CONTRACT NO. DACW64-79-C-0037

FINAL REPORT - GALVESTON WINTER SERIES

BIOASSAY, CHEMICAL ANALYSES, AND STATISTICAL ANALYSES OF SAMPLES OBTAINED FROM GALVESTON HARBOR, TEXAS

PREPARED FOR:
DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS

DECEMBER 1979

NUS CORPORATION

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FINAL REPORT

GALVESTON HARBOR CHANNEL BIOASSAY STUDIES

CONTRACT NO. DACW64-79-C-0037

PREPARED FOR:
DEPARTMENT OF THE ARMY
GALVESTON DISTRICT, CORPS OF ENGINEERS

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FINAL REPORT

This report has been reviewed by the Corps of Engineers and approved for publication. Approval does not signify that the contents reflect the views and policies of the Corps, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

ABSTRACT

In May 1979, Contract No. DACW64-79-C-0037, for performance of bioassays and bioaccumulation studies, chemical analyses of sediments, seawater and elutriate materials, and appropriate statistical analyses of samples obtained from the Galveston Harbor and Sabine-Neches Waterway channels, was awarded to NUS Corporation by the Army Corps of Engineers, Galveston District. These studies are part of a continuing evaluation of the potential environmental effects of proposed ocean disposal of dredged materials and are required for compliance with provisions of Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532). This final report presents the results of dredged material evaluations for the Galveston Harbor Channel project area.

Channel sediments collected at designated locations in the project area were evaluated by bioassays of liquid, suspended particulate, and solid phase materials. A variety of sensitive marine vertebrates and invertebrates were used, including a fish, a crustacean, a crustacean postlarva (zooplankton), a polychaete, and a bivalve. Evaluative procedures were as established in "Ecological Evaluation of Proposed Discharge of Dredged Materials into Ocean Waters" (EPA/CE, 1977). The results of these bioassays showed that sediments of the Galveston Harbor Channel pose no serious or unacceptable hazard to the marine environment.

The potential for bioaccumulation of selected pesticides, polychlorinated biphenyls (PCB's), heavy metals and petroleum hydrocarbons in tissues of marine organisms was evaluated by laboratory methodologies. The results of tissue analyses of sandworms and hard clams exposed to Galveston Harbor Channel sediments indicated that the concentration of all constituents analyzed was not significantly different between animals exposed to test and reference materials. There was no indication that the test animals had accumulated constituents of interest from the test materials to a greater extent than from the reference sediment.

Chemical analyses for a variety of heavy metals, selected pesticides and PCB's, nitrogen derivatives, and oil and grease residues in sediments, seawater and elutriate materials were performed to define ambient concentrations of these constituents in the project environs. Many constituents exhibited no concentration above a quantifiable analytical detection limit. Several constituents (notably Aroclor 1254, arsenic, chromium, copper, lead, nickel, zinc, ammonia, nitrate, TKN, and oil and grease in sediments, and ammonia and TKN in seawater) displayed a general trend toward highest concentrations at shoreward sampling areas. Mercury was present in sediment

materials throughout the project area, but was not found in excessive concentrations. The concentrations of oil and grease residues in seawater samples were highest at seaward sampling areas. It was conservatively determined that mercury concentrations in elutriate materials from all channel sampling areas would exceed the established marine water quality criterion; however, the initial mixing zone available at the designated disposal area is adequate to achieve the required dilution factors.

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1.0 INTRODUCTION

Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972, Public Law (PL) 92-532, specifies that all proposed operations involving the transportation and dumping of dredged material into ocean waters must be evaluated to determine the potential environmental impact of such activities. The mandate for administering Section 103 was given jointly to the Secretary of the Army and the Administrator of the U.S. Environmental Protection Agency (EPA), acting cooperatively through the respective District Engineer (Corps of Engineers) and the Regional Administrator (EPA).

Criteria for the performance of environmental evaluations under Section 103, published by EPA (FR, Vol. 42, No. 7, Tuesday, 11 January 1977, herein referred to as the Register), included provisions for joint development, by EPA and the Corps of Engineers (CE), of an implementation manual describing the applicability of specific evaluative approaches and procedures. In July 1977, the EPA/CE Technical Committee on Criteria for Dredged and Fill Material published "Ecological Evaluation of Proposed Discharge of Dredged Material Into Ocean Waters". This implementation manual places heavy emphasis on bioassays as a tool for environmental evaluations and establishes standard methodologies for performance of dredged material bioassays with marine organisms.

In May 1979, NUS Corporation was awarded Contract No. DACW64-79-C-0037, by the Galveston District Corps of Engineers, for evaluation of the potential environmental effects on marine organisms of proposed ocean disposal of dredged materials from Galveston Harbor Channel and Sabine-Neches Waterway. Specific work items included performance of bioassay studies, laboratory bioaccumulation assessments and chemical analyses of water, sediment and elutriate samples.

The bioassay studies, consisting of tests of liquid, suspended particulate, and solid phases of dredged materials using a variety of marine vertebrates and invertebrates, provide a basis for assessment of the potential toxicity of the dredged materials. The laboratory bioaccumulation assessments evaluate the potential for uptake and bioconcentration of heavy metals, pesticides, chlorinated hydrocarbons and petroleum hydrocarbons from sediments in tissues of marine benthic organisms. The chemical analyses define ambient concentrations for a variety of constituents in seawater, sediment materials and elutriate samples.

This final report presents the results of winter studies of the Galveston Harbor Channel project area in partial fulfillment of the requirements of Contract No. DACW64-79-C-0037.

2.0 MATERIALS AND METHODS

The field and laboratory methods and bioassay procedures used in performance of work under Contract No. DACW64-79-C-0037 are described in the following subsections. These methods were established by publication of "Ecological Evaluation of Proposed Discharge of Dredged Materials into Ocean Waters" (EPA/CE, July 1977) and subsequently were made part of and required by the contract.

2.1 FIELD STUDIES

2.1.1 STATION LOCATION

Sediment samples used for preparation of elutriate samples and dredged material liquid and suspended particulate phase test media, and in the solid phase bioassay were collected at Galveston Harbor Channel Stations G-1, G-2, and G-3 (Figure 1). Specific sampling station locations were as follows:

Station No.	
G-1	Channel Reach opposite Buoy 6
G-2	Channel Reach opposite Buoy 4
G-3	2,000 ft past Sea Buoy along extended channel centerline

Sediment samples for chemical analyses were collected at the channel stations and the disposal area shown in Figure 1. Reference sediments used in the solid phase bioassay were collected from an area located approximately 4 to 5 mi south and west of the channel centerline. Control sediments used in the solid phase bioassay were obtained on West Beach, Galveston, TX.

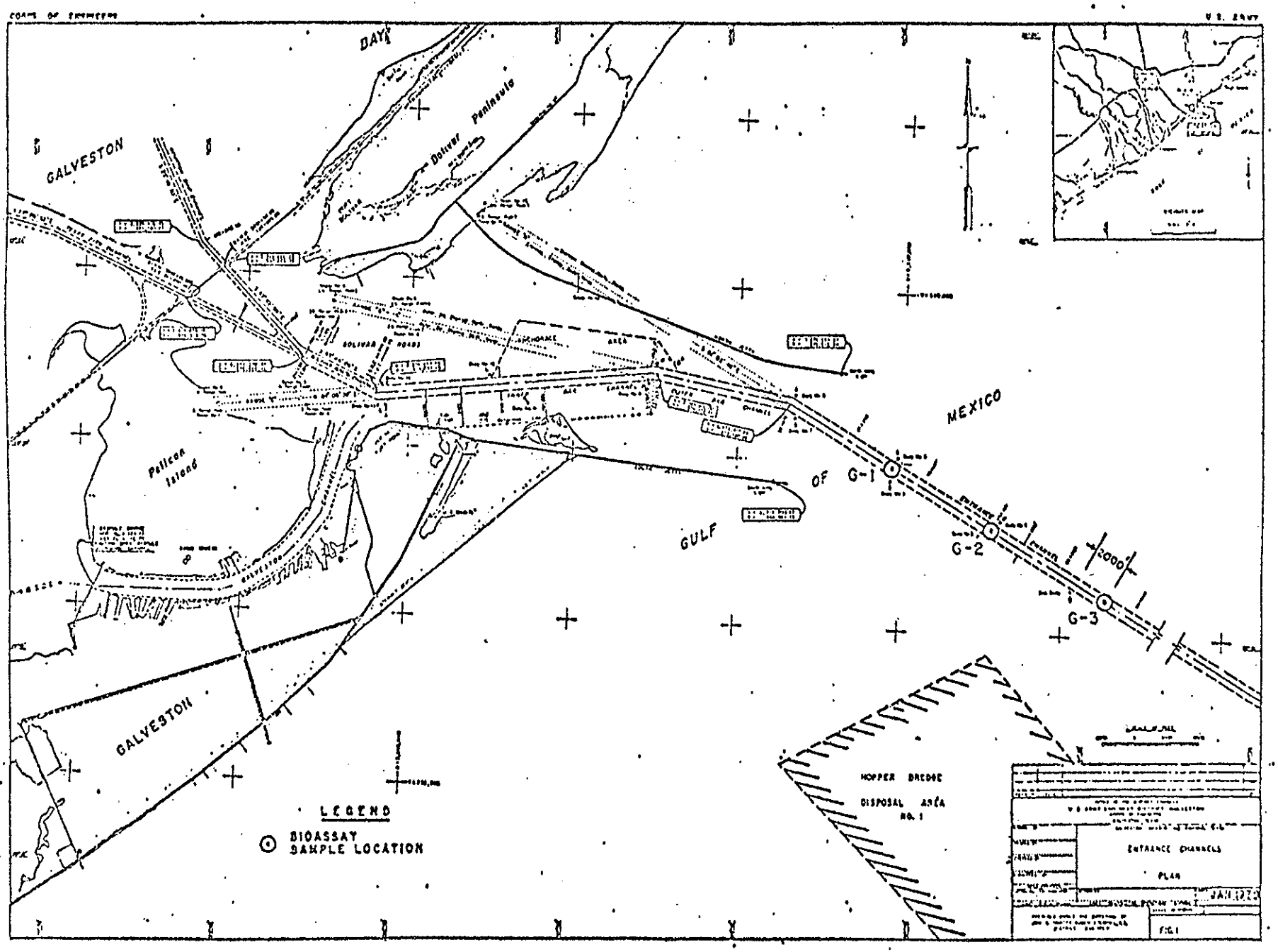

FIGURE 1. GALVESTON HARBOR CHANNEL PROJECT AREA

Disposal site water used for elutriate preparation, test media dilution, solid phase bioassay and bioaccumulation assessment, and chemical analyses were collected at Galveston Harbor Channel Disposal Area No. 1 (Figure 1). The specific locations of the disposal area, as defined in the contract, is as follows:

> Disposal Area No. 1 - Beginning at lat. 29°18'00", long. 94°39'30"; thence to lat. 29°15'54", long. 94°37'06"; thence to lat. 29°16'54", long. 94°41'30"; thence to point of beginning.

Additional water samples for chemical analyses were collected at Stations G-1, G-2, and G-3.

2.1.2 FIELD SAMPLING AND SAMPLE STORAGE METHODS

2.1.2.1 Sediment Samples

Test and reference sediments were collected with a stainless steel Smith-MacIntyre grab sampler. The control sediment used in the solid phase bioassay was obtained using a garden spade. After collection, sediments were placed in acid-cleaned, 18.9 ℓ[1] linear-polyethylene pails, covered with airtight lids, labeled and returned to the laboratory. All sediment samples were maintained at 4 C until used and generally stored less than 2 weeks to minimize changes in the dredged material characteristics.

Sediment samples for chemical analyses and preparation of elutriate samples were collected with a stainless-steel Smith-MacIntyre grab sampler. At each station, discrete triplicate samples were obtained through multiple drops of the grab sampler. After collection, the sediments were placed in wide-mouth glass jars (with foil-lined lids), labeled and returned to the laboratory. The samples were maintained at 4 C until processed for chemical analyses.

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[1] A table of factors for converting metric (SI) to U.S. Customary units of measurement can be found in Appendix A.

2.1.2.2 Water Samples

Disposal site water was collected approximately 0.5 m below the surface with the ship seawater intake pump[1] and composited directly into acid-cleaned, 18.9 ℓ linear-polyethylene drums. The samples were labeled and returned to the laboratory. Disposal site water was maintained at 4 C until used and generally stored less than 2 weeks to minimize any changes in the characteristics of the water. Prior to use, water samples were composited in large (750-1890 ℓ) fiberglass tanks to insure sample uniformity.

Water samples for chemical analyses were collected at near-surface, mid-depth and near-bottom with a plexiglass Kemmerer water bottle. Onboard ship, the stratified-depth subsamples were composited (approximately equal parts of each subsample) in an acid-cleaned linear-polyethylene pail and then distributed among glass (with foil-lined caps) sample bottles. At each sampling station, the sequence of events described above was repeated three times, providing discrete triplicate samples for chemical analyses. The samples were labeled, stored on ice and transported to the analytical laboratory. In the laboratory, water samples were maintained at 4 C until processed for chemical analyses.

2.1.2.3 Test Organisms

Species Selection. Animals used as bioassay test specimens were selected on the basis of the requirement that candidate species be considered an "appropriate sensitive marine organism" and available either through local field collections or by purchase from licensed commercial vendors. Test animal selections were made from those listed in Tables D1 and E1, Appendices D and E, of the contract and were approved by the Authorized Representative of the Contracting Officer.

[1] During the last sampling trip, seawater was collected approximately 5 m below the surface with a gasoline-powered centrifugal pump.

The liquid and suspended particulate phase bioassays were conducted with postlarval mysid shrimp (Mysidopsis almyra), adult grass shrimp (Palaemonetes pugio) and tidewater silverside (Menidia beryllina). The solid phase bioassay and laboratory bioaccumulation assessment utilized the sandworm (Nereis virens), the hard clam (Mercenaria mercenaria) and grass shrimp.

Collection of Test Organisms. Grass shrimp and tidewater silversides were collected with a beam trawl and/or beach seine from an estuarine pond near Texas City, TX. Specimens were placed in 80 ℓ coolers (half-filled with aerated collection site water) and returned to the laboratory. Postlarval mysid shrimp were obtained from brooding adults maintained in the laboratory. Sandworms and hard clams were purchased from commercial sources and acclimated to test conditions in the laboratory.

2.2 LABORATORY STUDIES

2.2.1 CONTROLLED ENVIRONMENT TEST CHAMBER

Acclimation of test animals and the dredged material bioassays/bioaccumulation assessment were conducted in a controlled environment test chamber designed specifically for bioassays. The test chamber satisfied the required conditions for temperature and light intensity as stated in the contract. Specifically, temperature was maintained at 12 (±1) C, and light intensity was maintained at a minimum of 1200 $\mu W/cm^2$ with a 14:10-hr light:dark photoperiod.

2.2.2 HOLDING/ACCLIMATION OF TEST ORGANISMS

Postlarval mysid shrimp used in zooplankton bioassays were harvested daily from a population of mature adults (obtained from field collections) using the methods of Reitsema and Neff. During laboratory culture, the adults and postlarvae were maintained at 25 C; however, postlarvae were thermally-acclimated to 12 C prior to test initiation. Brooding adults and postlarval mysids received a daily diet of 24-hr brine shrimp nauplii.

Adult grass shrimp were acclimated to the prescribed test temperature (12 C) in 155 ℓ glass aquaria containing aerated, filtered collection-site water. Salinity in the acclimation aquaria was adjusted when necessary from ambient to the appropriate test salinity through gradual addition of disposal site water (or dechlorinated tapwater). During holding and acclimation, the grass shrimp were fed dry fish flakes and monitored for evidence of stress.

Tidewater silversides were initially stocked in 155 ℓ aquaria containing aerated water collected concurrently with seining and acclimated to the test temperature (12 C). When necessary, salinity in these aquaria was adjusted from ambient to the appropriate test

salinity through the gradual addition of disposal site water (or dechlorinated tapwater). During holding and acclimation, the fish were fed twice daily (dry fish flakes) and checked for evidence of stress.

Sandworms used in the solid phase bioassay were obtained from a commercial bait wholesaler in Wiscasset, ME. Upon arrival at the laboratory, the animals were distributed (approximately 100 worms/ aquarium) among aquaria filled with aerated seawater and a layer of clean sand substrate. Thermal acclimation of the polychaetes to test temperature (12 C) was accomplished during a 48-hr period prior to initiation of the solid phase bioassay.

Hard clams were obtained from a commercial vendor in Long Island, NY. After receipt, the clams (length range, 2.5-3.8 cm) were placed in aquaria of aerated seawater located in the test chamber for acclimation to the test temperature (12 C). The animals were utilized in the solid phase bioassay following a 120-hr pre-test acclimation period.

2.2.3 BIOASSAY TEST MEDIA PREPARATION

2.2.3.1 Liquid and Suspended Particulate Phase Media

A standard sediment elutriate used for preparation of liquid and suspended particulate phase test media was prepared by mixing sediment and unfiltered disposal site water in a ratio of 1:4. A 114 ℓ linear-polyethylene trash can was calibrated at 37.8, 56.8 and 94.6 ℓ and used as a mixing vessel. Initially, 37.8 ℓ of disposal site water were placed in the mixing vessel and then 18.9 ℓ of sediment were added by volumetric displacement. Finally, the mixing vessel was filled to 94.6 ℓ and the sample thoroughly mixed for 30 min using an electric mixer equipped with a polyethylene-coated mixing paddle. Additional manual mixing with a wooden paddle was

utilized for particularly stiff (high clay content) sediments. After a 30-min mixing period, the sediment suspension was allowed to settle for 1 hr, and the supernatant with remaining suspended material was decanted.

An elutriate prepared as described above was used without further processing for preparation of suspended particulate phase bioassay media. Liquid phase bioassay media were prepared by pressure-filtering the standard elutriate through a graded cartridge filter series (20, 5, and 0.3 µm prefilters and 0.45 µm final filter). The liquid and suspended particulate phase bioassay media were used as soon as possible after preparation.

2.2.3.2 Solid Phase Media

The solid phase bioassay media were prepared by wet-sieving control, reference and test sediments through a 1.0-mm stainless steel screen to remove live organisms. This was accomplished by mixing the sediment with as small a volume of seawater as possible, and passing the resultant slurry through the screen. Material retained on the screen was hand-sorted to remove any animals and the remainder was returned to the settling container. The wet-sieved sediments were allowed to settle for 6 hr, the seawater decanted, and the sediments remixed to insure homogeneity. The animal-free control and reference sediments were used immediately in establishing the solid phase bioassay. Test sediments were stored at 4 C until used (approximately 48 hr).

2.2.4 BIOASSAY PROCEDURES

2.2.4.1 Liquid and Suspended Particulate Phase Bioassays

Treatment levels of 100, 50 and 10 percent test media were established by diluting the liquid or suspended particulate phase with an appropriate volume of disposal site water. Three replicates for

each treatment level and control were used in all bioassays. During the 96-hr exposure period, test media were not replenished or changed. Gentle aeration (60 to 180 bubbles/min) was provided to each aquarium from a small-diameter glass delivery tube. Temperature and dissolved oxygen were determined daily for each aquarium; salinity and pH were measured at the beginning and end of the bioassay.

Sediment bioassays using postlarval mysid shrimp were conducted in 100 x 50 mm glass crystallizing dishes. The test containers were filled with 0.2 ℓ of freshly prepared test medium or control water and allowed to equilibrate to 12 (±1) C. Ten test organisms, selected at random from the holding container, were placed into each replicate test treatment with a large-bore pipette. The dishes were arranged randomly (using random number tables) in the controlled environment test chamber and incubated for 96 hr. Survivor counts were made at 0, 4, 8, 24, 48, 72 and 96 hr during the test.

Bioassays using adult grass shrimp were conducted in 3.8 ℓ glass (wide-mouth jar) aquaria. Bioassays with tidewater silversides utilized 37.8 ℓ all-glass aquaria. The aquaria were arranged randomly (using random number tables) in the controlled environment test chamber, filled with an appropriate volume of test media or control water (3 or 30 ℓ, respectively, for shrimp and fish bioassays), and allowed to equilibrate to 12 (±1) C. Ten test organisms, selected at random from the holding tank, were placed into each replicate test treatment with a fine-mesh dip net. During the test, survivors were counted at 0, 4, 8, 24, 48, 72 and 96 hr.

2.2.4.2 Solid Phase Bioassay

The solid phase bioassay was conducted with wet-sieved control, reference and test sediments, prepared as discussed in Subsection 2.2.3.2, and water collected at Galveston Harbor Channel Disposal

Area No. 1. Five replicate treatments (each consisting of four aquaria) were used for each test sediment, reference and control. The test containers, 37.8 ℓ all-glass aquaria, were positioned randomly (using random number tables) in the controlled environment test chamber. During the acclimation and testing periods, each aquarium was provided gentle aeration (60 to 180 bubbles/min).

The test aquaria were filled partially with seawater and enough control or reference sediments added (by volumetric displacement) to produce an even 30-mm layer on the bottom. After settling for 1-hr, the seawater was decanted and the tanks were filled to 30 ℓ with fresh disposal area water. Forty clams, 20 sandworms and 20 grass shrimp were used in each replicate treatment. During a 48-hr acclimation period, the test animals were monitored for any indications of stress or obvious mortality. After 24 hr of the acclimation period, 75 percent of the water in each test aquarium was replaced.

At the end of the acclimation period, the 10-day solid phase bioassay was started by adding a 15-mm layer of test sediment on top of the 30-mm layer of reference sediment (tanks designated as control or reference treatments received an additional 15-mm layer of control or reference sediment). The sediments were allowed to settle for 1 hr and 75 percent of the water was replaced. During the 10-day test period, 75 percent[1] of the water was replaced at 48-hr intervals. Daily measurements of temperature, dissolved oxygen and salinity were made for each test aquarium.

At the end of the 10-day exposure period, the contents of each test tank were siphoned through a 0.5 mm screen. Live animals captured on the screen were counted and recorded.

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[1] Approximately 30% replacement during last two water change events.

2.2.5 METHODS FOR ASSESSMENT OF BIOACCUMULATION POTENTIAL

2.2.5.1 Tissue Preparation

A laboratory assessment of bioaccumulation potential was conducted using sandworms and hard clams from the solid phase bioassay. The worms and clams were transferred into clean, sediment-free aquaria for 2 days to allow the animals to void their gastrointestinal tracts of ingested sediment materials. The purged clams were subsequently deshelled, and the soft body parts of both species weighed and frozen for later chemical analyses.

2.2.5.2 Tissue Analyses

The animal tissue samples were homogenized with a Tekmar Tissuemizer^{R} and analyzed for heavy metals, chlorinated hydrocarbons, pesticides and petroleum hydrocarbons according to procedures referenced in Appendix F of the contract. The analytical instrumentation employed and the minimum detectable concentrations for each constituent are summarized in Appendix B, Table B-1.

2.3 STATISTICAL ANALYSES

The bioassay and bioaccumulation data were analyzed statistically by a variety of methods to determine whether the test sediments produced significant effects on the test organisms. The analytical methodologies employed are described in detail in the technical appendices of the contract or in Biometry (Sokal and Rohlf, 1969) and, therefore, are only briefly summarized herein.

2.3.1 LIQUID AND SUSPENDED PARTICULATE PHASE BIOASSAY STATISTICS

The following calculations were performed on the survival data for the liquid and suspended particulate phase bioassays: sum of observations [ΣX], mean [$\bar{X}$], sum of squares [$SS = \Sigma(X-\bar{X})^2$] and variance [$S^2=SS/n-1$]. Statistical analyses included Cochran's Test for variance homogeneity and Student's t-Test to compare the mean survival between controls and 100 percent test media. In comparisons where a significant difference was detected or where survival was less than 50 percent in any test medium, the median lethal concentration (LC50) of the test sediment was evaluated using the method of Litchfield and Wilcoxon (1949). The LPC of such materials was compared directly to the expected dilution of the dredged materials.

2.3.2 SOLID PHASE BIOASSAY STATISTICS

Statistical analyses were performed on survival data for the three test organisms exposed to test and reference sediments during the solid phase bioassay. The control sediment results were excluded from all statistical analyses. A preliminary evaluation was performed using pooled survival data in an ANOVA procedure to determine the overall effects of the dredged materials on the test animals. Similarly, survival of individual species was analyzed using an ANOVA or Student's t-Test procedure. For both preliminary and species-level analyses, summary statistics included:- sum of data [ΣX], mean [$\bar{X}$], sum of squared data [ΣX^2], corrected sum of

squares [CSS], and variance [S^2]. Prior to analysis, variance homogeneity was tested by Cochran's Test and the data were transformed when variances were heterogeneous. In cases where a significant difference was detected, a Student-Newman-Keuls multiple range test was performed to determine which material(s) produced the significant response.

2.3.3 BIOACCUMULATION ASSESSMENT STATISTICS

The results of chemical analyses for heavy metals, chlorinated hydrocarbons, pesticides, and petroleum compounds in tissues of sandworms and hard clams were evaluated statistically, comparing test sediments with the reference material. Variance homogeneity was tested by Cochran's Test, and data were transformed when variances were heterogeneous. ANOVA (or an approximate test for equality of means) was performed to determine whether significant differences were present between test and reference sediment tissue parameter concentrations. When indicated, significant differences were further analyzed by the Student-Newman-Keuls multiple range test, or by Student's t-test.

The volume of disposal site water (Vol) necessary to dilute the discharged liquid phase materials to an acceptable level was calculated using the equation:

$$Vol = D\ V_w$$

where; D = dilution factor,

and V_w = the volume of liquid phase in the discharge.

2.5 INITIAL MIXING CALCULATIONS

The release zone method was used to estimate initial mixing [defined in the Register, Section 227.29(a) as that dispersion or diffusion of liquid, suspended particulate, and solid phase of a material that occurs within 4 hr after disposal]. In this method, the liquid and suspended particulate phases of the dredged materials are assumed to be evenly distributed at the end of a 4-hr initial mixing period over a column of water bounded on the surface by the locus of points constantly 100 m from the perimeter of the conveyance engaged in disposal activities and extending to a depth (d) defined for the designated disposal area. The release zone, defined above, exists for a time beginning at the first moment in which dumping commences and ending at the moment dumping ceases.

The volume (V_m) of the initial mixing zone was calculated using the following equation:

$$V_m = \pi(100)^2 d + 200\ w\ d + (200 + w)\ (u\ t + \ell)\ d$$

where; π = 3.1416,
d = appropriate depth value,
w = width of the disposal vessel,
ℓ = length of the disposal vessel,
u = speed of the disposal vessel in meters per second,
and t = time in seconds required to empty disposal vessel during discharge.

The expected volume of liquid phase (V_w) that would be discharged during operations at the disposal site was calculated using the following equation:

$$V = \frac{P_b - P_d}{P_w - P_d}\ (V_T)$$

where; P_b = bulk density,

P_d = particle density,

P_w = density of liquid phase,

and V_T = total volume of disposal vessel.

To determine whether unknown constituents tested in the liquid phase bioassays may exceed the limiting permissible concentration (LPC, defined as the concentration that, after initial mixing, will not exceed a toxicity threshold of 0.01 of the acutely toxic concentration), the percent of the original liquid phase concentration (C_w) after initial mixing at the disposal site was calculated as follows:

$$C_w = \frac{V_w}{V_m} (100)$$

where; V_w = volume of liquid phase released in the discharge,

and V_m = volume of the initial mixing zone.

The solution of the above equation was used to prepare a dilution curve for the liquid phase materials and compared to time-concentration mortality curves for the appropriate liquid phase bioassays to determine whether the LPC would be exceeded.

Initial mixing of the suspended particulate phase was estimated in a manner similar to that discussed above for the liquid phase. The volume of suspended particulate phase contained in the disposal vessel was calculated using the following equation:

$$V_{sp} = (V_T - V_w) \frac{(P_c + P_s)}{100}$$

where; V_T = total volume of discharge vessel,

V_w = volume of liquid phase in the discharge,

P_c = percent clay in the dredged material,

and P_s = percent silt in the dredged material.

The percent of the original suspended particulate phase concentration (C_{sp}) after initial mixing at the disposal site was calculated as follows:

$$C_{sp} = \frac{V_{sp}}{V_m} (100)$$

where; V_{sp} = volume of suspended particulate phase in the discharge,

and V_m = volume of the initial mixing zone.

The solution of the above equation was used to prepare a dilution curve for the suspended particulate phase materials and compared to time-concentration mortality curves for the appropriate suspended particulate phase bioassay to determine whether the LPC would be exceeded.

3.0 RESULTS AND DISCUSSION

3.1 INITIAL MIXING

The oceanic environment is a physically dynamic system; thus, materials dumped into it will be dispersed, mixed, and diluted to varying degrees. Therefore, procedures used to evaluate the potential environmental effects of dredged materials disposed in the ocean must consider initial mixing expected at the disposal site. Initial mixing is defined [in Section 227.29(a) of the Register] as the dispersion or diffusion of liquid, suspended particulate, and solid phases of a material which occurs within 4 hr after disposal.

The calculations presented below estimate the concentration (expressed as a percent of the original concentration remaining at the end of the 4-hr initial mixing period) of the liquid or suspended particulate phase of a dredged material. The results are discussed further in Section 3.2 as they relate to the limiting permissible concentration of the liquid or suspended particulate phases of Galveston Harbor Channel dredged materials.

The following data were used in initial mixing calculations for the Galveston Harbor Channel Disposal Area:

Appropriate depth value (d)	= 13 m
Length of disposal vessel (ℓ)	= 107 m
Width of disposal vessel (w)	= 18 m
Speed of disposal vessel (u)	= 1.5 m/sec
Time required to empty vessel during discharge (t)	= 800 sec
Bulk density (P_b)	= 1.5
Particle density (P_d)	= 2.6
Density of Liquid Phase (P_w)	= 1.0
Total volume of disposal vessel (V_t)	= 1600 m^3

Percent clay in dredged sediment	= 50 percent
Percent silt in dredged sediment	= 40 percent

3.1.1 VOLUME OF INITIAL MIXING ZONE, V_m

The volume (V_m) of the initial mixing zone, available during disposal operations at the Galveston Harbor Channel Disposal Area was calculated as:

$$V_m = \pi(100)^2\, d + 200\, wd + (200 + w)\,(ut + \ell)\, d$$

$$= 3.1416\,(100)^2\,(13) + 200\,(18)\,(13) + (200 + 18)\,(1.5\,[800] + 107)\,(13) = 4{,}159{,}246\ m^3$$

3.1.2 VOLUME OF LIQUID PHASE, V_w

The estimated volume of liquid phase discharged at the Galveston Harbor Channel Disposal Area was calculated as:

$$V_w = \frac{P_b - P_d}{P_w - P_d}\,(V_t) = \frac{1.5 - 2.6}{1.0 - 2.6} = (1600\ m^3) = 1100\ m^3$$

3.1.3 PERCENT LIQUID PHASE AFTER INITIAL MIXING, C_w

The percent liquid phase after initial mixing was determined as:

$$C_w = \frac{V_w}{V_m}\,(100) = \frac{1100\ m^3}{4{,}159{,}246}\,(100) = 0.026 \text{ percent}$$

The time-concentration curve representing initial mixing and dilution of the liquid phase of dredged materials at the Galveston Harbor Channel Disposal Area is presented in Figure 2.

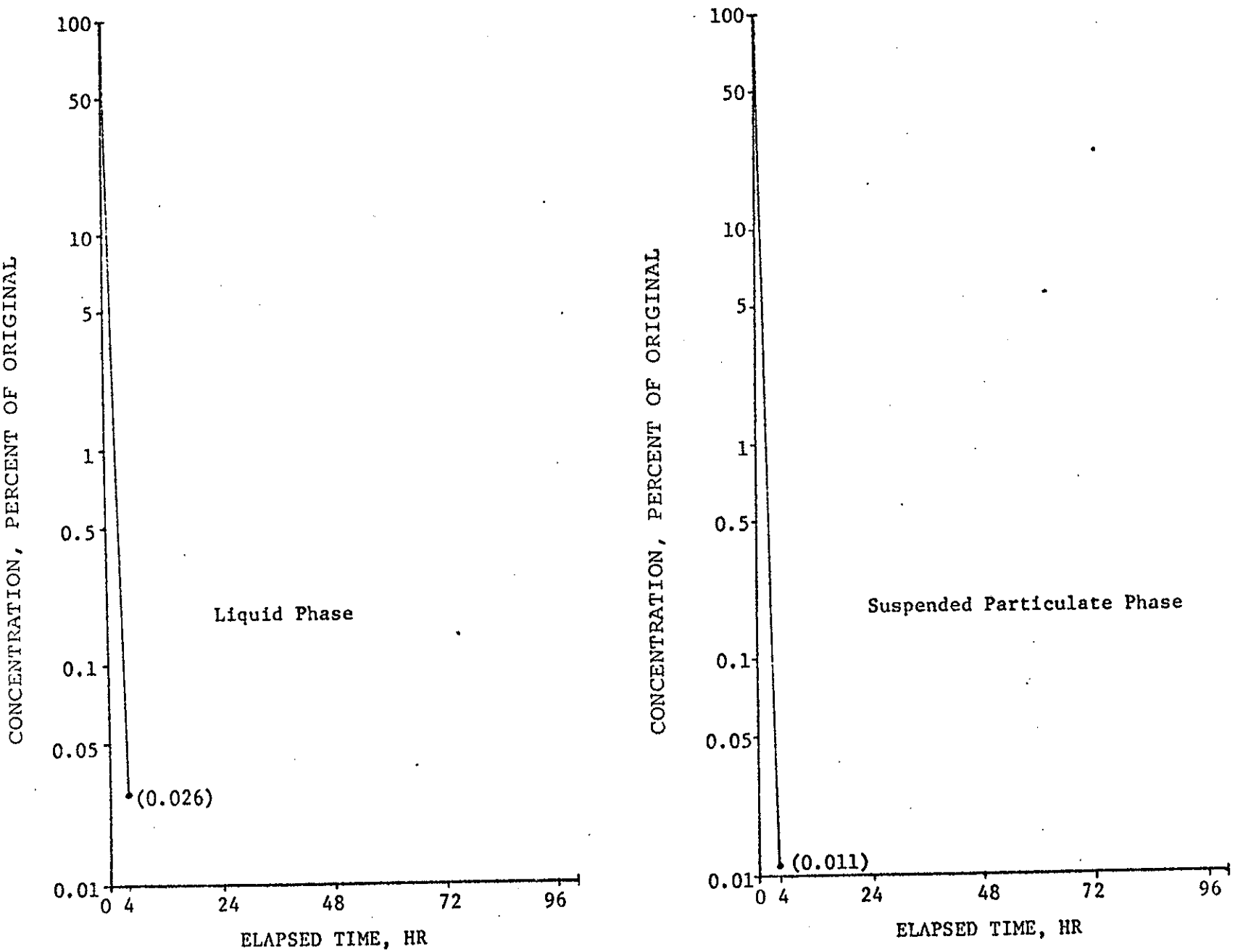

Figure 2: Predicted Dilution of Liquid and Suspended Particulate Phase Dredged Materials at the Galveston Harbor Channel Disposal Area.

3.1.4 VOLUME OF SUSPENDED PARTICULATE PHASE, V_{sp}

The estimated volume of suspended particulate phase discharged during disposal operations was calculated as:

$$V_{sp} = (V_t - V_w) \frac{(P_c + P_s)}{100}$$

$$= (1600 - 1100) \frac{40 + 50}{100} = 450 \text{ m}^3$$

3.1.5 PERCENT SUSPENDED PARTICULATE PHASE AFTER INITIAL MIXING, C_{sp}

The percent suspended particulate phase after initial mixing was determined as:

$$C_{sp} = \frac{V_{sp}}{V_m} (100) = \frac{450 \text{ m}^3}{4,159,246 \text{ m}^3} \times 100 = 0.011 \text{ percent}$$

The time-concentration curve representing initial mixing and dilution of the suspended particulate phase of dredged materials at the Galveston Harbor Channel Disposal Area is presented in Figure 2.

3.2 LIQUID AND SUSPENDED PARTICULATE PHASE BIOASSAYS

Liquid and suspended particulate phase bioassays were performed for Galveston Harbor Channel dredged materials using postlarval mysid shrimp (Mysidopsis almyra), adult grass shrimp (Palaemonetes pugio) and tidewater silversides (Menidia beryllina). The results of these bioassays, statistical analyses of the data (presented in Appendix C, Tables C-1 - C-18), and their relationship to the limiting permissible concentration (LPC) for the dredged materials are discussed in the following subsections. A summary of physical-chemical measurements (temperature, salinity, pH, and dissolved oxygen) performed during the bioassays is presented in Appendix D, Table D-1.

3.2.1 GALVESTON HARBOR CHANNEL STATION G-1

3.2.1.1 Liquid Phase Bioassays

The numbers of surviving postlarval mysid shrimp during the 96-hr liquid phase bioassay are presented in Table 1. Mortality in the control did not exceed the allowable 20 percent. Mortality was observed initially after 72 hr in all test media and the control. Although the difference in survival between postlarvae exposed to the 100 percent test medium and the control was statistically ($t = 2.74$) significant (α.05, 4 df), total mortality did not exceed 50 percent in any test treatment. Therefore, determination of a LC50 was precluded.

Grass shrimp survival during the 96-hr bioassay is presented in Table 2. No deaths occurred in the control treatment. Mortality was first observed after 72 hr in the 50 percent test medium and after 96 hr in the 100 percent test medium. The difference in survival of animals exposed to the 100 percent test medium and the control was statistically ($t = 0.16$) nonsignificant (α.05, 2 df). Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

Survival of tidewater silversides during the liquid phase bioassay is presented in Table 3. No deaths occurred during the 96-hr test period. The lack of mortality precluded determination of a LC50.

3.2.1.2 Suspended Particulate Phase Bioassays

The numbers of surviving postlarval mysid shrimp during the 96-hr bioassay are presented in Table 4. Test animal mortality in the control did not exceed the allowable 20 percent. Mortality was observed initially after 48 hr in the 10 and 50 percent test media, after 72 hr in the control, and after 96 hr in the 100 percent test medium. Test organism survival in the 100 percent test medium was greater than survival in the control, eliminating need for further statistical evaluation. Total mortality did not exceed 50 percent in any test treatment; therefore, determination of a LC50 was precluded.

Survival of grass shrimp during the 96-hr bioassay is presented in Table 5. Mortality occurred at 96-hr in the 10 and 50 percent test media and in the control. Test organism survival in the 100 percent test medium exceeded survival of animals in the control treatment, eliminating need for further statistical evaluation. Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

The numbers of surviving tidewater silversides during the 96-hr bioassay are presented in Table 6. No deaths occurred during the test period. The lack of mortality precluded determination of a LC50.

3.2.1.3 Limiting Permissible Concentrations of Station G-1 Dredged Materials

The acutely toxic concentrations of Station G-1 liquid and suspended particulate phase dredged materials could not be determined precisely, but were determined to be no less than 100 percent test media.

Therefore, the limiting permissible concentrations (LPC) [LPC is defined as that concentration which will not exceed a toxicity threshold of 0.01 of the acutely toxic concentration] could be no less than 1.0 percent of the initial concentrations of the liquid or suspended particulate phases. The LPC could be exceeded only if dilution by a factor $\leq$100 actually occurred during disposal operations. The estimate of initial mixing (Section 3.1) predicted that the liquid phase would be diluted by a factor of 3,780 to 0.026 percent of its initial concentration and the suspended particulate phase would be diluted by a factor of 9,240 to 0.011 percent of its initial concentration. As a result, no adverse impact due to potential toxic effects of the liquid or suspended particulate phases of dredged materials from Station G-1 is predicted.

3.2.2 GALVESTON HARBOR CHANNEL STATION G-2

3.2.2.1 Liquid Phase Bioassays

Survival of postlarval mysid shrimp during the 96-hr liquid phase bioassay is presented in Table 7. Mortality in the control did not exceed the allowable 20 percent. Mortality was observed initially after 48 hr in the 100 and 50 percent test media and after 72 hr in the 10 percent test medium and control. The difference between survival of organisms in the 100 percent test medium and the control was statistically ($t = 1.34$) nonsignificant (α.05, 4 df). Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

Grass shrimp survival during the liquid phase bioassay is presented in Table 8. No deaths occurred during the 96-hr test period. Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

Survival of tidewater silversides during the 96-hr bioassay is presented in Table 9. One death occurred at 96 hr in the 10 percent test medium. Test organism survival in the 100 percent test medium equaled that in the control, eliminating need for additional statistical evaluation. Since total mortality did not exceed 50 percent in any test treatment, determination of a LC50 was precluded.

3.2.2.2 Suspended Particulate Phase Bioassays

The numbers of surviving postlarval mysid shrimp during the 96-hr bioassay are presented in Table 10. One death occurred in the control; however, mortality did not exceed 20 percent. Mortality was observed initially after 24 hr in the 50 percent test medium, after 72 hr in the 10 percent test medium and control, and after 96 hr in the 100 percent test medium. Survival of test animals in the 100 percent test medium equaled survival of animals in the control, eliminating need for further statistical evaluation. Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

Grass shrimp survival during the 96-hr bioassay is presented in Table 11. Two deaths occurred in the control; however, mortality did not exceed the allowable 10 percent. Mortality was observed initially at 48 hr in the control and at 72 hr in the 10 percent test medium. Survival of test animals in the 100 percent test medium was greater than survival in the control, eliminating need for additional statistical evaluation. Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

The numbers of surviving tidewater silversides during the 96-hr bioassay are presented in Table 12. No mortality occurred in the control treatment. A single mortality was observed after 48 hr in

the 50 percent test medium. There was no difference in survival of organisms in the 100 percent test medium and the control. Mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

3.2.2.3 Limiting Permissible Concentrations of Station G-2 Dredged Materials

The acutely toxic concentrations of Station G-2 liquid and suspended particulate phase dredged materials could not be determined precisely, but were determined to be no less than 100 percent test media. Therefore, the limiting permissible concentrations (LPC) [LPC is defined as that concentration which will not exceed a toxicity threshold of 0.01 of the acutely toxic concentration] could be no less than 1.0 percent of the initial concentrations of the liquid or suspended particulate phases. The LPC could be exceeded only if dilution by a factor $\leq$ 100 actually occurred during disposal operations. The estimate of initial mixing (Section 3.1) predicted that the liquid phase would be diluted by a factor of 3,780 to 0.026 percent of its initial concentration and the suspended particulate phase would be diluted by a factor of 9,240 to 0.011 percent of its initial concentration. As a result, no adverse impact due to potential toxic effects of the liquid or suspended particulate phases of dredged materials from Station G-2 is predicted.

3.2.3 GALVESTON HARBOR CHANNEL STATION G-3

3.2.3.1 Liquid Phase Bioassays

The survival of postlarval mysid shrimp during the 96-hr liquid phase bioassay of Station G-3 dredged materials is summarized in Table 13. Mortality in the control did not exceed the allowable 20 percent. Mortality was first observed after 24 hr in the control, after 48 hr in the 50 and 10 percent test media, and after 72

hr in the 100 percent test medium. There was no difference between survival of test animals in the 100 percent test medium and the control. Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

The numbers of surviving grass shrimp during the 96-hr bioassay are presented in Table 14. No deaths occurred in any test treatment. The lack of mortality precluded determination of a LC50.

Survival of tidewater silversides during the 96-hr bioassay is presented in Table 15. No deaths were observed in any of the control or test treatments, precluding determination of a LC50.

3.2.3.2 Suspended Particulate Phase Bioassays

The numbers of surviving postlarval mysid shrimp during the 96-hr bioassay are presented in Table 16. Two organisms died in the control; however, mortality did not exceed 20 percent. Mortality was observed initially at 24 hr in the 100 percent test medium and at 48 hr in the 50 and 10 percent test media and the control. The difference between survival of postlarvae in the 100 percent test medium and the control was statistically ($t = 2.24$) significant (α .05, 4 df). However, total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

Survival of grass shrimp during the 96-hr bioassay is summarized in Table 17. No mortality occurred in the control. Deaths occurred at 96 hr in the 100 and 50 percent test media. The difference between survival of organisms exposed to the 100 percent test medium and the control was statistically ($t = 0.16$) nonsignificant (α .05, 2 df). Total mortality did not exceed 50 percent in any test treatment, precluding determination of a LC50.

The numbers of surviving tidewater silversides during the suspended particulate phase bioassay are presented in Table 18. No mortality was observed during the 96-hr test period, precluding determination of a LC50.

3.2.3.3 Limiting Permissible Concentrations of Station G-3 Dredged Materials

The acutely toxic concentrations of Station G-3 liquid and suspended particulate phase dredged materials could not be determined precisely, but were determined to be no less than 100 percent test media. Therefore, the limiting permissible concentrations (LPC) [LPC is defined as that concentration which will not exceed a toxicity threshold of 0.01 of the acutely toxic concentration] could be no less than 1.0 percent of the initial concentrations of the liquid or suspended particulate phases. The LPC could be exceeded only if dilution by a factor $\leq$ 100 actually occurred during disposal operations. The estimate of initial mixing (Section 3.1) predicted that the liquid phase would be diluted by a factor of 3,780 to 0.026 percent of its initial concentration and the suspended particulate phase would be diluted by a factor of 9,240 to 0.011 percent of its initial concentration. As a result, no adverse impact due to potential toxic effects of the liquid or suspended particulate phases of dredged materials from Station G-3 is predicted.

3.3 SOLID PHASE BIOASSAY

A solid phase bioassay was performed with grass shrimp (Palaemonetes pugio), hard clams (Mercenaria mercenaria), and sandworms (Nereis virens) using Galveston Harbor Channel sediments. The results and statistical analyses of this bioassay are presented in Tables 19 through 23. A summary of physical-chemical measurements during the bioassay is presented in Appendix D, Table D-2.

As shown in Table 19, grass shrimp survival was 98 and 97 percent in the control and reference sediments, respectively, and ranged from 95 to 99 percent in the test sediments. The mean survival of grass shrimp in all test treatments was 97 percent. Survival of clams was 99.5 and 100 percent, respectively, in the control and reference sediments and ranged from 98 to 100 percent in the test materials. Mean clam survival was 99.5 percent in all test treatments. Sandworm survival was 100 and 97 percent in the control and reference sediments, respectively, and ranged from 96 to 99 percent in the test sediments. Sandworm survival averaged 98 percent over all treatments.

The solid phase bioassay survival data[1] were pooled for a preliminary statistical evaluation as shown in Table 20. The results of the ANOVA procedure ($F = 1.36$) indicated that the observed differences in pooled survival of test animals were nonsignificant ($\alpha .05$; 3, 16 df). Although there was no indication of a potential "worst case" situation, to determine whether a sediment caused a greater effect within a particular species group, the survival data were partitioned along species lines for additional statistical analyses.

[1] The results of the control sediment treatment were excluded from subsequent statistical evaluations.

Mean survival of grass shrimp exposed to the reference and test materials was compared statistically (ANOVA), as summarized in Table 21. The results ($F = 1.29$) indicated that the observed differences in mean survival of grass shrimp were nonsignificant ($\alpha .05$; 3, 16 df).

Mean survival of hard clams exposed to the reference and test sediments was evaluated as presented in Table 22. The within-treatment variances were heterogenous and the data could not be satisfactorily transformed. However, as shown in Table 22, only in Station G-3 test materials was survival of clams less than that of animals exposed to the reference sediments. Therefore, further statistical evaluation was performed using the t-test procedure for similarity of means. The results ($t = 2.13$) of the t-test showed that the observed difference in mean survival of clams exposed to the reference and station G-3 test materials was nonsignificant ($\alpha .05$; 4 df).

The results of the statistical analysis of mean survival of sandworms exposed to the test and reference sediments are summarized in Table 23. As shown, the ANOVA procedure indicated ($F = 0.67$) that observed differences in survival of sandworms were nonsignificant ($\alpha .05$; 3, 16 df).

At present, there are no objective means for estimating initial mixing and dispersion characteristics (thus, determining the limiting permissible concentration) for the solid phase of dredged materials. Therefore, it is suggested (EPA/CE, 1977) that the limiting permissible concentration (LPC) of solid phase dredged materials be operationally determined by the results of a solid phase bioassay. In practice, a two-staged evaluation is applied as follows:

1) the survival data are analyzed to determine whether the observed differences between mean survival of animals in the reference and test sediments are statistically significant; and (if significant);

2) the absolute difference between mean survival of animals in the reference and test sediments is evaluated to determine whether such difference exceeds 10 percent of the mean survival of animals in the reference sediment.

If a positive determination is obtained for both criteria (i.e., the observed difference is both statistically significant and greater than 10 percent), the solid phase bioassay is assumed to have shown the LPC would be exceeded and that the dredged materials in question have a potential to cause environmentally unacceptable impacts on benthic organisms.

As discussed above, in no case was survival of animals exposed to test materials from Galveston Harbor Channel stations significantly less than survival of animals exposed to the reference sediment. Therefore, the solid phase bioassay showed that Galveston Harbor Channel dredged materials pose no serious or unacceptable hazard to marine benthic organisms.

3.4 BIOACCUMULATION ASSESSMENT

The potential for bioaccumulation of a variety of pesticides, polychlorinated biphenyls (PCB's), heavy metals and petroleum hydrocarbons from Galveston Harbor Channel sediments into marine organisms was assessed using tissues of sandworms (a polychaete) and hard clams exposed during the solid phase bioassay to test, reference and control sediments. Additionally, random subsamples of animals not exposed to sediment materials were analyzed to establish pre-test background concentrations for the constituents of interest. Specific analyses were conducted for the following constituents: lindane; heptachlor; p,p'-DDD, p,p'-DDE and p,p'-DDT; chlordane; dieldrin; endrin; toxaphene; PCB's (Aroclor 1242 and Aroclor 1254); mirex; methoxychlor; mercury and cadmium; and aliphatic and aromatic petroleum hydrocarbons.

Many constituents exhibited one or more observations (determination for a replicate sample) which was less than the analytical detection limit for the procedure employed. In such cases, the arbitrary but environmentally protective assumption that the actual concentration was only slightly less than the detection limit was made, and the detection limit was used as if it were the datum.

3.4.1 SANDWORM (Nereis virens)

The results of sandworm tissue analyses are presented in Tables 24 through 40 and are discussed below.

The concentrations of Aroclor 1254, chlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, dieldrin, endrin, heptachlor, lindane, methoxychlor, mirex, and toxaphene were less than or equal to the analytical detection limit in all observations (Tables 24 through 35). Consequently, the means and variances of these data sets were equal and required no statistical analyses. There was no evidence that the test animals had accumulated any of these constituents from the test materials.

The mean concentrations of Aroclor 1242 in sandworms are presented in Table 36. As shown, the mean concentrations of this constituent in animals exposed to test materials from Stations G-1, G-2 and G-3 were all less than or equal to the mean concentration determined in animals exposed to the reference sediment. Therefore, rigorous statistical evaluation was not required. There was no indication that the test animals had accumulated Aroclor 1242 from test sediments to a greater degree than from the reference sediment.

The concentrations of cadmium and mercury in sandworm tissues are presented in Tables 37 and 38. The mean concentrations of cadmium (0.042 mg/kg in animals exposed to Station G-1 test materials) and mercury (0.018 mg/kg in sandworms exposed to Station G-2 sediments) were greater than the corresponding mean concentrations of these constituents in animals exposed to the reference sediment (0.030 and 0.012 mg/kg, respectively, for cadmium and mercury). As shown, the within-treatment variances for both data sets were heterogeneous and could not be transformed satisfactorily. Data centricity in one or more treatments for each data set precluded application of the recommended statistical procedure; however, as noted above, only one treatment mean in each set required comparison with its corresponding reference mean. Therefore, statistical evaluations were performed using Cochran's test and Student's t-test, as summarized below:

---

cadmium (from Table 37)

Cochran's Test for Homogeneity of Variance $[C._{05}(k=2;v=4)=0.90]$

$$C = \frac{S^2_{max}}{\Sigma S^2} = \frac{7.2\times10^{-4}}{7.2\times10^{-4}} = 1.0^*$$

Student's t-test $[t._{05}(4\ df)=2.13]$

$$t = \frac{|\bar{X}_{ref} - \bar{X}_{G-1}|}{\sqrt{(S^2_{ref} + S^2_{G-1})/n}} = \frac{|3.0\times10^{-2} - 4.2\times10^{-2}|}{\sqrt{(0 + 7.2\times10^{-4})/5}} = 1.0\ NS$$

---

mercury (from Table 38)

Cochran's Test for Homogeneity of Variance $[C._{05}(k=2;v=4)=0.90]$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.7x10^{-4}}{1.9x10^{-4}} = 0.89 \text{ NS}$$

Student's t-test $[t._{05}(8 \text{ df})=1.86]$

$$t = \frac{|\bar{X}_{ref} - \bar{X}_{G-2}|}{\sqrt{(S^2_{ref} + S^2_{G-2})/n}} = \frac{|1.2x10^{-2} - 1.8x10^{-2}|}{\sqrt{(2.0x10^{-5} + 1.7x10^{-4})/5}} = 0.97 \text{ NS}$$

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* Significant (α.05)
NS = nonsignificant

The mean concentration of cadmium in animals exposed to dredged materials from Station G-1 and the mean concentration of mercury in sandworms exposed to sediments from Station G-2 were not statistically greater than the mean concentrations of these constituents in animals exposed to the reference sediments.

The concentrations of aliphatic petroleum hydrocarbons in tissues of polychaetes exposed to test and reference sediment materials are presented in Table 39. As shown, the variances were heterogeneous and the data could not be transformed satisfactorily. Accordingly, the approximate test of equality of means (Box 13.2; Sokal and Rohlf, 1969) was utilized for subsequent statistical evaluation. The result of this procedure showed that the observed differences between mean concentrations of aliphatic petroleum hydrocarbons in animals exposed to the test and reference sediment materials were statistically nonsignificant.

The mean concentrations of aromatic petroleum hydrocarbons were 1.2, 0.64, 1.3 and 0.50 mg/kg, respectively, in sandworms exposed to the reference sediment and Stations G-1, G-2 and G-3 test materials

(Table 40). Statistical evaluation (ANOVA) showed that the observed differences in concentrations of this constituent were significant. Therefore, the Student-Newman-Keuls (SNK) multiple range test was applied to determine which dredged material tissue sample mean(s), if any, differed significantly from the reference sediment tissue samples mean. The results of the SNK procedure are summarized below.

Mean Concentration of Aromatic Petroleum Hydrocarbons (from Table 40)

G-3	G-1	Reference	G-2
0.50	0.64	1.2	1.3

	k=2
$Q._{05}$(16 df)	2.998
$S_{\bar{x}}$	0.20
LSR	0.60

	k	LSR	|Difference|
Reference: G-2	2	0.60	1.2 - 1.3 = 0.1 NS

NS = nonsignificant

The results showed that the mean aromatic petroleum hydrocarbon concentration in sandworms exposed to sediments from Station G-2 was not significantly greater than the mean concentration of this constituent in animals exposed to the reference sediment. The concentrations of aromatic petroleum hydrocarbons in animals exposed to sediments from Stations G-1 and G-3 were less than that observed in animals exposed to the reference sediment; therefore, statistical evaluation was not required.

3.4.2 HARD CLAM (Mercenaria mercenaria)

The results of hard clam tissue analyses are presented in Tables 41 through 57 and are discussed below.

The concentrations of Aroclor 1254, chlordane, p,p'-DDD, dieldrin, endrin, heptachlor, lindane, methoxychlor, toxaphene and cadmium are presented in Tables 41 through 50. For each of these parameters except chlordane, the concentrations determined were less than or equal to the analytical detection limit in all observations. Background samples (animals not exposed to test, reference or control sediments) exhibited a mean chlordane concentration of 0.0012 mg/kg (Table 42). The means and variances of each data set were equal and required no statistical evaluation. There was no evidence that the test animals had accumulated any of these constituents from the test materials.

The mean concentrations of aliphatic petroleum hydrocarbons, aromatic petroleum hydrocarbons and mercury are presented in Tables 51 through 53. As shown the mean concentrations of each of these constituents in animals exposed to test materials from Stations G-1, G-2 and G-3 were less than or equal to the mean concentration observed in animals exposed to the reference sediment. Therefore, further statistical evaluation was not warranted. There was no indication that the clams had accumulated these constituents from test sediments to a greater degree than from the reference sediment.

The concentrations of p,p'-DDE, p,p'-DDT and mirex in clam tissues are presented in Tables 54 through 56. The mean concentration of p,p'-DDE (0.0014 mg/kg in animals exposed to Station G-1 test materials), p,p'-DDT (0.0056 mg/kg in clams exposed to Station G-2 test sediments) and mirex (0.016 mg/kg in animals exposed to Station G-1 dredged materials) were greater than the corresponding concentrations observed in animals exposed to the reference sediment (0.0010 mg/kg for p,p'-DDE and p,p'- DDT and 0.010 mg/kg for mirex).

As shown in Tables 54 through 56, the within-treatment variances for each data set were heterogeneous and could not be transformed satisfactorily. Data centricity in one or more treatments for each data set precluded application of the recommended statistical procedure; however, as noted above, only one treatment mean in each set required comparison with its corresponding reference mean. Therefore, statistical evaluations were performed using Cochran's test and Student's t-test, as summarized below:

---

p,p'-DDE (from Table 54)

Cochran's Test for Homogeneity of Variance $[C._{05}(k=2;v=4)=0.90]$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{8.0x10^{-7}}{8.0x10^{-7}} = 1.0\ *$$

Student's t-test $[t._{05}(4\ df)=2.13]$

$$t = \frac{|\bar{X}_{ref} - \bar{X}_{G-1}|}{\sqrt{(S^2_{ref} + S^2_{G-1})/n}} = \frac{|1.0x10^{-3} - 1.4x10^{-3}|}{\sqrt{(0 + 8.0x10^{-7})/5}} = 1.0\ NS$$

---

p,p'-DDT (from Table 55)

Cochran's Test for Homogeneity of Variance $[C._{05}(k=2;v=4)=0.90]$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{6.8x10^{-5}}{6.8x10^{-5}} = 1.0\ *$$

Student's t-test $[t._{05}(4\ df)=2.13]$

$$t = \frac{|X_{ref} - X_{G-2}|}{\sqrt{(S^2_{ref} + S^2_{G-2})/n}} = \frac{|1.0x10^{-3} - 5.6x10^{-3}|}{\sqrt{(0 + 6.8x10^{-5})/5}} = 1.25\ NS$$

---

mirex (from Table 56)

Cochran's Test for Homogeneity of Variance $[C._{05}(k=2;v=4)=0.90]$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.8x10^{-4}}{1.8x10^{-4}} = 1.0\ *$$

Student's t-test $[t_{.05}(4\ df)=2.13]$

$$t = \frac{|\bar{X}_{ref} - \bar{X}_{G-1}|}{\sqrt{(S^2_{ref} + S^2_{G-1})/n}} = \frac{|1.0\times10^{-2} - 1.6\times10^{-2}|}{\sqrt{(0 + 1.8\times10^{-4})/5}} = 1.0\ NS$$

---

* Significant (α.05)
NS = nonsignificant

For each constituent, the difference between mean concentrations observed in animals exposed to the test and reference sediment materials was nonsignificant.

The concentrations of Aroclor 1242 in tissues of hard clams exposed to test and reference sediments are presented in Table 57. As shown, the variances were heterogeneous and could not be transformed satisfactorily. Therefore, the approximate test of equality of means (Box 13.2; Sokal and Rohlf, 1969) was utilized for subsequent statistical evaluation. The results of this procedure showed that the observed differences between mean concentrations of Aroclor 1242 in clams exposed to the test and reference sediment materials were nonsignificant.

3.5 EVALUATION OF SEDIMENT, SEAWATER AND ELUTRIATE SAMPLES

3.5.1 SEDIMENT CHEMISTRY

The results of chemical analyses of sediments collected at Galveston Harbor Channel Stations G-1, G-2, G-3 and Disposal Area No. 1 are summarized in Table 58 and presented in detail in Appendix B, Tables B-3 through B-6. Many constituents, notably cadmium, nitrite, Aroclor 1254, lindane, heptachlor, DDT and its metabolites, chlordane, dieldrin, endrin, toxaphene, mirex and methoxychlor, exhibited concentrations either below or only slightly above the analytically quantifiable detection limit. Consequently, no obvious spatial distribution pattern was discerned. Other constituents, particularly Aroclor 1242, arsenic, chromium, copper, lead, nickel, zinc, ammonia and nitrate, displayed a spatial distribution pattern that tended toward higher concentrations at the shoreward sampling areas (Stations G-1 and G-2). Total kjeldahl nitrogen and oil and grease residues were present at highest concentrations in sediments from Station G-2. Mercury was present at approximately equal levels in all sediment samples. The concentrations observed for each of these constituents are not considered excessive and do not exceed any known screening levels.

3.5.2 SEAWATER QUALITY

The results of chemical analyses of seawater samples collected at Galveston Harbor Channel Stations G-1, G-2, G-3 and Disposal Areas No. 1 are summarized in Table 59 and presented in detail in Appendix B, Tables B-7 through B-10. For comparison, a summary of applicable marine water quality criteria (EPA, 1976) is also provided in Appendix B, Table B-2.

All but three constituents (ammonia, total kjeldahl nitrogen and oil and grease) exhibited no concentration above the analytically quantifiable detection limit. Ammonia and total kjeldahl nitrogen

were found only in samples from Station G-1. Oil and grease residues were present in all samples and tended toward slightly higher concentrations at the seaward sampling stations and disposal area.

As noted in Appendix B, Table B-2, many parameters analyzed in Galveston Harbor Channel seawater samples have no established marine water quality criterion. However, specific numerical criteria have been established for selected pesticides, polychlorinated biphenyls (PCB's), and two metals, cadmium and mercury (EPA, 1976). Interestingly, the quality criteria for pesticides and PCB's are established in the range of nanograms-per-liter (parts per trillion) and, as such, are far below present state-of-the art analytical detection limits. These marine water quality criteria were derived through use of conservative application factors based on 96-hr LC50's determined through bioassays with highly sensitive organisms.

The marine quality criteria for mercury and cadmium are, respectively, 0.10 µg/ℓ and 5.0 µg/ℓ (EPA, 1976). The concentrations of mercury and cadmium in seawater samples from the Galveston Harbor Channel project area were, in all samples respectively, reported as <0.2 µg/ℓ and <0.005 mg/ℓ (equivalent to <5 µg/ℓ). For both constituents, the reported values represent the minimum analytically quantifiable concentrations available through standard analytical methods. In all determinations for these constituents in seawater samples, only very minute concentrations, if any, of cadmium or mercury were detected. Therefore, for purposes of estimating the dilution of liquid phase dredged materials (discussed in the following subsection), it is assumed that ambient cadmium and mercury concentrations were less than the established marine water quality criteria.

3.5.3 LIQUID PHASE ELUTRIATE QUALITY

The results of chemical analyses of liquid phase elutriate samples prepared from Galveston Harbor Channel dredged materials and disposal site water are summarized in Table 60 and presented in detail in Appendix B, Tables B-11 through B-13. As discussed in the previous subsection, all parameters except cadmium and mercury either have no marine water quality criterion or have a numerical criterion that is below present state-of-the-art analytical capability. Therefore, this section addresses only the potential for dilution of cadmium and mercury.

The mean concentration of cadmium in each liquid phase elutriate sample was less than the established criterion of 5 µg/ℓ for cadmium in marine waters (EPA, 1976). Therefore, no dilution, during disposal operations, of dredged materials from Stations G-1, G-2 or G-3 would be necessary to meet the limiting permissible concentration requirement for cadmium.

The mean concentrations of mercury were 0.2, 27.3 and 0.2 µg/ℓ, respectively, in the liquid phase of dredged materials from Stations G-1, G-2 and G-3. The dilution factor, D, was determined for G-1 and G-3 materials as (terms were defined in Section 2.4.2):

$$D = \frac{C_e - C_s}{C_s - C_a} = \frac{0.2 - 0.1}{0.1 - 0.09} = 10$$

and for Station G-2 materials as follows:

$$D = \frac{C_e - C_s}{C_s - C_a} = \frac{27.3 - 0.1}{0.1 - 0.09} = 2720$$

The volume of water (Vol) necessary to achieve a 2720-fold dilution of the liquid phase dredged materials was calculated as:

$$Vol = 2720 \times 1100\ m^3 = 3.0 \times 10^6\ m^3$$

As discussed in Section 3.1.1, the volume available for initial mixing at Disposal Area No. 1 is approximately 4.2×10^6 m^3. Therefore, adequate capacity for dilution of mercury in the liquid phase of dredged materials from Station G-2, and also Stations G-1 and G-3, is available at the Galveston Harbor Channel disposal area.

4.0 SUMMARY

Bioassays of liquid and suspended particulate phases of dredged material samples collected at Galveston Harbor Channel Stations G-1, G-2 and G-3 were conducted using postlarval mysid shrimp, adult grass shrimp and tidewater silversides. In all of these bioassays, mortality did not exceed 50 percent in any test treatment, precluding precise determination of the median lethal concentration (LC50) of the dredged materials. The acutely toxic concentration was assumed to be at least 100 percent test medium. Accordingly, the limiting permissible concentrations (LPC) of Galveston Harbor Channel dredged materials would equal 1.0 percent of the original concentration of the liquid or suspended particulate phase and could be exceeded only if dilution by a factor $\leq$ 100 actually occurred. Based on consideration of conditions expected during initial mixing, dilution factors of 3,780 and 9,240 and final concentrations of 0.026 and 0.011 percent were estimated for the liquid and suspended particulate phases, respectively. Therefore, no serious or unacceptable hazard to the marine environment is anticipated as a result of disposal of liquid or suspended particulate phases of materials dredged from the Galveston Harbor Channel.

A solid phase bioassay of dredged materials from Galveston Harbor Channel Stations G-1, G-2 and G-3, including reference and control sediments, was performed using grass shrimp, hard clams and sandworms. Mean survival of test organisms (pooled for the three species) averaged 99, 98, 98, 98 and 97 percent for the control and reference sediments and Stations G-1, G-2 and G-3, respectively. Statistical analyses showed that the observed differences in survival, between animals exposed to the test materials as compared to animals exposed to the reference materials, were nonsignificant.

Therefore, on the basis of the established criteria for evaluating results of solid phase bioassays (EPA/CE, 1977), Galveston Harbor Channel dredged materials did not show unacceptable environmental risk to marine benthic organisms.

The potential for bioaccumulation of a variety of pesticides, polychlorinated biphenyls, petroleum hydrocarbons, and mercury and cadmium in tissues of marine organisms in the vicinity of the Galveston Harbor Channel project area was assessed using sandworms and hard clams exposed to test and reference sediments during the solid phase bioassay. In many cases, the concentrations of these constituents in the animal tissues were below the detection limits for the analytical procedures employed. For all constituents, the analytically determined concentrations of these materials in animals exposed to test sediments from Stations G-1, G-2 and G-3 were either less than or statistically no greater than the concentrations found in animals exposed to the reference sediment.

Ambient concentrations of a variety of heavy metals, pesticides and polychlorinated biphenyls, nitrogen derivatives, and oil and grease residues were determined in sediments and water from the Galveston Harbor Channel sampling stations and disposal area. Several sediment parameters, including Aroclor 1242, arsenic, chromium, copper, lead, nickel, zinc, ammonia and nitrate displayed a general trend toward higher concentrations at shoreward sampling areas. Total Kjeldahl nitrogen and oil and grease residues were present in highest concentrations at Station G-2. Mercury was ubiquitous throughout the project area, but was not present in excessive concentrations. In seawater samples, only ammonia, total Kjeldahl nitrogen and oil and grease displayed discernable spatial trends. Ammonia and total Kjeldahl nitrogen were found in samples from Station G-2. Oil and grease was present in all seawater samples and

tended toward higher concentrations at seaward sampling areas. Most constituents (particularly in seawater samples) exhibited no concentration above the analytically quantifiable detection limit.

Pesticides and polychlorinated biphenyls were not found in liquid phase elutriate samples in concentrations above present state-of-the-art detection limits; therefore, it is assumed that ambient concentrations of these constituents did not exceed the established marine water quality criteria. In all samples, the concentration of cadmium was less than the established marine water quality criterion; therefore, dilution would not be required to meet the limiting permissible concentration for this constituent. In several replicate samples, the concentration of mercury was less than or equal to, or only slightly above, the minimum quantifiable analytical detection limit. However, because the quantifiable analytical detection limit is greater than the marine quality criterion and because concentrations above the detection limits were observed in several replicates, it was assumed that the actual concentration of mercury in elutriate samples equaled (or, in one case, exceeded) the detection limit concentration. Therefore, to meet the established water quality criterion for mercury, dredged materials from Stations G-1, G-2 and G-3 would require dilution. The initial mixing zone volume of Disposal Area No. 1 is more than adequate for dilution of dredged materials from the Galveston Harbor Channel.

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TABLE 1

The Number of Surviving Postlarval Mysidopsis almyra During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	8	8
Medium	2	10	10	10	7	6
	3	10	10	10	8	8
50% Test	1	10	10	10	9	8
Medium	2	10	10	10	10	10
	3	10	10	10	10	9
10% Test	1	10	10	10	8	7
Medium	2	10	10	10	10	9
	3	10	10	10	9	8
Dilution Water	1	10	10	10	10	10
	2	10	10	10	9	9
	3	10	10	10	10	9

TABLE 2

The Number of Surviving Palaemonetes pugio During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	9
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	9	9
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 3

The Number of Surviving Menidia beryllina During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 4

The Number of Surviving Postlarval Mysidopsis almyra During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	9
50% Test	1	10	10	10	10	10
Medium	2	10	10	9	9	9
	3	10	10	10	10	9
10% Test	1	10	10	10	10	10
Medium	2	10	10	9	9	9
	3	10	10	10	10	9
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	9
	3	10	10	10	9	9

TABLE 5

The Number of Surviving Palaemonetes pugio During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	9
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	9
	3	10	10	10	10	9
Dilution Water	1	10	10	10	10	9
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 6

The Number of Surviving Menidia beryllina During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 7

The Number of Surviving Postlarval Mysidopsis almyra During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	8	8
Medium	2	10	10	10	9	9
	3	10	10	9	9	9
50% Test	1	10	10	10	10	8
Medium	2	10	10	10	10	7
	3	10	10	9	8	6
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	9	8
	3	10	10	10	10	9
Dilution Water	1	10	10	10	10	10
	2	10	10	10	9	9
	3	10	10	10	10	9

TABLE 8

The Number of Surviving Palaemonetes pugio During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 9

The Number of Surviving Menidia beryllina During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	9
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 10

The Number of Surviving Postlarval Mysidopsis almyra During the Suspended Particulate Phase Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	9
	3	10	10	10	10	10
50% Test	1	10	10	10	10	9
Medium	2	10	9	9	9	9
	3	10	10	10	10	10
10% Test	1	10	10	10	8	8
Medium	2	10	10	10	9	9
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	9	9

TABLE 11

The Number of Surviving Palaemonetes pugio During the Suspended Particulate Phase Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	9	9
Dilution Water	1	10	10	10	10	10
	2	10	10	9	9	9
	3	10	10	10	10	9

TABLE 12

The Number of Surviving Menidia beryllina During the Suspended Particulate Bioassay of Station G-2 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	9	9	9
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 13

The Number of Surviving Postlarval *Mysidopsis almyra* During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	9
Medium	2	10	10	10	9	8
	3	10	10	10	8	7
50% Test	1	10	10	10	9	8
Medium	2	10	10	9	5	4
	3	10	10	9	9	9
10% Test	1	10	10	9	9	9
Medium	2	10	10	8	7	7
	3	10	10	10	8	8
Dilution Water	1	10	10	10	9	7
	2	10	9	9	9	8
	3	10	10	9	9	9

TABLE 14

The Number of Surviving Palaemonetes pugio During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test Medium	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test Medium	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test Medium	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 15

The Number of Surviving *Menidia beryllina* During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 16

The Number of Surviving Postlarval Mysidopsis almyra During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	9	8	8	8
Medium	2	10	10	10	10	9
	3	10	10	10	8	8
50% Test	1	10	10	9	9	9
Medium	2	10	10	9	9	9
	3	10	10	10	10	10
10% Test	1	10	10	8	7	7
Medium	2	10	10	10	10	10
	3	10	10	10	10	9
Dilution Water	1	10	10	10	9	9
	2	10	10	10	10	10
	3	10	10	9	9	9

TABLE 17

The Number of Surviving Palaemonetes pugio During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	9
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	9
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 18

The Number of Surviving Menidia beryllina During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

Treatment	Replicate Number	Time of Observation - Number of Survivors				
		0 hr	24 hr	48 hr	72 hr	96 hr
100% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
50% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
10% Test	1	10	10	10	10	10
Medium	2	10	10	10	10	10
	3	10	10	10	10	10
Dilution Water	1	10	10	10	10	10
	2	10	10	10	10	10
	3	10	10	10	10	10

TABLE 19

The Numbers and Percentages of Surviving Palaemonetes pugio, Mercenaria mercenaria and Nereis virens During the Solid Phase Bioassay of Galveston Harbor Channel Dredged Materials.

Test Organism	Replicate (n=5)	Number of Survivors				
		Control	Reference	G-1	G-2	G-3
Palaemonetes	1	19	20	20	20	20
pugio	2	20	19	19	19	20
20/replicate-treatment	3	19	20	18	20	19
(except as noted)	4	20	19	18	20	15/15[1]
	5	20	19	20	20	19
	Σ	98	97	95	99	93/95
	(%)	(98)	(97)	(95)	(99)	(98)
Mercenaria	1	40	40	40	40	39
mercenaria	2	39	40	40	40	38
40/replicate-treatment	3	40	40	40	40	40
	4	40	40	40	40	40
	5	40	40	40	40	39
	Σ	199	200	200	200	196
	(%)	(99.5)	(100)	(100)	(100)	(98)
Nereis	1	20	20	19	18	20
virens	2	20	20	20	20	19
20/replicate-treatment	3	20	19	20	20	19
	4	20	19	20	20	18
	5	20	19	20	18	20
	Σ	100	97	99	96	96
	(%)	(100)	(97)	(99)	(96)	(96)

[1] Replicate #4 received 15 grass shrimp at beginning of test sequence

TABLE 20

Summary Statistics and Analysis of Variance of Pooled Survival of Palaemonetes pugio, Mercenaria mercenaria and Nereis virens During the Solid-Phase Bioassay.

Replicate (n=5)	Pooled Number of Survivors			
	Reference	G-1	G-2	G-3
1	80	79	78	79
2	79	79	79	77
3	79	78	80	78
4	78	78	80	78[1]
5	78	80	78	78
ΣX	394	394	395	390
$\bar{X}$	78.8	78.8	79.0	78.0
X^2	31050	31050	31209	30422
CSS	2.8	2.8	4.0	2.0
S^2	0.7	0.7	1.0	0.5

Cochran's Test for Homogeneity of Variance

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.0}{2.9} = 0.34 \text{ NS } [C_{.05}(k=4;v=4) = 0.63]$$

Analysis of Variance

Source	df	SS	MS	F
Treatments	3	2.95	0.98	1.36 NS
Error	16	11.6	0.73	
Total	19	14.55	$[F_{.05}(3, 16 \text{ df})=3.24]$	

[1] Pooled survival for replicate #4 based on proportionalized survival of grass shrimp (15/15 = 20/20) and actual survival of clams and sandworms

NS = nonsignificant

TABLE 21

Summary Statistics and Analysis of Variance of Grass Shrimp Survival During the Solid Phase Bioassay.

Replicate (n=5)	Number of Survivors			
	Reference	G-1	G-2	G-3
1	20	20	20	20
2	19	19	19	20
3	20	18	20	19
4	19	18	20	20[1]
5	19	20	20	19
ΣX	97	95	99	98
$\bar{X}$	19.4	19.0	19.8	19.6
ΣX^2	1883	1809	1961	1922
CSS	1.2	4.0	0.8	1.2
S^2	0.3	1.0	0.2	0.3

Cochran's Test for Homogeneity of Variance

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.0}{1.8} = 0.56 \text{ NS } [C._{05}(k=4;v=4) = 0.63]$$

Analysis of Variance

Source	df	SS	MS	F
Treatments	3	1.75	0.58	1.29 NS
Error	16	7.20	0.45	
Total	19	8.95	$[F._{05}(3, 16 \text{ df})=3.24]$	

[1] Replicate #4 survival was proportionalized (15/15 = 20/20) to equalize sample size.

NS = nonsignificant

TABLE 22

Summary Statistics and t-Test for Similarity of Means of Hard Clam Survival During the Solid Phase Bioassay.

Replicate (n=5)	Number of Survivors			
	Reference	G-1	G-2	G-3
1	40	40	40	39
2	40	40	40	38
3	40	40	40	40
4	40	40	40	40
5	40	40	40	39
ΣX	200	200	200	196
$\bar{X}$	40	40	40	39.2
ΣX^2	8000	8000	8000	7686
CSS	0	0	0	2.8
S^2	0	0	0	0.7

Cochran's Test for Homogeneity of Variance (Reference and G-3)[1]

$$C = \frac{S^2 max}{\Sigma S^2} = \frac{0.7}{0.7} = 1.0^* \quad [C._{05}(k=2;v=4)=0.90]$$

t-Test for Similarity of Means

$$t = \frac{|\bar{X}_{reference} - \bar{X}_{G-3}|}{\sqrt{(S^2_{reference} + S^2_{G-3})/n}} = \frac{40 - 39.2}{\sqrt{(0 + 0.7)/5}} = 2.13 \text{ NS}$$

$$[t._{05}(4 \text{ df})=2.13]$$

[1] Mean survival of clams in reference sediments exceeded mean survival of clams exposed only to Station G-3 test materials, therefore, a t-test comparison of two means was used for subsequent statistical analysis

* significant ($\alpha._{05}$)

NS = nonsignificant

TABLE 23

Summary Statistics and Analysis of Variance of Sandworm Survival During the Solid Phase Bioassay.

Replicate (n=5)	Number of Survivors			
	Reference	G-1	G-2	G-3
1	20	19	18	20
2	20	20	20	19
3	19	20	20	19
4	19	20	20	18
5	19	20	18	20
ΣX	97	99	96	96
$\bar{X}$	19.4	19.8	19.2	19.2
ΣX^2	1883	1961	1848	1846
CSS	1.2	0.8	4.8	2.8
S^2	0.3	0.2	1.2	0.7

Cochran's Test for Homogeneity of Variance

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.2}{2.4} = 0.50 \text{ NS } [C._{.05}(k=4;v=4)=0.63]$$

Analysis of Variance

Source	df	SS	MS	F
Treatments	3	1.2	0.4	0.67 NS
Error	16	9.6	0.6	
Total	19	10.8	$[F._{.05}(3,16 \text{ df})=3.24]$	

NS = nonsignificant

TABLE 24

Results of a Bioaccumulation Assessment for Aroclor 1254 in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 25

Results of a Bioaccumulation Assessment for Chlordane in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	0.017	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	2.1×10^{-2}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	4.2×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	2.9×10^{-4}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	2.0×10^{-4}	0	0	0	0	0
X^2	5.1×10^{-5}	0	0	0	0	0

Statistical analysis not required

TABLE 26

Results of a Bioaccumulation Assessment for p,p'-DDD in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 27

Results of a Bioaccumulation Assessment for p,p'-DDE in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 28

Results of a Bioaccumulation Assessment for p,p'-DDT in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	0.007	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	0.001	<0.001
ΣX	1.1×10^{-2}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	2.2×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.3×10^{-5}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	2.9×10^{-5}	0	0	0	0	0
S^2	7.2×10^{-6}	0	0	0	0	0

Statistical analysis not required

TABLE 29

Results of a Bioaccumulation Assessment for Dieldrin in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 30

Results of a Bioaccumulation Assessment for Endrin in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 31

Results of a Bioaccumulation Assessment for Heptachlor in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 32

Results of a Bioaccumulation Assessment for Lindane in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 33

Results of a Bioaccumulation Assessment for Methoxychlor in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\bar{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 34

Results of a Bioaccumulation Assessment for Mirex in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required.

TABLE 35

Results of a Bioaccumulation Assessment for Toxaphene in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\bar{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 36

Results of a Bioaccumulation Assessment for Aroclor 1242 in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	0.02	0.02	<0.01	<0.01	<0.01
2	<0.01	0.02	0.02	0.03	<0.01	0.02
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	0.02	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	8.0×10^{-2}	7.0×10^{-2}	7.0×10^{-2}	5.0×10^{-2}	6.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.6×10^{-2}	1.4×10^{-2}	1.4×10^{-2}	1.0×10^{-2}	1.2×10^{-2}
ΣX^2	5.0×10^{-4}	1.4×10^{-3}	1.1×10^{-3}	1.3×10^{-3}	5.0×10^{-4}	8.0×10^{-4}
CSS	0	1.2×10^{-4}	1.2×10^{-4}	3.2×10^{-4}	0	8.0×10^{-5}
S^2	0	3.0×10^{-5}	3.0×10^{-5}	8.0×10^{-5}	0	2.0×10^{-5}

Statistical analysis not required

TABLE 37

Results of a Bioaccumulation Assessment for Cadmium in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
3	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
4	<0.03	<0.03	<0.03	0.09	<0.03	<0.03
5	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
ΣX	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	2.1×10^{-1}	1.5×10^{-1}	1.5×10^{-1}
$\bar{X}$	3.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}	4.2×10^{-2}	3.0×10^{-2}	3.0×10^{-2}
ΣX^2	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	1.2×10^{-2}	4.5×10^{-3}	4.5×10^{-3}
CSS	0	0	0	2.9×10^{-3}	0	0
S^2	0	0	0	7.2×10^{-4}	0	0

Cochran's Test

$$C=\frac{7.2\times10^{-4}}{7.2\times10^{-4}}=1.0^{*}$$

Cochran's Test for Transformed Data (transformation not shown)

$$C=\frac{6.0\times10^{-4}}{6.0\times10^{-4}}=1.0^{*} \qquad [C._{05}(k=4,v=4)\,0.63]$$

* Significant (α.05)

Recommended analysis (EPA/CE, 1977) is not appropriate for centric data

TABLE 38

Results of a Bioaccumulation Assessment for Mercury in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	0.05	0.02	<0.01	<0.01	<0.01	0.02
2	0.05	<0.01	<0.01	<0.01	<0.01	0.01
3	0.05	0.02	<0.01	<0.01	<0.01	0.01
4	0.07	<0.01	0.02	0.01	0.02	<0.01
5	0.04	0.01	0.01	<0.01	0.04	<0.01
ΣX	2.6×10^{-1}	7.0×10^{-2}	6.0×10^{-2}	5.0×10^{-2}	9.0×10^{-2}	6.0×10^{-2}
$\bar{X}$	5.2×10^{-2}	1.4×10^{-2}	1.2×10^{-2}	1.0×10^{-2}	1.8×10^{-2}	1.2×10^{-2}
ΣX^2	1.4×10^{-2}	1.1×10^{-3}	8.0×10^{-4}	5.0×10^{-4}	2.3×10^{-3}	8.0×10^{-4}
CSS	4.8×10^{-4}	1.2×10^{-4}	8.0×10^{-5}	0	6.8×10^{-4}	8.0×10^{-5}
S^2	1.2×10^{-4}	3.0×10^{-5}	2.0×10^{-5}	0	1.7×10^{-4}	2.0×10^{-5}

Cochran's Test

$$C=\frac{1.7\times10^{-4}}{2.1\times10^{-4}}=0.81^{*}$$

Cochran's Test for Transformed Data (transformation not shown)

$$C=\frac{3.05\times10^{-5}}{3.79\times10^{-5}}=0.80^{*} \quad [C._{05}(k=4,v=4)=0.63]$$

* Significant (α.05)

Recommended analysis (EPA/CE, 1977) is not appropriate for centric data

TABLE 39

Results of a Bioaccumulation Assessment for Aliphatic Petroleum Hydrocarbons in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.1	0.4	<0.1	0.3	<0.1	0.6
2	0.2	0.3	0.1	<0.1	0.3	2.0
3	1.2	<0.1	0.2	<0.1	0.2	<0.1
4	1.1	<0.1	0.4	<0.1	1.2	<0.1
5	1.1	<0.1	0.4	0.2	0.2	<0.1
ΣX	3.7×10^{0}	1.0×10^{0}	1.2×10^{0}	8.0×10^{-1}	2.0×10^{0}	2.9×10^{0}
$\overline{X}$	7.4×10^{-1}	2.0×10^{-1}	2.4×10^{-1}	1.6×10^{-1}	4.0×10^{-1}	5.8×10^{-1}
ΣX^2	3.9×10^{0}	2.8×10^{-1}	3.8×10^{-1}	1.6×10^{-1}	1.6×10^{0}	4.4×10^{0}
CSS	1.2×10^{0}	8.0×10^{-2}	9.2×10^{-2}	3.2×10^{-2}	8.2×10^{-1}	2.7×10^{0}
S^2	2.9×10^{-1}	2.0×10^{-2}	2.3×10^{-2}	8.0×10^{-3}	2.1×10^{-1}	6.8×10^{-1}

Cochran's Test

$$C=\frac{6.8\times10^{-1}}{9.2\times10^{-1}}=0.74^{*}$$

Cochran's Test for Transformed Data (transformations not shown)

$$C=\frac{1.9\times10^{-2}}{2.9\times10^{-2}}=0.65^{*} \qquad [C._{05}(k=4,v=4)=0.63]$$

Approximate Test of Equality of Means

Source	df	SSw	MSw	F's
Treatments	3	3.27	1.09	0.93 NS
Error	(7.8)≈8	0.64	1.17	$[F._{05}(3,8\ df)=4.07]$

* significant (α.05)
NS = nonsignificant

TABLE 40

Results of a Bioaccumulation Assessment of Aromatic Petroleum Hydrocarbons in Nereis virens.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	1.2	1.2	1.7	0.8	1.5	0.8
2	0.9	0.9	0.8	1.2	1.2	1.4
3	1.7	1.0	0.7	0.3	1.5	<0.1
4	1.9	0.8	0.8	0.5	1.2	<0.1
5	3.2	2.7	1.8	0.4	1.2	<0.1
ΣX	8.9×10^{0}	6.6×10^{0}	5.8×10^{0}	3.2×10^{0}	6.6×10^{0}	2.5×10^{0}
$\overline{X}$	1.8×10^{0}	1.3×10^{0}	1.2×10^{0}	6.4×10^{-1}	1.3×10^{0}	5.0×10^{-1}
ΣX^2	1.9×10^{1}	1.1×10^{1}	7.9×10^{0}	2.6×10^{0}	8.8×10^{0}	2.6×10^{0}
CSS	3.1×10^{0}	2.5×10^{0}	1.2×10^{0}	5.3×10^{-1}	1.1×10^{-1}	1.4×10^{0}
S^2	7.9×10^{-1}	6.2×10^{-1}	2.9×10^{-1}	1.3×10^{-1}	2.7×10^{-2}	3.4×10^{-1}

Cochran's Test

$$C=\frac{3.4\times10^{-1}}{7.9\times10^{-1}}=0.43 \text{ NS} \qquad [C._{05}(k=4,v=4)=0.63]$$

Analysis of Variance

Source	df	SS	MS	F
Treatment	3	2.3	0.77	3.9*
Error	16	3.2	0.20	
Total		5.5	[F.05(3,16df)=3.24]	

NS = nonsignificant; * significant (α.05)

TABLE 41

Results of a Bioaccumulation Assessment for Aroclor 1254 in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S	0	0	0	0	0	0

Statistical analysis not required

TABLE 42

Results of a Bioaccumulation Assessment for Chlordane in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	6.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	1.2×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	8.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	8.0×10^{-7}	0	0	0	0	0
S^2	2.0×10^{-7}	0	0	0	0	0

Statistical analysis not required

TABLE 43

Results of a Bioaccumulation Assessment for p,p'-DDD in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 44

Results of a Bioaccumulation Assessment for Dieldrin in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 45

Results of a Bioaccumulation Assessment for Endrin in Mercenaria mercenaria.

Replicate	Concentration (mg/kg, wet basis)					
	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 46

Results of a Bioaccumulation Assessment for Heptachlor in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 47

Results of a Bioaccumulation Assessment for Lindane in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\overline{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 48

Results of a Bioaccumulation Assessment for Methoxychlor in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\bar{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 49

Results of a Bioaccumulation Assessment for Toxaphene in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 50

Results of a Bioaccumulation Assessment for Cadmium in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
2	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
3	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
4	<0.03	<0.03	<0.03	0.03	<0.03	<0.03
5	<0.03	<0.03	<0.03	0.03	<0.03	<0.03
ΣX	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}	1.5×10^{-1}
$\overline{X}$	3.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}	3.0×10^{-2}
ΣX^2	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}	4.5×10^{-3}
CSS	0	0	0	0	0	0
S^2	0	0	0	0	0	0

Statistical analysis not required

TABLE 51

Results of a Bioaccumulation Assessment for Aliphatic Petroleum Hydrocarbons in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.1	<0.1	0.4	<0.1	<0.1	0.2
2	0.3	<0.1	0.5	<0.1	<0.1	0.3
3	<0.1	0.1	0.4	<0.1	<0.1	0.5
4	<0.1	0.1	0.4	<0.1	<0.1	0.4
5	<0.1	1.1	0.4	<0.1	<0.1	0.7
ΣX	7.0×10^{-1}	1.5×10^{0}	2.1×10^{0}	5.0×10^{-1}	5.0×10^{-1}	2.1×10^{0}
$\overline{X}$	1.4×10^{-1}	3.0×10^{-1}	4.2×10^{-1}	1.0×10^{-1}	1.0×10^{-1}	4.2×10^{-1}
ΣX^2	1.3×10^{-1}	1.3×10^{0}	8.9×10^{-1}	5.0×10^{-2}	5.0×10^{-2}	1.0×10^{0}
CSS	3.2×10^{-2}	8.0×10^{-1}	8.0×10^{-3}	0	0	1.5×10^{-1}
S^2	8.0×10^{-3}	2.0×10^{-1}	2.0×10^{-3}	0	0	3.7×10^{-2}

Statistical analysis not required

TABLE 52

Results of a Bioaccumulation Assessment for Aromatic Petroleum Hydrocarbons in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	1.3	0.3	1.1	<0.1	3.5	0.5
2	<0.1	0.4	0.9	<0.1	<0.1	0.3
3	<0.1	0.5	0.6	<0.1	<0.1	0.5
4	<0.1	0.4	1.2	<0.1	<0.1	1.1
5	<0.1	0.8	0.4	<0.1	0.2	0.8
ΣX	1.7×10^{0}	2.4×10^{0}	4.2×10^{0}	5.0×10^{-1}	4.0×10^{0}	3.2×10^{0}
$\bar{X}$	3.4×10^{-1}	4.8×10^{-1}	8.4×10^{-1}	1.0×10^{-1}	8.0×10^{-1}	6.4×10^{-1}
ΣX^2	1.7×10^{0}	1.3×10^{0}	4.0×10^{0}	5.0×10^{-2}	1.2×10^{1}	2.4×10^{0}
CSS	1.2×10^{0}	1.5×10^{-1}	4.5×10^{-1}	0	9.1×10^{0}	3.9×10^{-1}
S^2	2.9×10^{-1}	3.7×10^{-2}	1.1×10^{-1}	0	2.3×10^{0}	9.8×10^{-2}

Statistical analysis not required

TABLE 53

Results of a Bioaccumulation Assessment for Mercury in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	0.02	0.01	0.01	<0.01	<0.01	<0.01
2	0.02	<0.01	<0.01	<0.01	0.01	<0.01
3	0.02	<0.01	<0.01	<0.01	0.02	<0.01
4	0.02	<0.01	0.25	<0.01	<0.01	0.10
5	0.07	0.05	0.01	0.05	<0.01	<0.01
ΣX	1.5×10^{-1}	9.0×10^{-2}	2.9×10^{-1}	9.0×10^{-2}	6.0×10^{-2}	1.4×10^{-1}
$\overline{X}$	3.0×10^{-2}	1.8×10^{-2}	5.8×10^{-2}	1.8×10^{-2}	1.2×10^{-2}	2.8×10^{-2}
ΣX^2	6.5×10^{-3}	2.9×10^{-3}	6.3×10^{-2}	2.9×10^{-3}	8.0×10^{-4}	1.0×10^{-2}
CSS	2.0×10^{-3}	1.3×10^{-3}	4.6×10^{-2}	1.3×10^{-3}	8.0×10^{-5}	6.5×10^{-3}
S^2	5.0×10^{-4}	3.2×10^{-4}	1.2×10^{-2}	3.2×10^{-4}	2.0×10^{-5}	1.6×10^{-3}

Statistical analysis not required

TABLE 54

Results of a Bioaccumulation Assessment for p,p'-DDE in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
3	<0.001	<0.001	<0.001	0.003	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	7.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.4×10^{-3}	1.0×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	1.3×10^{-5}	5.0×10^{-6}	5.0×10^{-6}
CSS	0	0	0	3.2×10^{-6}	0	0
S^2	0	0	0	8.0×10^{-7}	0	0

Cochran's Test $C=\frac{8.0\times10^{-7}}{8.0\times10^{-7}}=1.0^{*}$ $[C._{05}(k=4,v=4)=0.63]$

* Significant (α.05)

Recommended analysis (EPA/CE, 1977) is not appropriate for centric data

TABLE 55

Results of a Bioaccumulation Assessment for p,p'-DDT in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.001	<0.001	<0.001	<0.001	0.02	<0.001
2	<0.001	<0.001	<0.001	<0.001	0.005	<0.001
3	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
4	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
5	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
ΣX	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	5.0×10^{-3}	2.8×10^{-2}	5.0×10^{-3}
$\bar{X}$	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-3}	5.6×10^{-3}	1.0×10^{-3}
ΣX^2	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	5.0×10^{-6}	4.3×10^{-4}	5.0×10^{-6}
CSS	0	0	0	0	2.7×10^{-4}	0
S^2	0	0	0	0	6.8×10^{-5}	0

Cochran's Test $C=\frac{6.8\times10^{-5}}{6.8\times10^{-5}}=1.0^*$ $[C_{.05}(k=4,v=4)=0.63]$

* Significant (α.05)

Recommended analysis (EPA/CE, 1977) is not appropriate for centric data

TABLE 56

Results of a Bioaccumulation Assessment for Mirex in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
3	<0.01	<0.01	<0.01	0.04	<0.01	<0.01
4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ΣX	5.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}	8.0×10^{-2}	5.0×10^{-2}	5.0×10^{-2}
$\overline{X}$	1.0×10^{-2}	1.0×10^{-2}	1.0×10^{-2}	1.6×10^{-2}	1.0×10^{-2}	1.0×10^{-2}
ΣX^2	5.0×10^{-4}	5.0×10^{-4}	5.0×10^{-4}	2.0×10^{-3}	5.0×10^{-4}	5.0×10^{-4}
CSS	0	0	0	7.2×10^{-4}	0	0
S^2	0	0	0	1.8×10^{-4}	0	0

Cochran's Test $\dot{C} = \frac{1.8 \times 10^{-4}}{1.8 \times 10^{-4}} = 1.0^*$ $[C_{.05}(k=4, v=4) = 0.63]$

* Significant (α.05)

Recommended analysis (EPA/CE, 1977) is not appropriate for centric data

TABLE 57

Results of a Bioaccumulation Assessment for Aroclor 1242 in Mercenaria mercenaria.

	Concentration (mg/kg, wet basis)					
Replicate	Background	Control	Reference	G-1	G-2	G-3
1	<0.01	<0.01	<0.01	0.03	0.10	<0.01
2	<0.01	<0.01	0.04	<0.01	0.02	0.01
3	<0.01	0.01	0.05	0.04	<0.01	0.01
4	<0.01	<0.01	<0.01	0.04	<0.01	0.01
5	<0.01	0.02	0.02	<0.01	<0.01	0.03
ΣX	5.0×10^{-2}	6.0×10^{-2}	1.3×10^{-1}	1.3×10^{-1}	1.5×10^{-1}	7.0×10^{-2}
$\bar{X}$	1.0×10^{-2}	1.2×10^{-2}	2.6×10^{-2}	2.6×10^{-2}	3.0×10^{-2}	1.4×10^{-2}
ΣX^2	5.0×10^{-4}	8.0×10^{-4}	4.7×10^{-3}	4.3×10^{-3}	1.1×10^{-2}	1.3×10^{-3}
CSS	0	8.0×10^{-5}	1.3×10^{-3}	9.2×10^{-4}	6.2×10^{-3}	3.2×10^{-4}
S^2	0	2.0×10^{-5}	3.3×10^{-4}	2.3×10^{-4}	1.6×10^{-3}	8.0×10^{-5}

Cochran's Test

$$C=\frac{1.6\times10^{-3}}{2.2\times10^{-3}}=0.73^{*}$$

Cochran's Test for Transformed Data (transformations not shown)

$$C=\frac{1.4\times10^{-3}}{2.0\times10^{-3}}=0.70^{*} \qquad [C._{05}(k=4,v=4)=0.63]$$

Approximate Test of Equality of Means

Source	df	SSw	MSw	F's
Treatments	3	3.74	1.25	1.07 NS
Error	(8.2)≈8	0.61	1.16	$[F_{.05}(3,8\ df)=4.07]$

* Significant (α.05)

NS = nonsignificant

TABLE 58

Mean Concentrations of Constituents Measured in Galveston Harbor Channel Sediment Samples.

Parameter (Unit)	Concentration G-1	G-2	G-3	Disposal Area
Solids, %	37.81	37.95	67.35	76.39
Arsenic, mg/kg	9	9	6	<2
Cadmium, mg/kg	<1	<1	<1	<1
Chromium, mg/kg	66	65	42	9
Copper, mg/kg	14	14	7	<3
Lead, mg/kg	16	18	8	<5
Mercury, mg/kg	0.17	0.17	0.19	0.17
Nickel, mg/kg	17	7	<2	<3
Zinc, mg/kg	67	70	48	6
Ammonia (N), mg/kg	68	74	11	4.8
Nitrate (N), mg/kg	23	19	13	4.3
Nitrite (N), mg/kg	<1	<1	<1	<1
Total Kjeldahl (N), mg/kg	987	1040	153	133
Oil and Grease, mg/kg	797	1177	460	220
Aroclor - 1242, mg/kg	0.05	0.03	<0.01	<0.01
Aroclor - 1254, mg/kg	<0.01	<0.01	<0.01	<0.01
Lindane, mg/kg	0.001	0.001	0.001	0.001
Heptachlor, mg/kg	<0.001	<0.001	<0.001	<0.001
p,p^1-DDD, mg/kg	<0.001	<0.001	<0.001	<0.001
p,p^1-DDE, mg/kg	<0.001	0.001	0.001	0.001
p,p^1-DDT, mg/kg	<0.001	<0.002	<0.001	<0.001
Chlordane, mg/kg	<0.001	<0.001	<0.001	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001	<0.001
Endrin, mg/kg	<0.001	<0.001	<0.001	<0.001
Toxaphene, mg/kg	<0.01	<0.01	<0.01	<0.01
Mirex, mg/kg	<0.01	<0.01	<0.01	<0.01
Methoxychlor, mg/kg	<0.01	<0.01	<0.01	<0.01

TABLE 59

Mean Concentrations of Constituents Measured in Galveston Harbor Channel Seawater Samples.

Parameter (Unit)	Concentration			
	G-1	G-2	G-3	Disposal Area
Arsenic, µg/ℓ	<10	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	<0.2	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	<0.2	<0.1	<0.1	<0.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	0.3	<0.1	<0.1	<0.1
Oil and Grease, mg/ℓ	1	2	2	<2
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001	<0.001

TABLE 60

Mean Concentrations of Constituents Measured in Galveston Harbor Channel Liquid Phase Elutriate Samples.

Parameter (Unit)	Concentration G-1	G-2	G-3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	0.2	27.3	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	3.4	3.6	1.1
Nitrate (N), mg/ℓ	<0.02	<0.04	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	5.2	5.8	1.3
Oil and Grease, mg/ℓ	<1	3	2
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

APPENDIX A

(TABLE A-1)

METRIC (SI) AND U.S. CUSTOMARY

UNITS OF MEASURE

TABLE A-1

Factors for Conversion of Metric (SI) to U.S. Customary Units of Measure.

Multiply	By	Obtain
meters	3.281	feet
centimeters	0.3937	inches
liters	0.2642	gallons

U.S. Customary Equivalents of Metric Units Used Frequently in this Report.

Metric Unit	U.S. Customary Equivalent
18.9 ℓ	5 gal
36.8 ℓ	10 gal
56.8 ℓ	15 gal
80 ℓ	21 gal
94.6 ℓ	25 gal
114 ℓ	30 gal
750 ℓ	200 gal
1890 ℓ	500 gal

Temperature Conversion - Celsius to Fahrenheit.

Degrees Celsius	Degrees Fahrenheit
4	39
12	54
22	72
25	77

APPENDIX B

(TABLES B-1 THROUGH B-13)

ANALYTICAL DETECTION LIMITS,

MARINE WATER QUALITY CRITERIA

AND

CHEMICAL ANALYSES OF SEDIMENT,

SEAWATER AND ELUTRIATE SAMPLES

TABLE B-1

Minimum Quantifiable Analytical Detection Limits[1] for Constituents Measured in Galveston Harbor Channel Sediment, Seawater, Elutriate and Animal Tissue Samples.

Constituent	Sediment	Water/Elutriate	Tissue
Arsenic[2]	1 mg/kg	10 µg/ℓ	NA[3]
Cadmium[2]	1 mg/kg	0.01 mg/ℓ	0.03 mg/kg
Chromium[2]	3 mg/kg	0.03 mg/ℓ	NA
Copper[2]	2 mg/kg	0.02 mg/ℓ	NA
Lead[2]	5 mg/kg	0.05 mg/ℓ	NA
Mercury[4]	0.01 mg/kg	0.2 µg/ℓ	0.01 mg/kg
Nickel[2]	2 mg/kg	0.02 mg/ℓ	NA
Zinc[2]	2 mg/kg	0.02 mg/ℓ	NA
Ammonia (N)[5]	5 mg/kg	0.1 mg/ℓ	NA
Nitrate (N)[5]	1 mg/kg	0.02 mg/ℓ	NA
Nitrite (N)[5]	1 mg/kg	0.02 mg/ℓ	NA
Total Kjeldahl (N)[5]	5 mg/kg	0.1 mg/ℓ	NA
Oil and Grease[6]	5 mg/kg	2 mg/ℓ	NA
Aroclor 1242[7]	0.01 mg/kg	0.001 mg/ℓ	0.01 mg/kg
Aroclor 1254[7]	0.01 mg/kg	0.001 mg/ℓ	0.01 mg/kg
Lindane[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
Heptachlor[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
p,p'-DDD[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
p,p'-DDE[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
p,p'-DDT[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
Chlordane[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg

[1] Determined by the original sample size, the concentration achieved during the extraction or digestion process, and the characteristics of the instrumentation employed.
[2] Instrumentation Laboratory Model 251 Atomic Absorption Spectrophotometer
[3] NA = not analyzed for sample type
[4] Coleman MAS-50 Cold-Vapor Mercury Analyzer
[5] Baush & Lomb Spectronic 20 or Beckman DR-DU Spectrophotometer
[6] Gravimetric procedure
[7] Hewlett-Packard 5830/5840 or Varian Aerograph 2700 Gas Chromatograph

TABLE B-1 (CONT'D)

Minimum Quantifiable Analytical Detection Limits[1] for Constituents Measured in Galveston Harbor Channel Sediment, Seawater, Elutriate and Animal Tissue Samples.

Constituent	Sediment	Water/Elutriate	Tissue
Dieldrin[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
Endrin[7]	0.001 mg/kg	0.001 mg/ℓ	0.001 mg/kg
Toxaphene[7]	0.01 mg/kg	0.001 mg/ℓ	0.01 mg/kg
Mirex[7]	0.01 mg/kg	0.001 mg/ℓ	0.01 mg/kg
Methoxychlor[7]	0.01 mg/kg	0.001 mg/ℓ	0.01 mg/kg
Aromatic Petroleum Hydrocarbons[7]	NA[3]	NA	0.01 mg/kg
Aliphatic Petroleum[7] Hydrocarbons	NA	NA	0.01 mg/kg

[1] Determined by the original sample size, the concentration achieved during the extraction or digestion process, and the characteristics of the instrumentation employed.
[2] Instrumentation Laboratory Model 251 Atomic Absorption Spectrophotometer
[3] NA = not analyzed for sample type
[4] Coleman MAS-50 Cold Vapor Mercury Analyzer
[5] Baush and Lomb Spectronic 20 or Beckman DR-DU Spectrophotometer
[6] Gravimetric procedure
[7] Hewlett-Packard 5830/5840 or Varian Aerograph 2700 Gas Chromatograph

TABLE B-2

Marine Water Quality Criteria[1] for Constituents Analyzed in Galveston Harbor Channel Seawater and Elutriate Samples.

Constituent	Criterion
Arsenic	no criterion
Cadmium	5 µg/ℓ
Chromium	no criterion
Copper	no criterion
Lead	no criterion
Mercury	0.10 µg/ℓ
Nickel	no criterion
Zinc	no criterion
Ammonia	no criterion
Nitrate	no criterion
Nitrite	no criterion
Total Kjeldahl Nitrogen	no criterion
Oil and Grease	no criterion
Aroclor - 1242 Aroclor - 1254	0.001 µg/ℓ, total PCB's
Lindane	0.004 µg/ℓ
Heptachlor	0.001 µg/ℓ
p,p'-DDD p,p'-DDE p,p'-DDT	0.001 µg/ℓ, total DDT and metabolites
Chlordane	0.004 µg/ℓ
Dieldrin	0.003 µg/ℓ
Endrin	0.004 µg/ℓ
Toxaphene	0.005 µg/ℓ
Mirex	0.001 µg/ℓ
Methoxychlor	0.03 µg/ℓ

[1] EPA, 1976

TABLE B-3

Results of Chemical Analyses of Sediment Samples Collected at Galveston Harbor Channel Station G-1.

Parameter (Unit)	Test Result/Replicate 1	2	3
Solids, %	32.62	38.85	41.96
Arsenic, mg/kg	8	10	8
Cadmium, mg/kg	<1	<1	<1
Chromium, mg/kg	75	68	55
Copper, mg/kg	17	15	11
Lead, mg/kg	20	14	14
Mercury, mg/kg	0.18	0.18	0.16
Nickel, mg/kg	15	20	16
Zinc, mg/kg	74	68	58
Ammonia (N), mg/kg	79	62	62
Nitrate (N), mg/kg	31	15	24
Nitrite (N), mg/kg	<1	<1	<1
Total Kjeldahl (N), mg/kg	1100	1100	760
Oil and Grease, mg/kg	850	970	570
Aroclor - 1242, mg/kg	0.08	0.05	0.03
Aroclor - 1254, mg/kg	<0.01	<0.01	<0.01
Lindane, mg/kg	0.002	0.001	0.001
Heptachlor, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDD, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDE, mg/kg	0.002	0.001	<0.001
p,p^1-DDT, mg/kg	<0.001	<0.001	<0.001
Chlordane, mg/kg	<0.001	<0.001	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001
Endrin, mg/kg	<0.001	<0.001	<0.001
Toxaphene, mg/kg	<0.01	<0.01	<0.01
Mirex, mg/kg	<0.01	<0.01	<0.01
Methoxychlor, mg/kg	<0.01	<0.01	<0.01

TABLE B-4

Results of Chemical Analyses of Sediment Samples Collected at Galveston Harbor Channel Station G-2.

Parameter (Unit)	Test Result/Replicate 1	2	3
Solids, %	39.41	37.43	37.02
Arsenic, mg/kg	10	10	8
Cadmium, mg/kg	<1	<1	<1
Chromium, mg/kg	63	68	63
Copper, mg/kg	12	14	15
Lead, mg/kg	17	17	20
Mercury, mg/kg	0.18	0.21	0.13
Nickel, mg/kg	8	10	4
Zinc, mg/kg	63	74	72
Ammonia (N), mg/kg	71	67	84
Nitrate (N), mg/kg	18	25	13
Nitrite (N), mg/kg	<1	<1	<1
Total Kjeldahl (N), mg/kg	1200	1000	920
Oil and Grease, mg/kg	1500	1750	280
Aroclor - 1242, mg/kg	0.04	0.03	0.02
Aroclor - 1254, mg/kg	<0.01	<0.01	<0.01
Lindane, mg/kg	0.001	0.001	0.001
Heptachlor, mg/kg	<0.001	<0.001	0.001
p,p^1-DDD, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDE, mg/kg	0.002	0.001	0.001
p,p^1-DDT, mg/kg	0.004	<0.001	0.001
Chlordane, mg/kg	<0.001	<0.001	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001
Endrin, mg/kg	<0.001	<0.001	<0.001
Toxaphene, mg/kg	<0.01	<0.01	<0.01
Mirex, mg/kg	<0.01	<0.01	<0.01
Methoxychlor, mg/kg	<0.01	<0.01	<0.01

TABLE B-5

Results of Chemical Analyses of Sediment Samples Collected at Galveston Harbor Channel Station G-3.

Parameter (Unit)	Test Result/Replicate 1	2	3
Solids, %	68.43	65.85	67.77
Arsenic, mg/kg	6	6	6
Cadmium, mg/kg	<1	<1	<1
Chromium, mg/kg	37	42	46
Copper, mg/kg	5	7	8
Lead, mg/kg	9	9	7
Mercury, mg/kg	0.21	0.18	0.18
Nickel, mg/kg	3	<2	<2
Zinc, mg/kg	48	48	47
Ammonia (N), mg/kg	10	12	11
Nitrate (N), mg/kg	16	12	11
Nitrite (N), mg/kg	<1	<1	<1
Total Kjeldahl (N), mg/kg	140	210	110
Oil and Grease, mg/kg	270	980	130
Aroclor - 1242, mg/kg	0.01	<0.01	<0.01
Aroclor - 1254, mg/kg	<0.01	<0.01	<0.01
Lindane, mg/kg	0.001	0.001	0.001
Heptachlor, mg/kg	<0.001	<0.001	0.001
p,p^1-DDD, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDE, mg/kg	0.001	0.001	0.001
p,p^1-DDT, mg/kg	<0.001	<0.001	0.001
Chlordane, mg/kg	<0.001	<0.001	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001
Endrin, mg/kg	<0.001	<0.001	<0.001
Toxaphene, mg/kg	<0.01	<0.01	<0.01
Mirex, mg/kg	<0.01	<0.01	<0.01
Methoxychlor, mg/kg	<0.01	<0.01	<0.01

TABLE B-6

Results of Chemical Analyses of Sediment Samples Collected at Galveston Harbor Channel Disposal Area No. 1.

Parameter (Unit)	Test Result/Replicate 1	2	3
Solids, %	73.29	75.95	79.93
Arsenic, mg/kg	<2	2	<2
Cadmium, mg/kg	<1	<1	<1
Chromium, mg/kg	10	11	7
Copper, mg/kg	3	4	<2
Lead, mg/kg	5	5	<5
Mercury, mg/kg	0.16	0.16	0.18
Nickel, mg/kg	4	<2	<2
Zinc, mg/kg	2	2	13
Ammonia (N), mg/kg	5.2	4.6	4.7
Nitrate (N), mg/kg	4	7	2
Nitrite (N), mg/kg	<1	<1	<1
Total Kjeldahl (N), mg/kg	150	140	110
Oil and Grease, mg/kg	200	310	150
Aroclor - 1242, mg/kg	<0.01	<0.01	<0.01
Aroclor - 1254, mg/kg	<0.01	<0.01	<0.01
Lindane, mg/kg	0.001	0.001	<0.001
Heptachlor, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDD, mg/kg	<0.001	<0.001	<0.001
p,p^1-DDE, mg/kg	<0.001	0.001	0.001
p,p^1-DDT, mg/kg	<0.001	<0.001	<0.001
Chlordane, mg/kg	<0.001	<0.001	<0.001
Dieldrin, mg/kg	<0.001	<0.001	<0.001
Endrin, mg/kg	<0.001	<0.001	<0.001
Toxaphene, mg/kg	<0.01	<0.01	<0.01
Mirex, mg/kg	<0.01	<0.01	<0.01
Methoxychlor, mg/kg	<0.01	<0.01	<0.01

TABLE B-7

Results of Chemical Analyses of Seawater Samples Collected at Galveston Harbor Channel Station G-1.

Parameter (Unit)	Test Result/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	<0.1	0.5	<0.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	0.2	0.6	<0.1
Oil and Grease, mg/ℓ	1	1	2
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-8

Results of Chemical Analyses of Seawater Samples Collected at Galveston Harbor Channel Station G-2.

Parameter (Unit)	Test Result/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	<0.1	<0.1	<0.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	<0.1	<0.1	<0.1
Oil and Grease, mg/ℓ	4	2	1
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-9

Results of Chemical Analyses of Seawater Samples Collected at Galveston Harbor Channel Station G-3.

Parameter (Unit)	Test Result/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	<0.1	<0.1	<0.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	<0.1	<0.1	<0.1
Oil and Grease, mg/ℓ	1	2	2
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-10

Results of Chemical Analyses of Seawater Samples Collected at Galveston Harbor Channel Disposal Area No. 1.

Parameter (Unit)	Test Result/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	<0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	<0.1	<0.1	<0.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	<0.1	<0.1	<0.1
Oil and Grease, mg/ℓ	2	3	<1
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-11

Results of Chemical Analyses of Liquid Phase Elutriates of Dredged Materials Collected at Galveston Harbor Channel Station G-1.

Parameter (Unit)	Test Results/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	0.2	0.3	0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	2.8	3.4	3.9
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	5.6	5.6	4.5
Oil and Grease, mg/ℓ	1	<1	<1
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-12

Results of Chemical Analyses of Liquid Phase Elutriates of Dredged Materials Collected at Galveston Harbor Channel Station G-2.

Parameter (Unit)	Test Results/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	2.2	70	9.6
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	0.02
Ammonia (N), mg/ℓ	3.4	3.9	3.4
Nitrate (N), mg/ℓ	<0.02	<0.02	0.07
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	5.6	6.2	5.6
Oil and Grease, mg/ℓ	4	3	3
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE B-13

Results of Chemical Analyses of Liquid Phase Elutriates of Dredged Materials Collected at Galveston Harbor Channel Station G-3.

Parameter (Unit)	Test Results/Replicate 1	2	3
Arsenic, µg/ℓ	<10	<10	<10
Cadmium, mg/ℓ	<0.005	<0.005	<0.005
Chromium, mg/ℓ	<0.03	<0.03	<0.03
Copper, mg/ℓ	<0.02	<0.02	<0.02
Lead, mg/ℓ	<0.05	<0.05	<0.05
Mercury, µg/ℓ	<0.2	<0.2	0.2
Nickel, mg/ℓ	<0.02	<0.02	<0.02
Zinc, mg/ℓ	<0.02	<0.02	<0.02
Ammonia (N), mg/ℓ	1.1	1.2	1.1
Nitrate (N), mg/ℓ	<0.02	<0.02	<0.02
Nitrite (N), mg/ℓ	<0.01	<0.01	<0.01
Total Kjeldahl (N), mg/ℓ	1.5	1.4	1.1
Oil and Grease, mg/ℓ	1	2	4
Aroclor - 1242, mg/ℓ	<0.001	<0.001	<0.001
Aroclor - 1254, mg/ℓ	<0.001	<0.001	<0.001
Lindane, mg/ℓ	<0.001	<0.001	<0.001
Heptachlor, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDD, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDE, mg/ℓ	<0.001	<0.001	<0.001
p,p^1-DDT, mg/ℓ	<0.001	<0.001	<0.001
Chlordane, mg/ℓ	<0.001	<0.001	<0.001
Dieldrin, mg/ℓ	<0.001	<0.001	<0.001
Endrin, mg/ℓ	<0.001	<0.001	<0.001
Toxaphene, mg/ℓ	<0.001	<0.001	<0.001
Mirex, mg/ℓ	<0.001	<0.001	<0.001
Methoxychlor, mg/ℓ	<0.001	<0.001	<0.001

TABLE C-1

Statistical Analysis of Postlarval Mysidopsis almyra Suvival During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	8
2		9	6
3		9	8
	ΣX =	28	22
	$\bar{X}$ =	9.3	7.3
	SS =	0.7	2.7
	S^2 =	0.3	1.3

Cochran's Test for Homogeneity of Variances $C_{.05(k=2,v=2)}=0.9750$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{1.3}{1.6} = 0.8$$

t Test for Similarity of Means $t_{.05(4\ df)} = 2.13$

$$t = \frac{|\bar{X}_c - \bar{X}_{100}|}{\sqrt{[(S^2_c + S^2_{100})/n]}} = \frac{|9.3 - 7.3|}{\sqrt{[(0.3 + 1.3)/3]}} = 2.74$$

TABLE C-2

Statistical Analysis of Palaemonetes pugio Survival During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	9
2		10	10
3		10	10
	ΣX =	30	29
	$\bar{X}$ =	10	9.7
	SS =	0	0.7
	S^2 =	0	0.3

Cochran's Test for Homogeneity of Variances $C_{.05(k=2,v=2)} = 0.9750$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{0.3}{0.3} = 1.0$$

t Test for Similarity of Means $t_{.05\ (2\ df)} = 2.92$

$$t = \frac{|\bar{X}_c - \bar{X}_{100}|}{\sqrt{[(S^2_c + S^2_{100})/n]}} = \frac{|10 - 9.7|}{\sqrt{[(0 + 0.3)/3]}} = 0.95$$

TABLE C-3

Statistical Analysis of Menidia beryllina Survival During the Liquid Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-4

Statistical Analysis of Postlarval Mysidopsis almyra Survival During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		9	10
3		9	9
	ΣX =	28	29
	$\bar{X}$ =	9.3	9.7
	SS =	0.7	0.7
	S^2 =	0.3	0.3

Statistical analysis not required

TABLE C-5

Statistical Analysis of Palaemonetes pugio Survival During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		9	10
2		10	10
3		10	10
	ΣX =	29	30
	$\bar{X}$ =	9.7	10
	SS =	0.7	0
	S^2 =	0.3	0

Statistical analysis not required.

TABLE C-6

Statistical Analysis of Menidia beryllina Survival During the Suspended Particulate Phase Bioassay of Station G-1 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-7

Statistical Analysis of Survival of Postlarval Mysidopsis almyra During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	8
2		9	9
3		9	9
	ΣX =	28	26
	$\bar{X}$ =	9.3	8.7
	SS =	0.7	0.7
	S^2 =	0.3	0.3

Cochran's Test for Homogeneity of Variances $C_{.05(k=2,v=2)} = 0.9750$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{0.3}{0.6} = 0.5$$

t Test for Similarity of Means $t_{.05(4\ df)} = 2.13$

$$t = \frac{|\bar{X}_c - \bar{X}_{100}|}{\sqrt{[(S^2_c + S^2_{100})/n]}} = \frac{|9.3 - 8.7|}{\sqrt{[(0.3 + 0.3)/3]}} = 1.34$$

TABLE C-8

Statistical Analysis of Palaemonetes pugio Survival During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-9

Statistical Analysis of Menidia beryllina Survival During the Liquid Phase Bioassay of Station G-2 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-10

Statistical Analysis of Postlarval Mysidopsis almyra Survival During the Suspended Particulate Phase Bioassay of Station G-2 Dredged Materials:

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	9
3		9	10
	ΣX =	29	29
	$\bar{X}$ =	9.7	9.7
	SS =	0.7	0.7
	S^2 =	0.3	0.3

Statistical analysis not required

TABLE C-11

Statistical Analysis of Palaemonetes pugio Survival During the Suspended Particulate Phase Bioassay of Station G-2 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		9	10
3		9	10
	ΣX =	28	30
	$\bar{X}$ =	9.3	10
	SS =	0.7	0
	S^2 =	0.3	0

Statistical analysis not required

TABLE C-12

Statistical Analysis of Menidia beryllina Survival During the Suspended Particulate Phase Bioassay of Station G-2 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-13

Statistical Analysis of Postlarval Mysidopsis almyra Survival During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		7	9
2		8	8
3		9	7
	ΣX =	24	24
	$\bar{X}$ =	8	8
	SS =	2	2
	S^2 =	1	1

Statistical analysis not required

TABLE C-14

Statistical Analysis of Palaemonetes pugio Survival During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required.

TABLE C-15

Statistical Analysis of Menidia beryllina Survival During the Liquid Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required

TABLE C-16

Statistical Analysis of Postlarval Mysidopsis almyra During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		9	8
2		10	9
3		9	8
	ΣX =	28	25
	$\bar{X}$ =	9.3	8.3
	SS =	0.7	0.7
	S^2 =	0.3	0.3

Cochran's Test for Homogeneity of Variances, $C_{.05(k=2,v=2)}=0.9750$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{0.3}{0.6} = 0.5$$

t Test for Similarity of Means $t_{.05(4\ df)}=2.13$

$$t = \frac{|\bar{X}_c - \bar{X}_{100}|}{\sqrt{[(S^2_c + S^2_{100})/n]}} = \frac{|9.3 - 8.3|}{\sqrt{[(0.3 + 0.3)/3]}} = 2.24$$

TABLE C-17

Statistical Analysis of Palaemonetes pugio Survival During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	9
2		10	10
3		10	10
	ΣX =	30	29
	$\bar{X}$ =	10	9.7
	SS =	0	0.7
	S^2 =	0	0.3

Cochran's Test for Homogeneity of Variances $C_{.05(k=2,v=2)} = 0.9750$

$$C = \frac{S^2max}{\Sigma S^2} = \frac{0.3}{0.3} = 1.0$$

t Test for Similarity of Means $t_{.05(2\ df)} = 2.92$

$$t = \frac{|\bar{X}_c - \bar{X}_{100}|}{\sqrt{[(S^2_c + S^2_{100})/n]}} = \frac{|10 - 9.7|}{\sqrt{[(0 + 0.3)/3]}} = 0.95$$

TABLE C-18

Statistical Analysis of Menidia beryllina Survival During the Suspended Particulate Phase Bioassay of Station G-3 Dredged Materials.

		Number of Survivors	
Replicate		Control	100% Test Medium
1		10	10
2		10	10
3		10	10
	ΣX =	30	30
	$\bar{X}$ =	10	10
	SS =	0	0
	S^2 =	0	0

Statistical analysis not required.

APPENDIX D

(TABLES D-1 AND D-2)

PHYSICAL-CHEMICAL MEASUREMENTS

TABLE D-1

Range of Physical-Chemical Measurements During the 96 hr Static Bioassays of Galveston Dredged Materials.

TEST	TEMPERATURE (°C)	SALINITY (PPT)	pH	DISSOLVED OXYGEN (mg/ℓ)
G-1, Liquid Phase				
Postlarval Mysids	11-13	24-27	7.8-8.0	8.2-10.2(8.9)[1]
Grass Shrimp	10-11	24-25	7.8-7.9	2.7-9.1(7.8)
Silversides	9-13	25-26	7.9-8.1	8.4-10.2(9.0)
G-1, Susp. Part. Phase				
Postlarval Mysids	11-11	25-28	7.8-8.0	8.3-9.4(8.8)
Grass Shrimp	11-13	24-25	7.7-8.3	1.8-9.2(8.5)
Silversides	9-12	26-26	7.2-8.2	8.5-9.8(9.2)
G-2, Liquid Phase				
Postlarval Mysids	11-13	24-28	7.8-8.0	8.0-10.0(8.8)
Grass Shrimp	10-12	24-25	7.9-8.0	5.6-9.7(8.5)
Silversides	9-12	24-26	7.8-8.1	8.3-9.6(8.9)

[1] Values in parentheses are means

TABLE D-1 (CONT'D)

Range of Physical-Chemical Measurements During the 96 hr Static Bioassays of Galveston Dredged Materials.

TEST	TEMPERATURE (°C)	SALINITY (PPT)	pH	DISSOLVED OXYGEN (mg/ℓ)
G-2, Susp. Part. Phase				
Postlarval Mysids	11-12	24-28	7.7-8.1	7.0-10.5(8.9)[1]
Grass Shrimp	11-13	24-25	7.8-8.3	5.3-9.0(8.6)
Silversides	9-14	24-26	7.6-8.2	8.4-10.0(9.0)
G-3, Liquid Phase				
Postlarval Mysids	10-12	25-26	7.8-8.1	7.8-9.1(8.5)
Grass Shrimp	10-12	24-25	7.9-8.1	5.5-9.6(8.4)
Silversides	12-13	24-25	7.8-8.1	7.5-9.1(8.5)
G-3, Susp. Part. Phase				
Postlarval Mysids	11-11	25-28	7.8-8.2	8.6-9.3(8.9)
Grass Shrimp	12-15	24-25	7.8-8.3	7.4-9.0(8.6)
Silversides	9-13	24-25	7.7-8.0	7.7-9.4(8.7)

[1] Values in parentheses are means

TABLE D-2

Results[1] of Physical-Chemical Measurements During the Solid Phase Bioassay.

TIME	STATION				
Hr (days)	G-1	G-2	G-3	G-REF.	G-CONT.
0 hr (0)					
Temp (^{o}C)	13-18	12-15	12-15	13-15	13-18
D.O. (mg/ℓ)	7.3-8.2(7.8)[2]	7.5-8.1(7.9)	7.8-8.5(8.1)	7.5-8.4(7.9)	7.6-8.4(8.2)
Sal. (ppt)	24-29	26-30	26-30	26-29	25-27
24 hr (1)					
Temp.	11-14	11-14	11-14	12-15	11-14
D.O.	5.4-8.8(8.1)	7.5-8.7(8.3)	7.6-8.8(8.4)	7.5-8.8(8.2)	7.9-8.8(8.5)
Sal.	25-29	26-29	25-29	25-28	25-27
48 hr (2)					
Temp.	10-14	11-14	11-14	11-15	11-14
D.O.	7.3-8.6(8.1)	7.7-8.5(8.2)	7.0-8.7(8.2)	6.9-8.5(8.1)	7.5-8.7(8.3)
Sal.	26-28	26-30	26-29	26-28	26-27

[1] Values presented as range for all treatments and replicates

[2] Values in parentheses are means

TABLE D-2 (CONT'D)

Results[1] of Physical-Chemical Measurements During the Solid Phase Bioassay.

TIME	STATION				
Hr (days)	G-1	G-2	G-3	G-REF.	G-CONT.
72 hr (3)					
Temp	9-12	10-12	9-12	10-12	8-12
D.O.	7.6-8.9(8.2)[2]	7.3-9.0(8.4)	7.4-9.0(8.4)	7.2-8.6(7.9)	8.1-9.5(8.7)
Sal.	25-26	25-26	24-26	25-29	24-26
96 hr (4)					
Temp	9-12	9-12	8-12	10-12	8-12
D.O.	7.5-8.8(8.4)	6.9-8.8(8.4)	5.4-8.8(8.3)	7.1-8.7(8.3)	8.3-9.3(8.8)
Sal.	25-26	25-26	24-26	25-26	24-25
120 hr (5)					
Temp	11-13	11-13	11-13	12-13	10-14
D.O.	7.4-8.6(8.2)	8.0-8.6(8.3)	7.3-9.2(8.3)	7.1-8.7(8.3)	7.1-8.7(8.4)
Sal.	25-25	24-25	25-26	25-26	25-25

[1] Values presented as range for all treatments and replicates

[2] Values in parentheses are means

TABLE D-2 (CONT'D)

Results[1] of Physical-Chemical Measurements During the Solid Phase Bioassay.

TIME	STATION				
Hr (days)	G-1	G-2	G-3	G-REF.	G-CONT.
144 hr (6)					
Temp.	11-13	11-13	10-13	11-13	10-13
D.O.	7.6-9.1(8.4)[2]	8.1-8.8(8.6)	6.9-9.0(8.5)	8.1-9.0(8.6)	8.2-9.3(8.8)
Sal.	25-25	25-25	25-25	25-26	25-25
168 hr (7)					
Temp.	11-13	11-14	11-14	11-13	10-14
D.O.	7.4-8.4(8.1)	7.9-8.6(8.3)	7.4-8.6(8.2)	7.4-8.5(8.1)	5.7-8.7(8.3)
Sal.	24-25	24-25	24-25	24-26	24-25
192 hr (8)					
Temp.	11-14	11-14	12-14	12-13	11-14
D.O.	8.0-8.8(8.4)	8.3-8.9(8.6)	8.2-8.7(8.5)	8.0-8.6(8.4)	8.0-9.0(8.6)
Sal.	25-26	25-26	25-26	25-27	25-25

[1] Values presented as range for all treatments and replicates

[2] Values in parentheses are means

TABLE D-2 (CONT'D)

Results[1] of Physical-Chemical Measurements During the Solid Phase Bioassay.

TIME	STATION				
Hr (days)	G-1	G-2	G-3	G-REF.	G-CONT.
216 hr (9)					
Temp.	11-14	10-13	10-13	11-13	9-13
D.O.	8.1-8.9(8.5)[2]	8.4-8.8(8.6)	8.4-8.8(8.6)	8.1-8.8(8.5)	8.3-9.4(8.8)
Sal.	25-26	25-26	25-26	25-25	25-25
240 hr (10)					
Temp.	9-12	10-12	9-12	10-12	9-13
D.O.	8.3-9.3(8.8)	8.4-9.2(8.8)	8.6-9.2(8.8)	7.9-9.0(8.7)	8.4-9.4(9.0)
Sal.	24-26	25-26	25-26	25-25	25-25

[1] Values presented as range for all treatments and replicates

[2] Values in parentheses are means