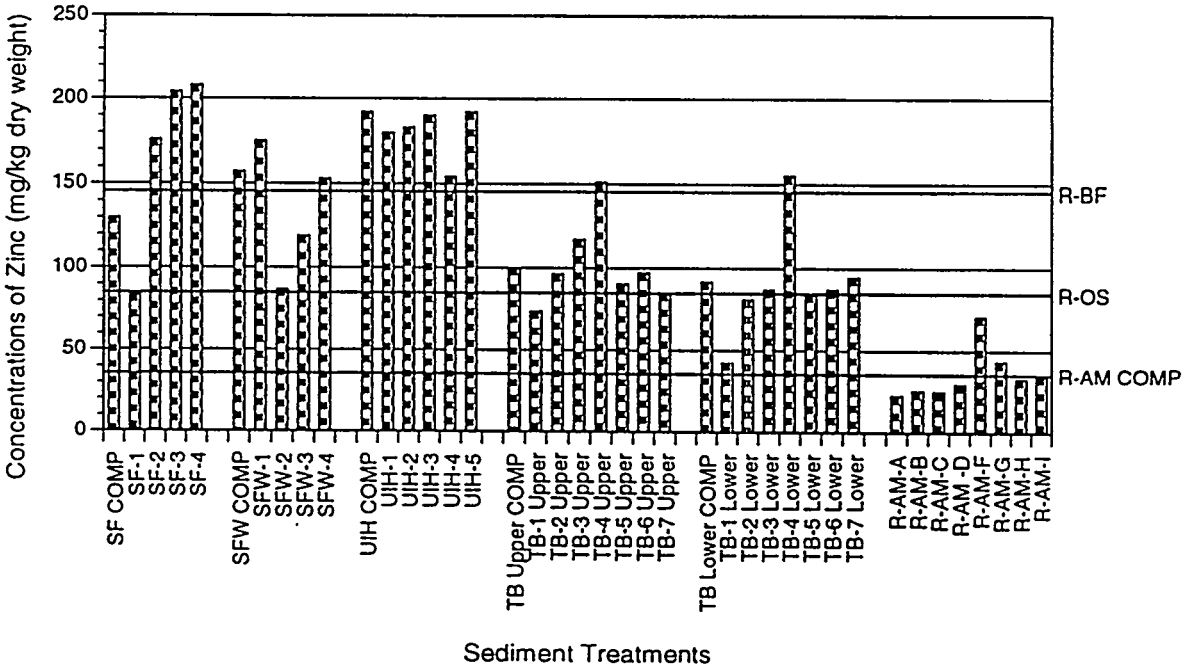


FIGURE 3.32. Concentrations of Zinc in Sediment Treatments

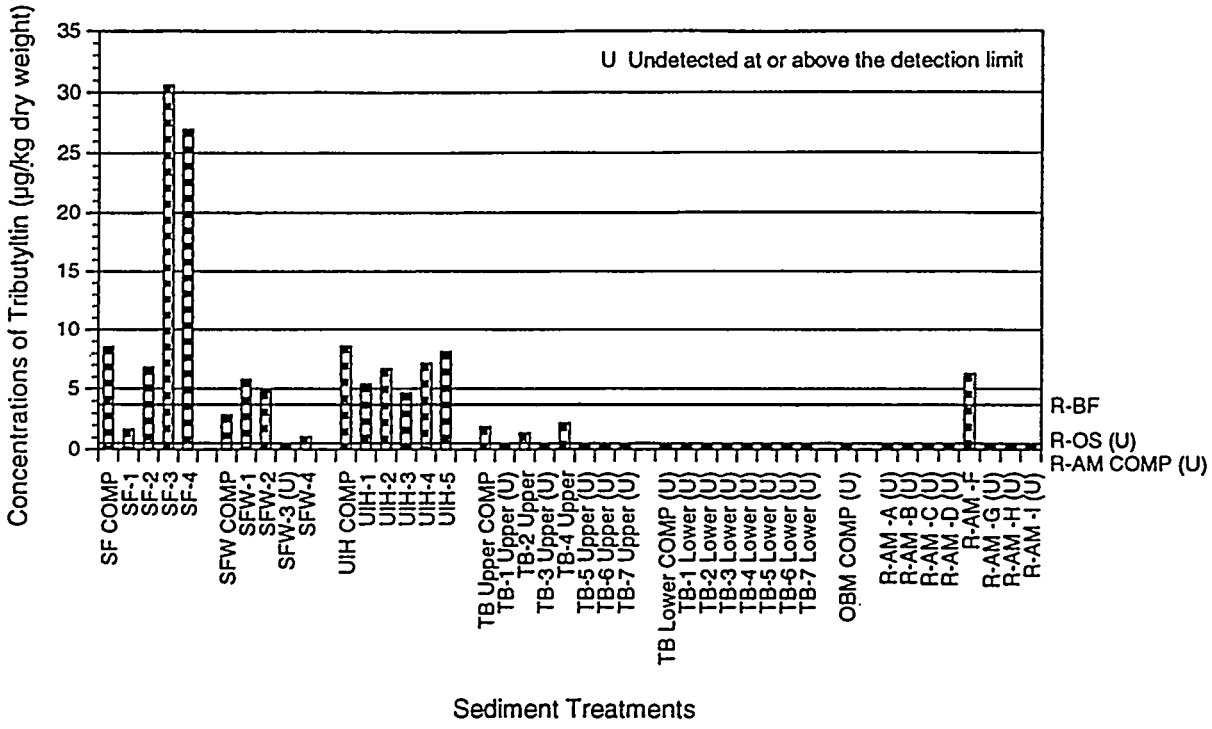


FIGURE 3.33. Concentrations of Tributyltin in Sediment Treatments

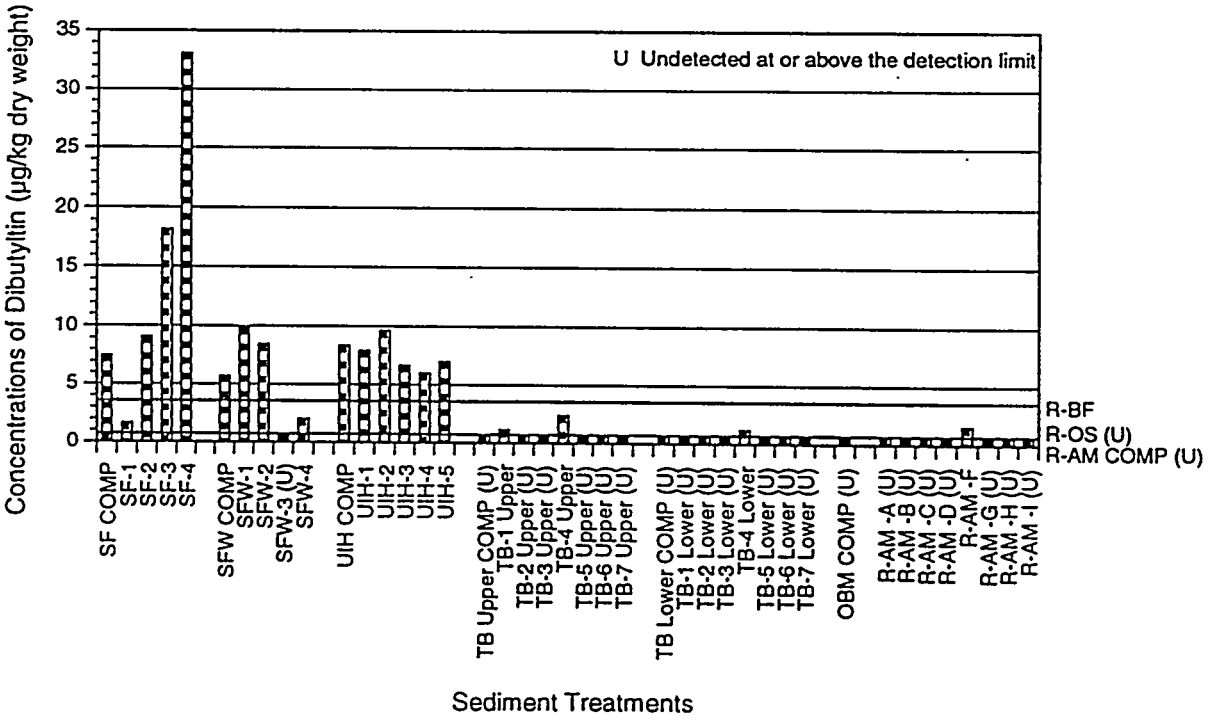


FIGURE 3.34. Concentrations of Dibutyltin in Sediment Treatments

The results of the metals analysis are shown in Tables C.27 through C.29. Nine of the 17 metals analyzed were undetected in all five test treatments. Five metals, As, barium (Ba), Cr, vanadium (V), and Ni, were detected in all five test treatments (Table 3.7). Hexavalent Cr was undetected in all test treatments. Nineteen pesticides and seven Aroclors were extracted using the WET and analyzed by Method 8080. None of these pesticides or Aroclors was detected in any of the five test treatments.

3.4 TOXICOLOGICAL TESTING RESULTS

Six toxicological tests were conducted to assess the biological toxicity and bioaccumulation potential of contaminants from Richmond Harbor Deepening Project sediments. The complete data for water quality monitoring, test results, and the reference toxicant tests, are contained in Appendixes E through N. The QA/QC summaries are located at the front of each appendix and provide information related to organism source, holding and acclimation, water quality parameters, reference toxicant information, and test validity.

Solid-phase toxicity tests were conducted on the five Richmond Harbor test treatments, the OBM COMP, and the appropriate "native" control sediment for each species. Three species of marine invertebrates were exposed for 10-days to the solid-phase treatments: *R. abronius, M. nasuta,* and *N. caecoides.* Survival data for these organisms are summarized in Table 3.8. A 28-day exposure of *M. nasuta* and *N. virens* to the five Richmond Harbor test treatments and the OBM COMP was conducted to assess bioaccumulation of contaminants in test organism tissues. The results of each solid-phase test were examined to ensure that the test was validated by 90% survival in the native control sediment. The data from the 10-day solid-phase acute toxicity tests were then evaluated by analysis of variance (ANOVA) and Dunnett's test to determine whether statistically significant differences occurred between the test and reference treatments (Table 3.9).

TABLE 3.7. Summary of Detected Metals Analyzed by the California Waste Extraction Test

Sediment Treatment	(mg/L) Arsenic	Barium	Chromium	Nickel	Vanadium
SF COMP	0.05	1.5	0.2	0.2	0.5
SFW COMP	0.08	2.5	0.3	0.2	0.6
UIH COMP	0.06	0.8	0.4	0.3	0.7
TB Upper COMP	0.08	1.1	0.1	0.2	0.6
TB Lower COMP	0.08	1.9	0.1	0.3	0.5

TABLE 3.8. Summary of 10-Day Solid-Phase Toxicity Tests, Richmond Harbor Deepening Project

Sediment Treatment	*R. abronius* Percent Survival	*R. abronius* Acute Toxicity	*M. nasuta* Percent Survival	*M. nasuta* Acute Toxicity	*N. caecoides* Percent Survival	*N. caecoides* Acute Toxicity
R-OS	89	NA[a]	100	NA	96	NA
SF COMP	89	NO[b]	100	NO	79	YES[c]
SFW COMP	77	NO	98	NO	81	YES
UIH COMP	77	NO	100	NO	88	NO
TB Upper COMP	70	NO	99	NO	86	NO
TB Lower COMP	50	YES	98	NO	96	NO
OBM COMP	72	NO	98	NO	38	YES
C-SB	93	NA	100	NA	96	NA
C-WB	98	NA	NA	NA	NA	NA
C-NE	NA	NA	100	NA	94	NA

(a) NA Not applicable.
(b) NO Indicates that test treatment was not statistically significantly different from the reference sediment R-OS at α=0.05.
(c) YES Indicates that test treatment was statistically significantly different from the reference sediment R-OS at α=0.05 and >10% lower in survival than R-OS (20% for *R. abronius*).

TABLE 3.9. ANOVA Results for the 10-Day Solid-Phase Toxicity Tests, Richmond Harbor Deepening Project

Source of Variation	Sum Squares	d.f.	Mean Square	F-Ratio	Significance Level
R. abronius					
Treatment	0.736	6	0.123	9.728	0.0001
Residual	0.353	28	0.013		
M. nasuta					
Treatment	0.042	6	0.007	0.959	0.4702
Residual	0.204	28	0.007		
N. caecoides					
Treatment	1.998	6	0.333	17.151	0.0001
Residual	0.544	28	0.019		

A test treatment was considered *acutely toxic* if it was statistically significantly different from the reference sediment and if the survival of the test organisms exposed to the test treatment was ≥10% lower than survival in the reference sediment (≥20% lower than reference for *R. abronius*).

Suspended-particulate-phase toxicity tests were conducted with the five Richmond Harbor test treatments and the OBM COMP. Three concentrations of SPP (10%, 50%, and 100%), were prepared and tested concurrently with a seawater control (0% SPP). Three species of marine organisms were exposed to the test treatments prepared as SPP: *C. stigmaeus, H. costata*, and *M. galloprovincialis*. Control survival was used to validate the tests. The data for the 0% (control) and the 100% SPP treatments were statistically compared using a two-sample t-test. If the result was statistically significant at an experiment-wide error rate of α=0.05 and there was at least 50% reduction in response relative to the control, an LC_{50} or EC_{50} estimate was made using the Trimmed Spearman-Karber method.

3.4.1 10-Day Solid-Phase Static Test with *R. abronius*

Tables 3.8 and 3.9 contain summaries of the solid-phase toxicity testing results for *R. abronius*. The test was validated by 98% survival of *R. abronius* in their native control sediment, C-WB. The fine-grained control sediment, C-SB also had an acceptable *R. abronius* survival of 93%. Survival in the test treatments ranged from 50% in TB Lower COMP to 89% in SF COMP. Only one test treatment, TB Lower COMP, was acutely toxic to *R. abronius* relative to R-OS, which had 89% survival. The population of amphipods used for this project was assessed using a Cd reference toxicant test. The resultant LC_{50} was 0.90 mg/L Cd (confidence interval = 0.77 mg/L to 1.06 mg/L Cd). This LC_{50} is within the range of 0.68 mg/L to 1.25 mg/L Cd established for measuring the sensitivity of *R. abronius* (ASTM 1990).

Ammonia concentrations were monitored in overlying water (Days 0, 1, 3, 7, and 10) and in porewater (Days 0 and 10) of each sediment treatment during the *R. abronius* solid-phase static test (Table 3.10). Ammonia measurements were taken from dummy jars that were set up and run concurrently with the test treatments. Total ammonia in sediment porewater ranged from 2.53 mg/L to 24.9 mg/L at test initiation, and from <1 mg/L to 13.8 mg/L by test termination. The highest levels of porewater ammonia occurred in TB Lower COMP (24.9 mg/L on Day 0 and 13.8 mg/L on Day 10). The lowest levels of porewater ammonia were found in the reference and control sediments, as well as in the OBM COMP.

In a 96-h water-only ammonia reference toxicant test with *R. abronius* collected from the same location but tested at a later date (May 1994), *R. abronius* responded to total ammonia concentrations between 20 mg/L and 200 mg/L, with an LC_{50} value of 72.18 mg/L total ammonia.

TABLE 3.10. Ammonia Monitoring Summary for the 10-Day *R. abronius* Solid-Phase Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Overlying Water Ammonia (mg/L)					Porewater Ammonia (mg/L)	
	Day 0	Day 1	Day 3	Day 7	Day 10	Day 0	Day 10
TB Upper COMP	3.33	9.35	9.70	9.45	1.80	12.3	1.70
TB Lower COMP	12.6	20.8	26.5	25.7	5.49	24.9	13.8
SF COMP	1.81	3.80	1.94	5.13	1.43	6.64	2.62
UIH COMP	8.47	10.7	13.1	11.7	1.76	13.7	3.00
SFW COMP	4.55	8.79	8.95	9.99	1.84	9.64	3.08
OBM COMP	1.11	1.96	2.14	3.34	1.32	2.53	2.49
R-AM	0.419	0.493	0.261	0.896	1.19	3.25	1.03
R-BF	0.779	1.43	1.74	0.700	1.23	3.38	0.663
R-OS	0.649	1.09	0.272	1.48	1.42	3.61	1.05
C-SB	0.756	1.94	0.844	1.14	1.30	4.22	1.07
C-WB	0.815	0.947	0.802	1.31	1.45	4.99	ND[a]

(a) ND No data; sediment was too sandy to extract an adequate quantity of interstitial water for ammonia measurement.

Figure 3.35 shows the average dose-response of *R. abronius* to ammonia that was established from five independent studies conducted in 1994. *R. abronius* survival in the test treatments and the measured porewater ammonia concentrations for each treatment were plotted on the dose-response curve. The test treatment SF COMP had *R. abronius* survival that fell within the 95% confidence interval of the dose-response curve. However, four of the remaining test treatments (UIH COMP, SFW COMP, OBM COMP, and TB Upper COMP) that fell below the dose-response curve were not considered acutely toxic to *R. abronius* when compared with sediment from R-OS.

The test treatment TB Lower COMP falls well below the dose-response line, indicating that toxicity of this treatment cannot be attributed entirely to ammonia. This composite was further evaluated in October 1994 and the results of this evaluation are presented in Section 4.0 of this report.

3.4.2 10-Day Solid-Phase Flow-Through Test with *M. nasuta* and *N. caecoides*

The results of the 10-day solid-phase flow-through test with *M. nasuta* and *N. caecoides* are presented in Table 3.8 and Table 3.9. The *M. nasuta* test was validated by 100% survival in the native control sediment C-SB. *M. nasuta* survival for the Richmond Harbor test treatments was at least 98%, whereas survival of organisms in sediment from the reference treatment R-OS

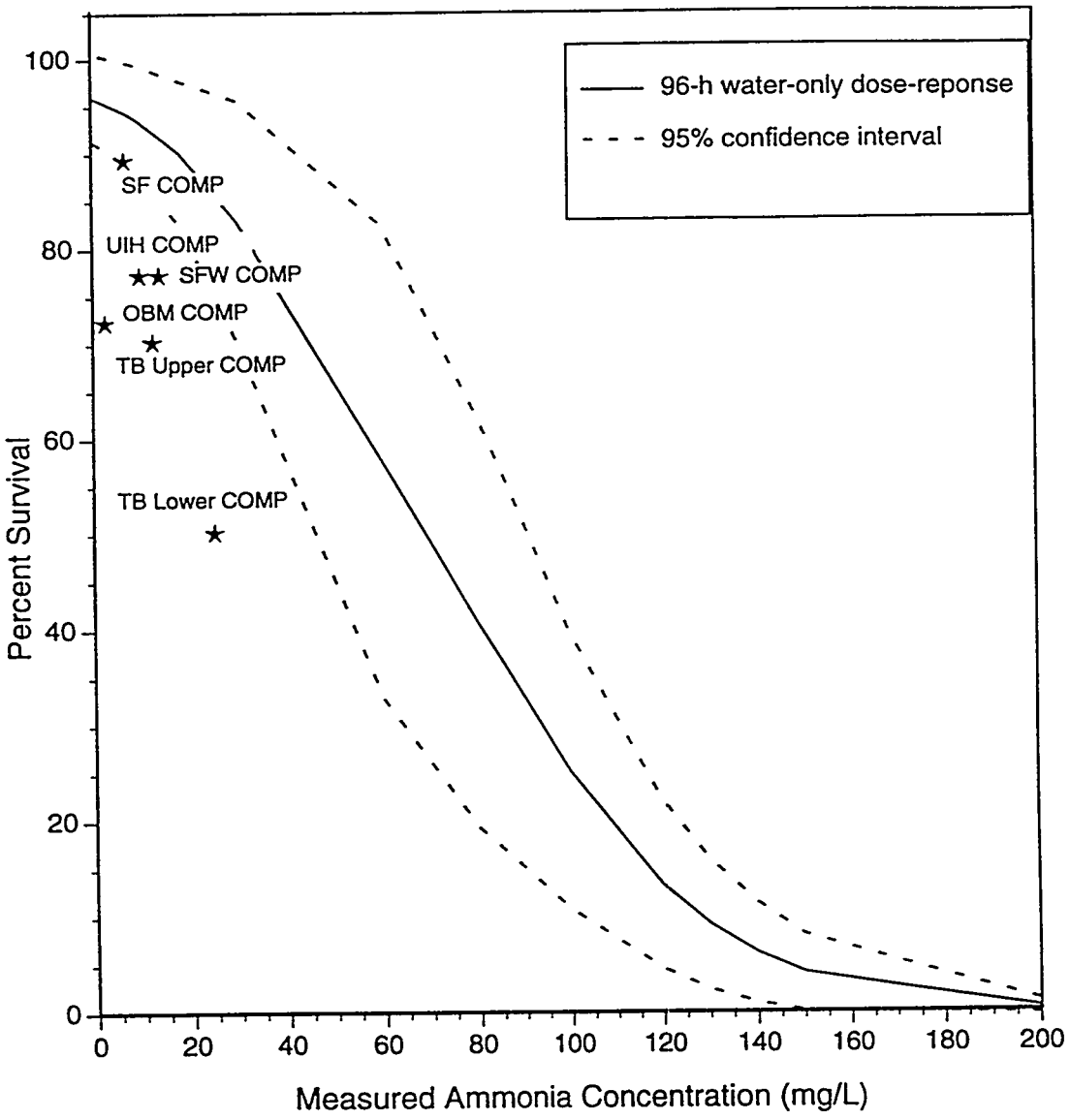


FIGURE 3.35. Response of *R. abronius* to Porewater Ammonia Concentrations in Richmond Harbor Deepening Sediments Relative to Water-Only Mean Response and 95% Confidence Interval

was 100%. Statistical analysis was performed on the data to compare the test treatments with R-OS. These results showed no statistically significant differences between organism survival in the test treatment when compared with survival in the reference treatment R-OS.

The toxicity test with *N. caecoides* was validated by 94% survival in their native control sediment C-NE. Survival of *N. caecoides* in the test treatments ranged from 38% in the OBM COMP to 96% in the TB Lower COMP. Statistical analysis of the survival results showed that sediment from three test treatments, SF COMP, SFW COMP, and OBM COMP, were acutely toxic to *N. caecoides* relative to the sediments from the reference treatment R-OS.

Ammonia concentrations were monitored in the overlying water of each sediment treatment on Days 0, 1, 3, 7, and 10 during the *M. nasuta*/*N. caecoides* solid-phase, flow-through test. Total ammonia values were generally the same or lower than the incoming flow-through seawater (≤0.45 mg/L). Unpublished data at the MSL show that *N. caecoides* survival was not affected when exposed to 90 mg/L ammonia in a 4-day test using ammonia spiked in seawater and then mixed with C-NE control sediment. Although porewater ammonia was not measured during this test because of the difficulty of removing sediment from the flow-through system, it can be inferred from other porewater ammonia data for the same sediment treatments (Table 3.10) that the sediment ammonia levels were not as high as 90 mg/L.

Sediment from SF COMP, SFW COMP, and OBM COMP had greater mortality than would be predicted based on the interstitial water ammonia concentrations. Therefore, some other contaminant in addition to or in place of ammonia is responsible for the mortality of *N. caecoides* to these sediment treatments.

3.4.3 28-Day Solid-Phase Flow-Through Test with *M. nasuta* and *N. virens*

Table 3.11 contains the results of the toxicity tests for the 28-day *M. nasuta* and *N. virens* tests. These tests were validated by 91% and 95% survival in the *M. nasuta* (C-SB) and *N. virens* (C-NE) native control sediments, respectively. The test treatment survival range for *M. nasuta* was 90% in the TB Lower COMP to 96% in the UIH COMP. The test treatment survival for the *N. virens* test ranged from 93% in SF COMP to 98% in the TB Lower COMP. Sediments from the reference treatment R-OS had 96% survival of *M. nasuta* and 98% survival of *N. virens*. Statistical analysis was not conducted on this data, since the purpose of the 28-day test was to provide results of the bioaccumulation potential of specific test treatments.

3.4.4 96-Hour Suspended-Particulate-Phase Static Test with *C. stigmaeus*

The results of the 96-h SPP static test with *C. stigmaeus* are presented in Table 3.12. The test was validated by 99% survival of *C. stigmaeus* in the 0% SPP. The survival of *C. stigmaeus* in any concentration of SPP for each test treatment was never below 98%. Results of the t-tests showed no statistically significant differences between the 100% SPP and

TABLE 3.11. Results of the 28-Day Solid-Phase Flow-Through Test with *M. nasuta* and *N. virens*, Richmond Harbor Deepening Project

Sediment Treatment	*M. nasuta* Percent Survival	*N. virens* Percent Survival
R-OS	96	98
SF COMP	95	93
SFW COMP	94	94
UIH COMP	96	96
TB Upper COMP	94	96
TB Lower COMP	90	98
OBM COMP	94	NA(a)
C-SB	91	NA
C-NV	NA	95

(a) NA Not applicable.

the 0% control for any test treatment. The LC_{50} values were not calculated because there was not a 50% reduction in survival of *C. stigmaeus*. The LC_{50} for copper was 0.88 mg/L Cu (95% confidence interval [CI]=0.77 to 1.00 mg/L Cu). These results are slightly below the LC_{50} range established from previous MSL studies (1.2 to 1.6 mg/L Cu) indicating that the test organisms were slightly more sensitive than species used in previous studies. This does not appear to have effected the results, based on the high survival of *C. stigmaeus* in all concentrations of SPP. The LC_{50} from the ammonia reference toxicant exposure was 23.9 mg/L. One other study has been conducted at the MSL with ammonia and *C. stigmaeus*; it resulted in an LC_{50} of 30.9 mg/L ammonia. Ammonia concentrations were measured in the 100% SPP of each sediment treatment on the day of initiation and again at the termination of each SPP test (Table 3.13). The total ammonia concentrations in SPP treatments were below the ammonia-effects ranges for *C. stigmaeus* derived from the two reference toxicant tests conducted at the MSL.

3.4.5 96-Hour Suspended-Particulate-Phase Static Test with *H. costata*

Table 3.14 shows the results of the toxicity test and statistical analysis for the *H. costata* test. This test was valid by a mean percent survival of 97% in the control (0% SPP) treatment. Survival in the test treatments ranged from 86% in the 100% SPP of SF COMP to 100% survival in the 50% SPP of TB Lower COMP. Results of the t-tests showed no statistically significant differences between the 100% SPP and the 0% control for any test treatment. The LC_{50} values were not calculated because there was not a 50% reduction in survival of *H. costata*.

TABLE 3.12. Summary of Mean Proportion Surviving 96-Hour *C. stigmaeus* Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Mean Percent Surviving	Survival in 100% SPP Significantly Lower Than Survival in 0% SPP	96-h LC_{50} (Percent SPP)
SF COMP	0	100		
SF COMP	10	100		
SF COMP	50	100		
SF COMP	100	100	NO	>100
SFW COMP	0	98		
SFW COMP	10	100		
SFW COMP	50	100		
SFW COMP	100	100	NO	>100
UIH COMP	0	98		
UIH COMP	10	100		
UIH COMP	50	100		
UIH COMP	100	98	NO	>100
TB Upper COMP	0	100		
TB Upper COMP	10	98		
TB Upper COMP	50	100		
TB Upper COMP	100	100	NO	>100
TB Lower COMP	0	98		
TB Lower COMP	10	100		
TB Lower COMP	50	100		
TB Lower COMP	100	100	NO	>100
OBM COMP	0	100		
OBM COMP	10	100		
OBM COMP	50	98		
OBM COMP	100	100	NO	>100

TABLE 3.13. Summary of Ammonia Concentrations Measured in the Suspended-Particulate-Phase of Sediments from the Richmond Harbor Deepening Project (all values are a mean of two replicate measurements)

Sediment Treatment	Total Ammonia in 100% SPP (mg/L) 100% SPP 0-hour	*C. stigmaeus* 96-hour	*H. costata* 96-hour	*M. galloprovincialis* 48-hour
SF COMP	2.20	4.02	4.04	2.00
SFW COMP	5.82	2.38	8.08	4.35
UIH COMP	10.2	3.02	11.4	5.50
TB Upper COMP	3.34	3.31	11.3	3.60
TB Lower COMP	7.33	4.75	11.4	5.50
OBM COMP	2.65	1.00	2.22	1.25

TABLE 3.14. Summary of Mean Proportion Surviving 96-Hour *H. costata* Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Mean Sediment Treatment	Concentration (Percent SPP)	Mean Percent Surviving	Survival in 100% SPP Significantly Lower Than Survival in 0% SPP	96-h LC_{50} (Percent SPP)
SF COMP	0	94		
SF COMP	10	98		
SF COMP	50	96		
SF COMP	100	86	No	>100
SFW COMP	0	98		
SFW COMP	10	96		
SFW COMP	50	96		
SFW COMP	100	88	No	>100
UIH COMP	0	100		
UIH COMP	10	96		
UIH COMP	50	94		
UIH COMP	100	90	No	>100
TB Upper COMP	0	96		
TB Upper COMP	10	98		
TB Upper COMP	50	96		
TB Upper COMP	100	96	No	>100
TB Lower COMP	0	98		
TB Lower COMP	10	94		
TB Lower COMP	50	100		
TB Lower COMP	100	94	No	>100
OBM COMP	0	98		
OBM COMP	10	94		
OBM COMP	50	98		
OBM COMP	100	96	No	>100

Two reference toxicant tests were used to assess *H. costata* sensitivity. The Cu reference toxicant test produced an LC_{50} of 70.7 µg/L Cu (95% CI=67.1 µg/L to 74.5 µg/L Cu). This result is similar to that from a previous study conducted at the MSL (LC_{50} of 68.3 µg/L Cu). The reference toxicant test with ammonia had an LC_{50} of 39.8 mg/L ammonia (CI= 32.3 mg/IL to 49.0 mg/L). Currently no other ammonia data are known for *H. costata*. A database of *H. costata* sensitivity to ammonia will be developed for future projects. Ammonia concentrations were measured in the 100% SPP of each sediment treatment on the day of test initiation and again at the termination of each SPP test (Table 3.13). The total ammonia concentrations in SPP treatments were below the observed LC_{50} for ammonia, suggesting that ammonia is not likely to have affected the survival rate of *H. costata*.

3.4.6 48-Hour Suspended-Particulate-Phase Static Test with *M. galloprovincialis*

The results of the 48-h suspended-particulate-phase test with *M. galloprovincialis* are presented in Table 3.15. The *M. galloprovincialis* test was validated by the high percentage of survival (90% or greater) in all the 0% SPP. The mean percentage of survival was calculated by dividing the total number of surviving larvae (sum of the normal D-shaped, the abnormal larvae, and the larval stages) by the mean of the initial stocking density of 253 embryos/10 mL for Test 1 (UIH COMP, TB Lower COMP, and SFW COMP) and 238 embryos/10 mL for Test 2 (TB Upper COMP, OBM COMP, and SF COMP). Survival of the bivalve larvae ranged from 80% in the 100% SPP of TB Upper COMP to 99% in the 50% SPP of SF COMP. Two test treatments, SFW COMP and TB Upper COMP showed statistically significant differences in larval survival between the 0% SPP and the 100% SPP. The LC_{50} could not be calculated in the test treatments because survival was always above 50%.

Normal development of the larvae to the D-shaped stage is more useful for assessing larval toxicity because abnormal or delayed development prior to this stage is suspected to lead to mortality under natural conditions. The percentage of normal embryos was calculated by dividing the number of normal D-shaped larvae at termination by the mean stocking density for each test. The percentage of normally developed larvae in the test treatments ranged from 0% in the 100% SPPs of both UIH and TB Lower COMPs to >96% in the 50% SPP of SF COMP and the 100% SPP of OBM COMP. Normal development of *M. galloprovincialis* was compared in the 0% SPP and the 100% SPP of each test treatment using a t-test. The difference in the percentage of normal larvae between the 0% and 100% SPP was statistically significantly different for four test treatments, SFW COMP, UIH COMP, TB Upper COMP, and TB Lower COMP. The EC_{50} values ranged from 57.6% SPP in UIH COMP to 80.0% SPP in SFW COMP.

Two reference toxicants, copper and ammonia, were used to assess the sensitivity of the bivalve larvae relative to that found in previous studies. Results for the copper sulfate test had

Table 3.15 Results of 48-Hour Suspended-Particulate-Phase Test with *M. galloprovincialis*

Sediment Treatment	Concentration (Percent SPP)	Mean Proportion Surviving[a]	Survival in 100% SPP Significantly Lower Than Survival in 0% SPP	LC_{50} (Percent SPP)	Mean Proportion Normal	Development in 100% SPP Significantly Lower Than Development in 0% SPP	EC_{50} (Percent SPP)
SF COMP	0	0.95			0.94		
SF COMP	10	0.97			0.96		
SF COMP	50	0.99			0.98		
SF COMP	100	0.97	NO	>100	0.96	NO	>100
SFW COMP	0	0.97			0.91		
SFW COMP	10	0.95			0.90		
SFW COMP	50	0.96			0.87		
SFW COMP	100	0.81	YES	>100	0.26	YES	80
UIH COMP	0	0.93			0.90		
UIH COMP	10	0.96			0.92		
UIH COMP	50	0.93			0.73		
UIH COMP	100	0.90	NO	>100	0.00	YES	57.6
TB Upper COMP	0	0.97			0.96		
TB Upper COMP	10	0.92			0.91		
TB Upper COMP	50	0.93			0.92		
TB Upper COMP	100	0.80	YES	>100	0.17	YES	74.8
TB Lower COMP	0	0.90			0.82		
TB Lower COMP	10	0.95			0.87		
TB Lower COMP	50	0.94			0.80		
TB Lower COMP	100	0.96	NO	>100	0.00	YES	69.7
OBM COMP	0	0.98			0.98		
OBM COMP	10	0.96			0.95		
OBM COMP	50	0.91			0.91		
OBM COMP	100	0.98	NO	>100	0.96	NO	>100

(a) Stocking density based on 253 embryos/10 mls for UIH COMP, TB Lower COMP, and SFW COMP and 238 enbryos/10 ml for TB Upper COMP, OBM COMP, and SF COMP.

LC_{50} of 24.5 µg/L (95% CI=17.2 µg/L to 26.0 µg/L) and 12.1 µg/L (95% CI=11.1 µg/L to 13.3 µg/L) for Tests 1 and 2, respectively. The EC_{50} results were 6.7 µg/L (95% CI=6.4 µg/L to 7.1 µg/L) for Test 1 and 8.0 µg/L (95% CI=7.86 µg/L to 8.04 µg/L) for Test 2. These values are within the range of responses (LC_{50} values ranging from 5.8 µg/L to 35.0 µg/L Cu; EC_{50} values ranging from 5.7 µg/L to 21.0 µg/L Cu) previously reported both by the MSL and by other scientists (Dinnel et al. 1983; EPA 1985).

The LC_{50} results from the two ammonia reference toxicant tests were 63.0 mg/L (95% CI=59.2 mg/L to 67.1 mg/L) for Test 1 and 43.2 mg/L total ammonia (95% CI=40.8 mg/L to 45.9 mg/L) for Test 2. The EC_{50} results for the ammonia reference toxicant tests were 2.23 mg/L (95% CI=2.11 mg/L to 2.36 mg/L) and 2.76 mg/L (95% CI=2.71 mg/L to 2.80 mg/L), for Tests 1 and 2, respectively.

Ammonia concentrations were measured in the 100% SPP of each sediment treatment on the day of test initiation and again at the termination of each SPP test (Table 3.13). Ammonia cannot be ruled out as a factor affecting normal development in bivalve larvae exposed to Richmond Harbor SPP treatments. The two ammonia reference toxicant tests were conducted using the same *M. galloprovincialis* larvae that were exposed in the SPP tests. In these ammonia-only tests, a reduced number of normally developed larvae was observed at low total ammonia concentrations (estimated EC_{50} values of 2.23 mg/L and 2.76 mg/L). The dose-response curve for the ammonia exposures as well as the mean percentage of normal larvae in the 100% SPP of each treatment plotted against the ammonia concentration in that 100% SPP is presented in Figures 3.36 and 3.37. Normal larval development of *M. galloprovincialis* in SF, SFW, UIH, and TB Lower COMPs is within the 95% confidence limits of the ammonia-only dose-response; this suggests that the reduced normal development of larvae in those treatments could have been largely attributed to ammonia. Normal development of *M. galloprovincialis* larvae exposed to SPP from SF COMP, TB Upper COMP, and OBM COMP falls below the lower 95% confidence limit; this suggests that the reduced normal development cannot be positively attributed to ammonia alone.

3.5 TISSUE BIOACCUMULATION

M. nasuta and *N. virens* were used in a 28-day bioaccumulation test in which they were exposed to test, reference, and control sediment treatments. The tissues of *M. nasuta* and *N. virens* exposed to the test and reference sediments were analyzed for PAHs, phthalate esters, chlorinated pesticides, PCBs, metals, and organotins. Complete tissue chemistry results in wet and dry weight, and QC data for these analyses are presented in Appendixes O and P. The appendixes also contain QA/QC summaries for each chemical parameter and contain

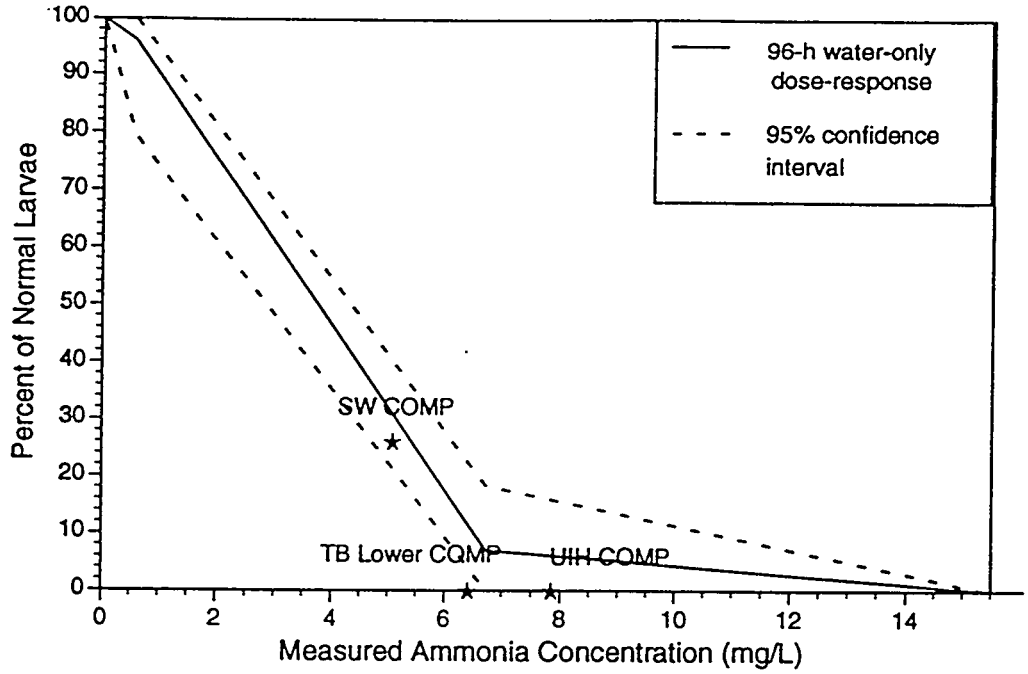


FIGURE 3.36. Response of *M. galloprovincialis* to Ammonia in 100% SPP from the Test Treatments Relative to the Water-Only Mean Response for Test 1

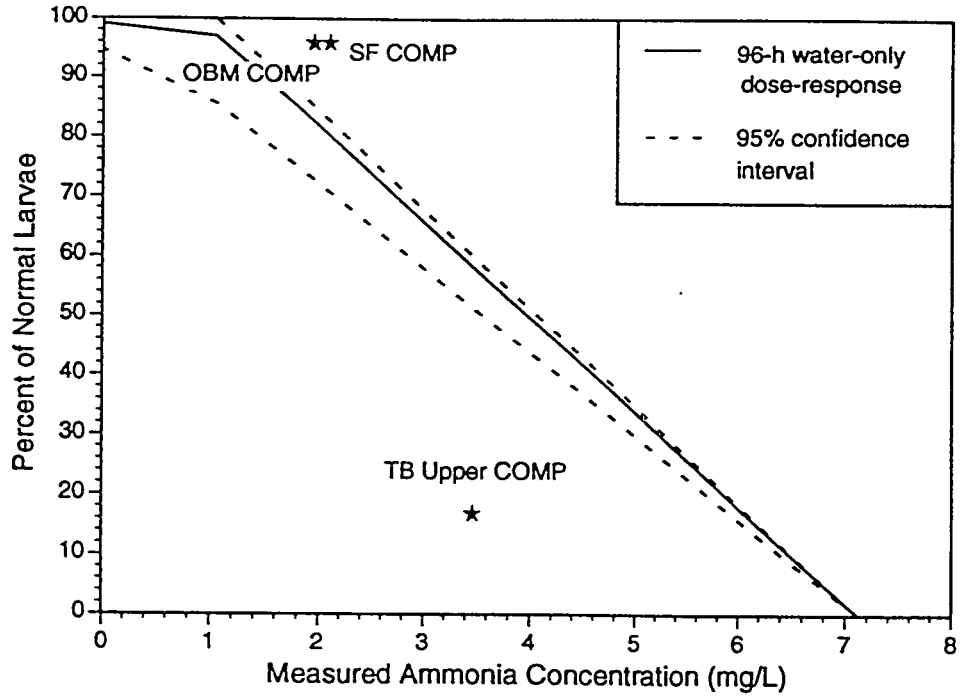


FIGURE 3.37. Response of *M. galloprovincialis* to Ammonia in 100% SPP from the Test Treatments Relative to the Water-Only Mean Response for Test 2

information regarding analytical laboratory, holding times, detection limits, dates of analysis, matrix spike data, replicate analysis, and SRM results.

3.5.1 Statistical Analyses of Bioaccumulation Results

The tissue chemistry results summarized in the following section were analyzed using Dunnett's test ($\alpha = 0.05$) for statistical comparison of all test treatments to the reference treatment R-OS. If a contaminant was detected (no U or J qualifier) in tissues exposed to any replicate test treatment and if the mean tissue concentration of the test replicates was greater than the mean tissue value of the reference treatment, a statistical comparison between test treatment and reference treatment concentrations was made. Reference treatments were used regardless of whether the values were detected or undetected. If a value was undetected (U flag), the detection limit value was used in the statistical analysis. If a compound was detected below the method detection limit (J flag), then the associated value was used for statistical analysis. When all five replicate values of a test treatment were either undetected or detected below the method detection limit (U or J qualifier), then the test treatment was not statistically compared with the reference sediment. The background tissues were taken from *M. nasuta* and *N. virens* that were held in clean sediment and then allowed to depurate prior to subsampling for chemical analysis. The purpose of the background tissues was to determine whether *M. nasuta* and *N. virens* were exposed to contaminants prior to biological testing. Background (preexposure) concentrations and control concentrations were not included in the statistical analysis. Mean contaminant concentrations and the results of the statistical comparisons are presented in the following sections.

3.5.2 Bioaccumulation Results for *M. nasuta and N. virens*

The mean values of contaminants detected in the tissues of *M. nasuta* and *N. virens* are summarized in Tables 3.16 and 3.17, respectively, for the 28-day bioaccumulation tests. The complete results are reported in Appendix O, Tables O.1 through O.27 for *M. nasuta* and Appendix P, Tables P.1 through P.27, for *N. virens*. In the appendixes, the data are reported in both wet and dry weight.

Concentrations of contaminants were compared in *M. nasuta* and *N. virens* tissues exposed to the test treatment and those exposed to the reference sediment R-OS. Table 3.18 is a summary organized by test treatment showing those compounds that were statistically significantly elevated at levels of five times or greater when compared with concentrations in the reference R-OS.

Bioaccumulation of PAHs was seen primarily in test-treated *M. nasuta* tissues and was predominantly from the HPAH compounds. Four of these HPAHs, pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene, were elevated in *M. nasuta* tissues exposed to

TABLE 3.16. Mean Values of Contaminants Detected in Tissues of *M. nasuta* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-OS when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-OS; shaded box indicates value is >5 times but ≤10 times R-OS; shaded double-lined box indicates value is >10 times R-OS)

Analyte	R-OS	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB[a]	*M. nasuta* Background[a]
PAHs, µg/kg dry weight									
Naphthalene	9.72	11.9	33.5	10.8	16.8	11.9	NA[b]	10.8	9.82 B[c]
Acenaphthylene	7.50 U	7.57 U	8.79	8.02 U	12.7	7.53 U[d]	NA	5.91 U	8.56
Acenaphthene	7.29	7.26	54.2	7.63 U	12.4	7.14 U	NA	5.99	9.61
Fluorene	12.8	12.7 U	74.7	13.9	21.3 U	12.6 U	NA	10.0	14.1 U
Phenanthrene	7.19	11.8	56.2	12.5	14.1	8.31	NA	9.37	23.9
Anthracene	20.3 U	27.4	103	26.8	35.2	20.6	NA	16.0 U	23.4
Fluoranthene	29.5 *[e]	75.7 *	673	72.4 *	58.8 *	30.0 *	NA	47.8 *	72.8 *
Pyrene	10.8 U	131	732	170	37.2	13.2	NA	8.49 U	46.6 *B
Benzo(a)anthracene	12.1 B	42.0	165	32.1 B	24.0 B	10.9 B	NA	12.3 B	13.5 B
Chrysene	10.2	45.9	136	39.2	21.8	12.7	NA	15.1	23.0 B
Benzo(b)fluoranthene	12.5	306	303	198	632	22.3	NA	24.5 *	29.5 *B
Benzo(k)fluoranthene	8.38	113	107	74.7	33.4	13.2	NA	12.3	25.4
Benzo(a)pyrene	15.7 *	171	185	116	44.5 *	20.8 *	NA	18.6 *	26.2 *B
Indeno(1,2,3-cd)pyrene	24.7 U	57.4	51.2	53.1	43.5	26.0	NA	19.5 U	33.7
Benzo(g,h,i)perylene	23.0	65.8	78.6	74.9	54.4	24.1	NA	46.8	29.6
Phthalate Esters, µg/kg dry weight									
Diethyl Phthalate	301	288 B	257	235	888	233	NA	188	210
Di-n-butyl Phthalate	330	253	358	357	368	256	NA	144 U	207
Butylbenzyl Phthalate	618 *	575	493 *	705	694	556	NA	798 *	204 U
Bis(2-ethylhexyl) Phthalate	776	859	810	906	1020	757	NA	845	502

TABLE 3.16. (contd)

Analyte	R-OS	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB[a]	*M. nasuta* Background[a]
Pesticides/PCBs, µg/kg dry weight									
beta BHC	2.3 U	2.3 U	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
delta BHC	2.3 U	2.3 U	2.6	2.4 U	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
gamma BHC	1.1	1.1 U	1.7	1.2 U	1.8 U	1.3 U	1.8 U	0.94	1.2 U
4,4'-DDD	2.1 U	489	543	182	3.6 U	2.5 U	3.4 U	1.7 U	2.4 U
4,4'-DDE	0.7 U	112	329	0.7 U	2.68	0.6 U	1.0 U	0.5 U	2.9
4,4'-DDT	1.6 U	1.6 U	1.8 U	1.7 U	3.5	1.9 U	2.6 U	1.3 U	17
Dieldrin	1.5 U	510	118	29.5	2.5 U	1.7 U	2.3 U	1.2 U	1.6 U
Endosulfan I	2.3 U	2.5	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
Aroclor 1254	160 U	160 U	210	140	140 U	150 U	150 U	150 U	140 U
Metals, mg/kg dry weight									
Silver	0.249	0.216	0.192	0.183	0.196	0.197	NA[b]	0.183	0.492
Arsenic	23.2	24.7	27.1	20.8	22.8	23.4	NA	24.2	31.2
Cadmium	0.183	0.202	0.199	0.183	0.200	0.210	NA	0.178	0.254
Chromium	2.31	1.99	2.10	2.05	2.21	2.04	NA	1.54	1.12
Copper	12.4	12.8	11.3	12.4	15.1	11.5	NA	12.4	15.1
Mercury	0.069	0.060	0.076	0.063	0.084	0.062	NA	0.051	0.063
Nickel	4.85	3.86	3.68	3.66	4.09	4.90	NA	3.02	2.62
Lead	1.11	2.11	2.30	2.11	1.57	1.24	NA	1.34	1.34
Selenium	1.84	1.69	1.79	1.66	1.65	1.57	NA	1.65	1.79
Zinc	97.0	107	110	93.9	105	96.6	NA	89.4	107
Butyltins, µg/kg dry weight									
Tributyltin	13.8	23.5	11.5	17.2	8.73	9.05	13.6	10.8	4.31
Dibutyltin	12.3	11.8	9.30	10.4	9.44 U[c]	12.0	10.9	10.1	10.3

(a) Treatment not included in Dunnett's Test data set.
(b) NA Not applicable.
(c) B All replicate values are <5 times the amount detected in the associated method blank.
(d) U Undetected in all replicates; value is mean of dry weight detection limits.
(e) * Ion Ratio out or confirmation ion not detected in all replicates.

TABLE 3.17. Mean Values of Contaminants Detected in Tissues of *N. virens* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-OS when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-OS; shaded box indicates value is >5 times but ≤10 times R-OS; shaded double-lined box indicates value is >10 times R-OS)

Analyte	R-OS	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV[a]	*N. virens* Background[a]
PAHs, µg/kg dry weight								
Naphthalene	19.9	20.5	25.3	20.2	20.0	18.6	26.5	15.6 B[b]
Acenaphthylene	11.9 U	14.6 U	14.7	14.7 U[c]	12	12.3 U	19.1	14.2
Acenaphthene	11.7	**16.8**	65.5	14.0	12.1	13.0	20.1	13.6
Phenanthrene	13.7*[d]	15.4	**28.2**	15.7 *	13.2 *	13.0	19.1	13.8 B
Anthracene	34.4	40.9	41.2	40.2	31.8	33.5 U	49.4	37.7 U
Fluoranthene	36.8 *	46.5	**84.1**	45.8 *	38.6 *	36.2 *	59.2 *	44.8 *
Pyrene	42.6 *B	51.7 *B	**84.6** B	52.0 B	41.7 *B	38.3	63.5 *B	50.7 *B
Benzo(a)anthracene	16.7 B	21.0 *B	**24.9** B	20.0 B	15.8 B	16.3 *B	26.0 *B	20.1 B
Chrysene	9.47 U	**17.1**	**29.6**	14.3	11.8	11.2	18.9	18.2
Benzo(b)fluoranthene	4.03 U	44.2	53.3	35.1	17.8	11.2	25.0	38.4
Benzo(k)fluoranthene	21.1	38.8	**49.5** *	**45.9** *	26.3	26.5	33.9	42.5 *B
Benzo(a)pyrene	27.4 *	37.1	42.5 *	36.0 *	25.7 *	27.8	38.8 *	34.3 *B
Indeno(1,2,3-cd)pyrene	39.4 U	50.2	47.5 U	53.3	38.7 U	40.7 U	59.8 U	46.0 U
Benzo(g,h,i)perylene	39.0	**59.6**	**58.1**	48.8	36.0	37.7	57.0	44.1
Phthalate Esters, µg/kg dry weight								
Diethyl Phthalate	290 U	358	350 U	358 U	285 U	300 U	441 U	344
Butylbenzyl Phthalate	315	543	408	426	290	312	461	366
Bis(2-ethylhexyl) Phthalate	554	669	764	727	731	782	1020	693
Di-n-octyl Phthalate	290 U	355 U	350 U	358 U	464	300 U	441 U	869 U

TABLE 3.17. (contd)

Analyte	R-OS	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV[a]	*N. virens* Background[a]
Pesticides/PCBs, µg/kg dry weight								
Aldrin	1.30 U	2.47	8.92	1.64 U	1.32 U	1.36 U	5.78	9.82
4,4'-DDD	3.38 U	138	374	58.7	3.34 U	3.52 U	5.18 U	3.96 U
4,4'-DDE	1.00 U	9.70	1.22 U	4.32	1.04 U	1.06 U	1.58 U	4.13
4,4'-DDT	5.76	37.6	34.4	23.8	8.18	13.3	23.9	2.98 U
Dieldrin	2.90	47.6	151	28.9	3.10	2.36 U	5.05	2.64 U
Metals, mg/kg dry weight								
Silver	0.426	0.303	0.309	0.295	0.348	0.174	0.251	0.246
Arsenic	15.3	14.3	14.8	14.6	14.6	14.7	16.6	15.5
Cadmium	0.360	0.331	0.347	0.367	0.364	0.326	0.298	0.293
Chromium	1.11	1.35	0.997	0.930	1.25	1.62	0.898	9.37
Copper	10.4	11.0	10.6	10.8	10.5	11.0	8.95	13.7
Mercury	0.234	0.213	0.217	0.229	0.231	0.211	0.202	0.218
Nickel	1.91	1.70	1.62	1.56	2.17	3.53	1.13	3.86
Lead	0.815	1.03	1.02	0.900	1.04	0.912	0.911	1.03
Selenium	1.85	1.88	1.84	1.93	2.03	1.91	1.81	2.13
Zinc	157	270	197	200	240	177	214	208
Butyltins, µg/kg dry weight								
Tributyltin	4.23	3.90	3.91	3.60 U[b]	3.70	3.64 U	3.57 U	3.44 U
Dibutyltin	10.5	16.0	11.1	20.7	10.9	11.0	15.1	9.96 U

(a) Treatment not included in Dunnett's Test data set.
(b) B All replicate values are <5 times the amount detected in the associated method blank.
(c) U Undetected in all replicates; value is mean of dry weight detection limits.
(d) * Ion Ratio out or confirmation ion not detected in all replicates.

TABLE 3.18. Summary of Test Treatments with Statistically Significant Elevations in the Tissues of Either *M. nasuta* or *N. virens* at Levels Greater than Five Times Those of the Reference Treatment R-OS (number shown is the magnitude above the reference treatment R-OS).

Sediment Treatment	Analyte	*M. nasuta*	*N. virens*
SF COMP	Pyrene	12	---(a)
	Benzo(b)fluoranthene	24	10
	Benzo(k)fluoranthene	13	—
	Benzo(a)pyrene	10	—
	4,4'-DDD	232	40
	4,4'-DDE	160	9
	4,4'-DDT	—	6
	Dieldrin	34	16
SFW COMP	Acenaphthene	7	5
	Fluorene	5	—
	Phenanthrene	78	—
	Anthracene	5	—
	Fluoranthene	22	—
	Pyrene	67	—
	Benzo(a)anthracene	13	—
	Chrysene	13	—
	Benzo(b)fluoranthene	24	13
	Benzo(k)fluoranthene	12	—
	Benzo(a)pyrene	11	—
	4,4'-DDD	258	110
	4,4'-DDE	470	6
	4,4'-DDT	—	5
	Dieldrin	78	52
	Aldrin	—	6
UIH COMP	Pyrene	15	—
	Benzo(b)fluoranthene	15	8
	Benzo(k)fluoranthene	8	—
	Benzo(a)pyrene	7	—
	4,4'-DDD	86	16
	Dieldrin	19	9
TB Upper COMP	Benzo(b)fluoranthene	5	—
TB Lower COMP	Compounds were not statistically significant at levels 5 times or greater than R-OS.		
OBM COMP	Compounds were not statistically significant at levels 5 times or greater than R-OS.		

(a) — Analyte was not statistically significantly elevated at levels five times or greater than levels in the tissue of R-OS.

SF COMP, SFW COMP, and UIH COMP at levels ranging from 7 times up to 67 times those in tissues exposed to the reference sediments, henceforth called *reference levels*. The HPAH benzo(b)fluoranthene was also elevated in *N. virens* tissues exposed to SF COMP, SFW COMP, and UIH COMP at levels up to 13 times those of the reference levels. Phthalate esters were not statistically significantly bioaccumulated in the tissues of either species.

At least one of the five pesticides, (4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dieldrin, or aldrin), among the 18 analyzed, bioaccumulated in one or both species exposed to sediment from SF COMP, SFW COMP, and UIH COMP. These compounds were elevated between 5 times and up to 470 times over the reference levels.

M. nasuta and *N.virens* tissues exposed to most test treatments did not bioaccumulate metals or butyltins at levels ≥ 5 times over the reference levels. Relative to concentrations found in tissues exposed to R-OS, there was a statistically significant difference in the concentration of each of the following: Pb in *M. nasuta* tissue exposed to SF COMP, SFW COMP, UIH COMP, and TB Upper COMP; Ni in *N. virens* tissues exposed to TB Lower COMP; TBT in *M. nasuta* tissues exposed to SF COMP; and DBT in *N. virens* tissues exposed to UIH COMP.

Concentrations of pesticides, PCBs, and butyltins were compared in *M. nasuta* tissues exposed to test treatment OBM COMP and those exposed to the reference sediment R-OS. Relative to concentrations found in tissues exposed to R-OS, there was no statistically significant elevation of any of the contaminants analyzed.

4.0 RESULTS OF THE ANALYSIS OF THE INTENSIVE STUDY OF THE TURNING BASIN

The results presented in Section 3.0 of this report showed that TB Lower COMP was acutely toxic to the amphipod, *R. abronius,* when compared with the survival of *R. abronius* exposed to R-OS. The larvae of the bivalve, *M. galloprovincialis,* also showed acute toxicity when exposed to the SPP from this sediment treatment. Porewater and overlying ammonia concentrations were monitored, as appropriate, for both toxicity tests. Figure 3.35 shows the dose-response of *R. abronius* survival plotted against the initial porewater ammonia concentrations measured in each sediment treatment. Survival of *R. abronius* exposed to TB Lower sediments is less than expected based upon the 4-day dose-response curve and 95% confidence limits. This reduced survival suggests that the toxicity of this sediment treatment cannot be attributed entirely to ammonia. Figure 3.36 shows the dose-response of the number of normally developed larvae of *M. galloprovincialis* plotted against the measured porewater ammonia concentrations in the 100% SPP of each sediment treatment. This figure suggests that the reduction in normal development of bivalve larvae exposed to the 100% SPP of TB Lower COMP is closely related to the concentration of ammonia.

An examination of sediment chemistry data from the Turning Basin samples showed that most contaminants of concern were located at one station, TB-4. Since the Turning Basin represents approximately 333,500 cubic yards of potential dredged material, higher resolution testing of this area was requested by USACE and EPA and conducted in October 1994. The Turning Basin was originally characterized by seven field stations. Two additional stations, TB-8 and TB-9, located to the northeast and southwest of station TB-4, were sampled in an effort to determine contaminant concentrations and effects in this area (Figure 4.1). Each core representing TB-1 through TB-9 was subjected to a geological description, chemical analysis, and a 10-day *R. abronius* test. By treating each core separately, more conclusive information was obtained concerning the nature and extent of chemical contamination and potential toxicity in Turning Basin sediment. This study will be referred to as the Intensive Study of the Turning Basin.

In addition to sampling in the Turning Basin, sediment was also collected from four other Richmond Harbor stations (UIH-2, UIH-4, SFW-1 and SFW-3). The older bay mud portion of cores from these stations were combined into an OBM COMP (Figure 4.1). The OBM COMP was analyzed for sediment chemical parameters and used in a standard 10-day *R. abronius* toxicity test.

The methods used in the Intensive Study of the Turning Basin, including those specific to collecting test, reference, and control samples; obtaining test organisms; preparing sediment samples; conducting chemical analysis; performing toxicity tests; interpreting and analyzing data; and following QA/QC procedures, were previously described in Sections 2.1 through 2.6 of this

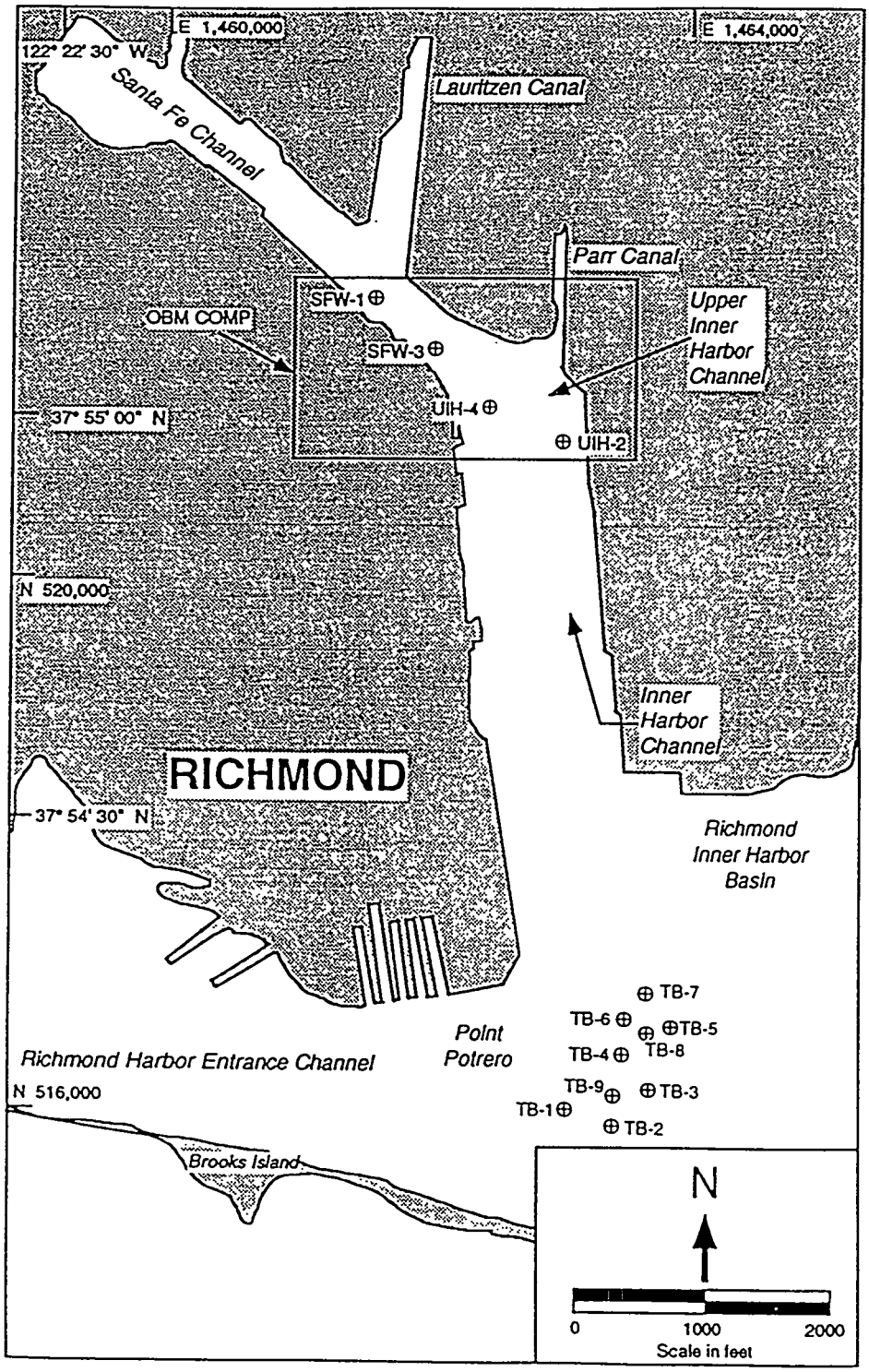


FIGURE 4.1. Sampling Stations for the Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

report. The only difference in these methods was that TOC analyses for the Turning Basin sediments and the OBM COMP were performed by ARI rather than by Global Geochemistry. Briefly, ARI used the method described in Plumb 1981, which involves direct combustion at 850°C in a resistance furnace. Combustion products are carried in the oxygen stream through a catalytic converter (to assure complete oxidation to CO_2) and into the IR machine. Prior to analysis, samples are purged of inorganic carbon by acidification, dried at 70°C, and then ground to pass through a 120-µm mesh sieve. The methods used by ARI and Global Geochemistry are comparable in performing TOC analysis.

4.1 SEDIMENT COLLECTION AND SAMPLE PREPARATION

The field sampling effort occurred over a 2-day period on October 11 and 12, 1994. Sediment core samples were collected to -40 ft MLLW from the nine Turning Basin stations and to -42 ft MLLW from the four stations composited to form the OBM COMP. Either the 4-in. and 12-in. core barrels were used to collect these sediments. Sediments were also collected from the three reference areas (R-OS, R-BF, and R-AM) and two control areas (C-WB and C-SB). Table 4.1 summarizes the field sampling information. Table 4.2 contains field collection information for the reference and control treatments.

The reference sediments were collected with a pipe dredge deployed from the *F/V Cobra* as described in Section 2.1.2. One station was sampled to represent R-OS (Figure 3.2), four stations were sampled to represent R-BF (Figure 3.3), and seven stations were sampled to represent R-AM. Station R-AM-F was omitted from the R-AM composite because when the individual stations surrounding Alcatraz Island were chemically analyzed in January 1994, R-AM-F had much higher levels of LPAHs and HPAHs relative to the other stations (Appendix C, Tables C.8 and C.9). Consequently, USACE decided to omit R-AM-F from the R-AM composite. Sediment was collected from C-SB, the experimental grain size control, using a van Veen grab sampler, and from C-WB, the native control sediment for the *R. abronius* test (Figures 3.5 and 3.6) using the amphipod dredge sampler.

Navigation support was provided by Sea Surveyors of Benicia, California. A laser/range azimuth positioning system was used to position the barge at the correct sampling locations. Water depths were checked and recorded at each station by measuring the actual depth with a recording fathometer, measuring the water surface elevation, and calculating the difference between the water surface elevation and 0 ft MLLW.

The characteristics of the Richmond Harbor Turning Basin sediments were geologically described from mudline to -40 ft MLLW using the 4-in. core samples. The cores were logged according to ASTM Procedure D2488-84 (ASTM 1984) as previously described in Section 3.2 of

TABLE 4.1. Sampling Information for Richmond Harbor Turning Basin, Intensive Study of the Turning Basin (4-in. core was collected at each station)

Station	California State Plane Coordinates (Zone III) North	East	Latitude (N)	Longitude (W)	Mudline (-ft MLLW)	Depth of Core Used for Testing (-ft MLLW)
Upper Sections						
TB-1	515,991.57	1,463,063.01	37° 54' 08.713"	122° 21' 43.661"	30.6	30.6 to 35.6[a]
TB-2	515,866.32	1,463,411.22	37° 54' 07.543"	122° 21' 39.287"	6.5	6.5 to 11.5
TB-3	516,137.50	1,463,700.97	37° 54' 10.280"	122° 21' 35.739"	5.1	5.1 to 10.1
TB-4[b]	516,409.71	1,463,492.21	37° 54' 12.930"	122° 21' 38.411"	28.4	28.4 to 33.4
TB-5	516,617.02	1,463,878.19	37° 54' 15.055"	122° 21' 33.647"	7.3	7.3 to 12.3
TB-6	516,679.64	1,463,514.96	37° 54' 15.603"	122° 21' 38.194"	33.7	33.7 to 38.7
TB-7	516,867.52	1,463,673.61	37° 54' 17.491"	122° 21' 36.261"	10.3	10.3 to 15.3
TB-8	516,585.28	1,463,657.75	37° 54' 14.698"	122° 21' 36.389"	7.5	7.5 to 12.5
TB-9	516,114.12	1,463,430.42	37° 54' 09.996"	122° 21' 39.109"	31.3	31.3 to 36.3
Lower Sections						
TB-1	515,991.57	1,463,063.01	37° 54' 08.713"	122° 21' 43.661"	NA[c]	35.6 to 40.0
TB-2	515,866.32	1,463,411.22	37° 54' 07.543"	122° 21' 39.287"	NA	11.5 to 40.0
TB-3	516,137.50	1,463,700.97	37° 54' 10.280"	122° 21' 35.739"	NA	10.1 to 40.0
TB-4	516,409.71	1,463,492.21	37° 54' 12.930"	122° 21' 38.411"	NA	38.8 to 40.0
TB-5	516,617.02	1,463,878.19	37° 54' 15.055"	122° 21' 33.647"	NA	12.3 to 40.0
TB-6	516,679.64	1,463,514.96	37° 54' 15.603"	122° 21' 38.194"	NA	38.7 to 40.0
TB-7	516,867.52	1,463,673.61	37° 54' 17.491"	122° 21' 36.261"	NA	15.3 to 40.0
TB-8	516,585.28	1,463,657.75	37° 54' 14.698"	122° 21' 36.389"	NA	12.5 to 40.0
TB-9	516,114.12	1,463,430.42	37° 54' 09.996"	122° 21' 39.109"	NA	36.3 to 40.0
UIH-2[d]	521,006.09	1,463,026.02	37° 54' 58.271"	122° 21' 45.368"	NA	40.6 to 42.0
UIH-4[d]	521,259.72	1,462,444.64	37° 55' 00.664"	122° 21' 52.685"	NA	39.0 to 42.0
SFW-1[d]	522,094.73	1,461,576.21	37° 55' 08.747"	122° 22' 03.728"	NA	39.4 to 42.0
SFW-3[d]	521,710.61	1,462,016.69	37° 55' 05.037"	122° 21' 58.136"	NA	37.1 to 42.0

(a) TB Upper COMP was representative of TB stations from mudline to 5 ft below mudline. The sediment from this depth was archived in case chemical analysis was required.
(b) TB-4 Middle COMP was composed of sediment from -33.4 to -38.8 ft MLLW.
(c) NA Not applicable.
(d) Older bay mud (OBM) sediment was collected from these stations using the 12-in. core barrel.

TABLE 4.2. Reference and Control Sediment Sampling Data

Reference Area	Station	Station Location		Depth (ft)	Volume (gal)
		Latitude (N)	Longitude (W)		
Bay Farm	R-BF 2	37°44.63'	122°16.75'	20	5
	R-BF 3	37°44.34'	122°16.74'	28	5
	R-BF 4	37°44.38'	122°16.60'	31	5
	R-BF 5	37°44.54'	122°16.60'	31	5
	TOTAL R-BF				20
Alcatraz Environs	R-AM A	37°49.75'	122°25.88'	62	3
	R-AM B	37°49.79'	122°25.40'	45	3
	R-AM C	37°49.76'	122°24.89'	69	3
	R-AM D	37°49.27'	122°25.82'	70	3
	R-AM G	37°48.80'	122°25.84'	45	3
	R-AM H	37°48.82'	122°25.57'	50	3
	R-AM I	37°48.83'	122°24.90'	50	3
	TOTAL R-AM				21
Deep Off-Shelf Area	R-OS	37°24.86'	123°14.38'	4400	8
Sequim Bay Control	C-SB	48°03.70'	123°01.50'	25-30	10
Tomales Bay Control	C-NE	38°13.83'	122°57.67'	intertidal	10
West Beach Control	C-WB	48°23.83'	122°40.00'	15-20	5

this report. A detailed description of the methods used to describe each core is presented in Appendix A. Appendix B contains the core logs for both the January and October 1994 field sampling efforts.

Nine cores were collected in the proposed turning basin east of Point Potrero (TB-1 through TB-9). Core locations are shown in Figure 4.1. Sediment characteristics were similar to those observed in the January 1994 cores collected from the same locations. The YBM ranged in thickness from 3.8 ft at station TB-1 to greater than 33.5 ft at station TB-2.

The OBM was encountered at three stations: TB-1, TB-7, and TB-8. The elevation of the YBM/OBM contact at these stations was -34.4 ft MLLW, -33.6 ft MLLW, and -37.2 ft MLLW, respectively. The OBM at station TB-1 consisted of olive gray and olive brown, soft to firm interbedded clayey gravel and silt. The OBM at stations TB-7 and TB-8 consisted of dark gray firm clayey silt.

The YBM was composed primarily of dark gray, very soft to soft clay containing numerous whole and fragmented clam shells (*Macoma sp.*). At stations TB-6, TB-7, and TB-9,

the uppermost 3 ft to 5 ft of sediment had a disrupted texture characterized by a mixture of the dark gray clay found at the other stations and oily, black silty clay with shreds of wood and a hydrocarbon odor. At station TB-4, the disrupted layer extended to 10.4 ft below the mudline.

The sediment from each 4-in. core was split into two composite samples except for TB-4, which was split into three composite samples. One sample consisted of sediment from mudline to 5 ft below the mudline, and the other consisted of sediment from 5 ft below the mudline to the project depth of -40 ft MLLW. In the core from station TB-4, sediment from -33.4 ft to -38.8 ft MLLW, representing the middle section, was composited separately because of its disrupted appearance and hydrocarbon odor. An aliquot of the sediment from mudline to 5 ft below mudline from each core was archived in 1-lL glass containers in the event that additional analyses would be required.

The sediment from 5 ft below mudline to -40 ft MLLW was thoroughly mixed for each station, subsampled for chemistry, and used for biological testing. The OBM COMP sediment was collected using the 12-in. core barrel. The OBM sediment was taken from depths ranging from -37 ft to -40.6 ft MLLW from the four stations contributing to the OBM COMP (UIH-2, UIH-4, SFW-1, and SFW-3). These sediments were thoroughly mixed to create the OBM COMP that was submitted for chemical analysis and biological testing.

Sediments from the reference and control treatments were processed in the same manner as the test treatments with one exception. The reference and control sediments were press-sieved through 0.5 or 1.0-mm mesh to remove organisms, and then homogenized and subsampled for chemical analysis.

4.2 SEDIMENT CHEMISTRY

4.2.1 Sediment Conventional Measurements

The sediment conventional measurements analyzed in the turning basin sediments are grain size, TOC, TVS, oil and grease, and TPH. Grain size, TOC, and TVS are expressed as percentages of dry weight of sample. Oil and grease and TPH are expressed as mg/kg dry weight. Table 4.3.summarizes the results of these analyses. The complete results, including QA/QC summaries, are presented in Appendix D, Tables D.1 through D. 6. The results of the conventional analysis of the sediment treatments are also graphically illustrated in Figures 4.2 through 4.6. The chemical analyses of the OBM COMP are also reported in the appropriate sections. The grain size results from the Richmond Harbor Intensive Study of the Turning Basin were similar to those obtained during the January 1994 study. The Turning Basin test treatments, TB-2 Lower through TB-9 Lower, the reference treatment, R-OS, the OBM COMP, and the control treatment, C-SB, were all predominantly fine-grained with 74% to 96% of these

TABLE 4.3. Conventional Sediment Measurement Results for the Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Percent Dry Weight: Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	mg/kg Dry Weight: Oil and Grease	TPH
R-OS	0	26	53	21	1.0	2.4	100	77
TB-1 Lower	13	49	23	15	0.11	0.79	14	9.9 U[a]
TB-2 Lower	3	18	47	32	0.67	2.3	50	27
TB-3 Lower	1	15	50	34	0.67	2.1	40	16 U
TB-4 Middle	0[b]	4[b]	48[b]	48[b]	1.1	2.6	18 U	18 U
TB-4 Lower	0	10	44	46	0.58	2.1	16 U	16 U
TB-5 Lower	0	7	54	39	0.90	2.2	56	58
TB-6 Lower	1	5	40	54	0.81	2.6	17 U	17 U
TB-7 Lower	1	7	53	39	0.70	2.4	15 U	15 U
TB-8 Lower	0	6	55	39	0.76	2.6	43	16 U
TB-9 Lower	0	15	44	41	0.59	2.1	20	16 U
OBM COMP	0	18	56	26	0.16	1.9	11 U	11 U

(a) U Undetected at or above the detection limit.
(b) Value is mean of the replicate analysis.

sediments in the silt and clay categories. Sediments from test treatment TB-1 Lower and C-WB were predominantly sand.

Percentages of TOC ranged from 0.11% to 1.1%. The level of TOC in the R-OS sediments (1.0%) was only exceeded by that in sediment from TB-4 Middle. The percentage of TOC in OBM COMP was 0.16%. The percentages of TVS in the test treatments ranged from 0.79% to 2.6%; the percentage of TVS in the reference treatment was 2.4%. Sediment from TB-4 Middle, TB-6 Lower, and TB-8 Lower had higher concentrations of total volatile solids than that in R-OS. The OBM COMP had a TVS value of 1.9%. These results were comparable to those found during the January 1994 effort.

Oil and grease concentrations were above detection limits in most of the test treatments, ranging from 14 mg/kg to 56 mg/kg. The concentration of oil and grease in the reference sediment R-OS was twice the detected concentrations in the test treatments. Only two test treatments, TB-2 Lower (27 mg/kg) and TB-5 Lower (58 mg/kg), had detectable concentrations of TPH. Again, the reference treatment R-OS had higher concentrations of TPH (77 mg/kg). The oil and grease and TPH concentrations for test treatments TB-4 Middle and TB-5 Lower do not concur with the concentrations of other organics found in these sediments and should be considered suspect.

FIGURE 4.2. Grain Size Distribution in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

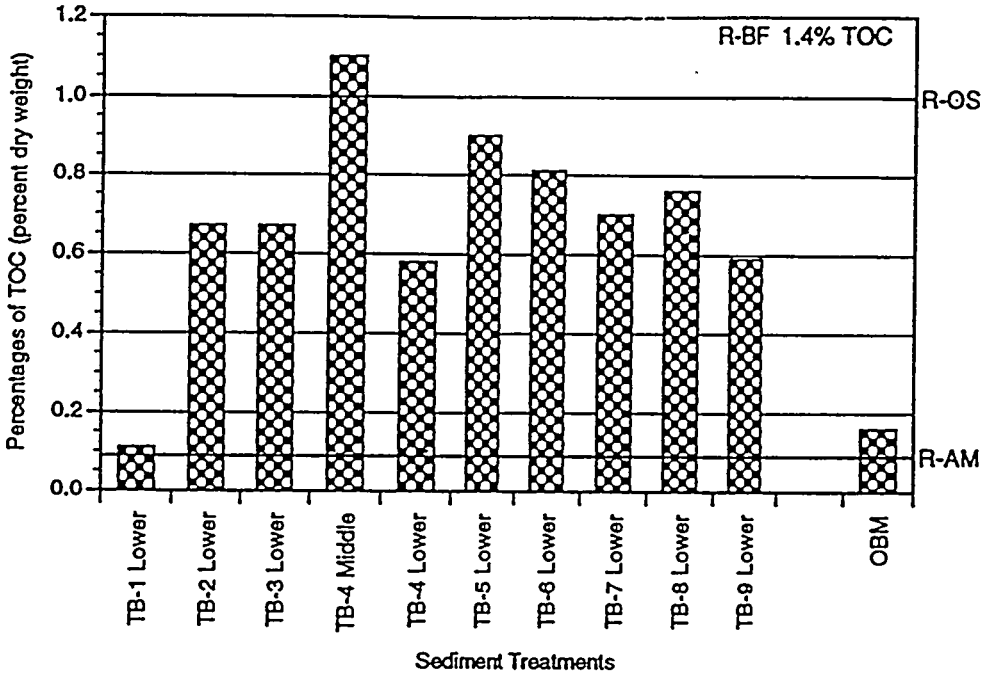


FIGURE 4.3. Percentage of TOC in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

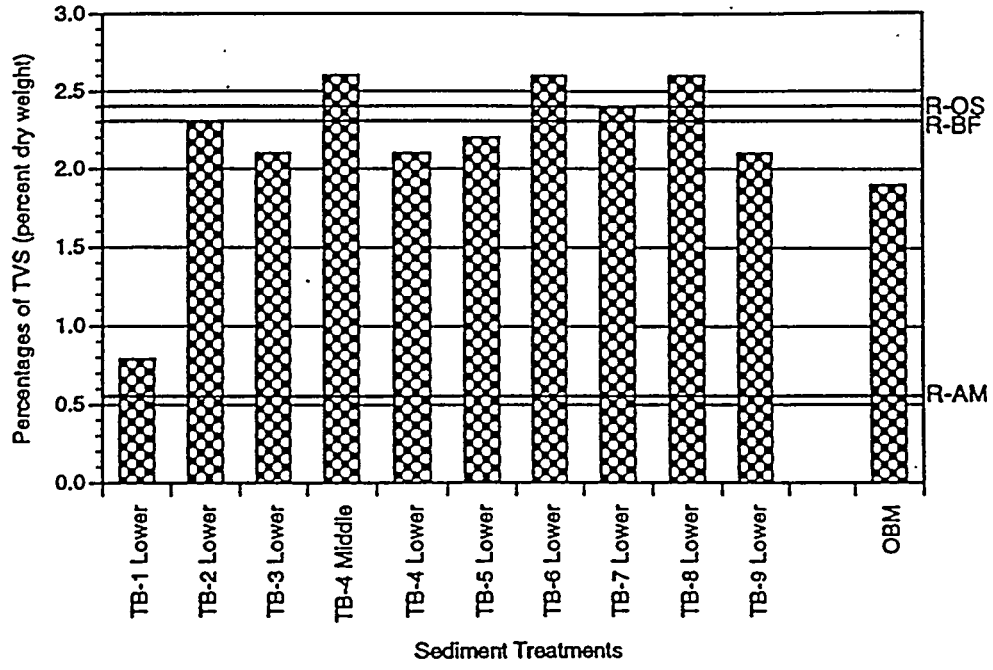


FIGURE 4.4. Percentage of TVS in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

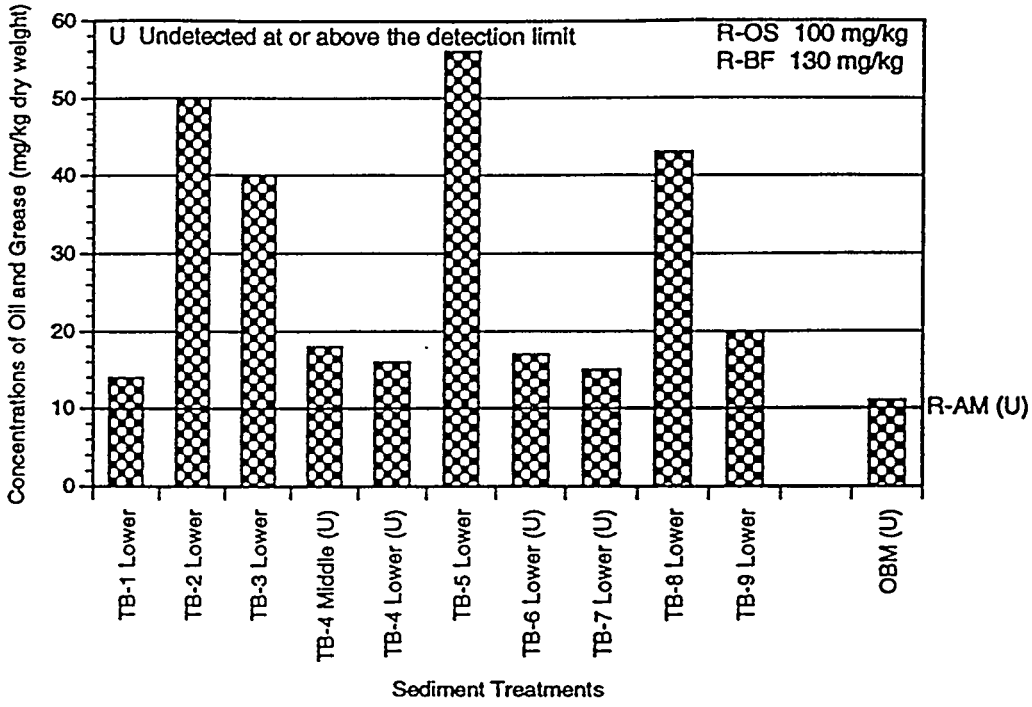


FIGURE 4.5. Concentrations of Oil and Grease in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

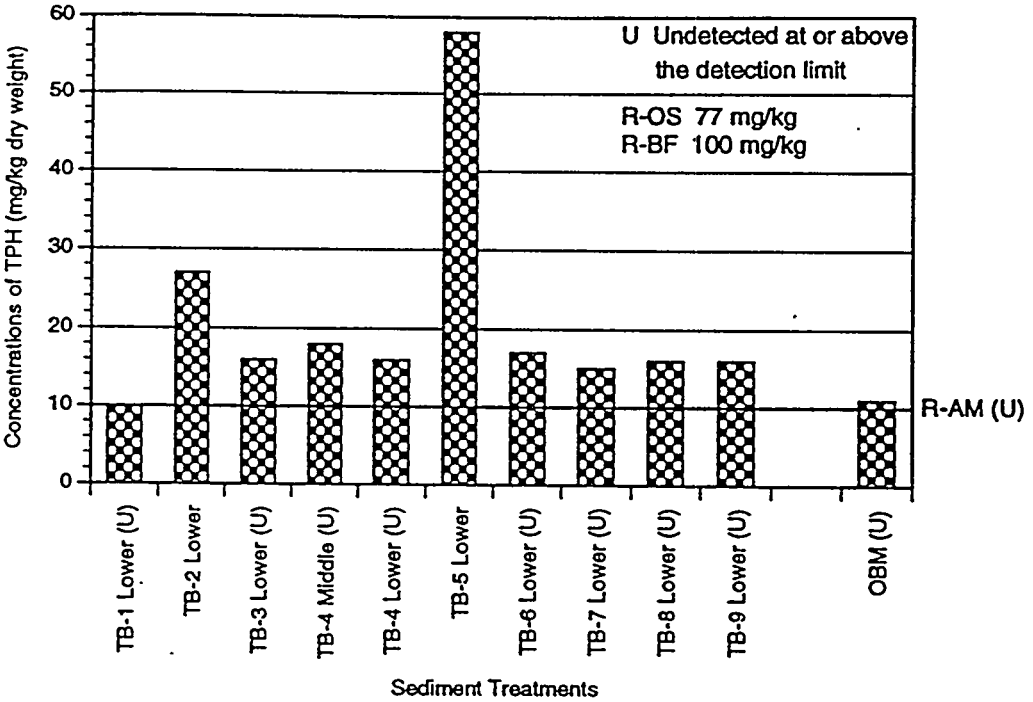


FIGURE 4.6. Concentrations of TPH in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

4.2.2 Polynuclear Aromatic Hydrocarbons

The Richmond Harbor Intensive Study of the Turning Basin sediment treatments were analyzed for 16 PAHs as listed in the *1991 Implementation Manual*. The complete results including QA/QC results are reported in Appendix D, Tables D.7 through D.12.

Table 4.4 is a summary of those organic compounds that were detected in at least one of the test treatments. Figure 4.7 is a graph showing the concentrations of PAHs in the test treatments relative to PAH concentrations in the reference sediments. The concentrations of LPAHs and HPAHs in the reference sediment R-OS were higher than those of the test treatments, with the exception of the TB-4 Middle stations. The sediment concentrations of LPAHs and HPAHs in the TB-4 Middle sediment were 339 µg/kg and 2355 µg/kg, respectively. The OBM COMP had a total LPAH concentration of 29 µg/kg and a total HPAH concentration of 28 µg/kg.

4.2.3 Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs)

Eighteen pesticides and four PCB congeners were analyzed in the sediments from the Richmond Harbor Intensive Study of the Turning Basin. The complete results including QA/QC results are reported in Appendix D, Tables D.13 through D.19. Four pesticides and one Aroclor congener were detected in at least one sediment treatment (Table 4.4). Detected concentrations

TABLE 4.4. Detected Total PAHs, Pesticides, and PCBs in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (values in µg/kg dry weight)

Sediment Treatment	Total LPAHs	Total HPAHs	Aldrin	4,4'-DDD	4,4'-DDE	4,4'-DDT	Aroclor 1254
R-OS	65	124	0.25 U[a]	0.31 U	1.29	0.87 U	20 U
R-BF	355	2116	2.15	5.19	2.61	1.19 U	46.8
R-AM	538	1055	1.32	0.21 U	0.11 U	0.58 U	20 U
TB-1 Lower	17	37	0.17 U	0.21 U	0.11 U	0.58 U	20 U
TB-2 Lower	22	36	0.66	0.17 U	0.09 U	0.47 U	20 U
TB-3 Lower	38	58	0.21 U	0.26 U	0.14 U	0.74 U	20 U
TB-4 Middle	339	2355	1.15	19.3	15.1	9.3	101
TB-4 Lower	47	66	0.21 U	0.26 U	0.14 U	0.72 U	20 U
TB-5 Lower	51	62	0.22 U	0.27 U	0.15 U	0.76 U	20 U
TB-6 Lower	52	67	1.17	0.29 U	0.16 U	0.83 U	20 U
TB-7 Lower	35	69	1.69	0.27 U	0.15 U	0.77 U	20 U
TB-8 Lower	38	67	0.97	0.27 U	0.15 U	0.76 U	20 U
TB-9 Lower	43	62	0.35 U	0.43 U	0.24 U	1.21 U	20 U
OBM COMP	29	28	0.18 U	0.22 U	0.12 U	0.63 U	20 U

(a) U Undetected at or above the detection limit.

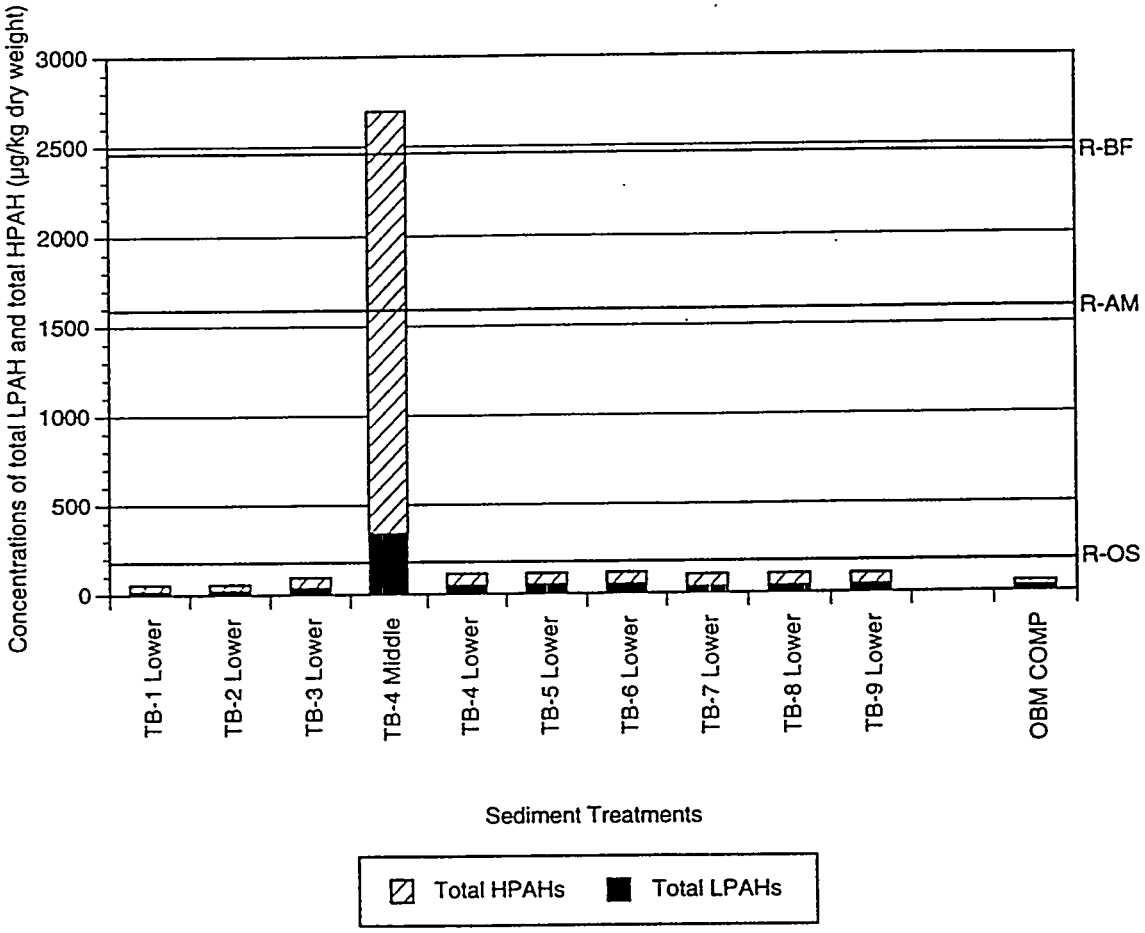


FIGURE 4.7. Concentrations of Total PAH in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

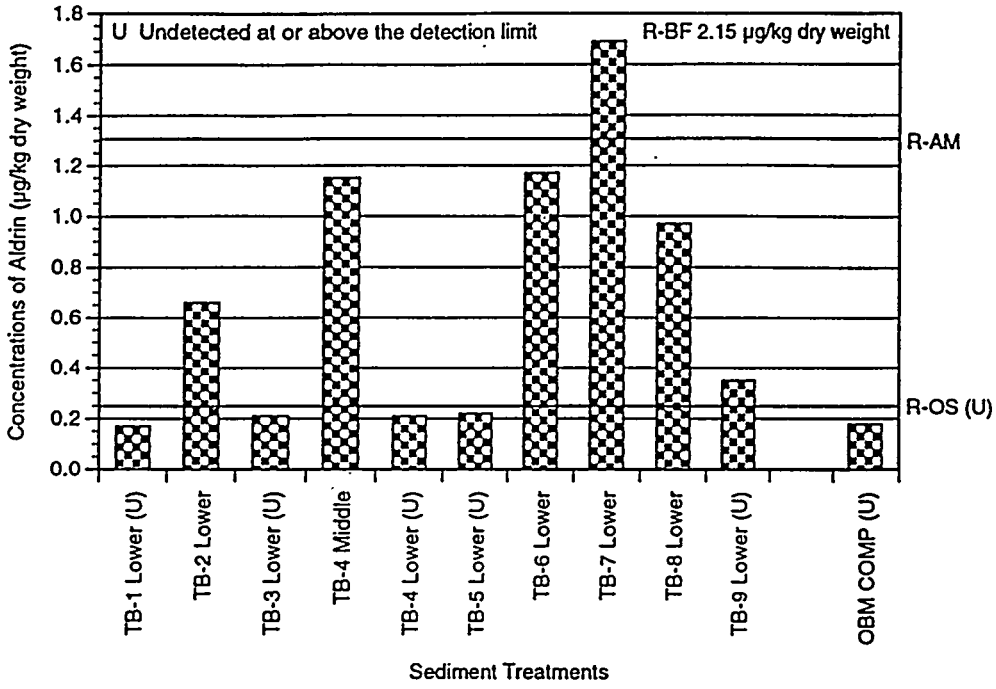


FIGURE 4.8. Concentrations of Aldrin in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

of aldrin ranged from 0.66 µg/kg to 1.69 µg/kg in the test treatments; aldrin was undetected in R-OS sediments. The test treatment TB-4 Middle had detectable concentrations of 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and Aroclor 1254. The concentrations of these pesticides and Aroclor 1254 were at least five times higher than concentrations in the reference treatment R-OS. Pesticides and PCBs were not detected in sediments from the OBM COMP. Figures 4.8 through 4.12 show the relationship between concentrations of pesticides and Aroclor 1254 in the test treatments plotted against those found in the reference treatments.

4.2.4 Metals

Ten metals were analyzed in the Richmond Harbor Intensive Study of the Turning Basin sediments (Table 4.5). The complete results including QA/QC results are reported in Appendix D, Tables D.20 and D.21. Each of these metals was detected in all of the test treatments, with the exception of selenium, which had detectable concentrations for three test treatments (TB-4 Middle, TB-7 and TB-8). Test treatment TB-4 Middle had the highest concentrations of eight metals (Ag, As, Cd, Cu, Hg, Pb, Se, and Zn). The concentrations of Ag, Cd, Hg, and Se at R-OS were higher than those in all sediment treatments except TB-4 Middle. Metals concentrations of the OBM COMP were within the range observed for the reference treatments, with the exception of cadmium, the concentration of which was higher than those

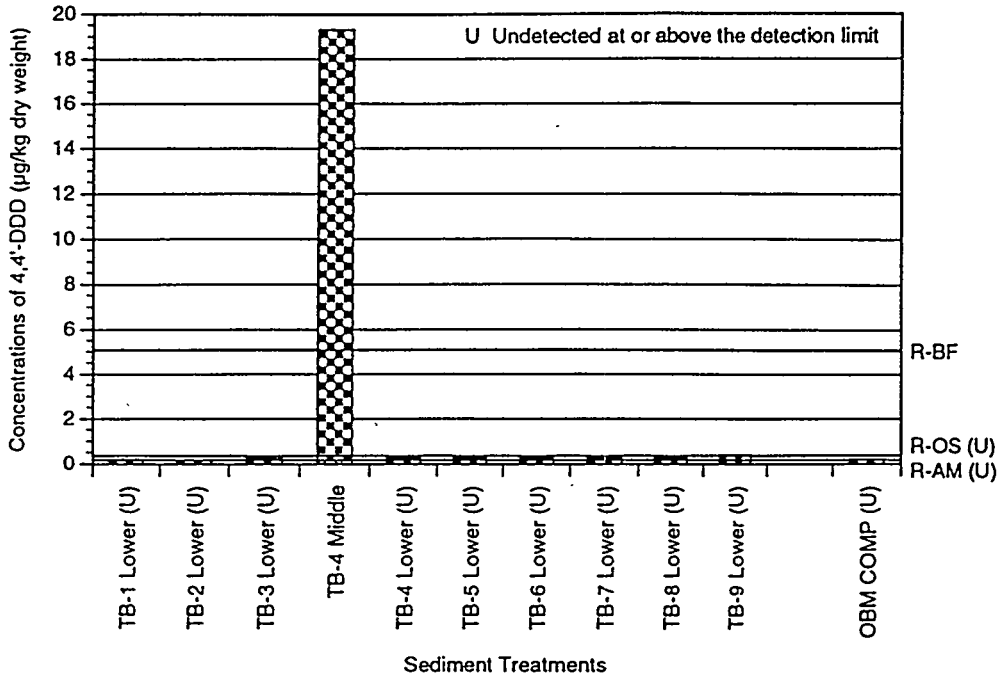


FIGURE 4.9. Concentrations of 4,4'-DDD in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

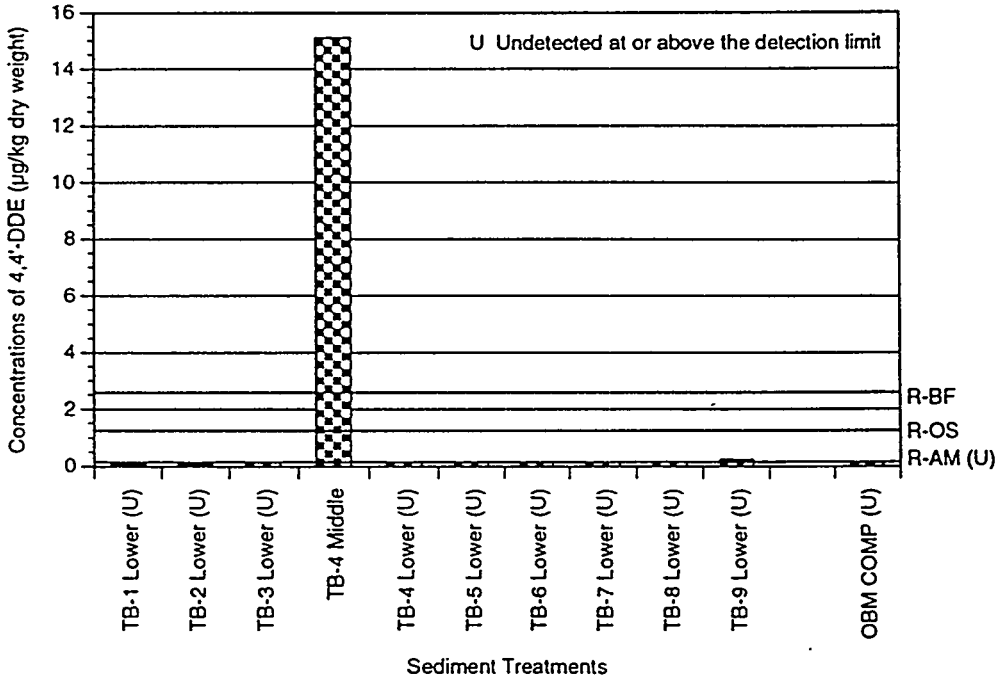


FIGURE 4.10. Concentrations of 4,4'-DDE in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

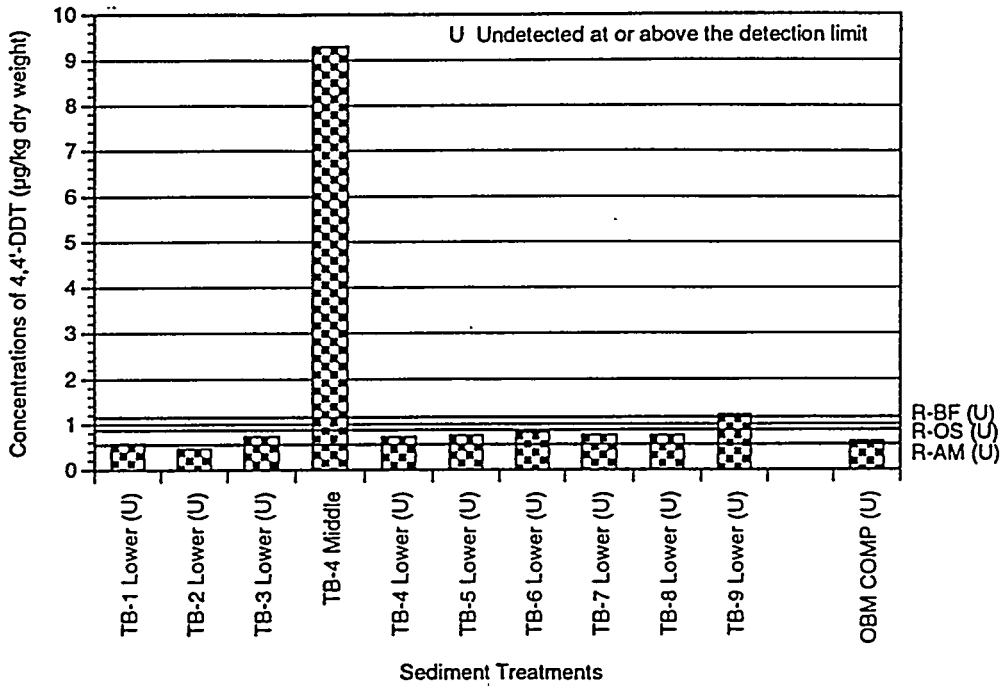


FIGURE 4.11. Concentrations of 4,4'-DDT in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

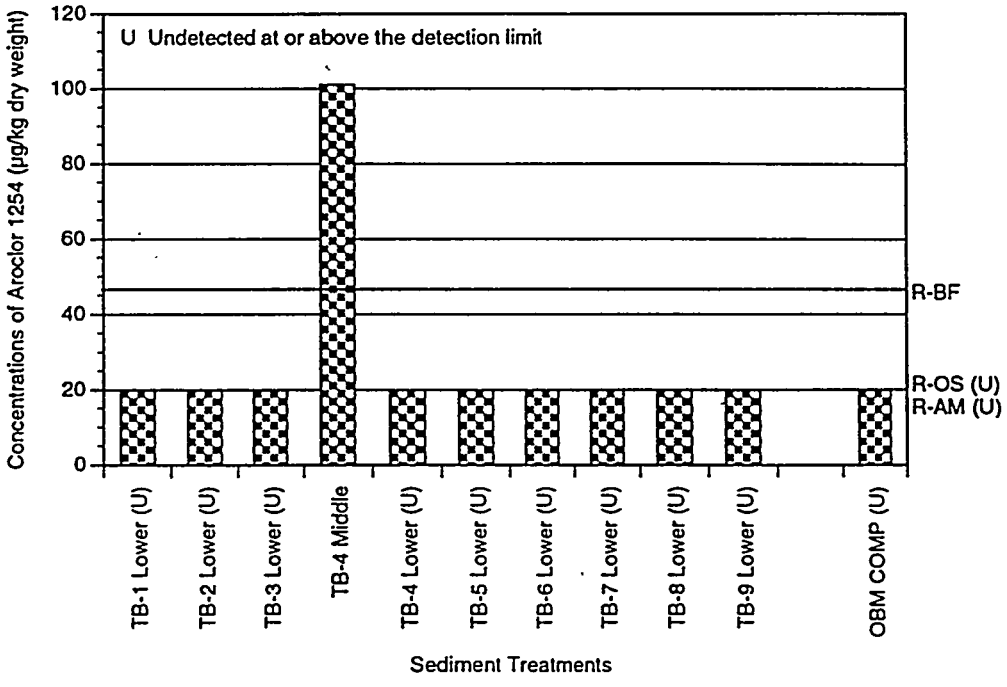


FIGURE 4.12. Concentrations of Aroclor 1254 in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

observed in sediment from all treatments except TB-4 Middle (0.56 mg/kg). Figures 4.13 through 4.22 illustrate the trends of metals enrichment for the Richmond Harbor Intensive Study of the Turning Basin sediments.

4.2.5 Butyltins

Three organotin compounds were analyzed in the sediments for this study. The complete results including QA/QC results are reported in Appendix D, Tables D.22 and D.23. Table 4.5 summarizes the results for the TBT and DBT analysis, and Figures 4.23 and 4.24 graphically depict these results. Monobutyltin was not detected in any of the sediment treatments. Detectable concentrations of TBT ranged from 0.49 µg/kg to 3.66 µg/kg. TB-4 Middle was the only test treatment with a TBT concentration that was higher than that of the reference treatment R-OS. Detectable concentrations of DBT in the test treatments ranged from 0.76 µg/kg to 1.05 µg/kg. DBT was not detected in the sediments from R-OS. The OBM COMP had no detectable concentrations of either TBT or DBT.

4.3 TOXICOLOGICAL TESTING RESULTS

The 10-day *R. abronius* solid-phase test was conducted on the nine test treatments, the OBM COMP, the three reference treatments, and the two control treatments. The complete data, including test results, observations, water quality monitoring, and reference toxicant tests, are contained in Appendixes F, G, and H. The QA/QC summaries are located at the front of each appendix and provide information related to organism collection, holding and acclimation, water quality, reference toxicant information, and test validation. The results of the comparison with the reference treatment R-BF is in Appendix Q, and the comparison with the reference treatment R-AM is in Appendix R.

R. abronius test results were evaluated by ANOVA and Dunnett's test to determine whether statistically significant differences occurred between test and reference treatments. A test treatment was considered acutely toxic if it was statistically significantly different from the reference treatment and if survival of the test organisms exposed to the test treatment was ≥20% lower than survival in the reference treatment.

4.3.1 Methods and Test Design

The standard 10-day *R. abronius* test was performed on 10 test treatments, three reference treatments and two control treatments. Six test treatments, TB-2 Lower, TB-3 Lower, TB-4 Middle, TB-4 Lower, TB-5 Lower, and TB-9 Lower, had initial porewater ammonia concentrations that were greater than 20 mg/L, which is considered the no-observable-effects concentration (NOEC) for *R. abronius* based on *Methods for Assessing the Toxicity of Sediment-Associated Contaminants with Estuarine and Marine Amphipods* (EPA 1994). Therefore, in addition to the standard 10-day test, a second 10-day test was conducted using sediments from

TABLE 4.5. Metal and Butyltin Concentrations in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-OS	0.44	5.39	0.35	186	31.8	0.123	77.3	8.0	1.34	94.7	0.62	0.56 U[a]
TB-1 Lower	0.10	6.07	0.25	231	20.9	0.059	55.3	11.1	0.17 U	51.2	0.57	0.56 U
TB-2 Lower	0.11	10.2	0.21	221	39.8	0.071	84.4	11.8	0.17 U	88.6	0.53	1.05
TB-3 Lower	0.11	9.2	0.20	184	36.1	0.058	85.1	9.3	0.17 U	85.4	0.49	0.56 U
TB-4 Middle	0.65	16.5	0.54	182	74.0	0.734	94.6	43.9	0.39	185	3.66	0.82
TB-4 Lower	0.11	9.7	0.17	181	44.3	0.076	93.6	12.1	0.17 U	90.7	0.61	0.56 U
TB-5 Lower	0.10[b]	10.1[b]	0.21[b]	192[b]	41.2[b]	0.058[b]	97.6[b]	10.6[b]	0.17 U[b]	94.3[b]	0.48 U	0.76
TB-6 Lower	0.12	12.4	0.20	173	53.4	0.037	113	8.4	0.17 U	105	0.54	0.56 U
TB-7 Lower	0.11	9.8	0.20	188	42.4	0.038	92.7	11.1	0.19	95.8	0.52	0.56 U
TB-8 Lower	0.10	10.7	0.21	182	45.8	0.066	101	10.3	0.19	97.2	0.48 U	0.56 U
TB-9 Lower	0.10	7.8	0.15	196	41.2	0.068	87.9	14.1	0.17 U	82.7	0.48 U	0.56 U
OBM COMP	0.11	3.28	0.56	142	27.4	0:044	62.7	10.6	0.17 U	68.3	0.48 U	0.56 U

(a) U Undetected at or above detection limit.
(b) Values is mean of replicate analysis.

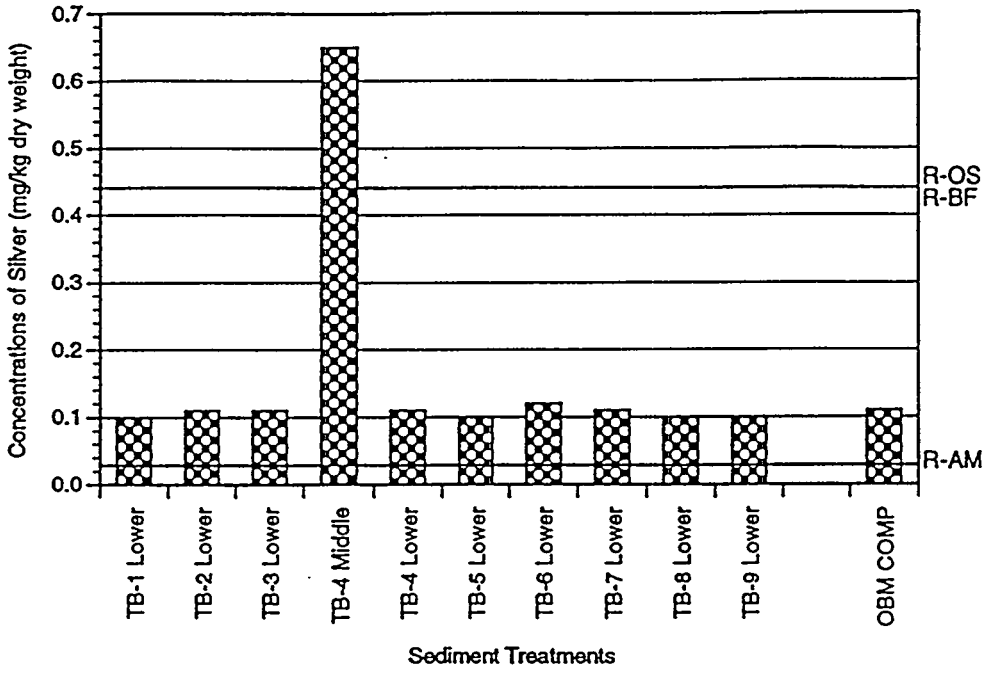


FIGURE 4.13. Concentrations of Silver in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

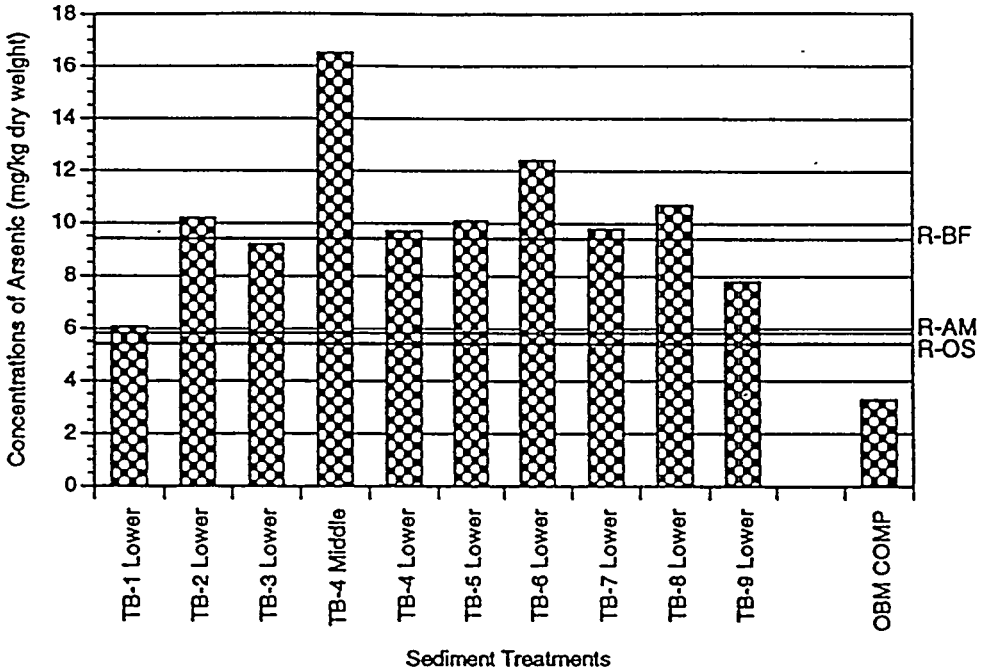


FIGURE 4.14. Concentrations of Arsenic in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

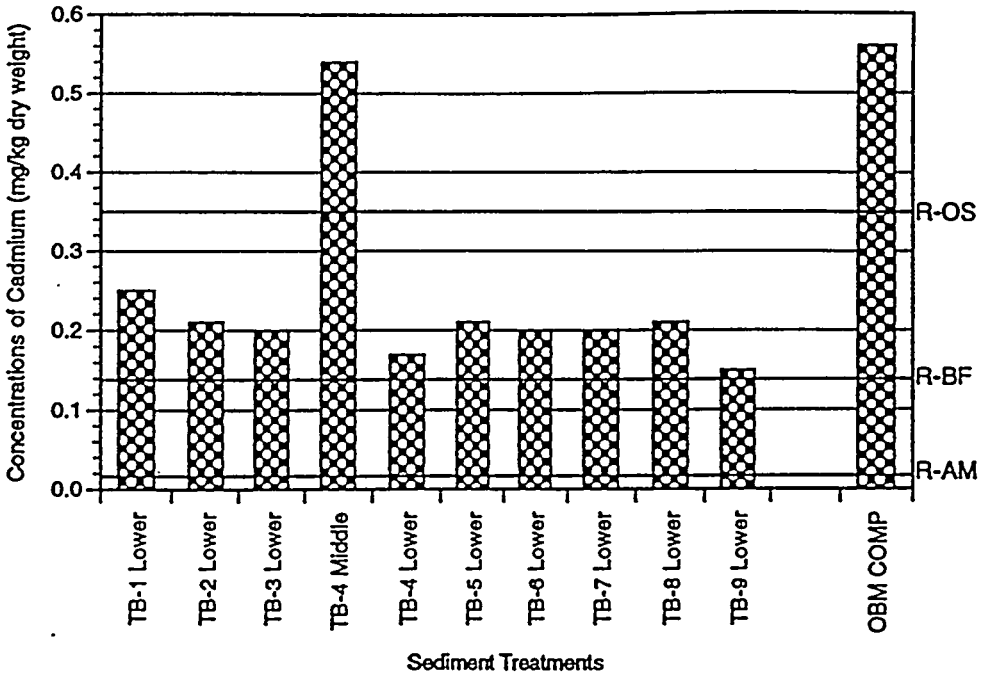


FIGURE 4.15. Concentrations of Cadmium in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

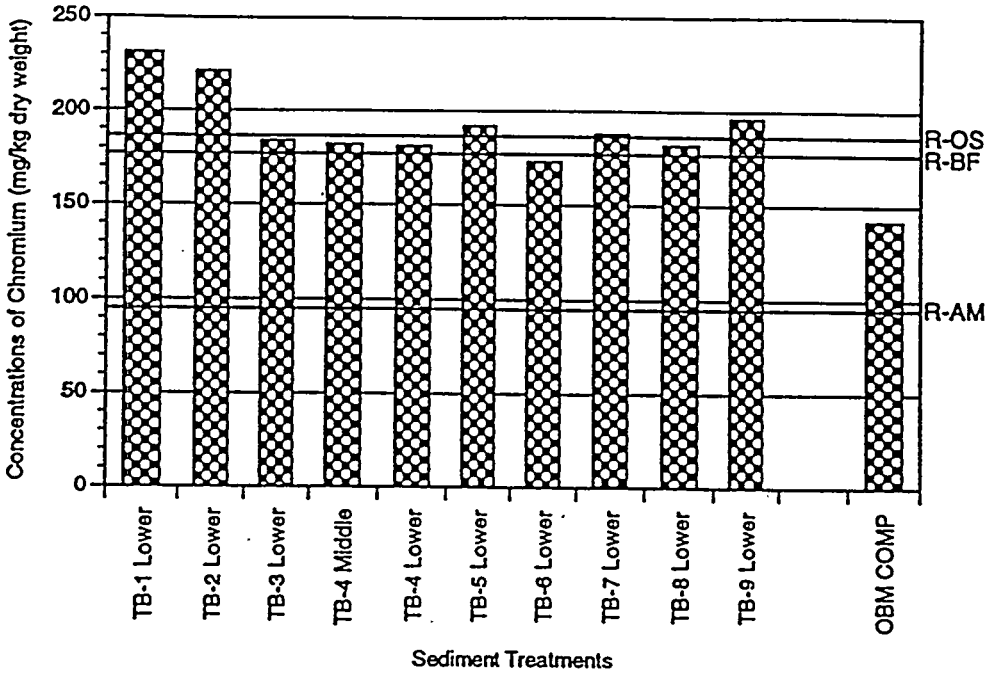


FIGURE 4.16. Concentrations of Chromium in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

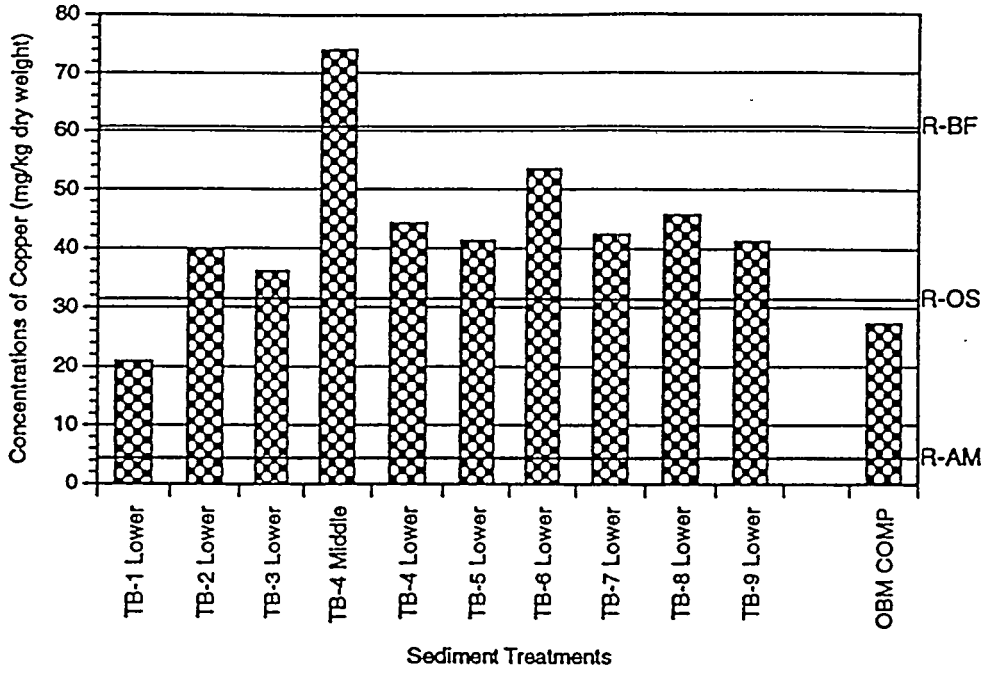


FIGURE 4.17. Concentrations of Copper in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

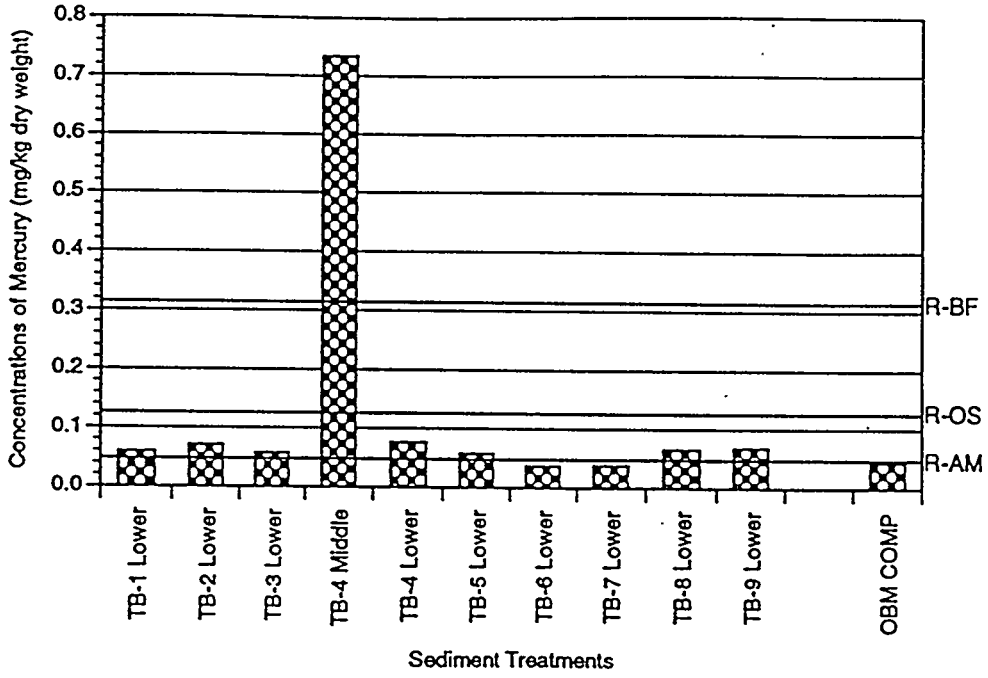


FIGURE 4.18. Concentrations of Mercury in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

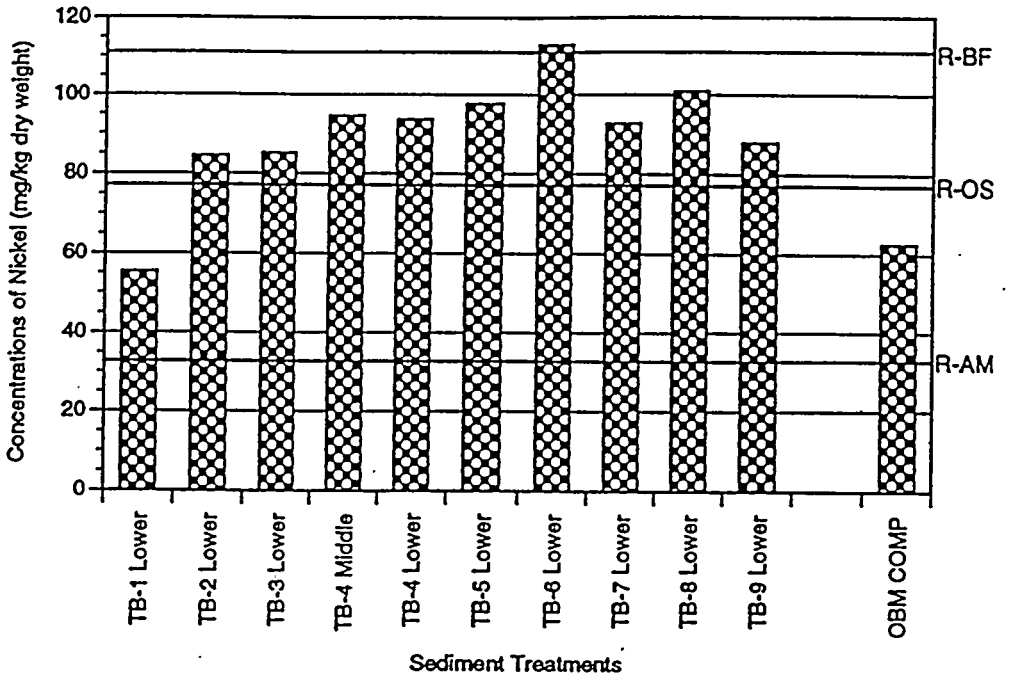


FIGURE 4.19. Concentrations of Nickel in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

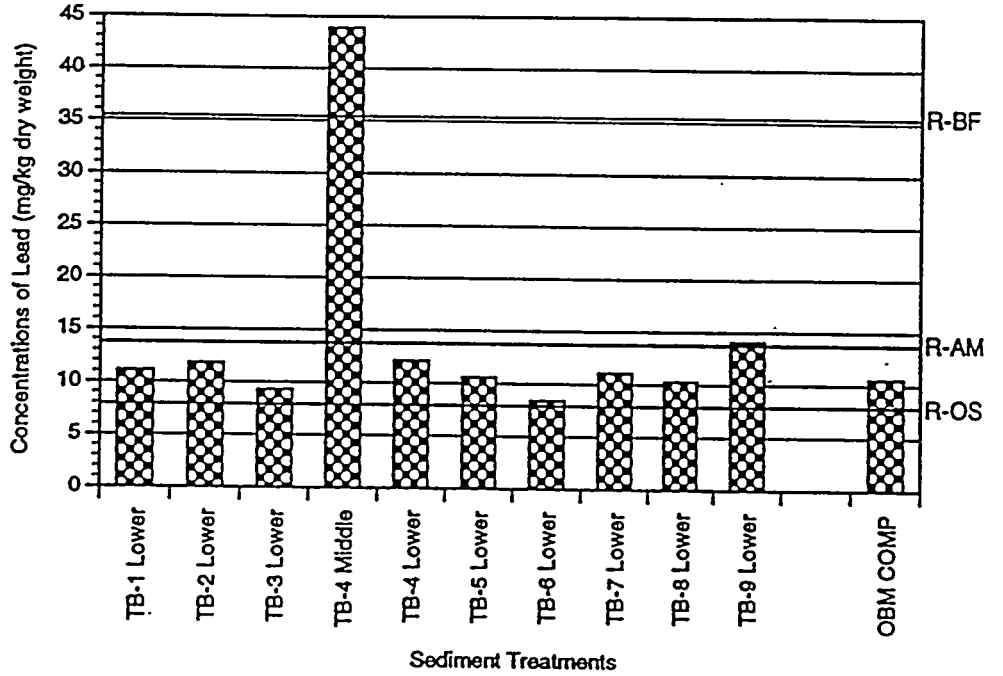


FIGURE 4.20. Concentrations of Lead in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

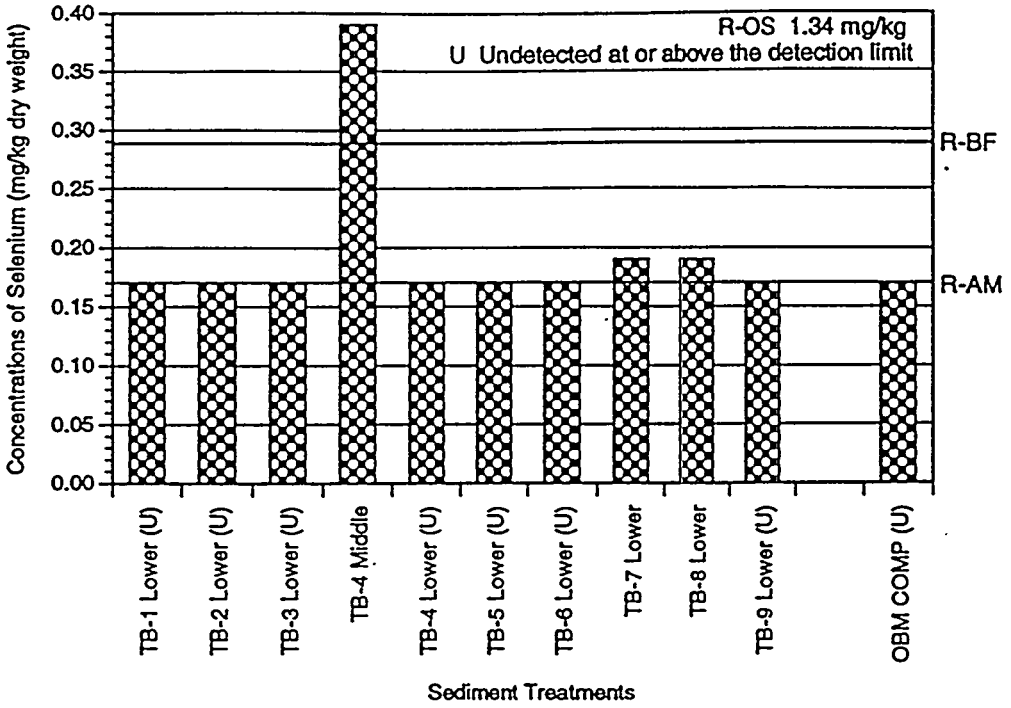


FIGURE 4.21. Concentrations of Selenium in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

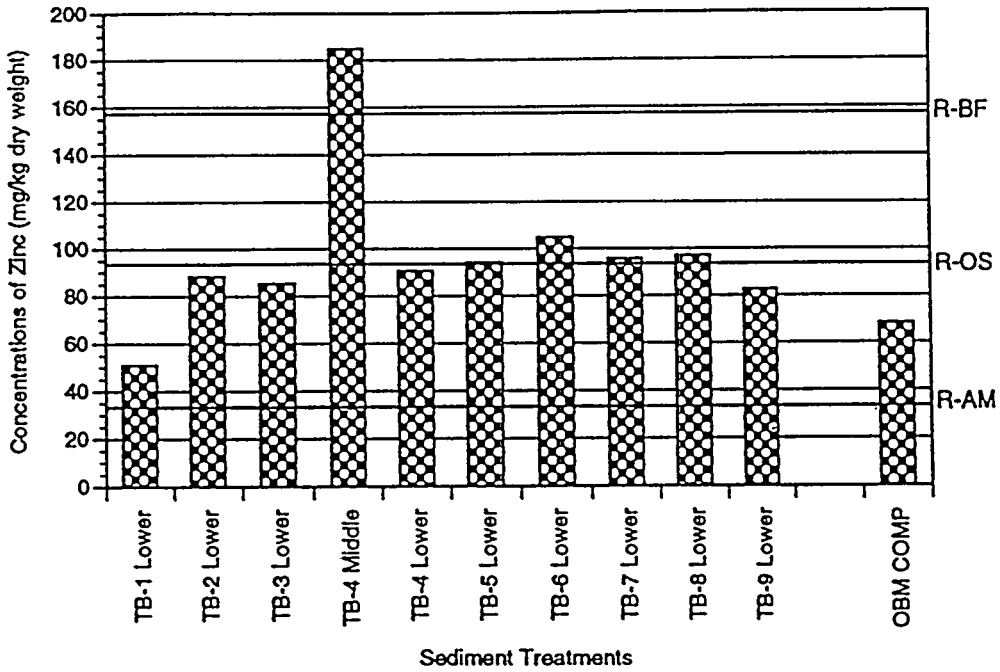


FIGURE 4.22. Concentrations of Zinc in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

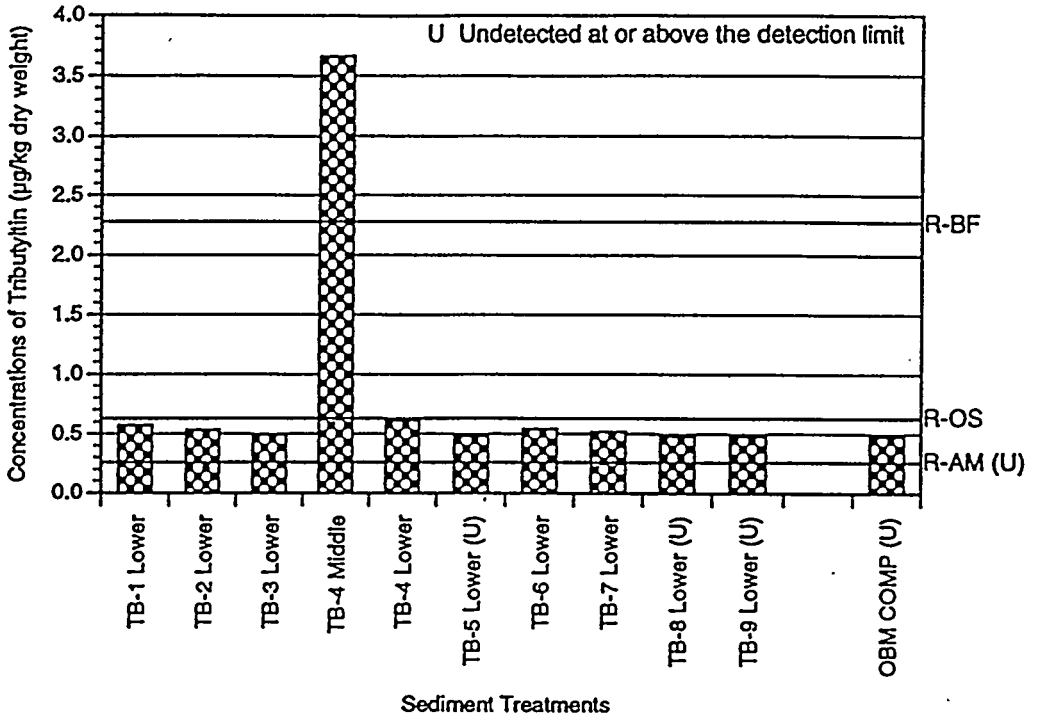


FIGURE 4.23. Concentrations of Tributyltin in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

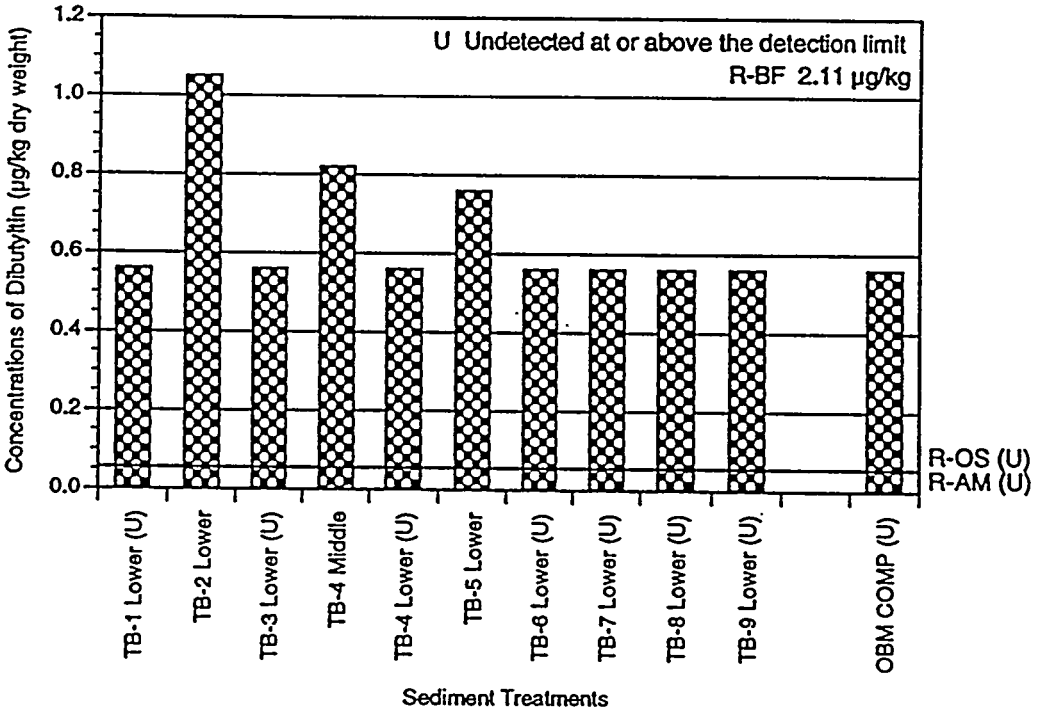


FIGURE 4.24. Concentrations of Dibutyltin in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

the six test treatments with porewater ammonia concentrations that were greater than 20 mg/L. This second test, called the ammonia reduction to <20 mg/L test, followed the procedures outlined in EPA 1994. To reduce the levels of ammonia in the test containers, the overlying water was exchanged from the test containers by running the system under flow-through conditions for 30 min twice a day. It took approximately seven days or 14 exchanges for the porewater ammonia concentrations to reach <20 mg/L. When the ammonia levels were <20 mg/L in all test treatments, the test organisms were added to the test containers, and the test proceeded as a static 10-day test. The same batch of test organisms was used for the standard 10-day test and the ammonia reduction to <20 mg/L test. Consequently, the reference toxicant test results apply to both tests.

Current research conducted at the MSL indicates that at 20 mg/L acute toxicity effects could be observed and that this concentration, therefore, could be an inappropriate NOEC for *R. abronius.* Our research suggests that 15 mg/L could be a more appropriate NOEC for ammonia toxicity to *R. abronius.* To test this hypothesis, a third *R. abronius* test was performed following the same procedures as the ammonia reduction to <20 mg/L test, with the exception that all ammonia concentrations were lowered to <15 mg/L prior to the addition of test organisms. Prior to testing, the sediments were held in the cold room at 4°C. Four test treatments were used for this experiment, TB-3 Lower, TB-7 Lower, TB-8 Lower, and TB-9 Lower. These test treatments were chosen because of their reduced survival of *R. abronius* in either the standard 10-day or ammonia reduction to <20 mg/L tests. The sediments for this test were layered into the test containers and the overlying water was exchanged from the test containers 26 times (this process took 13 days) before ammonia level were <15 mg/L. When the ammonia levels were <15 mg/L in all test treatments, the test organisms were added to the test containers, and the test proceeded as a static 10-day test. A new batch of test organisms was required for the ammonia reduction to <15 mg/L test. Consequently, a second reference toxicant test results was conducted with this experiment. The results of all three tests, the standard 10-day static test, the ammonia reduction to <20 mg/L test, and the ammonia reduction to <15 mg/L test, are described below.

4.3.2 The Standard 10-day Test with *R. abronius*

Ammonia concentrations in the standard 10-day test were monitored in the overlying water (Days 0, 1, 3, 7, and 10) and in the porewater (Days 0 and 10) of each sediment treatment (Table 4.6). Porewater ammonia measurements were taken from dummy jars that were set up and run concurrently with the test containers. Total ammonia concentrations in the porewater were highest for test treatment TB-9 Lower with a concentration of 39.4 mg/L on Day 10 of the test. The reference treatment R-OS and control treatments had porewater ammonia concentrations <2.46 mg/L.

TABLE 4.6. Ammonia Monitoring Summary for the 10-Day *R. abronius* Solid-Phase Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Overlying Water Ammonia (mg/L)					Porewater Ammonia (mg/L)		Static Test	
	Day 0	Day 1	Day 3	Day 7	Day 10	Day 0	Day 10	Percent Survival	Acute Toxicity
R-OS	0.447	0.396	0.579	1.12	0.566	1.18	1.01	94	NA(a)
TB-1 Lower	3.10	3.06	2.55	4.94	2.42	8.18	5.61	87	NO
TB-2 Lower	13.4	16.1	14.3	19.0	15.8	31.4	23.7	52	YES
TB-3 Lower	11.7	12.3	14.4	19.3	14.7	24.7	21.9	25	YES
TB-4 Middle	12.5	13.0	14.2	21.0	15.9	33.4	24.9	82	NO
TB-4 Lower	10.6	14.2	14.0	19.7	16.3	32.9	23.6	76	NO
TB-5 Lower	11.6	10.2	12.7	16.4	13.6	22.4	19.2	62	YES
TB-6 Lower	7.82	10.9	11.4	12.5	11.7	20.0	15.6	76	NO
TB-7 Lower	8.38	11.3	12.1	13.7	12.0	17.9	14.9	55	YES
TB-8 Lower	7.46	5.57	8.12	11.5	9.63	16.2	14.9	64	YES
TB-9 Lower	25.3	18.5	27.7	28.3	32.1	38.5	39.4	28	YES
OBM COMP	0.734	0.639	0.723	1.13	0.380	1.14	0.637	68	NA
C-SB	1.67	1.61	1.23	1.08	0.597	2.46	1.08	89	NA
C-WB	0.347	0.330	0.778	1.39	0.564	2.20	2.71	98	NA

(a) NA Not applicable.

Reference toxicant tests using Cd and ammonia were conducted to assess the sensitivity of the test organisms used in the standard 10-day test. The LC_{50} for the Cd reference toxicant test was 0.81 mg/L Cd (confidence interval = 0.57 mg/L to 1.17 mg/L Cd). This LC_{50} is within the range of 0.68 mg/L to 1.25 mg/L Cd established for *R. abronius* (ASTM 1990), indicating that the response of this batch of test organisms was similar to that of organisms used in past studies and that these data can be used to compare with other data sets. The results of a 96-h ammonia reference toxicant test indicate that the LC_{50} for this batch of test organisms was 80.57 mg/L total ammonia (confidence interval = 69.10 mg/L to 93.95 mg/L total ammonia).

The standard 10-day test was validated by 98% survival of *R. abronius* in the native control sediment C-WB. The experimental grain size control sediment (C-SB) also had adequate control survival of 89%. *R. abronius* survival in the standard 10-day test ranged from 25% for TB-3 Lower to 87% for TB-1 Lower. A statistical comparison of the standard 10-day test results showed that six test treatments were acutely toxic relative to the reference treatment R-OS (Table 4.6). The survival of *R. abronius* exposed to OBM COMP was 68%. Ammonia concentrations in the porewater of OBM COMP prior to test initiation was 1.1 mg/L, indicating that ammonia was not responsible for reduced toxicity in this composite.

Figure 4.25 is a dose-response curve of *R. abronius* survival to ammonia in a 96-h reference toxicant test plotted against the survival and corresponding porewater ammonia measurements for the test treatments. The dose-response line is shown along with a difference of 10% or 20% from the dose-response line to give a range of ammonia response used for comparison. These values were chosen based on their applicability from the *1991 Implementation Manual*, which states that a given test sediment is acutely toxic if mortality is statistically significant and exceeds mortality in a reference sediment by difference of 10% or 20% (for amphipods). The figure shows that eight test treatments are below the dose-response line for ammonia. Six of these eight treatments were also considered acutely toxic to *R. abronius* relative to survival of *R. abronius* exposed to sediment from R-OS.

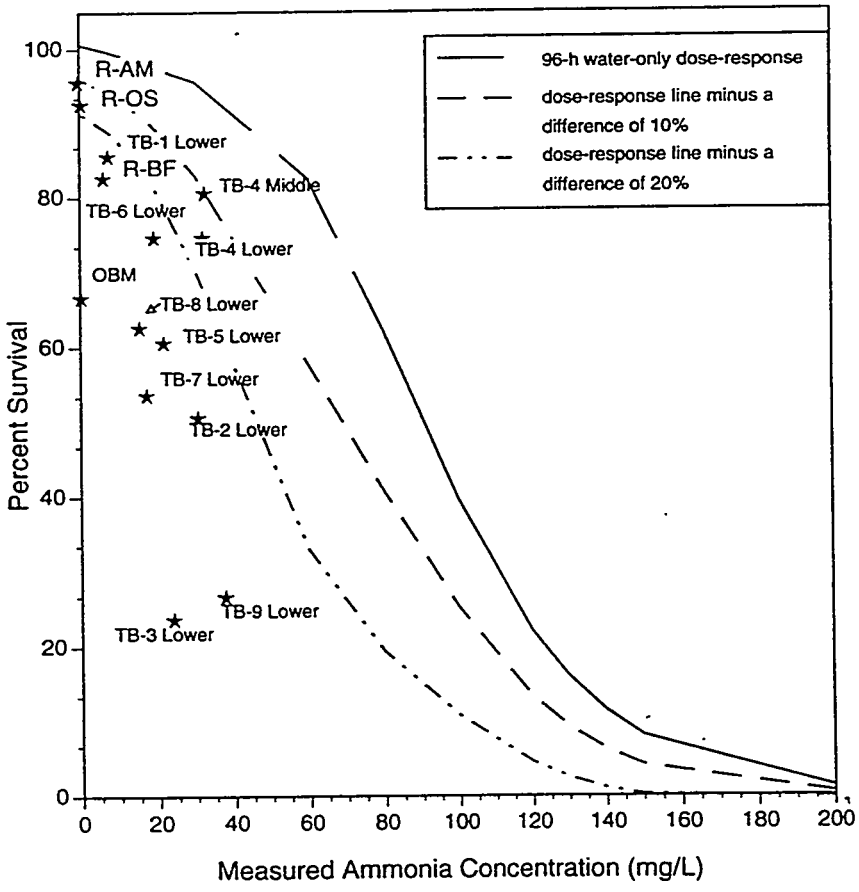


FIGURE 4.25. Response of *R. abronius* to Porewater Ammonia Concentrations in the Intensive Study of the Turning Basin Sediments from the Standard 10-Day Test Relative to the Ammonia Reference Toxicant Dose-Response Curve

4.3.3 Ammonia Reduction to <20 mg/L Test with *R. abronius*

Ammonia concentrations in the ammonia reduction to <20 mg/L test were monitored in the overlying water and porewater of each sediment treatment following the same protocols as those for the standard 10-day test. Table 4.7 is a summary of the ammonia measurements taken during this test. The highest porewater ammonia concentration (18 mg/L) was observed for test treatment TB-9 Lower.

The population of amphipods used for the ammonia reduction to <20 mg/L was the same as that used for the standard 10-day test. The reference toxicant results for this test are reported in the preceding section.

The ammonia reduction to <20 mg/L was performed on the six test treatments that had porewater ammonia concentrations greater than 20 mg/L. The test results for the ammonia reduction to <20 mg/L test ranged from 70% for TB-3 Lower to 89% for TB-4 Middle. Statistical analysis showed that one test treatment, TB-3 Lower, was acutely toxic relative to the reference treatment R-OS (Table 4.7).

The survival results from this test and the corresponding porewater ammonia measurements were plotted against the dose-response curve for this batch of test organisms. Figure 4.26 shows that when the porewater ammonia levels in the test treatments were brought down to the theoretical NOEC for ammonia, the results for three additional test treatments, TB-5 Lower, TB-2 Lower and TB-4 Lower, fell within the dose-response curve and corresponding 20% response. This finding suggest that ammonia could have been the primary reason for the acute toxicity of these sediments to *R. abronius*.

TABLE 4.7. Ammonia Monitoring Summary for the 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Overlying Water Ammonia (mg/L)					Porewater Ammonia (mg/L)		Ammonia Reduction to <20 mg/L	
	Day 0	Day 1	Day 3	Day 6	Day 10	Day 0	Day 10	Percent Survival	Acute Toxicity
R-OS	0.447	0.396	0.579	1.12	0.566	1.18	1.01	94	NA[a]
TB-2 Lower	1.23	1.15	2.18	4.75	8.87	14.2	10.3	79	NO
TB-3 Lower	0.733	1.23	2.51	3.56	4.97	9.87	12.6	70	YES
TB-4 Middle	1.07	1.14	2.89	4.63	9.01	15.1	9.49	89	NO
TB-4 Lower	ND[a]	0.991	1.92	4.16	8.30	ND	13.9	81	NO
TB-5 Lower	0.915	1.20	2.81	4.94	6.08	11.7	12.5	82	NO
TB-9 Lower	3.79	1.72	4.24	8.64	7.28	18.0	15.6	74	NO

(a) ND No data.

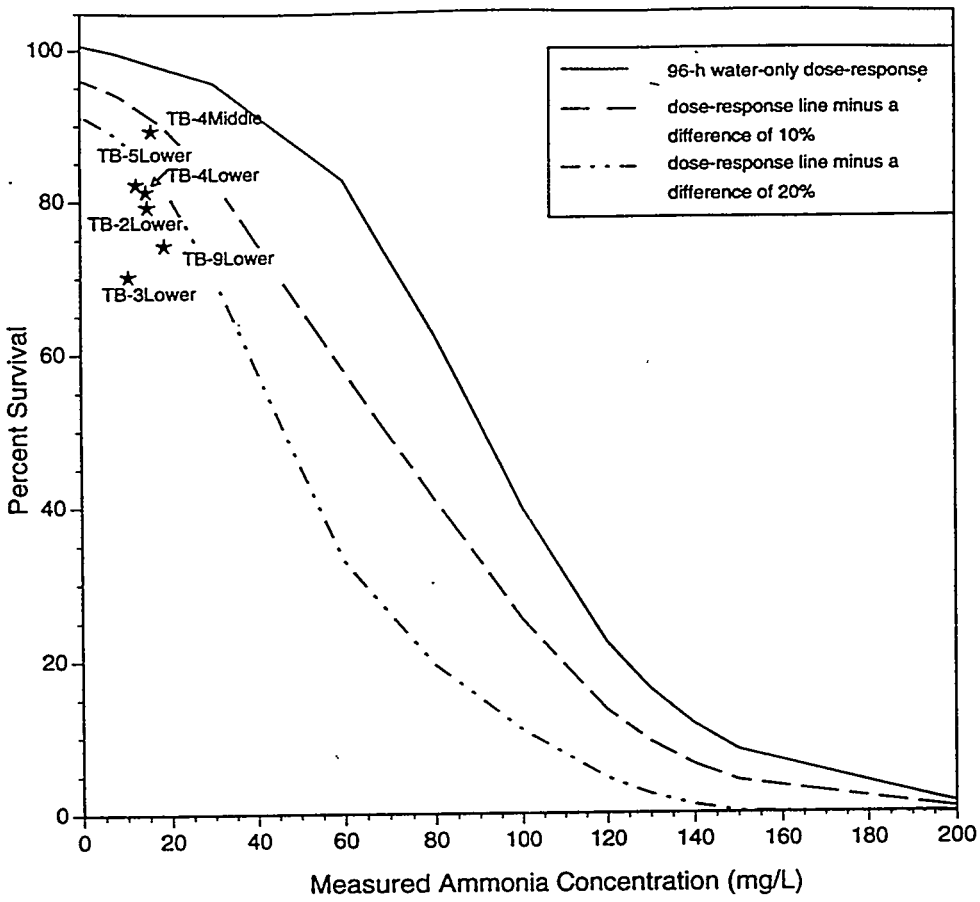


FIGURE 4.26. Response of *R. abronius* to Porewater Ammonia Concentrations in the Intensive Study of the Turning Basin Sediments from the Ammonia Reduction to <20 mg/L Test Relative to the Ammonia Reference Toxicant Dose-Response Curve

4.3.4 Ammonia reduction to <15 mg/L Test with *R. abronius*

Ammonia measurements were monitored in the overlying water and porewater of each test treatment following the same procedures previously outlined. Total ammonia in the sediment porewater ranged from 1.34 mg/L (C-WB) to 14.7 mg/L (TB-9 Lower) at test initiation and from 4.42 mg/L (TB-8 Lower) to 12.8 mg/L (TB- 9 Lower) at test termination (Table 4.8).

The sensitivity of amphipods used for the ammonia reduction to <15 mg/L test was assessed using Cd and ammonia. The resultant LC_{50} was 0.27 mg/L Cd (confidence interval = 0.14 mg/L to 0.52 mg/L Cd). This LC_{50} is below the range of sensitivity (0.68 mg/L to 1.25 mg/L Cd) reported in ASTM 1990 and studies performed previously at the MSL, suggesting that this particular population could have been more sensitive to stresses such as contaminant load or temperature fluctuations compared with the batch used for the standard 10-day test and the ammonia reduction to <20 mg/L test. Because of the acceptable survival of *R. abronius* in the native control sediment, the results of this test were used to assess the acute toxicity of *R. abronius* to Turning Basin sediments. The results of the 96-h ammonia reference toxicant test

TABLE 4.8. Ammonia Monitoring Summary for the 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Overlying Water Ammonia (mg/L)					Porewater Ammonia (mg/L)		Ammonia Reduction to <15 mg/L	
	Day 0	Day 1	Day 3	Day 7	Day 10	Day 0	Day 10	Percent Survival	Acute Toxicity
TB-3 Lower	0.135	0.944	2.45	2.55	1.66	4.71	7.14	83	NO
TB-7 Lower	0.189	3.28	3.27	4.17	2.13	7.79	7.75	75	NO
TB-8 Lower	0.121	0.706	2.18	2.81	1.01	8.18	4.42	81	NO
TB-9 Lower	0.356	1.76	4.41	7.43	6.56	14.7	12.8	80	NO
C-WB	0.038	0.133	0.211	0.124	0.051	1.34	ND[a]	100	NA[b]

(a) ND No data.
(b) NA Not applicable.

using *R. abronius* had an LC_{50} of 30.9 mg/L ammonia (confidence interval = 25.9 to 36.9 mg/L of total ammonia). This result also indicates a test population that was more sensitive than those documented in past data sets.

The ammonia reduction to <15 mg/L test was validated by 100% survival of *R. abronius* in the native control sediment C-WB. Survival of *R. abronius* in the test treatments ranged from 75% for TB-7 Lower to 83% for TB-3 Lower (Table 4.6). None of the test treatments was acutely toxic to *R. abronius* when compared with R-OS.

Figure 4.27 shows the results of the ammonia reference toxicant test conducted with the ammonia <15 mg/L test plotted against the survival and porewater measurements for the test treatments. Again, the dose-response curve was fitted with a difference of 10% or 20% from the dose-response line. This figure shows that once the ammonia concentrations were reduced to <15 mg/L, survival in all four test treatments increased significantly until none of the test treatments was acutely toxic compared with R-OS.

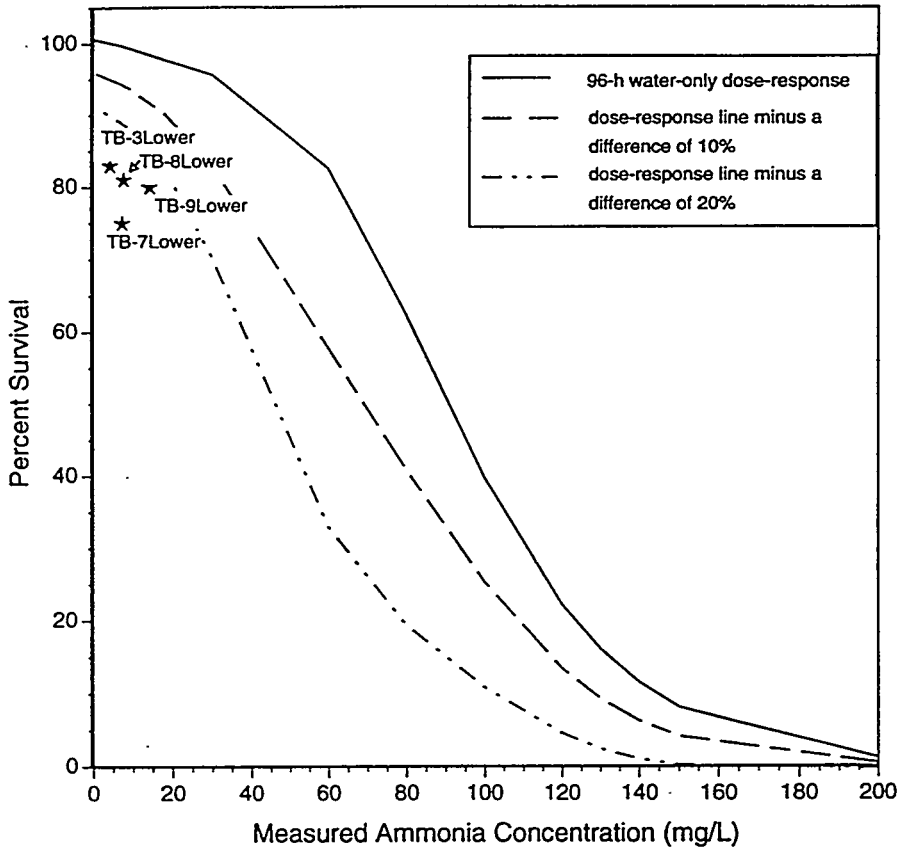


FIGURE 4.27. Response of *R. abronius* to Porewater Ammonia Concentrations in the Intensive Study of the Turning Basin Sediments from the Ammonia Reduction to <15 mg/L Test Relative to the Ammonia Reference Toxicant Dose-Response Curve

5.0 DISCUSSION

In this section, the analyses of sediments from the Richmond Harbor Program and the Intensive Study of the Turning Basin are compared with sediment from the reference station R-OS and discussed in the context of the Tier II and Tier III guidelines in the *1991 Implementation Manual*. Potential water column effects of dredged material disposal are evaluated for compliance with the limiting permissible concentration (LPC) set forth under Tier II. According to the *1991 Implementation Manual*, "the purpose of Tier II is to provide a reliable, rapid screen for potential impact and thereby eliminate the need for further testing." Tier III guidelines for determination of compliance with criteria for ocean disposal, defined under CFR 40, Section 227.13(c), Appendix A of the *1991 Implementation Manual*, include assessments of water column toxicity, deposited sediment (solid-phase) toxicity, and deposited sediment bioaccumulation. Physical characterization and sediment chemistry analysis of Richmond Harbor and the Turning Basin sediments are used in support of toxicity tests and bioaccumulation results to evaluate appropriate disposal options.

5.1 SEDIMENT CHARACTERISTICS

Mudline elevations of the 20 Richmond Harbor sampling stations ranged from -30.4 ft to -41.4 ft MLLW. Geologic evaluations of the 4-in. cores show that sediment from the Richmond Harbor Deepening Project is composed primarily of unconsolidated YBM. The homogenous fine-grained nature of the Richmond Harbor sediments indicate that they were deposited in an environment with low current speed.

Physical and chemical analyses were performed on the Richmond Harbor test sediments from mudline to -40 ft MLLW. The reference treatment R-OS had a higher percentage of TOC than was found in any test treatment. The sediments from the stations comprising SF COMP, SFW COMP, and UIH COMP generally had the highest levels of TVS, oil and grease, TPH, PAHs, and pesticides. The pesticides, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin, were considerably elevated in SF COMP, SFW COMP, and UIH COMPs, and the individual stations comprising these composites, over levels found in R-OS. The primary source of these pesticides is the former United Heckathorn property on the eastern shore of the Lauritzen Canal (Figure 3.1), which is now a federal Superfund site (White et al. 1994).

Mudline elevations for the Turning Basin sediments ranged from -5.1 ft to -33.7 ft MLLW and were composed of unconsolidated YBM with numerous whole or fragmented clam shells. Three stations, TB-1 Lower, TB-7 Lower, and TB-8 Lower contained segments of OBM sediment. All of the test treatments and the reference treatment R-OS were fine-grained sediments except for TB-1 Lower, which was predominantly sand. Concentrations of TOC and

TVS in both the test and reference treatments were typical of fine-grained sediments. The reference treatment R-OS had the highest concentrations of oil and grease, TPH and PAHs of any sediment treatment except for TB-4 Middle, which had higher concentrations of both LPAHs and HPAHs. TB-4 Middle also had the highest detectable concentrations of 4,4'-DDD, 4,4-DDE, 4,4-DDT, Aroclor 1254, 8 of the 10 metals, and TBT.

5.2 TIER III EVALUATIONS

5.2.1 Deposited Sediment (Solid-Phase) Acute Toxicity

Deposited sediment toxicity was determined by exposing three species of marine organisms (*R. abronius*, *M. nasuta*, and *N. caecoides*) to test sediment treatments in 10-day solid-phase tests. If the difference between survival in proposed dredged material (test treatments) and in the reference treatment is statistically significant and exceeds 10% (20% for *R. abronius*), then the test material does not meet the criteria for open ocean disposal as stated in Appendix A of the *1991 Implementation Manual.* The Richmond Harbor test treatments UIH COMP and TB Upper COMP were not acutely toxic to any of the solid-phase test species (Table 5.1). Acute toxicity to *R. abronius* exposed to test treatment TB Lower COMP was observed when compared with those exposed to the reference sediment R-OS. The mortality of *R. abronius* in this sediment is greater than the average dose-response curve for ammonia, as shown in Figure 3.35, indicating that other contaminants or factors are potentially responsible for the sensitivity of *R. abronius* to TB Lower COMP. This composite was evaluated more extensively in the Intensive Study of the Turning Basin, and the results are reported below.

The Intensive Study of the Turning Basin (Table 5.2) evaluated the toxicity at nine Turning Basin locations, the OBM COMP, reference sediments, and control sediments using the standard 10-day *R. abronius* test. Sediment from station TB-1 Lower did not show a statistically significant increase in toxicity relative to reference or control sediments. Test treatments TB-4 Middle, TB-4 Lower, TB-6 Lower, and the OBM COMP were not acutely toxic to *R. abronius* relative to R-OS. The remaining six test treatments (TB-2 Lower, TB-3 Lower, TB-5 Lower, TB-7 Lower, TB-8 Lower, and TB-9 Lower) were acutely toxic to *R. abronius*, with survival ranging from 25% to 64%.

The sediment from these six test treatments came from core sections that were buried by 5 ft of Richmond Harbor sediment. Using these sediments could have enhanced the quantity and influence of ammonia in acute toxicity tests with *R. abronius*. Consequently, those test treatments with a porewater ammonia concentration greater than 20 mg/L of ammonia were subjected to an ammonia reduction protocol, whereas test treatments with less than 20 mg/L ammonia were not. In all cases where ammonia was reduced to <20 mg/L prior to test initiation,

TABLE 5.1. Comparison of Richmond Harbor Solid-Phase Acute Toxicity to that of the Deep Off-Shelf Reference R-OS (shading indicates mean survival statistically significantly lower than the reference based on Dunnett's test and ≥10% difference between treatment and reference and for *M. nasuta* and *N. caecoides*, ≥20% difference for *R. abronius*)

Sediment Treatment	*R. abronius* Percent Survival	*M. nasuta* Percent Survival	*N. caecoides* Percent Survival
R-OS	89	100	96
SF COMP	89	100	79
SFW COMP	77	98	81
UIH COMP	77	100	88
TB Upper COMP	70	99	86
TB Lower COMP(a)	50	98	96
OBM COMP	72	98	38

(a) Evaluation of *R. abronius* toxicity to TB Lower COMP is based on the results from the three tests performed in the Intensive Study of the Turning Basin in October 1994.

TABLE 5.2. Comparison of Richmond Harbor Solid-Phase Acute Toxicity to that of the Deep Off-Shelf Reference R-OS, Intensive Study of the Turning Basin (bold type indicates mean survival statistically significantly lower than the reference based on Dunnett's test and ≥20% difference for *R. abronius*)

Sediment Treatment	Average Percent Survival		
	R. abronius static 10-day test	*R. abronius* ammonia reduction to <20 mg/L	*R. abronius* ammonia reduction to <15 mg/L
R-OS	94	94	94
TB-1 Lower	87	NA(a)	NA
TB-2 Lower	52	79	NA
TB-3 Lower	25	70	83
TB-4 Middle	82	89	NA
TB-4 Lower	76	81	NA
TB-5 Lower	62	82	NA
TB-6 Lower	76	NA	NA
TB-7 Lower	55	NA	75
TB-8 Lower	64	NA	81
TB-9 Lower	28	74	80
OBM COMP	68	NA	NA
C-WB	98	98	100
C-SB	89	89	NA

(a) NA Not applicable.

the survival of *R. abronius* increased to at least 70% (70%-89%). As a result of the ammonia reduction to <20 mg/L test, five test treatments were not acutely toxic to *R. abronius* and only one test treatment, TB-3 Lower, was still considered acutely toxic. Further examination of this data set plus data from other studies previously conducted at the MSL showed that a porewater ammonia concentration of 15 mg/L could be a more appropriate level to use as the ammonia NOEC. Based on this new ammonia level, an ammonia reduction to <15 mg/L test was performed on four test treatments, TB-3 Lower, TB-7 Lower, TB-8 Lower, and TB-9 Lower. In all cases, the survival of *R. abronius* increased above 75% and none of the test treatments was acutely toxic to *R. abronius* when compared with R-OS.

The results from the three tests, combined with numerous data sets previously established at the MSL, suggest that sediments taken from core sections below the influence of native flora and fauna have high concentrations of interstitial porewater ammonia. This could be due to the lack of nitrifying bacterial populations that convert ammonia to nitrite and ultimately to nitrate. As bacterial populations are established in the test containers (current research shows this process can take up to 38 days), the ammonia levels decrease and the effects caused by ammonia are either diminished or removed.

Test treatments SF COMP, SFW COMP, and OBM COMP were acutely toxic to *N. caecoides* relative to the reference sediment R-OS. Known response to ammonia indicates that > 90 mg/L of ammonia are required to produce an LC_{50} value. None of the porewater levels exceeded 25 mg/L; therefore, contributors other than ammonia must be present to cause the observed response. A study on the importance of food concentrations in sediments to the survival of *N. caecoides* was implemented and is reported in *The Older Bay Mud Study* (a).

5.2.2 Water Column Effects

Estimates of toxicity in the water column were also evaluated by exposing three sensitive marine species (*C. stigmaeus*, *H. costata*, and *M. galloprovincialis*) to three concentrations of SPP and a control (0% SPP). The results for *C. stigmaeus* and *H. costata* showed that none of the test treatments was statistically significantly different between the 0% and 100% SPP (Table 5.3). The percentage of *M. galloprovincialis* survival was statistically significantly different between the 0% and 100% SPP for two test treatments, SFW COMP and TB Upper COMP. None of the percent survival results for *M. galloprovincialis* was below 50%; therefore, LC_{50} values could not be calculated. The results for normal development with *M. galloprovincialis* showed statistically significant response to test treatments SFW COMP, UIH COMP, TB Upper COMP, and TB Lower COMP relative to the control. The EC_{50} values that could be calculated were as follows: 80% SPP for SFW COMP, 57.6% SPP for UIH COMP, 74.8% SPP for

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(a) 1995 draft report, Pacific Northwest Laboratory, Richland, Washington.

TABLE 5.3. Summary of Suspended-Particulate-Phase Toxicity Tests, Richmond Harbor Deepening Project (bold type indicates mean survival in 100% SPP significantly lower than control in 2-sample T-test, α 0.05)

	Mysid *H. costata*			Bivalve *M. galloprovincialis*			Sanddab *C. stigmaeus*		
	Mean Survival (%)		LC_{50} as	Mean Normal D (%)		EC_{50} as	Mean Survival (%)		LC_{50} as
Treatment	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP
SF COMP	94	86	>100	94	96	>100	100	100	>100
SFW COMP	98	88	>100	91	**26**	80.0	98	100	>100
UIH COMP	100	90	>100	90	**0**	57.6	98	98	>100
TB Upper COMP	96	96	>100	96	**17**	74.8	100	100	>100
TB Lower COMP	98	94	>100	82	**0**	69.7	98	100	>100
OBM COMP	98	96	>100	98	96	>100	100	100	>100

TB Upper COMP, and 69.7% SPP for TB Lower COMP. Normal development could have been affected by ammonia released from the sediment into the SPP of the SFW COMP, UIH COMP, and the TB Lower COMP (Figure 3.36). The EC_{50} values for these composites are within the range of expected effects caused by ammonia. This is not the case for TB Lower COMP; the response exceeds the 95% confidence interval for ammonia, suggesting that additional contaminants or factors combined with ammonia could be responsible for the lower percentage of development to normal larvae in the 100% SPP of this composite.

Under *1991 Implementation Manual* guidelines, LPC of dissolved plus suspended contaminants cannot exceed 0.01 of the acutely toxic concentration (LC_{50}) at the boundaries of the disposal site, after allowing 4 h for initial mixing. However, the LPC values cannot be obtained using LC_{50} values, since none could be calculated.

In the bivalve test, the percentage of larvae normality is probably more indicative of the test treatment toxicity than the percentage of survival because only normal developed larvae at 48 h are likely to survive to adulthood. Therefore, the most environmentally protective approach would be to base the LPC on the EC_{50} results for *M. galloprovincialis* larvae. As with the LPC calculations using LC_{50} values, the EC_{50} for *M. galloprovincialis* larval abnormality requires application of the Addams model (Schroeder and Palermo 1990) to predict contaminant concentrations at the edge of the mixing zone. The concentration of SPP for the Richmond Harbor test sediments at the edge of the mixing zone would have to be less than 0.57% to meet the requirements in the *1991 Implementation Manual.*

5.2.3 Deposited Sediment Bioaccumulation

The potential for bioaccumulation of contaminants was evaluated through 28-day solid-phase exposures of *M. nasuta* and *N. virens* to Richmond Harbor sediments, followed by chemical analysis of the tissues. The tissue contaminant concentrations were compared with

existing FDA limits and were statistically compared with the tissues exposed to the reference sediment R-OS. Compliance criteria for bioaccumulation are not as well-defined as for water column or deposited sediment toxicity. If any statistically significant bioaccumulation is detected, then other considerations are examined, such as the number of elevated compounds, the number of species showing elevated contaminant levels, the magnitude of increase in contaminant concentrations, the degree or magnitude of the elevations relative to tissues exposed to reference sediment, and related sediment toxicity.

M. nasuta and *N. virens* tissue contaminant concentrations were one to five orders of magnitude below the FDA action levels for fish and shellfish after exposure to Richmond Harbor sediments (Table 5.4). There were, however, tissue contaminant concentrations in the test treatments that were statistically significantly elevated when compared with concentrations in the tissues exposed to the reference treatment R-OS. Table 5.5 is a summary of this comparison.

Nine HPAHs, up to three pesticides (4,4'-DDD, 4,4'-DDE, and dieldrin), and one metal, (Pb) showed statistically significant bioaccumulation in *M. nasuta* tissues exposed to SF COMP, SFW COMP, UIH COMP, and TB Upper COMP relative to bioaccumulation in tissues exposed to R-OS. In all cases, the pesticides found in tissues exposed to SF COMP, SFW COMP and UIH COMP were elevated at levels greater than 10 times (from 20 to 259 times) those found in *M. nasuta* tissues exposed to reference treatment R-OS. Three test treatments, SF COMP, SFW COMP, and UIH COMP, had HPAH concentrations that were elevated at levels greater than 10 times (from 13 to 68 times) levels found in the tissues exposed to R-OS. Elevated levels of PAHs in tissues of *M. nasuta* exposed to the TB Lower COMP were always less than two times the concentration in tissues exposed to the reference site R-OS.

The bioaccumulation results for test-treated *N. virens* tissues are similar to those for *M. nasuta* for the following compounds, relative to those found in tissues exposed to R-OS: the HPAHs and four pesticides (4,4'-DDT, 4,4'-DDD, 4,4'-DDE and dieldrin or aldrin) were the most prevalent contaminants in *N. virens* tissues exposed to SF COMP, SFW COMP, and UIH COMP. In tests using these composites, 4,4'-DDD and benzo(b)fluoranthene were elevated in *N. virens* tissues at a level or at levels greater than 10 times (from 10 to 111 times) higher than in *N. virens* tissues exposed to R-OS.

5.3 CONCLUSIONS

Sediment chemistry, acute toxicity and bioaccumulation data for each Richmond Harbor test treatment and Turning Basin test treatment are summarized in the following paragraphs. Test sediments from Richmond Harbor was evaluated based on four criteria where applicable:

TABLE 5.4. Comparison of FDA Action Levels With Contaminant Levels in *M. nasuta* and *N. virens* Exposed to Richmond Harbor Sediments

Contaminant	FDA Action Level (mg/kg wet weight)	Maximum Concentration (mg/kg wet weight) *M. nasuta*	*N. virens*
Benzene Hexachloride (BHC)[a]	0.3	0.00096	U
Chlordane	0.3	U[b]	U
DDT + DDE	5.0	0.0055	0.001038
Dieldrin + Aldrin	0.3	0.00224	0.002309
Endrin	0.3	U	U
Heptachlor + Heptachlor Epoxide	0.3	U	U
Toxaphene	5.0	U	U
PCBs	2.0	0.00040	U

(a) Total BHCs (alpha-, beta-, delta-, and gamma-BHC).
(b) U Undetected at or above detection limit.

1) concentrations and magnifications of contaminants in the test sediment treatments relative to the reference sediment; 2) calculable LC_{50} or EC_{50} values for organisms exposed to dissolved and suspended material in the water column relative to a control (0% SPP); 3) solid-phase acute toxicity of the test treatments compared with the reference sediment; and 4) concentrations and magnifications of contaminants in the tissues of both *M. nasuta* and *N. virens* exposed to the test treatments relative to those in tissues exposed to the reference sediment. The matrix in Figure 5.1 presents the results of these evaluations.

Figure 5.1 also shows the acute toxicity of the test treatments relative to that of reference sediment R-OS, the number of contaminants in *M. nasuta* and *N. virens* that were elevated above levels found in the reference sediment R-OS, and the range of magnitudes (2-, 5- 10-times R-OS) of contaminant accumulation, and cases in which similar classes of contaminants were accumulated for both species. The following paragraphs present an overview of the results for each test treatment relative to the reference sediment R-OS to assist the USACE, EPA, and other resource agencies in evaluating suitable disposal options for the Richmond Harbor sediments.

SF COMP is located in the center of Santa Fe Channel and represents approximately 23,000 cubic yards of dredged material. Mudline depths range from -35.9 ft MLLW to -38.5 ft MLLW. Sediment from this composite are predominantly silt and clay with lower concentrations of TOC, TVS, oil and grease, and TPH than in the R-OS sediments. The detectable concentrations of PAHs, pesticides, PCBs, metals, and butyltins were higher in

TABLE 5.5. Summary of Statistically Significant Acute Toxicity and Bioaccumulation for Richmond Harbor Deepening Project Sediment Treatments Relative to the Reference Sediment R-OS

Sediment Treatment	Acute Toxicity	*M. nasuta* Bioaccumulation					*N. virens* Bioaccumulation				
		PAH	Pesticides	PCB	Metals	TBT	PAH	Pesticides	PCB	Metals	TBT
SF COMP	N[a]	LPAH,HPAH	DDD,DDE,Diel	---[b]	Pb	TBT	LPAH,HPAH	DDD,DDE,DDT,Diel	---	---	---
SFW COMP	N,B[c]	LPAH,HPAH	DDD,DDE,Diel	1254	Pb	---	LPAH,HPAH	Ald,DDD,DDT,Diel	---	---	---
UIH COMP	B	LPAH,HPAH	DDD,Diel	---	Pb	---	HPAH	DDD,DDE,DDT,Diel	---	---	DBT
TB Upper COMP	B	LPAH,HPAH	DDE,DDT	---	Pb	---	---	---	---	---	---
TB Lower COMP[d]	R[e],B	HPAH	---	---	---	---	---	---	---	Ni	---
OBM COMP	N	NA[f]	---	---	NA	---	NA	NA	NA	NA	NA

(a) N Acutely toxic to *N. caecoides* in the 10-day solid-phase test.
(b) --- No statistically significant acute toxicity or bioaccumulation.
(c) B Statistically significantly different in percent normal development to *M. galloprovincialis* in the 48-h SPP test.
(d) Evaluation of *R. abronius* toxicity to TB Lower Comp is based on the results from the Intensive Study of the Turning Basin in October 1994 in which only TB-3 Lower was acutely toxic when compared to R-OS.
(e) R Acutely toxic to *R. abronius* in the 10-day solid-phase test.
(f) NA Not Applicable.

Sediment Treatments	Sediment Chemistry				Toxicity	Significant Bioaccumulation						Bioaccumulation ≥ 2 < 5 times						Bioaccumulation ≥ 5 < 10 times						Bioaccumulation ≥ 10 times					
	sediment LPAH > R-OS	sediment HPAH > R-OS	# of sediment Pesticide and PCB > R-OS	# of sediment Metals > R-OS	# of sediment Butyltins > R-OS	species associated with SPP toxicity	species with solid-phase acute toxicity	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)
SF COMP	√	√	5	8	2		N	1/1	9/3	3/4		1/1			5/							4/1	3/2			
SFW COMP	√	√	5	9	2	B	N	5/2	9/7	3/4	1/	1/		1/1	2/3			1/		3/1		1/7	3/2			
UIH COMP	√	√	5	9	2	B		1/	9/2	2/4		1/	1/		5/1	2/					2/1	2/1				
TB Upper COMP	√	√	3	6	1	B		1/	9/	2/		1/			5/	2/					1/					
TB Lower COMP		√	1	6		B	R		3/			1/														
OBM COMP				NA			N	NA	NA			NA														

√ Total LPAH or HPAH with detected values above the reference R-OS

C Calculable LC_{50} value in the *C. stigmaeus* test
B Calculable EC_{50} value in the *M. galloprovincialis* test
H Calculable LC_{50} value in the *H. costata* test
R Acute Toxicity in the *R. abronius* 10-day test
N Acute Toxicity in the *N. caecoides* 10-day test

NA Not applicable; sediment treatment not analyzed for this parameter

Z Number of Compounds Bioaccumulating in *M. nasuta* Tissues
Number of Compounds Bioaccumulating in *N. virens* Tissues

FIGURE 5.1. Matrix of Sediment Chemistry, Significant Acute Toxicity, and the Bioaccumulation for Richmond Harbor Deepening Sediment Treatments Relative to the Deep Off-Shelf Reference Sediment, R-OS

sediments from this composite than from the reference treatment R-OS. SF COMP was acutely toxic to *N. caecoides*. Bioaccumulation of nine HPAHs and four pesticides occurred in the tissues of *M. nasuta* and *N. virens* relative to that found in tissues exposed to R-OS. In most cases, the elevations of pesticides in tissues of both test-treated species was greater than 10 times (from 16 to 233 times) higher than in tissues exposed to R-OS sediments. Metals and butyltins concentrations were also statistically significantly higher in *M. nasuta* tissues exposed to test sediment.

Test treatment SFW COMP is located in the berthing area for National Gypsum and GATX and represents approximately 19,000 cubic yards of dredged material. Mudlines in this area range from -28 ft MLLW to -34.1 ft MLLW. The grain size fractionation in this composite is similar to that in the reference sediment R-OS, with similar contributions to the sand (23%), silt (37%), and clay (35%) categories. Concentrations of TOC and TVS were lower than in the reference R-OS. The oil and grease, TPH, total PAH, detectable pesticides (except for 4,4'-DDT), and Aroclor concentrations were higher in this composite than in any of the other test treatments or in the reference treatment. This composite also had higher concentrations of nine metals and butyltins relative to the reference sediment, R-OS. Sediment from SFW COMP was acutely toxic to *N. caecoides* in the 10-day solid-phase test. The SPP test with *M. galloprovincialis* was statistically significantly different in percentage of normal development to a D-cell stage relative to the results in 0% SPP. The EC_{50} for this composite was 80% SPP. Normal development could have been affected by ammonia released from sediment into SPP (Section 3.4.7, Figure 3.36). The EC_{50} falls within the dose-response curve generated from *M. galloprovincialis,* suggesting that ammonia could be responsible for the reduction in the number of larvae that developed normally to the D-cell stage. Bioaccumulation of at least nine of the PAHs and three pesticides (4,4'-DDD, 4,4'-DDE and dieldrin) were statistically significantly elevated in both the *M. nasuta* and *N. virens* tissues exposed to sediment from SFW COMP relative to levels found in the tissues exposed to R-OS. In many cases, the bioaccumulation of PAHs and pesticides in the tissues of *M. nasuta (*11 PAHs and 3 pesticides) or *N. virens* (2 PAHs and 4 pesticides) exposed to this composite were found at levels at least five times greater than in tissues exposed to R-OS. Eight of the PAHs that bioaccumulated in *M. nasuta* tissues were also elevated at greater than 10 times the concentrations found in the *M. nasuta* tissues exposed to R-OS.

The UIH COMP is located in the Upper Inner Harbor Channel and represents approximately 60,000 cubic yards of dredged material. Mudlines in this channel range from -34.4 ft MLLW to -37.3 ft MLLW. Sediments from this composite are a fine-grained silt-clay mixture. Percentages of TOC and TVS in this composite are similar to those in reference sediment R-OS. The oil and grease, TPH, total PAH, detectable pesticides and PCBs, 9 of the 10 metals, and butyltins were higher in this sediment relative to what was found in sediment from

R-OS. Acute toxicity was observed in the percentage of normal development of the *M. galloprovincialis*. An EC_{50} of 57.6% SPP was calculated for this composite. Again, ammonia could be the cause of the reduction in percentage of normally developed larvae to the D-cell stage (Figure 3.36). At least two HPAHs (benzo[b and k]fluoranthenes), and two pesticides (4,4'-DDD and dieldrin) were statistically significantly elevated in both *M. nasuta* and *N. virens* tissues exposed to sediments from this composite relative to concentration in tissues exposed to R-OS. Seven other HPAHs were also elevated in *M. nasuta* tissues exposed to this composite relative to those in *M. nasuta* tissues exposed to R-OS.

The TB Upper COMP is located in the Turning Basin, which sits at the entrance to the Inner Harbor and Santa Fe Channels. The Turning Basin represents 500,000 cubic yards of sediment. The sediments from this composite are predominantly fine-grained silts and clays. Percentages of TOC and TVS are similar in this composite to the reference sediment R-OS. Oil and grease, total PAHs, six metals, and TBT were higher in sediments from TB Upper COMP than in sediments from R-OS. The percentage of normally developed *M. galloprovincialis* larvae exposed to the 100% SPP of this composite was statistically significantly different from that of normally developed larvae exposed to the 0% SPP. An EC_{50} of 74.8% SPP was calculated for this composite. Normal development of *M. galloprovincialis* larvae of this composite falls below the 95% confidence limit, suggesting that ammonia cannot fully account for this affect. Bioaccumulation of nine HPAHs and two pesticides (4,4'-DDT and 4,4'-DDE) occurred in *M. nasuta* tissues exposed to this composite relative to *M. nasuta* tissues exposed to the sediment from R-OS.

Test treatment TB Lower COMP is composed of seven stations from 5 ft below the mudline to -40 ft MLLW. Sediments are predominantly fine-grained silts and clays with lower concentfations of TOC, TVS, and oil and grease than are found in sediments from R-OS. The concentrations of HPAHs and six metals were higher in this sediment composite than sediment from R-OS. TB Lower COMP was acutely toxic to *R. abronius*. Since the observed toxicity appeared to be related to ammonia, additional testing during the Intensive Study of the Turning Basin was performed to verify this relationship. The results from the additional testing are described below. There was a statistically significant difference between the 0% and 100% SPP of this composite in the percentage of *M. galloprovincialis* that reached the normal D-cell stage. An EC_{50} of 69.7% SPP was calculated for TB Lower COMP. This EC_{50} provides an ammonia concentration that falls within the ammonia dose-response curve generated for *M. galloprovincialis* (Figure 3.36), suggesting that the reduced normal development of larvae exposed to the SPP from this composite may be largely due to ammonia. The elevations of three HPAHs in *M. nasuta* exposed to TB Lower COMP was statistically significant but ≤ 2 times the concentrations found in *M. nasuta* tissues exposed to R-OS. Of the contaminants measured in *N. virens* tissues

exposed to TB Lower COMP, only Ni showed any elevation that was statistically significant, but less than two times the level in tissues exposed to R-OS.

The TB Lower COMP was split into 10 individual stations during the Intensive Study of the Turning Basin. These stations were tested independent of the composite to provide more definitive data for the evaluation of the suitability of Turning Basin sediments. The results of each Turning Basin station are presented below.

The depth of the core tested for the TB-1 Lower station ranged from -35.6 ft to -40 ft MLLW. Sediment from this station was primarily sand with overall lower concentrations of contaminants of interest relative to the other stations and the reference sediment R-OS. The results of the standard 10-day *R. abronius* test showed that TB-1 Lower sediments were not acutely toxic to *R. abronius* relative to R-OS.

TB-2 Lower sediments were tested between -11.5 ft to -40 ft MLLW. The sediments from this station were fine-grained and had lower concentrations of the conventional and organic parameters and five metals relative to R-OS. TB-2 Lower was tested in both the standard 10-day test and the ammonia reduction to <20 mg/L test. The results showed that TB-2 Lower was acutely toxic for the standard test but was not acutely toxic for the ammonia reduction to <20 mg/L test when compared to R-OS.

The depths of the core tested for station TB-3 Lower ranged from -10.1 ft to -40 ft MLLW. TB-3 Lower sediments were fine-grained with lower concentrations of detectable conventional, organic, six metals, and butyltin parameters relative to sediment from R-OS. The sediment from TB-3 Lower was tested during all three *R. abronius* tests with the following results: acutely toxic to *R. abronius* for both the standard 10-day test and the ammonia reduction to <20 mg/L test; not acutely toxic to *R. abronius* for the ammonia reduction to <15 mg/L test.

TB-4 Middle was tested using sediment ranging from -33.4 to -38.8 ft MLLW. Sediments from this station were fine-grained and had the highest concentrations of PAHs, some pesticides, PCBs, eight metals, and butyltins relative to any sediment treatment including the reference R-OS. The station TB-4 Middle was tested during the standard 10-day test and the ammonia reduction to <20 mg/L test and was not acutely toxic to *R. abronius* in either test relative to R-OS.

The testing depths for TB-4 Lower ranged from -38.8 to -40 ft MLLW. The sediments from this station were fine-grained and had lower concentrations of oil and grease, TPH, organics, six metals, and tributyltin when compared to sediment from R-OS. The *R. abronius* results for the standard test and the ammonia reduction to <20 mg/L test showed that TB-4 Lower was not acutely toxic when compared with R-OS.

TB-5 Lower sediments used for testing ranged from -12.3 to -40 ft MLLW. This sediment was also fine-grained and had lower concentrations of organics, five metals, and tributyltin when

compared with sediment from R-OS. Sediments from TB-5 Lower had the highest concentrations of oil and grease and TPH when compared with the other test treatments. The results of the *R. abronius* test showed that TB-5 Lower was acutely toxic to *R. abronius* during the standard 10-day test but not acutely toxic to *R. abronius* during the ammonia reduction to <20 mg/L test.

The depth of the core tested for the TB-6 Lower station ranged from -38.7 ft to -40 ft MLLW. Sediment from this station was primarily fine-grained with higher concentrations of aldrin, As, Cu, Ni, Pb, and Zn than the reference sediment R-OS. The station TB-6 Lower was tested during the standard 10-day test and was not acutely toxic to *R. abronius* relative to R-OS.

The sediments used for testing station TB-7 ranged from -15.3 to -40 ft MLLW. TB-7 Lower was fine-grained and had higher concentrations of aldrin and six metals when compared with sediment from R-OS. Sediment from TB-7 Lower was acutely toxic to *R abronius* for the standard test but not acutely toxic to *R. abronius* for the ammonia reduction to <15 mg/L test.

Station TB-8 was tested from depths ranging from -12.5 to -40 ft MLLW. TB-8 Lower sediments were fine-grained and had higher concentrations of oil and grease and five metals relative to R-OS. Sediments from TB-8 Lower were acutely toxic to *R. abronius* for the standard test but not acutely toxic to *R. abronius* for the ammonia reduction to <15 mg/L test.

The depth of the core tested for the TB-9 Lower station ranged from -36.3 to -40 ft MLLW. Sediments from this station were fine-grained and had higher concentrations of oil and grease and five metals relative to the reference sediment R-OS. Sediments from TB-9 Lower were tested during all three *R. abronius* tests and the results of the comparison with R-OS provided the following results: acutely toxic to *R. abronius* during the standard 10-day test but not acutely toxic to *R. abronius* for either the ammonia reduction to <20 mg/L test or the ammonia reduction <15 mg/L test.

The OBM COMP was created using samples taken from the -40 ft to -42 ft MLLW sections of any field cores that contained OBM. The sediment from this composite was analyzed for PAHs, pesticides, and butyltins. None of these contaminants was elevated in the OBM sediment over levels found in sediment from R-OS. Sediments from OBM were acutely toxic to *N. caecoides* in a 10-day test. Pesticides, PCBs, and butyltins were examined in *M. nasuta* tissues. None of these parameters was elevated in *M. nasuta* tissues exposed to OBM COMP relative to levels found in tissues exposed to sediment from R-OS.

The OBM COMP sediments were further evaluated during the Intensive Study of the Turning Basin. The sediment results from that study confirmed those reported in January 1994 that none of the contaminants of interest were above levels reported in the reference sediment

R-OS. The acute toxicity of OBM sediments to *N. caecoides* was included in a more definitive study called *The Older Bay Mud Study* (Pinza et al. 1995) published in a separate report.

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APPENDIX A

MATERIALS AND METHODS USED FOR THE DESCRIPTION OF SEDIMENT CORES

APPENDIX A

MATERIALS AND METHODS USED FOR THE DESCRIPTION OF SEDIMENT CORES

A.1 MATERIALS

The following is a checklist of items and materials useful for the examination and description of sediment cores.

- ASTM Procedure D 2488-84
- Stainless-steel knife
- Hand lens (10X magnification)
- 10 N Hydrochloric acid (HCl)
- Ruler (scaled in 0.1-foot increments)
- Blank log forms (see Figure A.1)
- Clipboard
- AGI Data Sheets
- Munsell Color Charts

In addition, the charts and/or reference materials listed in Table A.1, and included in this appendix, are useful in the description of specific sediment characteristics.

A.2 METHODS

Descriptions of the physical, chemical, and biological features preserved in sediments aid in the interpretation of the types of geologic processes active both during and after the sediment was deposited. A total of 17 sediment characteristics, outlined in ASTM (1984), are commonly used to describe inorganic soils. These are listed in Table A.2.

Moisture condition was not routinely logged because of the saturated nature of the sediments. Furthermore, since particles were rarely larger than coarse sand, neither were angularity, particle shape, range in particle size, nor hardness logged. For this reason, these sediment characteristics were not included in the log form used for the description of the sediments (Figure A.1). However, in the few instances where these characteristics did apply, they were described under the "COMMENTS" column.

The definition of "soil" from the engineers standpoint (ASTM, 1984), includes any unconsolidated sediment. The geologic definition of soil is slightly different and restricts soils to those sedimentary deposits that have undergone alteration near the land's surface by either physical, chemical, and/or biological processes; therefore, in a strict sense, not all sediments are soils. For the purposes of this discussion, however, "soils" and "sediments" will be used synonymously.

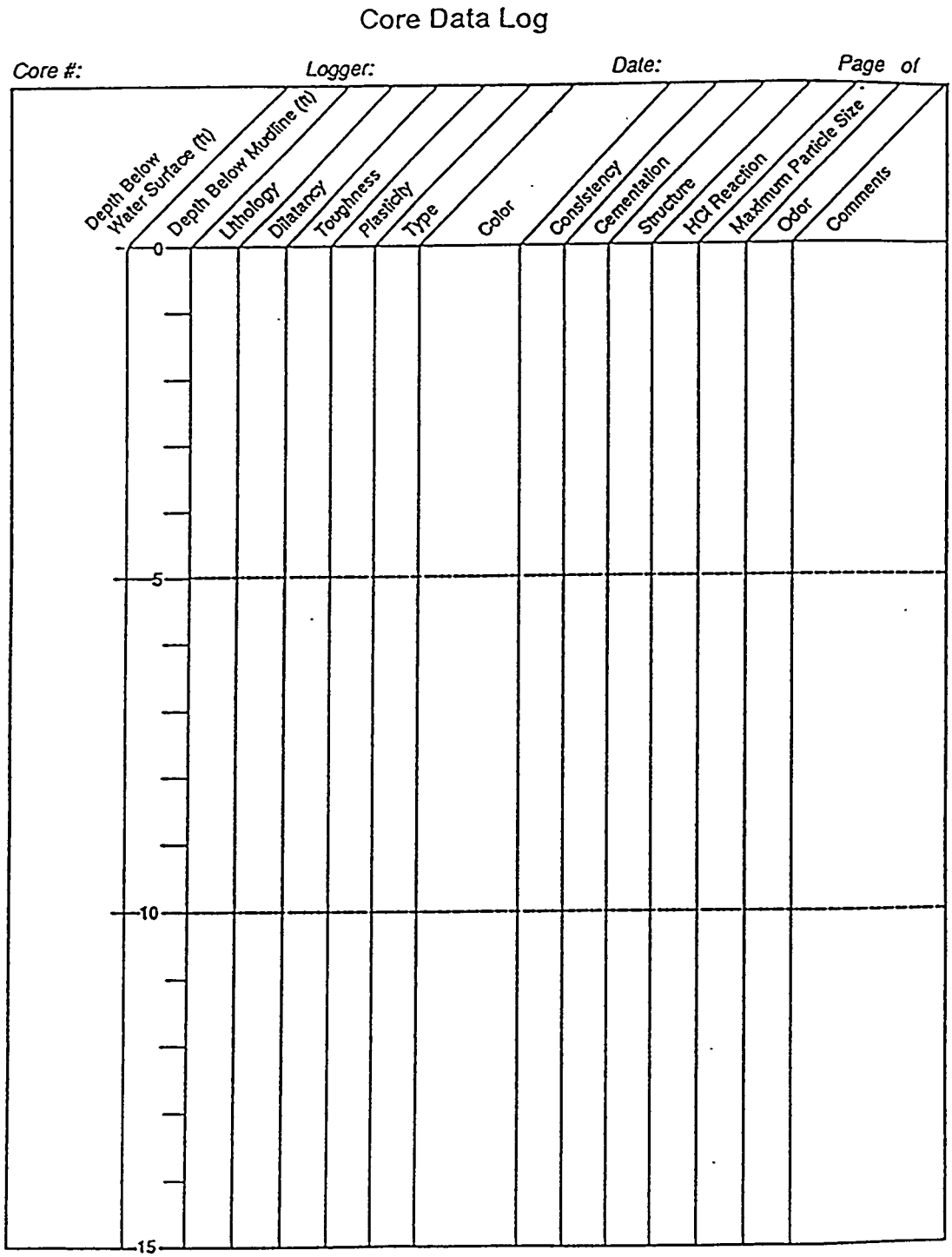


FIGURE A.1. Log Form Used to Record Sediment Descriptions

TABLE A.1. Charts and Other Reference Materials Used to Provide Standardized Descriptions of Sediment Characteristics.

CHART/REFERENCE	PURPOSE	FIGURE #
• Percentage Estimate Chart	Estimate percentage of individual particles or constituents	A.2
• Roundness Scale	Roundness of sand and coarser particles	A.3A
• Sorting Chart	Estimate of grading	A.3B
• Particle Shape	Reference to describe particle shape	A.4
• Munsell Soil Color Charts	Soil color	A.5
• Unified Soil Classification System	Method for designating sediment type	A.6, A.7
• Grain-size Scales	Range of particle sizes; maximum particle size	A.8, A.9
• Lithologic Symbols	Graphic patterns for lithologic log	A.10, A.11

TABLE A.2. Sediment characteristics identified in ASTM Procedure D2488-84.

1) angularity(a)
2) particle shape(a)
3) color
4) odor
5) moisture condition
6) HCl reaction
7) consistency (i.e., firmness)
8) cementation(a)
9) structure
10) sediment classification type (i.e., lithology)
11) range of particle sizes(a)
12) maximum particle size
13) hardness(a)
14) dry strength(b)
15) dilatancy(b)
16) toughness(b)
17) plasticity(b)

(a) Applies to coarse-grained sediment (sand and larger particles).
(b) Applies to fine-grained sediment of mostly silt and/or clay.
Features not generally logged for this study are underlined.

It is sometimes helpful to provide an estimate of the relative proportions of different constituents in sediments (e.g. light- versus dark-colored minerals). This is made easier and more accurate by using a percentage estimate chart, which provides a graphic reference with varying concentrations of a particular constituent (Figure A.2).

The criteria used to describe each of the 17 sediment characteristics identified in ASTM (1984) are discussed below.

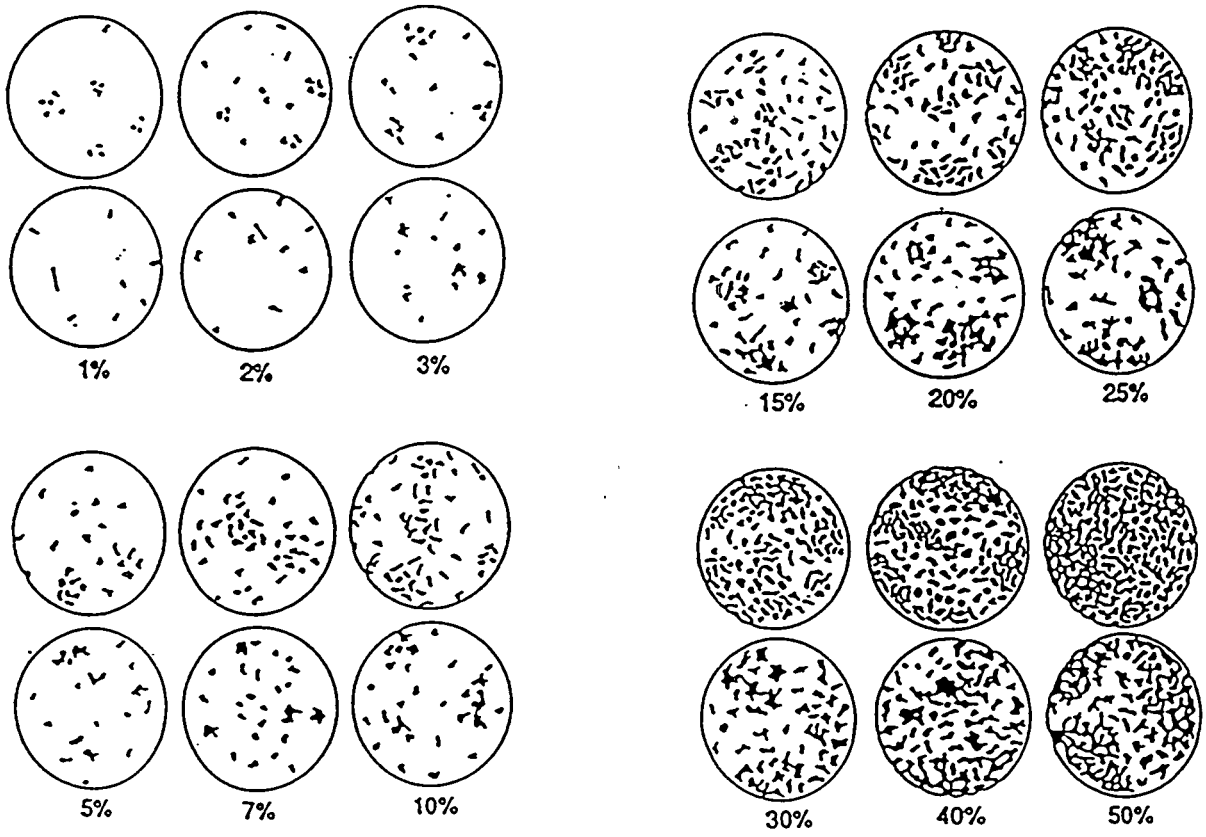


FIGURE A.2. Comparison Chart Used to Estimate the Percentages of Constituents (from AGI 1982).

A.2.1 Angularity

The angularity of sedimentary particles is a reflection of the sedimentary environment and the amount of time that has elapsed before deposition and burial. A chart showing how to classify the angularity of sedimentary particles is presented in Figure A.3A. A range of angularity may be stated, such as, subrounded to rounded.

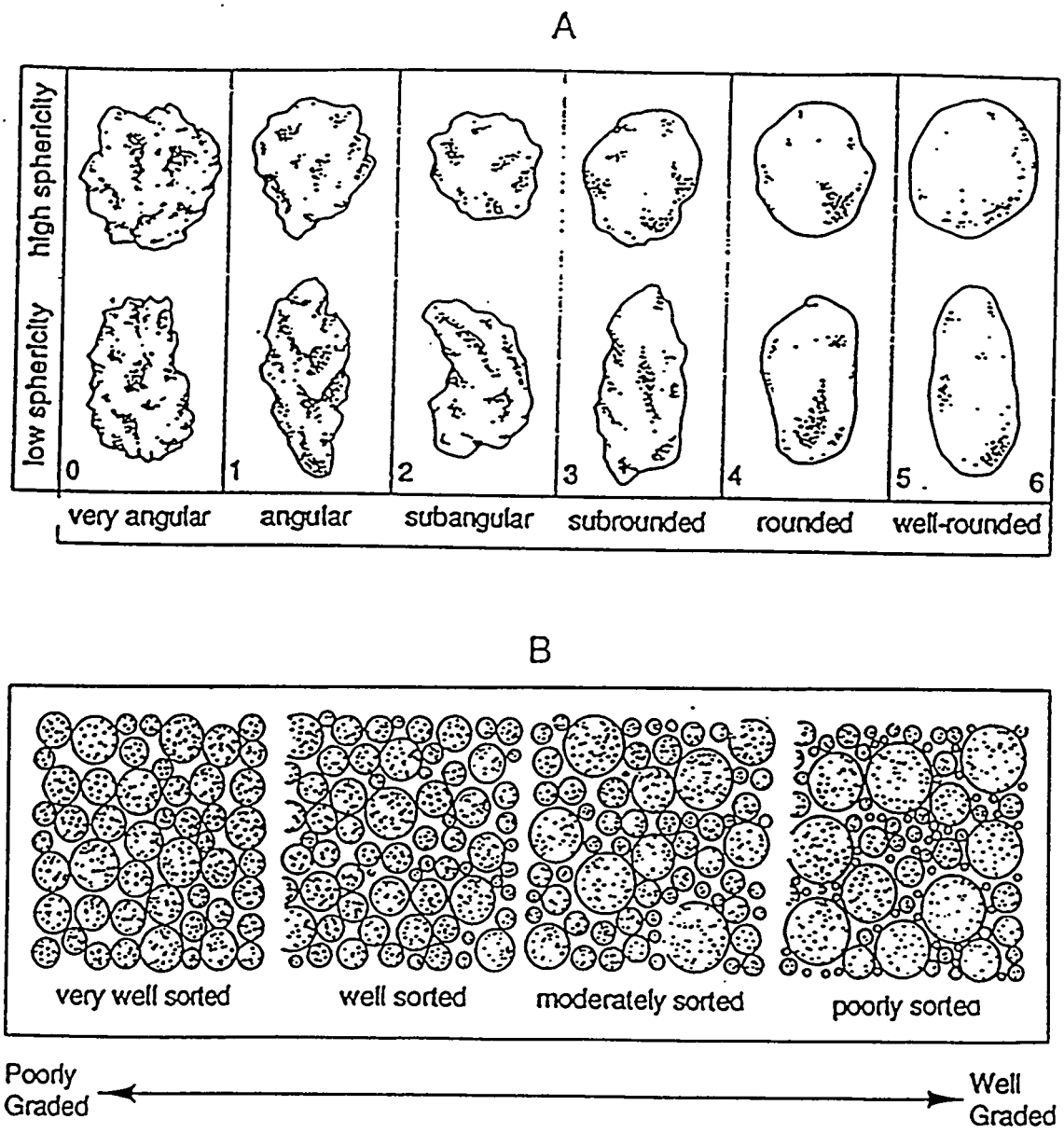
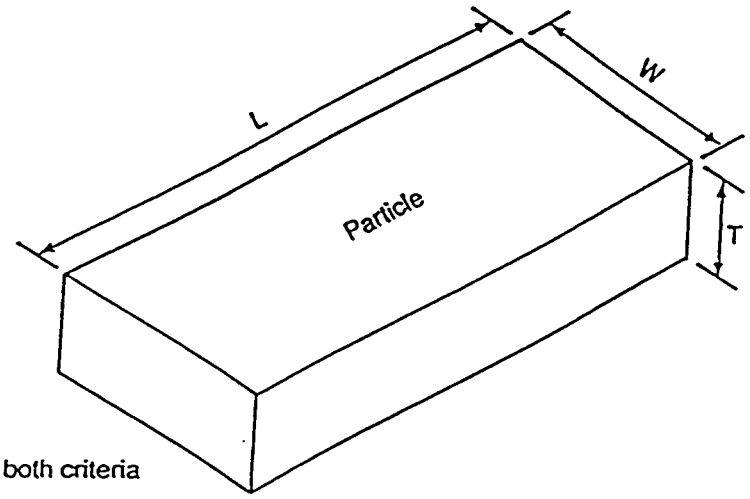


FIGURE A.3. Charts Used to Visually Estimate (A) Roundness/Sphericity and (B) Sorting/Grading

A.2.2 Shape

Shapes of sedimentary particles often reflect the internal characteristics (e.g., preferential parting) of the material or sometimes the type of sedimentary environment. For example gravel clasts deposited in high-energy environments, such as beaches and river bottoms, are often worn flat.

According to Figure A.4, gravel-sized clasts may be described in one of four ways. First, if the ratio of the clast's width to thickness is >3, it is classified as flat. Second, if the ratio of the clast's length to width is >3, the clast is elongate. Third, if both criteria apply the clast is both flat and elongate. And last, if none of the criteria apply, then shape is not mentioned. Indicate the fraction of the clasts that have the shape, such as, one-third of gravel clasts are flat. Particle shape did not apply to most of the sediments logged during this project and the few pebbles that were observed were neither flat nor elongate.



W = Width
T = Thickness
L = Length
Flat: W/T>3
Elongated: L/W>3
Flat and Elongated: meets both criteria

FIGURE A.4. Criteria Used to Describe Particle Shape of Pebbles and Large Gravels (From ASTM 1984)

A.2.3 Color

Color may be useful in identifying materials of similar geologic origin. For example, color was often a useful criteria for differentiating younger bay mud from older bay mud. Sediment color was determined by comparing the wet sediment with standard sediment colors given in Munsell (1975). The advantage to using the Munsell soil color system is that it provides a consistent, standardized method for describing color and subjectivity is minimized.

The Munsell color notation consists of three simple variables that combine to describe all colors known in the Munsell soil color system. The three variables are: hue, value, and chroma (Figure A.5). The hue notation indicates the relation of the sediment color with respect to red, yellow, green, blue and purple; the value notation indicates its lightness, and the chroma notation indicates its strength (i.e., intensity).

Color can be described either by the Munsell notation (e.g. 5YR 5/3; hue=5YR, value=5, chroma=3) or by its equivalent color name (e.g., reddish brown). Both the color name and Munsell notation were recorded on core logs (see Appendix B). Only rarely was there not a reasonable match between the true color of the core sediment and one of the colors on a Munsell color chart.

A.2.4 Odor

Odors may indicate the presence of contaminants or be the result of the geochemical environment. Odors most frequently noted were that of petroleum hydrocarbons and the smell of rotten eggs (an indication of the presence of hydrogen sulfide). Both of these odors were restricted to the younger bay mud unit. Petroleum odors may be the result of contamination of the sediments by shipping spills or industrial waste, or perhaps is derived from the abundant decaying organic matter present in these sediments. Hydrogen sulfide is a common natural by-product in chemically reducing environments such as the Richmond Harbor estuary.

A.2.5 Moisture Condition

Moisture condition is described as either dry, moist, or wet according to the following criteria:

DRY Absence of moisture, dry to the touch

MOIST Damp but no visible water

WET Visible free water, usually soil is below water table (i.e., saturated)

All the sediments logged for this project were taken from below sea level and did not lose any significant moisture between the time they were drilled and logged. Therefore, they are all classified as wet.

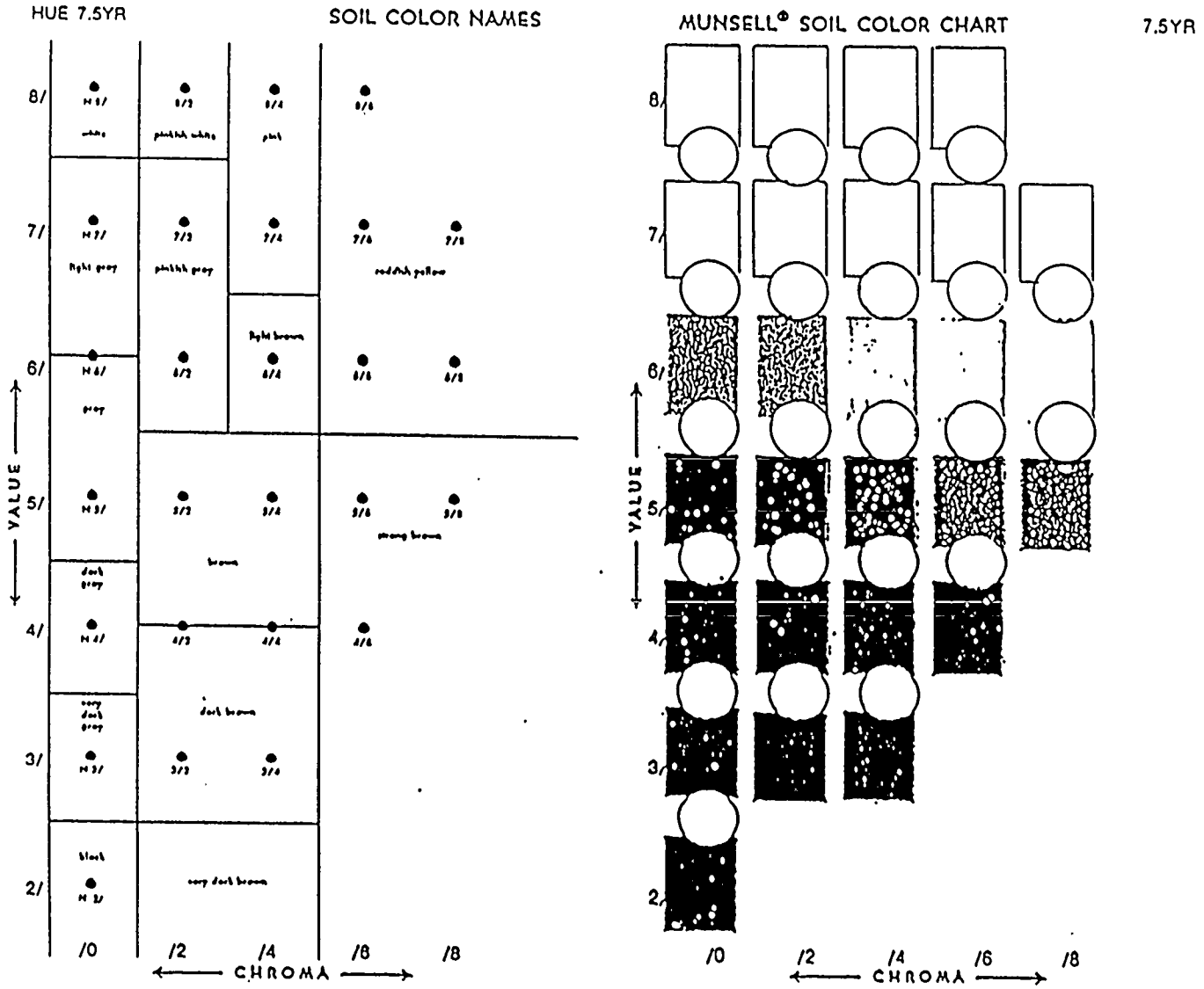


FIGURE A.5. Example of a Page from the Munsell Soil Color for Hue 7.5YR

A.2.6 HCl Reaction

The reaction (i.e., effervescence) of sedimentary material, as a result of adding dilute hydrochloric acid, is an indication of the presence of calcium carbonate. Calcium carbonate in sediments may be derived from a variety of sources including: 1) physical disintegration of preexisting carbonate rocks (e.g., limestone, marble), 2) biogenic precipitation (e.g., shell, bone), and, 3) soil development. In the last example, calcium carbonate concentrations, often referred to as caliche or calcrete, may accumulate over time near the land's surface in arid climates. Where calcium carbonate concentrations occur in combination with other evidence for soil development, such as root traces and oxidation, then a pedogenic (soil forming) origin is favored. Criteria for describing the reaction with 10 N HCl are as follows:

NONE	No visible reaction
WEAK	Some reaction, with bubbles forming slowly
STRONG	Violent reaction, with bubbles forming immediately

A solution of 10 N HCl is obtained by slowly adding one part of concentrated hydrochloric acid to three parts of distilled water. (To avoid a violent exothermic reaction never add water to acid.)

A.2.7 Consistency

Consistency is a measure of the firmness or consolidation of sedimentary material. In general, there is a direct relationship between consistency and age of the deposit (i.e., older deposits are usually more firm because of compaction and/or cementation). Consistency is most applicable to fine-grained sediments and least applicable on sediments that contain significant amounts of gravel. The criteria used to determine consistency are as follows:

VERY SOFT	Penetrometer penetrates soil greater than 4 cm
SOFT	Penetrometer penetrates soil 2.0 to 4.0 cm
FIRM	Penetrometer penetrates soil 0.25 to 2.0 cm
HARD	Penetrometer penetrates soil less than 0.25 cm.

The penetrometer used for sediment core descriptions consists of a 6-in. nail spike attached to a clay brick for a total mass of 2.0 kg; the nail spike is marked in centimeter increments to quantify the amount of soil penetration.

A.2.8 Cementation

Often sedimentary particles are held together with a binding cement. Three common natural cements are calcium carbonate (lime), silica, and iron-oxide compounds. Particles cemented with calcium carbonate effervesce in the presence of hydrochloric acid (see Section A.2.6 above). Sediments cemented with iron oxide are usually some shade of red, yellow, or brown. Usually there is a relationship between consistency (Section A.2.7) and cementation, in that strongly cemented deposits are also hard to very hard. Criteria used to describe the degree of cementation are:

WEAK	Crumbles or breaks with handling or light finger pressure
MODERATE	Crumbles or breaks with considerable finger pressure
STRONG	Will not crumble or break with finger pressure.

A.2.9 Structure

Structures are features that originate within the layers of sediment or at the sediment/water interface in response to various physical, biologic and/or chemical processes. Structures may be classified into two categories: primary and secondary. Primary structures form as the sediment is being deposited (e.g., lamination, stratification). Secondary structures form after deposition, often as a result of compaction or other stresses (e.g., fissured, slickensided), biologic activity (e.g., root traces, mottling), and soil development (e.g., homogeneous, blocky, mottled). The following are some common structures observed in sedimentary deposits.

PRIMARY STRUCTURES

STRATIFIED	Alternating layers of varying material or color with layers at least 6 mm thick
LAMINATED	Alternating layers of varying material or color with the layers less than 6 mm thick
LENSED	Inclusion of small pockets of different sediment type, such as small lenses of sand scattered through a mass of clay. (This type of structure may also be secondary).

SECONDARY STRUCTURES

FISSURED	Breaks along definite planes of fracture with little resistance to fracturing
SLICKENSIDED	Fracture planes appear polished or glossy, sometimes striated
BLOCKY	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
MOTTLED	Variation in color of sediments as represented by localized spots or blotches of color or shades of color
HOMOGENEOUS	Same color and appearance throughout.

A.2.10 Sediment Classification Type

The classification method used in this study is the Unified Soil Classification System, which consists of a two-letter designation for most soils (i.e., unconsolidated sediments). A simplified version of the Unified Soil Classification System is presented in Figure A.6, whereas a more-detailed breakdown is presented in Figure A.7.

According to the Unified Soil Classification System, coarse-grained sediments are classified based on grain-size distribution and grading (i.e., sorting), while fine-grained sediments are classified on the basis of grain size and liquid limit vs. plasticity.

Particle-size distribution may be determined with precision using laboratory methods (e.g., sieving of sand and coarser particles; pipette or hydrometer analysis of silt and clay). Because these methods are expensive and time-consuming, it is more desirable to estimate grain size using rapid visual-manual techniques described below. For example, sand and coarser particles are most easily identified via comparison with standard charts of grain size (Figures A.8 and A.9). Fine-grained soils, consisting of mostly silt and/or clay, on the other hand, are identified based on manual tests of their dry strength, dilatancy, toughness, and plasticity (Figure A.10).

In the Unified Soil Classification System, the first letter of the sediment-type symbol represents the predominant grain-size interval, be it gravel (G), sand (S), silt (M), or clay (C). For coarse-grained sediments, the first letter (i.e., G or S) may be followed by a descriptor of grading, either W (well graded) or P (poorly graded), or a secondary grain-size descriptor (M or C). The definition of grading is opposite that of sorting, a common geologic term. For example, a clean, well-sorted sand, consisting of particles over a narrow range in grain size, is referred to as poorly graded in the Unified Soil Classification System and would receive the designation "SP". The relationship between grading and sorting is shown graphically in Figure A.3B. The second letter in the fine-grained soil designation consists of either L (low liquid limit) or H (high liquid limit).

The lithology column on the geologic log (Figure A.1) essentially represents a graphic display of sediment type, which can be utilized for quick easy reference and comparison between different cores and thus make interpretations easier. Examples of lithologic symbols in common use are presented in Figure A.11. Additional symbols may be used as long as they are graphically representative of the feature and are specifically defined and identified in a key that accompanies lithologic logs.

Major Divisions			Group Symbols	Description
Coarse-Grained Sediments More than half of particles are larger than very fine sand	≥50% Gravel	Clean Gravels	GW	Well-graded (i.e., poorly sorted) gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded (i.e., well sorted) gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	≥50% Sands	Clean Sands	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands, gravelly sands, little or no fines
		Sands with Fines	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
Fine-Grained Sediments More than half of particles are smaller than very fine sand	Silts and Clays	Low Liquid Limit	ML	Silts and very fine sands, silty or clayey fine sands, or clayey silts, with slight plasticity
			CL	Clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		High Liquid Limit	MH	Silts or fine sandy silts with moderate plasticity
			CH	Clays of high plasticity, fat clays

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FIGURE A.6. Abbreviated Form of the Unified Soil Classification System (From AGI 1982)

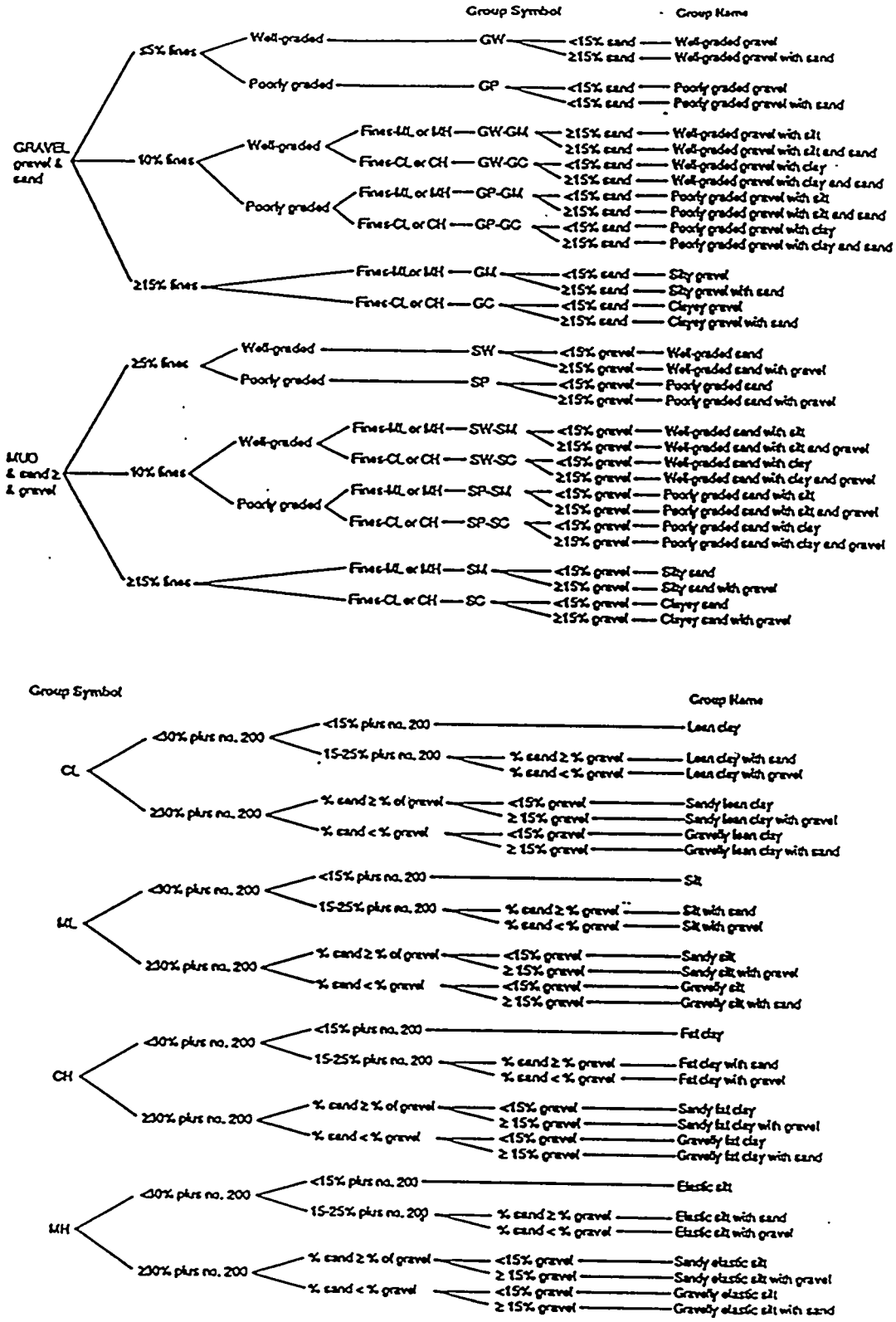


FIGURE A.7. Detailed Flow Chart For the Classification of Coarse- and Fine-Grained Soils Using the Unified Soil Classification System

Grade Limits			inches	U.S. Standard Sieve Series	Grade Name		
phi	mm	mm					
-12	4096		161.3		very large		
-11	2048		80.6		large		
-10	1024		40.3		medium	Boulders	
-9	512		20.2		small		
-8	256		10.1		large		
-7	128		5.0		small	Cobbles	GRAVEL
-6	64		2.52	63 mm	very coarse		
-5	32		1.26	31.5 mm	coarse		
-4	16		0.63	16 mm	medium	Pebbles	
-3	8		0.32	8 mm	fine		
-2	4		0.16	No. 5	very fine		
-1	2		0.08	No. 10	very coarse		
0	1		0.04	No. 18	coarse		
+1	1/2	0.500		No. 35	medium	Sand	SAND
+2	1/4	0.250		No. 60	fine		
+3	1/8	0.125		No. 120	very fine		
+4	1/16	0.062		No. 230	coarse		
+5	1/32	0.031			medium		
+6	1/64	0.016			fine	Silt	
+7	1/128	0.008			very fine		
+8	1/256	0.004			coarse		MUD
+9	1/512	0.002			medium		
+10	1/1024	0.001			fine	Clay Size	
+11	1/2048	0.0005			very fine		
+12	1/4096	0.00025					

FIGURE A.8. Grain-size Scale Used to Determine Sedimentary Particle Size

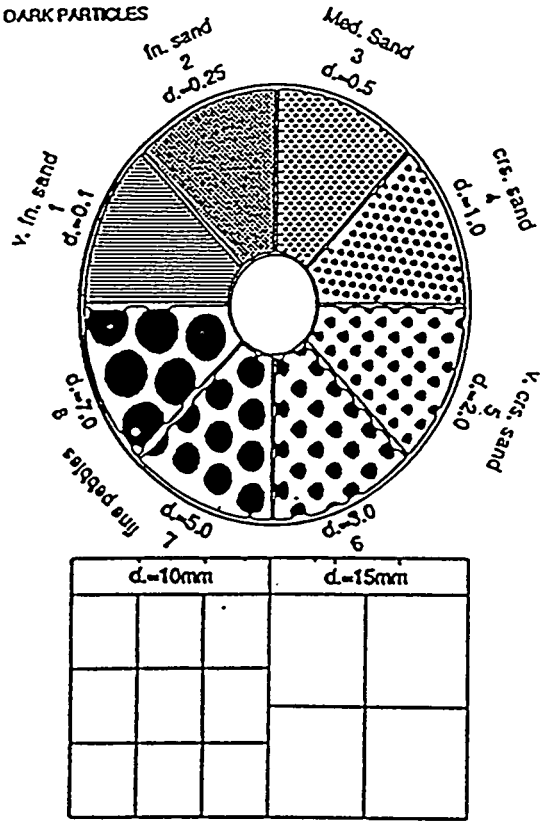


FIGURE A.9. Comparison Chart Used to Distinguish Among Sand to Pebble-size Particles (From AGI 1982). For larger particles, refer to Figure A.8; for smaller particles, refer to Sections A.2.13 and A.2.16 in this Appendix

Sediment Type	Dry Strength					Dilatancy			Toughness			Plasticity			
	None	Low	Medium	High	Very High	None	Slow	Rapid	Low	Medium	High	Nonplastic	Low	Medium	High
ML (Silt)		▨	▨				▨	▨		▨			▨	▨	
MH (Elastic Silt)			▨	▨			▨	▨			▨			▨	
CL (Lean Clay)			▨	▨			▨	▨		▨	▨			▨	
CH (Fat Clay)				▨	▨		▨				▨				▨

FIGURE A.10. Identification of Inorganic Fine-grained Soils From Manual Tests

Lithology:

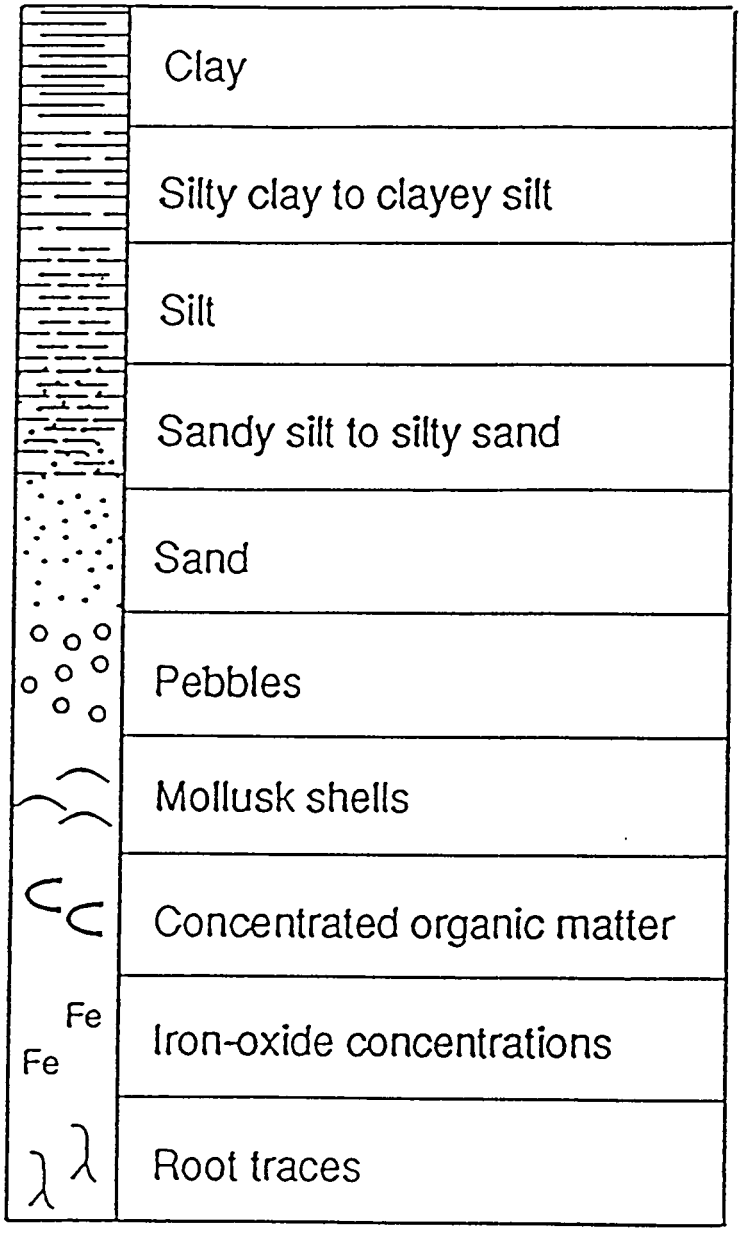


FIGURE A.11. Lithologic Symbols Used on Core Log Forms

A.2.11 Range of Particle Sizes

For gravel- and sand-sized particles, the range of particle sizes within each component is defined. For example, 20% fine to coarse gravel, 40% fine to coarse sand. The sizes of particles corresponding to the different size components are presented in Figures A.8 and A.9.

A.2.12 Maximum Particle Size

Maximum particle size is significant because it gives a general indication of the amount of turbulence or energy associated with deposition. If the maximum particle size is sand, it should be described as either fine, medium, or coarse sand. If the maximum particle size is in the gravel range, the largest particle is measured and its width recorded along the narrowest axis. The sizes of particles corresponding to the different size components are presented in Figures A.8 and A.9.

The maximum grain size observed for the younger bay muds ranged from silt to medium sand, while the older bay mud usually ranged from fine sand to coarse sand. The largest particles observed anywhere were fine pebbles in the older bay mud unit.

A.2.13 Dry Strength

Dry strength, along with dilatancy, toughness, and plasticity are physical characteristics used to distinguish fine-grained inorganic soils, consisting of mostly silt and/or clay. Basically, the more clay present in a soil the greater its dry strength (Figure A.10). To perform a manual test of dry strength enough material must be selected in order to mold into a ball about 1 in. in diameter. Mold the material until it has the consistency of putty, adding water if necessary. From the molded material, make at least three test specimens each about 1/2 in. in diameter. Allow the test specimens to dry in air, sun or by artificial means, as long as the temperature does not exceed 60°C (ASTM, 1984). The criteria for determining dry strength are as follows:

NONE	The dry specimen crumbles into powder with mere pressure of handling
LOW	The dry specimen crumbles into powder with light finger pressure
MEDIUM	The dry specimen breaks into pieces or crumbles with considerable finger pressure
HIGH	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
VERY HIGH	The dry specimen cannot be broken between the thumb and a hard surface.

Dry strength was determined from the cores by sampling selected intervals and allowing the samples to air dry overnight. Dry strength was determined the next day and noted in the comments column of the geologic log.

A.2.14 Dilatancy

Dilatancy is a measure of how easily a soil gives up water when shaken. For example, some clays have the ability to absorb and retain large amounts of water into their crystal lattice. "Fat" clays tend to retain their water even under stress whereas "lean" clays and silt tend to release water when shaken.

To test for dilatancy select enough material to mold into a ball about 1/2 in. in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky consistency. Smooth the soil ball in the palm of the hand with a blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction. Specimens with high dilatancy will quickly yield water when shaken and absorb water when squeezed. The criteria for describing dilatancy are:

NONE	No visible change in the specimen
SLOW	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
RAPID	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

The range of dilatancy for the different fine-grained sediment types is shown in Figure A.10. From this figure it is apparent that dilatancy decreases with decreasing grain size.

A.2.15 Toughness

After completion of the dilatancy test, shape the same specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 in. The thread will crumble at a diameter of 1/8 in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading and classify into one of the following categories.

LOW Only slight pressure is required to roll the thread near the plastic limit. The thread and lump are weak and soft

MEDIUM Medium pressure is required to roll the thread to near the plastic limit. The thread and lump have medium stiffness.

HIGH Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

The range of toughness for the different fine-grained sediment types is shown in Figure A.10. From this figure it is apparent that toughness increases with a decrease in particle size.

A.2.16 Plasticity

On the basis of observations made during the toughness test, describe the plasticity of the material according to the following criteria:

NONPLASTIC A 1/8 in. thread cannot be rolled at any water content

LOW The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.

MEDIUM The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.

HIGH It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

The range of plasticity for the different fine-grained sediment types is shown in Figure A.10. From this figure it is apparent that an increase in plasticity accompanies a decrease in grain size.

A.3 REFERENCES

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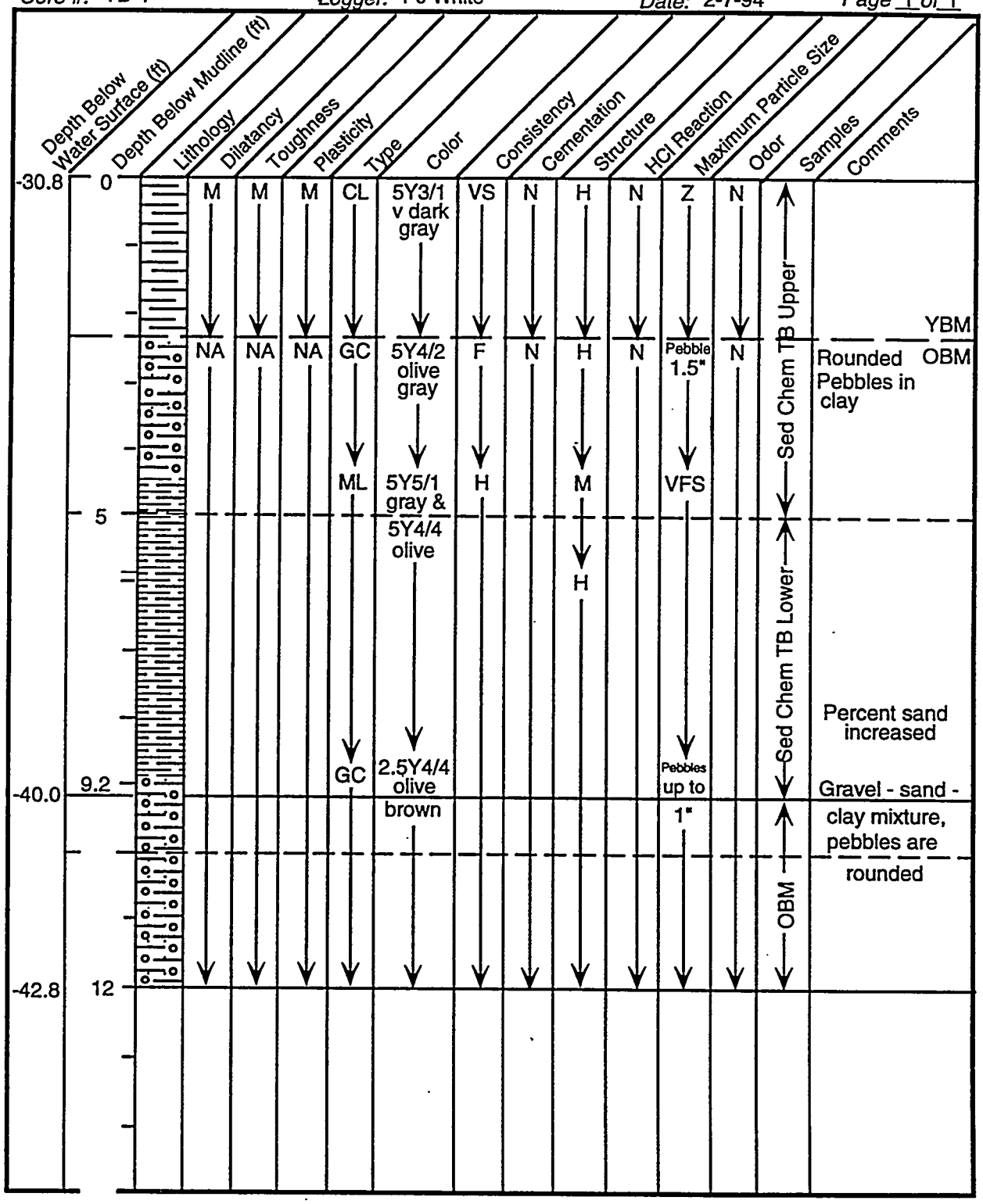
APPENDIX B

CORE DATA LOGS

Core Data Log

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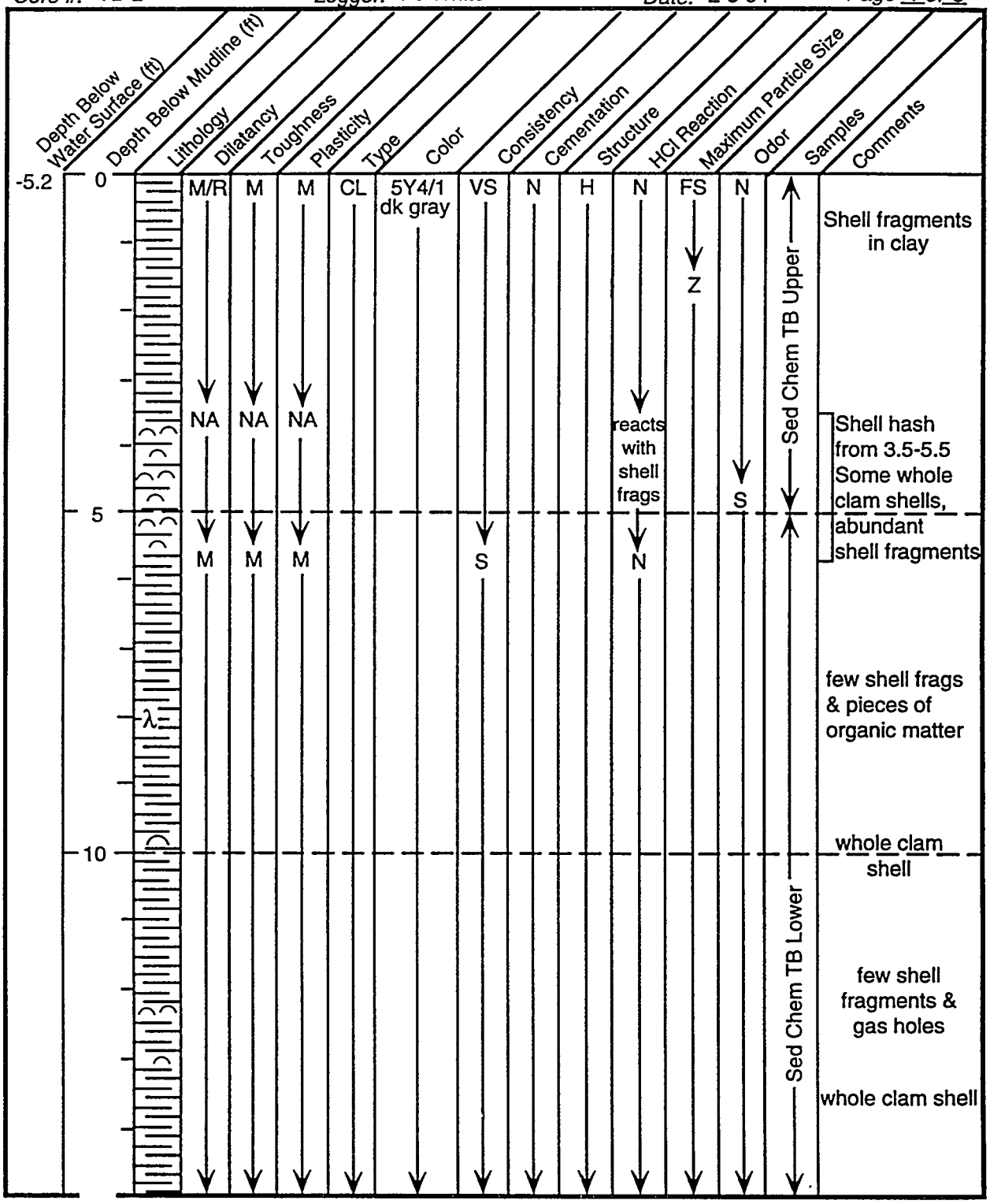
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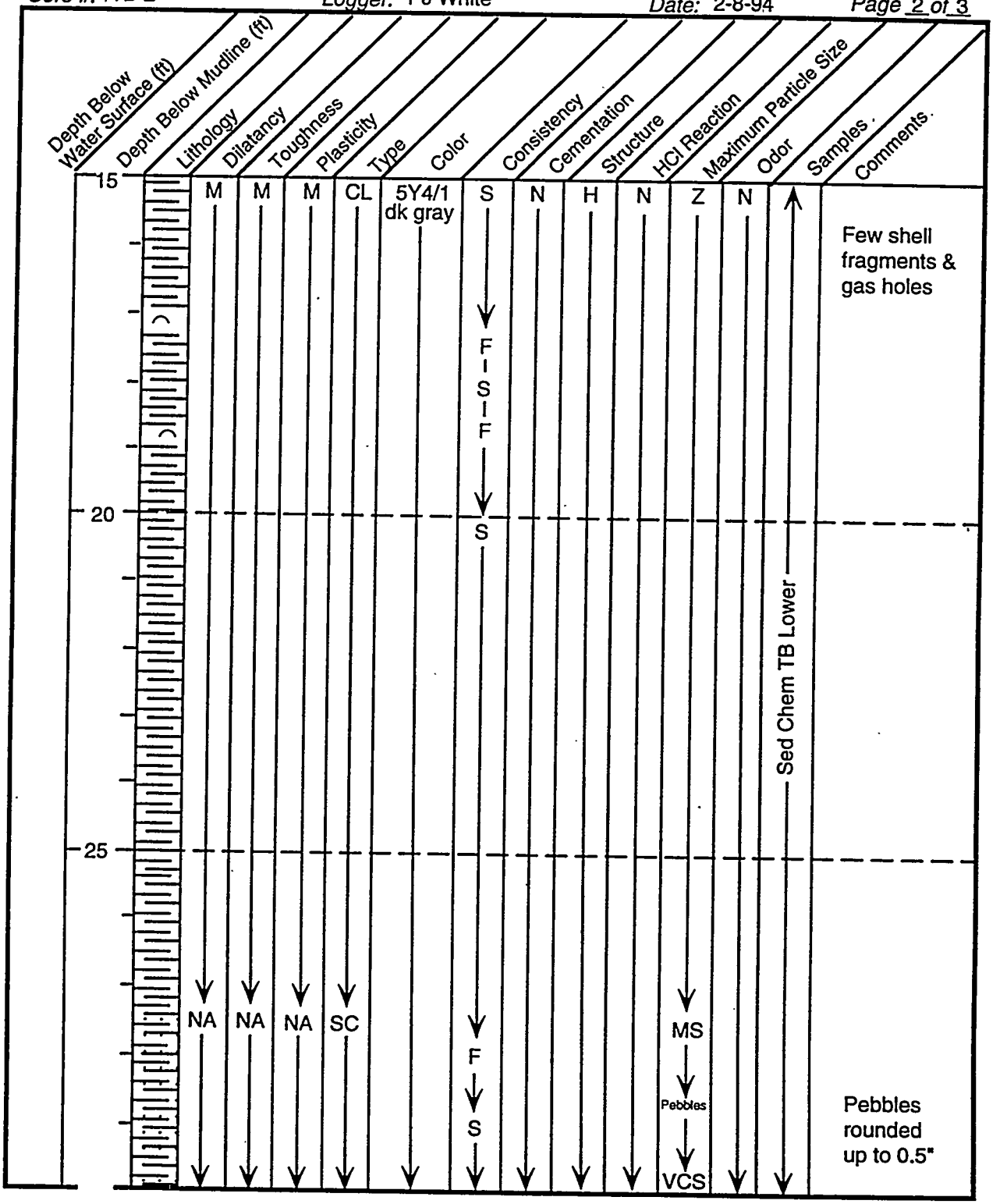
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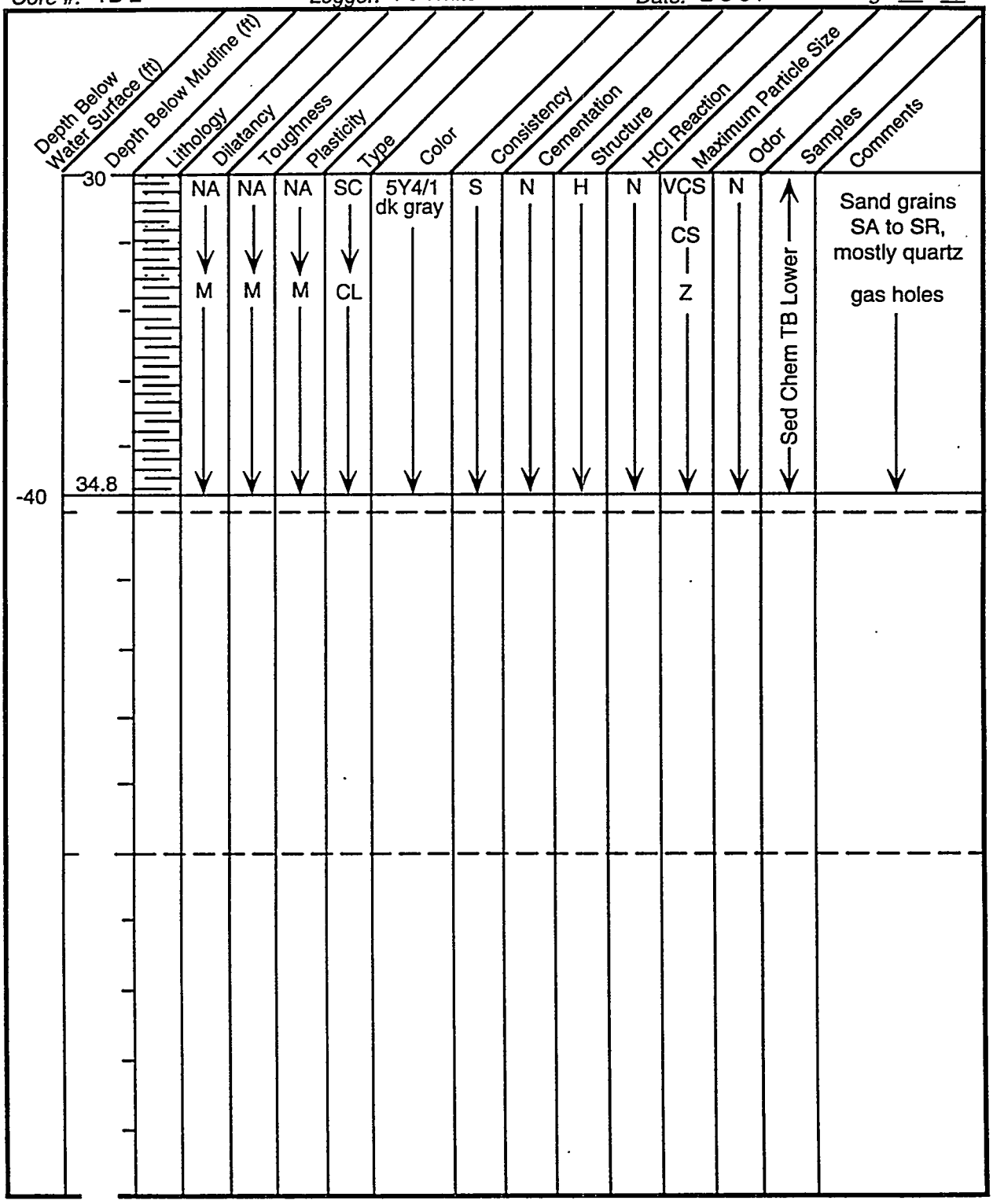
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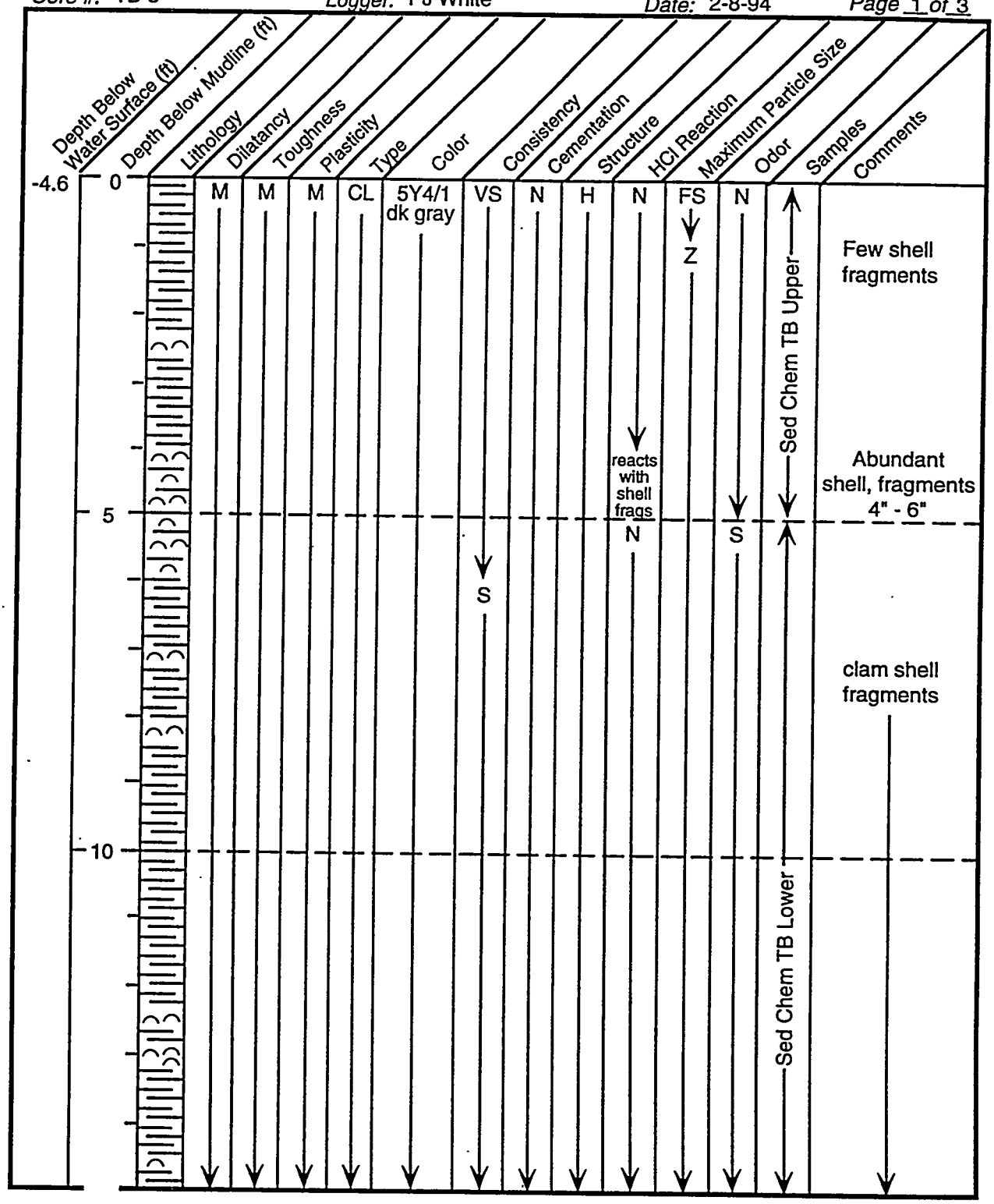
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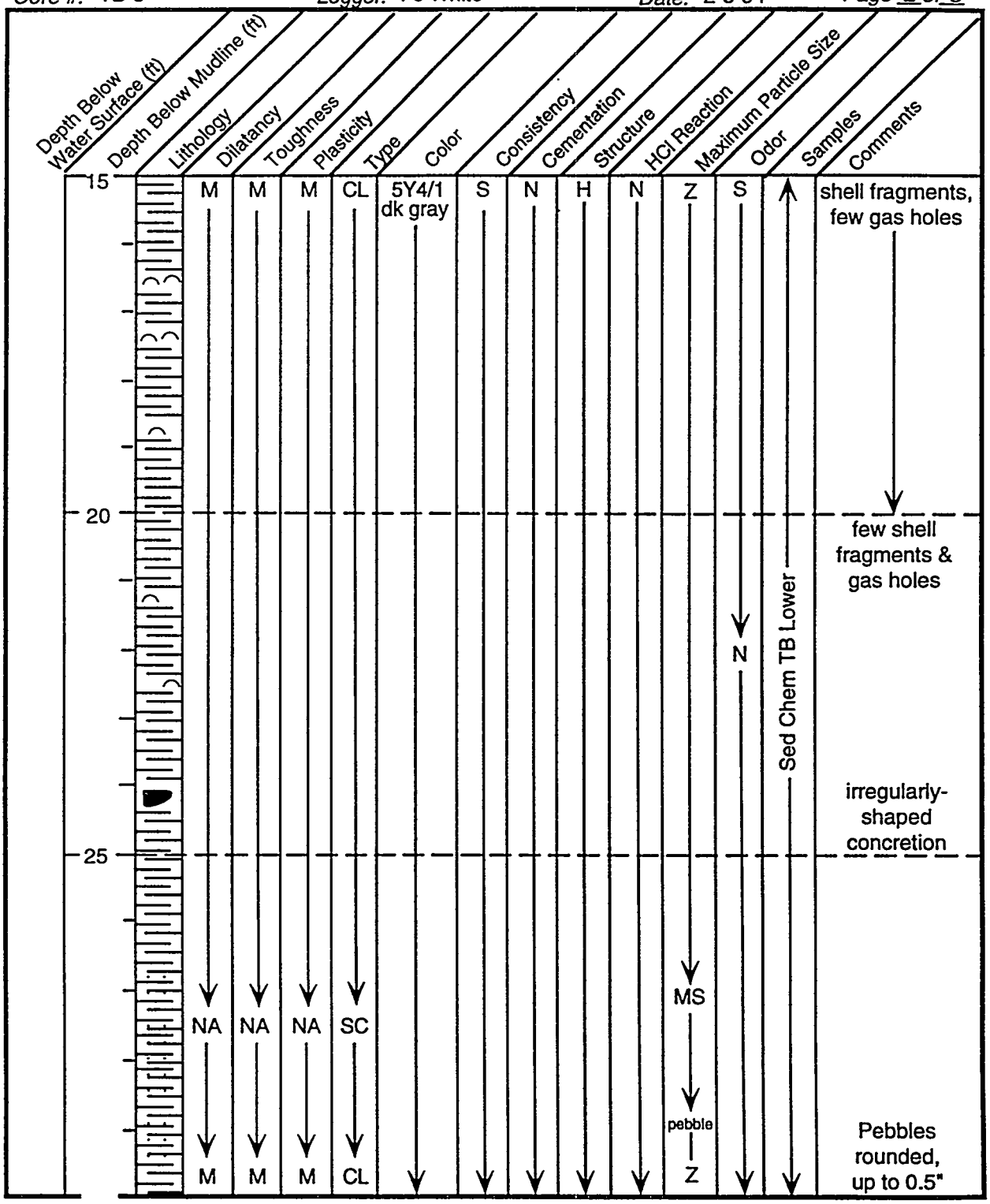
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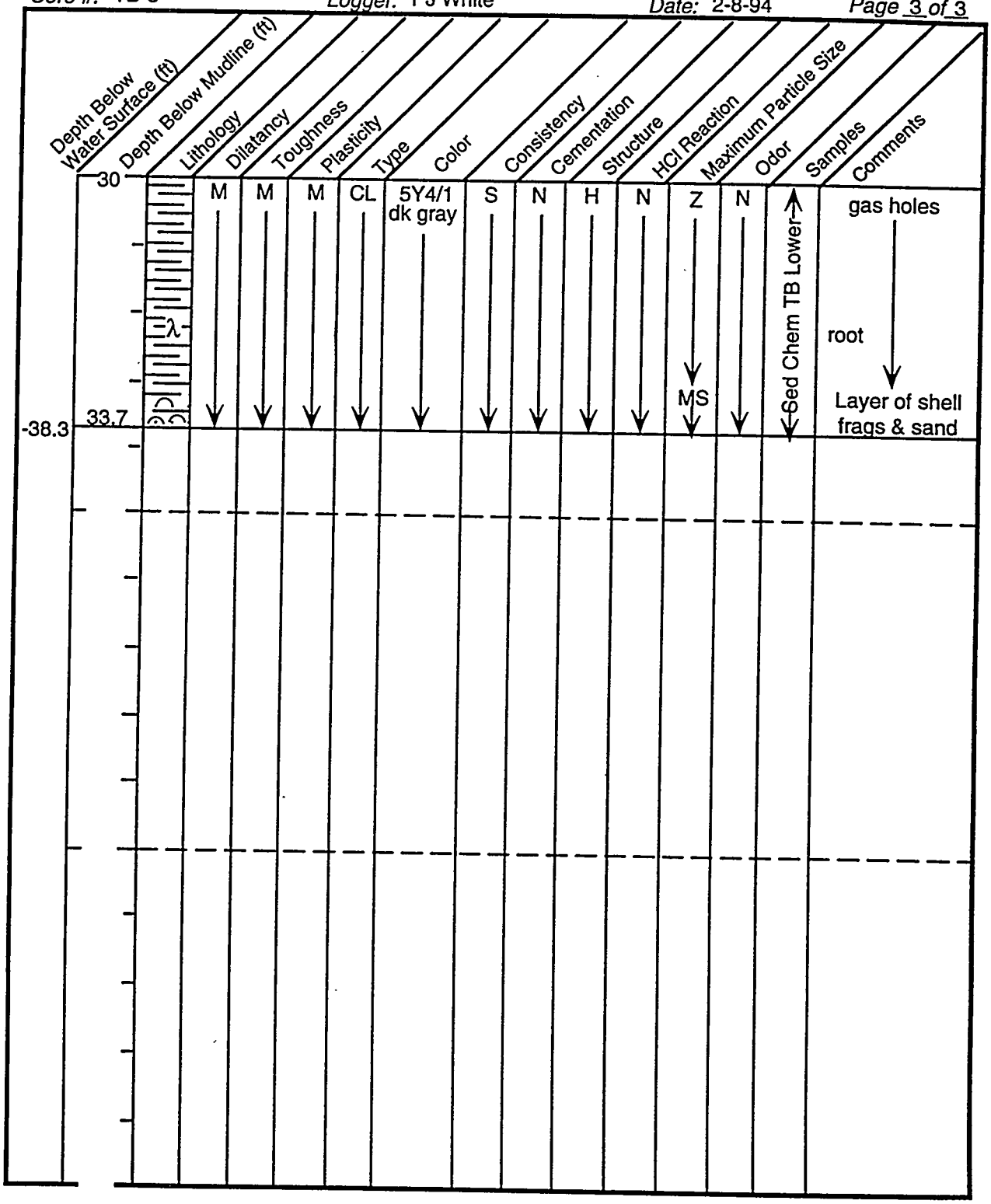
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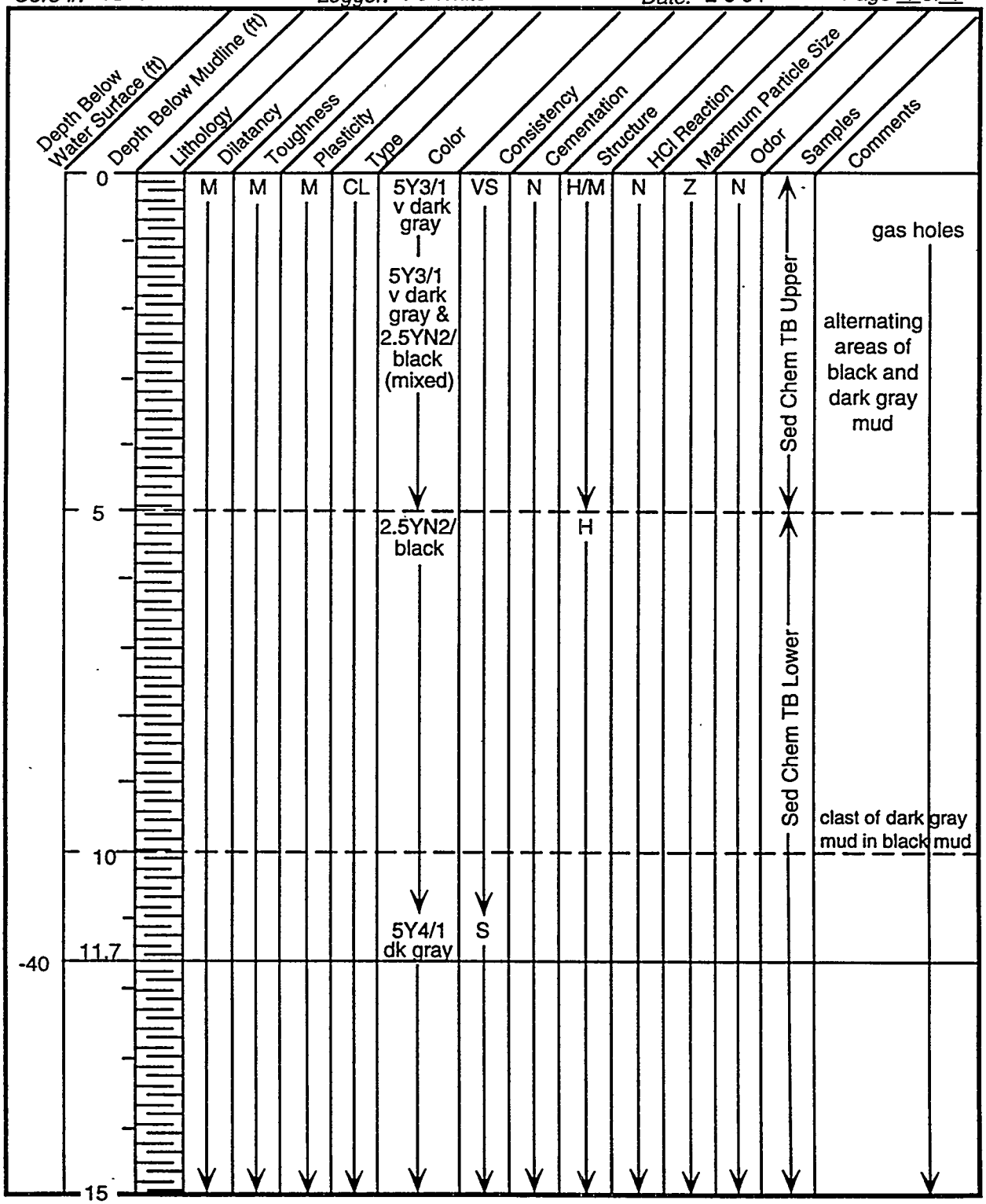
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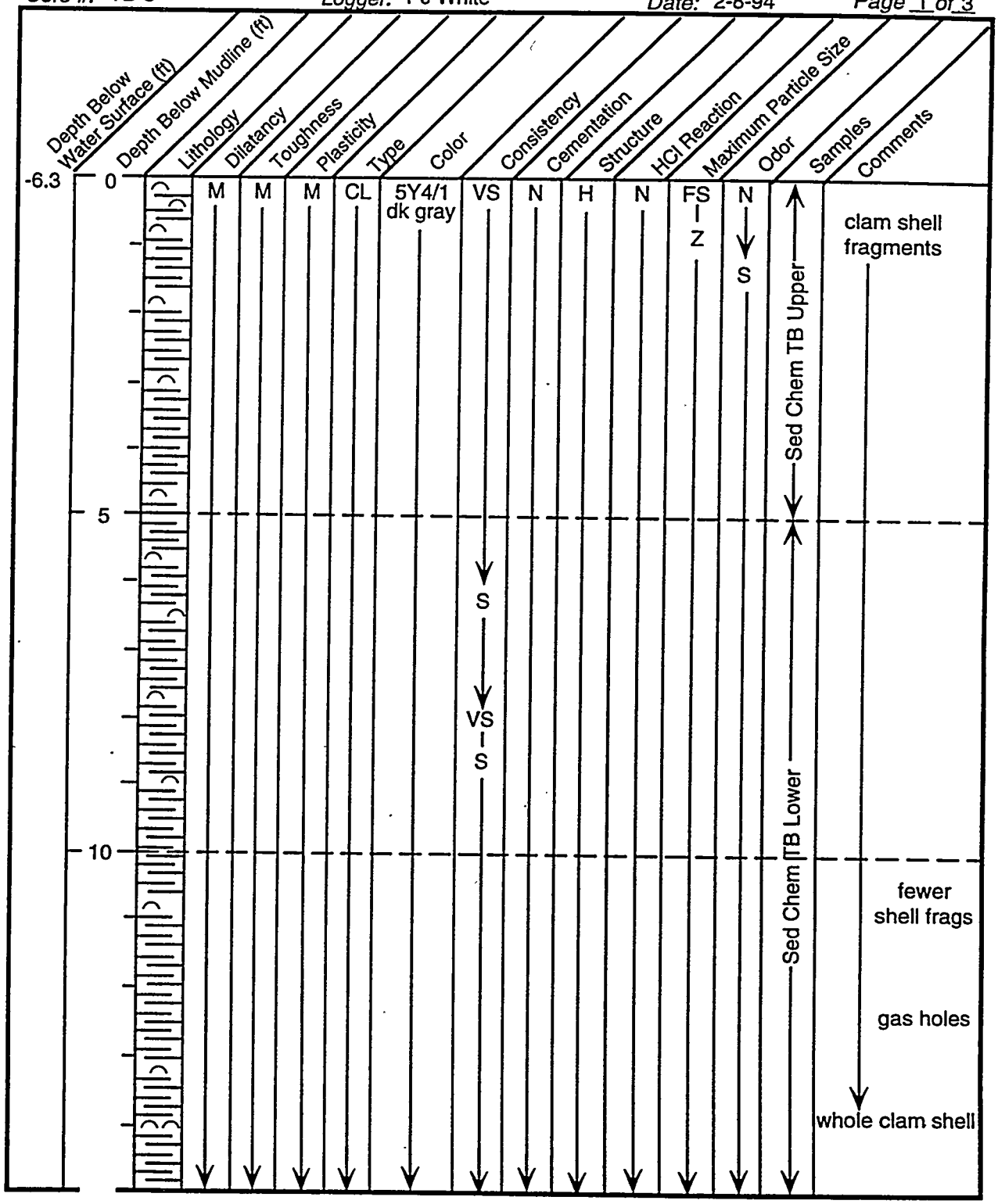
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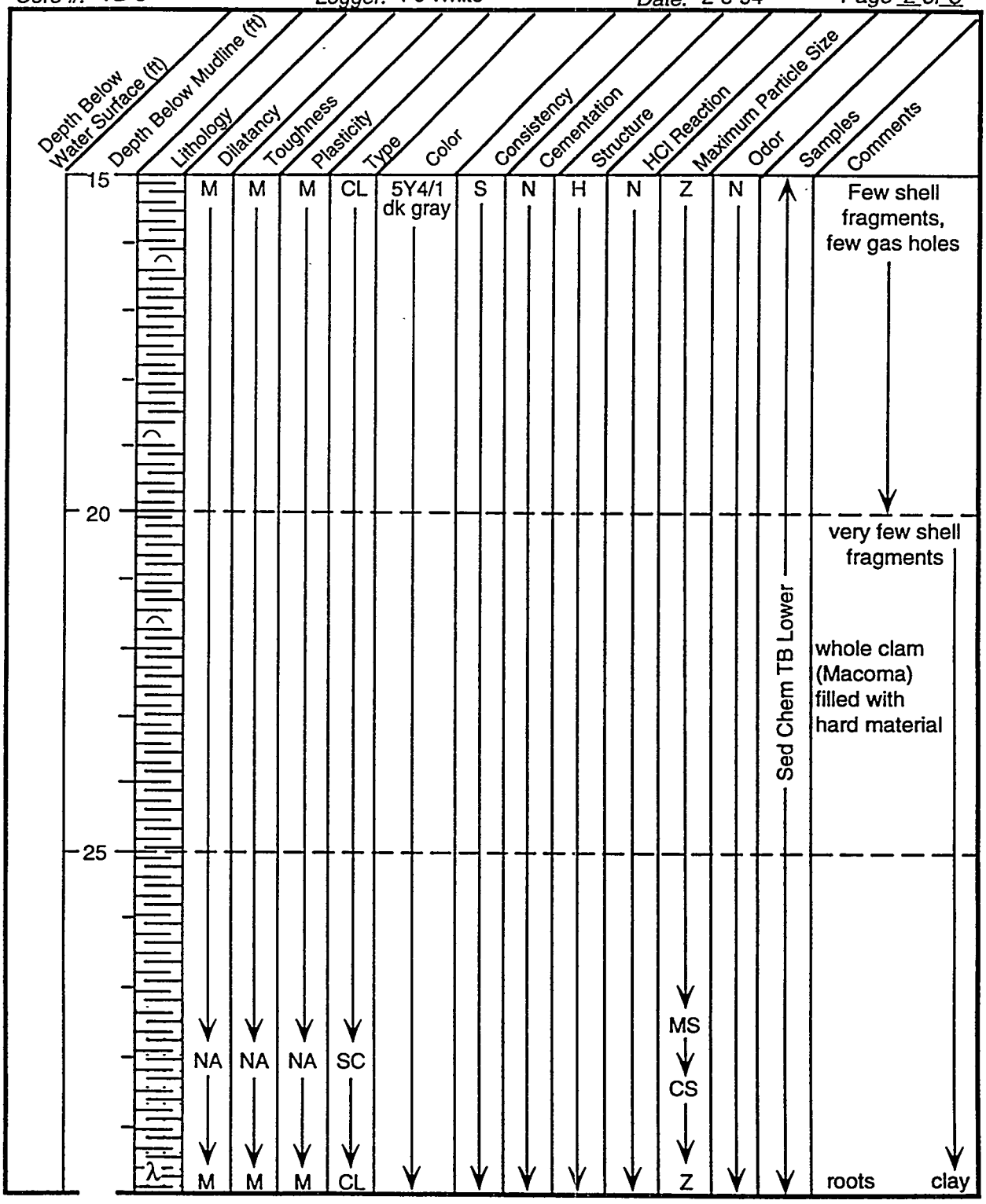
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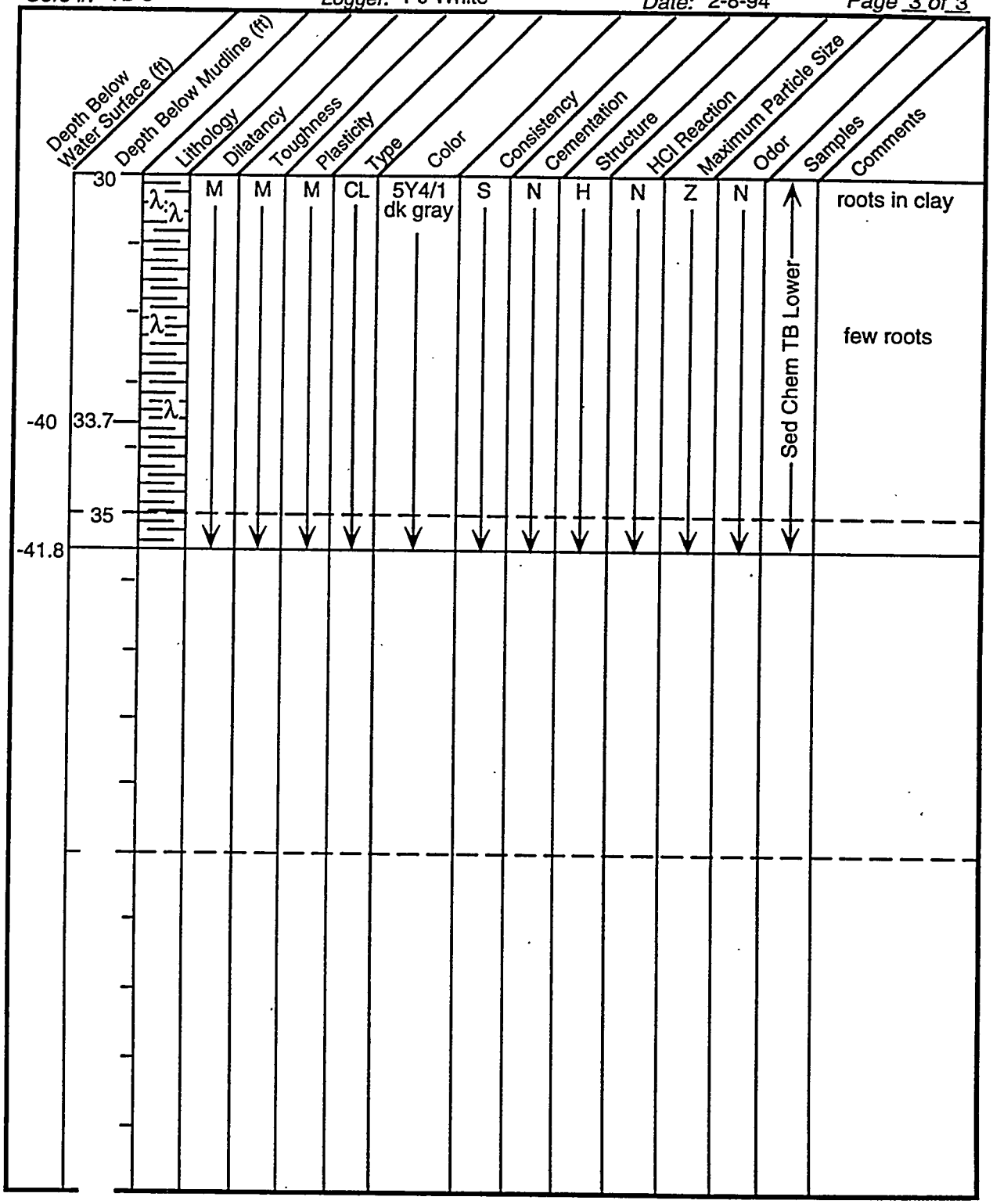
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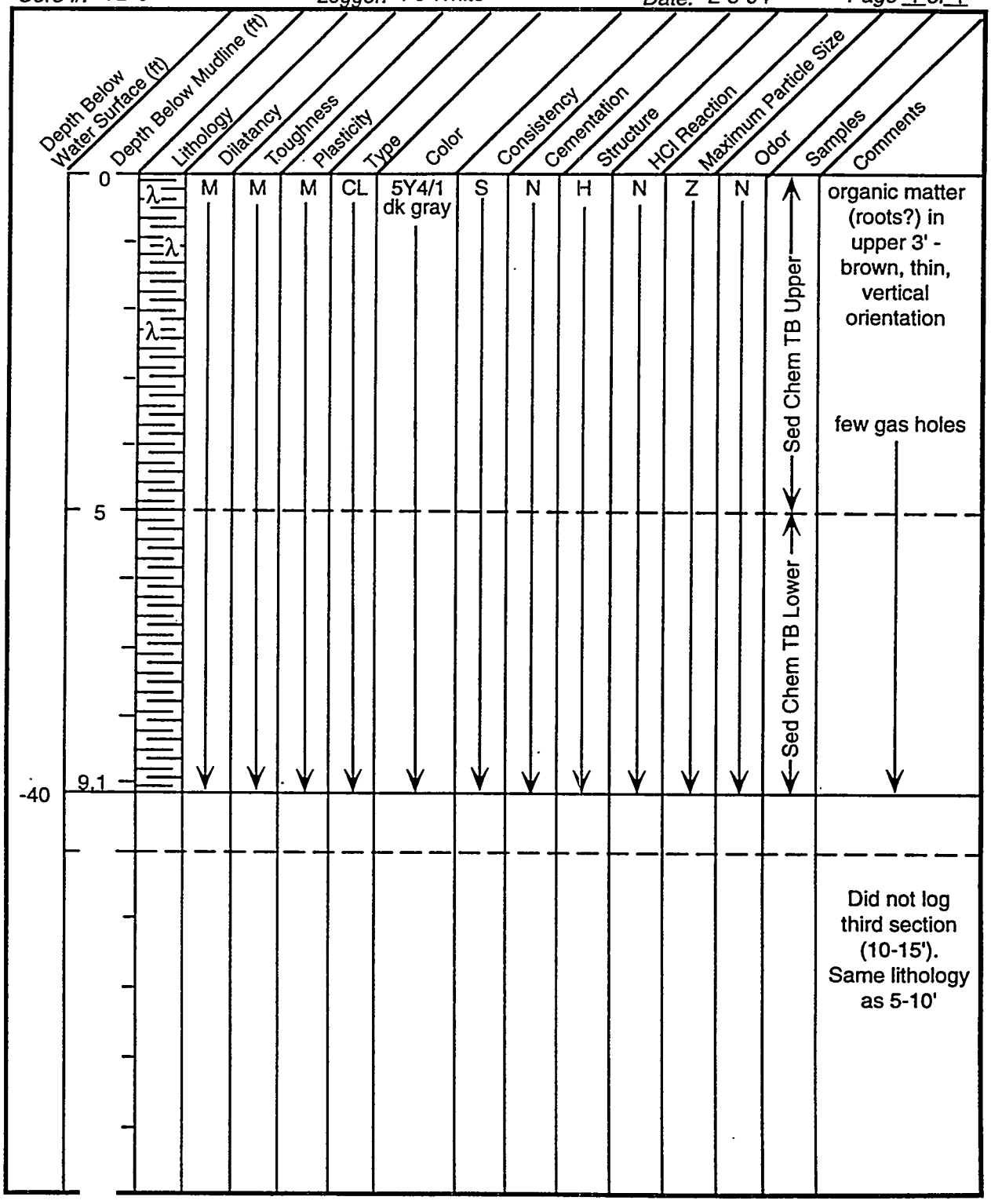
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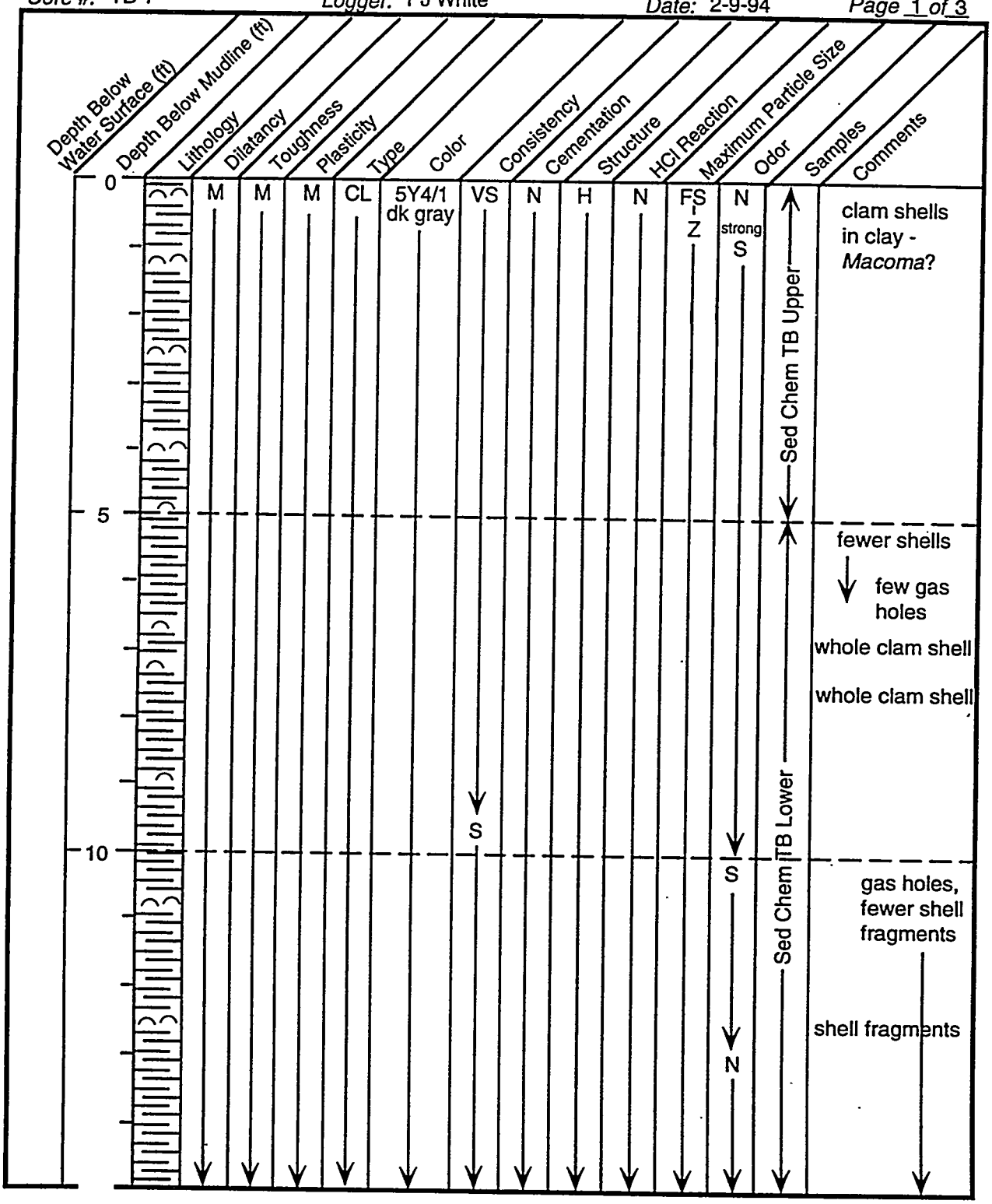
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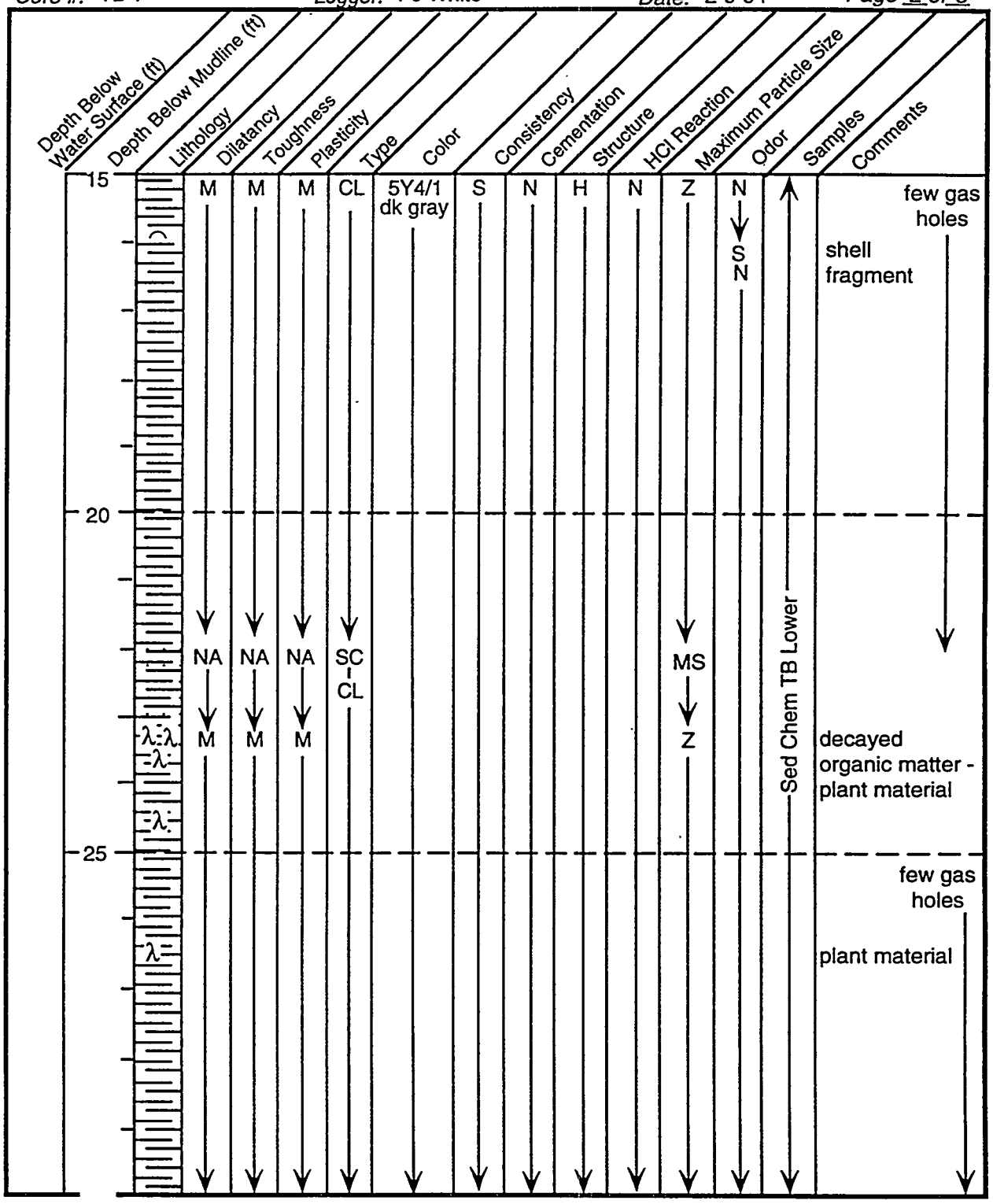
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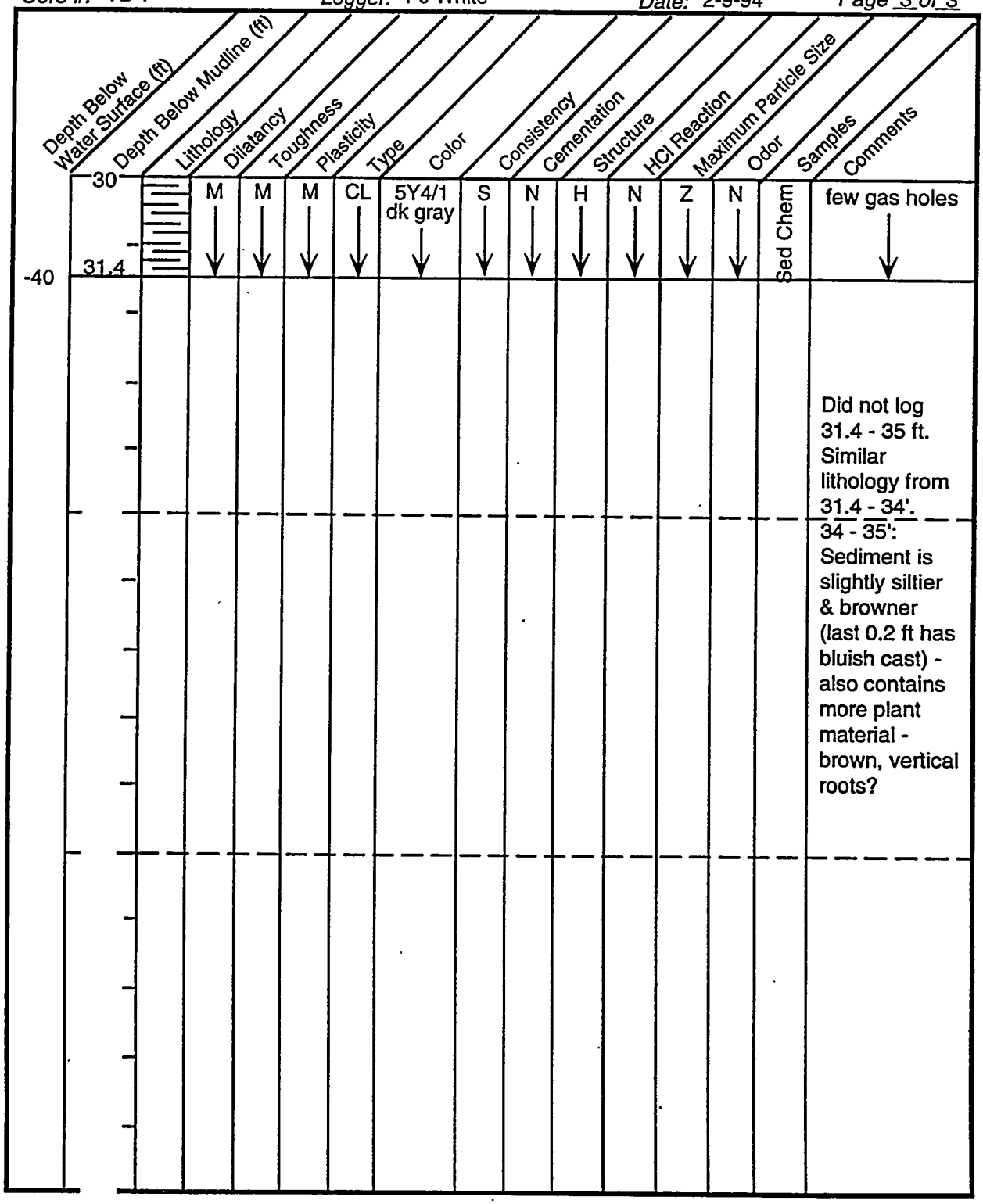
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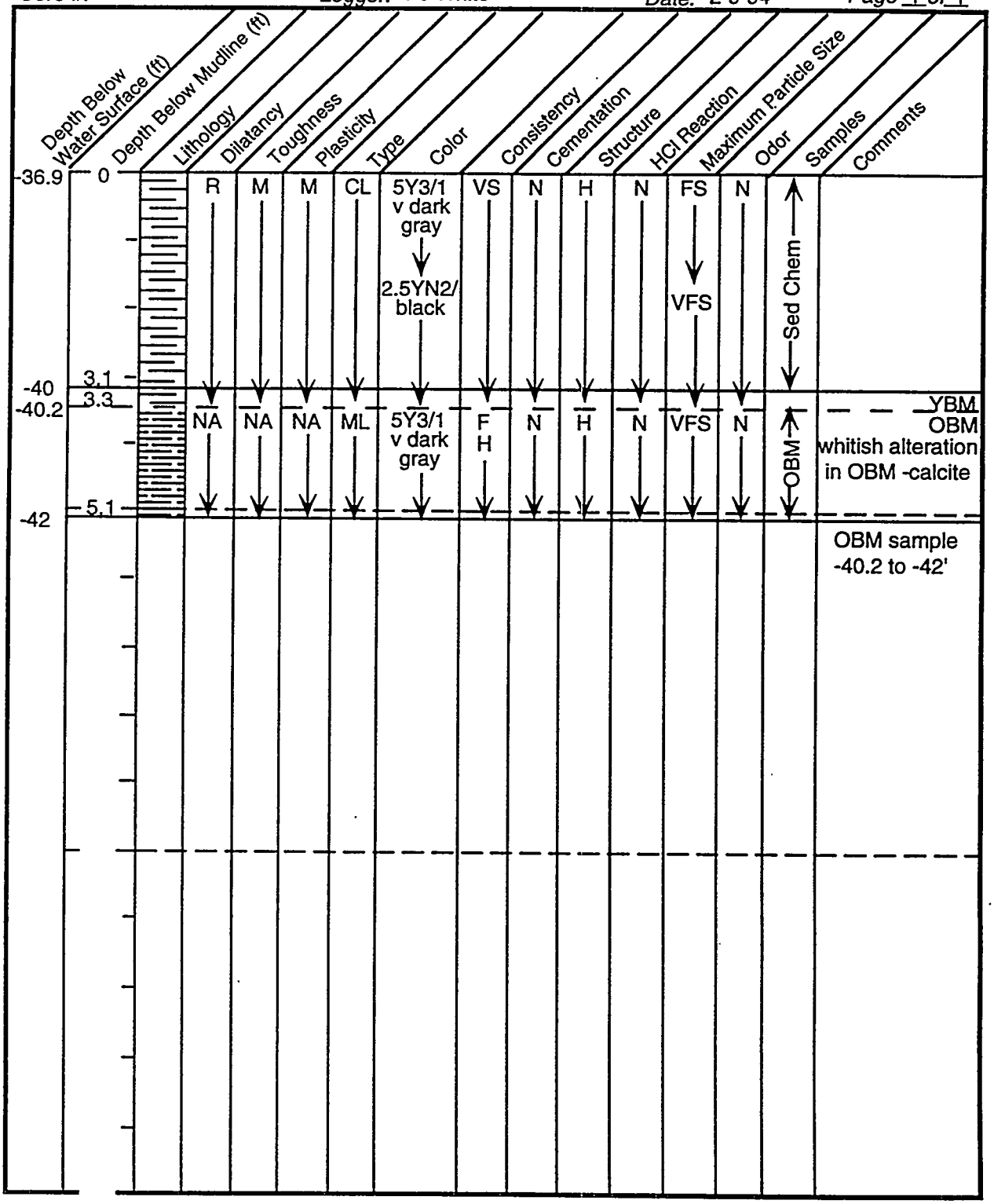
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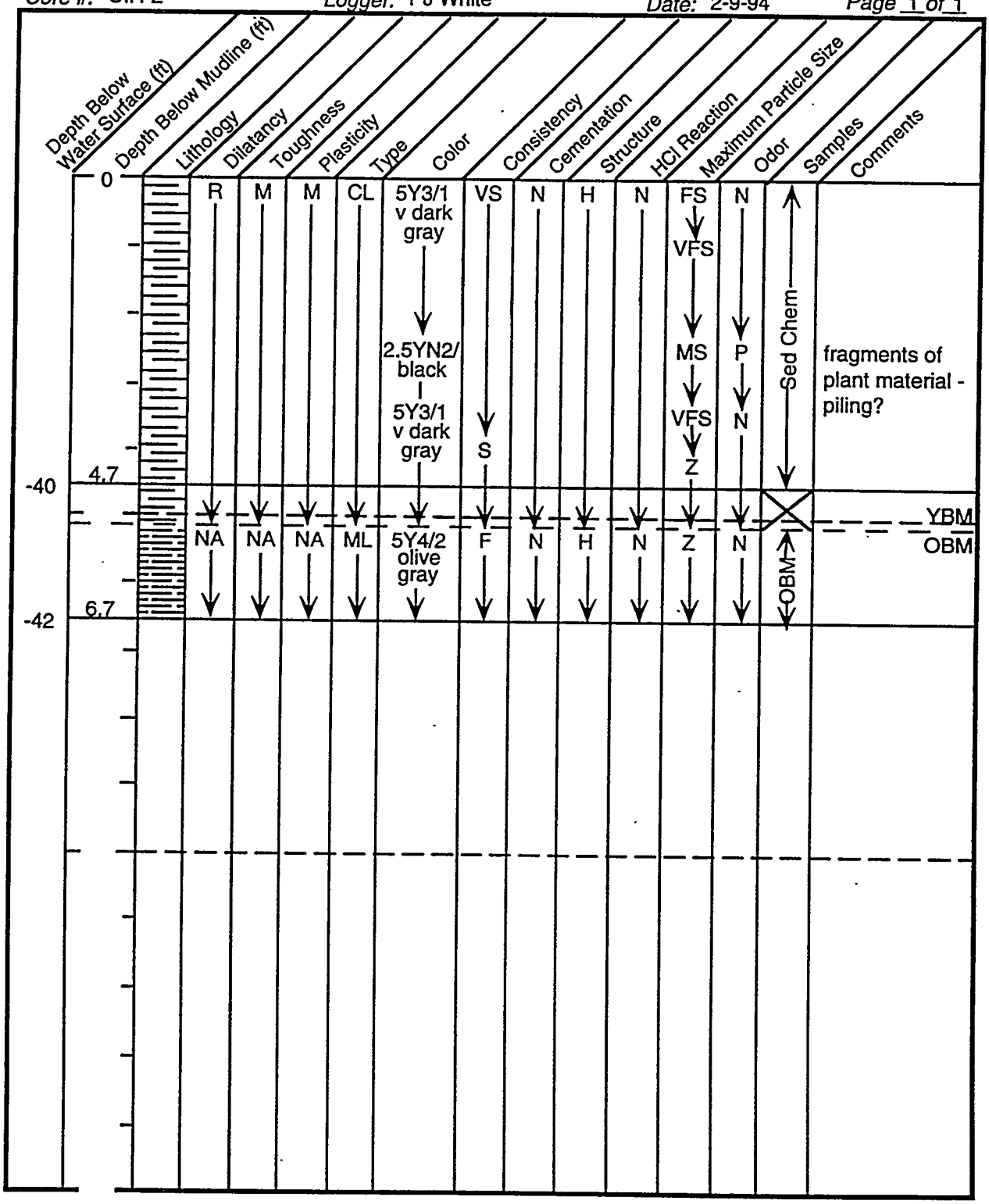
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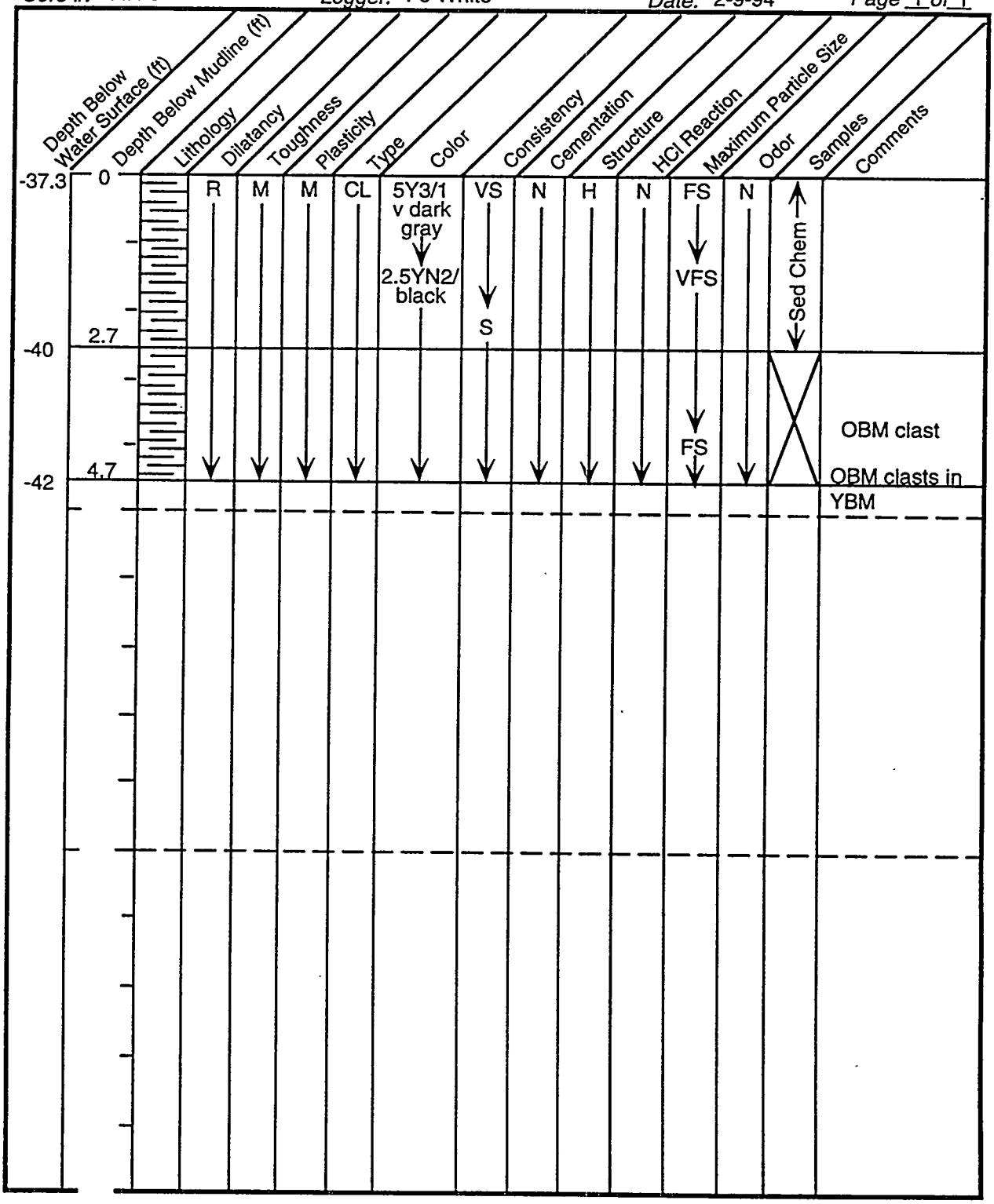
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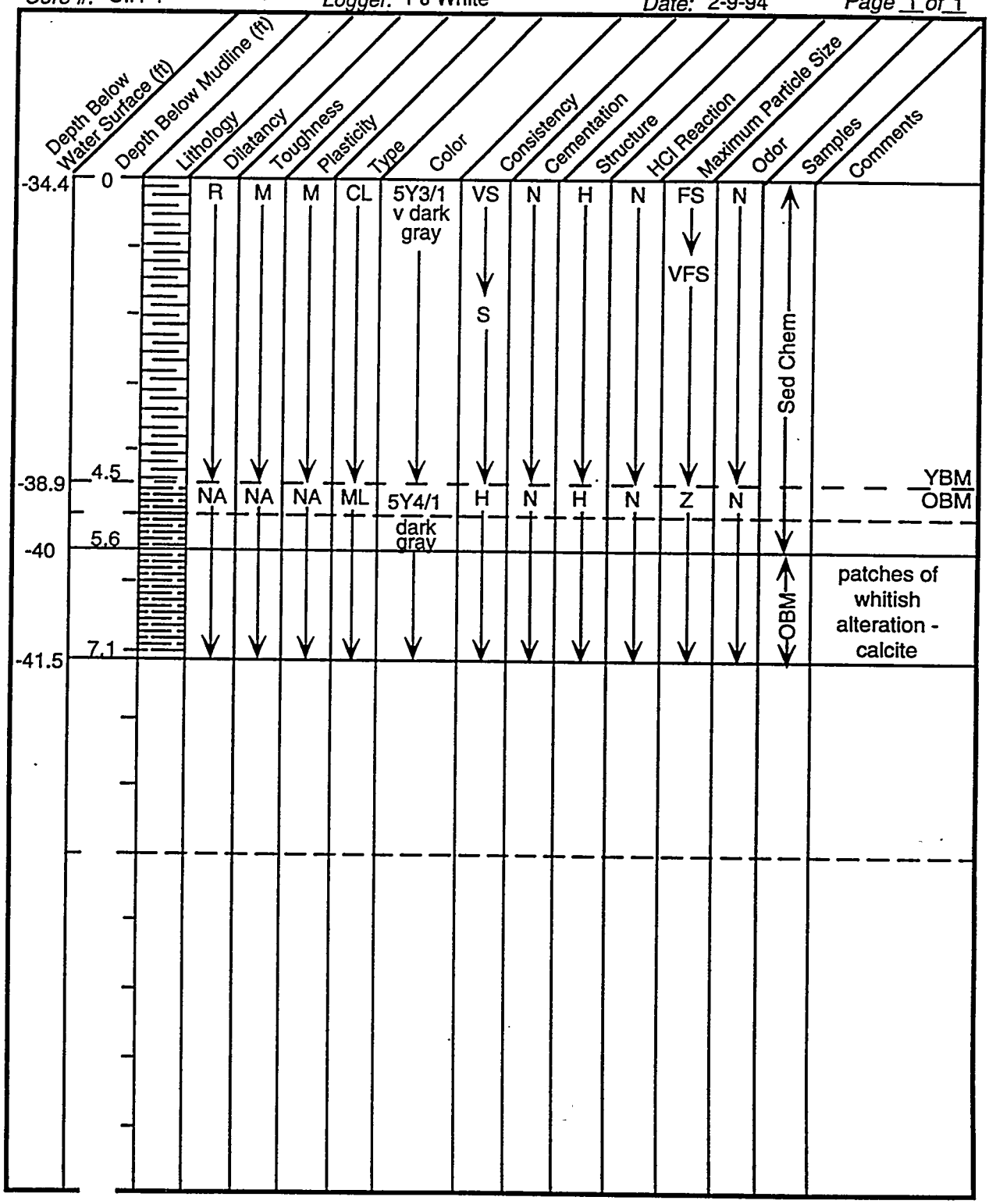
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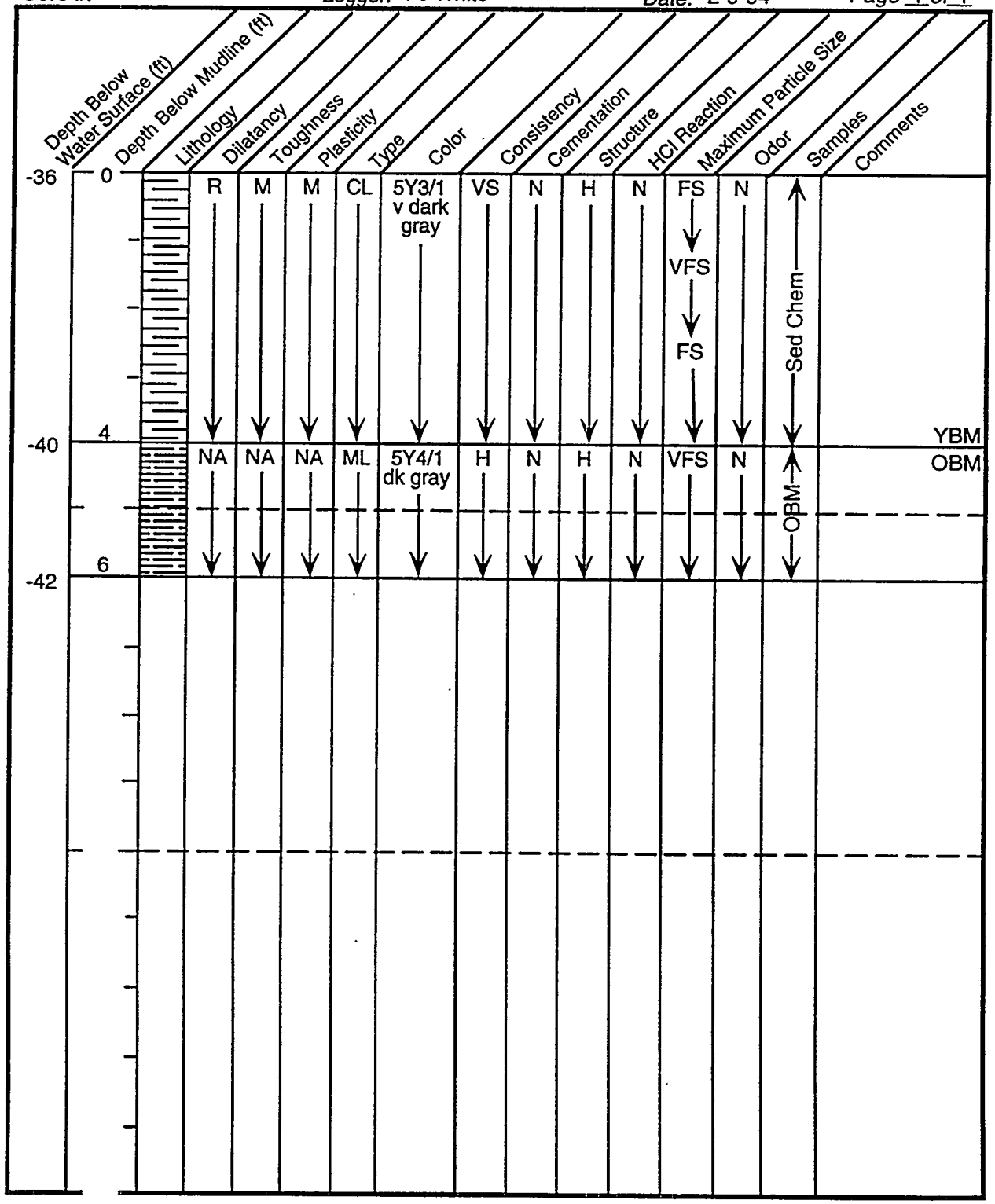
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Project: Richmond Harbor Intensive Study

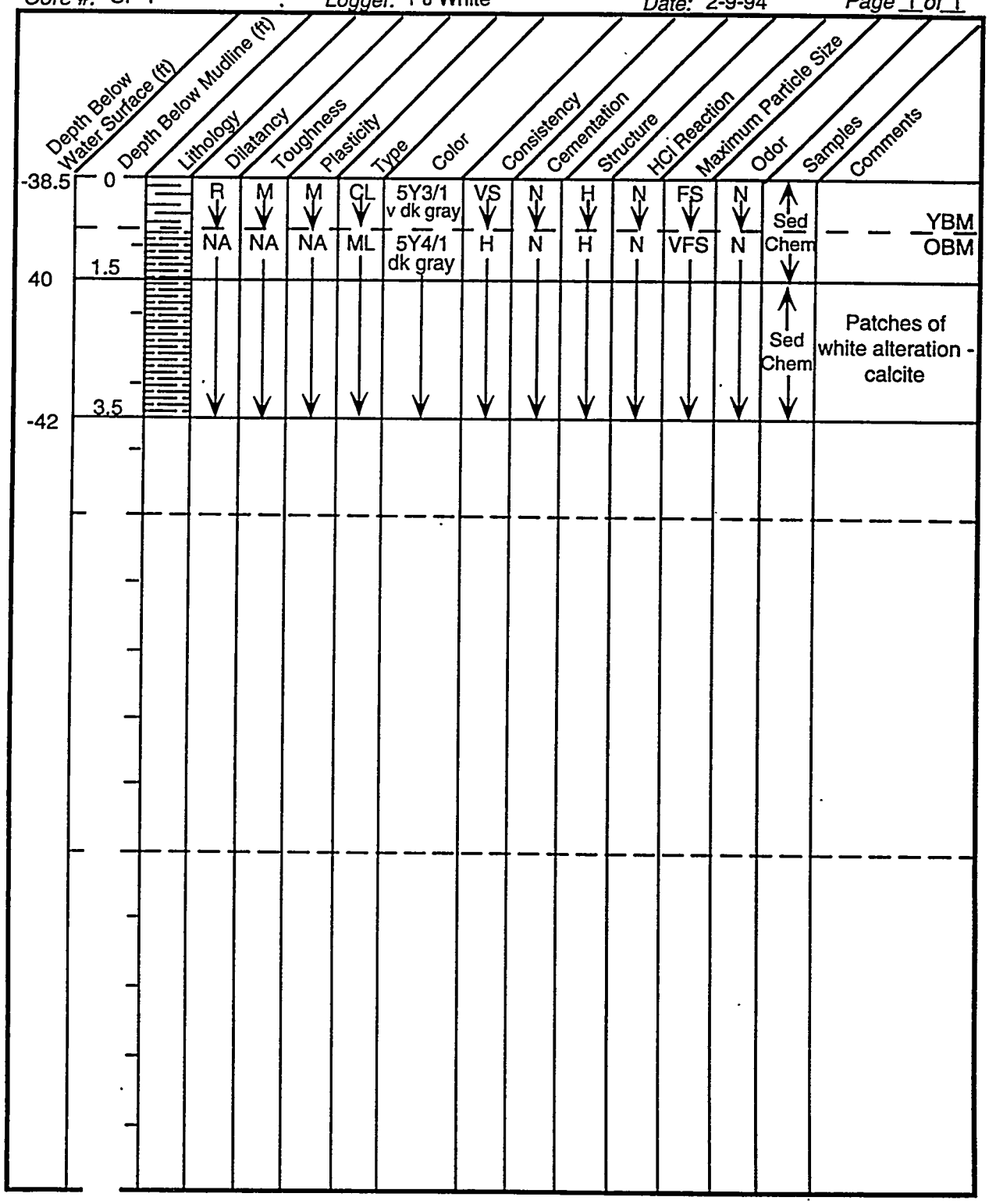
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Core Data Log

Project: Richmond Harbor Intensive Study

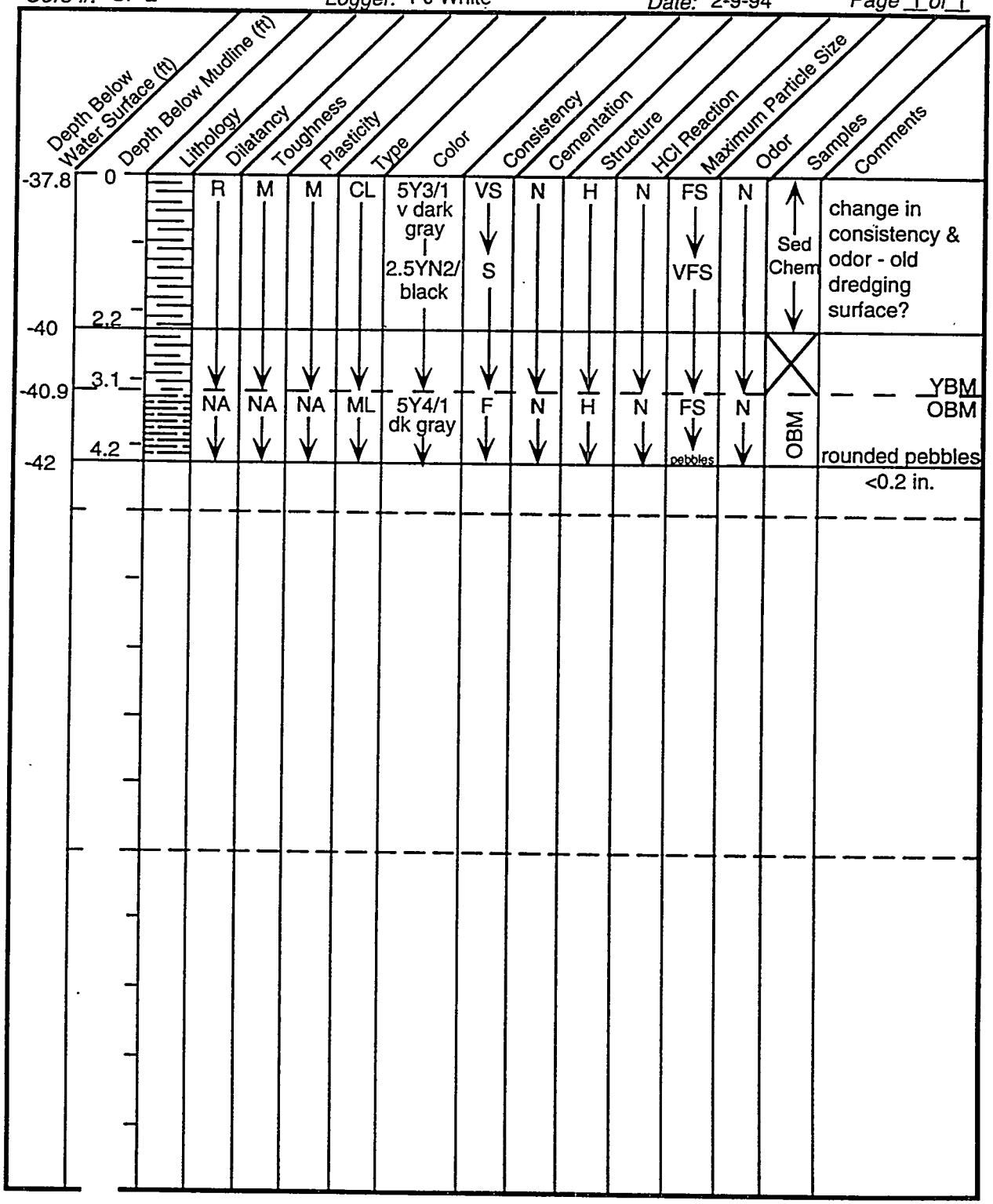
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Core Data Log

Project: Richmond Harbor Intensive Study

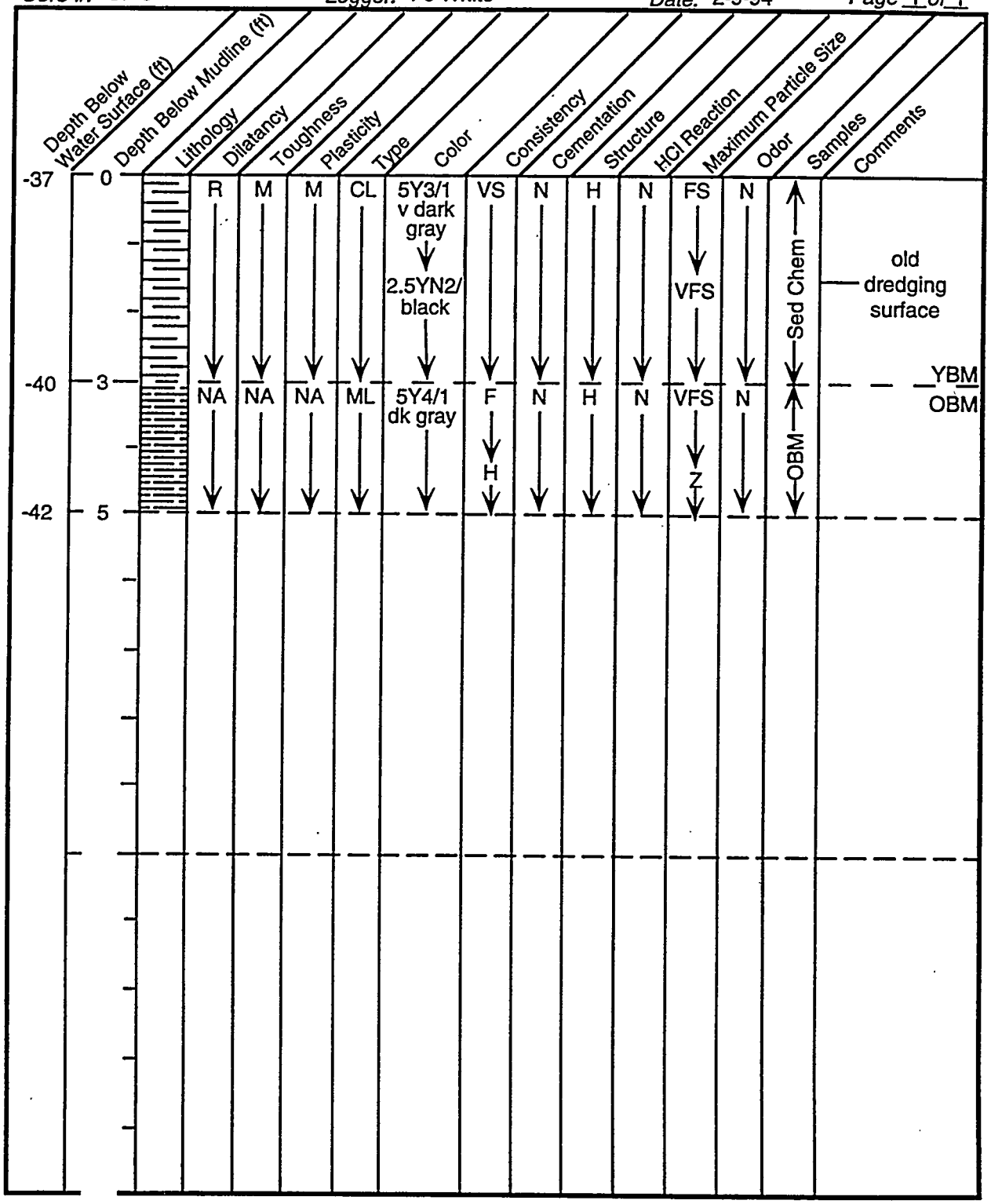
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Core Data Log

Project: Richmond Harbor Intensive Study

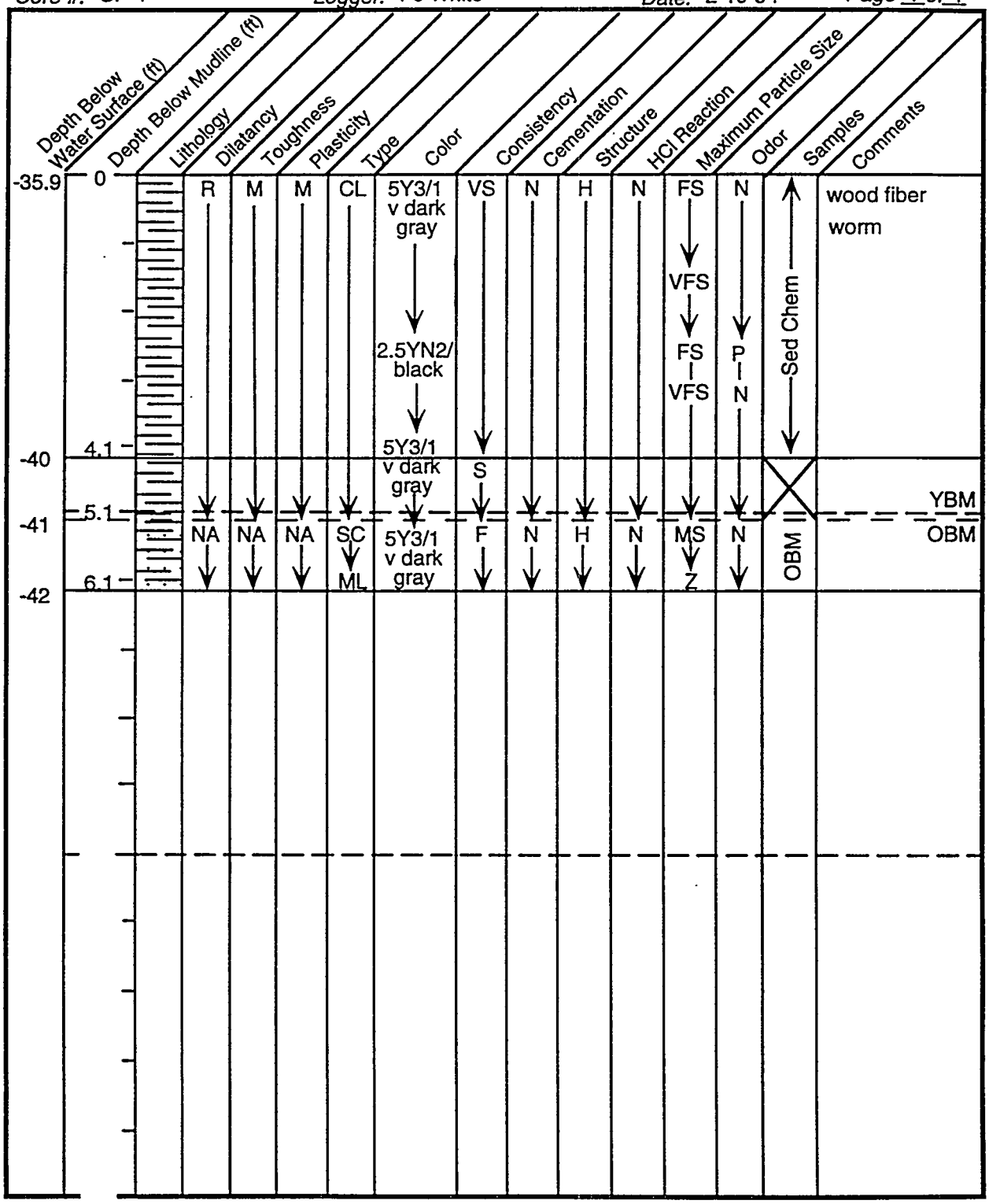
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Core Data Log

Project: Richmond Harbor Intensive Study

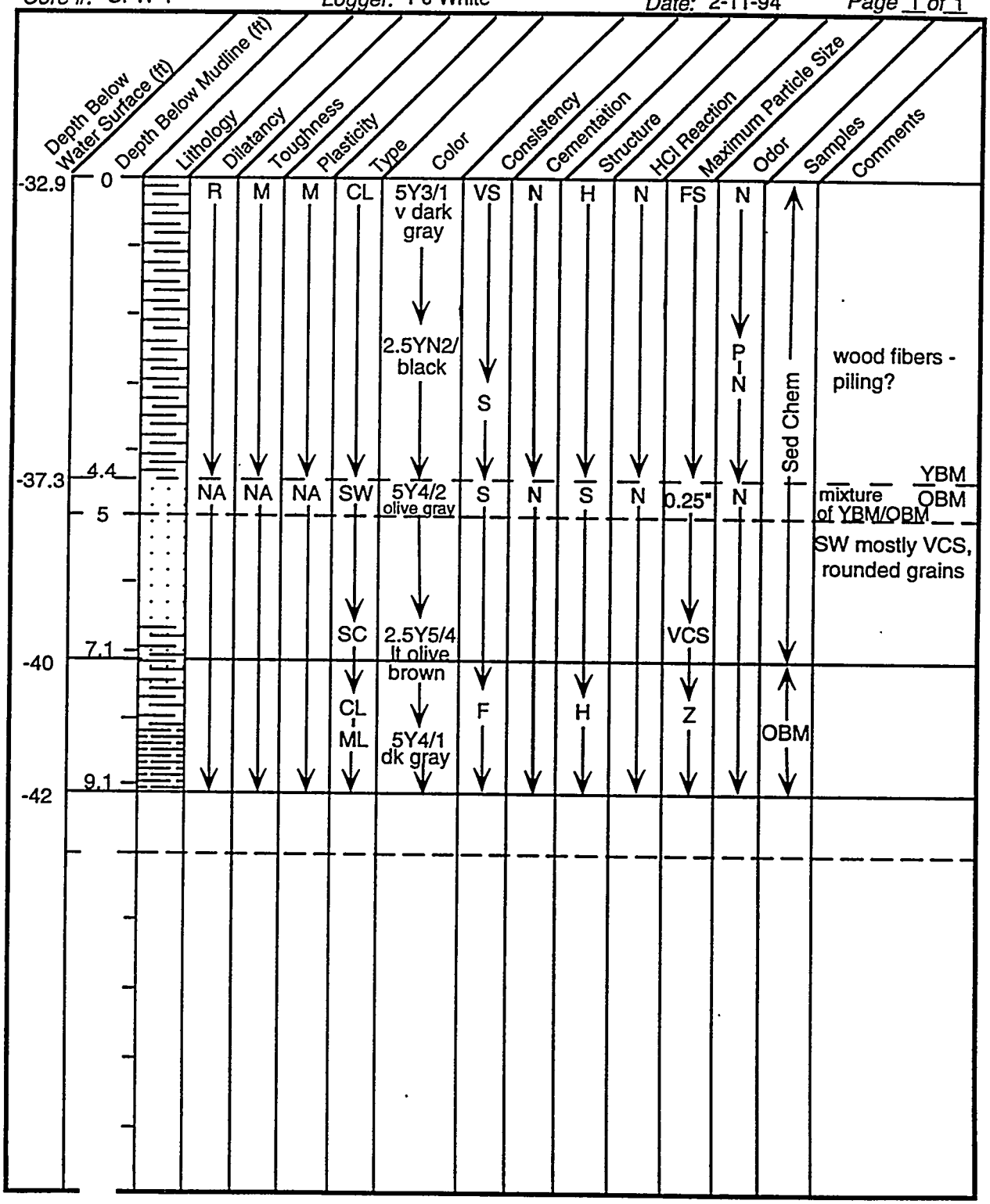
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Core Data Log

Project: Richmond Harbor Intensive Study

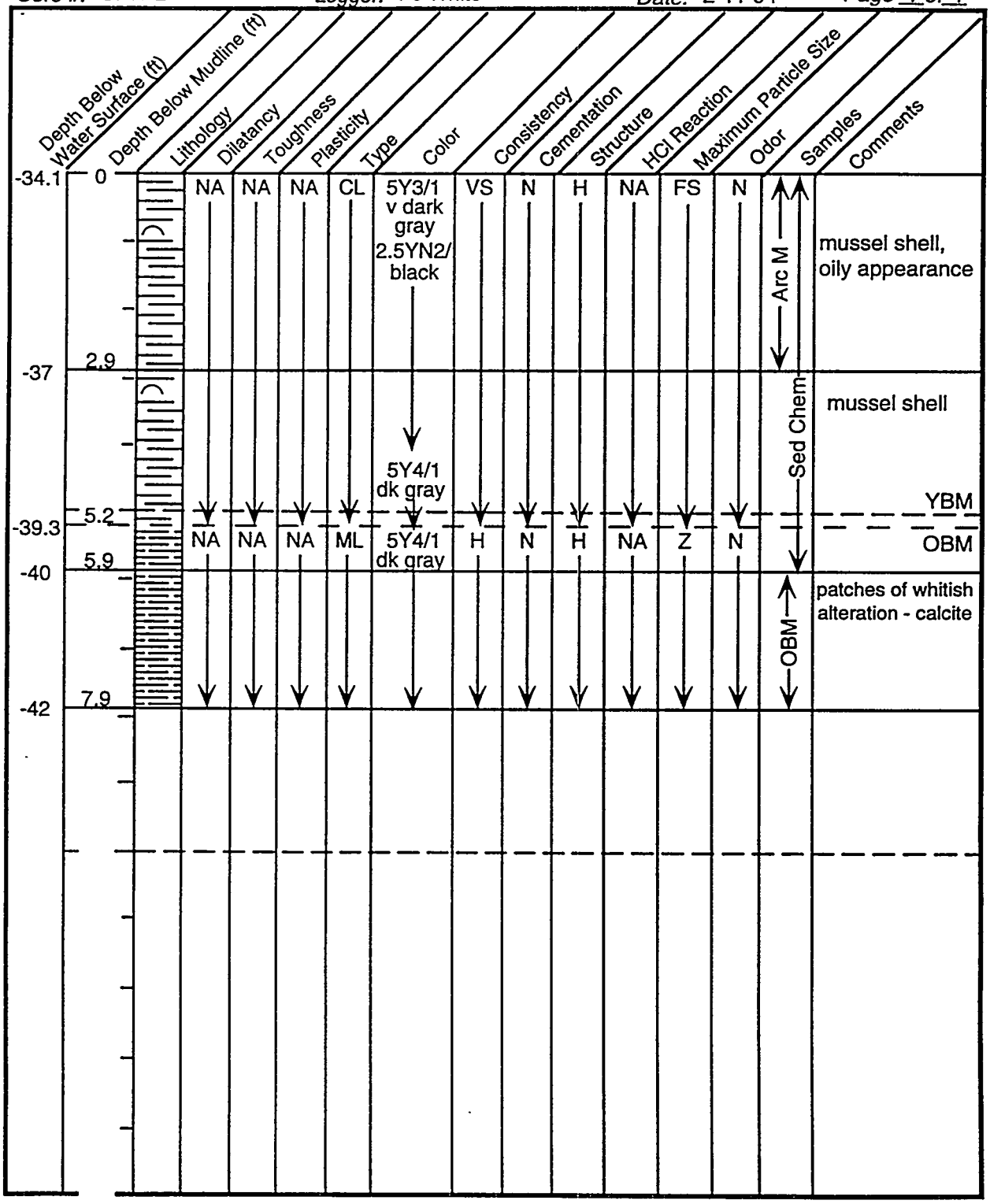
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Core Data Log

Project: Richmond Harbor Intensive Study

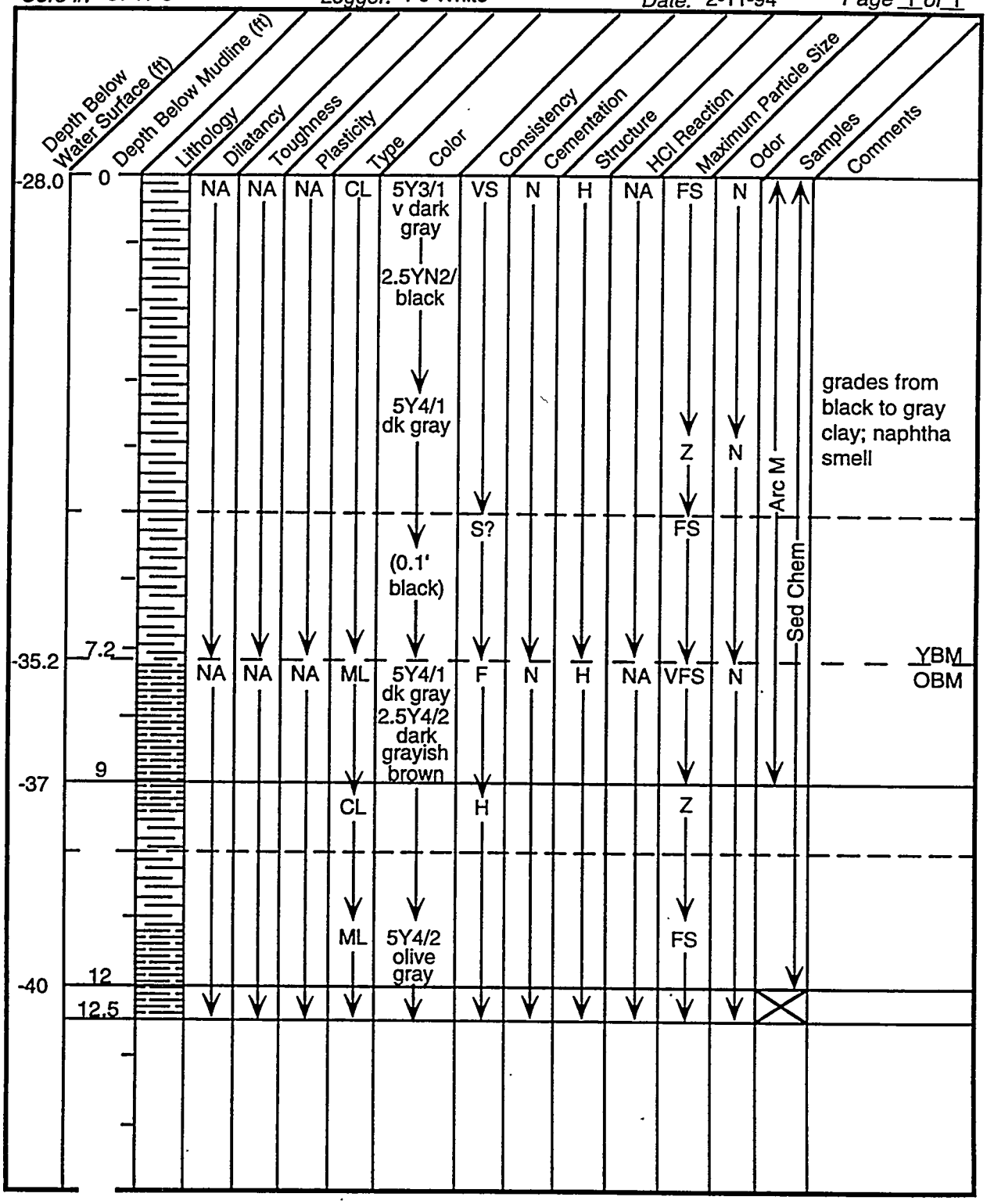
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Core Data Log

Project: Richmond Harbor Intensive Study

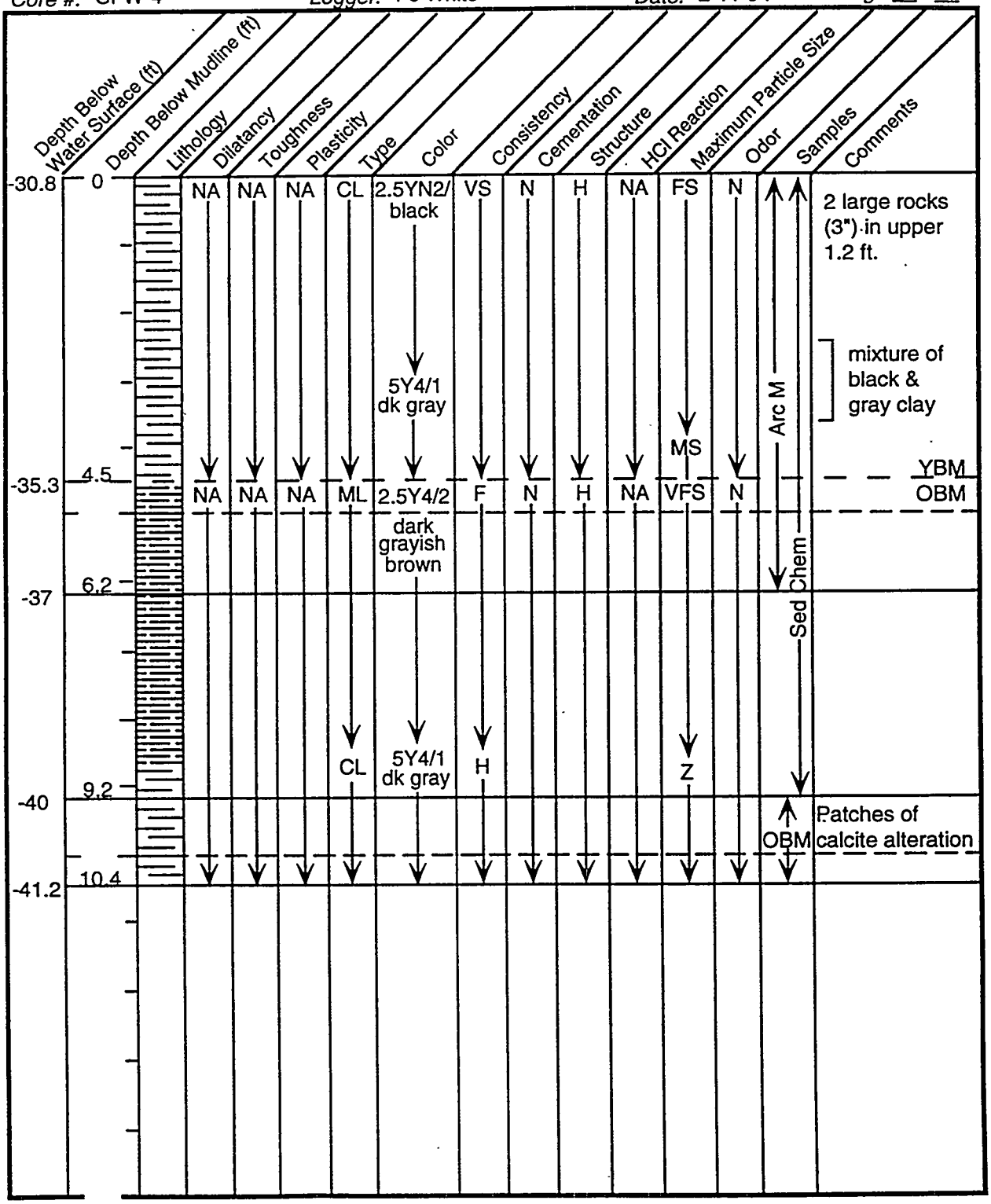
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Core Data Log

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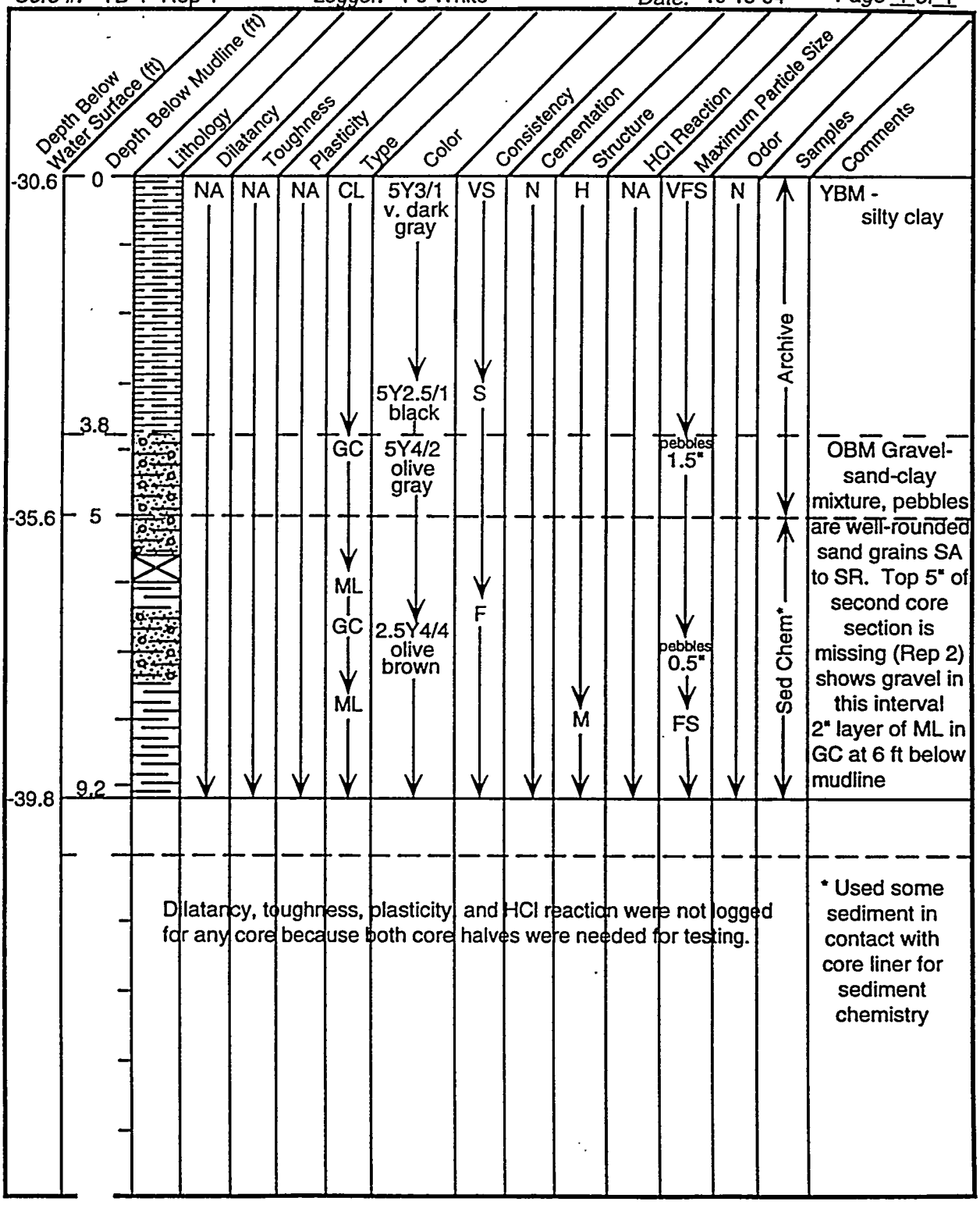
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

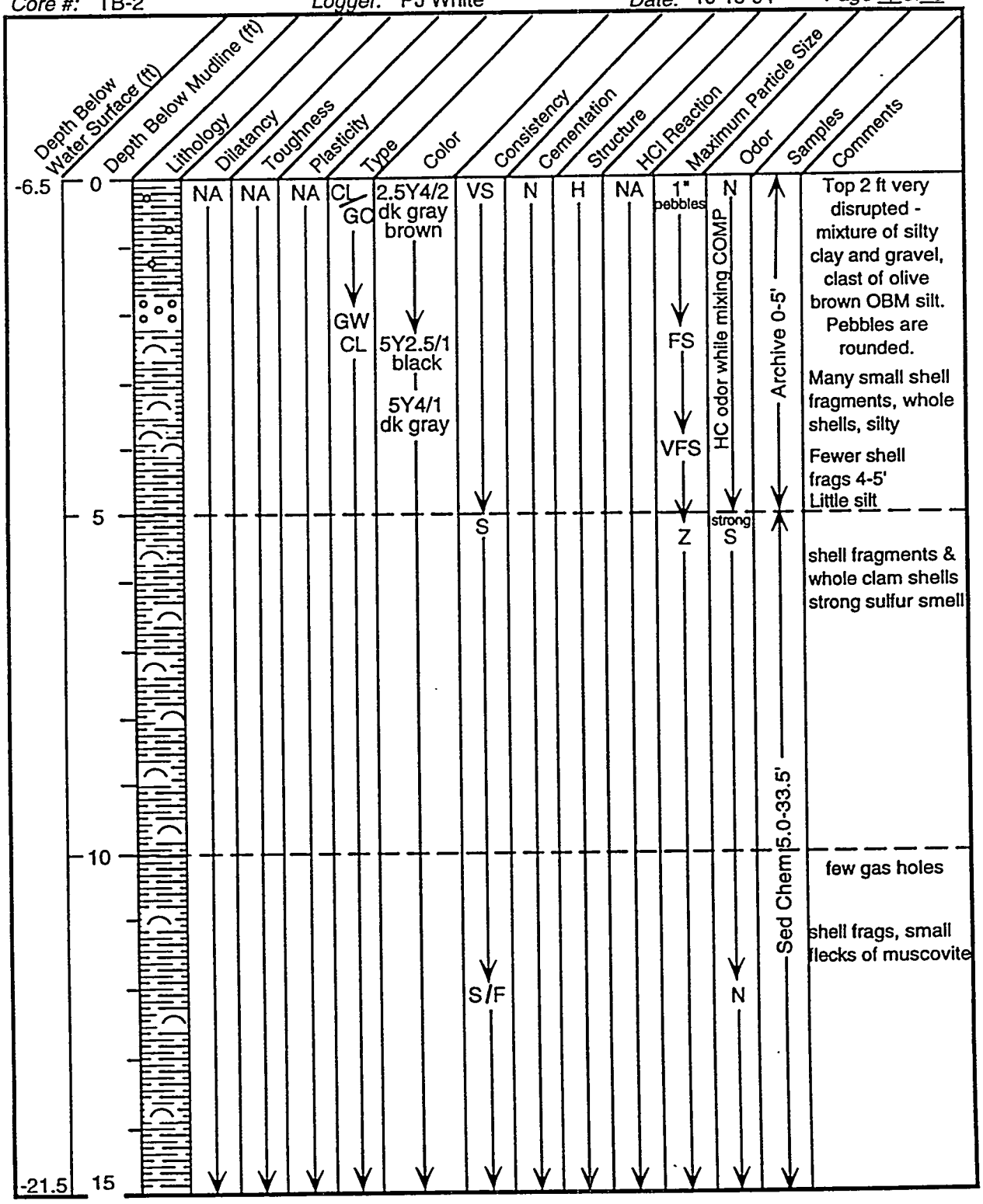
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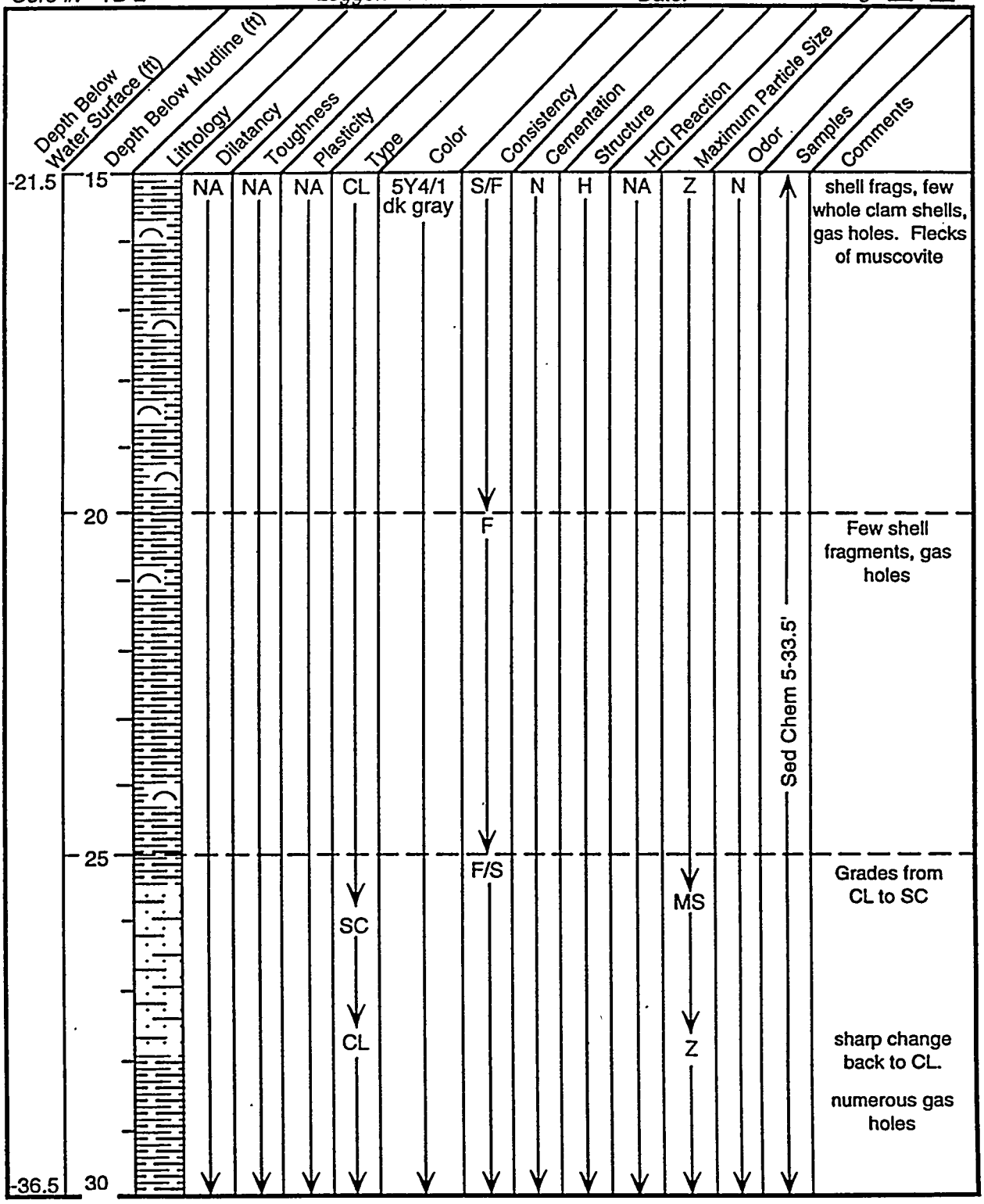
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

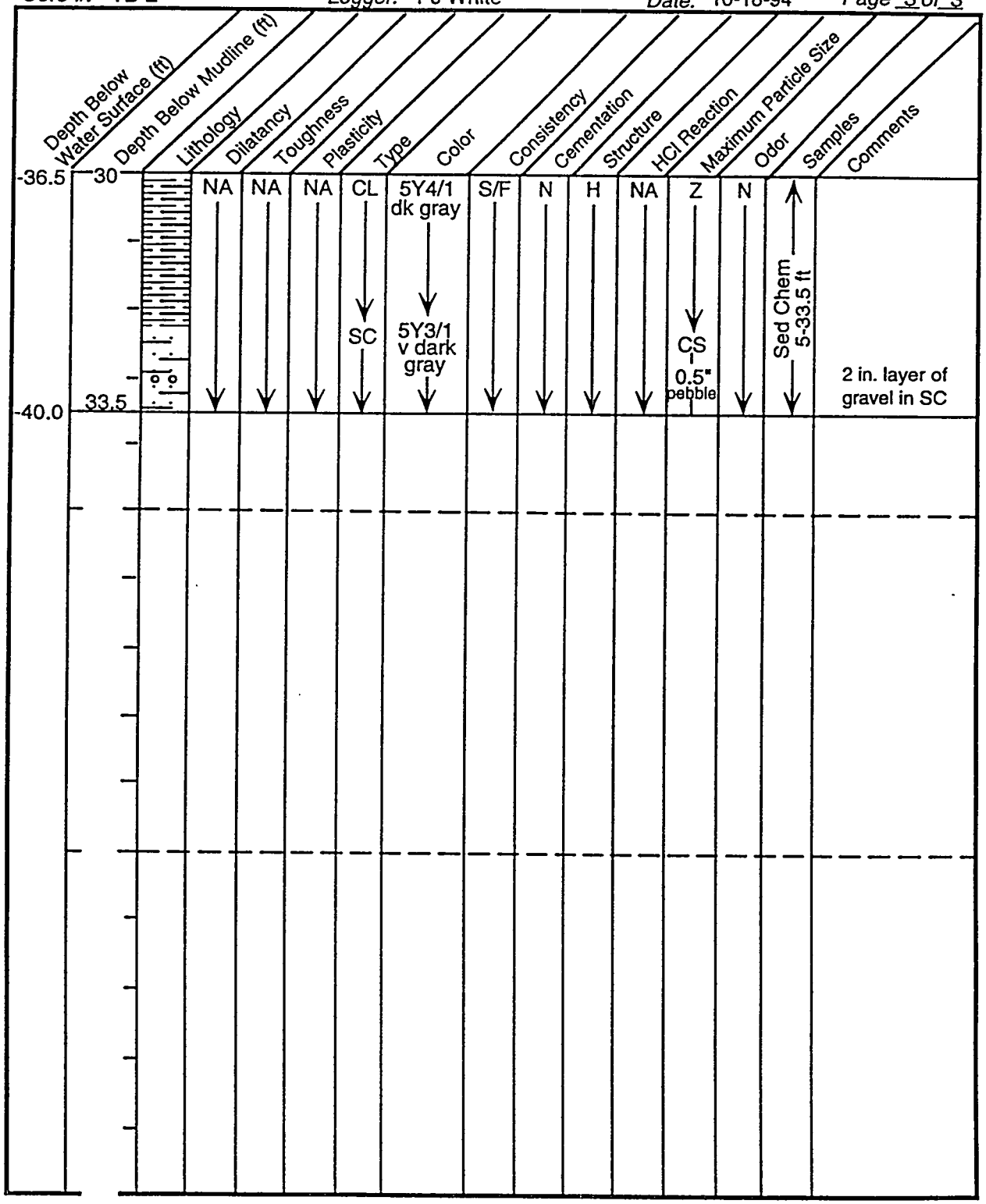
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

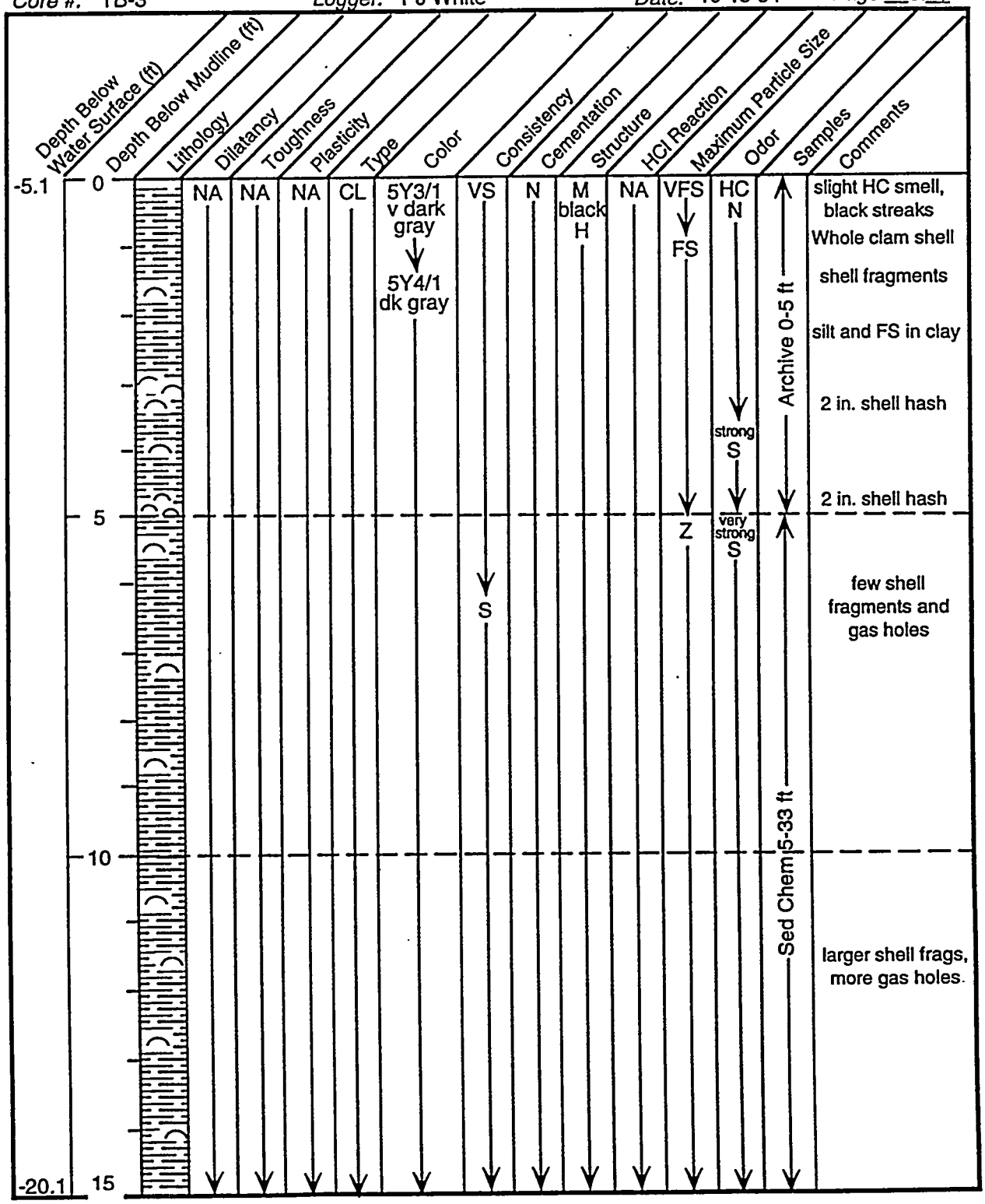
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

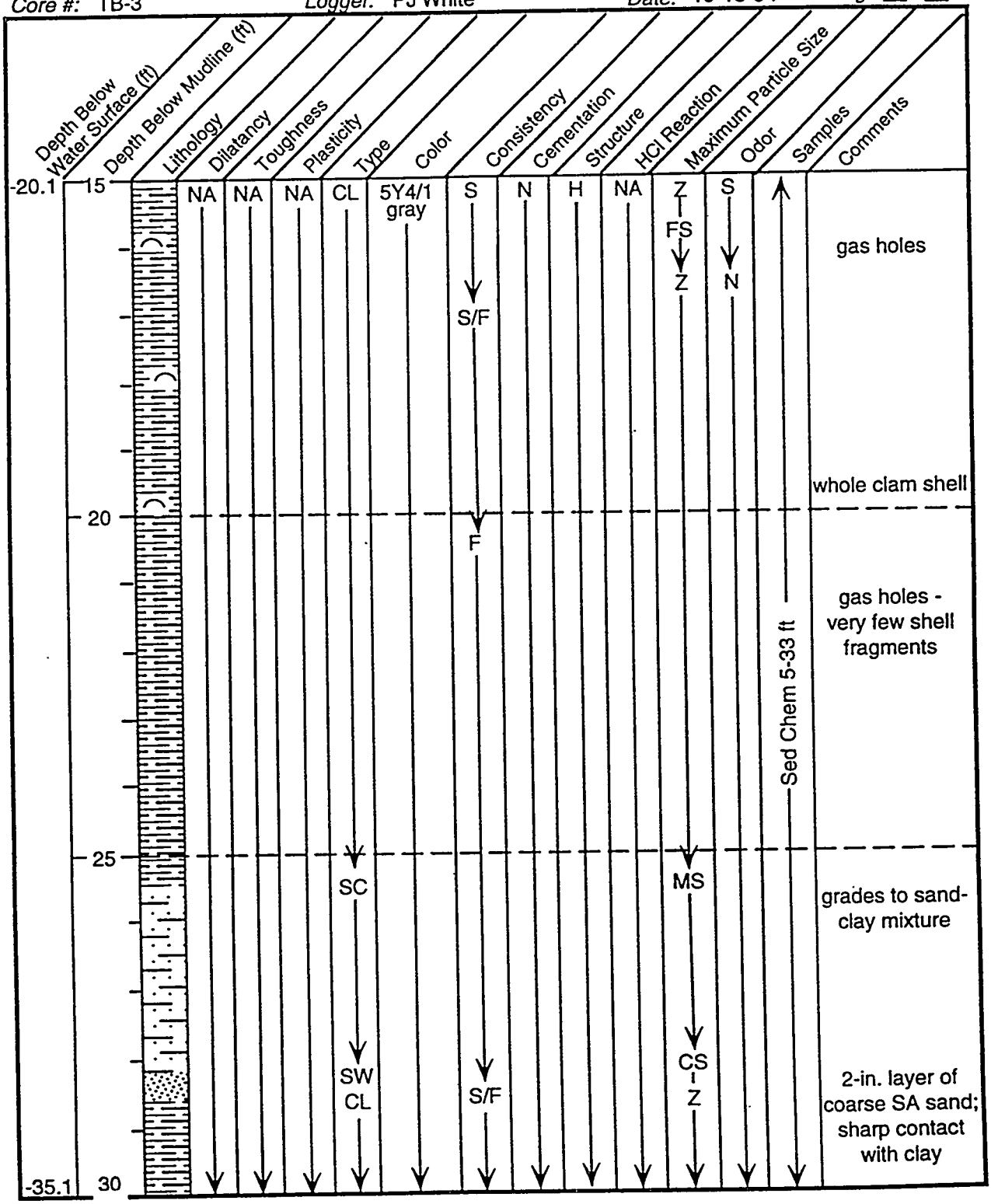
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

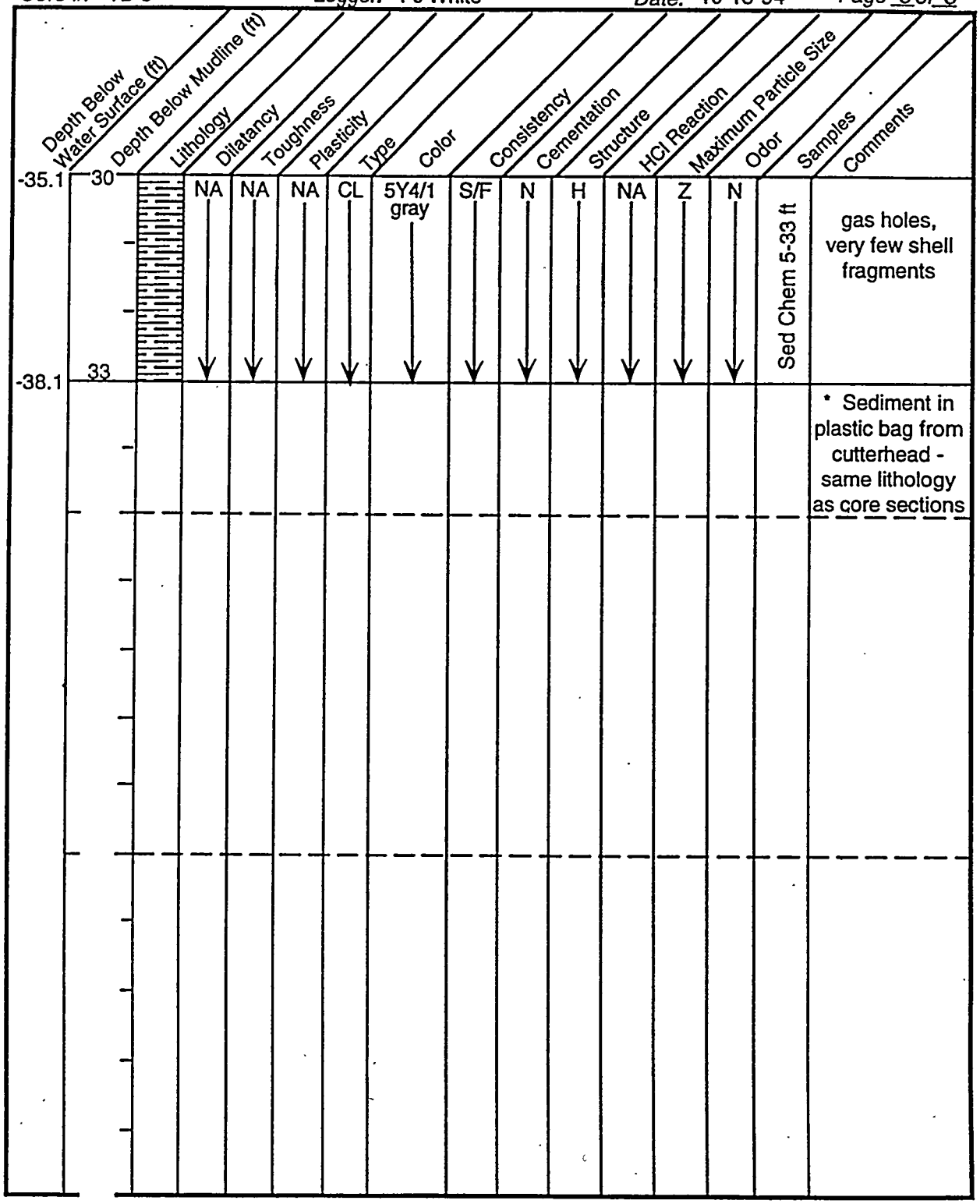
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Project: Richmond Harbor Intensive Study of the Turning Basin

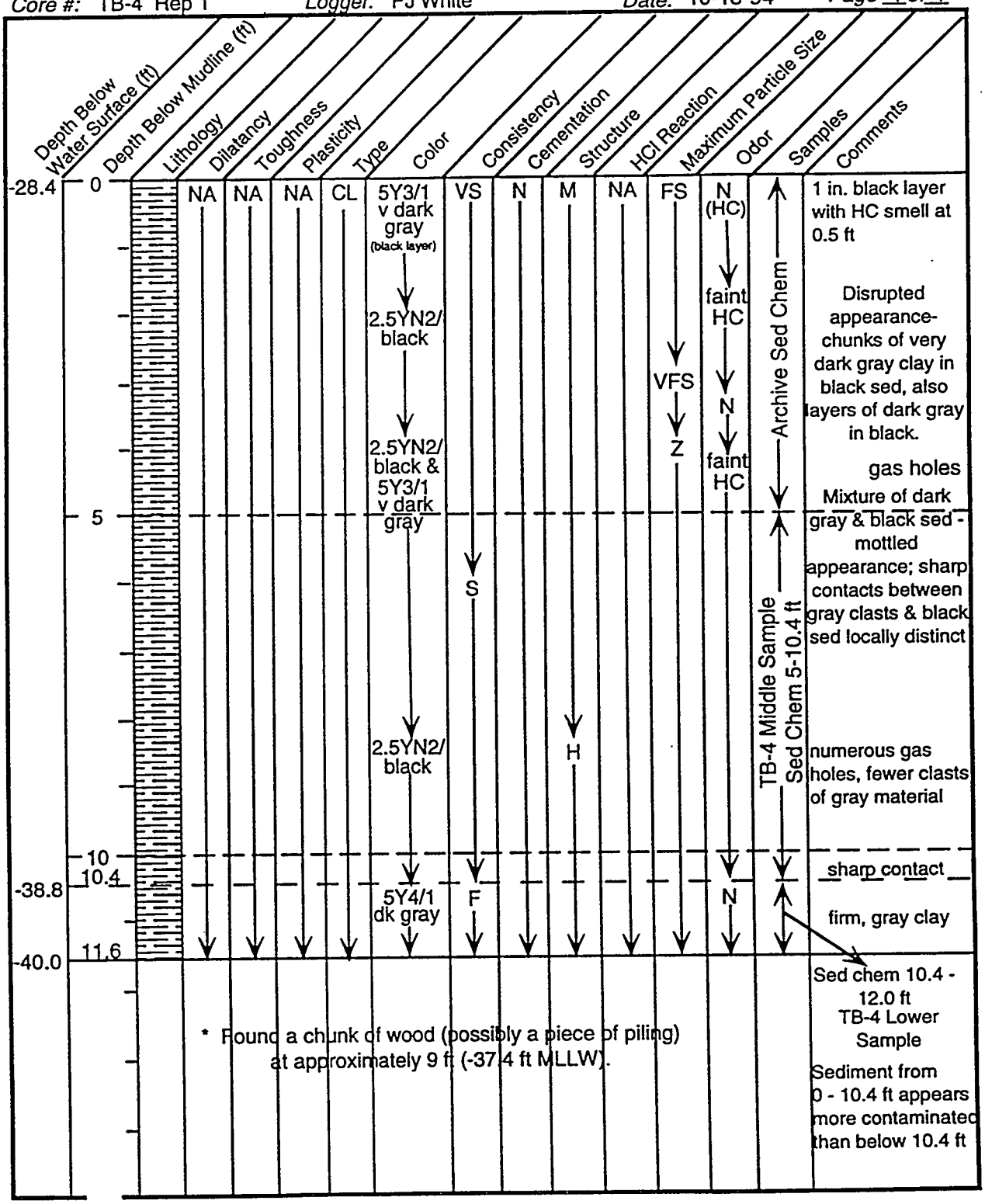
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

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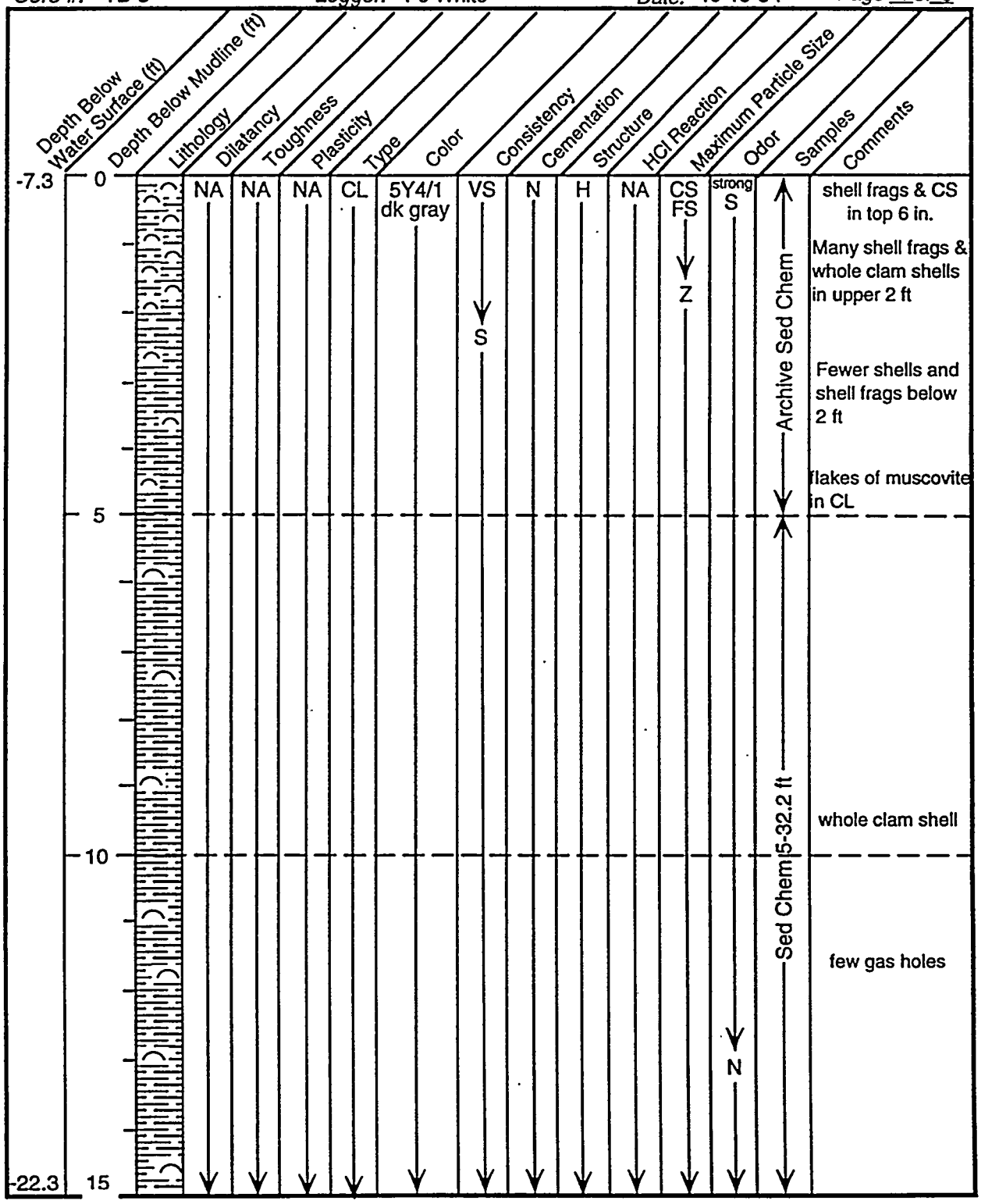


* Found a chunk of wood (possibly a piece of piling) at approximately 9 ft (-37.4 ft MLLW).

Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

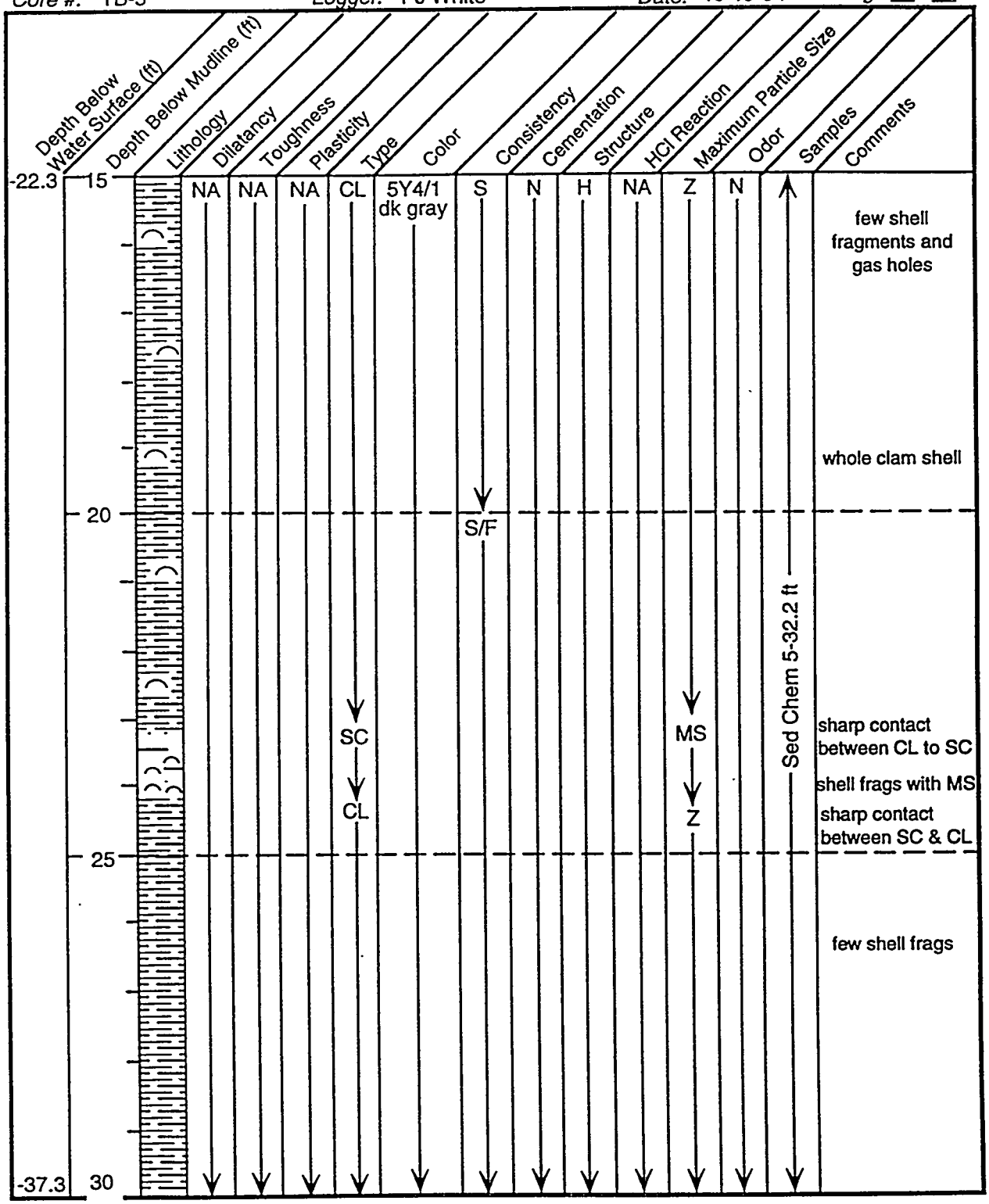
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

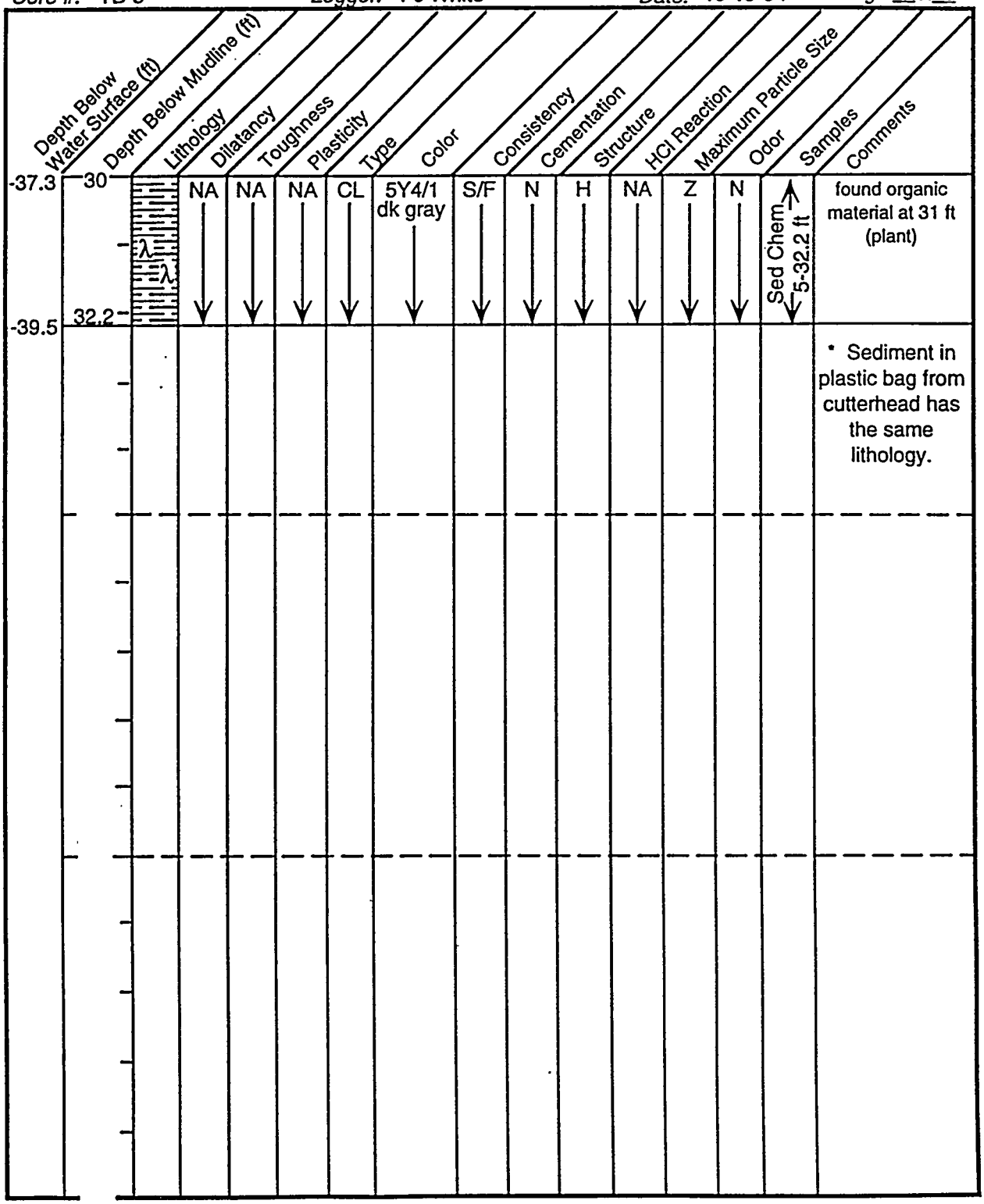
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

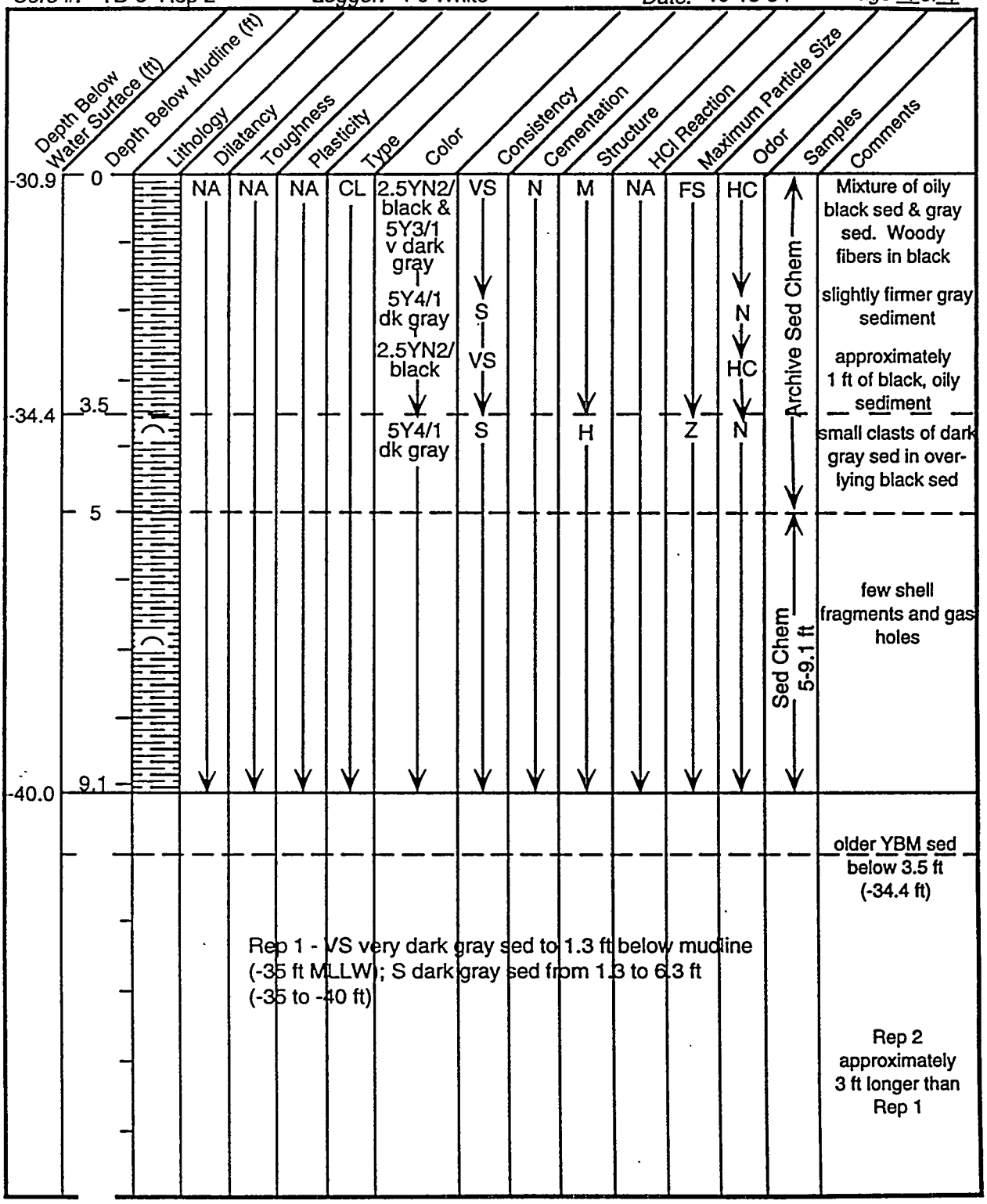
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

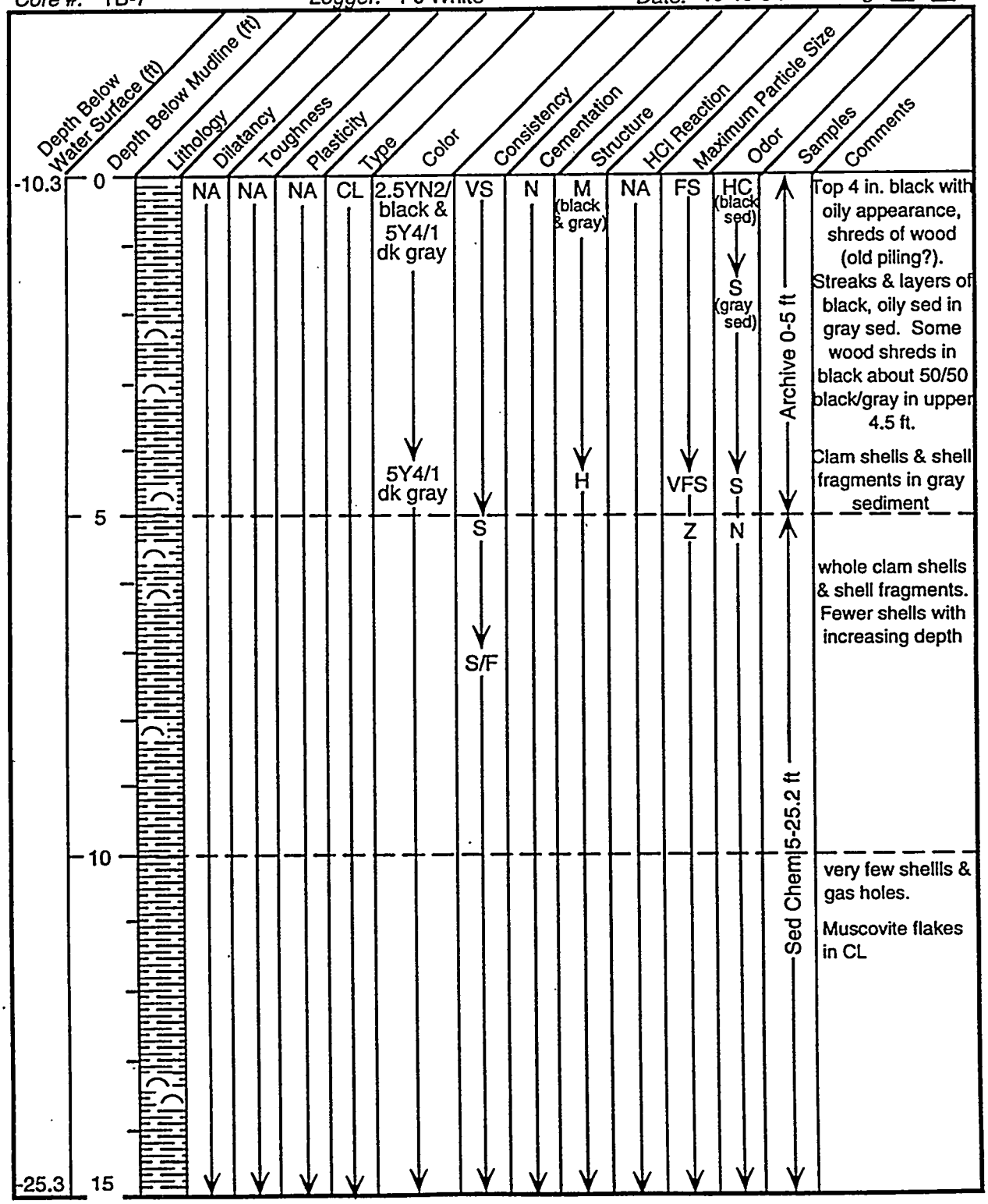
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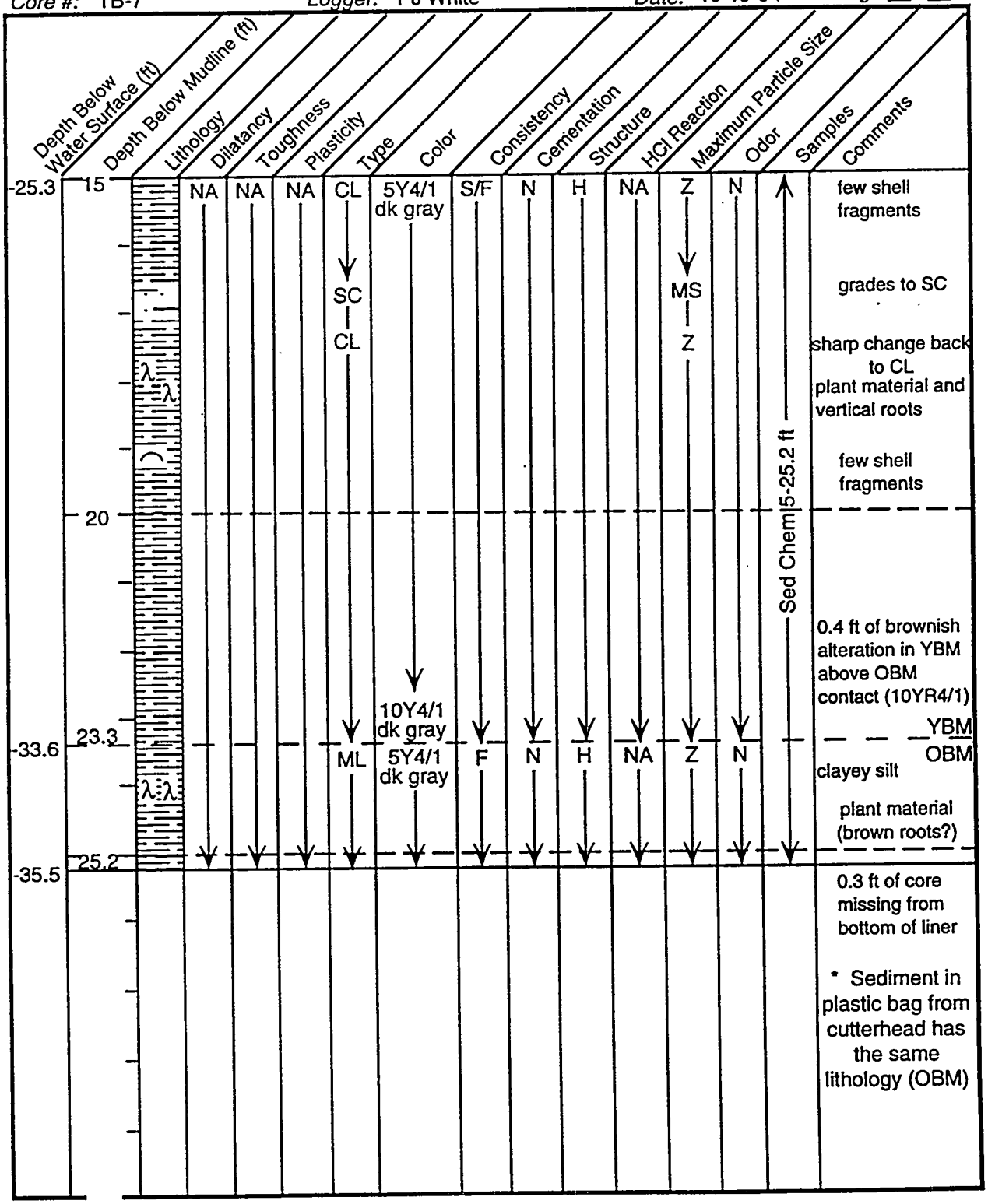
Core #: TB-7 *Logger:* PJ White *Date:* 10-19-94 *Page* 1 of 2



Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

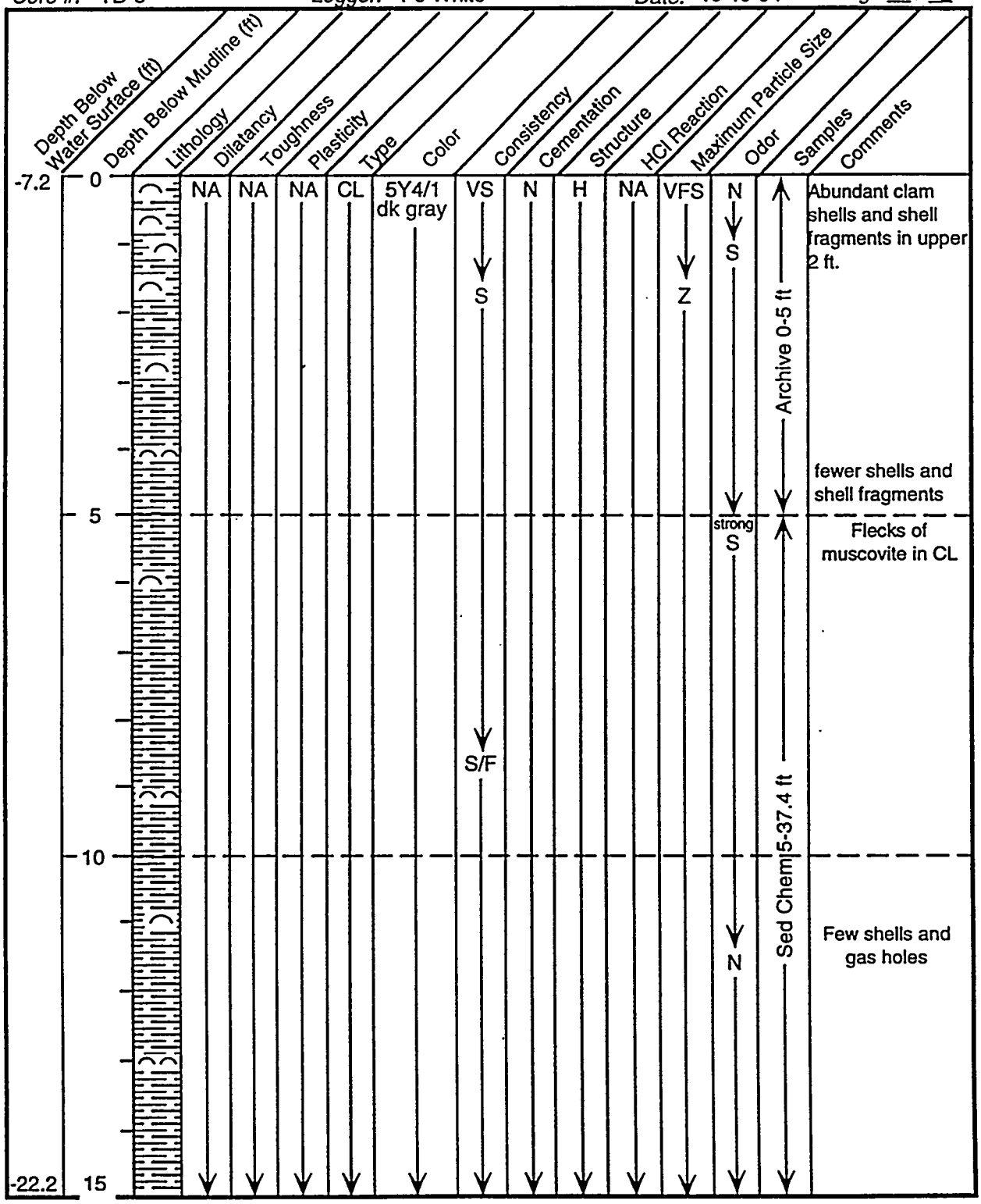
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

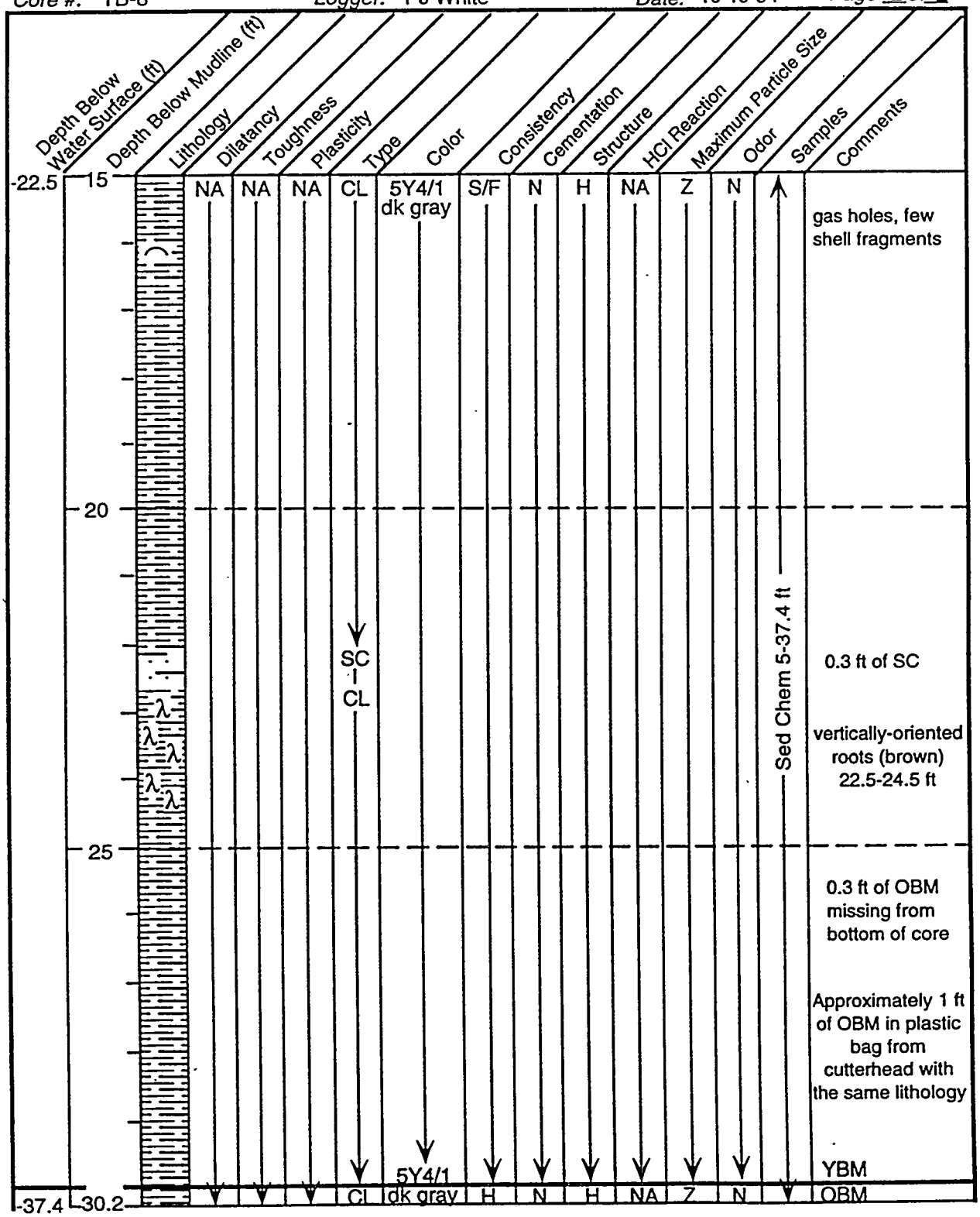
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Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

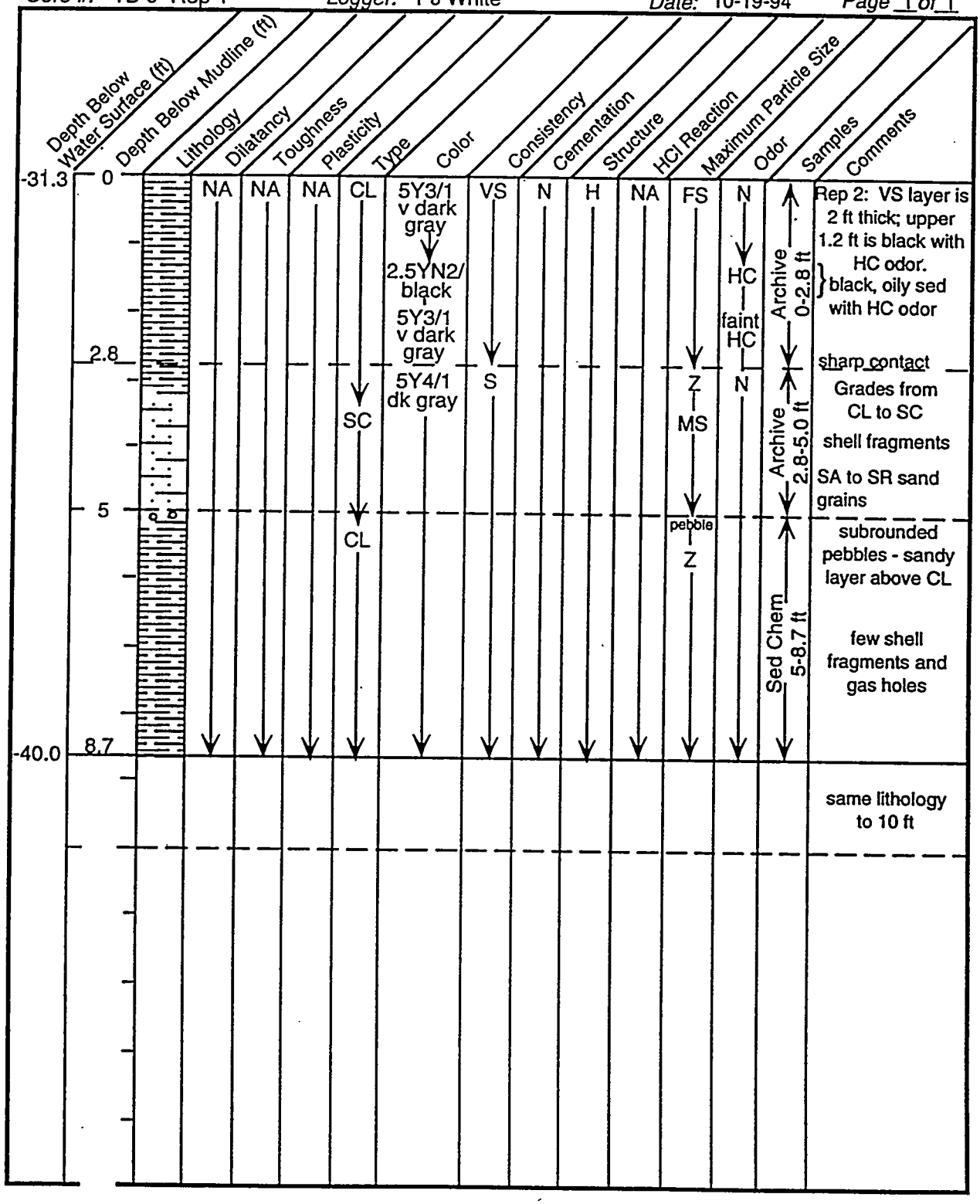
Core #: TB-8 *Logger:* PJ White *Date:* 10-19-94 *Page* 2 of 2



Core Data Log

Project: Richmond Harbor Intensive Study of the Turning Basin

Core #: TB-9 Rep 1 *Logger:* PJ White *Date:* 10-19-94 *Page* 1 *of* 1



APPENDIX C

SEDIMENT CHEMISTRY AND QUALITY ASSURANCE DATA

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Grain Size
LABORATORY: Soil Technology
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at Soil Technology on 2/15/94 in good condition. Samples were analyzed in two batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
PSEP 1986	Not applicable	≤20% for fractions greater than 5%	1.0%

METHOD

Sixteen grain size fractions were determined by a combination of sieve and pipette techniques. An additional measurement for salt content was performed and each grain size fraction was corrected for this salt measurement.

HOLDING TIME

The holding time of 6 months was met for all grain size analyses.

REPLICATES

Three sets of triplicates were analyzed with the samples. The precision criteria was exceeded in one grain size fraction in one set of triplicates, with a relative standard deviation of 22%.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Total Organic Carbon (TOC)
LABORATORY: Global Geochemistry
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at Global Geochemistry on 2/15/94 in good condition. Samples were analyzed in four batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
EPA 1986	≤20%	≤10%	0.1%

METHOD

Total organic carbon is the amount of non-volatile, partially volatile, volatile, and particulate organic carbon compounds in a sample. Each sample was dried and ball milled to a fine powder. Before combustion, inorganic carbon in the sample was removed by acidification. The TOC was then determined by measuring the carbon dioxide released during combustion of the sample.

HOLDING TIMES

The holding time of 6 months was met for all TOC analyses.

METHOD BLANKS

Six method blanks were analyzed with the samples. All procedural blanks contained less than 0.005% TOC. No QC criteria are designated for TOC method blanks.

REPLICATES

Two sets of duplicates and three sets of triplicates were analyzed with the samples. The relative percent difference for one set of duplicates was 100%; however, the TOC content in these samples was less than 0.05%. The relative standard deviation for one set of triplicates was 13%; these samples also contained ≤0.05% TOC.

DETECTION LIMITS

The achieved detection limit was lower than the target detection limit of 0.1% TOC.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Total Volatile Solids (TVS)
LABORATORY: ARI
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at ARI on 2/15/94 in good condition. Samples were analyzed in three batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
160.4	NA	≤20%	0.1%

METHOD

Total volatile solids are a measure of the fraction of total solids that are lost on ignition at higher temperature. First, the sample was oven dried to constant weight and then removed, weighed, and ignited at 550°C. The sample was cooled in a desiccator and then reweighed. The amount of sample lost during ignition was defined as the volatile solids fraction.

HOLDING TIMES

A holding time is not specified for TVS analyses.

METHOD BLANKS

One method blank was analyzed with the samples. No TVS were detected.

REPLICATES

Three sets of triplicates were analyzed with the samples. The relative standard deviation for each set of triplicates was within the QC criteria of ≤20%.

DETECTION LIMITS

The achieved detection limit was lower than the target detection limit of 0.1% TVS.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Total Solids
LABORATORY: ARI
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at ARI on 2/15/94 in good condition. Samples were analyzed in three batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
EPA 160.3	NA	≤20%	1%

METHOD

HOLDING TIMES

A holding time is not specified for Total Solids analyses.

METHOD BLANKS

One method blank was analyzed with the samples. No solids were detected.

REPLICATES

Three sets of triplicates were analyzed with the samples. The relative standard deviation for each set of triplicates was within the QC criteria of ≤20%.

DETECTION LIMITS

The achieved detection limit met the target detection limit of 1% solids.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Oil and Grease
LABORATORY: Analytical Resources, Inc.
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at ARI on 2/15/94 in good condition. Samples were analyzed in three batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
418.1	50%-150%	≤20%	20 mg/kg dry

METHOD

Total oil and grease includes vegetable oils, animal fats, soaps, waxes, and any other carbon-hydrogen material extractable by the solvent Freon. An aliquot of sample material was dried with anhydrous sodium sulfate and extracted with Freon. The extract was shaken, allowed to settle, removed, and scanned from 4000 to 600 cm^{-1} by infrared spectrophotometry (IR). The peak height measured at 2930 cm^{-1} was used to quantify the concentration of oil and grease in the sample.

HOLDING TIMES

The samples were analyzed from 2/28 through 3/3/94, which is within the holding time of 28 days.

METHOD BLANKS

One procedural blank was processed with each batch of samples. No hydrocarbons were detected in the method blanks at concentrations above the detection limit.

MATRIX SPIKES

One matrix spike (MS) was analyzed with each batch of samples. Percent recoveries ranged from 97% to 106%.

REPLICATES

One set of triplicates was analyzed with each batch of samples. The relative standard deviation exceeded the QC criteria of ≤20% in the triplicates for Batch 1 (23%).

DETECTION LIMITS

Achieved detection limits ranged from 18 to 29 mg/kg, some of which are higher than the 20 mg/kg target detection limit.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Total Petroleum Hydrocarbons (TPH)
LABORATORY: Analytical Resources, Inc.
MATRIX: Sediment

SAMPLE CUSTODY

Forty-three samples were received at ARI on 2/15/94 in good condition. Samples were analyzed in three batches.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
418.1	50%-150%	≤20%	20 mg/kg dry

METHOD

Total petroleum hydrocarbons comprise the nonpolar mineral fraction of total oil and grease that is not removed by silica gel absorption. An aliquot of sample material was dried with anhydrous sodium sulfate and extracted with Freon. Silica gel was added to the extract to remove the more polar animal and vegetable based oils. The extract was shaken, allowed to settle, removed, and scanned from 4000 to 600 cm^{-1} by infrared spectrophotometry (IR). The peak height measured at 2930 cm^{-1} was used to quantify the concentration of hydrocarbons in the sample.

HOLDING TIMES

Samples were analyzed from 2/28/94 through 3/3/94. The samples were analyzed within the holding time of 28 days.

METHOD BLANKS

One procedural blank was processed with each batch of samples. No hydrocarbons were detected in the method blanks at concentrations above the detection limit.

MATRIX SPIKES

One matrix spike (MS) was analyzed with each batch of samples. Percent recoveries ranged from 93% to 104%.

REPLICATES

One set of triplicates was analyzed with each batch of samples. The relative standard deviation was 15% for the one set of triplicates that contained TPH in all three samples.

DETECTION LIMITS

Achieved detection limits ranged from 17 to 38 mg/kg, some of which are higher than the 20 mg/kg target detection limit.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Polynuclear Aromatic Hydrocarbons (PAH) and Phthalates
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry wt)
GC/MS	40-120%	≤30%	≤30%	20 µg/kg

METHOD

Sediment samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-042, Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics which is based on methods used by the National Oceanic and Atmospheric Administration for their Status and Trends Program (Krahn et al. 1988). Samples were then cleaned using Silica/Alumina (5% deactivated) chromatography followed by HPLC cleanup. Modifications in the clean-up method were required to adequately recover the phthalate compounds. In the first batch of samples, the Si column clean-up step was eliminated. In the second and third batches of samples, extracts were eluted through silica and alumina per the SOP, but twice the usual amount of methylene chloride was used.

Extracts were quantified using gas chromatography/mass spectrometry (GC/MS) in the selected ion mode (SIM) following SOP MSL-M-043, Identification and Quantification of Polynuclear Aromatic Hydrocarbons by GC/MS which is based on EPA method 8270 (EPA 1986).

HOLDING TIMES

Forty four (44) samples were received on 2/15/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/MS/SIM analysis dates:

Batch	Extraction	Analysis
Batch 1	3/2/94	3/12/94
Batch 2	3/10/94	3/19/94
Batch 3	3/23/94	3/31-4/1/94

DETECTION LIMITS

Target detection limits of 20 µg/kg dry wt were met for all PAH compounds. Achieved detection limits for PAHs were determined by multiplying the standard deviation of 7 spiked replicates by the student t value. Target detection limits of 20 µg/kg for phthalates were exceeded. Limits of quantitation (LOQ) for phthalates were determined by multiplying the standard deviation of 7 spiked replicates by 10. LOQs were higher than MDLs because phthalates were detected in the background blank sample. The LOQs ranged from 22.7 µg/kg to 163 µg/kg dry weight depending on the sample weight and percent moisture.

QA/QC SUMMARY (continued)

METHOD BLANKS

One method blank was extracted with each extraction batch. Any sample values that were less than 5 times the value in the associated method blank were flagged with a "B." Other analytes detected in the method blanks were either unconfirmed or detected at less than the QC criteria of 5 times the MDL.

SURROGATES

Five isotopically labelled compounds were added prior to extraction to assess the efficiency of the method. These were d8-Naphthalene, d8-Acenaphthene, d12-Chrysene, d10-Pyrene and d14-Dibenzo(a,h) Anthracene. Recoveries of all surrogates were within the quality control limits of 40-120%. Two samples in Batch 2 (SF-3 and SFW-3) had low surrogate recoveries because of extraction problems; these samples were re-extracted and reanalyzed with Batch 3. Surrogate recoveries were within QC limits for the reanalyses.

MATRIX SPIKES

One sample from each batch was spiked with all PAH and phthalate compounds in Batches 1 and 3, and with PAH compounds only in Batch 2. Matrix spike recoveries for 13 of the 22 PAH compounds in Batch 1 and 12 of 16 PAH compounds in Batch 2 were above the upper control limit. In Batch 3, recoveries of 2 PAH compounds exceeded the acceptable range, and recoveries of 2 phthalate compounds were below the minimum acceptable recovery of 40%. The high recoveries of PAH compounds in the matrix spikes for Batches 1 and 2 appear to be due to sample inhomogeneity. Recoveries of spiked compounds in blank spikes analyzed with each batch of samples were within QC limits, and results for SRMs are generally good. The Batch 2 matrix spike was analyzed in triplicate with Batch 3 to test sample homogeneity; RSDs for 17 of 18 compounds exceeded 30% (these results are not reported with the sample data).

REPLICATES

One sample from each batch was extracted and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSDs were $\leq$30% for analytes greater than 10 times the MDL except for phenanthrene in Batch 1 (RSD of 31%), and 9 compounds in Batch 2. The 9 compounds in Batch 2 had RSDs between 32% and 37%. In Batch 3, 6 of 17 compounds greater than 10 times the MDL had RSDs exceeding 30%.

SRMs

One SRM,1941a, a marine sediment obtained by the National Institute for Science and Technology was analyzed with each batch. Fourteen of the sixteen PAH compounds analyzed are certified. All PAHs were detected within 30% of the certified mean with the exception of chrysene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene in Batches 1 and 2, and benzo(b)fluoranthene and dibenzo(a,h)anthracene in Batch 3.

MISC

Some of the compounds are flagged to indicate that the ion ratio for that compound was outside of the QC range. This is due primarily to low levels of the compound of interest. Because the confirmation ion is present at only a fraction of the level of the parent ion, when the native level of the compound is low, the amount of error in the concentration measurement of the confirmation ion goes up. The compound is actually quantified from the parent ion only so most likely this will not affect the quality of the data. For sample values that are relatively high (>5 times the MDL) it may be an indication of some sort of interference.

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, U.S.E.P.A., Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Chlorinated Pesticides and PCBs
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry wt)
GC/ECD	40-120%	≤30%	≤30%	2.0 - 30 µg/kg

METHOD

Sediment samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-M-079, "Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics following the Surrogate Internal Standard Method" based on EPA Methods 3510 and 8080 (EPA 1986) and NOAA status and trends methods (Krahn et al. 1988). Samples were then cleaned using silica/alumina (5% deactivated) chromatography followed by HPLC cleanup (Krahn et al. 1988). Modifications in the clean-up method were required to adequately recover the phthalate compounds. In the first batch of samples, the Si column clean-up step was eliminated. In the second and third batches of samples, extracts were eluted through silica and alumina per the SOP, but twice the usual amount of methylene chloride was used. Extracts were analyzed using Gas Chromatography/ Electron Capture Detection (GC/ECD) following SOP MSL-M-044, "Analysis of PCBs and Chlorinated Pesticides by GC/ECD" based on EPA method 8080 (1986). The column used was a J&W DB-17 and the confirmatory column was a DB-1701, both capillary columns (30 m x 0.25 mm I.D.).

HOLDING TIMES

Forty-four (44) samples were received on 2/15/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/ECD analysis dates:

Batch	Extraction	Analysis
Batch 1	3/2/94	3/14-19/94
Batch 2	3/10/94	3/21-25/94
Batch 3	3/23/94	4/2-4/94

DETECTION LIMITS

Target detection limits were met for all samples. Detection limits reported are based on an MDL study involving low level spikes of 7 replicate extractions. MDLs are defined as 3x the standard deviation of the mean recovery.

METHOD BLANKS

One method blank was extracted with the extraction batch. No pesticides or PCBs were detected in the blanks.

QA/QC SUMMARY (continued)

SURROGATES Two compounds, PCB congeners 103 and 198, were added to all samples prior to extraction to assess the efficiency of the analysis. These compounds are also used to correct all sample results and are considered surrogate internal standards (SIS). Recoveries of these compounds were within the QC guidelines of 40-120% for all samples analyzed.

MATRIX SPIKES One sample from each batch was spiked with a subset of 6 pesticides and Aroclor 1254. Matrix spike recoveries were within the laboratory QC recovery limit (40-120%) for all pesticides and for Aroclor 1254 with the exception of g-BHC, Aldrin, and Endrin in Batch 1. One of the phthalate compounds spiked into the solution interfered with the recovery of Aldrin.

REPLICATES One sample from each batch was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. Only one pesticide was detected in all 3 replicates in Batches 1 and 2; the RSD was less than 30%. Six pesticides were detected in all 3 replicates in Batch 3; RSDs were less than 30%.

SRMs One SRM, 1941a, a marine sediment sample obtained from the National Institute of Science and Technology (NIST) was analyzed with each batch. Only two pesticides are certified, 4,4-DDE and 4,4-DDD. The recovery of 4,4'-DDD was higher than the certified value in the SRMs from Batches 1 and 2. The modified cleanup procedures for these samples resulted in a very complex chromatogram for the SRM, and interferences may have affected the recovery of this compound. The recoveries of both compounds were within QC criteria for the Batch 3 SRM.

Misc. - All pesticide detections are confirmed on a secondary column. The RPD criteria is 67%.

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, USEPA, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Butyltins
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry weight)
Unger et al.	40-120%	≤30%	≤30%	1 µg/kg

METHOD

Butyltin analyses were performed according to MSL-SOP-M-004 following the method of Unger et al. (1986). Sediment samples were extracted with methylene chloride using a roller under ambient conditions followed by derivitization using a Grignard reagent to change to a form compatible with gas chromatography. Sample extracts were then cleaned by passing through a florisil column. Extracts were analyzed using Gas Chromatography/Flame Photometric Detection (GC/FPD).

HOLDING TIMES

Forty-four (44) samples were received on 2/15/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20°C until extraction. Samples were extracted in three batches. Holding times were met for all extractions and analyses. The following table summarizes the extraction dates and GC/FPD analysis dates:

Batch	Extraction	Analysis
Batch 1	2/25/94	3/2-3/94
Batch 2	3/7/94	3/9-10/94
Batch 3	3/11/94	3/16-17/94

DETECTION LIMITS

Target detection limits of 1 µg/kg dry wt. were met for all butyltin compounds. These detection limits represent the method detection limit defined as roughly 3 times the standard deviation of results from 7 replicate low level matrix spikes.

METHOD BLANKS

One method blank was extracted with each extraction batch. No butyltins were detected in the blanks.

SURROGATES

One compound, Tripentyltin chloride, was added to all samples prior to extraction to assess the efficiency of the method. This compound is also used as an internal standard as all data is corrected for the recovery of the compound. Surrogate recoveries were within the QC limits of 40-120% for all samples.

QA/QC SUMMARY (continued)

MATRIX SPIKES

One sample from each batch was spiked with tri- and dibutyltin. Matrix spike recoveries for tri- and dibutyltin ranged from 83 to 128%. Tributyltin in the matrix spike for batch 3 exceeded the QC limits of 40-120%; however, the SRM for the corresponding batch was within QC limits.

REPLICATES

One sample in each batch was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. No butyltins were detected in the replicates from batches 1 and 2. RSDs for Batch 3 were within the QC criteria of $\leq$30%.

SRMs

PACS-1, an estuarine sediment obtained from the National Canadian Research Council (NRCC) was analyzed along with the samples from each batch. The results for tri- and dibutyltin were within 30% of the certified mean value for all batches with the exception of dibutyltin in batch 2, which was below the lower control limit. The recovery of dibutyltin in the matrix spike for batch 2 was 103%, which is within the control limits.

REFERENCES

Unger,, M.A., W.G. Macintyre, J. Reaves and R.J. Huggett. 1986. "GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation." *Chemosphere.* 15:461-470.

QA/QC SUMMARY

PROGRAM:	**Richmond Harbor Deepening Project**
PARAMETER:	**Waste Extraction Test (WET) and STLC of metals**
LABORATORY:	**Clayton Environmental Consultants, Pleasanton, California**
MATRIX:	**Sediment**

SAMPLE CUSTODY Five sediment samples were received at Clayton Environmental Consultants on 2/15/94, in good condition.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
NA[a]	NA	NA	NA

METHOD The WET extracts (membrane-filtered liquid portion of sediment sample) were measured for metals by either EPA Method 6010 (inductively-coupled plasma or ICP) or by atomic absorption (AA).

HOLDING TIMES The holding time of 6 months was met for all WET test analysis.

METHOD BLANKS One method blank was analyzed with the samples. No metals were detected in the blank.

MATRIX SPIKES Two matrix spikes were analyzed with the samples. The percent recoveries ranged from 85% to 106%.

REPLICATES Precision was measured by calculating the RPD between the matrix spike and matrix spike duplicate recoveries. The RPD values ranged from 0% to 8%.

DETECTION LIMITS The achieved detection limits were approximately one-tenth of the soluble threshold limit concentration (STLC) values.

(a) Data Quality Objectives not established prior to analysis of sediment samples.

QA/QC SUMMARY

PROGRAM:	**Richmond Harbor Deepening Project**
PARAMETER:	**Waste Extraction Test (WET) and STLC of pesticides and PCBs**
LABORATORY:	**Clayton Environmental Consultants, Pleasanton, California**
MATRIX:	**Sediment**

SAMPLE CUSTODY Five sediment samples and one water sample were received at Clayton Environmental Consultants on 2/15/94, in good condition.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
NA(a)	NA	NA	NA

METHOD The WET extracts (membrane-filtered liquid portion of sediment sample) were measured for pesticides and PCBs following EPA Methods 3510 and 8080.

HOLDING TIMES The holding time of 6 months was met for all WET test analysis.

METHOD BLANKS One method blank was analyzed with the samples. No PAHs, pesticides, or PCBs were detected in the blank.

MATRIX SPIKES Two matrix spikes were analyzed with the samples. The percent recoveries ranged from 73% to 119%.

REPLICATES Precision was measured by calculating the RPD between the matrix spike and matrix spike duplicate recoveries. The RPD values ranged from 0% to 7%.

SURROGATES Two surrogate internal standards (decachorobiphenyl and tetrachloro-m-xylene) were added prior to extraction. The percent recovery of these surrogates ranged from 104% to 110%.

DETECTION LIMITS The achieved detection limits were approximately one-tenth of the soluble threshold limit concentration (STLC) values.

(a) Data Quality Objectives not established prior to analysis of sediment samples.

TABLE C.1. Summary of Sediment Grain Size Including Quality Control Data, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Total Percent (dry weight) Gravel >2000 μm	Sand 62.5-2000 μm	Silt 3.9-62.5 μm	Clay <3.9 μm
SF COMP	1	1	29	35	35
SF-1	2	1	29	42	28
SF-2	1	6	18	34	42
SF-3	1	0	9	32	59
SF-4	1	0	5	32	63
SFW COMP	1	5	23	37	35
SFW-1	2	13	35	21	31
SFW-2	2	8	15	35	42
SFW-3	2	2	18	47	33
SFW-4	2	3	27	45	25
UIH COMP	1	0	6	33	61
UIH-1	1	0	5	35	60
UIH-2	1	0	2	33	65
UIH-3	2	0	7	35	58
UIH-4	2	1	13	35	51
UIH-5	1	0	7	39	54
TB Upper COMP	1	8	14	45	33
TB-1 Upper	1	22	33	24	21
TB-2 Upper	2	5	20	41	34
TB-3 Upper	2	1	13	48	38
TB-4 Upper	1	0	3	46	51
TB-5 Upper	1	1	7	58	34
TB-6 Upper	1	0	3	49	48
TB-7 Upper	1	0	5	66	29
TB Lower COMP, Replicate 1	1	6	14	46	34
TB Lower COMP, Replicate 2	1	2	15	46	37
TB Lower COMP, Replicate 3	1	1	15	47	37
TB-1 Lower	1	9	53	23	15
TB-2 Lower	1	1	23	43	33
TB-3 Lower, Replicate 1	2	0	13	51	36
TB-3 Lower, Replicate 2	2	1	12	53	34
TB-3 Lower, Replicate 3	2	0	14	53	33
TB-4 Lower	1	0	4	47	49
TB-5 Lower	2	0	12	55	33

TABLE C.1. (contd)

Sediment Treatment	Analytical Batch	Total Percent (dry weight) Gravel >2000 μm	Sand 62.5-2000 μm	Silt 3.9-62.5 μm	Clay ≤3.9 μm
TB-6 Lower, Replicate 1	2	0	7	52	41
TB-6 Lower, Replicate 2	2	0	7	50	43
TB-6 Lower, Replicate 3	2	0	7	49	44
TB-7 Lower	1	1	3	55	41
R-OS	1	0	34	45	21
R-BF	1	0	5	39	56
R-AM COMP	1	0	97	1	2
R-AM-A	2	0	99	0	1
R-AM-B	2	0	98	1	1
R-AM-C	2	0	99	0	1
R-AM-D	2	0	98	1	1
R-AM-F	2	0	79	12	9
R-AM-G	2	0	97	1	2
R-AM-H	2	0	97	1	2
R-AM-I	2	0	98	0	2
Quality Control Data					
Analytical Replicates					
TB Lower COMP, Replicate 1	1	6	14	46	34
TB Lower COMP, Replicate 2	1	2	15	46	37
TB Lower COMP, Replicate 3	1	1	15	47	37
RSD		NA[(a)]	4%	1%	5%
TB-3 Lower, Replicate 1	2	0	13	51	36
TB-3 Lower, Replicate 2	2	1	12	53	34
TB-3 Lower, Replicate 3	2	0	14	53	33
RSD		NA	8%	2%	4%
TB-6 Lower, Replicate 1	2	0	7	52	41
TB-6 Lower, Replicate 2	2	0	7	50	43
TB-6 Lower, Replicate 3	2	0	7	49	44
RSD		NA	0%	3%	4%

(a) NA Not applicable.

TABLE C.2. Sediment Grain Size Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Percent at Size Fraction															
		phi						4	4.5	5	5.5	6	7	8	9	10	11
		μm	3350-	2000-	1000-	250-	125-	62.5-	48-	31.2-	23-	15.6-	7.8-	3.9-	1.9-	0.9-	
		>3350	2000	1000	250	125	62.5	48	31.2	23	15.6	7.8	3.9	1.9	0.9	0.4	<0.4
SF COMP	1	0	1	1	6	9	13	4	6	5	4	9	7	8	6	6	15
SF-1	2	0	1	1	5	9	14	6	6	7	5	10	8	6	5	5	12
SF-2	1	5	1	1	4	6	7	4	4	4	3	9	10	9	8	7	18
SF-3	1	0	0	1	1	3	4	3	1	3	4	8	13	13	11	10	25
SF-4	1	0	0	0	1	1	3	2	3	2	4	9	12	13	12	10	28
SFW COMP	1	1	4	3	6	5	9	5	5	4	5	10	8	8	7	6	14
SFW-1	2	7	6	11	17	3	4	2	2	3	2	5	7	6	7	5	13
SFW-2	2	6	2	1	4	5	5	4	5	4	6	7	9	8	8	8	18
SFW-3	2	1	1	0	3	5	10	5	8	6	6	13	9	7	6	5	15
SFW-4	2	2	1	3	6	7	11	8	9	5	6	10	7	6	5	3	11
UIH COMP	1	0	0	0	2	1	3	1	2	4	5	9	12	14	10	9	28
UIH-1	1	0	0	0	2	1	2	3	2	4	3	10	13	12	12	11	25
UIH-2	1	0	0	0	0	1	1	2	1	4	4	9	13	14	12	10	29
UIH-3	2	0	0	0	2	1	4	2	3	5	3	11	11	12	11	10	25
UIH-4	2	1	0	1	3	4	5	2	3	4	5	10	11	10	10	8	23
UIH-5	1	0	0	0	2	1	4	3	4	5	6	9	12	12	10	9	23
TB Upper COMP	1	6	2	4	4	1	5	8	8	7	5	9	8	7	5	5	16
TB-1 Upper	1	16	6	7	12	6	8	4	3	3	3	6	5	4	4	4	9
TB-2 Upper	2	2	3	5	6	3	6	8	8	5	5	8	7	2	9	8	15
TB-3 Upper	2	0	1	1	1	1	10	11	10	7	5	8	7	7	6	5	20
TB-4 Upper	1	0	0	0	0	1	2	5	7	6	6	11	11	11	9	9	22
TB-5 Upper	1	0	1	0	1	1	5	11	13	9	8	10	7	6	5	5	18
TB-6 Upper	1	0	0	0	1	0	2	4	5	6	6	13	15	8	9	7	24
TB-7 Upper	1	0	0	1	0	0	4	14	16	12	8	10	6	4	4	5	16
TB Lower COMP, Replicate 1	1	5	1	1	3	5	5	6	7	8	7	10	8	6	6	6	16
TB Lower COMP, Replicate 2	1	1	1	1	3	5	6	5	7	8	7	10	9	7	6	5	19
TB Lower COMP, Replicate 3	1	0	1	1	4	4	6	6	8	6	8	10	9	7	5	6	19
TB-1 Lower	1	6	3	3	14	15	21	7	4	2	2	4	4	3	2	2	8
TB-2 Lower	1	0	1	1	9	7	6	6	6	7	6	10	8	6	5	5	17
TB-3 Lower, Replicate 1	2	0	0	1	3	3	6	4	12	8	7	12	8	6	6	5	19
TB-3 Lower, Replicate 2	2	0	1	0	3	4	5	6	10	9	8	12	8	6	5	6	17
TB-3 Lower, Replicate 3	2	0	0	1	4	4	5	6	10	9	8	12	8	6	5	5	17
TB-4 Lower	1	0	0	0	0	0	4	6	7	6	6	12	10	10	8	8	23
TB-5 Lower	2	0	0	0	2	4	6	12	8	8	7	11	9	5	5	5	18
TB-6 Lower, Replicate 1	2	0	0	0	0	1	6	12	7	7	6	11	9	8	8	7	18
TB-6 Lower, Replicate 2	2	0	0	0	0	1	6	10	7	7	5	11	10	9	7	7	20
TB-6 Lower, Replicate 3	2	0	0	0	0	1	6	10	7	6	6	10	10	9	7	7	21
TB-7 Lower	1	1	0	0	1	1	1	6	8	10	8	12	11	7	7	6	21

TABLE C.2. (contd)

Sediment Treatment	Analytical Batch	Percent at Size Fraction															
		phi						4	4.5	5	5.5	6	7	8	9	10	11
		μm	3350-	2000-	1000-	250-	125-	62.5-	48-	31.2-	23-	15.6-	7.8-	3.9-	1.9-	0.9-	
		>3350	2000	1000	250	125	62.5	48	31.2	23	15.6	7.8	3.9	1.9	0.9	0.4	<0.4
R-OS	1	0	0	0	2	3	29	23	8	3	3	5	3	4	3	3	11
R-BF	1	0	0	0	3	1	1	4	5	6	5	9	10	11	10	10	25
R-AM COMP	1	0	0	0	77	19	1	0	0	0	0	1	0	0	1	0	1
R-AM-A	2	0	0	0	95	3	1	0	0	0	0	0	0	0	0	0	1
R-AM-B	2	0	0	0	91	7	0	0	1	0	0	0	0	0	0	0	1
R-AM-C	2	0	0	0	80	18	1	0	0	0	0	0	0	0	0	0	1
R-AM-D	2	0	0	0	73	25	0	0	0	1	0	0	0	0	0	0	1
R-AM-F	2	0	0	0	28	47	4	4	1	1	1	2	3	2	2	2	3
R-AM-G	2	0	0	0	60	36	1	0	0	0	1	0	0	0	0	1	1
R-AM-H	2	0	0	0	86	11	0	1	0	0	0	0	0	0	0	0	2
R-AM-I	2	0	0	0	84	14	0	0	0	0	0	0	0	0	1	0	1

TABLE C.3. Quality Control Data for Sediment Grain Size Results (Percent Dry Weight), Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Percent at Size Fraction															
		phi						4	4.5	5	5.5	6	7	8	9	10	11
		µm	3350-	2000-	1000-	250-	125-	62.5-	48-	31.2-	23-	15.6-	7.8-	3.9-	1.9-	0.9-	
		>3350	2000	1000	250	125	62.5	48	31.2	23	15.6	7.8	3.9	1.9	0.9	0.4	<0.4
Analytical Replicates																	
TB Lower COMP, Replicate 1	1	5	1	1	3	5	5	6	7	8	7	10	8	6	6	6	16
TB Lower COMP, Replicate 2	1	1	1	1	3	5	6	5	7	8	7	10	9	7	6	5	19
TB Lower COMP, Replicate 3	1	0	1	1	4	4	6	6	8	6	8	10	9	7	5	6	19
RSD		NA[a]	NA	NA	NA	12%	10%	10%	8%	16%	8%	0%	7%	9%	10%	10%	10%
TB-3 Lower, Replicate 1	2	0	0	1	3	3	6	4	12	8	7	12	8	6	6	5	19
TB-3 Lower, Replicate 2	2	0	1	0	3	4	5	6	10	9	8	12	8	6	5	6	17
TB-3 Lower, Replicate 3	2	0	0	1	4	4	5	6	10	9	8	12	8	6	5	5	17
RSD		NA	NA	NA	NA	NA	11%	22%[b]	11%	7%	8%	0%	0%	0%	11%	11%	7%
TB-6 Lower, Replicate 1	2	0	0	0	0	1	6	12	7	7	6	11	9	8	8	7	18
TB-6 Lower, Replicate 2	2	0	0	0	0	1	6	10	7	7	5	11	10	9	7	7	20
TB-6 Lower, Replicate 3	2	0	0	0	0	1	6	10	7	6	6	10	10	9	7	7	21
RSD		NA	NA	NA	NA	NA	0%	11%	0%	9%	10%	5%	6%	7%	8%	0%	8%

(a) NA Not applicable.
(b) Value exceeds relative precision goal of ≤20%.

TABLE C.4. Sediment Total Organic Carbon (TOC), Total Percent Solids, and Total Volatile Solids (TVS) Results, Richmond Harbor Deepening Project

Sediment Treatment	TOC Batch	TOC (percent dry weight)	Total Solids and TVS Batch	Total Percent Solids	TVS (percent dry weight)
Target DL[a]	NA[b]	0.01	NA	0.1	0.1
Achieved DL	NA	0.001	NA	0.01	0.01
SF COMP	3	0.71	2	54.78	2.32
SF-1	3	0.33	2	68.93	2.27
SF-2	3	0.98	2	52.44	2.62
SF-3, Replicate 1	2	1.26	2	43.63	2.67
SF-3, Replicate 2	2	1.28	2	43.63	NA
SF-4	3	1.37	2	41.24	2.70
SFW COMP, Replicate 1	4	0.78	3	57.06	2.26
SFW COMP, Replicate 2	4	0.76	3	NA	NA
SFW COMP, Replicate 3	4	0.75	3	NA	NA
SFW-1	3	1.00	2	55.41	2.21
SFW-2	3	1.09	2	50.54	2.84
SFW-3	3	0.49	2	63.41	2.32
SFW-4	3	0.32	2	70.66	2.01
UIH COMP	4	1.23	3	42.87	2.69
UIH-1	2	1.17	2	42.68	2.80
UIH-2	2	1.20	2	40.81	2.73
UIH-3	2	1.12	2	45.97	2.81
UIH-4	2	0.87	2	52.91	2.83
UIH-5	2	0.97	2	44.97	2.74
TB Upper COMP	4	0.85	3	52.91	2.48
TB-1 Upper	1	0.50	1	67.94	2.45
TB-2 Upper	1	0.73	1	63.83	3.25
TB-3 Upper	1	0.78	1	55.89	2.47
TB-4 Upper	1	1.09	1	44.59	2.63
TB-5 Upper	1	0.79	1	59.65	2.44
TB-6 Upper	1	0.66	1	57.96	2.43
TB-7 Upper	1	0.63	1	64.00	2.38

TABLE C.4. (contd)

Sediment Treatment	TOC Batch	TOC (percent dry weight)	Total Solids and TVS Batch	Total Percent Solids	TVS (percent dry weight)
TB Lower COMP	4	0.69	3	60.39	2.15
TB-1 Lower	1	0.05	1	81.56	1.73
TB-2 Lower	1	0.62	1	66.81	2.08
TB-3 Lower	1	0.70	1	62.25	2.21
TB-4 Lower	1	0.93	1	52.95	2.88
TB-5 Lower	1	0.70	1	64.20	2.27
TB-6 Lower	1	0.55	1	61.48	2.27
TB-7 Lower	2	0.72	2	61.03	2.43
R-OS	3	1.35	2	54.33	2.49
R-BF	2	1.24	2	35.54	2.34
R-AM COMP	2	0.02	2	78.26	0.776
R-AM-A	1	0.03	1	90.72	0.589
R-AM-B	1	0.01	1	89.91	0.602
R-AM-C, Replicate 1	1	0.01	1	79.09	0.572
R-AM-C, Replicate 2	1	0.03	1	NA	NA
R-AM-D, Replicate 1	1	0.03	1	80.42	0.623
R-AM-D, Replicate 2	1	0.03	1	80.86	0.622
R-AM-D, Replicate 3	1	0.03	1	81.56	0.594
R-AM-F	1	0.28	1	71.44	1.73
R-AM-G, Replicate 1	2	0.04	1	76.42	0.707
R-AM-G, Replicate 2	2	0.05	1	NA	NA
R-AM-G, Replicate 3	2	0.04	1	NA	NA
R-AM-H	2	0.04	2	82.63	0.678
R-AM-I	1	0.04	1	86.12	0.658

(a) DL Detection Limit.
(b) NA Not applicable.

TABLE C.5. Quality Control Data for Sediment Total Organic Carbon (TOC), Total Percent Solids, and Total Volatile Solids (TVS) Results, Richmond Harbor Deepening Project

Sediment Treatment	TOC Batch	TOC (percent dry weight)	Total Solids and TVS Batch	Total Percent Solids	TVS (percent dry weight)
Method Blanks					
Blank 1	1	0.002	1	<1 mg	1.0 mg U
Blank 2	2	0.002	NA[a]	NA	NA
Blank 3	2	0.002	NA	NA	NA
Blank 4	2	0.003	NA	NA	NA
Blank 5	3	0.001	NA	NA	NA
Blank 6	4	0.002	NA	NA	NA
Standard Reference Material					
MESS-1		2.53	NA	NA	NA
MESS-1		2.53	NA	NA	NA
MESS-1		2.59	NA	NA	NA
Analytical Duplicates					
R-AM-C, Replicate 1	1	0.01	NA	NA	NA
R-AM-C, Replicate 2	1	0.03	NA	NA	NA
RPD		100%[b]	NA	NA	NA
I-Stat		0.50	NA	NA	NA
SF-3, Replicate 1	2	1.26	NA	NA	NA
SF-3, Replicate 2	2	1.28	NA	NA	NA
RPD		2%	NA	NA	NA
I-Stat		0.01	NA	NA	NA
Analytical Triplicates					
TB-7 Upper, Replicate 1	1	NA	1	64.00	2.38
TB-7 Upper, Replicate 2	1	NA	1	64.36	2.28
TB-7 Upper, Replicate 3	1	NA	1	64.15	2.35
RSD		NA	NA	0%	2%

TABLE C.5. (contd)

Sediment Treatment	TOC Batch	TOC (percent dry weight)	Total Solids and TVS Batch	Total Percent Solids	TVS (percent dry weight)
R-AM-D, Replicate 1	1	0.03	1	80.42	0.623
R-AM-D, Replicate 2	1	0.03	1	80.86	0.622
R-AM-D, Replicate 3	1	0.03	1	81.56	0.594
RSD		0%	NA	1%	3%
R-AM-G, Replicate 1	2	0.04	NA	NA	NA
R-AM-G, Replicate 2	2	0.05	NA	NA	NA
R-AM-G, Replicate 3	2	0.04	NA	NA	NA
RSD		13%	NA	NA	NA
SF-4	3	NA	2	41.24	2.70
SF-4	3	NA	2	41.64	2.73
SF-4	3	NA	2	41.00	2.65
RSD		NA	NA	1%	2%
SFW COMP, Replicate 1	4	0.78	NA	NA	NA
SFW COMP, Replicate 2	4	0.76	NA	NA	NA
SFW COMP, Replicate 3	4	0.75	NA	NA	NA
RSD		2%	NA	NA	NA

(a) NA Not applicable.
(b) Value exceeds relative precision goal of ≤20%.

TABLE C.6. Sediment Oil & Grease and Total Petroleum Hydrocarbons (TPH) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Oil and Grease (mg/kg dry weight)	TPH (mg/kg dry weight)
Target DL[a]		20	20
Achieved DL		18-29	17-38
SF COMP	2	29 U[b]	29 U
SF-1	2	36	23 U
SF-2	2	66	34
SF-3	2	136	67
SF-4	2	98	57
SFW COMP[c]	3	232	104
SFW COMP, Replicate 1	3	106	80
SFW COMP, Replicate 2	3	106	62
SFW COMP, Replicate 3	3	95	62
SFW-1	2	44	35
SFW-2	2	79	69
SFW-3	2	117	84
SFW-4	2	27	22 U
UIH COMP	3	91	65
UIH-1	2	204	75
UIH-2	2	97	38 U
UIH-3	2	80	34 U
UIH-4	2	142	72
UIH-5	2	139	70
TB Upper COMP	3	47	30 U
TB-1 Upper	1	36	23 U
TB-2 Upper	1	36	25 U
TB-3 Upper	1	28 U	28 U
TB-4 Upper	1	169	57
TB-5 Upper	1	26 U	26 U
TB-6 Upper	1	83	32
TB-7 Upper[c]	2	20 U	20 U
TB-7 Upper, Replicate 1	2	29	25 U
TB-7 Upper, Replicate 2	2	33	25 U
TB-7 Upper, Replicate 3	2	26	24 U
TB Lower COMP	3	35	26 U
TB-1 Lower	1	19 U	19 U
TB-2 Lower	1	29	24 U
TB-3 Lower	1	30	25 U
TB-4 Lower	1	58	30 U
TB-5 Lower	1	25 U	25 U
TB-6 Lower	1	26 U	26 U
TB-7 Lower	2	26 U	26 U

TABLE C.6. (contd)

Sediment Treatment	Analytical Batch	Oil and Grease (mg/kg dry weight)	TPH (mg/kg dry weight)
R-OS	2	39	29 U
R-BF	2	143	45 U
R-AM COMP	2	26	20 U
R-AM-A	1	23	17 U
R-AM-B	1	18 U	18 U
R-AM-C	1	41	20 U
R-AM-D[(c)]	1	18 U	18 U
R-AM-D, Replicate 1	1	42	19 U
R-AM-D, Replicate 2	1	43	19 U
R-AM-D, Replicate 3	1	62	20 U
R-AM-F	1	38	22 U
R-AM-G	1	37	20 U
R-AM-H	2	19 U	19 U
R-AM-I	1	18 U	18 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Sample re-analyzed approximately 1 month after initial analyses to provide appropriate matrix spike information.

TABLE C.7. Quality Control Data for Sediment Oil & Grease and Total Petroleum Hydrocarbons (TPH) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Oil and Grease (mg/kg dry weight)	TPH (mg/kg dry weight)
Method Blank			
Blank		20 U[a]	20 U
Matrix Spikes			
R-AM-D[b]	1	18 U	18 U
R-AM-D, MS	1	6520	5800
Concentration Recovered		6520	5800
Amount Spiked		6700	6240
Percent Recovery		97%	93%
TB-7 Upper[b]	2	20 U	20 U
TB-7 Upper, MS	2	10200	9320
Concentration Recovered		10200	9320
Amount Spiked		9630	8970
Percent Recovery		106%	104%
SFW COMP[b]	3	232	104
SFW COMP, MS	3	13100	12500
Concentration Recovered		12900	12400
Amount Spiked		13100	12200
Percent Recovery		98%	102%
Analytical Triplicates			
R-AM-D, Replicate 1	1	42	19 U
R-AM-D, Replicate 2	1	43	19 U
R-AM-D, Replicate 3	1	62	20 U
RSD		23%	NA
TB-7 Upper, Replicate 1	2	29	25 U
TB-7 Upper, Replicate 2	2	33	25 U
TB-7 Upper, Replicate 3	2	26	24 U
RSD		12%	NA
SFW COMP, Replicate 1	3	106	80
SFW COMP, Replicate 2	3	106	62
SFW COMP, Replicate 3	3	95	62
RSD		6%	15%

(a) U Undetected at or above detection limit.
(b) Sample re-analyzed approximately 1 month after initial analyses to provide appropriate matrix spike information.

TABLE C.8. Sediment Total Polynuclear Aromatic Hydrocarbons (PAHs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	(µg/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
SF COMP	2	228	1345	1573
SF-1	2	79	390	469
SF-2	2	273	1876	2149
SF-3, Replicate 1	3	414	3288	3702
SF-3, Replicate 2	3	528	3259	3787
SF-4	2	489	3274	3763
SFW COMP	2	3897	1806	5703
SFW-1	2	248	1735	1983
SFW-2	2	386	3390	3776
SFW-3	3	2188	1105	3293
SFW-4	2	71	396	467
UIH COMP, Replicate 1	3	260	1812	2072
UIH COMP, Replicate 2	3	319	2478	2797
UIH COMP, Replicate 3	3	697	2825	3522
UIH-1	2	253	1596	1849
UIH-2	2	278	1987	2265
UIH-3	2	245	1709	1954
UIH-4	2	227	1712	1939
UIH-5	2	283	1843	2126
TB Upper COMP	3	115	820	935
TB-1 Upper	1	48	368	416
TB-2 Upper, Replicate 1	1	132	1063	1195
TB-2 Upper, Replicate 2	1	217	1371	1588
TB-2 Upper, Replicate 3	1	167	1206	1373
TB-3 Upper	1	161	1322	1483
TB-4 Upper	1	216	1622	1838
TB-5 Upper	1	91	383	474
TB-6 Upper	1	13	18	31
TB-7 Upper	1	26	26	52
TB Lower COMP	3	31	94	125
TB-1 Lower	1	0	2	2
TB-2 Lower	1	13	17	30
TB-3 Lower	1	16	26	42
TB-4 Lower	1	260	2023	2283
TB-5 Lower	1	19	25	44
TB-6 Lower	1	14	20	34
TB-7 Lower	2	28	27	55
OBM COMP	3	8	4	12

TABLE C.8. (contd)

Sediment Treatment	Analytical Batch	(µg/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
R-OS	2	48	68	116
R-BF	2	228	1527	1755
R-AM COMP, Replicate 1	2	1507	3229	4736
R-AM COMP, Replicate 2	2	773	1772	2545
R-AM COMP, Replicate 3	2	1251	2277	3528
R-AM-A	1	19	102	121
R-AM-B	1	16	45	61
R-AM-C	1	58	102	160
R-AM-D	1	354	744	1098
R-AM-F	1	1062	3325	4387
R-AM-G	1	195	549	744
R-AM-H	2	220	477	697
R-AM-I	1	627	1533	2160

TABLE C.9. Sediment Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Target DL[a]		20	20	20	20	20	20
Achieved DL		1.07-2.68	1.14-2.86	0.54-1.36	0.84-2.10	1.09-2.72	1.39-3.46
SF COMP	2	37.5	12.4 B[b]	11.2	15.8	95.7	55.8
SF-1	2	17.1 B	5.23[c] B	4.75[c]	6.34	29.0 B	16.4
SF-2	2	47.3	19.7	11.6	20.5	99.7	74.6
SF-3, Replicate 1	3	68.4	23.0	15.6	32.3	175	99.7
SF-3, Replicate 2	3	76.1	28.8	17.5	35.9	198	172
SF-4	2	84.2	31.3	20.7	36.4	184	132
SFW COMP	2	2830	13.8	198	181	551	123
SFW-1	2	45.7	16.1	10.1	18.9[c]	87.9	69.3
SFW-2	2	74.5	21.7	22.9	33.6	124	109
SFW-3	3	1300	6.57	151	290	323	117
SFW-4	2	15.9 B	4.95[c] B	4.36	5.05[c]	23.7 B	17.2
UIH COMP, Replicate 1	3	40.6	15.5	9.76	18.0	112	64.1
UIH COMP, Replicate 2	3	43.1	17.2	13.0	22.3	139	84.4
UIH COMP, Replicate 3	3	42.9	26.5	12.1	33.9	314	268
UIH-1	2	43.7	13.9	11.3[c]	15.4[c]	113	55.2
UIH-2	2	47.2	17.7	12.6	18.8	114	67.9
UIH-3	2	43.3	17.3	9.51[c]	17.3	99.0	59.0
UIH-4	2	43.9	13.6	8.90[c]	14.1[c]	86.8	59.4
UIH-5	2	49.6	18.4	11.8	19.3	116	67.8
TB Upper COMP	3	18.2	7.82	4.48	6.57	60.8	17.4
TB-1 Upper	1	8.18	3.18[c]	2.63	4.36	21.2	8.81
TB-2 Upper, Replicate 1	1	20.6	11.2	3.77	7.77[c]	64.7	23.9
TB-2 Upper, Replicate 2	1	21.9	13.9	5.94	12.3	121	42.4
TB-2 Upper, Replicate 3	1	21.5	12.0	5.39	9.66	86.9	31.6
TB-3 Upper	1	23.3	13.4	3.01[c]	9.24	82.5	29.6
TB-4 Upper	1	34.4	15.8	8.71	15.9	104	37.0
TB-5 Upper	1	10.5	35.1[c]	1.94	6.00	28.0	9.22
TB-6 Upper	1	1.99[c]	1.85 U[d]	0.88 U	4.67	6.47	2.25 U
TB-7 Upper	1	4.61	1.83 U	0.87 U	5.19	12.4	4.22[c]
TB Lower COMP	3	5.98 B	1.95[c]	1.94[c]	3.88[c]	13.4	4.14[c]
TB-1 Lower	1	1.29 U	1.37 U	0.65 U	1.01 U	1.31 U	1.66 U
TB-2 Lower	1	2.40	1.6 U	0.76 U	3.70	6.98	1.94 U
TB-3 Lower	1	2.81	1.83 U	0.87 U	4.56	8.67	2.22 U
TB-4 Lower	1	40.5	18.4	9.35	14.7[c]	124	53.4
TB-5 Lower	1	2.79	1.65 U	0.78 U	4.02	8.52	3.62[c]
TB-6 Lower	1	2.29[c]	1.76 U	0.84 U	4.30	4.93	2.13
TB-7 Lower	2	7.25 B	1.85[c] B	3.33	4.74	11.2 B	2.22 U
OBM COMP	3	3.94 B	1.47 U	1.62[c]	1.08 U	2.11	1.77 U

TABLE C.9. (contd)

Sediment Treatment	Analytical Batch	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
R-OS	2	12.3	2.37(c) B	0.98 U	5.67	18.9 B	8.90
R-BF	2	40.1	15.3	12.2	13.4	112	34.7
R-AM COMP, Replicate 1	2	46.0	63.6	32.4	92.2	925	348
R-AM COMP, Replicate 2	2	29.6	32.6	37.8	44.3	456	173
R-AM COMP, Replicate 3	2	38.1	56.6	20.5(c)	94.0	783	259
R-AM-A	1	5.62	2.11(c)	0.54 U	0.84 U	7.30	3.93(c)
R-AM-B	1	2.40	1.17 U	0.56 U	2.54(c)	7.49	3.57(c)
R-AM-C	1	9.12	3.18(c)	3.12	5.33	24.0	13.5
R-AM-D	1	10.5	20.0	5.28	13.6	213	91.7
R-AM-F	1	101	59.3	86.7	66.3	572	177
R-AM-G	1	9.95	11.8	4.27(c)	11.3	116	42.0
R-AM-H	2	36.4	11.4 B	5.09	12.4(c)	113	41.9
R-AM-I	1	18.1	38.9	10.1(c)	39.9	377	143

(a) DL Detection limit.
(b) B Analyte detected in sample is less than five times the value in associated method blank.
(c) Ratio of confirmation ion between the primary and secondary column is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(d) U Undetected at or above detection limit.

TABLE C.10. Sediment High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	HPAHs (µg/kg dry weight) Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene	Benzo(g,h,i)perylene
Target DL[a]		20	20	20	20	20	20	20	20	20	20
Achieved DL		1.48-3.69	1.19-2.97	0.59-1.48	1.09-2.72	0.50-1.25	1.09-2.73	1.19-2.97	2.32-5.80	3.34-8.36	3.63-9.08
SF COMP	2	134	182	94.6	139	238	84.2	156	146	34.3	137
SF-1	2	38.2	42.4[b]	27.4	33.1	70.9	25.6	47.1	47.7	10.2	47.4
SF-2	2	133	216	111	174	398	131	261	213	47.8	191
SF-3, Replicate 1	3	312	480	200	324	637	222	447	291	81.9	293
SF-3, Replicate 2	3	235	438	194	332	685	236	466	297	80.2	296
SF-4	2	235	509	195	303	642	220	421	348	87.7	313
SFW COMP	2	297	421	117	137	248	85.8	166	152	29.3	153
SFW-1	2	114	263	107	169	339	119	228	182	47.3	167
SFW-2	2	396	905	268	312	457	169	328	262	57.2	236
SFW-3	3	183	296	61.4	72.5	138	42.9	105	90.5	13.6	102
SFW-4	2	28.9	58.7	21.7	27.4	72.5	25.7	49.7	51.4	9.65	50.1
UIH COMP, Replicate 1	3	166	309	106	153	314	104	232	190	36.2	202
UIH COMP, Replicate 2	3	193	352	164	243	452	163	344	252	55.0	260
UIH COMP, Replicate 3	3	335	541	228	260	420	150	343	245	51.6	251
UIH-1	2	161	260	103	133	248	85.5	189	188	33.6	195
UIH-2	2	160	373	121	165	330	115	241	217	43.6	221
UIH-3	2	135	254[b]	94.4	126	309	107	214	220	39.9	210
UIH-4	2	113	311	97.9	161	313	110	218	180	39.3	169
UIH-5	2	164	253	116	153	328	109	232	225	43.6	219
TB Upper COMP	3	105	142	51.1	56.0	110	35.0	104	97.3	12.8	107
TB-1 Upper	1	44.6	58.6	23.0	22.6	51.5	17.5	43.9	48.9	6.13	51.7
TB-2 Upper, Replicate 1	1	122	159	74.2	76.8	150	53.4	142	129	16.6	140
TB-2 Upper, Replicate 2	1	188	224	99.5	105	187	61.4	174	150	20.6	161
TB-2 Upper, Replicate 3	1	147	188	88.0	88.9	168	55.6	161	141	19.2	149
TB-3 Upper	1	151	197	87.8	90.4	184	61.3	183	166	20.0	181
TB-4 Upper	1	196	257	98.1	110	232	78.0	207	200	24.9	219
TB-5 Upper	1	40.9	50.9	25.3	26.0	59.6	23.0	51.5	47.3	7.03	51.7
TB-6 Upper	1	4.42[b]	1.92 U[c]	3.71[b]	2.73[b]	6.65[b]	1.77 U	1.92 U	3.76 U	5.42 U	5.88 U
TB-7 Upper	1	4.73[b]	1.90 U	4.36[b]	3.42	7.95[b]	2.98[b]	2.13[b]	3.71 U	5.35 U	5.81 U

TABLE C.10. (contd)

Sediment Treatment	Analytical Batch	HPAHs (µg/kg dry weight) Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene	Benzo(g,h,i)perylene
TB Lower COMP	3	15.0	13.2	7.61 B	7.19	13.3	3.98	9.14	11.9	5.35 U	12.5
TB-1 Lower	1	1.77 U	1.42 U	2.47 (b)	1.31 U	0.60 U	1.31 U	1.42 U	2.79 U	4.01 U	4.36 U
TB-2 Lower	1	3.46 (b)	1.66 U	3.92 (b)	2.53	5.22	1.53 U	1.66 (b)	3.25 U	4.68 U	5.08 U
TB-3 Lower	1	4.38 (b)	1.90 U	4.22 (b)	3.04	5.89	2.63 (b)	1.90 U	3.71 U	5.35 U	5.81
TB-4 Lower	1	221	338	112	127	290	93.9	269	259	29.8	283
TB-5 Lower	1	3.63 (b)	1.71 U	3.80 (b)	2.90	5.62 (b)	2.38 (b)	1.71 (b)	3.34 U	4.82 U	5.23
TB-6 Lower	1	4.90	2.19 (b)	4.05 (b)	2.67	6.59	1.68 U	1.83 U	3.57 U	5.15 U	5.59 U
TB-7 Lower	2	5.90 (b) B (d)	1.90 U	4.42 (b)	1.94 (b)	4.66	1.75 U	1.90 U	3.94 (b)	5.35 U	6.11 (b)
OBM COMP	3	2.50 (b) B	1.52 U	1.37 (b) B	1.39 U	0.64 U	1.40 U	1.52 U	2.97 U	4.28 U	4.65 U
R-OS	2	11.3 B	7.39	6.88	4.55	9.30	3.41	2.58	10.1	6.02 U	12.2
R-BF	2	199	241	94.7	103	200	66.7	175	210	23.7	214
R-AM COMP, Replicate 1	2	616	751	386	382	290	105	308	182	44.3	165
R-AM COMP, Replicate 2	2	322	395	194	190	167	59.8	185	121	23.5	115
R-AM COMP, Replicate 3	2	452	545	261	255	200	71.3	215	129	30.4	118
R-AM-A	1	18.7	19.7	12.4	10.2	11.6	5.66 (b)	10.9	6.85	3.34 U	6.34
R-AM-B	1	6.76	7.66	4.97	3.74	5.57	3.05 (b)	5.08	3.68	3.41 U	4.00
R-AM-C	1	17.9	21.5	12.2	11.8	10.6	5.41	10.4	6.36	4.08 U	5.89
R-AM-D	1	164	174	73.8	67.4	69.7	27.2	70.3	45.6	9.19	43.1
R-AM-F	1	582	814	253	241	359	124	361	273	39.7	278
R-AM-G	1	91.0	117	55.7	56.2	61.2	23.1	62.5	37.6	7.75	36.6
R-AM-H	2	85.9	109	54.1	54.6	42.6	15.9	44.4	32.3	7.84	30.2
R-AM-I	1	308	371	161	163	137	52.3	143	91.0	19.4	87.3

(a) DL Detection limit.
(b) Ratio of confirmation ion between the primary and secondary column is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) U Undetected at or above detection limit.
(d) B Analyte detected in sample is less than five times the value in associated method blank.

TABLE C.11. Quality Control Data for Sediment Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Method Blanks							
Blank-1	1	1.50 U[a]	1.60 U	0.76 U	1.18 U	1.52 U	0.19 U
Blank-2	1	1.48 U	1.58 U	0.75 U	1.16 U	1.50 U	1.91 U
Blank-1	2	5.78	2.49[b]	0.93 U	1.43 U	6.32[b]	2.36 U
Blank-1	3	2.70	1.92 U	0.92 U	1.41 U	1.83 U	2.33 U
Matrix Spikes							
R-AM-I	1	18.1	38.9	10.1[b]	39.9	377	143
R-AM-I, MS		84.8	112	78.5	127	592	245
Concentration Recovered		66.7	73.1	68.4	87.1	215	102
Amount Spiked		58.0	58.0	58.0	58.0	58.0	58.0
Percent Recovery		115%	126%[c]	118%	150%[c]	371%[c]	176%[c]
R-AM-H	2	36.4	11.4	5.09	12.4[b]	113	41.9
R-AM-H, MS		54.6	44.2	33.0	45.0	197	132
Concentration Recovered		18.2	32.8	27.9	32.6	84.0	90.1
Amount Spiked		28.5	28.5	28.5	28.5	28.5	28.5
Percent Recovery		64%	115%	98%	114%	295%[c]	316%[c]
TB Upper COMP	3	18.2	7.82	4.48	6.57	60.8	17.4
TB Upper COMP		63.0	47.0	49.4	52.5	126	73.2
Concentration Recovered		44.8	39.2	44.9	45.9	65.2	55.8
Amount Spiked		42.0	42.0	42.0	42.0	42.0	42.0
Percent Recovery		107%	93%	107%	109%	155%[c]	133%[c]
Standard Reference Material							
Certified		1010	NC[d]	NC	97.3	489	184
value NIST 1941a		±140	NC	NC	±8.6	±23	±14
SRM 1941a	1	853	NA[e]	NA	93.5	478	199
SRM 1941a	2	865	NA	NA	90.6	508	208
SRM 1941a	3	749	NA	NA	83.8	455	193
Analytical Duplicates							
SF-3, Replicate 1	3	68.4	23.0	15.6	32.3	175	99.7
SF-3, Replicate 2	3	76.1	28.8	17.5	35.9	198	172
RPD		11%	22%	11%	11%	12%	53%
I-Stat		0.05	0.11	0.06	0.05	0.06	0.27
Analytical Triplicates							
TB-2 Upper, Replicate 1	1	20.6	11.2	3.77	7.77[b]	64.7	23.9
TB-2 Upper, Replicate 2	1	21.9	13.9	5.94	12.3	121	42.4
TB-2 Upper, Replicate 3	1	21.5	12.0	5.39	9.66	86.9	31.6
RSD		3%	11%	22%	23%	31%[f]	28%
R-AM COMP, Replicate 1	2	46.0	63.6	32.4	92.2	925	348
R-AM COMP, Replicate 2	2	29.6	32.6	37.8	44.3	456	173
R-AM COMP, Replicate 3	2	38.1	56.6	20.5[b]	94.0	783	259
RSD		22%	32%[f]	29%	37%[f]	33%[f]	34%[f]

TABLE C.11. (contd)

Sediment Treatment	Analytical Batch	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
UIH COMP, Replicate 1	3	40.6	15.5	9.76	18.0	112	64.1
UIH COMP, Replicate 2	3	43.1	17.2	13.0	22.3	139	84.4
UIH COMP, Replicate 3	3	42.9	26.5	12.1	33.9	314	268
RSD		3%	30%	14%	33%(f)	58%(f)	81%(f)

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion between the primary and secondary column is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(d) NC Not certified.
(e) NA Not applicable.
(f) Exceeds quality control criteria (≤30%) for precision.

TABLE C.12. Quality Control Data for Sediment High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	HPAHs (µg/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a) pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Method Blanks											
Blank-1	1	2.07 U[a]	1.66 U	3.08[b]	1.52 U	0.70 U	1.53 U	1.66 U	3.25 U	4.68 U	5.08 U
Blank-2	1	2.04 U[b]	1.64 U	3.00[b]	1.50 U	0.69 U	1.51 U	1.64 U	3.20 U	4.61 U	5.01 U
Blank-1	2	4.52[b]	2.02 U	1.01 U	1.85 U	0.85 U	1.86 U	2.02 U	3.95 U	5.69 U	6.17 U
Blank-1	3	2.85	1.99 U	1.78	1.83 U	0.84 U	1.84 U	1.99 U	3.90 U	5.62 U	6.10 U
Matrix Spikes											
R-AM-I	1	308	371	161	163	137	52.3	143	91.0	19.4	87.3
R-AM-I, MS		456	541	283	279	245	124	253	178	83.6	168
Concentration Recovered		148	170	122	116	108	71.7	110	87.0	64.2	80.7
Amount Spiked		58.0	58.0[c]	58.0[c]	58.0[c]	58.0[c]	58.0[c]	58.0[c]	58.0[c]	58.0	58.0[c]
Percent Recovery		255%	293%	210%	200%	186%	124%	190%	150%	111%	139%
R-AM-H	2	85.9	109	54.1	54.6	42.6	15.9	44.4	32.3	7.84	30.2
R-AM-H, MS		236	303	189	238	203	84.8	217	182	52.9	175
Concentration Recovered		150	194	135	183	160	68.9	173	150	45.1	145
Amount Spiked		28.5	28.5[c]	28.5[c]	28.5[c]	28.5[c]	28.5[c]	28.5[c]	28.5[c]	28.5[c]	28.5[c]
Percent Recovery		527%	681%	473%	644%	563%	242%	606%	525%	158%	508%
TB Upper COMP	3	105	142	51.1	56.0	110	35.0	104	97.3	12.8	107
TB Upper COMP		150	189	98.9	100	157	81.2	149	142	58.6	147
Concentration Recovered		45.0	47.0	47.8	44.0	47.0	46.2	45.0	44.7	45.8	40.0
Amount Spiked		42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Percent Recovery		107%	112%	114%	105%	112%	110%	107%	106%	109%	95%
Standard Reference Material											
Certified		981	811	427	380	740	361	628	501	73.9	525
Value NIST 1941a		±78	±24	±25	±24	±110	±18	±52	±72	±9.7	±67
SRM NIST 1941a	1	811[d]	647	407	516[d]	1124[d]	370	563	520	129[d]	471
SRM NIST 1941a	2	768[d]	625	421	519[d]	1010[d]	343	519	532	130[d]	476
SRM NIST 1941a	3	718	609	371	483	1010[d]	327	508	489	123[d]	453

TABLE C.12. (contd)

Sediment Treatment	Analytical Batch	HPAHs (µg/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a) pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Analytical Duplicates											
SF-3, Replicate 1	3	312	480	200	324	637	222	447	291	81.9	293
SF-3, Replicate 2	3	235	438	194	332	685	236	466	297	80.2	296
RPD		28%	9%	3%	2%	7%	6%	4%	2%	2%	1%
I-Stat		0.14	0.05	0.02	0.01	0.04	0.03	0.02	0.01	0.01	0.01
Analytical Triplicates											
TB-2 Upper, Replicate 1	1	122	159	74.2	76.8	150	53.4	142	129	16.6	140
TB-2 Upper, Replicate 2	1	188	224	99.5	105	187	61.4	174	150	20.6	161
TB-2 Upper, Replicate 3	1	147	188	88.0	88.9	168	55.6	161	141	19.2	149
RSD		22%	17%	15%	16%	11%	7%	10%	8%	11%	7%
R-AM COMP, Replicate 1	2	616	751	386	382	290	105	308	182	44.3	165
R-AM COMP, Replicate 2	2	322	395	194	190	167	59.8	185	121	23.5	115
R-AM COMP, Replicate 3	2	452	545	261	255	200	71.3	215	129	30.4	118
RSD		32%(e)	32%(e)	5%(e)	35%(e)	29%	30%	27%	23%	32%(e)	21%
UIH COMP, Replicate 1	3	166	309	106	153	314	104	232	190	36.2	202
UIH COMP, Replicate 2	3	193	352	164	243	452	163	344	252	55.0	260
UIH COMP, Replicate 3	3	335	541	228	260	420	150	343	245	51.6	251
RSD		39%(e)	31%(e)	37%(e)	26%	18%	22%	21%	15%	21%	13%

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion between the primary and secondary column is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(d) Outside quality control criteria (±30%) for SRMs.
(e) Exceeds quality control criteria (≤30%) for precision.

TABLE C.13. Sediment Phthalate Ester Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Phthalates (µg/kg dry weight)					
		Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Target DL[a]		20	20	20	20	20	20
Achieved DL		33.7-84.2[b]	28.0-69.9[b]	22.7-56.7[b]	26.0-65.0[b]	65.3-163[b]	47.3-118[b]
SF COMP	2	58.0 U[c]	48.1 U	39.0 U	44.7 U	254	81.3 U
SF-1	2	47.2 U	39.1 U	31.7 U	36.4 U	131	66.2 U
SF-2	2	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
SF-3, Replicate 1	3	75.5 U	62.6 U	50.8 U	58.2 U	328	106 U
SF-3, Replicate 2	3	70.8 U	58.7 U	47.6 U	54.6 U	416	99.3 U
SF-4	2	72.1 U	59.8 U	48.5 U	55.6 U	473	101 U
SFW COMP	2	59.3 U	49.2 U	39.9 U	45.7 U	367	83.2 U
SFW-1	2	60.7 U	50.3 U	40.8 U	46.8 U	282	85.1 U
SFW-2	2	59.3 U	49.2 U	39.9 U	45.7 U	439	83.2 U
SFW-3	3	52.6 U	43.6 U	35.4 U	40.5 U	104	73.8 U
SFW-4	2	45.8 U	38.0 U	30.8 U	35.3 U	88.8 U	64.3 U
UIH COMP, Replicate 1	3	61.3 U	50.9 U	41.3 U	47.3 U	325	86.0 U
UIH COMP, Replicate 2	3	72.1 U	59.8 U	48.5 U	55.6 U	354	101 U
UIH COMP, Replicate 3	3	72.8 U	60.4 U	49.0 U	56.1 U	296	102 U
UIH-1	2	67.4 U	55.9 U	45.3 U	52.0 U	205	94.6 U
UIH-2	2	80.9 U	67.1 U	54.4 U	62.4 U	282	113 U
UIH-3	2	74.1 U	61.5 U	49.9 U	57.2 U	404	104 U
UIH-4	2	53.9 U	44.7 U	36.3 U	41.6 U	199	75.6 U
UIH-5	2	74.1 U	61.5 U	49.9 U	58.0	416	104 U
TB Upper COMP	3	59.3 U	49.2 U	39.9 U	45.7 U	115 U	83.2 U
TB-1 Upper	1	48.5 U	40.3 U	32.7 U	37.4 U	126	68.1 U
TB-2 Upper, Replicate 1	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-2 Upper, Replicate 2	1	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
TB-2 Upper, Replicate 3	1	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
TB-3 Upper	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-4 Upper	1	74.1 U	61.5 U	49.9 U	57.2 U	182	104 U
TB-5 Upper	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-6 Upper	1	54.6 U	45.3 U	36.7 U	42.1 U	106 U	76.6 U
TB-7 Upper	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U

TABLE C.13. (contd)

Sediment Treatment	Analytical Batch	Phthalates (µg/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
TB Lower COMP	3	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-1 Lower	1	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
TB-2 Lower	1	47.2 U	39.1 U	31.7 U	36.4 U	91.4 U	66.2 U
TB-3 Lower	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-4 Lower	1	62.0 U	51.4 U	41.7 U	47.8 U	130	87.0 U
TB-5 Lower	1	48.5 U	40.3 U	32.7 U	37.4 U	94.0 U	68.1 U
TB-6 Lower	1	51.9 U	43.0 U	34.9 U	40.0 U	101 U	72.8 U
TB-7 Lower	2	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
OBM COMP	3	43.1 U	35.8 U	29.0 U	33.3 U	83.5 U	60.5 U
R-OS	2	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
R-BF	2	84.2 U	69.9 U	56.7 U	65.0 U	163 U	118 U
R-AM COMP, Replicate 1	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM COMP, Replicate 2	2	40.4 U	33.5 U	27.2 U	31.2 U	136	56.7 U
R-AM COMP, Replicate 3	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM-A	1	33.7 U	28.0 U	22.7 U	26.0 U	65.3 U	47.3 U
R-AM-B	1	34.4 U	28.5 U	23.1 U	26.5 U	66.6 U	48.2 U
R-AM-C	1	41.1 U	34.1 U	27.7 U	31.7 U	79.6 U	57.7 U
R-AM-D	1	33.7 U	28.0 U	22.7 U	26.0 U	65.3 U	47.3 U
R-AM-F	1	42.5 U	35.2 U	28.6 U	32.7 U	82.2 U	59.6 U
R-AM-G	1	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM-H	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM-I	1	39.8 U	33.0 U	26.8 U	30.7 U	102	55.8 U

(a) DL Detection limit.
(b) These are Limits of Quantitation not MDLs.
(c) U Undetected at or above detection limit.

TABLE C.14. Quality Control Data for Sediment Phthalate Ester Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Phthalates (µg/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Method Blanks							
Blank-1	1	47.2 U[a]	39.1 U	31.7 U	36.4 U	91.4 U	66.2 U
Blank-2	1	46.5 U	38.6 U	31.3 U	35.9 U	90.1 U	65.2 U
Blank-1	2	57.3 U	47.5 U	38.5 U	44.2 U	111 U	80.4 U
Blank-1	3	56.6 U	47.0 U	38.1 U	43.7 U	110 U	79.4 U
Matrix Spikes							
R-AM-I	1	39.8 U	33.0 U	26.8 U	30.7 U	102	55.8 U
R-AM-I, MS		509	529	439	463	485	504
Concentration Recovered		509	529	439	463	383	504
Amount Spiked		464	464	464	464	464	464
Percent Recovery		110%	114%	95%	100%	83%	109%
R-AM-H	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM-H, MS		412	382	357	382	387	386
Concentration Recovered		412	382	357	382	387	386
Amount Spiked		456	456	456	456	456	456
Percent Recovery		90%	84%	78%	84%	85%	85%
TB Upper COMP	3	59.3 U	49.2 U	39.9 U	45.7 U	115 U	83.2 U
TB Upper COMP		245	243	393	501	741	592
Concentration Recovered		245	243	393	501	741	592
Amount Spiked		672	672	672	672	672	672
Percent Recovery		36%[b]	36%[b]	58%	75%	110%	88%
Standard Reference Material							
Certified SRM not available for phthalates.							
Analytical Duplicates							
SF-3, Replicate 1	3	75.5 U	62.6 U	50.8 U	58.2 U	328	106 U
SF-3, Replicate 2	3	70.8 U	58.7 U	47.6 U	54.6 U	416	99.3 U
RPD		NA[c]	NA	NA	NA	24%	NA
I-Stat		NA	NA	NA	NA	0.12	NA

TABLE C.14. (contd)

Sediment Treatment	Analytical Batch	Phthalates (µg/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Analytical Triplicates							
TB-2 Upper, Replicate 1	1	53.9 U	44.7 U	36.3 U	41.6 U	104 U	75.6 U
TB-2 Upper, Replicate 2	1	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
TB-2 Upper, Replicate 3	1	60.7 U	50.3 U	40.8 U	46.8 U	117 U	85.1 U
RSD		NA	NA	NA	NA	NA	NA
R-AM COMP, Replicate 1	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
R-AM COMP, Replicate 2	2	40.4 U	33.5 U	27.2 U	31.2 U	136	56.7 U
R-AM COMP, Replicate 3	2	40.4 U	33.5 U	27.2 U	31.2 U	78.3 U	56.7 U
RSD		NA	NA	NA	NA	NA	NA
UIH COMP, Replicate 1	3	61.3 U	50.9 U	41.3 U	47.3 U	325	86.0 U
UIH COMP, Replicate 2	3	72.1 U	59.8 U	48.5 U	55.6 U	354	101 U
UIH COMP, Replicate 3	3	72.8 U	60.4 U	49.0 U	56.1 U	296	102 U
RSD		NA	NA	NA	NA	9%	NA

(a) U Undetected at or above detection limit.
(b) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(c) NA Not applicable.

TABLE C.15. Surrogate Percent Recoveries for Sediment Polynuclear Aromatic Hydrocarbons (PAHs) Including Quality Control Data, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries: Naphthalene d8	Acenaphthene d10	Chrysene d12	Dibenzo(a,h,i) Anthracene d14
SF COMP	2	65	73	96	94
SF-1	2	70	75	106	95
SF-2	2	63	71	97	90
SF-3, Replicate 1	3	75	78	89	80
SF-3, Replicate 2	3	65	68	87	75
SF-4	2	62	72	95	95
SFW COMP	2	64	72	87	84
SFW-1	2	65	74	96	90
SFW-2	2	68	75	93	93
SFW-3	3	67	71	85	74
SFW-4	2	68	78	97	87
UIH COMP, Replicate 1	3	68	75	95	86
UIH COMP, Replicate 2	3	56	65	83	76
UIH COMP, Replicate 3	3	72	75	91	83
UIH-1	2	69	77	102	97
UIH-2	2	66	73	93	86
UIH-3	2	71	78	102	96
UIH-4	2	58	66	92	79
UIH-5	2	62	70	94	87
TB Upper COMP	3	69	73	86	82
TB-1 Upper	1	81	78	94	80
TB-2 Upper, Replicate 1	1	79	80	102	86
TB-2 Upper, Replicate 2	1	74	75	97	80
TB-2 Upper, Replicate 3	1	80	80	104	86
TB-3 Upper	1	82	81	403	87
TB-4 Upper	1	80	79	100	79
TB-5 Upper	1	68	69	88	70
TB-6 Upper	1	60	61	80	54
TB-7 Upper	1	77	75	96	67
TB Lower COMP	3	66	70	82	77
TB-1 Lower	1	72	71	87	77
TB-2 Lower	1	76	74	88	71
TB-3 Lower	1	71	70	79	65
TB-4 Lower	1	64	65	90	68
TB-5 Lower	1	72	69	91	72
TB-6 Lower	1	75	72	88	71
TB-7 Lower	2	75	76	94	85
OBM COMP	3	69	72	84	79
R-OS	2	63	67	95	90
R-BF	2	69	73	96	83
R-AM COMP, Replicate 1	2	71	72	94	84
R-AM COMP, Replicate 2	2	65	67	85	75
R-AM COMP, Replicate 3	2	69	71	93	84
R-AM-A	1	78	75	89	77
R-AM-B	1	74	71	84	64
R-AM-C	1	68	66	80	66
R-AM-D	1	84	82	99	87
R-AM-F	1	54	54	67	60
R-AM-G	1	78	76	97	71
R-AM-H	2	54	69	85	82
R-AM-I	1	72	69	92	83

TABLE C.15. (contd)

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries: Naph-thalene d8	Acenaph-thene d10	Chrysene d12	Dibenzo(a,h,i) Anthracene d14
Quality Control Data					
Method Blanks					
Blank-1	1	81	74	78	63
Blank-2	1	82	76	78	62
Blank-1	2	85	78	80	69
Blank-1	3	84	81	90	75
Matrix Spikes					
R-AM-I	1	72	69	92	83
R-AM-I, MS		77	76	88	86
R-AM-H	2	54	69	85	82
R-AM-H, MS		76	75	95	87
TB Upper COMP	3	69	73	86	82
TB Upper COMP, MS		74	77	64	82
Analytical Duplicates					
SF-3, Replicate 1	3	75	78	89	80
SF-3, Replicate 2	3	65	68	87	75
Analytical Triplicates					
TB-2 Upper, Replicate 1	1	79	80	102	86
TB-2 Upper, Replicate 2	1	74	75	97	80
TB-2 Upper, Replicate 3	1	80	80	104	86
R-AM COMP, Replicate 1	2	71	72	94	84
R-AM COMP, Replicate 2	2	65	67	85	75
R-AM COMP, Replicate 3	2	69	71	93	84
UIH COMP, Replicate 1	3	68	75	95	86
UIH COMP, Replicate 2	3	56	65	83	76
UIH COMP, Replicate 3	3	72	75	91	83

TABLE C.16. Sediment Chlorinated Pesticide Results (alphabetical, Aldrin - 4,4' DDT), Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
Target DL[a]		2	2	2	2	2	30	2	2	2
Achieved DL		0.04-0.09	0.71-1.78	0.71-1.78	0.71-1.78	0.04-0.09	30	0.04-0.11	0.10-0.26	0.30-0.74
SF COMP	2	2.31	1.22 U[b]	1.20 U	1.22 U	0.06 U	30 U	34.2	203 [c]	140 [c]
SF-1	2	1.02	1.01 U	1.01 U	1.01 U	0.05 U	30 U	11.6	82.8[c]	23.3
SF-2	2	3.46	1.32 U	1.32 U	1.32 U	0.10	30 U	65.2	285 [c]	78.7[c]
SF-3, Replicate 1	3	3.39	1.59 U	1.59 U	1.59 U	0.14	30 U	34.6[c]	267 [c]	304 [c]
SF-3, Replicate 2	3	3.78	1.49 U	1.49 U	1.49 U	0.14	30 U	37.5[c]	298 [c]	412 [c]
SF-4	2	3.98	1.52 U	1.52 U	1.52 U	0.08 U	30 U	66.5	288 [c]	137 [c]
SFW COMP	2	3.37	1.25 U	1.25 U	1.25 U	0.29	30 U	82.3[c]	267 [c]	81.7[c]
SFW-1	2	1.67	1.21 U	1.21 U	1.21 U	0.06 U	30 U	31.1	191 [c]	112 [c]
SFW-2	2	2.29	1.25 U	1.25 U	1.25 U	0.15	30 U	57.2	184 [c]	87.4[c]
SFW-3	3	1.64	1.11 U	1.11 U	1.11 U	0.06 U	30 U	31.8[c]	127 [c]	56.3[c]
SFW-4	2	0.76	0.97 U	0.97 U	0.97 U	0.05 U	30 U	18.7	88.4[c]	38.4
UIH COMP	3	2.86	1.52 U	1.52 U	1.52 U	0.08 U	30 U	19.2[c]	114 [c]	68.2[c]
UIH COMP	3	2.53	1.30 U	1.30 U	1.30 U	0.07 U	30 U	20.3[c]	112 [c]	50.6[c]
UIH COMP	3	3.01	1.54 U	1.54 U	1.54 U	0.08 U	30 U	16.9[c]	105 [c]	40.7[c]
UIH-1	2	0.07 U	1.38 U	1.38 U	1.38 U	0.07 U	30 U	13.1	76.1[c]	49.2
UIH-2	2	1.09	1.64 U	1.64 U	1.64 U	0.08 U	30 U	14.0	75.8[c]	48.8
UIH-3	2	3.10	1.54 U	1.54 U	1.54 U	0.08 U	30 U	24.3	157 [c]	85.2
UIH-4	2	1.40	1.20 U	1.20 U	1.20 U	0.06 U	30 U	14.2	70.5[c]	44.2
UIH-5	2	2.53	1.49 U	1.49 U	1.49 U	0.08 U	30 U	40.4	178 [c]	60.5[c]
TB Upper COMP	3	1.26	1.25 U	1.25 U	1.25 U	0.06 U	30 U	0.08 U	1.99	0.73
TB-1 Upper	1	0.05 U	1.02 U	1.02 U	1.02 U	0.05 U	30 U	0.06 U	1.83	1.24
TB-2 Upper, Replicate 1	1	0.06 U	1.15 U	1.15 U	1.15 U	0.06 U	30 U	0.07 U	1.91	0.48 U
TB-2 Upper, Replicate 2	1	0.06 U	1.12 U	1.22 U	1.22 U	0.06 U	30 U	1.03	2.20	4.48
TB-2 Upper, Replicate 3	1	0.06 U	1.25 U	1.25 U	1.25 U	0.06 U	30 U	0.08 U	2.21	1.04
TB-3 Upper	1	0.06 U	1.20 U	1.20 U	1.20 U	0.06 U	30 U	0.07 U	1.01	0.50 U
TB-4 Upper	1	1.08	1.57 U	1.57 U	1.57 U	0.08 U	30 U	5.16	17.0	4.74
TB-5 Upper	1	0.06 U	1.14 U	1.14 U	1.14 U	0.06 U	30 U	0.07 U	0.75	6.87
TB-6 Upper	1	0.06 U	1.15 U	1.15 U	1.15 U	0.06 U	30 U	0.07 U	0.17 U	0.48 U
TB-7 Upper	1	0.05 U	1.10 U	1.10 U	1.10 U	0.06 U	30 U	0.07 U	0.16 U	0.46 U

TABLE C.16. (contd)

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
TB Lower COMP	3	1.12	1.14 U	1.14 U	1.14 U	0.06 U	30 U	0.07 U	0.97	0.47 U
TB-1 Lower	1	0.04 U	0.95 U	0.85 U	0.85 U	0.04 U	30 U	0.05 U	0.12 U	0.36 U
TB-2 Lower	1	0.05 U	0.95 U	0.95 U	0.95 U	0.05 U	30 U	0.06 U	0.14 U	0.40 U
TB-3 Lower	1	0.05 U	1.10 U	1.10 U	1.10 U	0.06 U	30 U	0.07 U	0.16 U	0.46 U
TB-4 Lower	1	0.07 U	1.31 U	1.31 U	1.31 U	0.07 U	30 U	0.08 U	24.9	12.8
TB-5 Lower	1	0.05 U	1.02 U	1.02 U	1.02 U	0.05 U	30 U	0.06 U	0.15 U	0.43 U
TB-6 Lower	1	0.05 U	1.10 U	1.10 U	1.10 U	0.06 U	30 U	0.07 U	0.16 U	0.46 U
TB-7 Lower	2	0.05 U	1.08 U	1.08 U	1.08 U	0.06 U	30 U	0.07 U	0.16 U	0.45 U
OBM COMP	3	0.05 U	0.91 U	0.91 U	0.91 U	0.05 U	30 U	0.06 U	0.13 U	0.38 U
R-OS	2	0.06 U	1.22 U	1.22 U	1.22 U	0.06 U	30 U	0.94	0.18 U	0.51 U
R-BF	2	5.07	1.78 U	1.78 U	1.78 U	4.83	30 U	1.69	1.05	12.1
R-AM COMP, Replicate 1	2	0.04 U	0.90 U	0.90 U	0.90 U	0.05 U	30 U	0.06 U	0.56	0.66
R-AM COMP, Replicate 2	2	0.04 U	0.88 U	0.88 U	0.88 U	0.05 U	30 U	0.05 U	0.66	0.46
R-AM COMP, Replicate 3	2	0.04 U	0.87 U	0.87 U	0.87 U	0.05 U	30 U	0.05 U	0.13 U	0.45
R-AM-A	1	0.04 U	0.71 U	0.71 U	0.71 U	0.04 U	30 U	0.04 U	0.10 U	0.30 U
R-AM-B	1	0.04 U	0.73 U	0.73 U	0.73 U	0.04 U	30 U	0.05 U	0.11 U	0.30 U
R-AM-C	1	0.04 U	0.87 U	0.87 U	0.87 U	0.05 U	30 U	0.05 U	0.13 U	0.36 U
R-AM-D	1	0.04 U	0.71 U	0.71 U	0.71 U	0.04 U	30 U	0.04 U	0.10 U	0.30 U
R-AM-F	1	0.04 U	0.90 U	0.90 U	0.90 U	0.05 U	30 U	0.06 U	1.25	3.21
R-AM-G	1	0.04 U	0.87 U	0.87 U	0.87 U	0.05 U	30 U	0.05 U	0.64	0.36 U
R-AM-H	2	0.04 U	0.83 U	0.83 U	0.83 U	0.04 U	30 U	0.05 U	0.12 U	0.34 U
R-AM-I	1	0.04 U	0.84 U	0.84 U	0.84 U	0.04 U	30 U	0.05 U	0.12 U	0.35 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Sample was diluted and analyzed due to analyte concentrations above the instrument linear range of calibration.

TABLE C.17. Sediment Chlorinated Pesticide Results (alphabetical, Dieldrin - Toxaphene), Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan Sulfate	Endrin	Endrin Aldehyde	Heptachlor	Heptachlor epoxide	Toxaphene
Target DL[a]		2	2	2	2	2	2	2	2	30
Achieved DL		0.22-0.56	0.71-1.78	0.71-1.78	0.08-0.21	0.71-1.78	0.71-1.78	0.26-0.66	0.16-0.40	30
SF COMP	2	14.0	1.22 U[b]	1.22 U	1.22 U	1.22 U	1.22 U	0.45 U	1.24	30 U
SF-1	2	5.51	1.01 U	1.01 U	1.01 U	1.01 U	1.01 U	0.37 U	0.79	30 U
SF-2	2	25.8	1.32 U	1.32 U	1.32 U	4.11	1.32 U	0.69	1.91	30 U
SF-3, Replicate 1	3	22.3	1.59 U	1.59 U	1.59 U	1.59 U	1.59 U	0.59 U	1.88	30 U
SF-3, Replicate 2	3	25.9	1.49 U	1.49 U	1.49 U	1.49 U	1.49 U	0.55 U	2.07	30 U
SF-4	2	22.8	1.52 U	1.52 U	1.52 U	5.00	1.52 U	0.56 U	0.34 U	30 U
SFW COMP	2	46.2	1.25 U	1.25 U	1.25 U	4.78	1.25 U	0.46 U	0.28 U	30 U
SFW-1	2	12.9	1.21 U	1.21 U	1.21 U	3.82	1.21 U	0.45 U	1.20	30 U
SFW-2	2	17.1	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	0.46 U	1.47	30 U
SFW-3	3	17.5	1.11 U	1.11 U	1.11 U	1.11 U	1.11 U	0.41 U	1.01	30 U
SFW-4	2	6.26	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.36 U	0.82	30 U
UIH COMP, Replicate 1	3	8.69	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	0.56 U	1.56	30 U
UIH COMP, Replicate 2	3	9.60	1.30 U	1.30 U	1.30 U	1.30 U	1.30 U	0.48 U	1.50	30 U
UIH COMP, Replicate 3	3	9.22	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	0.57 U	1.86	30 U
UIH-1	2	6.48	1.38 U	1.38 U	1.38 U	1.38 U	1.38 U	0.51 U	1.38	30 U
UIH-2	2	7.24	1.64 U	1.64 U	1.64 U	1.64 U	1.64 U	0.60 U	1.47	30 U
UIH-3	2	10.8	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	0.67	2.11	30 U
UIH-4	2	5.47	1.20 U	1.20 U	1.20 U	1.23	1.20 U	0.44 U	1.14	30 U
UIH-5	2	16.8	1.49 U	1.49 U	1.49 U	2.84	1.49 U	0.55 U	0.34 U	30 U
TB Upper COMP	3	1.06	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	0.46 U	0.28 U	30 U
TB-1 Upper	1	0.32 U	1.02 U	1.02 U	1.02 U	1.02 U	1.02 U	0.38 U	0.42	30 U
TB-2 Upper, Replicate 1	1	0.35 U	1.15 U	1.15 U	1.15 U	1.15 U	1.15 U	0.43 U	0.26 U	30 U
TB-2 Upper, Replicate 2	1	0.98	1.22 U	1.22 U	1.22 U	1.22 U	1.22 U	0.45 U	0.28 U	30 U
TB-2 Upper, Replicate 3	1	0.39 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	0.64	0.28 U	30 U
TB-3 Upper	1	0.85	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	0.44 U	0.34	30 U
TB-4 Upper	1	2.05	1.57 U	1.57 U	1.57 U	1.57 U	1.57 U	0.58 U	1.24	30 U
TB-5 Upper	1	0.62	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	0.42 U	0.33	30 U
TB-6 Upper	1	0.36 U	1.15 U	1.15 U	1.15 U	1.15 U	1.15 U	0.77	0.26 U	30 U
TB-7 Upper	1	0.34 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	0.78	0.25 U	30 U

TABLE C.17. (contd)

Sediment Treatment	Analytical Batch	Pesticides (μg/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan Sulfate	Endrin	Endrin Alde-hyde	Hepta-chlor	Hepta chlor-epoxide	Toxa-phene
TB Lower COMP	3	0.36 U	1.14 U	1.14 U	1.14 U	1.14 U	1.14 U	0.42 U	0.26 U	30 U
TB-1 Lower	1	0.27 U	0.85 U	0.85 U	0.85 U	0.85 U	0.85 U	0.31 U	0.19 U	30 U
TB-2 Lower	1	0.30 U	0.95 U	0.95 U	0.95 U	0.95 U	0.95 U	0.35 U	0.22 U	30 U
TB-3 Lower	1	0.34 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	0.40 U	0.33	30 U
TB-4 Lower	1	1.86	1.31 U	1.31 U	1.31 U	1.31 U	1.31 U	0.48 U	1.24	30 U
TB-5 Lower	1	0.32 U	1.02 U	1.02 U	1.02 U	1.02 U	1.02 U	0.38 U	0.23 U	30 U
TB-6 Lower	1	0.34 U	1.10 U	1.10 U	1.10 U	1.10 U	1.10 U	0.40 U	0.25 U	30 U
TB-7 Lower	2	0.34 U	1.08 U	1.08 U	1.08 U	1.08 U	1.08 U	0.58	0.24 U	30 U
OBM COMP	3	0.28 U	0.91 U	0.91 U	0.91 U	0.91 U	0.91 U	0.34 U	0.21 U	30 U
R-OS	2	0.38 U	1.22 U	1.22 U	1.22 U	1.22 U	1.22 U	0.45 U	0.28 U	30 U
R-BF	2	13.0	1.78 U	1.78 U	1.78 U	14.7	1.78 U	2.59	0.89	30 U
R-AM COMP, Replicate 1	2	0.28 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.33 U	0.20 U	30 U
R-AM COMP, Replicate 2	2	0.28 U	0.88 U	0.88 U	0.88 U	0.88 U	0.88 U	0.33 U	0.20 U	30 U
R-AM COMP, Replicate 3	2	0.27 U	0.87 U	0.87 U	0.87 U	0.87 U	0.87 U	0.32 U	0.20 U	30 U
R-AM-A	1	0.22 U	0.71 U	0.71 U	0.71 U	0.71 U	0.71 U	0.26 U	0.16 U	30 U
R-AM-B	1	0.23 U	0.73 U	0.73 U	0.73 U	0.73 U	0.73 U	0.27 U	0.16 U	30 U
R-AM-C	1	0.63	0.87 U	0.87 U	0.87 U	0.87 U	0.87 U	0.32 U	0.20 U	30 U
R-AM-D	1	0.22 U	0.71 U	0.71 U	0.71 U	0.71 U	0.71 U	0.26 U	0.16 U	30 U
R-AM-F	1	0.76	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.33 U	0.44	30 U
R-AM-G	1	0.27 U	0.87 U	0.87 U	0.87 U	0.87 U	0.87 U	0.32 U	0.20 U	30 U
R-AM-H	2	0.26 U	0.83 U	0.83 U	0.83 U	0.8 U	0.83 U	0.31	0.19 U	30 U
R-AM-I	1	0.26 U	0.84 U	0.84 U	0.84 U	0.84 U	0.84 U	0.31 U	0.19 U	30 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE C.18. Quality Control Data for Sediment Chlorinated Pesticide Results (alphabetical, Aldrin - 4,4'-DDT), Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
Method Blanks										
Blank-1	1	0.05 U[a]	0.98 U	0.98 U	0.98 U	0.05 U	30 U	0.06 U	0.14 U	0.41 U
Blank-2	1	0.05 U	0.98 U	0.98 U	0.98 U	0.05 U	30 U	0.06 U	0.14 U	0.41 U
Blank-1	2	0.06 U	1.21 U	1.21 U	1.21 U	0.06 U	30 U	0.08 U	0.18 U	0.50 U
Blank-1	3	0.06 U	1.20 U	1.20 U	1.20 U	0.06 U	30 U	0.07 U	0.17 U	0.50 U
Matrix Spikes										
R-AM-I	1	0.04 U	NA[b]	NA	NA	0.04 U	NA	NA	NA	0.35 U
R-AM-I, MS		5.07	NA	NA	NA	4.83	NA	NA	NA	12.1
Concentration Recovered		5.07	NA	NA	NA	4.83	NA	NA	NA	12.1
Amount Spiked		2.80	NS[c]	NS	NS	2.80	NS	NS	NS	11.2
Percent Recovery		181%[d]	NA	NA	NA	173%[d]	NA	NA	NA	108%
R-AM-H	2	0.04 U	NA	NA	NA	0.04 U	NA	NA	0.12 U	NA
R-AM-H, MS		2.89	NA	NA	NA	2.48	NA	NA	11.1	NA
Concentration Recovered		2.89	NA	NA	NA	2.48	NA	NA	11.1	NA
Amount Spiked		2.85	NS	NS	NS	2.85	NS	NS	11.6	NS
Percent Recovery		101%	NA	NA	NA	87%	NA	NA	96%	NA
TB Upper COMP	3	1.26	NA	NA	NA	0.06 U	NA	NA	NA	0.73
TB Upper COMP, MS		4.37	NA	NA	NA	4.07	NA	NA	NA	20.0
Concentration Recovered		3.11	NA	NA	NA	4.07	NA	NA	NA	19.3
Amount Spiked		4.20	NS	NS	NS	4.20	NS	NS	NS	16.8
Percent Recovery		74%	NA	NA	NA	97%	NA	NA	NA	115%
Standard Reference Material										
Certified Value NIST 1941a		NC[e]	NC	NC	NC	NC	NC	6.59 ±0.56	5.06 ±0.58	NC
SRM NIST 1941a	1	NA	NA	NA	NA	NA	NA	7.39	7.44[f]	NA
SRM NIST 1941a	2	NA	NA	NA	NA	NA	NA	7.72	7.97[f]	NA
SRM NIST 1941a	3	NA	NA	NA	NA	NA	NA	8.35	5.55	NA

TABLE C.18. (contd)

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
Analytical Duplicates										
SF-3, Replicate 1	3	3.39	1.59 U	1.59 U	1.59 U	0.14	30 U	34.6(g)	267(g)	304(g)
SF-3, Replicate 2	3	3.78	1.49 U	1.49 U	1.49 U	0.14	30 U	37.5(g)	298(g)	412(g)
RPD		11%	NA	NA	NA	0%	NA	8%	11%	30%
I-Stat		0.05	NA	NA	NA	0.00	NA	0.04	0.05	0.15
Analytical Triplicates										
TB-2 Upper, Replicate 1	1	0.06 U	1.15 U	1.15 U	1.15 U	0.06 U	30 U	0.07 U	1.91	0.48 U
TB-2 Upper, Replicate 2	1	0.06 U	1.12 U	1.22 U	1.22 U	0.06 U	30 U	1.03	2.20	4.48
TB-2 Upper, Replicate 3	1	0.06 U	1.25 U	1.25 U	1.25 U	0.06 U	30 U	0.08 U	2.21	1.04
RSD		NA	NA	NA	NA	NA	NA	NA	8%	NA
R-AM COMP, Replicate 1	2	0.04 U	0.90 U	0.90 U	0.90 U	0.05 U	30 U	0.06 U	0.56	0.66
R-AM COMP, Replicate 2	2	0.04 U	0.88 U	0.88 U	0.88 U	0.05 U	30 U	0.05 U	0.13 U	0.46
R-AM COMP, Replicate 3	2	0.04 U	0.87 U	0.87 U	0.87 U	0.05 U	30 U	0.05 U	0.13 U	0.45
RSD		NA	NA	NA	NA	NA	NA	NA	NA	23%
UIH COMP, Replicate 1	3	2.53	1.30 U	1.30 U	1.30 U	0.07 U	30 U	20.3(g)	112(g)	50.6(g)
UIH COMP, Replicate 2	3	2.86	1.52 U	1.52 U	1.52 U	0.08 U	30 U	19.2(g)	114(g)	68.2(g)
UIH COMP, Replicate 3	3	3.01	1.54 U	1.54 U	1.54 U	0.08 U	30 U	16.9(g)	105(g)	40.7(g)
RSD		9%	NA	NA	NA	NA	NA	9%	4%	26%

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(e) NC Not certified.
(f) Outside quality control criteria (±30%) for SRMs.
(g) Sample was diluted and analyzed due to analyte concentrations above the instrument linear range of calibration.

TABLE C.19. Quality Control Data for Sediment Chlorinated Pesticide Results (alphabetical, Dieldrin - Toxaphene), Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan Sulfate	Endrin	Endrin Aldehyde	Heptachlor	Heptachlor epoxide	Toxaphene
Method Blanks										
Blank-1	1	0.31 U[a]	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.36 U	0.22 U	30 U
Blank-2	1	0.31 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.36 U	0.22 U	30 U
Blank-1	2	0.38 U	1.21 U	1.21 U	1.21 U	1.21 U	1.21 U	0.45 U	0.27 U	30 U
Blank-1	3	0.37 U	1.20 U	1.20 U	1.20 U	1.20 U	1.20 U	0.44 U	0.27 U	30 U
Matrix Spikes										
R-AM-I	1	0.26 U	NA[b]	NA	NA	0.84 U	NA	0.31 U	NA	NA
R-AM-I, MS		13.0	NA	NA	NA	14.7	NA	2.59	NA	NA
Concentration Recovered		13.0	NA	NA	NA	14.7	NA	2.59	NA	NA
Amount Spiked		11.2	NS[c]	NS	NS	11.2	NS	2.80	NS	NS
Percent Recovery		116%	NA	NA	NA	131%[d]	NA	93%	NA	NA
R-AM-H	2	0.26 U	NA	NA	NA	0.83 U	NA	0.31	NA	NA
R-AM-H, MS		9.98	NA	NA	NA	11.8	NA	2.78	NA	NA
Concentration Recovered		9.98	NA	NA	NA	11.8	NA	2.47	NA	NA
Amount Spiked		11.6	NS	NS	NS	11.6	NS	2.85	NS	NS
Percent Recovery		86%	NA	NA	NA	102%	NA	87%	NA	NA
TB Upper COMP	3	1.06	NA	NA	NA	1.25 U	NA	0.46 U	NA	NA
TB Upper COMP, MS		14.9	NA	NA	NA	15.7	NA	4.38	NA	NA
Concentration Recovered		13.8	NA	NA	NA	15.7	NA	4.38	NA	NA
Amount Spiked		16.8	NS	NS	NS	16.0	NS	4.20	NS	NS
Percent Recovery		82%	NA	NA	NA	98%	NA	104%	NA	NA
Standard Reference Material										
Certified Value NIST 1941a		NC[e]	NC	NC	NC	NC	NC	NC	NC	NC
SRM NIST 1941a	1	NA	NA	NA	NA	NA	NA	NA	NA	NA
SRM NIST 1941a	2	NA	NA	NA	NA	NA	NA	NA	NA	NA
SRM NIST 1941a	3	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE C.19. (contd)

Sediment Treatment	Analytical Batch	Pesticides (µg/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan Sulfate	Endrin	Endrin Aldehyde	Heptachlor	Heptachlor epoxide	Toxaphene
Analytical Duplicates										
SF-3, Replicate 1	3	22.3	1.59 U	1.59 U	1.59 U	1.59 U	1.59 U	0.59 U	1.88	30 U
SF-3, Replicate 2	3	25.9	1.49 U	1.49 U	1.49 U	1.49 U	1.49 U	0.55 U	2.07	30 U
RPD		15%	NA	NA	NA	NA	NA	NA	10%	NA
I-Stat		0.07	NA	NA	NA	NA	NA	NA	0.05	NA
Analytical Triplicates										
TB-2 Upper, Replicate 1	1	0.35 U	1.15 U	1.15 U	1.15 U	1.15 U	1.15 U	0.43 U	0.26 U	30 U
TB-2 Upper, Replicate 2	1	0.98	1.22 U	1.22 U	1.22 U	1.22 U	1.22 U	0.45 U	0.28 U	30 U
TB-2 Upper, Replicate 3	1	0.39 U	1.25 U	1.25 U	1.25 U	1.25 U	1.25 U	0.64	0.28 U	30 U
RSD		NA	NA	NA	NA	NA	NA	NA	NA	NA
R-AM COMP, Replicate 1	2	0.28 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.33 U	0.20 U	30 U
R-AM COMP, Replicate 2	2	0.28 U	0.88 U	0.88 U	0.88 U	0.88 U	0.88 U	0.33 U	0.20 U	30 U
R-AM COMP, Replicate 3	2	0.27 U	0.87 U	0.87 U	0.87 U	0.87 U	0.87 U	0.32 U	0.20 U	30 U
RSD		NA	NA	NA	NA	NA	NA	NA	NA	NA
UIH COMP, Replicate 1	3	9.60	1.30 U	1.30 U	1.30 U	1.30 U	1.30 U	0.48 U	1.50	30 U
UIH COMP, Replicate 2	3	8.69	1.52 U	1.52 U	1.52 U	1.52 U	1.52 U	0.56 U	1.56	30 U
UIH COMP, Replicate 3	3	9.22	1.54 U	1.54 U	1.54 U	1.54 U	1.54 U	0.57 U	1.86	30 U
RSD		5%	NA	NA	NA	NA	NA	NA	12%	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(e) NC Not certified.

TABLE C.20. Sediment Polychlorinated Biphenyls (PCBs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Target DL(a)		20	20	20	20
Achieved DL		20	20	20	20
SF COMP	2	20 U(b)	20 U	107	20 U
SF-1	2	20 U	20 U	33.6	20 U
SF-2	2	20 U	20 U	177	20 U
SF-3, Replicate 1	3	20 U	20 U	155	20 U
SF-3, Replicate 2	3	20 U	20 U	210	20 U
SF-4	2	20 U	20 U	198	20 U
SFW COMP	2	20 U	20 U	145	20 U
SFW-1	2	20 U	20 U	108	20 U
SFW-2	2	20 U	20 U	20 U	165
SFW-3	3	20 U	20 U	39.4	20 U
SFW-4	2	20 U	20 U	20 U	20 U
UIH COMP, Replicate 1	3	20 U	20 U	93.8	20 U
UIH COMP, Replicate 2	3	20 U	20 U	82.7	20 U
UIH COMP, Replicate 3	3	20 U	20 U	101	20 U
UIH-1	2	20 U	20 U	72.0	20 U
UIH-2	2	20 U	20 U	92.3	20 U
UIH-3	2	20 U	20 U	157	20 U
UIH-4	2	20 U	20 U	67.5	20 U
UIH-5	2	20 U	20 U	140	20 U
TB Upper COMP	3	20 U	20 U	20 U	20 U
TB-1 Upper	1	20 U	20 U	8.51 J(c)	20 U
TB-2 Upper, Replicate 1	1	20 U	20 U	20 U	20 U
TB-2 Upper, Replicate 2	1	20 U	20 U	20 U	20 U
TB-2 Upper, Replicate 3	1	20 U	20 U	20 U	20 U
TB-3 Upper	1	20 U	20 U	4.68 J	20 U
TB-4 Upper	1	20 U	20 U	46.8	20 U
TB-5 Upper	1	20 U	20 U	20 U	20 U
TB-6 Upper	1	20 U	20 U	20 U	20 U
TB-7 Upper	1	20 U	20 U	20 U	20 U
TB Lower COMP	3	20 U	20 U	20 U	20 U
TB-1 Lower	1	20 U	20 U	20 U	20 U
TB-2 Lower	1	20 U	20 U	20 U	20 U
TB-3 Lower	1	20 U	20 U	20 U	20 U
TB-4 Lower	1	20 U	20 U	59.3	20 U
TB-5 Lower	1	20 U	20 U	20 U	20 U
TB-6 Lower	1	20 U	20 U	20 U	20 U
TB-7 Lower	2	20 U	20 U	20 U	20 U

TABLE C.20. (contd)

Sediment Treatment	Analytical Batch	PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
OBM COMP	3	20 U	20 U	20 U	20 U
R-OS	2	20 U	20 U	20 U	20 U
R-BF	2	20 U	20 U	23.3	20 U
R-AM COMP, Replicate 1	2	20 U	20 U	20 U	20 U
R-AM COMP, Replicate 2	2	20 U	20 U	20 U	20 U
R-AM COMP, Replicate 3	2	20 U	20 U	20 U	20 U
R-AM -A	1	20 U	20 U	20 U	20 U
R-AM -B	1	20 U	20 U	20 U	20 U
R-AM -C	1	20 U	20 U	20 U	20 U
R-AM -D	1	20 U	20 U	20 U	20 U
R-AM -F	1	20 U	20 U	33.6	20 U
R-AM -G	1	20 U	20 U	20 U	20 U
R-AM -H	2	20 U	20 U	20 U	20 U
R-AM -I	1	20 U	20 U	20 U	20 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) J Analyte detected below method detection limit (MDL), but above instrument detection limit (IDL).

TABLE C.21. Quality Control Data for Sediment Polychlorinated Biphenyls (PCBs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	PCBs (µg/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Method Blanks					
Blank-1	1	20 U[a]	20 U	20 U	20 U
Blank-2	1	20 U	20 U	20 U	20 U
Blank-1	2	20 U	20 U	20 U	20 U
Blank-1	3	20 U	20 U	20 U	20 U
Matrix Spikes					
R-AM-I	1	NA[b]	NA	20 U	NA
R-AM-I, MS	1	NA	NA	59.6	NA
Concentration Recovered		NA	NA	59.6	NA
Amount Spiked		NS[c]	NS	56.0	NS
Percent Recovery		NA	NA	106%	NA
R-AM-H	2	NA	NA	20 U	NA
R-AM-H, MS		NA	NA	55.8	NA
Concentration Recovered		NA	NA	55.8	NA
Amount Spiked		NS	NS	57.0	NS
Percent Recovery		NA	NA	98%	NA
TB Upper COMP	3	NA	NA	20 U	NA
TB Upper COMP, MS		NA	NA	92.1	NA
Concentration Recovered		NA	NA	92.1	NA
Amount Spiked		NS	NS	84.0	NS
Percent Recovery		NA	NA	110%	NA
Standard Reference Material					
Certified SRM not available for PCBs.					
Analytical Duplicates					
SF-3, Replicate 1	3	20 U	20 U	155	20 U
SF-3, Replicate 2	3	20 U	20 U	210	20 U
RPD		NA	NA	30%	NA
I-Stat		NA	NA	0.15	NA
Analytical Triplicates					
TB-2 Upper, Replicate 1	1	20 U	20 U	20 U	20 U
TB-2 Upper, Replicate 2	1	20 U	20 U	20 U	20 U
TB-2 Upper, Replicate 3	1	20 U	20 U	20 U	20 U
RSD		NA	NA	NA	NA
R-AM COMP, Replicate 1	2	20 U	20 U	20 U	20 U
R-AM COMP, Replicate 2	2	20 U	20 U	20 U	20 U
R-AM COMP, Replicate 3	2	20 U	20 U	20 U	20 U
RSD		NA	NA	NA	NA

TABLE C.21. (contd)

Sediment Treatment	Analytical Batch	PCBs (µg/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
UIH COMP, Replicate 1	3	20 U	20 U	93.8	20 U
UIH COMP, Replicate 2	3	20 U	20 U	82.7	20 U
UIH COMP, Replicate 3	3	20 U	20 U	101	20 U
RSD		NA	NA	10%	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE C.22. Surrogate Recoveries and Quality Control Data for Sediment Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs) Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
SF COMP	2	66	75
SF-1	2	67	76
SF-2	2	64	80
SF-3, Replicate 1	3	65	83
SF-3, Replicate 2	3	59	75
SF-4	2	63	80
SFW COMP	2	60	61
SFW-1	2	64	75
SFW-2	2	61	118
SFW-3	3	58	71
SFW-4	2	65	73
UIH COMP	3	55	70
UIH COMP	3	60	81
UIH COMP	3	62	78
UIH-1	2	69	86
UIH-2	2	63	78
UIH-3	2	68	91
UIH-4	2	56	82
UIH-5	2	58	70
TB Upper COMP	3	65	71
TB-1 Upper	1	73	78
TB-2 Upper, Replicate 1	1	62	88
TB-2 Upper, Replicate 2	1	65	81
TB-2 Upper, Replicate 3	1	73	85
TB-3 Upper	1	73	87
TB-4 Upper	1	66	84
TB-5 Upper	1	66	70
TB-6 Upper	1	63	60
TB-7 Upper	1	70	72
TB Lower COMP	3	67	69
TB-1 Lower	1	69	73
TB-2 Lower	1	66	72
TB-3 Lower	1	66	64
TB-4 Lower	1	57	75
TB-5 Lower	1	68	73
TB-6 Lower	1	69	73
TB-7 Lower	2	73	74
OBM COMP	3	70	72

TABLE C.22. (contd)

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
R-OS	2	68	70
R-BF	2	65	94
R-AM COMP, Replicate 1	2	65	76
R-AM COMP, Replicate 2	2	61	70
R-AM COMP, Replicate 3	2	65	73
R-AM-A	1	71	74
R-AM-B	1	78	70
R-AM-C	1	64	65
R-AM-D	1	74	77
R-AM-F	1	48	59
R-AM-G	1	70	74
R-AM-H	2	66	67
R-AM-I	1	71	75
Quality Control Data			
Method Blanks			
Blank-1	1	67	70
Blank-2	1	71	72
Blank-1	2	74	75
Blank-1	3	76	78
Matrix Spikes			
R-AM-I	1	71	75
R-AM-I, MS		65	94
R-AM-H	2	66	67
R-AM-H, MS		66	71
TB Upper COMP	3	65	71
TB Upper COMP, MS		65	71
Standard Reference Material			
Certified SRM not available for PCBs.			
Analytical Duplicates			
SF-3, Replicate 1	3	65	83
SF-3, Replicate 2	3	59	75

TABLE C.22. (contd)

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
Analytical Triplicates			
TB-2 Upper, Replicate 1	1	62	88
TB-2 Upper, Replicate 2	1	65	81
TB-2 Upper, Replicate 3	1	73	85
R-AM COMP, Replicate 1	2	65	76
R-AM COMP, Replicate 2	2	61	70
R-AM COMP, Replicate 3	2	65	73
UIH COMP, Replicate 1	3	60	81
UIH COMP, Replicate 2	3	55	70
UIH COMP, Replicate 3	3	62	78

TABLE C.23. Sediment Metals Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Target DL[a]		0.1	2.5	0.1	33	5.5	0.02	7.5	6.2	0.10	7.8
Achieved DL		0.01	2.5	0.016	33	5.5	0.02	7.5	6.2	0.128	7.8
SF COMP	1	0.391	9.4	0.511	189	55.0	0.360	80.3	35.2	0.235	130
SF-1	1	0.303	7.0	0.922	178	35.6	0.115	71.0	18.9	0.128 U[b]	83.5
SF-2	1	0.566	14.2	0.654	202	71.7	0.490	93.5	48.6	0.418	176
SF-3	1	0.626	13.4	0.474	214	92.9	0.528	111	56.5	0.336	204
SF-4	1	0.694	14.0	0.564	215	107	0.689	109	64.8	0.412	208
SFW COMP	1	0.603	12.4	0.890	192	65.3	0.943	92.5	45.8	0.522	157
SFW-1	1	0.438	14.4	0.482	169	68.5	0.377	82.6	55.8	0.235	175
SFW-2	1	0.615	4.48	0.855	158	34.3	0.857	67.6	20.1	0.421	86.7
SFW-3	1	0.537	9.6	0.782	166	55.6	0.465	86.6	30.4	0.796	119
SFW-4	1	0.268	13.1	0.628	183	59.6	0.158	85.1	44.3	0.243	153
UIH COMP, Replicate 1	1	0.640	16.1	0.521	204	76.6	0.493	112	49.1	0.339	191
UIH COMP, Replicate 2	1	0.648	12.7	0.503	205	85.3	0.537	114	56.0	0.328	191
UIH COMP, Replicate 3	1	0.628	11.9	0.515	199	81.6	0.493	110	52.4	0.335	194
UIH-1	1	0.599	14.2	0.484	192	75.6	0.607	115	53.6	0.507	180
UIH-2	1	0.670	13.6	0.465	193	83.9	0.618	117	53.0	0.434	183
UIH-3	1	0.713	14.8	0.596	189	85.7	0.644	111	59.5	0.331	190
UIH-4	1	0.491	10.9	0.733	168	68.0	0.311	101	37.3	0.150	154
UIH-5	1	0.663	15.4	0.570	202	82.1	0.516	114	58.2	0.413	192
TB Upper COMP	1	0.223	10.3	0.249	166	40.5	0.234	86.9	17.4	0.240	100
TB-1 Upper	1	0.163	11.0	0.159	210	33.6	0.201	71.7	14.7	0.128 U	73.4
TB-2 Upper	1	0.214	12.1	0.300	173	42.6	0.373	78.8	21.2	0.240	96.3
TB-3 Upper	1	0.275	12.0	0.306	169	46.3	0.532	91.5	27.2	0.337	117
TB-4 Upper	1	0.501	14.5	0.352	164	68.3	0.401	105	36.6	0.420	151
TB-5 Upper	1	0.145	9.6	0.299	171	34.0	0.175	84.4	13.8	0.426	90.6
TB-6 Upper	1	0.135	9.9	0.224	184	47.1	0.109	108	10.3	0.340	97.2
TB-7 Upper	1	0.102	9.2	0.288	212	26.0	0.066	74.1	9.4	0.243	85.0
TB Lower COMP	1	0.158	11.6	0.252	180	39.4	0.140	90.3	9.4	0.128 U	91.8
TB-1 Lower	1	0.128	6.7	0.100	206	17.2	0.077	47.5	8.2	0.128 U	42.4
TB-2 Lower	1	0.106	11.4	0.250	201	33.5	0.073	91.5	13.7	0.346	81.0
TB-3 Lower	1	0.114	8.3	0.269	203	44.2	0.078	91.6	13.8	0.330	87.0
TB-4 Lower	1	0.501	13.8	0.549	181	65.0	0.642	98.2	40.2	0.413	155
TB-5 Lower	1	0.12	10.3	0.281	201	33.6	0.062	85.8	10.4	0.333	84.4
TB-6 Lower	1	0.143	10.7	0.217	205	47.6	0.088	101	12.7	0.240	87.1
TB-7 Lower, Replicate 1	1	0.166	10.7	0.298	203	44.7	0.083	105	10.7	0.333	92.0
TB-7 Lower, Replicate 2	1	0.130	11.5	0.273	196	43.3	0.078	102	8.7	0.239	95.5
TB-7 Lower, Replicate 3	1	0.125	10.2	0.281	181	46.1	0.073	109	11.9	0.246	95.9

TABLE C.23. (contd)

Sediment Treatment	Analytical Batch	Metals (mg/kg dry weight)									
		Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
R-OS	1	0.556	2.19 J[c]	0.489	171	23.5	0.084	68.1	10.8	1.25	84.3
R-BF	1	0.530	11.4	0.205	178	57.3	0.373	103	30.5	0.417	145
R-AM COMP	1	0.052	7.7	0.043	118	10.0	0.039	38.0	18.3	0.128 U	35.6
R-AM-A	1	0.022	8.0	0.038	98.0	8.2	0.031	32.2	11.9	0.128 U	22.3
R-AM-B	1	0.030	6.83	0.042	78.3	5.8	0.020 U	32.4	9.8	0.128 U	25.4
R-AM-C	1	0.029	7.4	0.036	107	9.3	0.024	29.6	10.5	0.128 U	24.6
R-AM-D, Replicate 1	1	0.030	6.9	0.047	124	16.6	0.355	33.0	17.6	0.128 U	28.7
R-AM-D, Replicate 2	1	0.038	5.5	0.041	130	17.1	0.369	31.4	19.6	0.128 U	32.9
R-AM-D, Replicate 3	1	0.034	6.4	0.041	125	13.9	0.506	27.3	14.4	0.128 U	26.6
R-AM-F	1	0.170	6.2	0.167	617	21.0	0.168	55.6	23.7	0.128 U	70.8
R-AM-G	1	0.039	4.99	0.047	135	11.2	0.057	40.8	19.1	0.128 U	43.5
R-AM-H	1	0.050	6.46	0.041	102	10.3	0.044	27.4	16.7	0.128 U	32.9
R-AM-I	1	0.042	6.1	0.057	79.1	8.5	0.057	33.9	18.4	0.128 U	34.6

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) J Analyte detected below method detection limit (MDL), but above instrument detection limit (IDL).

TABLE C.24. Quality Control Data for Sediment Metals Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Method Blanks											
Blank 1	1	0.021	NA[a]	0.016 U[b]	NA	NA	0.02 U	NA	NA	0.128 U	NA
Blank 2	1	0.025	NA	0.016 U	NA	NA	0.02 U	NA	NA	0.128 U	NA
Blank 3	1	0.021	NA	0.016 U	NA	NA	0.02 U	NA	NA	0.128 U	NA
Matrix Spike											
UIH COMP[c]	1	0.639	NA	0.513	NA	NA	0.508	NA	NA	0.334	NA
UIH COMP, MS	1	1.64	NA	1.41	NA	NA	1.35	NA	NA	1.42	NA
Concentration Recovered		1.00	NA	0.897	NA	NA	0.842	NA	NA	1.09	NA
Amount Spiked		1.00	NS[d]	1.00	NS	NS	0.979	NS	NS	1.00	NS
Percent Recovery		100%	NA	90%	NA	NA	86%	NA	NA	109%	NA
TB-7 Lower(c)	1	0.140	NA	0.284	NA	NA	0.078	NA	NA	0.273	NA
TB-7 Lower, MS	1	1.36	NA	1.28	NA	NA	0.942	NA	NA	1.50	NA
Concentration Recovered		1.22	NA	1.00	NA	NA	0.864	NA	NA	1.23	NA
Amount Spiked		1.00	NS	1.00	NS	NS	0.981	NS	NS	1.00	NS
Percent Recovery		122%	NA	100%	NA	NA	88%	NA	NA	123%	NA
R-AM-D(c)	1	0.034	NA	0.043	NA	NA	0.410	NA	NA	0.128 U	NA
R-AM-D, MS	1	1.08	NA	1.23	NA	NA	1.29	NA	NA	0.915	NA
Concentration Recovered		1.05	NA	1.19	NA	NA	0.880	NA	NA	0.915	NA
Amount Spiked		1.00	NS	1.00	NS	NS	1.03	NS	NS	1.00	NS
Percent Recovery		105%	NA	119%	NA	NA	85%	NA	NA	92%	NA
Standard Reference Material											
Certified		NC[e]	11.6	0.36	76	18	0.063	32	28.2	NC	138
Value 1646		NC	±1.3	±0.07	±3	±3	±0.012	±3	±1.8	NC	±6
SRM 1646	1	NA	10.7	0.390	56.0	22.0	0.085[f]	27.2	28.7	NA	126
SRM 1646	1	NA	12.8	0.373	72.0	21.4	0.089[f]	32.8	28.1	NA	134
SRM 1646	1	NA	12.7	0.368	55.0	19.0	0.076	30.8	28.5	NA	134
Certified		NC	NC	NC	NC	NC	0.092	NC	NC	NC	NC
Value BEST-1		NC	NC	NC	NC	NC	±0.009	NC	NC	NC	NC
BEST-1	1	NA	NA	NA	NA	NA	0.096	NA	NA	NA	NA
BEST-1	1	NA	NA	NA	NA	NA	0.099	NA	NA	NA	NA
BEST-1	1	NA	NA	NA	NA	NA	0.081	NA	NA	NA	NA

TABLE C.24. (contd)

Sediment Treatment	Analytical Batch	Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Analytical Replicate											
UIH COMP, Replicate 1	1	0.640	16.1	0.521	204	76.6	0.493	112	49.1	0.339	191
UIH COMP, Replicate 2	1	0.648	12.7	0.503	205	85.3	0.537	114	56.0	0.328	191
UIH COMP, Replicate 3	1	0.628	11.9	0.515	199	81.6	0.493	110	52.4	0.335	194
RSD		2%	16%	2%	2%	5%	5%	2%	7%	2%	1%
TB-7 Lower, Replicate 1	1	0.166	10.7	0.298	203	44.7	0.083	105	10.7	0.333	92.0
TB-7 Lower, Replicate 2	1	0.130	11.5	0.273	196	43.3	0.078	102	8.7	0.239	95.5
TB-7 Lower, Replicate 3	1	0.125	10.2	0.281	181	46.1	0.073	109	11.9	0.246	95.9
RSD		16%	6%	4%	6%	3%	6%	3%	15%	19%	2%
R-AM-D, Replicate 1	1	0.030	6.9	0.047	124	16.6	0.355	33.0	17.6	0.128 U	28.7
R-AM-D, Replicate 2	1	0.038	5.5	0.041	130	17.1	0.369	31.4	19.6	0.128 U	32.9
R-AM-D, Replicate 3	1	0.034	6.4	0.041	125	13.9	0.506	27.3	14.4	0.128 U	26.6
RSD		12%	11%	8%	3%	11%	20%	10%	15%	NA	11%

(a) NA Not applicable.
(b) U Undetected at or above detection limit.
(c) Mean of replicated sample.
(d) NS Not spiked.
(e) NC Not certified.
(f) Outside quality control criteria (±30%) for SRMs.

TABLE C.25. Sediment Butyltin Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Tripentyltin Percent Internal Standard	Butyltin species (µg/kg dry weight) Tri-butyltin	Di-butyltin	Mono-butyltin
Target DL[a]			1.00	1.00	1.00
Achieved DL			0.40	0.65	0.59
SF COMP	3	97	8.52	7.48	2.50
SF-1	3	98	1.67	1.59	0.59 U[b]
SF-2	2	102	6.78	9.05	2.58
SF-3	2	106	30.6	18.2	3.59
SF-4	3	99	27.0	33.1	6.49
SFW COMP	3	96	2.85	5.73	2.54
SFW-1	3	100	5.76	9.88	1.71
SFW-2	3	99	4.79	8.46	1.52
SFW-3	3	94	0.40 U	0.65 U	0.59 U
SFW-4	3	92	1.05	2.01	0.59 U
UIH COMP, Replicate 1	3A	107	9.32	9.30	0.59 U
UIH COMP, Replicate 2	3A	91	7.48	7.74	0.59 U
UIH COMP, Replicate 3	3A	100	8.98	8.11	1.61
UIH-1	2	104	5.38	7.95	0.59 U
UIH-2	2	99	6.67	9.67	3.05
UIH-3	2	99	4.66	6.68	2.37
UIH-4	2	100	7.12	6.02	0.59 U
UIH-5	2	97	8.11	7.04	0.59 U
TB Upper COMP	3	98	1.87	0.65 U	3.46
TB-1 Upper	1	102	0.40 U	1.13	1.03
TB-2 Upper	1	102	1.35	0.65 U	0.59 U
TB-3 Upper	1	100	0.40 U	0.65 U	0.59 U
TB-4 Upper	1	105	2.18	2.38	0.59 U
TB-5 Upper	1	99	0.40 U	0.65 U	3.65
TB-6 Upper	1	92	0.40 U	0.65 U	0.59 U
TB-7 Upper	1	99	0.40 U	0.65 U	0.59 U
TB Lower COMP	3	92	0.40 U	0.65 U	5.55
TB-1 Lower	1	93	0.40 U	0.65 U	0.59 U
TB-2 Lower	1	91	0.40 U	0.65 U	0.59 U
TB-3 Lower	1	101	0.40 U	0.65 U	0.59 U
TB-4 Lower	1	103	0.40 U	1.20	1.48
TB-5 Lower	1	95	0.40 U	0.65 U	0.59 U
TB-6 Lower	1	93	0.40 U	0.65 U	0.59 U
TB-7 Lower	2	93	0.40 U	0.65 U	0.59 U
OBM COMP	3	80	0.40 U	0.65 U	0.59 U

TABLE C.25. (contd)

Sediment Treatment	Analytical Batch	Tripentyltin Percent Internal Standard	Butyltin species (µg/kg dry weight) Tri-butyltin	Di-butyltin	Mono-butyltin
R-OS	2	99	0.40 U	0.65 U	0.59 U
R-BF	2	102	3.82	3.38	0.59 U
R-AM COMP	2	104	0.40 U	0.65 U	0.59 U
R-AM-A	1	90	0.40 U	0.65 U	0.59 U
R-AM-B, Replicate 1	1	96	0.40 U	0.65 U	0.59 U
R-AM-B, Replicate 2	1	80	0.40 U	0.65 U	0.59 U
R-AM-B, Replicate 3	1	97	0.40 U	0.65 U	0.59 U
R-AM-C	1	85	0.40 U	0.65 U	0.59 U
R-AM-D	1	96	0.40 U	0.65 U	0.59 U
R-AM-F	1	100	6.29	1.57	0.59 U
R-AM-G	1	93	0.40 U	0.65 U	2.78
R-AM-H, Replicate 1	2	91	0.40 U	0.65 U	0.59 U
R-AM-H, Replicate 2	2	94	0.40 U	0.65 U	0.59 U
R-AM-H, Replicate 3	2	105	0.40 U	0.65 U	0.59 U
R-AM-I	1	99	0.40 U	0.65 U	0.59 U

(a) DL Detection limit.
(b) U Not detected above detection limit.

TABLE C.26. Quality Control Data for Sediment Butyltin Results, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Tripentyltin Percent Internal Standard	Butyltin species (µg/kg dry weight) Tri-butyltin	Di-butyltin	Mono-butyltin
Method Blanks					
Blank	1	92	0.40 U[a]	0.65 U	0.59 U
Blank	2	100	0.40 U	0.65 U	0.59 U
Blank	3	91	0.40 U	0.65 U	0.59 U
Blank	3A	95	0.40 U	0.65 U	0.59 U
Matrix Spikes					
R-AM-A	1	90	0.40 U	0.65 U	0.59 U
R-AM-A, MS		88	24.0	24.9	7.08
Concentration Recovered		NA[b]	24.0	24.9	7.08
Amount Spiked		NA	26.4	26.4	26.4
Percent Recovery		NA	91%	94%	27%[c]
R-AM COMP	2	104	0.40 U	0.65 U	0.59 U
R-AM COMP, MS		103	31.9	31.7	9.90
Concentration Recovered		NA	31.9	31.7	9.90
Amount Spiked		NA	30.9	30.9	30.9
Percent Recovery		NA	103%	103%	32%[c]
SF COMP	3	97	8.52	7.48	2.50
SF COMP, MS		90	64.6	44.0	10.3
Concentration Recovered		NA	56.1	36.5	7.80
Amount Spiked		NA	43.9	43.9	43.9
Percent Recovery		NA	128%[c]	83%	18%[c]
Standard Reference Material					
Certified		NA	1270	1160	280
Value PACS-1		NA	±220	±180	170
PACS-1	1	103	1040	1100[d]	118[d]
PACS-1	2	103	1060	659[d]	88.4[d]
PACS-1	3	99	1110	1210	138[d]
Analytical Replicate					
R-AM-B, Replicate 1	1	96	0.40 U	0.65 U	0.59 U
R-AM-B, Replicate 2	1	80	0.40 U	0.65 U	0.59 U
R-AM-B, Replicate 3	1	97	0.40 U	0.65 U	0.59 U
RSD		NA	NA	NA	NA
R-AM-H, Replicate 1	2	91	0.40 U	0.65 U	0.59 U
R-AM-H, Replicate 2	2	94	0.40 U	0.65 U	0.59 U
R-AM-H, Replicate 3	2	105	0.40 U	0.65 U	0.59 U
RSD		NA	NA	NA	NA
UIH COMP, Replicate 1	3A	107	9.32	9.30	0.59 U
UIH COMP, Replicate 2	3A	91	7.48	7.74	0.59 U
UIH COMP, Replicate 3	3A	100	8.98	8.11	1.61
RSD		NA	11%	10%	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(d) Outside quality control criteria (±30%) for SRMs.

TABLE C.27. Waste Extraction Test for Pesticides Including Quality Control Data, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Surrogate Percent Recoveries: Deca-chloro-biphenyl	Surrogate Percent Recoveries: Tetra-chloro-m-xylene	Pesticides (mg/L): Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	(Lindane) Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Detection limit		NA	NA	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0001	0.0001	0.0001
SF COMP	1	107	106	0.0001 U(a)	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
SFW COMP	1	105	109	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
UIH COMP	1	106	110	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
TB Upper COMP	1	106	110	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
TB Lower COMP	1	104	108	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
Quality Control Data												
Method Blank												
Blank	1	104	107	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
Matrix Spikes												
Standard Sample	1	NA	NA	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
MS Sample				1.76	NA (b)	NA	NA	2.30	NA	NA	NA	1.46
Concentration Recovered				1.76	NA	NA	NA	2.30	NA	NA	NA	1.46
Amount Spiked				2.00	NS (c)	NS	NS	2.00	NS	NS	NS	2.00
MS Percent Recovery				88%	NA	NA	NA	115%	NA	NA	NA	73%
Standard Sample	1	NA	NA	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.0001 U	0.0001 U	0.0001 U
MSD Sample				1.75	NA	NA	NA	2.38	NA	NA	NA	1.57
Concentration Recovered				1.75	NA	NA	NA	2.38	NA	NA	NA	1.57
Amount Spiked				2.00	NS	NS	NS	2.00	NS	NS	NS	2.00
MSD Percent Recovery				88%	NA	NA	NA	119%	NA	NA	NA	79%
RPD		NA	NA	0%	NA	NA	NA	3%	NA	NA	NA	7%
I-Stat		NA	NA	0.00	NA	NA	NA	0.02	NA	NA	NA	0.04

TABLE C.27. (contd)

Sediment Treatment	Analytical Batch	Pesticides (mg/L) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan Sulfate	Endrin	Endrin alde-hyde	Hepta-chlor	Hepta-chlor epoxide	Methoxy-chlor	Toxa-phene
Detection limit		0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.01
SF COMP	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
SFW COMP	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
UIH COMP	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
TB Upper COMP	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
TB Lower COMP	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
Quality Control Data											
Method Blank											
Blank	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
Matrix Spikes											
Standard Sample	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
MS Sample		2.21	NA	NA	NA	2.17	NA	1.75	NA	NA	NA
Concentration Recovered		2.21	NA	NA	NA	2.17	NA	1.75	NA	NA	NA
Amount Spiked		2.00	NS	NS	NS	2.00	NS	2.00	NS	NS	NS
MS Percent Recovery		111%	NA	NA	NA	109%	NA	88%	NA	NA	NA
Standard Sample	1	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0001 U	0.0005 U	0.01 U
MSD Sample		2.27	NA	NA	NA	2.25	NA	1.74	NA	NA	NA
Concentration Recovered		2.27	NA	NA	NA	2.25	NA	1.74	NA	NA	NA
Amount Spiked		2.00	NS	NS	NS	2.00	NS	2.00	NS	NS	NS
MSD Percent Recovery		114%	NA	NA	NA	113%	NA	87%	NA	NA	NA
RPD		3%	NA	NA	NA	4%	NA	1%	NA	NA	NA
I-Stat		0.01	NA	NA	NA	0.02	NA	0.01	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE C.28. Waste Extraction Test for Polychlorinated Biphenyls (PCBs), Including Quality Control Data, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	PCBs (mg/L) Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Detection limit		0.005	0.005	0.005	0.005	0.005	0.005	0.005
SF COMP	1	0.005 U(a)	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
SFW COMP	1	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
UIH COMP	1	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
TB Upper COMP	1	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
TB Lower COMP	1	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Quality Control Data								
Method Blank								
Blank	1	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Matrix Spike								
Matrix spike not available for PCBs.								

(a) U Undetected at or above detection limit.

TABLE C.29. Waste Extraction Test for Metals Analysis, Including Quality Control Data, Richmond Harbor Deepening Project

Sediment Treatment	Analytical Batch	Metals (mg/L) Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Hexavalent Chromium
Analytical method		6010	7060	6010	6010	6010	6010	6010	6010	7196
Detection Limit		0.2	0.05	0.1	0.05	0.05	0.1	0.1	0.1	0.01
SF COMP	1	0.2 U(a)	0.05	1.5	0.05 U	0.05 U	0.2	0.1 U	0.1 U	0.01 U
SFW COMP	1	0.2 U	0.08	2.5	0.05 U	0.05 U	0.3	0.1 U	0.1 U	0.01 U
UIH COMP	1	0.2 U	0.06	0.8	0.05 U	0.05 U	0.4	0.1	0.1 U	0.01 U
TB Upper COMP	1	0.2 U	0.08	1.1	0.05 U	0.05 U	0.1	0.1 U	0.1 U	0.01 U
TB Lower COMP	1	0.2 U	0.08	1.9	0.05 U	0.05 U	0.1	0.1	0.1 U	0.01 U
Quality Control Data										
Method Blank										
Blank	1	0.2 U	0.05 U	0.1 U	0.05 U	0.05 U	0.1 U	0.1 U	0.1 U	0.01 U
Matrix Spikes										
Standard Sample	1	0.2 U	0.0770	0.110	0.05 U	0.05 U	0.1 U	0.1 U	0.1 U	0.01 U
MS Sample		9.19	0.162	9.53	9.28	9.01	9.21	9.38	9.37	0.178
Concentration Rec		9.19	0.085	9.42	9.28	9.01	9.21	9.38	9.37	0.178
Amount Spiked		10.0	0.100	10.0	10.0	10.0	10.0	10.0	10.0	0.200
MS Percent Recovery		92%	85%	94%	93%	90%	92%	94%	94%	89%
Standard Sample	1	0.2 U	0.0770	0.110	0.05 U	0.05 U	0.1 U	0.1 U	0.1 U	0.01 U
MSD Sample		9.26	0.169	9.55	9.34	9.14	9.27	9.47	9.43	0.175
Concentration Rec		9.26	0.092	9.44	9.34	9.14	9.27	9.47	9.43	0.175
Amount Spiked		10.0	0.100	10.0	10.0	10.0	10.0	10.0	10.0	0.200
MSD Percent Recovery		93%	92%	94%	93%	91%	93%	95%	94%	87.5%
RPD		1%	8%	0%	0%	1%	1%	1%	0%	2%
I-Stat		0.01	0.04	0.00	0.00	0.01	0.01	0.01	0.00	0.01

TABLE C.29. (contd)

Sediment Treatment	Analytical Batch	Metals (mg/L) Lead	Mercury	Molyb-denum	Nickel	Selenium	Silver	Thallium	Vanadium	Zinc
Analytical method		6010	7470	6010	6010	7741	6010	6010	6010	6010
Detection Limit		0.1	0.01	0.1	0.1	0.05	0.1	0.2	0.1	0.1
SF COMP	1	0.3	0.01 U	0.1 U	0.2	0.05 U	0.1 U	0.2 U	0.5	0.9
SFW COMP	1	0.9	0.01 U	0.1 U	0.2	0.05 U	0.1 U	0.2 U	0.6	1.0
UIH COMP	1	0.2	0.01 U	0.1 U	0.3	0.05 U	0.1 U	0.2 U	0.7	1.1
TB Upper COMP	1	0.3	0.01 U	0.1 U	0.2	0.05 U	0.1 U	0.2 U	0.6	0.4
TB Lower COMP	1	0.1 U	0.01 U	0.1 U	0.3	0.05 U	0.1 U	0.2 U	0.5	0.1 U
Quality Control Data										
Method Blank										
Blank		0.1 U	0.01 U	0.1 U	0.1 U	0.05 U	0.1 U	0.2 U	0.1 U	0.1 U
Matrix Spikes										
Standard Sample		0.1 U	0.01 U	0.1 U	14.5	0.05 U	0.1 U	0.2 U	0.1 U	0.1 U
MS Sample		9.05	0.104	9.45	24.3	0.0990	9.19	9.31	9.27	9.10
Concentration Rec		9.05	0.104	9.45	9.8	0.0990	9.19	9.31	9.27	9.10
Amount Spiked		10.0	0.100	10.0	10.0	0.100	10.0	10.0	10.0	10.0
MS Percent Recovery		91%	104%	95%	98%	99%	92%	93%	93%	91%
Standard Sample		0.1 U	0.01 U	0.1 U	14.5	0.05 U	0.1 U	0.2 U	0.1 U	0.1 U
MSD Sample		9.20	0.106	9.57	24.2	0.106	9.28	9.67	9.34	9.19
Concentration Rec		9.20	0.106	9.57	9.7	0.106	9.28	9.67	9.34	9.19
Amount Spiked		10.0	0.100	10.0	10.0	0.100	10.0	10.0	10.0	10.0
MSD Percent Recovery		92%	106%	96%	97%	106%	93%	97%	93%	92%
RPD		1%	2%	1%	1%	7%	1%	4%	0%	1%
I-Stat		0.01	0.01	0.01	0.01	0.03	0.01	0.02	0.00	0.05

(a) U Undetected at or above detection limit.

APPENDIX D

INTENSIVE STUDY OF THE TURNING BASIN SEDIMENT CHEMISTRY AND QUALITY ASSURANCE DATA

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin
PARAMETER: Grain Size
LABORATORY: Soil Technology
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received at Soil Technology on 10/25/94 in good condition. Samples were analyzed in one batch.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
PSEP 1986 EPA/USACE 1991	Not applicable	≤20% for fractions greater than 5%	1.0%

METHOD

Sixteen grain size fractions were determined by a combination of sieve and pipette techniques. An additional measurement for salt content was performed and each grain size fraction was corrected for this salt measurement.

HOLDING TIME

The holding time of 6 months was met for all grain size analyses.

REPLICATES

A triplicate sample of one sample was analyzed with the samples. The precision criteria of ≤20% for the relative standard deviation (RSD) was met for the four main size fractions. One of the RSD values for the 16 size fractions was 30% which is outside the QC criteria.

REFERENCES

PSEP (Puget Sound Estuary Program). 1986. *Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound.* Vols. 1 and 2. Prepared by Tetra Tech, Inc. for the Puget Sound Estuary Program, Bellevue, Washington.

U.S. Environmental Protection Agency/U.S. Army Corps of Engineers (EPA/USACE). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

QA/QC SUMMARY

PROGRAM:	**Richmond Harbor Deepening Project-Intensive Study of the Turning Basin**
PARAMETER:	**Total Organic Carbon (TOC)**
LABORATORY:	**Analytical Resources, Inc.**
MATRIX:	**Sediment**

SAMPLE CUSTODY

Eighteen samples were received at Analytical Resources, Inc. on 11/30/94 in good condition. Samples were analyzed in one batch.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
Plumb 1981	≤20%	≤10%	0.1%

METHOD

Total organic carbon is the amount of non-volatile, partially volatile, volatile, and particulate organic carbon compounds in a sample. Each sample was dried and ball milled to a fine powder. Before combustion, inorganic carbon in the sample was removed by acidification. The TOC was then determination by measuring the carbon dioxide released during combustion of the sample.

HOLDING TIME

The holding time of 6 months was met for all TOC analyses.

METHOD BLANKS

The method blank analyzed with the samples was 0.002% TOC. No QC criteria are designated for TOC method blanks.

REPLICATES

One sample was analyzed in triplicate with the samples. The relative standard deviation was 13%, which is above the relative precision criteria of ≤10%.

DETECTION LIMITS

The achieved detection limit was lower than the target detection of 0.1% TOC.

REFERENCE

Plumb, R.H. Jr. 1981. *Procedure for Handling and Chemical Analyses of Sediment and Water Samples.* Technical Report EPA/CE-81-1, prepared for Great Lakes Laboratory, State University College at Buffalo, NY, for the U.S. Environmental Protection Agency/U.S. Army Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. Published by U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin
PARAMETER: Total Volatile Solids (TVS)
LABORATORY: Analytical Resources, Inc.
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received at Analytical Resources, Inc. on 10/25/94 in good condition. Samples were analyzed in one batch.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
EPA 160.4	NA	≤20%	0.1%

METHOD

Total volatile solids are a measure of the fraction of total solids that are lost on ignition at higher temperature. First, the sample was oven dried to constant weight and then removed, weighed, and ignited at 550°C. The sample was cooled in a desiccator and then reweighed. The amount of sample lost during ignition was defined as the volatile solids fraction.

HOLDING TIME

A holding time is not specified for TVS analyses.

METHOD BLANKS

One method blank was analyzed with the samples. No TVS were detected.

REPLICATES

One sample was analyzed in triplicate with the samples. The relative standard deviation was 7% which was within the QC criteria of ≤20%.

DETECTION LIMITS

The achieved detection limit was lower the target detection limit of 0.1%.

REFERENCE

U.S. Environmental Protection Agency (EPA. 1979. *Methods for Chemical Analysis of Water and Wastes.* EPA-600 4-79-020 Methods 160.4, 413.2, 418.1, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

QA/QC SUMMARY

PROGRAM:	Richmond Harbor Deepening Project-Intensive Study of the Turning Basin
PARAMETER:	Oil and Grease
LABORATORY:	Analytical Resources, Inc.
MATRIX:	Sediment

SAMPLE CUSTODY

Fourteen samples were received at Analytical Resources, Inc. on 10/25/94 in good condition. Samples were analyzed in one batch.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
418.1	50%-150%	≤20%	20 mg/kg

METHOD

Total oil and grease includes vegetable oils, animal fats, soaps, waxes, and any other carbon-hydrogen material extractable by the solvent Freon. An aliquot of sample material was dried with anhydrous sodium sulfate and extracted with Freon. The extract was shaken, allowed to settle, removed, and scanned from 4000 to 600 cm^{-1} by infrared spectrophotometry (IR). The peak height measured at 2930 cm^{-1} was used to quantify the concentration of oil and grease in the sample.

HOLDING TIME

The samples were extracted and analyzed on 10/31/94, which is within the holding time of 28 days. There was blank contamination at concentrations above the detection limit. Therefore, the samples were re-extracted and re-analyzed until there was minimal or no blank contamination in the samples and the data presented is from the analysis on 12/27/94.

METHOD BLANKS

One procedural blank was processed with the samples. Concentrations of oil and grease were detected in the method blanks but at concentrations below the detection limit.

MATRIX SPIKES

One matrix spike (MS) was analyzed with the samples. The percent recovery was 99%.

REPLICATES

One set of triplicates was analyzed with the samples. The relative standard deviation could not be calculated because the concentrations were all undetected at or below the detection limit.

DETECTION LIMITS

Achieved detection limits ranged from 10 to 18 mg/kg, which are less than the target detection limit of 20 mg/kg.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin
PARAMETER: Total Petroleum Hydrocarbons (TPH)
LABORATORY: Analytical Resources, Inc.
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received at Analytical Resources, Inc. on 10/25/94 in good condition. Samples were analyzed in one batch.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit
418.1	50%-150%	≤20%	20 mg/kg

METHOD

Total petroleum hydrocarbons comprise the nonpolar mineral fraction of total oil and grease that is not removed by silica gel absorption. An aliquot of sample material was dried with anhydrous sodium sulfate and extracted with Freon. Silica gel was added to the extract to remove the more polar animal and vegetable based oils. The extract was shaken, allowed to settle, removed, and scanned from 4000 to 600 cm^{-1} by infrared spectrophotometry (IR). The peak height measured at 2930 cm^{-1} was used to quantify the concentration of hydrocarbons in the sample.

HOLDING TIME

The samples were extracted and analyzed on 10/31/94, which is within the holding time of 28 days. There was blank contamination at concentrations above the detection limit. Therefore, the samples were re-extracted and re-analyzed until there was minimal or no blank contamination in the samples and the data presented is from the analysis on 12/27/94.

METHOD BLANKS

One procedural blank was processed with the samples. Concentrations of TPH were detected in the method blanks but at concentrations below the detection limit.

MATRIX SPIKES

One matrix spike (MS) was analyzed with the samples. The percent recovery was 95%.

REPLICATES

One set of triplicates was analyzed with the samples. The relative standard deviation could not be calculated because the concentrations were all undetected at or below the detection limit.

DETECTION LIMITS

Achieved detection limits ranged from 9.9 to 18 mg/kg, which are less than the target detection limit of 20 mg/kg.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project - Intensive Study of the Turning Basin
PARAMETER: Polynuclear Aromatic Hydrocarbons (PAH)
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received on 10/24/94 in good condition. Samples were assigned a Battelle Central File ID number and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry wt)
GC/MS	40-120%	≤30%	≤30%	20 µg/kg

METHOD

Sediment samples were extracted with methylene chloride using a roller under ambient conditions following a procedure based on methods used by the National Oceanic and Atmospheric Administration for their Status and Trends Program (Krahn et al, 1988). Samples were then cleaned using Silica/Alumina (5% deactivated) chromatography followed by HPLC cleanup (Krahn et al. 1988). Extracts were quantified using gas chromatography/mass spectrometry (GC/MS) in the selected ion mode (SIM) following a procedure based on EPA method 8270 (EPA 1986).

HOLDING TIMES

Samples were stored at approximately -20° C until extraction. Samples were extracted on 11/3/94. Extracts were analyzed by GC/MS from 11/9-11/10/94.

DETECTION LIMITS

Target detection limits of 20 µg/kg dry wt. were met for all PAH compounds. Actual detection limits were determined from multiplying the standard deviation of 7 spiked sediment replicates by the student t-value.

METHOD BLANKS

One method blank was extracted with the samples. Five of the 16 PAH compounds were detected in the method blank. Concentrations were less than 5 times the MDL for all compounds detected. Any sample value, however, that was less than 5 times the value in the method blank was flagged with a "B".

SURROGATES

Five isotopically labelled compounds were added prior to extraction to assess the efficiency of the method. These were d8-Naphthalene, d10-Acenaphthene, d12-Chrysene, d10-Perylene and d14-Dibenzo(a,h,i) Anthracene. Recoveries of all surrogates were within the quality control limits of 40-120%.

QA/QC SUMMARY (continued)

MATRIX SPIKES

One sample was spiked with all PAH compounds. Matrix spike recoveries were within the control limits of 40-120% for all PAHs with the exception of pyrene and benzo(k)fluoranthene. Recoveries for these two compounds were 123% and 131% respectively.

REPLICATES

One sample was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. All RSDs were within the control limit of ≤30%.

SRMs

One SRM,1941, a marine sediment obtained by the National Institute for Science and Technology was analyzed with the samples. Fourteen of the sixteen PAH compounds analyzed are certified. All PAHs were detected within 30% of the certified mean with the exception of anthracene, chrysene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene.

MISCELLANEOUS

Some of the compounds are flagged to indicate that the ion ratio for that compound was outside of the QC range. This is due primarily to low levels of the compound of interest. Because the confirmation ion is present at only a fraction of the level of the parent ion, when the native level of the compound is low, the amount of error in the concentration measurement of the confirmation ion goes up. The compound is actually quantified from the parent ion only so most likely this will not effect the quality of the data. For sample values that are relatively high (>5 times the MDL), it may be an indication of some sort of interference.

REFERENCES

Krahn, M.M., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Bogar, W.D. MacLeod, Jr., S.L. Chan, and D.W. Brown. 1988. "New HPLC Cleanup and Revised Extraction Procedures for Organic Contaminants." *NOAA Technical Memorandum NMFS f/NWC-153.* NOAA/NMFS/NWFSC, Seattle, Washington.

U.S. Environmental Protection Agency (EPA). 1986. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods.* SW-846. EPA-955-001-00000, U.S. Government Printing Office, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project - Intensive Study of the Turning Basin
PARAMETER: Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs)
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received on 10/24/94 in good condition. Samples were assigned a Battelle Central File ID number and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

	Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry wt)
Pesticides	GC/ECD	40-120%	≤30%	≤30%	2.0 - 30 µg/kg

METHOD

Sediment samples were extracted with methylene chloride using a roller under ambient conditions following a procedure based on EPA method 3510 and 8080 (EPA1986) and NOAA status and trends methodology (Krahn et al. 1988). Samples were then cleaned using Silica/Alumina (5% deactivated) chromatography followed by HPLC cleanup (Krahn et al. 1988). Extracts were analyzed using Gas Chromatography/Electron Capture Detection (GC/ECD) following a procedure based on EPA method 8080 (1986). The column used was a J&W DB-17 and the confirmatory column was a DB-1701, both capillary columns (30m x 0.25mm I.D.).

HOLDING TIMES

Samples were stored at approximately -20° C until extraction. Samples were extracted on 11/3/94. Extracts were analyzed by GC/ECD on 11/12-13/94.

DETECTION LIMITS

Target detection limits were met for all samples. Actual detection limits were determined from multiplying the standard deviation of 7 spiked sediment replicates by the student t-value.

METHOD BLANKS

One method blank was extracted with the extraction batch. No pesticides or PCBs were detected in the blank.

SURROGATES

Two compounds, PCB congeners 103 and 198, were added to all samples prior to extraction to assess the efficiency of the analysis. These compounds are also used to correct all sample results and are considered surrogate internal standards (SIS). Sample surrogate recoveries for these compounds were within the control limits of 40-120%.

QA/QC SUMMARY/PCBs (continued)

MATRIX SPIKES

One sample was spiked with a subset of 6 pesticides and Aroclor 1254. Matrix spike recoveries were within the control limits of 40-120% for all spiked compounds with the exception of 4,4'-DDT that had a recovery of 135%.

REPLICATES

One sample was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. No pesticides or PCBs were detected in any of the replicates; therefore, no RSD values were calculated.

SRMs

One SRM,1941, a marine sediment obtained by the National Institute for Science and Technology was analyzed with the samples. Only two pesticides are certified. The recovery of 4,4'-DDD was within the control limit of ≤30% and the recovery of 4,4'-DDE was 34%.

MISCELLANEOUS

All pesticide and PCB detections are confirmed on a secondary column. The RPD criteria is 67%.

REFERENCES

Krahn, M.M., C.A. Wigren, R.W. Pearce, L.K. Moore, R.G. Bogar, W.D. MacLeod, Jr., S.L. Chan, and D.W. Brown. 1988. "New HPLC Cleanup and Revised Extraction Procedures for Organic Contaminants." *NOAA Technical Memorandum NMFS f/NWC-153.* NOAA/NMFS/NWFSC, Seattle, Washington.

U.S. Environmental Protection Agency (EPA). 1986. *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods.* SW-846. EPA-955-001-00000, U.S. Government Printing Office, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project - Intensive Study of the Turning Basin
PARAMETER: Metals
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received on 10/24/94 in good condition. Samples were assigned a Battelle Central File ID number and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

	Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry wt)
Arsenic	XRF	NA	≤30%	≤20%	2.5
Cadmium	GFAA	75-125	≤30%	≤20%	0.1
Chromium	XRF	NA	≤30%	≤20%	33
Copper	XRF	NA	≤30%	≤20%	5.5
Lead	XRF	NA	≤30%	≤20%	6.2
Mercury	CVAA	75-125	≤30%	≤20%	0.01
Nickel	XRF	NA	≤30%	≤20%	7.5
Selenium	GFAA	75-125	≤30%	≤20%	0.1
Silver	GFAA	75-125	≤30%	≤20%	0.02
Zinc	XRF	NA	≤30%	≤20%	7.8

METHOD

A total of ten (10) metals were analyzed for the Richmond Harbor Deepening project: silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se), and zinc (Zn). Six metals, As, Cr, Cu, Ni, Pb, and Zn, were analyzed by energy diffusive x-ray fluorescence (XRF) following a PNL SOP. Three metals, Ag, Cd, and Se, were analyzed using Zeeman Graphite Furnace Atomic Absorption (GFAA) spectrometry following the EPA Method 200.9 (EPA 1991). Mercury was analyzed using cold-vapor atomic absorption spectroscopy (CVAA) according to the method of Bloom and Crecelius (1983).

To prepare sediments for analysis, samples were freeze-dried and blended in a Spex mixer-mill. Approximately 5 g of mixed sample was ground in a ceramic ball mill. The XRF analysis was performed on a 0.5-g aliquot of dried, ground material pressed into a pellet with a diameter of 2 cm. For GFAA and CVAA analyses, 0.2- to 0.5-g aliquots of dried homogenous sample were digested using a mixture of nitric/perchloric and hydrofluoric acids.

QA/QC SUMMARY (continued)

HOLDING TIMES

Upon receipt, samples were frozen to -80°C and subsequently freeze dried within approximately 14 days of sample receipt. Samples were all analyzed within 180 days of receipt. Analysis dates are summarized in the following table:

Task	Date Performed
Sample Digestion	11/16/94
XRF	11/29-30/94
GFAA/Ag	12/6/94
GFAA/Cd	12/6/94
GFAA/Se	12/6/94
CVAA-Hg	12/12/94

DETECTION LIMITS

Target detection limits were met for all metals except Se. The actual detection limit for Se was 0.17 which slightly exceeded the target limit of 0.10. The method detection limits for XRF and CVAA were determined by multiplying the standard deviation of 7 replicate analyses of an SRM by 3. The method detection limits for GFAA represent 3 times the standard deviation of 3 replicate analyses of the method blank.

METHOD BLANKS

One method blank was analyzed with the samples. The metals Ag and Cd were detected in the blank at approximately 3 times the MDL, which is less than the acceptable limit. All sample results for Ag and Cd are blank corrected. Method blanks are not analyzed by XRF; therefore, no blank results are reported for XRF metals.

MATRIX SPIKES

One sample was spiked with four metals (Ag, Cd, Hg, and Se). All spike recoveries were within the control limits of 75-125%.

REPLICATES

One sample was digested and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. All RSDs were within the control limits of ≤20% with the exception of Hg.

SRMs

One sample of SRM 1646 (an estuarine sediment obtained from the National Research Council of Canada, NRCC), was analyzed with the samples for all metals. All results were within 30% of the certified value. A second SRM, BEST-1 (an estuarine sediment obtained from the National Research Council of Canada, NRCC), was also analyzed for Hg only. The result for BEST was within the QC limits.

REFERENCES

Bloom, N. S., and E.A. Crecelius. 1983. "Determination of Mercury in Seawater at Sub-Nanogram per Liter Levels." *Marine Chemistry* 21:337-390.

U.S. Environmental Protection Agency (EPA). 1991. *Methods for the Determination of Metals in Environmental Samples.* EPA-600/4-91-010 Methods 200.8, 200.9, Environmental Services Division, Monitoring Management Branch, Cincinnati, Ohio.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project - Intensive Study of the Turning Basin
PARAMETER: Butyltins
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Sediment

SAMPLE CUSTODY

Fourteen samples were received on 10/24/94 in good condition. Samples were assigned a Battelle Central File ID number and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry weight)
Unger et al.	40-120%	≤30%	≤30%	1 µg/kg

METHOD

Butyltin analyses were performed according to a procedure following the method of Unger et al. (1986). Sediment samples were extracted with methylene chloride using a roller under ambient conditions followed by derivitization using a Grignard reagent to change to a form compatible with gas chromatography. Sample extracts were then cleaned by passing through a florisil column. Extracts were analyzed using Gas Chromatography/Flame Photometric Detection (GC/FPD).

HOLDING TIMES

Samples were stored at approximately -20°C until extraction. Samples were extracted on 10/31/94 and analyzed on 11/4/94. Holding times were met.

DETECTION LIMITS

Target detection limits of 1 µg/kg dry wt. were met for di- and tributyltin compounds. Actual detection limits were determined from multiplying the standard deviation of 7 spiked sediment replicates by the student t-value.

METHOD BLANKS

One method blank was extracted with the samples and no butyltins were detected in the blanks.

SURROGATES

One compound, tripentyltin chloride, was added to all samples prior to extraction to assess the efficiency of the method. This compound is also used as an internal standard as all data is corrected for the recovery of the compound. Surrogate recoveries were within the QC limits of 40-120% for all samples.

QA/QC SUMMARY (continued)

MATRIX SPIKES

One sample was spiked with tri- and dibutyltin. Matrix spike recoveries for tri- and dibutyltin were within the control limits of 40-120%.

REPLICATES

One sample was extracted and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSD values were within the control limits of ≤30%.

SRMs

The SRM, PACS-1, is an estuarine sediment obtained from the National Canadian Research Council (NRCC) and was analyzed along with the samples from each batch. The results for di- and tributyltin were within 30% of the certified mean value.

NOTE: Monobutyltin results are provided for information only. Recoveries of monobutyltin are low due to the nature and the low efficiency of extraction of this compound. This is evidenced by the low matrix spike and SRM recoveries.

REFERENCES

Unger, M.A., W.G. MacIntyre, J. Reaves and R.J. Huggett. 1986. "GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation." *Chemosphere.* 15(4):461-470.

TABLE D.1. Summary of Sediment Grain Size Including Quality Control Data, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Total Percent (dry weight) Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm
TB-1 Lower	13	49	23	15
TB-2 Lower	3	18	47	32
TB-3 Lower	1	15	50	34
TB-4 Middle, Replicate 1	0	4	49	47
TB-4 Middle, Replicate 2	0	4	48	48
TB-4 Middle, Replicate 3	0	4	47	49
TB-4 Lower	0	10	44	46
TB-5 Lower	0	7	54	39
TB-6 Lower	1	5	40	54
TB-7 Lower	1	7	53	39
TB-8 Lower	0	6	55	39
TB-9 Lower	0	15	44	41
OBM COMP	0	18	56	26
R-OS	0	26	53	21
R-BF	0	1	39	60
R-AM	0	99	0	1
Quality Control Data				
Analytical Replicates				
TB-4 Middle, Replicate 1	0	4	49	47
TB-4 Middle, Replicate 2	0	4	48	48
TB-4 Middle, Replicate 3	0	4	47	49
RSD	NA[(a)]	0%	2%	2%

(a) NA Not applicable.

TABLE D.2. Sediment Grainsize Results and Quality Control Data, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

	Percent at Size Fraction															
Sediment Treatment	phi µm > 3350	3350- 2000	2000- 1000	1000- 250	250- 125	125- 62.5	4 62.5- 48	4.5 48- 31.2	5 31.2- 23	5.5 23- 15.6	6 15.6- 7.8	7 7.8- 3.9	8 3.9- 1.9	9 1.9- 0.9	10 0.9- 0.4	11 <0.4
TB-1 Lower	9	4	3	8	14	24	6	4	3	2	5	3	3	3	1	8
TB-2 Lower	3	0	1	3	6	8	8	9	6	7	10	7	6	5	5	16
TB-3 Lower	1	0	0	3	5	7	7	9	9	7	11	7	6	6	5	17
TB-4 Middle, Replicate 1	0	0	0	0	1	3	8	9	6	6	9	11	8	10	7	22
TB-4 Middle, Replicate 2	0	0	0	0	1	3	11	6	5	6	10	10	9	9	7	23
TB-4 Middle, Replicate 3	0	0	0	0	1	3	6	8	7	6	10	10	9	10	6	24
TB-4 Lower	0	0	0	0	1	9	13	3	4	5	9	10	9	8	7	22
TB-5 Lower	0	0	0	2	2	3	9	11	6	8	11	9	7	7	4	21
TB-6 Lower	0	1	0	1	1	3	5	2	4	4	12	13	10	11	7	26
TB-7 Lower	1	0	0	1	3	3	7	8	9	7	13	9	7	7	5	20
TB-8 Lower	0	0	0	1	1	4	8	9	9	8	12	9	7	7	5	20
TB-9 Lower	0	0	0	2	2	11	9	6	4	5	10	10	8	8	5	20
OBM COMP	0	0	1	1	2	14	14	9	8	7	10	8	5	5	4	12
R-OS	0	0	0	1	2	23	28	8	5	4	4	4	3	5	3	10
R-BF	0	0	0	0	1	0	3	6	5	5	9	11	12	11	10	27
R-AM	0	0	0	86	12	1	0	0	0	0	0	0	0	0	0	1
Quality Control Data																
Analytical Replicates																
TB-4 Middle, Replicate 1	0	0	0	0	1	3	8	9	6	6	9	11	8	10	7	22
TB-4 Middle, Replicate 2	0	0	0	0	1	3	11	6	5	6	10	10	9	9	7	23
TB-4 Middle, Replicate 3	0	0	0	0	1	3	6	8	7	6	10	10	9	10	6	24
RSD	NA[a]	NA	NA	NA	0%	0%	30%[b]	20%	17%	0%	0%	6%	7%	0%	9%	4%

(a) NA Not applicable.
(b) Value exceeds relative precision goal of ≤20%.

TABLE D.3. Sediment Total Organic Carbon (TOC), Total Percent Solids, and Total Volatile Solids (TVS), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	(percent dry weight) TOC	Total Solids	Total Volatile Solids
Method DL[a]	0.1	0.01	0.1
Achieved DL	0.002	1.0	1.0
TB-1 Lower	0.11	80.8	0.79
TB-2 Lower	0.67	64.2	2.3
TB-3 Lower	0.67	59.5	2.1
TB-4 Middle	1.1	50.6	2.6
TB-4 Lower	0.58	60.5	2.1
TB-5 Lower	0.90	58.4	2.2
TB-6 Lower	0.81	58.1	2.6
TB-7 Lower	0.70	64.4	2.4
TB-8 Lower	0.76	65.2	2.6
TB-9 Lower	0.59	61.5	2.1
OBM	0.16	74.1	1.9
OBM-0.4% TOC[b]	0.24	NA [c]	NA
OBM-0.6% TOC[b]	0.27	NA	NA
OBM-1.0% TOC[b]	0.39	NA	NA
OBM-1.4% TOC[b]	0.44	NA	NA
R-OS	1.0	53	2.4
R-BF	1.4	36.5	2.3
R-AM, Replicate 1	0.096	82.1	0.5
R-AM, Replicate 2	0.096	82.6	0.6

(a) DL Detection limit.
(b) Prior to analysis, TOC was estimated in the OBM sediments; the actual values obtained from analysis are shown in the TOC column.
(c) NA Not applicable.

TABLE D.4. Quality Control Data for Sediment Total Organic Carbon (TOC), Total Percent Solids, and Total Volatile Solids (TVS), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	(percent dry weight) TOC	Total Percent Solids	Total Volatile Solids
Method Blank			
Blank	0.0018	1.0 mg U[a]	1.0 mg U
Matrix Spike			
R-AM	0.0962	NA [b]	NA
R-AM, MS	0.681	NA	NA
Concentration Recovered	0.585	NA	NA
Amount Spiked	0.547	NS [c]	NS
Percent Recovery	107%	NA	NA
R-AM	0.0962	NA	NA
R-AM, MSD	0.782	NA	NA
Concentration Recovered	0.686	NA	NA
Amount Spiked	0.711	NS	NS
Percent Recovery	96%	NA	NA
RPD	10%	NA	NA
Standard Reference Material			
MESS-1	2.80[d]	NA	NA
Certified value SRM NBS 2704	3.35	NA	NA
NBS 2704	2.87	NA	NA
NBS 2704	3.37	NA	NA
Analytical Replicates			
R-AM, Replicate 1	0.096	82.1	0.5
R-AM, Replicate 2	0.096	82.6	0.6
R-AM, Replicate 3	0.12	NA	NA
RSD/RPD	13%	.6%	18%

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) MESS-1 is not certified for TOC, but frequent analysis at MSL indicates a value of 2.6%.

TABLE D.5. Sediment Oil & Grease and Total Petroleum Hydrocarbons (TPH) Results, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	(mg/kg dry weight) Oil and Grease	TPH
Method DL[a]	20	20
Achieved DL	10-18	9.9-18
TB-1 Lower	14	9.9 U
TB-2 Lower	50	27
TB-3 Lower	40	16 U
TB-4 Middle	18 U[b]	18 U
TB-4 Lower	16 U	16 U
TB-5 Lower	56	58
TB-6 Lower	17 U	17 U
TB-7 Lower	15 U	15 U
TB-8 Lower	43	16 U
TB-9 Lower	20	16 U
OBM	11 U	11 U
R-OS	100	77
R-BF	130	100
R-AM	10 U	10 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE D.6. Quality Control Data for Sediment Oil & Grease and Total Petroleum Hydrocarbons (TPH) Analysis, Richmond Harbor Deepening Project-Intensive of the Turning Basin

Sediment Treatment	(mg/kg dry weight) Oil and Grease	TPH
Method Blank		
Blank	13	11
Matrix Spike		
R-AM	10 U	10 U[(a)]
R-AM	11 U	11 U
Concentration Recovered	12700	10600
Amount Spiked	12800	11100
Percent Recovery	99%	95%
Analytical Replicates		
R-AM, Replicate 1	11 U	11 U
R-AM, Replicate 2	11 U	11 U
R-AM, Replicate 3	10 U	10 U
RSD	NA [(b)]	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.

TABLE D.7. Total Polynuclear Aromatic Hydrocarbons (PAHs) Found in Sediment, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Total Low Molecular Weight PAHs	Total Low Molecular Weight PAHs	Total PAHs
TB-1 Lower	17	37	54
TB-2 Lower	22	36	58
TB-3 Lower	38	58	96
TB-4 Lower	47	66	113
TB-4 Middle	339	2355	2694
TB-5 Lower	51	62	113
TB-6 Lower	52	67	119
TB-7 Lower	35	69	104
TB-8 Lower	38	67	105
TB-9 Lower, Replicate 1	43	65	108
TB-9 Lower, Replicate 2	40	63	103
TB-9 Lower, Replicate 3	46	58	104
OBM COMP	29	28	57
R-OS	65	124	189
R-BF	355	2116	2471
R-AM	538	1055	1593

TABLE D.8. Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Target DL[a]	20	20	20	20	20	20
Achieved DL	1.13-2.97	1.02-2.70	0.68-1.78	1.47-3.89	2.04-5.39	2.18-5.75
TB-1 Lower	8.08 B[b][c]	1.83 U[d]	1.64 U	3.27 U	8.93 B	4.69 U
TB-2 Lower	7.24 B	1.47 U	1.32 U	3.37	11.1 B	3.77 U
TB-3 Lower	11.3 B	2.34 U	5.32	4.97	16.2 B	6.00 U
TB-4 Lower	13.6 B	2.31 U	5.31	5.72	15.9 B[c]	6.32
TB-4 Middle	52.1	18.3	13.6	17.8	173	64.2
TB-5 Lower	13.5 B	2.40 U	5.61 [c]	5.48	19.9 B	6.31 [c]
TB-6 Lower	11.7 B	4.39 [c]	5.50	6.49	17.3 B	6.85 [c]
TB-7 Lower	10.9 B	2.40 U	2.15 U	5.58	18.1 B	6.15 U
TB-8 Lower	13.1 B[c]	2.43 U	2.18 U	5.78	19.4 B	6.23 U
TB-9 Lower, Replicate 1	12.5 B	2.46 U	5.98	6.03	18.4 B	6.31 U
TB-9 Lower, Replicate 2	11.8 B[c]	2.43 U	6.25	5.97	16.2 B	6.23 U
TB-9 Lower, Replicate 3	15.7 B	2.31 U	5.48	5.60	19.2 B	5.92 U
OBM COMP	9.29 B	3.27 [c]	4.87	3.59 U	11.4 B	5.15 U
R-OS	16.5 B	2.97 U	6.80	6.18	27.9 B	7.91 [c]
R-BF	55.0	19.8 [c]	14.7	18.7	189	57.5
R-AM[e]	28.8 B	24.0	9.39	30.2	296	150

(a) DL Detection limit.

(b) B Analyte detected in sample at less than five times value in associated method blank.

(c) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.

(d) U Undetected at or above detection limit.

(e) Field station RAM-F was not included in the composite.

TABLE D.9. High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	HPAHs (µg/kg dry weight)									
	Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Target DL[a]	20	20	20	20	20	20	20	20	20	20
Achieved DL	0.80-2.10	0.71-1.86	0.44-1.15	0.66-1.74	0.77-2.02	1.11-2.93	0.99-2.62	0.56-1.47	0.59-1.55	0.56-1.47
TB-1 Lower	7.84 B[b][c]	10.3 B[c]	4.23 [c]	0.71 U[d]	4.85 [c]	2.29 U	2.73 B[c]	3.65 [c]	1.04 U	3.70 [c]
TB-2 Lower	7.01 B[c]	9.26 B[c]	3.67 [c]	2.31 [c]	4.96 [c]	1.84 U	2.45 B[c]	2.77 [c]	0.83 U	3.38 [c]
TB-3 Lower	11.0 B[c]	13.7 B[c]	5.88 [c]	3.29 [c]	7.21 [c]	3.21 [c]	3.78 B[c]	4.37 [c]	1.33 U	5.29 [c]
TB-4 Lower	13.1 B	15.5 B	6.17 [c]	3.98 [c]	8.59	3.47 [c]	3.42 B[c]	5.25 [c]	1.31 U	6.69
TB-4 Middle	293	441	129	150	305	107	288	295	32.8	314
TB-5 Lower	12.7 B	15.9 B	6.21 [c]	3.85 [c]	9.39	3.00 U	3.87 B[c]	4.71 [c]	1.36 U	5.77 [c]
TB-6 Lower	14.1 B	16.2 B	6.69 [c]	4.48 [c]	9.90	3.12 U	3.56 B[c]	5.29 [c]	1.41 U	6.40
TB-7 Lower	12.5 B	15.4 B	6.42 [c]	3.95 [c]	9.32	3.70 [c]	4.25 B[c]	6.07 [c]	1.36 U	6.99
TB-8 Lower	12.9 B[c]	16.7 B[c]	6.45 [c]	4.36 [c]	10.4	3.04 U	3.66 B[c]	5.33 [c]	1.38 U	6.81
TB-9 Lower, Replicate 1	14.4 B	16.7 B	6.36 [c]	3.69 [c]	8.87 [c]	3.08 U	3.81 B[c]	5.11 [c]	1.39 U	5.86 [c]
TB-9 Lower, Replicate 2	12.6 B[c]	16.1 B	6.23 [c]	3.61 [c]	8.83 [c]	3.04 U	3.96 B[c]	4.92 [c]	1.38 U	6.44 [c]
TB-9 Lower, Replicate 3	14.2 B[c]	16.0 B	5.88 [c]	3.74 [c]	7.77 [c]	2.89 U	2.25 U	4.55 [c]	1.31 U	5.54 [c]
OBM COMP	8.64 B[c]	11.2 B	4.61 [c]	0.78 U	1.49 U	2.52 U	3.49 B[c]	0.90 U	1.14 U	0.82 U
R-OS	22.7 B	27.1 B	9.85	8.10	18.7	3.72 U	8.73 B	10.9	4.50 [c]	13.5
R-BF	287	337	114	147	280	110	250	279	29.8	282
R-AM[e]	199	238	113	133	96.5	42.7	105	60.8	14.0	53.0

(a) DL Detection limit.
(b) B Analyte detected in sample at less than five times value in associated method blank.
(c) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(d) U Undetected at or above detection limit.
(e) Field station RAM-F was not included in the composite.

TABLE D.10. Quality Control Data for Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	LPAHs (µg/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Method Blank						
Blank	8.11 [a]	2.16 U[b]	1.94 U	3.86 U	11.3	5.54 U
Matrix Spike						
OBM COMP	9.29	3.27 [a]	4.87	3.59 U	11.4	5.15 U
OBM COMP, MS	29.5	22.1	24.8	20.1	28.7	19.3
Concentration Recovered	20.2	18.8	19.9	20.1	17.3	19.3
Amount Spiked	22.0	22.0	22.0	22.0	22.0	22.0
Percent Recovery	92%	86%	91%	91%	79%	88%
Standard Reference Material						
Certified	1010	NC [c]	NC	97.3	489	184
value NIST 1941a	±140	NC	NC	±8.6	±23	±14
1941a	893	NA [d]	NA	92.3	608	242 [e]
Analytical Replicate						
TB-9 Lower, Replicate 1	12.5 B[f]	2.46 U	5.98	6.03	18.4 B	6.31 U
TB-9 Lower, Replicate 2	11.8 B[a]	2.43 U	6.25	5.97	16.2 B	6.23 U
TB-9 Lower, Replicate 3	15.7 B	2.31 U	5.48	5.60	19.2 B	5.92 U
RSD	16%	NA	7%	4%	9%	NA

(a) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(b) U Undetected at or above detection limit.
(c) NC Not certified.
(d) NA Not applicable.
(e) Outside quality control criteria (±30%) for SRMs.
(f) B Analyte detected in sample at less than five times value in associated method blank.

TABLE D.11. Quality Control Data for High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

	HPAHs (µg/kg dry weight)									
Sediment Treatment	Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Method Blank										
Blank	8.65 [a]	11.5 [a]	0.76 U [b]	0.84 U	1.60 U	2.70 U	2.93 [a]	0.97 U	1.22 U	0.88 U
Matrix Spike										
OBM COMP	8.64 [a]	11.2 U	4.61 [a]	0.78 U	1.49 U	2.52 U	3.49 [a]	0.90 U	1.14 U	0.82 U
OBM COMP, MS	26.8	27.1	22.2	23.8	24.2	28.9	21.2	22.1	22.2	21.4
Concentration Recovered	18.2	27.1	17.6	23.8	24.2	28.9	17.7	22.1	22.2	21.4
Amount Spiked	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
Percent Recovery	83%	123% [c]	80%	108%	110%	131% [c]	81%	100%	101%	97%
Standard Reference Material										
Certified value NIST 1941a	981 ±78	811 ±24	427 ±25	380 ±24	740 ±110	361 ±18	628 ±52	501 ±72	73.9 ±9.7	525 ±67
SRM NIST 1941a	921	739	442	603 [d]	1100 [d]	382	579	580	128 [d]	503

TABLE D.11. (contd)

Sediment Treatment	HPAHs (µg/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Analytical Replicate										
TB-9 Lower, Replicate 1	14.4 B[e]	16.7 B	6.36 [a]	3.69 [a]	8.87 [a]	3.08 U	3.81 B[a]	5.11 [a]	1.39 U	5.86 [a]
TB-9 Lower, Replicate 2	12.6 B[a]	16.1 B	6.23 [a]	3.61 [a]	8.83 [a]	3.04 U	3.96 B[a]	4.92 [a]	1.38 U	6.44 [a]
TB-9 Lower, Replicate 3	14.2 B[a]	16.0 B	5.88 [a]	3.74 [a]	7.77 [a]	2.89 U	2.25 U	4.55 [a]	1.31 U	5.54 [a]
RSD	7%	2%	4%	2%	7%	NA [f]	NA	NA	NA	8%

(a) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(b) U Undetected at or above detection limit.
(c) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(d) Outside quality control criteria (±30%) for SRMs.
(e) B Analyte detected in sample at less than five times value in associated method blank.
(f) NA Not applicable.

TABLE D.12. Surrogate Percent Recoveries for Polynuclear Aromatic Hydrocarbons (PAHs) Including Quality Control Data for Sediment, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Surrogate Percent Recoveries: Naphthalene d8	Acenaphthene d10	Chrysene d12	Perylene d12	Dibenzo(a,h,i) Anthracene d14
TB-1 Lower	69	69	69	65	67
TB-2 Lower	54	57	56	61	55
TB-3 Lower	61	63	61	66	64
TB-4 Lower	59	63	67	67	66
TB-4 Middle	42	58	73	68	71
TB-5 Lower	58	60	68	68	67
TB-6 Lower	56	61	59	64	62
TB-7 Lower	61	66	71	71	67
TB-8 Lower	63	65	58	64	65
TB-9 Lower, Replicate 1	69	72	64	70	67
TB-9 Lower, Replicate 2	63	66	66	65	64
TB-9 Lower, Replicate 3	65	68	65	70	63
OBM COMP	62	63	66	63	65
R-OS	64	67	65	66	64
R-BF	44	48	71	67	69
R-AM[(a)]	48	57	76	70	75
Quality Control Data					
Method Blank					
Blank	46	56	60	62	55
Matrix Spike					
OBM COMP	62	63	66	63	65
OBM COMP, MS	58	61	64	61	64
Analytical Replicate					
TB-9 Lower, Replicate 1	69	72	64	70	67
TB-9 Lower, Replicate 2	63	66	66	65	64
TB-9 Lower, Replicate 3	65	68	65	70	63

(a) Field station RAM-F was not included in the composite.

TABLE D.13. Sediment Chlorinated Pesticide Results (alphabetical, Aldrin - 4,4'-DDT), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Pesticides (µg/kg dry weight)								
	Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	T Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
Target DL[a]	2	2	2	2	2	30	2	2	2
Achieved DL	0.13-0.36	0.23-0.59	0.23-0.59	0.23-0.59	0.14-0.37	30	0.09-0.24	0.17-0.44	0.47-1.24
TB-1 Lower	0.17 U[b]	0.28 U	0.28 U	0.28 U	0.17 U	30 U	0.11 U	0.21 U	0.58 U
TB-2 Lower	0.66	0.23 U	0.23 U	0.23 U	0.14 U	30 U	0.09 U	0.17 U	0.47 U
TB-3 Lower	0.21 U	0.36 U	0.36 U	0.36 U	0.22 U	30 U	0.14 U	0.26 U	0.74 U
TB-4 Middle	1.15	0.41 U	0.41 U	0.41 U	0.25 U	30 U	15.1	19.3	9.30
TB-4 Lower	0.21 U	0.35 U	0.35 U	0.35 U	0.21 U	30 U	0.14 U	0.26 U	0.72 U
TB-5 Lower	0.22 U	0.36 U	0.36 U	0.36 U	0.22 U	30 U	0.15 U	0.27 U	0.76 U
TB-6 Lower	1.17	0.40 U	0.40 U	0.40 U	0.24 U	30 U	0.16 U	0.29 U	0.83 U
TB-7 Lower	1.69	0.37 U	0.37 U	0.37 U	0.23 U	30 U	0.15 U	0.27 U	0.77 U
TB-8 Lower	0.97	0.36 U	0.36 U	0.36 U	0.22 U	30 U	0.15 U	0.27 U	0.76 U
TB-9 Lower, Replicate 1	0.36 U	0.59 U	0.59 U	0.59 U	0.37 U	30 U	0.24 U	0.44 U	1.24 U
TB-9 Lower, Replicate 2	0.35 U	0.59 U	0.59 U	0.59 U	0.36 U	30 U	0.24 U	0.43 U	1.22 U
TB-9 Lower, Replicate 3	0.33 U	0.56 U	0.56 U	0.56 U	0.34 U	30 U	0.23 U	0.41 U	1.16 U
OBM COMP	0.18 U	0.30 U	0.30 U	0.30 U	0.19 U	30 U	0.12 U	0.22 U	0.63 U
R-OS	0.25 U	0.42 U	0.42 U	0.42 U	0.26 U	30 U	1.29	0.31 U	0.87 U
R-BF	2.15	0.57 U	0.57 U	0.57 U	0.35 U	30 U	2.61	5.19	1.19 U
R-AM	1.32	0.28 U	0.28 U	0.28 U	0.17 U	30 U	0.11 U	0.21 U	0.58 U

(a) DL Detection limit.

(b) U Undetected at or above detection limit.

TABLE D.14. Sediment Chlorinated Pesticide Results (alphabetical, Dieldrin - Toxaphene), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Pesticides (µg/kg dry weight)								
	Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Alde-hyde	Hepta-chlor	Hepta chlor-epoxide	Toxa-phene
Target DL[a]	2	2	2	2	2	2	2	2	30
Achieved DL	0.13-0.35	0.23-0.59	0.23-0.59	0.23-0.59	0.23-0.59	0.23-0.59	0.04-0.11	0.20-0.52	30
TB-1 Lower	0.16 U[b]	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.05 U	0.24 U	30 U
TB-2 Lower	0.13 U	0.23 U	0.23 U	0.23 U	0.23 U	0.23 U	0.04 U	0.20 U	30 U
TB-3 Lower	0.21 U	0.36 U	0.36 U	0.36 U	0.36 U	0.36 U	0.07 U	0.31 U	30 U
TB-4 Middle	0.24 U	0.41 U	0.41 U	0.41 U	0.41 U	0.41 U	0.08 U	0.36 U	30 U
TB-4 Lower	0.20 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.06 U	0.30 U	30 U
TB-5 Lower	0.21 U	0.36 U	0.36 U	0.36 U	0.36 U	0.36 U	0.07 U	0.32 U	30 U
TB-6 Lower	0.23 U	0.40 U	0.40 U	0.40 U	0.40 U	0.40 U	0.07 U	0.35 U	30 U
TB-7 Lower	0.22 U	0.37 U	0.37 U	0.37 U	0.37 U	0.37 U	0.07 U	0.32 U	30 U
TB-8 Lower	0.21 U	0.36 U	0.36 U	0.36 U	0.36 U	0.36 U	0.07 U	0.32 U	30 U
TB-9 Lower, Replicate 1	0.35 U	0.59 U	0.59 U	0.59 U	0.59 U	0.59 U	0.11 U	0.52 U	30 U
TB-9 Lower, Replicate 2	0.34 U	0.59 U	0.59 U	0.59 U	0.59 U	0.59 U	0.11 U	0.51 U	30 U
TB-9 Lower, Replicate 3	0.33 U	0.56 U	0.56 U	0.56 U	0.56 U	0.56 U	0.10 U	0.49 U	30 U
OBM COMP	0.18 U	0.30 U	0.30 U	0.30 U	0.30 U	0.30 U	0.06 U	0.26 U	30 U
R-OS	0.25 U	0.42 U	0.42 U	0.42 U	0.42 U	0.42 U	0.08 U	0.36 U	30 U
R-BF	0.33 U	0.57 U	0.57 U	0.57 U	0.57 U	0.57 U	0.11 U	0.50 U	30 U
R-AM	0.16 U	0.28 U	0.28 U	0.28 U	0.28 U	0.28 U	0.05 U	0.24 U	30 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE D.15. Quality Control Data for Sediment Chlorinated Pesticide Results (alphabetical, Aldrin - 4,4'-DDT), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Pesticides (µg/kg dry weight)								
	Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	T Chlordane	4,4'-DDE	4,4'-DDD	4,4'-DDT
Method Blank									
Blank	0.23 U[a]	0.39 U	0.39 U	0.39 U	0.24 U	30 U	0.16 U	0.29 U	0.83 U
Matrix Spike									
OBM COMP	0.18 U	NA [b]	NA	NA	0.19 U	NA	NA	NA	0.63 U
OBM COMP, MS	1.80	NA	NA	NA	1.75	NA	NA	NA	11.9
Concentration Recovered	1.80	NA	NA	NA	1.75	NA	NA	NA	11.9
Amount Spiked	2.20	NS [c]	NS	NS	2.20	NS	NS	NS	8.80
Percent Recovery	82%	NA	NA	NA	80%	NA	NA	NA	135% [d]
Standard Reference Material									
Certified	NC [e]	NC	NC	NC	NC	NC	6.59	5.06	NC
value NIST 1941a	NC	NC	NC	NC	NC	NC	±0.56	±0.58	NC
NIST 1941a	NA	NA	NA	NA	NA	NA	8.85 [f]	5.80	NA
Analytical Replicate									
TB-9 Lower, Replicate 1	0.36 U	0.59 U	0.59 U	0.59 U	0.37 U	30 U	0.24 U	0.44 U	1.24 U
TB-9 Lower, Replicate 2	0.35 U	0.59 U	0.59 U	0.59 U	0.36 U	30 U	0.24 U	0.43 U	1.22 U
TB-9 Lower, Replicate 3	0.33 U	0.56 U	0.56 U	0.56 U	0.34 U	30 U	0.23 U	0.41 U	1.16 U
RSD	NA	NA	NA	NA	NA	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) Outside quality control criteria (40%-120%) for matrix spike recoveries.
(e) NC Not certified.
(f) Outside quality control criteria (±30%) for SRMs.

TABLE D.16. Quality Control Data for Sediment Chlorinated Pesticide Results (alphabetical, Dieldrin - Toxaphene), Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Pesticides (µg/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Alde-hyde	Hepta-chlor	Hepta chlor-epoxide	Toxa-phene
Method Blank									
Blank	0.23 U[a]	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.07 U	0.34 U	30 U
Matrix Spike									
OBM COMP	0.18 U	NA [b]	NA	NA	0.30 U	NA	0.06 U	NA	NA
OBM COMP, MS	8.40	NA	NA	NA	10.4	NA	1.81	NA	NA
Concentration Recovered	8.40	NA	NA	NA	10.4	NA	1.81	NA	NA
Amount Spiked	8.80	NS [c]	NS	NS	8.80	NS	2.20	NS	NS
Percent Recovery	95%	NA	NA	NA	118%	NA	82%	NA	NA
Standard Reference Material									
Certified	NC [d]	NC	NC	NC	NC	NC	NC	NC	NC
value NIST 1941a	NC	NC	NC	NC	NC	NC	NC	NC	NC
NIST 1941a	NA	NA	NA	NA	NA	NA	NA	NA	NA
Analytical Replicate									
TB-9 Lower, Replicate 1	0.35 U	0.59 U	0.59 U	0.59 U	0.59 U	0.59 U	0.11 U	0.52 U	30 U
TB-9 Lower, Replicate 2	0.34 U	0.59 U	0.59 U	0.59 U	0.59 U	0.59 U	0.11 U	0.51 U	30 U
TB-9 Lower, Replicate 3	0.33 U	0.56 U	0.56 U	0.56 U	0.56 U	0.56 U	0.10 U	0.49 U	30 U
RSD	NA	NA	NA	NA	NA	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) NC Not certified.

TABLE D.17. Sediment Polychlorinated Biphenyls (PCBs) Results, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	PCBs (µg/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Target DL[a]	20	20	20	20
Achieved DL	20	20	20	20
TB-1 Lower	20 U[b]	20 U	20 U	20 U
TB-2 Lower	20 U	20 U	20 U	20 U
TB-3 Lower	20 U	20 U	20 U	20 U
TB-4 Middle	20 U	20 U	101	20 U
TB-4 Lower	20 U	20 U	20 U	20 U
TB-5 Lower	20 U	20 U	20 U	20 U
TB-6 Lower	20 U	20 U	20 U	20 U
TB-7 Lower	20 U	20 U	20 U	20 U
TB-8 Lower	20 U	20 U	20 U	20 U
TB-9 Lower, Replicate 1	20 U	20 U	20 U	20 U
TB-9 Lower, Replicate 2	20 U	20 U	20 U	20 U
TB-9 Lower, Replicate 3	20 U	20 U	20 U	20 U
OBM COMP	20 U	20 U	20 U	20 U
R-OS	20 U	20 U	20 U	20 U
R-BF	20 U	20 U	46.8	20 U
R-AM	20 U	20 U	20 U	20 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE D.18. Quality Control Data for Sediment Polychlorinated Biphenyls (PCBs) Analysis, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	PCBs (µg/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Method Blank				
Blank	20 U[a]	20 U	20 U	20 U
Matrix Spike				
OBM COMP	NA [b]	NA	20 U	NA
OBM COMP, MS	NA	NA	44.5	NA
Concentration Recovered	NA	NA	44.5	NA
Amount Spiked	NS [c]	NS	44.0	NS
Percent Recovery	NA	NA	101%	NA
Standard Reference Material				
SRMs not available for PCBs.				
Analytical Replicate				
TB-9 Lower, Replicate 1	20 U	20 U	20 U	20 U
TB-9 Lower, Replicate 2	20 U	20 U	20 U	20 U
TB-9 Lower, Replicate 3	20 U	20 U	20 U	20 U
RSD	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE D.19. Surrogate Percent Recoveries and Quality Control Data for Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs) in Sediment, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Surrogate Percent Recoveries	
	PCB 103	PCB 198
TB-1 Lower	69	68
TB-2 Lower	64	53
TB-3 Lower	73	60
TB-4 Middle	65	70
TB-4 Lower	79	62
TB-5 Lower	75	62
TB-6 Lower	73	59
TB-7 Lower	78	65
TB-8 Lower	74	62
TB-9 Lower, Replicate 1	79	64
TB-9 Lower, Replicate 2	75	61
TB-9 Lower, Replicate 3	78	65
OBM COMP	70	63
R-OS	81	67
R-BF	77	61
R-AM	81	58
Quality Control Data		
Method Blank		
Blank	64	62
Matrix Spike		
OBM COMP	70	63
OBM COMP, MS	70	62
Standard Reference Material		
Certified SRM not available for PCBs.		
Analytical Replicates		
TB-9 Lower, Replicate 1	79	64
TB-9 Lower, Replicate 2	75	61
TB-9 Lower, Replicate 3	78	65

TABLE D.20. Metals Analysis in Sediment, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Metals (mg/kg dry weight)									
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Target DL[a]	0.1	2.5	0.1	33	5.5	0.02	7.5	6.2	0.10	7.8
Achieved DL	0.01	2.5	0.01	33	5.5	0.002	7.5	6.2	0.17	7.8
TB-1 Lower	0.10	6.07	0.25	231	20.9	0.059	55.3	11.1	0.17 U[b]	51.2
TB-2 Lower	0.11	10.2	0.21	221	39.8	0.071	84.4	11.8	0.17 U	88.6
TB-3 Lower	0.11	9.2	0.20	184	36.1	0.058	85.1	9.3	0.17 U	85.4
TB-4 Midddle	0.65	16.5	0.54	182	74.0	0.734	94.6	43.9	0.39	185
TB-4 Lower	0.11	9.7	0.17	181	44.3	0.076	93.6	12.1	0.17 U	90.7
TB-5 Lower, Replicate 1	0.10	10.0	0.21	202	43.2	0.029	94.7	10.7	0.17 U	92.4
TB-5 Lower, Replicate 2	0.10	9.0	0.20	174	39.3	0.073	98.1	11.9	0.17 U	95.3
TB-5 Lower, Replicate 3	0.10	11.2	0.21	201	41.1	0.071	99.9	9.2	0.17 U	95.1
TB-6 Lower	0.12	12.4	0.20	173	53.4	0.037	113	8.4	0.17 U	105
TB-7 Lower	0.11	9.8	0.20	188	42.4	0.038	92.7	11.1	0.19	95.8
TB-8 Lower	0.10	10.7	0.21	182	45.8	0.066	101	10.3	0.19	97.2
TB-9 Lower	0.10	7.8	0.15	196	41.2	0.068	87.9	14.1	0.17 U	82.7
OBM COMP	0.11	3.28	0.56	142	27.4	0.044	62.7	10.6	0.17 U	68.3
R-OS	0.44	5.39	0.35	186	31.8	0.123	77.3	8.0	1.34	94.7
R-BF	0.44	9.4	0.14	178	60.6	0.315	111	35.3	0.29	158
R-AM	0.026	5.88	0.015	95.4	4.30	0.049	33.6	13.9	0.17 U	32.8

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE D.21. Quality Control Data for Metals Analysis in Sediment, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Metals (mg/kg dry weight)									
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Method Blank										
Blank	0.026	NA [a]	0.032	NA	NA	0.002 U [b]	NA	NA	0.17 U	NA
Matrix Spike										
TB-5 Lower [c]	0.100	NA	0.207	NA	NA	0.058	NA	NA	0.17 U	NA
TB-5 Lower, MS	2.39	NA	2.29	NA	NA	1.60	NA	NA	2.13	NA
Concentration Recovered	2.29	NA	2.08	NA	NA	1.54	NA	NA	2.13	NA
Amount Spiked	2.00	NS [d]	2.00	NS	NS	2.00	NS	NS	2.00	NS
Percent Recovery	115%	NA	104%	NA	NA	77%	NA	NA	107%	NA
Standard Reference Material										
Certified	NC [e]	11.6	0.36	76	18	0.063	32	28.2	NC	138
Value 1646	NC	±1.3	±0.07	±3	±3	±0.012	±3	±1.8	NC	±6
1646	NA	11.2	0.32	70.6	20.2	0.066	29.4	29.6	NA	138
Certified	NC	NC	NC	NC	NC	0.092	NC	NC	NC	NC
Value BEST-1	NC	NC	NC	NC	NC	±0.009	NC	NC	NC	NC
BEST-1	NA	NA	NA	NA	NA	0.090	NA	NA	NA	NA

TABLE D.21. (contd)

Sediment Treatment	Metals (mg/kg dry weight)									
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Analytical Replicate										
TB-5 Lower, Replicate 1	0.10	10.0	0.21	202	43.2	0.029	94.7	10.7	0.17 U	92.4
TB-5 Lower, Replicate 2	0.10	9.0	0.20	174	39.3	0.073	98.1	11.9	0.17 U	95.3
TB-5 Lower, Replicate 3	0.10	11.2	0.21	201	41.1	0.071	99.9	9.2	0.17 U	95.1
RSD	0%	11%	3%	8%	5%	43% (f)	3%	13%	NA	2%

(a) NA Not applicable.
(b) U Undetected at or above detection limit.
(c) Mean of replicated sample.
(d) NS Not spiked.
(e) NC Not certified.
(f) Value exceeds relative precision goal of <20%.

TABLE D.22. Sediment Butyltin Results, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Batch	Tripentyltin % Internal Standard	Butyltin Species (µg/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Target DL[a]			1.00	1.00	1.00
Achieved DL			0.48	0.56	1.82
TB-1 Lower	1	70	0.57	0.56 U[b]	1.82 U
TB-2 Lower	1	90	0.53	1.05	1.82 U
TB-3 Lower	1	92	0.49	0.56 U	1.82 U
TB-4 Midddle	1	91	3.66	0.82	1.82 U
TB-4 Lower	1	79	0.61	0.56 U	1.82 U
TB-5 Lower	1	101	0.48 U	0.76	1.82 U
TB-6 Lower	1	97	0.54	0.56 U	1.82 U
TB-7 Lower	1	94	0.52	0.56 U	1.82 U
TB-8 Lower	1	95	0.48 U	0.56 U	1.82 U
TB-9 Lower	1	99	0.48 U	0.56 U	1.82 U
OBM COMP	1	94	0.48 U	0.56 U	1.82 U
R-OS, Replicate 1	1	98	0.67	0.56 U	1.82 U
R-OS, Replicate 2	1	103	0.54	0.56 U	1.82 U
R-OS, Replicate 3	1	98	0.66	0.56 U	1.82 U
R-BF	1	104	2.27	2.11	1.82 U
R-AM	1	93	0.48 U	0.56 U	1.82 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE D.23. Quality Control Data for Sediment Butyltin Results, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Batch	Tripentyltin % Internal Standard	Butyltin Species (µg/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Method Blank					
Blank	1	101	0.55	0.56 U[a]	1.82 U
Matrix Spike					
TB-3 Lower	1	92	0.49	0.56 U	1.82 U
TB-3 Lower, MS	1	85	45.1	26.6	0.89 J[b]
Concentration Recovered		NA[c]	44.6	26.6	0.89 J
Amount Spiked		NS[d]	50.0	50.0	50.0
Percent Recovery		NA	89%	53%	2% [e]
Standard Reference Material					
Certified		NA	1270	1160	280
Value PACS-1		NA	±220	±180	±170
PACS-1	1	96	897	1080	142 [f]
Analytical Replicate					
R-OS, Replicate 1	1	98	0.67	0.56 U	1.82 U
R-OS, Replicate 2	1	103	0.54	0.56 U	1.82 U
R-OS, Replicate 3	1	98	0.66	0.56 U	1.82 U
RSD		NA	12%	NA	NA

(a) U Undetected at or above detection limit.
(b) J Analyte detected below method detection limit (MDL), but above instrument detection limit (IDL
(c) NA Not applicable.
(d) NS Not spiked.
(e) Outside quality control criteria of 40-120% for matrix spike recoveries.
(f) Outside quality control criteria (±30%) for SRMs.

APPENDIX E

BIOASSAY RESULTS FOR 10-DAY SOLID-PHASE, STATIC TEST AND 96-HOUR REFERENCE TOXICANT TEST FOR *RHEPOXYNIUS abronius*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Rhepoxynius abronius*
TEST TYPE: Solid-phase, static with aeration
TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Battelle MSL personnel collected approximately 4000 wild captured (mixed age groups) organisms from West Beach, Whidbey Island, Washington.

HOLDING/ACCLIMATION Test organisms were held for 12 days at the following conditions prior to test initation. Temperature acclimation was abrupt under normal conditions but did not appear to affect the test organisms.

	Temperature	pH	Dissolved Oxygen	Salinity
acclimation min/max	6.7-14.5°C	7.65-7.70	7.3-7.9 mg/L	30.0-31.0‰
holding min/max	13.9-15.1°C	7.57-7.86	7.7-8.9 mg/L	30.5-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing except for pH, that was above the acceptable range for C-SB for less than 24 hours, and salinity, that was above the acceptable range for OBM Comp for less than 96 hours. All water quality parameters for the cadmium reference toxicant test were within the acceptable ranges throughout the 96 hours of testing.

TEST VALIDATION The test was validated by 98% survival in the control sediment (C-WB).

REFERENCE TOXICANT TEST The test was validated by 93.3% survival in the seawater control. An LC_{50} value of 0.90 mg/L of cadmium was calculated.

COMMENTS Not applicable.

REFERENCES

ASTM (American Society for Testing and Materials). 1990. *Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods.* ASTM Designation: E 1367-90. American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE E.1. Test Results for 10-Day R. abronius Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	R. abronius Live(a)	R. abronius Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	1	18	2	0.90		
SF COMP	2	17	3	0.85		
SF COMP	3	17	3	0.85		
SF COMP	4	18	2	0.90		
SF COMP	5	19	1	0.95	0.89	0.04
SFW COMP	1	15	5	0.75		
SFW COMP	2	16	4	0.80		
SFW COMP	3	12	8	0.60		
SFW COMP	4	18	2	0.90		
SFW COMP	5	16	4	0.80	0.77	0.11
UIH COMP	1	16	4	0.80		
UIH COMP	2	15	5	0.75		
UIH COMP	3	14	6	0.70		
UIH COMP	4	17	3	0.85		
UIH COMP	5	15	5	0.75	0.77	0.06
TB UPPER COMP	1	15	5	0.75		
TB UPPER COMP	2	14	6	0.70		
TB UPPER COMP	3	16	4	0.80		
TB UPPER COMP	4	9	11	0.45		
TB UPPER COMP	5	16	4	0.80	0.70	0.15
TB LOWER COMP	1	13	7	0.65		
TB LOWER COMP	2	8	12	0.40		
TB LOWER COMP	3	12	8	0.60		
TB LOWER COMP	4	7	13	0.35		
TB LOWER COMP	5	10	10	0.50	0.50	0.13
OBM COMP	1	14	6	0.70		
OBM COMP	2	13	7	0.65		
OBM COMP	3	17	3	0.85		
OBM COMP	4	13	7	0.65		
OBM COMP	5	15	5	0.75	0.72	0.08
R-OS	1	17	3	0.85		
R-OS	2	19	1	0.95		
R-OS	3	19	1	0.95		
R-OS	4	16	4	0.80		
R-OS	5	18	2	0.90	0.89	0.07

TABLE E.1. (contd)

Sediment Treatment	Replicate	R. abronius Live(a)	R. abronius Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
R-BF	1	17	3	0.85		
R-BF	2	19	1	0.95		
R-BF	3	20	0	1.00		
R-BF	4	19	1	0.95		
R-BF	5	19	1	0.95	0.94	0.05
R-AM COMP	1	20	0	1.00		
R-AM COMP	2	20	0	1.00		
R-AM COMP	3	20	0	1.00		
R-AM COMP	4	20	0	1.00		
R-AM COMP	5	19	1	0.95	0.99	0.02
C-WB	1	20	0	1.00		
C-WB	2	19	1	0.95		
C-WB	3	20	0	1.00		
C-WB	4	20	0	1.00		
C-WB	5	19	1	0.95	0.98	0.03
C-SB	1	18	2	0.90		
C-SB	2	18	2	0.90		
C-SB	3	20	0	1.00		
C-SB	4	17	3	0.85		
C-SB	5	20	0	1.00	0.93	0.07

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

TABLE E.2. Daily Observations of R. abronius on Sediment Surface During 10-Day Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	R. abronius on Sediment for Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	0	0	1	0	0	0	0	0	0	0
SF COMP	2	0	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	1	0	0	0	0	0
SF COMP	4	0	0	0	1	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	0	1	0	0	0	0	0	0
SFW COMP	2	0	0	0	1	0	1	0	0	0	0
SFW COMP	3	0	0	0	0	2	0	0	0	0	0
SFW COMP	4	0	1	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	1	1	0	0	0	1	0
UIH COMP	1	0	0	0	1	0	0	0	0	0	0
UIH COMP	2	1	0	0	0	1	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	1	0	0	0	0	0
TB Upper COMP	3	0	0	0	1	1	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	1	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	1
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	1	0	2	0	0	0	0
TB Lower COMP	3	0	1	0	2	2	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	1	0	0	0	0	0	0	1	1	0
OBM COMP	1	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	0	0	0	0	1	0	0	0	0	0
OBM COMP	3	0	0	0	0	0	0	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	0	0	0	0	0
R-OS	1	0	0	0	0	0	0	1	1	1	0
R-OS	2	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	1	0	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	1	0	0	0	0
R-BF	1	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	1	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0

TABLE E.2. (contd)

Sediment Treatment	Replicate	R. abronius on Sediment for Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	0	0	0	0	0	0	0	1	1	0
R-AM COMP	5	0	0	0	0	0	0	0	0	0	0
C-WB	1	0	0	0	0	0	0	0	0	0	0
C-WB	2	0	0	0	0	0	0	0	0	0	0
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	1	0	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	0	1	1
C-SB	1	0	0	0	0	0	0	0	0	0	0
C-SB	2	0	0	1	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0
C-SB	4	1	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	0

TABLE E.3. Daily Observations of R. abronius Floating on Surface During 10-Day Solid-Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	R. abronius Floating for Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	0	0	0	0	0	2	2	2	3	4
SF COMP	2	0	0	0	0	0	0	0	1	0	2
SF COMP	3	0	0	1	2	4	3	0	4	0	2
SF COMP	4	0	0	0	2	2	1	4	0	6	4
SF COMP	5	0	1	2	2	1	1	1	4	1	3
SFW COMP	1	1	0	4	5	2	2	5	4	5	4
SFW COMP	2	3	4	3	3	4	8	3	4	3	8
SFW COMP	3	0	2	3	2	3	5	3	4	3	2
SFW COMP	4	0	0	0	1	1	0	0	2	0	1
SFW COMP	5	0	0	0	0	2	0	2	3	2	3
UIH COMP	1	1	2	1	1	2	1	0	1	1	3
UIH COMP	2	0	1	1	2	2	2	2	0	3	2
UIH COMP	3	0	0	1	0	1	3	3	4	2	1
UIH COMP	4	0	0	0	0	2	1	1	2	0	3
UIH COMP	5	2	0	1	0	3	3	5	0	2	3
TB Upper COMP	1	0	0	0	1	1	1	2	2	2	1
TB Upper COMP	2	0	0	0	0	1	0	1	2	1	1
TB Upper COMP	3	0	1	3	1	3	1	1	1	2	2
TB Upper COMP	4	0	0	0	0	0	0	2	0	1	1
TB Upper COMP	5	0	1	1	3	1	2	3	1	4	1
TB Lower COMP	1	0	0	1	0	0	0	0	0	4	1
TB Lower COMP	2	0	1	0	1	0	3	2	1	0	2
TB Lower COMP	3	0	1	0	1	0	3	1	1	0	1
TB Lower COMP	4	1	0	0	0	1	0	2	0	3	1
TB Lower COMP	5	0	0	1	0	0	2	2	0	1	0
OBM COMP	1	0	0	3	0	1	0	6	3	4	5
OBM COMP	2	0	0	1	3	1	3	1	2	3	3
OBM COMP	3	0	2	2	3	2	4	2	2	3	5
OBM COMP	4	1	2	2	2	3	1	3	0	3	3
OBM COMP	5	0	0	0	0	0	1	2	2	1	1
R-OS	1	1	0	1	2	0	0	1	1	1	2
R-OS	2	1	0	1	1	0	1	0	0	0	1
R-OS	3	0	0	0	1	0	1	2	0	0	0
R-OS	4	0	1	1	0	1	2	0	1	0	1
R-OS	5	0	0	1	0	1	2	1	2	2	1
R-BF	1	0	1	0	1	3	1	2	1	1	1
R-BF	2	0	0	1	0	0	2	3	1	2	0
R-BF	3	0	0	0	2	1	0	2	3	1	0
R-BF	4	1	1	0	2	0	2	1	3	2	1
R-BF	5	1	0	1	2	2	3	0	2	1	1

TABLE E.3. (contd)

Sediment Treatment	Replicate	R. abronius Floating for Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	1
R-AM COMP	3	1	0	0	0	0	1	0	0	0	0
R-AM COMP	4	0	0	0	0	0	0	0	0	0	0
R-AM COMP	5	0	0	0	0	1	0	0	0	0	0
C-WB	1	0	0	0	0	0	0	0	0	0	0
C-WB	2	0	0	0	0	0	0	0	0	0	0
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	0	0	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	1	0	0
C-SB	1	0	0	0	0	1	0	0	1	2	1
C-SB	2	0	2	0	0	0	0	0	0	3	0
C-SB	3	1	0	0	0	1	0	1	1	2	0
C-SB	4	0	0	1	0	1	1	0	0	0	2
C-SB	5	0	0	2	0	0	0	1	0	0	0

TABLE E.4. Water Quality Summary for 10-Day R. abronius Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Temperature (C°)		pH		Dissolved Oxygen (mg/L)		Salinity o/oo	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA (a)	28.0	32.0
SF COMP	14.6	15.9	7.74	7.97	7.3	8.5	31.0	32.0
SFW COMP	14.6	15.9	7.61	8.06	7.4	8.3	31.0	32.0
UIH COMP	14.6	15.9	7.72	8.11	7.3	8.5	31.0	32.0
TB Upper COMP	14.6	15.8	7.71	8.17	7.4	8.4	30.0	32.0
TB Lower COMP	14.6	15.9	7.65	8.18	7.3	8.4	30.0	32.0
OBM COMP	14.6	16.1	7.89	8.10	7.2	8.6	31.0	32.5 (b)
R-OS	14.6	15.9	7.49	8.01	7.4	8.4	31.0	32.0
R-BF	14.7	15.9	7.49	7.92	7.5	8.5	30.0	32.0
R-AM COMP	14.6	15.7	7.49	7.97	7.3	8.5	31.0	32.0
C-WB	14.6	16.0	7.67	7.99	7.3	8.3	31.5	32.0
C-SB	14.6	15.9	7.76	8.40 (b)	7.2	8.4	31.0	32.0

(a) NA Not applicable.
(b) Data point out of range.

TABLE E.5. Ammonia Measurements in Overlying Water for 10-Day R. abronius Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	Ammonia (mg/L)				
	Day 0	Day 1	Day 3	Day 7	Day 10
SF COMP	1.81	3.80	1.94	5.13	1.43
SFW COMP	4.55	8.79	8.95	9.99	1.84
UIH COMP	8.47	10.7	13.1	11.7	1.76
TB Upper COMP	3.33	9.35	9.70	9.45	1.80
TB Lower COMP	12.6	20.8	26.5	25.7	5.49
OBM COMP	1.11	1.96	2.14	3.34	1.32
R-OS	0.65	1.09	0.272	1.48	1.42
R-BF	0.78	1.43	1.74	0.700	1.23
R-AM COMP	0.42	0.493	0.261	0.896	1.19
C-WB	0.82	0.947	0.802	1.31	1.45
C-SB	0.76	1.94	0.844	1.14	1.30

TABLE E.6. Water Quality Measurements in Porewater for 10-Day R. abronius Solid-Phase, Static Test, Richmond Harbor Deepening Project

Sediment Treatment	pH		Salinity (o/oo)		Porewater Ammonia (mg/L)	
	Min	Max	Min	Max	Day 0	Day 10
SF COMP	7.57	7.99	32.0	32.0	6.64	2.62
SFW COMP	7.70	8.08	32.0	32.0	9.64	3.08
UIH COMP	7.79	7.94	32.0	32.0	13.70	3.00
TB Upper COMP	7.81	7.97	32.0	32.0	12.30	1.70
TB Lower COMP	7.88	8.11	31.5	31.5	24.9	13.8
OBM COMP	8.08	8.30	32.0	32.0	2.53	2.49
R-OS	7.87	8.00	32.0	32.0	3.61	1.05
R-BF	7.61	7.96	32.0	32.0	3.38	0.66
R-AM COMP	7.92	7.93	32.0	32.0	3.25	1.03
C-WB	7.71	7.71	32.0	32.0	4.99	NI (a)
C-SB	7.82	7.85	32.0	32.0	4.22	1.07

(a) NI Not initiated; not enough water in sediment sample.

TABLE E.7. Test Results for 96-Hour R. abronius Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project

Cadmium Concentration (mg/L)	Replicate	R. abronius		Proportion Surviving	Mean Proportion Surviving	Standard Deviation
		Live(a)	Dead or Missing			
0.00	1	19	1	0.95		
0.00	2	17	3	0.85		
0.00	3	20	0	1.00	0.93	0.08
0.38	1	15	5	0.75		
0.38	2	10	10	0.50		
0.38	3	5	15	0.25	0.50	0.25
0.75	1	11	9	0.55		
0.75	2	12	8	0.60		
0.75	3	15	5	0.75	0.63	0.10
1.50	1	5	15	0.25		
1.50	2	3	17	0.15		
1.50	3	3	17.	0.15	0.18	0.06
3.00	1	0	20	0.00		
3.00	2	0	20	0.00		
3.00	3	0	20	0.00	0.00	0.00

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

TABLE E.8. Daily Observations of R. abronius Floating on Surface During 96-Hour 96-Hour Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project

Cadmium Concentration (mg/L)	Replicate	R. abronius Floating on Surface			
		2 h	24 h	48 h	72 h
0.00	1	1	0	0	0
0.00	2	0	0	0	0
0.00	3	0	1	0	0
0.38	1	0	0	3	2
0.38	2	0	2	3	0
0.38	3	0	1	1	0
0.75	1	0	0	0	0
0.75	2	0	2	0	0
0.75	3	1	5	5	0
1.50	1	0	1	6	0
1.50	2	0	1	5	0
1.50	3	0	3	3	0
3.00	1	0	6	3	0
3.00	2	1	4	4	2
3.00	3	0	2	5	0

TABLE E.9. Water Quality Summary for 96-Hour R. abronius Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project

Cadmium Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	5.0	NA (a)	28.0	32.0
0.00	15.1	15.5	7.83	7.96	7.4	8.4	31.5	32.0
0.38	15.1	15.5	7.83	7.92	7.3	8.6	31.5	32.0
0.75	15.1	15.5	7.84	7.93	7.6	8.6	31.0	32.0
1.50	15.1	15.4	7.79	7.91	7.7	8.7	31.5	32.0
3.00	15.2	15.5	7.79	7.85	7.4	8.7	31.5	32.0

(a) NA Not applicable.

APPENDIX F

INTENSIVE STUDY OF THE TURNING BASIN BIOASSAY RESULTS FOR 10-DAY SOLID-PHASE, STATIC TEST AND 96-HOUR REFERENCE TOXICANT TEST FOR *RHEPOXYNIUS abronius*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin
TEST ORGANISM: *Rhepoxynius abronius*
TEST TYPE: Solid-phase; static with aeration
TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from October 11-13, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Battelle MSL personnel collected approximately 5000 wild capture (mixed age groups) organisms from West Beach, Whidbey Island, Washington.

HOLDING/ACCLIMATION Test organisms were held for 4 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	11.1-14.2°C	7.55-7.80	6.1-7.5 mg/L	30.5-31.5‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing except for the pH and salinity in a few replicates. These exceedences did not appear to effect the test organisms. Ammonia was measured in the overlying and interstitial water in "dummy" jars on Day 0 and 10. Ammonia in the overlying water was measured in the test jars on Days 0, 1, 3, 7, and 10. All water quality parameters for the cadmium and ammonia reference toxicant tests were within the acceptable ranges throughout the 96 hours of testing.

TEST VALIDATION The test was validated by 98% survival in the control sediment (C-WB).

REFERENCE TOXICANT TEST The cadmium chloride reference toxicant test was validated by 95% survival in the seawater control. An LC_{50} value of 0.81 mg/L of cadmium was calculated.

The ammonia reference toxicant test was validated by 100% survival in the seawater control. An LC_{50} value of 80.57 mg/L of ammonia was calculated.

COMMENTS Not applicable.

REFERENCES

ASTM (American Society for Testing and Materials). 1990. *Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods.* ASTM Designation: E 1367-90. American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA/USACE (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE F.1. Test Results for 10-Day *R. abronius* Solid-Phase Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	Live[(a)]	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
TB-1 Lower	1	17	3	0.85		
TB-1 Lower	2	17	3	0.85		
TB-1 Lower	3	16	4	0.80		
TB-1 Lower	4	17	3	0.85		
TB-1 Lower	5	20	0	1.00	0.87	0.08
TB-2 Lower	1	14	6	0.70		
TB-2 Lower	2	10	10	0.50		
TB-2 Lower	3	8	12	0.40		
TB-2 Lower	4	11	9	0.55		
TB-2 Lower	5	9	11	0.45	0.52	0.12
TB-3 Lower	1	4	16	0.20		
TB-3 Lower	2	7	13	0.35		
TB-3 Lower	3	2	18	0.10		
TB-3 Lower	4	6	14	0.30		
TB-3 Lower	5	6	14	0.30	0.25	0.10
TB-4 Middle	1	17	3	0.85		
TB-4 Middle	2	13	7	0.65		
TB-4 Middle	3	17	3	0.85		
TB-4 Middle	4	16	4	0.80		
TB-4 Middle	5	19	1	0.95	0.82	0.12
TB-4 Lower	1	16	4	0.80		
TB-4 Lower	2	19	1	0.95		
TB-4 Lower	3	16	4	0.80		
TB-4 Lower	4	12	8	0.60		
TB-4 Lower	5	13	7	0.65	0.76	0.14
TB-5 Lower	1	14	6	0.70		
TB-5 Lower	2	15	5	0.75		
TB-5 Lower	3	11	9	0.55		
TB-5 Lower	4	12	8	0.60		
TB-5 Lower	5	10	10	0.50	0.62	0.10

TABLE F.1. (contd)

Sediment Treatment	Replicate	Live	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
TB-6 Lower	1	12	8	0.60		
TB-6 Lower	2	16	4	0.80		
TB-6 Lower	3	15	5	0.75		
TB-6 Lower	4	17	3	0.85		
TB-6 Lower	5	16	4	0.80	0.76	0.10
TB-7 Lower	1	10	10	0.50		
TB-7 Lower	2	11	9	0.55		
TB-7 Lower	3	9	11	0.45		
TB-7 Lower	4	14	6	0.70		
TB-7 Lower	5	11	9	0.55	0.55	0.09
TB-8 Lower	1	15	5	0.75		
TB-8 Lower	2	12	8	0.60		
TB-8 Lower	3	10	10	0.50		
TB-8 Lower	4	13	7	0.65		
TB-8 Lower	5	14	6	0.70	0.64	0.10
TB-9 Lower	1	8	12	0.40		
TB-9 Lower	2	3	17	0.15		
TB-9 Lower	3	4	16	0.20		
TB-9 Lower	4	4	16	0.20		
TB-9 Lower	5	9	11	0.45	0.28	0.14
OBM COMP	1	13	7	0.65		
OBM COMP	2	15	5	0.75		
OBM COMP	3	16	4	0.80		
OBM COMP	4	13	7	0.65		
OBM COMP	5	11	9	0.55	0.68	0.10
R-OS	1	19	1	0.95		
R-OS	2	17	3	0.85		
R-OS	3	19	1	0.95		
R-OS	4	20	0	1.00		
R-OS	5	19	1	0.95	0.94	0.05

TABLE F.1. (contd)

Sediment Treatment	Replicate	Live	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
R-BF	1	19	1	0.95		
R-BF	2	17	3	0.85		
R-BF	3	15	5	0.75		
R-BF	4	19	1	0.95		
R-BF	5	14	6	0.70	0.84	0.11
R-AM	1	17	3	0.85		
R-AM	2	20	0	1.00		
R-AM	3	20	0	1.00		
R-AM	4	20	0	1.00		
R-AM	5	20	0	1.00	0.97	0.07
C-WB	1	19	1	0.95		
C-WB	2	19	1	0.95		
C-WB	3	20	0	1.00		
C-WB	4	20	0	1.00		
C-WB	5	20	0	1.00	0.98	0.03
C-SB	1	18	2	0.90		
C-SB	2	17	3	0.85		
C-SB	3	17	3	0.85		
C-SB	4	20	0	1.00		
C-SB	5	17	3	0.85	0.89	0.07

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

TABLE F.2. Daily Observations of *R. abronius* on Sediment During 10-Day Solid-Phase, Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* on Sediment for Day 0 through 9									
		0[(a)]	1	2	3	4	5	6	7	8	9
TB-1 Lower	1	0	0	0	0	0	0	0	0	1	0
TB-1 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-1 Lower	3	0	0	0	0	0	0	0	0	1	0
TB-1 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-1 Lower	5	0	1	0	0	1	0	0	0	0	0
TB-2 Lower	1	0	0	0	2	0	0	0	2	2	3
TB-2 Lower	2	0	0	0	0	0	0	0	1	3	3
TB-2 Lower	3	0	0	0	0	0	0	0	0	0	1
TB-2 Lower	4	1	0	0	0	0	0	0	0	1	0
TB-2 Lower	5	0	0	0	1	1	0	1	1	1	1
TB-3 Lower	1	0	1	0	0	0	0	0	0	1	2
TB-3 Lower	2	1	0	0	0	2	0	2	1	2	0
TB-3 Lower	3	2	0	0	0	0	0	0	0	1	0
TB-3 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	5	0	0	0	0	0	0	1	0	1	0
TB-4 Middle	1	2	1	0	1	0	0	0	1	1	1
TB-4 Middle	2	0	1	0	0	0	0	0	0	1	1
TB-4 Middle	3	1	1	0	0	0	0	0	0	0	1
TB-4 Middle	4	1	0	0	0	0	0	0	0	0	0
TB-4 Middle	5	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	1	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	3	1	1	0	0	1	0	0	0	0	0
TB-4 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	5	1	0	0	0	0	0	0	0	0	0
TB-5 Lower	1	0	0	0	0	1	0	1	1	1	0
TB-5 Lower	2	0	0	0	0	0	0	0	0	0	1
TB-5 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	4	0	0	0	0	0	0	0	1	1	1
TB-5 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-6 Lower	1	1	0	0	1	0	0	0	0	0	0
TB-6 Lower	2	0	1	0	0	0	0	0	0	0	0
TB-6 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-6 Lower	4	0	1	0	0	0	0	0	0	0	0
TB-6 Lower	5	1	0	0	0	0	0	0	0	1	0

TABLE F.2. (contd)

Sediment Treatment	Replicate	*R. abronius* on Sediment for Day 0 through 9									
		0	1	2	3	4	5	6	7	8	9
TB-7 Lower	1	0	0	0	1	0	0	0	0	1	0
TB-7 Lower	2	0	0	0	0	0	0	1	1	1	1
TB-7 Lower	3	0	1	0	1	1	0	0	0	0	0
TB-7 Lower	4	0	1	0	0	0	0	0	0	0	0
TB-7 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-8 Lower	1	1	0	0	0	0	0	0	0	0	0
TB-8 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-8 Lower	3	0	0	0	1	1	1	1	0	0	0
TB-8 Lower	4	1	0	0	0	0	0	0	0	0	0
TB-8 Lower	5	0	0	0	0	0	0	0	1	0	0
TB-9 Lower	1	0	0	0	0	0	0	0	1	3	4
TB-9 Lower	2	0	0	0	1	1	0	0	1	6	4
TB-9 Lower	3	0	1	0	2	0	0	0	0	3	4
TB-9 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	5	0	0	0	0	0	0	1	2	2	2
OBM COMP	1	0	0	0	1	0	0	1	0	1	0
OBM COMP	2	1	0	0	0	0	0	0	0	0	0
OBM COMP	3	0	0	0	0	0	0	0	0	1	1
OBM COMP	4	1	0	0	1	2	2	3	1	T[(b)]	0
OBM COMP	5	1	0	0	0	0	0	0	0	2	0
R-OS	1	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	1	1	0	0	0	0	0
R-OS	3	0	0	0	0	0	0	1	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	1	1	0	1	1
R-BF	1	0	1	0	0	0	0	1	0	2	0
R-BF	2	1	0	0	0	1	0	1	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0
R-AM	1	0	0	0	0	1	0	0	1	1	1
R-AM	2	0	0	0	0	0	0	0	0	0	0
R-AM	3	0	1	0	0	0	0	0	0	0	2
R-AM	4	0	0	0	0	0	0	0	0	0	0
R-AM	5	1	0	0	0	0	0	0	0	0	0

TABLE F.2. (contd)

Sediment Treatment	Replicate	*R. abronius* on Sediment for Day 0 through 9									
		0	1	2	3	4	5	6	7	8	9
C-WB	1	0	0	0	0	0	0	0	0	1	1
C-WB	2	0	0	0	0	0	0	0	1	1	1
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	0	1	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	0	0	0
C-SB	1	0	0	0	1	1	1	1	1	1	0
C-SB	2	0	1	0	2	0	0	0	0	0	0
C-SB	3	0	0	0	0	1	0	1	0	2	0
C-SB	4	0	0	0	0	0	0	0	0	2	0
C-SB	5	0	1	0	1	2	0	1	0	1	0

(a) On Test Day 0 observations were performed 2 hours after test initiation.
(b) T Too turbid for observations.

TABLE F.3. Daily Observations of *R. abronius* Floating on Surface During 10-Day Solid-Phase, Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* Floating on Surface for Day 0 through 9									
		0[(a)]	1	2	3	4	5	6	7	8	9
TB-1 Lower	1	0	0	0	1	0	0	4	0	2	0
TB-1 Lower	2	0	0	1	0	0	2	0	3	2	1
TB-1 Lower	3	0	2	0	1	1	1	0	0	1	2
TB-1 Lower	4	0	0	2	1	1	2	2	3	2	1
TB-1 Lower	5	0	0	0	1	0	2	2	1	2	2
TB-2 Lower	1	0	0	0	0	1	0	2	0	0	1
TB-2 Lower	2	0	0	1	0	0	1	2	0	0	0
TB-2 Lower	3	0	0	0	0	1	0	0	0	1	0
TB-2 Lower	4	0	0	0	0	0	1	0	0	0	0
TB-2 Lower	5	1	0	0	0	1	0	0	0	2	2
TB-3 Lower	1	0	0	0	0	1	1	1	0	0	0
TB-3 Lower	2	0	0	0	0	0	1	0	0	0	0
TB-3 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	4	0	0	0	2	0	0	0	0	2	0
TB-3 Lower	5	0	0	0	0	1	0	2	0	0	0
TB-4 Middle	1	0	0	0	1	1	1	2	1	1	1
TB-4 Middle	2	0	0	0	0	0	1	1	1	0	1
TB-4 Middle	3	0	0	0	3	0	2	0	2	2	2
TB-4 Middle	4	0	0	0	1	1	0	0	0	0	0
TB-4 Middle	5	0	1	0	0	1	1	1	1	1	0
TB-4 Lower	1	0	0	0	0	0	0	0	1	0	0
TB-4 Lower	2	0	0	0	1	0	1	1	0	1	0
TB-4 Lower	3	0	1	0	1	0	0	2	3	1	0
TB-4 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	5	1	0	0	0	0	0	0	1	1	1
TB-5 Lower	1	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	2	0	0	0	0	1	1	0	1	0	2
TB-5 Lower	3	0	0	0	0	2	0	0	0	0	0
TB-5 Lower	4	0	0	1	1	4	1	1	0	1	0
TB-5 Lower	5	0	0	0	0	0	0	0	1	0	0
TB-6 Lower	1	0	1	0	0	1	0	0	1	0	2
TB-6 Lower	2	0	0	0	1	0	0	0	1	0	0
TB-6 Lower	3	0	0	1	0	2	0	0	1	0	0
TB-6 Lower	4	0	0	1	0	0	2	1	0	2	1
TB-6 Lower	5	0	0	0	0	1	2	0	0	0	0

TABLE F.3. (contd)

Sediment Treatment	Replicate	*R. abronius* Floating on Surface for Day 0 through 9									
		0	1	2	3	4	5	6	7	8	9
TB-7 Lower	1	0	0	0	0	0	1	1	1	0	0
TB-7 Lower	2	0	0	1	1	1	3	1	0	1	0
TB-7 Lower	3	0	0	0	2	0	0	0	1	0	0
TB-7 Lower	4	0	0	0	0	0	1	0	0	0	0
TB-7 Lower	5	0	0	0	0	0	0	1	2	0	1
TB-8 Lower	1	0	0	0	0	0	1	2	1	1	1
TB-8 Lower	2	0	0	0	1	0	0	0	0	0	0
TB-8 Lower	3	0	0	0	0	0	1	0	0	1	1
TB-8 Lower	4	0	0	0	0	0	0	0	0	1	0
TB-8 Lower	5	0	0	0	0	0	0	0	0	0	1
TB-9 Lower	1	0	0	0	0	0	0	0	0	0	3
TB-9 Lower	2	0	0	0	0	0	3	1	0	0	0
TB-9 Lower	3	0	0	0	0	0	2	0	1	0	1
TB-9 Lower	4	0	0	0	0	0	1	0	0	0	0
TB-9 Lower	5	0	0	0	0	0	0	0	0	0	2
OBM COMP	1	0	0	0	0	0	0	1	0	0	0
OBM COMP	2	0	0	0	1	0	0	0	0	0	0
OBM COMP	3	0	1	0	0	0	0	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	0	0	0	0	0
R-OS	1	0	T[(b)]	0	1	1	1	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	1	0
R-OS	3	0	T	0	0	0	0	0	0	0	0
R-OS	4	0	T	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0
R-BF	1	0	0	0	0	0	1	2	1	1	2
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	1	0	0	0	0
R-BF	5	0	0	0	0	1	1	0	0	0	0
R-AM	1	0	0	0	0	0	0	0	0	0	0
R-AM	2	0	0	0	0	0	0	0	0	0	0
R-AM	3	0	0	0	0	0	0	0	0	0	0
R-AM	4	0	0	0	0	0	0	0	0	0	0
R-AM	5	0	0	0	0	0	0	0	0	0	0

TABLE F.3. (contd)

Sediment Treatment	Replicate	*R. abronius* Floating on Surface for Day 0 through 9									
		0	1	2	3	4	5	6	7	8	9
C-WB	1	0	0	0	0	0	0	0	0	0	0
C-WB	2	0	0	0	0	0	0	0	0	0	0
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	0	0	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	0	0	0
C-SB	1	0	2	0	2	0	4	2	1	3	3
C-SB	2	1	0	1	2	1	2	2	1	2	2
C-SB	3	0	0	2	3	3	1	3	1	3	1
C-SB	4	1	1	2	2	5	1	0	0	0	2
C-SB	5	0	3	0	4	1	4	4	3	4	2

(a) On Test Day 0 observations were performed 2 hours after test initiation.
(b) T Too turbid for observations.

TABLE F.4. Water Quality Summary for 10-day *R. abronius* Solid-Phase, Static Test
Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA [a]	28.0	32.0
TB-1 Lower	15.0	15.9	7.95	8.14	7.5	7.9	30.5	32.0
TB-2 Lower	15.0	15.9	8.15	8.39 [b]	7.3	7.9	30.0	31.5
TB-3 Lower	15.0	16.0	8.14	8.42 [b]	7.3	7.9	30.0	31.5
TB-4 Middle	15.0	15.9	8.08	8.40 [b]	7.2	7.9	30.5	31.5
TB-4 Lower	15.0	15.5	8.11	8.29	7.4	7.9	30.5	31.5
TB-5 Lower	15.1	16.0	8.11	8.37 [b]	7.3	7.9	30.0	31.5
TB-6 Lower	15.1	16.0	7.99	8.19	7.4	8.0	30.0	31.0
TB-7 Lower	15.0	15.8	8.02	8.26	7.1	7.9	30.0	30.5
TB-8 Lower	15.1	15.9	8.07	8.28	7.3	8.0	30.0	31.0
TB-9 Lower	14.9	15.8	8.10	8.41 [b]	7.4	7.9	30.5	32.0
OBM COMP	15.0	15.8	7.98	8.18	7.6	8.0	31.0	33.0 [b]
R-OS	15.0	15.9	7.94	8.11	7.5	7.9	31.0	33.0 [b]
R-BF	15.1	15.8	7.86	8.09	7.4	7.8	31.0	32.5 [b]
R-AM	15.0	15.9	7.87	8.10	7.4	7.9	30.5	33.0 [b]
C-WB	15.0	15.9	7.80	8.09	7.3	7.9	31.0	32.5 [b]
C-SB	15.0	15.9	7.81	8.19	7.3	7.9	31.0	33.0 [b]

(a) NA Not applicable.
(b) Data point out of range.

TABLE F.5. Ammonia Measurements in Overlying Water for 10-Day *R. abronius* Solid-Phase, Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-1 Lower	3.10	16.3	8.03	7.5	31.0
TB-2 Lower	13.4	16.0	8.39	7.7	30.5
TB-3 Lower	11.7	16.1	8.45	7.8	30.5
TB-4 Middle	12.5	16.3	8.13	6.8	31.0
TB-4 Lower	10.6	16.3	8.18	7.5	31.0
TB-5 Lower	11.6	16.0	8.28	7.5	30.0
TB-6 Lower	7.82	15.9	8.17	7.6	30.0
TB-7 Lower	8.38	15.8	8.25	7.6	30.0
TB-8 Lower	7.46	15.9	8.21	7.5	30.5
TB-9 Lower	25.3	15.9	8.40	7.8	30.0
OBM COMP	0.734	15.9	8.21	7.7	31.0
R-OS	0.447	15.9	8.12	7.7	32.0
R-BF	2.71	16.1	8.11	7.6	31.5
R-AM	0.140	15.9	8.05	7.7	31.0
C-WB	0.347	16.0	7.95	7.4	32.0
C-SB	1.67	16.0	8.08	7.5	31.5
			Day 1		
TB-1 Lower	3.06	14.8	8.05	7.7	30.5
TB-2 Lower	16.1	14.9	8.35	7.6	30.5
TB-3 Lower	12.3	14.8	8.31	7.7	31.0
TB-4 Middle	13.0	14.7	8.22	7.5	30.5
TB-4 Lower	14.2	14.6	8.22	7.6	31.0
TB-5 Lower	10.2	14.6	8.32	7.6	30.5
TB-6 Lower	10.9	15.0	8.15	7.5	30.0
TB-7 Lower	11.3	15.0	8.21	7.5	30.5
TB-8 Lower	5.57	14.6	8.19	7.4	30.5
TB-9 Lower	18.5	14.8	8.30	7.6	30.5
OBM COMP	0.639	15.1	8.10	7.7	31.0
R-OS	0.396	14.5	8.07	7.6	31.0
R-BF	2.83	14.8	8.08	7.6	31.0
R-AM	0.180	14.8	8.02	7.7	30.5
C-WB	0.330	14.8	7.92	7.4	31.0
C-SB	1.61	14.8	8.02	7.6	31.0

TABLE F.5. (contd)

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 3		
TB-1 Lower	2.55	15.3	8.06	7.9	31.5
TB-2 Lower	14.3	15.2	8.39	7.9	30.0
TB-3 Lower	14.4	15.3	8.38	7.8	30.5
TB-4 Middle	14.2	15.2	8.26	7.9	31.0
TB-4 Lower	14.0	15.2	8.33	7.9	31.0
TB-5 Lower	12.7	15.3	8.34	7.8	30.5
TB-6 Lower	11.4	15.1	8.20	8.0	30.0
TB-7 Lower	12.1	15.3	8.06	7.7	30.0
TB-8 Lower	8.12	15.3	8.20	7.8	30.0
TB-9 Lower	27.7	15.6	8.42	7.9	30.5
OBM COMP	0.723	15.1	8.11	7.8	31.5
R-OS	0.579	15.5	8.07	7.8	31.5
R-BF	2.60	15.5	8.10	7.8	31.5
R-AM	0.177	15.4	8.02	7.7	31.5
C-WB	0.778	15.5	8.03	7.8	31.5
C-SB	1.23	15.4	7.98	7.9	31.5
			Day 7		
TB-1 Lower	4.94	15.7	8.13	7.8	31.0
TB-2 Lower	19.0	15.7	8.35	7.8	31.5
TB-3 Lower	19.3	15.7	8.42	7.9	30.5
TB-4 Middle	21.0	15.8	8.39	7.9	31.5
TB-4 Lower	19.7	15.7	8.23	7.8	31.0
TB-5 Lower	16.4	15.7	8.33	7.7	30.5
TB-6 Lower	12.5	15.7	8.15	7.9	30.5
TB-7 Lower	13.7	15.7	8.26	7.8	30.0
TB-8 Lower	11.5	15.7	8.22	7.9	30.5
TB-9 Lower	28.3	15.8	8.40	7.7	30.5
OBM COMP	1.13	15.7	8.12	8.0	32.0
R-OS	1.12	15.7	8.08	7.9	32.0
R-BF	1.90	15.8	8.03	7.8	31.5
R-AM	0.350	15.7	8.07	7.8	31.5
C-WB	1.39	15.8	8.08	7.9	32.0
C-SB	1.08	15.7	8.03	7.8	32.0

TABLE F.5. (contd)

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 10		
TB-1 Lower	2.42	14.8	8.15	7.6	32.0
TB-2 Lower	15.8	14.7	8.34	7.4	31.0
TB-3 Lower	14.7	14.7	8.44	7.6	31.0
TB-4 Middle	15.9	14.8	8.36	7.6	31.5
TB-4 Lower	16.3	14.9	8.14	7.2	30.5
TB-5 Lower	13.6	14.7	8.36	7.5	30.5
TB-6 Lower	11.7	14.7	8.21	7.6	30.5
TB-7 Lower	12.0	14.7	8.12	7.5	30.5
TB-8 Lower	9.63	14.7	8.27	7.6	30.5
TB-9 Lower	32.1	14.6	8.33	7.5	30.5
OBM COMP	0.380	14.9	8.09	7.7	32.0
R-OS	0.566	14.9	8.12	7.6	32.5
R-BF	0.630	14.9	8.14	7.6	32.0
R-AM	0.295	14.9	8.05	7.6	32.0
C-WB	0.564	14.9	8.08	7.6	32.0
C-SB	0.597	14.9	8.34	7.5	32.0

TABLE F.6. Water Quality Measurements in Porewater for 10-Day *R. abronius* Solid-Phase, Static Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-1 Lower	8.18	15.8	7.85	6.7	30.0
TB-2 Lower	31.4	15.4	8.08	4.4	30.0
TB-3 Lower	24.7	15.5	8.11	4.9	30.0
TB-4 Middle	33.4	15.0	7.90	3.7	30.0
TB-4 Lower	32.9	15.8	7.93	4.7	29.5
TB-5 Lower	22.4	15.4	8.05	4.8	30.0
TB-6 Lower	20.0	14.6	7.70	4.8	28.5
TB-7 Lower	17.9	14.1	8.07	4.4	29.0
TB-8 Lower	16.2	15.2	8.00	4.6	29.5
TB-9 Lower	38.5	14.8	7.93	4.4	30.0
OBM COMP	1.14	14.7	8.31	5.8	32.0
R-OS	1.18	14.7	7.95	5.3	32.0
R-BF	6.98	15.4	7.45	4.0	31.5
R-AM	0.476	14.4	7.84	7.5	32.0
C-WB	2.20	15.6	7.79	5.6	31.0
C-SB	2.46	15.4	7.71	3.6	32.0
			Day 10		
TB-1 Lower	5.61	15.6	7.75	6.8	32.0
TB-2 Lower	23.7	15.5	7.98	4.9	31.0
TB-3 Lower	21.9	15.4	7.98	4.8	31.0
TB-4 Middle	24.9	15.6	7.68	4.3	32.0
TB-4 Lower	23.6	15.6	7.86	5.3	32.0
TB-5 Lower	19.2	15.5	7.92	4.9	30.5
TB-6 Lower	15.6	15.5	7.67	5.5	29.5
TB-7 Lower	14.9	15.5	7.82	5.4	30.0
TB-8 Lower	14.9	15.5	7.82	5.0	30.5
TB-9 Lower	39.4	15.3	7.86	4.6	30.5
OBM COMP	0.637	15.5	8.25	6.7	31.5
R-OS	1.01	15.5	7.76	5.4	32.5
R-BF	2.11	15.5	7.46	4.4	32.0
R-AM	0.156	15.6	7.47	NA [a]	32.0
C-WB	2.71	15.5	7.60	NA	32.0
C-SB	1.08	15.4	7.30	4.2	32.0

(a) NA Not applicable.

TABLE F.7. Test Results for 96-Hour *R. abronius* Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration (mg/L)	Live[(a)]	Dead or Missing	Proportion Surviving
0.00	19	1	0.95
0.25	15	5	0.75
0.50	12	8	0.60
1.00	10	10	0.50
1.50	5	15	0.25
2.00	2	18	0.10
4.00	0	20	0.00

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

TABLE F.8. Daily Observations of *R. abronius* Floating on Surface During 96-Hour Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration (mg/L)	*R. abronius* Floating on Surface			
	2 h	24 h	48 h	72 h
0.00	0	0	0	2
0.25	0	2	1	1
0.50	1	4	3	0
1.00	0	3	2	0
1.50	2	3	2	0
2.00	0	4	0	0
4.00	0	3	0	0

TABLE F.9. Water Quality Summary for 96-Hour *R. abronius* Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration mg/L	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA[(a)]	28.0	32.0
0.00	15.1	15.5	7.78	8.09	7.7	7.8	31.5	32.0
0.25	15.2	15.5	7.73	8.09	7.7	8.0	31.5	32.0
0.50	15.2	15.4	7.78	8.08	7.8	8.1	31.5	32.0
1.00	15.1	15.5	7.77	8.05	7.8	8.0	31.5	32.0
1.50	15.2	15.5	7.71	8.04	7.9	8.1	31.5	32.0
2.00	15.1	15.5	7.62	8.01	7.8	8.0	31.5	32.0
4.00	15.1	15.5	7.60	7.96	7.9	8.0	31.5	32.0

(a) NA Not applicable.

TABLE F.10. Test Results for 96-Hour *R. abronius* Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration mg/L	Live[(a)]	Dead or Missing	Proportion Surviving
0	20	0	1.00
10	20	0	1.00
20	20	0	1.00
40	19	1	0.95
80	13	7	0.65
120	5	15	0.25
160	0	20	0.00

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

TABLE F.11. Daily Observations of *R. abronius* Floating on Surface During 96-Hour Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration (mg/L)	*R. abronius* Floating on Surface			
	2 h	24 h	48 h	72 h
0	0	2	3	2
10	1	0	2	5
20	0	0	1	0
40	2	0	1	1
80	1	2	1	0
120	2	2	0	0
160	3	1	0	0

TABLE F.12. Water Quality Summary for 96-Hour *R. abronius* Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)	
mg/L	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA[a]	28.0	32.0	NE[b]	NE
0	15.0	15.6	7.71	8.05	7.7	7.8	31.5	32.0	0.212	0.419
10	15.0	15.6	7.65	8.04	7.8	8.0	31.5	32.0	9.15	10.5
20	14.9	15.6	7.65	8.05	7.7	8.0	31.0	32.0	17.3	21.7
40	14.9	15.5	7.60	8.08	7.8	8.1	31.0	32.0	34.7	40.0
80	14.9	15.5	7.59	8.06	7.8	8.0	31.5	32.0	66.2	78.6
120	15.0	15.5	7.60	8.03	7.8	8.1	31.5	32.0	99.5	126
160	15.0	15.5	7.45	8.01	7.8	8.1	31.5	32.0	132	179

(a) NA Not applicable.
(b) NE Not established.

APPENDIX G

INTENSIVE STUDY OF THE TURNING BASIN
BIOASSAY RESULTS FOR 10-DAY SOLID-PHASE,
AMMONIA REDUCTION TO <20 MG/L TEST FOR *RHEPOXYNIUS abronius*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

TEST ORGANISM: *Rhepoxynius abronius*

TEST TYPE: Solid-phase; flow-through to reduce ammonia to <20 mg/L then static with aeration

TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from October 11-13, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Battelle MSL personnel collected approximately 5000 wild capture (mixed age groups) organisms from West Beach, Whidbey Island, Washington.

HOLDING/ACCLIMATION Test organisms were held for 4 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	11.1-14.2°C	7.55-7.80	6.1-7.5 mg/L	30.5-31.5‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing except for salinity in a few replicates. These exceedences did not appear to effect the test organisms. Two pre-initiation "dummy" jars were measured for interstitial and overlying ammonia 4 days and 2 days prior to initiation of the organisms. When the ammonia was <20 mg/L in the interstitial water, the test was initiated. Ammonia was then measured in the overlying and interstitial water in "dummy" jars on Day 0 and 10. Ammonia in the overlying water was measured in the test jars on Days 0, 1, 3, 6, and 10. All water quality parameters for the cadmium and ammonia reference toxicant tests were within the acceptable ranges throughout the 96 hours of testing.

TEST VALIDATION The test was validated by 98% survival in the control sediment (C-WB).

QA/QC SUMMARY (contd)

REFERENCE TOXICANT TEST

The cadmium chloride reference toxicant test was validated by 95% survival in the seawater control. An LC_{50} value of 0.81 mg/L of cadmium was calculated.

The ammonia reference toxicant test was validated by 100% survival in the seawater control. An LC_{50} value of 80.57 mg/L of ammonia was calculated.

COMMENTS

Not applicable.

REFERENCES

ASTM (American Society for Testing and Materials). 1990. *Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods.* ASTM Designation: E 1367-90. American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA/USACE (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE G.1. Test Results for 10-Day *R. abronius* Solid-Phase Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	Live[(a)]	Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
TB-2 Lower	1	14	6	0.70		
TB-2 Lower	2	17	3	0.85		
TB-2 Lower	3	19	1	0.95		
TB-2 Lower	4	14	6	0.70		
TB-2 Lower	5	15	5	0.75	0.79	0.11
TB-3 Lower	1	18	2	0.90		
TB-3 Lower	2	15	5	0.75		
TB-3 Lower	3	11	9	0.55		
TB-3 Lower	4	8	12	0.40		
TB-3 Lower	5	18	2	0.90	0.70	0.22
TB-4 Middle	1	18	2	0.90		
TB-4 Middle	2	20	0	1.00		
TB-4 Middle	3	16	4	0.80		
TB-4 Middle	4	17	3	0.85		
TB-4 Middle	5	18	2	0.90	0.89	0.07
TB-4 Lower	1	16	4	0.80		
TB-4 Lower	2	18	2	0.90		
TB-4 Lower	3	14	6	0.70		
TB-4 Lower	4	15	5	0.75		
TB-4 Lower	5	18	2	0.90	0.81	0.09
TB-5 Lower	1	14	6	0.70		
TB-5 Lower	2	16	4	0.80		
TB-5 Lower	3	17	3	0.85		
TB-5 Lower	4	16	4	0.80		
TB-5 Lower	5	19	1	0.95	0.82	0.09
TB-9 Lower	1	14	6	0.70		
TB-9 Lower	2	17	3	0.85		
TB-9 Lower	3	15	5	0.75		
TB-9 Lower	4	10	10	0.50		
TB-9 Lower	5	18	2	0.90	0.74	0.16

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

TABLE G.2. Daily Observations of *R. abronius* on Sediment Surface During 10-Day Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* on Sediment for Days 0 through 9									
		0[(a)]	1	2	3	4	5	6	7	8	9
TB-2 Lower	1	0	0	0	0	0	1	1	1	1	1
TB-2 Lower	2	0	0	0	0	0	0	2	1	0	0
TB-2 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-2 Lower	4	T[(b)]	0	0	0	0	0	0	0	0	0
TB-2 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	1	0	0	0	0	0	0	1	0	0	0
TB-3 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	1	0	0	0	0	0	1	0	0	0	0
TB-4 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-4 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-4 Middle	1	0	0	0	0	0	0	0	0	0	0
TB-4 Middle	2	0	0	0	0	0	0	0	0	0	0
TB-4 Middle	3	0	0	0	0	0	0	0	0	0	0
TB-4 Middle	4	0	0	0	0	0	0	0	0	0	0
TB-4 Middle	5	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	1	0	0	0	0	0	0	0	1	0	0
TB-5 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-5 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	1	0	0	1	0	0	0	0	0	0	0
TB-9 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	5	0	0	0	0	0	0	0	0	0	0

(a) On Test Day 0 observations were performed 2 hours after test initiation.
(b) Too turbid.

TABLE G.3. Daily Observations of *R. abronius* Floating on Surface During 10-Day Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* Floating for Days 0 through 9									
		0[(a)]	1	2	3	4	5	6	7	8	9
TB-2 Lower	1	0	0	0	0	1	0	0	0	0	1
TB-2 Lower	2	0	0	0	1	1	1	0	2	3	0
TB-2 Lower	3	0	0	0	0	0	1	2	1	0	0
TB-2 Lower	4	0	0	0	0	2	0	1	1	3	1
TB-2 Lower	5	0	0	0	0	0	0	0	2	0	1
TB-3 Lower	1	1	0	0	0	1	0	2	2	0	1
TB-3 Lower	2	0	0	0	1	0	1	3	0	0	1
TB-3 Lower	3	0	0	0	0	0	1	0	0	0	1
TB-3 Lower	4	1	0	0	0	0	1	1	0	0	0
TB-3 Lower	5	0	0	0	0	2	0	1	0	1	0
TB-4 Lower	1	0	0	0	0	1	1	2	3	1	1
TB-4 Lower	2	0	0	0	0	0	0	1	1	1	0
TB-4 Lower	3	0	0	0	1	1	2	0	1	1	1
TB-4 Lower	4	0	0	1	0	0	1	0	0	0	3
TB-4 Lower	5	0	0	0	0	0	0	0	0	1	0
TB-4 Middle	1	0	0	0	0	2	3	0	4	1	5
TB-4 Middle	2	0	0	0	0	0	2	3	1	1	3
TB-4 Middle	3	0	0	0	1	0	2	1	4	3	3
TB-4 Middle	4	0	0	0	1	1	1	1	2	1	4
TB-4 Middle	5	0	1	2	0	1	2	3	4	2	1
TB-5 Lower	1	0	1	1	1	1	0	1	1	0	1
TB-5 Lower	2	0	0	0	0	0	2	0	0	2	2
TB-5 Lower	3	0	0	0	1	0	1	1	0	2	0
TB-5 Lower	4	0	0	0	1	2	1	2	2	1	3
TB-5 Lower	5	0	0	0	0	0	1	1	0	1	2
TB-9 Lower	1	0	2	0	0	0	0	0	1	1	0
TB-9 Lower	2	0	0	0	1	3	0	0	2	1	0
TB-9 Lower	3	0	0	0	0	1	1	0	1	2	1
TB-9 Lower	4	0	0	0	0	0	0	1	0	1	1
TB-9 Lower	5	0	0	0	0	0	0	0	1	0	0

(a) On Test Day 0 observations were performed 2 hours after test initiation.

TABLE G.4. Water Quality Summary for 10-day *R. abronius* Solid-Phase Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA[a]	28.0	32.0
TB-2 Lower	14.8	16.0	7.86	8.10	7.1	8.0	31.5	32.5[b]
TB-3 Lower	14.8	16.0	7.81	8.06	7.5	8.0	31.0	32.5[b]
TB-4 Middle	14.8	16.1	7.83	8.16	7.6	8.0	31.0	32.5[b]
TB-4 Lower	14.8	16.0	7.89	8.09	7.6	8.0	31.0	32.5[b]
TB-5 Lower	14.8	16.1	7.78	8.13	7.5	8.1	31.0	33.0[b]
TB-9 Lower	14.7	16.1	7.77	8.11	7.5	8.0	31.0	33.0[b]

(a) NA Not applicable.
(b) Data point out of range.

TABLE G.5. Ammonia Measurements in Overlying Water and Porewater Prior to Initiation of the 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
Overlying	4 Days Prior to Initiation				
TB-2 Lower	1.30	14.9	8.06	7.3	31.5
TB-3 Lower	3.09	14.7	7.98	7.0	31.5
TB-4 Middle	1.75	14.7	7.97	7.6	31.5
TB-4 Lower	1.57	14.8	8.07	7.6	31.5
TB-5 Lower	3.19	14.8	8.01	7.2	31.5
TB-9 Lower	4.21	14.9	8.02	7.4	31.5
Porewater	4 Days Prior to Initiation				
TB-2 Lower	20.7	15.1	7.91	4.4	30.0
TB-3 Lower	16.1	15.1	7.87	4.9	30.0
TB-4 Middle	19.1	15.4	7.61	5.0	30.5
TB-4 Lower	20.4	15.2	7.83	5.0	30.0
TB-5 Lower	17.9	15.5	7.87	6.0	30.0
TB-9 Lower	31.8	15.1	7.91	4.8	30.0
Overlying	2 Days Prior to Initiation				
TB-2 Lower	1.32	15.0	7.94	7.6	31.5
TB-3 Lower	2.02	14.9	7.94	7.5	31.5
TB-4 Middle	1.58	14.9	7.88	7.3	31.5
TB-4 Lower	1.35	15.0	7.97	7.5	31.5
TB-5 Lower	1.73	15.1	8.00	7.6	31.5
TB-9 Lower	3.39	15.1	7.95	7.7	31.5
Porewater	2 Days Prior to Initiation				
TB-2 Lower	20.2	15.2	7.87	4.0	31.5
TB-3 Lower	20.4	15.3	7.94	4.5	31.5
TB-4 Middle	16.3	15.2	7.63	4.4	31.5
TB-4 Lower	17.9	15.2	7.76	4.5	31.0
TB-5 Lower	15.5	15.2	7.84	4.1	30.0
TB-9 Lower	28.8	15.2	7.86	4.1	30.5

TABLE G.6. Ammonia Measurements in Overlying Water for 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-2 Lower	1.23	14.7	7.88	8.0	31.5
TB-3 Lower	0.733	14.9	7.86	7.9	31.5
TB-4 Middle	1.07	14.9	7.89	7.9	31.0
TB-4 Lower	ND [a]	14.9	7.90	7.9	31.5
TB-5 Lower	0.915	14.7	7.86	7.8	31.5
TB-9 Lower	3.79	14.8	7.85	7.9	31.5
			Day 1		
TB-2 Lower	1.15	13.8	8.02	7.8	31.5
TB-3 Lower	1.23	13.9	7.90	7.7	31.5
TB-4 Middle	1.14	13.9	7.96	7.8	31.0
TB-4 Lower	0.991	13.9	8.02	7.8	31.5
TB-5 Lower	1.20	13.9	7.99	7.7	31.5
TB-9 Lower	1.72	14.0	7.93	7.8	31.5
			Day 3		
TB-2 Lower	2.18	15.7	8.01	7.7	31.5
TB-3 Lower	2.51	15.7	8.06	7.5	32.0
TB-4 Middle	2.89	15.6	7.94	7.6	32.0
TB-4 Lower	1.92	15.7	8.03	7.6	31.5
TB-5 Lower	2.81	15.7	8.04	7.7	31.5
TB-9 Lower	4.24	15.6	7.99	7.6	31.5
			Day 6		
TB-2 Lower	4.75	13.9	8.01	7.6	32.0
TB-3 Lower	3.56	13.8	7.94	7.5	32.0
TB-4 Middle	4.63	13.9	8.09	7.6	32.0
TB-4 Lower	4.16	13.9	8.03	7.6	32.5
TB-5 Lower	4.94	13.8	7.98	7.6	32.5
TB-9 Lower	8.64	13.8	8.08	7.7	32.5

TABLE G.6. (contd)

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 10		
TB-2 Lower	8.87	15.3	8.02	7.5	32.0
TB-3 Lower	4.97	15.2	8.06	7.5	32.0
TB-4 Middle	9.01	15.2	8.11	7.6	32.0
TB-4 Lower	8.30	15.3	7.79	6.0	32.0
TB-5 Lower	6.08	15.3	8.09	7.9	32.0
TB-9 Lower	7.28	15.3	8.02	7.4	32.0

(a) ND No data.

TABLE G.7. Water Quality Measurements of Porewater for 10-Day Solid-Phase, Ammonia Reduction to <20 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-2 Lower	14.2	15.0	7.97	5.6	31.5
TB-3 Lower	9.87	14.9	7.94	5.4	31.5
TB-4 Middle	15.1	14.9	7.73	4.5	31.5
TB-4 Lower	ND [(a)]	ND	ND	ND	ND
TB-5 Lower	11.7	14.9	7.96	5.3	31.5
TB-9 Lower	18.0	14.9	7.94	6.0	31.5
			Day 10		
TB-2 Lower	10.3	16.4	7.83	5.3	32.0
TB-3 Lower	12.6	16.4	7.79	5.2	32.0
TB-4 Middle	9.49	16.3	7.61	5.0	32.0
TB-4 Lower	13.9	16.3	7.64	5.1	32.0
TB-5 Lower	12.5	16.3	7.84	5.6	32.0
TB-9 Lower	15.6	16.3	7.77	5.4	32.0

(a) ND No data.

APPENDIX H

INTENSIVE STUDY OF THE TURNING BASIN
BIOASSAY RESULTS FOR 10-DAY SOLID-PHASE, AMMONIA REDUCTION
TO <15 MG/L TEST AND 96-HOUR REFERENCE TOXICANT TEST FOR
RHEPOXYNIUS abronius

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

TEST ORGANISM: *Rhepoxynius abronius*

TEST TYPE: Solid-phase; flow-through to reduce ammonia to <15 mg/L then static with aeration

TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from October 11-13, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Battelle MSL personnel collected approximately 1000 wild captured (mixed age groups) organisms from West Beach, Whidbey Island, Washington.

HOLDING/ACCLIMATION Test organisms were held for 14 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	7.3-15.4°C	7.66-7.83	7.3-8.4 mg/L	30.5-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing. Pre-initiation "dummy" jars were measured for interstitial and overlying ammonia 13 days, 10 days, 6 days, and 3 days prior to initiation of the organisms. When the ammonia was <15 mg/L in the interstitial water, the test was initiated. Ammonia was then measured in the overlying and interstitial water in "dummy" jars on Day 0 and 10. Ammonia in the overlying water was measured in the test jars on Days 1, 3, 7, and 10.

TEST VALIDATION The test was validated by 100% survival in the control sediment (C-WB).

QA/QC SUMMARY (contd)

REFERENCE TOXICANT TEST

The cadmium chloride reference toxicant test was validated by 95% survival in the seawater control. An LC_{50} value of 0.27 mg/L of cadmium was calculated.

The ammonia reference toxicant test was validated by 95% survival in the seawater control. An LC_{50} value of 30.92 mg/L of ammonia was calculated.

COMMENTS

Not applicable.

REFERENCES

ASTM (American Society for Testing and Materials). 1990. *Standard Guide for Conducting 10-day Static Sediment Toxicity Tests with Marine and Estuarine Amphipods.* ASTM Designation: E 1367-90. American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA/USACE (U.S. Environmental Protection Agency/U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE H.1. Test Results for 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Treatment	Replicate	Live[a]	Dead or Missing	Proportion Surviving	Mean Proportion Surviving
TB-3 Lower	1	17	3	0.85	
TB-3 Lower	2	19	1	0.95	
TB-3 Lower	3	16	4	0.80	
TB-3 Lower	4	14	6	0.70	
TB-3 Lower	5	17	3	0.85	0.83
TB-7 Lower	1	17	3	0.85	
TB-7 Lower	2	12	8	0.60	
TB-7 Lower	3	9	11	0.45	
TB-7 Lower	4	18	2	0.90	
TB-7 Lower	5	19	1	0.95	0.75
TB-8 Lower	1	15	5	0.75	
TB-8 Lower	2	17	3	0.85	
TB-8 Lower	3	16	4	0.80	
TB-8 Lower	4	16	4	0.80	
TB-8 Lower	5	17	3	0.85	0.81
TB-9 Lower	1	17	3	0.85	
TB-9 Lower	2	12	8	0.60	
TB-9 Lower	3	16	4	0.80	
TB-9 Lower	4	18	2	0.90	
TB-9 Lower	5	17	3	0.85	0.80
C-WB	1	20	0	1.00	
C-WB	2	20	0	1.00	
C-WB	3	20	0	1.00	
C-WB	4	20	0	1.00	
C-WB	5	20	0	1.00	1.00

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

TABLE H.2. Daily Observations of *R. abronius* on Sediment Surface During 10-Day Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* on Sediment for Test Days 0 through 9									
		0[a]	1	2	3	4	5	6	7	8	9
TB-3 Lower	1	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	2	0	0	0	0	0	0	0	0	0	1
TB-3 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-7 Lower	1	0	0	0	0	1	0	0	0	0	0
TB-7 Lower	2	0	0	0	1	0	0	0	0	1	0
TB-7 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-7 Lower	4	0	0	0	0	0	0	0	0	0	1
TB-7 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-8 Lower	1	0	0	0	1	0	0	0	0	0	0
TB-8 Lower	2	0	0	0	0	0	0	0	0	0	0
TB-8 Lower	3	0	0	0	0	0	1	0	0	0	2
TB-8 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-8 Lower	5	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	1	1	0	0	0	0	0	0	0	0	0
TB-9 Lower	2	0	0	0	0	2	0	0	0	0	0
TB-9 Lower	3	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	4	0	0	0	0	0	0	0	0	0	0
TB-9 Lower	5	0	0	0	0	0	0	0	0	0	0
C-WB	1	0	0	0	0	0	0	0	0	0	0
C-WB	2	0	0	0	0	0	0	0	0	0	0
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	0	0	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	0	0	0

(a) On Test Day 0 observations were performed 2 hours after test initiation.

TABLE H.3. Daily Observations of *R. abronius* Floating on Surface During 10-Day Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Replicate	*R. abronius* Floating on Surface for Test Days 0 through 9									
		0[(a)]	1	2	3	4	5	6	7	8	9
TB-3 Lower	1	0	0	0	0	0	0	0	0	0	0
TB-3 Lower	2	0	0	0	0	1	0	1	0	0	0
TB-3 Lower	3	0	1	0	0	0	1	0	0	2	1
TB-3 Lower	4	0	1	0	1	0	1	3	1	0	2
TB-3 Lower	5	0	0	1	0	1	1	0	0	1	1
TB-7 Lower	1	1	0	1	0	2	1	0	0	0	0
TB-7 Lower	2	0	1	1	0	0	0	2	3	1	2
TB-7 Lower	3	0	0	1	2	0	0	0	1	1	0
TB-7 Lower	4	0	0	1	0	0	2	3	1	1	3
TB-7 Lower	5	0	2	0	0	0	0	0	2	3	3
TB-8 Lower	1	0	0	0	2	0	0	0	1	0	1
TB-8 Lower	2	0	1	0	1	0	1	1	1	0	0
TB-8 Lower	3	0	0	0	3	0	2	2	0	2	2
TB-8 Lower	4	0	0	1	0	1	0	0	0	2	4
TB-8 Lower	5	0	3	1	0	1	2	4	1	3	1
TB-9 Lower	1	0	0	0	0	1	0	1	0	0	1
TB-9 Lower	2	0	1	2	0	0	2	0	4	3	1
TB-9 Lower	3	0	0	0	0	0	1	2	3	0	4
TB-9 Lower	4	0	0	1	1	0	1	1	0	1	1
TB-9 Lower	5	1	0	0	0	0	0	0	0	1	1
C-WB	1	0	0	0	0	0	0	0	0	0	0
C-WB	2	0	0	0	0	0	0	0	0	0	0
C-WB	3	0	0	0	0	0	0	0	0	0	0
C-WB	4	0	0	0	0	0	0	0	0	0	0
C-WB	5	0	0	0	0	0	0	0	0	0	0

(a) On Test Day 0 observations were performed 2 hours after test initiation.

TABLE H.4. Water Quality Summary for 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA [(a)]	28.0	32.0
TB-3 Lower	15.1	15.7	7.77	8.03	7.5	7.9	30.5	32.0
TB-7 Lower	15.1	15.8	7.76	7.96	6.9	7.9	30.5	31.5
TB-8 Lower	15.1	15.8	7.71	7.99	7.1	8.0	30.5	32.0
TB-9 Lower	15.1	15.7	7.82	8.12	7.4	8.0	30.5	32.0
C-WB	15.1	15.8	7.85	8.13	7.5	8.0	30.5	32.0

(a) NA Not applicable.

TABLE H.5. Ammonia Measurements in Overyling and Porewater Prior to Initiation of the 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
Overlying		13 Days Prior to Initiation			
TB-3 Lower	1.66	13.3	8.00	5.7	31.5
TB-7 Lower	0.640	13.3	7.92	5.8	31.5
TB-8 Lower	0.837	13.4	7.95	5.8	31.5
TB-9 Lower	0.955	13.3	7.90	5.9	31.5
C-WB	ND [a]	ND	ND	ND	ND
Porewater		13 Days Prior to Initiation			
TB-3 Lower	20.3	13.2	7.94	4.4	30.0
TB-7 Lower	19.0	13.3	7.94	3.9	28.0
TB-8 Lower	18.6	13.3	7.93	3.9	28.0
TB-9 Lower	37.3	13.3	8.18	4.0	30.0
C-WB	ND	ND	ND	ND	ND
Overlying		10 Days Prior to Initiation			
TB-3 Lower	1.81	14.9	8.05	7.3	31.0
TB-7 Lower	1.56	14.9	8.05	7.4	31.5
TB-8 Lower	1.98	14.9	7.99	7.5	31.0
TB-9 Lower	2.03	14.9	8.08	7.2	31.5
C-WB	0.164	14.9	7.98	7.6	31.0
Porewater		10 Days Prior to Initiation			
TB-3 Lower	14.8	14.9	7.92	5.1	30.0
TB-7 Lower	13.3	14.8	7.87	4.5	28.5
TB-8 Lower	12.9	14.8	7.84	4.6	28.5
TB-9 Lower	29.9	14.8	8.01	4.6	30.0
C-WB	2.07	14.9	7.52	5.9	31.5

TABLE H.5. (contd)

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
Overlying		6 Days Prior to Initiation			
TB-3 Lower	1.82	14.4	7.98	7.4	32.0
TB-7 Lower	1.99	14.4	7.93	7.3	32.0
TB-8 Lower	1.60	14.4	7.94	7.1	32.0
TB-9 Lower	3.58	14.4	7.97	7.4	32.0
C-WB	0.116	14.4	7.83	7.6	32.0
Porewater		6 Days Prior to Initiation			
TB-3 Lower	9.99	14.5	7.91	5.1	30.5
TB-7 Lower	11.2	14.4	7.73	4.1	29.5
TB-8 Lower	10.4	14.4	7.68	4.0	29.5
TB-9 Lower	22.5	14.4	7.92	3.7	30.0
C-WB	2.32	14.5	7.58	5.6	31.0
Overlying		3 Days Prior to Initiation			
TB-3 Lower	0.246	14.9	7.84	7.7	31.0
TB-7 Lower	1.45	14.9	7.83	7.2	31.0
TB-8 Lower	0.179	14.8	7.83	7.6	31.0
TB-9 Lower	0.537	14.9	7.83	7.6	31.0
C-WB	0.054	14.9	7.85	7.6	31.0
Porewater		3 Days Prior to Initiation			
TB-3 Lower	11.0	14.8	7.85	6.0	31.0
TB-7 Lower	12.9	14.9	7.85	4.8	30.5
TB-8 Lower	10.9	14.8	7.79	6.0	30.5
TB-9 Lower	17.5	14.9	7.93	5.2	31.0
C-WB	4.78	14.8	ND	ND	31.0

(a) ND No data.

TABLE H.6. Ammonia Measurements in Overlying Water for 10-Day *R. abronius* Solid-Phase, Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-3 Lower	0.135	13.3	7.84	7.7	30.5
TB-7 Lower	0.189	13.2	7.88	7.5	30.5
TB-8 Lower	0.121	13.4	7.85	7.5	30.5
TB-9 Lower	0.356	13.3	7.88	7.7	30.5
C-WB	0.038	13.3	7.86	7.7	30.5
			Day 1		
TB-3 Lower	0.944	13.2	7.99	7.7	31.0
TB-7 Lower	3.28	13.1	7.95	7.5	31.0
TB-8 Lower	0.706	13.2	7.97	7.7	30.5
TB-9 Lower	1.76	13.1	7.97	7.5	30.5
C-WB	0.133	13.2	8.01	7.6	30.5
			Day 3		
TB-3 Lower	2.45	14.0	7.89	7.6	31.0
TB-7 Lower	3.27	13.9	7.92	7.6	30.5
TB-8 Lower	2.18	13.9	7.89	7.6	31.0
TB-9 Lower	4.41	14.0	7.99	7.7	31.0
C-WB	0.211	14.0	8.08	7.8	31.0
			Day 7		
TB-3 Lower	2.55	15.2	7.92	7.7	31.5
TB-7 Lower	4.17	15.2	7.95	7.8	31.5
TB-8 Lower	2.81	15.2	7.96	7.9	31.5
TB-9 Lower	7.43	15.1	8.02	7.8	31.5
C-WB	0.124	15.1	8.02	7.9	31.5
			Day 10		
TB-3 Lower	1.66	13.9	8.11	7.4	32.0
TB-7 Lower	2.13	13.8	8.04	7.5	32.0
TB-8 Lower	1.01	13.8	7.93	7.6	31.5
TB-9 Lower	6.56	14.0	8.17	7.6	34.0 [a]
C-WB	0.051	13.7	8.17	7.6	32.0

(a) Data point out of range.

TABLE H.7. Water Quality Measurements of Porewater for 10-Day Solid-Phase Ammonia Reduction to <15 mg/L Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Ammonia (mg/L)	Temperature (°C)	pH	Dissolved Oxygen (mg/L)	Salinity (o/oo)
			Day 0		
TB-3 Lower	4.71	12.9	7.90	6.3	32.5
TB-7 Lower	7.79	12.8	7.79	6.2	31.0
TB-8 Lower	8.18	12.9	7.80	5.9	31.5
TB-9 Lower	14.7	12.8	7.89	6.0	32.0
C-WB	1.34	13.0	7.81	6.0	32.0
			Day 10		
TB-3 Lower	7.14	13.9	8.14	7.4	32.0
TB-7 Lower	7.75	13.8	7.99	7.6	32.0
TB-8 Lower	4.42	14.0	8.06	7.5	31.5
TB-9 Lower	12.8	14.0	8.09	7.7	33.0 [a]
C-WB	ND [b]	ND	ND	ND	ND

(a) Data point out of range.
(b) ND No data.

TABLE H.8. Test Results for 96-Hour *R. abronius* Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration (mg/L)	Live[(a)]	Dead or Missing	Proportion Surviving
0.00	19	1	0.95
0.25	10	10	0.50
0.50	6	14	0.30
1.00	2	18	0.10
1.50	1	19	0.05
2.00	0	20	0.00
4.00	0	20	0.00

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

TABLE H.9. Daily Observations of *R. abronius* Floating on Surface During 96-Hour Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration (mg/L)	*R. abronius* Floating on Surface			
	2 h	24 h	48 h	72 h
0.00	3	0	2	1
0.25	1	2	0	3
0.50	1	4	4	4
1.00	0	1	0	3
1.50	0	1	1	1
2.00	2	3	2	0
4.00	1	4	1	0

TABLE H.10. Water Quality Summary for 96-Hour *R. abronius* Cadmium Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Cadmium Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA [(a)]	28.0	32.0
0.00	15.2	15.5	8.09	8.14	7.6	8.1	30.5	31.5
0.25	15.3	15.6	8.04	8.14	7.8	8.0	30.5	31.5
0.50	15.3	15.6	8.06	8.13	7.8	8.1	30.5	31.5
1.00	15.3	15.6	8.05	8.12	7.8	8.1	30.5	31.5
1.50	15.3	15.6	8.00	8.09	7.8	8.1	30.5	31.5
2.00	15.3	15.6	7.89	8.08	7.9	8.1	30.5	31.5
4.00	15.2	15.6	7.89	7.97	7.7	8.1	30.5	31.0

(a) NA Not applicable.

TABLE H.11. Test Results for 96-Hour *R. abronius* Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration (mg/L)	Live[(a)]	Dead or Missing	Proportion Surviving
0	19	1	0.95
10	20	0	1.00
20	19	1	0.95
40	7	13	0.35
80	3	17	0.15
120	0	20	0.00
160	0	20	0.00

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

TABLE H.12. Daily Observations of *R. abronius* Floating on Surface During 96-Hour Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration (mg/L)	*R. abronius* Floating on Surface			
	2 h	24 h	48 h	72 h
0	0	0	0	3
10	2	1	0	3
20	1	0	0	0
40	1	1	0	2
80	2	0	0	0
120	1	1	0	0
160	6	0	0	0

TABLE H.13. Water Quality Summary for 96-Hour *R. abronius* Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Ammonia Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA [a]	28.0	32.0	NE [b]	NE
0	15.2	15.5	7.89	8.14	7.6	8.1	30.5	31.5	0.069	0.217
10	15.3	15.6	7.85	8.13	7.6	8.1	30.5	31.5	7.58	8.46
20	15.3	15.6	7.84	8.14	7.6	8.1	30.5	31.5	15.2	16.1
40	15.3	15.6	7.81	8.13	7.8	8.1	30.5	31.5	29.7	30.8
80	15.3	15.6	7.84	8.11	7.7	8.1	30.5	31.5	60.0	66.0
120	15.3	15.6	7.69	8.11	7.8	8.0	30.5	31.5	97.4	102
160	15.3	15.7	7.66	8.08	7.7	8.0	30.5	31.0	145	151

(a) NA Not applicable
(b) NE Not established.

APPENDIX I

BIOASSAY RESULTS FOR 10-DAY SOLID-PHASE, FLOW-THROUGH TEST WITH *MACOMA nasuta* AND *NEPHTYS caecoides*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Macoma nasuta*
TEST TYPE: Solid-phase, flow-through
TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	115-135 ml/min	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Johnson and Gunstone, Discovery Bay, Washington. Wild captured organisms (mixed age group-1 to 2.5 in. in size) were collected in Discovery Bay.

HOLDING/ACCLIMATION Approximately 3500 organisms were received dry in mesh bags between January 24 and 26. The organisms were held for 25 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
17 days acclimation min/max	6.7-14.1°C	7.57-7.96	7.4-9.7 mg/L	30.5-32.0‰
8 days holding min/max	9.6-14.7°C	7.59-7.74	8.0-9.1 mg/L	31.0-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing.

TEST VALIDATION The test was validated by 100% survival in the control sediment (C-SB).

REFERENCE TOXICANT TEST Not applicable.

COMMENTS Flow rates generally remained within the acceptable range of 115-135 ml/min. Slight fluctuations (<5 ml) did occur during the 10 days of testing but were corrected within 24 hours.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Nephtys caecoides*
TEST TYPE: Solid-phase, flow-through
TEST DURATION: 10 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	115-135 ml/min	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Brezina and Associates, Dillon Beach, California. Wild captured organisms (mixed age group-less than 3 in. length) were collected in Dillon Beach.

HOLDING/ACCLIMATION Approximately 2000 organisms were received on February 10, 1994 and held for 8 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
8 days acclimation/holding min/max	9.5-14.7°C	7.16-7.75	8.0-12.2 mg/L	31.5-33.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 10 days of testing.

TEST VALIDATION The test was validated by 94% survival in the control sediment (C-NE).

REFERENCE TOXICANT TEST Not applicable.

COMMENTS Flow rates generally remained within the acceptable range of 115-135 ml/min. Slight fluctuations (<5 ml) did occur during the 10 days of testing but were corrected within 24 hours.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE I.1. Test Results for 10-Day M. nasuta Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Live(a)	M. nasuta Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	1	20	0	1.00		
SF COMP	2	20	0	1.00		
SF COMP	3	20	0	1.00		
SF COMP	4	20	0	1.00		
SF COMP	5	20	0	1.00	1.00	0.00
SFW COMP	1	23	2	0.92		
SFW COMP	2	25	0	1.00		
SFW COMP	3	25	0	1.00		
SFW COMP	4	25	0	1.00		
SFW COMP	5	25	0	1.00	0.98	0.04
UIH COMP	1	25	0	1.00		
UIH COMP	2	25	0	1.00		
UIH COMP	3	25	0	1.00		
UIH COMP	4	25	0	1.00		
UIH COMP	5	25	0	1.00	1.00	0.00
TB Upper COMP	1	20	0	1.00		
TB Upper COMP	2	20	0	1.00		
TB Upper COMP	3	20	0	1.00		
TB Upper COMP	4	20	0	1.00		
TB Upper COMP	5	19	1	0.95	0.99	0.02
TB Lower COMP	1	25	0	1.00		
TB Lower COMP	2	24	1	0.96		
TB Lower COMP	3	25	0	1.00		
TB Lower COMP	4	25	0	1.00		
TB Lower COMP	5	24	1	0.96	0.98	0.02
OBM COMP	1	25	0	1.00		
OBM COMP	2	25	0	1.00		
OBM COMP	3	24	1	0.96		
OBM COMP	4	25	0	1.00		
OBM COMP	5	24	1	0.96	0.98	0.02
R-OS	1	25	0	1.00		
R-OS	2	25	0	1.00		
R-OS	3	25	0	1.00		
R-OS	4	25	0	1.00		
R-OS	5	25	0	1.00	1.00	0.00
R-BF	1	25	0	1.00		
R-BF	2	25	0	1.00		
R-BF	3	25	0	1.00		
R-BF	4	25	0	1.00		
R-BF	5	25	0	1.00	1.00	0.00

TABLE I.1. (contd)

Sediment Treatment	Replicate	M. nasuta Live	M. nasuta Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
R-AM COMP	1	25	0	1.00		
R-AM COMP	2	25	0	1.00		
R-AM COMP	3	25	0	1.00		
R-AM COMP	4	NI (b)	NI	NA (c)		
R-AM COMP	5	25	0	1.00	1.00	0.00
C-SB	1	20	0	1.00		
C-SB	2	20	0	1.00		
C-SB	3	20	0	1.00		
C-SB	4	20	0	1.00		
C-SB	5	20	0	1.00	1.00	0.00
C-NE	1	20	0	1.00		
C-NE	2	20	0	1.00		
C-NE	3	20	0	1.00		
C-NE	4	20	0	1.00		
C-NE	5	20	0	1.00	1.00	0.00

(a) Survival based on initial exposure of either 20 or 25 organisms per replicate.
(b) NI Not initiated; insufficient organisms to test all five replicates.
(c) NA Not applicable.

TABLE I.2. Daily Observations of M. nasuta on Sediment Surface During 10-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta on Sediment Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	1	1	1	1	1	1	1	1	1	1
SF COMP	2	1	1	1	1	1	0	1	1	1	1
SF COMP	3	4	3	2	1	1	1	1	1	1	0
SF COMP	4	1	1	1	0	0	0	0	0	0	0
SF COMP	5	2	2	2	1	0	0	0	0	0	0
SFW COMP	1	10	7	6	2	1	1	0	0	0	0
SFW COMP	2	8	5	1	1	1	0	0	0	0	0
SFW COMP	3	9	5	3	0	0	0	0	0	0	0
SFW COMP	4	8	6	3	2	1	2	1	2	1	0
SFW COMP	5	3	7	4	3	1	1	1	0	0	0
UIH COMP	1	2	1	2	1	0	0	0	0	0	0
UIH COMP	2	3	2	1	1	1	0	1	1	1	1
UIH COMP	3	3	1	0	1	0	0	0	0	0	0
UIH COMP	4	2	1	2	1	1	1	0	0	0	0
UIH COMP	5	4	4	3	2	2	1	1	0	0	0
TB Upper COMP	1	T (a)	1	0	0	0	0	0	0	0	0
TB Upper COMP	2	4	3	3	3	2	2	2	2	2	1
TB Upper COMP	3	5	4	4	3	1	1	2	1	1	1
TB Upper COMP	4	9	3	1	0	0	0	0	1	0	0
TB Upper COMP	5	4	3	3	2	2	2	2	1	0	0
TB Lower COMP	1	3	2	2	2	1	1	1	0	1	1
TB Lower COMP	2	8	6	4	3	2	2	1	1	0	0
TB Lower COMP	3	10	5	6	5	4	4	3	2	2	2
TB Lower COMP	4	4	4	4	4	4	4	3	3	2	2
TB Lower COMP	5	6	5	4	3	3	2	2	1	0	0
OBM COMP	1	21	23	22	21	13	13	12	12	10	8
OBM COMP	2	17	15	12	11	11	10	10	9	8	6
OBM COMP	3	25	23	25	22	19	18	17	17	16	14
OBM COMP	4	19	20	19	18	18	17	14	15	13	11
OBM COMP	5	22	19	18	16	16	13	13	13	13	13
R-OS	1	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	1	0	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0
R-OS	5	1	0	0	0	0	0	0	0	0	0

TABLE I.2. (contd)

Sediment Treatment	Replicate	M. nasuta on Sediment Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-BF	1	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	2	1	1	1	2	1	1	1	1	0
R-BF	4	0	0	0	0	0	0	0	0	0	0
R-BF	5	3	0	0	0	0	0	0	0	0	0
R-AM COMP	1	2	2	1	1	1	1	1	2	1	1
R-AM COMP	2	1	0	0	0	0	0	0	1	0	0
R-AM COMP	3	1	2	2	2	2	2	2	2	2	1
R-AM COMP	4	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI
R-AM COMP	5	2	3	2	0	1	0	1	1	1	1
C-NE	1	0	0	0	1	0	1	1	0	0	1
C-NE	2	1	2	2	3	3	1	2	3	3	3
C-NE	3	3	2	0	1	2	2	1	4	2	3
C-NE	4	0	0	0	0	0	0	1	1	1	1
C-NE	5	3	1	3	2	2	1	1	5	6	5
C-SB	1	0	0	0	0	0	0	0	0	0	0
C-SB	2	0	0	0	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0
C-SB	4	1	1	0	2	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	1

(a) T Too turbid for observations.
(b) NI Not initiated; insufficient organisms to test all five replicates.

TABLE I.3. Daily Observations of M. nasuta Siphons Exposed During 10-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Siphons Exposed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	4	4	5	4	2	7	4	4	4	4
SF COMP	2	3	3	1	2	2	0	2	2	2	0
SF COMP	3	1	0	3	0	2	2	2	1	2	1
SF COMP	4	4	10	7	0	0	0	0	0	0	0
SF COMP	5	4	1	3	2	2	0	0	0	0	1
SFW COMP	1	14	10	11	3	1	0	1	0	1	0
SFW COMP	2	12	5	4	3	4	2	1	1	1	1
SFW COMP	3	17	12	9	4	3	2	2	3	1	0
SFW COMP	4	8	13	11	5	7	6	3	3	4	0
SFW COMP	5	2	13	4	4	4	3	6	3	2	0
UIH COMP	1	0	2	4	1	1	0	0	0	0	0
UIH COMP	2	5	5	2	4	1	0	1	0	3	0
UIH COMP	3	4	4	2	1	2	1	0	0	0	0
UIH COMP	4	9	7	7	2	3	1	2	2	1	2
UIH COMP	5	4	4	2	0	2	1	0	0	0	0
TB Upper COMP	1	T (a)	3	3	1	1	2	0	0	0	0
TB Upper COMP	2	8	3	3	6	7	3	3	5	3	1
TB Upper COMP	3	6	3	5	0	2	1	2	0	0	1
TB Upper COMP	4	4	2	4	2	3	1	0	0	0	2
TB Upper COMP	5	10	13	13	6	8	6	3	5	2	0
TB Lower COMP	1	12	8	7	5	4	4	7	4	6	3
TB Lower COMP	2	10	12	7	6	2	5	5	5	3	3
TB Lower COMP	3	15	11	8	8	7	4	6	3	5	3
TB Lower COMP	4	5	7	4	6	6	3	4	1	0	0
TB Lower COMP	5	9	2	2	2	4	3	3	0	0	0
OBM COMP	1	17	13	30	25	20	14	25	18	16	17
OBM COMP	2	29	17	20	19	15	12	19	14	16	13
OBM COMP	3	36	26	26	30	23	28	30	25	23	18
OBM COMP	4	21	27	25	33	36	28	30	22	28	34
OBM COMP	5	18	11	18	24	13	24	16	18	17	13
R-OS	1	0	0	2	0	0	0	1	0	0	0
R-OS	2	4	6	2	0	2	1	2	1	1	2
R-OS	3	2	3	1	2	0	1	1	2	2	2
R-OS	4	0	0	0	1	1	0	0	0	0	0
R-OS	5	3	2	2	2	3	4	1	2	1	1

TABLE I.3. (contd)

Sediment Treatment	Replicate	M. nasuta Siphons Exposed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-BF	1	0	1	0	1	0	0	0	0	0	0
R-BF	2	1	4	1	1	1	0	1	0	0	0
R-BF	3	6	2	0	2	1	2	3	1	1	1
R-BF	4	0	0	0	0	1	0	0	0	0	0
R-BF	5	2	0	0	0	0	0	0	0	0	0
R-AM COMP	1	0	1	2	2	3	2	2	3	2	4
R-AM COMP	2	0	5	1	0	0	1	2	1	0	0
R-AM COMP	3	3	3	2	3	3	2	3	4	4	2
R-AM COMP	4	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI
R-AM COMP	5	6	4	1	1	2	2	3	0	6	2
C-NE	1	1	0	8	0	0	0	2	1	0	0
C-NE	2	6	4	5	6	5	1	5	5	6	7
C-NE	3	11	6	6	5	5	5	7	6	5	4
C-NE	4	5	2	2	4	0	0	0	0	0	1
C-NE	5	3	2	4	1	2	2	3	7	8	5
C-SB	1	1	0	1	0	0	0	0	0	0	0
C-SB	2	2	0	1	0	0	0	1	0	0	0
C-SB	3	2	1	0	0	0	0	0	0	0	0
C-SB	4	0	1	3	2	1	0	1	1	0	0
C-SB	5	2	1	0	0	1	3	1	0	0	0

(a) T Too turbid for observations.
(b) NI Not initiated; insufficient organisms to test all five replicates.

TABLE I.4. Daily Observations of M. nasuta Dead and Removed During 10-Day Solid, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Dead and Removed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	0	0	0	0	0	0	0	0	0	0
SF COMP	2	0	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0
SF COMP	4	0	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	1	0	0	0	0	0	0	0
SFW COMP	2	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	0	0	0	0	0	0	0	0	0	0
SFW COMP	4	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	0	0	0	0	0	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	1	0	0	0	0	0	0	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	0	0	1	0	0	0	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	0	0	0	0	0	0	0	1	0	0
OBM COMP	1	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	0	0	0	0	0	0	0	0	0	0
OBM COMP	3	0	0	0	0	0	1	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	1	0	0	0	0
R-OS	1	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	0	0	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0

TABLE I.4. (contd)

Sediment Treatment	Replicate	M. nasuta Dead and Removed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-BF	1	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	NI (a)	NI	NI	NI	NI	NI	NI	NI	NI	NI
R-AM COMP	5	0	0	0	0	0	0	0	0	0	0
C-NE	1	0	0	0	0	0	0	0	0	0	0
C-NE	2	0	0	0	0	0	0	0	0	0	0
C-NE	3	0	0	0	0	0	0	0	0	0	0
C-NE	4	0	0	0	0	0	0	0	0	0	0
C-NE	5	0	0	0	0	0	0	0	0	0	0
C-SB	1	0	0	0	0	0	0	0	0	0	0
C-SB	2	0	0	0	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0
C-SB	4	0	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	0

(a) NI Not initiated; insufficient organisms to test all five replicates.

TABLE I.5. Water Quality Summary for 10-Day M. nasuta/N. caecoides Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	5.0	NA (a)	28.0	32.0
SF COMP	14.3	15.6	7.37	7.97	7.2	8.5	30.5	31.5
SFW COMP	14.3	15.5	7.39	7.90	7.3	8.5	30.5	31.5
UIH COMP	14.2	15.5	7.39	8.07	7.5	8.5	31.0	32.0
TB Upper COMP	14.2	15.6	7.45	8.02	7.3	8.5	30.5	32.0
TB Lower COMP	14.2	15.5	7.37	7.86	7.5	8.4	30.5	31.5
OBM COMP	14.3	15.6	7.32	7.87	7.4	8.6	30.5	32.0
R-OS	14.2	15.5	7.40	7.90	7.4	8.5	30.5	32.0
R-BF	14.2	15.5	7.32	7.89	7.3	8.5	30.5	32.0
R-AM COMP	14.3	15.6	7.43	8.00	7.5	8.5	31.0	32.0
C-NE	14.3	15.6	7.34	8.20	7.1	8.5	30.5	32.0
C-SB	14.2	15.6	7.42	7.89	7.2	8.4	30.5	32.0

(a) NA Not applicable.

TABLE I.6. Ammonia Measurements in Overlying Water for 10-Day M. nasuta/N. caecoides Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Ammonia (mg/L) Day 1	Day 3	Day 7	Day 10
SF COMP	0.151	0.211	0.368	0.137
SFW COMP	0.220	0.159	0.357	0.123
UIH COMP	0.136	0.261	0.420	0.150
TB Upper COMP	0.161	0.188	0.351	0.131
TB Lower COMP	0.314	0.224	0.393	0.319
OBM COMP	0.134	0.159	0.372	0.177
R-OS	0.149	0.348	0.352	0.232
R-BF	0.177	0.143	0.352	0.178
R-AM COMP	0.118	0.300	0.364	0.125
C-NE	0.137	0.150	0.361	0.133
C-SB	0.127	0.358	0.373	0.144

TABLE I.7. Test Results for 10-Day N. caecoides Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	N. caecoides Live	N. caecoides Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	1	14	6	0.70		
SF COMP	2	16	4	0.80		
SF COMP	3	17	3	0.85		
SF COMP	4	15	5	0.75		
SF COMP	5	17	3	0.85	0.79	0.07
SFW COMP	1	17	3	0.85		
SFW COMP	2	15	5	0.75		
SFW COMP	3	17	3	0.85		
SFW COMP	4	17	3	0.85		
SFW COMP	5	15	5	0.75	0.81	0.05
UIH COMP	1	17	3	0.85		
UIH COMP	2	14	6	0.70		
UIH COMP	3	18	2	0.90		
UIH COMP	4	19	1	0.95		
UIH COMP	5	20	0	1.00	0.88	0.12
TB Upper COMP	1	18	2	0.90		
TB Upper COMP	2	17	3	0.85		
TB Upper COMP	3	15	5	0.75		
TB Upper COMP	4	18	2	0.90		
TB Upper COMP	5	18	2	0.90	0.86	0.07
TB Lower COMP	1	19	1	0.95		
TB Lower COMP	2	20	0	1.00		
TB Lower COMP	3	18	2	0.90		
TB Lower COMP	4	20	0	1.00		
TB Lower COMP	5	19	1	0.95	0.96	0.04
OBM COMP	1	6	14	0.30		
OBM COMP	2	11	9	0.55		
OBM COMP	3	4	16	0.20		
OBM COMP	4	11	9	0.55		
OBM COMP	5	6	14	0.30	0.38	0.16
R-OS	1	19	1	0.95		
R-OS	2	20	0	1.00		
R-OS	3	19	1	0.95		
R-OS	4	18	2	0.90		
R-OS	5	20	0	1.00	0.96	0.04

TABLE I.7. (contd)

Sediment Treatment	Replicate	N. caecoides Live	N. caecoides Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
R-BF	1	17	3	0.85		
R-BF	2	19	1	0.95		
R-BF	3	17	3	0.85		
R-BF	4	18	2	0.90		
R-BF	5	20	0	1.00	0.91	0.07
R-AM COMP	1	19	1	0.95		
R-AM COMP	2	20	0	1.00		
R-AM COMP	3	19	1	0.95		
R-AM COMP	4	NI (b)	NI	NA (c)		
R-AM COMP	5	19	1	0.95	0.96	0.03
C-NE	1	18	2	0.90		
C-NE	2	20	0	1.00		
C-NE	3	18	2	0.90		
C-NE	4	18	2	0.90		
C-NE	5	20	0	1.00	0.94	0.05
C-SB	1	20	0	1.00		
C-SB	2	19	1	0.95		
C-SB	3	19	1	0.95		
C-SB	4	19	1	0.95		
C-SB	5	19	1	0.95	0.96	0.02

(a) Survival based on initial exposure of 20 organisms per replicate.
(b) NI Not initiated; insufficient organisms for all five replicates.
(c) NA Not applicable.

TABLE I.8. Daily Observations of N. caecoides on Sediment Surface During 10-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening

Sediment Treatment	Replicate	N. caecoides on Sediment Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	0	0	1	0	0	0	0	0	0	0
SF COMP	2	0	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0
SF COMP	4	1	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	1	0	0	0	0	2	0	0
SFW COMP	2	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	0	0	1	0	0	0	1	0	0	0
SFW COMP	4	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	1	0	0	0	0	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	T (a)	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	0	0	0	0	0	0	0	0	0	0
OBM COMP	1	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	0	0	0	0	0	0	0	0	0	0
OBM COMP	3	0	0	0	0	1	0	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	0	0	0	0	0
R-OS	1	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0
R-OS	3	1	0	0	0	0	0	0	0	0	0
R-OS	4	1	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0
R-BF	1	2	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	1	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0

TABLE I.8. (contd)

Sediment Treatment	Replicate	N. caecoides on Sediment Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI
R-AM COMP	5	0	0	0	0	0	0	0	1	1	0
C-NE	1	0	0	1	0	0	0	0	0	0	0
C-NE	2	0	0	0	0	0	0	0	0	0	0
C-NE	3	0	0	0	0	0	0	0	0	0	0
C-NE	4	0	0	0	0	0	0	0	0	0	0
C-NE	5	0	0	0	0	0	0	0	0	0	0
C-SB	1	1	0	0	0	0	0	0	0	0	0
C-SB	2	1	0	0	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0
C-SB	4	0	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	0

(a) T Too turbid for observations.
(b) NI Not initiated; insufficient organisms to test all five replicates.

TABLE I.9. Daily Observations of N. caecoides Dead and Removed During 10-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	N. caecoides Dead and Removed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
SF COMP	1	0	0	0	0	0	0	0	0	0	0
SF COMP	2	0	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0
SF COMP	4	1 (a)	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	0	0	0	0	0	0	0	0
SFW COMP	2	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	0	0	0	0	0	0	0	0	0	0
SFW COMP	4	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	1 (a)	0	0	0	0	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	0	0	0	0	0	0	0	0	0	0
OBM COMP	1	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	0	0	0	0	0	0	0	0	0	0
OBM COMP	3	0	0	0	0	0	0	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	0	0	0	0	0
R-OS	1	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0
R-OS	3	1 (a)	0	0	0	0	0	0	0	0	0
R-OS	4	1 (a)	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0

TABLE I.9. (contd)

Sediment Treatment	Replicate	N. caecoides Dead and Removed Test Days 0 through 9									
		0	1	2	3	4	5	6	7	8	9
R-BF	1	2 (a)	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI
R-AM COMP	5	0	0	0	0	0	0	0	0	1	0
C-NE	1	0	0	1	0	0	0	0	0	0	0
C-NE	2	0	0	0	0	0	0	0	0	0	0
C-NE	3	0	0	0	0	0	0	0	0	0	0
C-NE	4	0	0	0	0	0	0	0	0	0	0
C-NE	5	0	0	0	0	0	0	0	0	0	0
C-SB	1	1 (a)	0	0	0	0	0	0	0	0	0
C-SB	2	1 (a)	0	0	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0
C-SB	4	0	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	0

(a) For Day 0 observations only, replaced dead organisms with live N. caecoides.
(b) NI Not initiated; insufficient organisms to test all five replicates.

APPENDIX J

BIOASSAY RESULTS FOR 28-DAY SOLID-PHASE, FLOW-THROUGH TEST WITH *MACOMA nasuta*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Macoma nasuta*
TEST TYPE: Solid-phase, flow-through; Bioaccumulation
TEST DURATION: 28 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	115-135 ml/min	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Johnson and Gunstone, Discovery Bay, Washington. Wild captured organisms (mixed age group-1 to 2.5 in. in size) were collected in Discovery Bay.

HOLDING/ACCLIMATION Approximately 3500 organisms were received dry in mesh bags between January 24 and 26. The organisms were held for 25 days at the following conditions prior to test initiation.

	Temperature	pH	Dissolved Oxygen	Salinity
17 days acclimation min/max	6.7-14.1°C	7.57-7.96	7.4-9.7 mg/L	30.5-32.0‰
8 days holding min/max	9.6-14.7°C	7.59-7.74	8.0-9.1 mg/L	31.0-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 28 days of testing with the exception of a 2°C drop in temperature (10.9°C) which occurred between test days 22 and 23 in all test chambers. This temporary drop in temperature did not appear to have any detrimental effect on any of the test organisms.

TEST VALIDATION The test was validated by 91% survival in the control sediment (C-SB).

REFERENCE TOXICANT TEST Not applicable.

COMMENTS Flow rates generally remained within the acceptable range of 115-135 ml/min. Slight fluctuations (<5 ml) did occur during the 28 days of testing but were corrected within 24 hours.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE J.1. Test Results for 28-Day M. nasuta Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Live(a)	M. nasuta Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	1	25	0	1.00		
SF COMP	2	22	3	0.88		
SF COMP	3	23	2	0.92		
SF COMP	4	24	1	0.96		
SF COMP	5	25	0	1.00	0.95	0.05
SFW COMP	1	23	2	0.92		
SFW COMP	2	21	4	0.84		
SFW COMP	3	25	0	1.00		
SFW COMP	4	25	0	1.00		
SFW COMP	5	24	1	0.96	0.94	0.07
UIH COMP	1	25	0	1.00		
UIH COMP	2	23	2	0.92		
UIH COMP	3	24	1	0.96		
UIH COMP	4	24	1	0.96		
UIH COMP	5	24	1	0.96	0.96	0.03
TB Upper COMP	1	25	0	1.00		
TB Upper COMP	2	24	1	0.96		
TB Upper COMP	3	24	1	0.96		
TB Upper COMP	4	23	2	0.92		
TB Upper COMP	5	22	3	0.88	0.94	0.05
TB Lower COMP	1	23	2	0.92		
TB Lower COMP	2	24	1	0.96		
TB Lower COMP	3	22	3	0.88		
TB Lower COMP	4	20	5	0.80		
TB Lower COMP	5	24	1	0.96	0.90	0.07
OBM COMP	1	25	0	1.00		
OBM COMP	2	22	3	0.88		
OBM COMP	3	25	0	1.00		
OBM COMP	4	22	3	0.88		
OBM COMP	5	24	1	0.96	0.94	0.06
R-OS	1	25	0	1.00		
R-OS	2	23	2	0.92		
R-OS	3	22	3	0.88		
R-OS	4	25	0	1.00		
R-OS	5	25	0	1.00	0.96	0.06
R-BF	1	25	0	1.00		
R-BF	2	25	0	1.00		
R-BF	3	23	2	0.92		
R-BF	4	22	3	0.88		
R-BF	5	23	2	0.92	0.94	0.05

TABLE J.1. (contd)

Sediment Treatment	Replicate	M. nasuta Live(a)	M. nasuta Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
R-AM COMP	1	23	2	0.92		
R-AM COMP	2	24	1	0.96		
R-AM COMP	3	23	2	0.92		
R-AM COMP	4	25	0	1.00		
R-AM COMP	5	23	2	0.92	0.94	0.04
C-SB	1	23	2	0.92		
C-SB	2	22	3	0.88		
C-SB	3	24	1	0.96		
C-SB	4	24	1	0.96		
C-SB	5	21	4	0.84	0.91	0.05

(a) Survival based on initial exposure of 25 organisms per replicate.

TABLE J.2. Daily Observations for M. nasuta on Sediment Surface During 28-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta on Sediment Test Days 0 through 27																											
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
SF COMP	1	3	3	4	2	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	2	4	2	12	2	2	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0
SF COMP	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	ND (a)	0	0	0	0	0	0	0	0	0	0	0
SF COMP	4	4	2	2	2	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
SF COMP	5	4	4	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	10	6	3	3	5	2	1	0	1	0	1	0	0	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0
SFW COMP	2	10	8	0	3	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	6	6	0	5	5	5	3	5	5	2	2	2	3	4	2	3	0	0	0	0	0	0	0	0	1	0	0	0
SFW COMP	4	4	3	2	2	2	3	0	T (b)	0	0	0	0	0	0	0	0	0	0	0	T	0	T	0	0	0	0	0	0
SFW COMP	5	6	5	3	3	2	2	2	2	2	2	2	2	2	5	5	4	0	1	0	0	0	0	0	0	3	0	0	0
UIH COMP	1	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	9	6	4	3	2	2	1	1	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	1	0	0	0
UIH COMP	3	5	3	2	2	5	2	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
UIH COMP	4	4	1	2	2	1	1	0	1	1	0	1	1	1	0	0	0	7	0	0	0	0	0	0	0	1	0	0	0
UIH COMP	5	7	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	2	2	1	0	3	2	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	5	6	4	4	4	3	2	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	2	2	2	3	3	2	2	2	2	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	0	0	0	0
TB Upper COMP	5	2	1	2	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	0	0	0	0	0	1	0	0	0
TB Lower COMP	1	14	9	6	5	4	3	2	2	2	2	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	14	11	8	5	5	4	3	3	0	0	1	0	0	0	1	2	0	1	0	4	0	0	0	0	2	0	0	0
TB Lower COMP	3	11	7	3	4	5	5	2	4	2	3	3	2	1	1	2	1	1	1	0	2	0	0	0	0	1	0	0	0
TB Lower COMP	4	9	8	7	6	5	3	1	2	0	0	2	2	1	1	1	1	0	0	1	1	0	0	0	0	0	0	0	0
TB Lower COMP	5	18	15	4	10	8	5	0	2	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	0	0
OBM COMP	1	1	0	0	0	2	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	T	7	5	6	6	5	5	4	3	4	5	4	5	4	3	2	2	2	2	3	2	2	2	2	3	2	2	2
OBM COMP	3	T	18	20	18	18	16	11	14	13	9	8	6	6	6	8	5	4	1	1	1	0	0	0	0	0	0	0	0
OBM COMP	4	8	4	4	3	3	3	2	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
OBM COMP	5	12	11	11	8	9	9	6	7	4	4	4	2	2	3	2	1	1	1	1	0	1	1	0	0	2	1	0	0
R-OS	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
R-OS	2	1	0	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	4	T	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0
R-OS	5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	1	3	2	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	2	T	1	7	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	3	3	3	1	2	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	4	1	0	1	1	1	0	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	5	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE J.2. (contd)

Sediment Treatment	Replicate	M. nasuta on Sediment Test Days 0 through 27																										
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
R-AM COMP	1	2	1	1	1	4	3	0	0	2	0	4	6	6	6	6	7	7	7	5	4	5	5	4	1	4	2	4	4
R-AM COMP	2	1	0	1	1	3	4	4	5	6	3	4	3	3	1	4	6	4	2	6	7	6	6	6	6	6	3	6	3
R-AM COMP	3	1	2	2	0	3	4	3	6	5	7	3	4	5	4	5	5	3	3	3	0	1	2	4	3	3	3	3	3
R-AM COMP	4	1	1	1	2	2	2	3	6	5	7	8	5	4	3	4	6	0	6	6	6	5	4	3	5	6	4	5	5
R-AM COMP	5	4	1	1	1	1	3	2	2	3	4	6	5	5	4	6	6	0	4	5	6	7	4	4	3	1	4	4	1
C-SB	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
C-SB	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-SB	3	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-SB	4	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

(a) ND No Data.
(b) T Too Turbid for observations.

TABLE J.3. Daily Observations for M. nasuta Siphons Exposed During 28-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Siphons Exposed Test Days 0 through 27																											
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
SF COMP	1	16	13	11	7	5	4	1	3	1	4	13	1	1	2	2	3	3	3	1	0	3	1	1	1	4	1	1	2
SF COMP	2	8	3	13	11	5	3	2	3	3	3	3	1	2	2	1	2	3	2	2	0	1	3	2	1	3	3	3	1
SF COMP	3	12	4	7	7	1	5	2	3	2	2	1	1	1	2	3	2	ND (a)	4	2	0	0	1	1	0	0	1	1	1
SF COMP	4	15	11	4	9	3	6	2	2	1	4	6	3	0	2	2	2	4	8	3	2	3	1	0	0	2	2	2	2
SF COMP	5	10	8	9	4	1	1	3	2	0	4	1	2	2	2	0	2	1	0	0	1	2	2	2	2	2	2	2	2
SFW COMP	1	19	7	8	8	2	2	2	2	4	1	1	1	3	1	2	1	2	2	2	1	3	1	2	1	3	0	0	0
SFW COMP	2	10	12	1	14	5	6	5	5	6	4	8	6	11	5	6	3	2	2	3	5	3	2	1	1	0	0	0	0
SFW COMP	3	12	3	0	6	4	5	6	8	6	3	3	6	9	2	2	6	4	4	3	2	4	0	1	2	0	1	0	2
SFW COMP	4	4	5	4	3	4	4	2	T (b)	0	0	0	5	9	3	1	1	0	0	0	T	0	T	0	1	2	0	1	0
SFW COMP	5	9	8	6	3	3	6	4	4	5	6	6	4	5	5	5	3	2	1	2	2	2	2	1	1	0	4	3	4
UIH COMP	1	4	3	1	4	3	2	0	0	0	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0	0	0	0
UIH COMP	2	8	7	10	6	4	3	2	1	2	2	2	1	1	1	1	2	2	8	9	7	5	4	2	2	2	1	1	0
UIH COMP	3	13	10	8	5	7	6	5	5	5	5	3	5	3	4	3	3	3	3	0	3	3	3	3	2	0	2	0	0
UIH COMP	4	17	9	6	8	3	4	2	6	2	2	3	3	2	0	0	2	11	0	1	1	0	1	0	3	2	1	1	2
UIH COMP	5	16	11	15	8	9	2	2	3	1	2	2	3	2	2	6	2	0	0	1	2	0	1	1	0	0	1	1	2
TB Upper COMP	1	7	5	8	4	1	2	1	2	2	0	0	1	0	1	1	2	0	0	0	0	0	0	0	0	2	0	0	1
TB Upper COMP	2	12	5	9	8	8	7	6	6	6	4	6	3	3	2	1	3	1	2	1	2	0	0	3	0	3	2	1	0
TB Upper COMP	3	10	11	11	10	7	5	4	1	4	3	3	1	10	3	3	4	3	1	1	3	2	3	3	0	2	1	1	3
TB Upper COMP	4	16	7	5	5	6	7	5	4	6	5	3	3	2	2	2	3	0	1	0	1	3	0	1	2	3	3	1	2
TB Upper COMP	5	9	10	7	4	5	6	5	4	3	5	3	3	4	3	4	6	2	5	4	4	4	4	3	4	3	0	1	2
TB Lower COMP	1	23	7	9	6	3	5	3	3	2	1	2	1	1	2	1	1	2	1	2	0	1	1	1	0	0	1	0	0
TB Lower COMP	2	29	20	22	16	11	13	8	10	6	9	9	5	4	5	5	5	7	8	8	0	4	3	2	3	4	4	2	4
TB Lower COMP	3	12	3	6	5	6	6	3	0	5	5	6	4	2	2	7	3	5	2	1	5	3	4	0	0	0	1	0	0
TB Lower COMP	4	8	8	10	6	6	7	3	2	3	4	3	6	2	2	2	3	2	3	3	1	1	0	0	0	0	0	0	2
TB Lower COMP	5	21	23	16	22	17	5	6	5	7	4	3	5	4	6	6	6	5	7	2	3	3	2	2	2	3	0	3	1
OBM COMP	1	4	7	1	5	9	11	7	18	7	3	7	6	10	5	2	3	3	5	3	2	3	5	2	0	3	4	3	1
OBM COMP	2	T	16	17	13	15	9	13	11	12	10	9	7	8	9	11	6	2	4	2	4	3	3	3	4	4	3	3	2
OBM COMP	3	T	14	26	12	18	20	21	27	29	16	15	17	17	12	14	17	15	4	12	11	9	7	6	4	2	5	3	4
OBM COMP	4	15	7	10	8	9	8	4	9	9	2	3	2	2	3	2	2	0	1	1	4	2	3	3	2	2	4	0	1
OBM COMP	5	22	26	32	30	26	24	17	21	18	13	14	10	9	13	9	7	4	7	7	6	6	2	3	4	5	3	4	4
R-OS	1	4	4	0	1	2	0	1	0	0	1	2	1	2	3	0	1	11	2	3	0	3	0	0	0	2	2	3	0
R-OS	2	12	7	6	4	5	3	2	6	3	4	3	3	6	5	7	7	0	4	4	5	4	0	2	2	4	1	5	3
R-OS	3	11	2	8	4	17	1	2	2	1	4	2	2	3	2	4	3	2	3	0	4	2	2	2	1	0	1	1	0
R-OS	4	T	1	12	0	0	2	0	0	0	1	2	0	3	0	1	0	0	0	1	0	1	0	0	0	2	0	0	0
R-OS	5	7	3	5	1	3	3	2	3	3	3	2	3	3	1	0	3	2	2	2	4	1	3	0	0	0	0	2	2
R-BF	1	5	4	4	0	3	3	1	2	3	2	1	1	1	2	2	2	0	2	1	0	2	0	0	0	2	0	0	0
R-BF	2	T	3	7	7	1	0	1	3	0	0	0	1	0	0	2	1	1	1	1	1	2	0	1	2	3	2	1	2
R-BF	3	3	5	5	5	3	2	6	3	0	0	0	1	0	1	1	2	0	1	1	0	2	4	0	0	0	1	2	1
R-BF	4	7	5	6	4	4	3	2	5	5	4	4	5	2	2	2	3	2	4	4	4	3	2	3	4	3	0	0	0
R-BF	5	12	7	6	2	3	2	2	1	2	2	4	2	2	2	2	2	2	0	1	0	0	3	2	1	2	2	2	1
R-AM COMP	1	9	0	1	2	6	5	3	4	6	2	6	6	10	13	13	10	14	22	20	9	16	14	10	3	7	10	9	8
R-AM COMP	2	2	1	7	1	2	4	6	7	4	4	7	10	4	13	8	9	6	9	15	8	7	8	9	8	7	10	13	6
R-AM COMP	3	3	3	5	6	4	3	8	6	7	8	10	11	4	6	10	13	4	4	2	2	9	5	7	3	3	5	4	6
R-AM COMP	4	2	1	2	5	2	4	6	10	8	10	12	6	8	10	8	8	1	10	10	10	5	3	6	9	7	10	9	13
R-AM COMP	5	9	5	7	3	3	3	5	4	5	7	10	11	7	7	10	14	4	16	15	12	16	10	10	6	2	11	12	6

TABLE J.3. (contd)

Sediment Treatment	Replicate	M. nasuta Siphons Exposed Test Days 0 through 27																											
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
C-SB	1	7	1	1	1	1	0	0	0	0	1	0	0	0	1	1	1	2	0	0	0	1	0	1	2	3	2	1	0
C-SB	2	3	3	4	2	1	0	1	2	0	0	0	3	1	1	2	0	2	1	1	12	12	2	4	4	2	5	2	2
C-SB	3	6	2	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0
C-SB	4	6	1	14	1	1	0	0	2	1	0	1	0	2	2	2	1	3	0	1	1	0	0	0	0	2	0	0	2
C-SB	5	1	0	10	0	0	0	1	0	2	1	2	2	1	2	1	3	2	0	1	0	1	2	5	1	2	1	1	3

(a) ND No data.
(b) T Too turbid for observations.

TABLE J.4. Daily Observations for M. nasuta Dead and Removed During 28-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	M. nasuta Dead and Removed Test Days 0 through 27																											
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
SF COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
SF COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	0	0
SFW COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
UIH COMP	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
TB Lower COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TB Lower COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
OBM COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OBM COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
OBM COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OBM COMP	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
OBM COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R-OS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
R-BF	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1
R-BF	5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	ND (a)	0	0	0	0	0	0	0	0	0	0	1
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
R-AM COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	5	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

TABLE J.4. (contd)

Sediment Treatment	Replicate	M. nasuta Dead and Removed Test Days 0 through 27																									
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
C-SB	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
C-SB	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
C-SB	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-SB	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
C-SB	5	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0

(a) ND No data.

TABLE J.5. Water Quality Summary for 28-Day M. nasuta Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA (a)	28.0	32.0
SF COMP	11.2 (b)	16.4	7.55	7.93	7.5	8.9	30.0	32.0
SFW COMP	11.1 (b)	16.5	7.55	7.93	7.4	8.8	30.0	32.0
UIH COMP	10.9 (b)	16.5	7.57	7.93	7.4	8.8	30.0	32.0
TB Upper COMP	11.0 (b)	16.5	7.54	7.93	7.2	8.9	30.0	32.0
TB Lower COMP	10.9 (b)	16.4	7.56	7.93	7.3	8.8	30.0	32.0
OBM COMP	11.0 (b)	16.4	7.56	7.93	7.4	8.9	30.0	32.0
R-OS	10.9 (b)	16.5	7.56	7.94	7.4	8.9	30.0	32.0
R-BF	11.0 (b)	16.5	7.53	7.93	7.3	8.8	30.0	32.0
R-AM COMP	11.0 (b)	16.5	7.52	7.93	7.4	8.8	30.0	32.0
C-SB	10.9 (b)	16.5	7.51	7.90	7.3	8.8	30.0	32.0

(a) NA Not applicable.
(b) Data point out of range.

APPENDIX K

BIOASSAY RESULTS FOR 28-DAY SOLID-PHASE, FLOW-THROUGH TEST WITH *NEREIS virens*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Nereis virens*
TEST TYPE: Solid-phase, flow-through; Bioaccumulation
TEST DURATION: 28 days

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	115-135 ml/min	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection.

SOURCE/AGE Aquatic Research Organisms, Hampton, New Hampshire. Wild captured organisms (mixed age groups) were collected off the Maine coast.

HOLDING/ACCLIMATION Approximately 2500 organisms were received in moist algal mats on February 11, 1994. The organisms were delayed in transit for 3 days but appeared healthy upon arrival at the Battelle MSL. The organisms were then acclimated for 5 days prior to testing.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	9.4-13.7°C	7.57-8.07	8.1-9.0 mg/L	31.5-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 28 days of testing with the exception of a 2°C drop in temperature (11°C) which occurred between test days 22 and 23 in all test chambers. This temporary drop in temperature did not appear to have any detrimental effect on any of the test organisms.

TEST VALIDATION The test was validated by 95% survival in the control sediment (C-NV).

REFERENCE TOXICANT TEST Not applicable.

COMMENTS Flow rates generally remained within the acceptable range of 115-135 ml/min. Slight fluctuations (<5 ml) did occur during the 28 days of testing but were corrected within 24 hours.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE K.1. Test Results for 28-Day N. virens Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	N. virens Live(a)	N. virens Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	1	20	5	0.80		
SF COMP	2	24	1	0.96		
SF COMP	3	24	1	0.96		
SF COMP	4	24	1	0.96		
SF COMP	5	24	1	0.96	0.93	0.07
SFW COMP	1	23	2	0.92		
SFW COMP	2	25	0	1.00		
SFW COMP	3	24	1	0.96		
SFW COMP	4	23	2	0.92		
SFW COMP	5	23	2	0.92	0.94	0.04
UIH COMP	1	23	2	0.92		
UIH COMP	2	25	0	1.00		
UIH COMP	3	24	1	0.96		
UIH COMP	4	25	0	1.00		
UIH COMP	5	23	2	0.92	0.96	0.04
TB Upper COMP	1	25	0	1.00		
TB Upper COMP	2	25	0	1.00		
TB Upper COMP	3	24	1	0.96		
TB Upper COMP	4	21	4	0.84		
TB Upper COMP	5	25	0	1.00	0.96	0.07
TB Lower COMP	1	23	2	0.92		
TB Lower COMP	2	25	0	1.00		
TB Lower COMP	3	25	0	1.00		
TB Lower COMP	4	25	0	1.00		
TB Lower COMP	5	25	0	1.00	0.98	0.04
R-OS	1	25	0	1.00		
R-OS	2	25	0	1.00		
R-OS	3	25	0	1.00		
R-OS	4	24	1	0.96		
R-OS	5	23	2	0.92	0.98	0.04
R-BF	1	24	1	0.96		
R-BF	2	24	1	0.96		
R-BF	3	24	1	0.96		
R-BF	4	24	1	0.96		
R-BF	5	24	1	0.96	0.96	0.00
R-AM COMP	1	25	0	1.00		
R-AM COMP	2	25	0	1.00		
R-AM COMP	3	24	1	0.96		
R-AM COMP	4	25	0	1.00		
R-AM COMP	5	25	0	1.00	0.99	0.02

TABLE K.1. (contd)

Sediment Treatment	Replicate	N. virens Live(a)	N. virens Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
C-NV	1	23	2	0.92		
C-NV	2	25	0	1.00		
C-NV	3	24	1	0.96		
C-NV	4	23	2	0.92		
C-NV	5	NI (a)	NI	NI	0.95	0.04

(a) Survival based on initial exposure of 25 organisms per replicate.
(b) NI Not initiated; insufficient sediment to test all five replicates.

TABLE K.2. Daily Observations for N. virens on Sediment Surface During 28-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	N. virens on Sediment Surface Test Days 0 through 27																												
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
SF COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SF COMP	2	T (a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	4	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
SFW COMP	2	T	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	T	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	T	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	T	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	1	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	1	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	3	T	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	T	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
R-AM COMP	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	T	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
R-AM COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	3	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	5	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI

(a) T Too Turbid for observations.
(b) NI Not Initiated.

TABLE K.3. Daily Observations for N. virens Dead and Removed During 28-Day Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	N. virens Dead and Removed Test Days 0 through 27																											
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
SF COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
SF COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SF COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
SFW COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SFW COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
UIH COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Upper COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TB Lower COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	2	1 R(a)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-OS	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-BF	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R-AM COMP	4	1 R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
R-AM COMP	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
C-NV	5	NI (b)	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI	NI

(a) R Replaced dead organisms with live N. virens for Day 0 observations only.
(b) NI Not initiated.

TABLE K.4. Water Quality Summary for 28-Day N. virens Solid-Phase, Flow-Through Test, Richmond Harbor Deepening Project

Sediment Treatment	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity o/oo	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA (a)	28.0	32.0
SF COMP	11.4 (b)	16.5	7.56	7.95	7.3	8.7	30.0	32.0
SFW COMP	11.0 (b)	16.5	7.58	7.94	7.2	8.9	30.0	32.0
UIH COMP	11.2 (b)	16.5	7.51	7.95	7.2	8.8	30.0	32.0
TB Upper COMP	11.0 (b)	16.5	7.51	7.95	7.3	8.8	30.0	32.0
TB Lower COMP	11.2 (b)	16.5	7.53	7.93	7.2	8.8	30.0	32.0
R-OS	11.0 (b)	16.5	7.55	7.94	7.3	8.7	30.0	32.0
R-BF	11.0 (b)	16.5	7.56	7.94	7.4	8.7	30.0	32.0
R-AM COMP	11.0 (b)	16.5	7.54	7.94	7.3	8.6	30.0	32.0
C-NV	11.0 (b)	16.5	7.57	7.97	7.4	8.6	30.0	32.0

(a) Not applicable.
(b) Data point out of range.

APPENDIX L

BIOASSAY RESULTS FOR 96-HOUR SUSPENDED-PARTICULATE-PHASE TEST AND 96-HOUR REFERENCE TOXICANT TESTS FOR *CITHARICHTHYS stigmaeus*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Citharichthys stigmaeus*
TEST TYPE: Suspended-particulate-phase; static with aeration
TEST DURATION: 96 hours

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection. Each SPP was tested within 24 hours after preparation.

SOURCE/AGE Brezina and Associates, Dillon Beach, California. Wild captured organisms (juveniles sorted 1 in. to 2 in. size) were collected in Tomales Bay, California.

HOLDING/ACCLIMATION Approximately 1300 organisms were received on each of 2 days (February 25 and March 2, 1994) and held for a minimum of 48 hours prior to testing.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	10.6-16.3°C	6.79-7.76	7.3 - >20 mg/L	29.5-33.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 96 hours of testing for the SPP and ammonia and cadmium reference toxicant tests.

TEST VALIDATION The test was validated by >90% survival in the seawater controls estabilished for each of the tests.

REFERENCE TOXICANT TEST Validation of >90% survival in the seawater controls. An LC_{50} value of 0.88 mg/L of copper and an LC_{50} value of 23.92 mg/L of ammonia were calculated.

COMMENTS Fish were fed 8 oz of finely ground salmon feed once or twice daily throughout the holding/acclimation period.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE L.1. Test Results for 96-Hour C. stigmaeus Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live(a)	C. stigmaeus Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	0	1	10	0	1.00		
SF COMP	0	2	10	0	1.00		
SF COMP	0	3	10	0	1.00		
SF COMP	0	4	10	0	1.00		
SF COMP	0	5	10	0	1.00	1.00	0.00
SF COMP	10	1	10	0	1.00		
SF COMP	10	2	10	0	1.00		
SF COMP	10	3	10	0	1.00		
SF COMP	10	4	10	0	1.00		
SF COMP	10	5	10	0	1.00	1.00	0.00
SF COMP	50	1	10	0	1.00		
SF COMP	50	2	10	0	1.00		
SF COMP	50	3	10	0	1.00		
SF COMP	50	4	10	0	1.00		
SF COMP	50	5	10	0	1.00	1.00	0.00
SF COMP	100	1	10	0	1.00		
SF COMP	100	2	10	0	1.00		
SF COMP	100	3	10	0	1.00		
SF COMP	100	4	10	0	1.00		
SF COMP	100	5	10	0	1.00	1.00	0.00
SFW COMP	0	1	10	0	1.00		
SFW COMP	0	2	10	0	1.00		
SFW COMP	0	3	9	1	0.90		
SFW COMP	0	4	10	0	1.00		
SFW COMP	0	5	10	0	1.00	0.98	0.04
SFW COMP	10	1	10	0	1.00		
SFW COMP	10	2	10	0	1.00		
SFW COMP	10	3	10	0	1.00		
SFW COMP	10	4	NI (b)	NI	NI		
SFW COMP	10	5	NI	NI	NI	1.00	0.00
SFW COMP	50	1	10	0	1.00		
SFW COMP	50	2	10	0	1.00		
SFW COMP	50	3	10	0	1.00		
SFW COMP	50	4	NI	NI	NI		
SFW COMP	50	5	NI	NI	NI	1.00	0.00
SFW COMP	100	1	10	0	1.00		
SFW COMP	100	2	10	0	1.00		
SFW COMP	100	3	10	0	1.00		
SFW COMP	100	4	NI	NI	NI		
SFW COMP	100	5	NI	NI	NI	1.00	0.00

TABLE L.1. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live(a)	C. stigmaeus Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
UIH COMP	0	1	10	0	1.00		
UIH COMP	0	2	10	0	1.00		
UIH COMP	0	3	9	1	0.90		
UIH COMP	0	4	10	0	1.00		
UIH COMP	0	5	10	0	1.00	0.98	0.04
UIH COMP	10	1	10	0	1.00		
UIH COMP	10	2	10	0	1.00		
UIH COMP	10	3	10	0	1.00		
UIH COMP	10	4	10	0	1.00		
UIH COMP	10	5	10	0	1.00	1.00	0.00
UIH COMP	50	1	10	0	1.00		
UIH COMP	50	2	10	0	1.00		
UIH COMP	50	3	10	0	1.00		
UIH COMP	50	4	10	0	1.00		
UIH COMP	50	5	10	0	1.00	1.00	0.00
UIH COMP	100	1	9	1	0.90		
UIH COMP	100	2	10	0	1.00		
UIH COMP	100	3	10	0	1.00		
UIH COMP	100	4	10	0	1.00		
UIH COMP	100	5	10	0	1.00	0.98	0.04
TB Upper COMP	0	1	10	0	1.00		
TB Upper COMP	0	2	10	0	1.00		
TB Upper COMP	0	3	10	0	1.00		
TB Upper COMP	0	4	10	0	1.00		
TB Upper COMP	0	5	10	0	1.00	1.00	0.00
TB Upper COMP	10	1	10	0	1.00		
TB Upper COMP	10	2	9	1	0.90		
TB Upper COMP	10	3	10	0	1.00		
TB Upper COMP	10	4	10	0	1.00		
TB Upper COMP	10	5	10	0	1.00	0.98	0.04
TB Upper COMP	50	1	10	0	1.00		
TB Upper COMP	50	2	10	0	1.00		
TB Upper COMP	50	3	10	0	1.00		
TB Upper COMP	50	4	10	0	1.00		
TB Upper COMP	50	5	10	0	1.00	1.00	0.00
TB Upper COMP	100	1	10	0	1.00		
TB Upper COMP	100	2	10	0	1.00		
TB Upper COMP	100	3	10	0	1.00		
TB Upper COMP	100	4	10	0	1.00		
TB Upper COMP	100	5	10	0	1.00	1.00	0.00

TABLE L.1. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live(a)	C. stigmaeus Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
TB Lower COMP	0	1	9	1	0.90		
TB Lower COMP	0	2	10	0	1.00		
TB Lower COMP	0	3	10	0	1.00		
TB Lower COMP	0	4	10	0	1.00		
TB Lower COMP	0	5	10	0	1.00	0.98	0.04
TB Lower COMP	10	1	10	0	1.00		
TB Lower COMP	10	2	10	0	1.00		
TB Lower COMP	10	3	10	0	1.00		
TB Lower COMP	10	4	10	0	1.00		
TB Lower COMP	10	5	10	0	1.00	1.00	0.00
TB Lower COMP	50	1	10	0	1.00		
TB Lower COMP	50	2	10	0	1.00		
TB Lower COMP	50	3	10	0	1.00		
TB Lower COMP	50	4	10	0	1.00		
TB Lower COMP	50	5	10	0	1.00	1.00	0.00
TB Lower COMP	100	1	10	0	1.00		
TB Lower COMP	100	2	10	0	1.00		
TB Lower COMP	100	3	10	0	1.00		
TB Lower COMP	100	4	10	0	1.00		
TB Lower COMP	100	5	10	0	1.00	1.00	0.00
OBM COMP	0	1	10	0	1.00		
OBM COMP	0	2	10	0	1.00		
OBM COMP	0	3	10	0	1.00		
OBM COMP	0	4	10	0	1.00		
OBM COMP	0	5	10	0	1.00	1.00	0.00
OBM COMP	10	1	10	0	1.00		
OBM COMP	10	2	10	0	1.00		
OBM COMP	10	3	10	0	1.00		
OBM COMP	10	4	10	0	1.00		
OBM COMP	10	5	10	0	1.00	1.00	0.00
OBM COMP	50	1	10	0	1.00		
OBM COMP	50	2	10	0	1.00		
OBM COMP	50	3	10	0	1.00		
OBM COMP	50	4	9	1	0.90		
OBM COMP	50	5	10	0	1.00	0.98	0.04
OBM COMP	100	1	10	0	1.00		
OBM COMP	100	2	10	0	1.00		
OBM COMP	100	3	10	0	1.00		
OBM COMP	100	4	10	0	1.00		
OBM COMP	100	5	10	0	1.00	1.00	0.00

(a) Survival based on initial exposure of 10 organisms per replicate.
(b) NI Not initiated; insufficient organisms to test all 5 replicates.

TABLE L.2. Summary of Mean Proportion Surviving 96-Hour C. stigmaeus Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Mean Proportion Surviving
SF COMP	0	1.00
SF COMP	10	1.00
SF COMP	50	1.00
SF COMP	100	1.00
SFW COMP	0	0.98
SFW COMP	10	1.00
SFW COMP	50	1.00
SFW COMP	100	1.00
UIH COMP	0	0.98
UIH COMP	10	1.00
UIH COMP	50	1.00
UIH COMP	100	0.98
TB Upper COMP	0	1.00
TB Upper COMP	10	0.98
TB Upper COMP	50	1.00
TB Upper COMP	100	1.00
TB Lower COMP	0	0.98
TB Lower COMP	10	1.00
TB Lower COMP	50	1.00
TB Lower COMP	100	1.00
OBM COMP	0	1.00
OBM COMP	10	1.00
OBM COMP	50	0.98
OBM COMP	100	1.00

TABLE L.3. Daily Observations of C. stigmaeus During 96-Hour Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live				C. stigmaeus Dead			
			2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
SF COMP	0	1	10	10	10	10	0	0	0	0
SF COMP	0	2	10	10	10	10	0	0	0	0
SF COMP	0	3	10	10	10	10	0	0	0	0
SF COMP	0	4	10	10	10	10	0	0	0	0
SF COMP	0	5	10	10	10	10	0	0	0	0
SF COMP	10	1	10	10	10	10	0	0	0	0
SF COMP	10	2	10	10	10	10	0	0	0	0
SF COMP	10	3	10	10	10	10	0	0	0	0
SF COMP	10	4	10	10	10	10	0	0	0	0
SF COMP	10	5	10	10	10	10	0	0	0	0
SF COMP	50	1	10	10	10	10	0	0	0	0
SF COMP	50	2	10	10	10	10	0	0	0	0
SF COMP	50	3	10	10	10	10	0	0	0	0
SF COMP	50	4	10	10	10	10	0	0	0	0
SF COMP	50	5	10	10	10	10	0	0	0	0
SF COMP	100	1	10	10	10	10	0	0	0	0
SF COMP	100	2	10	10	10	10	0	0	0	0
SF COMP	100	3	10	10	10	10	0	0	0	0
SF COMP	100	4	10	10	10	10	0	0	0	0
SF COMP	100	5	10	10	10	10	0	0	0	0
SFW COMP	0	1	10	10	10	10	0	0	0	0
SFW COMP	0	2	10	10	10	10	0	0	0	0
SFW COMP	0	3	10	10	9	9	0	0	1	0
SFW COMP	0	4	10	10	10	10	0	0	0	0
SFW COMP	0	5	10	10	10	10	0	0	0	0
SFW COMP	10	1	10	10	10	10	0	0	0	0
SFW COMP	10	2	10	10	10	10	0	0	0	0
SFW COMP	10	3	10	10	10	10	0	0	0	0
SFW COMP	10	4	NI (a)	NI	NI	NI	NI	NI	NI	NI
SFW COMP	10	5	NI	NI	NI	NI	NI	NI	NI	NI
SFW COMP	50	1	10	10	10	10	0	0	0	0
SFW COMP	50	2	10	10	10	10	0	0	0	0
SFW COMP	50	3	10	10	10	10	0	0	0	0
SFW COMP	50	4	NI	NI	NI	NI	NI	NI	NI	NI
SFW COMP	50	5	NI	NI	NI	NI	NI	NI	NI	NI
SFW COMP	100	1	10	10	10	10	0	0	0	0
SFW COMP	100	2	10	10	10	10	0	0	0	0
SFW COMP	100	3	10	10	10	10	0	0	0	0
SFW COMP	100	4	NI	NI	NI	NI	NI	NI	NI	NI
SFW COMP	100	5	NI	NI	NI	NI	NI	NI	NI	NI

TABLE L.3. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live				C. stigmaeus Dead			
			2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
UIH COMP	0	1	10	10	10	10	0	0	0	0
UIH COMP	0	2	10	10	10	10	0	0	0	0
UIH COMP	0	3	10	10	10	9	0	0	0	1
UIH COMP	0	4	10	10	10	10	0	0	0	0
UIH COMP	0	5	10	10	10	10	0	0	0	0
UIH COMP	10	1	10	10	10	10	0	0	0	0
UIH COMP	10	2	10	10	10	10	0	0	0	0
UIH COMP	10	3	10	10	10	10	0	0	0	0
UIH COMP	10	4	10	10	10	10	0	0	0	0
UIH COMP	10	5	10	10	10	10	0	0	0	0
UIH COMP	50	1	10	10	10	10	0	0	0	0
UIH COMP	50	2	10	10	10	10	0	0	0	0
UIH COMP	50	3	10	10	10	10	0	0	0	0
UIH COMP	50	4	10	10	10	10	0	0	0	0
UIH COMP	50	5	10	10	10	10	0	0	0	0
UIH COMP	100	1	10	9	9	9	0	1	0	0
UIH COMP	100	2	10	10	10	10	0	0	0	0
UIH COMP	100	3	10	10	10	10	0	0	0	0
UIH COMP	100	4	10	10	10	10	0	0	0	0
UIH COMP	100	5	10	10	10	10	0	0	0	0
TB Upper COMP	0	1	10	10	10	10	0	0	0	0
TB Upper COMP	0	2	10	10	10	10	0	0	0	0
TB Upper COMP	0	3	10	10	10	10	0	0	0	0
TB Upper COMP	0	4	10	10	10	10	0	0	0	0
TB Upper COMP	0	5	10	10	10	10	0	0	0	0
TB Upper COMP	10	1	10	10	10	10	0	0	0	0
TB Upper COMP	10	2	10	10	10	9	0	0	0	1
TB Upper COMP	10	3	10	10	10	10	0	0	0	0
TB Upper COMP	10	4	10	10	10	10	0	0	0	0
TB Upper COMP	10	5	10	10	10	10	0	0	0	0
TB Upper COMP	50	1	10	10	10	10	0	0	0	0
TB Upper COMP	50	2	10	10	10	10	0	0	0	0
TB Upper COMP	50	3	10	10	10	10	0	0	0	0
TB Upper COMP	50	4	10	10	10	10	0	0	0	0
TB Upper COMP	50	5	10	10	10	10	0	0	0	0
TB Upper COMP	100	1	10	10	10	10	0	0	0	0
TB Upper COMP	100	2	10	10	10	10	0	0	0	0
TB Upper COMP	100	3	10	10	10	10	0	0	0	0
TB Upper COMP	100	4	10	10	10	10	0	0	0	0
TB Upper COMP	100	5	10	10	10	10	0	0	0	0

TABLE L.3. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	C. stigmaeus Live 2 h	24 h	48 h	72 h	C. stigmaeus Dead 2 h	24 h	48 h	72 h
TB Lower COMP	0	1	10	10	10	9	0	0	0	1
TB Lower COMP	0	2	10	10	10	10	0	0	0	0
TB Lower COMP	0	3	10	10	10	10	0	0	0	0
TB Lower COMP	0	4	10	10	10	10	0	0	0	0
TB Lower COMP	0	5	10	10	10	10	0	0	0	0
TB Lower COMP	10	1	10	10	10	10	0	0	0	0
TB Lower COMP	10	2	10	10	10	10	0	0	0	0
TB Lower COMP	10	3	10	10	10	10	0	0	0	0
TB Lower COMP	10	4	10	10	10	10	0	0	0	0
TB Lower COMP	10	5	10	10	10	10	0	0	0	0
TB Lower COMP	50	1	10	10	10	10	0	0	0	0
TB Lower COMP	50	2	10	10	10	10	0	0	0	0
TB Lower COMP	50	3	10	10	10	10	0	0	0	0
TB Lower COMP	50	4	10	10	10	10	0	0	0	0
TB Lower COMP	50	5	10	10	10	10	0	0	0	0
TB Lower COMP	100	1	10	10	10	10	0	0	0	0
TB Lower COMP	100	2	10	10	10	10	0	0	0	0
TB Lower COMP	100	3	10	10	10	10	0	0	0	0
TB Lower COMP	100	4	10	10	10	10	0	0	0	0
TB Lower COMP	100	5	10	10	10	10	0	0	0	0
OBM COMP	0	1	10	10	10	10	0	0	0	0
OBM COMP	0	2	10	10	10	10	0	0	0	0
OBM COMP	0	3	10	10	10	10	0	0	0	0
OBM COMP	0	4	10	10	10	10	0	0	0	0
OBM COMP	0	5	10	10	10	10	0	0	0	0
OBM COMP	10	1	10	10	10	10	0	0	0	0
OBM COMP	10	2	10	10	10	10	0	0	0	0
OBM COMP	10	3	10	10	10	10	0	0	0	0
OBM COMP	10	4	10	10	10	10	0	0	0	0
OBM COMP	10	5	10	10	10	10	0	0	0	0
OBM COMP	50	1	10	10	10	10	0	0	0	0
OBM COMP	50	2	10	10	10	10	0	0	0	0
OBM COMP	50	3	10	10	10	10	0	0	0	0
OBM COMP	50	4	10	10	10	9	0	0	0	1
OBM COMP	50	5	10	10	10	10	0	0	0	0
OBM COMP	100	1	10	10	10	10	0	0	0	0
OBM COMP	100	2	10	10	10	10	0	0	0	0
OBM COMP	100	3	10	10	10	10	0	0	0	0
OBM COMP	100	4	10	10	10	10	0	0	0	0
OBM COMP	100	5	10	10	10	10	0	0	0	0

(a) NI Not initiated

TABLE L.4. Water Quality Summary for 96-Hour C. stigmaeus Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Temperature (°C) Min	Max	pH Min	Max	Dissolved Oxygen (mg/L) Min	Max	Salinity (o/oo) Min	Max	Ammonia (mg/L) Average(a)
Acceptable Range		13.0	17.0	7.30	8.30	6.0	NA (b)	28.0	32.0	NE (c)
SF COMP	0	13.8	15.5	7.63	7.95	7.7	8.4	30.5	32.0	NM (d)
SF COMP	10	14.2	15.6	7.69	7.96	7.7	8.4	30.5	31.5	NM
SF COMP	50	14.1	15.4	7.67	8.02	7.1	8.4	30.0	31.0	NM
SF COMP	100	14.1	15.4	7.76	8.14	7.6	8.8	30.0	30.5	4.02
SFW COMP	0	14.0	14.9	7.71	8.00	7.8	8.9	30.0	32.0	NM
SFW COMP	10	14.2	14.9	7.73	7.98	7.6	8.8	30.0	31.5	NM
SFW COMP	50	13.9	14.9	7.78	8.02	7.8	8.7	30.0	31.5	NM
SFW COMP	100	14.1	14.9	7.89	8.15	7.5	8.8	30.0	30.5	2.38
UIH COMP	0	14.6	15.6	7.42	7.88	7.4	8.3	30.5	32.0	NM
UIH COMP	10	14.8	15.5	7.50	7.95	7.4	8.2	30.5	32.0	NM
UIH COMP	50	14.9	15.7	7.74	8.11	7.4	8.2	30.0	32.0	NM
UIH COMP	100	15.1	15.6	7.75	8.24	6.6	8.2	29.0	30.5	3.02
TB Upper COMP	0	13.9	14.8	7.66	8.01	7.8	8.8	30.5	31.5	NM
TB Upper COMP	10	14.3	14.9	7.67	8.02	7.9	8.7	30.5	31.5	NM
TB Upper COMP	50	14.4	14.9	7.76	8.11	7.7	8.8	30.0	31.0	NM
TB Upper COMP	100	14.3	14.9	7.94	8.21	6.6	8.8	29.5	30.0	3.31
TB Lower COMP	0	13.5	15.1	7.52	7.94	7.2	8.2	30.0	32.0	NM
TB Lower COMP	10	14.0	14.9	7.62	7.99	7.4	8.2	30.0	31.5	NM
TB Lower COMP	50	14.2	15.0	7.73	8.10	7.4	8.4	30.0	30.0	NM
TB Lower COMP	100	14.2	15.0	7.77	8.15	7.0	8.3	28.5	31.0	4.75
OBM COMP	0	13.9	14.9	7.68	7.96	7.8	8.6	31.0	31.5	NM
OBM COMP	10	13.9	14.8	7.73	7.98	7.9	8.6	30.0	31.5	NM
OBM COMP	50	14.3	14.8	7.78	7.99	7.7	8.6	30.0	31.0	NM
OBM COMP	100	14.5	15.1	7.81	8.07	7.7	8.7	29.5	30.0	1.00

(a) Average of Day 4 measurements.
(b) NA Not applicable.
(c) NE Not established.
(d) NM Not measured.

TABLE L.5. Test Results for 96-Hour C. stigmaeus Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (mg/L)	Replicate	C. stigmaeus Live(a)	C. stigmaeus Dead or Missing	Proportion Surviving	Mean Proportion Survival	Standard Deviation
0.00	1	10	0	1.00		
0.00	2	10	0	1.00		
0.00	3	10	0	1.00	1.00	0.00
0.50	1	10	0	1.00		
0.50	2	10	0	1.00		
0.50	3	9	1	0.90	0.97	0.06
1.00	1	0	10	0.00		
1.00	2	1	9	0.10		
1.00	3	10	0	1.00	0.37	0.55
1.50	1	0	10	0.00		
1.50	2	0	10	0.00		
1.50	3	4	6	0.40	0.13	0.23
2.00	1	0	10	0.00		
2.00	2	1	9	0.10		
2.00	3	0	10	0.00	0.03	0.06

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

TABLE L.6. Daily Observations for C. stigmaeus During Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (mg/L)	Replicate	C. stigmaeus Live				C. stigmaeus Dead			
		2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
0.00	1	10	10	10	10	0	0	0	0
0.00	2	10	10	10	10	0	0	0	0
0.00	3	10	10	10	10	0	0	0	0
0.50	1	10	10	10	10	0	0	0	0
0.50	2	10	10	10	10	0	0	0	0
0.50	3	10	10	10	9	0	0	0	1
1.00	1	10	9	6	1	0	1	3	5
1.00	2	10	9	3	1	0	1	6	2
1.00	3	10	10	10	10	0	0	0	0
1.50	1	10	6	0	0	0	4	6	0
1.50	2	10	7	1	0	0	3	6	1
1.50	3	10	10	10	8	0	0	0	2
2.00	1	10	2	0	0	0	8	2	0
2.00	2	10	10	7	3	0	0	3	4
2.00	3	10	1	0	0	0	9	1	0

TABLE L.7. Water Quality Summary for 96-Hour C. stigmaeus Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA (a)	28.0	32.0
0.00	14.2	15.4	7.72	7.90	7.7	8.4	30.5	32.0
0.50	14.0	15.0	7.78	7.93	8.1	8.5	30.5	31.5
1.00	14.0	15.4	7.68	7.95	8.0	8.4	30.5	32.0
1.50	14.1	15.3	7.67	7.96	8.2	8.5	30.5	31.5
2.00	14.1	15.4	7.63	7.91	8.0	8.4	30.5	32.0

(a) NA Not applicable.

TABLE L.8. Test Results for 96-Hour C. stigmaeus Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Replicate	C. stigmaeus Live(a)	C. stigmaeus Dead or Missing	Proportion Surviving	Mean Proportion Survival	Standard Deviation
0.350	1	10	0	1.00		
0.350	2	10	0	1.00		
0.350	3	10	0	1.00	1.00	0.00
12.9	1	10	0	1.00		
12.9	2	10	0	1.00		
12.9	3	10	0	1.00	1.00	0.00
17.1	1	10	0	1.00		
17.1	2	10	0	1.00		
17.1	3	10	0	1.00	1.00	0.00
21.7	1	9	1	0.90		
21.7	2	7	3	0.70		
21.7	3	8	2	0.80	0.80	0.10
25.8	1	2	8	0.20		
25.8	2	1	9	0.10		
25.8	3	5	5	0.50	0.27	0.21

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

TABLE L.9. Daily Observations for C. stigmaeus During Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Replicate	C. stigmaeus Live				C. stigmaeus Dead			
		2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
0.350	1	10	10	10	10	0	0	0	0
0.350	2	10	10	10	10	0	0	0	0
0.350	3	10	10	10	10	0	0	0	0
12.9	1	10	10	10	10	0	0	0	0
12.9	2	10	10	10	10	0	0	0	0
12.9	3	10	10	10	10	0	0	0	0
17.1	1	10	10	10	10	0	0	0	0
17.1	2	10	10	10	10	0	0	0	0
17.1	3	10	10	10	10	0	0	0	0
21.7	1	10	9	9	9	0	1	0	0
21.7	2	10	7	7	7	0	3	0	0
21.7	3	10	8	8	8	0	2	0	0
25.8	1	10	2	2	2	0	8	0	0
25.8	2	10	1	1	1	0	9	0	0
25.8	3	10	5	5	5	0	5	0	0

TABLE L.10. Water Quality Summary for 96-Hour C. stigmaeus Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	6.0	NA (a)	28.0	32.0	NE (b)	NE
0.350	14.1	14.7	7.68	7.93	7.8	8.3	31.0	32.0	0.234	0.548
12.9	14.0	14.4	7.70	7.88	8.0	8.4	31.0	32.0	11.2	17.5
17.1	14.1	14.3	7.78	7.89	8.0	8.4	31.0	32.0	14.6	20.8
21.7	14.1	14.3	7.77	7.92	7.9	8.4	31.0	31.5	18.4	24.5
25.8	14.1	14.6	7.82	7.95	7.8	8.4	31.5	32.0	21.3	28.5

(a) NA Not applicable.
(b) NE Not established.

APPENDIX M

BIOASSAY RESULTS FOR 96-HOUR SUSPENDED-PARTICULATE-PHASE TEST AND 96-HOUR REFERENCE TOXICANT TESTS FOR *HOLMESIMYSIS costata*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
TEST ORGANISM: *Holmesimysis costata*
TEST TYPE: Suspended-particulate-phase; static with aeration
TEST DURATION: 96 hours

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
13-17°C	7.30-8.30	≥6.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection. Each SPP was tested within 24 hours after preparation.

SOURCE/AGE Brezina and Associates, Dillon Beach, California. Wild captured organisms (sorted to uniform juvenile size) were collected in Tomales Bay, California.

HOLDING/ACCLIMATION Approximately 1500 and 1300 organisms were received on each of 2 days (February 25 and March 2, 1994), respectively, and held for a minimum of 48 hours prior to testing.

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	11.7-16.2°C	7.18-7.85	6.5 - >20.0 mg/L	30.0-33.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 96 hours of testing for the SPP and ammonia and cadmium reference toxicant tests.

TEST VALIDATION The test was validated by >90% survival in the seawater controls estabilished for each of the tests.

REFERENCE TOXICANT TEST Validation of >90% survival in the seawater controls. An LC_{50} value of 70.71 µg/L of copper and an LC_{50} value of 39.75 mg/L of ammonia were calculated.

COMMENTS Mysids were fed 24-h-old brine shrimp nauplii once or twice daily during holding/acclimation and testing periods.

REFERENCES

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE M.1. Test Results for 96-Hour H. costata Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
SF COMP	0	1	9	1	0.90		
SF COMP	0	2	10	0	1.00		
SF COMP	0	3	9	1	0.90		
SF COMP	0	4	10	0	1.00		
SF COMP	0	5	9	1	0.90	0.94	0.05
SF COMP	10	1	10	0	1.00		
SF COMP	10	2	10	0	1.00		
SF COMP	10	3	9	1	0.90		
SF COMP	10	4	10	0	1.00		
SF COMP	10	5	10	0	1.00	0.98	0.04
SF COMP	50	1	9	1	0.90		
SF COMP	50	2	9	1	0.90		
SF COMP	50	3	10	0	1.00		
SF COMP	50	4	10	0	1.00		
SF COMP	50	5	10	0	1.00	0.96	0.05
SF COMP	100	1	10	0	1.00		
SF COMP	100	2	9	1	0.90		
SF COMP	100	3	7	3	0.70		
SF COMP	100	4	9	1	0.90		
SF COMP	100	5	8	2	0.80	0.86	0.11
SFW COMP	0	1	10	0	1.00		
SFW COMP	0	2	9	1	0.90		
SFW COMP	0	3	10	0	1.00		
SFW COMP	0	4	10	0	1.00		
SFW COMP	0	5	10	0	1.00	0.98	0.04
SFW COMP	10	1	9	1	0.90		
SFW COMP	10	2	10	0	1.00		
SFW COMP	10	3	10	0	1.00		
SFW COMP	10	4	10	0	1.00		
SFW COMP	10	5	9	1	0.90	0.96	0.05
SFW COMP	50	1	9	1	0.90		
SFW COMP	50	2	10	0	1.00		
SFW COMP	50	3	10	0	1.00		
SFW COMP	50	4	9	1	0.90		
SFW COMP	50	5	10	0	1.00	0.96	0.05
SFW COMP	100	1	9	1	0.90		
SFW COMP	100	2	9	1	0.90		
SFW COMP	100	3	9	1	0.90		
SFW COMP	100	4	10	0	1.00		
SFW COMP	100	5	7	3	0.70	0.88	0.11

TABLE M.1 (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
UIH COMP	0	1	10	0	1.00		
UIH COMP	0	2	10	0	1.00		
UIH COMP	0	3	10	0	1.00		
UIH COMP	0	4	10	0	1.00		
UIH COMP	0	5	10	0	1.00	1.00	0.00
UIH COMP	10	1	10	0	1.00		
UIH COMP	10	2	9	1	0.90		
UIH COMP	10	3	10	0	1.00		
UIH COMP	10	4	10	0	1.00		
UIH COMP	10	5	9	1	0.90	0.96	0.05
UIH COMP	50	1	9	1	0.90		
UIH COMP	50	2	10	0	1.00		
UIH COMP	50	3	10	0	1.00		
UIH COMP	50	4	9	1	0.90		
UIH COMP	50	5	9	1	0.90	0.94	0.05
UIH COMP	100	1	8	2	0.80		
UIH COMP	100	2	10	0	1.00		
UIH COMP	100	3	10	0	1.00		
UIH COMP	100	4	9	1	0.90		
UIH COMP	100	5	8	2	0.80	0.90	0.10
TB Upper COMP	0	1	9	1	0.90		
TB Upper COMP	0	2	10	0	1.00		
TB Upper COMP	0	3	10	0	1.00		
TB Upper COMP	0	4	9	1	0.90		
TB Upper COMP	0	5	10	0	1.00	0.96	0.05
TB Upper COMP	10	1	10	0	1.00		
TB Upper COMP	10	2	10	0	1.00		
TB Upper COMP	10	3	9	1	0.90		
TB Upper COMP	10	4	10	0	1.00		
TB Upper COMP	10	5	10	0	1.00	0.98	0.04
TB Upper COMP	50	1	10	0	1.00		
TB Upper COMP	50	2	9	1	0.90		
TB Upper COMP	50	3	9	1	0.90		
TB Upper COMP	50	4	10	0	1.00		
TB Upper COMP	50	5	10	0	1.00	0.96	0.05
TB Upper COMP	100	1	10	0	1.00		
TB Upper COMP	100	2	10	0	1.00		
TB Upper COMP	100	3	9	1	0.90		
TB Upper COMP	100	4	9	1	0.90		
TB Upper COMP	100	5	10	0	1.00	0.96	0.05

TABLE M.1 (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
TB Lower COMP	0	1	10	0	1.00		
TB Lower COMP	0	2	10	0	1.00		
TB Lower COMP	0	3	10	0	1.00		
TB Lower COMP	0	4	10	0	1.00		
TB Lower COMP	0	5	9	1	0.90	0.98	0.04
TB Lower COMP	10	1	9	1	0.90		
TB Lower COMP	10	2	10	0	1.00		
TB Lower COMP	10	3	10	0	1.00		
TB Lower COMP	10	4	8	2	0.80		
TB Lower COMP	10	5	10	0	1.00	0.94	0.09
TB Lower COMP	50	1	10	0	1.00		
TB Lower COMP	50	2	10	0	1.00		
TB Lower COMP	50	3	10	0	1.00		
TB Lower COMP	50	4	10	0	1.00		
TB Lower COMP	50	5	10	0	1.00	1.00	0.00
TB Lower COMP	100	1	9	1	0.90		
TB Lower COMP	100	2	9	1	0.90		
TB Lower COMP	100	3	10	0	1.00		
TB Lower COMP	100	4	10	0	1.00		
TB Lower COMP	100	5	9	1	0.90	0.94	0.05
OBM COMP	0	1	10	0	1.00		
OBM COMP	0	2	9	1	0.90		
OBM COMP	0	3	10	0	1.00		
OBM COMP	0	4	10	0	1.00		
OBM COMP	0	5	10	0	1.00	0.98	0.04
OBM COMP	10	1	9	1	0.90		
OBM COMP	10	2	10	0	1.00		
OBM COMP	10	3	9	1	0.90		
OBM COMP	10	4	10	0	1.00		
OBM COMP	10	5	9	1	0.90	0.94	0.05
OBM COMP	50	1	10	0	1.00		
OBM COMP	50	2	9	1	0.90		
OBM COMP	50	3	10	0	1.00		
OBM COMP	50	4	10	0	1.00		
OBM COMP	50	5	10	0	1.00	0.98	0.04
OBM COMP	100	1	10	0	1.00		
OBM COMP	100	2	10	0	1.00		
OBM COMP	100	3	9	1	0.90		
OBM COMP	100	4	10	0	1.00		
OBM COMP	100	5	9	1	0.90	0.96	0.05

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

TABLE M.2. Summary of Mean Proportion Surviving 96-Hour H. costata Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Mean Proportion Surviving(a)
SF COMP	0	0.94
SF COMP	10	0.98
SF COMP	50	0.96
SF COMP	100	0.86
SFW COMP	0	0.98
SFW COMP	10	0.96
SFW COMP	50	0.96
SFW COMP	100	0.88
UIH COMP	0	1.00
UIH COMP	10	0.96
UIH COMP	50	0.94
UIH COMP	100	0.90
TB Upper COMP	0	0.96
TB Upper COMP	10	0.98
TB Upper COMP	50	0.96
TB Upper COMP	100	0.96
TB Lower COMP	0	0.98
TB Lower COMP	10	0.94
TB Lower COMP	50	1.00
TB Lower COMP	100	0.94
OBM COMP	0	0.98
OBM COMP	10	0.94
OBM COMP	50	0.98
OBM COMP	100	0.96

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

TABLE M.3. Daily Observations of H. costata During 96-Hour Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live				H. costata Dead			
			2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
SF COMP	0	1	10	10	10	10	0	0	0	0
SF COMP	0	2	10	10	10	10	0	0	0	0
SF COMP	0	3	10	10	10	10	0	0	0	0
SF COMP	0	4	10	10	10	10	0	0	0	0
SF COMP	0	5	10	10	10	9	0	0	0	1
SF COMP	10	1	10	10	10	10	0	0	0	0
SF COMP	10	2	10	10	10	10	0	0	0	0
SF COMP	10	3	10	10	9	9	0	0	1	0
SF COMP	10	4	10	10	10	10	0	0	0	0
SF COMP	10	5	10	10	10	10	0	0	0	0
SF COMP	50	1	10	9	9	9	0	1	0	0
SF COMP	50	2	10	10	10	10	0	0	0	0
SF COMP	50	3	10	10	10	10	0	0	0	0
SF COMP	50	4	10	10	10	10	0	0	0	0
SF COMP	50	5	10	10	10	10	0	0	0	0
SF COMP	100	1	10	10	10	10	0	0	0	0
SF COMP	100	2	10	9	9	9	0	1	0	0
SF COMP	100	3	10	10	9	7	0	0	1	2
SF COMP	100	4	10	10	10	10	0	0	0	0
SF COMP	100	5	10	10	10	9	0	0	0	1
SFW COMP	0	1	10	10	10	10	0	0	0	0
SFW COMP	0	2	10	10	10	10	0	0	0	0
SFW COMP	0	3	10	10	10	10	0	0	0	0
SFW COMP	0	4	10	10	10	10	0	0	0	0
SFW COMP	0	5	10	10	10	10	0	0	0	0
SFW COMP	10	1	10	10	10	10	0	0	0	0
SFW COMP	10	2	10	10	10	10	0	0	0	0
SFW COMP	10	3	10	10	10	10	0	0	0	0
SFW COMP	10	4	10	10	10	10	0	0	0	0
SFW COMP	10	5	10	10	10	9	0	0	0	1
SFW COMP	50	1	10	10	9	9	0	0	1	0
SFW COMP	50	2	10	10	10	10	0	0	0	0
SFW COMP	50	3	10	10	10	10	0	0	0	0
SFW COMP	50	4	10	10	10	9	0	0	0	1
SFW COMP	50	5	10	10	10	10	0	0	0	0
SFW COMP	100	1	10	10	10	9	0	0	0	1
SFW COMP	100	2	10	9	9	9	0	1	0	0
SFW COMP	100	3	10	10	10	9	0	0	0	1
SFW COMP	100	4	10	10	10	10	0	0	0	0
SFW COMP	100	5	10	10	10	8	0	0	0	2

TABLE M.3. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live				H. costata Dead			
			2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
UIH COMP	0	1	10	10	10	10	0	0	0	0
UIH COMP	0	2	10	10	10	10	0	0	0	0
UIH COMP	0	3	10	10	10	10	0	0	0	0
UIH COMP	0	4	10	10	10	10	0	0	0	0
UIH COMP	0	5	10	10	10	10	0	0	0	0
UIH COMP	10	1	10	10	10	10	0	0	0	0
UIH COMP	10	2	10	9	9	9	0	1	0	0
UIH COMP	10	3	10	10	10	10	0	0	0	0
UIH COMP	10	4	10	10	10	10	0	0	0	0
UIH COMP	10	5	10	10	9	9	0	0	1	0
UIH COMP	50	1	10	10	10	9	0	0	0	1
UIH COMP	50	2	10	10	10	10	0	0	0	0
UIH COMP	50	3	10	10	10	10	0	0	0	0
UIH COMP	50	4	10	9	9	9	0	1	0	0
UIH COMP	50	5	10	10	9	9	0	0	1	0
UIH COMP	100	1	10	10	9	9	0	0	1	0
UIH COMP	100	2	10	10	10	10	0	0	0	0
UIH COMP	100	3	10	10	10	10	0	0	0	0
UIH COMP	100	4	10	10	9	9	0	0	1	0
UIH COMP	100	5	10	9	9	8	0	1	0	1
TB Upper COMP	0	1	10	10	10	10	0	0	0	0
TB Upper COMP	0	2	10	10	10	10	0	0	0	0
TB Upper COMP	0	3	10	10	10	10	0	0	0	0
TB Upper COMP	0	4	10	10	10	10	0	0	0	0
TB Upper COMP	0	5	10	10	10	10	0	0	0	0
TB Upper COMP	10	1	10	10	10	10	0	0	0	0
TB Upper COMP	10	2	10	10	10	10	0	0	0	0
TB Upper COMP	10	3	10	10	10	10	0	0	0	0
TB Upper COMP	10	4	10	10	10	10	0	0	0	0
TB Upper COMP	10	5	10	10	10	10	0	0	0	0
TB Upper COMP	50	1	10	10	10	10	0	0	0	0
TB Upper COMP	50	2	10	9	9	9	0	1	0	0
TB Upper COMP	50	3	10	10	10	10	0	0	0	0
TB Upper COMP	50	4	10	10	10	10	0	0	0	0
TB Upper COMP	50	5	10	10	10	10	0	0	0	0
TB Upper COMP	100	1	10	10	10	10	0	0	0	0
TB Upper COMP	100	2	10	10	10	10	0	0	0	0
TB Upper COMP	100	3	10	10	10	9	0	0	0	1
TB Upper COMP	100	4	10	10	10	9	0	0	0	1
TB Upper COMP	100	5	10	10	10	10	0	0	0	0

TABLE M.3. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	H. costata Live 2 h	24 h	48 h	72 h	H. costata Dead 2 h	24 h	48 h	72 h
TB Lower COMP	0	1	10	10	10	10	0	0	0	0
TB Lower COMP	0	2	10	10	10	10	0	0	0	0
TB Lower COMP	0	3	10	10	10	10	0	0	0	0
TB Lower COMP	0	4	10	10	10	10	0	0	0	0
TB Lower COMP	0	5	10	10	10	10	0	0	0	0
TB Lower COMP	10	1	10	10	10	10	0	0	0	0
TB Lower COMP	10	2	10	10	10	10	0	0	0	0
TB Lower COMP	10	3	10	10	10	10	0	0	0	0
TB Lower COMP	10	4	10	10	10	9	0	0	0	1
TB Lower COMP	10	5	10	10	10	10	0	0	0	0
TB Lower COMP	50	1	10	10	10	10	0	0	0	0
TB Lower COMP	50	2	10	10	10	10	0	0	0	0
TB Lower COMP	50	3	10	10	10	10	0	0	0	0
TB Lower COMP	50	4	10	10	10	10	0	0	0	0
TB Lower COMP	50	5	10	10	10	10	0	0	0	0
TB Lower COMP	100	1	10	9	9	9	0	1	0	0
TB Lower COMP	100	2	10	9	9	9	0	1	0	0
TB Lower COMP	100	3	10	10	10	10	0	0	0	0
TB Lower COMP	100	4	10	10	10	10	0	0	0	0
TB Lower COMP	100	5	10	10	10	10	0	0	0	0
OBM COMP	0	1	10	10	10	10	0	0	0	0
OBM COMP	0	2	10	10	9	9	0	0	1	0
OBM COMP	0	3	10	10	10	10	0	0	0	0
OBM COMP	0	4	10	10	10	10	0	0	0	0
OBM COMP	0	5	10	10	10	10	0	0	0	0
OBM COMP	10	1	10	10	10	9	0	0	0	1
OBM COMP	10	2	10	10	10	10	0	0	0	0
OBM COMP	10	3	10	10	10	9	0	0	0	1
OBM COMP	10	4	10	10	10	10	0	0	0	0
OBM COMP	10	5	10	10	10	10	0	0	0	0
OBM COMP	50	1	10	10	10	10	0	0	0	0
OBM COMP	50	2	10	10	10	9	0	0	0	1
OBM COMP	50	3	10	10	10	10	0	0	0	0
OBM COMP	50	4	10	10	10	10	0	0	0	0
OBM COMP	50	5	10	10	10	10	0	0	0	0
OBM COMP	100	1	10	10	10	10	0	0	0	0
OBM COMP	100	2	10	10	10	10	0	0	0	0
OBM COMP	100	3	10	10	10	9	0	0	0	1
OBM COMP	100	4	10	10	10	10	0	0	0	0
OBM COMP	100	5	10	10	10	9	0	0	0	1

TABLE M.4. Water Quality Summary for 96-Hour H. costata Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Temperature (°C) Min	Temperature (°C) Max	pH Min	pH Max	Dissolved Oxygen (mg/L) Min	Dissolved Oxygen (mg/L) Max	Salinity (o/oo) Min	Salinity (o/oo) Max	Ammonia (mg/L) Average
Acceptable Range		13.0	17.0	7.30	8.30	4.0	NA (a)	28.0	32.0	NE (b)
SF COMP	0	14.7	15.3	7.63	7.93	7.9	8.8	31.5	32.0	NM (c)
SF COMP	10	14.8	15.3	7.66	7.91	7.8	8.5	31.0	32.0	NM
SF COMP	50	14.7	15.3	7.73	7.95	7.4	8.5	30.5	31.5	NM
SF COMP	100	14.8	15.4	7.73	8.04	6.5	8.5	29.5	30.5	4.04
SFW COMP	0	15.0	15.8	7.75	7.88	7.7	8.6	31.0	32.0	NM
SFW COMP	10	15.0	15.7	7.71	7.84	7.6	8.5	30.5	32.0	NM
SFW COMP	50	15.0	15.7	7.75	7.94	7.7	8.5	30.0	31.5	NM
SFW COMP	100	15.0	15.7	7.79	8.00	6.3	8.4	29.5	30.5	8.08
UIH COMP	0	15.0	15.7	7.67	7.83	7.9	8.8	30.5	31.5	NM
UIH COMP	10	15.0	15.7	7.75	7.94	7.7	8.7	30.5	31.5	NM
UIH COMP	50	15.0	15.7	7.76	8.02	7.7	8.6	30.0	30.5	NM
UIH COMP	100	15.0	15.7	7.82	8.15	6.7	8.4	29.5	30.5	11.4
TB Upper COMP	0	15.1	16.0	7.69	7.87	7.6	8.6	31.0	32.0	NM
TB Upper COMP	10	15.1	15.8	7.72	7.91	7.6	8.5	30.5	32.0	NM
TB Upper COMP	50	15.0	15.8	7.75	8.01	7.5	8.4	30.0	31.0	NM
TB Upper COMP	100	15.1	15.8	7.01	8.08	6.2	8.5	29.5	30.0	11.3
TB Lower COMP	0	15.0	15.8	7.46	7.81	6.3	8.6	31.0	32.0	NM
TB Lower COMP	10	15.0	15.6	7.72	7.88	7.9	8.6	30.0	31.5	NM
TB Lower COMP	50	15.0	15.8	7.67	7.90	7.6	8.6	30.0	31.0	NM
TB Lower COMP	100	15.1	15.8	7.76	7.99	7.7	8.5	28.5	30.0	11.4
OBM COMP	0	14.9	15.9	7.69	8.05	7.5	8.3	31.0	32.0	NM
OBM COMP	10	14.9	15.9	7.62	8.07	7.7	8.3	30.5	32.0	NM
OBM COMP	50	15.0	15.8	7.62	8.12	7.7	8.3	30.0	31.5	NM
OBM COMP	100	15.0	15.9	7.66	8.17	7.7	8.4	30.0	30.5	2.22

(a) NA Not applicable.
(b) NE Not established.
(c) NM Not measured.

TABLE M.5. Test Results for 96-Hour H. costata Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (ug/L)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
0.0	1	10	0	1.00		
0.0	2	9	1	0.90		
0.0	3	9	1	0.90	0.93	0.06
50.0	1	9	1	0.90		
50.0	2	8	2	0.80		
50.0	3	9	1	0.90	0.87	0.06
100.0	1	1	9	0.10		
100.0	2	1	9	0.10		
100.0	3	0	10	0.00	0.07	0.06
150.0	1	0	10	0.00		
150.0	2	0	10	0.00		
150.0	3	0	10	0.00	0.00	0.00
200.0	1	0	10	0.00		
200.0	2	0	10	0.00		
200.0	3	0	10	0.00	0.00	0.00

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

TABLE M.6. Daily Observations of H. costata During Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (ug/L)	Replicate	H. costata Live				H. costata Dead			
		2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
0.0	1	10	10	10	10	0	0	0	0
0.0	2	10	10	10	10	0	0	0	0
0.0	3	10	10	10	9	0	0	0	1
50.0	1	10	10	10	9	0	0	0	1
50.0	2	10	10	9	8	0	0	1	1
50.0	3	10	9	9	9	0	1	0	0
100.0	1	10	6	6	2	0	4	0	4
100.0	2	10	5	5	1	0	5	0	4
100.0	3	10	6	5	2	0	4	1	3
150.0	1	10	0	0	0	0	10	TRM (a)	TRM
150.0	2	10	0	0	0	0	10	TRM	TRM
150.0	3	10	0	0	0	0	10	TRM	TRM
200.0	1	10	0	0	0	0	10	TRM	TRM
200.0	2	10	0	0	0	0	10	TRM	TRM
200.0	3	10	0	0	0	0	10	TRM	TRM

(a) TRM Terminated.

TABLE M.7. Water Quality Summary for 96-Hour H. costata Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (ug/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	4.0	NA (a)	28.0	32.0
0.0	14.7	15.7	7.62	7.91	7.8	8.7	30.5	32.0
50.0	14.8	15.8	7.69	7.88	7.7	8.4	30.5	32.0
100.0	14.7	15.9	7.72	8.01	7.8	8.5	30.5	32.0
150.0	15.1 (b)	15.5	7.75	7.77	7.8	8.5	30.0	31.5
200.0	15.1	15.9	7.75	7.79	8.0	8.1	30.5	31.5

(a) NA Not applicable.
(b) There was 100% mortality of H. costata after 24 hours.

TABLE M.8. Test Results for 96-Hour H. costata Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
Test 1						
0.68	1	9	1	0.90		
0.68	2	10	0	1.00		
0.68	3	10	0	1.00	0.97	0.06
0.71	1	8	2	0.80		
0.71	2	10	0	1.00		
0.71	3	9	1	0.90	0.90	0.10
0.79	1	9	1	0.90		
0.79	2	9	1	0.90		
0.79	3	10	0	1.00	0.93	0.06
0.87	1	9	1	0.90		
0.87	2	9	1	0.90		
0.87	3	9	1	0.90	0.90	0.00
1.32	1	9	1	0.90		
1.32	2	10	0	1.00		
1.32	3	8	2	0.80	0.90	0.10
Test 2						
1.64	1	9	1	0.90		
1.64	2	10	0	1.00		
1.64	3	9	1	0.90	0.93	0.06
3.03	1	10	0	1.00		
3.03	2	8	2	0.80		
3.03	3	9	1	0.90	0.90	0.10
6.66	1	9	1	0.90		
6.66	2	9	1	0.90		
6.66	3	8	2	0.80	0.87	0.06
14.8	1	8	2	0.80		
14.8	2	8	2	0.80		
14.8	3	8	2	0.80	0.80	0.00
29.96	1	9	1	0.90		
29.96	2	9	1	0.90		
29.96	3	7	3	0.70	0.83	0.12

TABLE M.8. (contd)

Ammonia Concentration (mg/L)	Replicate	H. costata Live(a)	H. costata Dead or Missing	Proportion Surviving	Mean Proportion Surviving	Standard Deviation
Test 3						
2.37	1	10	0	1.00		
2.37	2	10	0	1.00		
2.37	3	9	1	0.90	0.97	0.06
57.99	1	3	7	0.30		
57.99	2	5	5	0.50		
57.99	3	6	4	0.60	0.47	0.15
79.11	1	0	10	0.00		
79.11	2	0	10	0.00		
79.11	3	0	10	0.00	0.00	0.00
96.8	1	0	10	0.00		
96.8	2	0	10	0.00		
96.8	3	0	10	0.00	0.00	0.00

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

TABLE M.9. Daily Observations of H. costata During Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Replicate	H. costata Live 2 h	24 h	48 h	72 h	H. costata Dead 2 h	24 h	48 h	72 h
Test 1									
0.68	1	10	10	9	9	0	0	1	0
0.68	2	10	10	10	10	0	0	0	0
0.68	3	10	10	10	10	0	0	0	0
0.71	1	10	10	10	9	0	0	0	1
0.71	2	10	10	10	10	0	0	0	0
0.71	3	10	10	9	9	0	0	1	0
0.79	1	10	10	10	10	0	0	0	0
0.79	2	10	10	10	9	0	0	0	1
0.79	3	10	10	10	10	0	0	0	0
0.87	1	10	10	10	9	0	0	0	1
0.87	2	10	10	10	10	0	0	0	0
0.87	3	10	10	10	10	0	0	0	0
1.32	1	10	10	10	10	0	0	0	0
1.32	2	10	10	10	10	0	0	0	0
1.32	3	10	10	10	9	0	0	0	1
Test 2									
1.64	1	10	10	10	10	0	0	0	0
1.64	2	10	10	10	10	0	0	0	0
1.64	3	10	10	10	10	0	0	0	0
3.03	1	10	10	10	10	0	0	0	0
3.03	2	10	10	9	8	0	0	1	1
3.03	3	10	10	10	10	0	0	0	0
6.66	1	10	9	9	9	0	1	0	0
6.66	2	10	10	10	10	0	0	0	0
6.66	3	10	10	10	9	0	0	0	1
14.8	1	10	10	8	8	0	0	2	0
14.8	2	10	10	10	10	0	0	0	0
14.8	3	10	10	10	10	0	0	0	0
29.96	1	10	9	9	9	0	1	0	0
29.96	2	10	9	9	9	0	1	0	0
29.96	3	10	10	10	10	0	0	0	0

TABLE M.9. (contd)

Ammonia Concentration (mg/L)	Replicate	H. costata Live				H. costata Dead			
		2 h	24 h	48 h	72 h	2 h	24 h	48 h	72 h
Test 3									
2.37	1	10	10	10	10	0	0	0	0
2.37	2	10	10	10	10	0	0	0	0
2.37	3	10	10	9	9	0	0	1	0
57.99	1	10	9	8	7	0	1	1	1
57.99	2	10	10	8	8	0	0	2	0
57.99	3	10	10	9	9	0	0	1	0
79.11	1	10	8	6	2	0	2	2	4
79.11	2	10	10	4	2	0	0	6	2
79.11	3	10	7	5	3	0	3	2	2
96.8	1	10	8	2	0	0	2	6	2
96.8	2	10	8	3	0	0	2	5	3
96.8	3	10	9	4	0	0	1	5	4

TABLE M.10. Water Quality Summary for 96-Hour H. costata Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	13.0	17.0	7.30	8.30	4.0	NA (a)	28.0	32.0	NE (b)	NE
Test 1										
0.68	14.6	15.1	7.73	7.94	7.7	8.4	31.5	32.0	0.212	1.04
0.71	14.7	15.3	7.78	7.93	7.7	8.5	31.5	32.0	0.246	1.20
0.79	14.7	15.3	7.80	7.96	8.0	8.5	31.0	32.0	0.289	1.27
0.87	14.6	15.3	7.78	7.99	7.8	8.5	31.0	32.5 (c)	0.406	1.31
1.32	14.7	15.4	7.76	8.01	7.9	8.4	31.0	32.0	0.785	1.87
Test 2										
1.64	14.7	14.9	7.60	7.98	7.0	8.3	30.5	31.5	0.286	4.18
3.03	14.7	14.8	7.59	7.98	7.4	8.4	30.5	31.5	1.73	5.25
6.66	14.7	14.9	7.69	7.97	7.7	8.4	30.5	31.5	4.79	7.81
14.8	14.7	14.8	7.68	7.95	7.6	8.5	31.0	31.5	11.9	17.6
29.96	14.7	14.9	7.69	7.90	7.8	8.4	30.5	31.5	18.7	37.7
Test 3										
2.37	14.8	15.6	7.46	7.84	7.4	8.3	30.5	31.0	0.556	3.93
57.99	14.7	15.5	7.65	7.78	7.7	8.2	30.5	31.0	51.2	68.9
79.11	14.6	15.6	7.54	7.84	7.1	8.2	30.5	31.0	63.7	96.4
96.8	14.6	15.4	7.48	7.88	7.6	8.3	30.5	31.0	75.4	120

(a) NA Not applicable.
(b) NE Not established.
(c) Data point out of range.

APPENDIX N

BIOASSAY RESULTS FOR 48-HOUR SUSPENDED-PARTICULATE-PHASE TEST AND 48-HOUR REFERENCE TOXICANT TESTS FOR *MYTILUS galloprovincialis*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Program
TEST ORGANISM: *Mytilus galloprovincialis*
TEST TYPE: Suspended-particulate-phase; static with aeration
TEST DURATION: 48 hours

WATER QUALITY ACCEPTABLE RANGES:

Temperature	pH	Dissolved Oxygen	Salinity	Flow Rate	Ammonia
14-18°C	7.30-8.30	≥4.0 mg/L	28-32‰	NA	NA

TEST MATRIX Sediments were collected from January 28, 1994 to February 3, 1994. Sediments were composited and tested within 6 weeks holding time after collection. Each SPP was tested within 24 hours after preparation.

SOURCE/AGE Marinus, Inc., Long Beach, California. Adult mussels.

HOLDING/ACCLIMATION Approximately 125 adult mussels were received on January 16, 1994 (dry on ice). They were placed in outside holding tanks under ambient conditions and removed for spawning conditions as needed. Holding conditions for February 11 through 25, 1994, are as follows:

	Temperature	pH	Dissolved Oxygen	Salinity
min/max	4.9-8.9°C	7.40-7.80	8.1-10.4 mg/L	30.0-32.0‰

WATER QUALITY SUMMARY All water quality parameters remained within the acceptable ranges throughout the 48 hours of testing for the SPP and ammonia and cadmium reference toxicant tests.

TEST VALIDATION The test was validated by >90% survival in the seawater controls estabilished for each of the tests.

REFERENCE TOXICANT TEST Validation by a mean percent survival and mean percent normal larvae of >90% in the seawater controls. The LC_{50} values for copper ranged from 12.1 µg/L to 24.5 µg/L. The EC_{50} values for copper ranged from 7.3 µg/L to 8.0 µg/L. The LC_{50} values for ammonia ranged from 43.2 mg/L to 63.0 mg/L. The EC_{50} values for ammonia ranged from 2.23 mg/L to 2.76 mg/L.

COMMENTS One replicate of the seawater control for Berth 7 Comp was inadvertently knocked over during water quality measurements on Day 2 and not included in the test results.

REFERENCES

ASTM (American Society for Testing and Materials). 1989. *Standard Guide for Conducting Static Acute Toxicity Tests Starting with Embryos of Four Species of Saltwater Bivalve Molluscs.* ASTM Designation: E 724-89. American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA/USACE (U.S. Environmental Protection Agency/ U.S. Army Corps of Engineers). 1991. *Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual).* EPA-68-C8-0105, U.S. Environmental Protection Agency, Office of Marine and Estuarine Protection, Washington, D.C.

TABLE N.1. Test Results for 48-Hour Larval M. galloprovincialis Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Replicate	Mean Stocking Density	Number Larvae Surviving(a)	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
SF COMP	0	1	238	262	1.00 (b)			256	1.00 (b)		
SF COMP	0	2	238	283	1.00 (b)			277	1.00 (b)		
SF COMP	0	3	238	210	0.88			205	0.86		
SF COMP	0	4	238	235	0.99			231	0.97		
SF COMP	0	5	238	214	0.90	0.95	0.06	212	0.89	0.94	0.06
SF COMP	10	1	238	263	1.00 (b)			255	1.00 (b)		
SF COMP	10	2	238	213	0.89			209	0.88		
SF COMP	10	3	238	261	1.00 (b)			257	1.00 (b)		
SF COMP	10	4	238	231	0.97			227	0.95		
SF COMP	10	5	238	238	1.00	0.97	0.05	233	0.98	0.96	0.05
SF COMP	50	1	238	226	0.95			222	0.93		
SF COMP	50	2	238	246	1.00 (b)			241	1.00 (b)		
SF COMP	50	3	238	275	1.00 (b)			273	1.00 (b)		
SF COMP	50	4	238	239	1.00 (b)			231	0.97		
SF COMP	50	5	238	275	1.00 (b)	0.99	0.02	268	1.00 (b)	0.98	0.03
SF COMP	100	1	238	241	1.00 (b)			238	1.00		
SF COMP	100	2	238	224	0.94			218	0.92		
SF COMP	100	3	238	215	0.90			210	0.88		
SF COMP	100	4	238	277	1.00 (b)			268	1.00 (b)		
SF COMP	100	5	238	267	1.00 (b)	0.97	0.04	258	1.00 (b)	0.96	0.06
SFW COMP	0	1	253	230	0.91			213	0.84		
SFW COMP	0	2	253	255	1.00 (b)			229	0.91		
SFW COMP	0	3	253	266	1.00 (b)			252	1.00		
SFW COMP	0	4	253	258	1.00 (b)			236	0.93		
SFW COMP	0	5	253	242	0.96	0.97	0.04	223	0.88	0.91	0.06
SFW COMP	10	1	253	269	1.00 (b)			255	1.00 (b)		
SFW COMP	10	2	253	240	0.95			221	0.87		
SFW COMP	10	3	253	236	0.93			219	0.87		
SFW COMP	10	4	253	239	0.94			227	0.90		
SFW COMP	10	5	253	233	0.92	0.95	0.03	216	0.85	0.90	0.06
SFW COMP	50	1	253	252	1.00			223	0.88		
SFW COMP	50	2	253	207	0.82			183	0.72		
SFW COMP	50	3	253	259	1.00 (b)			227	0.90		
SFW COMP	50	4	253	256	1.00 (b)			234	0.92		
SFW COMP	50	5	253	254	1.00 (b)	0.96	0.08	234	0.92	0.87	0.08

TABLE N.1. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	Mean Stocking Density	Number Larvae Surviving(a)	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
SFW COMP	100	1	253	231	0.91			119	0.47		
SFW COMP	100	2	253	181	0.72			48	0.19		
SFW COMP	100	3	253	162	0.64			44	0.17		
SFW COMP	100	4	253	227	0.90			72	0.28		
SFW COMP	100	5	253	222	0.88	0.81	0.12	48	0.19	0.26	0.12
UIH COMP	0	1	253	242	0.96			223	0.88		
UIH COMP	0	2	253	207	0.82			200	0.79		
UIH COMP	0	3	253	225	0.89			210	0.83		
UIH COMP	0	4	253	269	1.00 (b)			252	1.00		
UIH COMP	0	5	253	277	1.00 (b)	0.93	0.08	259	1.00 (b)	0.90	0.10
UIH COMP	10	1	253	232	0.92			214	0.85		
UIH COMP	10	2	253	262	1.00 (b)			233	0.92		
UIH COMP	10	3	253	264	1.00 (b)			247	0.98		
UIH COMP	10	4	253	219	0.87			213	0.84		
UIH COMP	10	5	253	271	1.00 (b)	0.96	0.06	252	1.00	0.92	0.07
UIH COMP	50	1	253	214	0.85			202	0.80		
UIH COMP	50	2	253	242	0.96			134	0.53		
UIH COMP	50	3	253	252	1.00			208	0.82		
UIH COMP	50	4	253	214	0.85			144	0.57		
UIH COMP	50	5	253	275	1.00 (b)	0.93	0.08	238	0.94	0.73	0.18
UIH COMP	100	1	253	241	0.95			0	0.00		
UIH COMP	100	2	253	229	0.91			0	0.00		
UIH COMP	100	3	253	230	0.91			0	0.00		
UIH COMP	100	4	253	191	0.75			0	0.00		
UIH COMP	100	5	253	249	0.98	0.90	0.09	0	0.00	0.00	0.00
TB Upper COMP	0	1	238	235	0.99			232	0.97		
TB Upper COMP	0	2	238	244	1.00 (b)			242	1.00 (b)		
TB Upper COMP	0	3	238	255	1.00 (b)			252	1.00 (b)		
TB Upper COMP	0	4	238	254	1.00 (b)			246	1.00 (b)		
TB Upper COMP	0	5	238	207	0.87	0.97	0.06	202	0.85	0.96	0.07

TABLE N.1. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	Mean Stocking Density	Number Larvae Surviving(a)	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
TB Upper COMP	10	1	238	241	1.00 (b)			236	0.99		
TB Upper COMP	10	2	238	201	0.84			195	0.82		
TB Upper COMP	10	3	238	189	0.79			186	0.78		
TB Upper COMP	10	4	238	254	1.00 (b)			249	1.00 (b)		
TB Upper COMP	10	5	238	232	0.97	0.92	0.10	227	0.95	0.91	0.10
TB Upper COMP	50	1	238	188	0.79			185	0.78		
TB Upper COMP	50	2	238	251	1.00 (b)			248	1.00 (b)		
TB Upper COMP	50	3	238	209	0.88			201	0.84		
TB Upper COMP	50	4	238	244	1.00 (b)			233	0.98		
TB Upper COMP	50	5	238	258	1.00 (b)	0.93	0.10	256	1.00 (b)	0.92	0.10
TB Upper COMP	100	1	238	215	0.90			69	0.29		
TB Upper COMP	100	2	238	174	0.73			5	0.02		
TB Upper COMP	100	3	238	210	0.88			36	0.15		
TB Upper COMP	100	4	238	140	0.59			10	0.04		
TB Upper COMP	100	5	238	214	0.90	0.80	0.14	80	0.34	0.17	0.14
TB Lower COMP	0	1	253	231	0.91			214	0.85		
TB Lower COMP	0	2	253	229	0.91			206	0.81		
TB Lower COMP	0	3	253	210	0.83			181	0.72		
TB Lower COMP	0	4	253	220	0.87			193	0.76		
TB Lower COMP	0	5	253	268	1.00 (b)	0.90	0.06	242	0.96	0.82	0.09
TB Lower COMP	10	1	253	244	0.96			220	0.87		
TB Lower COMP	10	2	253	244	0.96			218	0.86		
TB Lower COMP	10	3	253	232	0.92			221	0.87		
TB Lower COMP	10	4	253	243	0.96			220	0.87		
TB Lower COMP	10	5	253	245	0.97	0.95	0.02	220	0.87	0.87	0.00
TB Lower COMP	50	1	253	248	0.98			207	0.82		
TB Lower COMP	50	2	253	228	0.90			197	0.78		
TB Lower COMP	50	3	253	230	0.91			191	0.75		
TB Lower COMP	50	4	253	254	1.00 (b)			225	0.89		
TB Lower COMP	50	5	253	223	0.88	0.93	0.05	193	0.76	0.80	0.06
TB Lower COMP	100	1	253	233	0.92			0	0.00		
TB Lower COMP	100	2	253	236	0.93			0	0.00		
TB Lower COMP	100	3	253	247	0.98			0	0.00		
TB Lower COMP	100	4	253	251	0.99			0	0.00		
TB Lower COMP	100	5	253	261	1.00 (b)	0.96	0.04	0	0.00	0.00	0.00

TABLE N.1. (contd)

Sediment Treatment	Concentration (Percent SPP)	Replicate	Mean Stocking Density	Number Larvae Surviving(a)	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
OBM COMP	0	1	238	277	1.00 (b)			269	1.00 (b)		
OBM COMP	0	2	238	256	1.00 (b)			251	1.00 (b)		
OBM COMP	0	3	238	247	1.00 (b)			242	1.00 (b)		
OBM COMP	0	4	238	254	1.00 (b)			251	1.00 (b)		
OBM COMP	0	5	238	217	0.91	0.98	0.04	214	0.90	0.98	0.05
OBM COMP	10	1	238	224	0.94			222	0.93		
OBM COMP	10	2	238	229	0.96			227	0.95		
OBM COMP	10	3	238	223	0.94			220	0.92		
OBM COMP	10	4	238	250	1.00 (b)			236	0.99		
OBM COMP	10	5	238	227	0.95	0.96	0.03	225	0.95	0.95	0.03
OBM COMP	50	1	238	196	0.82			194	0.82		
OBM COMP	50	2	238	232	0.97			230	0.97		
OBM COMP	50	3	238	214	0.90			212	0.89		
OBM COMP	50	4	238	204	0.86			203	0.85		
OBM COMP	50	5	238	260	1.00 (b)	0.91	0.08	253	1.00 (b)	0.91	0.08
OBM COMP	100	1	238	233	0.98			227	0.95		
OBM COMP	100	2	238	228	0.96			220	0.92		
OBM COMP	100	3	238	248	1.00 (b)			239	1.00		
OBM COMP	100	4	238	244	1.00 (b)			240	1.00 (b)		
OBM COMP	100	5	238	226	0.95	0.98	0.02	221	0.93	0.96	0.04

(a) Sum total of normal D-cell, abnormal D-cell, and developmentally delayed larvae.
(b) When number normal or number surviving exceeded the stocking density, a proportion normal and/or proportion survival of 1.00 was used for mean calculation and statistical analysis.

TABLE N.2. Water Quality Summary for 48-Hour Larval M. galloprovincialis Suspended-Particulate-Phase Test, Richmond Harbor Deepening Project

Sediment Treatment	Concentration (Percent SPP)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)
		Min	Max	Min	Max	Min	Max	Min	Max	Average(a)
Acceptable Range		14.0	18.0	7.30	8.30	4.0	NA (b)	28.0	32.0	NE (c)
SF COMP	0	15.4	15.6	7.75	8.05	7.2	8.2	32.0	32.0	1.23
SF COMP	10	15.4	15.5	7.76	8.05	7.3	8.1	31.5	32.0	NM (d)
SF COMP	50	15.4	15.6	7.79	8.06	7.0	8.0	30.5	32.0	NM
SF COMP	100	15.4	15.7	7.84	8.09	5.4	7.9	30.0	30.5	2.10
SFW COMP	0	15.4	15.8	7.80	8.01	6.9	8.1	31.0	32.0	0.41
SFW COMP	10	15.4	15.9	7.84	7.99	6.8	8.1	31.0	32.0	NM
SFW COMP	50	15.4	15.8	7.91	8.04	6.5	8.1	31.0	32.0	NM
SFW COMP	100	15.4	15.9	7.94	8.04	4.9	8.1	30.5	32.0	5.08
UIH COMP	0	15.4	15.8	7.45	8.01	6.8	8.0	31.5	32.0	0.409
UIH COMP	10	15.4	15.7	7.49	8.07	6.8	8.0	31.5	32.0	NM
UIH COMP	50	15.4	15.7	7.38	8.13	6.7	8.0	31.0	32.0	NM
UIH COMP	100	15.4	15.8	7.63	8.19	4.7	8.1	31.0	31.5	7.85
TB Upper COMP	0	15.3	15.6	7.70	8.02	7.2	8.8	30.5	32.0	1.23
TB Upper COMP	10	15.3	15.5	7.76	8.07	7.2	8.5	30.5	32.0	NM
TB Upper COMP	50	15.4	15.5	7.84	8.09	7.3	8.2	30.0	31.0	NM
TB Upper COMP	100	15.3	15.5	7.90	8.17	6.4	8.1	30.0	30.0	3.47
TB Lower COMP	0	15.4	15.8	7.76	8.06	6.9	8.3	32.0	32.0	0.41
TB Lower COMP	10	15.4	15.8	7.76	8.03	6.8	8.2	31.0	32.0	NM
TB Lower COMP	50	15.4	15.8	7.90	8.02	6.9	8.2	30.5	32.0	NM
TB Lower COMP	100	15.4	15.8	7.98	8.10	6.9	8.1	30.0	31.0	6.42
OBM COMP	0	15.4	15.6	7.74	7.99	7.2	8.2	31.5	32.0	1.23
OBM COMP	10	15.3	15.7	7.77	8.03	7.2	8.3	31.0	32.0	NM
OBM COMP	50	15.4	15.6	7.88	8.01	7.3	8.2	30.5	31.0	NM
OBM COMP	100	15.4	15.6	7.88	8.09	7.2	8.4	30.0	30.0	1.95

(a) Average of ammonia measurements taken during testing.
(b) NA Not applicable.
(c) NE Not established.
(d) NM Not measured.

TABLE N.3. Test Results for 48-Hour Larval M. galloprovincialis Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration ug/L	Replicate	Mean Stocking Density	Number Larvae Surviving	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
Test 1										
Site water	1	253	228	0.90			222	0.88		
Site water	2	253	258	1.00 (a)			256	1.00 (a)		
Site water	3	253	233	0.92	0.94	0.05	223	0.88	0.92	0.07
brine	1	253	281	1.00 (a)			252	1.00		
brine	2	253	252	1.00			235	0.93		
brine	3	253	235	0.93	0.97	0.04	211	0.83	0.92	0.08
0.00	1	253	ND (b)	NA (c)			ND	NA		
0.00	2	253	312	1.00 (a)			279	1.00 (a)		
0.00	3	253	277	1.00 (a)	1.00	0.00	252	1.00	0.67	0.00
1.00	1	253	245	0.97			224	0.89		
1.00	2	253	196	0.77			182	0.72		
1.00	3	253	206	0.81	0.85	0.10	181	0.72	0.77	0.10
4.00	1	253	257	1.00 (a)			221	0.87		
4.00	2	253	244	0.96			205	0.81		
4.00	3	253	237	0.94	0.97	0.03	195	0.77	0.82	0.05
16.0	1	253	162	0.64			0	0.00		
16.0	2	253	202	0.80			0	0.00		
16.0	3	253	81	0.32	0.59	0.24	0	0.00	0.00	0.00
64.0	1	253	44	0.17			0	0.00		
64.0	2	253	15	0.06			0	0.00		
64.0	3	253	39	0.15	0.13	0.06	0	0.00	0.00	0.00

TABLE N.3 (contd)

Copper Concentration ug/L	Replicate	Mean Stocking Density	Number Larvae Surviving	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
Test 2										
Site water	1	238	269	1.00 (a)			266	1.00 (a)		
Site water	2	238	287	1.00 (a)			283	1.00 (a)		
Site water	3	238	285	1.00 (a)	1.00	0.00	279	1.00 (a)	1.00	0.00
brine	1	238	303	1.00 (a)			297	1.00 (a)		
brine	2	238	235	0.99			231	0.97		
brine	3	238	263	1.00 (a)	1.00	0.01	259	1.00 (a)	0.99	0.02
0.00	1	238	238	1.00			232	0.97		
0.00	2	238	242	1.00 (a)			241	1.00 (a)		
0.00	3	238	280	1.00 (a)	1.00	0.00	277	1.00 (a)	0.99	0.01
1.00	1	238	244	1.00 (a)			240	1.00 (a)		
1.00	2	238	321	1.00 (a)			318	1.00 (a)		
1.00	3	238	272	1.00 (a)	1.00	0.00	271	1.00 (a)	1.00	0.00
4.00	1	238	241	1.00 (a)			236	0.99		
4.00	2	238	268	1.00 (a)			265	1.00 (a)		
4.00	3	238	257	1.00 (a)	1.00	0.00	247	1.00 (a)	1.00	0.00
16.0	1	238	88	0.37			0	0.00		
16.0	2	238	69	0.29			0	0.00		
16.0	3	238	54	0.23	0.30	0.07	0	0.00	0.00	0.00
64.0	1	238	6	0.03			0	0.00		
64.0	2	238	12	0.05			0	0.00		
64.0	3	238	15	0.06	0.05	0.02	0	0.00	0.00	0.00

(a) When number normal or number surviving exeeded the stocking density, a proportion normal and/or proportion surviving of 1.00 was used for mean calculations and statistical analysis.
(b) ND No data.
(c) NA Not applicable.

TABLE N.4. Water Quality Summary for 48-Hour Larval M. galloprovincialis Copper Reference Toxicant Test, Richmond Harbor Deepening Project

Copper Concentration (ug/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)	
	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	14.0	18.0	7.30	8.30	4.0	NA (a)	28.0	32.0
Test 1								
Site water	15.5	15.9	7.88	7.95	8.0	8.7	29.5	30.0
brine	15.4	15.8	7.83	7.97	6.9	7.9	30.0	32.0
0.0	15.5	15.8	7.70	7.86	6.8	7.9	31.0	32.0
1.00	15.4	15.7	7.77	7.89	6.9	7.9	31.0	32.0
4.00	15.4	15.7	7.79	7.91	6.9	7.7	31.0	31.5
16.0	15.4	15.7	7.82	7.92	6.9	8.0	31.0	31.5
64.0	15.4	15.8	7.81	7.94	6.9	7.9	30.5	31.0
Test 2								
Site water	15.4	15.5	7.75	7.83	7.2	7.9	30.0	30.0
brine	15.4	15.7	7.75	7.79	6.9	7.5	30.0	31.5
0.0	15.4	15.5	7.72	7.89	6.9	7.5	31.5	32.0
1.00	15.4	15.5	7.72	7.94	7.0	7.6	31.5	32.0
4.00	15.4	15.5	7.71	7.95	7.1	7.6	31.5	32.0
16.0	15.4	15.5	7.71	7.96	7.0	7.5	31.5	32.0
64.0	15.4	15.5	7.70	7.97	7.0	7.5	31.5	32.0

(a) NA Not applicable.

TABLE N.5. Test Results for 48-Hour Larval M. galloprovincialis Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Replicate	Mean Stocking Density	Number Larvae Surviving	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
Test 1										
Site water	1	253	228	0.90			222	0.88		
Site water	2	253	258	1.00 (a)			256	1.00 (a)		
Site water	3	253	233	0.92	0.94	0.05	223	0.88	0.92	0.07
brine	1	253	281	1.00 (a)			252	1.00		
brine	2	253	252	1.00			235	0.93		
brine	3	253	235	0.93	0.97	0.04	211	0.83	0.92	0.08
0.0	1	253	ND (b)	NA (c)			ND	NA		
0.0	2	253	312	1.00 (a)			279	1.00 (a)		
0.0	3	253	277	1.00 (a)	1.00	0.00	252	1.00	0.67	0.00
0.65	1	253	316	1.00 (a)			292	1.00 (a)		
0.65	2	253	264	1.00 (a)			251	0.99		
0.65	3	253	238	0.94	0.98	0.03	223	0.88	0.96	0.07
7.16	1	253	295	1.00 (a)			17	0.07		
7.16	2	253	277	1.00 (a)			6	0.02		
7.16	3	253	252	1.00	1.00	0.00	27	0.11	0.07	0.04
15.86	1	253	262	1.00 (a)			0	0.00		
15.86	2	253	230	0.91			0	0.00		
15.86	3	253	237	0.94	0.95	0.05	0	0.00	0.00	0.00
44.61	1	253	245	0.97			0	0.00		
44.61	2	253	223	0.88			0	0.00		
44.61	3	253	210	0.83	0.89	0.07	0	0.00	0.00	0.00
90.04	1	253	32	0.13			0	0.00		
90.04	2	253	14	0.06			0	0.00		
90.04	3	253	24	0.09	0.09	0.04	0	0.00	0.00	0.00

TABLE N.5. (contd)

Ammonia Concentration (mg/L)	Replicate	Mean Stocking Density	Number Larvae Surviving	Proportion Surviving	Mean Proportion Surviving	Standard Deviation	Number Normal D-cell Larvae	Proportion Normal	Mean Proportion Normal	Standard Deviation
Test 2										
Site water	1	238	269	1.00 (a)			266	1.00 (a)		
Site water	2	238	287	1.00 (a)			283	1.00 (a)		
Site water	3	238	285	1.00 (a)	1.00	0.00	279	1.00 (a)	1.00	0.00
brine	1	238	303	1.00 (a)			297	1.00 (a)		
brine	2	238	235	0.99			231	0.97		
brine	3	238	263	1.00 (a)	1.00	0.01	259	1.00 (a)	0.99	0.02
0.0	1	238	238	1.00			232	0.97		
0.0	2	238	242	1.00 (a)			241	1.00 (a)		
0.0	3	238	280	1.00 (a)	1.00	0.00	277	1.00 (a)	0.99	0.01
1.05	1	238	251	1.00 (a)			246	1.00 (a)		
1.05	2	238	282	1.00 (a)			280	1.00 (a)		
1.05	3	238	224	0.94	0.98	0.03	220	0.92	0.97	0.04
7.48	1	238	253	1.00 (a)			1	0.00		
7.48	2	238	211	0.89			0	0.00		
7.48	3	238	255	1.00 (a)	0.96	0.07	0	0.00	0.00	0.00
16.64	1	238	296	1.00 (a)			0	0.00		
16.64	2	238	251	1.00 (a)			0	0.00		
16.64	3	238	264	1.00 (a)	1.00	0.00	0	0.00	0.00	0.00
60.56	1	238	87	0.37			0	0.00		
60.56	2	238	113	0.47			0	0.00		
60.56	3	238	46	0.19	0.34	0.14	0	0.00	0.00	0.00
105.4	1	238	9	0.04			0	0.00		
105.4	2	238	0	0.00			0	0.00		
105.4	3	238	0	0.00	0.01	0.02	0	0.00	0.00	0.00

(a) When number normal or number surviving exeeded the stocking density, a proportion normal and/or proportion surviving of 1.00 was used for mean calculations and statistical analysis.

TABLE N.6. Water Quality Summary for 48-Hour Larval M. galloprovincialis Ammonia Reference Toxicant Test, Richmond Harbor Deepening Project

Ammonia Concentration (mg/L)	Temperature (°C)		pH		Dissolved Oxygen (mg/L)		Salinity (o/oo)		Ammonia (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Acceptable Range	14.0	18.0	7.30	8.30	4.0	NA (a)	28.0	32.0	NE (b)	NE
Test 1										
Site water	15.5	15.9	7.88	7.95	8.0	8.7	29.5	30.0	NM (c)	NM
brine	15.4	15.8	7.83	7.97	6.9	7.9	30.0	32.0	NM	NM
0.0	15.5	15.8	7.70	7.86	6.8	7.9	31.0	32.0	NM	NM
0.65	15.4	15.7	7.79	7.89	6.8	8.2	31.0	32.0	0.203	1.17
7.16	15.5	15.7	7.72	7.83	6.9	7.9	31.0	32.0	4.00	9.75
15.86	15.4	15.7	7.72	7.81	6.9	8.0	31.0	32.0	8.30	20.4
44.61	15.5	15.7	7.61	7.79	6.9	8.0	31.0	32.0	18.8	66.8
90.04	15.4	15.7	7.56	7.77	6.9	8.0	31.0	32.0	69.1	108
Test 2										
Site water	15.4	15.5	7.75	7.83	7.2	7.9	30.0	30.0	NM	NM
brine	15.4	15.8	7.83	7.97	6.9	7.9	30.0	32.0	NM	NM
0.0	15.5	15.8	7.70	7.86	6.8	7.9	31.0	32.0	NM	NM
1.05	15.4	15.5	7.68	7.84	7.2	8.0	31.5	32.0	0.80	1.90
7.48	15.4	15.4	7.64	7.85	7.2	8.0	31.0	32.0	6.6	9.66
16.64	15.3	15.5	7.65	7.86	7.2	7.9	30.0	31.0	14	20.9
60.56	15.4	15.5	7.57	7.85	7.2	8.0	28.5	30.0	46	80.7
105.4	15.4	15.5	7.48	7.78	7.2	8.0	28.0	28.0	89	123

(a) NA Not applicable.
(b) NE Not established.
(c) NM Not measured.

APPENDIX O

TISSUE CHEMISTRY AND QUALITY ASSURANCE DATA FOR *MACOMA nasuta*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Polynuclear Aromatic Hydrocarbons (PAH) and Phthalates
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit (dry wt)
GC/MS	40-120%	≤30%	20 µg/kg

METHOD

Tissue samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-042, "Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics," which is based on methods used by the National Oceanic and Atmospheric Administration for their Status and Trends Program (Krahn et al. 1988). Samples were then cleaned using silica/alumina chromatography followed by HPLC cleanup. The following modifications in the extraction and clean-up methods were required to adequately recover the phthalate compounds: twice the usual amount of methylene chloride was used in the extraction, and 4% rather than 2% deactivated silica was used. Extracts were quantified using gas chromatography/mass spectrometry (GC/MS) in the selected ion mode (SIM) following SOP MSL-M-043, "Identification and Quantification of Polynuclear Aromatic Hydrocarbons by GC/MS," which is based on EPA method 8270 (EPA 1986).

HOLDING TIMES

Ninety-nine (99) samples were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/MS/SIM analysis dates:

Batch	Extraction	Analysis
Batch 1	3/30/94	4/22-26/94
Batch 2	4/14/94	4/28-30/94
Batch 3	4/26/94	5/10-12/94
Batch 4	5/6/94	5/24-26/94
Batch 5	5/20/94	5/26-28/94
Batch 6	5/20/94	5/26-28/94

DETECTION LIMITS

Target detection limits of 20 µg/kg wet wt were met for all PAH compounds. Achieved detection limits for PAHs were determined by multiplying the standard deviation of 7 spiked replicates by the student t value. Achieved detection limits for phthalates ranged from 19.2 µg/kg to 80 µg/kg. The target detection limits were 20 µg/kg. Detection limits for phthalates were derived from the lowest calibration standard.

QA/QC SUMMARY (continued)

METHOD BLANKS One method blank was extracted with each batch of samples. No compounds were detected in the method blanks at concentrations greater than 5 times the method detection limit. Any sample values that were less than 5 times the value in the associated method blank were flagged with a "B".

SURROGATES Five isotopically labelled compounds were added prior to extraction to assess the efficiency of the method. These were d8-naphthalene, d8-acenaphthene, d12-chrysene, d10-pyrene and d14-dibenzo(a,h)anthracene. Recoveries of all surrogates were within the quality control limits of 40%-120% with the exception of d14-dibenzo(a,h)anthracene in the method blank for Batch 1, with a recovery of 33%.

MATRIX SPIKES One sample from each batch was spiked with all PAH and phthalate compounds. Matrix spike recoveries for PAHs were within the QC criteria of 40%-120% with the following exceptions: benzo(g,h,i)perylene in Batch 3 (125%), and benzo(b)fluoranthene (123%) and benzo(k)fluoranthene (121%) in Batch 5. Phthalate recoveries were within QC criteria with the following exceptions: di-n-octyl phthalate in all batches except Batch 3 (greater than 120%), bis(2-ethylhexyl)phthalate in Batch 1 (122%), and dimethyl- and diethylphthalate in Batch 2 (less than 40%).

REPLICATES One sample from each batch was extracted and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSDs were within the QC criteria of $\leq$30% for analytes greater than 10 times the MDL.

MISC. Samples TB Lower COMP Rep. 5 for both *M. nasuta* and *N. virens* were re-extracted and re-analyzed because the initial results showed unusually high concentrations of bis(2-ethylhexyl)phthalate. The results of the re-analyses are reported.

Some of the sample results are flagged to indicate that the confirmation ion ratio for that compound was outside of the QC range. This is due to a combination of two factors: low levels of the compound of interest, and interferences resulting from the modified cleanup method. Because the confirmation ion is present at only a fraction of the level of the parent ion, when the native level of the compound is low, the amount of error in the concentration measurement of the confirmation ion goes up. The compound is actually quantified from the parent ion only, so most likely this will not effect the quality of the data.

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, USEPA, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Chlorinated Pesticides and PCBs
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit (wet wt)
GC/ECD	40-120%	≤30%	2.0 - 30 µg/kg

METHOD

Tissue samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-M-079, "Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics following the Surrogate Internal Standard Method" based on EPA method 3510 and 8080 (EPA 1986) and NOAA status and trends methods (Krahn et al. 1988). Samples were then cleaned using silica/alumina chromatography followed by HPLC cleanup (Krahn et al. 1988). The following modifications in the clean-up method were required to adequately recover the phthalate compounds: twice the usual amount of methylene chloride was used in the extraction, and 4% rather than 2% deactivated silica was used. Extracts were analyzed using Gas Chromatography/ Electron Capture Detection (GC/ECD) following SOP MSL-M-044, "Analysis of PCBs and Chlorinated Pesticides by GC/ECD" based on EPA method 8080 (1986). The column used was a J&W DB-17 and the confirmatory column was a DB-1701, both capillary columns (30 m x 0.25 mm I.D.).

HOLDING TIMES

One hundred four (104) samples were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/ECD analysis dates:

Batch	Extraction	Analysis
Batch 1	3/30/94	4/22-26/94
Batch 2	4/14/94	4/28-30/94
Batch 3	4/26/94	5/10-12/94
Batch 4	5/6/94	5/21-24/94
Batch 5	5/20/94	6/2-6/94
Batch 6	5/20/94	6/2-6/94

DETECTION LIMITS

Target detection limits were met for all samples. Detection limits reported are based on an MDL study involving low level spikes of 7 replicate extractions. MDLs are defined as the standard deviation of the mean recovery multiplied by the student t value.

METHOD BLANKS

One method blank was extracted with the batch of samples. No pesticides or PCBs were detected in the blanks at concentrations exceeding the QC limit of 5 times the detection limit.

QA/QC SUMMARY (continued)

SURROGATES Two compounds, PCB congeners 103 and 198, were added to all samples prior to extraction to assess the efficiency of the analysis. These compounds are also used to correct all sample results and are considered surrogate internal standards (SIS). Recoveries of these compounds were within the QC guidelines of 40-120% for all samples analyzed.

MATRIX SPIKES One sample from each batch was spiked with a subset of 6 pesticides and Aroclor 1254. Matrix spike recoveries were within the QC limits of 40% -120% with the exception of DDT in Batch 1 (130%).

REPLICATES One sample from each batch was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. RSDs were less than the QC limit of 30%.

SRMs NA

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, USEPA, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Metals
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

SAMPLE CUSTODY

Ninety nine samples (49 *N. virens* and 50 *M. nasuta* tissue samples) were received on 3/21/94 in good condition. Samples and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

	Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (mg/kg wet wt)
Arsenic	ICP/MS	75%-125%	≤30%	≤20%	2.0
Cadmium	ICP/MS	75%-125%	≤30%	≤20%	0.1
Chromium	ICP/MS	75%-125%	≤30%	≤20%	1.0
Copper	ICP/MS	75%-125%	≤30%	≤20%	4.3
Lead	ICP/MS	75%-125%	≤30%	≤20%	1.0
Mercury	CVAA	75%-125%	≤30%	≤20%	0.02
Nickel	ICP/MS	75%-125%	≤30%	≤20%	1.0
Selenium	GFAA	75%-125%	≤30%	≤20%	1.0
Silver	ICP/MS	75%-125%	≤30%	≤20%	0.1
Zinc	ICP/MS	75%-125%	≤30%	≤20%	35

METHOD

A total of 10 metals were analyzed for the Richmond Harbor Deepening Project: silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se) and zinc (Zn). Eight metals (As, Cd, Cr, Cu, Pb, Ni, Ag, and Zn) were analyzed by inductively coupled plasma/mass spectrometry (ICP/MS) following EPA Method 200.8 (EPA 1991). One metal (Se) was analyzed using Zeeman Graphite Furnace Atomic Absorption (GFAA) spectrometry following SOP MSL-M-033, Trace Elements in Sediment in Tissue by Graphite Furnace Atomic Absorption, which is based on EPA Method 200.9 (EPA 1991). Mercury was analyzed using cold-vapor atomic absorption spectroscopy (CVAA) according to the method of Bloom and Crecelius (1983).

To prepare tissues for analysis, samples were freeze-dried and blended in a Spex mixer-mill. Approximately 5 g of mixed sample was ground in a ceramic ball mill. For ICP/MS and CVAA analyses, 0.2- to 0.5-g aliquots of dried homogenous sample were digested using a mixture of nitric, perchloric and hydrofluoric acids.

HOLDING TIMES

Upon receipt, samples were frozen to -80°C and subsequently freeze-dried within approximately 14 days of sample receipt. All samples were analyzed within 180 days of sample receipt with the exception of Hg, which was analyzed within 30 days of receipt. Analysis dates are summarized in the following table:

QA/QC SUMMARY (continued)

Task	Batch 1 (Worms)	Batch 2 (Clams)
Sample Digestion	4/6/94	4/11/94
GFAA/Se	5/18-20/94	5/20-23/94
CVAA-Hg	4/12-13/94	4/13-14/94
ICP/MS	4/20/94	4/21/94
ICP/MS, 715RHI-16 rerun	NA	6/2/94

Two samples (*N. virens* SFW COMP Rep 4 and *N. virens* background rep. 4) were reanalyzed for ICP metals because the initial results for some metals were unusually high. The reanalysis of the background sample confirmed the initial results, and the initial results were reported. The results of the reanalysis of SFW COMP rep. 4 were lower than the initial values for selected metals, and consistent with the other tissues; therefore, the results of the reanalysis are reported.

DETECTION LIMITS

Target detection limits were met for all metals except As and Zn. Achieved detection limits for As and Zn were higher than the target detection limits; however, these metals were detected in all of the samples. ICP/MS detection limits were determined by multiplying the standard deviation of 8 blank spike samples by the student "t" value (3.0). CVAA MDLs were determined by multiplying the standard deviation of 7 replicate analyses of an SRM by 3. GFAA detection limits represent 3 times the standard deviation of the 3 replicate analyses of the method blank.

METHOD BLANKS

Six method blanks were analyzed with the samples. No metals were detected in the blanks at concentrations exceeding the QC criteria of three times the MDL. All sample results are blank corrected.

MATRIX SPIKES

Six tissue samples (3 *M. nasuta* and 3 *N. virens*) were spiked with 10 metals. All spike recoveries were within the control limits of 75%-125% limits with the following exceptions: As in one *N. virens* sample (128%), Zn in two *N. virens* samples (190% and 158%), and Ag in one *M. nasuta* sample (74%).

REPLICATES

Six tissue samples (3 *M. nasuta* and 3 *N. virens*) were digested and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSDs were all within the QC limits of ≤20% with the exception of Cr in one set of *N. virens* replicates (41%), and Zn in all three *N. virens* replicates (41% to 61%).

SRMs

Six samples of the SRM 1566a (obtained from the National Research Council of Canada, NRCC), were analyzed with the samples for all metals. All results were within 30% of the certified values with the exception of Zn in one sample, which had a high recovery, and Ag in one sample, with a low recovery.

REFERENCES

Bloom, N. S., and E.A. Crecelius. 1983. "Determination of Mercury in Seawater at Sub-Nanogram per Liter Levels." *Mar. Chem.* 14:49-59.

EPA. 1991. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010. Environmental Services Division, Monitoring Management Branch.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Butyltins
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry weight)
Unger et al.	40-120%	≤30%	≤30%	1 µg/kg

METHOD

Butyltin analyses were performed according to MSL-SOP-M-004 following the method of Unger et al. (1986). Tissue samples were extracted with methylene chloride using a roller under ambient conditions followed by derivitization using a Grignard reagent to change to a form compatible with gas chromatography. Sample extracts were then cleaned by passing through a florisil column. Extracts were analyzed using Gas Chromatography/Flame Photometric Detection (GC/FPD).

HOLDING TIMES

One hundred four (104) samples of worm and clam tissue were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. Samples were extracted and analyzed in six batches, as follows:

	Date Extracted	Date Analyzed
Batch 1	4/11/94	4/14-15/94
Batch 2	4/18/94	4/22-23/94
Batch 3	4/25/94	4/29-30/94
Batch 4	5/2/94	5/12-13/94
Batch 5	5/9/94	5/12-13/94
Batch 6	5/25/94	5/26-27/94

DETECTION LIMITS

The target detection limit of 1 µg/kg wet wt was met for tri- and monobutyltin, but was exceeded for dibutyltin. The achieved detection limit for dibutyltin was 1.39 µg/kg. The method detection limits are defined as roughly 3 times the standard deviation of results from 7 replicate low level matrix spikes.

METHOD BLANKS

One method blank was extracted with each extraction batch. No butyltins were detected in the blanks.

SURROGATES

One compound, Tripentyltin chloride, is added prior to extraction to assess the efficiency of the method. This compound also is used as an internal standard as all data is corrected for the recovery of the compound. Sample recoveries ranged from 52% to 112%. All sample surrogate recoveries were within the QC limits of 40%-120%.

QA/QC SUMMARY (continued)

MATRIX SPIKES One sample from each extraction batch was spiked with mono-, di- and tributyltin. Matrix spike recoveries ranged from 93% to 114% for the tri- and dibutyltins, within the QC limits of 40-120%. The recovery for monobutyltin ranged from 26% to 51%. The lower recovery for monobutyltin is expected due to the inefficiency of the extraction of this compound as a result of its increased ionic nature.

REPLICATES One sample in each batch was digested in triplicate. Precision was measured by calculating the relative standard deviation (RSD) for the triplicate results. Tributyltin was detected in replicates for four of the batches; RSDs ranged from 3% to 6%.

SRM Not applicable.

REFERENCES

Unger, M.A., W.G. Macintyre, J. Reaves and R.J. Huggett. 1986. "GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation." *Chemosphere.* 15:461-470.

TABLE O.1. Total Detected Polynuclear Aromatic Hydrocarbons (PAHs), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta PAHs (ug/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
SF COMP	1	5	12.76	65	1157	1222
SF COMP	2	5	12.94	48	1163	1211
SF COMP	3	5	12.26	40	976	1016
SF COMP	4	5	12.60	30	905	935
SF COMP	5	5	14.42	45	821	866
SFW COMP	1	4	14.61	807	2431	3238
SFW COMP	2	4	17.91	1019	2559	3578
SFW COMP	3	6	14.49	635	1931	2566
SFW COMP	4	4	14.31	1083	3061	4144
SFW COMP	5	6	14.58	605	2174	2779
UIH COMP	1	5	13.71	52	921	973
UIH COMP	2	6	14.06	9	789	798
UIH COMP, Replicate 1	3	6	13.52	27	682	709
UIH COMP, Replicate 2	3	6	13.52	22	672	694
UIH COMP, Replicate 3	3	6	13.52	40	728	768
UIH COMP	4	5	15.23	49	828	877
UIH COMP	5	5	13.02	64	921	985
TB Upper COMP	1	4	15.21	22	279	301
TB Upper COMP, Replicate 1	2	4	14.75	24	296	321
TB Upper COMP, Replicate 2	2	4	14.75	49	286	335
TB Upper COMP, Replicate 3	2	4	14.75	21	312	333
TB Upper COMP	3	3	13.66	36	334	370
TB Upper COMP	4	3	15.16	43	345	388
TB Upper COMP	5	4	15.00	37	340	377
TB Lower COMP	1	4	13.17	33	131	164
TB Lower COMP	2	3	13.30	37	169	206
TB Lower COMP	3	5	12.74	15	94	109
TB Lower COMP	4	5	12.37	15	135	150
TB Lower COMP	5	6	13.89	18	85	103
R-OS	1	5	12.71	12	85	97
R-OS, Replicate 1	2	5	12.62	16	119	135
R-OS, Replicate 2	2	5	12.62	20	91	111
R-OS, Replicate 3	2	5	12.62	16	114	130
R-OS	3	5	13.84	25	73	98
R-OS	4	5	12.69	24	94	118
R-OS	5	5	13.41	13	71	84
R-BF	1	4	15.28	29	423	452
R-BF	2	3	14.64	47	449	496
R-BF	3	4	14.78	73	323	396
R-BF	4	4	15.91	23	310	333
R-BF	5	4	14.92	13	300	313

TABLE O.1. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta PAHs (ug/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
R-AM COMP	1	3	15.79	293	3321	3614
R-AM COMP	2	4	13.81	212	2072	2284
R-AM COMP	3	4	15.44	323	3188	3511
R-AM COMP	4	3	14.52	276	2414	2690
R-AM COMP	5	4	14.71	375	2739	3114
C-SB	.1	5	14.43	23	122	146
C-SB	2	5	13.25	26	292	317
C-SB	3	5	14.03	26	137	163
C-SB	4	5	13.57	22	138	160
C-SB	5	5	13.60	22	130	152
M. nasuta Background	1	3	13.46	53	271	324
M. nasuta Background	2	3	12.00	63	300	363
M. nasuta Background, Replicate 1	3	3	13.05	75	299	374
M. nasuta Background, Replicate 2	3	3	13.05	87	379	466
M. nasuta Background, Replicate 3	3	3	13.05	52	375	427
M. nasuta Background	4	3	14.21	57	283	340
M. nasuta Background	5	3	17.65	44	144	187

TABLE O.2. Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta LPAHs (ug/kg dry weight) Naphtha-lene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne	Anthra-cene
SF COMP	1	5	12.76	11.8	6.43 U(a)	6.50 (b)	10.8 U	17.6	28.9
SF COMP	2	5	12.94	8.35 (b)	6.26 U	5.95 U	10.4 U	10.9	28.3
SF COMP	3	5	12.26	7.75 (b)	6.69 U	6.36 U	11.3 U	9.30 (b)	23.0
SF COMP	4	5	12.60	19.4	12.8 U	12.1 U	21.4 U	10.6 (b)	34.7 U
SF COMP	5	5	14.42	12.3	5.69 U	5.41 U	9.57 U	10.6	22.3
SFW COMP	1	4	14.61	27.9 B(c)	10.7 U	58.7	80.8	537	103
SFW COMP	2	4	17.91	43.9 B	9.10 U	72.0	90.5	692	121
SFW COMP	3	6	14.49	32.5	6.69 (b)	38.6	54.2	418	84.9
SFW COMP	4	4	14.31	34.3 B	11.4 U	65.6	97.1	762	124
SFW COMP	5	6	14.58	28.7	6.04 (b)	35.9	50.8	403	80.2
UIH COMP	1	5	13.71	10.1	5.98 U	5.69 U	10.1 U	15.0	26.5
UIH COMP	2	6	14.06	8.82	10.5 U	10.0 U	17.6 U	8.32 U	28.5 U
UIH COMP, Replicate 1	3	6	13.52	17.7	12.1 U	11.5 U	20.3 U	9.62	33.0 U
UIH COMP, Replicate 2	3	6	13.52	10.3	11.9 U	11.3 U	20.0 U	11.5	32.3 U
UIH COMP, Replicate 3	3	6	13.52	27.1	12.1 U	11.5 U	20.3 U	13.3 (b)	33.0 U
UIH COMP	4	5	15.23	6.89	5.32 U	5.06 U	9.52 (b)	12.3	19.8
UIH COMP	5	5	13.02	9.83 (b)	6.22 U	5.91 U	12.1 (b)	15.6	26.3
TB Upper COMP	1	4	15.21	12.3 B(b)	10.2 U	9.66 U	17.0 U	9.80 (b)	27.5 U
TB Upper COMP, Replicate 1	2	4	14.75	24.3 B(b)	20.5 U	19.5 U	34.4 U	16.1 U	55.6 U
TB Upper COMP, Replicate 2	2	4	14.75	32.5 B	20.1 U	19.1 U	33.6 U	16.3 (b)	54.4 U
TB Upper COMP, Replicate 3	2	4	14.75	21.4 B	19.6 U	18.6 U	32.9 U	15.5 U	53.2 U
TB Upper COMP	3	3	13.66	5.27 B	5.93 U	5.64 U	9.88 U	13.2 B	18.0
TB Upper COMP	4	3	15.16	3.36 U	5.41 (b)	6.86	9.10 U	14.4 B	16.7 (b)
TB Upper COMP	5	4	15.00	37.1 B	21.9 U	20.9 U	36.7 U	17.3 U	59.4 U
TB Lower COMP	1	4	13.17	23.1 B(b)	12.5 U	11.8 U	20.9 U	10.3 (b)	33.9 U
TB Lower COMP	2	3	13.30	9.17 B	6.17 U	5.86 U	10.4 U	10.8 B	17.4 (b)
TB Lower COMP	3	5	12.74	9.11 (b)	6.44 U	6.12 U	10.8 U	5.57 (b)	17.5 U
TB Lower COMP	4	5	12.37	6.55	6.63 U	6.31 U	11.2 U	8.25	18.0 U
TB Lower COMP	5	6	13.89	11.5 B(b)	5.90 U	5.62 U	9.94 U	6.62	16.1 U
R-OS	1	5	12.71	6.53	6.37 U	6.06 U	10.6 U	5.82 (b)	17.2 U
R-OS, Replicate 1	2	5	12.62	16.3	12.8 U	12.1 U	21.4 U	10.1 U	34.6 U
R-OS, Replicate 2	2	5	12.62	20.3 (b)	12.6 U	12.0 U	21.2 U	10.0 U	34.2 U
R-OS, Replicate 3	2	5	12.62	15.8	12.8 U	12.1 U	21.4 U	10.1 U	34.6 U
R-OS	3	5	13.84	8.38	5.85 U	5.56 U	10.7 (b)	6.14	15.8 U
R-OS	4	5	12.69	10.2	6.46 U	6.93	10.9 U	6.93	17.6 U
R-OS	5	5	13.41	5.97	6.11 U	5.82 U	10.3 U	7.08	16.6 U

TABLE O.2. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta LPAHs (ug/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
R-BF	1	4	15.28	17.8 B	10.5 U	10.0 U	17.7 U	10.8	28.6 U
R-BF	2	3	14.64	5.81 B	5.60 U	6.28 (b)	9.43 U	15.4 B	19.5 (b)
R-BF	3	4	14.78	23.1 B	11.1 U	10.6 U	19.5	14.4 (b)	16.4 (b)
R-BF	4	4	15.91	12.9 B(b)	9.62 U	9.18 U	16.1 U	10.2 (b)	26.1 U
R-BF	5	4	14.92	13.3 B	10.9 U	11.1 U	18.3 U	8.58 U	29.6 U
R-AM COMP	1	3	15.79	9.44 B	12.8	8.42	15.1	153	94.4
R-AM COMP	2	4	13.81	13.9 B	11.9 U	11.3 U	25.1 (b)	106	66.8
R-AM COMP	3	4	15.44	15.1 B	14.6 (b)	10.1 U	22.8 (b)	166	104
R-AM COMP	4	3	14.52	11.4 B	14.7	9.30	20.3	140	79.9
R-AM COMP	5	4	14.71	20.3 B	13.1 (b)	13.0	32.1	182	114
C-SB	1	5	14.43	13.3	5.61 U	5.34 U	9.36 U	10.0	15.1 U
C-SB	2	5	13.25	11.1	6.11 U	7.62 (b)	10.2 U	6.94 (b)	16.5 U
C-SB	3	5	14.03	5.70 (b)	5.84 U	5.56 U	10.5 (b)	10.0 (b)	15.9 U
C-SB	4	5	13.57	11.5 (b)	5.97 U	5.67 U	9.95 U	10.5 (b)	16.1 U
C-SB	5	5	13.60	12.4 (b)	6.03 U	5.74 U	10.1 U	9.41 (b)	16.4 U
M. nasuta Background	1	3	13.46	8.40 B	6.09 U	6.61 (b)	10.3 U	21.2 B	17.2 (b)
M. nasuta Background	2	3	12.00	18.0 B(b)	13.4 U	15.8	22.5 U	28.8 B	36.4 U
M. nasuta Background, Replicate 1	3	3	13.05	13.5 B(b)	12.2 U	11.6 U	20.5 U	27.8 B	33.6 (b)
M. nasuta Background, Replicate 2	3	3	13.05	11.9 B(b)	11.9 U	12.3 (b)	19.8 U	28.7 B	33.9
M. nasuta Background, Replicate 3	3	3	13.05	10.1 B(b)	12.1 U	13.2 (b)	20.2 U	28.2 B	32.8 U
M. nasuta Background	4	3	14.21	6.19 B(b)	5.70 U	8.37	9.50 U	25.9 B	16.5 (b)
M. nasuta Background	5	3	17.65	4.70 B(b)	5.50 (b)	4.87 (b)	7.82 U	15.2 B	13.5 (b)

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample at less than five times value in associated method blank.

TABLE O.3. High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta HPAHs (ug/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
SF COMP	1	5	12.76	94.0 (a)	184 (a)	49.9	58.6 (a)	333	119	182	56.3	22.9 U(b)	79.9
SF COMP	2	5	12.94	87.3 (a)	196	39.3 B (c)	50.9	340	124	192	58.4	22.2 U	75.3
SF COMP	3	5	12.26	71.2 (a)	136 (a)	38.7 B	45.7	286	107	163	48.8	23.8 U	79.2
SF COMP	4	5	12.60	68.5 (a)	33.5	45.4	32.1 (a)	307	118	170	52.6	45.5 U	77.6
SF COMP	5	5	14.42	57.7 (a)	105	36.8 B	42.3	263	99.2	146	70.7	20.2 U	16.8 U
SFW COMP	1	4	14.61	645	712	155	136	323	112	194	52.9	38.1 U	101
SFW COMP	2	4	17.91	726	849	162	135	297	103	175	33.4	32.3 U	78.7
SFW COMP	3	6	14.49	517	545	135	113	259	89.7	164	50.7	19.8 U	57.5
SFW COMP	4	4	14.31	874	908	213	165	379	136	227	61.6	40.5 U	97.8
SFW COMP	5	6	14.58	604	646	160	132	259	95.3	163	57.3	20.0 U	57.8
UIH COMP	1	5	13.71	79.5 (a)	204 (a)	36.8 B	44.5	235	85.3	131	46.5	21.3 U	58.3
UIH COMP	2	6	14.06	63.8 (a)	115	36.1 B	38.3 (a)	192	78.9	126	49.3	37.4 U	89.6
UIH COMP, Replicate 1	3	6	13.52	78.4 (a)	112 (a)	8.88 B (a)	38.5	164	65.3	98.4	45.6	43.3 U	71.0
UIH COMP, Replicate 2	3	6	13.52	70.4 (a)	104	27.5 B	32.2	160	63.3	93.2	44.2	42.4 U	76.9
UIH COMP, Replicate 3	3	6	13.52	82.8 (a)	109 (a)	32.4 B (a)	38.7	166	70.6	94.7 (a)	44.5	43.3 U	89.5
UIH COMP	4	5	15.23	65.1 (a)	221 (a)	31.4 B	38.7	179	61.6	106	63.2	18.8 U	61.7
UIH COMP	5	5	13.02	76.2 (a)	200 (a)	33.5 B	38.0	220	81.4	124	62.0	22.0 U	86.0
TB Upper COMP	1	4	15.21	48.7 (a)	14.6 U	20.2 B (a)	19.1 (a)	57.9	27.5 (a)	43.5 (a)	33.5 U	36.2 U	61.7
TB Upper COMP, Replicate 1	2	4	14.75	72.5 (a)	29.4 U	34.2 B (a)	27.7 (a)	72.5	42.0 (a)	47.1 (a)	67.7 U	73.2 U	60.3 U
TB Upper COMP, Replicate 2	2	4	14.75	74.6 (a)	28.8 U	33.6 B (a)	23.8 (a)	68.5 (a)	38.5 (a)	47.2 (a)	66.2 U	71.2 U	59.1 U
TB Upper COMP, Replicate 3	2	4	14.75	71.2 (a)	28.1 U	30.3 B (a)	15.6 U	66.6 (a)	37.4 (a)	45.9 (a)	64.7 U	69.8 U	60.7 (a)
TB Upper COMP	3	3	13.66	47.7 (a)	51.2 B (a)	16.5 B	26.4 B	56.9 B	29.2 B (a)	40.8 (a)B	22.8	21.0 U	42.1 B
TB Upper COMP	4	3	15.16	56.6 (a)	60.0 B (a)	16.4 B	23.8 B	54.7 B	28.0 B	40.8 (a)B	22.3	19.3 U	42.3 B
TB Upper COMP	5	4	15.00	68.0 (a)	31.5 U	34.3 B (a)	17.4 U	77.3 (a)	43.2 (a)	50.8 (a)	72.7 U	78.0 U	66.0 (a)
TB Lower COMP	1	4	13.17	40.6 (a)	17.9 U	18.6 B (a)	14.0 (a)	29.5 (a)	12.5 U	28.2 (a)	41.2 U	44.4 U	36.8 U
TB Lower COMP	2	3	13.30	33.8 (a)	20.8 B (a)	5.56 B (a)	19.0 B	24.7 B (a)	19.6 B (a)	17.4 (a)B	20.4 U	22.0 U	27.7 B
TB Lower COMP	3	5	12.74	26.1 (a)	9.26 U	11.1 B (a)	6.83 (a)	19.7 (a)	10.4 (a)	20.2 (a)	21.3 U	22.9 U	19.0 U
TB Lower COMP	4	5	12.37	28.1 (a)	9.54 U	10.3 B	13.9	20.8 (a)	12.9 (a)	20.9 (a)	27.6	23.6 U	19.6 U
TB Lower COMP	5	6	13.89	21.5 (a)	8.50 U	8.78 B (a)	9.72	16.6 (a)	10.4 (a)	17.5 (a)	19.5 U	21.0 U	17.4 U
R-OS	1	5	12.71	27.3 (a)	9.13 U	10.6 B	7.63 (a)	13.7 (a)	10.7 (a)	14.6 (a)	20.9 U	22.6 U	18.6 U
R-OS, Replicate 1	2	5	12.62	36.3 (a)	18.3 U	19.7 B (a)	10.1 U	4.28 U	12.8 U	17.7 (a)	42.2 U	45.4 U	45.6 (a)
R-OS, Replicate 2	2	5	12.62	39.9 (a)	18.1 U	17.6 B (a)	14.6 (a)	4.28 U	12.7 U	18.5 (a)	41.7 U	44.9 U	37.2 U
R-OS, Replicate 3	2	5	12.62	35.4 (a)	18.3 U	16.6 B (a)	10.1 U	4.28 U	12.8 U	17.4 (a)	42.2 U	45.4 U	44.2 (a)
R-OS	3	5	13.84	25.7 (a)	8.38 U	9.32 B (a)	10.3	14.5 (a)	5.85 U	13.1 (a)	19.2 U	20.7 U	17.1 U
R-OS	4	5	12.69	32.9 (a)	9.30 U	11.8 B	13.6 (a)	16.6 (a)	6.46 U	18.9 (a)	21.4 U	23.0 U	19.1 U
R-OS	5	5	13.41	24.2 (a)	8.80 U	10.7 B (a)	7.90 (a)	13.5 (a)	6.11 U	14.2 (a)	20.2 U	21.8 U	18.0 U

TABLE O.3. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta HPAHs (ug/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
R-BF	1	4	15.28	79.2 (a)	15.1 U	29.8 B	31.5	77.2	34.6	54.6 (a)	40.4	37.5 U	75.9
R-BF	2	3	14.64	87.4 (a)	100 B (a)	22.8 B	37.2 B	72.4 B	34.5 B	13.0 (a)B	29.4	19.9 U	52.1 B
R-BF	3	4	14.78	30.2 U	16.0 U	40.2 B	39.8	85.3	37.3 (a)	60.8 (a)	36.7 U	39.6 U	60.0
R-BF	4	4	15.91	69.1 (a)	13.8 U	27.0 B	28.2	61.8	27.1	42.8 (a)	31.7 U	34.2 U	53.7
R-BF	5	4	14.92	65.5 (a)	15.7 U	23.9 B	25.1 (a)	62.5	29.8 (a)	47.0 (a)	36.0 U	38.8 U	45.9 (a)
R-AM COMP	1	3	15.79	703	766	327	476	336	129 B	308	111	25.3	140 B
R-AM COMP	2	4	13.81	457	413 (a)	211	309	198	89.8	188	86.2	42.4 U	120
R-AM COMP	3	4	15.44	680 (a)	751	343	448	321	128	291	95.2	37.9 U	131
R-AM COMP	4	3	14.52	481	577	213	355	248	99.2 B	221	88.8	21.4	110 B
R-AM COMP	5	4	14.71	569 (a)	633 (a)	250	379	278	109	251	122	37.8 U	148
C-SB	1	5	14.43	43.0 (a)	8.04 U	12.1 B	13.7	23.6	12.5 (a)	17.5 (a)	18.4 U	19.9 U	16.4 U
C-SB	2	5	13.25	44.8 (a)	8.75 U	11.7 B	13.2	23.2	12.2 (a)	21.4 (a)	20.1 U	21.7 U	165
C-SB	3	5	14.03	58.9 (a)	8.41 U	12.0 B	15.5	24.4	9.6 (a)	16.4 (a)	19.3 U	20.8 U	17.2 U
C-SB	4	5	13.57	49.4 (a)	8.55 U	13.4 B (a)	17.5	25.4	14.2 (a)	17.8 (a)	19.6 U	21.1 U	17.5 U
C-SB	5	5	13.60	43.1 (a)	8.68 U	12.2 B	15.4	25.8 (a)	13.2 (a)	20.1 (a)	19.9 U	21.5 U	17.8 U
M. nasuta Background	1	3	13.46	68.7 (a)	48.3 B (a)	11.1 B (a)	20.6 B	22.5 B (a)	19.2 B (a)	25.4 B (a)	27.9	21.7 U	27.1 B (a)
M. nasuta Background	2	3	12.00	82.3 (a)	48.3 B (a)	19.7 B	29.9 B	44.8 B (a)	39.4 B (a)	35.8 B (a)	44.3 U	47.8 U	39.5 U
M. nasuta Background, Replicate 1	3	3	13.05	95.0 (a)	41.9 B (a)	19.5 B (a)	30.3 B	42.8 B (a)	35.6 B (a)	33.9 B (a)	40.3 U	43.4 U	35.9 U
M. nasuta Background, Replicate 2	3	3	13.05	93.5 (a)	40.2 B (a)	19.5 B	28.1 B	38.8 B (a)	34.9 B (a)	31.6 B (a)	41.3	42.1 U	51.3 B (a)
M. nasuta Background, Replicate 3	3	3	13.05	93.5 (a)	72.8 B (a)	18.7 B (a)	29.0 B	42.5 B (a)	37.4 B (a)	33.1 B (a)	39.9 U	43.0 U	47.9 B (a)
M. nasuta Background	4	3	14.21	71.8 (a)	50.5 B (a)	10.0 B	21.3 B	22.0 B (a)	18.8 B (a)	26.1 B (a)	40.3	20.2 U	22.6 B (a)
M. nasuta Background	5	3	17.65	47.0 (a)	34.3 B (a)	7.20 B (a)	14.2 B (a)	16.9 B (a)	13.4 B (a)	10.7 B (a)	15.4 U	16.5 U	13.7 U

(a) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(b) U Undetected at or above detection limit.
(c) B Analyte detected in sample at less than five times value in associated method blank.

TABLE O.4. Total Detected Polynuclear Aromatic Hydrocarbons (PAHs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PAHs (ug/kg wet weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
SF COMP	1	5	8	148	156
SF COMP	2	5	6	150	156
SF COMP	3	5	5	120	125
SF COMP	4	5	4	114	118
SF COMP	5	5	7	118	125
SFW COMP	1	4	118	355	473
SFW COMP	2	4	183	458	641
SFW COMP	3	6	92	280	372
SFW COMP	4	4	155	438	593
SFW COMP	5	6	88	317	405
UIH COMP	1	5	7	126	133
UIH COMP	2	6	1	111	112
UIH COMP, Replicate 1	3	6	4	92	96
UIH COMP, Replicate 2	3	6	3	91	94
UIH COMP, Replicate 3	3	6	5	98	103
UIH COMP	4	5	7	126	133
UIH COMP	5	5	8	120	128
TB Upper COMP	1	4	3	42	45
TB Upper COMP, Replicate 1	2	4	4	44	48
TB Upper COMP, Replicate 2	2	4	7	42	49
TB Upper COMP, Replicate 3	2	4	3	46	49
TB Upper COMP	3	3	5	46	51
TB Upper COMP	4	3	7	52	59
TB Upper COMP	5	4	6	51	57
TB Lower COMP	1	4	4	17	21
TB Lower COMP	2	3	5	22	27
TB Lower COMP	3	5	2	12	14
TB Lower COMP	4	5	2	17	19
TB Lower COMP	5	6	3	12	15
R-OS	1	5	2	11	13
R-OS, Replicate 1	2	5	2	15	17
R-OS, Replicate 2	2	5	3	11	14
R-OS, Replicate 3	2	5	2	14	16
R-OS	3	5	3	10	13
R-OS	4	5	3	12	15
R-OS	5	5	2	10	12

TABLE O.4. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PAHs (ug/kg wet weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
R-BF	1	4	4	65	69
R-BF	2	3	7	66	73
R-BF	3	4	11	48	59
R-BF	4	4	4	49	53
R-BF	5	4	2	45	47
R-AM COMP	1	3	46	524	570
R-AM COMP	2	4	29	286	315
R-AM COMP	3	4	50	492	542
R-AM COMP	4	3	40	351	391
R-AM COMP	5	4	55	403	458
C-SB	1	5	3	18	21
C-SB	2	5	3	39	42
C-SB	3	5	4	19	23
C-SB	4	5	3	19	22
C-SB	5	5	3	18	21
M. nasuta Background	1	3	7	36	43
M. nasuta Background	2	3	8	36	44
M. nasuta Background, Replicate 1	3	3	10	39	49
M. nasuta Background, Replicate 2	3	3	11	49	60
M. nasuta Background, Replicate 3	3	3	7	49	56
M. nasuta Background	4	3	8	40	48
M. nasuta Background	5	3	8	25	33

TABLE O.5. Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta LPAHs (ug/kg wet weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Target DL(a)			20	20	20	20	20	20
Achieved DL			0.49-2.03	0.79-3.29	0.75-3.13	1.32-5.51	0.62-2.59	2.14-8.91
SF COMP	1	5	1.51	0.82 U(b)	0.83 (c)	1.38 U	2.24	3.69
SF COMP	2	5	1.08 (c)	0.81 U	0.77 U	1.35 U	1.41	3.66
SF COMP	3	5	0.95 (c)	0.82 U	0.78 U	1.38 U	1.14 (c)	2.82
SF COMP	4	5	2.44	1.61 U	1.53 U	2.70 U	1.33 (c)	4.37 U
SF COMP	5	5	1.77	0.82 U	0.78 U	1.38 U	1.53	3.21
SFW COMP	1	4	4.07 B	1.56 U	8.58	11.8	78.4	15.0
SFW COMP	2	4	7.87 B	1.63 U	12.9	16.2	124	21.6
SFW COMP	3	6	4.71	0.97 (c)	5.60	7.85	60.6	12.3
SFW COMP	4	4	4.91 B	1.63 U	9.39	13.9	109	17.7
SFW COMP	5	6	4.19	0.88 (c)	5.23	7.40	58.7	11.7
UIH COMP	1	5	1.39	0.82 U	0.78 U	1.38 U	2.05	3.63
UIH COMP	2	6	1.24	1.48 U	1.41 U	2.48 U	1.17 U	4.01 U
UIH COMP, Replicate 1	3	6	2.39	1.64 U	1.56 U	2.75 U	1.30	4.46 U
UIH COMP, Replicate 2	3	6	1.39	1.61 U	1.53 U	2.70 U	1.55	4.37 U
UIH COMP, Replicate 3	3	6	3.67	1.64 U	1.56 U	2.75 U	1.80 (c)	4.46 U
UIH COMP	4	5	1.05	0.81 U	0.77 U	1.45 (c)	1.87	3.02
UIH COMP	5	5	1.28 (c)	0.81 U	0.77 U	1.58 (c)	2.03	3.42
TB Upper COMP	1	4	1.87 B(c)	1.55 U	1.47 U	2.59 U	1.49 (c)	4.19 U
TB Upper COMP, Replicate 1	2	4	3.58 B(c)	3.02 U	2.88 U	5.07 U	2.38 U	8.20 U
TB Upper COMP, Replicate 2	2	4	4.80 B	2.96 U	2.82 U	4.96 U	2.40 (c)	8.02 U
TB Upper COMP, Replicate 3	2	4	3.15 B	2.89 U	2.75 U	4.85 U	2.28 U	7.84 U
TB Upper COMP	3	3	0.72 B	0.81 U	0.77 U	1.35 U	1.80 B	2.46
TB Upper COMP	4	3	0.51 U	0.82 (c)	1.04	1.38 U	2.18 B	2.53 (c)
TB Upper COMP	5	4	5.56 B	3.29 U	3.13 U	5.51 U	2.59 U	8.91 U
TB Lower COMP	1	4	3.04 B(c)	1.64 U	1.56 U	2.75 U	1.35 (c)	4.46 U
TB Lower COMP	2	3	1.22 B	0.82 U	0.78 U	1.38 U	1.43 B	2.31 (c)
TB Lower COMP	3	5	1.16 (c)	0.82 U	0.78 U	1.38 U	0.71 (c)	2.23 U
TB Lower COMP	4	5	0.81	0.82 U	0.78 U	1.38 U	1.02	2.23 U
TB Lower COMP	5	6	1.60 B(c)	0.82 U	0.78 U	1.38 U	0.92	2.23 U
R-OS	1	5	0.83	0.81 U	0.77 U	1.35 U	0.74 (c)	2.18 U
R-OS, Replicate 1	2	5	2.06	1.61 U	1.53 U	2.70 U	1.27 U	4.37 U
R-OS, Replicate 2	2	5	2.56 (c)	1.59 U	1.52 U	2.67 U	1.26 U	4.32 U
R-OS, Replicate 3	2	5	2.00	1.61 U	1.53 U	2.70 U	1.27 U	4.37 U
R-OS	3	5	1.16	0.81 U	0.77 U	1.48 (c)	0.85	2.18 U
R-OS	4	5	1.29	0.82 U	0.88	1.38 U	0.88	2.23 U
R-OS	5	5	0.80	0.82 U	0.78 U	1.38 U	0.95	2.23 U
R-BF	1	4	2.72 B	1.61 U	1.53 U	2.70 U	1.65	4.37 U
R-BF	2	3	0.85 B	0.82 U	0.92 (c)	1.38 U	2.26 B	2.86 (c)
R-BF	3	4	3.42 B	1.64 U	1.56 U	2.88	2.13 (c)	2.42 (c)
R-BF	4	4	2.05 B(c)	1.53 U	1.46 U	2.56 U	1.63 (c)	4.15 U
R-BF	5	4	1.98 B	1.63 U	1.65 U	2.73 U	1.28 U	4.41 U

TABLE O.5. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta LPAHs (ug/kg wet weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
R-AM COMP	1	3	1.49 B	2.02	1.33	2.39	24.1	14.9
R-AM COMP	2	4	1.92 B	1.64 U	1.56 U	3.46 (c)	14.6	9.23
R-AM COMP	3	4	2.33 B	2.26 (c)	1.56 U	3.52 (c)	25.6	16.1
R-AM COMP	4	3	1.66 B	2.14	1.35	2.95	20.3	11.6
R-AM COMP	5	4	2.98 B	1.92 (c)	1.91	4.72	26.7	16.7
C-SB	1	5	1.92	0.81 U	0.77 U	1.35 U	1.45	2.18 U
C-SB	2	5	1.47	0.81 U	1.01 (c)	1.35 U	0.92 (c)	2.18 U
C-SB	3	5	0.80 (c)	0.82 U	0.78 U	1.48 (c)	1.40 (c)	2.23 U
C-SB	4	5	1.56 (c)	0.81 U	0.77 U	1.35 U	1.42 (c)	2.18 U
C-SB	5	5	1.69 (c)	0.82 U	0.78 U	1.38 U	1.28 (c)	2.23 U
M. nasuta Background	1	3	1.13 B	0.82 U	0.89 (c)	1.38 U	2.86 B	2.32 (c)
M. nasuta Background	2	3	2.16 B(c)	1.61 U	1.89	2.70 U	3.45 B	4.37 U
M. nasuta Background, Replicate 1	3	3	1.76 B(c)	1.59 U	1.52 U	2.67 U	3.63 B	4.39 (c)
M. nasuta Background, Replicate 2	3	3	1.55 B(c)	1.55 U	1.61 (c)	2.59 U	3.75 B	4.42
M. nasuta Background, Replicate 3	3	3	1.32 B(c)	1.58 U	1.72 (c)	2.64 U	3.68 B	4.28 U
M. nasuta Background	4	3	0.88 B(c)	0.81 U	1.19	1.35 U	3.68 B	2.34 (c)
M. nasuta Background	5	3	0.83 B(c)	0.97 (c)	0.86 (c)	1.38 U	2.68 B	2.38 (c)

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.

TABLE O.6. High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

			M. nasuta HPAHs (ug/kg wet weight)									
Sediment Treatment	Replicate	Analytical Batch	Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Target DL(a)			20	20	20	20	20	20	20	20	20	20
Achieved DL			1.58-6.58	1.13-4.72	0.53-2.22	0.63-2.61	0.27-1.11	0.79-3.30	0.76-3.16	2.60-10.85	2.81-11.70	2.32-9.68
SF COMP	1	5	12.0	23.5	6.37	7.48	42.5	15.2	23.2	7.18	2.92 U(c)	10.2
SF COMP	2	5	11.3	25.3	5.09 B (d)	6.59	44.0	16.1	24.8	7.56	2.87 U	9.74
SF COMP	3	5	8.73	16.7	4.74 B	5.60	35.1	13.1	20.0	5.98	2.92 U	9.71
SF COMP	4	5	8.63	4.22	5.72	4.04	38.7	14.9	21.4	6.63	5.73 U	9.78
SF COMP	5	5	8.32	15.2	5.30 B	6.10	37.9	14.3	21.0	10.2	2.92 U	2.42 U
SFW COMP	1	4	94.3	104	22.6	19.8	47.2	16.3	28.4	7.73	5.56 U	14.7
SFW COMP	2	4	130	152	29.0	24.1	53.2	18.5	31.3	5.98	5.79 U	14.1
SFW COMP	3	6	74.9	79.0	19.6	16.4	37.6	13.0	23.7	7.35	2.87 U	8.33
SFW COMP	4	4	125	130	30.5	23.6	54.3	19.5	32.5	8.82	5.79 U	14.0
SFW COMP	5	6	88.1	94.2	23.3	19.2	37.7	13.9	23.8	8.35	2.92 U	8.43
UIH COMP	1	5	10.9	27.9	5.05 B	6.10	32.2	11.7	18.0	6.38	2.92 U	7.99
UIH COMP	2	6	8.97	16.2	5.08 B	5.39	27.0	11.1	17.7	6.93	5.26 U	12.6
UIH COMP, Replicate 1	3	6	10.6	15.2	1.20 B (b)	5.20	22.2	8.83	13.3	6.16	5.85 U	9.60
UIH COMP, Replicate 2	3	6	9.52	14.1	3.72 B	4.35	21.6	8.56	12.6	5.97	5.73 U	10.4
UIH COMP, Replicate 3	3	6	11.2	14.7	4.38 B (b)	5.23	22.4	9.54	12.8	6.02	5.85 U	12.1
UIH COMP	4	5	9.92	33.6	4.78 B	5.90	27.2	9.38	16.1	9.62	2.87 U	9.40
UIH COMP	5	5	9.92	26.0	4.36 B	4.95	28.6	10.6	16.2	8.07	2.87 U	11.2
TB Upper COMP	1	4	7.41	2.22 U	3.07 B (b)	2.90	8.81	4.19	6.62	5.10 U	5.50 U	9.38
TB Upper COMP, Replicate 1	2	4	10.7	4.34 U	5.04 B (b)	4.08	10.7	6.20	6.94	9.98 U	10.8 U	8.90 U
TB Upper COMP, Replicate 2	2	4	11.0	4.25 U	4.95 B (b)	3.51	10.1	5.68	6.96	9.77 U	10.5 U	8.71 U
TB Upper COMP, Replicate 3	2	4	10.5	4.15 U	4.47 B (b)	2.30 U	9.82	5.51	6.77	9.55 U	10.3 U	8.96 (b)
TB Upper COMP	3	3	6.52	7.00 B (b)	2.26 B	3.61 B	7.77 B	3.99 B (b)	5.58 B (b)	3.11	2.87 U	5.75 B
TB Upper COMP	4	3	8.58	9.10 B (b)	2.48 B	3.61 B	8.30 B	4.24 B	6.19 B (b)	3.38	2.92 U	6.42 B
TB Upper COMP	5	4	10.2	4.72 U	5.14 B (b)	2.61 U	11.6	6.48	7.62	10.9 U	11.7 U	9.90 (b)
TB Lower COMP	1	4	5.35	2.36 U	2.45 B (b)	1.85	3.89	1.65 U	3.71	5.43 U	5.85 U	4.84 U
TB Lower COMP	2	3	4.49	2.76 B (b)	0.74 B (b)	2.53 B	3.28 B (b)	2.61 B (b)	2.31 B (b)	2.71 U	2.92 U	3.68 B
TB Lower COMP	3	5	3.33	1.18 U	1.41 B (b)	0.87	2.51	1.32	2.57	2.71 U	2.92 U	2.42 U
TB Lower COMP	4	5	3.47	1.18 U	1.27 B	1.72	2.57	1.60	2.58	3.41	2.92 U	2.42 U
TB Lower COMP	5	6	2.98	1.18 U	1.22 B (b)	1.35	2.31	1.45	2.43	2.71 U	2.92 U	2.42 U

TABLE O.6. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta HPAHs (ug/kg wet weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
R-OS	1	5	3.47 (b)	1.16 U	1.35 B	0.97 (b)	1.74 (b)	1.36 (b)	1.85 (b)	2.66 U	2.87 U	2.37 U
R-OS, Replicate 1	2	5	4.58 (b)	2.31 U	2.49 B (b)	1.28 U	0.54 U	1.62 U	2.23 (b)	5.32 U	5.73 U	5.75 (b)
R-OS, Replicate 2	2	5	5.04 (b)	2.29 U	2.22 B (b)	1.84 (b)	0.54 U	1.60 U	2.34 (b)	5.26 U	5.67 U	4.69 U
R-OS, Replicate 3	2	5	4.47 (b)	2.31 U	2.09 B (b)	1.28 U	0.54 U	1.62 U	2.20 (b)	5.32 U	5.73 U	5.58 (b)
R-OS	3	5	3.55 (b)	1.16 U	1.29 B (b)	1.42	2.00 (b)	0.81 U	1.81 (b)	2.66 U	2.87 U	2.37 U
R-OS	4	5	4.17 (b)	1.18 U	1.50 B	1.72 (b)	2.11 (b)	0.82 U	2.40 (b)	2.71 U	2.92 U	2.42 U
R-OS	5	5	3.25 (b)	1.18 U	1.43 B (b)	1.06 (b)	1.81 (b)	0.82 U	1.91 (b)	2.71 U	2.92 U	2.42 U
R-BF	1	4	12.1 (b)	2.31 U	4.56 B	4.82	11.8	5.28	8.35 (b)	6.17	5.73 U	11.6
R-BF	2	3	12.8 (b)	14.7 B (b)	3.34 B	5.45 B	10.6 B	5.05 B	1.90 B (b)	4.30	2.92 U	7.63 B
R-BF	3	4	4.46 U	2.36 U	5.94 B	5.88	12.6	5.51 (b)	8.98 (b)	5.43 U	5.85 U	8.87
R-BF	4	4	11.0 (b)	2.19 U	4.30 B	4.49	9.83	4.31	6.81 (b)	5.05 U	5.44 U	8.55
R-BF	5	4	9.78 (b)	2.34 U	3.56 B	3.75 (b)	9.32	4.45 (b)	7.01 (b)	5.37 U	5.79 U	6.85 (b)
R-AM COMP	1	3	111	121	51.6	75.2	53.0	20.3 B	48.7	17.5	4.00	22.1 B
R-AM COMP	2	4	63.1	57.1 (b)	29.2	42.7	27.3	12.4	26.0	11.9	5.85 U	16.6
R-AM COMP	3	4	105 (b)	116	52.9	69.2	49.5	19.8	44.9	14.7	5.85 U	20.2
R-AM COMP	4	3	69.8	83.8	30.9	51.5	36.0	14.4 B	32.1	12.9	3.11	16.0 B
R-AM COMP	5	4	83.7 (b)	93.1 (b)	36.8	55.8	40.9	16.0	36.9	18.0	5.56 U	21.7
C-SB	1	5	6.20 (b)	1.16 U	1.74 B	1.98	3.40	1.80 (b)	2.53 (b)	2.66 U	2.87 U	2.37 U
C-SB	2	5	5.94 (b)	1.16 U	1.55 B	1.75	3.08	1.62 (b)	2.83 (b)	2.66 U	2.87 U	21.8
C-SB	3	5	8.26 (b)	1.18 U	1.68 B	2.18	3.43	1.34 (b)	2.30 (b)	2.71 U	2.92 U	2.42 U
C-SB	4	5	6.71 (b)	1.16 U	1.82 B (b)	2.38	3.45	1.93 (b)	2.41 (b)	2.66 U	2.87 U	2.37 U
C-SB	5	5	5.86 (b)	1.18 U	1.66 B	2.09	3.51 (b)	1.79 (b)	2.74 (b)	2.71 U	2.92 U	2.42 U
M. nasuta Background	1	3	9.25 (b)	6.50 B (b)	1.49 B (b)	2.77 B	3.03 B (b)	2.58 B (b)	3.42 B (b)	3.75	2.92 U	3.65 B (b)
M. nasuta Background	2	3	9.88 (b)	5.80 B (b)	2.36 B	3.59 B	5.38 B (b)	4.73 B (b)	4.30 B (b)	5.32 U	5.73 U	4.74 U
M. nasuta Background, Replicate 1	3	3	12.4 (b)	5.47 B (b)	2.55 B (b)	3.95 B	5.59 B	4.64 B (b)	4.42 B (b)	5.26 U	5.67 U	4.69 U
M. nasuta Background, Replicate 2	3	3	12.2 (b)	5.24 B (b)	2.55 B	3.67 B	5.06 B (b)	4.56 B (b)	4.13 B (b)	5.39	5.50 U	6.70 B (b)
M. nasuta Background, Replicate 3	3	3	12.2 (b)	9.50 B (b)	2.44 B (b)	3.78 B	5.55 B (b)	4.88 B (b)	4.32 B (b)	5.21 U	5.61 U	6.25 B (b)
M. nasuta Background	4	3	10.2 (b)	7.18 B (b)	1.42 B	3.02 B	3.12 B (b)	2.67 B (b)	3.71 B (b)	5.72	2.87 U	3.21 B (b)
M. nasuta Background	5	3	8.29 (b)	6.05 B (b)	1.27 B (b)	2.50 B (b)	2.98 B (b)	2.36 B (b)	1.88 B (b)	2.71 U	2.92 U	2.42 U

(a) DL Detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) U Undetected at or above detection limit.
(d) B Analyte detected in sample at less than five times the value in associated method blank.

TABLE O.7. Quality Control Data for Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LPAHs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta LPAHs (ug/kg wet weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Method Blanks								
Blank-1		3	1.25 (a)	1.73 U(b)	1.64 U	2.89 U	1.62 (a)	4.68 U
Blank-1		4	1.79 (a)	1.79 U	1.71 U	3.00 U	1.41 U	4.86 U
Blank-2		6	0.88 (a)	0.82 U	0.78 U	1.38 U	0.65 U	2.23 U
Blank-1		5	0.60 U	0.97 U	0.92 U	1.62 U	0.76 U	2.63 U
Blank-2		6	0.60 U	0.97 U	0.92 U	1.62 U	0.76 U	2.63 U
Matrix Spikes								
M. nasuta Background	2	3	2.16 B(a)(c)	1.61 U	1.89	2.70 U	3.45 B	4.37 U
M. nasuta Background, MS	2	3	44.7	42.8	45.5	42.9	46.5	46.4
Concentration Recovered			42.5	42.8	43.6	42.9	43.1	46.4
Amount Spiked			47.6	47.6	47.6	47.6	47.6	47.6
Percent Recovery			89%	90%	92%	90%	90%	97%
TB Upper COMP	5	4	5.56 B	3.29 U	3.13 U	5.51 U	2.59 U	8.91 U
TB Upper COMP, MS	5	4	90.4	85.2	89.7	86.1	83.5	89.0
Concentration Recovered			84.8	85.2	89.7	86.1	83.5	89.0
Amount Spiked			91.4	91.4	91.4	91.4	91.4	91.4
Percent Recovery			93%	93%	98%	94%	91%	97%
SF COMP	4	5	2.44	1.61 U	1.53 U	2.70 U	1.33 (a)	4.37 U
SF COMP, MS	4	5	50.5	48.3	50.7	48.8	49.1	56.6
Concentration Recovered			48.1	48.3	50.7	48.8	47.8	56.6
Amount Spiked			50.0	50.0	50.0	50.0	50.0	50.0
Percent Recovery			96%	97%	101%	98%	96%	113%
UIH COMP	2	6	1.24	1.48 U	1.41 U	2.48 U	1.17 U	4.01 U
UIH COMP, MS	2	6	51.8	48.3	50.1	50.6	50.9	59.5
Concentration Recovered			50.6	48.3	50.1	50.6	50.9	59.5
Amount Spiked			51.8	51.8	51.8	51.8	51.8	51.8
Percent Recovery			98%	93%	97%	98%	98%	115%
Standard Reference Material								
Certified SRM not available for PAHs.								
Analytical Replicates								
M. nasuta Background, Replicate 1	3	3	1.76 B(a)	1.59 U	1.52 U	2.67 U	3.63 B	4.39 (a)
M. nasuta Background, Replicate 2	3	3	1.55 B(a)	1.55 U	1.61 (a)	2.59 U	3.75 B	4.42
M. nasuta Background, Replicate 3	3	3	1.32 B(a)	1.58 U	1.72 (a)	2.64 U	3.68 B	4.28 U
RSD			14%	NA (d)	NA	NA	2%	NA
TB Upper COMP, Replicate 1	2	4	3.58 B(a)	3.02 U	2.88 U	5.07 U	2.38 U	8.20 U
TB Upper COMP, Replicate 2	2	4	4.80 B	2.96 U	2.82 U	4.96 U	2.40 (a)	8.02 U
TB Upper COMP, Replicate 3	2	4	3.15 B	2.89 U	2.75 U	4.85 U	2.28 U	7.84 U
RSD			22%	NA	NA	NA	NA	NA

TABLE O.7. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta LPAHs (ug/kg wet weight) Naphtha-lene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne	Anthra-cene
Analytical Replicates (contd)								
R-OS, Replicate 1	2	5	2.06	1.61 U	1.53 U	2.70 U	1.27 U	4.37 U
R-OS, Replicate 2	2	5	2.56 (a)	1.59 U	1.52 U	2.67 U	1.26 U	4.32 U
R-OS, Replicate 3	2	5	2.00	1.61 U	1.53 U	2.70 U	1.27 U	4.37 U
RSD			14%	NA	NA	NA	NA	NA
UIH COMP, Replicate 1	3	6	2.39	1.64 U	1.56 U	2.75 U	1.30	4.46 U
UIH COMP, Replicate 2	3	6	1.39	1.61 U	1.53 U	2.70 U	1.55	4.37 U
UIH COMP, Replicate 3	3	6	3.67	1.64 U	1.56 U	2.75 U	1.80 (a)	4.46 U
RSD			46%	NA	NA	NA	16%	NA

(a) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(b) U Undetected at or above detection limit.
(c) B Analyte detected in sample at less than five times value in associated method blank.
(d) NA Not applicable.

TABLE O.8. Quality Control Data for High Molecular Weight Polynuclear Aromatic Hydrocarbons (HPAHs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta HPAHs (ug/kg wet weight) Fluoranthene	Pyrene	Benzo(a)anthracene	Chrysene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenzo(a,h)anthracene	Benzo(g,h,i)perylene
Method Blanks												
Blank-1		3	3.45 U(a)	6.24 (b)	2.30	2.34 (b)	5.66 (b)	5.42 (b)	2.95 (b)	5.70 U	6.14 U	6.21 (b)
Blank-1		4	3.59 U	2.57 U	2.15 (b)	1.42 U	0.61 U	1.8 U	1.72 U	5.91 U	6.37 U	5.27 U
Blank-2		6	1.64 U	1.18 U	0.94 (b)	0.65 U	0.28 U	0.82 U	0.79 U	2.71 U	2.92 U	2.42 U
Blank-1		5	1.94 U	1.39 U	1.11 (b)	0.77 U	0.33 U	0.97 U	0.93 U	3.20 U	3.45 U	2.85 U
Blank-2		6	1.94 U	1.39 U	1.11 (b)	0.77 U	0.33 U	0.97 U	0.93 U	3.20 U	3.45 U	2.85 U
Matrix Spikes												
M. nasuta Background	2	3	9.88 (b)	5.80 B(b)(c)	2.36 B	3.59 B	5.38 B(b)	4.73 B(b)	4.30 B(b)	5.32 U	5.73 U	4.74 U
M. nasuta Background, MS	2	3	52.8	45.3	40.9	42.6	50.2	50.7	50.5	54.4	50.0	59.7
Concentration Recovered			42.9	39.5	38.5	39.0	44.8	46.0	46.2	54.4	50.0	59.7
Amount Spiked			47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
Percent Recovery			90%	83%	81%	82%	94%	97%	97%	114%	105%	125% (d)
TB Upper COMP	5	4	10.2 (b)	4.72 U	5.14 B(b)	2.61 U	11.6 (b)	6.48 (b)	7.62 (b)	10.9 U	11.7 U	9.90 (b)
TB Upper COMP, MS	5	4	96.2	63.5	88.7	80.1	100	96.6	94.8	89.1	90.6	93.2
Concentration Recovered			86.0	63.5	83.6	80.1	88.4	90.1	87.2	89.1	90.6	83.3
Amount Spiked			91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4	91.4
Percent Recovery			94%	69%	91%	88%	97%	99%	95%	97%	99%	91%
SF COMP	4	5	8.63 (b)	4.22	5.72	4.04 (b)	38.7	14.9	21.4	6.63	5.73 U	9.78
SF COMP, MS	4	5	58.2	57.8	53.8	51.7	100	75.4	78.2	54.2	53.2	55.6
Concentration Recovered			49.6	53.6	48.1	47.7	61.3	60.5	56.8	47.6	53.2	45.8
Amount Spiked			50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Percent Recovery			99%	107%	96%	95%	123% (d)	121% (d)	114%	95%	106%	92%
UIH COMP	2	6	8.97 (b)	16.2	5.08	5.39 (b)	27.0	11.1	17.7	6.93	5.26 U	12.6
UIH COMP, MS	2	6	61.9	68.4	55.0	49.7	79.6	64.2	67.2	55.0	50.8	62.9
Concentration Recovered			52.9	52.2	49.9	44.3	52.6	53.1	49.5	48.1	45.5	50.3
Amount Spiked			51.8	51.8	51.8	51.8	51.8	51.8	51.8	51.8	51.8	51.8
Percent Recovery			102%	101%	96%	86%	102%	103%	96%	93%	88%	97%

TABLE O.8. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta HPAHs (ug/kg wet weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Standard Reference Material												
Certified SRM not available for PAHs.												
Analytical Replicates												
M. nasuta Background, Replicate 1	3	3	12.4 (b)	5.47 B(b)	2.55 B(b)	3.95 B	5.59 B	4.64 B(b)	4.42 B(b)	5.26 U	5.67 U	4.69 U
M. nasuta Background, Replicate 2	3	3	12.2 (b)	5.24 B(b)	2.55 B	3.67 B	5.06 B(b)	4.56 B(b)	4.13 B(b)	5.39	5.50 U	6.70 B(b)
M. nasuta Background, Replicate 3	3	3	12.2 (b)	9.50 B(b)	2.44 B(b)	3.78 B	5.55 B(b)	4.88 B(b)	4.32 B(b)	5.21 U	5.61 U	6.25 B(b)
RSD			1%	36% (e)	3%	4%	5%	4%	3%	NA (f)	NA	NA
TB Upper COMP, Replicate 1	2	4	10.7 (b)	4.34 U	5.04 B(b)	4.08 (b)	10.7	6.20 (b)	6.94 (b)	9.98 U	10.8 U	8.90 U
TB Upper COMP, Replicate 2	2	4	11.0 (b)	4.25 U	4.95 B(b)	3.51 (b)	10.1 (b)	5.68 (b)	6.96 (b)	9.77 U	10.5 U	8.71 U
TB Upper COMP, Replicate 3	2	4	10.5 (b)	4.15 U	4.47 B(b)	2.30 U	9.82 (b)	5.51 (b)	6.77 (b)	9.55 U	10.3 U	8.96 (b)
RSD			2%	NA	6%	NA	4%	6%	2%	NA	NA	NA
R-OS, Replicate 1	2	5	4.58 (b)	2.31 U	2.49 B(b)	1.28 U	0.54 U	1.62 U	2.23 (b)	5.32 U	5.73 U	5.75 (b)
R-OS, Replicate 2	2	5	5.04 (b)	2.29 U	2.22 B(b)	1.84 (b)	0.54 U	1.60 U	2.34 (b)	5.26 U	5.67 U	4.69 U
R-OS, Replicate 3	2	5	4.47 (b)	2.31 U	2.09 B(b)	1.28 U	0.54 U	1.62 U	2.20 (b)	5.32 U	5.73 U	5.58 (b)
RSD			6%	NA	9%	NA	NA	NA	3%	NA	NA	NA
UIH COMP, Replicate 1	3	6	10.6 (b)	15.2 (b)	1.20 B(b)	5.20	22.2	8.83	13.3	6.16	5.85 U	9.60
UIH COMP, Replicate 2	3	6	9.52 (b)	14.1	3.72 B	4.35	21.6	8.56	12.6	5.97	5.73 U	10.4
UIH COMP, Replicate 3	3	6	11.2 (b)	14.7 (b)	4.38 B(b)	5.23	22.4	9.54	12.8 (b)	6.02	5.85 U	12.1
RSD			8%	4%	54% (e)	10%	2%	6%	3%	2%	NA	12%

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample at less than five times value in associated method blank.
(d) Outside quality control criteria (40-120%) for matrix spike recoveries.
(e) Value exceeds relative precision goal of <30%).
(f) NA Not applicable.

TABLE O.9. Phthalate Esters, Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta phthalate esters (ug/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
SF COMP	1	5	12.76	157 U(a)	196 B(b)	157 U	831 (c)	815	157 U
SF COMP	2	5	12.94	151 U	282 B	186 B	673 (c)	966	151 U
SF COMP	3	5	12.26	163 U	232 B	166 B	527	664	163 U
SF COMP	4	5	12.60	311 U	467 B	615 B	532 (c)	1230	311 U
SF COMP	5	5	14.42	139 U	262 B	139 U	310 (c)	621	139 U
SFW COMP	1	4	14.61	260 U	363 B	529	605 (c)	1080	260 U
SFW COMP	2	4	17.91	221 U	248 B	221 U	547 (c)	804 (c)	221 U
SFW COMP	3	6	14.49	135 U	214 B	266	423 (c)	669 B(b)	135 U
SFW COMP	4	4	14.31	277 U	277 U	541	525 (c)	915	277 U
SFW COMP	5	6	14.58	137 U	183 B	234	367 (c)	584 B	137 U
UIH COMP	1	5	13.71	146 U	146 U	146 U	766	832	146 U
UIH COMP	2	6	14.06	256 U	341 B	464	635 (c)	903 B(b)	256 U
UIH COMP, Replicate 1	3	6	13.52	296 U	296 U	296 U	581 (c)	1050 B(b)	296 U
UIH COMP, Replicate 2	3	6	13.52	290 U	425 B	1240	649	984 B(b)	290 U
UIH COMP, Replicate 3	3	6	13.52	296 U	473 B	570	791 (c)	1040 B(b)	296 U
UIH COMP	4	5	15.23	129 U	134 B(b)	320 B	650 (c)	775 (c)	129 U
UIH COMP	5	5	13.02	151 U	157 B	151 U	799 (c)	998 (c)	151 U
TB Upper COMP	1	4	15.21	247 U	953 B	300	548 (c)	927	247 U
TB Upper COMP, Replicate 1	2	4	14.75	499 U	1831 B	567	499 U	1170	499 U
TB Upper COMP, Replicate 2	2	4	14.75	488 U	1400 B	566	506 (c)	1110	488 U
TB Upper COMP, Replicate 3	2	4	14.75	477 U	1660 B	634	483 (c)	1130	477 U
TB Upper COMP	3	3	13.66	143 U	143 U	143 U	988	981	143 U
TB Upper COMP	4	3	15.16	132 U	132 U	158	732	831	132 U
TB Upper COMP	5	4	15.00	533 U	1580 B	650	707 (c)	1230 (c)	533 U
TB Lower COMP	1	4	13.17	304 U	311 B	503	534 (c)	858 (c)	304 U
TB Lower COMP	2	3	13.30	150 U	150 U	150 U	533	812	150 U
TB Lower COMP	3	5	12.74	157 U	199 B	157 U	934 (c)	673 (c)	157 U
TB Lower COMP	4	5	12.37	162 U	229 B	193 B	632 (c)	1080	162 U
TB Lower COMP	5	6	13.89	144 U	274 B(b)	279 B	145 (c)	361	144 U

TABLE O.9. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta phthalate esters (ug/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
R-OS	1	5	12.71	154 U	300 B(b)	436 B	549 (c)	723 (c)	154 U
R-OS, Replicate 1	2	5	12.62	311 U	616 B	746 B	666 (c)	1070	311 U
R-OS, Replicate 2	2	5	12.62	307	464 B	307 B	677 (c)	967 (c)	307 U
R-OS, Replicate 3	2	5	12.62	311 U	547 B	370 B	620 (c)	1090	311 U
R-OS	3	5	13.84	142 U	198 B	142 U	525 (c)	622 (c)	142 U
R-OS	4	5	12.69	158 U	281 B	325 B(b)	883 (c)	835 (c)	158 U
R-OS	5	5	13.41	149 U	183 B	271 B	479 (c)	658	149 U
R-BF	1	4	15.28	257 U	397 B	451	489 (c)	988	257 U
R-BF	2	3	14.64	137 U	137 U	143	840	908	137 U
R-BF	3	4	14.78	271 U	421 B	516 (c)	578 (c)	954 (c)	271 U
R-BF	4	4	15.91	234 U	685 B	492	660 (c)	918 (c)	234 U
R-BF	5	4	14.92	265 U	295 B	311	422 (c)	744 (c)	265 U
R-AM COMP	1	3	15.79	124 U	124 U	124 U	652	912	124 U
R-AM COMP	2	4	13.81	290 U	1060 B	481	356 (c)	700	290 U
R-AM COMP	3	4	15.44	259 U	751 B	259 U	699 (c)	920 (c)	259 U
R-AM COMP	4	3	14.52	132 U	155	132 U	132 U	625	132 U
R-AM COMP	5	4	14.71	258 U	372 B	333	809 (c)	1560	258 U
C-SB	1	5	14.43	136 U	141 B	136 U	667 (c)	901 (c)	136 U
C-SB	2	5	13.25	148 U	198 B	148 U	845 (c)	709 (c)	148 U
C-SB	3	5	14.03	143 U	220 B	143 U	834 (c)	798	143 U
C-SB	4	5	13.57	144 U	144 U	144 U	796 (c)	936 (c)	144 U
C-SB	5	5	13.60	147 U	237 B	147 U	846 (c)	882 (c)	147 U
M. nasuta Background	1	3	13.46	149 U	181	149 U	149 U	491	149 U
M. nasuta Background	2	3	12.00	327 U	327 U	327 U	327 U	698	327 U
M. nasuta Background, Replicate 1	3	3	13.05	297 U	297 U	297 U	297 U	717	297 U
M. nasuta Background, Replicate 2	3	3	13.05	288 U	288 U	338	288 U	542	288 U
M. nasuta Background, Replicate 3	3	3	13.05	294 U	294 U	294 U	294 U	539	294 U
M. nasuta Background	4	3	14.21	138 U	138 U	138 U	138 U	443	138 U
M. nasuta Background	5	3	17.65	113 U	113 U	113 U	113 U	280	113 U

(a) U Undetected at or above detection limit.
(b) B Analyte detected in sample at less than five times value in associated method blank.
(c) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.

TABLE O.10. Phthalate Esters, Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Target DL(a)			20	20	20	20	20	20
Achieved DL			19.2-80.0 (1)	19.2-80.0 (b)	19.2-80.0 (b)	19.2-80.0 (b)	19.2-80.0 (b)	19.2-80.0 (b)
SF COMP	1	5	20.0 U(c)	25.0 B(d)	20.0 U	106 (e)	104	20.0 U
SF COMP	2	5	19.6 U	36.5 B	24.1 B	87.1 (e)	125	19.6 U
SF COMP	3	5	20.0 U	28.5 B	20.4 B	64.6	81.4	20.0 U
SF COMP	4	5	39.2 U	58.8 B	77.5 B	67.0 (e)	155	39.2 U
SF COMP	5	5	20.0 U	37.8 B	20.0 U	44.7 (e)	89.6	20.0 U
SFW COMP	1	4	38.0 U	53.1 B	77.3	88.4 (e)	158	38.0 U
SFW COMP	2	4	39.6 U	44.4 B	39.6 U	97.9 (e)	144 (e)	39.6 U
SFW COMP	3	6	19.6 U	31.0 B	38.6	61.3 (e)	97.0 B(e)	19.6 U
SFW COMP	4	4	39.6 U	39.6 U	77.4	75.1 (e)	131	39.6 U
SFW COMP	5	6	20.0 U	26.7 B	34.1	53.5 (e)	85.1 B	20.0 U
UIH COMP	1	5	20.0 U	20.0 U	20.0 U	105	114	20.0 U
UIH COMP	2	6	36.0 U	47.9 B	65.2	89.3 (e)	127 B(e)	36.0 U
UIH COMP, Replicate 1	3	6	40.0 U	40.0 U	40.0 U	78.6 (e)	142 B(e)	40.0 U
UIH COMP, Replicate 2	3	6	39.2 U	57.4 B	167	87.8	133 B(e)	39.2 U
UIH COMP, Replicate 3	3	6	40.0 U	64.0 B	77.0	107 (e)	140 B(e)	40.0 U
UIH COMP	4	5	19.6 U	20.4 B(e)	48.8 B	99.0 (e)	118 (e)	19.6 U
UIH COMP	5	5	19.6 U	20.5 B	19.6 U	104 (e)	130 (e)	19.6 U
TB Upper COMP	1	4	37.6 U	145 B	45.6	83.4 (e)	141	37.6 U
TB Upper COMP, Replicate 1	2	4	73.6 U	270 B	83.7	73.6 U	172	73.6 U
TB Upper COMP, Replicate 2	2	4	72.0 U	207 B	83.5	74.6 (e)	163	72.0 U
TB Upper COMP, Replicate 3	2	4	70.4 U	245 B	93.5	71.3 (e)	167	70.4 U
TB Upper COMP	3	3	19.6 U	19.6 U	19.6 U	135	134	19.6 U
TB Upper COMP	4	3	20.0 U	20.0 U	24.0	111	126	20.0 U
TB Upper COMP	5	4	80.0 U	237 B	97.5	106 (e)	185 (e)	80.0 U
TB Lower COMP	1	4	40.0 U	40.9 B	66.2	70.3 (e)	113 (e)	40.0 U
TB Lower COMP	2	3	20.0 U	20.0 U	20.0 U	70.9	108	20.0 U
TB Lower COMP	3	5	20.0 U	25.4 B	20.0 U	119 (e)	85.7 (e)	20.0 U
TB Lower COMP	4	5	20.0 U	28.3 B	23.9 B	78.2 (e)	133	20.0 U
TB Lower COMP	5	6	20.0 U	38.0 B(e)	38.7 B	20.2 (e)	50.2	20.0 U

TABLE O.10. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
R-OS	1	5	19.6 U	38.1 B(d)	55.4 B	69.8 (e)	91.9 (e)	19.6 U
R-OS, Replicate 1	2	5	39.2 U	77.8 B	94.2 B	84.0 (e)	135	39.2 U
R-OS, Replicate 2	2	5	38.8	58.5 B	38.8 B	85.4 (e)	122 (e)	38.8 U
R-OS, Replicate 3	2	5	39.2 U	69.0 B	46.7 B	78.2 (e)	138	39.2 U
R-OS	3	5	19.6 U	27.4 B	19.6 U	72.6 (e)	86.1 (e)	19.6 U
R-OS	4	5	20.0 U	35.6 B	41.3 B(e)	112 (e)	106 (e)	20.0 U
R-OS	5	5	20.0 U	24.6 B	36.4 B	64.2 (e)	88.3	20.0 U
R-BF	1	4	39.2 U	60.6 B	68.9	74.7 (e)	151	39.2 U
R-BF	2	3	20.0 U	20.0 U	21.0	123	133	20.0 U
R-BF	3	4	40.0 U	62.2 B	76.2 (e)	85.4 (e)	141 (e)	40.0 U
R-BF	4	4	37.2 U	109 B	78.2	105 (e)	146 (e)	37.2 U
R-BF	5	4	39.6 U	44.0 B	46.4	62.9 (e)	111 (e)	39.6 U
R-AM COMP	1	3	19.6 U	19.6 U	19.6 U	103	144	19.6 U
R-AM COMP	2	4	40.0 U	147 B	66.4	49.2 (e)	96.7	40.0 U
R-AM COMP	3	4	40.0 U	116 B	40.0 U	108 (e)	142 (e)	40.0 U
R-AM COMP	4	3	19.2 U	22.5	19.2 U	19.2 U	90.7	19.2 U
R-AM COMP	5	4	38.0 U	54.7 B	49.0	119 (e)	229	38.0 U
C-SB	1	5	19.6 U	20.4 B	19.6 U	96.3 (e)	130 (e)	19.6 U
C-SB	2	5	19.6 U	26.3 B	19.6 U	112 (e)	94.0 (e)	19.6 U
C-SB	3	5	20.0 U	30.8 B	20.0 U	117 (e)	112	20.0 U
C-SB	4	5	19.6 U	19.6 U	19.6 U	108 (e)	127 (e)	19.6 U
C-SB	5	5	20.0 U	32.3 B	20.0 U	115 (e)	120 (e)	20.0 U
M. nasuta Background	1	3	20.0 U	24.3	20.0 U	20.0 U	66.1	20.0 U
M. nasuta Background	2	3	39.2 U	39.2 U	39.2 U	39.2 U	83.8	39.2 U
M. nasuta Background, Replicate 1	3	3	38.8 U	38.8 U	38.8 U	38.8 U	93.6	38.8 U
M. nasuta Background, Replicate 2	3	3	37.6 U	37.6 U	44.1	37.6 U	70.7	37.6 U
M. nasuta Background, Replicate 3	3	3	38.4 U	38.4 U	38.4 U	38.4 U	70.4	38.4 U
M. nasuta Background	4	3	19.6 U	19.6 U	19.6 U	19.6 U	62.9	19.6 U
M. nasuta Background	5	3	20.0 U	20.0 U	20.0 U	20.0 U	49.4	20.0 U

(a) DL Detection limit.
(b) Detection limit derived from lowest calibration standard as sample.
(c) U Undetected at or above detection limit.
(d) B Analyte detected in sample at less than five times value in associated method blank.
(e) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.

TABLE O.11. Quality Control Data for Phthalate Esters, Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Method Blanks								
Blank-1		3	42.0 U(a)	42.0 U	42.0 U	42.0 U	42.0 U	42.0 U
Blank-1		4	43.6 U	132	43.6 U	43.6 U	43.6 U	43.6 U
Blank-2		6	20 U	36.9	29.1	20 U	20 U	20 U
Blank-1		5	23.6 U	48.9	25.2	23.6 U	23.6 U	23.6 U
Blank-2		6	23.6 U	34.9	23.6 U	23.6 U	33.0	23.6 U
Matrix Spikes								
M. nasuta Background	2	3	39.2 U	39.2 U	39.2 U	39.2 U	83.8	39.2 U
M. nasuta Background, MS	2	3	314	370	413	463	509	602
Concentration Recovered			314	370	413	463	425	602
Amount Spiked			762	762	762	762	762	762
Percent Recovery			41%	49%	54%	61%	56%	79%
TB Upper COMP	5	4	80.0 U	237 B(b)	97.5	106 (c)	185 (c)	80.0 U
TB Upper COMP, MS	5	4	1160	1380	1450	1580	1560	1910
Concentration Recovered			1160	1140	1350	1470	1380	1910
Amount Spiked			1460	1460	1460	1460	1460	1460
Percent Recovery			79%	78%	93%	101%	94%	131% (d)
SF COMP	4	5	39.2 U	58.8 B	77.5 B	67.0 (c)	155	39.2 U
SF COMP, MS	4	5	461	513	826	909	893	1120
Concentration Recovered			461	454	749	842	738	1120
Amount Spiked			799	799	799	799	799	799
Percent Recovery			58%	57%	94%	105%	92%	140% (d)
UIH COMP	2	6	36.0 U	47.9	65.2	89.3 (c)	127 (c)	36.0 U
UIH COMP, MS	2	6	740	836	898	977	931	1130
Concentration Recovered			740	788	833	888	804	1130
Amount Spiked			798	798	798	798	798	798
Percent Recovery			93%	99%	104%	111%	101%	142% (d)

TABLE O.11. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Standard Reference Material								
Certified SRM not available for phthalates.								
Analytical Replicates								
M. nasuta Background, Replicate 1	3	3	38.8 U	38.8 U	38.8 U	38.8 U	93.6	38.8 U
M. nasuta Background, Replicate 2	3	3	37.6 U	37.6 U	44.1	37.6 U	70.7	37.6 U
M. nasuta Background, Replicate 3	3	3	38.4 U	38.4 U	38.4 U	38.4 U	70.4	38.4 U
RSD			NA (e)	NA	NA	NA	17%	NA
TB Upper COMP, Replicate 1	2	4	73.6 U	270 B	83.7	73.6 U	172	73.6 U
TB Upper COMP, Replicate 2	2	4	72.0 U	207 B	83.5	74.6 (c)	163	72.0 U
TB Upper COMP, Replicate 3	2	4	70.4 U	245 B	93.5	71.3 (c)	167	70.4 U
RSD			NA	13%	7%	NA	3%	NA
R-OS, Replicate 1	2	5	39.2 U	77.8 B	94.2 B	84.0 (c)	135	39.2 U
R-OS, Replicate 2	2	5	38.8	58.5 B	38.8 B	85.4 (c)	122 (c)	38.8 U
R-OS, Replicate 3	2	5	39.2 U	69.0 B	46.7 B	78.2 (c)	138	39.2 U
RSD			NA	14%	50% (f)	5%	6%	NA
UIH COMP, Replicate 1	3	6	40.0 U	40.0 U	40.0 U	78.6 (c)	142 B(c)	40.0 U
UIH COMP, Replicate 2	3	6	39.2 U	57.4 B	167	87.8	133 B(c)	39.2 U
UIH COMP, Replicate 3	3	6	40.0 U	64.0 B	77.0	107 (c)	140 B(c)	40.0 U
RSD			NA	NA	NA	16%	3%	NA

(a) U Undetected at or above detection limit.
(b) B Analyte detected in sample at less than five times value in associated method blank.
(c) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(d) Outside quality control criteria (40-120%) for matrix spike recoveries.
(e) NA Not applicable.
(f) Value exceeds relative precision goal of <30%.

TABLE O.12. Surrogate Percent Recoveries for Polynuclear Aromatic Hydrocarbons (PAHs), Including Quality Control Data, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naphthalene d8	Acenaphthene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
SF COMP	1	5	73	79	79	88
SF COMP	2	5	72	78	85	86
SF COMP	3	5	75	81	82	90
SF COMP	4	5	71	77	91	75
SF COMP	5	5	65	73	79	76
SFW COMP	1	4	72	78	81	89
SFW COMP	2	4	64	69	73	82
SFW COMP	3	6	71	77	75	82
SFW COMP	4	4	64	69	75	82
SFW COMP	5	6	70	75	76	89
UIH COMP	1	5	80	90	84	96
UIH COMP	2	6	70	73	71	85
UIH COMP, Replicate 1	3	6	68	73	75	88
UIH COMP, Replicate 2	3	6	75	78	76	92
UIH COMP, Replicate 3	3	6	64	68	70	77
UIH COMP	4	5	66	72	71	84
UIH COMP	5	5	65	78	67	79
TB Upper COMP	1	4	78	82	90	85
TB Upper COMP, Replicate 1	2	4	66	71	83	75
TB Upper COMP, Replicate 2	2	4	63	66	68	77
TB Upper COMP, Replicate 3	2	4	71	77	81	85
TB Upper COMP	3	3	71	75	81	81
TB Upper COMP	4	3	80	84	88	88
TB Upper COMP	5	4	73	76	75	85
TB Lower COMP	1	4	66	71	77	77
TB Lower COMP	2	3	69	75	82	82
TB Lower COMP	3	5	72	78	80	80
TB Lower COMP	4	5	76	83	91	89
TB Lower COMP	5	6	70	74	76	74
R-OS	1	5	77	82	86	91
R-OS, Replicate 1	2	5	69	74	78	82
R-OS, Replicate 2	2	5	73	77	80	87
R-OS, Replicate 3	2	5	71	78	83	83
R-OS	3	5	72	77	81	86
R-OS	4	5	78	81	79	85
R-OS	5	5	73	77	79	87
R-BF	1	4	65	72	74	84
R-BF	2	3	74	79	82	81
R-BF	3	4	62	65	66	74
R-BF	4	4	71	75	84	77
R-BF	5	4	78	79	83	90

TABLE O.12. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naph-thalene d8	Acenaph-thene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
R-AM COMP	1	3	73	78	82	87
R-AM COMP	2	4	75	78	79	85
R-AM COMP	3	4	70	73	79	84
R-AM COMP	4	3	72	74	78	79
R-AM COMP	5	4	76	81	88	87
C-SB	1	5	70	82	78	80
C-SB	2	5	74	80	84	89
C-SB	3	5	72	79	74	80
C-SB	4	5	59	67	69	66
C-SB	5	5	64	70	70	71
M. nasuta Background	1	3	69	73	77	68
M. nasuta Background	2	3	65	71	72	69
M. nasuta Background, Replicate 1	3	3	70	77	81	77
M. nasuta Background, Replicate 2	3	3	62	67	72	69
M. nasuta Background, Replicate 3	3	3	70	72	73	68
M. nasuta Background	4	3	76	81	84	75
M. nasuta Background	5	3	77	79	82	81
Quality Control Data						
Method Blanks						
Blank-1		3	82	77	77	47
Blank-1		4	76	73	71	69
Blank-2		6	74	74	78	62
Blank-1		5	58	57	73	78
Blank-2		6	66	67	65	73
Matrix Spikes						
M. nasuta Background	2	3	65	71	72	69
M. nasuta Background, MS	2	3	67	72	76	73
TB Upper COMP	5	4	73	76	75	85
TB Upper COMP, MS	5	4	76	78	81	86
SF COMP	4	5	71	77	91	75
SF COMP, MS	4	5	76	80	85	90
UIH COMP	2	6	70	73	71	85
UIH COMP, MS	2	6	68	73	73	87

TABLE O.12. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naph-thalene d8	Acenaph-thene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
Analytical Replicates						
M. nasuta Background, Replicate 1	3	3	70	77	81	77
M. nasuta Background, Replicate 2	3	3	62	67	72	69
M. nasuta Background, Replicate 3	3	3	70	72	73	68
TB Upper COMP, Replicate 1	2	4	66	71	83	75
TB Upper COMP, Replicate 2	2	4	63	66	68	77
TB Upper COMP, Replicate 3	2	4	71	77	81	85
R-OS, Replicate 1	2	5	69	74	78	82
R-OS, Replicate 2	2	5	73	77	80	87
R-OS, Replicate 3	2	5	71	78	83	83
UIH COMP, Replicate 1	3	6	68	73	75	88
UIH COMP, Replicate 2	3	6	75	78	76	92
UIH COMP, Replicate 3	3	6	64	68	70	77

(a) NA Not applicable.

TABLE O.13. Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Pesticides (ug/kg dry weight)								
				Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
SF COMP	1	5	12.76	0.7 U(a)	2.0 U	2.0 U	2.0 U	0.9 U	240 U	548	123	1.4 U
SF COMP	2	5	12.94	0.7 U	1.9 U	1.9 U	1.9 U	0.9 U	230 U	549	130	1.3 U
SF COMP	3	5	12.26	0.7 U	2.0 U	2.0 U	2.0 U	1.0 U	250 U	476	111	1.4 U
SF COMP	4	5	12.60	1.43 U	3.9 U	3.9 U	3.9 U	1.9 U	240 U	475	104	2.8 U
SF COMP	5	5	14.42	0.6 U	1.7 U	1.7 U	1.7 U	0.8 U	210 U	399	93.6	1.2 U
SFW COMP	1	4	14.61	1.16 U	3.3 U	3.3 U	3.3 U	1.6 U	210 U	608	371	2.3 U
SFW COMP	2	4	17.91	1.01 U	2.8 U	2.8 U	2.8 U	1.3 U	170 U	538	309	2.0 U
SFW COMP	3	6	14.49	0.6 U	1.7 U	1.7 U	1.9	3.2	210 U	470	293	1.2 U
SFW COMP	4	4	14.31	1.26 U	3.5 U	3.5 U	3.5 U	1.7 U	210 U	635	387	2.4 U
SFW COMP	5	6	14.58	0.6 U	1.7 U	1.7 U	1.7 U	0.8 U	210 U	464	286	1.2 U
UIH COMP	1	5	13.71	0.7 U	1.8 U	1.8 U	1.8 U	0.8 U	220 U	225	0.5 U	1.2 U
UIH COMP	2	6	14.06	1.21 U	3.3 U	3.3 U	3.3 U	1.6 U	210 U	156	0.92 U	2.3 U
UIH COMP, Replicate 1	3	6	13.52	1.33 U	3.7 U	7.1	3.7 U	1.8 U	220 U	135	1.04 U	2.7 U
UIH COMP, Replicate 2	3	6	13.52	1.33 U	3.6 U	3.6 U	3.6 U	1.8 U	220 U	131	1.04 U	2.6 U
UIH COMP, Replicate 3	3	6	13.52	1.26 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	112	0.96 U	2.5 U
UIH COMP	4	5	15.23	0.6 U	1.6 U	1.6 U	1.6 U	0.8 U	200 U	186	0.5 U	1.1 U
UIH COMP	5	5	13.02	0.7 U	1.9 U	1.9 U	1.9 U	0.9 U	230 U	215	0.5 U	1.3 U
TB Upper COMP	1	4	15.21	1.12 U	3.1 U	3.1 U	3.1 U	1.5 U	200 U	2.9 U	0.85 U	2.2 U
TB Upper COMP, Replicate 1	2	4	14.75	2.31 U	6.2 U	6.2 U	6.2 U	3.0 U	200 U	5.8 U	1.76 U	4.4 U
TB Upper COMP, Replicate 2	2	4	14.75	2.24 U	6.1 U	6.1 U	6.1 U	2.9 U	200 U	5.8 U	1.69 U	4.3 U
TB Upper COMP, Replicate 3	2	4	14.75	2.17 U	6.0 U	6.0 U	6.0 U	2.8 U	200 U	5.6 U	1.69 U	4.3 U
TB Upper COMP	3	3	13.66	0.66 U	1.8 U	1.8 U	1.8 U	0.9 U	220 U	1.7 U	5.34	1.2 U
TB Upper COMP	4	3	15.16	0.59 U	1.6 U	1.6 U	1.6 U	0.8 U	200 U	1.5 U	3.69	5.3
TB Upper COMP	5	4	15.00	2.40 U	6.5 U	6.5 U	6.5 U	3.1 U	200 U	6.1 U	1.80 U	4.7 U
TB Lower COMP	1	4	13.17	1.37 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	3.6 U	1.06 U	2.7 U
TB Lower COMP	2	3	13.30	0.7 U	1.9 U	1.9 U	1.9 U	0.9 U	230 U	1.7 U	0.5 U	1.3 U
TB Lower COMP	3	5	12.74	0.7 U	2.0 U	2.0 U	2.0 U	0.9 U	240 U	1.8 U	0.5 U	1.4 U
TB Lower COMP	4	5	12.37	0.73 U	2.0 U	2.0 U	2.0 U	1.0 U	240 U	1.9 U	0.1 U	1.4 U
TB Lower COMP	5	4	13.89	1.30 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.4 U	1.01 U	2.6 U
OBM COMP	1	4	14.01	1.28 U	3.6 U	3.6 U	3.6 U	1.7 U	210 U	3.3 U	1.00 U	2.5 U
OBM COMP	2	4	13.17	1.37 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	3.5 U	1.06 U	2.7 U
OBM COMP	3	4	12.21	1.39 U	3.9 U	3.9 U	3.9 U	1.9 U	250 U	3.7 U	1.06 U	2.8 U
OBM COMP	4	4	14.29	1.26 U	3.5 U	3.5 U	3.5 U	1.7 U	210 U	3.3 U	0.98 U	2.5 U
OBM COMP	5	4	14.51	1.24 U	3.4 U	3.4 U	3.4 U	1.7 U	210 U	3.2 U	0.96 U	2.5 U

TABLE O.13. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Pesticides (ug/kg dry weight)								
				Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
R-OS	1	5	12.71	0.71 U	2.0 U	2.0 U	2.0 U	1.0	240 U	1.8 U	0.6 U	1.3 U
R-OS, Replicate 1	2	5	12.62	1.43 U	3.9 U	3.9 U	3.9 U	1.9 U	240 U	3.6 U	1.11 U	2.8 U
R-OS, Replicate 2	2	5	12.62	1.43 U	3.9 U	3.9 U	3.9 U	1.8 U	240 U	3.6 U	1.11 U	2.8 U
R-OS, Replicate 3	2	5	12.62	1.43 U	3.9 U	3.9 U	3.9 U	1.9 U	240 U	3.6 U	1.11 U	2.8 U
R-OS	3	5	13.84	0.65 U	1.8 U	1.8 U	1.8 U	0.9 U	220 U	1.7 U	0.5 U	1.2 U
R-OS	4	5	12.69	0.71 U	2.0 U	2.0 U	2.0 U	0.9 U	240 U	1.8 U	0.6 U	1.4 U
R-OS	5	5	13.41	0.67 U	1.9 U	1.9 U	1.9 U	0.9 U	220 U	1.7 U	0.5 U	1.3 U
R-BF	1	4	15.28	1.11 U	3.1 U	3.1 U	3.1 U	1.5 U	200 U	2.9 U	0.85 U	2.2 U
R-BF	2	3	14.64	0.61 U	1.7 U	1.7 U	1.7 U	0.8 U	210 U	1.6 U	7.79	12.4
R-BF	3	4	14.78	1.22 U	3.4 U	3.4 U	3.4 U	1.6 U	200 U	3.2 U	0.95 U	2.4 U
R-BF	4	4	15.91	1.07 U	3.0 U	3.0 U	3.0 U	1.4 U	190 U	2.8 U	0.82 U	2.1 U
R-BF	5	4	14.92	1.21 U	3.4 U	3.4 U	3.4 U	1.6 U	200 U	3.1 U	0.94 U	2.3 U
R-AM COMP	1	3	15.79	0.6 U	1.6 U	1.6 U	1.6 U	0.8 U	190 U	1.5 U	0.4 U	18.4
R-AM COMP	2	4	13.81	1.30 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.01 U	2.5 U
R-AM COMP	3	4	15.44	1.17 U	3.2 U	3.2 U	3.2 U	1.6 U	190 U	3.0 U	0.91 U	2.3 U
R-AM COMP	4	3	14.52	0.62 U	1.7 U	1.7 U	1.7 U	0.8 U	210 U	1.6 U	7.09	1.2 U
R-AM COMP	5	4	14.71	1.16 U	3.3 U	3.3 U	3.3 U	1.6 U	200 U	3.1 U	0.88 U	2.3 U
C-SB	1	5	14.43	0.62 U	1.7 U	1.7 U	1.7 U	1.0	210 U	1.6 U	0.5 U	1.2 U
C-SB	2	5	13.25	0.68 U	1.9 U	1.9 U	1.9 U	0.9 U	230 U	1.7 U	0.5 U	1.3 U
C-SB	3	5	14.03	0.64 U	1.8 U	1.8 U	1.8 U	0.9 U	210 U	1.6 U	0.5 U	1.2 U
C-SB	4	5	13.57	0.07 U	1.8 U	1.8 U	1.8 U	0.9 U	220 U	1.7 U	0.5 U	1.3 U
C-SB	5	5	13.60	0.66 U	1.8 U	1.8 U	1.8 U	1.0	220 U	1.7 U	0.5 U	1.3 U
M. nasuta Background	1	3	13.46	14.3	1.9 U	1.9 U	1.9 U	0.9 U	220 U	1.7 U	4.01	15.3
M. nasuta Background	2	3	12.00	1.50 U	4.1 U	4.1 U	4.1 U	2.0 U	250 U	3.8 U	3.17	33.8
M. nasuta Background, Replicate 1	3	3	13.05	18.0	3.8 U	3.8 U	3.8 U	1.8 U	230 U	3.5 U	1.07 U	22.1
M. nasuta Background, Replicate 2	3	3	13.05	21.4	3.6 U	3.6 U	3.6 U	1.8 U	230 U	3.4 U	4.06	26.5
M. nasuta Background, Replicate 3	3	3	13.05	22.6	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.4 U	1.00 U	19.5
M. nasuta Background	4	3	14.21	0.63 U	1.8 U	1.8 U	1.8 U	0.8 U	210 U	1.6 U	2.18	8.23
M. nasuta Background	5	3	17.65	7.82	1.4 U	1.4 U	1.4 U	0.7 U	170 U	1.3 U	3.12	7.25

(a) U Undetected at or above detection limit.

TABLE O.14. Chlorinated Pesticides (alphabetical Dieldrin - Toxaphene), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Pesticides (ug/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
SF COMP	1	5	12.76	55.5	2.0 U(a)	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	1.9 U	240 U
SF COMP	2	5	12.94	59.3	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.5 U	1.9 U	230 U
SF COMP	3	5	12.26	45.8	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	2.0 U	250 U
SF COMP	4	5	12.60	51.9	4.7	3.9 U	3.9 U	3.9 U	3.9 U	1.19 U	3.8 U	240 U
SF COMP	5	5	14.42	42.5	2.0	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.7 U	210 U
SFW COMP	1	4	14.61	127	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	0.96 U	3.2 U	210 U
SFW COMP	2	4	17.91	125	2.8 U	2.8 U	2.8 U	2.8 U	2.8 U	0.84 U	2.7 U	170 U
SFW COMP	3	6	14.49	112	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.7 U	210 U
SFW COMP	4	4	14.31	125	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	1.05 U	3.4 U	210 U
SFW COMP	5	6	14.58	99.5	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.6 U	210 U
UIH COMP	1	5	13.71	29.0	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.5 U	1.7 U	220 U
UIH COMP	2	6	14.06	31.3	3.8	3.3 U	3.3 U	3.3 U	3.3 U	1.00 U	3.3 U	210 U
UIH COMP, Replicate 1	3	6	13.52	30.7	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.11 U	3.6 U	220 U
UIH COMP, Replicate 2	3	6	13.52	31.2	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.11 U	3.6 U	220 U
UIH COMP, Replicate 3	3	6	13.52	30.2	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.04 U	3.5 U	220 U
UIH COMP	4	5	15.23	25.9	2.4	1.6 U	1.6 U	1.6 U	1.6 U	0.5 U	1.6 U	200 U
UIH COMP	5	5	13.02	30.4	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.5 U	1.8 U	230 U
TB Upper COMP	1	4	15.21	2.0 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	0.92 U	3.0 U	200 U
TB Upper COMP, Replicate 1	2	4	14.75	4.0 U	6.2 U	6.2 U	6.2 U	6.2 U	6.2 U	1.90 U	6.1 U	200 U
TB Upper COMP, Replicate 2	2	4	14.75	3.9 U	6.1 U	6.1 U	6.1 U	6.1 U	6.1 U	1.83 U	6.0 U	200 U
TB Upper COMP, Replicate 3	2	4	14.75	3.8 U	6.0 U	6.0 U	6.0 U	6.0 U	6.0 U	1.83 U	5.8 U	200 U
TB Upper COMP	3	3	13.66	1.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.5 U	1.8 U	220 U
TB Upper COMP	4	3	15.16	1.1 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	0.5 U	1.6 U	200 U
TB Upper COMP	5	4	15.00	4.1 U	6.5 U	6.5 U	6.5 U	6.5 U	6.5 U	2.00 U	6.4 U	200 U
TB Lower COMP	1	4	13.17	2.4 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.14 U	3.7 U	230 U
TB Lower COMP	2	3	13.30	1.2 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.5 U	1.8 U	230 U
TB Lower COMP	3	5	12.74	1.3 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	1.9 U	240 U
TB Lower COMP	4	5	12.37	1.3 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	1.9 U	240 U
TB Lower COMP	5	4	13.89	2.3 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.08 U	3.5 U	220 U
OBM COMP	1	4	14.01	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.07 U	3.4 U	210 U
OBM COMP	2	4	13.17	2.4 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.14 U	3.6 U	230 U
OBM COMP	3	4	12.21	2.5 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.15 U	3.8 U	250 U
OBM COMP	4	4	14.29	2.2 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	1.05 U	3.4 U	210 U
OBM COMP	5	4	14.51	2.2 U	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	1.03 U	3.4 U	210 U

TABLE O.14. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Pesticides (ug/kg dry weight)								
				Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
R-OS	1	5	12.71	1.3 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	1.9 U	240 U
R-OS, Replicate 1	2	5	12.62	2.5 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.19 U	3.8 U	240 U
R-OS, Replicate 2	2	5	12.62	2.5 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.19 U	3.7 U	240 U
R-OS, Replicate 3	2	5	12.62	2.5 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.19 U	3.8 U	240 U
R-OS	3	5	13.84	1.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.5 U	1.7 U	220 U
R-OS	4	5	12.69	1.3 U	2.0 U	2.0 U	2.0 U	2.0 U	2.0 U	0.6 U	1.9 U	240 U
R-OS	5	5	13.41	1.2 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.6 U	1.8 U	220 U
R-BF	1	4	15.28	2.0 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	0.92 U	3.1 U	200 U
R-BF	2	3	14.64	1.1 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.6 U	210 U
R-BF	3	4	14.78	2.2 U	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	1.01 U	3.3 U	200 U
R-BF	4	4	15.91	1.9 U	3.0 U	3.0 U	3.0 U	3.0 U	3.0 U	0.88 U	2.9 U	190 U
R-BF	5	4	14.92	2.1 U	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	1.01 U	3.2 U	200 U
R-AM COMP	1	3	15.79	1.0 U	1.6 U	1.6 U	1.6 U	1.6 U	1.6 U	0.4 U	1.5 U	190 U
R-AM COMP	2	4	13.81	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.09 U	3.5 U	220 U
R-AM COMP	3	4	15.44	2.1 U	3.2 U	3.2 U	3.2 U	3.2 U	3.2 U	0.97 U	3.2 U	190 U
R-AM COMP	4	3	14.52	1.0 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.7 U	210 U
R-AM COMP	5	4	14.71	2.0 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	0.95 U	3.2 U	200 U
C-SB	1	5	14.43	1.1 U	1.7 U	1.7 U	1.7 U	1.7 U	1.7 U	0.5 U	1.7 U	210 U
C-SB	2	5	13.25	1.2 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.5 U	1.8 U	230 U
C-SB	3	5	14.03	1.1 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.5 U	1.7 U	210 U
C-SB	4	5	13.57	1.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.1 U	1.8 U	220 U
C-SB	5	5	13.60	1.2 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.6 U	1.8 U	220 U
M. nasuta Background	1	3	13.46	1.2 U	1.9 U	1.9 U	1.9 U	1.9 U	1.9 U	0.6 U	1.8 U	220 U
M. nasuta Background	2	3	12.00	2.6 U	4.1 U	4.1 U	4.1 U	4.1 U	4.1 U	1.25 U	4.0 U	250 U
M. nasuta Background, Replicate 1	3	3	13.05	2.4 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.15 U	3.6 U	230 U
M. nasuta Background, Replicate 2	3	3	13.05	2.3 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.07 U	3.5 U	230 U
M. nasuta Background, Replicate 3	3	3	13.05	2.4 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.07 U	3.6 U	230 U
M. nasuta Background	4	3	14.21	1.1 U	1.8 U	1.8 U	1.8 U	1.8 U	1.8 U	0.5 U	1.7 U	210 U
M. nasuta Background	5	3	17.65	0.9 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	0.5 U	1.4 U	170 U

(a) U Undetected at or above detection limit.

TABLE O.15. Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

			M. nasuta Pesticides (ug/kg wet weight)								
Sediment Treatment	Replicate	Analytical Batch	Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Target DL(a)			2	2	2	2	2	30	2	2	2
Achieved DL			0.09-0.36	0.24-1.00	0.24-1.00	0.24-1.00	0.12-0.48	30-30	0.23-0.94	0.07-0.28	0.17-0.71
SF COMP	1	5	0.09 U(b)	0.25 U	0.25 U	0.25 U	0.12 U	30 U	69.9	15.7	0.18 U
SF COMP	2	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	71.1	16.8	0.17 U
SF COMP	3	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	58.3	13.6	0.17 U
SF COMP	4	5	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	59.9	13.1	0.35 U
SF COMP	5	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	57.5	13.5	0.17 U
SFW COMP	1	4	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	88.8	54.2	0.34 U
SFW COMP	2	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	96.3	55.4	0.35 U
SFW COMP	3	6	0.09 U	0.25 U	0.25 U	0.28	0.46	30 U	68.1	42.4	0.17 U
SFW COMP	4	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	90.8	55.4	0.35 U
SFW COMP	5	6	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	67.7	41.7	0.18 U
UIH COMP	1	5	0.09 U	0.24 U	0.24 U	0.24 U	0.11 U	30 U	30.9	0.07 U	0.17 U
UIH COMP	2	6	0.17 U	0.47 U	0.47 U	0.47 U	0.22 U	30 U	21.9	0.13 U	0.33 U
UIH COMP, Replicate 1	3	6	0.18 U	0.50 U	0.96	0.50 U	0.24 U	30 U	18.3	0.14 U	0.36 U
UIH COMP, Replicate 2	3	6	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	17.7	0.14 U	0.35 U
UIH COMP, Replicate 3	3	6	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	15.2	0.13 U	0.34 U
UIH COMP	4	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	28.3	0.07 U	0.17 U
UIH COMP	5	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	28.0	0.07 U	0.17 U
TB Upper COMP	1	4	0.17 U	0.47 U	0.47 U	0.47 U	0.23 U	30 U	0.44 U	0.13 U	0.33 U
TB Upper COMP, Replicate 1	2	4	0.34 U	0.92 U	0.92 U	0.92 U	0.44 U	30 U	0.86 U	0.26 U	0.65 U
TB Upper COMP, Replicate 2	2	4	0.33 U	0.90 U	0.90 U	0.90 U	0.43 U	30 U	0.85 U	0.25 U	0.64 U
TB Upper COMP, Replicate 3	2	4	0.32 U	0.88 U	0.88 U	0.88 U	0.42 U	30 U	0.83 U	0.25 U	0.63 U
TB Upper COMP	3	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.73	0.17 U
TB Upper COMP	4	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.56	0.81
TB Upper COMP	5	4	0.36 U	0.98 U	0.98 U	0.98 U	0.47 U	30 U	0.92 U	0.27 U	0.70 U
TB Lower COMP	1	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
TB Lower COMP	2	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.17 U
TB Lower COMP	3	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.18 U
TB Lower COMP	4	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.01 U	0.17 U
TB Lower COMP	5	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
OBM COMP	1	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
OBM COMP	2	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
OBM COMP	3	4	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	0.34 U
OBM COMP	4	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
OBM COMP	5	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U

TABLE O.15. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
R-OS	1	5	0.09 U	0.25 U	0.25 U	0.25 U	0.13	30 U	0.23 U	0.07 U	0.17 U
R-OS, Replicate 1	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-OS, Replicate 2	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	0.35 U
R-OS, Replicate 3	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-OS	3	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.17 U
R-OS	4	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.18 U
R-OS	5	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.18 U
R-BF	1	4	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	0.34 U
R-BF	2	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	1.14	1.81
R-BF	3	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
R-BF	4	4	0.17 U	0.47 U	0.47 U	0.47 U	0.22 U	30 U	0.44 U	0.13 U	0.33 U
R-BF	5	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-AM COMP	1	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	2.91
R-AM COMP	2	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-AM COMP	3	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
R-AM COMP	4	3	0.09 U	0.24 U	0.24 U	0.24 U	0.12 U	30 U	0.23 U	1.03	0.17 U
R-AM COMP	5	4	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	0.34 U
C-SB	1	5	0.09 U	0.25 U	0.25 U	0.25 U	0.15	30 U	0.23 U	0.07 U	0.17 U
C-SB	2	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.17 U
C-SB	3	5	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.17 U
C-SB	4	5	0.01 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.07 U	0.17 U
C-SB	5	5	0.09 U	0.25 U	0.25 U	0.25 U	0.14	30 U	0.23 U	0.07 U	0.18 U
M. nasuta Background	1	3	1.93	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.54	2.06
M. nasuta Background	2	3	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.38	4.06
M. nasuta Background, Replicate 1	3	3	2.35	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	2.88
M. nasuta Background, Replicate 2	3	3	2.79	0.47 U	0.47 U	0.47 U	0.23 U	30 U	0.44 U	0.53	3.46
M. nasuta Background, Replicate 3	3	3	2.95	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	2.55
M. nasuta Background	4	3	0.09 U	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.31	1.17
M. nasuta Background	5	3	1.38	0.25 U	0.25 U	0.25 U	0.12 U	30 U	0.23 U	0.55	1.28

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE O.16. Chlorinated Pesticides (alphabetical, Dieldrin - Toxaphene), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
Target DL(a)			2	2	2	2	2	2	2	2	30
Achieved DL			0.15-0.64	0.24-1.00	0.24-1.00	0.24-1.00	0.24-1.00	0.24-1.00	0.07-0.30	0.24-0.98	30-30
SF COMP	1	5	7.08	0.25 U(b)	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
SF COMP	2	5	7.67	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
SF COMP	3	5	5.62	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
SF COMP	4	5	6.54	0.59	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
SF COMP	5	5	6.13	0.29	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
SFW COMP	1	4	18.5	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
SFW COMP	2	4	22.4	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
SFW COMP	3	6	16.3	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
SFW COMP	4	4	17.9	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
SFW COMP	5	6	14.5	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
UIH COMP	1	5	3.98	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.07 U	0.23 U	30 U
UIH COMP	2	6	4.40	0.53	0.47 U	0.47 U	0.47 U	0.47 U	0.14 U	0.46 U	30 U
UIH COMP, Replicate 1	3	6	4.15	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
UIH COMP, Replicate 2	3	6	4.22	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
UIH COMP, Replicate 3	3	6	4.08	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
UIH COMP	4	5	3.95	0.37	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
UIH COMP	5	5	3.96	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
TB Upper COMP	1	4	0.30 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.14 U	0.46 U	30 U
TB Upper COMP, Replicate 1	2	4	0.59 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
TB Upper COMP, Replicate 2	2	4	0.57 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.27 U	0.88 U	30 U
TB Upper COMP, Replicate 3	2	4	0.56 U	0.88 U	0.88 U	0.88 U	0.88 U	0.88 U	0.27 U	0.86 U	30 U
TB Upper COMP	3	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
TB Upper COMP	4	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
TB Upper COMP	5	4	0.62 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.30 U	0.96 U	30 U
TB Lower COMP	1	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
TB Lower COMP	2	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
TB Lower COMP	3	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
TB Lower COMP	4	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
TB Lower COMP	5	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
OBM COMP	1	4	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
OBM COMP	2	4	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
OBM COMP	3	4	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
OBM COMP	4	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
OBM COMP	5	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U

TABLE O.16. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
R-OS	1	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
R-OS, Replicate 1	2	5	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-OS, Replicate 2	2	5	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
R-OS, Replicate 3	2	5	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-OS	3	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
R-OS	4	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
R-OS	5	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
R-BF	1	4	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
R-BF	2	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
R-BF	3	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
R-BF	4	4	0.30 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.14 U	0.46 U	30 U
R-BF	5	4	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-AM COMP	1	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
R-AM COMP	2	4	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-AM COMP	3	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
R-AM COMP	4	3	0.15 U	0.24 U	0.24 U	0.24 U	0.24 U	0.24 U	0.07 U	0.24 U	30 U
R-AM COMP	5	4	0.30 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
C-SB	1	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
C-SB	2	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
C-SB	3	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
C-SB	4	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.01 U	0.24 U	30 U
C-SB	5	5	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
M. nasuta Background	1	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U
M. nasuta Background	2	3	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
M. nasuta Background, Replicate 1	3	3	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
M. nasuta Background, Replicate 2	3	3	0.30 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.14 U	0.46 U	30 U
M. nasuta Background, Replicate 3	3	3	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
M. nasuta Background	4	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.07 U	0.24 U	30 U
M. nasuta Background	5	3	0.16 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.08 U	0.24 U	30 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE O.17. Quality Control Data for Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Method Blanks											
Blank-1		3	0.19 U(a)	0.53 U	0.53 U	0.53 U	0.25 U	30 U	0.49 U	0.15 U	0.37 U
Blank-1		4	0.20 U	0.55 U	0.55 U	0.55 U	0.26 U	30 U	0.51 U	0.15 U	0.39 U
Blank		5	0.11 U	0.30 U	0.30 U	0.30 U	0.14 U	30 U	0.28 U	0.08 U	0.21 U
Blank		6	0.11 U	0.30 U	0.30 U	0.30 U	0.14 U	30 U	0.28 U	0.08 U	0.21 U
Matrix Spikes											
M. nasuta Background	2	3	0.18 U	NA (b)	NA	NA	0.24 U	NA	NA	NA	4.06
M. nasuta Background, MS	2	3	3.75	NA	NA	NA	4.08	NA	NA	NA	19.3
Concentration Recovered			3.75	NA	NA	NA	4.08	NA	NA	NA	15.2
Amount Spiked			4.75	NS (c)	NS	NS	4.75	NS	NS	NS	19.0
Percent Recovery			79	NA	NA	NA	86	NA	NA	NA	80
TB Upper COMP	5	4	0.36 U	NA	NA	NA	0.47 U	NA	NA	NA	0.70 U
TB Upper COMP, MS	5	4	6.35	NA	NA	NA	9.90	NA	NA	NA	34.1
Concentration Recovered			6.35	NA	NA	NA	9.90	NA	NA	NA	34.1
Amount Spiked			9.15	NS	NS	NS	9.15	NS	NS	NS	36.6
Percent Recovery			69%	NA	NA	NA	108%	NA	NA	NA	93%
SF COMP	4	5	0.18 U	NA	NA	NA	0.24 U	NA	NA	NA	0.35 U
SF COMP, MS	4	5	3.66	NA	NA	NA	2.49	NA	NA	NA	15.6
Concentration Recovered			3.66	NA	NA	NA	2.49	NA	NA	NA	15.6
Amount Spiked			5.00	NS	NS	NS	5.00	NS	NS	NS	20.0
Percent Recovery			73%	NA	NA	NA	50%	NA	NA	NA	78%
UIH COMP	2	6	0.17 U	NA	NA	NA	0.22 U	NA	NA	NA	0.33 U
UIH COMP, MS	2	6	3.45	NA	NA	NA	2.27	NA	NA	NA	15.8
Concentration Recovered			3.45	NA	NA	NA	2.27	NA	NA	NA	15.8
Amount Spiked			5.00	NS	NS	NS	5.00	NS	NS	NS	20.0
Percent Recovery			69%	NA	NA	NA	45%	NA	NA	NA	79%

Standard Reference Material

Certified SRM not available for pesticides.

TABLE O.17. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Aldrin	Alpha BHC	Beta BHC	Delta BHC	Gamma BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Analytical Replicates											
M. nasuta Background, Replicate 1	3	3	2.35	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	2.88
M. nasuta Background, Replicate 2	3	3	2.79	0.47 U	0.47 U	0.47 U	0.23 U	30 U	0.44 U	0.53	3.46
M. nasuta Background, Replicate 3	3	3	2.95	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	2.55
RSD			12%	NA	NA	NA	NA	NA	NA	NA	16%
TB Upper COMP, Replicate 1	2	4	0.34 U	0.92 U	0.92 U	0.92 U	0.44 U	30 U	0.86 U	0.26 U	0.65 U
TB Upper COMP, Replicate 2	2	4	0.33 U	0.90 U	0.90 U	0.90 U	0.43 U	30 U	0.85 U	0.25 U	0.64 U
TB Upper COMP, Replicate 3	2	4	0.32 U	0.88 U	0.88 U	0.88 U	0.42 U	30 U	0.83 U	0.25 U	0.63 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA
R-OS, Replicate 1	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-OS, Replicate 2	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	0.35 U
R-OS, Replicate 3	2	5	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA
UIH COMP, Replicate 1	3	6	0.18 U	0.50 U	0.96	0.50 U	0.24 U	30 U	18.3	0.14 U	0.36 U
UIH COMP, Replicate 2	3	6	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	17.7	0.14 U	0.35 U
UIH COMP, Replicate 3	3	6	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	15.2	0.13 U	0.34 U
RSD			NA	NA	NA	NA	NA	NA	10%	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE O.18. Quality Control Data for Chlorinated Pesticides (alphabetical, Dieldrin - Toxaphene), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
Method Blank											
Blank-1		3	0.33 U(a)	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.16 U	0.51 U	30 U
Blank-1		4	0.35 U	0.55 U	0.55 U	0.55 U	0.55 U	0.55 U	0.16 U	0.53 U	30 U
Blank		5	0.19 U	0.30 U	0.30 U	0.30 U	0.30 U	0.30 U	0.09 U	0.29 U	30 U
Blank		6	0.19 U	0.30 U	0.30 U	0.30 U	0.30 U	0.30 U	0.09 U	0.29 U	30 U
Matrix Spikes											
M. nasuta Background	2	3	0.31 U	NA (b)	NA	NA	0.49 U	NA	0.15 U	NA	NA
M. nasuta Background, MS	2	3	16.3	NA	NA	NA	15.9	NA	3.79	NA	NA
Concentration Recovered			16.3	NA	NA	NA	15.9	NA	3.79	NA	NA
Amount Spiked			19.0	NS (c)	NS	NS	19.0	NS	4.75	NS	NS
Percent Recovery			86%	NA	NA	NA	84%	NA	80%	NA	NA
TB Upper COMP	5	4	0.62 U	NA	NA	NA	0.98 U	NA	0.30 U	NA	NA
TB Upper COMP, MS	5	4	30.6	NA	NA	NA	24.4	NA	4.53	NA	NA
Concentration Recovered			30.6	NA	NA	NA	24.4	NA	4.53	NA	NA
Amount Spiked			36.6	NS	NS	NS	36.6	NS	9.15	NS	NS
Percent Recovery			84%	NA	NA	NA	67%	NA	50%	NA	NA
SF COMP	4	5	6.54	NA	NA	NA	0.49 U	NA	0.15 U	NA	NA
SF COMP, MS	4	5	24.2	NA	NA	NA	12.7	NA	3.07	NA	NA
Concentration Recovered			17.7	NA	NA	NA	12.7	NA	3.07	NA	NA
Amount Spiked			20.0	NS	NS	NS	20.0	NS	5.00	NS	NS
Percent Recovery			88%	NA	NA	NA	64%	NA	61%	NA	NA
UIH COMP	2	6	4.40	NA	NA	NA	0.47 U	NA	0.14 U	NA	NA
UIH COMP, MS	2	6	20.4	NA	NA	NA	12.2	NA	2.96	NA	NA
Concentration Recovered			16.0	NA	NA	NA	12.2	NA	2.96	NA	NA
Amount Spiked			20.0	NS	NS	NS	20.0	NS	5.00	NS	NS
Percent Recovery			80%	NA	NA	NA	61%	NA	59%	NA	NA
Standard Reference Material											

Certified SRM not available for pesticides.

TABLE O.18. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor epoxide	Toxa-phene
Analytical Replicates											
M. nasuta Background, Replicate 1	3	3	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
M. nasuta Background, Replicate 2	3	3	0.30 U	0.47 U	0.47 U	0.47 U	0.47 U	0.47 U	0.14 U	0.46 U	30 U
M. nasuta Background, Replicate 3	3	3	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA
TB Upper COMP, Replicate 1	2	4	0.59 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
TB Upper COMP, Replicate 2	2	4	0.57 U	0.90 U	0.90 U	0.90 U	0.90 U	0.90 U	0.27 U	0.88 U	30 U
TB Upper COMP, Replicate 3	2	4	0.56 U	0.88 U	0.88 U	0.88 U	0.88 U	0.88 U	0.27 U	0.86 U	30 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA
R-OS, Replicate 1	2	5	1.03	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-OS, Replicate 2	2	5	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
R-OS, Replicate 3	2	5	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA
UIH COMP, Replicate 1	3	6	4.15	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
UIH COMP, Replicate 2	3	6	4.22	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
UIH COMP, Replicate 3	3	6	4.08	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
RSD			2%	NA	NA	NA	NA	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE O.19. Polychlorinated Biphenyls (PCBs), Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
SF COMP	1	5	12.76	160 U(a)	160 U	160 U	160 U
SF COMP	2	5	12.94	160 U	160 U	160 U	160 U
SF COMP	3	5	12.26	160 U	160 U	160 U	160 U
SF COMP	4	5	12.60	160 U	160 U	160 U	160 U
SF COMP	5	5	14.42	140 U	140 U	140 U	140 U
SFW COMP	1	4	14.61	140 U	140 U	180	140 U
SFW COMP	2	4	17.91	110 U	110 U	150	110 U
SFW COMP	3	6	14.49	140 U	140 U	240	140 U
SFW COMP	4	4	14.31	140 U	140 U	230	140 U
SFW COMP	5	6	14.58	140 U	140 U	270	140 U
UIH COMP	1	5	13.71	150 U	150 U	140	150 U
UIH COMP	2	6	14.06	140 U	140 U	140 U	140 U
UIH COMP, Replicate 1	3	6	13.52	150 U	150 U	150 U	150 U
UIH COMP, Replicate 2	3	6	13.52	150 U	150 U	150 U	150 U
UIH COMP, Replicate 3	3	6	13.52	150 U	150 U	150 U	150 U
UIH COMP	4	5	15.23	130 U	130 U	120	130 U
UIH COMP	5	5	13.02	150 U	150 U	140	150 U
TB Upper COMP	1	4	15.21	130 U	130 U	130 U	130 U
TB Upper COMP, Replicate 1	2	4	14.75	140 U	140 U	140 U	140 U
TB Upper COMP, Replicate 2	2	4	14.75	140 U	140 U	140 U	140 U
TB Upper COMP, Replicate 3	2	4	14.75	140 U	140 U	140 U	140 U
TB Upper COMP	3	3	13.66	146 U	150 U	150 U	150 U
TB Upper COMP	4	3	15.16	130 U	130 U	130 U	130 U
TB Upper COMP	5	4	15.00	130 U	130 U	130 U	130 U
TB Lower COMP	1	4	13.17	150 U	150 U	150 U	150 U
TB Lower COMP	2	3	13.30	150 U	150 U	150 U	150 U
TB Lower COMP	3	5	12.74	160 U	160 U	160 U	157 U
TB Lower COMP	4	5	12.37	160 U	160 U	160 U	160 U
TB Lower COMP	5	4	13.89	140 U	140 U	140 U	140 U
OBM COMP	1	4	14.01	140 U	140 U	140 U	140 U
OBM COMP	2	4	13.17	150 U	150 U	150 U	150 U
OBM COMP	3	4	12.21	160 U	160 U	160 U	160 U
OBM COMP	4	4	14.29	140 U	140 U	140 U	140 U
OBM COMP	5	4	14.51	140 U	140 U	140 U	140 U
R-OS	1	5	12.71	160 U	160 U	160 U	160 U
R-OS, Replicate 1	2	5	12.62	160 U	160 U	160 U	160 U
R-OS, Replicate 2	2	5	12.62	160 U	160 U	160 U	160 U
R-OS, Replicate 3	2	5	12.62	160 U	160 U	160 U	160 U
R-OS	3	5	13.84	150 U	150 U	150 U	150 U
R-OS	4	5	12.69	160 U	160 U	160 U	160 U
R-OS	5	5	13.41	150 U	150 U	150 U	150 U

TABLE O.19. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
R-BF	1	4	15.28	130 U	130 U	130 U	130 U
R-BF	2	3	14.64	140 U	140 U	140 U	140 U
R-BF	3	4	14.78	140 U	140 U	140 U	140 U
R-BF	4	4	15.91	130 U	130 U	130 U	130 U
R-BF	5	4	14.92	130 U	130 U	130 U	130 U
R-AM COMP	1	3	15.79	130 U	130 U	130 U	130 U
R-AM COMP	2	4	13.81	150 U	150 U	150 U	150 U
R-AM COMP	3	4	15.44	130 U	130 U	130 U	130 U
R-AM COMP	4	3	14.52	140 U	140 U	140 U	140 U
R-AM COMP	5	4	14.71	140 U	140 U	140 U	140 U
C-SB	1	5	14.43	140 U	140 U	140 U	140 U
C-SB	2	5	13.25	150 U	150 U	150 U	150 U
C-SB	3	5	14.03	140 U	140 U	140 U	140 U
C-SB	4	5	13.57	150 U	150 U	150 U	150 U
C-SB	5	5	13.60	150 U	150 U	150 U	150 U
M. nasuta Background	1	3	13.46	150 U	150 U	150 U	150 U
M. nasuta Background	2	3	12.00	170 U	170 U	170 U	170 U
M. nasuta Background, Replicate 1	3	3	13.05	150 U	150 U	150 U	150 U
M. nasuta Background, Replicate 2	3	3	13.05	150 U	150 U	150 U	150 U
M. nasuta Background, Replicate 3	3	3	13.05	150 U	150 U	150 U	150 U
M. nasuta Background	4	3	14.21	140 U	140 U	140 U	140 U
M. nasuta Background	5	3	17.65	110 U	110 U	110 U	110 U

(a) Undetected at or above detection limit.

TABLE O.20. Polychlorinated Biphenyls (PCBs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Target DL(a)			20	20	20	20
Achieved DL			20	20	20	20
SF COMP	1	5	20 U(b)	20 U	20 U	20 U
SF COMP	2	5	20 U	20 U	20 U	20 U
SF COMP	3	5	20 U	20 U	20 U	20 U
SF COMP	4	5	20 U	20 U	20 U	20 U
SF COMP	5	5	20 U	20 U	20 U	20 U
SFW COMP	1	4	20 U	20 U	26.5	20 U
SFW COMP	2	4	20 U	20 U	26.0	20 U
SFW COMP	3	6	20 U	20 U	34.0	20 U
SFW COMP	4	4	20 U	20 U	32.2	20 U
SFW COMP	5	6	20 U	20 U	40.0	20 U
UIH COMP	1	5	20 U	20 U	18.7	20 U
UIH COMP	2	6	20 U	20 U	20 U	20 U
UIH COMP, Replicate 1	3	6	20 U	20 U	20 U	20 U
UIH COMP, Replicate 2	3	6	20 U	20 U	20 U	20 U
UIH COMP, Replicate 3	3	6	20 U	20 U	20 U	20 U
UIH COMP	4	5	20 U	20 U	18.8	20 U
UIH COMP	5	5	20 U	20 U	18.3	20 U
TB Upper COMP	1	4	20 U	20 U	20 U	20 U
TB Upper COMP, Replicate 1	2	4	20 U	20 U	20 U	20 U
TB Upper COMP, Replicate 2	2	4	20 U	20 U	20 U	20 U
TB Upper COMP, Replicate 3	2	4	20 U	20 U	20 U	20 U
TB Upper COMP	3	3	20 U	20 U	20 U	20 U
TB Upper COMP	4	3	20 U	20 U	20 U	20 U
TB Upper COMP	5	4	20 U	20 U	20 U	20 U
TB Lower COMP	1	4	20 U	20 U	20 U	20 U
TB Lower COMP	2	3	20 U	20 U	20 U	20 U
TB Lower COMP	3	5	20 U	20 U	20 U	20 U
TB Lower COMP	4	5	20 U	20 U	20 U	20 U
TB Lower COMP	5	4	20 U	20 U	20 U	20 U
OBM COMP	1	4	20 U	20 U	20 U	20 U
OBM COMP	2	4	20 U	20 U	20 U	20 U
OBM COMP	3	4	20 U	20 U	20 U	20 U
OBM COMP	4	4	20 U	20 U	20 U	20 U
OBM COMP	5	4	20 U	20 U	20 U	20 U

TABLE O.20. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
R-OS	1	5	20 U	20 U	20 U	20 U
R-OS, Replicate 1	2	5	20 U	20 U	20 U	20 U
R-OS, Replicate 2	2	5	20 U	20 U	20 U	20 U
R-OS, Replicate 3	2	5	20 U	20 U	20 U	20 U
R-OS	3	5	20 U	20 U	20 U	20 U
R-OS	4	5	20 U	20 U	20 U	20 U
R-OS	5	5	20 U	20 U	20 U	20 U
R-BF	1	4	20 U	20 U	20 U	20 U
R-BF	2	3	20 U	20 U	20 U	20 U
R-BF	3	4	20 U	20 U	20 U	20 U
R-BF	4	4	20 U	20 U	20 U	20 U
R-BF	5	4	20 U	20 U	20 U	20 U
R-AM COMP	1	3	20 U	20 U	20 U	20 U
R-AM COMP	2	4	20 U	20 U	20 U	20 U
R-AM COMP	3	4	20 U	20 U	20 U	20 U
R-AM COMP	4	3	20 U	20 U	20 U	20 U
R-AM COMP	5	4	20 U	20 U	20 U	20 U
C-SB	1	5	20 U	20 U	20 U	20 U
C-SB	2	5	20 U	20 U	20 U	20 U
C-SB	3	5	20 U	20 U	20 U	20 U
C-SB	4	5	20 U	20 U	20 U	20 U
C-SB	5	5	20 U	20 U	20 U	20 U
M. nasuta Background	1	3	20 U	20 U	20 U	20 U
M. nasuta Background	2	3	20 U	20 U	20 U	20 U
M. nasuta Background, Replicate 1	3	3	20 U	20 U	20 U	20 U
M. nasuta Background, Replicate 2	3	3	20 U	20 U	20 U	20 U
M. nasuta Background, Replicate 3	3	3	20 U	20 U	20 U	20 U
M. nasuta Background	4	3	20 U	20 U	20 U	20 U
M. nasuta Background	5	3	20 U	20 U	20 U	20 U

(a) DL Detection limit.
(b) Undetected at or above detection limit.

TABLE O.21. Quality Control Data for Polychlorinated Biphenyls (PCBs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Method Blanks						
Blank-1		3	20 U(a)	20 U	20 U	20 U
Blank-1		4	20 U	20 U	20 U	20 U
Blank		5	20 U	20 U	20 U	20 U
Blank		6	20 U	20 U	20 U	20 U
Matrix Spikes						
M. nasuta Background	2	3	NA (b)	NA	20 U	NA
M. nasuta Background, MS	2	3	NA	NA	101	NA
Concentration Recovered			NA	NA	101	NA
Amount Spiked			NS (c)	NS	95	NS
Percent Recovery			NA	NA	106	NA
TB Upper COMP	5	4	NA	NA	20 U	NA
TB Upper COMP, MS	5	4	NA	NA	131	NA
Concentration Recovered			NA	NA	131	NA
Amount Spiked			NS	NS	183	NS
Percent Recovery			NA	NA	72%	NA
SF COMP	4	5	NA	NA	20 U	NA
SF COMP, MS	4	5	NA	NA	101	NA
Concentration Recovered			NA	NA	101	NA
Amount Spiked			NS	NS	100	NS
Percent Recovery			NA	NA	101%	NA
UIH COMP	2	6	NS	NS	20.1	NS
UIH COMP, MS	2	6	NS	NS	110	NS
Concentration Recovered			NS	NS	90	NS
Amount Spiked			NS	NS	100	NS
Percent Recovery			NS	NS	90%	NS
Standard Reference Material						
Certified SRM not available for PCBs.						
Analytical Replicates						
M. nasuta Background, Replicate 1	3	3	20 U	20 U	20 U	20 U
M. nasuta Background, Replicate 2	3	3	20 U	20 U	20 U	20 U
M. nasuta Background, Replicate 3	3	3	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA

TABLE O.21. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
TB Upper COMP, Replicate 1	2	4	20 U	20 U	20 U	20 U
TB Upper COMP, Replicate 2	2	4	20 U	20 U	20 U	20 U
TB Upper COMP, Replicate 3	2	4	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA
R-OS, Replicate 1	2	5	20 U	20 U	20 U	20 U
R-OS, Replicate 2	2	5	20 U	20 U	20 U	20 U
R-OS, Replicate 3	2	5	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA
UIH COMP, Replicate 1	3	6	20 U	20 U	20 U	20 U
UIH COMP, Replicate 2	3	6	20 U	20 U	20 U	20 U
UIH COMP, Replicate 3	3	6	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE O.22. Surrogate Percent Recoveries and Quality Control Data for Pesticides and Polychlorinated Biphenyls (PCBs), Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
SF COMP	1	5	75	66
SF COMP	2	5	80	68
SF COMP	3	5	80	66
SF COMP	4	5	78	64
SF COMP	5	5	72	68
SFW COMP	1	4	81	64
SFW COMP	2	4	65	57
SFW COMP	3	6	79	73
SFW COMP	4	4	71	56
SFW COMP	5	6	72	73
UIH COMP	1	5	89	89
UIH COMP	2	6	76	66
UIH COMP, Replicate 1	3	6	77	65
UIH COMP, Replicate 2	3	6	83	68
UIH COMP, Replicate 3	3	6	74	60
UIH COMP	4	5	77	71
UIH COMP	5	5	78	78
TB Upper COMP	1	4	82	71
TB Upper COMP, Replicate 1	2	4	71	61
TB Upper COMP, Replicate 2	2	4	66	57
TB Upper COMP, Replicate 3	2	4	73	64
TB Upper COMP	3	3	65	69
TB Upper COMP	4	3	70	71
TB Upper COMP	5	4	71	60
TB Lower COMP	1	4	70	59
TB Lower COMP	2	3	67	69
TB Lower COMP	3	5	81	72
TB Lower COMP	4	5	79	81
TB Lower COMP	5	4	69	64
OBM COMP	1	4	66	51
OBM COMP	2	4	66	54
OBM COMP	3	4	61	53
OBM COMP	4	4	65	55
OBM COMP	5	4	72	61
R-OS	1	5	83	69
R-OS, Replicate 1	2	5	73	62
R-OS, Replicate 2	2	5	74	66
R-OS, Replicate 3	2	5	71	66
R-OS	3	5	78	67
R-OS	4	5	79	73
R-OS	5	5	77	69

TABLE O.22. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
R-BF	1	4	64	63
R-BF	2	3	69	70
R-BF	3	4	59	53
R-BF	4	4	75	62
R-BF	5	4	74	70
R-AM COMP	1	3	72	75
R-AM COMP	2	4	75	72
R-AM COMP	3	4	72	66
R-AM COMP	4	3	69	65
R-AM COMP	5	4	76	68
C-SB	1	5	78	87
C-SB	2	5	82	77
C-SB	3	5	79	73
C-SB	4	5	74	62
C-SB	5	5	77	65
M. nasuta Background	1	3	67	95
M. nasuta Background	2	3	67	80
M. nasuta Background, Replicate 1	3	3	70	93
M. nasuta Background, Replicate 2	3	3	63	80
M. nasuta Background, Replicate 3	3	3	62	93
M. nasuta Background	4	3	67	116
M. nasuta Background	5	3	71	75
Quality Control Data				
Method Blank				
Blank-1		3	73	77
Blank-1		4	77	68
Blank		5	70	74
Blank		6	69	65
Matrix Spike				
M. nasuta Background	2	3	67	80
M. nasuta Background, MS	2	3	69	84
TB Upper COMP	5	4	71	60
TB Upper COMP, MS	5	4	73	64
SF COMP	4	5	78	64
SF COMP, MS	4	5	81	68
UIH COMP	2	6	76	66
UIH COMP, MS	2	6	73	68

TABLE O.22. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries PCB 103	PCB 198
Analytical Replicates				
M. nasuta Background, Replicate 1	3	3	70	93
M. nasuta Background, Replicate 2	3	3	63	80
M. nasuta Background, Replicate 3	3	3	62	93
TB Upper COMP, Replicate 1	2	4	71	61
TB Upper COMP, Replicate 2	2	4	66	57
TB Upper COMP, Replicate 3	2	4	73	64
R-OS, Replicate 1	2	5	73	62
R-OS, Replicate 2	2	5	74	66
R-OS, Replicate 3	2	5	71	66
UIH COMP, Replicate 1	3	6	77	65
UIH COMP, Replicate 2	3	6	83	68
UIH COMP, Replicate 3	3	6	74	60

TABLE O.23. Metals Analysis, Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Metals (mg/kg wet weight)									
				Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
SF COMP	1	2	12.76	0.026	2.68	0.033	0.227	1.34	0.007	0.465	0.256	0.209	13.9
SF COMP	1	2	12.26	0.035	4.07	0.035	0.283	2.07	0.006	0.645	0.273	0.253	17.2
SF COMP	2	2	12.94	0.023	2.87	0.019	0.259	1.69	0.011	0.450	0.274	0.192	12.0
SF COMP	4	2	12.60	0.035	3.72	0.021	0.235	1.66	0.005	0.450	0.287	0.200	10.9
SF COMP	5	2	14.42	0.020	2.54	0.022	0.290	1.48	0.010	0.481	0.272	0.244	15.4
SFW COMP	1	2	14.61	0.016	3.29	0.024	0.282	1.44	0.013	0.447	0.301	0.247	16.7
SFW COMP, Replicate 1	2	2	17.91	0.022	5.54	0.037	0.256	1.67	0.018	0.616	0.358	0.369	21.0
SFW COMP, Replicate 2	2	2	17.91	0.022	5.66	0.034	0.281	1.70	0.016	0.609	0.361	0.344	21.3
SFW COMP, Replicate 3	2	2	17.91	0.020	5.63	0.035	0.284	1.70	0.018	0.614	0.377	0.353	21.0
SFW COMP	3	2	14.49	0.045	3.48	0.033	0.361	1.69	0.009	0.610	0.407	0.229	16.1
SFW COMP	4	2	14.31	0.031	4.34	0.035	0.365	1.86	0.011	0.631	0.360	0.275	17.5
SFW COMP	5	2	14.58	0.030	4.00	0.022	0.293	1.85	0.008	0.479	0.298	0.257	12.6
UIH COMP	1	2	13.71	0.038	3.04	0.025	0.241	2.20	0.007	0.510	0.263	0.228	12.8
UIH COMP	2	2	14.06	0.022	2.22	0.023	0.256	1.49	0.010	0.475	0.298	0.226	10.2
UIH COMP	3	2	13.52	0.018	3.10	0.021	0.324	1.66	0.010	0.522	0.289	0.226	14.7
UIH COMP, Replicate 1	4	2	15.23	0.027	3.61	0.036	0.335	1.78	0.009	0.546	0.336	0.268	14.9
UIH COMP, Replicate 2	4	2	15.23	0.026	3.38	0.032	0.289	1.70	0.009	0.549	0.301	0.239	13.9
UIH COMP, Replicate 3	4	2	15.23	0.025	3.25	0.031	0.262	1.66	0.011	0.518	0.280	0.250	13.6
UIH COMP	5	2	13.02	0.022	2.68	0.027	0.306	1.51	0.007	0.497	0.307	0.219	13.3
TB Upper COMP	1	2	15.21	0.019	3.96	0.026	0.459	3.14	0.014	0.673	0.211	0.192	15.4
TB Upper COMP	2	2	14.75	0.041	3.47	0.034	0.308	2.47	0.012	0.606	0.264	0.288	19.6
TB Upper COMP	3	2	13.66	0.019	2.79	0.024	0.278	1.48	0.009	0.541	0.200	0.216	11.0
TB Upper COMP	4	2	15.16	0.025	3.17	0.032	0.251	1.53	0.012	0.571	0.204	0.215	11.3
TB Upper COMP	5	2	15.00	0.041	3.51	0.032	0.339	2.53	0.015	0.628	0.276	0.303	20.1
TB Lower COMP	1	2	13.17	0.026	2.89	0.024	0.195	1.50	0.008	0.515	0.156	0.191	13.1
TB Lower COMP	2	2	13.30	0.018	3.11	0.027	0.315	1.25	0.007	0.642	0.146	0.198	10.9
TB Lower COMP	3	2	12.74	0.029	4.01	0.028	0.249	1.59	0.008	0.558	0.156	0.210	17.7
TB Lower COMP	4	2	12.37	0.034	2.38	0.036	0.272	1.58	0.008	0.733	0.178	0.215	10.9
TB Lower COMP	5	2	13.89	0.020	2.89	0.020	0.307	1.57	0.011	0.758	0.169	0.208	10.3
R-OS	1	2	12.71	0.022	2.31	0.023	0.204	1.23	0.007	0.512	0.138	0.214	14.4
R-OS	2	2	12.62	0.031	2.99	0.024	0.289	1.37	0.009	0.648	0.170	0.247	11.5
R-OS	3	2	13.84	0.024	2.87	0.023	0.300	1.50	0.010	0.621	0.127	0.241	13.1
R-OS	4	2	12.69	0.058	4.05	0.026	0.440	2.51	0.013	0.847	0.167	0.273	12.9
R-OS	5	2	13.41	0.026	2.90	0.023	0.269	1.46	0.006	0.524	0.116	0.221	11.3

TABLE O.23. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	M. nasuta Metals (mg/kg wet weight)									
				Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
R-BF	1	2	15.28	0.056	3.85	0.035	0.292	2.53	0.013	0.793	0.368	0.345	23.5
R-BF, Replicate 1	2	2	14.64	0.044	3.60	0.030	0.355	2.07	0.016	0.711	0.304	0.303	16.8
R-BF, Replicate 2	2	2	14.64	0.041	3.63	0.028	0.364	2.06	0.013	0.695	0.292	0.278	17.1
R-BF, Replicate 3	2	2	14.64	0.041	3.56	0.029	0.395	2.07	0.014	0.695	0.291	0.271	17.0
R-BF	3	2	14.78	0.026	3.25	0.020 U	0.422	2.05	0.016	0.657	0.300	0.173	12.0
R-BF	4	2	15.91	0.017 U	2.74	0.022	0.337	1.63	0.014	0.587	0.235	0.186	15.1
R-BF	5	2	14.92	0.027	3.39	0.027	0.376	1.83	0.014	0.586	0.296	0.201	10.0
R-AM COMP	1	2	15.79	0.024	3.43	0.029	0.208	1.67	0.012	0.412	0.227	0.256	16.9
R-AM COMP	2	2	13.81	0.034	2.74	0.031	0.208	1.71	0.015	0.464	0.226	0.226	15.2
R-AM COMP	3	2	15.44	0.060	5.07	0.027	0.262	2.74	0.015	0.501	0.338	0.292	13.7
R-AM COMP	4	2	14.52	0.026	2.82	0.037	0.210	1.53	0.013	0.554	0.264	0.238	14.0
R-AM COMP	5	2	14.71	0.035	2.99	0.031	0.222	1.72	0.015	0.447	0.248	0.157	13.7
C-SB	1	2	14.43	0.021	3.22	0.026	0.202	1.63	0.009	0.440	0.180	0.248	13.3
C-SB	2	2	13.25	0.021	3.31	0.021	0.188	1.69	0.007	0.389	0.180	0.217	12.3
C-SB	3	2	14.03	0.020	3.16	0.025	0.217	1.44	0.006	0.402	0.169	0.230	11.7
C-SB	4	2	13.57	0.031	3.58	0.028	0.286	1.77	0.007	0.468	0.186	0.239	11.3
C-SB	5	2	13.60	0.032	3.36	0.023	0.164	1.97	0.006	0.379	0.206	0.205	12.9
M. nasuta Background	1	1	13.46	0.101	4.04	0.028	0.235	2.15	0.008	0.307	0.227	0.218	11.1
M. nasuta Background	2	2	12.00	0.048	4.30	0.029	0.135	1.44	0.007	0.348	0.116	0.224	13.4
M. nasuta Background	3	2	13.05	0.048	3.24	0.040	0.107	1.97	0.009	0.322	0.127	0.215	16.1
M. nasuta Background	4	2	14.21	0.097	4.73	0.038	0.138	3.09	0.010	0.402	0.343	0.274	15.3
M. nasuta Background	5	2	17.65	0.046	5.65	0.044	0.167	1.83	0.011	0.466	0.112	0.330	19.1

(a) U Undetected at or above detection limit.

TABLE O.24. Metals Analysis, Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Target DL(a)			0.1	2.0	0.1	1.0	4.3	0.02	1.0	1.0	1.0	35
Achieved DL			0.109	2.93	0.132	0.758	3.34	0.004	0.933	0.417	0.11	39.7
SF COMP	1	2	0.203	21.0	0.260	1.78	10.5	0.057	3.65	2.01	1.64	109
SF COMP	1	2	0.285	33.2	0.286	2.31	16.9	0.052	5.26	2.23	2.06	140
SF COMP	2	2	0.177	22.2	0.143	2.00	13.1	0.083	3.48	2.12	1.48	93.1
SF COMP	4	2	0.276	29.5	0.167	1.87	13.2	0.038	3.57	2.28	1.59	86.4
SF COMP	5	2	0.137	17.6	0.153	2.01	10.3	0.068	3.34	1.89	1.69	107
SFW COMP	1	2	0.109 U(b)	22.5	0.167	1.93	9.87	0.087	3.06	2.06	1.69	114
SFW COMP, Replicate 1	2	2	0.121	30.9	0.208	1.43	9.30	0.099	3.44	2.00	2.06	117
SFW COMP, Replicate 2	2	2	0.122	31.6	0.190	1.57	9.51	0.092	3.40	2.02	1.92	119
SFW COMP, Replicate 3	2	2	0.112	31.4	0.196	1.59	9.52	0.098	3.43	2.11	1.97	117
SFW COMP	3	2	0.308	24.0	0.231	2.49	11.7	0.064	4.21	2.81	1.58	111
SFW COMP	4	2	0.217	30.3	0.247	2.55	13.0	0.078	4.41	2.52	1.92	122
SFW COMP	5	2	0.206	27.4	0.151	2.01	12.7	0.057	3.29	2.05	1.76	86.2
UIH COMP	1	2	0.278	22.2	0.179	1.76	16.1	0.050	3.72	1.92	1.66	93.3
UIH COMP	2	2	0.157	15.8	0.162	1.82	10.6	0.072	3.38	2.12	1.61	72.4
UIH COMP	3	2	0.136	22.9	0.153	2.40	12.3	0.076	3.86	2.14	1.67	109
UIH COMP, Replicate 1	4	2	0.177	23.7	0.234	2.20	11.7	0.058	3.59	2.21	1.76	97.6
UIH COMP, Replicate 2	4	2	0.171	22.2	0.213	1.90	11.2	0.058	3.61	1.98	1.57	91.0
UIH COMP, Replicate 3	4	2	0.161	21.3	0.204	1.72	10.9	0.070	3.40	1.84	1.64	89.5
UIH COMP	5	2	0.172	20.6	0.206	2.35	11.6	0.055	3.82	2.36	1.68	102
TB Upper COMP	1	2	0.126	26.0	0.169	3.02	20.7	0.089	4.43	1.39	1.26	101
TB Upper COMP	2	2	0.276	23.5	0.229	2.09	16.8	0.083	4.11	1.79	1.95	133
TB Upper COMP	3	2	0.141	20.4	0.174	2.04	10.9	0.066	3.96	1.47	1.58	80.8
TB Upper COMP	4	2	0.163	20.9	0.214	1.66	10.1	0.082	3.77	1.35	1.42	74.8
TB Upper COMP	5	2	0.276	23.4	0.216	2.26	16.9	0.102	4.19	1.84	2.02	134

TABLE O.24. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
TB Lower COMP	1	2	0.201	21.9	0.186	1.48	11.4	0.058	3.91	1.19	1.45	99.6
TB Lower COMP	2	2	0.138	23.4	0.204	2.37	9.39	0.049	4.83	1.10	1.49	82.0
TB Lower COMP	3	2	0.227	31.5	0.223	1.96	12.5	0.064	4.38	1.23	1.65	139
TB Lower COMP	4	2	0.278	19.2	0.292	2.20	12.8	0.061	5.93	1.44	1.74	88.1
TB Lower COMP	5	2	0.141	20.8	0.144	2.21	11.3	0.077	5.46	1.22	1.50	74.1
R-OS	1	2	0.176	18.2	0.179	1.61	9.67	0.059	4.03	1.09	1.68	113
R-OS	2	2	0.242	23.7	0.193	2.29	10.9	0.073	5.14	1.35	1.96	91.1
R-OS	3	2	0.173	20.7	0.164	2.17	10.9	0.069	4.49	0.918	1.74	94.5
R-OS	4	2	0.458	31.9	0.208	3.47	19.8	0.099	6.68	1.32	2.15	102
R-OS	5	2	0.194	21.6	0.171	2.01	10.9	0.045	3.91	0.866	1.65	84.5
R-BF	1	2	0.365	25.2	0.228	1.91	16.6	0.084	5.19	2.41	2.26	154
R-BF, Replicate 1	2	2	0.303	24.6	0.202	2.43	14.2	0.110	4.86	2.08	2.07	115
R-BF, Replicate 2	2	2	0.279	24.8	0.194	2.49	14.1	0.092	4.75	2.00	1.90	117
R-BF, Replicate 3	2	2	0.281	24.3	0.195	2.70	14.2	0.093	4.75	1.99	1.85	116
R-BF	3	2	0.179	22.0	0.132 U	2.86	13.9	0.109	4.45	2.03	1.17	81.1
R-BF	4	2	0.109 U	17.2	0.140	2.12	10.3	0.091	3.69	1.48	1.17	94.8
R-BF	5	2	0.181	22.7	0.179	2.52	12.3	0.092	3.93	1.99	1.35	67.1
R-AM COMP	1	2	0.151	21.7	0.186	1.32	10.6	0.078	2.61	1.44	1.62	107
R-AM COMP	2	2	0.246	19.8	0.226	1.51	12.4	0.106	3.36	1.64	1.64	110
R-AM COMP	3	2	0.388	32.8	0.174	1.70	17.8	0.100	3.25	2.19	1.89	88.8
R-AM COMP	4	2	0.179	19.4	0.252	1.45	10.6	0.092	3.82	1.82	1.64	96.1
R-AM COMP	5	2	0.239	20.3	0.208	1.51	11.7	0.099	3.04	1.69	1.07	93.3
C-SB	1	2	0.147	22.3	0.177	1.40	11.3	0.060	3.05	1.25	1.72	92.0
C-SB	2	2	0.159	25.0	0.160	1.42	12.8	0.054	2.94	1.36	1.64	92.7
C-SB	3	2	0.143	22.5	0.180	1.55	10.3	0.043	2.87	1.21	1.64	83.6
C-SB	4	2	0.226	26.4	0.204	2.11	13.1	0.054	3.45	1.37	1.76	83.3
C-SB	5	2	0.238	24.7	0.167	1.21	14.5	0.043	2.79	1.52	1.51	95.2
M. nasuta Background	1	1	0.748	30.0	0.205	1.75	16.0	0.062	2.28	1.69	1.62	82.1
M. nasuta Background	2	2	0.399	35.8	0.243	1.13	12.0	0.059	2.90	0.970	1.87	112
M. nasuta Background	3	2	0.371	24.8	0.304	0.818	15.1	0.066	2.47	0.977	1.65	123
M. nasuta Background	4	2	0.680	33.3	0.269	0.968	21.8	0.067	2.83	2.42	1.93	108
M. nasuta Background	5	2	0.262	32.0	0.250	0.948	10.4	0.061	2.64	0.633	1.87	108

(a) DL Detection limit.
(b) U Undetected at or above detection limit.

TABLE O.25. Quality Control Data for Metals Analysis, Dry Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Method Blanks												
Blank-1		2	0.109 U(a)	3.99	0.132 U	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.11 U	39.7 U
Blank-2		2	0.109 U	2.96	0.132 U	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.11 U	39.7 U
Blank-3		2	0.109 U	2.93 U	0.132 U	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.11 U	39.7 U
Matrix Spikes												
SF COMP	2	2	0.177	22.2	0.143	2.00	13.1	0.083	3.48	2.12	1.48	93.1
SF COMP, MS	2	2	0.936	48.8	1.96	6.87	37.3	0.509	8.55	4.31	5.38	286
Concentration Recovered			0.759	26.6	1.81	4.87	24.2	0.426	5.07	2.19	3.90	193
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.497	5.00	2.00	5.00	200
Percent Recovery			76	106	91	97	97	86	101	109	78	96
TB Lower COMP	5	2	0.141	20.8	0.144	2.21	11.3	0.077	5.46	1.22	1.50	74.1
TB Lower COMP, MS	5	2	0.878	48.7	2.03	7.04	36.3	0.610	10.4	3.30	5.72	270
Concentration Recovered			0.737	27.9	1.88	4.83	25.0	0.533	4.94	2.08	4.22	196
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.497	5.00	2.00	5.00	200
Percent Recovery			74 (b)	112	94	97	100	107	99	104	84	98
R-AM COMP	1	2	0.151	21.7	0.186	1.32	10.6	0.078	2.61	1.44	1.62	107
R-AM COMP, MS	1	2	1.00	50.9	2.13	6.27	36.5	0.561	7.64	3.48	5.92	315
Concentration Recovered			0.852	29.2	1.94	4.95	25.9	0.483	5.03	2.04	4.30	208
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.500	5.00	2.00	5.00	200
Percent Recovery			85	117	97	99	104	97	101	102	86	104
Standard Reference Material												
Certified Value 1566a			1.68 +/-0.15	14 +/-1.2	4.15 +/-0.38	1.43 +/-0.46	66.3 +/-4.3	0.0642 +/-0.0067	2.25 +/-0.44	0.371 +/-0.014	2.21 +/-0.24	830 +/-57
SRM 1566a-1		2	1.53	15.3	4.13	1.22	64.3	0.056	1.70	0.367	2.35	896
SRM 1566a-2		2	1.00 (c)	14.2	4.05	1.13	67.2	0.066	1.83	0.390	2.56	935
SRM 1566a-3		2	1.48	14.2	4.14	1.22	68.0	0.059	2.32	0.372	2.12	943

TABLE O.25. (contd)

Sediment Treatment	Replicate	Analytical Batch	M. nasuta Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Analytical Replicates												
SFW COMP, Replicate 1	2	2	0.121	30.9	0.208	1.43	9.30	0.099	3.44	2.00	2.06	117
SFW COMP, Replicate 2	2	2	0.122	31.6	0.190	1.57	9.51	0.092	3.40	2.02	1.92	119
SFW COMP, Replicate 3	2	2	0.112	31.4	0.196	1.59	9.52	0.098	3.43	2.11	1.97	117
RSD			5%	1%	5%	6%	1%	4%	1%	3%	4%	1%
UIH COMP, Replicate 1	4	2	0.177	23.7	0.234	2.20	11.7	0.058	3.59	2.21	1.76	97.6
UIH COMP, Replicate 2	4	2	0.171	22.2	0.213	1.90	11.2	0.058	3.61	1.98	1.57	91.0
UIH COMP, Replicate 3	4	2	0.161	21.3	0.204	1.72	10.9	0.070	3.40	1.84	1.64	89.5
RSD			5%	5%	7%	13%	4%	11%	3%	9%	6%	5%
R-BF, Replicate 1	2	2	0.303	24.6	0.202	2.43	14.2	0.110	4.86	2.08	2.07	115
R-BF, Replicate 2	2	2	0.279	24.8	0.194	2.49	14.1	0.092	4.75	2.00	1.90	117
R-BF, Replicate 3	2	2	0.281	24.3	0.195	2.70	14.2	0.093	4.75	1.99	1.85	116
RSD			5%	1%	2%	6%	0%	10%	1%	2%	6%	1%

(a) U Undetected at or above detection limit.
(b) Outside quality control range (75-125%) for matrix spike recoveries.
(c) Outside quality control criteria (+/-30%) for SRMs.

TABLE O.26. Butyltin Results, Wet and Dry Weight, in Tissue M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin % Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin	Percent Dry Weight	(ug/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Target DL(a)		NA	NA (b)	1.00	1.00	1.00	NA	NA	NA	NA
Achieved DL		NA	NA	0.48	1.39	0.39	NA	NA	NA	NA
SF COMP	1	6	95	3.22	1.86	0.39 U(c)	12.76	25.2	14.6	3.06 U
SF COMP	2	6	89	3.18	1.52	0.39 U	12.94	24.6	11.7	3.01 U
SF COMP	3	6	95	2.42	1.39 U	0.39 U	12.26	19.7	11.3 U	3.18 U
SF COMP	4	5	94	3.52	1.51	0.39 U	12.60	27.9	12.0	3.10 U
SF COMP, Replicate 1	5	6	99	2.97	1.39 U	0.39 U	14.42	20.6	9.64 U	2.70 U
SF COMP, Replicate 2	5	6	92	2.82	1.39 U	0.39 U	14.42	19.6	9.64 U	2.70 U
SF COMP, Replicate 3	5	6	95	2.97	1.39 U	0.39 U	14.42	20.6	9.64 U	2.70 U
SFW COMP	1	5	99	1.87	1.39 U	0.39 U	14.61	12.8	9.51 U	2.67 U
SFW COMP	2	5	96	1.93	1.39 U	0.39 U	17.91	10.8	7.76 U	2.18 U
SFW COMP	3	6	84	1.41	1.39 U	0.39 U	14.49	9.73	9.59 U	2.69 U
SFW COMP	4	5	95	2.00	1.45	0.39 U	14.31	14.0	10.1	2.73 U
SFW COMP	5	6	86	1.47	1.39 U	0.39 U	14.58	10.1	9.53 U	2.67 U
UIH COMP	1	6	89	2.43	1.39 U	0.39 U	13.71	17.7	10.1 U	2.84 U
UIH COMP	2	6	87	2.60	1.56	0.39 U	14.06	18.5	11.1	2.77 U
UIH COMP	3	6	95	2.09	1.39 U	0.39 U	13.52	15.5	10.3 U	2.88 U
UIH COMP	4	6	80	2.23	1.48	0.39 U	15.23	14.6	9.72	2.56 U
UIH COMP	5	6	82	2.59	1.39 U	0.39 U	13.02	19.9	10.7 U	3.00 U
TB Upper COMP, Replicate 1	1	4	92	1.21	1.39 U	0.39 U	15.21	7.96	9.14 U	2.56 U
TB Upper COMP, Replicate 2	1	4	96	1.26	1.39 U	0.39 U	15.21	8.28	9.14 U	2.56 U
TB Upper COMP, Replicate 3	1	4	95	1.11	1.39 U	0.39 U	15.21	7.30	9.14 U	2.56 U
TB Upper COMP	2	4	95	1.23	1.39 U	0.39 U	14.75	8.34	9.42 U	2.64 U
TB Upper COMP	3	4	94	1.38	1.39 U	0.39 U	13.66	10.1	10.2 U	2.86 U
TB Upper COMP	4	4	90	1.51	1.39 U	0.39 U	15.16	9.96	9.17 U	2.57 U
TB Upper COMP	5	4	91	1.11	1.39 U	0.39 U	15.00	7.40	9.27 U	2.60 U
TB Lower COMP	1	5	102	1.68	1.39 U	0.39 U	13.17	12.8	10.6 U	2.96 U
TB Lower COMP	2	4	95	0.77	1.39 U	0.39 U	13.30	5.79	10.5 U	2.93 U
TB Lower COMP	3	6	94	0.92	1.39 U	0.39 U	12.74	7.22	10.9 U	3.06 U
TB Lower COMP	4	6	65	1.02	2.22	0.39 U	12.37	8.25	17.9	3.15 U
TB Lower COMP	5	5	100	1.56	1.39 U	0.39 U	13.89	11.2	10.0 U	2.81 U

TABLE O.26. (contd)

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin % Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin	Percent Dry Weight	(ug/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
OBM COMP	1	5	99	1.61	1.39 U	0.39 U	14.01	11.5	9.92 U	2.78 U
OBM COMP	2	5	94	2.03	1.72	0.39 U	13.17	15.4	13.1	2.96 U
OBM COMP	3	5	100	1.89	1.39 U	0.39 U	12.21	15.5	11.4 U	3.19 U
OBM COMP	4	5	94	1.89	1.53	0.39 U	14.29	13.2	10.7	2.73 U
OBM COMP	5	5	98	1.83	1.39 U	0.39 U	14.51	12.6	9.58 U	2.69 U
R-OS	1	5	106	1.66	2.02	0.39 U	12.71	13.1	15.9	3.07 U
R-OS	2	5	52	1.94	1.76	0.39 U	12.62	15.4	13.9	3.09 U
R-OS	3	5	61	1.85	1.39 U	0.39 U	13.84	13.4	10.0 U	2.82 U
R-OS	4	5	99	1.75	1.39 U	0.39 U	12.69	13.8	11.0 U	3.07 U
R-OS, Replicate 1	5	5	99	1.82	1.39 U	0.39 U	13.41	13.6	10.4 U	2.91 U
R-OS, Replicate 2	5	5	107	1.86	1.47	0.39 U	13.41	13.9	11.0	2.91 U
R-OS, Replicate 3	5	5	98	1.73	1.39 U	0.39 U	13.41	12.9	10.4 U	2.91 U
R-BF	1	5	98	2.95	1.39 U	0.39 U	15.28	19.3	9.10 U	2.55 U
R-BF	2	4	82	2.30	1.39 U	0.39 U	14.64	15.7	9.49 U	2.66 U
R-BF	3	5	102	3.11	1.57	0.39 U	14.78	21.0	10.6	2.64 U
R-BF	4	4	96	2.74	1.92	0.39 U	15.91	17.2	12.1	2.45 U
R-BF	5	5	100	2.38	1.69	0.39 U	14.92	16.0	11.3	2.61 U
R-AM COMP	1	4	93	3.88	1.40	0.39 U	15.79	24.6	8.87	2.47 U
R-AM COMP	2	4	85	4.87	2.10	0.39 U	13.81	35.3	15.2	2.82 U
R-AM COMP	3	4	94	3.31	1.39 U	0.39 U	15.44	21.4	9.00 U	2.53 U
R-AM COMP	4	4	91	3.86	1.39 U	0.39 U	14.52	26.6	9.57 U	2.69 U
R-AM COMP	5	5	92	4.45	1.49	0.39 U	14.71	30.3	10.1	2.65 U
C-SB	1	6	95	1.56	1.39	0.39 U	14.43	10.8	9.63	2.70 U
C-SB	2	6	97	1.39	1.39 U	0.39 U	13.25	10.5	10.5 U	2.94 U
C-SB	3	6	90	1.47	1.39 U	0.39 U	14.03	10.5	9.91 U	2.78 U
C-SB	4	6	90	1.60	1.39 U	0.39 U	13.57	11.8	10.2 U	2.87 U
C-SB	5	6	90	1.41	1.39 U	0.39 U	13.60	10.4	10.2 U	2.87 U
M. nasuta Background	1	4	89	0.55	1.39 U	0.39 U	13.46	4.09	10.3 U	2.90 U
M. nasuta Background	2	4	95	0.53	1.39 U	0.39 U	12.00	4.42	11.6 U	3.25 U
M. nasuta Background	3	4	96	0.65	1.39 U	0.39 U	13.05	4.98	10.7 U	2.99 U
M. nasuta Background	4	4	66	0.48 U	1.39 U	0.39 U	14.21	3.38 U	9.78 U	2.74 U
M. nasuta Background	5	4	91	0.83	1.57	0.39 U	17.65	4.70	8.90	2.21 U

(a) DL Detection limit.
(b) NA Not applicable.
(c) U Undetected at or above detection limit.

TABLE O.27. Quality Control Data for Butyltin Results, Wet Weight, in Tissue of M. nasuta, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin % Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Method Blanks						
Blank-1		4	100	0.48 U(a)	1.39 U	0.39 U
Blank-1		5	103	0.48 U	1.39 U	0.39 U
Blank-1		6	97	0.48 U	1.39 U	0.39 U
Matrix Spikes						
TB Lower COMP	2	4	95	0.77	1.39 U	0.39 U
TB Lower COMP, MS		4	98	54.2	46.6	12.8
Concentration Recovered			NA (b)	54.2	46.6	12.8
Amount Spiked			NA	50.0	50.0	50.0
Percent Recovery			NA	108%	93%	26% (c)
OBM COMP	3	5	100	1.89	1.39 U	0.39 U
OBM COMP, MS	3	5	99	49.0	48.7	15.9
Concentration Recovered			NA	47.1	48.7	15.9
Amount Spiked			NA	49.6	49.6	49.6
Percent Recovery			NA	95%	98%	32% (c)
C-SB	4	6	90	1.60	1.39 U	0.39 U
C-SB, MS	4	6	93	52.5	49.8	25.0
Concentration Recovered			NA	50.9	49.8	25.0
Amount Spiked			NA	48.7	48.7	48.7
Percent Recovery			NA	105%	102%	51%
Analytical Replicates						
TB Upper COMP, Replicate 1	1	4	92	1.21	1.39 U	0.39 U
TB Upper COMP, Replicate 2	1	4	96	1.26	1.39 U	0.39 U
TB Upper COMP, Replicate 3	1	4	95	1.11	1.39 U	0.39 U
RSD			NA	6%	NA	NA
R-OS, Replicate 1	5	5	99	1.82	1.39 U	0.39 U
R-OS, Replicate 2	5	5	107	1.86	1.47	0.39 U
R-OS, Replicate 3	5	5	98	1.73	1.39 U	0.39 U
RSD			NA	4%	NA	NA
SF COMP, Replicate 1	5	6	99	2.97	1.39 U	0.39 U
SF COMP, Replicate 2	5	6	92	2.82	1.39 U	0.39 U
SF COMP, Replicate 3	5	6	95	2.97	1.39 U	0.39 U
RSD			NA	3%	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) Outside quality control range (40-120%) for matrix spike recoveries.

APPENDIX P

TISSUE CHEMISTRY AND QUALITY ASSURANCE DATA FOR *NEREIS virens*

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Polynuclear Aromatic Hydrocarbons (PAH) and Phthalates
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit (dry wt)
GC/MS	40-120%	≤30%	20 µg/kg

METHOD

Tissue samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-042, "Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics," which is based on methods used by the National Oceanic and Atmospheric Administration for their Status and Trends Program (Krahn et al. 1988). Samples were then cleaned using silica/alumina chromatography followed by HPLC cleanup. The following modifications in the extraction and clean-up methods were required to adequately recover the phthalate compounds: twice the usual amount of methylene chloride was used in the extraction, and 4% rather than 2% deactivated silica was used. Extracts were quantified using gas chromatography/mass spectrometry (GC/MS) in the selected ion mode (SIM) following SOP MSL-M-043, "Identification and Quantification of Polynuclear Aromatic Hydrocarbons by GC/MS," which is based on EPA method 8270 (EPA 1986).

HOLDING TIMES

Ninety-nine (99) samples were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/MS/SIM analysis dates:

Batch	Extraction	Analysis
Batch 1	3/30/94	4/22-26/94
Batch 2	4/14/94	4/28-30/94
Batch 3	4/26/94	5/10-12/94
Batch 4	5/6/94	5/24-26/94
Batch 5	5/20/94	5/26-28/94
Batch 6	5/20/94	5/26-28/94

DETECTION LIMITS

Target detection limits of 20 µg/kg wet wt were met for all PAH compounds. Achieved detection limits for PAHs were determined by multiplying the standard deviation of 7 spiked replicates by the student t value. Achieved detection limits for phthalates ranged from 19.2 µg/kg to 80 µg/kg. The target detection limits were 20 µg/kg. Detection limits for phthalates were derived from the lowest calibration standard.

QA/QC SUMMARY (contd)

METHOD BLANKS

One method blank was extracted with each batch of samples. No compounds were detected in the method blanks at concentrations greater than 5 times the method detection limit. Any sample values that were less than 5 times the value in the associated method blank were flagged with a "B."

SURROGATES

Five isotopically labelled compounds were added prior to extraction to assess the efficiency of the method. These were d8-naphthalene, d8-acenaphthene, d12-chrysene, d10-pyrene and d14-dibenzo(a,h)-anthracene. Recoveries of all surrogates were within the quality control limits of 40%-120% with the exception of d14-dibenzo(a,h)anthracene in the method blank for Batch 1, with a recovery of 33%.

MATRIX SPIKES

One sample from each batch was spiked with all PAH and phthalate compounds. Matrix spike recoveries for PAHs were within the QC criteria of 40%-120% with the following exceptions: benzo(g,h,i)perylene in Batch 3 (125%), and benzo(b)fluoranthene (123%) and benzo(k)fluoranthene (121%) in Batch 5. Phthalate recoveries were within QC criteria with the following exceptions: di-n-octyl phthalate in all batches except Batch 3 (greater than 120%), bis(2-ethylhexyl)phthalate in Batch 1 (122%), and dimethyl- and diethylphthalate in Batch 2 (less than 40%).

REPLICATES

One sample from each batch was extracted and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSDs were within the QC criteria of ≤30% for analytes greater than 10 times the MDL.

MISC.

Samples TB Lower COMP Rep. 5 for both *M. nasuta* and *N. virens* were re-extracted and re-analyzed because the initial results showed unusually high concentrations of bis(2-ethylhexyl)phthalate. The results of the re-analyses are reported.

Some of the sample results are flagged to indicate that the confirmation ion ratio for that compound was outside of the QC range. This is due to a combination of two factors: low levels of the compound of interest, and interferences resulting from the modified cleanup method. Because the confirmation ion is present at only a fraction of the level of the parent ion, when the native level of the compound is low, the amount of error in the concentration measurement of the confirmation ion goes up. The compound is actually quantified from the parent ion only, so most likely this will not effect the quality of the data.

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, USEPA, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Chlorinated Pesticides and PCBs
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	Relative Precision	Detection Limit (wet wt)
GC/ECD	40-120%	≤30%	2.0 - 30 µg/kg

METHOD

Tissue samples were extracted with methylene chloride using a roller under ambient conditions following SOP MSL-M-079, "Extraction and Clean-up of Sediment and Tissue for Semivolatile Organics following the Surrogate Internal Standard Method" based on EPA Method 3510 and 8080 (EPA 1986) and NOAA status and trends methods (Krahn et al. 1988). Samples were then cleaned using silica/alumina chromatography followed by HPLC cleanup (Krahn et al. 1988). The following modifications in the clean-up method were required to adequately recover the phthalate compounds: twice the usual amount of methylene chloride was used in the extraction, and 4% rather than 2% deactivated silica was used. Extracts were analyzed using Gas Chromatography/ Electron Capture Detection (GC/ECD) following SOP MSL-M-044, "Analysis of PCBs and Chlorinated Pesticides by GC/ECD" based on EPA method 8080 (1986). The column used was a J&W DB-17 and the confirmatory column was a DB-1701, both capillary columns (30 m x 0.25 mm I.D.).

HOLDING TIMES

One hundred four (104) samples were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. The following summarizes the extraction dates and GC/ECD analysis dates:

Batch	Extraction	Analysis
Batch 1	3/30/94	4/22-26/94
Batch 2	4/14/94	4/28-30/94
Batch 3	4/26/94	5/10-12/94
Batch 4	5/6/94	5/21-24/94
Batch 5	5/20/94	6/2-6/94
Batch 6	5/20/94	6/2-6/94

DETECTION LIMITS

Target detection limits were met for all samples. Detection limits reported are based on an MDL study involving low level spikes of 7 replicate extractions. MDLs are defined as the standard deviation of the mean recovery multiplied by the student t value.

METHOD BLANKS

One method blank was extracted with the batch of samples. No pesticides or PCBs were detected in the blanks at concentrations exceeding the QC limit of 5 times the detection limit.

QA/QC SUMMARY (contd)

SURROGATES Two compounds, PCB congeners 103 and 198, were added to all samples prior to extraction to assess the efficiency of the analysis. These compounds are also used to correct all sample results and are considered surrogate internal standards (SIS). Recoveries of these compounds were within the QC guidelines of 40-120% for all samples analyzed.

MATRIX SPIKES One sample from each batch was spiked with a subset of 6 pesticides and Aroclor 1254. Matrix spike recoveries were within the QC limits of 40% -120% with the exception of DDT in Batch 1 (130%).

REPLICATES One sample from each batch was extracted in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. RSDs were less than the QC limit of 30%.

SRMs NA

REFERENCES

Krahn, M. M., C. A. Wigren, R. W. Pearch, L. K. Moore, R. G. Bogar, W. D. MacLeod, Jr., S. L. Chan, and D. W. Brown. 1988. "A Rapid High-Performance Liquid Chromatographic Method for Isolating Organic Contaminants from Tissue and Sediment Extracts." NOAA Technical Memorandum NMFS F/NWC-153, Silver Spring, Maryland.

U.S. Environmental Protection Agency (EPA). 1986. Test Methods for Evaluating Solid Waste: Physical/Chemical Methods. SW-846. U.S. Document No. 955-001-00000, USEPA, Washington D.C.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Metals
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

SAMPLE CUSTODY

Ninety nine samples (49 *N. virens* and 50 *M. nasuta* tissue samples) were received on 3/21/94 in good condition. Samples and were logged into Battelle's log-in system.

QA/QC DATA QUALITY OBJECTIVES

	Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (mg/kg wet wt)
Arsenic	ICP/MS	75%-125%	≤30%	≤20%	2.0
Cadmium	ICP/MS	75%-125%	≤30%	≤20%	0.1
Chromium	ICP/MS	75%-125%	≤30%	≤20%	1.0
Copper	ICP/MS	75%-125%	≤30%	≤20%	4.3
Lead	ICP/MS	75%-125%	≤30%	≤20%	1.0
Mercury	CVAA	75%-125%	≤30%	≤20%	0.02
Nickel	ICP/MS	75%-125%	≤30%	≤20%	1.0
Selenium	GFAA	75%-125%	≤30%	≤20%	1.0
Silver	ICP/MS	75%-125%	≤30%	≤20%	0.1
Zinc	ICP/MS	75%-125%	≤30%	≤20%	35

METHOD

A total of 10 metals was analyzed for the Richmond Harbor Deepening Project: silver (Ag), arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), mercury (Hg), nickel (Ni), lead (Pb), selenium (Se) and zinc (Zn). Eight metals (As, Cd, Cr, Cu, Pb, Ni, Ag, and Zn) were analyzed by inductively coupled plasma/mass spectrometry (ICP/MS) following EPA Method 200.8 (EPA 1991). One metal (Se) was analyzed using Zeeman Graphite Furnace Atomic Absorption (GFAA) spectrometry following SOP MSL-M-033, Trace Elements in Sediment in Tissue by Graphite Furnace Atomic Absorption, which is based on EPA Method 200.9 (EPA 1991). Mercury was analyzed using cold-vapor atomic absorption spectroscopy (CVAA) according to the method of Bloom and Crecelius (1983).

To prepare tissues for analysis, samples were freeze-dried and blended in a Spex mixer-mill. Approximately 5 g of mixed sample was ground in a ceramic ball mill. For ICP/MS and CVAA analyses, 0.2- to 0.5-g aliquots of dried homogenous sample were digested using a mixture of nitric, perchloric and hydrofluoric acids.

HOLDING TIMES

Upon receipt, samples were frozen to -80°C and subsequently freeze-dried within approximately 14 days of sample receipt. All samples were analyzed within 180 days of sample receipt with the exception of Hg, which was analyzed within 30 days of receipt. Analysis dates are summarized in the following table:

QA/QC SUMMARY (contd)

Task	Batch 1 (Worms)	Batch 2 (Clams)
Sample Digestion	4/6/94	4/11/94
GFAA/Se	5/18-20/94	5/20-23/94
CVAA-Hg	4/12-13/94	4/13-14/94
ICP/MS	4/20/94	4/21/94
ICP/MS, 715RHI-16 rerun	NA	6/2/94

Two samples (*N. virens* SFW COMP Rep 4 and *N. virens* background rep. 4) were reanalyzed for ICP metals because the initial results for some metals were unusually high. The reanalysis of the background sample confirmed the initial results, and the initial results were reported. The results of the reanalysis of SFW COMP rep. 4 were lower than the initial values for selected metals, and consistent with the other tissues; therefore, the results of the reanalysis are reported.

DETECTION LIMITS

Target detection limits were met for all metals except As and Zn. Achieved detection limits for As and Zn were higher than the target detection limits; however, these metals were detected in all of the samples. ICP/MS detection limits were determined by multiplying the standard deviation of 8 blank spike samples by the student "t" value (3.0). CVAA MDLs were determined by multiplying the standard deviation of 7 replicate analyses of an SRM by 3. GFAA detection limits represent 3 times the standard deviation of the 3 replicate analyses of the method blank.

METHOD BLANKS

Six method blanks were analyzed with the samples. No metals were detected in the blanks at concentrations exceeding the QC criteria of three times the MDL. All sample results are blank corrected.

MATRIX SPIKES

Six tissue samples (3 *M. nasuta* and 3 *N. virens*) were spiked with ten metals. All spike recoveries were within the control limits of 75%-125% limits with the following exceptions: As in one *N. virens* sample (128%), Zn in two *N. virens* samples (190% and 158%), and Ag in one *M. nasuta* sample (74%).

REPLICATES

Six tissue samples (3 *M. nasuta* and 3 *N. virens*) were digested and analyzed in triplicate. Precision was measured by calculating the relative standard deviation (RSD) between the replicate results. The RSDs were all within the QC limits of ≤20% with the exception of Cr in one set of *N. virens* replicates (41%), and Zn in all three *N. virens* replicates (41% to 61%).

SRMs

Six samples of the SRM 1566a (obtained from the National Research Council of Canada, NRCC), were analyzed with the samples for all metals. All results were within 30% of the certified values with the exception of Zn in one sample, which had a high recovery, and Ag in one sample, with a low recovery.

REFERENCES

Bloom, N. S., and E.A. Crecelius. 1983. "Determination of Mercury in Seawater at Sub-Nanogram per Liter Levels." *Mar. Chem.* 14:49-59.

EPA. 1991. Methods for the Determination of Metals in Environmental Samples. EPA-600/4-91-010. Environmental Services Division, Monitoring Management Branch, Cincinnati, Ohio.

QA/QC SUMMARY

PROGRAM: Richmond Harbor Deepening Project
PARAMETER: Butyltins
LABORATORY: Battelle/Marine Sciences Laboratory, Sequim, Washington
MATRIX: Tissue

QA/QC DATA QUALITY OBJECTIVES

Reference Method	Range of Recovery	SRM Accuracy	Relative Precision	Detection Limit (dry weight)
Unger et al.	40-120%	≤30%	≤30%	1 µg/kg

METHOD

Butyltin analyses were performed according to MSL-SOP-M-004 following the method of Unger et al. (1986). Tissue samples were extracted with methylene chloride using a roller under ambient conditions followed by derivitization using a Grignard reagent to change to a form compatible with gas chromatography. Sample extracts were then cleaned by passing through a florisil column. Extracts were analyzed using Gas Chromatography/Flame Photometric Detection (GC/FPD).

HOLDING TIMES

One hundred four (104) samples of worm and clam tissue were received on 3/21/94 in good condition. Samples were logged into Battelle's log-in system and stored at approximately -20° C until extraction. Samples were extracted and analyzed in six batches, as follows:

	Date Extracted	Date Analyzed
Batch 1	4/11/94	4/14-15/94
Batch 2	4/18/94	4/22-23/94
Batch 3	4/25/94	4/29-30/94
Batch 4	5/2/94	5/12-13/94
Batch 5	5/9/94	5/12-13/94
Batch 6	5/25/94	5/26-27/94

DETECTION LIMITS

The target detection limit of 1 µg/kg wet wt was met for tri- and monobutyltin, but was exceeded for dibutyltin. The achieved detection limit for dibutyltin was 1.39 µg/kg. The method detection limits are defined as roughly 3 times the standard deviation of results from 7 replicate low level matrix spikes.

METHOD BLANKS

One method blank was extracted with each extraction batch. No butyltins were detected in the blanks.

SURROGATES

One compound, Tripentyltin chloride, is added prior to extraction to assess the efficiency of the method. This compound also is used as an internal standard as all data is corrected for the recovery of the compound. Sample recoveries ranged from 52% to 112%. All sample surrogate recoveries were within the QC limits of 40%-120%.

QA/QC SUMMARY (contd)

MATRIX SPIKES One sample from each extraction batch was spiked with mono-, di- and tributyltin. Matrix spike recoveries ranged from 93% to 114% for the tri- and dibutyltins, within the QC limits of 40-120%. The recovery for monobutyltin ranged from 26% to 51%. The lower recovery for monobutyltin is expected due to the inefficiency of the extraction of this compound as a result of its increased ionic nature.

REPLICATES One sample in each batch was digested in triplicate. Precision was measured by calculating the relative standard deviation (RSD) for the triplicate results. Tributyltin was detected in replicates for four of the batches; RSDs ranged from 3% to 6%.

SRM Not applicable.

REFERENCES

Unger, M.A., W.G. Macintyre, J. Reaves and R.J. Huggett. 1986. "GC Determination of Butyltins in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation." *Chemosphere*. 15:461-470.

TABLE P.1. Total Detected Polynuclear Aromatic Hydrocarbons, Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens PAHs (ug/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
SF COMP	1	1	13.45	41	196	237
SF COMP, Replicate 1	2	3	13.61	47	413	460
SF COMP, Replicate 2	2	3	13.61	19	434	453
SF COMP, Replicate 3	2	3	13.61	77	441	518
SF COMP	3	1	13.25	89	365	454
SF COMP	4	1	13.42	86	201	287
SF COMP	5	2	12.94	86	295	381
SFW COMP, Replicate 1	1	1	12.99	138	567	705
SFW COMP, Replicate 2	1	1	13.36	142	436	578
SFW COMP, Replicate 3	1	1	13.85	117	340	457
SFW COMP	2	2	12.32	92	408	500
SFW COMP	3	2	13.78	163	477	640
SFW COMP	4	1	13.08	154	339	493
SFW COMP	5	1	13.95	179	413	592
UIH COMP	1	2	13.70	32	195	227
UIH COMP	2	1	13.21	26	223	249
UIH COMP	3	3	13.03	35	368	403
UIH COMP	4	1	13.28	62	276	338
UIH COMP	5	1	12.99	84	304	388
TB Upper COMP	1	1	14.09	34	141	175
TB Upper COMP	2	1	13.33	35	201	236
TB Upper COMP	3	2	13.17	52	211	263
TB Upper COMP	4	1	13.45	60	115	175
TB Upper COMP	5	2	14.65	56	199	255
TB Lower COMP	1	2	13.26	52	214	266
TB Lower COMP	2	1	12.88	43	128	171
TB Lower COMP	3	2	13.79	46	194	240
TB Lower COMP	4	2	12.49	48	167	215
TB Lower COMP	5	2	13.61	14	79	93
R-OS	1	2	14.02	48	153	201
R-OS	2	1	13.37	31	124	155
R-OS	3	1	13.54	33	124	157
R-OS	4	2	13.97	35	150	185
R-OS	5	1	13.34	80	190	270

TABLE P.1. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens PAHs (ug/kg dry weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
R-BF	1	1	14.51	75	127	202
R-BF	2	2	13.20	49	129	178
R-BF	3	2	13.95	50	205	255
R-BF	4	2	12.57	50	216	266
R-BF	5	2	13.94	45	133	178
R-AM COMP	1	1	13.57	107	297	404
R-AM COMP	2	2	13.43	46	223	269
R-AM COMP	3	2	13.95	49	169	218
R-AM COMP	4	1	13.45	27	213	240
R-AM COMP	5	3	13.75	46	279	325
C-NV	1	1	12.66	103	290	393
C-NV, Replicate 1	2	2	14.27	86	383	469
C-NV, Replicate 2	2	2	14.27	91	216	307
C-NV, Replicate 3	2	2	14.27	64	248	312
C-NV	3	2	13.15	35	238	273
C-NV	4	3	13.21	60	238	298
N. virens Background	1	3	14.64	45	406	451
N. virens Background	2	3	13.30	51	277	328
N. virens Background	3	3	13.79	26	202	228
N. virens Background	4	3	14.11	37	178	215
N. virens Background	5	3	13.99	27	220	247

TABLE P.2. Low Molecular Weight Polynuclear Aromatic Hydrocarbons, Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens LPAHs (ug/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
SF COMP	1	1	13.45	16.2	11.8 U(a)	12.0 (b)	19.9 U	12.5	32.1 U
SF COMP, Replicate 1	2	3	13.61	23.8 B(c)	24.2 U	23.0 U	40.5 U	22.9 (b)	65.5 U
SF COMP, Replicate 2	2	3	13.61	18.8 B	24.2 U	23.0 U	40.5 U	19.0 U	65.5 U
SF COMP, Replicate 3	2	3	13.61	22.9 B	24.2 U	28.9	40.5 U	25.3 (b)	65.5 U
SF COMP	3	1	13.25	22.5	12.3 U	14.0 (b)	20.6 U	16.5 (b)	36.3 (b)
SF COMP	4	1	13.42	20.4	12.0 U	19.4 (b)	20.1 U	9.91 (b)	35.8
SF COMP	5	2	12.94	21.7 B	12.6 U	13.8	21.1 U	15.5 (b)	34.9
SFW COMP, Replicate 1	1	1	12.99	35.6 (b)	23.2 U	71.2	39.0 U	30.9	63.1 U
SFW COMP, Replicate 2	1	1	13.36	36.5	23.4 U	67.1	39.1 U	38.0 (b)	63.4 U
SFW COMP, Replicate 3	1	1	13.85	32.9	22.5 U	55.2	37.5 U	29.0 (b)	60.8 U
SFW COMP	2	2	12.32	8.12 U	13.2 U	63.6	22.2 U	28.7	35.8 U
SFW COMP	3	2	13.78	34.7 B	11.9 U	62.4	20.0 U	29.4	36.1
SFW COMP	4	1	13.08	24.7	12.5 (b)	59.4	20.6 U	22.2	35.3 (b)
SFW COMP	5	1	13.95	24.2	12.7 (b)	77.4	19.1 U	28.2	36.3 (b)
UIH COMP	1	2	13.70	17.0 B	11.8 U	11.2 U	19.7 U	14.5 (b)	31.9 U
UIH COMP	2	1	13.21	14.5	12.4 U	11.8 U	20.8 U	11.6 (b)	33.8 U
UIH COMP	3	3	13.03	19.9 B	12.6 U	12.0 U	21.1 U	14.8 (b)	34.2 U
UIH COMP	4	1	13.28	13.6	12.3 U	11.7 U	20.7 U	13.7 (b)	35.1 (b)
UIH COMP	5	1	12.99	36.2	24.4 U	23.5 (b)	40.9 U	23.9 (b)	66.2 U
TB Upper COMP	1	1	14.09	19.2	11.6 U	11.0 U	19.4 U	14.3 (b)	31.3 U
TB Upper COMP	2	1	13.33	21.5	12.1 U	11.5 U	20.3 U	13.8 (b)	32.8 U
TB Upper COMP	3	2	13.17	22.2 B	12.2 U	15.9 (b)	20.5 U	14.0 (b)	33.2 U
TB Upper COMP	4	1	13.45	17.2	11.7 U	11.2 U	19.6 U	10.8 (b)	31.9 (b)
TB Upper COMP	5	2	14.65	20.0 B	12.2 (b)	10.8 (b)	18.4 U	13.3 (b)	29.8 U
TB Lower COMP	1	2	13.26	22.9 B	12.1 U	13.4 (b)	20.4 U	15.6 (b)	33.0 U
TB Lower COMP	2	1	12.88	16.5	12.7 U	12.3 (b)	21.2 U	14.1 (b)	34.2 U
TB Lower COMP	3	2	13.79	21.8 B	11.8 U	12.3 (b)	19.8 U	12.0 (b)	32.0 U
TB Lower COMP	4	2	12.49	18.3 B	13.1 U	15.3 (b)	21.9 U	13.9	35.3 U
TB Lower COMP	5	2	13.61	13.7 B	12.0 U	11.5 U	20.2 U	9.55 U	32.8 U
R-OS	1	2	14.02	22.3 B	11.6 U	12.4 (b)	19.5 U	13.1 (b)	31.5 U
R-OS	2	1	13.37	18.9	12.3 U	11.7 U	20.6 U	12.0 (b)	33.4 U
R-OS	3	1	13.54	19.7	12.0 U	11.4 U	20.2 U	13.2 (b)	40.8 U
R-OS	4	2	13.97	21.5 B	11.7 U	11.1 U	19.5 U	13.6 (b)	31.6 U
R-OS	5	1	13.34	16.9	12.1 U	12.1	20.2 U	16.4 (b)	34.6 (b)
R-BF	1	1	14.51	14.9	11.0 U	10.5 U	18.4 U	25.6 (b)	34.8 (b)
R-BF	2	2	13.20	21.0 B	12.4 U	14.3 (b)	20.8 U	13.6	33.8 U
R-BF	3	2	13.95	21.5 B	11.7 U	16.2	19.6 U	12.7 (b)	31.6 U
R-BF	4	2	12.57	22.9 B	13.0 U	13.3 (b)	21.7 U	14.2 (b)	35.1 U
R-BF	5	2	13.94	18.7 B	11.7 U	14.6 (b)	19.6 U	11.9 (b)	31.6 U
R-AM COMP	1	1	13.57	15.8 (b)	11.6 (b)	13.5 (b)	19.5 (b)	14.6 (b)	31.5 (b)
R-AM COMP	2	2	13.43	18.9 B	12.0 U	12.3	20.1 U	15.2 (b)	32.5 U
R-AM COMP	3	2	13.95	23.3 B	11.5 U	12.5 (b)	19.4 U	13.5	31.3 U
R-AM COMP	4	1	13.45	14.0 (b)	12.0 U	11.4 U	20.1 U	13.3 (b)	32.5 U
R-AM COMP	5	3	13.75	14.9 B	11.9 U	14.2 (b)	20.0 U	17.0 (b)	32.4 U

TABLE P.2. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens LPAHs (ug/kg dry weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
C-NV	1	1	12.66	19.4 (b)	13.4 (b)	16.0	21.3 U	18.6 (b)	35.2 (b)
C-NV, Replicate 1	2	2	14.27	29.5 B	23.1 U	35.3	38.6 U	21.3	62.4 U
C-NV, Replicate 2	2	2	14.27	40.5 B	25.4 (b)	21.8 U	38.4 U	25.4 (b)	62.2 U
C-NV, Replicate 3	2	2	14.27	39.9 B	22.6 U	21.5 U	37.8 U	23.8 (b)	61.2 U
C-NV	3	2	13.15	34.7 B	24.5 U	23.3 U	41.1 U	19.3 U	66.5 U
C-NV	4	3	13.21	15.4 B	14.7 (b)	14.9	20.8 U	15.1 (b)	33.8 U
N. virens Background	1	3	14.64	24.1 B	22.5 U	21.4 U	37.6 U	20.8 (b)	60.9 U
N. virens Background	2	3	13.30	11.6 B	13.3 (b)	13.1 (b)	20.3 U	12.9 (b)	32.9 U
N. virens Background	3	3	13.79	13.8 B	11.9 U	11.3 U	19.9 U	11.8 (b)	32.3 U
N. virens Background	4	3	14.11	13.5 B	11.8 (b)	11.1 U	19.5 U	12.0 B	31.6 U
N. virens Background	5	3	13.99	14.9 B	11.4 U	10.9 U	19.1 U	11.7 B	30.9 U

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample at less than five times value in associated method blank.

TABLE P.3. High Molecular Weight Polynuclear Aromatic Hydrocarbons, Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

				N. virens HPAHs (ug/kg dry weight)									
Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
SF COMP	1	1	13.45	36.8 (a)	41.5 (a)B(b)	17.2 (a)B	9.44 U(c)	40.6 (a)	35.0 (a)	24.7 (a)	39.1 U	42.2 U	34.9 U
SF COMP, Replicate 1	2	3	13.61	75.7 (a)	82.3 (a)B	36.1 (a)B	19.2 U	77.1 (a)B	70.4 (a)B	71.1 (a)B	80.1 U	86.0 U	71.1 U
SF COMP, Replicate 2	2	3	13.61	74.9 (a)	83.0 (a)B	31.8 (a)B	31.8 (a)B	78.6 (a)B	72.2 (a)B	61.9 (a)B	80.1 U	86.0 U	71.1 U
SF COMP, Replicate 3	2	3	13.61	75.7 (a)	83.8 (a)B	32.3 (a)B	30.2 (a)B	77.1 (a)B	71.2 (a)B	70.8 (a)B	80.1 U	86.0 U	71.1 U
SF COMP	3	1	13.25	39.5 (a)	43.5 (a)B	16.0 (a)B	16.5 (a)	44.2 (a)	37.2 (a)	50.9 (a)	50.6 B	43.7 U	66.3
SF COMP	4	1	13.42	40.4 (a)	41.4 (a)B	17.0 (a)B	15.9 (a)	15.4 (a)	12.1 U	11.5 U	39.6 U	42.7 U	70.5
SF COMP	5	2	12.94	40.5	49.3 (a)B	21.2 (a)B	16.8 (a)	43.2 (a)	38.6 (a)	30.4 (a)	41.5 U	44.7 U	55.1 (a)
SFW COMP, Replicate 1	1	1	12.99	89.3 (a)	80.1 (a)B	35.3 (a)B	35.6 (a)	76.5 (a)	69.7 (a)	65.5 (a)	76.8 U	83.1 U	115 (a)
SFW COMP, Replicate 2	1	1	13.36	86.8 (a)	95.8 B	34.1 (a)B	18.6	75.6 (a)	68.9 (a)	55.8 (a)	77.1 U	83.1 U	68.8 U
SFW COMP, Replicate 3	1	1	13.85	80.9 (a)	76.5 (a)B	26.7 B	29.2 (a)	7.58 U	74.4 (a)	52.7 (a)	74.4 U	80.1 U	66.0 U
SFW COMP	2	2	12.32	84.4 (a)	80.0 B	22.0 (a)B	28.7	55.3 (a)	49.5 (a)	36.2 (a)	43.6 U	47.0 U	51.8
SFW COMP	3	2	13.78	89.3	104 (a)B	32 B	36.9 (a)	59.2 (a)	45.9 (a)	49.6 (a)	39.4 U	42.5 U	60.1 (a)
SFW COMP	4	1	13.08	63.5	65.8 B	18.4 B	24.1	45.3 (a)	37.5 (a)	31.7 (a)	40.7 U	43.8 U	53.1 (a)
SFW COMP	5	1	13.95	97.5	88.9 B	20.1 B	30.4	53.3	43.7 (a)	37.1 (a)	37.7 U	40.6 U	42.1 (a)
UIH COMP	1	2	13.70	36.6 (a)	40.9 (a)B	18.8 B	9.34 U	39.1 (a)	36.1 (a)	23.6 (a)	38.8 U	41.8 U	34.6 U
UIH COMP	2	1	13.21	39.7 (a)	46.4 B	14.9 (a)B	9.92 U	41.5 (a)	39.9 (a)	40.4 (a)	41.1 U	44.3 U	36.6 U
UIH COMP	3	3	13.03	39.7 (a)	43.9 (a)B	18.8 (a)B	16.7 (a)B	43.8 (a)B	41.5 (a)B	41.2 (a)B	65.1 (a)	44.9 U	56.9 (a)B
UIH COMP	4	1	13.28	39.2 (a)	44.3 (a)B	17.3 (a)B	16.1 (a)	43.0 (a)	39.8 (a)	31.6 (a)	40.9 U	44.1 U	44.2 (a)
UIH COMP	5	1	12.99	73.6 (a)	84.7 B	30.4 (a)B	19.4 U	8.24 U	72.2 (a)	43.4 (a)	80.8 U	87.0 U	71.9 U
TB Upper COMP	1	1	14.09	36.1 (a)	43.0 (a)B	14.2 (a)B	15.8 (a)	3.90 U	11.6 U	32.2 (a)	38.1 U	41.1 U	34.0 U
TB Upper COMP	2	1	13.33	37.2 (a)	42.6 (a)B	14.9 (a)B	9.60 U	4.05 U	35.8 (a)	27.7 (a)	39.9 U	43.0 U	42.9 (a)
TB Upper COMP	3	2	13.17	37.4 (a)	43.1 (a)B	16.0 B	15.8 (a)	39.9 (a)	37.3 (a)	21.7 (a)	40.4 U	43.5 U	36.0 U
TB Upper COMP	4	1	13.45	37.5 (a)	41.6 (a)B	14.3 (a)B	9.29 U	3.94 U	11.7 U	21.9 (a)	38.7 U	41.7 U	34.5 U
TB Upper COMP	5	2	14.65	44.9 (a)	38.2 (a)B	19.4 (a)B	8.74 U	37.1 (a)	34.9 (a)	24.8 (a)	36.3 U	39.1 U	32.4 U
TB Lower COMP	1	2	13.26	37.6 (a)	41.8 (a)B	16.5 (a)B	16.7 (a)	39.2 (a)	35.2 (a)	26.8 (a)	40.1 U	43.2 U	35.7 U
TB Lower COMP	2	1	12.88	39.7 (a)	45.3 (a)B	17.2 (a)B	10.0 U	4.27 U	12.7 U	25.9 (a)	41.7 U	45.0 U	37.2 U
TB Lower COMP	3	2	13.79	37.6 (a)	41.1 (a)B	15.9 (a)B	9.35 U	3.99 U	34.2 (a)	22.9 (a)	38.9 U	42.0 U	41.8 (a)
TB Lower COMP	4	2	12.49	39.9 (a)	45.8 (a)B	17.5 (a)B	10.3 U	4.40 U	38.4 (a)	25.6 (a)	43.0 U	46.4 U	38.4 U
TB Lower COMP	5	2	13.61	26.4 (a)	17.3 U	14.5 (a)B	9.63 U	4.11 U	12.1 U	37.9	39.9 U	43.0 U	35.6 U
R-OS	1	2	14.02	36.0 (a)	42.1 (a)B	18.0 (a)B	9.20 U	3.92 U	34.1 (a)	23.0 (a)	38.3 U	41.3 U	34.2 U
R-OS	2	1	13.37	37.2 (a)	45.0 (a)B	14.8 (a)B	9.80 U	4.19 U	12.3 U	27.2 (a)	40.6 U	43.8 U	36.2 U
R-OS	3	1	13.54	36.5 (a)	43.4 (a)B	16.6 (a)B	9.53 U	4.06 U	12.0 U	27.3 (a)	39.7 U	42.8 U	35.4 U
R-OS	4	2	13.97	36.6 (a)	41.5 (a)B	16.5 (a)B	9.23 U	3.94 U	34.8 (a)	20.8 (a)	38.4 U	41.4 U	34.3 U
R-OS	5	1	13.34	37.5 (a)	41.0 (a)B	17.5 B	9.60 U	4.05 U	12.1 U	38.5 (a)	39.9 U	43.0 U	55.0 (a)

TABLE P.3. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens HPAHs (ug/kg dry weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
R-BF	1	1	14.51	37.0 (a)	38.3 (a)B	16.3 (a)B	14.7 (a)	3.72 U	11.0 U	20.8 (a)	36.3 U	39.1 U	32.3 U
R-BF	2	2	13.20	39.8 (a)	49.4 (a)B	17.7 B	9.92 U	4.24 U	12.5 U	22.4 (a)	41.1 U	44.3 U	36.7 U
R-BF	3	2	13.95	37.3 (a)	41.4 (a)B	15.4 (a)B	15.3 (a)	37.6 (a)	34.1 (a)	24.3 (a)	38.5 U	41.5 U	34.3 U
R-BF	4	2	12.57	41.7 (a)	52.3 (a)B	17.6 (a)B	10.3 U	41.7 (a)	39.1 (a)	23.5 (a)	42.7 U	46.1 U	38.1 U
R-BF	5	2	13.94	35.8 (a)	40.8 (a)B	16.9 (a)B	15.4 (a)	3.95 U	11.7 U	24.1 (a)	38.5 U	41.5 U	34.4 U
R-AM COMP	1	1	13.57	40.8 (a)	40.7 (a)	16.6	15.3 (a)	38.2 (a)	35.2 (a)	27.7 (a)	38.4 U	41.3 (a)	41.6 (a)
R-AM COMP	2	2	13.43	41.6 (a)	41.5 (a)B	19.1 (a)B	17.1 (a)	40.1 (a)	38.3 (a)	25.5 (a)	39.6 U	42.7 U	35.3 U
R-AM COMP	3	2	13.95	37.1 (a)	41.1 (a)B	15.6 (a)B	15.6 (a)	3.87 U	35.0 (a)	24.1 (a)	38.1 U	41.1 U	34.0 U
R-AM COMP	4	1	13.45	39.9 (a)	42.4 (a)B	15.3 (a)B	16.9 (a)	38.5 (a)	35.1 (a)	24.8 (a)	39.6 U	42.6 U	35.2 U
R-AM COMP	5	3	13.75	45.0 (a)	40.7 (a)B	18.8 (a)B	19.6 (a)B	40.2 (a)B	37.2 (a)B	36.5 (a)B	40.7 (a)	42.5 U	35.2 U
C-NV	1	1	12.66	47.5 (a)	44.9 (a)B	20.3 (a)B	18.6 (a)	43.6 (a)	37.6 (a)	31.2 (a)	42.0 U	45.3 U	45.8 (a)
C-NV, Replicate 1	2	2	14.27	71.5 (a)	80.6 (a)B	31.0 (a)B	18.3 U	7.78 U	66.9 (a)	46.7 (a)	76.4 U	82.0 U	86.2
C-NV, Replicate 2	2	2	14.27	67.8 (a)	79.2 (a)B	28.0 (a)B	18.2 U	7.78 U	23.0 U	41.2 (a)	75.7 U	81.3 U	67.5 U
C-NV, Replicate 3	2	2	14.27	70.1 (a)	79.9 (a)B	29.8 (a)B	29.2 (a)	7.64 U	22.6 U	38.6 (a)	74.3 U	80.6 U	66.4 U
C-NV	3	2	13.15	76.0 (a)	85.9 (a)B	33.5 (a)B	19.5 U	8.29 U	24.6 U	42.7 (a)	80.6 U	87.5 U	72.1 U
C-NV	4	3	13.21	43.4 (a)	43.1 (a)B	20.7 (a)B	15.5 (a)B	40.2 (a)B	35.9 (a)B	39.0 (a)B	41.1. U	44.3 U	36.6 U
N. virens Background	1	3	14.64	68.0 (a)	87.4 (a)B	30.2 (a)B	28.6 (a)B	72.4 (a)B	69.0 (a)B	50.5 (a)B	74.5 U	79.9 U	66.1 U
N. virens Background	2	3	13.30	43.3 (a)	43.7 (a)B	15.9 (a)B	19.6 U	39.5 (a)B	38.5 (a)B	25.0 (a)B	40.0 U	43.1 U	51.7 (a)B
N. virens Background	3	3	13.79	35.1 (a)	41.5 (a)B	19.8 B	9.50 U	38.3 (a)B	36.0 (a)B	31.2 (a)B	39.4 U	42.4 U	35.1 U
N. virens Background	4	3	14.11	38.2 (a)	40.8 (a)B	18.4 (a)B	15.5 (a)B	3.97 U	34.7 (a)B	30.4 (a)B	38.5 U	41.5 U	34.3 U
N. virens Background	5	3	13.99	39.5 (a)	40.2 (a)B	16.3 (a)B	17.9 (a)B	37.6 (a)B	34.2 (a)B	34.6 (a)B	37.6 U	40.5 U	33.5 U

(a) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(b) B Analyte detected in sample at less than five times value in associated method blank.
(c) U Undetected at or above detection limit.

TABLE P.4. Total Detected Polynuclear Aromatic Hydrocarbons (PAHs), Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens PAHs (ug/kg wet weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
SF COMP	1	1	5	26	31
SF COMP, Replicate 1	2	3	6	56	62
SF COMP, Replicate 2	2	3	3	59	62
SF COMP, Replicate 3	2	3	10	60	70
SF COMP	3	1	12	48	60
SF COMP	4	1	11	27	38
SF COMP	5	2	11	38	49
SFW COMP, Replicate 1	1	1	18	74	92
SFW COMP, Replicate 2	1	1	19	58	77
SFW COMP, Replicate 3	1	1	16	47	63
SFW COMP	2	2	11	50	61
SFW COMP	3	2	22	66	88
SFW COMP	4	1	20	44	64
SFW COMP	5	1	25	58	83
UIH COMP	1	2	4	27	31
UIH COMP	2	1	3	29	32
UIH COMP	3	3	5	48	53
UIH COMP	4	1	8	37	45
UIH COMP	5	1	11	40	51
TB Upper COMP	1	1	5	20	25
TB Upper COMP	2	1	5	27	32
TB Upper COMP	3	2	7	28	35
TB Upper COMP	4	1	8	16	24
TB Upper COMP	5	2	8	29	37
TB Lower COMP	1	2	7	28	35
TB Lower COMP	2	1	6	16	22
TB Lower COMP	3	2	6	27	33
TB Lower COMP	4	2	6	21	27
TB Lower COMP	5	2	2	11	13
R-OS	1	2	7	21	28
R-OS	2	1	4	17	21
R-OS	3	1	4	17	21
R-OS	4	2	5	21	26
R-OS	5	1	11	25	36

TABLE P.4. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens PAHs (ug/kg wet weight) Total Low Molecular Weight PAHs	Total High Molecular Weight PAHs	Total PAHs
R-BF	1	1	11	18	29
R-BF	2	2	6	17	23
R-BF	3	2	7	29	36
R-BF	4	2	6	27	33
R-BF	5	2	6	19	25
R-AM COMP	1	1	6	35	41
R-AM COMP	2	2	6	30	36
R-AM COMP	3	2	7	24	31
R-AM COMP	4	1	4	29	33
R-AM COMP	5	3	6	38	44
C-NV	1	1	13	37	50
C-NV, Replicate 1	2	2	12	55	67
C-NV, Replicate 2	2	2	13	31	44
C-NV, Replicate 3	2	2	9	35	44
C-NV	3	2	5	31	36
C-NV	4	3	8	31	39
N. virens Background	1	3	7	59	66
N. virens Background	2	3	7	37	44
N. virens Background	3	3	4	28	32
N. virens Background	4	3	5	25	30
N. virens Background	5	3	4	31	35

TABLE P.5. Low Molecular Weight Polynuclear Aromatic Hydrocarbons, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens LPAHs (ug/kg wet weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Target DL(a)			20	20	20	20	20	20
Achieved DL			0.49-2.03	0.79-3.29	0.75-3.13	1.32-5.51	0.62-2.59	2.14-8.91
SF COMP	1	1	2.18	1.59 U(a)	1.61 (b)	2.67 U	1.68	4.32 U
SF COMP, Replicate 1	2	3	3.24 B(c)	3.29 U	3.13 U	5.51 U	3.12 (b)B	8.91 U
SF COMP, Replicate 2	2	3	2.56 B	3.29 U	3.13 U	5.51 U	2.59 U	8.91 U
SF COMP, Replicate 3	2	3	3.11 B	3.29 U	3.93	5.51 U	3.44 (b)B	8.91 U
SF COMP	3	1	2.98	1.63 U	1.85 (b)	2.73 U	2.18 (b)	4.81 (b)
SF COMP	4	1	2.74	1.61 U	2.60 (b)	2.70 U	1.33 (b)	4.81
SF COMP	5	2	2.81 B	1.63 U	1.78	2.73 U	2.00 (b)	4.52
SFW COMP, Replicate 1	1	1	4.63 (b)	3.02 U	9.25	5.07 U	4.01	8.20 U
SFW COMP, Replicate 2	1	1	4.87	3.12 U	8.97	5.23 U	5.08 (b)	8.47 U
SFW COMP, Replicate 3	1	1	4.55	3.11 U	7.64	5.20 U	4.02 (b)	8.42 U
SFW COMP	2	2	1.00 U	1.63 U	7.84	2.73 U	3.54	4.41 U
SFW COMP	3	2	4.78 B	1.64 U	8.60	2.75 U	4.05	4.98
SFW COMP	4	1	3.23	1.63 (b)	7.77	2.70 U	2.90	4.62 (b)
SFW COMP	5	1	3.38	1.77 (b)	10.8	2.67 U	3.93	5.06 (b)
UIH COMP	1	2	2.33 B	1.61 U	1.53 U	2.70 U	1.99 (b)	4.37 U
UIH COMP	2	1	1.92	1.64 U	1.56 U	2.75 U	1.53 (b)	4.46 U
UIH COMP	3	3	2.59 B	1.64 U	1.56 U	2.75 U	1.93 (b)B	4.46 U
UIH COMP	4	1	1.81	1.64 U	1.56 U	2.75 U	1.82 (b)	4.66 (b)
UIH COMP	5	1	4.70	3.17 U	3.05 (b)	5.31 U	3.11 (b)	8.60 U
TB Upper COMP	1	1	2.70	1.63 U	1.55 U	2.73 U	2.01 (b)	4.41 U
TB Upper COMP	2	1	2.86	1.61 U	1.53 U	2.70 U	1.84 (b)	4.37 U
TB Upper COMP	3	2	2.92 B	1.61 U	2.09 (b)	2.70 U	1.84 (b)	4.37 U
TB Upper COMP	4	1	2.31	1.58 U	1.50 U	2.64 U	1.45 (b)	4.29 (b)
TB Upper COMP	5	2	2.93 B	1.78 (b)	1.58 (b)	2.70 U	1.95 (b)	4.37 U
TB Lower COMP	1	2	3.04 B	1.61 U	1.78 (b)	2.70 U	2.07 (b)	4.37 U
TB Lower COMP	2	1	2.12	1.63 U	1.58 (b)	2.73 U	1.81 (b)	4.41 U
TB Lower COMP	3	2	3.00 B	1.63 U	1.69 (b)	2.73 U	1.66 (b)	4.41 U
TB Lower COMP	4	2	2.28 B	1.63 U	1.91 (b)	2.73 U	1.74	4.41 U
TB Lower COMP	5	2	1.86 B	1.64 U	1.56 U	2.75 U	1.30 U	4.46 U
R-OS	1	2	3.12 B	1.63 U	1.74 (b)	2.73 U	1.83 (b)	4.41 U
R-OS	2	1	2.53	1.64 U	1.56 U	2.75 U	1.60 (b)	4.46 U
R-OS	3	1	2.67	1.63 U	1.55 U	2.73 U	1.79 (b)	5.52 U
R-OS	4	2	3.00 B	1.63 U	1.55 U	2.73 U	1.90 (b)	4.41 U
R-OS	5	1	2.26	1.61 U	1.62	2.70 U	2.19 (b)	4.61 (b)

TABLE P.5. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens LPAHs (ug/kg wet weight) Naphtha-lene	Acenaph-thylene	Acenaph-thene	Fluorene	Phenan-threne	Anthra-cene
R-BF	1	1	2.16	1.59 U	1.52 U	2.67 U	3.71 (b)	5.05 (b)
R-BF	2	2	2.77 B	1.64 U	1.89 (b)	2.75 U	1.79	4.46 U
R-BF	3	2	3:00 B	1.63 U	2.26	2.73 U	1.77 (b)	4.41 U
R-BF	4	2	2.88 B	1.63 U	1.67 (b)	2.73 U	1.79 (b)	4.41 U
R-BF	5	2	2.60 B	1.63 U	2.03 (b)	2.73 U	1.66 (b)	4.41 U
R-AM COMP	1	1	2.15 (b)	1.58 U	1.83 (b)	2.64 U	1.98 (b)	4.28 U
R-AM COMP	2	2	2.54 B	1.61 U	1.65	2.70 U	2.04 (b)	4.37 U
R-AM COMP	3	2	3.25 B	1.61 U	1.74 (b)	2.70 U	1.88	4.37 U
R-AM COMP	4	1	1.88 (b)	1.61 U	1.53 U	2.70 U	1.79 (b)	4.37 U
R-AM COMP	5	3	2.05 B	1.64 U	1.95 (b)	2.75 U	2.34 (b)B	4.46 U
C-NV	1	1	2.46 (b)	1.70 (b)	2.02	2.70 U	2.36 (b)	4.46 (b)
C-NV, Replicate 1	2	2	4.21 B	3.29 U	5.04	5.51 U	3.04	8.91 U
C-NV, Replicate 2	2	2	5.78 B	3.63 (b)	3.11 U	5.48 U	3.63 (b)	8.87 U
C-NV, Replicate 3	2	2	5.69 B	3.22 U	3.07 U	5.40 U	3.40 (b)	8.74 U
C-NV	3	2	4.56 B	3.22 U	3.07 U	5.40 U	2.54 U	8.74 U
C-NV	4	3	2.04 B	1.94 (b)	1.97	2.75 U	1.99 (b)B	4.46 U
N. virens Background	1	3	3.53 B	3.29 U	3.13 U	5.51 U	3.04 (b)B	8.91 U
N. virens Background	2	3	1.54 B	1.77 (b)	1.74 (b)	2.70 U	1.71 (b)B	4.37 U
N. virens Background	3	3	1.90 B	1.64 U	1.56 U	2.75 U	1.63 (b)B	4.46 U
N. virens Background	4	3	1.90 B	1.66 (b)	1.56 U	2.75 U	1.69 B	4.46 U
N. virens Background	5	3	2.09 B	1.59 U	1.52 U	2.67 U	1.64 B	4.32 U

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample is less than five times value in associated method blank.

TABLE P.6. High Molecular Weight Polynuclear Aromatic Hydrocarbons, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

			N. virens HPAHs (ug/kg wet weight)										
Sediment Treatment	Replicate	Analytical Batch	Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Target DL(a)			20	20	20	20	20	20	20	20	20	20
Achieved DL			1.58-6.58	1.13-4.72	0.53-2.22	0.63-2.61	0.27-1.11	0.79-3.30	0.76-3.16	2.60-10.85	2.81-11.70	2.32-9.68
SF COMP	1	1	4.95 (b)	5.58 (b)B(c)	2.32 (b)B	1.27 U(d)	5.46 (b)	4.71 (b)	3.32 (b)	5.26 U	5.67 U	4.69 U
SF COMP, Replicate 1	2	3	10.3 (b)	11.2 (b)B	4.91 (b)B	2.61 U	10.5 (b)B	9.58 (b)B	9.68 (b)B	10.9 U	11.7 U	9.68 U
SF COMP, Replicate 2	2	3	10.2 (b)	11.3 (b)B	4.33 (b)B	4.33 (b)B	10.7 (b)B	9.83 (b)B	8.43 (b)B	10.9 U	11.7 U	9.68 U
SF COMP, Replicate 3	2	3	10.3 (b)	11.4 (b)B	4.40 (b)B	4.11 (b)B	10.5 (b)B	9.69 (b)B	9.64 (b)B	10.9 U	11.7 U	9.68 U
SF COMP	3	1	5.24 (b)	5.77 (b)B	2.12 (b)B	2.18 (b)	5.86 (b)	4.93 (b)	6.74 (b)	6.71 B	5.79 U	8.79
SF COMP	4	1	5.42 (b)	5.55 (b)B	2.28 (b)B	2.13 (b)	2.07 (b)	1.62 U	1.55 U	5.32 U	5.73 U	9.46
SF COMP	5	2	5.24	6.38 (b)B	2.74 (b)B	2.18 (b)	5.59 (b)	4.99 (b)	3.93 (b)	5.37 U	5.79 U	7.13 (b)
SFW COMP, Replicate 1	1	1	11.6 (b)	10.4 (b)B	4.59 (b)B	4.62 (b)	9.94 (b)	9.06 (b)	8.51 (b)	9.98 U	10.8 U	15.0 (b)
SFW COMP, Replicate 2	1	1	11.6 (b)	12.8 B	4.55 (b)B	2.48	10.1 (b)	9.21 (b)	7.45 (b)	10.3 U	11.1 U	9.19 U
SFW COMP, Replicate 3	1	1	11.2 (b)	10.6 (b)B	3.70 B	4.05 (b)	1.05 U	10.3 (b)	7.30 (b)	10.3 U	11.1 U	9.14 U
SFW COMP	2	2	10.4 (b)	9.86 B	2.71 (b)B	3.53	6.81 (b)	6.10 (b)	4.46 (b)	5.37 U	5.79 U	6.38
SFW COMP	3	2	12.3	14.4 (b)B	4.46 B	5.08 (b)	8.16 (b)	6.32 (b)	6.84 (b)	5.43 U	5.85 U	8.28 (b)
SFW COMP	4	1	8.30	8.61 B	2.41 B	3.15	5.92 (b)	4.91 (b)	4.15 (b)	5.32 U	5.73 U	6.94 (b)
SFW COMP	5	1	13.6	12.4 B	2.81 B	4.24	7.44	6.10 (b)	5.17 (b)	5.26 U	5.67 U	5.87 (b)
UIH COMP	1	2	5.02 (b)	5.60 (b)B	2.57 B	1.28 U	5.36 (b)	4.94 (b)	3.23 (b)	5.32 U	5.73 U	4.74 U
UIH COMP	2	1	5.24 (b)	6.13 B	1.97 (b)B	1.31 U	5.48 (b)	5.27 (b)	5.34 (b)	5.43 U	5.85 U	4.84 U
UIH COMP	3	3	5.17 (b)	5.72 (b)B	2.45 (b)B	2.18 (b)B	5.71 (b)B	5.41 (b)B	5.37 (b)B	8.48 (b)	5.85 U	7.41 (b)B
UIH COMP	4	1	5.21 (b)	5.88 (b)B	2.30 (b)B	2.14 (b)	5.71 (b)	5.28 (b)	4.19 (b)	5.43 U	5.85 U	5.87 (b)
UIH COMP	5	1	9.56 (b)	11.0 B	3.95 (b)B	2.52 U	1.07 U	9.38 (b)	5.64 (b)	10.5 U	11.3 U	9.34 U
TB Upper COMP	1	1	5.08 (b)	6.06 (b)B	2.00 (b)B	2.22 (b)	0.55 U	1.63 U	4.54 (b)	5.37 U	5.79 U	4.79 U
TB Upper COMP	2	1	4.96 (b)	5.68 (b)B	1.98 (b)B	1.28 U	0.54 U	4.77 (b)	3.69 (b)	5.32 U	5.73 U	5.72 (b)
TB Upper COMP	3	2	4.93 (b)	5.67 (b)B	2.11 B	2.08 (b)	5.26 (b)	4.91 (b)	2.86 (b)	5.32 U	5.73 U	4.74 U
TB Upper COMP	4	1	5.04 (b)	5.60 (b)B	1.92 (b)B	1.25 U	0.53 U	1.58 U	2.94 (b)	5.21 U	5.61 U	4.64 U
TB Upper COMP	5	2	6.58 (b)	5.59 (b)B	2.84 (b)B	1.28 U	5.43 (b)	5.11 (b)	3.63 (b)	5.32 U	5.73 U	4.74 U
TB Lower COMP	1	2	4.99 (b)	5.54 (b)B	2.19 (b)B	2.21 (b)	5.20 (b)	4.67 (b)	3.55 (b)	5.32 U	5.73 U	4.74 U
TB Lower COMP	2	1	5.11 (b)	5.83 (b)B	2.22 (b)B	1.29 U	0.55 U	1.63 U	3.33 (b)	5.37 U	5.79 U	4.79 U
TB Lower COMP	3	2	5.18 (b)	5.67 (b)B	2.19 (b)B	1.29 U	0.55 U	4.72 (b)	3.16 (b)	5.37 U	5.79 U	5.77 (b)
TB Lower COMP	4	2	4.98 (b)	5.72 (b)B	2.19 (b)B	1.29 U	0.55 U	4.80 (b)	3.20 (b)	5.37 U	5.79 U	4.79 U
TB Lower COMP	5	2	3.59 (b)	2.36 U	1.97 (b)B	1.31 U	0.56 U	1.65 U	5.16	5.43 U	5.85 U	4.84 U

TABLE P.6. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens HPAHs (ug/kg wet weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
R-OS	1	2	5.05 (b)	5.90 (b)B	2.52 (b)B	1.29 U	0.55 U	4.78 (b)	3.22 (b)	5.37 U	5.79 U	4.79 U
R-OS	2	1	4.98 (b)	6.02 (b)B	1.98 (b)B	1.31 U	0.56 U	1.65 U	3.64 (b)	5.43 U	5.85 U	4.84 U
R-OS	3	1	4.94 (b)	5.88 (b)B	2.25 (b)B	1.29 U	0.55 U	1.63 U	3.69 (b)	5.37 U	5.79 U	4.79 U
R-OS	4	2	5.12 (b)	5.80 (b)B	2.31 (b)B	1.29 U	0.55 U	4.86 (b)	2.90 (b)	5.37 U	5.79 U	4.79 U
R-OS	5	1	5.00 (b)	5.47 (b)B	2.33 B	1.28 U	0.54 U	1.62 U	5.13 (b)	5.32 U	5.73 U	7.34 (b)
R-BF	1	1	5.37 (b)	5.56 (b)B	2.36 (b)B	2.14 (b)	0.54 U	1.60 U	3.02 (b)	5.26 U	5.67 U	4.69 U
R-BF	2	2	5.25 (b)	6.52 (b)B	2.34 B	1.31 U	0.56 U	1.65 U	2.96 (b)	5.43 U	5.85 U	4.84 U
R-BF	3	2	5.21 (b)	5.78 (b)B	2.15 (b)B	2.14 (b)	5.24 (b)	4.76 (b)	3.39 (b)	5.37 U	5.79 U	4.79 U
R-BF	4	2	5.24 (b)	6.57 (b)B	2.21 (b)B	1.29 U	5.24 (b)	4.92 (b)	2.95 (b)	5.37 U	5.79 U	4.79 U
R-BF	5	2	4.99 (b)	5.69 (b)B	2.36 (b)B	2.14 (b)	0.55 U	1.63 U	3.36 (b)	5.37 U	5.79 U	4.79 U
R-AM COMP	1	1	5.54 (b)	5.52 (b)	2.25 (b)	2.08 (b)	5.18 (b)	4.77 (b)	3.76 (b)	5.21 U	5.61 U	5.64 (b)
R-AM COMP	2	2	5.59 (b)	5.57 (b)B	2.56 (b)B	2.29 (b)	5.38 (b)	5.14 (b)	3.43 (b)	5.32 U	5.73 U	4.74 U
R-AM COMP	3	2	5.18 (b)	5.74 (b)B	2.17 (b)B	2.18 (b)	0.54 U	4.88 (b)	3.36 (b)	5.32 U	5.73 U	4.74 U
R-AM COMP	4	1	5.37 (b)	5.70 (b)B	2.06 (b)B	2.27 (b)	5.18 (b)	4.72 (b)	3.33 (b)	5.32 U	5.73 U	4.74 U
R-AM COMP	5	3	6.19 (b)	5.59 (b)B	2.58 (b)B	2.69 (b)B	5.53 (b)B	5.12 (b)B	5.02 (b)B	5.60 (b)	5.85 U	4.84 U
C-NV	1	1	6.01 (b)	5.68 (b)B	2.57 (b)B	2.35 (b)	5.52 (b)	4.76 (b)	3.95 (b)	5.32 U	5.73 U	5.80 (b)
C-NV, Replicate 1	2	2	10.2 (b)	11.5 (b)B	4.42 (b)B	2.61 U	1.11 U	9.55 (b)	6.67 (b)	10.9 U	11.7 U	12.3
C-NV, Replicate 2	2	2	9.67 (b)	11.3 (b)B	3.99 (b)B	2.60 U	1.11 U	3.28 U	5.88 (b)	10.8 U	11.6 U	9.63 U
C-NV, Replicate 3	2	2	10.0 (b)	11.4 (b)B	4.25 (b)B	4.17 (b)	1.09 U	3.23 U	5.51 (b)	10.6 U	11.5 U	9.48 U
C-NV	3	2	10.0 (b)	11.3 (b)B	4.41 (b)B	2.56 U	1.09 U	3.23 U	5.62 (b)	10.6 U	11.5 U	9.48 U
C-NV	4	3	5.73 (b)	5.70 (b)B	2.74 (b)B	2.05 (b)B	5.31 (b)B	4.74 (b)B	5.15 (b)B	5.43 U	5.85 U	4.84 U
N. virens Background	1	3	9.95 (b)	12.8 (b)B	4.42 (b)B	4.18 (b)B	10.6 (b)B	10.1 (b)B	7.40 (b)B	10.9 U	11.7 U	9.68 U
N. virens Background	2	3	5.76 (b)	5.81 (b)B	2.11 (b)B	2.61 B	5.25 (b)B	5.12 (b)B	3.33 (b)B	5.32 U	5.73 U	6.88 (b)B
N. virens Background	3	3	4.84 (b)	5.72 (b)B	2.73 B	1.31 U	5.28 (b)B	4.96 (b)B	4.30 (b)B	5.43 U	5.85 U	4.84 U
N. virens Background	4	3	5.39 (b)	5.75 (b)B	2.59 (b)B	2.18 (b)B	0.56 U	4.90 (b)B	4.29 (b)B	5.43 U	5.85 U	4.84 U
N. virens Background	5	3	5.53 (b)	5.62 (b)B	2.28 (b)B	2.50 (b)B	5.26 (b)B	4.79 (b)B	4.84 (b)B	5.26 U	5.67 U	4.69 U

(a) DL Detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample is less than five times value in associated method blank.
(d) U Undetected at or above detection limit.

TABLE P.7. Quality Control Data for Low Molecular Weight Polynuclear Aromatic Hydrocarbons, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens (ug/kg wet weight) Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene
Method Blanks								
Blank-1		1	0.99 U(a)	1.61 U	1.53 U	2.70 U	1.27 U	4.37 U
Blank-1		2	1.19 (b)	1.63 U	1.55 U	2.73 U	1.28 U	4.41 U
Blank-1		3	1.25 (b)	1.73 U	1.64 U	2.89 U	1.62 (b)	4.68 U
Matrix Spikes								
UIH COMP	5	1	4.70	3.17 U	3.05 (b)	5.31 U	3.11 (b)	8.60 U
UIH COMP, MS	5	1	91.4	84.2	89.8	83.5	84.5	84.8
Concentration Recovered			86.7	84.2	86.8	83.5	81.4	84.8
Amount Spiked			89.6	89.6	89.6	89.6	89.6	89.6
Percent Recovery			97%	94%	97%	93%	91%	95%
C-NV	3	2	4.56 B(c)	3.22 U	3.07 U	5.40 U	2.54 U	8.74 U
C-NV, MS	3	2	100	92.9	99.9	90.3	95.0	95.3
Concentration Recovered			95.4	92.9	99.9	90.3	95.0	95.3
Amount Spiked			96.9	96.9	96.9	96.9	96.9	96.9
Percent Recovery			98%	96%	103%	93%	98%	98%
N. virens Background	1	3	3.53 B	3.29 U	3.13 U	5.51 U	3.04 (b)B	8.91 U
N. virens Background, MS	1	3	96.2	89.7	96.7	88.0	92.3	95.5
Concentration Recovered			92.7	89.7	96.7	88.0	89.3	95.5
Amount Spiked			96.9	96.9	96.9	96.9	96.9	96.9
Percent Recovery			96%	93%	100%	91%	92%	99%
Standard Reference Material								
Certified SRM not available for PAHs.								
Analytical Replicates								
SFW COMP, Replicate 1	1	1	4.63 (b)	3.02 U	9.25	5.07 U	4.01	8.20 U
SFW COMP, Replicate 2	1	1	4.87	3.12 U	8.97	5.23 U	5.08 (b)	8.47 U
SFW COMP, Replicate 3	1	1	4.55	3.11 U	7.64	5.20 U	4.02 (b)	8.42 U
RSD			4%	NA (d)	10%	NA	14%	NA
C-NV, Replicate 1	2	2	4.21 B	3.29 U	5.04	5.51 U	3.04	8.91 U
C-NV, Replicate 2	2	2	5.78 B	3.63 (b)	3.11 U	5.48 U	3.63 (b)	8.87 U
C-NV, Replicate 3	2	2	5.69 B	3.22 U	3.07 U	5.40 U	3.40 (b)	8.74 U
RSD			17%	NA	NA	NA	9%	NA
SF COMP, Replicate 1	2	3	3.24 B	3.29 U	3.13 U	5.51 U	3.12 (b)B	8.91 U
SF COMP, Replicate 2	2	3	2.56 B	3.29 U	3.13 U	5.51 U	2.59 U	8.91 U
SF COMP, Replicate 3	2	3	3.11 B	3.29 U	3.93	5.51 U	3.44 (b)B	8.91 U
RSD			12%	NA	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample is less than five times value in associated method blank.
(d) NA Not applicable.

TABLE P.8. Quality Control Data for High Molecular Weight Polynuclear Aromatic Hydrocarbons, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens (ug/kg wet weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Method Blanks												
Blank-1		1	3.22 U(a)	5.66 (b)	1.96 (b)	1.28 U	0.54 U	1.62 U	1.55 U	5.32 (b)	5.73 U	4.74 U
Blank-1		2	3.26 U	5.66 (b)	1.96 (b)	1.29 U	0.55 U	1.63 U	1.57 U	5.37 U	5.79 U	4.79 U
Blank-1		3	3.45 U	6.24 (b)	2.30	2.34 (b)	5.66 (b)	5.42 (b)	2.95 (b)	5.70 U	6.14 U	6.21 (b)
Matrix Spikes												
UIH COMP	5	1	9.56 (b)	11.0 B(c)	3.95 (b)B	2.52 U	1.07 U	9.38 (b)	5.64 (b)	10.5 U	11.3 U	9.34 U
UIH COMP, MS	5	1	93.0	84.2	80.8	81.2	105	105	101	95.9	97.2	98.5
Concentration Recovered			83.4	73.2	76.9	81.2	105	95.6	95.4	95.9	97.2	98.5
Amount Spiked			89.6	89.6	89.6	89.6	89.6	89.6	89.6	89.6	89.6	89.6
Percent Recovery			93%	82%	86%	91%	117%	107%	106%	107%	108%	110%
C-NV	3	2	10.0 (b)	11.3 (b)B	4.41 (b)B	2.56 U	1.09 U	3.23 U	5.62 (b)	10.6 U	11.5 U	9.48 U
C-NV, MS	3	2	102	92.3	89.2	89.3	102	107	103	105	107	110
Concentration Recovered			92.0	81.0	84.8	89.3	102	107	97.4	105	107	110
Amount Spiked			96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9
Percent Recovery			95%	84%	88%	92%	105%	110%	100%	108%	110%	114%
N. virens Background	1	3	9.95 (b)	12.8 (b)B	4.42 (b)B	4.18 (b)B	10.6 (b)B	10.1 (b)B	7.40 (b)B	10.9 U	11.7 U	9.68 U
N. virens Background, MS	1	3	99.8	88.6	86.7	87.1	101	107	103	118	107	118
Concentration Recovered			89.9	75.8	82.3	82.9	90.4	96.9	95.6	118	107	118
Amount Spiked			96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9	96.9
Percent Recovery			93%	78%	85%	86%	93%	100%	99%	122% (d)	110%	122% (d)
Standard Reference Material												
Certified SRM not available for PAHs.												

TABLE P.8. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens (ug/kg wet weight) Fluor-anthene	Pyrene	Benzo(a)-anthra-cene	Chrysene	Benzo(b)-fluor-anthene	Benzo(k)-fluor-anthene	Benzo(a)-pyrene	Indeno-(1,2,3-cd) pyrene	Dibenzo-(a,h) anthra-cene	Benzo-(g,h,i) perylene
Analytical Replicates												
SFW COMP, Replicate 1	1	1	11.6 (b)	10.4 (b)B	4.59 (b)B	4.62 (b)	9.94 (b)	9.06 (b)	8.51 (b)	9.98 U	10.8 U	15.0 (b)
SFW COMP, Replicate 2	1	1	11.6 (b)	12.8 B	4.55 (b)B	2.48	10.1 (b)	9.21 (b)	7.45 (b)	10.3 U	11.1 U	9.19 U
SFW COMP, Replicate 3	1	1	11.2 (b)	10.6 (b)B	3.70 B	4.05 (b)	1.05 U	10.3 (b)	7.30 (b)	10.3 U	11.1 U	9.14 U
RSD			2%	12%	12%	30%	NA (e)	7%	9%	NA	NA	NA
C-NV, Replicate 1	2	2	10.2 (b)	11.5 (b)B	4.42 (b)B	2.61 U	1.11 U	9.55 (b)	6.67 (b)	10.9 U	11.7 U	12.3
C-NV, Replicate 2	2	2	9.67 (b)	11.3 (b)B	3.99 (b)B	2.60 U	1.11 U	3.28 U	5.88 (b)	10.8 U	11.6 U	9.63 U
C-NV, Replicate 3	2	2	10.0 (b)	11.4 (b)B	4.25 (b)B	4.17 (b)	1.09 U	3.23 U	5.51 (b)	10.6 U	11.5 U	9.48 U
RSD			3%	1%	5%	NA	NA	NA	10%	NA	NA	NA
SF COMP, Replicate 1	2	3	10.3 (b)	11.2 (b)B	4.91 (b)B	2.61 U	10.5 (b)B	9.58 (b)B	9.68 (b)B	10.9 U	11.7 U	9.68 U
SF COMP, Replicate 2	2	3	10.2 (b)	11.3 (b)B	4.33 (b)B	4.33 (b)B	10.7 (b)B	9.83 (b)B	8.43 (b)B	10.9 U	11.7 U	9.68 U
SF COMP, Replicate 3	2	3	10.3 (b)	11.4 (b)B	4.40 (b)B	4.11 (b)B	10.5 (b)B	9.69 (b)B	9.64 (b)B	10.9 U	11.7 U	9.68 U
RSD			1%	1%	7%	NA	1%	1%	8%	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) Ratio of confirmation ion to primary ion is outside of the theoretical ratio of 20% established for EPA-CLP programs.
(c) B Analyte detected in sample is less than five times value in associated method blank.
(d) Outside quality control criteria (40-120%) for matrix spike recoveries.
(e) NA Not applicable.

TABLE P.9. Phthalate Esters, Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens phthalate esters (ug/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
SF COMP	1	1	13.45	288 U(a)	288 U	288 U	288 U	351	288 U
SF COMP, Replicate 1	2	3	13.61	588 U	588 U	588 U	604	1010	588 U
SF COMP, Replicate 2	2	3	13.61	588 U	588 U	588 U	588 U	697	588 U
SF COMP, Replicate 3	2	3	13.61	588 U	588 U	588 U	588 U	1270	588 U
SF COMP	3	1	13.25	299 U	299 U	299 U	299 U	299 U	299 U
SF COMP	4	1	13.42	292 U	292 U	292 U	1006	564	292 U
SF COMP	5	2	12.94	306 U	321	306 U	529	1140	306 U
SFW COMP, Replicate 1	1	1	12.99	567 U	567 U	567 U	567 U	567 U	567 U
SFW COMP, Replicate 2	1	1	13.36	569 U	569 U	569 U	569 U	569 U	569 U
SFW COMP, Replicate 3	1	1	13.85	546 U	546 U	546 U	546 U	546 U	546 U
SFW COMP	2	2	12.32	321 U	321 U	321 U	537	1240	321 U
SFW COMP	3	2	13.78	290 U	290 U	290 U	366	784	290 U
SFW COMP	4	1	13.08	300 U	300 U	300 U	300 U	757	300 U
SFW COMP	5	1	13.95	278 U	278 U	278 U	278 U	478	278 U
UIH COMP	1	2	13.70	286 U	286 U	286 U	286 U	1160	286 U
UIH COMP	2	1	13.21	303 U	303 U	303 U	303 U	481	303 U
UIH COMP	3	3	13.03	307 U	307 U	307 U	646	829	307 U
UIH COMP	4	1	13.28	301 U	301 U	301 U	301 U	499	301 U
UIH COMP	5	1	12.99	594 U	594 U	594 U	594 U	665	594 U
TB Upper COMP	1	1	14.09	281 U	281 U	281 U	281 U	1120	281 U
TB Upper COMP	2	1	13.33	294 U	294 U	294 U	294 U	335	294 U
TB Upper COMP	3	2	13.17	298 U	298 U	298 U	323	964	298 U
TB Upper COMP	4	1	13.45	286 U	286 U	286 U	286 U	391	1180
TB Upper COMP	5	2	14.65	268 U	268 U	268 U	268 U	846	268 U
TB Lower COMP	1	2	13.26	296 U	296 U	296 U	296 U	958	296 U
TB Lower COMP	2	1	12.88	307 U	307 U	307 U	307 U	521	307 U
TB Lower COMP	3	2	13.79	287 U	287 U	287 U	287 U	631	287 U
TB Lower COMP	4	2	12.49	317 U	317 U	317 U	378	1170	317 U
TB Lower COMP	5	2	13.61	294 U	294 U	294 U	294 U	629	294 U
R-OS	1	2	14.02	282 U	282 U	282 U	282 U	785	282 U
R-OS	2	1	13.37	299 U	299 U	299 U	299 U	441	299 U
R-OS	3	1	13.54	292 U	292 U	292 U	292 U	303	292 U
R-OS	4	2	13.97	283 U	283 U	283 U	407	945	283 U
R-OS	5	1	13.34	294 U	294 U	294 U	294 U	294 U	294 U
R-BF	1	1	14.51	267 U	267 U	267 U	267 U	307	267 U
R-BF	2	2	13.20	303 U	303 U	303 U	303 U	717	303 U
R-BF	3	2	13.95	284 U	284 U	284 U	366	652	284 U
R-BF	4	2	12.57	315 U	315 U	315 U	315 U	649	315 U
R-BF	5	2	13.94	284 U	284 U	284 U	284 U	421	284 U
R-AM COMP	1	1	13.57	283 U	283 U	283 U	283 U	588	283 U
R-AM COMP	2	2	13.43	292 U	292 U	292 U	396	1360	292 U
R-AM COMP	3	2	13.95	281 U	281 U	281 U	281 U	669	281 U
R-AM COMP	4	1	13.45	291 U	291 U	291 U	291 U	345	291 U
R-AM COMP	5	3	13.75	291 U	291 U	291 U	401	640	291 U

TABLE P.9. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens phthalate esters (ug/kg dry weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
C-NV	1	1	12.66	310 U	310 U	310 U	310 U	932	310 U
C-NV, Replicate 1	2	2	14.27	561 U	561 U	561 U	799	1230	561 U
C-NV, Replicate 2	2	2	14.27	558 U	558 U	558 U	558 U	1140	558 U
C-NV, Replicate 3	2	2	14.27	549 U	549 U	549 U	549 U	1030	549 U
C-NV	3	2	13.15	596 U	596 U	596 U	596 U	1050	596 U
C-NV	4	3	13.21	303 U	303 U	303 U	303 U	969	303 U
N. virens Background	1	3	14.64	546 U	546 U	546 U	546 U	1150	546 U
N. virens Background	2	3	13.30	295 U	295 U	295 U	374	409	295 U
N. virens Background	3	3	13.79	290 U	290 U	290 U	351	661	290 U
N. virens Background	4	3	14.11	283 U	312	283 U	283 U	692	283 U
N. virens Background	5	3	13.99	277 U	277 U	277 U	277 U	552	277 U

(a) U Undetected at or above detection limit.

TABLE P.10. Phthalate Esters, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Target DL(a)			20	20	20	20	20	20
Achieved DL			19.2-80.0(b)	19.2-80.0(b)	19.2-80.0(b)	19.2-80.0(b)	19.2-80.0(b)	19.2-80.0(b)
SF COMP	1	1	38.8 U(c)	38.8 U	38.8 U	38.8 U	47.2	38.8 U
SF COMP, Replicate 1	2	3	80.0 U	80.0 U	80.0 U	82.2	137	80.0 U
SF COMP, Replicate 2	2	3	80.0 U	80.0 U	80.0 U	80.0 U	94.9	80.0 U
SF COMP, Replicate 3	2	3	80.0 U	80.0 U	80.0 U	80.0 U	173	80.0 U
SF COMP	3	1	39.6 U	39.6 U	39.6 U	39.6 U	39.6 U	39.6 U
SF COMP	4	1	39.2 U	39.2 U	39.2 U	135	75.7	39.2 U
SF COMP	5	2	39.6 U	41.5	39.6 U	68.5	148	39.6 U
SFW COMP, Replicate 1	1	1	73.6 U	73.6 U	73.6 U	73.6 U	73.6 U	73.6 U
SFW COMP, Replicate 2	1	1	76.0 U	76.0 U	76.0 U	76.0 U	76.0 U	76.0 U
SFW COMP, Replicate 3	1	1	75.6 U	75.6 U	75.6 U	75.6 U	75.6 U	75.6 U
SFW COMP	2	2	39.6 U	39.6 U	39.6 U	66.1	153	39.6 U
SFW COMP	3	2	40.0 U	40.0 U	40.0 U	50.4	108	40.0 U
SFW COMP	4	1	39.2 U	39.2 U	39.2 U	39.2 U	99.0	39.2 U
SFW COMP	5	1	38.8 U	38.8 U	38.8 U	38.8 U	66.7	38.8 U
UIH COMP	1	2	39.2 U	39.2 U	39.2 U	39.2 U	159	39.2 U
UIH COMP	2	1	40.0 U	40.0 U	40.0 U	40.0 U	63.5	40.0 U
UIH COMP	3	3	40.0 U	40.0 U	40.0 U	84.2	108	40.0 U
UIH COMP	4	1	40.0 U	40.0 U	40.0 U	40.0 U	66.3	40.0 U
UIH COMP	5	1	77.2 U	77.2 U	77.2 U	77.2 U	86.4	77.2 U
TB Upper COMP	1	1	39.6 U	39.6 U	39.6 U	39.6 U	158	39.6 U
TB Upper COMP	2	1	39.2 U	39.2 U	39.2 U	39.2 U	44.6	39.2 U
TB Upper COMP	3	2	39.2 U	39.2 U	39.2 U	42.6	127	39.2 U
TB Upper COMP	4	1	38.4 U	38.4 U	38.4 U	38.4 U	52.6	159
TB Upper COMP	5	2	39.2 U	39.2 U	39.2 U	39.2 U	124	39.2 U
TB Lower COMP	1	2	39.2 U	39.2 U	39.2 U	39.2 U	127	39.2 U
TB Lower COMP	2	1	39.6 U	39.6 U	39.6 U	39.6 U	67.1	39.6 U
TB Lower COMP	3	2	39.6 U	39.6 U	39.6 U	39.6 U	87.0	39.6 U
TB Lower COMP	4	2	39.6 U	39.6 U	39.6 U	47.2	146	39.6 U
TB Lower COMP	5	2	40.0 U	40.0 U	40.0 U	40.0 U	85.6	40.0 U
R-OS	1	2	39.6 U	39.6 U	39.6 U	39.6 U	110	39.6 U
R-OS	2	1	40.0 U	40.0 U	40.0 U	40.0 U	58.9	40.0 U
R-OS	3	1	39.6 U	39.6 U	39.6 U	39.6 U	41.0	39.6 U
R-OS	4	2	39.6 U	39.6 U	39.6 U	56.8	132	39.6 U
R-OS	5	1	39.2 U	39.2 U	39.2 U	39.2 U	39.2 U	39.2 U
R-BF	1	1	38.8 U	38.8 U	38.8 U	38.8 U	44.5	38.8 U
R-BF	2	2	40.0 U	40.0 U	40.0 U	40.0 U	94.6	40.0 U
R-BF	3	2	39.6 U	39.6 U	39.6 U	51.1	91.0	39.6 U
R-BF	4	2	39.6 U	39.6 U	39.6 U	39.6 U	81.6	39.6 U
R-BF	5	2	39.6 U	39.6 U	39.6 U	39.6 U	58.7	39.6 U
R-AM COMP	1	1	38.4 U	38.4 U	38.4 U	38.4 U	79.8	38.4 U
R-AM COMP	2	2	39.2 U	39.2 U	39.2 U	53.2	183	39.2 U
R-AM COMP	3	2	39.2 U	39.2 U	39.2 U	39.2 U	93.3	39.2 U
R-AM COMP	4	1	39.2 U	39.2 U	39.2 U	39.2 U	46.4	39.2 U
R-AM COMP	5	3	40.0 U	40.0 U	40.0 U	55.2	88.0	40.0 U

TABLE P.10. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens phthalate esters (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
C-NV	1	1	39.2 U	39.2 U	39.2 U	39.2 U	118	39.2 U
C-NV, Replicate 1	2	2	80.0 U	80.0 U	80.0 U	114	176	80.0 U
C-NV, Replicate 2	2	2	79.6 U	79.6 U	79.6 U	79.6 U	162	79.6 U
C-NV, Replicate 3	2	2	78.4 U	78.4 U	78.4 U	78.4 U	147	78.4 U
C-NV	3	2	78.4 U	78.4 U	78.4 U	78.4 U	138	78.4 U
C-NV	4	3	40.0 U	40.0 U	40.0 U	40.0 U	128	40.0 U
N. virens Background	1	3	80.0 U	80.0 U	80.0 U	80.0 U	169	80.0 U
N. virens Background	2	3	39.2 U	39.2 U	39.2 U	49.8	54.4	39.2 U
N. virens Background	3	3	40.0 U	40.0 U	40.0 U	48.4	91.2	40.0 U
N. virens Background	4	3	40.0 U	44.0	40.0 U	40.0 U	97.7	40.0 U
N. virens Background	5	3	38.8 U	38.8 U	38.8 U	38.8 U	77.2	38.8 U

(a) DL Detection limit.
(b) Detection limit derived from lowest calibration standard as sample.
(c) U Undetected at or above detection limit.

TABLE P.11. Quality Control Data for Phthalate Esters, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens phthalates (ug/kg wet weight) Dimethyl Phthalate	Diethyl Phthalate	Di-n-butyl Phthalate	Butyl benzyl Phthalate	Bis (2-ethylhexyl) Phthalate	Di-n-octyl Phthalate
Method Blanks								
Blank-1		1	39.2 U(a)	39.2 U	39.2 U	39.2 U	39.2 U	39.2 U
Blank-1		2	39.6 U	39.6 U	39.6 U	39.6 U	39.6 U	39.6 U
Blank-1		3	42.0 U	42.0 U	42.0 U	42.0 U	42.0 U	42.0 U
Matrix Spikes								
UIH COMP	5	1	77.2 U	77.2 U	77.2 U	77.2 U	86.4	77.2 U
UIH COMP, MS	5	1	973	1100	1480	1640	1840	2380
Concentration Recovered			973	1100	1480	1640	1750	2380
Amount Spiked			1430	1430	1430	1430	1430	1430
Percent Recovery			68%	77%	103%	115%	122% (b)	166% (b)
C-NV	3	2	78.4 U	78.4 U	78.4 U	78.4 U	138	78.4 U
C-NV, MS	3	2	437	520	1230	1490	1770	2050
Concentration Recovered			437	520	1230	1490	1630	2050
Amount Spiked			1550	1550	1550	1550	1550	1550
Percent Recovery			28% (b)	34% (b)	79%	96%	105%	132% (b)
N. virens Background	1	3	80.0 U	80.0 U	80.0 U	80.0 U	169	80.0 U
N. virens Background, MS	1	3	1140	1210	1440	1630	1820	2170
Concentration Recovered			1140	1210	1440	1630	1650	2170
Amount Spiked			1550	1550	1550	1550	1550	1550
Percent Recovery			74%	78%	93%	105%	106%	140% (b)
Standard Reference Material								
Certified SRM not available for phthalates.								
Analytical Replicates								
SFW COMP, Replicate 1	1	1	73.6 U	73.6 U	73.6 U	73.6 U	73.6 U	73.6 U
SFW COMP, Replicate 2	1	1	76.0 U	76.0 U	76.0 U	76.0 U	76.0 U	76.0 U
SFW COMP, Replicate 3	1	1	75.6 U	75.6 U	75.6 U	75.6 U	75.6 U	75.6 U
RSD			NA (c)	NA	NA	NA	NA	NA
C-NV, Replicate 1	2	2	80.0 U	80.0 U	80.0 U	114	176	80.0 U
C-NV, Replicate 2	2	2	79.6 U	79.6 U	79.6 U	79.6 U	162	79.6 U
C-NV, Replicate 3	2	2	78.4 U	78.4 U	78.4 U	78.4 U	147	78.4 U
RSD			NA	NA	NA	NA	9%	NA
SF COMP, Replicate 1	2	3	80.0 U	80.0 U	80.0 U	82.2	137	80.0 U
SF COMP, Replicate 2	2	3	80.0 U	80.0 U	80.0 U	80.0 U	94.9	80.0 U
SF COMP, Replicate 3	2	3	80.0 U	80.0 U	80.0 U	80.0 U	173	80.0 U
RSD			NA	NA	NA	NA	29%	NA

(a) U Undetected at or above detection limit.
(b) Outside quality control criteria (40-120%) for matrix spike recoveries.
(c) NA Not applicable.

TABLE P.12. Surrogate Percent Recoveries for Polynuclear Aromatic Hydrocarbons, Including Quality Control Data, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naptha-lene d8	Acenaph-thene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
SF COMP	1	1	70	74	77	70
SF COMP, Replicate 1	2	3	77	86	94	85
SF COMP, Replicate 2	2	3	86	90	77	88
SF COMP, Replicate 3	2	3	75	82	90	81
SF COMP	3	1	73	75	74	60
SF COMP	4	1	75	78	82	77
SF COMP	5	2	70	73	68	63
SFW COMP, Replicate 1	1	1	73	76	76	63
SFW COMP, Replicate 2	1	1	74	76	82	64
SFW COMP, Replicate 3	1	1	74	75	62	62
SFW COMP	2	2	72	77	80	78
SFW COMP	3	2	74	77	77	67
SFW COMP	4	1	72	76	74	68
SFW COMP	5	1	58	63	65	61
UIH COMP	1	2	76	81	84	83
UIH COMP	2	1	62	64	68	58
UIH COMP	3	3	83	88	92	78
UIH COMP	4	1	64	68	72	67
UIH COMP	5	1	68	71	70	65
TB Upper COMP	1	1	63	66	69	63
TB Upper COMP	2	1	70	74	83	77
TB Upper COMP	3	2	71	76	80	77
TB Upper COMP	4	1	63	66	70	56
TB Upper COMP	5	2	70	73	76	73
TB Lower COMP	1	2	71	75	81	78
TB Lower COMP	2	1	68	71	74	68
TB Lower COMP	3	2	86	89	88	85
TB Lower COMP	4	2	73	77	80	76
TB Lower COMP	5	2	76	77	77	85
R-OS	1	2	70	69	69	67
R-OS	2	1	64	68	73	65
R-OS	3	1	68	69	73	64
R-OS	4	2	76	80	82	77
R-OS	5	1	67	70	74	62

TABLE P.12. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naptha-lene d8	Acenaph-thene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
R-BF	1	1	71	75	78	69
R-BF	2	2	72	74	79	75
R-BF	3	2	84	87	89	82
R-BF	4	2	73	74	76	71
R-BF	5	2	79	81	82	79
R-AM COMP	1	1	67	71	74	72
R-AM COMP	2	2	73	76	78	71
R-AM COMP	3	2	76	78	75	70
R-AM COMP	4	1	65	69	70	64
R-AM COMP	5	3	70	88	93	82
C-NV	1	1	66	69	72	64
C-NV, Replicate 1	2	2	93	93	68	70
C-NV, Replicate 2	2	2	74	80	81	68
C-NV, Replicate 3	2	2	80	81	82	72
C-NV	3	2	87	88	86	78
C-NV	4	3	75	80	83	78
N. virens Background	1	3	70	74	76	72
N. virens Background	2	3	62	67	70	65
N. virens Background	3	3	79	82	87	80
N. virens Background	4	3	79	84	87	83
N. virens Background	5	3	75	80	82	76
Quality Control Data						
Method Blanks						
Blank-1		1	72	70	84	33
Blank-1		2	92	89	89	46
Blank-1		3	82	77	77	47
Matrix Spikes						
UIH COMP	5	1	68	71	70	65
UIH COMP, MS	5	1	76	78	80	75
C-NV	3	2	87	88	86	78
C-NV, MS	3	2	79	81	80	76
N. virens Background	1	3	70	74	76	72
N. virens Background, MS	1	3	70	72	77	69

TABLE P.12. (contd)

Sediment Treatment	Replicate	Analytical Batch	Surrogate Percent Recoveries: Naptha-lene d8	Acenaph-thene d10	Chrysene d12	Dibenzo (a,h,i) Anthracene d14
Analytical Replicates						
SFW COMP, Replicate 1	1	1	73	76	76	63
SFW COMP, Replicate 2	1	1	74	76	82	64
SFW COMP, Replicate 3	1	1	74	75	62	62
C-NV, Replicate 1	2	2	93	93	68	70
C-NV, Replicate 2	2	2	74	80	81	68
C-NV, Replicate 3	2	2	80	81	82	72
SF COMP, Replicate 1	2	3	77	86	94	85
SF COMP, Replicate 2	2	3	86	90	77	88
SF COMP, Replicate 3	2	3	75	82	90	81

TABLE P.13. Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Pesticides (ug/kg dry weight)								
				Aldrin	Alpha-BHC	Beta BHC	Delta BHC	Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
SF COMP	1	1	13.45	1.3 U(a)	3.6 U	3.6 U	3.6 U	1.7 U	220 U	102	7.73	52.9
SF COMP, Replicate 1	2	3	13.61	8.60	7.2 U	7.2 U	7.2 U	3.5 U	220 U	90.4	12.4	63.9
SF COMP, Replicate 2	2	3	13.61	2.7 U	7.3 U	7.3 U	7.3 U	3.5 U	220 U	88.2	9.33	58.6
SF COMP, Replicate 3	2	3	13.61	9.55	7.2 U	7.2 U	7.2 U	3.5 U	220 U	91.8	14.7	50.6
SF COMP	3	1	13.25	1.4 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	111	9.06	23.7 U
SF COMP	4	1	13.42	1.3 U	3.7 U	3.7 U	3.7 U	1.8 U	220 U	210	9.61	32.0
SF COMP	5	2	12.94	1.4 U	3.9 U	3.9 U	3.9 U	1.9 U	230 U	177	10.0	21.6
SFW COMP, Replicate 1	1	1	12.99	19.9	7.1 U	7.1 U	7.1 U	3.4 U	230 U	247	2.0 U	44.0
SFW COMP, Replicate 2	1	1	13.36	19.9	6.9 U	6.9 U	6.9 U	3.3 U	230 U	203	1.9 U	36.8
SFW COMP, Replicate 3	1	1	13.85	19.0	6.9 U	6.9 U	6.9 U	3.3 U	220 U	168	1.9 U	27.9
SFW COMP	2	2	12.32	1.5 U	4.1 U	4.1 U	4.1 U	1.9 U	240 U	372	1.1 U	27.3
SFW COMP	3	2	13.78	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	342	1.0 U	29.2
SFW COMP	4	1	13.08	11.0	3.7 U	3.7 U	3.7 U	1.8 U	230 U	310	1.1 U	33.4
SFW COMP	5	1	13.95	11.2	3.5 U	3.5 U	3.5 U	1.6 U	220 U	642	1.0 U	45.6
UIH COMP	1	2	13.70	1.3 U	3.6 U	3.6 U	3.6 U	1.8 U	220 U	17.6	1.0 U	39.6
UIH COMP	2	1	13.21	1.4 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	37.6	1.1 U	24.1
UIH COMP	3	3	13.03	1.4 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	79.8	9.13	47.4
UIH COMP	4	1	13.28	1.4 U	3.7 U	3.7 U	3.7 U	1.8 U	230 U	78.2	8.28	2.6 U
UIH COMP	5	1	12.99	2.7 U	7.5 U	7.5 U	7.5 U	3.6 U	230 U	70.4	2.1 U	5.3 U
TB Upper COMP	1	1	14.09	1.3 U	3.5 U	3.5 U	3.5 U	1.7 U	210 U	3.3 U	1.0 U	2.5 U
TB Upper COMP	2	1	13.33	1.4 U	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.5 U	1.1 U	2.6 U
TB Upper COMP	3	2	13.17	1.4 U	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.5 U	1.1 U	2.7 U
TB Upper COMP	4	1	13.45	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.0 U	15.0
TB Upper COMP	5	2	14.65	1.2 U	3.3 U	3.3 U	3.3 U	1.6 U	210 U	3.1 U	1.0 U	18.1
TB Lower COMP	1	2	13.26	1.4 U	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.5 U	1.1 U	18.3
TB Lower COMP	2	1	12.88	1.4 U	3.9 U	3.9 U	3.9 U	1.9 U	230 U	3.6 U	1.1 U	16.3
TB Lower COMP	3	2	13.79	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.0 U	13.6
TB Lower COMP	4	2	12.49	1.4 U	4.0 U	4.0 U	4.0 U	1.9 U	240 U	3.7 U	1.1 U	15.6
TB Lower COMP	5	4	13.61	1.3 U	3.7 U	3.7 U	3.7 U	1.8 U	220 U	3.5 U	1.0 U	2.6 U
R-OS	1	2	14.02	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	210 U	3.3 U	1.0 U	18.4
R-OS	2	1	13.37	1.3 U	3.7 U	3.7 U	3.7 U	1.8 U	220 U	3.5 U	1.0 U	2.7 U
R-OS	3	1	13.54	1.3 U	3.7 U	3.7 U	3.7 U	1.8 U	220 U	3.4 U	1.0 U	2.6 U
R-OS	4	2	13.97	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.0 U	2.5 U
R-OS	5	1	13.34	1.3 U	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.4 U	1.0 U	2.6 U

TABLE P.13. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Pesticides (ug/kg dry weight)								
				Aldrin	Alpha-BHC	Beta BHC	Delta BHC	Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
R-BF	1	1	14.51	1.2 U	3.4 U	3.4 U	3.4 U	1.6 U	210 U	3.2 U	1.0 U	2.4 U
R-BF	2	2	13.20	1.4 U	3.8 U	3.8 U	3.8 U	1.8 U	230 U	3.6 U	1.1 U	24.1
R-BF	3	2	13.95	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.0 U	18.7
R-BF	4	2	12.57	1.4 U	4.0 U	4.0 U	4.0 U	1.9 U	240 U	3.7 U	1.1 U	2.8 U
R-BF	5	2	13.94	1.3 U	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	1.0 U	15.7
R-AM COMP	1	1	13.57	1.3 U	3.5 U	3.5 U	3.5 U	1.7 U	220 U	3.3 U	1.0 U	17.9
R-AM COMP	2	2	13.43	1.3 U	3.6 U	3.6 U	3.6 U	1.8 U	220 U	3.4 U	1.0 U	20.6
R-AM COMP	3	2	13.95	1.3 U	2.9 U	3.5 U	3.5 U	1.7 U	220 U	3.3 U	1.0 U	17.5
R-AM COMP	4	1	13.45	1.3 U	3.6 U	3.6 U	3.6 U	1.8 U	220 U	3.4 U	1.0 U	2.6 U
R-AM COMP	5	3	13.75	17.3	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.4 U	1.0 U	33.7
C-NV	1	1	12.66	1.4 U	3.9 U	3.9 U	3.9 U	1.9 U	240 U	3.6 U	1.1 U	2.8 U
C-NV, Replicate 1	2	2	14.27	2.5 U	7.01 U	7.01 U	7.01 U	3.4 U	210 U	6.6 U	2.0 U	43.6
C-NV, Replicate 2	2	2	14.27	2.5 U	7.01 U	7.01 U	7.01 U	3.4 U	210 U	6.6 U	2.0 U	30.6
C-NV, Replicate 3	2	2	14.27	2.5 U	7.01 U	7.01 U	7.01 U	3.4 U	210 U	6.6 U	2.0 U	26.2
C-NV	3	2	13.15	2.7 U	7.5 U	7.5 U	7.5 U	3.6 U	230 U	7.0 U	2.1 U	21.6
C-NV(b)	4	3	13.21	16.5	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.5 U	1.1 U	37.5
N. virens Background	1	3	14.64	2.5 U	6.8 U	6.8 U	6.8 U	3.3 U	210 U	6.4 U	1.9 U	4.8 U
N. virens Background	2	3	13.30	12.0	3.7 U	3.7 U	3.7 U	1.8 U	230 U	3.5 U	8.87	2.6 U
N. virens Background	3	3	13.79	13.5	3.6 U	3.6 U	3.6 U	1.7 U	220 U	3.3 U	7.90	2.5 U
N. virens Background	4	3	14.11	9.78	3.5 U	3.5 U	3.5 U	1.6 U	210 U	3.3 U	1.0 U	2.5 U
N. virens Background	5	3	13.99	11.3	3.5 U	3.5 U	3.5 U	1.6 U	210 U	3.3 U	1.0 U	2.5 U

(a) U Undetected at or above detection limit.
(b) Insufficient organisms to test all five replicates.

TABLE P.14. Chlorinated Pesticides (alphabetical, Dieldrin - Toxaphene), Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Pesticides (ug/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
SF COMP	1	1	13.45	43.4	3.6 U(a)	36.4 U	3.6 U	3.6 U	3.6 U	1.1 U	3.5 U	220 U
SF COMP, Replicate 1	2	3	13.61	47.5	7.2 U	7.2 U	7.2 U	7.2 U	7.2 U	2.1 U	7.0 U	220 U
SF COMP, Replicate 2	2	3	13.61	45.6	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	2.2 U	7.1 U	220 U
SF COMP, Replicate 3	2	3	13.61	49.1	7.2 U	7.2 U	7.2 U	7.2 U	7.2 U	2.1 U	7.0 U	220 U
SF COMP	3	1	13.25	45.9	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.1 U	3.6 U	230 U
SF COMP	4	1	13.42	60.6	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	220 U
SF COMP	5	2	12.94	40.7	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.2 U	3.7 U	230 U
SFW COMP, Replicate 1	1	1	12.99	158	7.1 U	7.1 U	7.1 U	7.1 U	7.1 U	2.2 U	6.9 U	230 U
SFW COMP, Replicate 2	1	1	13.36	129	6.9 U	6.9 U	6.9 U	6.9 U	6.9 U	2.1 U	6.7 U	230 U
SFW COMP, Replicate 3	1	1	13.85	109	6.9 U	6.9 U	6.9 U	6.9 U	6.9 U	2.0 U	6.7 U	220 U
SFW COMP	2	2	12.32	165	4.1 U	4.1 U	4.1 U	4.1 U	4.1 U	1.2 U	3.9 U	240 U
SFW COMP	3	2	13.78	132	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.6 U	220 U
SFW COMP	4	1	13.08	127	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.7 U	230 U
SFW COMP	5	1	13.95	198	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	1.1 U	3.4 U	220 U
UIH COMP	1	2	13.70	22.5	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.5 U	220 U
UIH COMP	2	1	13.21	31.9	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.1 U	3.7 U	230 U
UIH COMP	3	3	13.03	31.5	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.2 U	3.8 U	230 U
UIH COMP	4	1	13.28	28.2	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
UIH COMP	5	1	12.99	30.6	7.5 U	7.5 U	7.5 U	7.5 U	7.5 U	2.2 U	7.2 U	230 U
TB Upper COMP	1	1	14.09	2.2 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	1.1 U	3.4 U	210 U
TB Upper COMP	2	1	13.33	6.5	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
TB Upper COMP	3	2	13.17	2.4 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
TB Upper COMP	4	1	13.45	2.3 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.0 U	3.5 U	220 U
TB Upper COMP	5	2	14.65	2.1 U	3.3 U	3.3 U	3.3 U	3.3 U	3.3 U	1.0 U	3.3 U	210 U
TB Lower COMP	1	2	13.26	2.3 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
TB Lower COMP	2	1	12.88	2.4 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.2 U	3.7 U	230 U
TB Lower COMP	3	2	13.79	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.5 U	220 U
TB Lower COMP	4	2	12.49	2.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.2 U	3.8 U	240 U
TB Lower COMP	5	4	13.61	2.4 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	220 U

TABLE P.14. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Pesticides (ug/kg dry weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
R-OS	1	2	14.02	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.4 U	210 U
R-OS	2	1	13.37	2.4 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.7 U	220 U
R-OS	3	1	13.54	2.3 U	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.5 U	220 U
R-OS	4	2	13.97	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.4 U	220 U
R-OS	5	1	13.34	5.4	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
R-BF	1	1	14.51	2.1 U	3.4 U	3.4 U	3.4 U	3.4 U	3.4 U	1.0 U	3.2 U	210 U
R-BF	2	2	13.20	2.4 U	3.8 U	3.8 U	3.8 U	3.8 U	3.8 U	1.1 U	3.7 U	230 U
R-BF	3	2	13.95	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.4 U	220 U
R-BF	4	2	12.57	2.5 U	4.0 U	4.0 U	4.0 U	4.0 U	4.0 U	1.2 U	3.8 U	240 U
R-BF	5	2	13.94	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.4 U	220 U
R-AM COMP	1	1	13.57	2.3 U	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U	1.0 U	3.5 U	220 U
R-AM COMP	2	2	13.43	2.3 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.6 U	220 U
R-AM COMP	3	2	13.95	2.2 U	3.5 U	3.5 U	3.6 U	3.5 U	3.6 U	1.1 U	3.4 U	220 U
R-AM COMP	4	1	13.45	2.3 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.6 U	220 U
R-AM COMP	5	3	13.75	9.6	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.6 U	220 U
C-NV	1	1	12.66	2.4 U	3.9 U	3.9 U	3.9 U	3.9 U	3.9 U	1.2 U	3.8 U	240 U
C-NV, Replicate 1	2	2	14.27	4.5 U	7.01 U	7.01 U	7.01 U	7.01 U	7.01 U	2.1 U	6.9 U	210 U
C-NV, Replicate 2	2	2	14.27	4.5 U	7.01 U	7.01 U	7.01 U	7.01 U	7.01 U	2.1 U	6.9 U	210 U
C-NV, Replicate 3	2	2	14.27	4.5 U	7.01 U	7.01 U	7.01 U	7.01 U	7.01 U	2.1 U	6.9 U	210 U
C-NV	3	2	13.15	4.7 U	7.5 U	7.5 U	7.5 U	7.5 U	7.5 U	2.3 U	7.3 U	230 U
C-NV(b)	4	3	13.21	8.6	3.7 U	3.7 U	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
N. virens Background	1	3	14.64	4.3 U	6.8 U	6.8 U	6.8 U	6.8 U	6.8 U	2.0 U	6.6 U	210 U
N. virens Background	2	3	13.30	2.3 U	3.7 U	7.3	3.7 U	3.7 U	3.7 U	1.1 U	3.6 U	230 U
N. virens Background	3	3	13.79	2.2 U	3.6 U	3.6 U	3.6 U	3.6 U	3.6 U	1.1 U	3.5 U	220 U
N. virens Background	4	3	14.11	2.2 U	3.5 U	4.5	3.5 U	3.5 U	3.5 U	1.1 U	3.3 U	210 U
N. virens Background	5	3	13.99	2.2 U	3.5 U	4.9	3.5 U	3.5 U	3.5 U	1.1 U	3.4 U	210 U

(a) U Undetected at or above detection limit.
(b) Insufficient organisms to test all five replicates.

TABLE P.15. Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Target DL(a)			2	2	2	2	2	30	2	2	2
Achieved DL			0.09-0.36	0.24-1.00	0.24-1.00	0.24-1.00	0.12-0.48	30-30	0.23-0.94	0.07-0.28	0.17-0.71
SF COMP	1	1	0.18 U(b)	0.49 U	0.49 U	0.49 U	0.23 U	30 U	13.7	1.04	7.11
SF COMP, Replicate 1	2	3	1.17	0.98 U	0.98 U	0.98 U	0.47 U	30 U	12.3	1.69	8.69
SF COMP, Replicate 2	2	3	0.36 U	0.99 U	0.99 U	0.99 U	0.48 U	30 U	12.0	1.27	7.98
SF COMP, Replicate 3	2	3	1.30	0.98 U	0.98 U	0.98 U	0.47 U	30 U	12.5	2.00	6.89
SF COMP	3	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	14.8	1.20	3.14 U
SF COMP	4	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	28.2	1.29	4.30
SF COMP	5	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	22.9	1.30	2.80
SFW COMP, Replicate 1	1	1	2.59	0.92 U	0.92 U	0.92 U	0.44 U	30 U	32.1	0.26 U	5.72
SFW COMP, Replicate 2	1	1	2.66	0.92 U	0.92 U	0.92 U	0.44 U	30 U	27.1	0.26 U	4.92
SFW COMP, Replicate 3	1	1	2.63	0.95 U	0.95 U	0.95 U	0.46 U	30 U	23.2	0.26 U	3.87
SFW COMP	2	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	45.8	0.14 U	3.36
SFW COMP	3	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	47.1	0.14 U	4.03
SFW COMP	4	1	1.44	0.49 U	0.49 U	0.49 U	0.24 U	30 U	40.5	0.14 U	4.37
SFW COMP	5	1	1.56	0.49 U	0.49 U	0.49 U	0.23 U	30 U	89.6	0.14 U	6.36
UIH COMP	1	2	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	2.41	0.14 U	5.43
UIH COMP	2	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	4.97	0.14 U	3.19
UIH COMP	3	3	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	10.4	1.19	6.18
UIH COMP	4	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	10.4	1.10	0.35 U
UIH COMP	5	1	0.35 U	0.97 U	0.97 U	0.97 U	0.47 U	30 U	9.15	0.27 U	0.69 U
TB Upper COMP	1	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
TB Upper COMP	2	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
TB Upper COMP	3	2	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
TB Upper COMP	4	1	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	2.02
TB Upper COMP	5	2	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	2.65
TB Lower COMP	1	2	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	2.42
TB Lower COMP	2	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	2.10
TB Lower COMP	3	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	1.87
TB Lower COMP	4	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	1.95
TB Lower COMP	5	4	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U

TABLE P.15. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
R-OS	1	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	2.58
R-OS	2	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	0.36 U
R-OS	3	1	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-OS	4	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-OS	5	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-BF	1	1	0.18 U	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	0.35 U
R-BF	2	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	3.18
R-BF	3	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	2.61
R-BF	4	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-BF	5	2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	2.19
R-AM COMP	1	1	0.17 U	0.48 U	0.48 U	0.48 U	0.23 U	30 U	0.45 U	0.13 U	2.43
R-AM COMP	2	2	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	2.76
R-AM COMP	3	2	0.18 U	0.40 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	2.44
R-AM COMP	4	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
R-AM COMP	5	3	2.38	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.47 U	0.14 U	4.63
C-NV	1	1	0.18 U	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
C-NV, Replicate 1	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	6.22
C-NV, Replicate 2	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	4.36
C-NV, Replicate 3	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	3.74
C-NV	3	2	0.36 U	0.98 U	0.98 U	0.98 U	0.47 U	30 U	0.92 U	0.27 U	2.84
C-NV(c)	4	3	2.18	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	4.96
N. virens Background	1	3	0.36 U	0.99 U	0.99 U	0.99 U	0.48 U	30 U	0.93 U	0.28 U	0.70 U
N. virens Background	2	3	1.60	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	1.18	0.35 U
N. virens Background	3	3	1.86	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	1.09	0.35 U
N. virens Background	4	3	1.38	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	0.35 U
N. virens Background	5	3	1.58	0.49 U	0.49 U	0.49 U	0.23 U	30 U	0.46 U	0.14 U	0.35 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Insufficient organisms to test all five replicates.

TABLE P.16. Chlorinated Pesticides (alphabetical, Dieldrin - Toxaphene), Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
Target DL(a)			2	2	2	2	2	2	2	2	30
Achieved DL			0.15-0.64	0.24-1.00	0.24-1.00	0.24-1.00	0.24-1.00	0.24-1.00	0.07-0.30	0.24-0.98	30-30
SF COMP	1	1	5.84	0.49 U(b)	4.90 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
SF COMP, Replicate 1	2	3	6.47	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.29 U	0.95 U	30 U
SF COMP, Replicate 2	2	3	6.20	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.30 U	0.97 U	30 U
SF COMP, Replicate 3	2	3	6.68	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.29 U	0.95 U	30 U
SF COMP	3	1	6.08	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
SF COMP	4	1	8.13	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
SF COMP	5	2	5.27	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
SFW COMP, Replicate 1	1	1	20.5	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
SFW COMP, Replicate 2	1	1	17.2	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
SFW COMP, Replicate 3	1	1	15.1	0.95 U	0.95 U	0.95 U	0.95 U	0.95 U	0.28 U	0.93 U	30 U
SFW COMP	2	2	20.3	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
SFW COMP	3	2	18.2	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
SFW COMP	4	1	16.7	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
SFW COMP	5	1	27.7	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
UIH COMP	1	2	3.08	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
UIH COMP	2	1	4.21	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
UIH COMP	3	3	4.10	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
UIH COMP	4	1	3.75	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
UIH COMP	5	1	3.97	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.29 U	0.94 U	30 U
TB Upper COMP	1	1	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
TB Upper COMP	2	1	0.87	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
TB Upper COMP	3	2	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
TB Upper COMP	4	1	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
TB Upper COMP	5	2	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
TB Lower COMP	1	2	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
TB Lower COMP	2	1	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
TB Lower COMP	3	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
TB Lower COMP	4	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
TB Lower COMP	5	4	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U

TABLE P.16. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
R-OS	1	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-OS	2	1	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
R-OS	3	1	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-OS	4	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-OS	5	1	0.72	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-BF	1	1	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
R-BF	2	2	0.32 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
R-BF	3	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-BF	4	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-BF	5	2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
R-AM COMP	1	1	0.31 U	0.48 U	0.48 U	0.48 U	0.48 U	0.48 U	0.14 U	0.47 U	30 U
R-AM COMP	2	2	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-AM COMP	3	2	0.31 U	0.49 U	0.49 U	0.50 U	0.49 U	0.50 U	0.15 U	0.48 U	30 U
R-AM COMP	4	1	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
R-AM COMP	5	3	1.32	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.49 U	30 U
C-NV	1	1	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
C-NV, Replicate 1	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
C-NV, Replicate 2	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
C-NV, Replicate 3	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
C-NV	3	2	0.62 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.30 U	0.96 U	30 U
C-NV(c)	4	3	1.14	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
N. virens Background	1	3	0.63 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.30 U	0.97 U	30 U
N. virens Background	2	3	0.31 U	0.49 U	0.97	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
N. virens Background	3	3	0.31 U	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
N. virens Background	4	3	0.31 U	0.49 U	0.64	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U
N. virens Background	5	3	0.31 U	0.49 U	0.68	0.49 U	0.49 U	0.49 U	0.15 U	0.47 U	30 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Insufficient organisms to test all five replicates.

TABLE P.17. Quality Control Data for Chlorinated Pesticides (alphabetical, Aldrin - 4,4'-DDT), Wet Weight, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Chlordane	4,4'-DDD	4,4'-DDE	4,4'-DDT
Method Blanks											
Blank-1		1	0.18 U(a)	0.49 U	0.49 U	0.49 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
Blank-1		2	0.18 U	0.50 U	0.50 U	0.50 U	0.24 U	30 U	0.46 U	0.14 U	0.35 U
Blank-1		3	0.19 U	0.53 U	0.53 U	0.53 U	0.25 U	30 U	0.49 U	0.15 U	0.37 U
Matrix Spikes											
UIH COMP	5	1	0.35 U	NA (b)	NA	NA	0.47 U	NA	NA	NA	0.69 U
UIH COMP, MS	5	1	7.99	NA	NA	NA	5.42	NA	NA	NA	46.4
Concentration Recovered			7.99	NA	NA	NA	5.42	NA	NA	NA	46.4
Amount Spiked			8.95	NS (c)	NS	NS	8.95	NS	NS	NS	35.8
Percent Recovery			89	NA	NA	NA	61	NA	NA	NA	130 (d)
C-NV	3	2	0.36 U	NA	NA	NA	0.47 U	NA	NA	NA	2.84
C-NV, MS	3	2	8.56	NA	NA	NA	10.1	NA	NA	NA	40.9
Concentration Recovered			8.56	NA	NA	NA	10.1	NA	NA	NA	38.1
Amount Spiked			9.70	NS	NS	NS	9.70	NS	NS	NS	38.8
Percent Recovery			88	NA	NA	NA	104	NA	NA	NA	98
N. virens Background	1	3	0.36	NA	NA	NA	NA	NA	NA	NA	0.70
N. virens Background, MS	1	3	7.84	NA	NA	NA	NA	NA	NA	NA	36.0
Concentration Recovered			7.84	NA	NA	NA	NA	NA	NA	NA	35.3
Amount Spiked			9.70	NS	NS	NS	NS	NS	NS	NS	38.8
Percent Recovery			81%	NA	NA	NA	NA	NA	NA	NA	91%
Standard Reference Material											
Certified SRM not available for pesticides.											
Analytical Replicates											
SFW COMP, Replicate 1	1	1	2.59	0.92 U	0.92 U	0.92 U	0.44 U	30 U	32.1	0.26 U	5.72
SFW COMP, Replicate 2	1	1	2.66	0.92 U	0.92 U	0.92 U	0.44 U	30 U	27.1	0.26 U	4.92
SFW COMP, Replicate 3	1	1	2.63	0.95 U	0.95 U	0.95 U	0.46 U	30 U	23.2	0.26 U	3.87
RSD			1%	NA	NA	NA	NA	NA	16%	NA	19%
C-NV, Replicate 1	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	6.22
C-NV, Replicate 2	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	4.36
C-NV, Replicate 3	2	2	0.36 U	1.00 U	1.00 U	1.00 U	0.48 U	30 U	0.94 U	0.28 U	3.74
RSD			NA	NA	NA	NA	NA	NA	NA	NA	27%
SF COMP, Replicate 1	2	3	1.17	0.98 U	0.98 U	0.98 U	0.47 U	30 U	12.3	1.69	8.69
SF COMP, Replicate 2	2	3	0.36 U	0.99 U	0.99 U	0.99 U	0.48 U	30 U	12.0	1.27	7.98
SF COMP, Replicate 3	2	3	1.30	0.98 U	0.98 U	0.98 U	0.47 U	30 U	12.5	2.00	6.89
RSD			NA	NA	NA	NA	NA	NA	2%	22%	12%

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.
(d) Outside quality control criteria (40-120%) for matrix spike recoveries.

TABLE P.18. Quality Control Data for Chlorinated Pesticides (alphabetical, Dieldrin - Toxaphene), Wet Weight, in Tissue of N. virens
Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
Method Blanks											
Blank-1		1	0.31 U(a)	0.49 U	0.49 U	0.49 U	0.49 U	0.49 U	0.15 U	0.48 U	30 U
Blank-1		2	0.31 U	0.50 U	0.50 U	0.50 U	0.50 U	0.50 U	0.15 U	0.48 U	30 U
Blank-1		3	0.33 U	0.53 U	0.53 U	0.53 U	0.53 U	0.53 U	0.16 U	0.51 U	30 U
Matrix Spike											
UIH COMP	5	1	3.97	NA (b)	NA	NA	0.97 U	NA	0.29 U	NA	NA
UIH COMP, MS	5	1	34.1	NA	NA	NA	30.6	NA	10.2	NA	NA
Concentration Recovered			30.1	NA	NA	NA	30.6	NA	10.2	NA	NA
Amount Spiked			35.8	NS (c)	NS	NS	35.8	NS	8.95	NS	NS
Percent Recovery			84%	NA	NA	NA	85%	NA	114%	NA	NA
C-NV	3	2	0.62 U	NA	NA	NA	0.98 U	NA	0.30 U	NA	NA
C-NV, MS	3	2	35.2	NA	NA	NA	35.4	NA	7.90	NA	NA
Concentration Recovered			35.2	NA	NA	NA	35.4	NA	7.90	NA	NA
Amount Spiked			38.8	NS	NS	NS	38.8	NS	9.70	NS	NS
Percent Recovery			91%	NA	NA	NA	91%	NA	81%	NA	NA
N. virens Background	1	3	0.63	NA	NA	NA	0.99	NA	0.30	NA	NA
N. virens Background, MS	1	3	34.7	NA	NA	NA	34.5	NA	7.32	NA	NA
Concentration Recovered			34.7	NA	NA	NA	34.5	NA	7.32	NA	NA
Amount Spiked			38.8	NS	NS	NS	38.8	NS	9.70	NS	NS
Percent Recovery			89%	NA	NA	NA	89%	NA	75%	NA	NA
Standard Reference Material											
Certified SRM not available for pesticides.											
Analytical Replicates											
SFW COMP, Replicate 1	1	1	20.5	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
SFW COMP, Replicate 2	1	1	17.2	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.28 U	0.90 U	30 U
SFW COMP, Replicate 3	1	1	15.1	0.95 U	0.95 U	0.95 U	0.95 U	0.95 U	0.28 U	0.93 U	30 U
RSD			15%	NA	NA	NA	NA	NA	NA	NA	NA
C-NV, Replicate 1	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
C-NV, Replicate 2	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
C-NV, Replicate 3	2	2	0.64 U	1.00 U	1.00 U	1.00 U	1.00 U	1.00 U	0.30 U	0.98 U	30 U
RSD			NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE P.18. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens Pesticides (ug/kg wet weight) Dieldrin	Endo-Sulfan I	Endo-Sulfan II	Endo-Sulfan-Sulfate	Endrin	Endrin Aldehyde	Hepta-chlor	Hepta-chlor-epoxide	Toxa-phene
SF COMP, Replicate 1	2	3	6.47	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.29 U	0.95 U	30 U
SF COMP, Replicate 2	2	3	6.20	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.30 U	0.97 U	30 U
SF COMP, Replicate 3	2	3	6.68	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.29 U	0.95 U	30 U
RSD			4%	NA	NA	NA	NA	NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE P.19. Polychlorinated Biphenyls (PCBs), Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
SF COMP	1	1	13.45	150 U	150 U	150 U	150 U
SF COMP, Replicate 1	2	3	13.61	150 U	150 U	150 U	150 U
SF COMP, Replicate 2	2	3	13.61	150 U	150 U	150 U	150 U
SF COMP, Replicate 3	2	3	13.61	150 U	150 U	150 U	150 U
SF COMP	3	1	13.25	150 U	150 U	150 U	150 U
SF COMP	4	1	13.42	150 U	150 U	150 U	150 U
SF COMP	5	2	12.94	160 U	160 U	160 U	160 U
SFW COMP, Replicate 1	1	1	12.99	150 U	150 U	150 U	150 U
SFW COMP, Replicate 2	1	1	13.36	150 U	150 U	150 U	150 U
SFW COMP, Replicate 3	1	1	13.85	140 U	140 U	140 U	140 U
SFW COMP	2	2	12.32	160 U	160 U	160 U	160 U
SFW COMP	3	2	13.78	150 U	150 U	150 U	150 U
SFW COMP	4	1	13.08	150 U	150 U	150 U	150 U
SFW COMP	5	1	13.95	140 U	140 U	140 U	140 U
UIH COMP	1	2	13.70	150 U	150 U	150 U	150 U
UIH COMP	2	1	13.21	150 U	150 U	150 U	150 U
UIH COMP	3	3	13.03	150 U	150 U	150 U	150 U
UIH COMP	4	1	13.28	150 U	150 U	150 U	150 U
UIH COMP	5	1	12.99	150 U	150 U	150 U	150 U
TB Upper COMP	1	1	14.09	140 U	140 U	140 U	140 U
TB Upper COMP	2	1	13.33	150 U	150 U	150 U	150 U
TB Upper COMP	3	2	13.17	150 U	150 U	150 U	150 U
TB Upper COMP	4	1	13.45	150 U	150 U	150 U	150 U
TB Upper COMP	5	2	14.65	140 U	140 U	140 U	140 U
TB Lower COMP	1	2	13.26	150 U	150 U	150 U	150 U
TB Lower COMP	2	1	12.88	160 U	160 U	160 U	160 U
TB Lower COMP	3	2	13.79	150 U	150 U	150 U	150 U
TB Lower COMP	4	2	12.49	160 U	160 U	160 U	160 U
TB Lower COMP	5	4	13.61	150 U	150 U	150 U	150 U
R-OS	1	2	14.02	140 U	140 U	140 U	140 U
R-OS	2	1	13.37	150 U	150 U	150 U	150 U
R-OS	3	1	13.54	150 U	150 U	150 U	150 U
R-OS	4	2	13.97	140 U	140 U	140 U	140 U
R-OS	5	1	13.34	150 U	150 U	150 U	150 U
R-BF	1	1	14.51	140 U	140 U	140 U	140 U
R-BF	2	2	13.20	150 U	150 U	150 U	150 U
R-BF	3	2	13.95	140 U	140 U	140 U	140 U
R-BF	4	2	12.57	160 U	160 U	160 U	160 U
R-BF	5	2	13.94	140 U	140 U	140 U	140 U

TABLE P.19. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens PCBs (ug/kg dry weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
R-AM COMP	1	1	13.57	150 U	150 U	150 U	150 U
R-AM COMP	2	2	13.43	150 U	150 U	150 U	150 U
R-AM COMP	3	2	13.95	140 U	140 U	140 U	140 U
R-AM COMP	4	1	13.45	150 U	150 U	150 U	150 U
R-AM COMP	5	3	13.75	150 U	150 U	150 U	150 U
C-NV	1	1	12.66	160 U	160 U	160 U	160 U
C-NV, Replicate 1	2	2	14.27	140 U	140 U	140 U	140 U
C-NV, Replicate 2	2	2	14.27	140 U	140 U	140 U	140 U
C-NV, Replicate 3	2	2	14.27	140 U	140 U	140 U	140 U
C-NV	3	2	13.15	150 U	150 U	150 U	150 U
C-NV(b)	4	3	13.21	150 U	150 U	150 U	150 U
N. virens Background	1	3	14.64	140 U	140 U	140 U	140 U
N. virens Background	2	3	13.30	150 U	150 U	150 U	150 U
N. virens Background	3	3	13.79	150 U	150 U	150 U	150 U
N. virens Background	4	3	14.11	140 U	140 U	140 U	140 U
N. virens Background	5	3	13.99	140 U	140 U	140 U	140 U

(a) U Undetected at or above detection limit.
(b) Insufficient organisms to test all five replicates.

TABLE P.20. Polychlorinated Biphenyls, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Target DL(a)			20	20	20	20
Achieved DL			20	20	20	20
SF COMP	1	1	20 U(b)	20 U	20 U	20 U
SF COMP, Replicate 1	2	3	20 U	20 U	20 U	20 U
SF COMP, Replicate 2	2	3	20 U	20 U	20 U	20 U
SF COMP, Replicate 3	2	3	20 U	20 U	20 U	20 U
SF COMP	3	1	20 U	20 U	20 U	20 U
SF COMP	4	1	20 U	20 U	20 U	20 U
SF COMP	5	2	20 U	20 U	20 U	20 U
SFW COMP, Replicate 1	1	1	20 U	20 U	20 U	20 U
SFW COMP, Replicate 2	1	1	20 U	20 U	20 U	20 U
SFW COMP, Replicate 3	1	1	20 U	20 U	20 U	20 U
SFW COMP	2	2	20 U	20 U	20 U	20 U
SFW COMP	3	2	20 U	20 U	20 U	20 U
SFW COMP	4	1	20 U	20 U	20 U	20 U
SFW COMP	5	1	20 U	20 U	20 U	20 U
UIH COMP	1	2	20 U	20 U	20 U	20 U
UIH COMP	2	1	20 U	20 U	20 U	20 U
UIH COMP	3	3	20 U	20 U	20 U	20 U
UIH COMP	4	1	20 U	20 U	20 U	20 U
UIH COMP	5	1	20 U	20 U	20 U	20 U
TB Upper COMP	1	1	20 U	20 U	20 U	20 U
TB Upper COMP	2	1	20 U	20 U	20 U	20 U
TB Upper COMP	3	2	20 U	20 U	20 U	20 U
TB Upper COMP	4	1	20 U	20 U	20 U	20 U
TB Upper COMP	5	2	20 U	20 U	20 U	20 U
TB Lower COMP	1	2	20 U	20 U	20 U	20 U
TB Lower COMP	2	1	20 U	20 U	20 U	20 U
TB Lower COMP	3	2	20 U	20 U	20 U	20 U
TB Lower COMP	4	2	20 U	20 U	20 U	20 U
TB Lower COMP	5	4	20 U	20 U	20 U	20 U

TABLE P.20. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
R-OS	1	2	20 U	20 U	20 U	20 U
R-OS	2	1	20 U	20 U	20 U	20 U
R-OS	3	1	20 U	20 U	20 U	20 U
R-OS	4	2	20 U	20 U	20 U	20 U
R-OS	5	1	20 U	20 U	20 U	20 U
R-BF	1	1	20 U	20 U	20 U	20 U
R-BF	2	2	20 U	20 U	20 U	20 U
R-BF	3	2	20 U	20 U	20 U	20 U
R-BF	4	2	20 U	20 U	20 U	20 U
R-BF	5	2	20 U	20 U	20 U	20 U
R-AM COMP	1	1	20 U	20 U	20 U	20 U
R-AM COMP	2	2	20 U	20 U	20 U	20 U
R-AM COMP	3	2	20 U	20 U	20 U	20 U
R-AM COMP	4	1	20 U	20 U	20 U	20 U
R-AM COMP	5	3	20 U	20 U	20 U	20 U
C-NV	1	1	20 U	20 U	20 U	20 U
C-NV, Replicate 1	2	2	20 U	20 U	20 U	20 U
C-NV, Replicate 2	2	2	20 U	20 U	20 U	20 U
C-NV, Replicate 3	2	2	20 U	20 U	20 U	20 U
C-NV	3	2	20 U	20 U	20 U	20 U
C-NV(c)	4	3	20 U	20 U	20 U	20 U
N. virens Background	1	3	20 U	20 U	20 U	20 U
N. virens Background	2	3	20 U	20 U	20 U	20 U
N. virens Background	3	3	20 U	20 U	20 U	20 U
N. virens Background	4	3	20 U	20 U	20 U	20 U
N. virens Background	5	3	20 U	20 U	20 U	20 U

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Insufficient organisms to test all five replicates.

TABLE P.21. Quality Control Data for Polychlorinated Biphenyls, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens PCBs (ug/kg wet weight) Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Method Blanks						
Blank-1		1	20 U(a)	20 U	20 U	20 U
Blank-1		2	20 U	20 U	20 U	20 U
Blank-1		3	20 U	20 U	20 U	20 U
Matrix Spikes						
UIH COMP	5	1	NA (b)	NA	20 U	NA
UIH COMP, MS	5	1	NA	NA	182	NA
Concentration Recovered			NA	NA	182	NA
Amount Spiked			NS (c)	NS	179	NS
Percent Recovery			NA	NA	102	NA
C-NV	3	2	NA	NA	20 U	NA
C-NV, MS	3	2	NA	NA	186	NA
Concentration Recovered			NA	NA	186	NA
Amount Spiked			NS	NS	194	NS
Percent Recovery			NA	NA	96	NA
N. virens Background	1	3	NA	NA	20 U	NA
N. virens Background, MS	1	3	NA	NA	200	NA
Concentration Recovered			NA	NA	200	NA
Amount Spiked			NS	NS	194	NS
Percent Recovery			NA	NA	103%	NA
Standard Reference Material						
Certified SRM not available for PCBs.						
Analytical Replicates						
SFW COMP, Replicate 1	1	1	20 U	20 U	20 U	20 U
SFW COMP, Replicate 2	1	1	20 U	20 U	20 U	20 U
SFW COMP, Replicate 3	1	1	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA
C-NV, Replicate 1	2	2	20 U	20 U	20 U	20 U
C-NV, Replicate 2	2	2	20 U	20 U	20 U	20 U
C-NV, Replicate 3	2	2	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA
SF COMP, Replicate 1	2	3	20 U	20 U	20 U	20 U
SF COMP, Replicate 2	2	3	20 U	20 U	20 U	20 U
SF COMP, Replicate 3	2	3	20 U	20 U	20 U	20 U
RSD			NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.
(c) NS Not spiked.

TABLE P.22. Surrogate Percent Recoveries for Chlorinated Pesticides and Polychlorinated Biphenyls (PCBs), Including Quality Control Data, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	Surrogate Percent Recoveries PCB 103	PCB 198
SF COMP	1	1	13.45	66	68
SF COMP, Replicate 1	2	3	13.61	88	107
SF COMP, Replicate 2	2	3	13.61	89	99
SF COMP, Replicate 3	2	3	13.61	86	100
SF COMP	3	1	13.25	66	71
SF COMP	4	1	13.42	70	77
SF COMP	5	2	12.94	72	62
SFW COMP, Replicate 1	1	1	12.99	69	67
SFW COMP, Replicate 2	1	1	13.36	73	69
SFW COMP, Replicate 3	1	1	13.85	68	69
SFW COMP	2	2	12.32	82	69
SFW COMP	3	2	13.78	81	77
SFW COMP	4	1	13.08	66	64
SFW COMP	5	1	13.95	57	54
UIH COMP	1	2	13.70	82	73
UIH COMP	2	1	13.21	60	62
UIH COMP	3	3	13.03	86	106
UIH COMP	4	1	13.28	61	63
UIH COMP	5	1	12.99	69	58
TB Upper COMP	1	1	14.09	63	60
TB Upper COMP	2	1	13.33	74	73
TB Upper COMP	3	2	13.17	81	69
TB Upper COMP	4	1	13.45	66	60
TB Upper COMP	5	2	14.65	76	68
TB Lower COMP	1	2	13.26	81	74
TB Lower COMP	2	1	12.88	67	63
TB Lower COMP	3	2	13.79	89	76
TB Lower COMP	4	2	12.49	79	84
TB Lower COMP	5	4	13.61	78	115
R-OS	1	2	14.02	73	61
R-OS	2	1	13.37	65	64
R-OS	3	1	13.54	62	64
R-OS	4	2	13.97	81	72
R-OS	5	1	13.34	69	67
R-BF	1	1	14.51	69	65
R-BF	2	2	13.20	81	68
R-BF	3	2	13.95	89	76
R-BF	4	2	12.57	77	65
R-BF	5	2	13.94	82	74
R-AM COMP	1	1	13.57	66	65
R-AM COMP	2	2	13.43	79	64
R-AM COMP	3	2	13.95	75	63
R-AM COMP	4	1	13.45	70	59
R-AM COMP	5	3	13.75	90	105

TABLE P.22. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	Surrogate Percent Recoveries PCB 103	PCB 198
C-NV	1	1	12.66	65	63
C-NV, Replicate 1	2	2	14.27	90	77
C-NV, Replicate 2	2	2	14.27	81	71
C-NV, Replicate 3	2	2	14.27	84	68
C-NV	3	2	13.15	87	73
C-NV(a)	4	3	13.21	78	101
N. virens Background	1	3	14.64	76	84
N. virens Background	2	3	13.30	66	73
N. virens Background	3	3	13.79	82	103
N. virens Background	4	3	14.11	85	95
N. virens Background	5	3	13.99	78	100
Quality Control Data					
Method Blanks					
Blank-1		1	NA (b)	76	78
Blank-1		2	NA	86	79
Blank-1		3	NA	73	77
Matrix Spikes					
UIH COMP	5	1	12.99	69	58
UIH COMP, MS	5	1	NA	72	68
C-NV	3	2	13.15	87	73
C-NV, MS	3	2	NA	82	67
N. virens Background	1	3	14.64	76	84
N. virens Background, MS	1	3	NA	71	82
Standard Reference Material					
Certified SRM not available for pesticides and PCBs.					
Analytical Replicates					
SFW COMP, Replicate 1	1		12.99	69	67
SFW COMP, Replicate 2	1		13.36	73	69
SFW COMP, Replicate 3	1		13.85	68	69
C-NV, Replicate 1	2		14.27	90	77
C-NV, Replicate 2	2		14.27	81	71
C-NV, Replicate 3	2		14.27	84	68
SF COMP, Replicate 1	2		13.61	88	107
SF COMP, Replicate 2	2		13.61	89	99
SF COMP, Replicate 3	2		13.61	86	100

(a) Insufficient organisms to test all five replicates.
(b) NA Not applicable.

TABLE P.23. Metals Analysis, Wet Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Metals (mg/kg wet weight)									
				Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
SF COMP	1	1	14.09	0.0617	2.07	0.0452	0.107 U(a)	1.67	0.0266	0.160	0.098	0.290	51.3
SF COMP	2	1	13.61	0.0148 U	1.73	0.0440	0.103 U	1.41	0.0238	0.196	0.163	0.237	41.6
SF COMP	3	1	13.28	0.0548	2.02	0.0438	0.198	1.23	0.0266	0.173	0.129	0.244	37.2
SF COMP	4	1	13.54	0.0605	1.94	0.0492	0.141	1.38	0.0355	0.202	0.113	0.244	28.0
SFCOMP	5	1	12.94	0.0141 U	1.86	0.0413	0.349	1.71	0.0307	0.405	0.185	0.254	25.2
SFW COMP	1	1	12.99	0.0501	1.75	0.0423	0.124	1.53	0.0300	0.232	0.108	0.233	19.9
SFW COMP	2	1	12.32	0.0134 U	1.72	0.0444	0.126	1.25	0.0249	0.207	0.138	0.208	15.6
SFW COMP	3	1	13.78	0.0373	2.09	0.0506	0.104 U	1.46	0.0280	0.211	0.137	0.291	23.6
SFW COMP	4	1	13.08	0.0349	2.37	0.0420	0.167	1.30	0.0311	0.175	0.150	0.230	40.4
SFW COMP	5	1	13.95	0.0716	1.84	0.0502	0.136	1.46	0.0293	0.248	0.136	0.259	31.1
UIH COMP	1	1	13.70	0.0200	2.23	0.0480	0.104 U	1.68	0.0284	0.203	0.117	0.284	21.2
UIH COMP	2	1	13.85	0.0564	1.87	0.0507	0.140	1.36	0.0317	0.220	0.113	0.262	34.6
UIH COMP	3	1	13.03	0.0208	2.01	0.0503	0.107	1.44	0.0306	0.201	0.145	0.240	38.8
UIH COMP	4	1	13.21	0.0505	1.88	0.0511	0.134	1.37	0.0322	0.215	0.105	0.235	18.5
UIH COMP	5	1	12.99	0.0491	1.77	0.0452	0.137	1.34	0.0300	0.205	0.120	0.268	20.5
TB Upper COMP	1	1	12.66	0.0571	1.72	0.0485	0.190	1.23	0.0313	0.295	0.122	0.215	63.8
TB Upper COMP	2	1	13.42	0.0558	1.91	0.0505	0.264	1.47	0.0333	0.349	0.118	0.286	12.4
TB Upper COMP	3	1	13.17	0.0356	1.94	0.0460	0.122	1.41	0.0288	0.233	0.211	0.269	22.7
TB Upper COMP, Replicate 1	4	1	13.45	0.0584	1.80	0.0465	0.119	1.33	0.0305	0.237	0.115	0.262	43.4
TB Upper COMP, Replicate 2	4	1	13.45	0.0577	2.02	0.0436	0.138	1.34	0.0288	0.249	0.118	0.268	48.6
TB Upper COMP, Replicate 3	4	1	13.45	0.0561	1.84	0.0519	0.136	1.46	0.0320	0.266	0.106	0.256	20.0
TB Upper COMP	5	1	14.65	0.0255	2.39	0.0530	0.132	1.56	0.0312	0.337	0.136	0.340	22.7
TB Lower COMP	1	1	13.26	0.0145 U	2.12	0.0371	0.532	1.69	0.0280	0.774	0.148	0.244	11.1
TB Lower COMP	2	1	12.88	0.0422	1.51	0.0397	0.137	1.21	0.0267	0.350	0.092	0.214	26.8
TB Lower COMP	3	1	13.79	0.0217	2.12	0.0498	0.136	1.61	0.0272	0.520	0.111	0.319	13.5
TB Lower COMP	4	1	12.49	0.0210	2.05	0.0461	0.154	1.46	0.0299	0.365	0.140	0.245	33.5
TB Lower COMP	5	1	13.61	0.0148 U	1.93	0.0423	0.109	1.25	0.0271	0.329	0.110	0.241	30.9
R-OS	1	1	14.02	0.0296	1.99	0.0565	0.141	1.43	0.0307	0.238	0.124	0.231	17.4
R-OS	2	1	14.51	0.0678	2.28	0.0451	0.143	1.43	0.0238	0.184	0.100	0.252	12.8
R-OS	3	1	13.34	0.0791	2.12	0.0492	0.145	1.26	0.0329	0.233	0.112	0.237	33.8
R-OS	4	1	13.97	0.0495	2.22	0.0506	0.174	1.69	0.0405	0.317	0.123	0.309	9.65
R-OS	5	1	13.36	0.0675	1.98	0.0472	0.164	1.37	0.0337	0.343	0.104	0.251	33.8

TABLE P.23. (contd)

Sediment Treatment	Replicate	Analytical Batch	Percent Dry Weight	N. virens Metals (mg/kg wet weight)									
				Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
R-BF	1	1	13.33	0.0621	1.81	0.0428	0.115	1.31	0.0304	0.173	0.102	0.223	32.4
R-BF	2	1	13.20	0.0178	1.97	0.0430	0.100 U	1.53	0.0275	0.226	0.114	0.275	23.5
R-BF	3	1	13.95	0.0391	2.01	0.0407	0.106 U	1.46	0.0296	0.132	0.105	0.269	27.3
R-BF, Replicate 1	4	1	12.57	0.0175	1.73	0.0377	0.242	1.42	0.0258	0.309	0.137	0.228	10.7
R-BF, Replicate 2	4	1	12.57	0.0211	1.68	0.0363	0.224	1.36	0.0274	0.285	0.141	0.217	34.3
R-BF, Replicate 3	4	1	12.57	0.0225	1.84	0.0419	0.244	1.43	0.0288	0.318	0.148	0.222	25.3
R-BF	5	1	13.94	0.0289	2.19	0.0417	0.118	1.50	0.0329	0.206	0.109	0.284	23.8
R-AM COMP	1	1	13.57	0.0589	2.29	0.0502	0.153	1.41	0.0346	0.210	0.094	0.269	14.8
R-AM COMP	2	1	13.43	0.0395	2.20	0.0443	0.129	1.53	0.0293	0.195	0.106	0.289	31.2
R-AM COMP	3	1	13.29	0.0291	2.22	0.0513	0.119	1.58	0.0351	0.210	0.120	0.245	15.2
R-AM COMP	4	1	13.37	0.0464	1.70	0.0433	0.126	1.22	0.0275	0.224	0.139	0.271	21.0
R-AM COMP	5	1	13.75	0.0276	2.32	0.0545	0.501	1.59	0.0393	0.311	0.133	0.286	19.5
C-NV	1	1	13.25	0.0538	2.16	0.0351	0.100 U	1.12	0.0249	0.129	0.096	0.231	31.7
C-NV	2	1	14.27	0.0345	2.35	0.0410	0.108 U	1.33	0.0291	0.145	0.124	0.244	31.1
C-NV	3	1	13.15	0.0251	2.34	0.0396	0.120	1.14	0.0309	0.173	0.129	0.258	40.9
C-NV(b)	4	1	13.21	0.0218	2.07	0.0448	0.154	1.23	0.0240	0.157	0.141	0.243	11.7
N. virens Background, Replicate 1	1	1	14.64	0.0326	2.15	0.0441	0.498	1.93	0.0319	0.704	0.170	0.335	45.1
N. virens Background, Replicate 2	1	1	14.64	0.0360	2.28	0.0432	0.651	2.06	0.0331	0.823	0.167	0.319	17.4
N. virens Background, Replicate 3	1	1	14.64	0.0340	2.12	0.0425	1.090	1.99	0.0309	0.609	0.167	0.316	16.8
N. virens Background	2	1	13.30	0.0398	2.06	0.0398	0.290	1.69	0.0336	0.408	0.141	0.277	49.3
N. virens Background	3	1	13.79	0.0291	2.25	0.0405	0.252	1.96	0.0268	0.400	0.127	0.285	22.6
N. virens Background	4	1	14.11	0.0336	2.20	0.0388	5.150	1.88	0.0272	0.906	0.165	0.288	29.2
N. virens Background	5	1	13.99	0.0348	2.15	0.0421	0.173	2.05	0.0326	0.289	0.118	0.313	16.5

(a) U Undetected at or above detection limit.
(b) Insufficient organisms to test all five replicates.

TABLE P.24. Metals Analysis, Dry Weight, in Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Metals (mg/kg dry weight)									
			Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Target DL(a)			0.1	2.0	0.1	1.0	4.3	0.02	1.0	1.0	1.0	35
Achieved DL			0.109	2.93	0.132	0.76	3.34	0.004	0.933	0.417	0.12	39.7
SF COMP	1	1	0.438	14.7	0.321	0.76 U(b)	11.9	0.189	1.14	0.696	2.06	364
SF COMP	2	1	0.109 U	12.7	0.323	0.76 U	10.4	0.175	1.44	1.20	1.74	306
SF COMP	3	1	0.413	15.2	0.330	1.49	9.28	0.200	1.30	0.973	1.84	280
SF COMP	4	1	0.447	14.3	0.363	1.04	10.2	0.262	1.49	0.838	1.80	207
SFCOMP	5	1	0.109 U	14.4	0.319	2.69	13.2	0.237	3.13	1.43	1.96	195
SFW COMP	1	1	0.386	13.5	0.326	0.95	11.8	0.231	1.79	0.831	1.79	153
SFW COMP	2	1	0.109 U	14.0	0.360	1.02	10.2	0.202	1.68	1.12	1.69	127
SFW COMP	3	1	0.271	15.2	0.367	0.76 U	10.6	0.203	1.53	0.996	2.11	171
SFW COMP	4	1a	0.267	18.1	0.321	1.28	9.97	0.238	1.34	1.15	1.76	309
SFW COMP	5	1	0.513	13.2	0.360	0.97	10.5	0.210	1.78	0.977	1.86	223
UIH COMP	1	1	0.146	16.3	0.350	0.76 U	12.3	0.207	1.48	0.855	2.07	155
UIH COMP	2	1	0.407	13.5	0.366	1.01	9.84	0.229	1.59	0.816	1.89	250
UIH COMP	3	1	0.160	15.4	0.386	0.82	11.1	0.235	1.54	1.11	1.84	298
UIH COMP	4	1	0.382	14.2	0.387	1.01	10.4	0.244	1.63	0.792	1.78	140
UIH COMP	5	1	0.378	13.6	0.348	1.05	10.3	0.231	1.58	0.925	2.06	158
TB Upper COMP	1	1	0.451	13.6	0.383	1.50	9.73	0.247	2.33	0.965	1.70	504
TB Upper COMP	2	1	0.416	14.2	0.376	1.96	11.0	0.248	2.60	0.878	2.13	92.1
TB Upper COMP	3	1	0.270	14.7	0.349	0.92	10.7	0.219	1.77	1.60	2.04	172
TB Upper COMP, Replicate 1	4	1	0.434	13.4	0.346	0.88	9.88	0.227	1.76	0.857	1.95	323
TB Upper COMP, Replicate 2	4	1	0.429	15.0	0.324	1.02	9.98	0.214	1.85	0.879	1.99	361
TB Upper COMP, Replicate 3	4	1	0.417	13.7	0.386	1.01	10.9	0.238	1.98	0.791	1.90	149
TB Upper COMP	5	1	0.174	16.3	0.362	0.9	10.7	0.213	2.30	0.926	2.32	155
TB Lower COMP	1	1	0.109 U	16.0	0.280	4.01	12.8	0.211	5.84	1.12	1.84	83.4
TB Lower COMP	2	1	0.328	11.7	0.308	1.06	9.39	0.207	2.72	0.714	1.66	208
TB Lower COMP	3	1	0.157	15.4	0.361	0.98	11.7	0.197	3.77	0.802	2.31	98.1
TB Lower COMP	4	1	0.168	16.4	0.369	1.23	11.7	0.239	2.92	1.12	1.96	268
TB Lower COMP	5	1	0.109 U	14.2	0.311	0.8	9.20	0.199	2.42	0.806	1.77	227

TABLE P.24. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
R-OS	1	1	0.211	14.2	0.403	1.00	10.2	0.219	1.70	0.884	1.65	124
R-OS	2	1	0.467	15.7	0.311	0.98	9.86	0.164	1.27	0.692	1.74	88.0
R-OS	3	1	0.593	15.9	0.369	1.08	9.41	0.247	1.75	0.836	1.78	253
R-OS	4	1	0.354	15.9	0.362	1.24	12.1	0.290	2.27	0.882	2.21	69.1
R-OS	5	1	0.505	14.8	0.353	1.22	10.3	0.252	2.57	0.781	1.88	253
R-BF	1	1	0.466	13.6	0.321	0.86	9.86	0.228	1.30	0.764	1.67	243
R-BF	2	1	0.135	14.9	0.326	0.76 U	11.6	0.208	1.71	0.861	2.08	178
R-BF	3	1	0.280	14.4	0.292	0.76 U	10.5	0.212	0.947	0.753	1.93	196
R-BF, Replicate 1	4	1	0.139	13.8	0.300	1.92	11.3	0.205	2.46	1.09	1.81	85.2
R-BF, Replicate 2	4	1	0.168	13.4	0.289	1.78	10.8	0.218	2.27	1.12	1.73	273
R-BF, Replicate 3	4	1	0.179	14.6	0.333	1.94	11.4	0.229	2.53	1.18	1.77	201
R-BF	5	1	0.207	15.7	0.299	0.84	10.8	0.236	1.48	0.779	2.04	171
R-AM COMP	1	1	0.434	16.9	0.370	1.12	10.4	0.255	1.55	0.694	1.98	109
R-AM COMP	2	1	0.294	16.4	0.330	0.96	11.4	0.218	1.45	0.786	2.15	232
R-AM COMP	3	1	0.219	16.7	0.386	0.89	11.9	0.264	1.58	0.906	1.84	114
R-AM COMP	4	1	0.347	12.71	0.324	0.95	9.16	0.206	1.68	1.04	2.03	157
R-AM COMP	5	1	0.201	16.9	0.396	3.64	11.6	0.286	2.26	0.964	2.08	142
C-NV	1	1	0.406	16.3	0.265	0.76 U	8.48	0.188	0.973	0.723	1.74	239
C-NV	2	1	0.242	16.5	0.287	0.76 U	9.32	0.204	1.02	0.870	1.71	218
C-NV	3	1	0.191	17.8	0.301	0.91	8.69	0.235	1.32	0.981	1.96	311
C-NV(c)	4	1	0.165	15.7	0.339	1.16	9.31	0.182	1.19	1.07	1.84	88.3
N. virens Background, Replicate 1	1	1	0.223	14.7	0.301	3.40	13.2	0.218	4.81	1.16	2.29	308
N. virens Background, Replicate 2	1	1	0.246	15.6	0.295	4.44	14.1	0.226	5.62	1.14	2.18	119
N. virens Background, Replicate 3	1	1	0.232	14.5	0.290	7.44	13.6	0.211	4.16	1.14	2.16	115
N. virens Background	2	1	0.299	15.5	0.299	2.18	12.7	0.253	3.07	1.06	2.08	371
N. virens Background	3	1	0.211	16.3	0.294	1.82	14.2	0.194	2.90	0.921	2.07	164
N. virens Background	4	1a	0.238	15.6	0.275	36.5	13.3	0.193	6.42	1.17	2.04	207
N. virens Background	5	1	0.249	15.4	0.301	1.23	14.7	0.233	2.07	0.844	2.24	118

(a) DL Detection limit.
(b) U Undetected at or above detection limit.
(c) Insufficient organisms to test all five replicates.

TABLE P.25. Quality Control Data for Metals, Dry Weight, In Tissue of N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	N. virens Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Method Blanks												
Blank-1		1	0.219	3.07	0.132 U(a)	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.15 U	39.7 U
Blank-2		1	0.109 U	7.64	0.132 U	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.15 U	39.7 U
Blank-3		1	0.109 U	4.59	0.132 U	0.758 U	3.34 U	0.004 U	0.933 U	0.417 U	0.12 U	39.7 U
Blank-4		1a	0.109 U	2.93 U	0.132 U	0.758 U	3.34 U	NA	0.933 U	0.417 U	NA	39.7 U
Matrix Spikes												
SF COMP	5	1	0.109 U	14.4	0.319	2.69	13.2	0.226	3.13	1.43	1.96	195
SF COMP, MS	5	1	1.01	44.8	2.26	7.69	39.7	0.632	8.66	3.43	7.32	510
Concentration Recovered			1.01	30.4	1.94	5.00	26.5	0.406	5.53	2.00	5.36	315
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.497	5.00	2.00	5.00	200
Percent Recovery			101%	122%	97%	100%	106%	82%	111%	100%	107%	158% (b)
TB Upper COMP	2	1	0.416	14.2	0.376	1.96	11.0	0.248	2.60	0.878	2.13	92.1
TB Upper COMP, MS	2	1	1.23	46.1	2.34	7.05	36.7	0.756	8.05	2.67	7.36	472
Concentration Recovered			0.817	31.9	1.96	5.09	25.7	0.508	5.45	1.79	5.23	380
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.498	5.00	2.00	5.00	200
Percent Recovery			82%	128% (b)	98%	102%	103%	102%	109%	90%	105%	190% (b)
R-AM COMP	3	1	0.219	16.7	0.386	0.894	11.9	0.264	1.58	0.906	1.84	114
R-AM COMP, MS	3	1	1.11	46.2	2.36	5.99	37.6	0.696	7.02	2.95	7.17	277
Concentration Recovered			0.894	29.5	1.97	5.10	25.7	0.432	5.44	2.04	5.33	163
Amount Spiked			1.00	25.0	2.00	5.00	25.0	0.498	5.00	2.00	5.00	200
Percent Recovery			89%	118%	98%	102%	103%	87%	109%	102%	107%	82%
Standard Reference Material												
Certified Value SRM 1566a			1.68 +/-0.15	14 +/-1.2	4.15 +/-0.38	1.43 +/-0.46	66.3 +/-4.3	0.0642 +/-0.0067	2.25 +/-0.44	0.371 +/-0.014	2.21 +/-0.24	830 +/-57
SRM 1566a-1		1	1.61	13.9	4.26	1.57	72.1	0.062	2.42	0.312	2.40	1130 (c)
SRM 1566a-2		1	1.48	15.9	4.16	1.33	65.7	0.061	1.93	0.400	2.29	899
SRM 1566a-3		1	1.53	15.1	4.20	1.34	71.7	0.067	2.37	0.368	2.19	941
SRM 1566a-4		1a	1.54	15.7	3.92	1.01	71.7	NA	1.97	0.363	NA	737

TABLE P.25. (contd)

Sediment Treatment	Replicate	Analytical Batch	N. virens Metals (mg/kg dry weight) Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
Analytical Replicates												
TB Upper COMP, Replicate 1	4	1	0.434	13.4	0.346	0.884	9.88	0.227	1.76	0.857	1.95	323
TB Upper COMP, Replicate 2	4	1	0.429	15.0	0.324	1.02	9.98	0.214	1.85	0.879	1.99	361
TB Upper COMP, Replicate 3	4	1	0.417	13.7	0.386	1.01	10.9	0.238	1.98	0.791	1.90	149
RSD			2%	6%	9%	8%	5%	5%	6%	5%	2%	41% (d)
R-BF, Replicate 1	4	1	0.139	13.8	0.300	1.92	11.3	0.205	2.46	1.09	1.81	85.2
R-BF, Replicate 2	4	1	0.168	13.4	0.289	1.78	10.8	0.218	2.27	1.12	1.73	273
R-BF, Replicate 3	4	1	0.179	14.6	0.333	1.94	11.4	0.229	2.53	1.18	1.77	201
RSD			13%	4%	7%	5%	3%	6%	6%	4%	2%	51% (d)
N. virens Background, Replicate 1	1	1	0.223	14.7	0.301	3.40	13.2	0.218	4.81	1.16	2.29	308
N. virens Background, Replicate 2	1	1	0.246	15.6	0.295	4.44	14.1	0.226	5.62	1.14	2.18	119
N. virens Background, Replicate 3	1	1	0.232	14.5	0.290	7.44	13.6	0.211	4.16	1.14	2.16	115
RSD			5%	4%	2%	41% (d)	3%	3%	15%	1%	3%	61% (d)

(a) U Undetected at or above detection limit.
(b) Outside quality control range (75-125%) for matrix spike recoveries.
(c) Outside quality control criteria (+/-30%) for SRMs.
(d) Value exceeds relative precision goal of ≤20%.

TABLE P.26. Butyltin Results, Wet and Dry Weight, in Tissue N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin (%) Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin	Percent Dry Weight	(ug/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Target DL(a)				1.00	1.00	1.00	NA (b)	NA	NA	NA
Achieved DL				0.48	1.39	0.39	NA	NA	NA	NA
SF COMP	1	1	97	0.48 U(c)	1.86	0.39 U	14.09	3.41 U	13.20	2.77 U
SF COMP	2	3	79	0.48 U	2.88	0.39 U	13.61	3.53 U	21.16	2.87 U
SF COMP	3	1	90	0.48 U	1.59	0.39 U	13.28	3.61 U	11.97	2.94 U
SF COMP	4	1	88	0.48 U	2.23	0.39 U	13.54	3.55 U	16.47	2.88 U
SFCOMP	5	3	101	0.70	2.23	0.39 U	12.94	5.41	17.23	3.01 U
SFW COMP	1	1	93	0.66	1.39 U	0.39 U	12.99	5.08	10.70 U	3.00 U
SFW COMP	2	3	96	0.48 U	1.39 U	0.39 U	12.32	3.90 U	11.28 U	3.17 U
SFW COMP	3	3	96	0.48 U	1.47	0.39 U	13.78	3.48 U	10.67	2.83 U
SFW COMP	4	1	77	0.48 U	1.69	0.39 U	13.08	3.67 U	12.92	2.98 U
SFW COMP	5	2	101	0.48 U	1.39 U	0.39 U	13.95	3.44 U	9.96 U	2.80 U
UIH COMP	1	3	83	0.48 U	1.54	0.39 U	13.70	3.50 U	11.24	2.85 U
UIH COMP	2	1	97	0.48 U	2.24	0.39 U	13.85	3.47 U	16.17	2.82 U
UIH COMP	3	3	89	0.48 U	6.39	0.39 U	13.03	3.68 U	49.04	2.99 U
UIH COMP	4	1	92	0.48 U	1.43	0.39 U	13.21	3.63 U	10.83	2.95 U
UIH COMP	5	2	95	0.48 U	2.09	0.39 U	12.99	3.70 U	16.09	3.00 U
TB Upper COMP, Replicate 1	1	1	98	0.72	1.39 U	1.25	12.66	5.69	10.98 U	9.87
TB Upper COMP, Replicate 2	1	1	102	0.48 U	2.37	0.39 U	12.66	3.79 U	18.72	3.08 U
TB Upper COMP, Replicate 3	1	1	105	0.48 U	1.39 U	0.39 U	12.66	3.79 U	10.98 U	3.08 U
TB Upper COMP	2	1	102	0.48 U	1.39 U	0.39 U	13.42	3.58 U	10.36 U	2.91 U
TB Upper COMP	3	2	102	0.48 U	1.39 U	0.39 U	13.17	3.64 U	10.55 U	2.96 U
TB Upper COMP	4	1	81	0.48 U	1.39 U	0.39 U	13.45	3.57 U	10.33 U	2.90 U
TB Upper COMP	5	2	104	0.48 U	1.39 U	0.39 U	14.65	3.28 U	9.49 U	2.66 U
TB Lower COMP	1	2	105	0.48 U	1.39 U	0.39 U	13.26	3.62 U	10.48 U	2.94 U
TB Lower COMP	2	1	82	0.48 U	1.39 U	0.39 U	12.88	3.73 U	10.79 U	3.03 U
TB Lower COMP	3	2	97	0.48 U	1.71	0.39 U	13.79	3.48 U	12.40	2.83 U
TB Lower COMP	4	3	96	0.48 U	1.39 U	0.39 U	12.49	3.84 U	11.13 U	3.12 U
TB Lower COMP	5	3	97	0.48 U	1.39	0.39 U	13.61	3.53 U	10.21	2.87 U

TABLE P.26. (contd)

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin (%) Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin	Percent Dry Weight	(ug/kg dry weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
R-OS	1	3	97	1.01	1.71	0.39 U	14.02	7.20	12.20	2.78 U
R-OS	2	1	104	0.48 U	1.39 U	0.39 U	14.51	3.31 U	9.58 U	2.69 U
R-OS	3	1	73	0.48 U	1.39 U	0.39 U	13.34	3.60 U	10.42 U	2.92 U
R-OS	4	2	99	0.48 U	1.39 U	0.39 U	13.97	3.44 U	9.95 U	2.79 U
R-OS	5	1	95	0.48 U	1.39 U	0.39 U	13.36	3.59 U	10.40 U	2.92 U
R-BF	1	1	103	0.52	1.39 U	0.39 U	13.33	3.90	10.43 U	2.93 U
R-BF	2	2	71	0.48 U	1.42	0.39 U	13.20	3.64 U	10.76	2.95 U
R-BF	3	2	99	0.48 U	1.48	0.39 U	13.95	3.44 U	10.61	2.80 U
R-BF	4	2	103	0.48 U	1.39 U	0.39 U	12.57	3.82 U	11.06 U	3.10 U
R-BF	5	2	112	0.48 U	1.39 U	0.39 U	13.94	3.44 U	9.97 U	2.80 U
R-AM COMP	1	2	81	0.48 U	1.39 U	0.39 U	13.57	3.54 U	10.24 U	2.87 U
R-AM COMP	2	2	73	0.48 U	1.39 U	0.39 U	13.43	3.57 U	10.35 U	2.90 U
R-AM COMP, Replicate 1	3	2	99	0.48 U	1.39 U	0.39 U	13.95	3.44 U	9.96 U	2.80 U
R-AM COMP, Replicate 2	3	2	99	0.48 U	1.93	0.39 U	13.95	3.44 U	13.84	2.80 U
R-AM COMP, Replicate 3	3	2	103	0.48 U	1.82	0.39 U	13.29	3.61 U	13.69	2.93 U
R-AM COMP	4	1	77	0.48 U	1.39 U	0.39 U	13.37	3.59 U	10.40 U	2.92 U
R-AM COMP	5	3	90	0.48 U	1.39 U	0.39 U	13.75	3.49 U	10.11 U	2.84 U
C-NV	1	1	87	0.48 U	1.39 U	0.39 U	13.25	3.62 U	10.49 U	2.94 U
C-NV	2	2	95	0.48 U	1.39 U	0.39 U	14.27	3.36 U	9.74 U	2.73 U
C-NV	3	2	92	0.48 U	3.92	0.39 U	13.15	3.65 U	29.81	2.97 U
C-NV(d)	4	3	73	0.48 U	1.39 U	0.39 U	13.21	3.63 U	10.52 U	2.95 U
N. virens Background	1	3	74	0.48 U	1.39 U	0.39 U	14.64	3.28 U	9.49 U	2.66 U
N. virens Background	2	3	92	0.48 U	1.39 U	0.39 U	13.30	3.61 U	10.45 U	2.93 U
N. virens Background	3	3	95	0.48 U	1.39 U	0.39 U	13.79	3.48 U	10.08 U	2.83 U
N. virens Background	4	3	97	0.48 U	1.39 U	0.39 U	14.11	3.40 U	9.85 U	2.76 U
N. virens Background, Replicate 1	5	3	96	0.48 U	1.39 U	0.39 U	13.99	3.43 U	9.94 U	2.79 U
N. virens Background, Replicate 2	5	3	99	0.48 U	1.39 U	0.39 U	13.99	3.43 U	9.94 U	2.79 U
N. virens Background, Replicate 3	5	3	84	0.48 U	1.39 U	0.39 U	13.99	3.43 U	9.94 U	2.79 U

(a) DL Detection limit.
(b) NA Not applicable.
(c) U Undetected at or above detection limit.
(d) Insufficient organisms to test all five replicates.

TABLE P.27. Quality Control Data for Butyltin Results, Wet Weight, in Tissue N. virens, Richmond Harbor Deepening Project

Sediment Treatment	Replicate	Analytical Batch	Tripentyltin % Internal Standard	(ug/kg wet weight) Tri-Butyltin	Di-Butyltin	Mono-Butyltin
Method Blanks						
Blank		1	100	0.48 U(a)	1.39 U	0.39 U
Blank		2	107	0.48 U	1.39 U	0.39 U
Blank		3	89	0.48 U	1.39 U	0.39 U
Matrix Spikes						
TB Upper COMP	5	2	104	0.48 U	1.39 U	0.39 U
TB Upper COMP, MS	5	2	107	47.5	47.4	14.3
Concentration Recovered			NA (b)	47.5	47.4	14.3
Amount Spiked			NA	49.6	49.6	49.6
Percent Recovery			NA	96%	96%	29%
R-AM COMP	4	1	77	0.48 U	1.39 U	0.39 U
R-AM COMP, MS	4	1	91	55.3	51.0	23.0
Concentration Recovered			NA	55.3	51.0	23.0
Amount Spiked			NA	48.6	48.6	48.6
Percent Recovery			NA	114%	105%	47%
R-AM COMP	5	3	90	0.48 U	1.39 U	0.39 U
R-AM COMP, MS	5	3	113	49.7	47.3	21.9
Concentration Recovered			NA	49.7	47.3	21.9
Amount Spiked			NA	48.5	48.5	48.5
Percent Recovery			NA	102%	98%	45%
Analytical Replicates						
TB Upper COMP, Replicate 1	1	1	98	0.72	1.39 U	1.25
TB Upper COMP, Replicate 2	1	1	102	0.48 U	2.37	0.39 U
TB Upper COMP, Replicate 3	1	1	105	0.48 U	1.39 U	0.39 U
RSD			NA	NA	NA	NA
R-AM COMP, Replicate 1	3	2	99	1.31	1.39 U	0.39 U
R-AM COMP, Replicate 2	3	2	99	1.35	1.93	0.39 U
R-AM COMP, Replicate 3	3	2	103	1.26	1.82	0.39 U
RSD			NA	3%	NA	NA
N. virens Background, Replicate 1	5	3	96	0.48 U	1.39 U	0.39 U
N. virens Background, Replicate 2	5	3	99	0.48 U	1.39 U	0.39 U
N. virens Background, Replicate 3	5	3	84	0.48 U	1.39 U	0.39 U
RSD			NA	NA	NA	NA

(a) U Undetected at or above detection limit.
(b) NA Not applicable.

APPENDIX Q

POTENTIAL EFFECTS OF DISPOSAL OF RICHMOND HARBOR DEEPENING SEDIMENTS AND THE INTENSIVE STUDY OF THE TURNING BASIN SEDIMENTS AT THE BAY FARM BORROW AREA

APPENDIX Q

POTENTIAL EFFECTS OF DISPOSAL OF RICHMOND HARBOR DEEPENING SEDIMENTS AND THE INTENSIVE STUDY OF THE TURNING BASIN SEDIMENTS AT THE BAY FARM BORROW AREA

This appendix presents the results of physical/chemical sediment analysis, acute toxicity tests, bioaccumulation tests, statistical comparisons, and a Tier III evaluation of Richmond Harbor Deepening sediments and the Intensive Study of the Turning Basin sediments relative to the Bay Farm Borrow Area reference sediment (R-BF) (Figure Q.1). The Bay Farm Borrow Area could be a potential in-bay dredged material disposal area. All methods and results for sampling, physical descriptions, sediment chemistry, biological testing, and tissue chemistry are contained in Sections 2, 3, and 4 of this report; supporting data are contained in Appendixes A through R. As stated in Section 2.5 of this report, the use of Dunnett's test for statistical comparisons of non-independent data sets increases the chance of Type II statistical errors in all comparisons, resulting in the identification of a greater number of significant differences than if multiple comparison tests are used.

Q.1 SEDIMENT CHARACTERISTICS

The five Richmond Harbor Deepening composites are fairly representative of the sediment characteristics of their contributing stations with respect to the sediment parameters that were measured (Tables Q.1 through Q.3). Generally, the Richmond Harbor Deepening sediments had less clay and more sand than the reference sediment R-BF, although UIH COMP and its contributing stations had a grain-size distribution similar to R-BF (Table Q.1). Richmond Harbor Deepening sediments also had less TOC than R-BF sediments. The TVS in UIH COMP and TB Upper COMP was consistently higher than TVS in R-BF; TVS in other composites and contributing stations was similar to or lower than TVS in R-BF. Oil and grease concentrations in Richmond Harbor sediments were similar to or lower than in R-BF; however, TPH was detected at a number of stations in SF, SFW, and UIH COMPs, whereas no TPH was detected in R-BF.

Comparisons of Richmond Harbor Deepening sediment PAHs, pesticides, and PCBs to R-BF are shown in Table Q.2. Concentrations of PAHs were elevated in SF, SFW, and UIH COMPs, their respective stations, or both, relative to R-BF. Concentrations of PAHs were relatively high in both the upper and lower sections of Station TB-4. The other TB stations had very low PAHs in their lower sections (>5 ft below mudline). The chlorinated pesticides 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT were considerably elevated in SF, SFW, and UIH COMPs and their respective stations relative to R-BF. Dieldrin was also elevated in SF and SFW

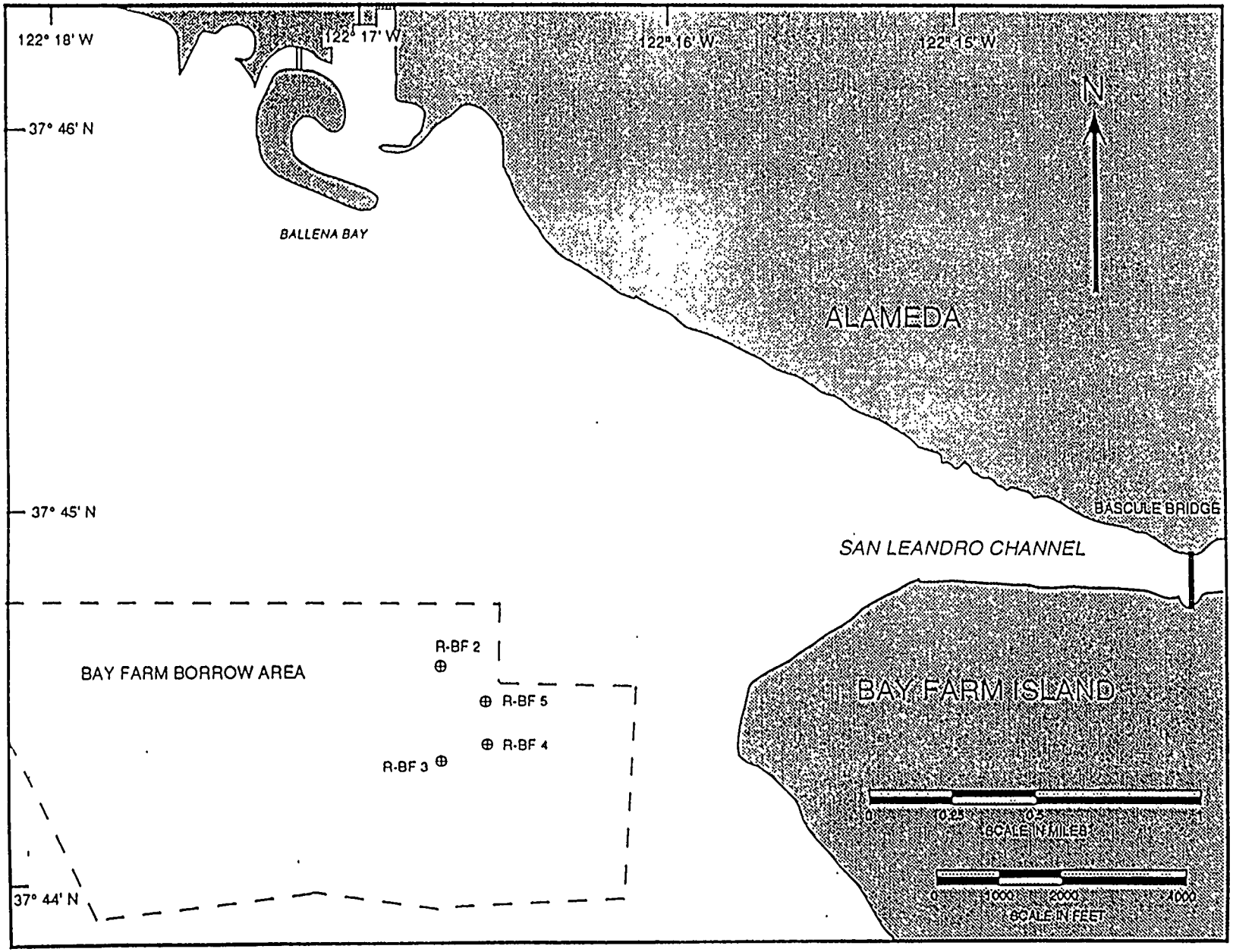


FIGURE Q.1. Location of Bay Farm Reference Area (R-BF)

TABLE Q.1. Conventional Sediment Measurement Results for the Richmond Harbor Deepening Project Sediment Treatments

Sediment Treatment	Percent Dry Weight: Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	mg/kg Dry Weight: Oil and Grease	TPH
R-BF	0	5	39	56	1.24	2.34	143	45U[a]
SF COMP	1	29	35	35	0.71	2.32	29U	29U
SF-1	1	29	42	28	0.33	2.27	36	23U
SF-2	6	18	34	42	0.98	2.62	66	34
SF-3	0	9	32	59	1.27[b]	2.67	136	67
SF-4	0	5	32	63	1.37	2.70	98	57
SFW COMP	5	23	37	35	0.76[b]	2.26	102[b]	68[b]
SFW COMP[c]	NA[d]	NA	NA	NA	NA	NA	232	104
SFW-1	13	35	21	31	1.00	2.21	44	35
SFW-2	8	15	35	42	1.09	2.84	79	69
SFW-3	2	18	47	33	0.49	2.32	117	84
SFW-4	3	27	45	25	0.32	2.01	27	22U
UIH COMP	0	6	33	61	1.23	2.69	91	65
UIH-1	0	5	35	60	1.17	2.80	204	75
UIH-2	0	2	33	65	1.20	2.73	97	38U
UIH-3	0	7	35	58	1.12	2.81	80	34U
UIH-4	1	13	35	51	0.87	2.83	142	72
UIH-5	0	7	39	54	0.97	2.74	139	70
TB Upper COMP	8	14	45	33	0.85	2.48	47	30U
TB-1 Upper	22	33	24	21	0.50	2.45	36	23U
TB-2 Upper	5	20	41	34	0.73	3.25	36	25U
TB-3 Upper	1	13	48	38	0.78	2.47	28U	28U
TB-4 Upper	0	3	46	51	1.09	2.63	169	57
TB-5 Upper	1	7	58	34	0.79	2.44	26U	26U
TB-6 Upper	0	3	49	48	0.66	2.43	83	32
TB-7 Upper	0	5	66	29	0.63	2.38	29[b]	25U[b]
TB-7 Upper[c]	NA	NA	NA	NA	NA	NA	20U	20U
TB Lower COMP	3[b]	15[b]	46[b]	36[b]	0.69	2.15	35	26U
TB-1 Lower	9	53	23	15	0.05	1.73	19U	19U
TB-2 Lower	1	23	43	33	0.62	2.08	29	24U
TB-3 Lower	0[b]	13[b]	52[b]	36[b]	0.70	2.21	30	25U
TB-4 Lower	0	4	47	49	0.93	2.88	58	30U
TB-5 Lower	0	12	55	33	0.70	2.27	25U	25U
TB-6 Lower	0[b]	7[b]	50[b]	43[b]	0.55	2.27	26U	26U
TB-7 Lower	1	3	55	41	0.72	2.43	26U	26U

(a) U Undetected at or above the detection limit.
(b) Value is mean of analytical replicates.
(c) Sample re-analyzed approximately one month after original oil and grease and TPH analysis to provide appropriate matrix spike data.
(d) NA Not applicable.

TABLE Q.2. Detected PAH, Pesticides, and PCBs in Richmond Harbor Deepening Project Sediment Treatments (shading indicates detected values greater than the Bay Farm Borrow Area [R-BF] reference sediment; all concentrations in µg/kg dry weight)

Sediment Treatment	Total LPAH	Total HPAH	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
R-BF	228	1527	1.05	1.69	12.1	13.0	23.3
SF COMP	228	1345	203 D[a]	34.2	140 D	14.0	107
SF-1	79	390	82.8 D	11.6	23.3	5.51	33.6
SF-2	273	1876	285 D	65.2	78.7 D	25.8	177
SF-3[b]	471	3274	283 D	36.1 D	358	24.1	183
SF-4	489	3274	288 D	66.5	137 D	22.8	198
SFW COMP	3897	1806	267 D	82.3 D	81.7 D	46.2	145
SFW-1	248	1735	191 D	31.1	112 D	12.9	108
SFW-2	386	3390	184 D	57.2	87.4 D	17.1	20 U[b]
SFW-3	2188	1105	127 D	31.8 D	56.3 D	17.5	39.4
SFW-4	71	396	88.4 D	18.7	38.4	6.26	20 U
UIH COMP[b]	425	2372	110 D	18.8 D	53.2 D	9.17	92.5
UIH-1	253	1596	76.1 D	13.1	49.2	6.48	72.0
UIH-2	278	1987	75.8 D	14.0	48.8	7.24	92.3
UIH-3	245	1709	157 D	24.3	85.2	10.8	157
UIH-4	227	1712	70.5 D	14.2	44.2	5.47	67.5
UIH-5	283	1843	178 D	40.4	60.5 D	16.8	140
TB Upper COMP	115	820	1.99	0.08 U	0.73	1.06	20 U
TB-1 Upper	48	368	1.89	0.06 U	1.24	0.32 U	8.51 J[c]
TB-2 Upper[b]	172	1213	2.11	0.39	2.00	0.57	20 U
TB-3 Upper	161	1322	1.01	0.07 U	0.50 U	0.85	4.68 J
TB-4 Upper	216	1622	17.0	5.16	4.74	2.05	46.8
TB-5 Upper	91	383	0.75	0.07 U	6.87	0.62	20 U
TB-6 Upper	13	18	0.17 U	0.07 U	0.48 U	0.36 U	20 U
TB-7 Upper	26	26	0.16 U	0.07 U	0.46 U	0.34 U	20 U

TABLE Q.2. (contd)

Sediment Treatment	Total LPAH	Total HPAH	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
TB Lower COMP	31	94	0.97	0.07 U	0.47 U	0.36 U	20 U
TB-1 Lower	0	2	0.12 U	0.05 U	0.36 U	0.27 U	20 U
TB-2 Lower	13	17	0.14 U	0.06 U	0.40 U	0.30 U	20 U
TB-3 Lower	16	26	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-4 Lower	260	2023	24.9	0.08 U	12.8	1.86	59.3
TB-5 Lower	19	25	0.15 U	0.06 U	0.43 U	0.32 U	20 U
TB-6 Lower	14	20	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-7 Lower	28	27	0.16 U	0.07 U	0.45 U	0.34 U	20 U
OBM COMP	8	4	0.13 U	0.06 U	0.38 U	0.28 U	20 U

(a) D Diluted sample.
(b) U Undetected at or above the detection limit.
(c) J Detected below method detection limit but above instrument detection limit.

TABLE Q.3. Metal and Butyltin Concentrations in Richmond Harbor Deepening Project Sediment Treatments (shading indicates values greater than the Bay Farm Borrow Area [R-BF] reference sediment; metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-BF	0.530	11.4	0.205	178	57.3	0.373	103	30.5	0.417	145	3.82	3.38
SF COMP	0.391	9.4	0.511	189	55.0	0.360	80.3	35.2	0.235	130	8.52	7.48
SF-1	0.303	7.0	0.922	178	35.6	0.115	71.0	18.9	0.128 U[a]	83.5	1.67	1.59
SF-2	0.566	14.2	0.654	202	71.7	0.490	93.5	48.6	0.418	176	6.78	9.05
SF-3	0.626	13.4	0.474	214	92.9	0.528	111	56.5	0.336	204	30.6	18.2
SF-4	0.694	14.0	0.564	215	107	0.689	109	64.8	0.412	208	27.0	33.1
SFW COMP	0.603	12.4	0.890	192	65.3	0.943	92.5	45.8	0.522	157	2.85	5.73
SFW-1	0.438	14.4	0.482	169	68.5	0.377	82.6	65.8	0.235	175	5.76	9.88
SFW-2	0.615	4.48	0.855	158	34.3	0.857	67.6	20.1	0.421	86.7	4.79	8.46
SFW-3	0.537	9.6	0.782	166	55.6	0.465	86.6	30.4	0.796	119	0.40 U	0.65 U
SFW-4	0.268	13.1	0.628	183	59.6	0.158	85.1	44.3	0.243	153	1.05	2.01
UIH COMP	0.639	13.6	0.513	203	81.2	0.508	112	52.5	0.334	192	8.59	8.38
UIH-1	0.599	14.2	0.484	192	75.6	0.607	115	53.6	0.507	180	5.38	7.95
UIH-2	0.670	13.6	0.465	193	83.9	0.618	117	53.0	0.434	183	6.67	9.67
UIH-3	0.713	14.8	0.596	189	85.7	0.644	111	59.5	0.331	190	4.66	6.68
UIH-4	0.491	10.9	0.733	168	68.0	0.311	101	37.3	0.150	154	7.12	6.02
UIH-5	0.663	15.4	0.570	202	82.1	0.516	114	58.2	0.413	192	8.11	7.04
TB Upper COMP	0.223	10.3	0.249	166	40.5	0.234	86.9	17.4	0.240	100	1.87	0.65 U
TB-1 Upper	0.163	11.0	0.159	210	33.6	0.201	71.7	14.7	0.128 U	73.4	0.40 U	1.13
TB-2 Upper	0.214	12.1	0.300	173	42.6	0.373	78.8	21.2	0.240	96.3	1.35	0.65 U
TB-3 Upper	0.275	12.0	0.306	169	46.3	0.532	91.5	27.2	0.337	117	0.40 U	0.65 U
TB-4 Upper	0.501	14.5	0.352	164	68.3	0.401	105	36.6	0.420	151	2.18	2.38
TB-5 Upper	0.145	9.6	0.299	171	34.0	0.175	84.4	13.8	0.426	90.6	0.40 U	0.65 U
TB-6 Upper	0.135	9.9	0.224	184	47.1	0.109	108	10.3	0.340	97.2	0.40 U	0.65 U
TB-7 Upper	0.102	9.2	0.288	212	26.0	0.066	74.1	9.4	0.243	85.0	0.40 U	0.65 U

TABLE Q.3. (contd)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
TB Lower COMP	0.158	11.6	0.252	180	39.4	0.140	90.3	9.4	0.128 U	91.8	0.40 U	0.65 U
TB-1 Lower	0.128	6.7	0.100	206	17.2	0.077	47.5	8.2	0.128 U	42.4	0.40 U	0.65 U
TB-2 Lower	0.106	11.4	0.250	201	33.5	0.073	91.5	13.7	0.346	81.0	0.40 U	0.65 U
TB-3 Lower	0.114	8.3	0.269	203	44.2	0.078	91.6	13.8	0.330	87.0	0.40 U	0.65 U
TB-4 Lower	0.501	13.8	0.549	181	65.0	0.642	98.2	40.2	0.413	155	0.40 U	1.20
TB-5 Lower	0.115	10.3	0.281	201	33.6	0.062	85.8	10.4	0.333	84.4	0.40 U	0.65 U
TB-6 Lower	0.143	10.7	0.217	205	47.6	0.088	101	12.7	0.240	87.1	0.40 U	0.65 U
TB-7 Lower	0.140	10.8	0.284	193	44.7	0.078	105	10.4	0.273	94.5	0.40 U	0.65 U
OBM COMP	NA(b)	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.40 U	0.65 U

(a) U Undetected at or above the detection limit.
(b) NA Not applicable.

COMPs and most of their respective stations. The primary source of these pesticides is the former United Heckathorn plant on the east shore of Lauritzen Canal (Figure 3.1), which is now a federal Superfund site. The PCB Aroclor 1254 was also elevated in SF, SFW, and UIH COMPs and their respective stations, but was below the method detection limit in all other stations except TB-4 (Upper and Lower).

Metals concentrations were elevated in SF, SFW, and UIH COMPs, their respective stations, or both, relative to R-BF. Butyltin concentrations were low in Richmond Harbor Deepening sediments, except at Stations SF-3 and SF-4 (Table Q.3).

The Intensive Study of the Turning Basin sediments were predominantly fine-grained with a similar composition to the reference sediment R-BF, except for TB-1 Lower, which was predominantly sand and gravel. Sediments from R-BF had higher detectable concentrations of TOC, oil and grease, TPH, PAHs, pesticides, PCBs, six metals, and butyltins than the Turning Basin sediments, with the exception of TB-4 Middle. This test treatment had higher detectable concentrations of PAHs, pesticides, PCBs, 8 of the 10 metals, and TBT than any other sediment treatment. The results of the sediment chemistry analysis for the Turning Basin sediments are shown in Tables Q.4 through Q.6.

Q.2 DEPOSITED SEDIMENT TOXICITY

The acute solid-phase tests with Richmond Harbor Deepening sediments showed no acute toxicity to *M. nasuta* when compared with the reference treatment R-BF (Table Q.7). However, the OBM COMP was acutely toxic to *N. caecoides* relative to R-BF. At this time, no dose response of *N. caecoides* to ammonia is available to determine the contribution of ammonia in sediment to toxicity. The *R. abronius* 10-day test showed statistically significant differences and a >20% difference in survival in TB Upper, TB Lower, and OBM COMPs, when compared with the reference R-BF (Table Q.7). The mortality observed in *R. abronius* exposed to TB Lower COMP is greater than can be attributed to ammonia acting alone (see Section 3.4.1, Figure 3.37). However, the low *R. abronius* survival in TB Upper COMP and OBM COMP could largely be attributed to ammonia. Although the relationship of observed mortality and total ammonia in the interstitial water of TB Upper COMP was below the expected effects range of ammonia as a sole toxicant (Figure 3.37), the mean mortality was affected by one very low replicate (rep 4, 45% survival). If that replicate were not included in the mean, the response to TB Upper would be within the expected effects range of ammonia.

Solid-phase toxicity tests for the Turning Basin sediments consisted of three *R. abronius* 10-day tests (Table Q.8). Test results for the static 10-day test with no ammonia manipulation showed that five test treatments were acutely toxic to *R. abronius* when compared with R-BF.

TABLE Q.4. Conventional Sediment Measurement Results for the Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Percent Dry Weight: Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	mg/kg Dry Weight: Oil and Grease	TPH
R-BF	0	1	39	60	1.4	2.3	130	100
TB-1 Lower	13	49	23	15	0.11	0.79(a)	14	9.9 U(b)
TB-2 Lower	3	18	47	32	0.67	2.3	50	27
TB-3 Lower	1	15	50	34	0.67	2.1	40	16 U
TB-4 Middle	0(a)	4(a)	48(a)	48(a)	1.1	2.6	18 U	18 U
TB-4 Lower	0	10	44	46	0.58	2.1	16 U	16 U
TB-5 Lower	0	7	54	39	0.90	2.2	56	58
TB-6 Lower	1	5	40	54	0.81	2.6	17 U	17 U
TB-7 Lower	1	7	53	39	0.70	2.4	15 U	15 U
TB-8 Lower	0	6	55	39	0.76	2.6	43	16 U
TB-9 Lower	0	15	44	41	0.59	2.1	20	16 U
OBM COMP	0	18	56	26	0.16	1.9	11 U	11 U

(a) Value is mean of analytical replicates.
(b) U Undetected at or above the detection limit.

TABLE Q.5. Detected Total PAHs, Pesticides, and PCBs in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (values in µg/kg dry weight)

Sediment Treatment	Total LPAHs	Total HPAHs	Aldrin	4,4'-DDD	4,4'-DDE	4,4'-DDT	Aroclor 1254
R-BF	355	2116	2.15	5.19	2.61	1.19 U(a)	46.8
TB-1 Lower	17	37	0.17 U	0.21 U	0.11 U	0.58 U	20 U
TB-2 Lower	22	36	0.66	0.17 U	0.09 U	0.47 U	20 U
TB-3 Lower	38	58	0.21 U	0.26 U	0.14 U	0.74 U	20 U
TB-4 Middle	339	2355	1.15	19.3	15.1	9.3	101
TB-4 Lower	47	66	0.21 U	0.26 U	0.14 U	0.72 U	20 U
TB-5 Lower	51	63	0.22 U	0.27 U	0.15 U	0.76 U	20 U
TB-6 Lower	52	66	1.17	0.29 U	0.16 U	0.83 U	20 U
TB-7 Lower	35	69	1.69	0.27 U	0.15 U	0.77 U	20 U
TB-8 Lower	38	67	0.97	0.27 U	0.15 U	0.76 U	20 U
TB-9 Lower	43	62	0.35 U	0.43 U	0.24 U	1.21 U	20 U
OBM COMP	29	28	0.18 U	0.22 U	0.12 U	0.63 U	20 U

(a) U Undetected at or above the detection limit.

TABLE Q.6. Metal and Butyltin Concentrations in Sediment Treatments Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-BF	0.44	9.4	0.14	178	60.6	0.315	111	35.3	0.29	158	2.27	2.11
TB-1 Lower	0.10	6.07	0.25	231	20.9	0.059	55.3	11.1	0.17 U	51.2	0.57	0.56 U[a]
TB-2 Lower	0.11	10.2	0.21	221	39.8	0.071	84.4	11.8	0.17 U	88.6	0.53	1.05
TB-3 Lower	0.11	9.2	0.20	184	36.1	0.058	85.1	9.3	0.17 U	85.4	0.49	0.56 U
TB-4 Middle	0.65	16.5	0.54	182	74.0	0.734	94.6	43.9	0.39	185	3.66	0.82
TB-4 Lower	0.11	9.7	0.17	181	44.3	0.076	93.6	12.1	0.17 U	90.7	0.61	0.56 U
TB-5 Lower	0.10[b]	10.1[b]	0.21[b]	192[b]	41.2[b]	0.058[b]	97.6[b]	10.6[b]	0.17 U[b]	94.3[b]	0.48 U	0.76
TB-6 Lower	0.12	12.4	0.20	173	53.4	0.037	113	8.4	0.17 U	105	0.54	0.56 U
TB-7 Lower	0.11	9.8	0.20	188	42.4	0.038	92.7	11.1	0.19	95.8	0.52	0.56 U
TB-8 Lower	0.10	10.7	0.21	182	45.8	0.066	101	10.3	0.19	97.2	0.48 U	0.56 U
TB-9 Lower	0.10	7.8	0.15	196	41.2	0.068	87.9	14.1	0.17 U	82.7	0.48 U	0.56 U
OBM COMP	0.11	3.28	0.56	142	27.4	0.044	62.7	10.6	0.17 U	68.3	0.48 U	0.56 U

(a) U Undetected at or above detection limit.
(b) Values is mean of replicate analysis.

TABLE Q.7 Summary of 10-Day Solid-Phase Toxicity Tests, Richmond Harbor Deepening Project

Sediment Treatment	*R. abronius* Percent Survival	*R. abronius* Acute Toxicity	*M. nasuta* Percent Survival	*M. nasuta* Acute Toxicity	*N. caecoides* Percent Survival	*N. caecoides* Acute Toxicity
R-BF	94	NA[a]	100	NA	91	NA
SF COMP	89	NO[b]	100	NO	79	NO
SFW COMP	77	NO	98	NO	81	NO
UIH COMP	77	NO	100	NO	88	NO
TB Upper COMP	70	YES[c]	99	NO	86	NO
TB Lower COMP	50	YES	98	NO	96	NO
OBM COMP	72	YES	98	NO	38	YES
C-SB	93	NA	100	NA	96	NA
C-WB	98	NA	NA	NA	NA	NA
C-NE	NA	NA	100	NA	94	NA

(a) NA Not applicable.

(b) NO No statistically significant difference from the reference sediment R-BF at α=0.05.

(c) YES Statistically significantly different from the reference sediment R-BF at α=0.05 and >10% lower survival than R-BF (20% for *R. abronius*).

TABLE Q.8. Summary of 10-Day Solid-Phase *R. abronius* Toxicity Tests, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Static Percent Survival	Static Acute Toxicity	Ammonia Reduction to <20 mg/L Percent Survival	Ammonia Reduction to <20 mg/L Acute Toxicity	Ammonia Reduction to <15 mg/L Percent Percent	Ammonia Reduction to <15 mg/L Acute Toxicity
R-BF	84	NA[a]	84	NA	NA	NA
TB-1 Lower	87	NO	NA	NA	NA	NA
TB-2 Lower	52	YES	79	NO	NA	NA
TB-3 Lower	25	YES	70	NO	83	NO
TB-4 Middle	82	NO	89	NO	NA	NA
TB-4 Lower	76	NO	81	NO	NA	NA
TB-5 Lower	62	YES	82	NO	NA	NA
TB-6 Lower	76	NO	NA	NA	NA	NA
TB-7 Lower	55	YES	NA	NA	75	NO
TB-8 Lower	64	NO	NA	NA	81	NO
TB-9 Lower	28	YES	74	NO	80	NO
OBM COMP	68	NA	NA	NA	NA	NA
C-WB	98	NA	98	NA	100	NA
C-SB	89	NA	89	NA	NA	NA

(a) NA Not applicable.

These test treatments were TB-2 Lower, TB-3 Lower, TB-5 Lower, TB-7 Lower, and TB-9 Lower. When these test treatments were further tested either during the ammonia reduction to <20 mg/L test or the ammonia reduction to <15 mg/L test, none were acutely toxic to *R. abronius* when compared with the survival of *R. abronius* exposed to the sediments from R-BF.

Q.3 WATER COLUMN EFFECTS

The evaluation of water column effects does not include comparisons with the reference sediment because the reference sediment is not tested for water column toxicity. The results of the three water column (SPP) toxicity tests conducted with Richmond Harbor Deepening test treatments are presented in Table Q.9. There was no acute toxicity to either the mysid, *H. costata*, or to the sanddab, *C. stigmaeus*. T-test results showed that the SPP from SFW, UIH, TB Upper, and TB Lower COMPs significantly affected survival to normal D-cell stage in *M. galloprovincialis* larvae. The EC_{50} values for those treatments ranged from 57.6% SPP to 80.0% SPP. Normal development could have been affected by ammonia released from sediment into the SPP (see Section 3.4.7, Figure 3.38). Ammonia concentrations and normal development in 100% SPP of SFW, UIH, and TB Lower COMPs were within the range of expected effects for ammonia acting alone. However, normal development in TB Upper COMP SPP appeared to be reduced more than would be expected from ammonia only.

Q.4 DEPOSITED SEDIMENT BIOACCUMULATION

Bioaccumulation of contaminants by the clam, *M. nasuta*, and the polychaete, *N. virens*, was assessed through a 28-day exposure to Richmond Harbor Deepening composites followed by chemical analysis of tissue samples. The 28-day test methods and results are reported in Sections 2 and 3 and Appendixes M and N. Complete tissue chemistry results, QC data, and QA/QC summaries are presented in Appendixes O and P. The concentrations of contaminants in *M. nasuta* and *N. virens* exposed to the Richmond Harbor sediment treatments were compared with the FDA action limits for contaminants in fish and shellfish (Table Q.10). None of the FDA action limits was exceeded for any of the contaminants.

Contaminant concentrations in *M. nasuta* and *N. virens* exposed to the Richmond Harbor test treatments were statistically compared using Dunnett's Test with concentrations in organisms that were exposed to the reference treatment R-BF. Mean tissue concentrations of metals, butyltins, pesticides, PCBs, PAHs, and phthalate esters in *M. nasuta* and *N. virens* are shown in Tables Q.11 and Q.12, respectively. Relative to R-BF, metals were not bioaccumulated in *M. nasuta* at all, and only slightly in *N. virens* (Cd in three COMPs, Ni in one COMP, dibutyltin in one COMP). Bioaccumulation of 4,4'-DDD and dieldrin by both *M. nasuta* and *N. virens*

TABLE Q.9. Summary of Suspended-Particulate-Phase Toxicity Tests, Richmond Harbor Deepening Project (bold type indicates mean survival in 100% SPP significantly lower than control in 2-sample T-test, $\alpha = 0.05$)

	Mysid *H. costata*			Bivalve *M. galloprovincialis*			Sanddab *C. stigmaeus*		
	Mean Survival (%)		LC_{50} as	Mean Normal D (%)		EC_{50} as	Mean Survival (%)		LC_{50} as
Treatment	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP
SF COMP	94	86	>100	94	96	>100	100	100	>100
SFW COMP	98	88	>100	91	**26**	80.0	98	100	>100
UIH COMP	100	90	>100	90	**0**	57.6	98	98	>100
TB Upper COMP	96	96	>100	96	**17**	74.8	100	100	>100
TB Lower COMP	98	94	>100	82	**0**	69.7	98	100	>100
OBM COMP	98	96	>100	98	96	>100	100	100	>100

TABLE Q.10. Comparison of FDA Action Levels With Contaminant Levels in *M. nasuta* and *N. virens* Exposed to Richmond Harbor Deepening Project Sediment Treatments

Contaminant	FDA Action Level (mg/kg wet weight)	Maximum Concentration (mg/kg wet weight) *M. nasuta*	*N. virens*
Benzene Hexachloride (BHC)[a]	0.3	0.00096	U[b]
Chlordane	0.3	U	U
DDT + DDE	5.0	0.0055	0.001038
Dieldrin + Aldrin	0.3	0.00224	0.002309
Endrin	0.3	U	U
Heptachlor + Heptachlor Epoxide	0.3	U	U
Toxaphene	5.0	U	U
PCBs	2.0	0.00040	U

(a) Total BHCs (alpha-, beta-, delta-, and gamma-BHC).
(b) U Undetected at or above detection limit.

TABLE Q.11. Mean Values of Contaminants Detected in Tissues of *M. nasuta* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-BF when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-BF; shaded box indicates value is >5 times but ≤10 times R-BF; shaded double-lined box indicates value is >10 times R-BF)

Analyte	R-BF	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB[a]	*M. nasuta* Background[a]
PAHs, µg/kg dry weight									
Naphthalene	14.6 B[b]	11.9	**33.5**	10.8	16.8	11.9	NA[c]	10.8	9.82
Acenaphthylene	9.54 U[d]	7.57 U	8.79	8.02 U	12.7	7.53 U	NA	5.91 U	8.56
Acenaphthene	9.43	7.26	**54.2**	7.63 U	12.4	7.14 U	NA	5.99	9.61
Fluorene	16.2	12.7 U	**74.7**	13.9	21.3 U	12.6 U	NA	10.0	14.1 U
Phenanthrene	11.9	11.8	**562**	12.5	14.1	8.31	NA	9.37	23.9
Anthracene	24.0	27.4	**103**	26.8	35.2	20.6	NA	16.0 U	23.4
Fluoranthene	66.3	75.7 *[e]	**673**	72.4 *	58.8 *	30.0 *	NA	47.8 *	72.8 *
Pyrene	32.1	**131**	**732**	**170**	37.2	13.2	NA	8.49 U	46.6 *B
Benzo(a)anthracene	28.7 B	42.0	**165**	32.1 B	24.0 B	10.9 B	NA	12.3 B	13.5 B
Chrysene	32.4	**45.9**	**136**	39.2	21.8	12.7	NA	15.1	23.0 B
Benzo(b)fluoranthene	71.8	**306**	**303**	**198**	63.2	22.3	NA	24.5 *	29.5 *B
Benzo(k)fluoranthene	32.7	**113**	**107**	**74.7**	33.4	13.2	NA	12.3	25.4
Benzo(a)pyrene	43.6 *	**171**	**185**	**116**	44.5 *	20.8 *	NA	18.6 *	26.2 *B
Indeno(1,2,3-cd)pyrene	34.8	**57.4**	51.2	53.1	43.5	26.0	NA	19.5 U	33.7
Benzo(g,h,i)perylene	57.5	65.8	78.6	74.9	54.4	24.1	NA	46.8	29.6
Phthalates, µg/kg dry weight									
Diethyl Phthalate	387	288 B	257	235	888	233	NA	188	210
Di-n-butyl Phthalate	383	253	358	357	368	256	NA	144 U	207
Butylbenzyl Phthalate	598	575	493 *	705	694	556	NA	798 *	204 U
Bis(2-ethylhexyl) Phthalate	902	859	810	906	1020	757	NA	845	502

TABLE Q.11. (contd)

Analyte	R-BF	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB(a)	*M. nasuta* Background(a)
Pesticides/PCBs, µg/kg dry weight									
beta BHC	2.9 U	2.3 U	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
delta BHC	2.9 U	2.3 U	2.6	2.4 U	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
gamma BHC	1.4 U	1.1 U	1.7	1.2 U	1.8 U	1.3 U	1.8 U	0.94	1.2 U
4,4'-DDD	2.7 U	489	543	182	3.6 U	2.5 U	3.4 U	1.7 U	2.4 U
4,4'-DDE	2.27	112	329	0.7 U	2.68	0.6 U	1.0 U	0.5 U	2.9
4,4'-DDT	4.3	1.6 U	1.8 U	1.7 U	3.5	1.9 U	2.6 U	1.3 U	17
Dieldrin	1.9 U	51.0	118	29.5	2.5 U	1.7 U	2.3 U	1.2 U	1.6 U
Endosulfan I	2.9 U	2.5	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
Aroclor 1254	130 U	160 U	210	140	140 U	150 U	150 U	150 U	140 U
Metals, mg/kg dry weight									
Silver	0.224	0.216	0.192	0.183	0.196	0.197	NA	0.183	0.492
Arsenic	22.3	24.7	27.1	20.8	22.8	23.4	NA	24.2	31.2
Cadmium	0.175	0.202	0.199	0.183	0.200	0.210	NA	0.178	0.254
Chromium	2.39	1.99	2.10	2.05	2.21	2.04	NA	1.54	1.12
Copper	13.4	12.8	11.3	12.4	15.1	11.5	NA	12.4	15.1
Mercury	0.095	0.060	0.076	0.063	0.084	0.062	NA	0.051	0.063
Nickel	4.41	3.86	3.68	3.66	4.09	4.90	NA	3.02	2.62
Lead	1.99	2.11	2.30	2.11	1.57	1.24	NA	1.34	1.34
Selenium	1.58	1.69	1.79	1.66	1.65	1.57	NA	1.65	1.79
Zinc	103	107	110	93.9	105	96.6	NA	89.4	107
Butyltins, µg/kg dry weight									
Tributyltin	17.8	23.5	11.5	17.2	8.73	9.05	13.6	10.8	4.31
Dibutyltin	10.5	11.8	9.30	10.4	9.44 U	12.0	10.9	10.1	10.3

(a) Treatment not included in Dunnett's Test data set.
(b) B All replicate values are <5 times the amount detected in the associated method blank.
(c) NA Not applicable.
(d) U Undetected in all replicates; value is mean of dry weight detection limits.
(e) * Ion Ratio out or confirmation ion not detected in all replicates.

TABLE Q.12. Mean Values of Contaminants Detected in Tissues of *N. virens* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-BF when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-BF; shaded box indicates value is >5 times but ≤10 times R-BF; shaded double-lined box indicates value is >10 times R-BF)

Analyte	R-BF	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV[a]	*N. virens* Background[a]
PAHs, µg/kg dry weight								
Naphthalene	19.8	20.5	25.3	20.2	20.0	18.6	26.5	15.6 B[b]
Acenaphthylene	12.0 U[c]	14.6 U	14.7	14.7 U	12	12.3 U	19.1	14.2
Acenaphthene	13.8	16.8	65.5	14.0	12.1	13.0	20.1	13.6
Phenanthrene	15.6	15.4	28.2	15.7 *[d]	13.2 *	13.0	19.1	13.8 B
Anthracene	33.4	40.9	41.2	40.2	31.8	33.5 U	49.4	37.7 U
Fluoranthene	38.3 *	46.5	84.1	45.8 *	38.6 *	36.2 *	59.2 *	44.8 *
Pyrene	44.4 *B	51.7 *B	84.6 B	52.0 B	41.7 *B	38.3	63.5 *B	50.7 *B
Benzo(a)anthracene	16.8 B	21.0 *B	24.9 B	20.0 B	15.8 B	16.3 *B	26.0 *B	20.1 B
Chrysene	13.1	17.1	29.6	14.3	11.8	11.2	18.9	18.2
Benzo(b)fluoranthene	18.2	44.2 *	53.3	35.1	17.8	11.2	25.0	38.4
Benzo(k)fluoranthene	21.7	38.8	49.5 *	45.9 *	26.3	26.5	33.9	42.5 *B
Benzo(a)pyrene	23.0 *	37.1	42.5 *	36.0 *	25.7 *	27.8	38.8 *	34.3 *B
Indeno(1,2,3-cd)pyrene	39.4 U	50.2	47.5 U	53.3	38.7 U	40.7 U	59.8 U	46.0 U
Benzo(g,h,i)perylene	35.2 U	59.6	58.1	48.8	36.0	37.7	57.0	44.1
Phthalate Esters, µg/kg dry weight								
Diethyl Phthalate	291 U	358	350 U	358 U	285 U	300 U	441 U	344
Butylbenzyl Phthalate	307	543	408	426	290	312	461	366
Bis(2-ethylhexyl) Phthalate	549	669	764	727	731	782	1020	693
Di-n-octyl Phthalate	291 U	355 U	350 U	358 U	464	300 U	441 U	869 U

TABLE Q.12. (contd)

Analyte	R-BF	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV(a)	*N. virens* Background(a)
Pesticides/PCBs, µg/kg dry weight								
Aldrin	1.32 U	2.47	8.92	1.64 U	1.32 U	1.36 U	5.78	9.82
4,4'-DDD	3.42 U	138	374	56.7	3.34 U	3.52 U	5.18 U	3.96 U
4,4'-DDE	1.04 U	9.70	1.22 U	4.32	1.04 U	1.06 U	1.58 U	4.13
4,4'-DDT	12.7	37.6	34.4	23.8	8.18	13.3	23.9	2.98 U
Dieldrin	2.28 U	47.6	151	28.9	3.10	2.36 U	5.05	2.64 U
Metals, mg/kg dry weight								
Silver	0.250	0.303	0.309	0.295	0.348	0.174	0.251	0.246
Arsenic	14.5	14.3	14.8	14.6	14.6	14.7	16.6	15.5
Cadmium	0.309	0.331	0.347	0.367	0.364	0.326	0.298	0.293
Chromium	1.02	1.35	0.997	0.930	1.25	1.62	0.898	9.37
Copper	10.8	11.0	10.6	10.8	10.5	11.0	8.95	13.7
Mercury	0.220	0.213	0.217	0.229	0.231	0.211	0.202	0.218
Nickel	1.57	1.70	1.62	1.56	2.17	3.53	1.13	3.86
Lead	0.857	1.03	1.02	0.900	1.04	0.912	0.911	1.03
Selenium	1.90	1.88	1.84	1.93	2.03	1.91	1.81	2.13
Zinc	195	270	197	200	240	177	214	208
Butyltins, µg/kg dry weight								
Tributyltin	3.65	3.90	3.91	3.60 U	3.70	3.64 U	3.57 U	3.44 U
Dibutyltin	10.6	16.0	11.1	20.7	10.9	11.0	15.1	9.96 U
Monobutyltin	2.92 U	2.89 U	2.96 U	2.92 U	3.35	2.96 U	2.90 U	2.79 U

(a) Treatment not included in Dunnett's Test data set.
(b) B All replicate values are <5 times the amount detected in the associated method blank.
(c) U Undetected in all replicates; value is mean of dry weight detection limits.
(d) * Ion Ratio out or confirmation ion not detected in all replicates.

exposed to SF, SFW, and UIH COMPs was both statistically significant and of high magnitude. Significant bioaccumulation of PAHs at moderate to high magnitude occurred in *M. nasuta* and *N. virens* exposed to SFW COMP. Several HPAHs were also bioaccumulated by *M. nasuta* exposed to SF and UIH Comps.

Q.5 CONCLUSION

In this appendix, comparisons of Richmond Harbor Deepening dredged material and Intensive Study of the Turning Basin dredged material with the Bay Farm Borrow Area reference are provided to evaluate the acceptability of this sediment for in-bay disposal. For each test treatment, sediment contaminant levels, contribution to acute toxicity, either as water column effect or deposited sediment effect, and potential for bioaccumulation are shown in Table Q.13. The matrix in Figure Q.2 is a summary of sediment chemistry, acute toxicity, and bioaccumulation potential for the Richmond Harbor Deepening test treatments relative only to the reference R-BF. This matrix shows the number of contaminants in *M. nasuta* and *N. virens* that were elevated above a range of magnitudes (2, 5, and 10 times R-BF) and in which cases similar classes of contaminants were accumulated by both species. This summary is intended to assist USACE, EPA, and other resource agencies in evaluating the potential effects of in-bay disposal of dredged material from Richmond Harbor.

TABLE Q.13. Summary of Statistically Significant Acute Toxicity and Bioaccumulation for Richmond Harbor Deepening Proejct Sediment Treatments Relative to the Reference Sediment R-BF

Sediment Treatment	Acute Toxicity	*M. nasuta* Bioaccumulation					*N. virens* Bioaccumulation				
		PAH	Pesticides	PCB	Metals	TBT	PAH	Pesticides	PCB	Metals	TBT
SF COMP	---(a)	HPAH	DDD,DDE,Diel	---	---	TBT	HPAH,phth	DDD,DDE,DDT,Diel	---	---	---
SFW COMP	B(b)	LPAH,HPAH	DDD,DDE,Diel	1254	---	---	LPAH,HPAH	Ald,DDD,DDT,Diel	---	Cd	---
UIH COMP	B	HPAH	DDD,Diel	---	---	---	HPAH	DDD,DDE,Diel	---	Cd	DBT
TB Upper COMP	B,R(c)	---	---	---	---	---	---	---	---	Cd	---
TB Lower COMP(d)	B,R(d)	---	---	---	---	---	---	---	---	Ni	---
OBM COMP	R,N(e)	NA(f)	---	---	NA	---	NA	NA	NA	NA	NA

(a) --- No statistically significant acute toxicity or bioaccumulation.
(b) B Acutely toxic to *M. galloprovincialis* in the 48-h SPP test.
(c) R Acutely toxic to *R. abronius* in the 10-day solid-phase test.
(d) Evaluation of *R. abronius* toxicity to TB Lower Comp is based on the results from the Intensive Study of the Turning Basin in October 1994. The results of this study showed that the nine individual stations making up the TB Lower COMP were not acutely toxic to *R. abronius*.
(e) N Acutely toxic to *N. caecoides* in the 10-day solid-phase test.
(f) NA Not Applicable.

	Sediment Chemistry					Toxicity		Significant Bioaccumulation						Bioaccumulation ≥ 2 < 5 times						Bioaccumulation ≥ 5 < 10 times						Bioaccumulation ≥ 10 times					
Sediment Treatments	sediment LPAH > R-BF	sediment HPAH > R-BF	# of sediment Pesticide and PCB > R-BF	# of sediment Metals > R-BF	# of sediment Butyltins > R-BF	species associated with SPP toxicity	species with solid-phase acute toxicity	# of LPAH compounds (6 possible)	# of HPAH/phthalates (16 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH/phthalates (16 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH/phthalates (16 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH/phthalates (16 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)
SF COMP			5	3	2				6/3	3/4			1		4/1	1/1						1/1						3/2			
SFW COMP	√	√	5	9	1	B		5/2	7/8	3/4	1	1		3/1	4/4	1/1				1	1	1/1				1	2	3/2			
UIH COMP	√	√	4	9	2	B			4/1	2/3		1	1		3/1	1/1					1							2/2			
TB Upper COMP			1	1		B	R					1																			
TB Lower COMP				3		B	R					1						1													
OBM COMP				NA			RN	NA	NA			NA																			

√ Total LPAH or HPAH with detected values above the reference R-BF

C Calculable LC_{50} values in the *C. stigmaeus* test
B Calculable EC_{50} values in the *M. galloprovincialis* test
H Calculable LC_{50} values in the *H. costata* test
R Acute Toxicity in the *R. abronius* 10-day test
N Acute Toxicity in the *N. caecoides* 10-day test

NA Not applicable; sediment treatment not analyzed for this parameter

Number of Compounds Bioaccumulating in *M. nasuta* Tissues
Number of Compounds Bioaccumulating in *N. virens* Tissues

FIGURE Q.2. Matrix of Sediment Chemistry, Significant Acute Toxicity, and the Bioaccumulation for Richmond Harbor Deepening Sediment Treatments Relative to the Bay Farm Borrow Pit Reference Area, R-BF

APPENDIX R

POTENTIAL EFFECTS OF DISPOSAL OF RICHMOND HARBOR DEEPENING AND TURNING BASIN SEDIMENTS AT ALCATRAZ ISLAND DISPOSAL SITE AND AT ALCATRAZ ENVIRONS REFERENCE AREA

APPENDIX R

POTENTIAL EFFECTS OF DISPOSAL OF RICHMOND HARBOR DEEPENING AND TURNING BASIN SEDIMENTS AT ALCATRAZ ISLAND DISPOSAL SITE AND AT ALCATRAZ ENVIRONS REFERENCE AREA

This appendix presents the results of physical/chemical sediment analysis, acute toxicity tests, bioaccumulation tests, statistical comparisons, and a Tier III evaluation of Richmond Harbor Deepening and Intensive Study of the Turning Basin sediments relative to the Alcatraz Environs Reference Area (R-AM) (Figure R.1). The Alcatraz Environs Reference Area is used to evaluate sediment for in-bay disposal at the Alcatraz Island Disposal Site. All methods and results for sampling, physical descriptions, sediment chemistry, biological testing, and tissue chemistry are contained in Sections 2, 3, and 4 of this report; supporting data are contained in Appendixes A through R. As stated in Section 2.5 of this report, the use of Dunnett's test for statistical comparisons of non-independent data sets increases the chance of Type II statistical errors in all comparisons, resulting in the identification of a greater number of significant differences than if a multiple comparison test were used.

R.1 SEDIMENT CHARACTERISTICS

The five Richmond Harbor Deepening composites were fairly representative of the sediment characteristics of their contributing stations with respect to the sediment parameters that were measured (Tables R.1 through R.3). All of the Richmond Harbor Deepening sediments had much more silt and clay than the reference sediment R-AM, which is almost entirely sand (Table R.1). The other conventional parameters were also considerably higher in most test sediments than in R-AM, which is typical for fine-grained sediment.

Comparisons of Richmond Harbor Deepening sediment PAHs, pesticides, and PCBs with R-AM are shown in Table R.2. Concentrations of PAHs were relatively high in R-AM sediment, indicating possible contamination of the Alcatraz Environs Reference Area from the Alcatraz Island Disposal Site. The PAHs were present in nearly all Richmond Harbor samples, but only five test treatments (all in Santa Fe Channel) had higher PAH concentrations than R-AM. The chlorinated pesticides 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin, were considerably elevated in SF, SFW, and UIH COMPs and their respective stations relative to R-AM. Some of these pesticides were present in TB Upper and Lower COMPs and their contributing stations. The primary source of these pesticides is the former United Heckathorn plant on the east shore of Lauritzen Canal (Figure 3.1), which is now a federal Superfund site. PCB Aroclor 1254 was also elevated in SF, SFW, and UIH COMPs and their contributing stations, but was below the method detection limit in all other stations except TB-4 Upper and Lower stations.

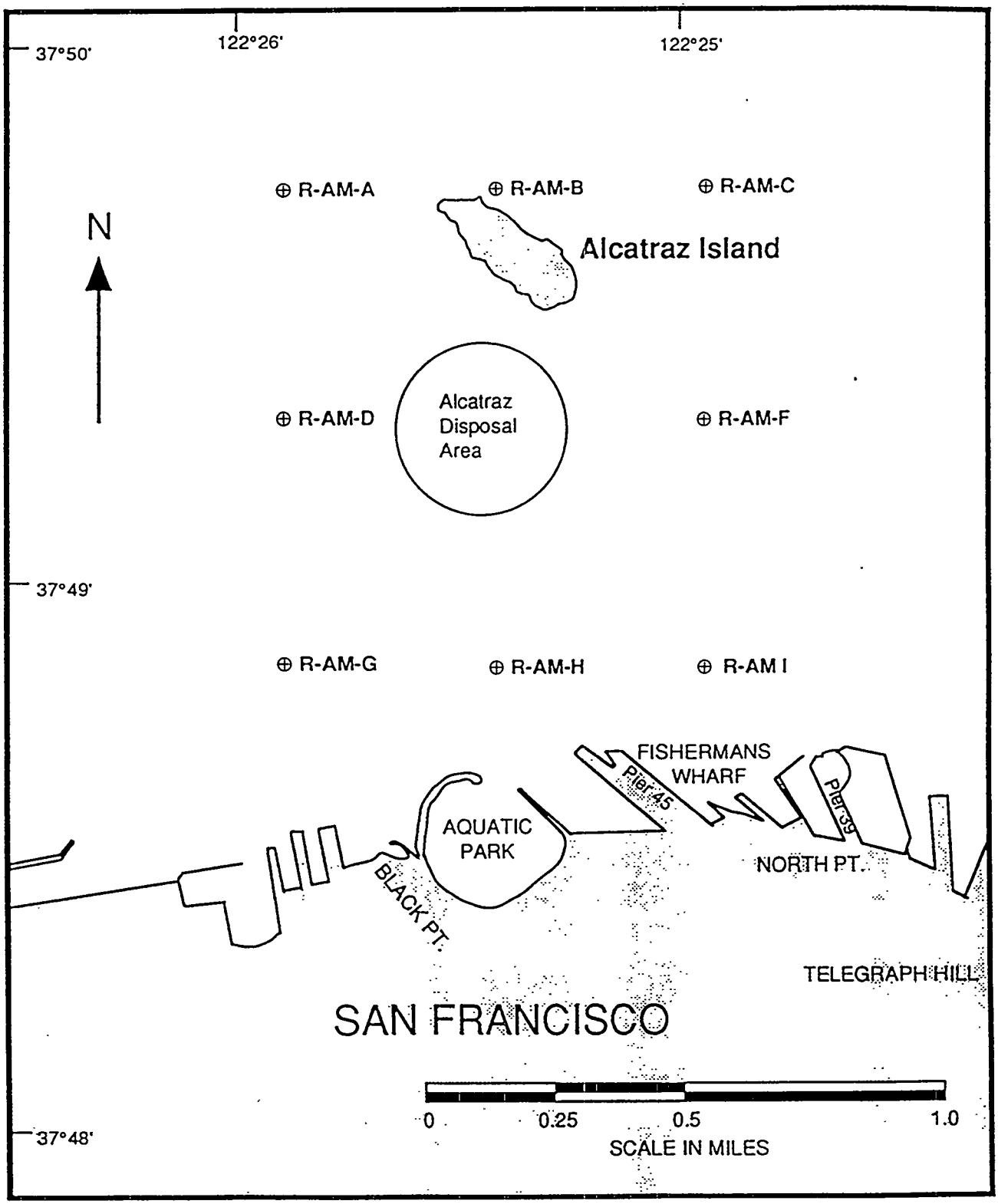


FIGURE R.1. Location of Alcatraz Environs Reference Area (R-AM)

TABLE R.1. Conventional Sediment Measurement Results for the Richmond Harbor Deepening Project Sediment Treatments

Sediment Treatment	Percent Dry Weight						mg/kg Dry Weight	
	Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	Oil and Grease	TPH
R-AM COMP	0	97	1	2	0.02	0.776	26	20U[a]
R-AM -A	0	99	0	1	0.03	0.589	23	17U
R-AM -B	0	98	1	1	0.01	0.602	18U	18U
R-AM -C	0	99	0	1	0.02[b]	0.572	41	20U
R-AM -D	0	98	1	1	0.03[b]	0.613[b]	49[b]	19[b]
R-AM -D[c]	NA[d]	NA	NA	NA	NA	NA	18U	18U
R-AM -F	0	79	12	9	0.28	1.73	38	22U
R-AM - G	0	97	1	2	0.04[b]	0.707	37	20U
R-AM -H	0	97	1	2	0.04	0.678	19U	19U
R-AM -I	0	98	0	2	0.04	0.658	18U	18U
SF COMP	1	29	35	35	0.71	2.32	29U	29U
SF-1	1	29	42	28	0.33	2.27	36	23U
SF-2	6	18	34	42	0.98	2.62	66	34
SF-3	0	9	32	59	1.27[b]	2.67	136	67
SF-4	0	5	32	63	1.37	2.70	98	57
SFW COMP	5	23	37	35	0.76[b]	2.26	102[b]	68[b]
SFW COMP[c]	NA	NA	NA	NA	NA	NA	232	104
SFW-1	13	35	21	31	1.00	2.21	44	35
SFW-2	8	15	35	42	1.09	2.84	79	69
SFW-3	2	18	47	33	0.49	2.32	117	84
SFW-4	3	27	45	25	0.32	2.01	27	22U
UIH COMP	0	6	33	61	1.23	2.69	91	65
UIH-1	0	5	35	60	1.17	2.80	204	75
UIH-2	0	2	33	65	1.20	2.73	97	38U
UIH-3	0	7	35	58	1.12	2.81	80	34U
UIH-4	1	13	35	51	0.87	2.83	142	72
UIH-5	0	7	39	54	0.97	2.74	139	70
TB Upper COMP	8	14	45	33	0.85	2.48	47	30U
TB-1 Upper	22	33	24	21	0.50	2.45	36	23U
TB-2 Upper	5	20	41	34	0.73	3.25	36	25U
TB-3 Upper	1	13	48	38	0.78	2.47	28U	28U
TB-4 Upper	0	3	46	51	1.09	2.63	169	57
TB-5 Upper	1	7	58	34	0.79	2.44	26U	26U
TB-6 Upper	0	3	49	48	0.66	2.43	83	32
TB-7 Upper	0	5	66	29	0.63	2.38	29[b]	25U[b]
TB-7 Upper[c]	NA	NA	NA	NA	NA	NA	20U	20U

TABLE R.1. (contd)

Sediment Treatment	Percent Dry Weight: Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	mg/kg Dry Weight: Oil and Grease	TPH
TB Lower COMP	3(b)	15(b)	46(b)	36(b)	0.69	2.15	35	26U
TB-1 Lower	9	53	23	15	0.05	1.73	19U	19U
TB-2 Lower	1	23	43	33	0.62	2.08	29	24U
TB-3 Lower	0(b)	13(b)	52(b)	36(b)	0.70	2.21	30	25U
TB-4 Lower	0	4	47	49	0.93	2.88	58	30U
TB-5 Lower	0	12	55	33	0.70	2.27	25U	25U
TB-6 Lower	0(b)	7(b)	50(b)	43(b)	0.55	2.27	26U	26U
TB-7 Lower	1	3	55	41	0.72	2.43	26U	26U

(a) U Undetected at or above the detection limit.
(b) Value is mean of analytical replicates.
(c) Sample reanalyzed approximately one month after original oil and grease and TPH analysis to provide appropriate matrix spike data.
(d) NA Not applicable.

The sediment from R-AM has very low concentrations of most metals and butyltins and all five test treatments had elevated concentrations of metals relative to R-AM (Table R.3). Many metals tend to be associated with the silt/clay grain-size fraction, which was predominant in Richmond Harbor sediment but essentially absent in R-AM sediment. Butyltins were exceptionally high in Stations SF-3 and SF-4, located just upchannel from the entrance to Lauritzen Canal (see Figure 3.1).

The sediments from the Intensive Study of the Turning Basin were predominantly silt and clay except for TB-1 Lower, which was predominantly sand mixed with gravel. The sediment from R-AM was also predominantly sand and had the lowest concentrations of TOC, TVS, oil and grease, and TPH of any sediment treatment (Table R.4). The concentrations of PAHs and aldrin were higher in R-AM sediments than in most of the test treatments. A summary of the organic compounds detected in the test and reference treatment is shown in Table R.5. Seven of the 10 metals that were analyzed were lower in R-AM sediments than in any of the test treatments. Butyltins were not detected in the sediment from R-AM (Table R.6).

R.2 DEPOSITED SEDIMENT TOXICITY

The acute solid-phase tests with Richmond Harbor Deepening sediments showed no acute toxicity to *M. nasuta* when compared with the reference sediment from R-AM (Table R.7). However, three COMPs were acutely toxic to *N. caecoides* (SF, SFW, and OBM). At this time,

TABLE R.2. Detected PAHs, Pesticides, and PCBs in Richmond Harbor Deepening Project Sediment Treatments (shading indicates detected values greater than the Alcatraz Environs [R-AM COMP] reference sediment; all concentrations in µg/kg dry weight)

Sediment Treatment	Total LPAH	Total HPAH	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
R-AM COMP	1777	2426	0.45	0.05 U[a]	0.52	0.28 U	20 U
R-AM -A	19	102	0.10 U	0.04 U	0.30 U	0.22 U	20 U
R-AM -B	16	45	0.11 U	0.05 U	0.30 U	0.23 U	20 U
R-AM -C	58	102	0.13 U	0.05 U	0.36 U	0.63	20 U
R-AM -D	354	744	0.10 U	0.04 U	0.30 U	0.22 U	20 U
R-AM -F	1062	3325	1.25	0.06 U	3.21	0.76	33.6
R-AM -G	195	549	0.64	0.05 U	0.36 U	0.27 U	20 U
R-AM -H	220	477	0.12 U	0.05 U	0.34 U	0.26 U	20 U
R-AM -I	627	1533	0.12 U	0.05 U	0.35 U	0.26 U	20 U
SF COMP	228	1345	203 D[b]	34.2	140 D	14.0	107
SF-1	79	390	82.8 D	11.6	23.3	5.51	33.6
SF-2	273	1876	285 D	65.2	78.7 D	25.8	177
SF-3[c]	471	3274	283 D	36.1 D	358	24.1	183
SF-4	489	3274	288 D	66.6	137 D	22.8	198
SFW COMP	3897	1806	267 D	82.3 D	81.7 D	46.2	145
SFW-1	248	1735	191 D	31.1	112 D	12.9	108
SFW-2	386	3390	184 D	67.2	87.4 D	17.1	20 U
SFW-3	2188	1105	127 D	31.8 D	56.3 D	17.5	39.4
SFW-4	71	396	88.4 D	18.7	38.4	6.26	20 U
UIH COMP[b]	425	2372	110 D	18.8 D	53.2 D	9.17	92.5
UIH-1	253	1596	76.1 D	13.1	49.2	6.48	72.0
UIH-2	278	1987	75.8 D	14.0	48.8	7.24	92.3
UIH-3	245	1709	157 D	24.3	85.2	10.8	157
UIH-4	227	1712	70.5 D	14.2	44.2	5.47	67.5
UIH-5	283	1843	178 D	40.4	60.5 D	16.8	140

TABLE R.2. (contd)

Sediment Treatment	Total LPAH	Total HPAH	4,4'-DDD	4,4'-DDE	4,4'-DDT	Dieldrin	Aroclor-1254
TB Upper COMP	115	820	1.99	0.08 U	0.73	1.06	20 U
TB-1 Upper	48	368	1.83	0.06 U	1.24	0.32 U	8.51 J[d]
TB-2 Upper[b]	172	1213	2.11	0.39	2.00	0.57	20 U
TB-3 Upper	161	1322	1.01	0.07 U	0.50 U	0.85	4.68 J
TB-4 Upper	216	1622	17.0	5.16	4.74	2.05	46.8
TB-5 Upper	91	383	0.75	0.07 U	6.87	0.62	20 U
TB-6 Upper	13	18	0.17 U	0.07 U	0.48 U	0.36 U	20 U
TB-7 Upper	26	26	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB Lower COMP	31	94	0.97	0.07 U	0.47 U	0.36 U	20 U
TB-1 Lower	0	2	0.12 U	0.05 U	0.36 U	0.27 U	20 U
TB-2 Lower	13	17	0.14 U	0.06 U	0.40 U	0.30 U	20 U
TB-3 Lower	16	26	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-4 Lower	260	2023	24.9	0.08 U	12.8	1.86	59.3
TB-5 Lower	19	25	0.15 U	0.06 U	0.43 U	0.32 U	20 U
TB-6 Lower	14	20	0.16 U	0.07 U	0.46 U	0.34 U	20 U
TB-7 Lower	28	27	0.16 U	0.07 U	0.45 U	0.34 U	20 U
OBM COMP	8	4	0.13 U	0.06 U	0.38 U	0.28 U	20 U

(a) U Undetected at or above the detection limit.
(b) D Diluted sample.
(c) Values are mean of analytical replicates.
(d) J Detected below method detection limit but above instrument detection limit.

TABLE R.3. Metal and Butyltin Concentrations in Richmond Harbor Deepening Project Sediment Treatments (shading indicates values greater than the Alcatraz Environs reference sediment [R-AM]; metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-AM COMP	0.052	7.7	0.043	118	10.0	0.039	38.0	18.3	0.128 U[a]	35.6	0.40 U	0.65 U
R-AM -A	0.022	8.0	0.038	98.0	8.2	0.031	32.2	11.9	0.128 U	22.3	0.40 U	0.65 U
R-AM -B	0.030	6.83	0.042	78.3	5.8	0.020 U	32.4	9.8	0.128 U	25.4	0.40 U	0.65 U
R-AM -C	0.029	7.4	0.036	107	9.3	0.024	29.6	10.5	0.128 U	24.6	0.40 U	0.65 U
R-AM -D	0.034	6.3	0.043	126	15.9	0.410	30.6	17.2	0.128 U	29.4	0.40 U	0.65 U
R-AM -F	0.170	6.2	0.167	617	21.0	0.168	55.6	23.7	0.128 U	70.8	6.29	1.57
R-AM -G	0.039	4.99	0.047	135	11.2	0.057	40.8	19.1	0.128 U	43.5	0.40 U	0.65 U
R-AM -H	0.050	6.46	0.041	102	10.3	0.044	27.4	16.7	0.128 U	32.9	0.40 U	0.65 U
R-AM -I	0.042	6.1	0.057	79.1	8.5	0.057	33.9	18.4	0.128 U	34.6	0.40 U	0.65 U
SF COMP	0.391	9.4	0.511	189	55.0	0.360	80.3	35.2	0.235	120	8.52	7.46
SF-1	0.303	7.0	0.922	178	35.6	0.116	71.0	18.9	0.128 U	83.5	1.67	1.59
SF-2	0.566	14.2	0.654	202	71.7	0.490	93.5	48.6	0.418	176	6.78	9.05
SF-3	0.626	13.4	0.474	214	92.9	0.628	111	56.5	0.338	204	30.6	18.2
SF-4	0.694	14.0	0.564	215	107	0.689	109	64.8	0.412	208	27.0	33.1
SFW COMP	0.603	12.4	0.890	192	65.3	0.843	92.5	45.8	0.522	157	2.85	5.73
SFW-1	0.438	14.4	0.462	169	68.5	0.377	82.6	55.8	0.235	175	5.76	9.86
SFW-2	0.615	4.48	0.856	158	34.3	0.857	67.6	20.1	0.421	86.7	4.79	8.46
SFW-3	0.537	9.6	0.782	166	55.6	0.465	86.6	30.4	0.796	119	0.40 U	0.65 U
SFW-4	0.268	13.1	0.628	183	59.6	0.158	85.1	44.3	0.243	153	1.05	2.01
UIH COMP	0.639	13.6	0.513	203	81.2	0.508	112	52.5	0.334	192	8.59	8.38
UIH-1	0.599	14.2	0.484	192	75.6	0.607	115	53.6	0.507	180	5.28	7.95
UIH-2	0.670	13.6	0.465	193	83.9	0.618	117	53.0	0.434	183	6.67	9.67
UIH-3	0.713	14.8	0.696	189	85.7	0.644	111	59.5	0.331	190	4.66	6.68
UIH-4	0.491	10.9	0.733	168	68.0	0.311	101	37.3	0.160	154	7.12	6.02
UIH-5	0.663	16.4	0.670	202	82.1	0.516	114	58.2	0.413	192	9.11	7.04

TABLE R.3. (contd)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
TB Upper COMP	0.223	10.3	0.249	166	40.5	0.234	86.9	17.4	0.240	100	1.87	0.65 U
TB-1 Upper	0.163	11.0	0.159	210	33.6	0.201	71.7	14.7	0.128 U	73.4	0.40 U	1.13
TB-2 Upper	0.214	12.1	0.300	173	42.6	0.373	78.8	21.2	0.240	96.3	1.35	0.65 U
TB-3 Upper	0.275	12.0	0.306	169	46.3	0.532	91.5	27.2	0.337	117	0.40 U	0.65 U
TB-4 Upper	0.501	14.5	0.352	164	68.3	0.401	105	36.8	0.420	151	2.18	2.38
TB-5 Upper	0.145	9.6	0.299	171	34.0	0.175	84.4	13.8	0.426	90.6	0.40 U	0.65 U
TB-6 Upper	0.135	9.9	0.224	184	47.1	0.109	108	10.3	0.340	97.2	0.40 U	0.65 U
TB-7 Upper	0.102	9.2	0.288	212	26.0	0.066	74.1	9.4	0.243	85.0	0.40 U	0.65 U
TB Lower COMP	0.158	11.6	0.252	180	39.4	0.140	90.3	9.4	0.128 U	91.8	0.40 U	0.65 U
TB-1 Lower	0.128	6.7	0.100	205	17.2	0.077	47.5	8.2	0.128 U	42.4	0.40 U	0.65 U
TB-2 Lower	0.108	11.4	0.250	201	33.5	0.073	91.5	13.7	0.346	81.0	0.40 U	0.65 U
TB-3 Lower	0.114	8.3	0.269	203	44.2	0.078	91.6	13.8	0.330	87.0	0.40 U	0.65 U
TB-4 Lower	0.501	13.8	0.649	181	85.0	0.642	98.2	40.2	0.413	155	0.40 U	1.20
TB-5 Lower	0.115	10.3	0.281	201	33.6	0.062	85.6	10.4	0.333	84.4	0.40 U	0.65 U
TB-6 Lower	0.143	10.7	0.217	205	47.6	0.088	101	12.7	0.240	87.1	0.40 U	0.65 U
TB-7 Lower	0.140	10.8	0.284	193	44.7	0.078	105	10.4	0.273	94.5	0.40 U	0.65 U
OBM COMP	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.40 U	0.65 U

(a) U Undetected at or above the detection limit.

TABLE R.4. Conventional Sediment Measurement Results for the Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Percent Dry Weight						mg/kg Dry Weight	
	Gravel >2000 µm	Sand 62.5-2000 µm	Silt 3.9-62.5 µm	Clay <3.9 µm	TOC	TVS	Oil and Grease	TPH
R-AM	0	99	0	1	0.104[a]	0.6	10 U[b]	10 U
TB-1 Lower	13	49	23	15	0.11	0.79[b]	14	9.9 U
TB-2 Lower	3	18	47	32	0.67	2.3	50	27
TB-3 Lower	1	15	50	34	0.67	2.1	40	16 U
TB-4 Middle	0[b]	4[b]	48[b]	48[b]	1.1	2.6	18 U	18 U
TB-4 Lower	0	10	44	46	0.58	2.1	16 U	16 U
TB-5 Lower	0	7	54	39	0.90	2.2	56	58
TB-6 Lower	1	5	40	54	0.81	2.6	17 U	17 U
TB-7 Lower	1	7	53	39	0.70	2.4	15 U	15 U
TB-8 Lower	0	6	55	39	0.76	2.6	43	16 U
TB-9 Lower	0	15	44	41	0.59	2.1	20	16 U
OBM COMP	0	18	56	26	0.16	2.1	11 U	11 U

(a) Value is mean of analytical replicates.
(b) U Undetected at or above the detection limit.

TABLE R.5. Detected Total PAHs, Pesticides, and PCBs in Sediment Treatments, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (values in µg/kg dry weight)

Sediment Treatment	Total LPAHs	Total HPAHs	Aldrin	4,4'-DDD	4,4'-DDE	4,4'-DDT	Aroclor 1254
R-AM	538	1055	1.32	0.21 U[a]	0.11 U	0.58 U	20 U
TB-1 Lower	17	37	0.17 U	0.21 U	0.11 U	0.58 U	20 U
TB-2 Lower	22	36	0.66	0.17 U	0.09 U	0.47 U	20 U
TB-3 Lower	38	58	0.21 U	0.26 U	0.14 U	0.74 U	20 U
TB-4 Middle	339	2355	1.15	19.3	15.1	9.3	101
TB-4 Lower	47	66	0.21 U	0.26 U	0.14 U	0.72 U	20 U
TB-5 Lower	51	63	0.22 U	0.27 U	0.15 U	0.76 U	20 U
TB-6 Lower	52	66	1.17	0.29 U	0.16 U	0.83 U	20 U
TB-7 Lower	35	69	1.69	0.27 U	0.15 U	0.77 U	20 U
TB-8 Lower	38	67	0.97	0.27 U	0.15 U	0.76 U	20 U
TB-9 Lower	43	62	0.35 U	0.43 U	0.24 U	1.21 U	20 U
OBM COMP	29	28	0.18 U	0.22 U	0.12 U	0.63 U	20 U

(a) U Undetected at or above the detection limit.

TABLE R.6. Metal and Butyltin Concentrations in Sediment Treatments Richmond Harbor Deepening Project-Intensive Study of the Turning Basin (metals in mg/kg dry weight; butyltins in µg/kg dry weight)

Sediment Treatment	Metals										Butyltins	
	Ag	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn	TBT	DBT
R-AM	0.026	5.88	0.015	95.4	4.30	0.049	33.6	13.9	0.17 U[a]	32.8	0.48 U	0.56 U
TB-1 Lower	0.10	6.07	0.25	231	20.9	0.059	55.3	11.1	0.17 U	51.2	0.57	0.56 U
TB-2 Lower	0.11	10.2	0.21	221	39.8	0.071	84.4	11.8	0.17 U	88.6	0.53	1.05
TB-3 Lower	0.11	9.2	0.20	184	36.1	0.058	85.1	9.3	0.17 U	85.4	0.49	0.56 U
TB-4 Middle	0.65	16.5	0.54	182	74.0	0.734	94.6	43.9	0.39	185	3.66	0.82
TB-4 Lower	0.11	9.7	0.17	181	44.3	0.076	93.6	12.1	0.17 U	90.7	0.61	0.56 U
TB-5 Lower	0.10[b]	10.1[b]	0.21[b]	192[b]	41.2[b]	0.058[b]	97.6[b]	10.6[b]	0.17 U[b]	94.3[b]	0.48 U	0.76
TB-6 Lower	0.12	12.4	0.20	173	53.4	0.037	113	8.4	0.17 U	105	0.54	0.56 U
TB-7 Lower	0.11	9.8	0.20	188	42.4	0.038	92.7	11.1	0.19	95.8	0.52	0.56 U
TB-8 Lower	0.10	10.7	0.21	182	45.8	0.066	101	10.3	0.19	97.2	0.48 U	0.56 U
TB-9 Lower	0.10	7.8	0.15	196	41.2	0.068	87.9	14.1	0.17 U	82.7	0.48 U	0.56 U
OBM COMP	0.11	3.28	0.56	142	27.4	0.044	62.7	10.6	0.17 U	68.3	0.48 U	0.56 U

(a) U Undetected at or above detection limit.
(b) Values is mean of analytical replicates.

TABLE R.7. Summary of 10-day Solid-Phase Toxicity Tests, Richmond Harbor Deepening Project

Sediment Treatment	*R. abronius* Percent Survival	*R. abronius* Acute Toxicity	*M. nasuta* Percent Survival	*M. nasuta* Acute Toxicity	*N. caecoides* Percent Survival	*N. caecoides* Acute Toxicity
R-AM	99	NA[a]	100	NA	96	NA
SF COMP	89	NO[b]	100	NO	79	YES[c]
SFW COMP	77	YES	98	NO	81	YES
UIH COMP	77	YES	100	NO	88	NO
TB Upper COMP	70	YES	99	NO	86	NO
TB Lower COMP	50	YES	98	NO	96	NO
OBM COMP	72	YES	98	NO	38	YES
C-SB	93	NA	100	NA	96	NA
C-WB	98	NA	NA	NA	NA	NA
C-NE	NA	NA	100	NA	94	NA

(a) NA Not applicable.
(b) NO No statistically significant difference from the reference sediment R-AM at α=0.05.
(c) YES Statistically significantly different from the reference sediment R-AM at α=0.05 and >10% lower in survival than R-AM (20% for *R. abronius*).

no dose response of *N. caecoides* to ammonia is available to determine the contribution of ammonia in sediment to toxicity. The *R. abronius* 10-day test showed statistically significant differences and a >20% difference in survival in all COMPs except SF COMP when compared with the reference treatment R-AM (Table R.7). The low *R. abronius* survival in SF, SFW, UIH, and possibly TB Upper and OBM COMPs, could be attributed to ammonia; the relationship of observed mortality and total ammonia in the interstitial water of these test treatments was within the expected effects range of ammonia as a sole toxicant (see Section 3.4.1, Figure 3.37). This figure also shows that the mortality observed in OBM and TB Lower COMPs is greater than can be attributed to ammonia; therefore, these COMPs possess some other factor to which *R. abronius* are sensitive.

To investigate the toxic response of *R. abronius* to the TB Lower COMP, all nine field stations from the TB Lower COMP were tested independently in October 1994. These results are summarized in Table R.8, which shows that for the static test with no ammonia manipulation, eight test treatments, TB-2 Lower, TB-3 Lower, TB-4 Lower, TB-5 Lower, TB-6 Lower, TB-7 Lower, TB-8 Lower and TB-9 Lower were acutely toxic to *R. abronius* when compared with R-AM sediments. These results improved in the ammonia reduction to <20 mg/L test where only two test treatments, TB-3 Lower and TB-9 Lower, were acutely toxic relative to R-AM. The

TABLE R.8. Summary of 10-Day Solid-Phase *R. abronius* Toxicity Tests, Richmond Harbor Deepening Project-Intensive Study of the Turning Basin

Sediment Treatment	Static		Ammonia Reduction to <20 mg/L		Ammonia Reduction to <15 mg/L	
	Percent Survival	Acute Toxicity	Percent Survival	Acute Toxicity	Percent Percent	Acute Toxicity
R-AM	97	NA(a)	97	NA	NA	NA
TB-1 Lower	87	NO	NA	NA	NA	NA
TB-2 Lower	52	YES	79	NO	NA	NA
TB-3 Lower	25	YES	70	YES	83	NO
TB-4 Middle	82	NO	89	NO	NA	NA
TB-4 Lower	76	YES	81	NO	NA	NA
TB-5 Lower	62	YES	82	NO	NA	NA
TB-6 Lower	76	YES	NA	NA	NA	NA
TB-7 Lower	55	YES	NA	NA	75	YES
TB-8 Lower	64	YES	NA	NA	81	NO
TB-9 Lower	28	YES	74	YES	80	NO
OBM COMP	68	NA	NA	NA	NA	NA
C-WB	98	NA	98	NA	100	NA
C-SB	89	NA	89	NA	NA	NA

(a) NA Not applicable.

results of the ammonia reduction to <15 mg/L test showed that only one test treatment, TB-7 Lower, was acutely toxic to *R. abronius* when compared with R-AM sediments.

R.3 WATER COLUMN EFFECTS

The evaluation of water column effects does not include comparisons with the reference sediment because the reference sediment is not tested for water column toxicity. The results of the three water column (SPP) toxicity tests conducted with Richmond Harbor Deepening test treatments are presented in Table R.9. There was no acute toxicity to either the mysid, *H. costata*, or to the sanddab, *C. stigmaeus*. T-test results showed that the SPP from SFW, UIH, TB Upper, and TB Lower COMPs significantly affected survival to normal D-cell stage in *M. galloprovincialis* larvae. The EC_{50} values for those treatments ranged from 57.6% SPP to 80.0% SPP. Normal development could have been affected by ammonia released from sediment into the SPP (see Section 3.4.7, Figure 3.38). Ammonia concentrations and normal development

TABLE R.9. Summary of Suspended-Particulate-Phase Toxicity Test Results, Richmond Harbor Deepening Project (bold type indicates mean survival in 100% SPP significantly lower than control in 2-sample T-test, α=0.05)

	Mysid *H. costata*			Bivalve *M. galloprovincialis*			Sanddab *C. stigmaeus*		
	Mean Survival (%)		LC_{50} as	Mean Normal D (%)		EC_{50} as	Mean Survival (%)		LC_{50} as
Treatment	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP	0% SPP	100% SPP	% SPP
SF COMP	94	86	>100	94	96	>100	100	100	>100
SFW COMP	98	88	>100	91	**26**	80.0	98	100	>100
UIH COMP	100	90	>100	90	**0**	57.6	98	98	>100
TB Upper COMP	96	96	>100	96	**17**	74.8	100	100	>100
TB Lower COMP	98	94	>100	82	**0**	69.7	98	100	>100
OBM COMP	98	96	>100	98	96	>100	100	100	>100

in 100% SPP of SFW, UIH, and TB Lower COMPs were within the range of expected effects for ammonia acting alone. However, normal development in TB Upper COMP SPP appeared to be reduced slightly more than would be expected from ammonia only.

R.4 DEPOSITED SEDIMENT BIOACCUMULATION

Bioaccumulation of contaminants by the clam, *M. nasuta*, and the polychaete, *N. virens*, was assessed through a 28-day exposure to Richmond Harbor Deepening composites followed by chemical analysis of tissue samples. The 28-day test methods and results are reported in Sections 2 and 3 and Appendixes M and N. Complete tissue chemistry results, QC data, and QA/QC summaries are presented in Appendixes O and P. The concentrations of contaminants in *M. nasuta* and *N. virens* exposed to the Richmond Harbor sediment treatments were compared with the FDA action limits for contaminants in fish and shellfish (Table R.10). None of the FDA action limits was exceeded for any of the contaminants.

Contaminant concentrations in *M. nasuta* and *N. virens* exposed to the Richmond Harbor test treatments were statistically compared using Dunnett's Test with concentrations in organisms that were exposed to the reference treatment R-AM. Mean tissue concentrations of PAHS, pesticides, phthalate esters, PCBs, metals, and butyltins in *M. nasuta* and *N. virens* are shown in Table R.11 and Table R.12, respectively. These tables also show the magnitude of contaminant bioaccumulation relative to the reference treatment R-AM. Relative to R-AM, two metals from each COMP were bioaccumulated in *M. nasuta*; Cr and Pb in SF, SFW, and UIH COMPs; Cr and Ni in TB Upper and Lower COMPs. Only Ni was accumulated by *N. virens* exposed to TB Lower COMP. None of the metals was more than two times the R-AM tissue value except for the Ni in *N. virens*, which was 2.1 times the Ni in *N. virens* exposed to R-AM. Dibutyltin was accumulated

TABLE R.10. Comparison of FDA Action Levels With Contaminant Levels in *M. nasuta* and *N. virens* Exposed to Richmond Harbor Deepening Sediment Treatments

Contaminant	FDA Action Level (mg/kg wet weight)	Maximum Concentration (mg/kg wet weight) *M. nasuta*	*N. virens*
Benzene Hexachloride (BHC)[a]	0.3	0.00096	U[b]
Chlordane	0.3	U	U
DDT + DDE	5.0	0.0055	0.001038
Dieldrin + Aldrin	0.3	0.00224	0.002309
Endrin	0.3	U	U
Heptachlor + Heptachlor Epoxide	0.3	U	U
Toxaphene	5.0	U	U
PCBs	2.0	0.00040	U

(a) Total BHCs (alpha-, beta-, delta-, and gamma-BHC).
(b) U Undetected at or above detection limit.

by *N. virens* exposed to UIH COMP, but there was no other instance of butyltin bioaccumulation in either species.

Bioaccumulation of 4,4'-DDD and dieldrin by *M. nasuta* and *N. virens* exposed to SF, SFW, and UIH COMPs was both statistically significant and of high magnitude. Both species accumulated 4,4'-DDE from SF COMP at high magnitudes. *M. nasuta* also bioaccumulated significant 4,4'-DDE from SFW COMP, and *N. virens* bioaccumulated significant 4,4'-DDE from UIH COMP. Significant bioaccumulation of PAHs at moderate magnitude occurred in *M. nasuta* and *N. virens* exposed to SFW COMP relative to R-AM. There are few instances of PAH bioaccumulation relative to R-AM despite high concentrations of PAHs in tissues of *M. nasuta* and *N. virens* exposed to SF, SFW, and UIH COMPs. This is because the R-AM sediment had high concentrations of PAHs (Table R.2).

R.5 CONCLUSIONS

In this appendix, comparisons of Richmond Harbor Deepening dredged material and the Intensive Study of the Turning Basin dredged material with the Alcatraz Environs Reference Area are provided to evaluate the acceptability of this sediment for in-bay disposal. For each test treatment, sediment contaminant levels, contribution to acute toxicity, either as water column effect or deposited sediment effect, and potential for bioaccumulation are shown in Table R.13 and Figure R.2. The matrix in Figure R.2 is a summary of sediment chemistry, acute toxicity, and bioaccumulation potential for the test treatments from the Deepening Project relative only to the Alcatraz Environs Reference Area, R-AM. For the bioaccumulation potential, the matrix shows the

TABLE R.11. Mean Values of Contaminants Detected in Tissues of *M. nasuta* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-AM when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-AM; shaded box indicates value is >5 times but ≤10 times R-AM; shaded double-lined box indicates value is >10 times R-AM)

Analyte	R-AM	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB[a]	*M. nasuta* Background[a]
PAHs, µg/kg dry weight									
Naphthalene	14.0	11.9	33.5	10.8	16.8	11.9	NA[b]	10.8	9.82
Acenaphthylene	13.4	7.57 U[c]	8.79	8.02 U	12.7	7.53 U	NA	5.91 U	8.56
Acenaphthene	10.4	7.26	54.2	7.63 U	12.4	7.14 U	NA	5.99	9.61
Fluorene	23.1	12.7 U	74.7	13.9	21.3 U	12.6 U	NA	10.0	14.1 U
Phenanthrene	149	11.8	562	12.5	14.1	8.31	NA	9.37	23.9 B[d]
Anthracene	91.8	27.4	103	26.8	35.2	20.6	NA	16.0 U	23.4
Fluoranthene	578	75.7 *[e]	673	72.4 *	58.8 *	30.0 *	NA	47.8 *	72.8 *
Pyrene	628	131	732	170	37.2	13.2	NA	8.49 U	46.6 *B
Benzo(a)anthracene	269	42.0	165	32.1 B	24.0 B	10.9 B	NA	12.3 B	13.5 B
Chrysene	393	45.9	136	39.2	21.8	12.7	NA	15.1	23.0 B
Benzo(b)fluoranthene	276	306	303	198	63.2	22.3	NA	24.5 *	29.5 *B
Benzo(k)fluoranthene	111	113	107	74.7	33.4	13.2	NA	12.3	25.4
Benzo(a)pyrene	252	171	185	116	44.5 *	20.8 *	NA	18.6 *	26.2 *B
Indeno(1,2,3-cd)pyrene	101	57.4	51.2	53.1	43.5	26.0	NA	19.5 U	33.7
Benzo(g,h,i)perylene	130	65.8	78.6	74.9	54.4	24.1	NA	46.8	29.6
Phthalates, µg/kg dry weight									
Diethyl Phthalate	492	288 B	257	235	888	233	NA	188	210
Di-n-butyl Phthalate	266	253	358	357	368	256	NA	144 U	207
Butylbenzyl Phthalate	530	575	493 *	705	694	556	NA	798 *	204 U
Bis(2-ethylhexyl) Phthalate	943	859	810	906	1020	757	NA	845	502

TABLE R.11. (contd)

Analyte	R-AM	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	OBM COMP	C-SB(a)	*M. nasuta* Background(a)
Pesticides/PCBs, µg/kg dry weight									
beta BHC	2.7 U	2.3 U	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
delta BHC	2.7 U	2.3 U	2.6	2.4 U	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
gamma BHC	1.3 U	1.1 U	1.7	1.2 U	1.8 U	1.3 U	1.8 U	0.94	1.2 U
4,4'-DDD	2.5 U	489	543	182	3.6 U	2.5 U	3.4 U	1.7 U	2.4 U
4,4'-DDE	2.06	112	329	0.7 U	2.68	0.6 U	1.0 U	0.5 U	2.9
4,4'-DDT	5.3	1.6 U	1.8 U	1.7 U	3.5	1.9 U	2.6 U	1.3 U	17
Dieldrin	1.7 U	51.0	118	29.5	2.5 U	1.7 U	2.3 U	1.2 U	1.6 U
Endosulfan I	2.7 U	2.5	2.6 U	2.7	3.8 U	2.7 U	3.6 U	1.8 U	2.6 U
Aroclor 1254	140 U	160 U	210	140	140 U	150 U	150 U	150 U	140 U
Metals, mg/kg dry weight									
Silver	0.241	0.216	0.192	0.183	0.196	0.197	NA	0.183	0.492
Arsenic	22.8	24.7	27.1	20.8	22.8	23.4	NA	24.2	31.2
Cadmium	0.209	0.202	0.199	0.183	0.200	0.210	NA	0.178	0.254
Chromium	1.50	1.99	2.10	2.05	2.21	2.04	NA	1.54	1.12
Copper	12.6	12.8	11.3	12.4	15.1	11.5	NA	12.4	15.1
Mercury	0.095	0.060	0.076	0.063	0.084	0.062	NA	0.051	0.063
Nickel	3.22	3.86	3.68	3.66	4.09	4.90	NA	3.02	2.62
Lead	1.76	2.11	2.30	2.11	1.57	1.24	NA	1.34	1.34
Selenium	1.57	1.69	1.79	1.66	1.65	1.57	NA	1.65	1.79
Zinc	99.0	107	110	93.9	105	96.6	NA	89.4	107
Butyltins, µg/kg dry weight									
Tributyltin	27.6	23.5	11.5	17.2	8.73	9.05	13.6	10.8	4.31
Dibutyltin	10.5	11.8	9.30	10.4	9.44 U	12.0	10.9	10.1	10.3

(a) Treatment not included in Dunnett's Test data set.
(b) NA Not applicable.
(c) U Undetected in all replicates; value is mean of dry weight detection limits.
(d) B All replicate values are <5 times the amount detected in the associated method blank.
(e) * Ion ratio out or confirmation ion undetected in all replicates.

TABLE R.12. Mean Values of Contaminants Detected in Tissues of *N. virens* Exposed to Richmond Harbor Deepening Composites (bold type indicates value is statistically significantly greater than R-AM when compared by Dunnett's Test; box indicates value is >2 times but ≤5 times R-AM; shaded box indicates value is >5 times but ≤10 times R-AM; shaded double-lined box indicates value is >10 times R-AM)

Analyte	R-AM	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV[a]	*N. virens* Background[a]
PAHs, µg/kg dry weight								
Naphthalene	17.4	20.5	25.3	20.2	20.0	18.6	26.5	15.6 B[b]
Acenaphthylene	11.8	14.6 U[c]	14.7	14.7 U	12	12.3 U	19.1	14.2
Acenaphthene	12.8	16.8	65.6	14.0	12.1	13.0	20.1	13.6
Phenanthrene	14.7	15.4	**28.2**	15.7 *[d]	13.2 *	13.0	19.1	13.8 B
Anthracene	32.0	40.9	41.2	40.2	31.8	33.5 U	49.4	37.7 U
Fluoranthene	40.9 *	46.5	**84.1**	45.8 *	38.6 *	36.2 *	59.2 *	44.8 *
Pyrene	41.3 *	51.7 *B	**84.6 B**	52.0 B	41.7 *B	38.3	63.5 *B	50.7 *B
Benzo(a)anthracene	17.1	21.0 *B	**24.9 B**	20.0 B	15.8 B	16.3 *B	26.0 *B	20.1 B
Chrysene	16.9 *	17.1	**29.6**	14.3	11.8	11.2	18.9	18.2
Benzo(b)fluoranthene	32.2	44.2 *	53.3	35.1	17.8	11.2	25.0	38.4
Benzo(k)fluoranthene	36.2 *	38.8	49.5 *	45.9 *	26.3	26.5	33.9	42.5 *B
Benzo(a)pyrene	27.7 *	37.1	42.5 *	36.0 *	25.7 *	27.8	38.8 *	34.3 *B
Indeno(1,2,3-cd)pyrene	39.3	50.2	47.5 U	53.3	38.7 U	40.7 U	59.8 U	46.0 U
Benzo(g,h,i)perylene	36.3	**59.6**	**58.1**	48.8	36.0	37.7	57.0	44.1
Phthalates, µg/kg dry weight								
Diethyl Phthalate	288 U	358	350 U	358 U	285 U	300 U	441 U	344
Butylbenzyl Phthalate	330	543	408	426	290	312	461	366
Bis(2-ethylhexyl) Phthalate	720	669	764	727	731	782	1020	693
Di-n-octyl Phthalate	288 U	355 U	350 U	358 U	464	300 U	441 U	869 U

TABLE R.12. (contd)

Analyte	R-AM	SF COMP	SFW COMP	UIH COMP	TB Upper COMP	TB Lower COMP	C-NV(a)	*N. virens* Background(a)
Pesticides/PCBs, µg/kg dry weight								
Aldrin	4.50	2.47	8.92	1.64 U	1.32 U	1.36 U	5.78	9.82
4,4'-DDD	3.36 U	138	374	56.7	3.34 U	3.52 U	5.18 U	3.96 U
4,4'-DDE	1.00 U	9.70	1.22 U	4.32	1.04 U	1.06 U	1.58 U	4.13
4,4'-DDT	18.5	37.6	34.4	23.8	8.18	13.3	23.9	2.98 U
Dieldrin	3.74	47.6	151	28.9	3.10	2.36 U	5.05	2.64 U
Metals, mg/kg dry weight								
Silver	0.299	0.303	0.309	0.295	0.348	0.174	0.251	0.246
Arsenic	15.9	14.3	14.8	14.6	14.6	14.7	16.6	15.5
Cadmium	0.361	0.331	0.347	0.367	0.364	0.326	0.298	0.293
Chromium	1.51	1.35	0.997	0.930	1.25	1.62	0.898	9.37
Copper	10.9	11.0	10.6	10.8	10.5	11.0	8.95	13.7
Mercury	0.246	0.213	0.217	0.229	0.231	0.211	0.202	0.218
Nickel	1.70	1.70	1.62	1.56	2.17	3.53	1.13	3.86
Lead	0.878	1.03	1.02	0.900	1.04	0.912	0.911	1.03
Selenium	2.02	1.88	1.84	1.93	2.03	1.91	1.81	2.13
Zinc	151	270	197	200	240	177	214	208
Butyltins, µg/kg dry weight								
Tributyltin	3.54 U	3.90	3.91	3.60 U	3.70	3.64 U	3.57 U	3.44 U
Dibutyltin	10.7	16.0	11.1	20.7	10.9	11.0	15.1	9.96 U
Monobutyltin	2.87 U	2.89 U	2.96 U	2.92 U	3.35	2.96 U	2.90 U	2.79 U

(a) Treatment not included in Dunnett's Test data set.
(b) B All replicate values are <5 times the amount detected in the associated method blank.
(c) U Undetected in all replicates; value is mean of dry weight detection limits.
(d) * Ion ratio out or confirmation ion undetected in all replicates.

TABLE R.13. Summary of Statistically Significant Acute Toxicity and Bioaccumulation for Richmond Harbor Deepening Project Deepening Composites Relative to the Reference Sediment R-AM

Sediment Treatment	Acute Toxicity	*M. nasuta* Bioaccumulation					*N. virens* Bioaccumulation				
		PAH	Pesticides	PCB	Metals	TBT	PAH	Pesticides	PCB	Metals	TBT
SF COMP	N[a]	---[b]	DDD,DDE,Diel	---	Cr,Pb	---	HPAH	DDD,DDE,Diel	---	---	---
SFW COMP	B[c],R[d],N	LPAH	DDD,DDE,Diel	1254	Cr,Pb	---	LPAH,HPAH	DDD,Diel	---	---	---
UIH COMP	B,R	---	DDD,Diel	---	Cr,Pb	---	---	DDD,DDE,Diel	---	---	DBT
TB Upper COMP	B,R	---	----	---	Cr,Ni	---	---	---	---	---	---
TB Lower COMP[e]	B,R[e]	---	---	---	Cr,Ni	---	---	---	---	Ni	---
OBM COMP	R,N	NA[f]	---	---	NA	---	NA	NA	NA	NA	NA

(a) N Acutely toxic to *N. caecoides* in the 10-day solid-phase test.
(b) --- No statistically significant bioaccumulation.
(c) B Acutely toxic to *M. galloprovincialis* in the 48-h SPP test.
(d) R Acutely toxic to *R. abronius* in the 10-day solid-phase test.
(e) Evaluation of *R. abronius* toxicity to TB Lower COMP is based on the results from the Intensive Study of the Turning Basin in October 1994 in which only TB-3 Lower and TB-7 Lower was acutely toxic when compared with R-AM.
(f) NA Not Applicable.

Sediment Treatments	Sediment Chemistry					Toxicity		Significant Bioaccumulation						Bioaccumulation ≥ 2 < 5 times						Bioaccumulation ≥ 5 < 10 times						Bioaccumulation ≥ 10 times					
	sediment LPAH > R-AM	sediment HPAH > R-AM	# of sediment Pesticide and PCB > R-AM	# of sediment Metals > R-AM	# of sediment Butytins > R-AM	species associated with SPP toxicity	species with solid-phase acute toxicity	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)	# of LPAH compounds (6 possible)	# of HPAH compounds (10 possible)	# of Pesticide compounds (19 possible)	# of PCB compounds (4 possible)	# of Metals compounds (10 possible)	# of Butyltin compounds (3 possible)
SF COMP			5	10	2		N		1	3/3		2										1						3/2			
SFW COMP	√		5	10	2	B	RN	4/2	5	3/2	1	2		3	2					1/1								3/2			
UIH COMP			5	10	2	B	R			2/3		2	1			1						1						2/1			
TB Upper COMP			3	9	1	B	R					2																			
TB Lower COMP			1	8		B	R					2/1						1													
OBM COMP				NA			RN	NA	NA			NA																			

√ Total LPAH or HPAH with detected values above the reference R-AM

C Calculable LC_{50} values in the *C. stigmaeus* test
B Calculable EC_{50} values in the *M. galloprovincialis* test
H Calculable LC_{50} values in the *H. costata* test
R Acute Toxicity in the *R. abronius* 10-day test
N Acute Toxicity in the *N. caecoides* 10-day test

NA Not applicable; sediment treatment not analyzed for this parameter

Number of Compounds Bioaccumulating in *M. nasuta* Tissues
Number of Compounds Bioaccumulating in *N. virens* Tissues

FIGURE R.2. Matrix of Sediment Chemistry, Significant Acute Toxicity, and the Bioaccumulation for Richmond Harbor Deepening Sediment Treatments Relative to the Alcatraz Environs Reference Area, R-AM

number of contaminants in *M. nasuta* and *N. virens* that were elevated above a range of magnitudes (2, 5, and 10 times R-AM) and cases in which similar classes of contaminants were accumulated by both species. This summary is intended to assist USACE, EPA, and other resource agencies in evaluating the potential effects of in-bay disposal of dredged material from Richmond Harbor.

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