Results of Physical, Chemical, and Bioassay Testing of Sediments Collected From The Los Angeles River Estuary

Volume I

Prepared For:

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1.0 INTRODUCTION

1.1 Project Overview

MEC Analytical Systems, Inc. (MEC) conducted sampling and analysis of sediments from the lower Los Angeles River Estuary (LARE) Channel for the U.S. Army Corps of Engineers (USACE), Los Angeles District in accordance with the "Sampling and Analysis Plan for Testing of Sediments Collected from the Los Angeles River Estuary —Version 2" hereafter refered to as the Sampling and Analysis Plan (SAP). A copy of the SAP is provided in Appendix A. The USACE plans to dredge sediment from the entrance of the Queens Way Marina down the central channel of the LARE in southern California (Figure 1). Extensive shoaling in the channel has created a potential hazard to navigation by commercial traffic such as the Catalina Express Ferry. Existing depths range from –0.2 meters Mean Lower Low Water (MLLW) in the upper (northwest) portion of the area proposed for dredging to –9.8 meters MLLW in the lower (southeast) portion of the proposed dredging area. The USACE proposes to dredge the channel to a depth of -5.5 meters MLLW with a 0.6 meter dredging tolerance. Disposal of the dredged material is proposed for the LA-2 ocean disposal site.

This report presents results of physical, chemical and biological testing conducted on representative sediment collected at the proposed dredge site. Testing was performed to determine the suitability of the dredged material for ocean disposal at the designated LA-2 disposal site located approximately seven miles west of Queen's Gate in Long Beach Harbor along the 600 meter depth contour. Sediments were tested according to guidelines provided in the Ocean Disposal Manual (USEPA/USACE 1991).

This project design resulted in five dredge material samples for Tier III ocean disposal suitability testing (USEPA/USACE 1991). Chemical analysis of the sediment included metals, organotins, pesticides, PCBs, PAHs, and total phthalates. In addition, conventional analyses included grain size, total organic carbon (TOC), total and water soluble sulfides, total recoverable petroleum hydrocarbons (TRPH), and percent solids. Biological evaluation of the proposed dredged material for ocean disposal included three suspended particulate phase (SPP) tests (bivalve larvae, fish, mysid shrimp), two solid phase (SP) tests (polychaete worm and amphipod), and two bioaccumulation tests (polychaete worm and bivalve mollusc). Tissue chemistry for bioaccumulation tests included metals, organotins, pesticides, PCBs, total phthalates, and PAHs.

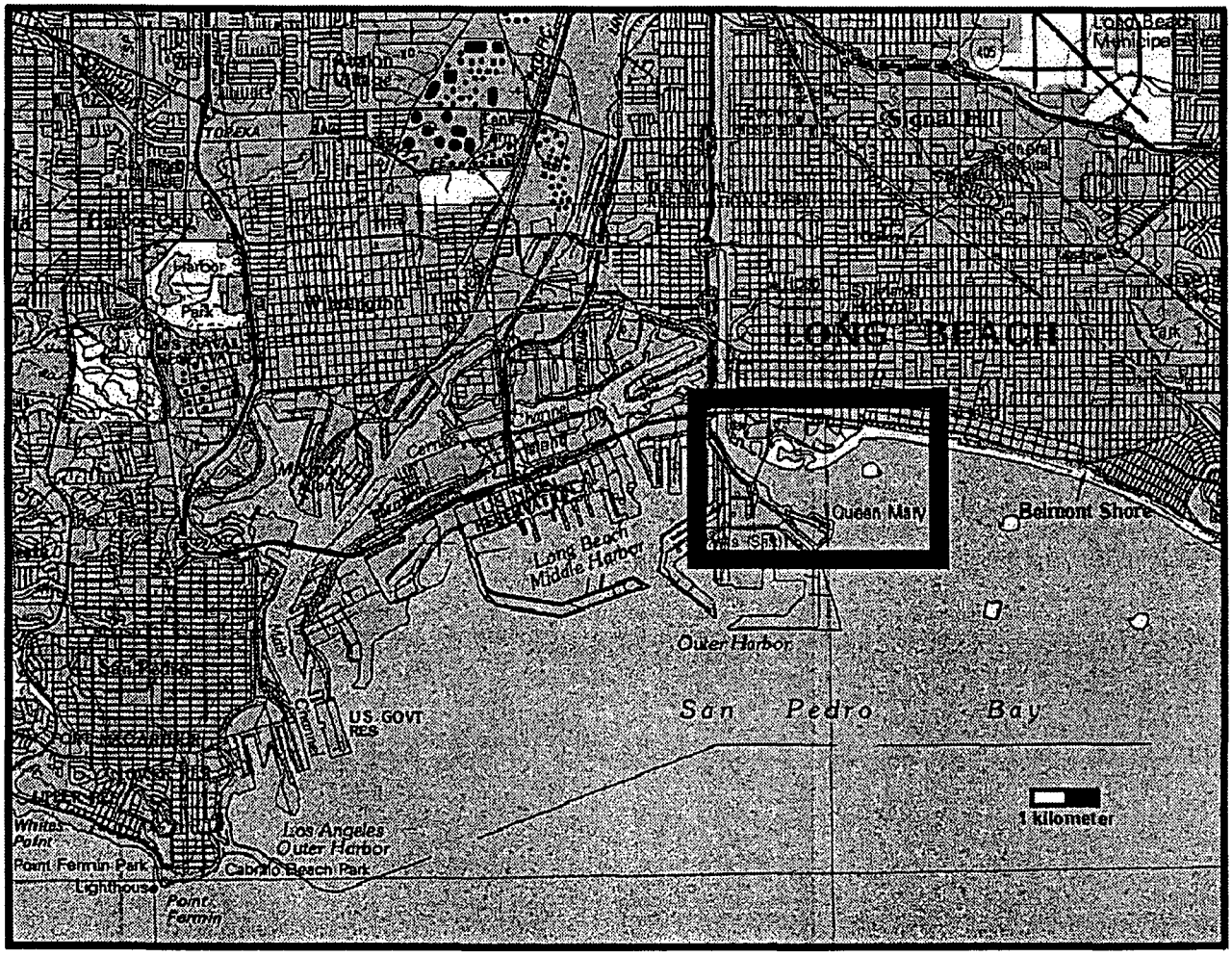

Figure 1: Los Angeles River Estuary study area.

1.2 Site History

The area proposed for dredging is subject to tidal influences of the Pacific Ocean and San Pedro Bay as well as the hydrologic influences of the Los Angeles River. The Los Angeles River drains a significant portion of the Los Angeles basin. The estuary is used predominately for recreational purposes, and provides access to Pacific Terrace Harbor. Vessels from the Catalina Cruises frequently transit the area enroute to or from the Queen's Way Marina. Adjacent land uses include the Queens Bay Marina, a variety of industrial activities, tourism, and various other urban land uses associated with the Los Angeles River Watershed.

During the winter storms of 1995 extensive shoaling in this area occurred, disrupting the operations of Catalina Cruises and leading to an emergency dredging contract issued by the USACE Los Angeles District in February of 1995 (USACE 1995). Approximately 230,000 cubic meters were removed and placed in a subaqueous borrow pit near the channel entrance (Coastal Frontiers Corporation 1996). A post dredging examination of sediment chemistry results (MEC 1995a) indicated the presence of elevated concentrations of arsenic, cadmium, copper, lead, mercury, nickel, zinc, organotins, petroleum hydrocarbons, polycyclic aromatic hydrocarbons (PAHs), phthalates, and polychlorinated biphenyls (PCBs). Results of this analysis lead the USEPA, Region IX to conclude that the material disposed at the borrow pit should be capped with a layer of clean material to isolate and confine this dredged material from the environment. A source of clean silty sediments from the Pier J Access Area dredged by the Port of Long Beach was used as the cap material. Following a numerical modeling study (USACE 1995), approximately 130,000 cubic meters of this material was used to cap the previously disposed LARE sediments in the borrow pit (Coastal Frontiers Corporation 1996).

Prior to 1995 the USACE has dredged some 250,000 cubic meters of material from the LARE and the City of Long Beach some 1,500,000 cubic meters (1,400,000 cubic meters in 1980) (MEC 1994, Moffatt & Nichol 1996). Because the material deposited in the estuary is predominately fine-grained, it is rare for LARE dredged material to be used for beach nourishment (MEC 1995).

2.0 METHODS

2.1 Sample Collection and Handling

2.1.1 Test Sediment (Field Techniques/Analyses)

Core sample locations are presented in Figure 2 and in the SAP in Appendix A (Figure 3). The proposed dredge area has been divided into three geographic sections (Area 1, Area 2, Area 3) as shown in Figure 2. Current target dredge depths are –5.5 meters MLLW. However, sampling and analysis was conducted to a depth of –9.6 meters MLLW at Areas 1 and 2, and –7.6 meters MLLW in Area 3 because of potential deepening of the channel. The sediment collected from Areas 1 and 2 were split vertically into top and bottom layers at –5.5 meters MLLW. One to four cores were collected while on position at each sampling station in order to collect sufficient sediment for the required analyses.

Sediment sampling was conducted 14-16 July 1998. Skies were generally overcast with light to heavy fog in the mornings clearing by late afternoon with a light breeze and the water was calm. Tides were ebbing in the morning and flooding until late evening. Currents were weak to moderate and posed no difficulty for sampling. Two vessels were used in the sampling effort: the R.V. *Early Bird* and a smaller auxiliary vessel for sample positioning and assisting in anchorage of the *Early Bird*.

Sample locations were preplotted on a field map. In the field, marker bouys were dropped at each station location by the auxiliary vessel. Sample locations were determined in the field using a Leica Differential Global Position System (DGPS) with an accuracy of ± 0.5 to 2 meters and verified visually. The system uses the U.S. Coast Guard Differential correction data. The DGPS systems was verified before and after sampling at USACE predefined boat tie up points. All final station locations were recorded in the field.

Cores were collected using a Rossfelder P-5 electric vibracore. The vibracore was deployed from the R/V *Early Bird*. The auxiliary vessel assisted in positioning and establishing a three-point anchorage for the R/V *Early Bird* to ensure a stable sampling platform and vertical control for operating the vibracore. Sediment cores were collected utilizing pre-cleaned 4-inch diameter aluminum tubing and a stainless steel cutter head/catcher assembly.

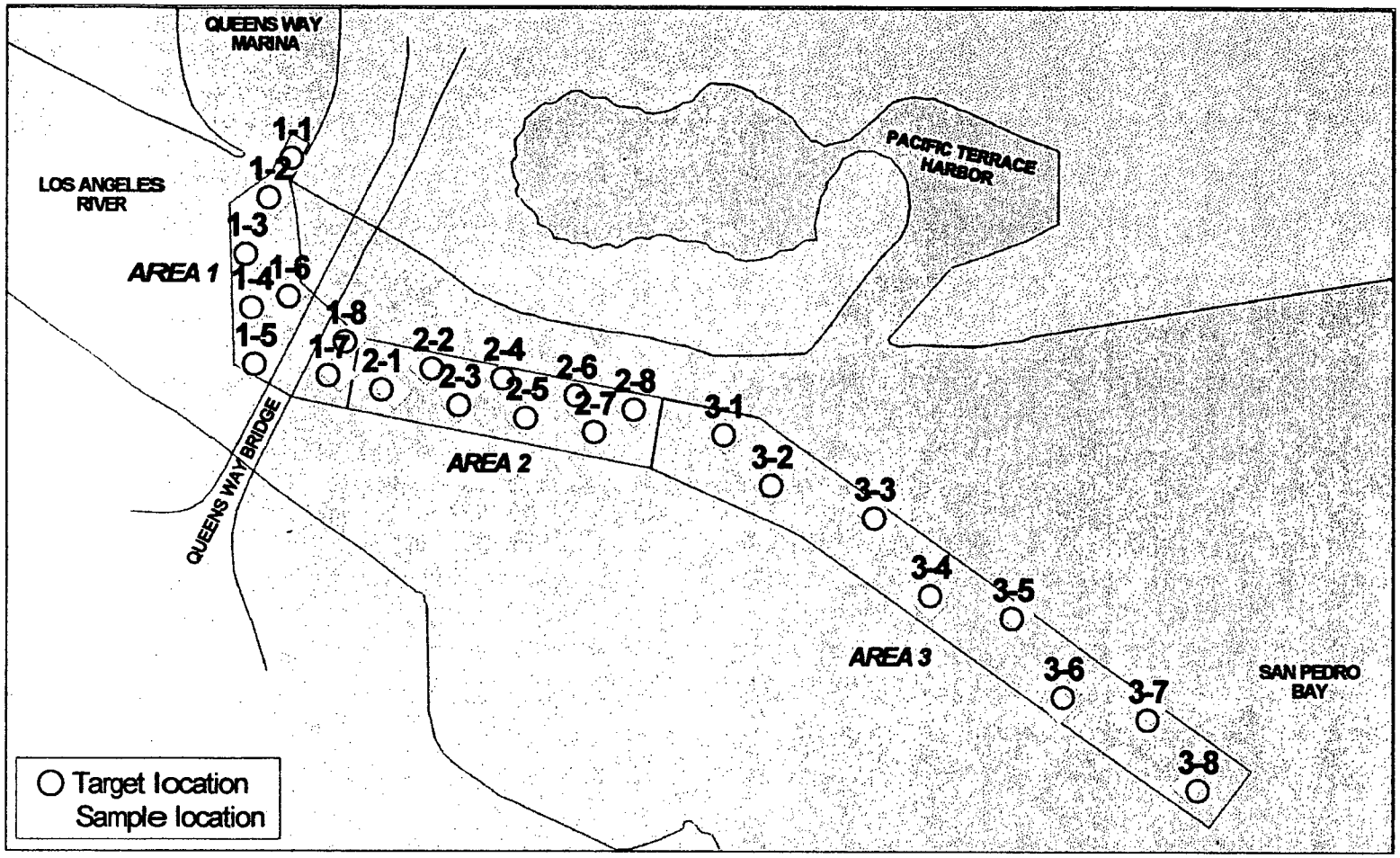

Figure 2. Site map with sample locations in the Los Angeles River Estuary.

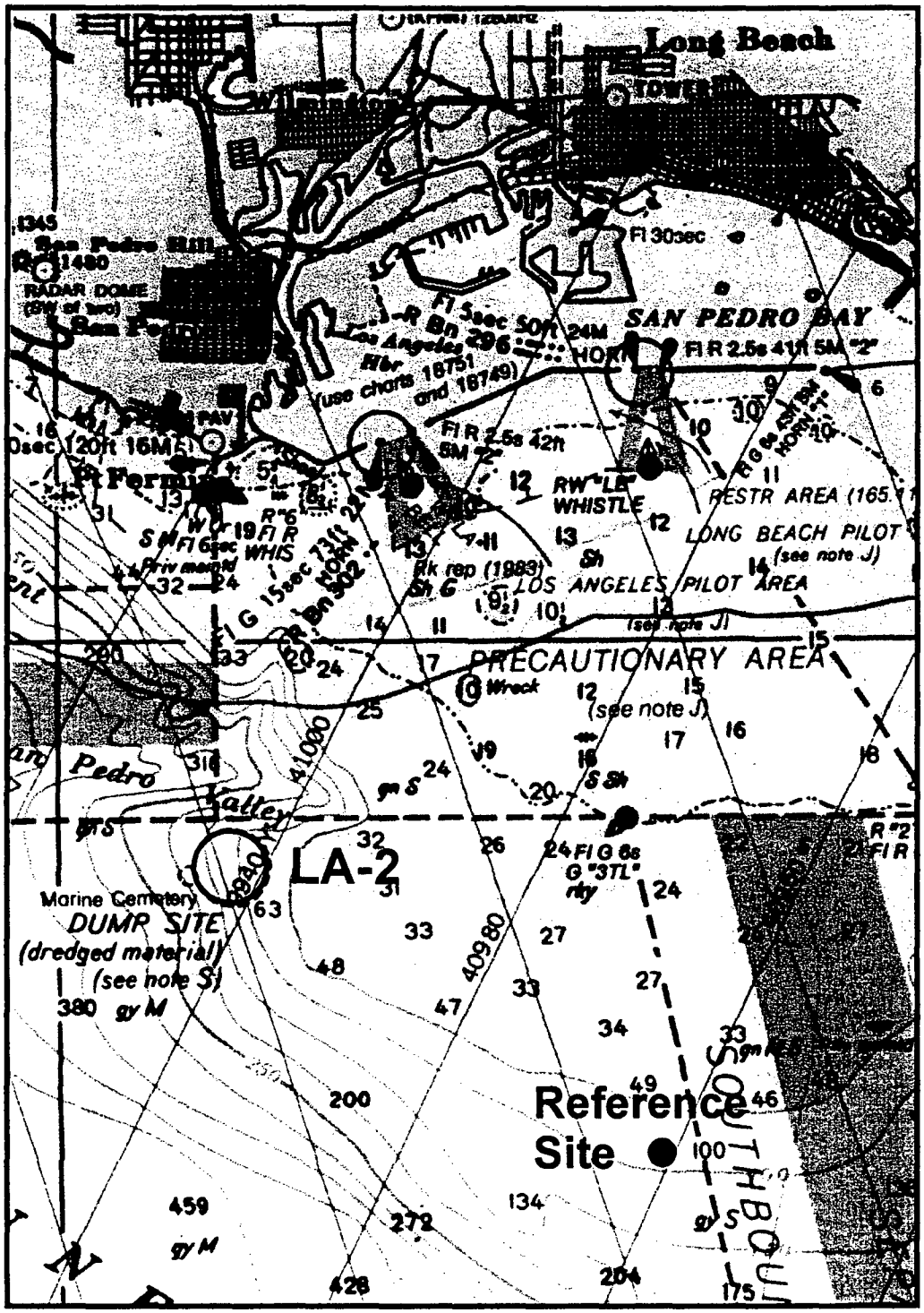

Figure 3. LA-2 Disposal and Reference Sites

The required sample depth ranged from –7.6 meters MLLW in Area 3 to –9.6 meters MLLW in Areas 1 & 2 which includes a 0.6 meter overdredge allowance. Once the core was collected it was extruded on the vessel onto polyethylene lined PVC collection trays for subsequent characterization. Cores were examined by a qualified scientist, measured to tenths of feet, photographed with a labeled placard, divided into upper and lower strata, enclosed in double polyethylene bags labeled for location, date, time, core segment, and collector and stored on ice in coolers until transferred to the laboratory for processing.

Field measurements include core location, sample designation, date, time, field personnel, core number, mudline elevation, penetration and recovery length/depth, and sediment geological characteristics (see below). All relevant project/ sample information and field measurements were recorded on customized core log data forms. Multiple cores were sampled at selected sites to ensure adequate sample volume for all analyses. A daily field log was maintained and formal chain-of-custody procedures will be followed and documented.

The geologic description of each core included the texture, odor, color, length, approximate grain size category, any evident stratification of the sediment, and any organic debris or trash. Material was divided into layers according to project depths (Area 1 and 2). Based upon the in field geological assessment, any obvious stratified sublayers observed within individual cores in Areas 1, 2, or 3 were composited separately for subsequent analysis of grain size and chemistry.

2.1.2 Reference Sediment Collection

Reference sediment was collected 13 July 1998 by Sea Ventures on the R.V. *Early Bird*. Samples were collected from the offshore reference location associated with the designated LA-2 disposal site. The reference site is located approximately 7 miles West of Queen's Gate (Figure 3). Coordinates for the site provided by the EPA are 33° 33.20' North and 118° 10.80' West at the 600 foot contour. Sediment was collected via a stainless steel pipe dredge. Approximately 95 Liters of sediment were collected to conduct solid phase toxicity and bioaccumulation tests.

2.1.3 Control Sediment Collection

Control sediment for the sediment bioassays and bioaccumulation test with *Neanthes arenaceodentata*, *Nephtys caecoides*, and *Macoma nasuta* were collected from Tomales Bay, California (Figure 4), by John Brezina and Associates on 15 July 1998 and shipped overnight to MEC Bioassay Laboratory in Carlsbad, CA on 16 July 1998. Control sediment for tests with *Eohaustorius estaurius* were collected from Beaver Creek, Oregon (Figure 5), by Northwest Aquatics on 27 July 1998 and shipped overnight to MEC Bioassay Laboratory in Tiburon, CA on 31 July 1998.

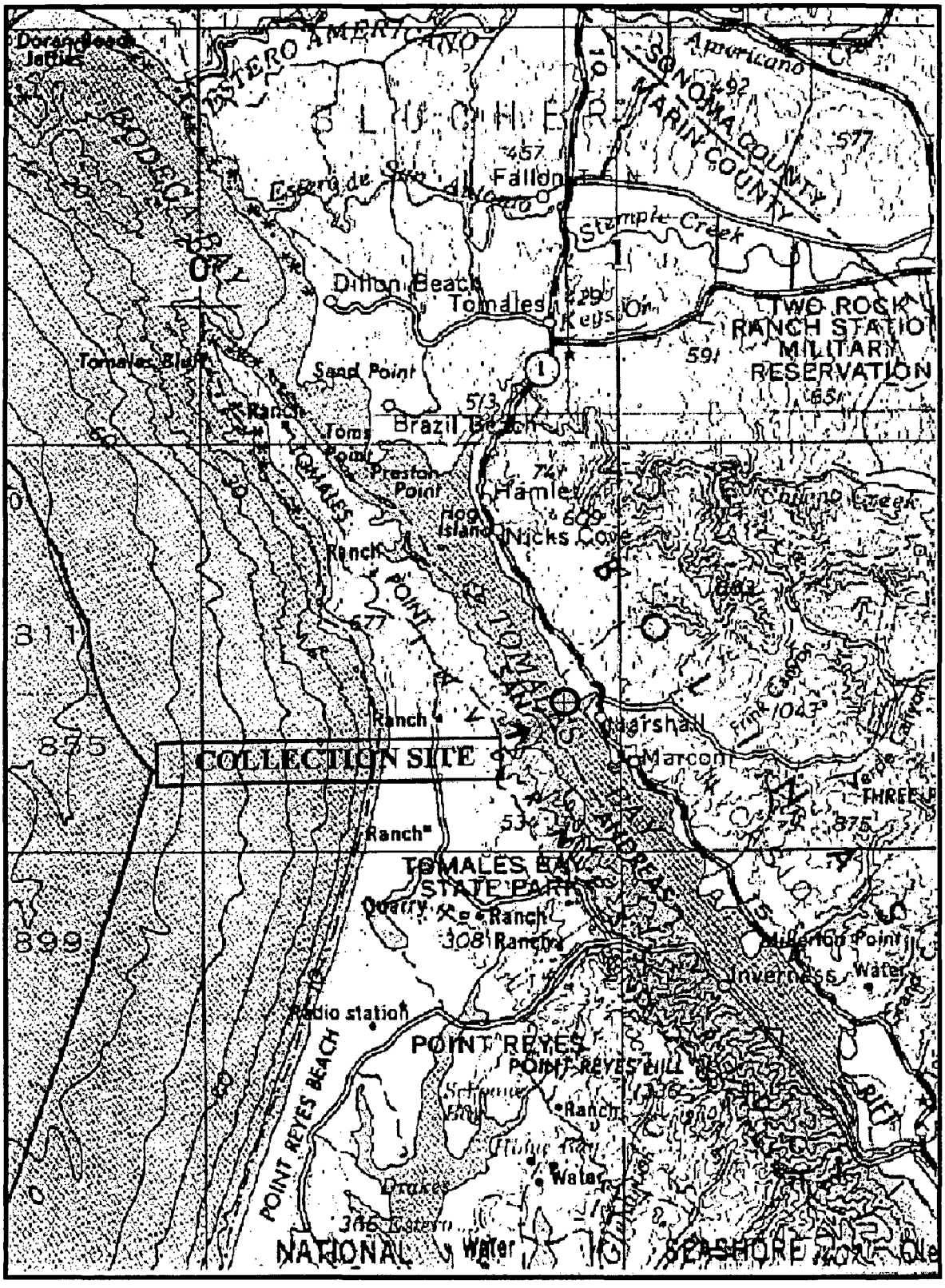

Figure 4. Tomales Bay Control Sediment Collection Site

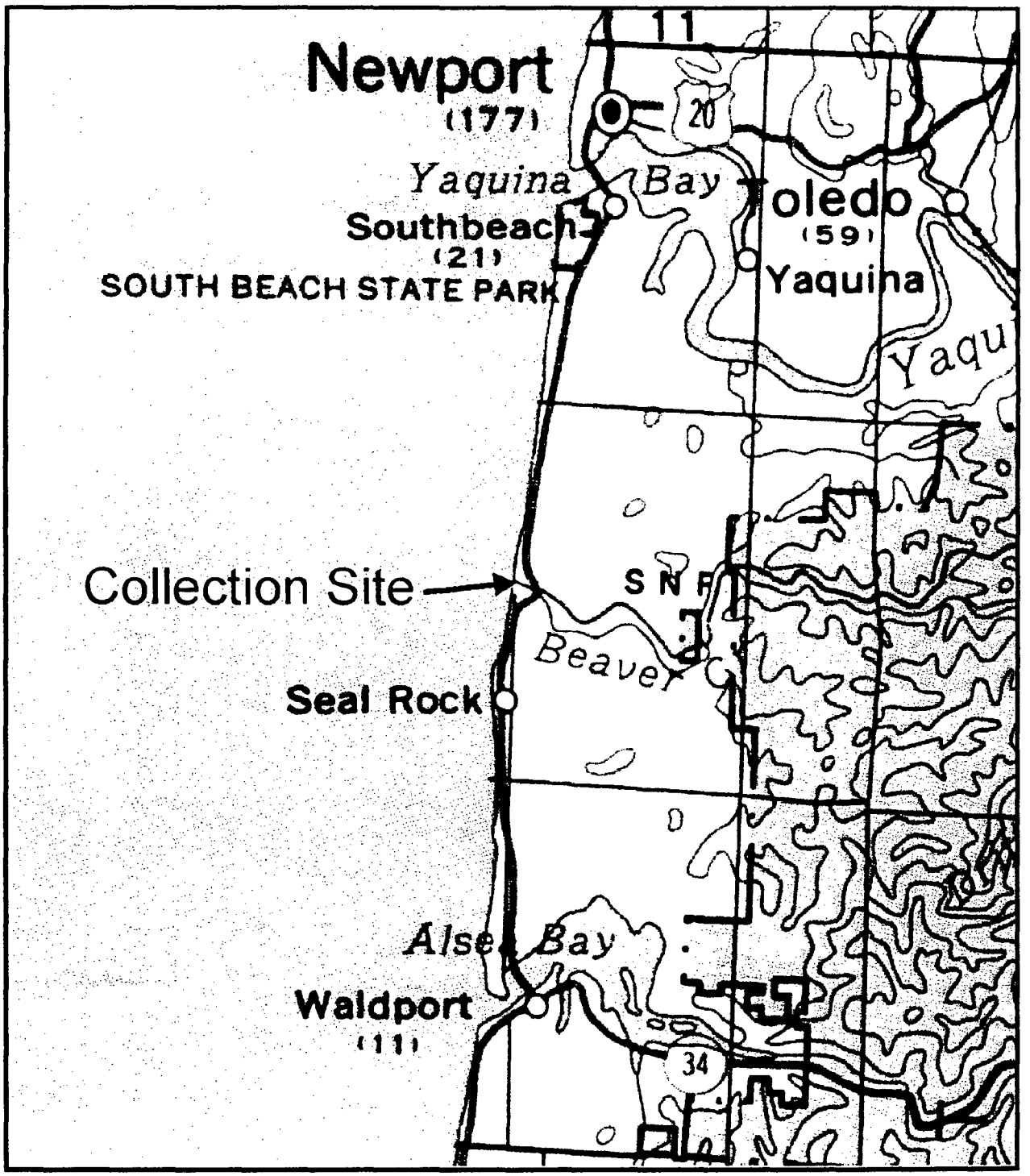

Figure 5. Beaver Creek, Oregon Control Sediment Site

2.1.4 Sample Processing

All samples were stored at 4°C until used, and testing begun as soon as possible (within two weeks) from the end of collection. Sediments were thoroughly homogenized to a uniform color and consistency at the laboratory using a stainless steel mixing apparatus. Sub-samples for chemical analysis were taken from each homogenized core (top and bottom layers where indicated) and placed into clean glass jars with Teflon lined lids. Archived samples were placed into 1 gal food grade plastic bags and archived at 4° C should further chemical characterization be required. A total of seven site composites for physical, chemical and bioassay testing were created from the three LARE areas (e.g., Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3), the LA-2 reference sample, and a control sediment (Table 1). Remaining sediment from each composite sample (both top and bottom layers, where indicated) was archived at 4° C to be used should additional bioassay testing be required.

Table 1. Sample Composites and Analyses by Area

AREA	DEPTH (m MLLW)	NUMBER OF LOCATIONS	SAMPLE COMPOSITING	ANALYSES
1	mudline to -5.5	8 upper	1 Composite	Chemistry, SPP & SP Bioassay, Bioaccumulation
1	-5.5 to –9.6	8 lower	1 Composite	Chemistry, SPP & SP Bioassay, Bioaccumulation
2	mudline to -5.5	8 upper	1 Composite	Chemistry, SPP & SP Bioassay, Bioaccumulation
2	-5.5 to –9.6	8 lower	1 Composite	Chemistry, SPP & SP Bioassay, Bioaccumulation
3	mudline to –7.6	8	1 Composite	Chemistry, SPP & SP Bioassay, Bioaccumulation
Reference	NA	1	1 grab	Chemistry, SP Bioassay, Bioaccumulation
Control	NA	NA	1	Chemistry Archive, SPP & SP Bioassay, Bioaccumulation

2.1.5 Sample Shipping

Prior to shipping, sample containers were sealed in plastic bags, wrapped in bubble wrap, and securely packed inside the cooler with ice packs or crushed ice. Chain-of-custody (COC) forms were filled out, and the original signed COC forms were sealed in a plastic bag and placed inside the cooler. Samples were then hand delivered by MEC personnel to Pacific Treatment Analytical Service (PTAS) for chemical analysis following sample handling and custody procedures.

2.2 Analytical Methods

The testing program described in this report involved several elements: chemical analysis of sediments and tissues, physical analysis of the sediments; suspended particulate phase bioassays, solid phase bioassays and bioaccumulation testing. Chemical analysis of sediments and tissues was conducted by Pacific Treatment Analytical Service (PTAS) in San Diego, California. Sediments were analyzed for grain size and total organic carbon by MEC in Carlsbad, California. The suspended particulate phase (SPP) bioassay with *Mytilus edulis*, the solid phase (SP) bioassay with *Neanthes arenaceodentata* and the bioaccumulation studies were performed at the MEC lab in Carlsbad, California. The remaining SPP tests with *Mysidopsis bahia* and *Menidia beryllina* and SP test with *Eohaustorius estuarius* were performed at the MEC lab in Tiburon, California.

All methods and procedures outlined in this section are in accordance with procedures set forth in the OTM (USEPA/USACE 1991).

2.2.1 Chemical and Physical Analysis of Sediments and Tissues

Sediment Analysis

All chemical analyses were performed using U.S. EPA (SW-846), National Oceanic and Atmospheric Administration (NOAA), Standard Methods for Examination of Water and Wastewater (SMEWW), or American Association for Testing and Materials (ASTM) methods; however, modifications were used to obtain detection limits that were lower than those specified in the prescribed methodologies. Sediments were analyzed for arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc using an inductively coupled plasma spectroscopy method (ICP) (EPA 6010) and atomic absorption/graphite furnace methods (AA/GF) (EPA 7000 Series); total and dissolved sulfides (SMEWW 4500D and Plumb 1981); chlorinated pesticides and polychlorinated biphenyls (Pesticides and PCBs) (EPA 3550/8080); polynuclear aromatic hydrocarbons (PAH's), and phthalates (GC/MS) (EPA 8270); petroleum hydrocarbon analyses (EPA 418.1); total organic carbon (TOC) (modified ASTM D2579); and organotins using a GC/FPD method (Krone et al. 1988; Stallard et al. 1989; Unger et al. 1986). Sediment grain size analysis followed Plumb (1981).

Tissue Chemistry

Tissues were analyzed for metals using an inductively coupled plasma spectroscopy method with a mass spectra detector (ICP/MS) (EPA 6020) and atomic absorption/graphite furnace methods (AA/GF) (EPA 7000 Series). Chemistry analyses for pesticides, PCBs, PAH's, phthalates, and organotins followed the same digestion/extraction methods and analytical procedures as those for the sediment. Target analyte detection limits were described in the Sampling and Analysis Plan (Appendix A).

2.2.2 Biological Testing

General Methods. Five composited dredged material samples (Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3), the LA-2 reference sample, and a laboratory control were tested in Tier III sediment bioassays in order to determine the suitability of LARE sediment for ocean disposal. Bioassay testing consisted of three suspended particulate phase (SPP) tests, two solid phase (SP) tests, and two bioaccumulation tests. Table 2 summarizes how the various test species were used in the Tier III assessment of LARE sediment. Tables 4 through 9 provide a summary of the test organisms, test procedures, and any deviation from procedures for the bioassays conducted. Results of the SPP bioassays were compared to seawater control. Test sediment results from the SP and tissue residue levels from the bioaccumulation study were compared to results from animals exposed to the reference site sediment.

Water Quality. Water quality was monitored daily as appropriate for each test, and data were recorded on data sheets. Dissolved oxygen was measured using YSI Model 57 and Orion Model 840 oxygen meters and probes; pH was measured using both the Beckman digital and Orion Model 230 A pH meters and probes. Salinity and temperature were measured with an Orion Model 140 conductivity/salinity meter. Ammonia was analyzed using an Orion 95-12 electrode and the Orion 720 digital ion analyzer and a two point calibration curve (1 and 10 mg/L).

Table 2: Summary of Test Organism Use and Acclimation

Type of Organism	Taxon	Test Phase			Acclimation Time (days)
		SPP	SP	Bio.	
Bivalve larvae	*Mytilus edulis*	X			0
Mysid shrimp	*Mysidopsis bahia*	X			0
Fish	*Menidia beryllina*	X			0
Amphipod	*Eohaustorius estuarius*		X		10, 1
Polychaete	*Neanthes arenaceodentata*		X		3, 3
Polychaete	*Nephtys caecoides*			X	5
Mollusc	*Macoma nasuta*			X	5

2.2.2.1 Suspended-Particulate Phase Testing

Suspended-particulate phase bioassay tests were performed to evaluate the potential short-term impact of ocean disposal of dredged sediments to organisms that live in the water column. Three species were tested, *Mysidopsis bahia* (the mysid shrimp), *Menidia beryllina* (the Inland silverside) and *Mytilus edulis* (the hard clam). Diluent/control water used in SSP test with *Mysidopsis bahia* and *Menidia beryllina* was Bodega Bay seawater while diluent/control water for tests with *Mytilus edulis* was Scripps Institution of Oceanography (SIO) Pier seawater. All seawater was filtered to 5 µm and U.V. sterilized.

Elutriate Preparation. SPP tests were performed according to the Ocean Testing Manual OTM procedures for testing of elutriates (USEPA/USACE 1991). Briefly, sediment and seawater were combined in a 1:4 ratio by volume, vigorously agitated for 30 minutes, and then allowed to settle for 1 hour. Following settling, the supernatant was gently decanted. The supernatant represented the 100% test concentration and was used in serial dilutions with clean seawater to create 50, 10, and 1% test concentrations for the SPP tests.

Mysidopsis bahia Test. The mysid SPP test methods are from ASTM E1191-97. Three concentrations of the elutriate (100%, 50% and 10%) and a control were tested. Three day old mysids were obtained from AquaTox of Hot Springs, Arkansas and used upon receipt. Five replicates containing 500 ml of the three elutriate concentrations in plastic chambers were used, each containing 10 mysids. Gentle aeration was applied to each replicate throughout the 4-day test period and organisms were fed daily (< 24 hour old *Artemia* nauplii). Water quality measurements, including salinity, dissolved oxygen, pH and temperature were recorded daily for one replicate of each concentration. Survival was recorded daily. Test acceptability criterion for the test is ≥90% mean survival in controls at test termination (96 hours). A reference toxicant test was conducted using copper sulfate with concentrations of 63, 125, 250, 500 and 1000 µg Cu^{2+}/L. Table 3 summarizes bioassays procedures and organism data for the SPP test of LARE sediments with *Mysidopsis bahia*.

Menidia beryllina Test. The *Menidia beryllina* test methods are from the OTM (USEPA/USACE 1991). *Menidia beryllina* were obtained from Aquatic Indicators of St. Augustine, Florida and used upon receipt. Three concentrations of the elutriate (100%, 50%, and 10%) and a seawater control were tested. The test was conducted with five replicate 600 mL beakers containing 250 mL of each test elutriate and 10 animals per replicate. Test was conducted at 20° C under a 16h:8h light:dark photoperiod. Gentle aeration was applied to each replicate throughout the test period. Water quality measurements, including salinity, dissolved oxygen, pH and temperature were recorded daily for each replicate. The *Menidia* were fed 0.2 mL of concentrated *Artemia*

nauplii (< 24 hours old) at 48 hours. Ammonia was measured in the control and all test concentrations at test initiation and termination. Survival in all replicates was recorded daily. Test acceptability criterion is ≥ 90% survival in the control at test termination. A reference toxicant test was conducted using copper sulfate with concentrations of 25.5, 51, 102, 204 and 408 µg Cu^{2+}/L. Table 4 summarizes bioassays procedures and organism data for the SPP test of LARE sediments with *Menidia beryllina*.

Mytilus edulis Test. Bivalve larvae bioassay methods are from the OTM (USEPA/USACE 1991). Four Concentrations of the elutriate (100%, 50%, 10%, and 1%) and a seawater control were tested. Adult *Mytilus edulis* were obtained from Carlsbad Aquafarms, Carlsbad, California. Spawning was induced by heat shocking adults. Unfertilized eggs were separated from debris by filtering the suspension through a 60 µm nitex mesh screen. Released gametes were then combined in individual containers of filtered seawater and allowed to fertilize for up to two hours under gentle aeration. Embryo stock density was estimated by counting an aliquot of dilute stock concentrate. Equal volumes of stock were then added to each test chamber to achieve an estimated density of 15-30 embyos/mL. The test was run using five replicates for each treatment and control at 16±2°C under a 16h:8h light:dark photoperiod. Temperature, pH, dissolved oxygen, and salinity were taken at test initiation and termination (48 hours). At 48 hours each treatment replicate was preserved using 0.5 mL of 35% formaldehyde solution. All larvae in each sample were counted in a Sedgwick-Rafter cell and the total number of normally and abnormally developed larvae were determined. Test acceptability criteria for the test are ≥ 70% control survival (normal embryos based on initial inoculation) and < 10% abnormal development of surviving control embryos. A reference toxicant test was conducted using copper sulfate with concentrations of 2.5, 5, 10, 20 and 40 µg Cu^{2+}/L. Table 5 summarizes bioassays procedures and organism data for the SPP test of LARE sediments with *Mytilus edulis*.

Table 3. Bioassay procedure and organism data for the 96 hour suspended particulate phase bioassay using *Mysidopsis bahia* (ASTM 1997).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Mysidopsis bahia***	
Supplier	AquaTox of Hot Springs, Arkansas	
Date Acquired	29 July, 1998	
Acclimation/Holding Time	None	
Age Class	3 day old	
Test Procedures	**ASTM E1191-97**	
Test Location	MEC Tiburon lab, 20°C room	
Test type/duration	Static – Acute SPP/96 hours	
Test Dates	29 July – 2 August, 1998	
Control Water	Bodega Bay seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 20±2°C	Actual: 19.2 – 20.9°C
Test Salinity	Recommended: 30±2ppt	Actual: 27-30ppt
Test Dissolved Oxygen	Recommended: >4.5	Actual: 5.2-8.3 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.8-8.5 mg/L
Test Photoperiod	16 hour light:8 hour dark	
Test Chamber	1 L glass beakers	
Replicates/SPP concentration/Treatment	5	
SPP Concentrations	100%, 50%, 10%	
Organisms/Replicate	10	
Exposure Volume	900 ml	
Feeding	0.2 mL dense stock of freshly hatched Artemia nauplii – days 0 & 2.	
Water Renewal	none	
Deviations from Test Protocol	Test salinity exceeded recommended range	

Table 4. Bioassay procedure and organism data for the 96 hour suspended particulate phase bioassay using *Menidia beryllina* (OTM 1991).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Menidia beryllina***	
Supplier	Aquatic Indicators, St. Augustine, Florida	
Date Acquired	29 July, 1998	
Acclimation/Holding Time	None	
Age Class	11 day old (1.5 mg)	
Test Procedures	**OTM 1991**	
Test Location	MEC Tiburon lab, 20°C room	
Test type/duration	Static – Acute SPP/96 hours	
Test Dates	29 July – 2 August, 1998	
Control Water	Bodega Bay seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 20±2°C	Actual: 19.4 – 21.1°C
Test Salinity	Recommended: 30±2ppt	Actual: 28-31ppt
Test Dissolved Oxygen	Recommended: >4.5	Actual: 5.8-8.3 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.8-8.6 mg/L
Test Photoperiod	16 hour light:8 hour dark	
Test Chamber	600 mL glass beakers	
Replicates/SPP concentration/Treatment	5	
SPP Concentrations	100%, 50%, 10%	
Organisms/Replicate	10	
Exposure Volume	250 ml	
Feeding	0.2 mL dense stock of freshly hatched Artemia nauplii – days 0 & 2.	
Water Renewal	none	
Deviations from Test Protocol	Test pH exceeded recommended range	

Table 5. Bioassay procedure and organism data for the 48 hour suspended particulate phase bioassay using *Mytilus edulis* (OTM 1991).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Mytilus edulis***	
Supplier	Carlsbad Aquafarms, Carlsbad, CA	
Date Acquired	29 July, 1998	
Acclimation/Holding Time	None	
Age Class	Adults for spawning	
Test Procedures	**OTM 1991**	
Test Location	MEC Carlsbad lab, 16°C room	
Test type/duration	Static – Acute SPP/48 hours	
Test Dates	29 July – 2 August, 1998	
Control Water	Scripps Institution of Oceanography seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 16±2°C	Actual: 16.1 – 18.9°C
Test Salinity	Recommended: 30±2ppt	Actual: 32 –33.1ppt
Test Dissolved Oxygen	Recommended: >4.5	Actual: 5.4-8 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.9-8.4 mg/L
Test Photoperiod	16 hour light:8 hour dark	
Test Chamber	20 mL glass scintillation vials	
Replicates/SPP concentration/Treatment	5	
SPP Concentrations	100%, 50%, 10%, 1%	
Organisms/Replicate	Recommended: 15 – 30 /ml	Actual: 19.6-26.9/ml
Exposure Volume	10 ml	
Feeding	none	
Water Renewal	none	
Deviations from Test Protocol	Test temperature and salinity exceeded recommended range	

2.2.2.2 Solid Phase Tests

Solid Phase tests were conducted with LARE sediment and results compared to the LA-2 reference site location to evaluate the potential impacts to benthic infauna. Sediments in all solid phase test were sieved through a 1.0 mm mesh prior to testing to remove large debris (rocks, shells, twigs, etc.) and any resident infauna. Two species were evaluated, the estuarine amphipod *Eohaustorius estuarius* and the marine polychaete worm *Neanthes arenaceodentata.* Overlying water used for the *Eohaustorius estuarius* SP test was Bodega Bay seawater and overlying water for tests with *Neanthes arenaceodentata* was SIO seawater. All seawater was filtered to 5 µm and U.V. sterilized.

Eohaustorius estuarius 10-Day Static Test. Bioassay methods for the infaunal amphipod bioassay are from ASTM E1367-92 (ASTM 1997). Test animals and laboratory control sediment were supplied by Northwest Aquatics of Newport, Oregon. Sediments from the 5 LARE composites (Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3), the LA-2 reference, and laboratory control sediment were placed in five replicate 900 mL glass jars to a thickness of 2 cm (150 mL) to which was added approximately 600 mL of 28±2 ppt seawater. Additional surrogate replicates (no animals) for each sediment were set up in order to obtain measurement of pore water ammonia and hydrogen sulfide at test initiation and termination. The test was run under a photoperiod of 16 hours light: 8 hours dark at a temperature of 15± 3°C and gentle aeration. After 24 hours, an initial set of water quality parameter measurements were made including temperature, dissolved oxygen, pH, and salinity was recorded for each replicate (ammonia was measured in the overlying water of one replicate from each control, reference, and test site). In addition, a surrogate replicate from each test treatment was broken down and sediment pore water was extracted via centrifugation for subsequent analysis of pH, salinity, ammonia and sulfides. Test organisms then were randomly distributed to test chambers (20 animals per chamber). Animals remaining in the water column and exhibiting abnormal behavior after one hour were replaced. The water level was brought slowly to 900 mL and the chambers were covered with watch glasses to minimize evaporation. Daily water quality measurements were taken and the number of dead and surfaced animals was noted for each replicate. On day 10, the sediments from the chambers were sieved through a 0.5 mm screen and the number of survivors was recorded. Test acceptability criteria are 90% mean control survival. A reference toxicant test was conducted using cadmium chloride with concentrations of 2, 4, 8, 16 and 32 µg Cd^{2+}/L. Table 6 summarizes bioassays procedures and organism data for the SP test of LARE sediments with *Eohaustorius estuarius.*

Neanthes arenaceodentata 10-Day Static-Renewal Test. Bioassay methods for the marine polychaete bioassay are from ASTM E1611-94 (ASTM 1997). Two to three week old juvenile worms were supplied by Dr. Don Reish of Long Beach, California. Sediments from the 5 LARE composites (Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3), the LA-2 reference, and laboratory control sediment were placed in five replicate 900 mL glass jars to a thickness of 2 cm (150 mL) to which was added approximately 600 mL of 28±2 ppt seawater. Additional surrogate replicates (no animals) for each sediment were set up in order to obtain measurement of pore water ammonia and hydrogen sulfide at test initiation and termination. The test was run under a 12:12 hour light:dark photoperiod at a temperature of 20 ± 3°C, a salinity of 28 ± 2 ppt and gentle aeration. After 24 hours, overlying water was renewed (80% of volume) and an initial set of water quality parameter measurements were made including temperature, dissolved oxygen, pH, and salinity was recorded for each replicate (ammonia was measured in the overlying water of one replicate from each control, reference, and test site). In addition, a surrogate replicate from each test treatment was broken down and sediment pore water was extracted via centrifugation for subsequent analysis of pH, salinity, ammonia and sulfides. Test organisms were then randomly distributed to test chambers (5 animals per chamber). The water level was brought slowly to 900 mL and the chambers were covered with watch glasses to minimize evaporation. Overlying water was renewed every other day (80% of volume) unless more frequent water changes were required to ameliorate potential effects of elevated pore water ammonia. Daily water quality measurements were taken and the number of dead and surfaced animals was noted for each replicate. On day 10, the sediments from the chambers were sieved through a 0.5 mm screen and the number of survivors was recorded. Test acceptability criterion is 90% mean control survival. A reference toxicant test was conducted using cadmium chloride with concentrations of 3.75, 7.5, 15, 30 and 60 µg Cd^{2+}/L. Table 7 summarizes bioassay procedures and organism data for the SP test of LARE sediments with *Neanthes arenaceodentata*.

Table 6: Bioassay procedure and organism data for the 10-day solid phase bioassay using *Eohaustorius estuarius* (ASTM 1997).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3, LA-2 reference, Control**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Eohaustorius estuarius***	
Supplier	Northwest Aquatics, Newport, Oregon	
Date Acquired	22 July , 1998; 4 August, 1998	
Acclimation/Holding Time	10 days; 1 day	
Age Class	Juvenile	
Test Procedures	**ASTM E1367-92**	
Test Location	MEC Tiburon lab, 15°C room	
Test type/duration	Static – Acute/ 10 days	
Test Dates	3-7 August, 1998; 5-9 August, 1998	
Control Water	Bodega Bay seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 15±2°C	Actual: 15 – 19.4°C
Test Salinity	Recommended: 30±2ppt	Actual: 28-31ppt
Test Dissolved Oxygen	Recommended: >5.0	Actual: 5.7-10.5 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.5-8.7 mg/L
Test Photoperiod	16 hour light: 8 hour dark	
Test Chamber	1 L glass jars	
Replicates/Treatment	5	
Organisms/Replicate	20	
Exposure Volume	2 cm sediment, 900 ml water	
Feeding	none	
Water Renewal	none	
Deviations from Test Protocol	Test temperature and pH exceeded recommended range; Twice daily water renewals (80% by volume) due to ammonia	

Table 7: Bioassay procedure and organism data for the 10-day solid phase bioassay using *Neanthes arenaceodentata* (ASTM 1997).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3, LA-2 reference, Control**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Neanthes arenaceodentata***	
Supplier	Don Reish	
Date Acquired	21 July, 1998; 31 July, 1998	
Acclimation/Holding Time	3 days	
Age Class	2-3 week old juveniles	
Test Procedures	**ASTM E1611-94**	
Test Location	MEC Carlsbad lab, 20°C room	
Test type/duration	Static – Acute/10 -day	
Test Dates	24 July – 3 August, 1998; 3 – 13 August 1998	
Control Water	Scripps Institution of Oceanography seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 20±2°C	Actual: 19.2 – 21°C
Test Salinity	Recommended: 30±2ppt	Actual: 29-30.9ppt
Test Dissolved Oxygen	Recommended: >4.5	Actual: 5.9-9.2 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.9-8.4 mg/L
Test Photoperiod	12 hour light: 12 hour dark	
Test Chamber	1L glass jars	
Replicates/SPP concentration/Treatment	5	
SPP Concentrations	100%, 50%, 10%	
Organisms/Replicate	5	
Exposure Volume	2 cm sediment; 900 ml water	
Feeding	none	
Water Renewal	none	
Deviations from Test Protocol	Twice daily water renewals 80% by volume due to ammonia	

2.2.2.3 Bioaccumulation Studies

Bioaccumulation studies were conducted with LARE sediment and results compared to the LA-2 reference site location to evaluate the potential for contaminant transfer through the food chain. Two species were used in this evaluation the hard clam *Macoma nasuta* and the polychaete *Nephtys caecoides*. *Macoma nasuta* were supplied by Kim Siewers of Santa Cruz, California and *Nephtys caecoides* were supplied by John Brezina and Associates of Dillon Beach, California. Exposures were conducted in accordance with procedures set forth in the USEPA's "Guidance Manual – Bedded Sediment Bioaccumulation Tests" (USEPA 1993) and the OTM (1991).

The bioaccumulation study was conducted in 70 x 20 x 18 cm (20 L) fiberglass tanks with a continuous flow (375 ml/min) of clean, filtered (<5 µm), UV sterilized San Diego Bay seawater (32-33 ppt salinity) at 15 ± 2°C. Exposures were conducted under continuous light and animals were not fed over the 28-day exposure. Twenty-five clams and 75 worms were placed together in four liters of sieved (1.0 mm mesh) control, LA-2 reference, and the 5 LARE test sediment treatments (five replicates each). It should be noted that Area 2-top, Area 2-bottom, and Area 3 sediments had only 4 replicates for the worm *Nephtys caecoides*, due to insufficient number of animals at test initiation. Water quality measurements, including salinity, pH, dissolved oxygen, and temperature, were monitored daily in each chamber and total ammonia was measured in one of the five replicates.

At exposure termination (28 days), sediments were gently sieved through a 0.75 mm stainless steel screens. All surviving clams and worms were counted and placed in sediment-free, flow through aquaria under test conditions for a period of 24 hours in order for the organisms to purge their gut contents. Following gut purging, animal tissues for each test species from each treatment replicate were placed in clean glass jars with teflon lined lids, frozen, and then sent via courier under chain-of-custody to Pacific Treatment Analytical Systems (PTAS). At PTAS, tissues were subsequently homogenized and assayed for tissue residue levels of trace metals (arsenic, cadmium, chromium, copper, lead, mercury, zinc, selenium, nickel and silver) as well as PAHs, phthalates, pesticides, PCBs, and organotins. Table 8 summarizes bioassay procedures and organism data for the bioaccumulation study of LARE sediments with *Nephtys caecoides and Macoma nasuta*.

Table 8: Bioassay procedure and organism data for the 28-day biaccumulation studies using *Nephtys caecoides* and *Macoma nasuta* (USEPA 1993; OTM 1991).

Sample Identification	**Area 1-top, Area 1-bottom, Area 2-Top, Area 2-Bottom, Area 3, LA-2 reference, Control**	
Date Sampled	21-22 July 1998	
Date Received at MEC	22, July, 1998	
Approximate Volume Received	60L	
Sample Storage Conditions	4°C, dark, minimal head space	
Test Species	***Nephtys caecoides ; Macoma Nasuta***	
Supplier	*N. caecoides* – Brezina & Assoc. Dillon Beach, California; M. nasuta – Kim Siewers Santa Cruz, California	
Date Acquired	17 July , 1998	
Acclimation/Holding Time	5 days	
Age Class	Adults	
Test Procedures	**USEPA (1993); OTM (1991)**	
Test Location	MEC San Diego Harbor Lab	
Test type/duration	Flow-through/ 28 days	
Test Dates	22 July - 19 August, 1998	
Control Water	San Diego Bay seawater; 0.5 µm filtered, U.V. sterilized	
Test Temperature	Recommended: 15±2°C	Actual: 14.8 – 16.7°C
Test Salinity	Recommended: 30±2ppt	Actual: 32.2-33ppt
Test Dissolved Oxygen	Recommended: >5.0	Actual: 7.1-8.0 mg/L
Test pH	Recommended: 8±0.5	Actual: 7.6-8.3 mg/L
Test Photoperiod	16 hour light: 8 hour dark	
Test Chamber	22 L fiberglass trays with noncontaminating covers	
Replicates/Treatment	5	
Organisms/Replicate	25 for *M. nasuta*; 75 for *N. caecoides*	
Exposure Volume	2 cm sediment (3.5 L), 10 L water	
Feeding	none	
Water Renewal	Flow through 375 mL per minute	
Deviations from Test Protocol	Test salinity exceeded recommended range	

2.2.3 Data Analysis and Statistical Methods

At the conclusion of all bioassays, test endpoint data were evaluated statistically. For the SPP toxicity tests EC50 values were estimated. An EC50 value is the estimated concentration that causes any effect, either lethal (LC) or sublethal (IC) on 50% of the test population. For the SP toxicity tests, percent survival of animals exposed to LARE sediments was compared statistically to survival of organisms exposed to the LA-2 reference site. Similarly for the bioaccumulation study measured tissue concentrations of contaminants from animals exposed to the LARE test sediment were compared statistically to tissue concentrations of animals exposed to the LA-2 reference sediment.

2.2.3.1 Analysis of Suspended-Particulate Phase Test Results

LC50 and IC50 values were estimated using the Probit or Linear Interpolation (Bootstrap) method. The toxicity threshold for each area was calculated as 0.01 of the lowest LC50 or IC50 from the three SPP tests. The Limiting Permissible Concentration (LPC) is exceeded when the concentration of the material in the receiving water, after allowance for initial mixing (Projected Concentration) exceeds the toxicity threshold. The projected concentration was estimated using the mixing zone model as described in the OTM (USEPA/USACE 1991). If the LC50 or IC50 exceeds 100% then the projected concentration is necessarily less than the toxicity threshold.

2.2.3.2 Analysis of Solid Phase Test Results

Survival data was analyzed via a Student's *t*-test when variances were homogeneous and a modified *t*-test when the variances were heterogeneous. All statistical comparisons were made at an alpha level = 0.05. A significant effect in the solid phase test is defined as >10% difference (reduction) and statistically significant difference ($p<0.05$) in survival of organisms exposed to the test sediment relative to survival of animals exposed to the reference material. For amphipods, a significant effect is defined as a 20% decrease and a statistical significant difference relative to the reference site survival value.

2.2.3.3 Analysis of Bioaccumulation Test Results

The mean analyte concentration from each site was compared to that of the reference site. If the mean of the data from a test site exceeds the mean of the reference site, a paired, one-tailed *t*-test was performed to determine if the difference was statistically significant ($p<0.05$). The *t*-test requires that the sample mean and variance are known and measurable. Statistical analysis of data sets containing non-detectable values is problematic; therefore, modified analysis of censored data sets has been advocated by several authors (Newman et al. 1989, Helsel 1990, Slymen and de Peyster 1994). Since some values were reported as non-detectable, or below the

Method Reporting Limit (MRL), it was necessary to estimate the mean and the variance around a value so statistical test could be performed.

To better describe the variance around the means when some, or all, of the individual replicate values are below the MRL of the analytical methodology, an estimate of the non-detectable is used to permit the required statistical evaluation. This estimate is based on the recommendation of using one half of the measured detection limit or MRL as the estimated mean or datum (Paasivirta 1991).

In situations in which more than one replicate was reported below the MRL, estimated data values were based on a symetrical breakdown of the data range in such a way that the mean of the estimates centered around a value one-half of the MRL. This statistical manipulation of the data was required to generate statistically valid means and variances so that the required statistical evaluation of the data could be performed. For example if all five replicate values for a particular analyte concentration were below the MRL of 20, then the data would be estimated as 5, 15, 10, 15, and 5. This would produce a value with a mean of 10 (i.e., one half the MRL) and an associated variance (assuming a normal distribution). For contaminants with a specified FDA action level mean tissue concentrations were compared to the FDA action levels via one sided confidence limits as specified in the OTM (USEPA/USACE 1991).

2.3 Quality Assurance Procedures

MEC's Quality control staff performs periodic audits to ensure that test conditions, data collection, and test procedures are conducted in accordance with the OTM and MEC SOPs. MEC's SOPs have been audited and approved by an independent EPA approved laboratory and placed in the QA file as well as laboratory files.

2.3.1 Field Collection and Sample Handling

All relevant project/ sample information and field measurements were recorded on waterproof customized core log data forms. A daily field log was maintained and formal chain-of-custody procedures were followed and documented. The DGPS system was verified before and after sampling at USACE predefined boat tie up points. All sampling equipment was cleaned between sample stations. Samples were double bagged and both inner and outer bags labeled. Samples were held on ice until delivery via courier to MEC in Carlsbad, CA. Chain-of-custody forms were prepared in the field during sediment collection by MEC personnel. Field personnel maintained custody of the samples until they were returned to the laboratory. Once sediments were

composited, a new chain of custody was prepared for the transfer of sediments for chemical and physical analyses.

2.3.2 Test Organism Handling

All test organisms were shipped via overnight to MEC's laboratories in Carlsbad and Tiburon, California with the exception of adult *Mytilus edulis*, which were delivered via courier to MEC in Carlsbad. All animals with the exception of those used in the SPP test were held for a period of time to observe general organism health prior to testing. Animals received at salinities and temperatures different from specified test conditions were acclimated gradually to test temperature (≅2°C / hour; 5°C max. in 24 hours) and salinity (≅2 ppt/day). If mortality of animals during acclimation exceeded 10%, animals were discarded and a new group of test animals ordered. All organism handling and acclimation was conducted in accordance with approved SOPs for the laboratory. Animal receipt and maintenance log books were used to record the source and health of the test organisms.

2.3.3 Chemical and Physical Characteristics of Sediments and Tissues

Complete copies of all reports issued by the analytical laboratories are included in Appendices C (sediment) and G (tissue). Chemical analysis were performed using quality control criteria specified in Guidelines for establishing Test Procedures for Analysis of Pollutants (USEPA 1983) and Test Methods for Evaluating Solid Waste (SW-846) (USEPA 1986), in California state certified laboratories. Grain size and Total Organic Carbon analysis performed by MEC were consistent with MEC's internal quality control criteria. Performance was evaluated via the use of standard reference materials or laboratory control samples, method blanks, surrogates, spiked samples, duplicate samples, and internal quality control samples. Precision and accuracy objectives were established for method reporting limits, spike recoveries, and duplicate analyses.

2.3.4 Biological Testing

The quality assurance objectives for toxicity testing conducted by MEC are identical to those mentioned in the OTM (USEPA/USACE 1991). These objectives for data quality include: 1) water sampling and handling; 2) source and condition of test organisms; 3) condition and maintenance of equipment; 4) test conditions; 5) instrument calibration; 6) use of reference toxicants; 7) record keeping; and 8) data evaluation.

Methods employed in these toxicity testing programs are detailed in ASTM (1997), the OTM (USEPA/USACE 1991), and in MEC's internal laboratory Standard Operating Procedures (SOPs). These SOPs and Protocols have been approved by the laboratory director. All data collected and produced are recorded on approved data sheets are included as part of the

permanent project file. These data sheets and all subsequent statistical analysis were checked to ensure that required test conditions were within specifications cited in the standard operating procedures and the analysis performed where appropriate. Any unforeseen circumstances that might have affected the integrity of the study were reported with the test results.

SOPs for each analytical instrument used in toxicity testing are maintained in the maintenance and Calibration Log. Equipment is maintained under a regular maintenance schedule to prevent equipment failure and/or changes in operational parameters. Instruments used in support of testing were calibrated daily and calibration data are logged by the technician performing the calibration. Stock standard solutions are stored in at least two separate containers, so that a fresh standard solution is available in the event that the stock standard currently in use becomes contaminated. Working standards that are in frequent contact with electrodes, pipettes, etc., are kept in separate working bottles to reduce the chance of contamination of stock standards.

Seawater sources are analyzed quarterly for priority pollutants and results are kept on file at each of MECs laboratory facilities.

Reference toxicant tests were used as an internal quality check of the sensitivity of test organisms. The results of these tests were compared with laboratory database values for the reference toxicant used to verify that test animal performance was within acceptable limits. Similarly water quality measurements were monitored to ensure that they fell with in the prescribed limits, and corrective action was taken if necessary.

2.3.5 Data Analysis and Statistical Methods

All toxicity and bioaccumulation tests were performed in accordance to protocols and conditions listed in MECs SOPs. Raw data and study records were checked to ensure that required test conditions were within specifications cited in the SOPs. Major deviations from prescribed protocols required approval of both the client and the quality control manager. Circumstances or deviations that might affect the integrity of the study are reported with the results. The data, analysis, and report were also reviewed for accuracy by the quality assurance manager. All data underwent a 100% quality assurance check for accuracy and completeness and an additional secondary check was performed on a minimum of 10% of the data.

3.0 RESULTS

3.1 Sample Collection and Handling

Field determined coordinates, number of cores/station, depth of penetration relative to the mudline (i.e., the sediment surface), and depth of recovery relative to the mudline for each station location are summarized in Table 9. Field core logs and other associated documentation for the field sampling effort are located in Appendix B. Refusal (i.e., <2.5 cm penetration/minute) was encountered prior to sample depth for nearly all stations in Areas 1 and 2 due to either hard packed sand or a dense detrital layer. Required sample depths were achieved for all cores in Area 3.

3.2 Analytical Results

3.2.1. Chemical and Physical Characteristics of Sediments

Results from chemical analyses of sediment are discussed below. All results are expressed in dry weight. Summary results are presented in Table 10 and the raw data is provided in Appendix C.

Reference Site

The reference site consisted of relatively coarse-grained sediments (68.9% sand) and contained a moderate percentage of total organic carbon (0.57%).

Total sulfide concentrations ranged from a low 1.4 mg/Kg to a high concentration of 152 mg/Kg. Total sulfide concentrations in the reference site were low 0.3 mg/Kg and concentrations of dissolved sulfides were below the target analyte detection limit. Total petroleum hydrocarbon concentrations was also not detectable.

Arsenic, chromium, copper, lead, nickel, silver, and zinc were all detected at relatively low concentrations ranging from 0.62 mg/Kg for silver to 46 mg/Kg for zinc. There were no detectable concentrations of mercury, cadmium, and selenium.

Table 9. Actual field coordinates and sample depths.

Site	Attempt	WGS 84 Latitude	Longitude	Depth Meters (MLLW)	Core Length Meters	Penetration meters	SAP depth meters (MLLW)	Actual Depth Sampled meters (MLLW)	Comments
1-1	1 of 1	33 45.696	118 11.985	5.5	4.1	5.4	9.6	10.9	
1-2	1 of 1	33 45.672	118 11.997	4.5	3.8	5.6	9.6	10.1	
1-3	1 of 1	33 45.639	118 12.013	1.7	2.7	4.3	9.6	5.9	refusal at 4.3 meters
1-4	1 of 2	33 45.609	118 12.011	0.7	2.7	5.5	9.6	6.2	refusal at 5.5 meters
1-4	2 of 2	33 45.609	118 12.011	0.8	2.4	3.3	9.6	4.1	refusal at 3.3 meters
1-5	1 of 1	33 45.579	118 12.011	1.8	4.0	5.9	9.6	7.7	refusal at 5.9 meters
1-6	1 of 1	33 45.619	118 11.985	4.3	5.1	5.5	9.6	9.8	
1-7	1 of 2	33 45.572	118 11.951	2.0	0.0	6.1	9.6	8.1	core barrel broke, core lost
1-7	2 of 2	33 45.572	118 11.951	2.3	4.3	5.1	9.6	7.4	refusal at 5.1 meters
1-8	1 of 1	33 45.592	118 11.944	4.5	4.6	4.6	9.6	9.1	refusal at 4.6 meters
2-1	1 of 3	33 45.562	118 11.922	4.2	0.6	1.7	9.6	5.9	refusal at 1.6 meters
2-1	2 of 3	33 45.561	118 11.919	4.2	2.1	4.1	9.6	8.4	refusal at 4.1 meters
2-1	3 of 3	33 45.562	118 11.913	4.3	5.3	5.8	9.6	10.1	
2-2	1 of 1	33 45.576	118 11.891	4.9	4.5	4.7	9.6	9.6	
2-3	1 of 2	33 45.555	118 11.869	4.4	4.1	5.3	9.6	9.8	
2-3	2 of 2	33 45.555	118 11.869	4.4	1.5	1.8	9.6	6.2	top only for bioassay
2-4	1 of 1	33 45.570	118 11.839	5.2	3.9	4.4	9.6	9.6	
2-5	1 of 4	33 45.547	118 11.821	4.9	0.0	0.0	9.6	4.9	refusal at 0 meters
2-5	2 of 4	33 45.547	118 11.820	4.5	0.6	1.8	9.6	6.3	refusal at 1.8 meters
2-5	3 of 4	33 45.548	118 11.825	4.8	2.6	4.0	9.6	8.8	refusal at 4 meters
2-5	4 of 4	33 45.547	118 11.825	4.7	4.2	2.3	9.6	7.0	refusal at 2.3 meters
2-6	1 of 1	33 45.555	118 11.787	6.4	2.7	3.2	9.6	9.6	
2-7	1 of 1	33 45.541	118 11.775	6.3	3.2	3.4	9.6	9.7	
2-8	1 of 1	33 45.552	118 11.749	6.5	3.1	3.5	9.6	10.0	
3-1	1 of 1	33 45.537	118 11.686	5.7	1.8	3.0	7.6	8.8	
3-2	1 of 1	33 45.508	118 11.654	5.5	2.0	2.4	7.6	7.9	
3-3	1 of 1	33 45.493	118 11.582	5.3	2.3	2.4	7.6	7.8	
3-4	1 of 1	33 45.441	118 11.543	4.9	2.4	3.0	7.6	8.0	
3-5	1 of 1	33 45.435	118 11.483	5.6	2.0	2.4	7.6	8.1	
3-6	1 of 2	33 45.382	118 11.454	4.6	1.5	3.0	7.6	7.6	
3-6	2 of 2	33 45.382	118 11.454	4.7	2.1	3.0	7.6	7.7	
3-7	1 of 1	33 45.382	118 11.391	5.5	2.8	3.0	7.6	8.6	
3-8	1 of 1	33 45.337	118 11.365	7.3	0.9	0.9	7.6	8.2	

Table 10. Summary of sediment characterization – Composite samples.

Analyte	LA-2 ODMDS Reference	Area 1		Area 2		Area 3
		Top	Bottom	Top	Bottom	Composite
Grain Size (%)						
Gravel	0.0	0.814	1.237	1.128	0.039	0.170
Sand	68.929	88.496	62.304	70.752	34.830	42.036
Silt	22.341	5.754	23.267	19.576	45.082	42.392
Clay	8.730	4.935	13.191	8.544	20.049	15.402
Total Organic Carbon (%)	0.569	0.851	2.492	1.479	3.186	1.929
TRPH (mg/kg)	<7	719	367	820	335	300
Percent Solids (%)	73.2	78.6	66.8	61.5	54	59.1
Total Sulfides (mg/kg)	0.3	1.4	28	28	152	97
Dissolved Sulfides (mg/kg)	<0.1	<0.1	<0.1	<0.2	<0.2	0.2
Metals (mg/kg)						
Arsenic	1.29	0.84	1.94	1.47	2.26	1.01
Cadmium	<0.14	0.34	1.37	0.9	2.6	1.49
Chromium	26	10	26	26	40	35
Copper	12	12	47	37	78	52
Lead	9.6	25	90	65	200	98
Mercury	<0.03	<0.03	0.18	0.19	0.3	0.22
Nickel	13	8	20	20	31	33
Selenium	<0.27	0.95	<0.3	0.69	<0.37	<0.35
Silver	0.62	0.15	0.57	0.4	1.16	0.86
Zinc	46	72	220	190	360	240
Organotins (µg/kg)						
Dibutyltin	<1.4	8	<15	<16	<19	<17
Monobutyltin	<1.4	<1.3	<15	<1.6	<1.9	<1.7
Tributyltin	<1.4	<1.3	1.9	<1.6	3.3	2.4
PAHs (µg/kg)						
Acenaphthene	<14	<13	<15	18	<19	<17
Acenaphthylene	<14	<13	<15	<16	<19	<17
Anthracene	<14	<13	16	28	33	<17
Benzo (b)Fluoranthene	<14	36	106	141	176	115
Benzo (k)Fluoranthene	<14	28	79	89	159	92
Benzo(a)Anthracene	<14	28	66	107	148	87
Benzo(a)Pyrene	<14	25	70	111	161	94
Benzo(ghi)Perylene	<14	38	144	161	294	168
Chrysene	<14	41	126	177	281	160
Dibenzo(a,h)Anthracene	<14	<13	18	21	46	28
Fluoranthrene	<14	62	150	228	289	163
Fluorene	<14	<13	18	20	39	<17
Indeno(1,2,3-cd)Pyrene	<14	25	106	159	209	151
Naphthalene	<14	<13	<15	55	<19	<17
Phenanthrene	<14	46	123	177	233	97
Pyrene	<14	90	250	361	511	295
Total Detectable PAHs	0	419	1272	1853	2579	1450

Table 10. Continued.

Analyte	LA-2 ODMDS Reference	Area 1		Area 2		Area 3
		Top	Bottom	Top	Bottom	Composite
Pesticides (µg/kg)						
4,4-DDD	<2.7	<2.5	<3	<3.2	<3.7	<3.4
4,4-DDE	<2.7	<2.5	<3	<3.2	<3.7	<3.4
4,4-DDT	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Aldrin	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Alpha-BHC	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Beta-BHC	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Chlordane	<27	<25	<30	<32	<37	<34
Delta-BHC	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Dieldrin	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Endosulfan I	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Endosulfan II	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Endosulfan Sulfate	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Endrin	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Endrin Aldehyde	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Gamma-BHC	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Heptachlor	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Heptachlor Epoxide	<2.7	<2.5	<3	<3.2	<3.7	<3.4
Methoxychlor	<27	<25	<30	<32	<137	<34
Toxaphene	<34	<32	<37	<41	<46	<42
PCBs (µg/kg)						
Arochlor-1016	<14	<13	<15	<16	<18	<17
Arochlor-1221	<14	<13	<15	<16	<18	<17
Arochlor-1232	<14	<13	<15	<16	<18	<17
Arochlor-1242	<14	<13	<15	<16	<18	<17
Arochlor-1248	<14	<13	<15	<16	<18	<17
Arochlor-1254	<14	<13	<15	<16	<18	<17
Arochlor-1260	<14	<13	21	26	94	44
Total Detectable PCBs	0	0	0	0	0	0
Phthalates (µg/kg)						
Bis(2-ethylhexyl)phthalate	77	14600	13200	2390	16200	3040
Butyl Benzyphthalate	15	449	177	163	263	224
Di-n-butylphthalate	63	64	72	106	96	311
Di-n-octylphthalate	<14	79	126	187	168	<17
Diethylphthalate	<14	<13	<15	<16	24	<17
Dimethylphthalate	<14	23	<15	23	22	<17

The concentrations of most of the organic analyses were below the detectable levels in the reference site sample. Organotins, Pesticides, PCBs, and PAHs were all below detectable levels in the reference site sample. Phthalates were detected in the reference site sample. Bis(2-ethylhexyl)phthalate and Di-n-butylphthalate were detected in the reference sample at 77 µg/Kg and 63 µg/Kg respectively. These two phthalate compounds were also detected in the laboratory analytical method blank and are suspected laboratory contaminants. Phthalates are ubiquitous compounds, commonly found in many plastic products. However, butyl benzylphthalate was also detected at 15 µg/Kg and was not found in any of the laboratory prepared QA samples, therefore, there is no evidence to demonstrate that butyl benzylphthalate was artificially introduced following sample collection.

Arsenic, chromium, mercury, nickel, selenium, and silver were all detected at relatively low concentrations ranging from 0.18 mg/Kg for mercury to 40 mg/Kg for chromium. Copper was detected at 12 mg/Kg in the reference sediment with concentrations ranging in dredge areas from 12 mg/Kg to 78 mg/Kg. Lead was detected at 9.6 mg/Kg in the reference sediment with concentrations in the dredge areas ranging from 25 mg/Kg to 200 mg/Kg. Cadmium was not detectable in the reference sediment, with concentrations in the dredge areas ranging from 0.34 mg/Kg to 2.60 mg/Kg. Zinc was detected at 46 mg/Kg in the reference sediment, with concentrations in the dredge areas ranging from 66 mg/Kg to 360 mg/Kg. were detected at moderate concentrations ranging from a high of 360 mg/Kg for zinc.

Test Samples

The composite sample from Area 1-top contained more than 88% coarse grains (0.8% gravel; 88.5% sand). The composite sample from Area 1-bottom contained more than 60% coarse grains (1.2% gravel; 62.3% sand). The composite sample from Area 2-top contained more than 70% coarse grains (1.1% gravel; 70.7% sand). The composite from Area 2-bottom contained 65% fines (45.1% silt; 20.0% clay); containing 34.8% sand and <1% gravel.

Total organic carbon levels were moderate in Area 1-top (0.85%). Total organic carbon levels in Area 1-bottom was 2.5%, Area 2-top was 1.5%, Area 2-bottom was 3.2% and Area 3 composite was 1.9%.

Total sulfide concentrations ranged from 1.4 mg/Kg in Area 1-top composite to 152 mg/Kg in Area 2-bottom composite. Dissolved sulfide results were at or below target analyte detection limits. Total petroleum hydrocarbon concentrations ranged from 300 mg/Kg in Area 3 composite to 820 mg/Kg in Area 2-bottom composite.

Measured concentrations for most of the metals were higher in several test areas than in the reference sediment. Among the test sediments, metals concentrations were the greatest in the Area 2-bottom composite. Metals concentrations were still relatively low in the test sediments. Lead and zinc had the highest concentrations with 200 mg/Kg lead and 360 mg/Kg zinc detected in Area 2-bottom composite. Also elevated were copper concentrations with 78 mg/Kg detected in Area 2-bottom. Also for Area 2-bottom chromium concentrations were 40 mg/Kg, mercury concentrations were 0.30 mg/Kg, nickel concentrations were 31 mg/Kg, cadmium concentrations were 2.60 mg/Kg, and silver concentrations were 1.16 mg/Kg. Metals concentrations in Area 1-top composite were all less than concentrations found in the reference sample with the exception of zinc (66 mg/Kg), lead (25 mg/Kg), cadmium (0.34 mg/Kg), and selenium (0.95 mg/Kg). In Area 1-bottom composite, the following metals were elevated above reference sample concentrations; arsenic (1.94 mg/Kg), mercury (0.18 mg/Kg), nickel (20 mg/Kg), copper (47 mg/Kg), zinc (220 mg/Kg), lead (90 mg/Kg), and cadmium (1.37 mg/Kg). In Area 2-top composite the following metals were elevated above the reference sample concentrations; arsenic (1.47 mg/Kg), mercury (0.19 mg/Kg), nickel 20 mg/Kg, copper (37 mg/Kg), zinc (190 mg/Kg), lead (65 mg/Kg), cadmium (0.90 mg/Kg), and selenium (0.69 mg/Kg). In Area-3 composite sample the following metals were elevated above the reference sample; chromium (35 mg/Kg), mercury (0.22 mg/Kg), nickel (33 mg/Kg), copper (52 mg/Kg), zinc (240 mg/Kg), lead (98 mg/Kg), cadmium (1.49 mg/Kg), and silver (0.86 mg/Kg).

Low levels of PAHs were detected in the samples with the highest level of PAH's, 2,580 µg/Kg detected in Area 2-bottom composite. Phthalates were detected in all area samples. Two of the phthalates were also detected in the laboratory method blank and are potential laboratory contaminants, however, there is no evidence to indicate other phthalates detected were introduced by laboratory contamination or preparation procedures. Additionally, phthalates were detected at previous studies, (Coastal Frontiers Corporation 1996). Total phthalate concentrations (including suspect laboratory contaminant concentrations) in Area 2-bottom composite were detected at 16,800 µg/Kg.

No pesticides were present above detectable concentrations in the test area samples. PCB (identified using peak matching as Arochlor 1260) was detected in all the test area samples. The highest concentration detected was 94 µg/Kg in Area 2-bottom composite.

Low levels of organotins were detected in the site samples. Tributyltin was detected at 3.3 µg/Kg in Area 2-bottom composite. In Area 1-top composite dibutyltin was detected at 8.0 ug/Kg. In Area-1 bottom composite 1.9 ug/Kg tributyltin was detection. In the Area-3 composite 2.4 ug/Kg tributyltin was detected.

Mytilus edulis Test Results. Water quality parameters were within appropriate limits with the exception of temperature which ranged slightly higher (16.1 to 18.9°C) than the recommended 16 ± 2°C and salinity which also ranged slightly higher (32.0 to 33.1ppt) than the recommended 30 ± 2 ppt. Mean percent control survival and normality were 99.4% and 92.7% respectively well above the acceptable control criteria of 70% for survival and 90% for normal development. IC50 values for survival were >100% for Area 1-top, 29.5% for Area 1-bottom, 74.3% for Area 2-top, 29.1% for Area 2-bottom and 26.7% for Area 3. IC50 values for normality ranged from 5.1% (Area 2-bottom) to 29.6% (Area 1-top). Test results for *M. edulis* are summarized in Table 11 and detailed in Appendix D.

The reference toxicant was copper sulfate, tested at nominal concentrations of 2.5, 5, 10, 20, and 40 µg Cu^{2+}/L. The IC50 for normality was 8.0 µg Cu^{2+}/L which was within two standard deviations (± 13.6 µg Cu^{2+}/L) of the laboratory mean of 8.5 µg Cu^{2+}/L indicating that the sensitivity of *M. edulis* used in the assessment of LARE sediments fell within the normal range. Results of the reference toxicant test with *M. edulis* are summarized in Table 11 and detailed in Appendix D.

Table 11: Summary of suspended particulate phase bioassay test results.

Sample ID	Conc. %	Bivalve Larvae – *Mytilus edulis*				Fish – *Menidia beryllina*		Mysid – *Mysidopsis bahia*	
		Average %		IC_{50} Survival and Development	IC_{50} % Normal	Average % Survival	IC_{50} Survival	Average % Survival	IC_{50} Survival
		Survival	Normal						
Control	0	99.4	92.7	NA	NA	96.0	NA	100.0	NA
Area 1 - Top	1	100.0	90.7	30.1%	29.6%	NA	78.8%	NA	>100%
	10	100.0	90.4			98.0		94.0	
	50	98.6	0.5			90.0		92.0	
	100	87.1	0.0			18.0		90.0	
Area 1 - Bottom	1	95.0	90.4	5.2%	5.4%	NA	28.7%	NA	25.6%
	10	99.1	0.0			90.2		82.0	
	50	0.0	0.0			0		0	
	100	0.0	0.0			0		0	
Area 2 - Top	1	97.2	89.4	28.1%	28.9%	NA	57.5%	NA	72.4%
	10	98.3	87.7			96.0		92.0	
	50	97.0	0.0			60.0		94.2	
	100	0.0	0.0			0		16.0	
Area 2 - Bottom	1	100.0	85.7	5.2%	5.1%	NA	29.6%	NA	26.2%
	10	95.4	0.0			94.0		84.0	
	50	0.0	0.0			0		0	
	100	0.0	0.0			0		0	
Area 3	1	98.7	83.5	26.2%	26.7%	NA	69.2%	NA	>100%
	10	97.3	82.0			96.3		100.0	
	50	98.8	0.0			78.0		88.0	
	100	77.7	0.0			0		62.0	

Copper Sulfate Reference Toxicant

Bivalve Larvae – *Mytilus edulis*					Fish – *Menidia beryllina*			Mysid – *Mysidopsis bahia*		
Conc. µg/L	Average %		IC_{50} Survival*	IC_{50} % Normal	Conc. µg/L	Average % Survival	IC_{50} Survival	Conc. µg/L	Average % Survival	EC_{50} Survival
	Survival	Normal								
Control	99.2	93.0	7.9 µg/L	8.0 µg/L	Control	90.0	158.5 µg/L	Control	95.0	156.9 µg/L
2.5	79.7	89.3			25.5	100.0		63	100.0	
5	85.0	86.5			51	95.0		125	70.0	
10	26.1	20.2			102	94.7		250	4.8	
20	2.6	20.1			204	9.5		500	5.0	
40	1.4	0.0			408	0		1000	0	

NA = not applicable.

* = The IC_{50} for survival only is calculated for reference toxicant tests.

3.2.2.2 Solid Phase Testing

Eohaustorius estuarius 10-Day Static Test Results. Initial pore water ammonia values measured at MEC's Tiburon Lab were elevated in all LARE sediments. Several of the test sediments had pore water ammonia values in excess of the maximum 60 mg/L for *Eohaustorius estuarius* as prescribed by the USEPA (USEPA 1994). Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3 had initial pore water ammonia values of 49.8, 170, 70.2, 128, and 42 mg/L, respectively.

As a consequence recommended procedures for ameliorating the effects of ammonia were initiated. Briefly, test chambers were set up as for normal testing with the exception that animals were not added. In addition to the normal test chambers a number of surrogate chambers were set-up for each test site for subsequent measurement of pore water ammonia levels. All chambers (test and surrogates) were placed on aeration and overlying water was exchanged twice daily (80% of volume). Each day a surrogate chamber from each treatment was broken down and pore water ammonia analyzed. When pore water ammonia fell below 20 mg/L in a given treatment the test for that treatment was initiated. Following 8 days of twice daily renewal, pore water ammonia values in the Area 1–top, Area 1-bottom, and Area 3 sediments were ≤ 20 mg/L and the test of those sediments was initiated. The test of Area 2-top and Area 2-bottom sediments were initiated 2 days later following an additional 4 renewals. Once tests were initiated renewal of overlying water was continued twice daily as per USEPA recommendations. Measured pore water ammonia values at test initiation may be found in Appendix E.

For the test of Area 1-top, Area 1-bottom, and Area 3 sediments water quality parameters were within the recommended limits with the exception of temperature, which ranged slightly higher (15 to 19.4°C) than the recommended 15 ± 2°C and pH, which also ranged slightly higher (7.8-8.7) than the recommended 8 ± 0.5. Control survival was 100%. Survival of amphipods exposed to Area 1-top and Area 1-bottom sediments were statistically different and twenty percent lower that survival of animals exposed to the LA-2 reference (96%). Survival of amphipods exposed to Area 3 sediments (97%) was not statistically different relative to survival of reference animals.

Animals from the same shipment as those used in the test of Area 1-top, Area 1-bottom and Area 3 sediments were evaluated in a reference toxicant test. The reference toxicant was cadmium chloride, tested at nominal concentrations of 2, 4, 8, and 16 µg Cd^{2+}/L. Due to an inadvertent oversight the highest test concentration of 32 µg Cd^{2+}/L was not run in accordance with laboratory SOPs. As a consequence an LC50 could not be calculated as the highest test concentration resulted in 69% survival. However, survival results for individual test concentrations closely match previous reference toxicant results for this species indicating that the sensitivity of *E.*

estuarius used in the assessment of these LARE sediments fell within the normal laboratory range (Table 12).

For the test of Area 2-top, and Area 2-bottom, water quality parameters were within the recommended limits with the exception of temperature which ranged slightly higher (15 to 18.8°C) than the recommended 15 ± 2°. Control survival was 100%. Survival of amphipods exposed to Area 2-top was statistically different and twenty percent lower that survival of animals exposed to the LA-2 reference (92%). Survival of amphipods exposed to Area 2-bottom sediment (95%) was not statistically different relative to survival of reference animals.

Animals from the same shipment as those used in the test of Area 2-top and Area 2-bottom LARE sediments were evaluated in a reference toxicant test. The reference toxicant was cadmium chloride, tested at nominal concentrations of 2, 4, 8, 16, and 32 µg Cd^{2+}/L. The LC50 was 15.9 µg Cu^{2+}/L, which was within two standard deviations (± 6 µg Cu^{2+}/L) of the laboratory mean of 15.6 µg Cu^{2+}/L, indicating that the sensitivity of *E. estuarius* used in the assessment of these LARE sediments fell within the normal range. Results for all tests conducted with *E. estuarius* are summarized in Table 12 and detailed in Appendix D.

Neanthes arenaceodentata 10-Day Static-renewal Test Results. Initial pore water ammonia values measured at MEC's Carlsbad Lab were elevated in all LARE sediments. Several of the test sediments had high pore water ammonia values similar to what were measured prior to SP tests with the amphipod. Area 1-top, Area 1-bottom, Area 2-top, Area 2-bottom, and Area 3 had initial pore water ammonia values of 66.1, 257, 74.8, 187, and 37.7 mg/L, respectively, measured as total ammonia. The LA-2 reference sediment had a pore water ammonia value of 8.2 mg/L. Because there is no guidance for ameliorating the potential confounding effects of pore water ammonia in SP tests with *N. arenaceodentata* the guidance prescribed for amphipod tests was followed as described above (USEPA 1994).

Following 6 days of twice daily renewal, pore water ammonia values in the Area 1–top, Area 2-top, and Area 3 sediments were ≤ 20 mg/L and testing of those sediments was initiated. Tests of Area 2-bottom and Area 3 sediments were not initiated for another 7 days (after a total of 13 days of twice-daily renewals). Once tests were initiated renewal of overlying water was continued twice daily as per USEPA recommendations. Measured pore water ammonia values at test initiation may be found in Appendix E.

For tests of Area 1-top, Area 2-top, and Area 3 sediments water quality parameters were within the recommended limits. Control survival was 94%. Survival of worms exposed to Area 1-top (100%) and Area 2-top (98%) and Area 3 (96%) LARE sediments was not statistically different relative to survival of animals exposed to the LA-2 reference (98%).

Animals from the same shipment as those used to test Area 1-top, Area 2-top and Area 3 sediments were evaluated in a reference toxicant test. The reference toxicant was cadmium chloride, tested at nominal concentrations of 3.8, 7.5, 15, 30, and 60 µg Cd^{2+}/L. The LC50 was 10.6 µg Cd^{2+}/L, which was within two standard deviations (± 5 µg Cd^{2+}/L) of the laboratory mean of 12.1 µg Cd^{2+}/L, indicating that the sensitivity of *N. arenaceodentata* used in the assessment of these LARE sediments fell within the normal range.

For the test of Area 1-bottom, and Area 2-bottom, water quality parameters were within the recommended limits. Control survival was 94%. Survival of worms exposed to Area 1-bottom (94%) and Area 2-bottom (90%) LARE sediments was not statistically different relative to survival of animals exposed to the LA-2 reference (92%).

Animals from the same shipment as those used in the test of Area 1-bottom and Area 2-bottom LARE sediments were evaluated in a reference toxicant test. The reference toxicant was cadmium chloride, tested at nominal concentrations of 3.8, 7.5, 15, 30, and 60 µg Cd^{2+}/L. The LC50 was 10.6 µg Cd^{2+}/L, which was within two standard deviations (± 5 µg Cd^{2+}/L) of the laboratory mean of 12.1 µg Cd^{2+}/L, indicating that the sensitivity of *N. arenaceodentata* used in the assessment of these LARE sediments fell within the normal range.

Results for all tests conducted with *Neanthes arenaceodentata* are summarized in Table 12 and detailed in Appendix E.

Table 12: Summary of solid phase bioassay test results.

Sample ID	Amphipod – *Eohaustorius estuarius*				Polychaete Worm – *Neanthes arenaceodentata*			
	% Survival [a]		% Survival [a]		% Survival [b]		% Survival [b]	
Control	100.0		100.0		94.0		100.0	
Reference	96.0		92.0		98.0		92.0	
Area 1 - Top	55.0 * +		-		100.0		-	
Area 1 - Bottom	73.0 * +		-		-		94.0	
Area 2 - Top	-		43.0 * +		98.0		-	
Area 2 - Bottom	-		95.0		-		90.0	
Area 3	97.0		-		96.0		-	
Reference Toxicant	Cd^{++} Conc. (mg/L)	% Surv. Test 1[c]	% Surv. Test 2	EC_{50}	Cd^{++} Conc. (mg/L)	% Surv. Test 1	% Surv. Test 2	EC_{50}[d]
	Control	100.0	100.0	15.9 mg/L	Control	68.0	100	10.6 mg/L
	2	88.0	100.0		3.8	100	100	
	4	94.0	96.6		7.5	100	100	
	8	88.0	86.7		15.0	0.0 *	0.0 *	
	16	69.0*	70.0 *		30.0	0.0 *	0.0 *	
	32	N.A.	0.0 *		60.0	0.0 *	0.0 *	

* = *t*–test significantly different ($p \leq 0.05$) relative to reference sediment or control (for reference toxicant tests only).
\+ = survival > 20% reduced relative to reference.
[a] = multiple tests run due to high initial pore water ammonia levels (e.g. >20 mg/L) in Area 2 – Top and Area 2 Bottom.
[b] = multiple tests run due to high initial pore water ammonia levels (e.g. >20 mg/L) in Area 1 – Bottom and Area 2 Bottom.
[c] = Concentration series for the first reference toxicant tests with *E. estuarius* did not include a 32 mg/L treatment and consequently an EC50 could not be calculated as there was no response greater than 69% mortality.
[d] = calculated EC_{50} values for both groups of organisms were identical.

3.2.2.3 Bioaccumulation Tests

Water quality parameters in the flow-through bioaccumulation exposures were within the recommended limits prescribed for the test species. Measurements of total ammonia in the overlying water were low (<0.2 mg/L) in all treatments. The full water quality data set is presented in Appendix F.

At the end of 28 days, the test organisms were removed by screening through a 1-mm screen, counted and placed in a flow-through chamber without sediment for purging of gut contents for 48 hours. Survival for both the bivalve and the polychaete were high in all sediments ranging from 95.2 to 98.4% for *M. nasuta* and from 77.3 to 95.2% for *N. caecoides*. A summary of survival results for bioaccumulation test species is presented in Table 13.

Table 13: Mean percent survival of test organisms in bioaccumulation studies.

Sample ID	Bivalve – *Macoma nasuta*	Polychaete Worm – *Nephtys caecoides*
	% Survival	% Survival
Control	97.6	88.8
Reference	97.6	95.2
Area 1 - Top	96.0	82.1
Area 1 - Bottom	98.4	83.5
Area 2 - Top	95.2	86.7 [a]
Area 2 - Bottom	96.0	85.3 [a]
Area 3	98.4	77.3 [a]

[a] = Only four replicates tested due to insufficient animals.

3.2.2.4 Bioaccumulation Tissue Chemistry

Bioaccumulation in *Macoma nasuta* Tissues

Contaminant residue levels in *M. nasuta* exposed to LARE sediments were below detection limits for the majority of analytes evaluated (Table 14). A few select contaminants (e.g., lead, nickel, selenium, dibutyltin, tributyltin, and the phthalates bis(2-ethylhexyl)phthalate and di-n-butylphthalate) were elevated in *M. nasuta* tissue for select LARE sediments relative to reference. However, in those instances where tissue residue levels were elevated relative to reference the differences were not dramatic (i.e., generally within a factor of 2 to 3 and all within an order of magnitude). Contaminant levels in reference exposed organisms were near or less than the detection limit.

Bioaccumulation in *Nephtys caecoides* Tissues

Tissue residues levels of contaminants in the polychaete *N. caecoides* were also generally below detection limits for the majority of target analytes (Table 15). A small number of contaminants (cadmium, copper, chromium, lead, nickel, selenium, zinc, and tributyltin) were elevated in *N. caecoides* for select LARE sediments when compared to reference tissue concentrations. However, in those instances where tissue residue levels were elevated relative to reference the differences were small (i.e. all were less than a factor of 2 to 3). Contaminant levels in reference exposed *N. caecoides* were near or less than the detection limit.

Table 14. Bioaccumulation summary of tissue analysis for the clam *Macoma nasuta*.

ANALYTE	Reference					Area 1 Bottom					Area 1 Top				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Metals (mg/kg)															
Arsenic	2.2	2.3	2.3	2.4	2.5	2.6	2.3	2.2	2.7	2.3	2.8	2.3	2.4	2.4	2.4
Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	0.47	0.53	0.49	0.4	0.42	0.4	1.2	0.41	0.42	0.38	0.43	0.44	0.35	0.45	0.38
Copper	4.5	5.6	4	3.9	5.3	5.8	4.6	5.5	10	12	5	6.6	5.4	4	4.3
Lead	0.39	0.44	0.35	0.36	0.4	1.2	1.2	0.98	1.2	1.2	1	0.96	0.87	0.83	0.98
Mercury	0.02	0.07	0.02	<0.02	0.02	<0.02	0.02	0.02	0.02	<0.02	0.02	0.02	0.02	<0.02	0.02
Nickel	1	0.94	1	1.1	1.1	1	2.1	1.3	1.1	1	1.3	1.2	0.93	1.1	0.95
Selenium	0.28	0.27	0.24	0.3	0.26	0.37	0.33	0.28	0.33	0.32	0.26	0.32	0.34	0.26	0.27
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	29	23	21	24	28	20	22	23	19	23	32	27	24	25	25
Organotins (µg/kg)															
Dibutyltin	1.2<1	1.2	<1	<1	1.1	1.9	<1	1.4	1.8	<1	1.5	1.7	1.3	1.3	1.8
Monobutyltin	<1	<1	<1	<1	<1	<1	2.6	<1	<1	<1	<1	<1	<1	<1	<1
Tributyltin	1.1<1	1.6	<1	<1	1.4	2.5	1	1.7	4.1	1.7	1.8	2.2	1.5	2.2	2.7
PAH (µg/kg)															
Acenaphthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (b)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (k)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(ghi)Perylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibenzo(a,h)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoranthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 14. Continued.

ANALYTE	Reference					Area 1 Bottom					Area 1 Top				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pesticides (µg/kg)															
4,4-DDD	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
4,4-DDE	8.1	6.7	3.3	4.3	8.8	<2	<2	<2	<2	<2	<2	2.2	2.4	<2	<2
4,4-DDT	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Aldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Alpha-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Arochlor-1016	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1221	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1232	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1242	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1248	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1254	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1260	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chlordane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Delta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dieldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan II	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan Sulfate	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin Aldehyde	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Gamma-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor Epoxide	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Methoxychlor	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Toxaphene	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Phthalates (µg/kg)															
Bis(2-ethylhexyl)phthalate	<10	<10	<10	<10	13	62	77	44	82	58	14	15	20	24	25
Butyl benzylphthalate	49	194	45	<10	83	18	25	282	<10	<10	<10	<10	<10	194	<10
Di-n-butylphthalate	<10	<10	12	<10	13	12	35	16	11	17	11	<10	10	19	11
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Diethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 14. Continued.

ANALYTE	Area 2 Bottom					Area 2 Top					Area 3				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Metals (mg/kg)															
Arsenic	2.3	2.2	2	2.3	2.1	2.6	2.1	2.1	2.2	2.1	2.4	2.2	2.3	2.1	2.3
Cadmium	<0.1	0.12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	0.47	0.39	0.46	0.43	0.5	0.43	0.45	0.38	1.1	0.48	0.6	0.56	0.57	0.44	0.44
Copper	4.6	2.9	4.6	4.5	4.2	4	7.2	7.1	6	4.4	5.1	8.7	6.6	4.2	3.7
Lead	1.4	1	1.3	1.3	1.3	0.93	0.97	1.1	1.2	1.2	1.2	1	1.1	0.87	0.81
Mercury	<0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.02	0.03	0.03	<0.02
Nickel	1.5	0.92	0.93	1.1	1.1	1.2	1.1	1	1.7	1.1	1.4	1.4	1.2	1.4	1.2
Selenium	0.18	0.2	0.24	0.27	0.21	0.34	0.36	0.34	0.33	0.34	0.19	0.23	0.21	0.16	0.23
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	21	18	24	23	22	30	31	20	25	23	25	26	34	24	25
Organotins (µg/kg)															
Dibutyltin	1	<1	1.3	<1	<1	<1	<1	<1	1.5	1.6	<1	<1	<1	<1	<1
Monobutyltin	<1	<1	<1	<1	<1	<1	<1	<1	2.7	2.1	1.2	<1	<1	<1	<1
Tributyltin	2.1	1.6	2.5	<1	1.1	1.9	1.2	1.1	2.6	2.3	1.2	1.3	<1	1.5	<1
PAH (µg/kg)															
Acenaphthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (b)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (k)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(ghi)Perylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibenzo(a,h)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoranthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 14. Continued.

ANALYTE	Area 2 Bottom					Area 2 Top					Area 3				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pesticides (µg/kg)															
4,4-DDD	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
4,4-DDE	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
4,4-DDT	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Aldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Alpha-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Arochlor-1016	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1221	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1232	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1242	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1248	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1254	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1260	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chlordane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Delta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dieldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan II	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan Sulfate	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin Aldehyde	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Gamma-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor Epoxide	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Methoxychlor	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Toxaphene	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Phthalates (µg/kg)															
Bis(2-ethylhexyl)phthalate	63	81	77	49	61	38	30	64	49	39	49	40	23	70	12
Butyl benzylphthalate	24	31	48	27	19	16	<10	73	41	23	24	32	<10	11	<10
Di-n-butylphthalate	28	42	46	34	46	19	20	38	20	20	48	55	18	36	20
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Diethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	10	10	<10	<10	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 15. Bioaccumulation summary of tissue analysis for the worm *Nephtys caecoides*.

ANALYTE	Reference					Area 1 Bottom					Area 1 Top				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Metals (mg/kg)															
Arsenic	3.5	3.2	3.6	3	2.8	3.6	2.9	3.4	3.1	3.3	3.3	3.5	3.5	3.2	3.1
Cadmium	<0.1	0.11	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.11	<0.1	0.11	0.11	<0.1	0.14	0.11
Chromium	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	1.9	1.3	1.6	1.4	1.4	2	1.7	1.6	1.6	2	1.8	2	2	1.6	1.8
Lead	0.17	0.16	0.14	0.15	0.13	0.28	0.31	0.24	0.25	0.19	0.19	0.93	0.2	0.22	0.18
Mercury	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Nickel	0.51	0.49	0.7	0.38	0.33	0.64	0.48	0.66	0.9	0.68	0.61	0.51	0.63	0.38	0.33
Selenium	0.44	0.4	0.44	0.43	0.37	0.47	0.42	0.52	0.51	0.51	0.52	0.55	0.43	0.48	0.41
Silver	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	33	29	32	31	29	36	31	36	36	32	35	40	38	37	36
Organotins (µg/kg)															
Dibutyltin	2	1.4	1.5	1.8	2.9	1.7	2.6	2.2	<1	<1	2	1.6	1.2	2.8	2.8
Monobutyltin	<1	<1	<1	<1	3.5	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tributyltin	2.1	1.7	2	2	2.5	4.4	5	4.8	<1	3.7	2.7	3.2	3.2	2.5	2.7
PAH (µg/kg)															
Acenaphthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Acenaphthylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (b)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo (k)Fluoranthene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Anthracene	<10	<10	<10	<10	<10	<10	<10	12	<10	<10	<10	<10	<10	<10	<10
Benzo(a)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Benzo(ghi)Perylene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Chrysene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Dibenzo(a,h)Anthracene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluoranthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Fluorene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Naphthalene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Phenanthrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Pyrene	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 15. Continued.

ANALYTE	Reference					Area 1 Bottom					Area 1 Top				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pesticides (µg/kg)															
4,4-DDD	<2	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2	<2	<2
4,4-DDE	13.9	5.9	7.4	16.9	12.3	<2	7.1	5.2	10.4	5.2	<2	3.3	2.3	<2	2.3
4,4-DDT	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Aldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Alpha-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Arochlor-1016	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1221	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1232	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1242	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1248	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1254	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Arochlor-1260	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Beta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chlordane	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Delta-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Dieldrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan I	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan II	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endosulfan Sulfate	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Endrin Aldehyde	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Gamma-BHC	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Heptachlor Epoxide	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Methoxychlor	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Toxaphene	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Phthalates (µg/kg)															
Bis(2-ethylhexyl)phthalate	23	25	57	28	38	46	40	55	66	38	41	29	39	35	24
Butyl benzylphthalate	25	32	19	<10	50	<10	<10	15	<10	<10	11	42	<10	42	26
Di-n-butylphthalate	73	68	112	79	73	51	30	53	44	48	152	40	63	124	51
Di-n-octylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Diethylphthalate	11	13	21	16	14	<10	<10	12	<10	<10	26	<10	11	26	<10
Dimethylphthalate	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10

Table 15. Continued.

ANALYTE	Area 2 Bottom					Area 2 Top					Area 3				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Metals (mg/kg)															
Arsenic	3	2.7	2.5	3.1		3.5	3.1	3.2		3.1	3.1	2.8	2.9	2.9	
Cadmium	<0.1	0.12	<0.1	0.11		<0.1	<0.1	<0.1		<0.1	0.12	<0.1	0.1	<0.1	
Chromium	0.38	0.22	0.25	0.46		<0.1	<0.1	<0.1		<0.1	0.2	0.19	0.26	0.2	
Copper	1.4	1.3	1.4	1.5		1.6	1.6	1.6		1.5	1.7	1.3	1.4	1.4	
Lead	0.32	0.29	0.59	0.32		0.22	0.18	0.21		0.16	0.28	0.19	0.37	0.17	
Mercury	<0.02	<0.02	<0.02	<0.02		<0.02	<0.02	<0.02		<0.02	<0.02	<0.02	<0.02	<0.02	
Nickel	0.29	0.64	0.79	0.54		0.62	0.26	0.52		0.46	0.67	0.6	0.9	0.61	
Selenium	0.46	0.52	0.53	0.61		0.5	0.41	0.52		0.51	0.57	0.5	0.54	0.46	
Silver	<0.1	<0.1	<0.1	<0.1		<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	
Zinc	34	33	32	41		35	32	34		31	38	29	35	28	
Organotins (µg/kg)															
Dibutyltin	<1	2.8	2.1	2.9		<1	1.7	2.2		<1	2.3	1.6	2.2	2.1	
Monobutyltin	<1	<1	<1	<1		<1	<1	<1		<1	<1	<1	<1	<1	
Tributyltin	2.5	4.8	3.7	4.1		1.5	3.5	3.8		1.6	2.5	2.7	2.4	2.5	
PAH (µg/kg)															
Acenaphthene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Acenaphthylene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Anthracene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Benzo (b)Fluoranthene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Benzo (k)Fluoranthene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Benzo(a)Anthracene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Benzo(a)Pyrene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Benzo(ghi)Perylene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Chrysene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Dibenzo(a,h)Anthracene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Fluoranthrene	<10	10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Fluorene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Indeno(1,2,3-cd)Pyrene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Naphthalene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Phenanthrene	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Pyrene	15	16	13	<10		<10	<10	<10		<10	<10	10	11	<10	

Table 15. Continued.

ANALYTE	Area 2 Bottom					Area 2 Top					Area 3				
Rep	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pesticides (µg/kg)															
4,4-DDD	<2	2.1	2.3	<2		2.1	<2	<2		<2	<2	<2	<2	<2	
4,4-DDE	3.4	8.1	5.6	7.6		5.1	6.8	<2		4.6	4.5	3.4	4.4	4.9	
4,4-DDT	9.8	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Aldrin	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Alpha-BHC	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Arochlor-1016	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1221	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1232	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1242	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1248	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1254	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Arochlor-1260	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Beta-BHC	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Chlordane	<20	<20	<20	<20		<20	<20	<20		<20	<20	<20	<20	<20	
Delta-BHC	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Dieldrin	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Endosulfan I	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Endosulfan II	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Endosulfan Sulfate	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Endrin	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Endrin Aldehyde	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Gamma-BHC	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Heptachlor	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Heptachlor Epoxide	<2	<2	<2	<2		<2	<2	<2		<2	<2	<2	<2	<2	
Methoxychlor	<20	<20	<20	<20		<20	<20	<20		<20	<20	<20	<20	<20	
Toxaphene	<25	<25	<25	<25		<25	<25	<25		<25	<25	<25	<25	<25	
Phthalates (µg/kg)															
Bis(2-ethylhexyl)phthalate	63	49	50	30		48	43	32		19	19	66	38	25	
Butyl benzylphthalate	<10	46	152	154		22	23	15		19	19	37	101	69	
Di-n-butylphthalate	48	33	28	19		68	39	35		25	27	59	38	42	
Di-n-octylphthalate	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	
Diethylphthalate	<10	11	16	<10		15	10	<10		<10	<10	10	11	<10	
Dimethylphthalate	<10	<10	<10	<10		<10	<10	<10		<10	<10	<10	<10	<10	

3.2.3 Quality Control Summary

3.2.3.1 Chemical Analysis

Method reporting limits (MRL) for target analytes were above method detection limits (MDL) and above instrument detection limits as required by EPA SW-846 protocol. MRLs are listed in Appendix C for the sediment analyses, and in Appendix G for the tissue analyses. Laboratory MRLs exceeded Target Detection Limit (MRL) criteria in cases where matrix interferences were encountered.

All laboratory control samples analyses met or exceeded the percent recovery criteria established for the appropriate methods. Unless otherwise noted below, all duplicate analyses met or exceeded the relative percent difference criteria established for the appropriate methods. Unless otherwise discussed below, all of the surrogate recoveries and spike recoveries for organic analysis and spike recoveries for metals were within appropriate recovery range established for the method.

3.2.3.2 Chemical Analysis of Sediments

Several MRLs were elevated above the target detection limits which were set for the sediment chemistry. These exceedance are discussed below. The MRLs for total sulfide analysis of several of the sediment samples was elevated above the MRL.

MRLs for metals were elevated above the target detection limits, which were set for sediment chemistry. This did not effect results because metals concentrations were above the detection limits in the test samples, with the exception of selenium. Selenium MRLs were elevated to account for dilution that was required to eliminate interference.

The analyses of sediment samples for pesticides and PCBs required multiple sample clean-up sets to eliminate interferences. Upon initial analyses for pesticides and PCBs, the presence of interfering analytes caused MRLs to be elevated above target analyte detection limits. Potential interferences in the Pesticide/PCB method (EPA 8080) analyses include sulfide and phthalates. As both sulfides and phthalates were found at levels that are anticipated to result in method interference, these analytes are considered the possible culprits. At MEC's request, PTAS subjected sediment to additional sample preparation and multiple clean-up processes in an attempt to remove interfering components. Following multiple clean-ups, target analyte detection limits were met.

Spike recoveries for arsenic and selenium analyses were below the PTAS acceptability criteria, this is attributable to sample matrix effects and a duplicate laboratory control sample was also analyzed, resulting in acceptable recovery, demonstrating acceptable method performance. Therefore sample batch analyses for arsenic was deemed within quality control criteria and acceptable.

Relative percent difference and spike recovery for cadmium were below PTAS acceptability criteria. This was attributable to sample heterogeneity. A second laboratory control sample analyses demonstrated method performance, precision, and accuracy.

Spike recoveries and relative percentage difference between recoveries was low for monobutyltin. Recovery for monobutyltin is extremely poor by this method in comparison to other butyltin compounds. Results for this compound should be considered estimates.

Since all other quality control data met or exceeded method protocol, reported results should be interpreted without qualification for all analyses for sediments, with the exception of monobutyltin (noted above). Quality control results are included in the final data package submitted by PTAS and are presented in Appendices C and G following results of the sample analyses.

3.2.3.3 Chemical Analysis of Tissues

The target analyte detection limits for all analytical parameters were met for tissue analyses.

Spike recoveries for mercury were below the PTAS acceptance criteria and attributed to matrix effects. A duplicate laboratory control sample was analyzed and the resulting recovery and relative percentage difference met or exceeded acceptance criteria, demonstrating method precision and accuracy. Spike recoveries and relative percentage difference between recoveries was low for monobutyltin. Recovery for monobutyltin is extremely poor by this method in comparison to other butyltin compounds. Results for this compound should be considered estimates.

Since all other quality control data met or exceeded method protocol, reported results should be interpreted without qualification for all analyses for tissue chemistry, with the exception of monobutyltin (noted above). Quality control results are included in the final data package submitted by PTAS and are presented in Appendices C and G following results of the sample analyses.

3.2.3.4 Biological Testing

All tests were initiated within two weeks of sample collection with the exception of the two SP tests which had to be delayed in order to ameliorate elevated pore water ammonia values in accordance with USEPA recommended procedures prior to testing (see Section 3.2.2.2). All SP tests were initiated within three weeks of sample collection. Sediments were handled, elutriates prepared, and tests conducted in accordance with specified protocols with the exception of the following minor procedural deviations.

- Water quality parameters were generally within the recommended ranges for all tests, however there were subtle deviations of temperature, salinity, and pH in selected tests as noted previously. These slight deviations did not appear to affect test organism response as control results were normal.

- Because of elevated initial pore water ammonia concentrations (i.e., >60 mg/L) the two solid phase tests could only be run after USEPA recommended procedures reduced pore water ammonia levels to ≤ 20 mg/L. In addition, SP tests were conducted with twice daily renewal of the overlying water to prevent potential toxicity due to ammonia again in accordance with USEPA recommended procedures.

- The number of *Nephtys caecoides* received from the supplier was not sufficient to replicate each of the treatments five times as the study was designed. Consequently, in consultation with Mr. Steven Johns of USEPA Region IX it was decided that exposures to Area 2-top, Area 2-bottom, and Area 3 LARE sediments would only be replicated four times for *N. caecoides*.

4.0 DISCUSSION

4.1 Chemical and Physical Characteristics of LARE sediments

Total organic carbon concentrations in the LARE sediments ranged from 0.851 to 3.186 %, similar to concentrations reported previously from 0.87 to 3.83 % (Coastal Frontiers Corporation 1997). Total recoverable petroleum hydrocarbons concentrations and total sulfide concentrations were less than previous results (Coastal Frontiers Corporation 1997). Total recoverable petroleum hydrocarbons ranged from 300 to 820 mg/Kg compared to concentrations detected in 1997 from 823 to 3,400 mg/Kg. Total sulfides ranged from 1.4 to 152 mg/Kg compared to concentrations reported from 570 to 3,100 mg/Kg (Coastal Frontiers Corporation 1997).

Concentrations of metals were detected in the LARE sediments above method reporting limit. The highest concentration of contaminants were found in Area-2 bottom. Concentrations that exceeded concentrations detected in LA-2 reference sediment were arsenic (2.26 mg/Kg), cadmium (2.6 mg/Kg), chromium (40mg/Kg), copper (78 mg/Kg), lead (200 mg/Kg), mercury (3.0 mg/Kg), nickel (31 mg/Kg), silver (1.16 mg/Kg), and zinc (360 mg/Kg).

Organotins were detected in several samples with dibutyltin detected in Area-1 top at 8 µg/Kg and tributyltin detected in Area-1 bottom (1.9 µg/Kg), Area-2 bottom (3.3 µg/Kg), and Area-3 (2.4 µg/Kg). Polynuclear Aromatic Hydrocarbons were detected in the sediment with total concentrations ranging from 419 µg/Kg (Area-1 top) to 2,579 µg/Kg (Area-2 Bottom).

Chlordane and derivatives detected in the 1997 study (Coastal Frontiers Corporation 1997) were not found in the LARE samples above method reporting limits. The PCB Arochlor 1260 was detected both in the 1997 study and in these sediment samples. Arochlor 1260 was found above detectable limits in Area-1 bottom (21 µg/Kg), Area-2 top (26 µg/Kg), Area-2 bottom (94 µg/Kg) and Area-3 (44 µg/Kg).

Phthalates were detected in 1997 in all LARE samples. Multiple phthalates were also detected in all 5 sediment composite samples. The phthalates bis(2-ethylhexyl)phthalate, butylbenzyphthalate, di-n-butylphthalate, di-n-octylphthalate, diethylphthalate, and dimethylphthalate were detected in concentrations ranging from 16,200 µg/Kg (bis(2-ethylhexyl)phthalate in Area-2 bottom) to 22 µg/Kg (dimethylphthalate in Area-2 bottom).

4.2 Biological Testing

4.2.1 Suspended Particulate Phase Tests

Results of the SPP tests conducted with *Mysidopsis bahia*, *Menidia beryllina*, and *Mytilus edulis* did not exceed the LPC for any of the sediments tested (Table 16) indicating that the LARE sediment would not result in unacceptable water column impacts. The lowest IC50 value obtained from the three test was 5.1% (e.g., normality in *M. edulis* exposed to area 2-bottom sediment SPP). Even after application of the 0.01 safety factor the resultant value (0.051%) was still greater than the LPC (0.0039%) for the disposal of LARE sediments at LA-2 which was calculated using the Open Water Disposal Model as per the OTM. (USEPA/USACE 1991).

Table 16. Calculation of the Limiting Permissible Concentration for *Mytilus edulis*.

Mixing Zone Estimation	Area 2 – Bottom
Depth of disposal site (m)	164
Pi	3.14159
Width of vessel (m)	12
Length of vessel (m)	40
Speed of vessel (m/sec)	0.5
Time of discharge (sec)	30
Depth of vessel (m)	5
Mixing Zone Volume (cu.m)	7458052
Volume of Liquid Phase	
Bulk density (constant)	1.3
Particle density (constant)	2.6
Density of liquid phase (constant)	1
Volume of disposal vessel (cu.m)	2400
Liquid phase volume (cu.m)	1950
Concentration of suspended phase	
Percent silt	45.1
Percent clay	20.0
Volume of suspended phase (cu.m)	293
Projected Concentration (Percent SP)	0.0039
Lowest LC50 or EC50 from bioassay	5.1
Factor LC50 or EC50 x 0.01	0.051

The factored LC50 or EC50 is higher than the projected concentration; therefore the Limiting permissible Concentration is not exceeded for dredged material from the LA River Estuary for the disposal site specified (LA 2).

4.2.2 Solid Phase Bioassays

Results of SP test with the amphipod *Eohaustorius estuarius* indicated significant toxicity in animals exposed to Area 1-top, Area 1-bottom and Area 2-top sediments. Survival in amphipods exposed to these sediments was statistically different ($p>0.05$) and more than 20% reduced relative to the LA-2 reference indicating that these sediments are not suitable for ocean disposal as per guidance in the OTM (USEPA/USACE 1991). Survival in solid phase tests with the polychaete worm *N. arenaceodentata* was not adversely affected by any of the LARE sediments.

4.2.3 Bioaccumulation Studies

In exposures with the clam *M. nasuta* and the polychaete *N. caecoides* all five LARE sediments showed some elevated tissue concentrations for selected contaminants relative to animals exposed to the LA-2 reference sediment (Table 17). The metals lead, nickel, and selenium, organotins (di and tributyltin) and the phthalates bis(2-ethylhexyl)phthalate and di-n-butylphthalate were statistically elevated relative reference in tissues of the clam *M. nasuta* at one or more of the five LARE areas. For the worm *N. caecoides* the metals cadmium, chromium, copper, selenium, zinc, and tributyltin were greater than reference at one or more of LARE areas. "Food and Drug Administration (FDA) action limits for Poisonous or Deleterious Substances in Fish and Shellfish for Human Food" have not been established for any of the compounds that accumulated in significant concentrations in *M. nasuta* or *N. caecoides* tissues. However, the elevated tissue residues were generally within a factor of 2-3 of tissue residues of the reference organisms which, in-turn, were at or near detection limits. A comparison to relevant residue-effects information obtained through the USACE/USEPA "Environmental Residue Effect Database" (ERED) (http://www.wes.army.mil/el/ered) suggests that all elevated residue concentrations measured in LARE exposed test organisms were below (i.e., survival and reproductive endpoints in related estuarine/marine species except where noted) relevant effect levels reported in the database (Table 17). (Note: since no data was available in the ERED for bis(2-ethylhexyl)phthalate, evaluations of tissue residues for this compound were made relative to available effect rages reported for the phthalate, di-n-butylphthalate.) Finally the compounds elevated above reference in LARE-sediment exposed organisms do not have a propensity to biomagnify. Consequently, measured tissue concentrations of analytes in LARE sediment exposed organisms are unlikely to affect higher trophic organisms via contaminant transfer through the food chain.

Table 17: Summary of statistically elevated tissue residues relative to reference from bioaccumulation tests of LARE sediments for the test species *M. nasuta* and N. caecoides.

AREA	Analyte*	Ref. Tissue Conc.	Test Tissue Conc.	Prob > *t*	Ratio Test Conc.: Ref. Conc.	Comment
			M. nasuta			
1 - top	Lead (mg/Kg wet)	0.39	0.93	0.000	2.4	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Dibutyltin (ug/Kg wet)	0.90	1.52	0.005	1.7	450 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (*Mytilus edulis*)
	Tributyltin (ug/Kg wet)	1.02	2.08	0.000	2.0	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)
	Bis(2-ethylhexyl)phthalate (ug/Kg wet)	6.60	19.60	0.000	3.0	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes). Note: Di-n-butylthalate used as surrogate since no data available for Bis(2-ethylhexyl)phthalate.
1-bottom	Lead (mg/Kg wet)	0.39	1.16	0.000	3.0	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Selenium (mg/Kg wet)	0.27	0.33	0.005	1.2	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Tributyltin (ug/Kg wet)	1.02	2.20	0.035	2.2	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)
	Bis(2-ethylhexyl)phthalate (ug/Kg wet)	6.60	64.60	0.000	9.8	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes). Note: Di-n-butylthalate used as surrogate since no data available for Bis(2-ethylhexyl)phthalate.
	Di-n-butylphthalate (ug/Kg wet)	8.00	18.20	0.030	2.3	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes).
2-top	Lead (mg/Kg wet)	0.39	1.08	0.000	2.8	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Selenium (mg/Kg wet)	0.27	0.34	0.000	1.3	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Tributyltin (ug/Kg wet)	1.02	1.82	0.030	1.8	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)
	Bis(2-ethylhexyl)phthalate (ug/Kg wet)	6.60	44.00	0.000	6.7	500 ug/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes). Note: Di-n-butylthalate used as surrogate since no data available for Bis(2-ethylhexyl)phthalate.
	Di-n-butylphthalate (ug/Kg wet)	8.00	23.40	0.000	2.9	500 ug/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes).

Table 17. Continued.

AREA	Analyte*	Ref. Tissue Conc.	Test Tissue Conc.	Prob > *t*	Ratio Test Conc.: Ref. Conc.	Comment
2-bottom	Lead (mg/Kg wet)	0.39	1.26	0.000	3.2	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Bis(2-ethylhexyl)phthalate (ug/Kg wet)	6.60	66.20	0.000	10.0	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes). Note: Di-n-butylthalate used as surrogate since no data available for Bis(2-ethylhexyl)phthalate.
	Di-n-butylphthalate (ug/Kg wet)	8.00	39.20	0.000	4.9	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes).
3	Lead (mg/Kg wet)	0.39	1.00	0.000	2.6	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Nickel (mg/Kg wet)	1.03	1.32	0.000	1.3	56.6 mg/Kg = Lowest No Observable Effect Dose reported in the ERED database (Mortality in the clam *Cerastroderma edule*)
	Bis(2-ethylhexyl)phthalate (ug/Kg wet)	6.60	38.80	0.015	5.9	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes). Note: Di-n-butylthalate used as surrogate since no data available for Bis(2-ethylhexyl)phthalate.
	Di-n-butylphthalate (ug/Kg wet)	8.00	35.40	0.005	4.4	500 µg/Kg = Lowest NOED reported in the ERED for a benthic invert. (Paleomometes).
N. Caecoides						
1-top	Cadmium (mg/Kg wet)	0.06	0.10	0.040	1.7	4.5 mg/Kg = Lowest NOED reported for a relevant benthic invert. (Reproduction in *Neanthes*).
	Copper (mg/Kg wet)	1.52	1.84	0.015	1.2	16.9 mg/Kg = Lowest LOED reported for a benthic invert. (*Corophium volutator*)
	Selenium (mg/Kg wet)	0.42	0.48	0.035	1.1	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Zinc (mg/Kg wet)	30.80	37.20	0.000	1.2	130 mg/Kg = Lowest LOED reported in the ERED for benthic infauna (*Mytilus edulis*).
	Tributyltin (ug/Kg wet)	2.06	2.86	0.000	1.4	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)

Table 17. Continued.

AREA	Analyte*	Ref. Tissue Conc.	Test Tissue Conc.	Prob > t	Ratio Test Conc.: Ref. Conc.	Comment
1-bottom	Lead (mg/Kg wet)	0.15	0.25	0.000	1.7	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Nickel (mg/Kg wet)	0.48	0.67	0.035	1.4	56.6 mg/Kg = Lowest No Observable Effect Dose reported in the ERED database. (Mortality in the clam *Cerastroderma edule*)
	Selenium (mg/Kg wet)	0.42	0.49	0.005	1.2	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Zinc (mg/kg wet)	30.80	34.20	0.015	1.1	130 mg/Kg = Lowest LOED reported in the ERED for benthic infauna (*Mytilus edulis*).
2-top	Lead (mg/Kg wet)	0.15	0.19	0.020	1.3	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna (Mortality in a freshwater Mussel -*Dreissena polymorpha*).
	Selenium (mg/Kg wet)	0.42	0.49	0.025	1.2	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
2-bottom	Chromium (mg/Kg wet)	0.06	0.33	0.000	5.2	1 mg/Kg = LOED reported in the ERED for the mudskipper, *Boleophthalmus dussumieri* (the only benthic infaunal data available).
	Lead (mg/Kg wet)	0.16	0.38	0.020	2.5	2 mg/Kg = Lowest NOED reported in the ERED for benthic infauna.
	Selenium (mg/Kg wet)	0.42	0.53	0.005	1.3	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Tributyltin (ug/Kg wet)	1.95	3.78	0.015	1.9	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)
3	Chromium (mg/Kg wet)	0.06	0.21	0.000	3.4	1 mg/Kg = LOED reported in the ERED for the mudskipper, *Boleophthalmus dussumieri* (the only benthic infaunal data available).
	Selenium (mg/Kg wet)	0.42	0.52	0.005	1.2	2 mg/Kg = Lowest LOED reported in the ERED for benthic invertebrate (Mortality in the freshwater midge, *Chironomus decores*).
	Tributyltin (ug/Kg wet)	1.95	2.53	0.000	1.3	41 µg/Kg = Lowest NOED reported in the ERED for benthic invert. (Development in *Nucella lapilus*)

* Only those analytes detected in test site concentrations significantly (alpha = 0.05) greater than reference are presented

5.0 SUMMARY AND CONCLUSIONS

- Comparison of suspended particulate phase test results with the model derived LPC for the LA-2 reference showed no unacceptable water column impacts for any of LARE sediments evaluated.

- Toxicity was observed in solid phase toxicity tests conducted with samples from Area 1-top, Area 1-bottom, and Area 2-top indicating that these sediments are not suitable for ocean disposal.

- Though tissue concentrations for a small number of contaminants were found to be elevated relative to reference in Area 2-bottom and Area 3 sediments these values were generally within a factor of 2-3 of the reference and close to detection limits. Furthermore, comparison to relevant residue-effect information via the USACE/USEPA ERED suggests that these tissue concentrations are unlikely to result in toxicity to benthic biota. This fact coupled with the low propensity of these compounds to biomagnify suggest that the statistically elevated compounds in Area 2-bottom and Area 3 exposed organisms are unlikely to result in either direct effects to benthic infauna or to higher trophic levels via food chain transfer.

6.0 REFERENCES

ASTM, 1997. Annual Book of Standards. Volume 11.05 "Biological Effects and Environmental Fate; Biotechnology; Pesticides." American Society of Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA.

Coastal Frontiers Corporation, 1997. "Analysis of Marine Sediment Samples from the Los Angeles River Estuary, Los Angeles River Estuary Borrow Pit and Pier J Access Area Long Beach Harbor, California, April 1997". Prepared by Coastal Frontiers Corp. and Environmental Applications, Inc. for the U.S. Army Corps of Engineers, Los Angeles, CA.

Coastal Frontiers Corporation, 1996. "Hydrographic and Sediment Profile Imaging Investigation Report, Long Beach Harbor, California, March and April 1996". Prepared by Coastal Frontiers Corp. and Striplin Environmental Associates for the U.S. Army Corps of Engineers, Los Angeles, CA.

Helsel, D.R. 1990. Less than obvious: Statistical treatment of data below the detection limit. Environmental Science and Technology. 24(12):1766-1774.

Krone et al. 1988. "A Method for Analysis of Butyltin Species and Measurements of Butyltins in Sediment and English Sole Livers from Puget Sound", National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Seattle, WA, November 1988.

MEC, 1995. "Results of Chemical, Physical, and Bioassay Testing for the Los Angeles District, U.S. Army Corps of Engineers, Los Angeles Harbor and Los Angeles River Estuary", prepared by MEC Analytical Systems, Inc. for the U.S. Army Corps of Engineers, Los Angeles, CA.

MEC, 1994. "Sampling and Analysis Plan for Maintenance Dredging, Port of Los Angeles and Los Angeles River Estuary", prepared by MEC Analytical Systems, Inc. for the U.S. Army Corps of Engineers, Los Angeles District, Los Angeles, CA.

Newman, M.C., P.M. Dixon, B.B. Looney, and J.E. Pinder, III. 1989. Estimating mean and variance for environmental samples with below detection limit observations. Water Resources Bulletin. 24(4):905-916.

Paasivirta, J. 1991. Interpretation of the Environmental Analysis Results. Chemical Ecotoxicology. Lewis Publishers. Chelsea, MI. pp.210.

Plumb, R.H., Jr. 1981. Procedures for handling and chemical analysis of sediment and water samples. Tech. Rep. EPA/CE-81-1, prepared by Great Lakes Laboratory, State University College at Buffalo, Buffalo, NY for the USEPA/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. Published by U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss. 450pp.

Slymen, D.J. and A. de Peyster 1994. Hypothesis testing with values below detection limit in environmental studies. Environmental Science and Technology. 28:989-1002.

Stallard and Cola 1989. Optimization of Butyltin Measurements for Seawater, Tissue, and Marine Sediment Samples. Applied Organometallic Chemistry 3:105-114

Unger et al. 1986. GC Determination of Butyltin in Natural Waters by Flame Photometric Detection of Hexyl Derivatives with Mass Spectrometric Confirmation. Chemosphere, Volume 15, Number 4. P 461.

USACE, 1995. "Borrow-Pit Capping", U,S, Army Corps of Engineers, Los Angeles District, Navigation Section, Los Angeles, CA.

USEPA. 1994. "Methods for Assessing the Toxicity of Sediment-associated Contaminants with Estuarine and Marine Amphipods." EPA/600/R-94/025. USEPA Office of Research and Development, Washington, D.C.

USEPA/USACE 1991. "Evaluation of Dredged Material Proposed for Ocean Disposal – Testing Manual" EPA-503/8-91/001. February 1991. USEPA, Office of Water, Department of the Army USACE.