

Chemical and Toxicological Characterization of the Lower Mobjack Bay, York River, Virginia Segment of the Chesapeake Bay

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ABSTRACT

The Chesapeake Bay segment called Lower Mobjack Bay Lower York River Virginia was found to have insufficient data to characterize in 1999. Therefore this area was selected for a chemical, toxicological, benthic community characterization study of the sediments in 2002. The segment was divided into 3 strata: the lower York River, the Poquoson River, and Back River, each with 4 randomly selected stations. Samples were collected in October 2002 for evaluation of conditions.

There were few significant chemical exceedances of the ER-L or ER-M in the three strata and no toxicologically effects from exposure to sediment samples from any stratum. In contrast, the Poquoson and Back River strata showed consistent community degradation ranging from degraded to seriously degraded. The lack of chemical and toxicological impacts and the intensive residential land use makes it reasonable to conclude that the likely explanation for the degraded benthic community is eutrophication. There is not, however, confirmatory data for this interpretation.

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To accomplish any complex task requires many individuals each contributing to some portion of the overall effort, and this project is no exception.

We are indebted to Dan Dauer and Bud Rodi for the evaluation of station sites for chemical and toxicological evaluation while they collected benthic community samples from the selected sites. The benthic community samples served as one leg of the sediment triad analysis.

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The chemical analyses of sediment samples were performed by unnamed individuals at the Division of Consolidated Laboratories.

Georgi Briggs provided day-to-day oversight of the toxicity tests. John Clements and Lynda Lawrence assisted with test set up, daily water quality measurements and observations and final teardown of the tests. Pam Blasco helped with preparation of the toxicity test report.

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1.0 INTRODUCTION

1.1 Need for Regional Characterization

For over a decade, the Chesapeake Bay Program, through its Toxics Subcommittee, supported a series of studies designed to characterize sections of the Bay from both a chemical and toxicological perspective. Beginning with the pilot studies of Hall *et al.* (1991, 1992, 1994 and 1997) and continuing through the ambient toxicity reports of 2000 (Hall *et al.* 1998a, 1998b, 2000a, 2000b, Roberts *et al.* 2000, McGee *et al.* 2001, Roberts *et al.*, 2002) and 2002 (Roberts *et al.*, 2002), many areas of the Bay system have been characterized from the mouth to the tidal limits. Focused on the major and minor tributaries of the bay, none of these reports placed a single station within the bay segment as defined by EPA as the Lower Mobjack Bay, Lower York River, Virginia (MOB-PH) including Back and Poquoson Rivers.

In the characterization report for the Chesapeake Bay (U.S. EPA, 1999), some significant areas were identified as lacking sufficient data to be characterized. Included among these areas in Virginia was the Lower Mobjack segment of the bay (south of the York River Mainstem) and its major tributaries, the Poquoson and Back Rivers.

Chemical data pertaining to this segment is limited to occasional sediment samples analyzed for chlorinated pesticides, SVOCs and PCB (Bieri *et al.*, 1982). No toxicologically significant amounts of contaminants were detected in these analyses. Hale and his team (Hale *et al.*, 1991; Gallagher *et al.*, 1993) identified polychlorinated terphenyls (PCT) in the Northwest Branch of Back River and mapped their distribution in the late 1980's. PCT are a class of chemicals analogous to PCB with three instead of two phenol rings. They demonstrated that the PCT came from the NASA facility on the NASA-Langley facility. Though no longer used at the facility, PCT, like PCB, are persistent bioaccumulable organic chemicals that are toxic to organisms, though not likely to cause mortality at any reasonable environmental concentration. Roberts and Vogelbein (1990) found no toxicity in some sediment samples from the area known to be contaminated with PCT. Three stations in Back River were revisited in 1998 as part of an evaluation by the Water Quality Standards and Biological Programs within the Office of Water Quality Programs of the DEQ, PCTs were not observed in two fish species and blue crabs collected at each station. PCTs were also not observed in sediment samples collected from each site.

Diaz *et al.* (1985; Roberts and Diaz, 1986) in a study of the effect of alum released into tidal waters, studied three areas, one of which is in this bay segment (the upper reach of the Poquoson River). One important component in this study was a benthic community analysis. They concluded that the benthic community observed was consistent with what one would expect in a tidal brackish water system in Virginia.

1.2 Objectives

- Assess ambient sediment chemistry and toxicity in Lower Mobjack segment of the Chesapeake Bay
- Assess the condition of the benthic community
- Characterize the condition of sediment in this segment of the Chesapeake Bay.

2.0 MATERIALS AND METHODS

2.1 Station Selection

The study area was arbitrarily divided into three strata with a total of 12 stations selected for sediment quality triad evaluation within the area. The large open water portion of the system was defined as Stratum 1 with 4 stations. The Poquoson River and Chisman Creek system was defined as Stratum 2 with 4 stations. The Back River system was defined as Stratum 3 with 4 stations. Thus the tributaries wherein there is more intense land use were sampled more intensively than the open water area with free water exchange with adjacent open water areas.

Stratum 1, the Lower Mobjack, York River section as defined by EPA (1999), is the open water area lying between Mobjack Bay on the north and the James River on the south. The York River drains through this Bay section. The Poquoson and Back Rivers also drain into this Bay section. To the east, the Bay section freely connects to the main stem of the Chesapeake Bay.

The Poquoson River (Stratum 2) originates at Harwood's Mill Dam that creates Harwood Mills Reservoir, flooding the former upland sources of the Poquoson. Fringed along its length by *Spartina* marshes and residential development, the primary inputs are those associated with residential development, ameliorated in some areas by the purification effects of the fringing marsh. Until 1984, a water plant located at the dam discharged alum. Alum (aluminum sulfate) was used as the coagulant for the filtration tanks at the plant. Alum sludge was then discharged into the Poquoson aperiodically. No significant accumulation of alum sludge was demonstrated in the river (Diaz *et al.* 1985, Roberts and Diaz, 1986). Further, the benthic community in the creek was typical for such soft-bottom systems in Virginia. Algal mats that occur within the river were attributed to excess nutrients from the residential community. The lower reaches of the river and its tributary, Chisman Creek, drain substantial residential areas to the north and south in York County. It is these lower reaches that are addressed in the present study.

The Back River drains the Langley Air Force Base and the NASA Space Center. These industrial sites have long been a suspected source for various chemicals known to produce adverse effects on biota. Metals (especially copper), polycyclic aromatic hydrocarbons (PAH), and polychlorinated biphenyls (PCB) were specifically mentioned as significant in this tributary (EPA, 1999). No mention was made of the finding of PCT by Hale *et al.* (1991; Gallagher *et al.*

1994). The creek also drains substantial residential areas of the City of Poquoson (north shore of Northwest Branch), the City of Hampton and York County (headwaters of Northwest Branch), and the City of Hampton (south shore and headwaters of Southwest Branch). Nutrient enrichment and various pesticides and herbicides are therefore likely contaminants.

Roberto Llanso of Versar specified 25 random station locations within stratum 1 and 10 random station locations within each of the other strata. The sampling cruise for the benthic community sampling, which predated the sampling cruise for the remaining portions of the study constituted a reconnaissance cruise for the chemical and toxicological sampling. Three criteria were used in station selection: 1) accessibility (depth sufficient to allow the research vessels to access the location), 2) sediment texture (sand content <70-80%) and 3) anaerobic layer present (a dark layer indicating substantial TOC, low oxygen content and high sulfides in sediments). The latter two criteria define areas where various contaminants are likely to be accumulated.

Final station selections are listed in Table 1 and plotted in Figure 2.1 along with the strata demarcations. Stations in the Lower York (Stratum 1) were code named MOBPHTOX followed by the random station number. Stations in stratum 2 and 3 are code named for the creek or watershed and assigned a number corresponding to the distance of the station from the watershed mouth. Twelve of the first 16 random sites in Stratum 1 were rejected using the aforementioned textural criterion as this stratum has a sand/shell bottom over much of its area. Fewer sites were rejected in stratum 2 or 3 the sediment textural criterion. These tributaries have a large proportion of fine grained bottom. In all three strata, no stations were rejected because they were inaccessible by boat.

Table 2.1. Station locations for the Lower Mobjack Bay, York River, Virginia.

Station Designation	Latitude	Longitude	Major Landmarks	Depth at MLW (ft)
Stratum 1				
MOBPHTOX-2	37°12'33.38"	-76°17'57.74"	Chesapeake Bay Mainstem – Poquoson Flats	31
MOBPHTOX-3	37°12'31.76"	-76°21'9.17"	Chesapeake Bay Mainstem – Poquoson Flats	22
MOBPHTOX-9	37°14'26.41"	-76°16'21.68"	Chesapeake Bay Mainstem – York Spit	22
MOBPHTOX-16	37°15'29.02"	-76°16'56.13"	Chesapeake Bay Mainstem – York Spit	24
Stratum 2				
7-POQ000.38	37°10'2.76"	-76°24'18.16"	East of Hodges Cove	14
7-POQ002.33	37° 8'57.58"	-76°25'26.16"	Mid channel east of Hunter Creek (between two points).	7
7-POQ002.90	37° 8'30.1	-76°25'40.08"	Mid channel east of Quarter March Creek	6
7-CHS000.54	37°10'53.39"	-76°24'40.16"	Mid channel north of Boathouse Creek.	8
Stratum 3				
7-NWB001.14	37° 6' 34.97"	-76°21'32.43"	Mid Channel North of Tabbs Point	2
7-NWB002.24	37° 6'47.5"	-76°22'17.5"	Immediately offshore from Cedar Point.	1
7-SWB001.31	37° 4'19.39"	-76°20'15.6"	Eastern Shore, Northeast/east of 278 bridge	1
7-BAK002.18	37° 5'36.4"	-76°20'20.7"	North of Willoughby Point	5

2.2 Sediment Collection

Sediment samples for all analyses were collected between 9 and 17 October 2002. These samples were collected by crews from the DEQ Central Office and the Tidewater Regional Office.

Samples were collected from three randomly chosen sites within a 100 by 100 m grid centered on the coordinates for each station. The upper 2 cm of sediment were retained for chemical analyses and toxicological tests. Multiple grabs were made at each point with a Ponar grab until sufficient sediment had been collected for both chemical and toxicological characterizations. Sediment was then homogenized and distributed among the sample containers. At each station, sediment samples were collected from three subsidiary sites for toxicity studies in order to evaluate field variability. Samples for particle size and total organic carbon (TOC) from each sample site were stored and analyzed separately. AVS/SEM samples were collected and stored separately, but composited before analysis under nitrogen in order to avoid oxidation of the material prior to analysis.

All samples were placed on ice and transported to the testing laboratories with delivery on the day of collection or early the following day. Once in the testing laboratories, all sediment was maintained in a 4°C cold room prior to processing and analysis. The samples for toxicity evaluations were tested within the 14-day holding time specified in the protocols.

While at each station, a Hydrosonde III was deployed to measure surface and bottom temperature (°C), conductivity ($\mu\text{mhos}/\text{cm}^2$), salinity (g/kg), dissolved oxygen (mg/l), pH (S.U.) and sampling depth (m). Surface conditions were measured at ca 0.3 m below the water surface, and bottom conditions at about 1 m above the sediment. For stations deeper than 6 m, the parameters were also measured at mid-depth. Thus these parameters were evaluated at three depths for all open-water stations but none of the inshore stations.

Control sediment for the toxicity tests was collected from Oldhouse Creek-Ware River-Chesapeake Bay (37°21'23.9"N, 76°26'52.1"W) by CBI. Although ambient water conditions were not measured during the sampling event, the porewater salinity for the control sediments was unusually low, only 12 ppt (usually around 20 ppt). The overlying water salinity at this site typically ranges from 10 to 25 ppt. The low porewater salinity reflects relatively low salinity of the overlying water for the period prior to collection probably as a result of unusually high rainfall. Sediment was dominated by clay (52.5%) and silts (34.6%) and had a sand content of 12.9%. Total Organic Carbon was 2.79%. Sediments were stored at 2-4°C until used in toxicity tests. Sediment from this site has been used previously for toxicity test reference tests.

2.3 Chemical Analyses

Sediment samples for bulk metal analyses were oven dried, weighed, and digested in nitric and hydrochloric acids by microwave technology. After cooling, the samples were brought up to 50 ml volume, mixed and allowed to settle overnight prior to analysis. From the digested sample,

metals are analyzed by ICPMS. The following elements are analyzed by this method: Al, Sb, As, Be, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, Tl, and Zn. In addition, acid volatile sulfides and simultaneously extractable metals (AVS/SEM) were determined on separate sediment aliquots using the methods of Leonard *et al.* (1996, 1999). These aliquots consisted of the composite of three independent samples, one from each substation, that were homogenized under nitrogen in the analytical laboratory.

Various organic chemicals in sediments were determined including semi-volatile organic compounds (SVOC), organophosphate pesticides, organochlorine pesticides, polychlorinated biphenyls (PCB), and herbicides. For SVOCs, sediment samples were ground with anhydrous sodium sulfate and Soxhlet extracted with methylene chloride for 18 to 24 hours. The extracts were concentrated and the sulfur content reduced using high performance GPC on porous styrene-divinylbenzene copolymer gel. The extracts were then concentrated and fractionated on a semipreparative aminosilane HPLC using step gradients; this resulted in three fractions containing broad compound classes ranging from aliphatic to polar. The fractionated extracts were then analyzed by capillary gas chromatography / mass spectrometry.

A flame photometric detector (FPD) operating in the phosphorous mode was used to identify and quantitate organophosphates. A halogen specific detector (XSD) was used to measure organochlorine pesticides and polychlorinated biphenyls (PCB). Polychlorinated ter-phenyls (PCT) were not included in the analyte list and hence not determined, though they may have been present in the fraction analyzed for PCB.

Portions of the extracts were subjected to water/ methylene chloride partitioning to remove residual acid and water-soluble interferences. The extracts are then methylated, concentrated to volume, and analyzed by gas chromatography utilizing a halogen specific detector (XSD) to identify and quantitate herbicides. Herbicides, however, could not be quantitated due to matrix interference with sulfur

Methods are fully described in the work plan submitted for this project.

2.4 Sediment Analyses

Sediment texture on composite subsamples from the field stations was determined by the Division of Consolidated Laboratory Services (DCLS) using the Folk (1980) method. A sediment sample is dried and passed through geological screens: 4 mm and 62.5 μm . Material retained on the 4 mm sieve represents gravel (weight not determined), and that passing the 4 mm sieve but retained on the 62.5 μm sieve is sand. The remainder of the sediment passing through the finest sieve is moistened and suspended in water. At fixed times after complete mixing, samples are drawn from specified depths, placed in tared weighing pans, dried and weighed. From this information, the amount of silt and clay can be calculated.

A subsample of the sediment was dried, weighed, incinerated, and reweighed to determine the dry weight and ash-free dry weight. The difference is the total organic carbon that is then expressed as a percentage of the original sample weight.

Coastal Bioanalysts measured percent pore water, porewater ammonia, and porewater pH for each sediment replicate from each station used for the toxicity tests. This provided the information to assess whether there was a toxicologically significant amount of ammonia released from the sediment or a deleterious pH.

2.5 Toxicological Analyses

Sediment preparation:

Samples were received in the laboratory from 10/9/02 to 10/17/02. In the laboratory a test identifying number from 1-37 was randomly assigned to each sample and laboratory control sediment. Laboratory control sediment was collected on 10/15/02 from Oldhouse Creek-Ware River-Chesapeake Bay (37°21'23.9" N, 76°26'52.1" W). Sediment samples were stored at 2-4° C until used in toxicity tests."

Prior to use in tests, samples were examined for the presence of potential predators and species similar to the test species, homogenized and large debris (e.g. sticks and shell) was removed. Because many samples contained polychaetes (potential predators of amphipods) as well as indigenous amphipods, sediments from all stations were press sieved through a 500 um mesh sieve. Aliquots of homogenized sample were collected for measurement of pore water pH, salinity and ammonia nitrogen.

Approximately 200 ml of sediment was placed in each 1-l glass test chamber and overlain with 750 ml of dilution water. The dilution water was laboratory control water consisting of synthetic seawater prepared using Wimex Hawaiian Marine Mix and ASTM Type I deionized water. The salinity of the synthetic seawater was 20 g/kg. As prepared, the pH was 7.83 and the dissolved oxygen was 7.3 mg/l. After a 1-day settling time, tests were initiated by adding test animals.

Test Organisms:

Amphipods (*Leptocheirus plumulosus*) used in the tests were hand delivered to the laboratory from Chesapeake Cultures, Hayes, VA. Amphipods were collected using stacked 710 um and 500 um mesh stainless steel sieves. The animals retained on the 500 um screen (3-5 mm in length) were used for tests. Amphipods were fed Tetramin[®] slurry *ad libitum* during the holding period prior to use in tests.

Sheepshead minnow (*Cyprinodon variegatus*) embryos, purchased from Aquatic Biosystems, Fort Collins, CO, were delivered to the laboratory by overnight courier. Embryos were obtained from natural spawning of cultured stock maintained at 25° C. Spawning occurred from 20 October 2002 (1530) to 21 October 2002 (1400) to provide embryos less than 48-h old used to initiate tests on 22 October 2002 at 1230. Prior to use in the tests, embryos were sorted with the aid of a stereomicroscope to insure that only viable, well-formed embryos were added to test chambers.

Test protocols:

Tests with each species were conducted in accordance with CBI SOPs STS003-AMB and STS0020-AMB. Summaries of essential elements of these test methods are provided in Tables 2.2a-b. Sediment and water were added to exposure chambers the day prior to addition of animals. Each chamber was then aerated by a stream of ca 100 bubbles/min introduced through Pasteur pipettes with tips positioned at mid depth.

Amphipod tests were static tests initiated on 22 October 2002. Amphipods were impartially distributed to portion cups containing ca. 20 ml dilution water until each cup contained 20 animals. The test was initiated by pouring the contents of one cup into each test chamber. Initial dry weights were obtained for three groups of 20 animals in portion cups selected from the beginning, middle and end of the portion cup array. Amphipods were fed 0.75ml YCT/chamber/day. Dead and emergent amphipods were noted daily. After a 10-day exposure, the contents of each chamber were wet sieved through a 500 μ m mesh sieve to recover the amphipods. Live amphipods were counted and transferred to plastic portion cups with a minimal amount of dilution water. Animals were killed by addition of several drops of 6 N HCl, washed onto a screen mesh to eliminate acidity and water, and transferred to small (5-9 mg) tared aluminum foil pans. After drying overnight at 100°C, dry weights were measured to the nearest 0.01 mg and the mean weight per individual calculated.

Sheepshead minnow embryo tests were also initiated on 22 October 2002. These tests were conducted as daily renewal tests lasting 10 days. Embryos were exposed in egg baskets made of 3" diameter PVC thin-wall pipe with 200 μ m Nitex solvent-welded to one end. The egg baskets were placed in the test chambers, screen end down and pushed slightly into the sediment surface. Twenty embryos were added to each egg basket. Each day until egg hatching was complete, the baskets were removed from the test chambers and placed in a dish of clean dilution water. Viable embryos (those that did not show obvious signs of mortality such as cloudiness, shrinkage, etc.) were rinsed of debris. Viable embryos and hatchlings were tallied daily. Obviously dead embryos were removed and discarded. After returning the egg basket to the test vessel, approximately 50% of the water was removed and replaced with fresh dilution water. *Artemia* nauplii were added to each test chamber at a rate of 0.1 g/chamber beginning on test day 6. The feeding rate was never increased because the hatch rate was slower than anticipated. The surviving fish fry in each test chamber were counted on day 10 to terminate the test. The viability of remaining embryos was determined by the presence of a well-formed embryo with an observable heartbeat when examined under a stereomicroscope.

Table 2.2a. Required conditions for 10-day sediment toxicity tests with *Leptocheirus plumulosus*.

TEST TYPE:	Whole sediment
RENEWAL FREQUENCY:	None for sediment or overlying water
REPLICATES:	3 with 20 animals each
RANDOMIZATION:	Test chambers arranged in randomized block (by replicate) design
TEST CHAMBERS:	1000 ml glass beakers
SEDIMENT VOLUME:	200 ml (2 cm)
OVERLYING WATER VOLUME:	750 ml
OVERLYING WATER:	Clean synthetic seawater at 20 ppt
TEMPERATURE:	25 ± 1°C
SALINITY:	20 g/kg
PHOTOPERIOD:	16 hr light: 8 hr dark
LIGHT INTENSITY:	10-20 µE/m ² /s (500-1000 ft-c) (ambient laboratory illumination)
SIZE AND LIFE STAGE OF AMPHIPODS:	3-5 mm, no mature males or females ¹
FEEDING:	YCT 0.75 ml/beaker/day
AERATION:	Aerate all chambers (100 small bubbles/min); overnight before start of test, and throughout test; trickle-flow aeration maintains >40% saturation of dissolved oxygen
WATER QUALITY MEASUREMENTS:	Total water quality (ammonia, pH, salinity, D.O., temperature) days 0 and 9 or 10 each treatment; temperature, D.O. pH, salinity daily on one replicate/treatment.
TEST DURATION:	10 days
TEST TERMINATION:	Tally survival
ENDPOINTS:	Survival and growth (dry weight)
ACCEPTABILITY CRITERIA:	Control survival >80%
SAMPLE HOLDING TIME:	2 weeks
TEST TREATMENTS:	Site, control, and reference sediment

¹A concurrent acute reference test using the same batch of animals is performed using KCl as the reference toxicant.

Table 2.2b. Required conditions for 10-day sediment toxicity tests with *Cyprinodon variegatus*.

TEST TYPE:	Static renewal, whole sediment
RENEWAL FREQUENCY:	Daily renew 50% of overlying water
REPLICATES:	3 with 10 animals each (i.e. 30 animals/sample tested)
RANDOMIZATION:	Test chambers arranged in randomized block (by replicate) design
TEST CHAMBERS:	1000 ml beakers, borosilicate glass & PVC-Nitex egg baskets
SEDIMENT VOLUME:	200 ml sediment
OVERLYING WATER VOLUME:	750 ml
OVERLYING WATER:	Synthetic seawater at 20 ppt
TEMPERATURE:	25 ± 1°C (23.5-26.4°C)
SALINITY:	20 g/kg
PHOTOPERIOD:	16 h light/8 h darkness
LIGHT INTENSITY:	10-20 µE/m ² /s (50-100 ft-c) (ambient laboratory illumination)
AGE:	≤ 48 h post-fertilization ¹
FEEDING:	Newly hatched (<24 h) <i>Artemia</i> nauplii; 0.1 g/replicate days 3-6 (earlier if hatching occurs); 0.15 g/replicate days 7-9
AERATION:	Aerate all chambers (100 small bubbles/min); overnight before start of test, and throughout test; trickle-flow aeration maintains >40% saturation of dissolved oxygen
CLEANING:	Siphon excess food and other debris daily and during renewal
WATER QUALITY MEASUREMENTS:	Temperature, salinity, pH, D.O. daily in one replicate of both “old” and “new” solution
TEST DURATION:	10 days
TEST TERMINATION:	Tally survival
ENDPOINTS:	Embryo and fry survival, egg hatching
ACCEPTABILITY CRITERIA:	Control survival >80%
SAMPLE HOLDING TIME:	2 weeks
TEST TREATMENTS:	Site, control, and reference sediment

¹A concurrent acute reference test using the same batch of animals is performed using KCl as the reference toxicant.

Data Analysis:

Endpoints for amphipods were total proportion surviving (number survivors/number exposed in replicate), dry weight (pooled replicate dry weight/number survivors in replicate) and total number observed emergent animals (a measure of sediment avoidance). Endpoints for minnows were proportion hatching (cumulative number hatched/initial number exposed in replicate) and hatched (post hatch) proportion surviving (number survivors/number eggs hatched in replicate).

Test data were analyzed using the Minitab (1995; version 10Xtra) statistical software package. Proportionate data (e.g. survival) were transformed as the arcsine of the square root of the proportion to obtain a more normal distribution. Data for amphipod growth, which did not exhibit a normal distribution in the untransformed state, were transformed using the base 10 logarithm. Fish hatch data were quantitatively analyzed only for test day ten because of an apparent delay in hatch. Because hatched proportion surviving was equal to proportion hatched in all test chambers except one (MOBPH.16A, replicate 2) the former endpoint was not analyzed.

Data were tested for normality and homogeneity of variance using the Ryan-Joiner (similar to Shapiro-Wilkes) and Bartlett's tests ($p = 0.01$), respectively, prior to hypothesis testing to determine if the assumptions of the test method were met. The following hypotheses were tested:

H_0 (#1): Laboratory Control < Field Sample

H_0 (#2): All Stations Equal

H_0 (#1) was tested using Dunnett's test ($p = 0.05$) in which all samples were compared against the laboratory control sediment. H_0 (#2) was tested using a nested one-way ANOVA (field replicates within stations). Non-parametric data sets (i.e. fish embryo hatch) were tested using the Kruskal-Wallis test for both hypotheses.

Printouts of statistics are included in Appendix B of the Coastal Bioanalysts report dated 27 November 2002. Tests of H_0 (#1) are labeled "Samples" for analyses at the field replicate or sample level and tests of H_0 (#2) are labeled "Stations" for analyses at the station level.

Quality Control:

A reference toxicant test was conducted concurrently with each sediment toxicity test using the same lot of organisms. Potassium chloride was used as the reference toxicant. Tests were static and 48 h (*C. variegatus*) or 96 h (*L. plumulosus*) in duration. LC50 values of the concurrent reference toxicant tests were compared with the mean value and 95% confidence limits of reference toxicant tests conducted previously in this lab using the same species and exposure duration.

2.6 Benthic Community Sampling

All twelve random stations save one were sampled on 4 September 2002; the final station was sampled on 16 September 2002. Four random stations were selected within each stratum (Back River, Poquoson River, and lower “Mobjack Bay”). Stations were sampled if there was a near-surface anaerobic layer (suggesting the presence of TOC) and sand content was less than 70-80%.

Two Young grab samples (area of 440 cm²) were obtained from each station. One sample was sieved through a 0.5 mm screen, and the retained material was preserved in the field by adding Rose Bengal in formaldehyde. The specimens were removed from the sediment, sorted to taxon, enumerated, and identified to the lowest possible taxon. Each taxon was then dried, weighed, and reweighed after incineration to determine ash-free dry weight biomass (AFDW). The second sample was used to characterize the texture of the sediment using the method of Folk (1980). Percent silt-clay, percent sand, and volatile solids were calculated.

2.7 Benthic Community Analysis

Weisberg *et al.* (1997) defined the Benthic Index of Biotic Integrity (B-IBI) for various habitats in the Chesapeake Bay system. The index is based on various metrics such as Shannon-Wiener Diversity Index, abundance, species numbers, life mode, pollution tolerance, pollution sensitivity, ash-free dry weight, and other community parameters (Dauer and Rodi, 2001; Alden *et al.* 2002) which are scored and averaged. These measures are compared to values expected at non-polluted sites of similar water and sediment quality, a rank is established for each measure and the mean range calculated as the B-IBI.

3.0 RESULTS

3.1 Water quality:

Surface water temperature ranged from 18.9-20.9°C, normal for the fall season (Table 3.1). Bottom temperatures were generally similar independent of whether the stations were shallow (1 m) or deep (8-10 m).

Within the shallow creeks, salinity varied little from surface to bottom. There was a slight but measurable decrease in salinity with distance upstream of the creek mouth. The surface salinity in the Lower York stratum ranged from 24.5 to 25.1 ppt. There was minimal depth stratification. The surface to bottom salinity gradient ranged from 0.3 to 1.7 ppt.

Oxygen concentrations in the creeks ranged from 6.26 to 8.33 mg/l at the surface in the two creeks. There was little difference in oxygen concentration from surface to bottom. In the Lower York River stratum, the surface oxygen concentration ranged from 7.36 to 7.82 mg/l. At two stations, 7-MOBPHTOX-3 and 7-MOBPHTOX-9, the oxygen concentration was 1-2 mg/l lower at the bottom than the surface, but the mid-depth concentration was close to the surface concentration. Thus there was no hypoxia at the time of sampling.

The pH was in the mid 7's with no substantial difference with depth or upstream distance. The creeks and offshore stations were similar in pH.

Table 3.1. Water quality measured at the time of collection at each station.

Sampling Date	Station	Sample Location	Temperature (°C)	Conductivity (µmhos/cm)	Salinity (g/kg)	DO (mg/L)	pH	Depth (Meters)	Weather Condition
10/9/2002	7-NWB001.14	Surface	20.9	39,100	24.9	7.04	7.62	0.3	Cloudy, low 60's Northwest Wind
		Bottom	20.9	39,100	24.9	7.13	7.59	1.7	
	7-NWB002.24	Surface	19.9	37,400	23.7	6.26	7.26	0.3	Cloudy, low 60's Northwest Wind
		Bottom	19.9	37,400	23.7	6.55	7.17	1.1	
	7-SWB001.31	Surface	20.7	38,600	24.6	7.96	7.88	0.3	Cloudy, low 60's Northwest Wind
		Bottom	20.7	38,600	24.6	7.80	7.71	1.4	
	7-BAK002.18	Surface	20.8	39,400	25.2	7.31	7.89	0.3	Cloudy, low 60's Northwest Wind
		Bottom	20.6	39,700	25.3	7.21	7.88	2.5	
10/15/2002	7-POQ000.38	Surface	18.9	38,200	24.3	7.27	7.47	0.3	Cloudy, low 50's Northeast wind
		Bottom	18.1	38,600	24.5	6.98	7.33	4.5	
	7-POQ002.33	Surface	18.9	36,800	23.3	7.72	7.45	0.4	Cloudy, low 50's Northeast wind
		Bottom	18.7	37,200	23.6	7.49	7.34	3.3	
	7-POQ002.90	Surface	18.9	36,500	23.0	8.33	7.56	1.0	Cloudy, low 50's Northeast wind
		Bottom	18.8	36,800	23.3	8.14	7.41	1.9	
	7-CHS000.54	Surface	19.7	38,200	24.3	6.60	7.46	0.3	Cloudy, low 50's Northeast wind
		Bottom	19.9	38,300	24.4	6.45	7.36	3	

Table 3.1 (Con't.). Water quality measured at the time of collection at each station.

Sampling Date	Station	Sample Location	Temperature (°C)	Conductivity (µmhos/cm)	Salinity (g/kg)	DO (mg/L)	pH	Depth (Meters)	Weather Condition
10/17/2002	MOBPHTOX-2	Surface	19.6	38,900	24.8	7.82	7.53	0.3	Sunny, low 60's Northwest wind
		Mid-depth	19.7	39,500	25.2	7.38	7.46	5	
		Bottom	20.5	41,000	26.3	7.30	7.40	10	
	MOBPHTOX-3	Surface	19.9	39,300	25.1	7.82	7.63	0.3	Sunny, low 60's Northwest wind
		Mid-depth	19.8	39,400	25.1	7.70	7.63	3.3	
		Bottom	19.6	39,800	25.4	5.92	7.49	6.5	
	MOBPHTOX-9	Surface	19.6	38,600	24.5	7.36	7.47	0.3	Sunny, mid 50's Northwest wind
		Mid-depth	19.6	38,600	24.6	7.17	7.46	4.0	
		Bottom	20.4	40,500	25.9	6.64	7.43	8.0	
	MOBPHTOX-16	Surface	19.8	38,700	24.6	7.43	7.35	0.3	Sunny, low 50's Northwest wind
		Mid-depth	19.8	38,700	24.7	7.45	7.33	4.0	
		Bottom	20.1	39,200	25.0	7.42	7.29	8.0	

3.2 Sediment Characteristics:

Sediments at the Back River stations were dominated by silts and clay (Tables 3.2 and 3.3). The two most upriver stations had the highest sand content at 30-40%. Similarly, sediments from the Poquoson River stations were predominantly silts and clay except for 2 substations at 7-POQ002.33 with sand content of 60-75%. In contrast, the sediments from the lower York River stations were dominated by sand (78-92% sand) except at station MOBPHTOX-3 (32-42% sand).

In general the inshore strata had sediments with 1-2% TOC, whereas the offshore stratum had sediments with <1% TOC. The AVS measurements were consistent with the measured TOC in the Poquoson and lower York sediments, but were unreasonably low for the measured TOC in the Back River sediments. A review of the primary data provides no insight into why the measured AVS was at or below the detection limit within this creek. Further, sediments collected from within the Back River system in the late 1980's (Roberts, unpublished) were black as with sulfides and had a sulfurous smell, though no AVS measurements were made.

3.3 Chemical Characterization

3.31 Metals

Concentrations of antimony, beryllium, cadmium, mercury, selenium, silver, and thallium were at or below the appropriate detection limits (Table 3.3). Arsenic and copper exceeded the ER-L but not the ER-M at two stations (7-POQ002.90 and 7-CHS000.54). Concentrations of all other metals that exceeded the detection limit were well below the ER-L when defined. Concentrations of aluminum, iron, selenium and magnesium were relatively low.

As noted above, the AVS values for the Back River stratum are below expected concentrations, even at the one station for which there was a value above the detection limit. For those stations at which AVS and SEM were measured, the SEM/AVS ratios are extremely low (<0.3), indicating a substantial capacity to bind with additional metals.

3.3.2 Semi-Volatile organic compounds (SVOC)

In general, the concentrations of SVOCs were low, and typically below detection. Three categories of chemicals were on the analyte list: phthalates, low molecular weight polycyclic aromatic hydrocarbons and high molecular weight polycyclic aromatic hydrocarbons.

Two phthalates had estimated concentrations: Di-N-butylphthalate and Diethyl Phthalate. The former was observed at three stations in the Back River stratum and the latter at one station (7-POQ002.33) in the Poquoson stratum.

Of the low molecular weight PAH, only Naphthalene was present in measured or estimated amounts. A measured amount was found at station 7-NWB002.24 and estimated concentrations

were observed in decreasing amounts at the two stations downstream. An estimated amount of naphthalene was also obtained in the Lower York River stratum (7-MOBPHTOX-2).

High molecular weight PAHs were generally present at less than detection limits. An estimated concentration was derived for Chrysene and Pyrene at station 7-POQ002.33, where phthalates were also detected.

3.3.3 Pesticides (Organophosphate and Organochlorine)

All organophosphates were below detection limits at all stations. Of the organochlorines compounds, only p,p'-DDT was detected at a concentration above detection limits, and only at station 7-BAK002.18. This single measurement exceeded the ER-M by a substantial amount.

3.3.4 PCB

In two samples, one isomer was present at a concentration above detection. PCB 126 was reported from station 7-BAK002.18, and PCB 101 was reported from station 7-CHS000.54. In neither case was the identification confirmed by Mass Spectrometry.

3.3.5 Herbicides

A list of herbicides was included in the analyte list. However, no values were reported by DCLS ostensibly because of interference with sulfur (Mark Richards, personal communication). This assertion by the analytical laboratory is somewhat inconsistent with the sulfide measurements reported above by the same laboratory. Since a substantial part of the land adjacent to the two creek strata is residential and agricultural, one would expect to find some herbicides.

Table 3.2. Characteristics of sediment from each station sampled. Each station is represented by 3 field replicates selected randomly from within a grid centered on the station coordinates.

Station	Field Replicate	Percent TOC	Acid Volatile Sulfide	Percent Sand	Percent Silt	Percent Clay
7-NWB001.14	A	1.39	--	10.52	50.72	38.75
	B	1.57	--	9.98	51.23	38.78
	C	1.92	5.0004	7.64	52.47	39.89
7-NWB002.24	A	2.00		7.19	51.01	41.8
	B	1.67		36.93	32.18	30.89
	C	1.57	< 5.0	35.18	34.68	30.13
7-SWB001.31	A	1.50		10.22	52.39	37.39
	B	1.78		10.06	52.83	37.11
	C	1.21	< 5.0	10.77	52.34	36.9
7-BAK002.18	A	0.85		33.15	41.68	25.17
	B	0.85		39.27	36.62	24.1
	C	0.78	< 5.0	39.15	36.37	24.47
7-POQ000.38	A	1.82		12.6	43.4	43.9
	B	1.89		11.16	38.62	50.21
	C	1.78	12.6178	14.67	38.1	47.24
7-POQ002.33	A	1.76		10.47	29.33	60.2
	A (FD)	1.84		10.52	29.19	60.29
	B	0.49		75.26	7.84	16.91
	B (FD)	0.50		75.98	7.6	16.42
	C	0.85	5.6074	59.79	14.14	26.07
	C (FD)	1.27	9.8332	59.36	13.31	27.33
7-POQ002.90	A	2.66		5.84	29.72	64.44
	B	1.88		7.12	31.06	61.82
	C	2.03	14.465	9.08	31.09	56.83
7-CHS000.54	A	1.91		4.47	36.77	58.76
	B	1.89		3.18	36.86	59.96
	C	1.89	15.369	4.36	45.3	50.4
MOBPHTOX-2	A	0.28		82.06	7.89	10.05
	B	0.34		79.99	8.2	11.81
	C	0.33	< 5.0	78.7	8.33	12.97
MOBPHTOX-3	A	0.51		42.59	40.22	15.32
	B	0.52		32.4	45.76	21.83
	C	5.33	< 5.0	40.49	40.79	18.72
MOBPHTOX-9	A	0.20		90.49	4.04	5.47
	B	0.20		89.43	4.49	6.07
	C	0.20	< 5.0	92.25	2.56	5.19
MOBPHTOX-16	A	0.20		79.36	12.42	8.22
	B	0.23		79.22	11.56	9.22
	C	0.21	< 5.0	77.54	13.61	8.85

Table 3.3. Metal concentrations ($\mu\text{g/g}$) in sediment samples collected during fall 2002 from the Lower York, Poquoson, and Back Rivers.

Station	Al	Sb	As	Be	Cd	Cr	Cu	Fe	Pb	Mn	Hg	Ni	Se	Ag	Th	Zn
7-NWB001.14	11,900	< 5	7.1	< 5	< 1	39.1	16.1	17,200	23.8	119	< 0.1	11.5	< 1	< 1	< 5	80.0
7-NWB002.24	8,550	< 5	7.3	< 5	< 1	29.4	16	17,900	21.7	102	< 0.1	8.9	< 1	< 1	< 5	71.7
7-SWB001.31	11,100	< 5	7.3	< 5	< 1	25.6	12.7	17,300	25.8	112	< 0.1	10.6	< 1	< 1	< 5	83.7
7-BAK002.18	8,190	< 5	< 5	< 5	< 1	49.2	8.9	12,200	14.2	86.2	< 0.1	8.7	< 1	< 1	< 5	56.1
7-POQ000.38	20,100	< 5	9	< 5	< 1	36.4	18.7	24,100	19.4	142	< 0.1	15.5	< 1	< 1	< 5	88.9
7-POQ002.33	7,770	< 5	5.5	< 5	< 1	16.1	15.8	12,200	13.6	81.5	< 0.1	7	< 1	< 1	< 5	48.7
7-POQ002.33 FD	10,100	< 5	5.7	< 5	< 1	19.3	17.1	13,700	14.4	89.2	< 0.1	8.1	< 1	< 1	< 5	53.6
7-POQ002.90	21,000	< 5	10.6	< 5	< 1	37.0	50.7	26,400	29.2	176	< 0.1	16	1.1	< 1	< 5	103
7-CHS000.54	16,800	< 5	10.1	< 5	< 1	34.1	37.3	24,600	27.2	143	0.10	15.7	1.4	< 1	< 5	112
MOBPHTOX-2	4,560	< 5	< 5	< 5	< 1	11.8	< 5	10,600	5.8	85.6	< 0.1	5.7	< 1	< 1	< 5	33.5
MOBPHTOX-3	6,540	< 5	< 5	< 5	< 1	14.9	6.3	11,600	7.7	99.4	< 0.1	8.7	< 1	< 1	< 5	43.1
MOBPHTOX-9	2,330	< 5	< 5	< 5	< 1	7.4	< 5	5,150	< 5	36.1	< 0.1	5.0	< 1	< 1	< 5	15.8
MOBPHTOX-16	3,310	< 5	< 5	< 5	< 1	10.7	< 5	6,780	< 5	57.1	< 0.1	5.0	< 1	< 1	< 5	22.5
Detection Limit	5.0	5.0	5.0	5.0	1.0	5.0	5.0	5.0	5.0	5.0	0.10	5.0	1.0	1.0	5.0	5.0
ER-L ^a			8.2		1.2	81	34		46.7		0.15	20.9		1.7		271
ER-M ^a			70.0		9.6	370	270		218		0.71	51.6		3.7		410

Underlined values exceed the relevant ER-M. Bolded values exceed the relevant ER-L.

FD = Field Duplicate

^a Long, E.R. et al. 1995.

Table 3.4. Sediment acid volatile sulfide and simultaneously extracted metals (expressed as $\mu\text{mole/g}$ wet weight) for sediments collected during fall 2002 from the Lower York, Poquoson and Back Rivers.

Station	Acid Volatile Sulfide	Cadmium	Copper	Lead	Mercury	Nickel	Zinc	Sum SEM	SEM/AVS RATIO
7-NWB001.14	5.0004	< 0.0128	0.1135	0.1009	< 0.0001	0.06	1.18	1.4544	0.2909
7-NWB002.24	< 5	< 0.0183	0.194	0.0991	< 0.0001	< 0.09	1.1344	1.4275	0.8704
7-SWB001.31	< 5	< 0.012	0.085	0.1108	< 0.0001	0.06	1.2396	1.4954	0.3287
7-BAK002.18	< 5	< 0.0098	0.0781	0.0532	< 0.0001	< 0.05	0.7726	0.9039	0.4903
7-POQ000.38	12.6178	< 0.0149	0.1581	< 0.0808	< 0.0001	0.09	1.2296	1.4777	0.1171
7-POQ002.33	5.6074	< 0.0116	0.1537	< 0.0628	< 0.0001	0.06	0.8068	1.0205	0.1820
7-POQ002.33 FD	9.8332	< 0.0146	0.1425	< 0.0795	< 0.0001	0.08	1.1335	1.356	0.146
7-POQ002.90	14.465	< 0.0178	0.2517	0.1061	< 0.0001	0.1	1.4832	1.941	0.1342
7-CHS000.54	15.3686	< 0.017	0.2258	0.1062	< 0.0001	0.08	1.551	1.963	0.1277
MOBPHTOX-2	< 5	< 0.0071	0.0314	< 0.0385	< 0.0001	0.04	0.3967	0.4681	0.1755
MOBPHTOX-3	< 5	< 0.0082	0.0361	< 0.0442	< 0.0001	0.08	0.4276	0.5437	0.6994
MOBPHTOX-9	< 5	< 0.006	< 0.0266	< 0.0326	< 0.0001	0.03	0.1241	0.1541	0.9135
MOBPHTOX-16	< 5	< 0.0057	0.0251	< 0.0308	< 0.0001	0.03	0.3224	0.3775	0.2025

FD = Field Duplicate

Table 3.5. Semi-Volatile Organic Compounds (ng/g, dry weight) in sediment samples collected during fall 2002 from the Lower York, Poquoson and Back Rivers.

	ER-L	ER-M	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
Analyte									FD						
Dimethyl phthalate			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Diethyl phthalate			< 106	< 96	< 102	< 107	< 140	< 98	33 *	< 182	< 151	< 191	< 75	< 178	< 60
Di-N-butylphthalate			< 106	54 *	65 *	45 *	< 140	81 *	69 *	< 182	< 151	194	< 75	< 178	< 60
Butylbenzylphthalate			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Bis[2-ethylhexyl]phthalate			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Di-N-octylphthalate			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
<i>Low Molecular PAHs</i>															
2-Methylnaphthalene	70	670	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Acenaphthylene	44	160	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Acenaphthene	16	500	NA	NA	NA	NA	NA								
Anthracene	85.3	1,100	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Fluorene	19	540	NA	NA	NA	NA	NA								
Naphthalene	160	2,100	< 106	184	75 *	30 *	< 140	< 98	109	< 182	< 151	58 *	< 75	< 178	< 60
Phenanthrene	240	1,500	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Total LM PAHs	552	3,160	ND	184	75	30	ND	ND	109	ND	ND	58	ND	ND	ND

Table 3.5 (Cont.). Semi-Volatile Organic Compounds (ng/g, dry weight) in sediment samples collected during fall 2002 from the Lower York, Back and Poquoson Rivers.

	ER-L	ER-M	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
<i>High Molecular PAHs</i>															
Benzo[a]anthracene	261	1600	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Benzo[b]fluoranthene			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Benzo[k]fluoranthene			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Benzo[e]pyrene			NA	NA	NA	NA	NA								
Benzo[a]pyrene	430	1600	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Benzo{g,h,i}perylene			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Chrysene	384	2,800	< 106	< 96	< 102	< 107	< 140	< 98	52 *	< 182	< 151	< 191	< 75	< 178	< 60
Dibenz[a,h]anthracene			< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Fluoranthene	600	5,100	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Indeno[1,2,3-cd]pyrene	63.4	260	< 106	< 96	< 102	< 107	< 140	< 98	< 100	< 182	< 151	< 191	< 75	< 178	< 60
Perylene			NA	NA	NA	NA	NA								
Pyrene	665	2,600	< 106	< 96	< 102	< 107	< 140	< 98	65 *	< 182	< 151	< 191	< 75	< 178	< 60
Total HM PAHs	1,700	9,600	ND	ND	ND	ND	ND	ND	117	ND	ND	0	ND	ND	ND
Total PAHs	4,022	44,792	ND	184	75	30	ND	ND	226	ND	ND	58	ND	ND	ND

Reporting Limits varied with each sample
 * Reported compounds are estimated concentrations
 ND = Not Detected
 NA = Not Analyzed
 FD = Field Duplicate

Table 3.6. Organophosphate pesticide concentrations (ng/g, dry weight) in sediment samples collected during fall 2002 from the Lower York, Poquoson and Back Rivers.

Compound	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
							FD						
Aspon	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Bolstar	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Carbophenothion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Chlorfenvinphos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Chlorpyrifos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Chlorpyrifos (methyl)	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Coumaphos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Crotoxyphos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Demeton	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Diazinon	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dichlorvos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dicrotophos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dimethoate	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dioxathion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Disulfoton	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
EPN	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Ethion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Ethoprop	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Famfur	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Fenitrothion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Fensulfotthion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Fenthion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Folex	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Guthion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0

Table 3.6 (con't). Organophosphate Pesticide concentrations (ng/g, dry weight) in sediment samples collected during fall 2002 from the Lower York, Poquoson and Back Rivers.

Compound	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
Leptophos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Malathion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Metasystox	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Mevinphos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Monocrotophos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Monophos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Naled	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Parathion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Parathion(methyl)	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Phorate	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Phosmet	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Phosphamidon+Dichlorofenthion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Ronnel	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Sulfotep	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
TEPP	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Terbufos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Tetrachlorvinphos	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Thionazin	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Tokuthion	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Trichlorate	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0

All results are reported in ng/g (dry weight)

The QLs have been adjusted for each sample based on % moisture.

FD = Field Duplicate

Table 3.7. Organochlorine pesticide concentrations (ng/g, dry weight) in sediment samples collected during fall 2002 from the Lower York, Poquoson and Back Rivers.

Analyte	ER-L	ER-M	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
									FD						
a-BHC & HCB			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Aldrin			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Alpha-Chlordane			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
b-BHC			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
d-BHC			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dibromochloropropane			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Dieldrin			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Endosulfan I			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Endosulfan II			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Endosulfan Sulfate			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Endrin			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Endrin Ketone			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Gamma-Chlordane			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
g-BHC			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
HCCP			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Heptachlor			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Heptachlor Epoxide			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Isodrin			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Methoxychlor			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
p,p'-DDD	2	20	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
p,p'-DDE			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
p,p'-DDT	1	7	< 5.3	< 4.8	< 5.4	<u>120</u>	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Toxaphene			< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0

The QLs have been adjusted for each sample based on % moisture.
 FD = Field Duplicate

Table 3.8. Polychlorinated Biphenyl congener concentrations (ng/g, dry weight basis) in sediment samples collected during the fall 2002 from the Lower York, Poquoson and Back Rivers.

Compound	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
							FD						
PCB 001	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 005+008	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 018	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 028+031	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 44	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 52	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 66	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 077	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 81+ 87	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 101	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	44 *	< 9.6	< 3.8	< 8.9	< 3.0
PCB 105	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 110	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 118	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 126	< 5.3	< 4.8	< 5.4	120 *	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 128	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 138	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 141	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 151	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 153	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 156	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 169	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 170	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 180	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 183	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0

Table 3.8 (Con't). Polychlorinated Biphenyl congener concentrations (ng/g, dry weight basis) in sediment samples collected during the fall 2002 from the Lower York, Poquoson and Back Rivers.

Compound	7-NWB001.14	7-NWB002.24	7-SWB001.31	7-BAK002.18	7-POQ000.38	7-POQ002.33	7-POQ002.33	7-POQ002.90	7-CHS000.54	MOBPHTOX-2	MOBPHTOX-3	MOBPHTOX-9	MOBPHTOX-16
PCB 187	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	FD	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 206	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
PCB 209	< 5.3	< 4.8	< 5.4	< 4.2	< 7.0	< 4.9	< 5.0	< 9.1	< 7.5	< 9.6	< 3.8	< 8.9	< 3.0
Total PCBs (as Congeners)	< 5.3	< 4.8	< 5.4	120	< 7.0	< 4.9	< 5.0	< 9.1	44	< 9.6	< 3.8	< 8.9	< 3.0

The QLs have been adjusted for each sample based on % moisture.

* Not confirmed with Mass Spectrometry (Tentative Identification)

FD = Field Duplicate

3.4 Toxicity Characterization

3.4.1 Pore Water Characterization

Pore water in the sediment samples used for toxicity tests was analyzed for ammonia, pH and salinity (Table 3.9). The salinity was similar to that of the bottom water at each station.

Ammonia concentrations were generally low and pH was comparable to the overlying water. The pore water of the sediment used for the laboratory control was initially 12 ppt, somewhat lower than the porewater salinity in sediment from sample locations, but comparable in porewater pH or ammonia. None of these conditions were inimical to the test animals.

3.4.2 Amphipod Test:

Survival of *L. plumulosus* was in excess of 90% in all but two station replicates (Station 7-SWB001.31 B and 7-POQ000.38 B) at which it was 88%, well above the acceptability criterion for a control treatment (Table 3.10). There was no significant difference in survival at any station from that in the laboratory control. Nor was there a significant difference among the replicates collected from a single station. All survival rates were within the range defined by the control curve for the laboratory (Table 3.11)

Final dry weights ranged from 0.263 to 0.393 mg (Table 3.10). No meaningful differences were noted in final dry weights among any three replicate substations or among the stations. No emergent test animals were detected throughout the test.

3.4.3 Sheepshead Minnow Test:

A few fish eggs hatched on test day 5 corresponding to a post-spawn time of 6-7 days. Most eggs hatched on days 9 and 10 (post-spawn time of 10-12 days). The expected time to hatch is 7-9 days post-spawn. The testing laboratory reported no fungal or bacterial growth on any eggs or sediment surfaces. A similar delay in hatch was observed for embryos from the same lot when incubated in clean seawater. It was also noted that embryos with beating hearts were still present on day 10 when the test was terminated in accordance with the protocol. This observation suggests that the true hatch percentage would have been higher had the test been extended.

The testing laboratory reported that many embryos were rejected for use in the test because they were judged non-viable or abnormally formed. Minimal control performance (83% hatch) and low experimental performance (overall 68% hatch) also suggest that embryo quality was low. However, the 96-hr LC50 value and confidence limits for the concurrent reference toxicity test fell within the 95% confidence limits of values of the control chart (Table 3.12). Physical conditions throughout the test were within acceptable ranges for all parameters.

On day 10, percent hatch ranged from 56.7% to 86.7% in the experimental treatments compared to 83.3% in the reference sediment. There was not systematic trend observed in the data. In every case save one, overall survival was identical with the percent hatch, indicating that all mortalities were associated with the hatch process. There is no statistical evidence of significant differences among field replicates or stations for the sediment tested.

Table 3.9. Sediment pore water characteristics and percent water.

Station	Pore Water NH3 (mg/l)	Pore Water pH (S.U.)	% Water	Pore Water Salinity (g/kg)
7-NWB001.14 A	3.4	7.70	56.4	22.0
7-NWB001.14 B	3.5	7.58	56.1	23.0
7-NWB001.14 C	4.7	7.55	60.2	23.0
7-NWB002.24 A	2.9	7.38	61.6	24.0
7-NWB002.24 B	2.3	7.54	56.5	21.0
7-NWB002.24 C	2.0	7.41	54.1	22.0
7-SWB001.31 A	2.6	7.59	56.8	23.0
7-SWB001.31 B	2.0	7.51	56.1	22.0
7-SWB001.31 C	2.8	7.54	57.3	25.0
7-BAK002.18 A	3.5	7.44	48.8	25.0
7-BAK002.18 B	4.2	7.60	46.6	24.0
7-BAK002.18 C	3.1	7.37	46.6	25.0
7-POQ000.38 A	3.4	7.52	63.0	24.0
7-POQ000.38 B	5.1	7.63	64.4	20.0
7-POQ000.38 C	3.3	7.61	62.2	23.0
7-POQ002.33 A	4.4	7.48	69.5	20.0
7-POQ002.33 B	2.4	7.51	43.3	22.0
7-POQ002.33 C	2.3	7.50	51.8	24.0
7-POQ002.90 A	3.8	7.41	71.6	23.0
7-POQ002.90 B	4.1	7.54	71.0	21.0
7-POQ002.90 C	3.8	7.56	69.3	22.0
7-CHS000.54 A	2.7	7.37	68.4	18.0
7-CHS000.54 B	4.5	7.69	67.8	24.0
7-CHS000.54 C	3.2	7.64	67.6	19.0
MOBPHTOX-2 A	1.8	7.45	31.3	26.0
MOBPHTOX-2 B	4.7	7.46	32.8	25.0
MOBPHTOX-2 C	2.1	7.67	32.2	25.0
MOBPHTOX-3 A	2.0	7.45	37.4	25.0
MOBPHTOX-3 B	2.2	7.71	43.1	19.0
MOBPHTOX-3 C	2.8	7.57	37.9	25.0
MOBPHTOX-9 A	3.1	7.57	32.2	24.0
MOBPHTOX-9 B	1.9	7.78	30.5	25.0
MOBPHTOX-9 C	2.4	7.73	24.8	21.0
MOBPHTOX-16 A	2.1	7.36	30.7	20.0
MOBPHTOX-16 B	1.7	7.41	27.9	21.0
MOBPHTOX-16 C	2.4	7.35	33.3	25.0
LAB CONTROL	1.6	7.51	65.2	12.0

Table 3.10. Survival and final weight of *Leptocheirus plumulosus* after a 10-day exposure to the sediments.

Station	Survival (%)		Dry Wt. (mg)		Total No. Emergent
	Mean	S.D.	Mean	S.D.	
7-NWB001.14 A	92	2.2	0.333	0.058	0
7-NWB001.14 B	95	3.3	0.348	0.017	0
7-NWB001.14 C	92	7.8	0.340	0.038	0
7-NWB002.24 A	97	2.2	0.335	0.098	0
7-NWB002.24 B	98	2.2	0.336	0.026	0
7-NWB002.24 C	97	4.4	0.335	0.043	0
7-SWB001.31 A	90	6.7	0.308	0.024	0
7-SWB001.31 B	88	7.8	0.276	0.031	0
7-SWB001.31 C	97	4.4	0.266	0.021	0
7-BAK002.18 A	93	2.2	0.321	0.026	0
7-BAK002.18 B	100	0.0	0.298	0.046	0
7-BAK002.18 C	97	2.2	0.359	0.031	0
7-POQ000.38 A	95	6.7	0.370	0.043	0
7-POQ000.38 B	88	8.9	0.340	0.047	0
7-POQ000.38 C	97	4.4	0.300	0.015	0
7-POQ002.33 A	98	2.2	0.393	0.049	0
7-POQ002.33 B	90	6.7	0.299	0.020	0
7-POQ002.33 C	92	2.2	0.291	0.006	0
7-POQ002.90 A	92	7.8	0.327	0.014	0
7-POQ002.90 B	95	6.7	0.361	0.008	0
7-POQ002.90 C	90	10.0	0.312	0.008	0
7-CHS000.54 A	97	4.4	0.355	0.014	0
7-CHS000.54 B	95	3.3	0.303	0.035	0
7-CHS000.54 C	97	2.2	0.319	0.015	0
MOBPHTOX-2 A	100	0.0	0.387	0.030	0
MOBPHTOX-2 B	97	2.2	0.270	0.023	0
MOBPHTOX-2 C	93	8.9	0.277	0.018	0
MOBPHTOX-3 A	93	4.4	0.263	0.029	0
MOBPHTOX-3 B	97	4.4	0.372	0.041	0
MOBPHTOX-3 C	97	4.4	0.296	0.019	0
MOBPHTOX-9 A	93	5.6	0.372	0.063	0
MOBPHTOX-9 B	100	0.0	0.388	0.056	0
MOBPHTOX-9 C	95	3.3	0.335	0.045	0
MOBPHTOX-16 A	98	2.2	0.361	0.021	0
MOBPHTOX-16 B	100	0.0	0.344	0.036	0
MOBPHTOX-16 C	95	0.0	0.369	0.039	0
LAB CONTROL	95	3.3	0.341	0.046	0

Table 3.11. Reference toxicant test results for species used in aqueous toxicity tests (Reference toxicant: KCl, Sigma “Ultra” lot #29H00321; values in mg/l).

	<i>L. plumulosus</i>	<i>C. variegatus</i>
Ref. Test Dates	10/22/02 to 10/26/02	10/31/02 to 11/2/02
LC50 (95% C.L.)	679.7 (582.5-793.3)	1140.2 (1019.5-1275.3)
Control Chart LC50 (95% C.L.)	858.0 (518.8-1197.1)	1114.1 (994.8-1233.4)

Table 3.12. Percent hatch and percent total survival for *Cyprinodon variegatus* exposed to sediment from the Lower York, Poquoson, and Back Rivers.

Station	Cumulative % Hatch						% Survival	
	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Post Hatch	Total
7-NWB001.14 A	0.0	3.3	13.3	16.7	26.7	73.3	100.0	73.3
7-NWB001.14 B	6.7	10.0	20.0	26.7	43.3	73.3	100.0	73.3
7-NWB001.14 C	0.0	10.0	13.3	16.7	30.0	56.7	100.0	56.7
7-NWB002.24 A	0.0	13.3	13.3	20.0	33.3	66.7	100.0	66.7
7-NWB002.24 B	0.0	0.0	3.3	10.0	16.7	60.0	100.0	60.0
7-NWB002.24 C	3.3	13.3	20.0	30.0	43.3	63.3	100.0	63.3
7-SWB001.31 A	3.3	23.3	43.3	46.7	50.0	73.3	100.0	73.3
7-SWB001.31 B	3.3	10.0	26.7	26.7	40.0	73.3	100.0	73.3
7-SWB001.31 C	6.7	30.0	43.3	46.7	50.0	70.0	100.0	70.0
7-BAK002.18 A	6.7	20.0	23.3	26.7	36.7	60.0	100.0	60.0
7-BAK002.18 B	0.0	3.3	23.3	36.7	43.3	70.0	100.0	70.0
7-BAK002.18 C	0.0	10.0	23.3	26.7	26.7	60.0	100.0	60.0
7-POQ000.38 A	0.0	3.3	13.3	30.0	50.0	70.0	100.0	70.0
7-POQ000.38 B	0.0	20.0	30.0	33.3	43.3	76.7	100.0	76.7
7-POQ000.38 C	3.3	20.0	30.0	30.0	36.7	66.7	100.0	66.7
7-POQ002.33 A	0.0	0.0	16.7	16.7	16.7	60.0	100.0	60.0
7-POQ002.33 B	0.0	10.0	13.3	46.7	63.3	86.7	100.0	86.7
7-POQ002.33 C	0.0	6.7	20.0	26.7	36.7	73.3	100.0	73.3
7-POQ002.90 A	0.0	0.0	6.7	10.0	10.0	60.0	100.0	60.0
7-POQ002.90 B	0.0	3.3	6.7	6.7	10.0	56.7	100.0	56.7
7-POQ002.90 C	3.3	6.7	10.0	23.3	26.7	70.0	100.0	70.0
7-CHS000.54 A	0.0	0.0	10.0	10.0	20.0	73.3	100.0	73.3
7-CHS000.54 B	0.0	3.3	3.3	3.3	10.0	63.3	100.0	63.3
7-CHS000.54 C	0.0	6.7	20.0	26.7	26.7	66.7	100.0	66.7
MOBPHTOX-2 A	3.3	30.0	30.0	40.0	53.3	70.0	100.0	70.0
MOBPHTOX-2 B	0.0	6.7	16.7	23.3	33.3	60.0	100.0	60.0
MOBPHTOX-2 C	3.3	36.7	50.0	56.7	60.0	76.7	100.0	76.7
MOBPHTOX-3 A	0.0	20.0	23.3	36.7	50.0	70.0	100.0	70.0
MOBPHTOX-3 B	0.0	3.3	13.3	20.0	30.0	60.0	100.0	60.0
MOBPHTOX-3 C	3.3	10.0	23.3	46.7	53.3	86.7	100.0	86.7
MOBPHTOX-9 A	0.0	3.3	10.0	30.0	33.3	70.0	100.0	70.0
MOBPHTOX-9 B	3.3	30.0	40.0	43.3	53.3	66.7	100.0	66.7
MOBPHTOX-9 C	0.0	30.0	36.7	46.7	50.0	80.0	100.0	80.0
MOBPHTOX-16 A	0.0	16.7	36.7	46.7	53.3	73.3	95.2	70.0
MOBPHTOX-16 B	0.0	0.0	16.7	40.0	43.3	60.0	100.0	60.0
MOBPHTOX-16 C	0.0	0.0	6.7	13.3	20.0	56.7	100.0	56.7
LAB CONTROL	0.0	6.7	13.3	20.0	56.7	83.3	100.0	83.3

3.5 Benthic Community Analysis

The sediment characteristics in samples collected independently for the benthic community analysis (Table 3.13) were broadly consistent with those collected for the chemical and toxicological characterization (Table 3.2), though there were small differences at some stations. Since there is considerable variability within a station at some stations (Table 3.2), it is not unreasonable that a single sample collected at another point within the station grid would differ from all others and the overall average. Despite these differences, one would characterize the stations as sand or silt-clay in the same way with either set of data.

The species richness in the lower York River stratum was more than double that in the tributaries (Table 3.14). One station in the Back River stratum has higher species richness than anywhere else in the tributaries, but the richness is still less than in the lower York River. This difference is not a function of salinity which was quite uniform over the study area (Table 3.1). The abundance of individuals ranged from 1800 to 7100 in the Back River stratum, from 2300 to 5000 in the Poquoson River stratum and from 3600 to 8500 in the lower York River stratum.

Sediments in the Lower York River Stratum (Table 3.15) were dominated by Annelids (40 species), Arthropods (14 species) and Molluscs (7 species). Another 6 phyla were represented by 1 or 2 species each. In the Poquoson River (Table 3.16), the number of annelid species was reduced to 18, arthropods to 6 species, and mollusks to 3 species. Two phyla present in stratum 1 (Cnidaria and Echinoderms) were absent in Stratum 2 (and 3). In the Back River (Table 3.17), the number of annelid species was 16, the number of arthropods 5 and the number of mollusks 3.

The exceptionally high animal abundance of at one station in the Back River Stratum was due to a single species (*Mediomastus ambiseta*) which represented more than half the total biota in the sample, but did not contribute greatly to the Ash Free Dry Weight (AFDW) (Table 3.17). This species was abundant in the Poquoson River Stratum (Table 3.16), and at all save one station in the Lower York River Stratum (Table 3.15).

The Benthic Index of Biological Integrity (B-IBI) score for the Lower York River stratum, ranging from 3.7 to 4.3, places this region in the “meets goals” to “exceeds goals” categories. In contrast, the two tributaries scored below 2.3, placing these strata in the “degraded” or “severely degraded” categories with the exception of station 7-POQ002.33 (B-IBI score of 3.0) (Table 3.14). The individual metric scores used to calculate the B-IBI and the derived B-IBI are listed in Table 3.18.

Table 3.13 Sediment Characteristics in sediment samples collected for benthic community analysis during fall 2002 from the Lower York, Poquoson and Back Rivers (from Dauer and Rodi, 2003).

Station	% sand	% silt-clay
Back River		
7-NWB001.14	6.2	93.8
7-NWB002.24	12.1	87.9
7-SWB001.31	35.8	64.2
7-BAK002.18	29.6	70.4
Poquoson River		
7-POQ000.38	13.9	86.1
7-POQ002.33	65.9	34.1
7-POQ002.90	4.1	95.9
7-CHS000.54	6.9	93.1
Lower York River		
MOBPHTOX-2	78.0	22.0
MOBPHTOX-3	42.4	57.6
MOBPHTOX-9	89.5	10.5
MOBPHTOX-16	67.9	32.1

Table 3.14 Benthic community parameters for stations in the Lower York, Poquoson and Back Rivers (from Dauer and Rodi, 2003).

Station	Total Species	Ind./sq.m	AFDW Biomass	B-IBI Score	Community Condition
Lower York River					
MOBPHTOX-2	31	6,214	5.625	3.7	Meets Goal
MOBPHTOX-3	32	8,482	5.284	3.7	Meets Goal
MOBPHTOX-9	28	3,674	2.427	4.3	Exceeds Goal
MOBPHTOX-16	26	3,924	2.676	3.7	Meets Goal
Poquoson River					
7-POQ000.38	14	4,717	2.177	1.7	Severely Degraded
7-POQ002.33	14	4,967	2.722	3.0	Meets Goal
7-POQ002.90	6	2,313	1.179	2.0	Degraded
7-CHS000.54	7	2,722	0.522	2.0	Degraded
Back River					
7-NWB001.14	9	1,792	0.522	2.3	Degraded
7-NWB002.24	19	7,144	1.089	1.7	Severely Degraded
7-SWB001.31	10	1,973	0.726	2.3	Degraded
7-BAK002.18	13	3,878	1.338	1.7	Severely Degraded

Table 3.15. Benthic species sample abundance list with ash-free dry weight biomass (AFDW in mg), Lower York River Stratum (modified from Dauer and Rodi, 2003).

Taxon Phylum	Class	Genus species	MOBPHTOX-2		MOBPHTOX-3		MOBPHTOX-9		MOBPHTOX-16	
			Abundance	AFDW	Abundance	AFDW	Abundance	AFDW	Abundance	AFDW
Annelida	Oligochaeta	Tubificoides spp. Group I								
Annelida	Polychaeta	Aglaophamus verrilli	10	1	1	1	18	1	8	1
Annelida	Polychaeta	Asabellides oculata					1	1		
Annelida	Polychaeta	Bhawania heteroseta	39	3	38	7	15	1	13	1
Annelida	Polychaeta	Brania clavata					3	1		
Annelida	Polychaeta	Cabira incerta	1	1			2	1		
Annelida	Polychaeta	Carazziella hobsonae	2	1	2	1			11	1
Annelida	Polychaeta	Chaetopterus variopedatus	1	33	1	6				
Annelida	Polychaeta	Clymenella torquata	1	6	1	1				
Annelida	Polychaeta	Demonax micropthalmus			21	1				
Annelida	Polychaeta	Diopatra cuprea							1	1
Annelida	Polychaeta	Drilonereis longa			1	1				
Annelida	Polychaeta	Eteone heteropoda								
Annelida	Polychaeta	Glycera americana			1	1	3	1	3	14
Annelida	Polychaeta	Glycinde solitaria								
Annelida	Polychaeta	Heteromastus filiformis								
Annelida	Polychaeta	Hydroides dianthus			16	1				
Annelida	Polychaeta	Leistoscoloplos spp.								
Annelida	Polychaeta	Lepidonotus sublevis	3	1			2	1		
Annelida	Polychaeta	Loimia medusa	15	33	11	28	6	5	10	17
Annelida	Polychaeta	Macroclymene zonalis					1	1	1	1
Annelida	Polychaeta	Malmgreniella taylora	4	1					2	1
Annelida	Polychaeta	Mediomastus ambiseta	12	1	38	1	9	1		
Annelida	Polychaeta	Melinna maculata			1	2				
Annelida	Polychaeta	Monticellina dorsobrancialis	13	1	6	1				
Annelida	Polychaeta	Neanthes succinea			99	28	1	1	5	1
Annelida	Polychaeta	Nephtys picta	4	10	4	1	3	7	3	5
Annelida	Polychaeta	Notomastus sp. A Ewing	13	81	52	86	36	66	12	51
Annelida	Polychaeta	Parahesion luteola	2	1						
Annelida	Polychaeta	Paraprionospio pinnata	66	17	32	4	8	2	24	2
Annelida	Polychaeta	Pectinaria gouldii	1	1	8	4	2	1	14	1
Annelida	Polychaeta	Phyllodoce arenae	1	1			4	1	1	1

Annelida	Polychaeta	Podarkeopsis levifuscina	6	1	13	1			2	1
Annelida	Polychaeta	Polycirrus eximius			1	1	1	1		
Annelida	Polychaeta	Prionospio perkinsi	3	1	3	1	1	1	2	1
Annelida	Polychaeta	Pseudeurythoe paucibranchiata	3	1					2	1
Annelida	Polychaeta	Sigambra tentaculata	31	1	2	1	3	1	19	1
Annelida	Polychaeta	Spiochaetopterus costarum			1	1	1	1		
Annelida	Polychaeta	Streblospio benedicti					1	1	1	1
Arthropoda	Amphipoda	Ampelisca spp.			2	1	8	1		
Arthropoda	Amphipoda	Cerapus tubularis	1	1						
Arthropoda	Amphipoda	Listriella barnardi	8	1			4	1	7	1
Arthropoda	Amphipoda	Listriella clymenellae			2	1				
Arthropoda	Amphipoda	Melita nitida			1	1				
Arthropoda	Cumacea	Oxyurostylis smithi							1	1
Arthropoda	Decapoda	Biffarius biformis	1	1						
Arthropoda	Decapoda	Ogyrides alphaerostris	1	1					1	1
Arthropoda	Decapoda	Panopeus herbstii			9	14				
Arthropoda	Decapoda	Polyonyx gibbesi	1	3						
Arthropoda	Decapoda	Upogebia affinis	1	1						
Arthropoda	Isopoda	Cyathura polita								
Arthropoda	Isopoda	Edotea triloba			1	1				
Arthropoda	Mysidacea	Mysidopsis bigelowi								
Chordata	Hemichordata	Hemichordata spp.	7	2	1	1			6	8
Cnidaria	Anthozoa	Diadumene leucolena			10	14				
Cnidaria	Anthozoa	Edwardia elegans	3	1	10	4				
Echinodermata	Ophiuroidea	Microphiopholis atra	7	36	2	9	4	2	2	2
Mollusca	Gastropoda	Acteocina canaliculata	3	1	2	1	2	1		
Mollusca	Gastropoda	Anachis obesa					1	1	8	2
Mollusca	Gastropoda	Turbonilla interrupta			1	1				
Mollusca	Bivalvia	Anadara transversa			1	1				
Mollusca	Bivalvia	Macoma tenta			3	34				
Mollusca	Bivalvia	Mulinia lateralis								
Mollusca	Bivalvia	Nucula proxima					4	1		
Mollusca	Bivalvia	Parvilucina multilineata					2	1		
Nemertea		Nemertea spp.	6	1	12	1	9	1	15	1
Phoronida		Phoronis spp.	8	4	2	1	10	3	7	1
Platyhelminthes	Turbellaria	Stylochus ellipticus	4	1	1	1				
Platyhelminthes	Turbellaria	Turbellaria spp.			1	1	1	1	1	1
Totals			282	251	414	267	166	110	182	121

Table 3.16. Benthic species sample abundance list with ash-free dry weight biomass (AFDW in mg), Poquoson River Stratum (modified from Dauer and Rodi, 2003).

Taxon	Class	Genus species	7-POQ000.38		7-POQ002.33		7-POQ002.90		CHS000.54	
			Abundance	AFDW	Abundance	AFDW	Abundance	AFDW	Abundance	AFDW
Annelida	Oligochaeta	Tubificoides spp. Group I			1	1				
Annelida	Polychaeta	Carazziella hobsonae	4	1						
Annelida	Polychaeta	Clymenella torquata			2	12				
Annelida	Polychaeta	Eteone heteropoda	1	1	5	1				
Annelida	Polychaeta	Glycinde solitaria	1	1					1	1
Annelida	Polychaeta	Heteromastus filiformis					2	4		
Annelida	Polychaeta	Leistoscoloplos spp.			3	9				
Annelida	Polychaeta	Lepidonotus sublevis			1	1				
Annelida	Polychaeta	Loimia medusa			2	20				
Annelida	Polychaeta	Mediomastus ambiseta	28	1	63	3	15	1	17	1
Annelida	Polychaeta	Neanthes succinea								
Annelida	Polychaeta	Notomastus sp. A Ewing	5	53	6	58				
Annelida	Polychaeta	Parahesione luteola	3	1						
Annelida	Polychaeta	Paraprionospio pinnata	80	25	12	8	17	29	27	11
Annelida	Polychaeta	Podarkeopsis levifuscina	1	1	5	1			2	1
Annelida	Polychaeta	Sigambra tentaculata	5	1	1	1				
Annelida	Polychaeta	Spiochaetopterus costarum								
Annelida	Polychaeta	Streblospio benedicti	69	2	110	2	63	3	70	4
Arthropoda	Amphipoda	Listriella barnardi	3	1						
Arthropoda	Amphipoda	Listriella clymenellae								
Arthropoda	Decapoda	Ogyrides alphaerostris	6	6						
Arthropoda	Isopoda	Cyathura polita								
Arthropoda	Isopoda	Edotea triloba								
Arthropoda	Mysidacea	Mysidopsis bigelowi					3	1		
Chordata	Hemichordata	Hemichordata spp.	1	1						
Mollusca	Gastropoda	Acteocina canaliculata	1	1	1	1				
Mollusca	Bivalvia	Macoma tenta					2	14	2	4
Mollusca	Bivalvia	Mulinia lateralis								
Nemertea		Nemertea spp.			2	1	3	1		
Phoronida		Phoronis spp.			6	2			1	1
Platyhelminthes	Turbellaria	Stylochus ellipticus								
Platyhelminthes	Turbellaria	Turbellaria spp.			5	1				
Totals			208	96	225	122	105	53	120	23

Table 3.17. Benthic species sample abundance list with ash-free dry weight biomass (AFDW in mg), Back River Stratum (modified from Dauer and Rodi, 2003).

Phylum	Taxon		7-NWB001.14		7-NWB002.24		7-SWB001.31		7-BAK002.18	
	Class	Genus species	Abundance	AFDW	Abundance	AFDW	Abundance	AFDW	Abundance	AFDW
Annelida	Oligochaeta	Tubificoides spp. Group I			11	1				
Annelida	Polychaeta	Clymenella torquata							1	7
Annelida	Polychaeta	Eteone heteropoda	1	1	4	1	3	1	1	1
Annelida	Polychaeta	Glycinde solitaria			3	2			2	1
Annelida	Polychaeta	Leistoscoloplos spp.	4	4	8	16	4	13	1	1
Annelida	Polychaeta	Loimia medusa			1	1				
Annelida	Polychaeta	Mediomastus ambiseta	23	1	199	4	30	1	36	1
Annelida	Polychaeta	Neanthes succinea			8	3				
Annelida	Polychaeta	Notomastus sp. A Ewing							1	10
Annelida	Polychaeta	Parahesion luteola			4	1				
Annelida	Polychaeta	Paraprionospio pinnata	12	11	1	4	22	11	63	29
Annelida	Polychaeta	Podarkeopsis levifuscina	1	1	5	1	4	1	1	1
Annelida	Polychaeta	Sigambra tentaculata							1	1
Annelida	Polychaeta	Spiochaetopterus costarum			3	1	2	1	4	1
Annelida	Polychaeta	Streblospio benedicti	13	1	53	1	7	1	38	1
Arthropoda	Amphipoda	Listriella clymenellae			3	1				
Arthropoda	Decapoda	Ogyrides alphaerostris			1	3			1	1
Arthropoda	Isopoda	Cyathura polita			2	1				
Arthropoda	Isopoda	Edotea triloba			1	1				
Arthropoda	Mysidacea	Mysidopsis bigelowi							1	1
Chordata	Hemichordata	Hemichordata spp.	1	1						
Mollusca	Gastropoda	Acteocina canaliculata			1	1				
Mollusca	Bivalvia	Macoma tenta			1	4				
Mollusca	Bivalvia	Mulinia lateralis					1	1		
Nemertea		Nemertea spp.	8	1	5	1	10	1		
Phoronida		Phoronis spp.	16	2	2	1	4	1	21	4
Platyhelminthes	Turbellaria	Stylochus ellipticus	1	1	1	1				
Totals			80	24	317	50	87	32	172	60

Table 3.18. Individual metric scores and calculated B-IBI for each station (modified from Dauer and Rodi, 2003).

Station	Shannon Index	Abundance	Biomass	Pollution Indicative Biomass	Pollution Sensitive Abundance	Pollution Sensitive Biomass	Carnivores/ omnivores	Deep deposit feeders	B-IBI Score
Mobjack Bay									
MOBPHTOX-2	5	3	5	3	3	-	-	3	3.7
MOBPHTOX-3	5	1	5	5	-	1	5	-	3.7
MOBPHTOX-9	5	5	3	5	3	-	-	5	4.3
MOBPHTOX-16	5	5	3	5	1	-	-	3	3.7
Poquoson River									
7-POQ000.38	1	3	3	1	-	1	1	-	1.7
7-POQ002.33	1	5	3	1	3	-	-	5	3.0
7-POQ002.90	1	5	3	1	-	1	1	-	2.0
7-CHS000.54	1	5	3	1		1	1	-	2.0
Back River									
7-NWB001.14	3	5	3	1	-	1	1	-	2.3
7-NWB002.24	1	3	3	1	-	1	1	-	1.7
7-SWB001.31	3	5	3	1	-	1	1	-	2.3
7-BAK002.18	1	3	3	1	-	1	1	-	1.7

4.0 DISCUSSION

The chemical and toxicological characterizations of the sediment provide no evidence of degradation at any station in any stratum. There were no exceedances of the ER-M for any metal or SVOC and only one exceedance for a pesticide (DDT) at a single location. Omitted from the analyte list for this region were polychlorinated ter-phenyls, known to be present in the Northwest Branch of Back River (Hale *et al.*, 1991; Gallagher *et al.*, 1993). These chemicals, however, are not known to produce toxic results in tests like those used here. In light of the chemical characterization and other information about chemicals in the region, the lack of toxicological effect is expected.

In stark contrast, however, the B-IBI indicates that most stations of the Poquoson and Back River strata are degraded or severely degraded. These scores are driven in the Back River by low scores for pollution indicative biomass, pollution sensitive biomass, and the carnivore/omnivore ratio. In the Poquoson River, the scores are driven by the Shannon Index as well.

Previous work in the Poquoson River by Diaz *et al.* (1985; Roberts and Diaz, 1986) covered a more upstream reach of the river from the Harwood Mill Dam to a point about 1 mile upstream of the most upstream station in the present study. Because of differences in methodology of the Diaz and Roberts study, one cannot derive a B-IBI for these earlier data. The upper reaches of the system were at a much lower salinity, so many of the parameters for the B-IBI (Shannon Index, species number, and abundance) would be low in any case. There was evidence, however, of eutrophication in the upper reaches of the Poquoson including algal mats that periodically floated to the surface. In such a situation, the B-IBI methodology would likely show the more upstream reach as degraded.

The B-IBI may indicate degradation of an environment not only when chemical contamination is evident, but also when dissolved oxygen concentrations are periodically critically low or when there is significant enrichment leading to species imbalances. Thus the index cannot at this time be used reliably to indicate the cause of degradation. It is clear that stations in both tidal tributaries are degraded, whereas stations in the open water stratum are not degraded. In the absence of chemical contaminants or apparent ambient toxicity using “chronic” test methods, it seems likely that the degradation stems from eutrophication. The residential land use of the uplands provides a likely source for the eutrophication.

In the present sampling program, all four stations selected in the Lower York River Stratum met or exceeded the benthic community goal. The assumption in the station selection protocol is that the 12 stations that were not selected would not show chemical or toxicological degradation predicated on the idea that contaminants are more likely to accumulate in fine-grained sediments and therein produce toxic responses. If the assumption is correct, then 100% of the first 16 stations in the stratum show no adverse chemical character or toxicological impact. However, no assumption can be made with respect to whether the benthic communities at the 12 non-selected stations meet the benthic community goal since this index is impacted by parameters beyond the chemical and toxicological characteristics examined in this study.

In the Poquoson River, 3 of the first 7 random locations were not selected, and therefore assumed to have no chemical or toxicological impacts. In the Back River stratum, 1 of first 5 random locations was not selected. In both cases, benthic community impacts were seen at all four sampled locations.

It is tempting to make inferences about the percent area adversely impacted. However, to make a sound inference about conditions from a small sample set is not defensible. In the B-IBI evaluation procedure, if 25 random samples are collected in a stratum, a statement can be made with some reasonable level of confidence, but with fewer samples, the confidence level is no longer reasonable. In the chemical and toxicological analysis procedure, no one has to date defined a method for estimating an area impacted with any level of confidence based on any sampling density, but assuredly the number of samples collected in this study are not sufficient to infer a percent degraded in any of the parameters.

It would be more useful to characterize strata with respect to chemical distribution, toxicological response and benthic community structure based on a greater number of stations rather than merely a few isolated stations within strata as is now done. This is true whenever we wish to compare the relative condition in different areas, to decide if one area is in worse condition than another, and therefore worthy of more expenditure for cleanup.

To achieve a goal of characterizing a stratum with regard to chemical and toxicological conditions in the same sense that strata are characterized in terms of benthic communities, one must sample a larger number of randomly selected stations within a stratum. Further, one must develop some reasonable approach to avoid performing expensive chemical and toxicological tests on sediments with a minimal probability of producing a negative signal while at the same time producing a robust and unbiased sampling regime. As it stands, unless we accept the untested stations as chemically and toxicologically clean, we bias the sampling design in such a way that no inferences can be made about any stratum.

In the three studies carried out by the present team (Roberts, *et al.* 2000; Roberts, *et al.*, 2002; present study), three true field replicates from each station were maintained for toxicological tests, each with three laboratory replicates to estimate variability resulting from laboratory procedures. This approach recognizes the natural variability in sediment conditions that may occur within a 100 m by 100 m grid as one assesses the variability in toxic response that may result. In these three studies, the laboratory variability equaled or exceeded the true replicate variability. In such a situation, it would be unlikely that one would be able to distinguish an effect attributable to position in the grid using a total of nine toxicity tests at each station (3 field replicates, each tested in triplicate).

A less costly testing approach that still addresses potential positional variability would involve sampling at three locations within a station grid which are then composited for toxicological tests. Assuming that an equal amount of sediment from each independent point in the grid is included in the composite, the resultant toxicological endpoint approximates the average of three independent measurements.

There is some loss in sensitivity of this protocol. If only one of the three substations sampled is extremely toxic and two are not toxic, the composite sample is likely to show evidence of toxicity. However, if one station of three is only moderately toxic, the composite is not likely to show evidence of this toxicity. If the distribution of toxicity within the grid is approximated by the random sampling distribution, then the composite estimate of toxicity is a reasonable representation of the character of sediments at the station, which is the primary objective of the testing procedure.

This approach of compositing three samples from within a station grid is already used as a cost saving approach to chemical characterization. By reducing the number of toxicological samples tested at a station from 9 to 3, one can collect data for 3 stations for approximately the same toxicological test cost as for 1 station using the present expanded design. The approach using composites of substation samples for toxicological characterization would allow a more comprehensive analysis of a stratum by increasing the number of stations evaluated. Admittedly there would be an increased cost for sample collection (relatively small increase compared to the cost of sample processing) and a substantial increased cost for chemical analyses. Therefore the gain in stations would not be 3 for 1. Though more modest, the gain in stratum coverage would provide more useful information than the present approach allows.

Comparing impacts (chemical and toxicological) at a station with those at other stations does allow one to identify "hot spots." It does not let one determine the extent of the "hot spot" nor does it allow one to define "clean" areas. If the total area of a stratum is large and the number of random stations occupied is fixed at some small number, the chance of detecting a "hot spot," even one of rather large size, is fairly small. Yet when a "hot spot" is found in a modest sampling design, the tendency is to mentally overestimate the importance of the "hot spot."

This tendency to overestimate the importance of a "hot spot" emphasizes the need to conduct spatially focused studies around stations demonstrated to be "hot spots." As the number of stations occupied increases, the ability to map areas that are degraded versus not degraded improves. If potential stations are rejected because of sediment type (and an assumed absence of toxic chemicals and effects), areas with such sediment types might reasonably be mapped as areas of free of sedimentary toxicological effects. The ability to map a stratum using all available information despite some uncertainties is ultimately more important to a clean-up effort than its characterization as X% degraded.

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Appendix A

Summary Water Quality Tables

Table A1. Summary Water Quality – Amphipod Test

Station	Temperature (°C)		Diss. Oxygen (mg/l)		pH (S.U.)		Salinity (g/kg)		NH3-N (mg/l)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
7-BAK002-18 A	25.0	0.0	6.8	0.1	7.94	0.13	21	1.2	0.2	0.0
7-BAK002-18 B	25.0	0.0	6.7	0.1	7.93	0.12	21	0.7	0.2	0.0
7-BAK002-18 C	25.0	0.0	6.8	0.1	7.95	0.17	21	1.2	0.2	0.0
7-CHS000-54 A	25.1	0.2	6.7	0.1	8.06	0.16	21	1.2	0.3	0.1
7-CHS000-54 B	25.0	0.0	6.7	0.1	8.05	0.17	20	0.5	0.3	0.1
7-CHS000-54 C	25.0	0.0	6.8	0.1	7.98	0.18	21	1.2	0.2	0.0
7-NWB001-14 A	25.0	0.0	6.7	0.1	7.98	0.18	20	0.5	0.2	0.0
7-NWB001-14 B	25.0	0.0	6.8	0.1	8.02	0.20	21	1.2	0.2	0.0
7-NWB001-14 C	25.0	0.0	6.8	0.1	7.98	0.34	21	0.8	0.2	0.0
7-NWB002-24 A	24.7	0.4	6.8	0.1	7.84	0.13	20	0.5	0.2	0.0
7-NWB002-24 B	25.0	0.0	6.8	0.2	7.96	0.15	20	0.5	0.2	0.0
7-NWB002-24 C	24.9	0.2	6.7	0.1	7.92	0.18	21	0.7	0.2	0.0
7-POQ000-38 A	24.7	0.4	6.8	0.2	7.98	0.17	21	0.9	0.2	0.0
7-POQ000-38 B	25.0	0.0	6.7	0.1	7.97	0.16	20	0.5	0.2	0.0
7-POQ000-38 C	25.0	0.0	6.7	0.1	8.00	0.18	21	1.0	0.2	0.0
7-POQ002-33 A	25.0	0.0	6.7	0.1	8.08	0.37	21	0.9	0.2	0.0
7-POQ002-33 B	25.2	0.3	6.9	0.1	7.98	0.14	20	0.6	0.2	0.0
7-POQ002-33 C	25.0	0.0	6.9	0.1	7.93	0.18	20	0.5	0.2	0.0
7-POQ002-90 A	25.0	0.0	6.8	0.1	8.10	0.18	21	0.7	0.2	0.0
7-POQ002-90 B	25.0	0.0	6.6	0.1	7.99	0.15	21	0.7	0.3	0.1
7-POQ002-90 C	24.7	0.4	6.8	0.1	7.95	0.16	20	0.5	0.2	0.0
7-SWB001-31 A	25.0	0.0	6.7	0.1	7.83	0.11	21	0.7	0.2	0.0
7-SWB001-31 B	25.1	0.2	6.7	0.1	7.87	0.07	21	1.2	0.2	0.0
7-SWB001-31 C	25.0	0.0	6.8	0.1	7.77	0.11	20	0.6	0.2	0.0
MOBPHTOX-16 A	25.1	0.2	6.8	0.1	7.94	0.14	21	0.8	0.2	0.0
MOBPHTOX-16 B	25.1	0.2	6.8	0.1	7.99	0.14	21	1.0	0.2	0.0
MOBPHTOX-16 C	25.0	0.0	6.7	0.2	7.91	0.20	21	1.2	0.2	0.0
MOBPHTOX-2 A	25.0	0.0	6.8	0.1	7.95	0.15	21	0.9	0.2	0.0
MOBPHTOX-2 B	25.0	0.0	6.8	0.1	7.92	0.14	21	1.0	0.2	0.0
MOBPHTOX-2 C	25.0	0.0	6.7	0.2	7.93	0.13	20	0.5	0.2	0.0
MOBPHTOX-3 A	25.0	0.0	6.7	0.1	7.93	0.16	21	0.8	0.2	0.0
MOBPHTOX-3 B	25.0	0.0	6.7	0.1	8.00	0.15	21	1.2	0.2	0.0
MOBPHTOX-3 C	24.6	0.5	6.9	0.2	7.88	0.14	20	0.6	0.4	0.2
MOBPHTOX-9 A	25.1	0.2	6.8	0.1	8.04	0.14	21	0.8	0.2	0.0
MOBPHTOX-9 B	25.0	0.0	6.7	0.2	8.02	0.13	21	0.7	0.2	0.0
MOBPHTOX-9 C	25.0	0.0	6.7	0.1	7.94	0.15	20	0.5	0.2	0.0
LAB CONTROL	25.0	0.0	6.8	0.1	7.94	0.16	20	0.6	0.2	0.0

Table A2. Summary Water Quality – Fish Embryo Test

Station	Temperature (°C)		Diss. Oxygen (mg/l)		pH (S.U.)		Salinity (g/kg)		NH3-N (mg/l)	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
7-BAK002-18 A	24.5	0.0	7.0	0.1	7.74	0.12	20	0.1	0.3	0.1
7-BAK002-18 B	24.4	0.0	6.9	0.1	7.71	0.11	20	0.0	0.2	0.0
7-BAK002-18 C	24.5	0.1	7.0	0.2	7.77	0.11	20	0.0	0.2	0.0
7-CHS000-54 A	24.6	0.0	7.0	0.2	7.76	0.15	20	0.1	0.4	0.2
7-CHS000-54 B	24.5	0.0	7.0	0.1	7.72	0.11	20	0.1	0.3	0.1
7-CHS000-54 C	24.6	0.0	7.0	0.2	7.81	0.11	20	0.0	0.3	0.1
7-NWB001-14 A	24.5	0.1	6.9	0.1	7.71	0.14	20	0.0	0.2	0.0
7-NWB001-14 B	24.6	0.0	6.9	0.2	7.79	0.12	20	0.0	0.4	0.2
7-NWB001-14 C	24.5	0.1	6.9	0.2	7.81	0.11	20	0.1	0.4	0.2
7-NWB002-24 A	24.6	0.1	6.9	0.2	7.63	0.10	20	0.0	0.3	0.1
7-NWB002-24 B	24.5	0.1	6.9	0.1	7.72	0.11	20	0.0	0.2	0.0
7-NWB002-24 C	24.6	0.1	6.9	0.2	7.65	0.11	20	0.0	0.3	0.1
7-POQ000-38 A	24.6	0.1	6.9	0.1	7.69	0.10	20	0.0	0.4	0.2
7-POQ000-38 B	24.5	0.1	6.9	0.2	7.74	0.10	20	0.0	0.3	0.1
7-POQ000-38 C	24.5	0.1	6.8	0.2	7.70	0.12	20	0.0	0.3	0.1
7-POQ002-33 A	24.5	0.1	7.0	0.2	7.84	0.14	20	0.0	0.5	0.3
7-POQ002-33 B	24.5	0.0	7.0	0.1	7.79	0.11	20	0.0	0.2	0.0
7-POQ002-33 C	24.5	0.0	7.0	0.1	7.79	0.12	20	0.0	0.2	0.0
7-POQ002-90 A	24.5	0.0	6.9	0.1	7.72	0.12	20	0.0	0.3	0.1
7-POQ002-90 B	24.4	0.0	6.9	0.1	7.75	0.11	20	0.0	0.4	0.2
7-POQ002-90 C	24.6	0.1	6.9	0.1	7.73	0.10	20	0.0	0.3	0.1
7-SWB001-31 A	24.5	0.0	6.9	0.2	7.70	0.11	20	0.0	0.2	0.0
7-SWB001-31 B	24.6	0.0	7.0	0.1	7.73	0.11	20	0.0	0.2	0.0
7-SWB001-31 C	24.5	0.1	6.9	0.1	7.73	0.12	20	0.0	0.2	0.0
MOBPHTOX-16 A	24.4	0.0	6.9	0.2	7.72	0.11	20	0.0	0.2	0.0
MOBPHTOX-16 B	24.6	0.0	7.0	0.1	7.75	0.10	20	0.0	0.2	0.0
MOBPHTOX-16 C	24.4	0.0	7.0	0.2	7.77	0.13	20	0.0	0.2	0.0
MOBPHTOX-2 A	24.5	0.0	6.9	0.1	7.74	0.11	20	0.1	0.2	0.0
MOBPHTOX-2 B	24.4	0.0	6.9	0.1	7.70	0.11	20	0.0	0.2	0.0
MOBPHTOX-2 C	24.5	0.1	6.8	0.2	7.71	0.09	20	0.0	0.3	0.1
MOBPHTOX-3 A	24.5	0.1	6.9	0.2	7.71	0.12	20	0.1	0.2	0.0
MOBPHTOX-3 B	24.5	0.0	6.9	0.2	7.80	0.12	20	0.0	0.2	0.0
MOBPHTOX-3 C	24.6	0.1	7.0	0.1	7.61	0.11	20	0.0	0.5	0.3
MOBPHTOX-9 A	23.5	0.2	7.0	0.1	7.78	0.10	20	0.0	0.2	0.0
MOBPHTOX-9 B	24.4	0.0	7.0	0.1	7.74	0.11	20	0.0	0.2	0.0
MOBPHTOX-9 C	24.5	0.0	6.9	0.2	7.71	0.11	20	0.0	0.2	0.0
LAB CONTROL	24.4	0.0	6.9	0.2	7.74	0.11	20	0.0	0.2	0.0