COMPREHENSIVE ANALYSIS OF THE SEDIMENTS RETAINED BEHIND HYDROELECTRIC DAMS OF THE LOWER SUSQUEHANNA RIVER

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SUSQUEHANNA RIVER BASIN COMMISSION

The Susquehanna River Basin Commission was created as an independent agency by a federal-interstate compact* among the states of Maryland, New York, Commonwealth of Pennsylvania, and the federal government. In creating the Commission, the Congress and state legislatures formally recognized the water resources of the Susquehanna River Basin as a regional asset vested with local, state, and national interests for which all the parties share responsibility. As the single federal-interstate water resources agency with basinwide authority, the Commission's goal is to coordinate the planning, conservation, management, utilization, development and control of basin water resources among the public and private sectors.

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Background

The District of Columbia, State of Maryland, Commonwealths of Pennsylvania and Virginia, Chesapeake Bay Commission (CBC), and U.S. Environmental Protection Agency (USEPA) have agreed to restore and protect the estuarine environment of the Chesapeake Bay (Bay). The Susquehanna River is the largest tributary to the Bay and transports about one-half of the freshwater and a substantial amount of sediment to the Bay. The loads transported by the Susquehanna River to the Bay are significantly affected by the deposition of sediment behind three large hydroelectric dams on the lower Susquehanna River. Currently, the reservoirs trap 50 to 70 percent of the sediment. In 20 to 30 years, when the sediment trapping capacity may be reached, sediment loads to the Bay are expected to substantially increase and produce degraded water quality conditions for the aquatic communities in the Bay.

Nationally, the USEPA has reported that sediment, in its various forms, is the single most-cited reason for streams not meeting their designated use criteria and consequently being placed on the Clean Water Act Section 303(d) list. Sediment is a principal carrier of pesticides, heavy metals, bacteria, viruses, and other contaminants in streams. The data evaluated from bottom sediments collected in reservoirs on the lower Susquehanna River provide information on contaminants and potential toxicity.

Introduction

The Susquehanna River Basin Commission (SRBC), with grant funding provided by the Pennsylvania Delegation of the CBC, convened a multi-agency, multi-disciplinary Sediment Task Force (STF) in July 1999. The STF was formed out of concern for sediment buildup and loss of storage capacity behind the large hydroelectric dams on the lower Susquehanna River. Additional concerns included water quality impacts to the Bay due to increases from delivered sediment and nutrient loads.

The STF evaluated a potential maintenance dredging operation behind one or more of the dams to maintain sediment retention capacity and minimize delivered loads to the Bay. This evaluation was consistent with a major sediment-related water quality goal contained in the Chesapeake 2000 Agreement, which calls for the Chesapeake Bay Program, in cooperation with the SRBC, to “adopt and begin implementing strategies that prevent the loss of the sediment retention capabilities of the Lower Susquehanna River dams” by the year 2003.

Before dredging can be considered an option, occurrence and distribution of toxic substances within the sediments must be evaluated. Previous studies have not focused extensively on sediment quality, and therefore, the data on the subject are limited. In order to prevent environmental damage that may occur from any mitigation efforts, resource managers need a more comprehensive assessment of contaminants in sediment.

Scope of Work

The scope of work for the study included a physical examination and chemical analyses of the sediments behind three dams on the lower Susquehanna River. This study was undertaken by SRBC with grant funding from the CBC and Pennsylvania Department of Environmental Protection. The sampling and analyses were conducted as part of a multi-disciplinary effort in cooperation with the U.S. Geological Survey (USGS), Maryland Geological Survey (MGS), and University of Maryland Center for Environmental Studies (UMCES).

The USGS collected continuous profiles of sediment cores in 3-inch aluminum irrigation tubes using a boat-mounted vibracore collection system. In deeper areas of the reservoirs, generally greater than 20 feet, a gravity core collection system was deployed. Most of the cores were vibracores, while only the cores closest to the dams were gravity cores. Box core samples were collected to analyze adsorption/desorption properties of phosphorus. Locations of all sites were measured using a global positioning system.

The sediment core samples collected in aluminum irrigation tubes were transported horizontally back to shore. Once on shore, the tubes were cut into approximately 1.5-meter lengths and refrigerated near the collection sites. Cores were later transported to MGS where they were stored at 4 degrees Celsius, X-rayed, split open, described, photographed, and sub-sampled within a week of receipt.

Sediment samples were collected from 34 cores in the reservoirs behind the dams (Figure 1). They were then partitioned into surface, middle, and bottom portions. Shallow box cores, of about 20 centimeters (8 inches), were collected and analyzed for phosphate associations and mobility in and out of the sediments. In addition, an evaluation was made of the antibiotic sensitivity of *in situ* bacteria. The deeper cores were analyzed for particle size (sand-silt-clay and coal fractions), X-rayed for composition of the various layers, tested for metal concentrations, nutrients, organics (polychlorinated byphenyls (PCBs), pesticides, etc.), and selected radionuclides, which can be used as indicators for dating the sediment layers.

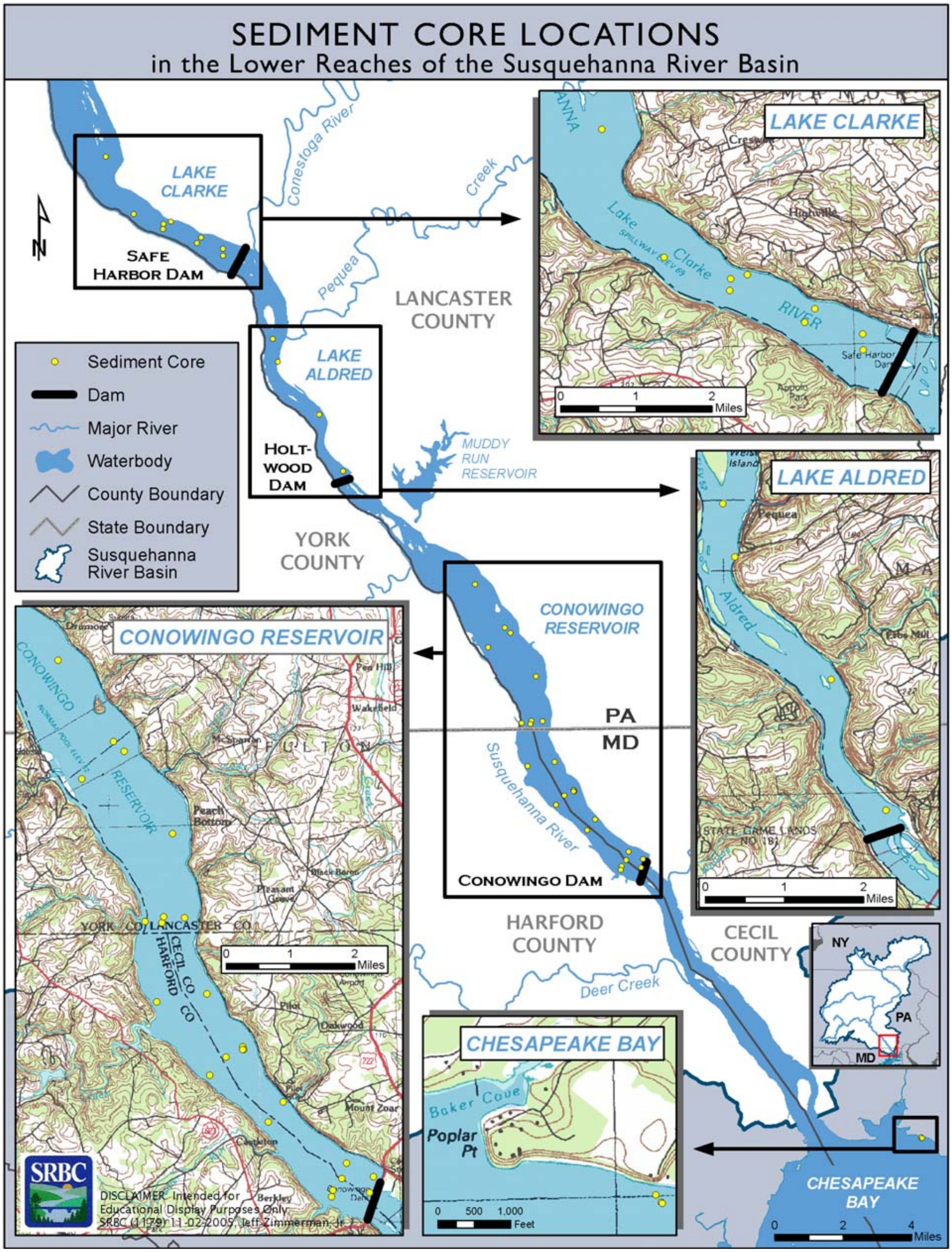

Figure 1. ***Sediment Core Sites Behind the Hydroelectric Dams on the Lower Susquehanna River and Upper Chesapeake Bay***

Findings

The results of the detailed investigations are located in Appendixes A, B, and C. Brief summaries and major findings for each report are listed below.

Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River

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The growing concern that the dams on the Susquehanna River are reaching their sediment storage capacity has spurred the need for detailed information concerning the sediment trapped behind the dams. Characterization of these sediments is the foundation for choosing management strategies to address the decreasing storage capacity. In order to characterize the sediment, cores (vibracores and gravity cores) were taken from 34 sites distributed behind the three lower dams on the Susquehanna River, and two sites in the Susquehanna Flats in the upper Bay. Sub-samples of these cores were divided among several laboratories as part of a coordinated effort to analyze the sediments. The MGS laboratories were responsible for taking X-rays of the cores for physical structures, determining water content and grain size, and performing analyses of total - carbon (C), nitrogen (N), sulfur (S), phosphorus (P), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb), and zinc (Zn).

The UMCES Chesapeake Biological Laboratory (CBL) was responsible for analyzing metals and metalloids, including silver (Ag), arsenic (As), cadmium (Cd), mercury (Hg), lead (Pb), and selenium (Se). CBL also analyzed sediments for polycyclic aromatic hydrocarbons (PAHs), PCBs, and pesticides.

Findings from the Maryland Geological Survey and University of Maryland Chesapeake Biological Laboratory include the following:

- Coal is a major component of the system. Of the 34 cores, 23 had distinct layers where coal was clearly the major constituent. Of these 23 cores, the average total length of the coal bearing layers was 24 centimeters for 100 centimeters of sediment depth. All samples analyzed to date contain coal whether visible on inspection or not. The average coal content of the sediment, excluding the visible coal layers, is approximately 11 percent.

- Sulfur content of the Susquehanna River sediments is approximately one-fourth to one-half the concentration of the lowest levels found in the Bay. The lower levels of sulfur indicate a lower potential for acid formation due to oxidation of the sulfur.

- Bed sediments behind the dams closely resemble the sediment in the northernmost reaches of the Bay, except for the high coal content and the lower levels of S and Mn (enriched in the northern Bay).

- The concentrations of metals analyzed in the Susquehanna River sediment cores were similar to concentrations found in the mainstem northern Bay. This is based on concentration ranges in the northern Bay, crustal abundance levels (using enrichment factors employing Fe concentrations to normalize the data), and baseline northern Bay metals behavior - As a result, the level of biological influence and expected toxicological effects of the metals would be similar to that found in the northern Bay sediments. The handling of Susquehanna sediments would be expected to be the same as the northern Bay sediments in this regard.

- Metal concentrations and geochemistry varied site to site. Specific locations and samples at greater depths had elevated metal concentrations. These variations in metal content are significant and must be addressed when deciding upon management options. For management options that result in sediment removal, one must evaluate the specific site and the depth to which sediment may be disturbed in order to assess any potential problems with sediment associated metals toxicity.

- High silver concentrations were found at depth, which suggests that in the past silver may have come from pollution sources within the river basin.

- Overall organic contaminant concentrations were comparable to those found in the upper Bay. However, the Susquehanna River appears to be the main source of PCBs to the upper Bay while pesticides and PAHs appear to be trapped behind the dams.

Phosphate Geochemistry and Microbial Activity in Surface Sediments from the Conowingo Reservoir and Susquehanna Flats, Md.: Summary of Findings

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The transport of phosphate is directly related to the transport of sediment. As part of a preliminary evaluation of the feasibility of dredging Conowingo Reservoir on the Susquehanna River, Pa., a characterization study was initiated that included a description of phosphorus biogeochemistry in the reservoir. Analyses included determination of total phosphorus and interstitial water phosphate concentrations, and phase association of phosphate from sequential extraction data. In addition, an evaluation was made of the antibiotic sensitivity of *in situ* bacteria.

Three box cores were collected in the reservoirs on the lower Susquehanna River in May 2000. To provide data for comparison of the characteristics of sediment that has been transported beyond the dam with the characteristics of sediment retained behind the dam, a fourth box core was collected at the mouth of the Susquehanna River, near Havre de Grace, Md., in August 2000. The box corer collected surface material to a depth of 20 cm (8-inches) without compaction of the sediment.

Findings from the U.S. Geological Survey include the following:

- Methane gas is escaping from the bottom sediments of the Conowingo Reservoir.

- Phosphate concentrations in the bottom sediments vary with location and with the amount of granular coal in the bottom sediment.

- Interstitial water contains small concentrations of phosphate with no increase in phosphate concentrations with depth from the sediment-water interface. Thus, the release of phosphate from bottom sediments does not occur by diffusion.

- The ranges in percent of total phosphorus for the geochemical phases are 2 to 4 percent exchangeable phosphate, 2 to 20 percent calcium-bound phosphate, 30 to 60 percent phosphate sorbed to iron oxides, and 30 to 70 percent organic phosphorus.

- The environmental conditions under which phosphorus could be released depend upon the geochemical phase of phosphorus. The exchangeable phosphate can be released to water if replaced by another anion. If calcium-bound phosphate is soluble, a slow release of phosphate can occur. Calcium-bound phosphate can be transported with suspended solids or formed in bottom sediment. Iron oxides could release phosphate under three conditions: (1) if oxidized iron is reduced (Fe^{3+} to Fe^{2+}); (2) if hydrogen sulfide produced by bacterial sulfate reduction precipitates iron; or (3) if sediment is exposed to acidic conditions. Organic phosphorus would be available when microbes degrade organic matter.

- The largest concentrations of organic phosphorus found in samples were those in bottom sediments from the channel of Conowingo Reservoir.

- Iron oxide associated phosphorus is the principal geochemical phase in the bottom sediments collected at shoreline sites within Conowingo Reservoir.

- The bottom sediments are not a source of dissolved reactive phosphate to the water column of Conowingo Reservoir.

- Bacteria in the sediment that could be cultured in the laboratory were, in general, antibiotic resistant.

- Bacteria from all sampling sites were resistant to penicillin and ampicillin at normal effective concentrations for inhibition of microbial growth, as well as significantly higher antibiotic concentrations.

- Bacteria in the sediment collected within the Susquehanna Flats were resistant to all five antibiotics: amoxicillin, penicillin, ampicillin, tetracycline, and sulfadimethoxine.

Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River: Activities of Anthropogenic Gamma Emitting Isotopes

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The management of sediments trapped behind the lower Susquehanna River dams requires an understanding of the concentrations of pollutants within the sediment bed. Analyses of sediment cores provided new data on the activity (concentration) of the gamma-emitting nuclides (especially cesium-137 (^{137}Cs)) and other relevant nuclide data. The sources of anthropogenic radiation in this system included direct atmospheric inputs from the testing of nuclear weapons, erosional inputs of these same inputs, and inputs from two nuclear power generating facilities.

Horn Point Laboratory analyzed nuclides of environmental interest. These nuclides included silver-110 (^{110}Ag), cobalt-58 (^{58}Co), cobalt-60 (^{60}Co), cesium-134 (^{134}Cs), ^{137}Cs, manganese-54 (^{54}Mn), zinc-65 (^{65}Zn), and zirconium-95 (^{95}Zr). In addition, radium-226 (^{226}Ra) was used for measurement calibration. While radium-226 (^{226}Ra) was not of environmental concern, its relatively constant activity in fine-grained muds provided a secondary check of the instrumentation counting system.

Most of the potential reactor nuclides in this study were not detected. Only ^{137}Cs with a 30.2-year half-life was routinely detectable. The highest activities found in this study were approximately 42 milli-becquerels per gram (mBq g^{-1}), a relatively small amount of radiation. The higher activities found in other studies were of limited geographical extent and generally restricted to narrow sediment horizons. These typical activities were less than 15 mBq g^{-1}, with a substantial number of samples with no detectable ^{137}Cs. Because anthropogenic nuclides have been around half the lifetime of the reservoirs, homogenization during activities such as dredging would result in sediment that would be extremely low in ^{137}Cs. The likelihood of radiation issues in the placement of Susquehanna reservoir sediment would be very low. Any further work at the time of sediment removal should be restricted to the immediate vicinity of Peach Bottom Atomic Power Station.

Findings from the University of Maryland Center for Environmental Science Horn Point Laboratory include the following:

- Activities of ^{110}Ag, ^{58}Co, ^{60}Co, ^{134}Cs, ^{54}Mn, ^{65}Zn, and ^{95}Zr were below the limit of detection due to the short half-lives of these nuclides.

- The highest activities of ^{137}Cs were found near the Peach Bottom Atomic Power station. These results are consistent with other studies conducted near the reactor.

- It is unlikely that higher activities near Peach Bottom would have any environmental consequences for sediment placement.

- When compared to measured results in other studies (Donoghue et al.1989; McClean et al. 1991), the activities of ^{137}Cs found in this investigation of reservoir sediments were generally lower than activities observed in core data near Peach Bottom and in surficial grab samples.

- The range of ^{226}Ra activities of 20-30 mBq g^{-1} were similar to ^{226}Ra activities documented in other studies of the Bay.

- Hot spots of high activity were not observed suggesting that radionuclide contamination was not a likely issue with these sediments.

APPENDIX A

Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River

Characterization of Bed Sediment
Behind the Lower Three Dams on the Susquehanna River

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EXECUTIVE SUMMARY

The growing concern that the dams on the Susquehanna River are reaching their sediment storage capacity has spurred the need for detailed information concerning the sediment trapped behind the dams. Characterization of these sediments is the foundation for choosing management strategies to address the decreasing storage capacity. In order to characterize the sediment, cores (vibracores and gravity cores) were taken from 34 sites distributed behind the three lower dams on the Susquehanna River, and two sites in the Susquehanna Flats in the Upper Chesapeake Bay. Sub-samples of these cores were divided between several laboratories as part of a coordinated effort to analyze the sediments. The Maryland Geological Survey (MGS) laboratories were responsible for: Taking X-rays of the cores for physical structures; opening and taking subsections of the cores; determining water content and grain size; and, analyses of total - Carbon (C), Nitrogen (N), Sulfur (S), Phosphorus (P), Cadmium (Cd), Chromium (Cr), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), and Zinc (Zn). The laboratories of the University of Maryland's Chesapeake Biological Laboratory (CBL) was responsible for analyzing: Aresenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg), Selenium(Se), and Silver (Ag) along with trace organic compounds (PAH's, PCB's, other priority pollutants)

Findings include the following:

- Coal is a major component of the system. Of the 34 cores, 23 had distinct layers where coal was clearly the major constituent. Of these 23 cores the average total length of the coal bearing layers was 24 centimeters for 100 centimeters of sediment depth. All samples analyzed to date contain coal whether visible on inspection or not. The average coal content of the sediment, excluding the visible coal layers, is approximately 11%.
- Reduced sulfur concentration average 0.129%, approximately one-fourth the concentration found in the Northern Chesapeake Bay. The lower levels of sulfur indicate a lower potential for acid formation due to oxidation of the sulfur.
- Based on concentrations ranges in the Northern Bay, crustal abundance levels [using enrichment factors employing Fe concentrations to normalize the data], and baseline line Northern Bay metals behavior - all of the metals were within the range of Northern main stem Chesapeake Bay levels. Thus the river sediments for those elements can be treated in a similar manner as Northern Bay sediments
- Metals concentration and behavior varied site to site, and as a function of depth (higher concentrations occurring at greater depths). These variations in metal content are significant and must be addressed when deciding upon management options.

- High silver (Ag) concentrations were found at depth which suggest that in the past Ag may have come from pollution sources within the river basin.
- Overall organic contaminant concentrations were comparable to those found in the Upper Chesapeake Bay.

INTRODUCTION

The growing concern that the dams on the Susquehanna River are reaching their sediment storage capacity has spurred the need for detailed information concerning the sediment trapped behind the dams. Characterization of these sediments is the foundation for choosing management strategies to address the decreasing storage capacity. In order to characterize the sediment, cores (vibracores and gravity cores) were taken from thirty-four (34) sites distributed behind the three lower dams on the Susquehanna River, with two additional sites for reference collected in the Susquehanna Flats area of the Upper Chesapeake Bay (see Appendix I). The locations of the thirty-four cores analyzed from the Susquehanna River are shown in Figure 1.

This figure shows the lower reaches of the Susquehanna River, with expanded details of the three dams where samples were collected. The sample distribution was based on the surface area of the ponded water behind each dam; 8 samples behind Safe Harbor, 4 behind Holtwood, and 21 (including two replicate cores) behind the Conowingo Dam. The sediments behind each dam form a wedge with the deepest layer of sediment close to the dam, and thinning out proceeding upstream. As a result the samples collected vary in their representation of the entire sedimentary record; in the upstream portion the whole sedimentary column may have been sampled, while close to the dam only the upper 10-20% of the sedimentary column may have been sampled. The parameters measured in the multi-disciplinary study to characterize the bed sediment are given in Table 1, along with the organization responsible for the analyses.

Table 1. Parameters analyzed to characterize the bed sediments of the lower reaches of the

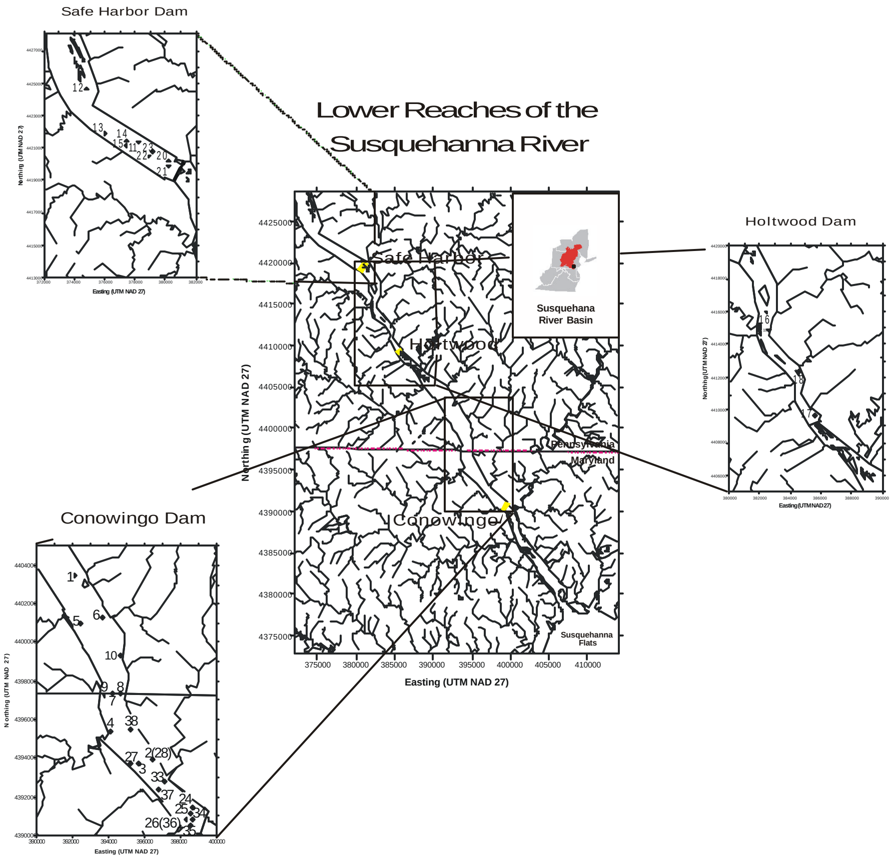

Figure 1. Location of cores collected to characterize the bed sediment of the lower reaches of the Susquehanna River.

Susquehanna River and the organizations responsible for the analyses.

PARAMETERS MEASURED ON BED SEDIMENTS

Maryland Geological Survey

Physical Description
X-rays of whole core, and Photographs of split cores
Grain Size, Water Content
Coal Content
Nutrients (total) - C, N, P, S
Metals (total) - Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn

University of Maryland

Metals - Ag, As, Cd, Hg, Pb, Se
Radio-isotopes
Trace Organic Compounds (PAH's, PCB's, other priority pollutants)

US Geological Survey (four stations)

Phosphorus Speciation

METHODOLOGY

Collection and Sampling

Samples were collected by the US Geological Survey (USGS), either using a vibracore or gravity core collection system. The selection of system was based on water depth; water depths <20', the vibracore was used, in deeper water, gravity cores were collected. Most of the cores were vibracores, only the cores closest to the dams were gravity cores. Locations of the sites were measured using a GPS system; the latitude and longitude of the sites is given in Appendix I along with the sampled intervals and the lengths of the cores.

The core samples were collected in aluminum irrigation tubes. These tubes were transported horizontally back to shore where they were cut into approximately 1.5 meter lengths then taken to refrigerated storage near the sites of collection. Cores were later transported to MGS where they were stored at 4°C, X-rayed, split open, described, photographed, and sub-sampled within a week of receipt. The descriptions of the cores are presented in Appendix II

Four samples for the complete analytical work up were taken from each core. The first sample was collected as close to the sediment-water interface as possible. It was not always practical to collect at the sediment-water interface because the upper sediments were disturbed by transport, especially during the horizontal transport back to shore. The deepest sample was collected above the brass core catcher “fingers” at the base of the core. The middle samples were selected to yield sample intervals that were approximately equidistance throughout the core. The calculated sampling intervals were adjusted if the sampling interval coincided with a predominately coal layer; the sample interval was moved to the nearest interval of detrital material without obvious coal content. This adjustment was not always possible because of the extreme amount of offset, in these cases the coal layers were sampled. The remainder of the core, not slated for analysis, was sampled at 10cm interval and archived.

Laboratory Analyses

Coal Analysis

Although not an originally in the scope of work, it became quickly apparent that this was a required component of the analytical scheme. This was based on:

1. Coal was a major constituent of the sediment distinct from the inorganic detrital sediment, based solely on lithologic description of the sediment;
2. Coal has a specific gravity of ~ 1.4-1.6 grams per cubic centimeter (g/cc). The routine grain size analysis uses a Stoke’s law settling velocity. The velocity of the settling of the sediment in water is strongly dependent on the density of the material. Inorganic detritial

material has a density of ~ 2.68 g/cc, almost twice the density of the coal. Thus the settling rate for coal would be substantially lower than for same sized inorganic particle, and;
3. During the sieving operation to remove the coarse sand sized particles it was noted that the more the coal was washed the more that past through the sieve. Effectively the coal was breaking apart during the mechanical separation producing finer coal particles. Coal is friable and this is to be expected. Consequently the grain size measured would not be the grain size found in the sediment.

As a result of these considerations coal was removed from the sediment prior to grain size analysis.

Coal separation was preformed using a heavy liquid having a density between that of coal (1.4 to 1.6 g/cc.) and that of alumina-silicates minerals (2.68 g/cc). When sediment/coal mixture is suspended in the heavy liquid, the coal will float to the top of the suspension and the mineral component will sink to the bottom. In this procedure, the heavy liquid is a solution of Cesium Chloride (CsCl), mixed to achieve a specific gravity of 1.85 to 1.9 [Approximately 500 grams of CsCl is dissolved in 500 ml of de-ionized H_2O], and the settling procedure is facilitated by use of centrifugation..

The procedure is done as part of the sediment cleaning process prior to sieving (sand/mud separation) in preparation for pipetting (see Grain Size Analysis section).

Procedure for coal separation, six (6) samples at a time:

1-After cleaning the samples with HCl and H_2O_2 (see Grain Size Analysis section), de-ionized water is used to transfer samples into 500 ml centrifuge bottles;
2- The centrifuge bottles are weighed with sample-water mixture, using additional water to bring weights within 1 gram of each other;
3- The samples are Centrifuged at 2500 rpm for 10 minutes (or longer, until supernatant liquid is clear of suspended particles); siphon as much water as possible from bottles;
4- Add CsCl solution to each bottle, filling approximately 1/3 full; stir samples to mix thoroughly; weigh all bottles with CsCl/sample mixture, using additional CsCl solution to bring weights within 1 gram of each other;
5- Centrifuge samples at 2500 rpm for 15 minutes; After centrifugation, the coal floats on top of suspension; there is a clear defined separation of coal from sediment which is compacted on bottle of bottle; if the separation is not complete, centrifuge for an additional 10 minutes.
6- Collect coal by pouring coal and supernatant liquid into a Buchner funnel lined with pre-weighed semi-quantitative filter paper. Wash the coal thoroughly with deionized water.
7- Dry the coal and filter paper at 70°C, and weigh until constant weight is achieved.
8- Filter CsCl filtrate through quantitative filter paper, and evaporate solution in order to concentrate CsCl for reuse.

Water Content and Grain Size Analysis

Water content was calculated as the percentage of the water weight to the total weight of the wet sediment:

$$Wc = \frac{Ww}{Wt} \times 100,$$

where Wc = water content (%)
Ww = weight of water (g)
Wt = weight of wet sediment (g).

Water weight was determined by weighing approximately 25 g of the wet sample, drying the sediment at 65°C, and reweighing it. The difference between total wet weight (Wt) and dry weight equals water weight (Ww). Bulk density was also calculated from water content measurements.

The relative proportions of sand, silt, and clay were determined using the sedimentological procedures described in Kerhin and others (1988). The sediment samples were pre-treated with hydrochloric acid and hydrogen peroxide to remove carbonate and organic matter, respectively. Then the samples were wet sieved through a 62-µm mesh to separate the sand from the mud (silt plus clay) fraction. The finer fraction was analyzed using the pipette method to determine the silt and clay components (Blatt and others, 1980). Each fraction was weighed; percent sand, silt, and clay were determined; and the sediments were categorized according to Pejrup's (1988), and Shepard's classifications. The results of these analyses are presented in Appendix III.

MGS Analytical Protocol for Metals and Phosphorus (Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn & P)

Sediment solids were analyzed for eight trace metals(cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn)) and total phosphorus. Metal and phosphorus concentrations were determined using a microwave digestion technique, followed by analysis of the digestate on an Inductively Coupled Argon Plasma unit (ICAP).

The steps in microwave digestion, modified from EPA Method #3051 to comply with NOAA Status and Trend requirements for total metal analyses, are outlined below:

1. Samples were homogenized in the "Whirl-Pak" bags in which they were stored and refrigerated (4°C).

2. Approximately 10 g of wet sample were transferred to Teflon evaporating dishes and dried overnight at 105-110°C.
3. Dried samples were then hand-ground with an agate mortar and pestle, powdered in a ball mill, and stored in "Whirl-Pak" bags.
4. 0.5000±0.0005 g of dried, ground sample was weighed and transferred to a Teflon digestion vessel.
5. 2.5 ml concentrated HNO_3 (trace metal grade), 7.5 ml concentrated HCl (trace metal grade), and 1 ml ultra-pure water were added to the Teflon vessel.
6. The vessel was capped with a Teflon seal, and the cap was hand tightened. Between four and twelve vessels were placed in the microwave carousel. (Preparation blanks were made by using 0.5 ml of high purity water plus the acids used in Step 5.)
7. Samples were irradiated using programmed steps appropriate for the number of samples in the carousel. These steps have been optimized based on pressure and percent power. The samples were brought to a temperature of 175°C in 5.5 minutes, then maintained between 175-180°C for 9.5 minutes. (The pressure during this time peaks at approximately 6 atm for most samples.)
8. Vessels were cooled to room temperature and uncapped. The contents were transferred to a 100 ml volumetric flask, and high purity water was added to bring the volume to 100 ml. The dissolved samples were transferred to polyethylene bottles and stored for analysis.
9. The samples were analyzed.

Samples were analyzed using a Thermo Jarrel-Ash Atom-Scan 25 sequential ICAP. The wavelengths and conditions selected for the elements of interest were determined using digested bottom sediments from the Susquehanna River bed sediments and standard reference materials from the National Institute of Standards and Technology (#1646 - Estuarine Sediment; #2704 - Buffalo River Sediment) and the National Research Council of Canada (PACS-1 - Marine Sediment).

The wavelengths and conditions were optimized for the expected metal levels and the sample matrix. Quality control was maintained by routinely including blanks, replicates and standard reference materials in the analysis. Blanks were run every 20 samples; one sample in every ten was replicated; and a standard reference material was analyzed after every ten samples.

Metal concentrations of the samples are reported in Appendix IV and phosphorus analyses are reported with the nutrient analyses in Appendix V.

CBL Analytical Protocol Metals and Metalloids (Hg, Ag, Cd, Pb, As, Se)

A subsample of sediment was used for dry weight determination. Weighed samples were placed in a VWR Scientific Forced Air Oven at 60^0C overnight and were then reweighed and a dry/wet ratio was then calculated. Another subsample (1-5 g wet weight) was placed in acid-cleaned flasks for further digestion, using EPA Methods (EPA Methods; Keith, 1991; Baker et al., 1997). Briefly, ten mL of 1:1 HNO_3 was added and the slurry was mixed and covered with a watch glass. The sample was heated to 95^0C and allowed to reflux for 15 minutes without boiling. The samples were cooled, 5 mL of concentrated HNO_3 was added, and then they were allowed to reflux for another 30 minutes. This step was repeated to ensure complete oxidation. The watch glasses were removed and the resulting solution was allowed to evaporate to 5 mL without boiling. When evaporation was completed and the samples cooled, 2 mL of 30% H_2O_2 was added. The flasks were then covered and returned to the hot plate for warming. The samples were heated until effervescence subsided. We continually added 30% H_2O_2 in 1 mL aliquots with warming until the effervescence was minimal. No more than a total of 10 mL of H_2O_2 was added to each sample. Lastly, 5 mL of concentrated HCl and 10 mL of deionized water were added and the samples refluxed for 15 minutes. The samples were then cooled and filtered through Whatman No. 41 filter paper by suction filtration and diluted to 100 mL with deionized water. Sediments were digested in a similar fashion. Samples for mercury (1-3 g wet weight) were separately digested in a solution of 70% sulfuric/30% nitric acid in Teflon vials, heating overnight in an oven at 60^0C (Mason et al., 1995). The digestate was then diluted to 10 mLs with distilled-deionized water.

Prior to mercury analysis, the digested samples were further oxidized for 30 minutes with 2 mL of bromine monochloride solution. The excess oxidant was neutralized with 10% hydroxylamine solution and the concentration of mercury in an aliquot of the solution was determined by tin chloride reduction cold vapor atomic fluorescence detection in accordance with protocols outlined in EPA Method 1631 (Mason et al., 1993). For the other metals and metalloids, samples were analyzed using a Hewlett-Packard 4500 Inductively Coupled Plasma Mass Spectrometer (ICP-MS) using well-established methods in our laboratory (Lawson *et al*., 2000).

Standard calibration curves were run daily, and a standard addition spike, added to one in every 15 samples, was used to check for matrix interferences. Externally certified reference samples (digestates of NIST SRM 1646a Sediment for Cd, Pb, As, and Se and IAEA SRM 142 for Hg) were also regularly included in the analytical protocols to verify the accuracy of the results. Furthermore, the laboratory participated in the Canadian National Water Research Institute intercalibration in the late summer of 1997 to confirm the analytical methods for trace metals. All results were within the accepted variability. Additionally, the laboratory is a regular participant in intercomparisons for Hg; the most recent being a comparison of the analysis of Hg and MMHg in Florida Everglades waters organized by Florida DEP for EPA. Overall, our results compare with those of others (within 20% of the mean for Hg and MMHg, within 10% for the other metals). Samples were run in duplicate during each sample batch and replicate samples were run on separate days to verify true analytical reproducibility. Field duplicates were collected routinely and precision was typical for these analyses. The result of these analyses is reported in Appendix VI.

Analytical Procedures for Organic Contaminants.

Sediment samples were weighed into suitable containers and were extracted and purified using the method described by Kucklick *et al*. (1996). A perdueterated PAH cocktail (d_8-napthalene, d_{10}-fluorene, d_{10}-fluoranthene, d_{12}-perylene) and a noncommercial PCB solution (IUPAC #'s 14, 65, 166) were added as surrogates to each sample to track extraction efficiency. The mixture was then extracted in a Soxhlet apparatus with 250 mL of dichloromethane (DCM) for 24 hours. The extracts were then concentrated to 10 mL using a vacuum rotary evaporator. Each sample was transferred to graduated centrifuge tubes and concentrated to 6 mL under a gentle stream of nitrogen. Gravimetric lipid analysis was performed on each sample (Kucklick, *et al*., 1996). Lipids were then removed through gel permeation chromatography, eluting DCM through Phenogel 50 x 7.8 mm guard, 250 x 22.5 mm Phenogel 10 ul 100 A, and 250 x 21.5 mm Phenogel 10 ul 100 A columns, in series, respectively. Samples were again concentrated in similar fashion as above, then solvent exchanged to hexane. The extracts were then eluted with 35 mL petroleum ether over deactivated Alumina [6% (w/w) water]. After concentrating, the extracts were spiked with a perdueterated PAH mixture (d_{10}-acenapthene, d_{10}-phenanthrene, d_{12}-benz[*a*]anthracene, d_{12}-benzo[*a*]pyrene, d_{12}-benzo[*g,h,I*]perylene) for quantification of PAH's. The samples were then analyzed using a Hewlett Packard 5890 gas chromatograph (GC) with a HP-5MS (cross linked 5% phenyl methyl siloxane) capillary column (30m x 0.25mm x 0.25um film thickness) and a HP-5972 series mass spectrometer (MS) for PAH's (Ko and Baker, 1995). Each sample was separated after GC/MS analysis into two fractions with 35 mL of petroleum ether and 50 mL of DCM/PET (1:1), respectively, over 8 g of deactivated Florisil (2% (w/w) water, Kucklick *et al*.1996). The first fraction (F-1), contains PCBs and 1-100%, by weight of the less polar organochlorine pesticides [heptachlor (100%), 4,4-DDT (40%), 4,4-DDE (100%), t-nonachlor (24%), heptachlor (1%), 4,4-DDT(44%)]. The second fraction, (F-2), contains 56-100% of the more polar organochlorine pesticides [a-HCH (100%), g-HCH (100%), c-chlordane (100%), t-chlordane (100%), t-nonachlor (76%), heptachlor (99%), heptachlor epoxide (100%), dieldrin (100%), 4,4-DDD (100%), 4,4-DDT (56%)]. Both fractions were solvent exchanged to hexane and concentrated to ~ 1 mL.

PCBs and remaining organochlorine pesticides (OCs) were analyzed by GC using a J&W Scientific DB-5 capillary column (60m x 0.32mm x 0.25um film thickness) coupled with an electron capture detector (ECD). PCBs were quantified on an individual congener basis following Mullins *et al*. (1985), using noncommercial PCB congeners (IUPAC#'s 30 and 204 added to each extract after purification) as internal standards. OCs were also quantified using PCB congeners 30 and 204 in both Florisil fractions.

Method detection limits were calculated from the minimum quantity detectable either by the analytical instrument or by the quantity significantly greater than analyte masses in field blanks. Instrument detection limits were calculated as the mass of each analyte required to generate a signal three times greater than the background noise. Blank-based detected limits were calculated as three times the mass of analyte detected in the field matrix blank. Therefore, the overall method limit is determined either by the sensitivity of the instrument's detector or by the cleanliness of the sampling and analytical procedure. In this report, we present only those concentrations of target organic analytes that exceed the method detection limit.

Method precision for organic contaminant analysis was determined by quantification of target analytes in NIST Standard Reference Materials. Overall method efficiency of each sample was assessed by adding surrogate PAHs and PCB congeners to the samples prior to extraction. A suite of surrogate compounds with different volatilities allows us to assess the overall method efficiency for each class of analytes. The analytical results of the sample analyses is reported on Appendix VII.

Total Carbon, Nitrogen, and Sulfur Analyses

The sediments were analyzed for total nitrogen, carbon and sulfur (CNS) contents using a Carlo Erba NA1500 analyzer. This analyzer uses complete combustion of the sample followed by separation and analysis of the resulting gasses by gas chromatographic techniques employing a thermal conductivity detector. The NA1500 Analyzer is configured for CNS analysis using the manufacturer's recommended settings. As a primary standard, 5-chloro- 4-hydroxy- 3-methoxy- benzylisothiourea phosphate is used. Blanks (tin capsules containing only vanadium pentoxide) were run at the beginning of the analyses and after 12 to 15 unknowns (samples) and standards. Replicates of every fifth sample are run. As a secondary standard, a NIST reference material (NIST SRM #1646 - Estuarine Sediment) are run after every 6 to 7 sediment samples. The results of the analyses for the samples collected for this study are given in Appendix V.

DISCUSSION

Coal

The bed sediments behind the lower three dams on the Susquehanna River contain a significant amount of coal. The coal in the sediment is the result of mining operations in the upper reaches of the basin. It has been estimated that ~17% of the coal mined in the basin was washed into the river during the size sorting of the coal. The large amount of coal that washed into the river made the sediment an economical source of coal to fuel a power plant, and was mined/dredged for this purpose until 1973 when Tropical storm Agnes redistributed the richer deposits and made the marginal recovery operations unfeasible. Of the 34 cores analyzed, 24 had distinct layers where coal was clearly the major constituent. Of these 24 cores the average total length of the coal bearing layers was 24 centimeters for each meter of sediment. All samples analyzed to date contain coal whether visible on inspection or not. The average coal content of the sediment, excluding the visible coal layers, is approximately 11%. Figure 2 (a-c) shows coal layers in sections of cores from behind each of the dams. For each core in the figures, there are two images; an X-ray image, on top and the photographic image on the bottom. The intensity of the shading of the X-ray image depends on the transparency of the material to X-rays; the more transparent the material X-rayed the darker the image. In the sediment, sand is the least transparent material (therefore the lightest in color), followed by silt and clay; coal and organic debris is virtually transparent (therefore the darkest).

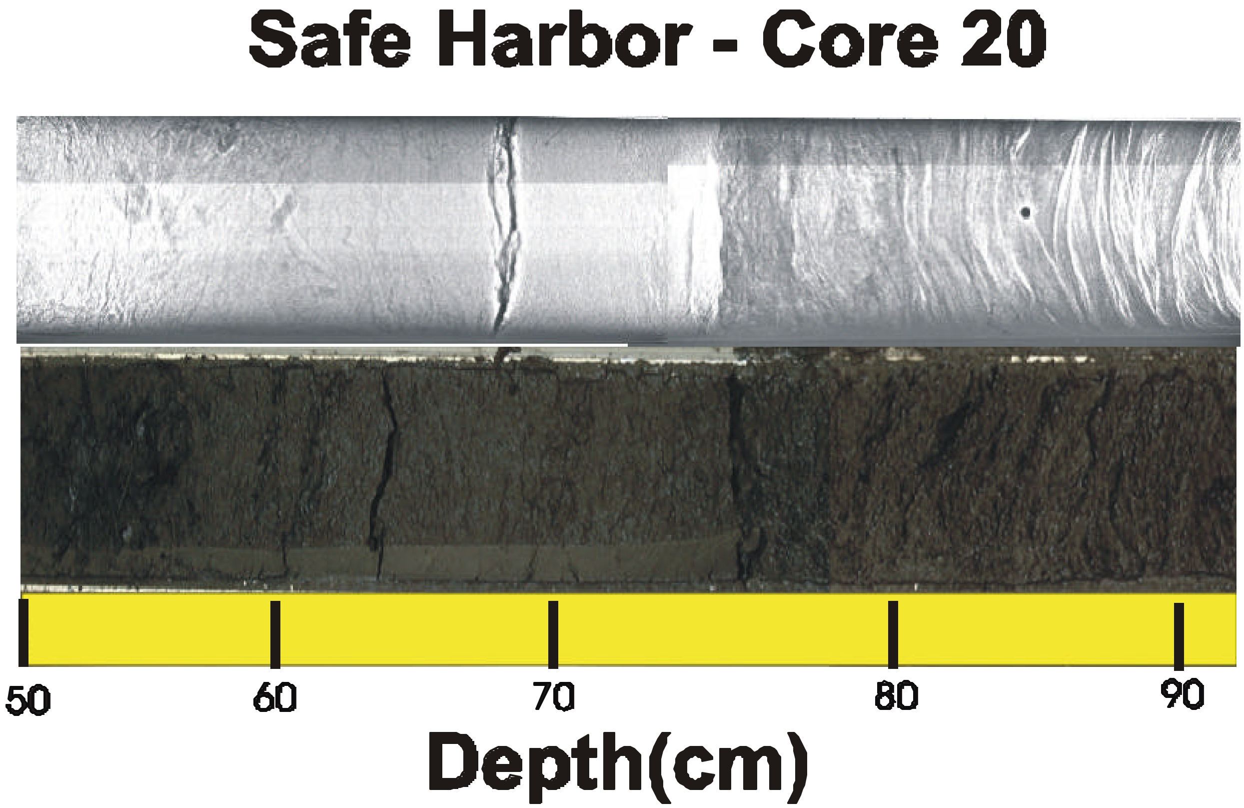

Figure 2a. Core section from behind Safe Harbor Dam showing a transition between fine grain sediments and a predominant coal bearing layer at a depth of 77 cm.

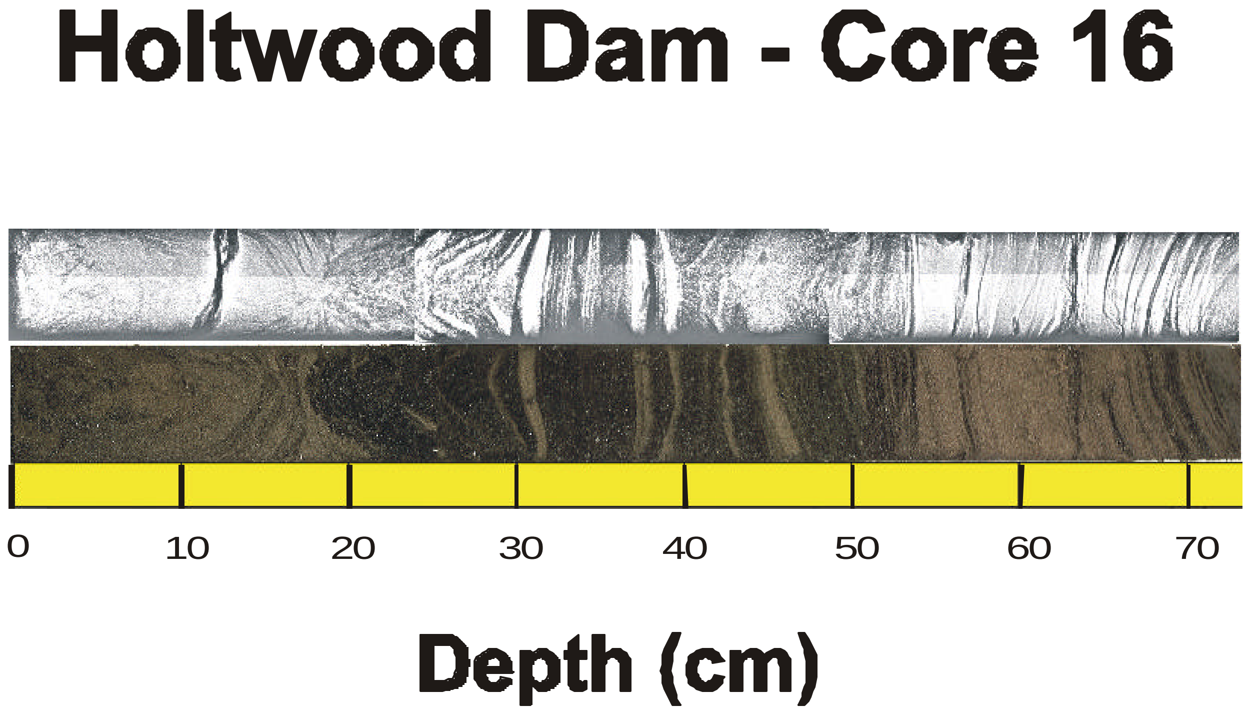

Figure 2b. A core section from behind Holtwood dam. The core displays strong interlayering of sands (light colored) and coarse coal (dark colored), on a relatively fine scale.

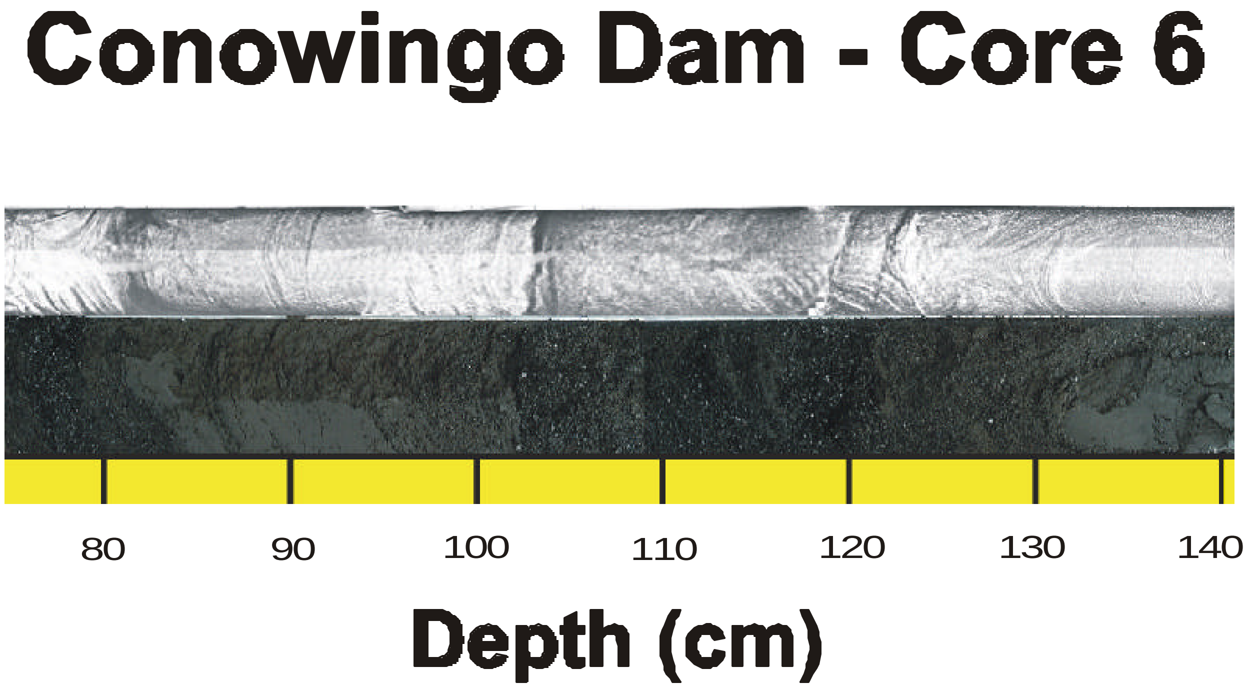

Figure 2c. A core section from behind Conowingo dam. This core shows 4 distinct layers alternating between predominantly coal and clayey-silts. Note the difference in layer thickness in comparison to Figure 2b.

Figure 2a shows a 40 cm section of a core behind Safe Harbor. In this figure a clear transition can be seen at approximately 77cm; <77cm - a relatively clean fine grain sediment, >77cm - interbedded silt and coal. Figure 2b shows a 75cm section of a core from behind Holtwood dam. This core is highly interlayered, alternating between coarse coal and sandy sediments throughout the length of the section. Comparison of the X-ray to the photograph highlights the detailed structure in the X-ray image that is not obvious on visual inspection. Although the photograph here is reproduced in black and white, the true color showed a strong contrast of buff colored sands offset by the black coal layers.

Figure 2c shows a 65cm core section from behind Conowingo dam. This core shows 4 distinct layers alternating between predominantly coal (containing fine scale sand laminations) and clayey-silts. The coal layers occur at depths <83cm, and 103-131cm, and the clayey-silts occur between 83-103cm, and >131cm. In comparison to the previous figure (2b) the layers are considerably thicker, and the nature of the detrital material is much finer, representing different hydrological regimes; Core 16 (Figure 2b) representing a higher energy environment than that of Core 6 (Figure 2c).

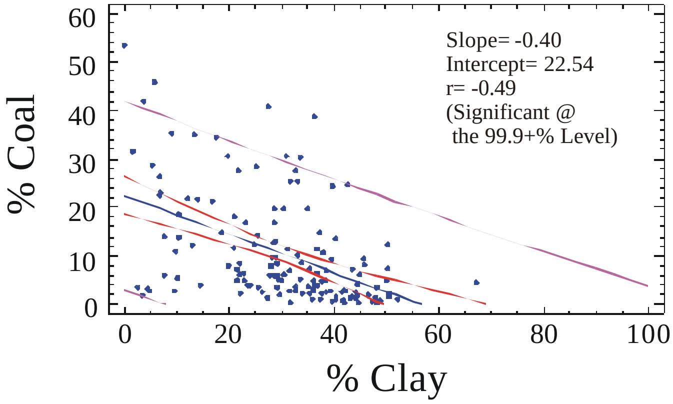

Figure 3. % Coal, in the layers which are not coal-dominant layers, as a function of the clay content of the sediment.

Analysis of the grain size data and the coal content of the sediment show that the coal is associated with the coarser grained sediment (Silt + Sand). This is shown in Figure 3 which is a plot of the coal content of the samples as a function of the Clay content of the sediment. A regression fit of the data, shown as the lines in the plot, indicate significant antithetic trend, with the coal content decreasing as the Clay content increases. Consequently, coal would be expected to be found in hydrological regimes which concentrate Sands and Silts, which are higher energy environments. This is shown in Figure 4, which is a plot of the coal concentration in the sample closest to the sediment water interface for each core and the sum of the thickness of all of the visually apparent coal layers (total coal interval) in each core as a function of distance from the Conowingo dam. The vertical lines indicate the location of the dams and the sloping lines are trend lines of the data. Generally the data track water depth, which is the deepest near the dams - thus a lower velocity, more quiescent environment where clay would settle, and shallowest farther upstream - which would be a higher energy regime which would concentrate coarse material such as sands and silt, and coal..

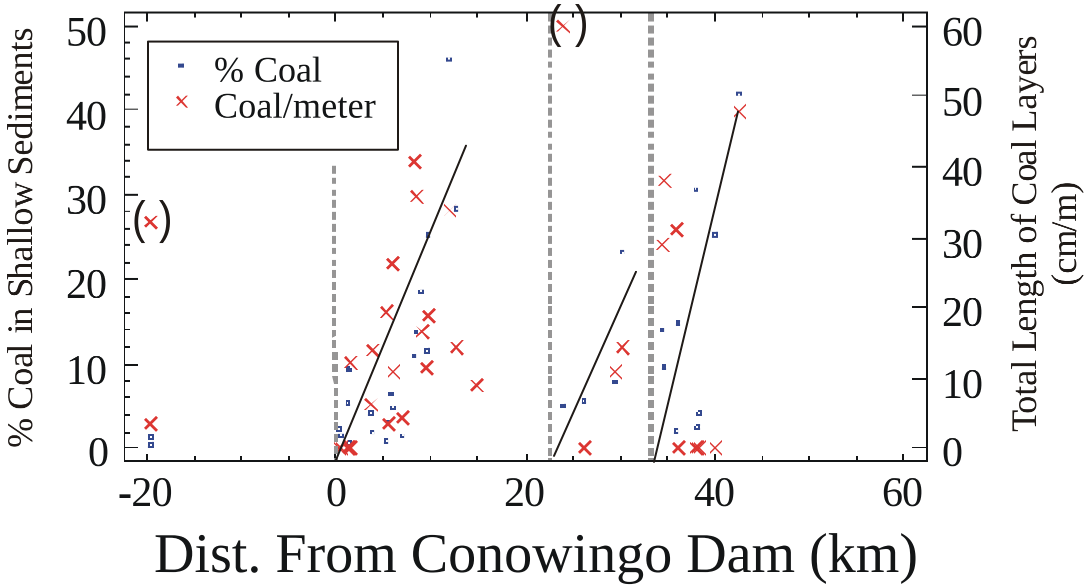

Figure 4. Coal content in the surface sediments and integrated length of coal in each meter of sediment as a function of distance from the Conowingo dam.

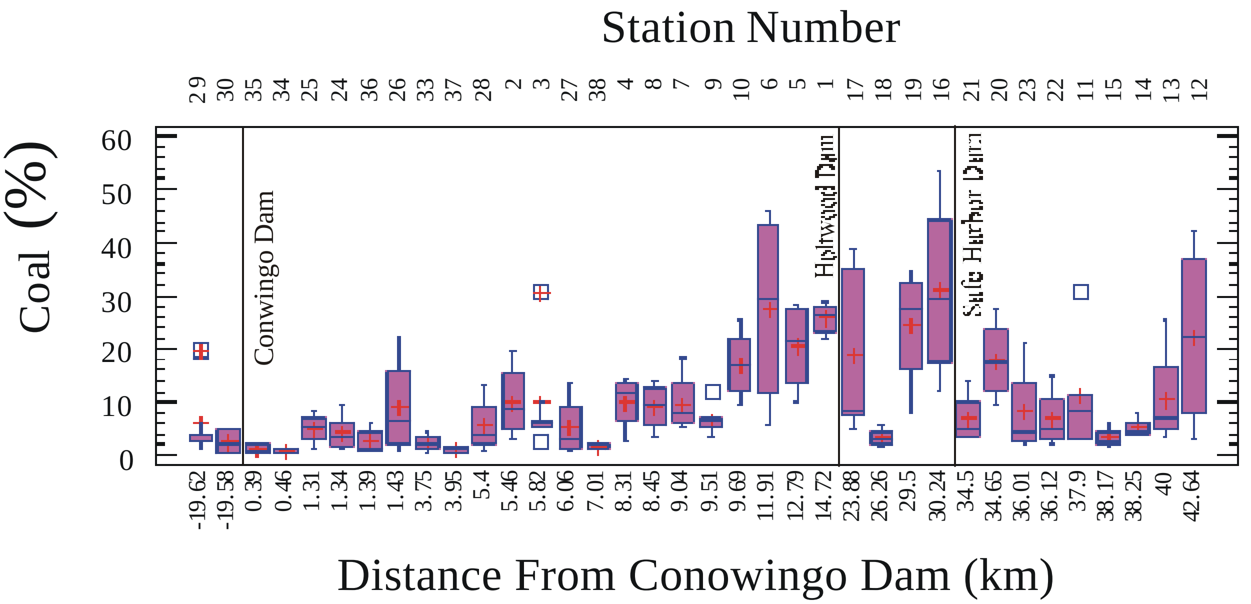

Figure 5. Distribution of coal in the samples collected for this study. The distance axis is a listing of the samples locations ordered by distance from the Conowingo Dam. The box and whisker diagrams represent the range of data from each sample location.

Along with the changes in the physical properties of the sediment, the coal also modifies the chemical composition of the sediment. These modifications are the result of the nutrient and metal content of the sediment which is distinct from that of the inorganic fraction of the sediment. The specific modifications to the sediment chemistry will be dealt with in the following sections. The general distribution of coal in the sediments in the study area are shown in Figure 5. This figure shows the range of the coal content of the sediment within each core as a box and whisker diagram and the cores are plotted as a function of distance from the Conowingo Dam; Samples north of the dam are positive, the Bay sample locations are negative. The distance axis is not to scale, it is a listing of the sample locations ordered by increasing distance from Conowingo dam. Box and whisker diagrams analyze the data using a normal distribution and by dividing data into four quadriles. The box represents the 50% of the data around the median (25% above and 25% below the median), each whisker is the next quadrile (25%) away from the median, the points beyond the whiskers represent data that are beyond the fitted normal range (i.e. > 3 standard deviations). The point in the middle of the box is the average value of the data. In Figure 5 the most prominent feature of the data are the high coal contents found in the sediments from ~10 - 36 km. This figure will be referenced often in the following sections when the effects of coal to the sedimentary environment is discussed.

Total Carbon, Nitrogen, Phosphate, and Sulfur

One of the natural consequences of the high coal content of the sediments is the elevated levels of carbon in the sediment. Organic carbon in sediments is the most reduced chemical species in the system and bacteria utilize this carbon which results in the development and maintenance of anoxic conditions in the sedimentary environment. The anoxic environment in the sediments controls the formation of reduced sulfur and other diagenetic chemical species which in turn control the storage and transport of metals and nutrients. This is particularly important when considering altering the environmental conditions of the sediments as during the placement of dredged material.

In marine and estuarine environments the major source of organic carbon to the sediment is from the by-products of primary production, i.e. anabolic biomass production from plankton in the water column. In fresh water systems, in addition to primary production there is a significant terrigenous source of carbon that is derived either directly from plant debris being swept into the system, or indirectly from plants as a result of the decay processes. Generally, terrigenous carbon is much less reactive than carbon derived from primary production and the associated nutrient load of nitrogen and phosphorus is much less. In the Susquehanna river there is the additional source of carbon from coal which is even less reactive than terrigenous carbon, however may contain significant levels of nutrients relative to the remaining portion of the sediment.

Figure 6 shows the concentration of organic carbon found in the all of the Susquehanna river samples, excluding the predominant coal layers, in comparison to carbon concentrations found in the Northern Chesapeake Bay; the Northern Bay samples are divided into classes based on the latitude interval they are found in the Bay. The data show that the carbon concentrations found in the Susquehanna River are significantly higher than that found in the Bay; note the separate scale required for the Susquehanna River sediment. Within the Bay there is a decrease

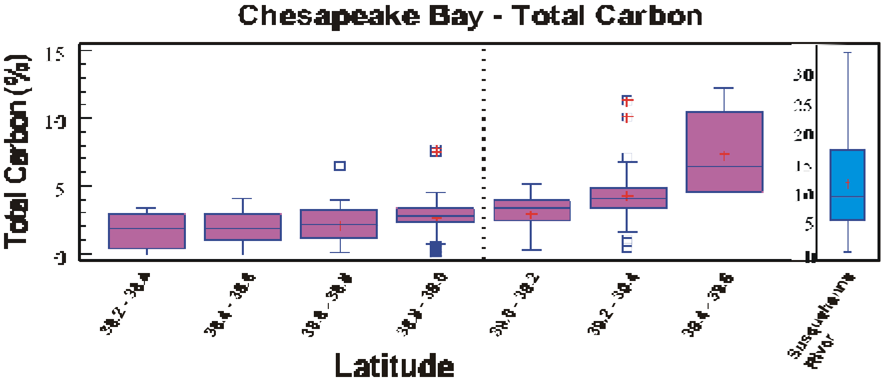

Figure 6. Comparison of the Susquehanna River bed sediment carbon concentrations to the concentrations found in the Maryland portion of the Chesapeake Bay.

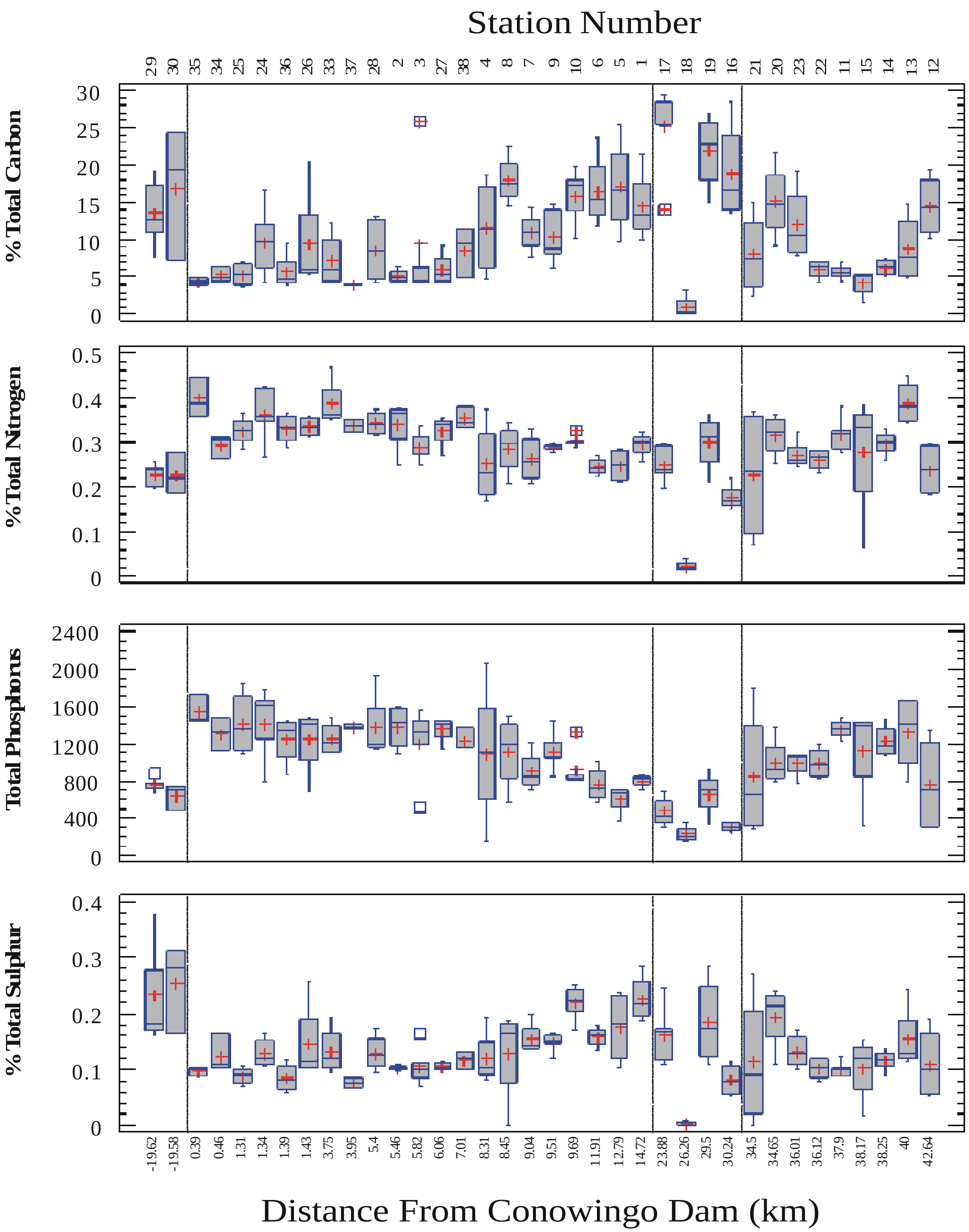

Figure 7. This figure is uses the same format as Figure 5 to show the distribution of the data in the core for total Carbon, Nitrogen, Phosphorus, and Sulfur.

going from north to south (away from the Susquehanna river) in the organic carbon content. High carbon levels in the Northern Bay and the southerly decrease in carbon has been attributed to coal from the Susquehanna river entering the Bay (Hennessee et al., 1983). This effect is found north of the Bay Bridge noted by the dashed line in the figure.

The effect of coal on other nutrients (N, P, and S) can be seen in Figure 7. This figure is uses the same format as Figure 5 to show the distribution of the data in the cores for total Carbon, Nitrogen, Phosphorus, and Sulfur. Coal in the sediment can either enrich the sediment if the coal has a higher elemental concentration than the sediment fraction, or it can deplete the sediment , by dilution, if the elemental concentrations are significantly lower than the sediment fraction. Finally, if the concentrations are comparable to the sediment fraction there will be no appreciable change to the overall sediment composition. All three of these behaviors are seen in the nutrient distribution patterns.

Figure 7 shows total carbon simply reflecting the coal content of the sediment; carbon being the principle component of coal. Total nitrogen shows no appreciable effects as a result of varying coal content, consequently it can be inferred that the N content of coal is comparable to the N content of inorganic fraction of the sediment. Total phosphorus shows an antithetic relationship to the coal content, indicating that the coal is diluting the more concentrated inorganic fraction of the sediment. On the other hand, total sulfur tracks coal, showing elevated levels where coal concentrations are high, indicating that the coal has a higher content of sulfur than the inorganic fraction of the sediment. This sulfur enrichment could either be the result of residual sulfur that is in the coal matrix, not weathered, i.e. oxidized, during the mining or transport process, or it could be the result of diagenetic mineral formation. The coal rich sediments may foster an anoxic environment which forms sulfide minerals more readily than the finer coal depleted sediments. Reduced sulfur, found in coal or as authegenic sulfide minerals, is a major concern in placement of dredged sediments.

Reduced sulfur in sediments and coal is found primarily in the forms of metal monosulfides and pyrite. These minerals when exposed to atmospheric conditions, oxidizes to produce sulfuric acid which in turn can leach metals, nutrients, and trace organic compounds; the process is the same as acid mine drainage. In order to form these reduced sulfur compounds in the sediment, two conditions must be met. First the sedimentary environment must be anoxic due to the presence of reactive organic carbon. Secondly there must be a source of sulfur to the sediment. The first condition is readily met due to the high levels of organic carbon. As for the second condition, the Susquehanna River is a fresh water system and there is very little sulfur

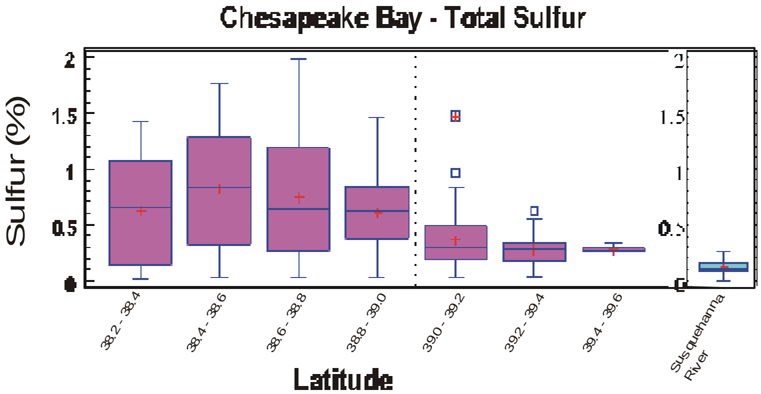

Figure 8. The total sulfur content of the sediments in the Susquehanna river in comparison to the Maryland portion of the Chesapeake Bay. Note the increasing sulfur content as the salinity increases.

available to the sediment. This is in contrast to marine and estuarine systems where there is abundant sulfur from sulfate, a major component of the salt content of sea water. In an estaurine system where fresh water mixes with salt water, one would expect a progression of low concentrations of reduced sulfur in sediments from fresher areas with the sulfur content increasing as the salinity increases. This is the case as shown in Figure 8, which compares the sulfur content of the Susquehanna sediment samples with samples found in the Maryland portion of the Chesapeake Bay. The sulfur content of the river sediments is generally 1/4 - ½ the concentration of the lowest levels found in the Bay. The low concentrations of sulfur will minimize the effects of sulfuric acid formation and leaching, the result of disposal of sediment in subaerial environments, i.e. upland disposal sites.

METALS

Any decision as to the disposition of the bed sediments behind the dam requires a knowledge of the composition of the material; the metal concentrations in the sediment are an important factor in this assessment. Within the Chesapeake Bay the Susquehanna river is often pointed to as a major source of loading of metals and nutrients. This is based on the concentration gradients found in the sediments of the northern Bay (concentrations decreasing from north to south) (Helz, 1989) and concentration of metals measured in the suspended material carried over the Conowingo dam (). However, there has been no data from the bed sediments which is the source of material to the Bay during major scouring events, and will be a more dominant source to the Bay as the reservoirs approach capacity. Figure 9 shows the range of data found for all of the metals analyzed by the Maryland Geological Survey (see Table 1). The data is again presented in the box-and-whisker format; all of the concentrations are in micrograms/gram except for Fe which is in weight percent.

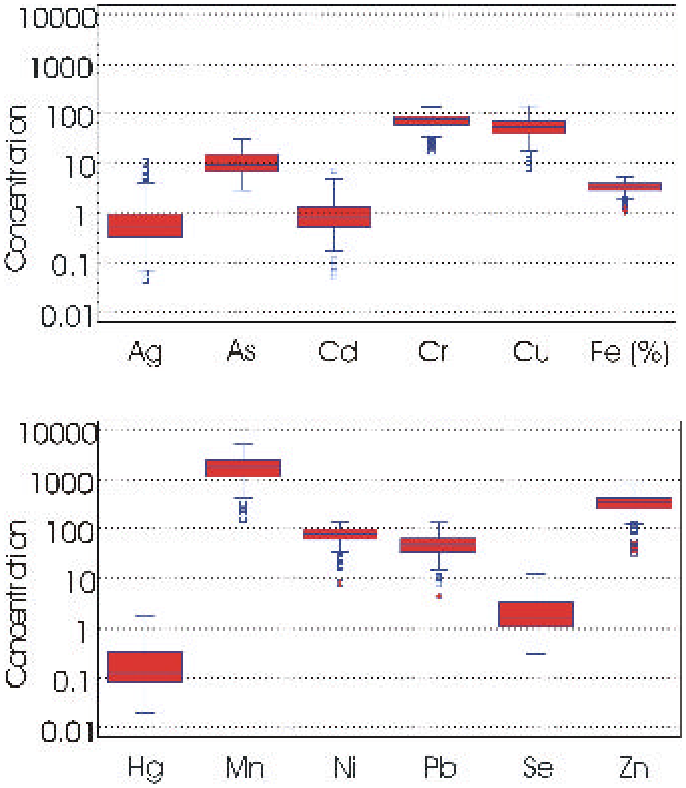

Figure 9. Box-and-whisker diagrams showing the ranges of the metals' data collected for the characterization study of the bed sediments of the Susquehanna River

This information is difficult to interpret without some frame of reference. A commonly employed method is the use of enrichment factors. Enrichment factors normalize measured data against

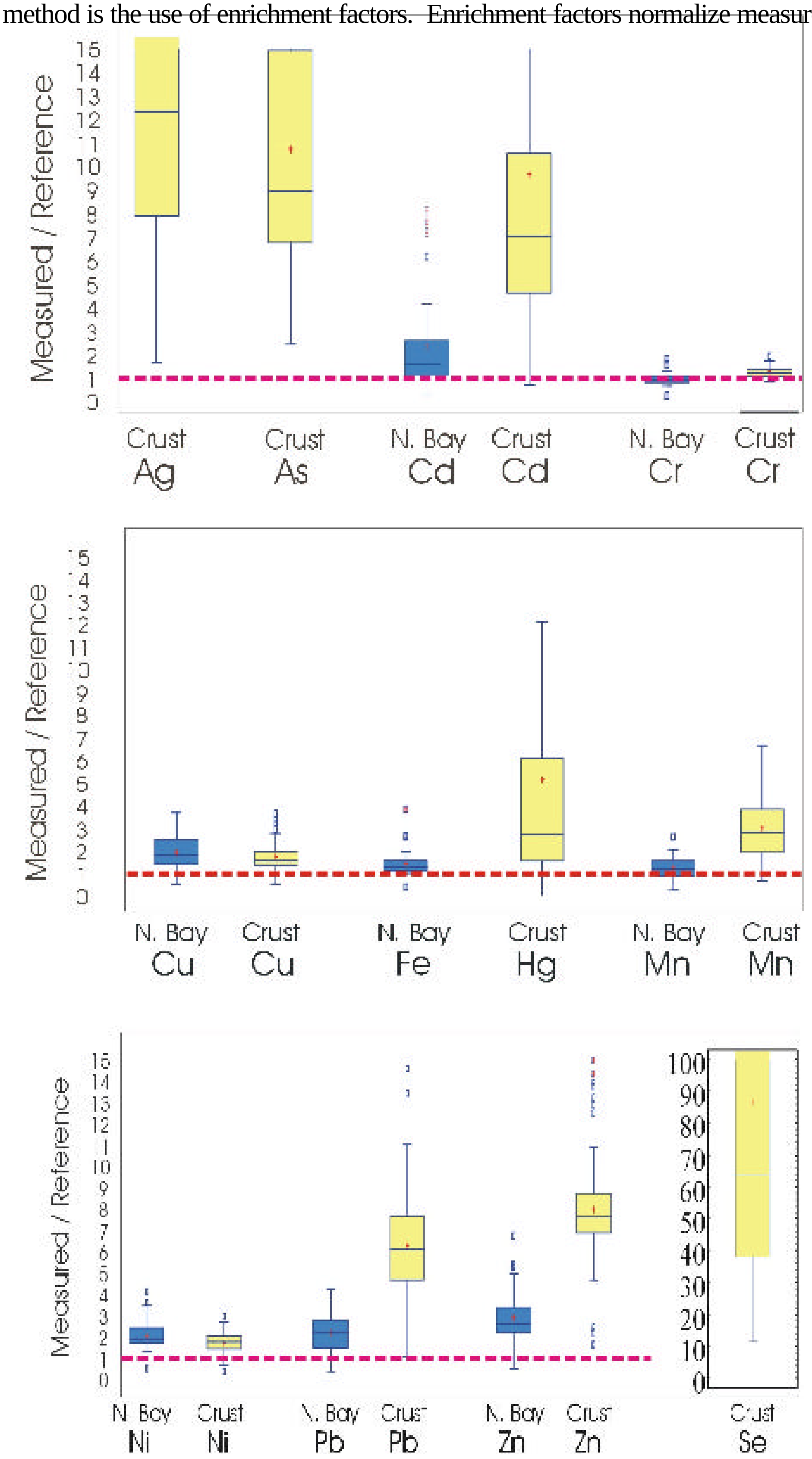

Figure 10. Range of Crustal and Northern Bay enrichment factors for the metals analyzed by MGS & CBL.

a reference in order to determine, either the similarity of the sample to the reference, or the degree to which the measured samples vary from the reference. Two types of enrichment factors were used to interpret this data; a crustal enrichment factor and a Northern Bay enrichment factor. These are calculated using the following equations:

Crustal Enrichment Factors -

$$EF(X)_{Measured} = \frac{(X/Fe)_{Measured}}{(X/Fe)_{Crust}}$$

Northern Bay Enrichment Factors -

$$EF(X)_{Measured} = \frac{X_{Measured}}{X_{Predicted}}$$

$$X_{Predicted} = a\ (\%Sand) + b\ (\%silt) + c\ (\%Clay)$$

$$EF(X)_{Measured} = 1 \left[\begin{array}{c} \text{For Concentrations Equal to} \\ \text{Crustal Abundances} \\ \text{or} \\ \text{Baseline Northern Bay Concentrations} \end{array} \right]$$

Equation 1

Equation 2

Equation 3

The Crustal Enrichment Factor uses the ratio of the measured metal of interest divided by the iron concentration; this is in turn divided by the same ratio as found in a standard reference material from the literature. The reference used here are the concentrations for the average crustal rock concentrations as determined in different publications; the reference values were taken from Taylor (1964). This reference is used because the large drainage basin of the Susquehanna river incorporates many of the major rock types found in the earth's crust. Consequently, the material entering the river would be expected to integrate these types and produce a composition similar to the average crustal rock. The ratios are normalized to Fe for two reasons: First, trace metal concentrations in sediments are highly dependent on the grain size - the finer the sediment the higher the metal content. It is important to minimize this effect as much as possible when looking at metal levels, and in the absence of grain size data normalizing by Fe concentration reduces the grain sized induced variability substantially. Most studies that analyze the metal content of sediments do not measure the grain size distribution of the sediment. Instead, they use a commonly occurring element as the normalizing factor. Iron is used as the normalizing element here because it is a major component of the sediment and it is unlikely that it's concentration would be greatly influenced by man's activities; in other studies in different areas other metals have sometimes been used as the normalizing element, e.g. Al, Sc, etc.

It is estimated that approximately 90% of the sediments deposited in the Northern Bay are derived from the Susquehanna River, and although there have been virtually no detailed analyses of Susquehanna River bed sediments, there is a considerable body of work on the Northern Bay sediments. The studies on the Bay sediments can be used as an estimate for the toxicological effects on benthic organisms since there are no reference levels for toxic effects for fresh water environments. The Northern Bay enrichment factor compares the measured metal content to a predicted metal content of the Northern Bay sediments. The predicted metal concentration is based on the correlation of metal content to grain size as given in the preceding equation; the coefficients are determined by a nonlinear regression fit of data from the reference area, in this case the Northern Bay. With these coefficients and the grain size of the sample, the equation can then be used to predict metals' concentration of the sample as if it were from the Northern Bay. There are several advantages to this method, the most important is that the grain size induced variability of the data is entirely compensated for.

Figure 10 shows the range of the two types of enrichment factors of the metals measured in the Susquehanna River sediments. Again the data is displayed using the box-and-whisker format and the dashed line is at an enrichment factor of one. In both of the enrichment factors described above, an enrichment factor of one means that the sample is the same as the reference (either average crustal abundance or Northern Bay Baseline). Values greater than one are multiples of the baseline behavior. Ag, As, Hg, & Se do not have northern Bay reference data so only the enrichment factors compared to crustal abundance are shown; these elements will be discussed in detail in a later section of this report, esp. in relation to metal values in the northern Chesapeake Bay. The remainder of this section will discuss the other metals.

Figure 10 shows that all of the metals fall within the range of Northern Bay sediments, though some of the elements are only marginally within the range (Cd, Pb, Zn). In these cases, crustal enrichment factors are also significantly elevated from the average crustal abundance. However, a comparison between the northern Bay reference and the river sediments is not entirely valid primarily due to the significant contribution of coal to the river sediments: the Northern Bay reference is calculated assuming the sediment is composed of three major factors - Sand, Silt and Clay - coal was a negligible component therefore not used in the baseline calculations. Consequently, a more accurate comparison would be between the Northern Bay baseline and the Susquehanna sediments with the coal fraction removed. In order to do this an estimate of the coal contribution to the sediment needs to be determined. This can be done using an equation similar to Equation 3, as follows:

$$\textbf{Metal Concentration} = \mathbf{a\,(Sand) + b(Silt) + c(Clay) + d(Coal)} \qquad \text{Equation 4}$$

This equation was applied to the river sediments for the elements (metals and nutrients) analyzed by MGS and a multivariable regression analysis was performed for each of the elements in order to determine the coefficients of the equation. The regression analyses were constrained so that no constant was determined; with respect to the model, if all of the four components are absent there should be no measurable elemental concentration, therefore no constant. Table 2 lists the determined coefficients for Equation 4 and the R^2 value for the regression fit. All of the relationships determined by the stepwise multivariable regression analyses are significant at confidence levels >99%, and the R^2 values are >82% for all of the elements except Cd (at 35%), which is near or below the detection limit for most of the samples.

Table 2. Results of regression analyses using Equation 4 to determine the association of the elements measured to the major components of the Susquehanna River sediments.

	a ***(Sand)***	**b** ***(Silt)***	**c** ***(Clay)***	**d** ***(Coal)***	**R^2**
Cd	0	1.38	0	0	35
Cr	17.9	97.6	87.0	75.0	95
Cu	0	82.6	40.4	118	88
Fe	1.16	3.64	4.88	3.10	97
Mn	0	1674	3715	0	88
Ni	26.0	81.6	124	46.6	94
Pb	0	91.2	0	81.6	88
Zn	0	484	299	452	90
N	0.47	0.286	0.42	0.382	97
P	0	1106	1827	449	94
S	.073	0.219	0	0.267	82

Note:
1. *All of the relationships are significant at > 99% confidence level.*
2. *All of the coefficients used in the model are significant at > 99% confidence level.*
3. *A zero (0) coefficient indicates an independent variable that is not significantly correlated and was rejected from the model.*
4. *The Durban- Watson statistic for all models show no serious autocorrelations in the residuals.*

Table 3. Estimated average sediment coal composition compared to the average analyses of 787 Pennsylvania coal samples from the USGS CoalQual Program

	Sediment Coal	Ave. PA Coal	Min. PA Coal	Max PA Coal
Cd	Negligible	0.1	-	2.3
Cr	75	21	2.2	72
Cu	118	18	1.1	130
Fe	3.10 %	1.80 %	0.05 %	6.0%
Mn	Negligible	25	1.2	560
Ni	46.6	20	3.1	100
Pb	81.6	11	0.36	65.0
Zn	452	24	1.0	230
N	0.382	N/A	-	-
P	449	213	11	3400
S	0.267	0.095	0.0007	1.10

Based on the regression fit of the data the average sediment coal composition can be estimated from the coefficient determined for Coal. This composition is shown in Table 3. with the summary statistics of 787 coal sample analyses from Pennsylvania. The coal samples are from coal deposits found throughout Pennsylvania compiled as part of the USGS CoalQual program (REF), and represent all grades of coal. The estimated average sediment coal has higher elemental concentrations than the average Pennsylvania coal; additionally, Cr, Cu, Pb & Zn are all higher in the sediment coal than the maximum measured concentration for Pennsylvanian coal.

The mode of occurrence of the metals is probably different in the coal beds as compared to the sedimentary coal in the river. In general, metals in coal are found in the inorganic fraction of the coal commonly either in sulfide minerals, clays and other silicate minerals, or carbonates and phosphates. The common mode of occurrence in coal of the metals analyzed in this study are:

Sulfide minerals - Cd, Pb, Zn
Clay Minerals - Cr
Carbonates - Mn
Mixed Sulfide and Clay Minerals - Fe, Ni

Not Referenced (probably Sulfide) - Cu
[Based on: Schobert (1995); Finkelman (1994); Karner et al. (1986); Benson et al. (1998)]

These modes of occurrence, can be altered by the processes which coal undergoes to be incorporated into the sediment. The pathway the coal takes is: extraction from the coal beds, grinding, washing and sorting, followed by the physical processes of sediment movement in the rivers and streams, ultimately leading to burial in the river sediments. Up to the point of burial of the coal in the sediments, the coal is in an oxidizing environment which physically abrades the material. It would be expected that the more reduced inorganic components of the coal would be oxidized, specifically sulfide and carbonate minerals. On the other hand, during transport and burial the coal could adsorb metals, nutrient and organic compounds due to it high surface area and its physio-chemical properties, and through diagenetic reactions which result in the formation of authegenic minerals. Without detailed analyses the modes of occurrence of elements associated with the sedimentary coal can not be specified. However general behavioral trends can be inferred from the distribution of the data.

Referring back to the section on nutrients, the distribution of the data in Figure 7 fits corresponds well with the composition of the average Sand, Silt, Clay and Coal, determined by the regression fit. Total nitrogen is comparable to the other dominant nitrogen containing fractions, Silt and Clay; thus yielding a distribution that is fairly uniform spatially. Total phosphorus in the Coal fraction is 1/4 - ½ the concentration of the Silt and Clay fraction thus when Coal becomes a significant component of the sediment an apparent reduction in the overall phosphorus concentration is observed due to dilution. Conversely, the Coal fraction contains the highest concentration of total sulfur, and when Coal becomes a significant fraction of the sediment, the overall sulfur concentration becomes elevated. These general behavioral patterns can be seen in the metals concentrations, however with the metals there are the additional tools of the enrichment factors. The next eight pages (Figures 11- 18) show the behavior for each of the metals. Each figure contains four graphs each s in the format of Figure 5 (i.e. box and whisker diagrams at each distance interval). The graphs in each figure are:

1. The absolute metal concentration. Also given on the graph are lines indicating the ERL (Effects Range Low) and ERM (Effects Range Maximum). These values are empirical threshold limits in *marine and estuarine environments* relating to biological impacts on benthic communities (Long et al., 1996). These limits are not valid in fresh water, but are given here for reference since these materials may potentially enter an estuarine system:
2. The enrichment factor based on crustal abundance;
3. The enrichment factors based on Northern Bay baseline sediments, and;
4. The enrichment factors based on Northern Bay baseline sediments with the predicted contribution from Coal removed. This allows for the samples to be compared more appropriately, the inorganic fraction of the Susquehanna River samples with the Northern Bay sediment baseline which is free of coal).

The last three graphs show the ideal baseline, one (1), marked as a horizontal line.

Cadmium (Cd)

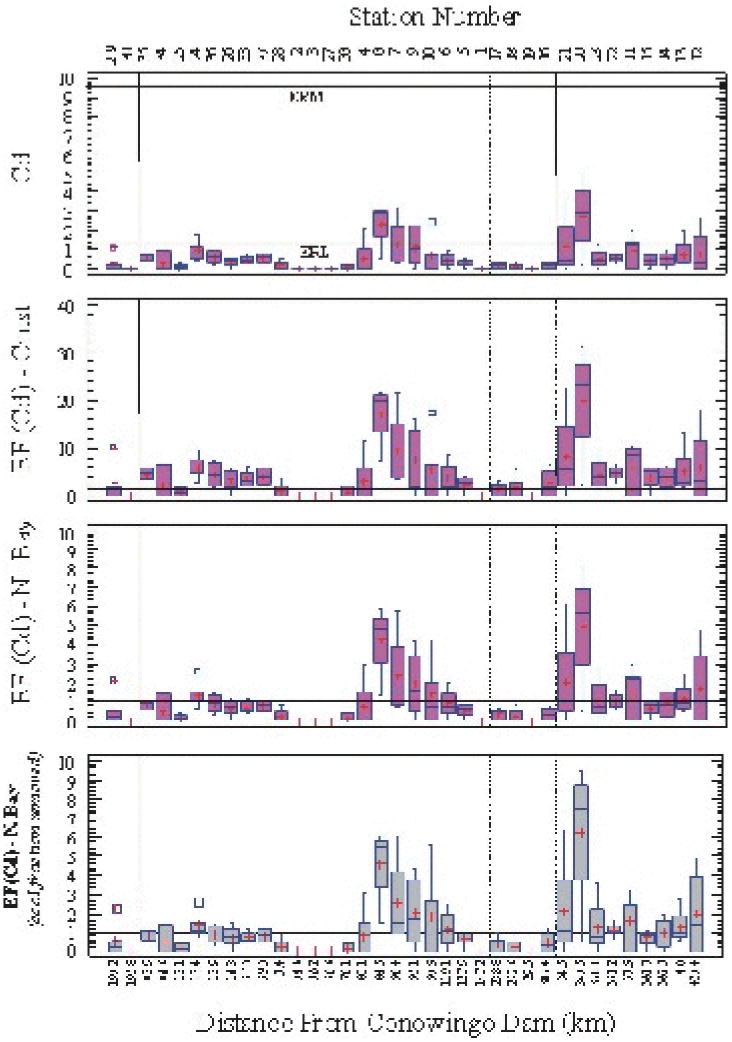

Figure 11: Distribution of Cd as a function of Distance from the Conowingo Dam (km)

The highest levels of Cd are found in Cores 8,7,9, and Cores 21 & 20. These cores are east-west transects across the Susquehanna. One transect (Cores 8, 7, & 9) is near the Maryland-Pennsylvania state line, south of the Peach Bottom Nuclear Power Plant; the other transect is Cores 20 & 21, the samples are upstream and closest to Safe Harbor Dam.. If these cores are removed from consideration, virtually all of the samples would fall below the ERL value, and all of the cores exhibit distributions of enrichment centering at or below the expected Northern Bay baseline level (both the corrected and uncorrected levels), and the enrichment factors as referenced to crustal abundance average around a factor of four (4). The range of data at any site reflects down core variability which will be addressed in a later section. Overall, the data excluding the two transects appears to be within expected levels consistent with levels found in the Northern Chesapeake Bay. On the other hand, the two transects show a considerable, significant elevation in Cd by any measure; however, the absolute levels are significantly below the ERM. though greater than the ERL.

Based on the regression fit of the data, the average coal does not contain a measurable amount of Cd. This is reflected in the low Cd concentrations seen in the cores that have significant coal concentrations (see Figure 5). Coal being essentially devoid of Cd as determined by the regression fit, dilutes the overall Cd content which resides primarily in the clastic sediments. When this dilution is factored out, an increase in the enrichment levels compared to the northern bay baseline can be seen (see bottom most graph in Figure 11).

Chromium (Cr)

Cr is the most well-behaved of all of the metals analyzed. The samples exhibit a low degree of variability within the study area which indicate the absence of local sources and the little variation through time (Figure 12). Coal does not appreciably effect the distribution of Cr in that the average coal composition is only ~25% less than the highest clastic component which is silt, and only ~14% less than clay which is the second most dominant component. Removal of the predicted Cr from the coal fraction increases the variability of the data, which reflects the variability in the average coal composition.

The concentrations of Cr in the sediment vary normally around the ERL level (81 ug/g), with 50% above and 50% below. In regard to the enrichment factors, Cr is effectively at the average Crustal abundance level, and similarly is at the Northern Bay Baseline Level for both the corrected and uncorrected enrichment factors. The difference between the Crustal EF and the Northern Bay EF is that the Northern Bay EF's show cores which have a greater degree of down core variability, more strongly effected by the coal content. This effect is enhanced by the removal of the coal related Cr which then increases the degree of down core variability.

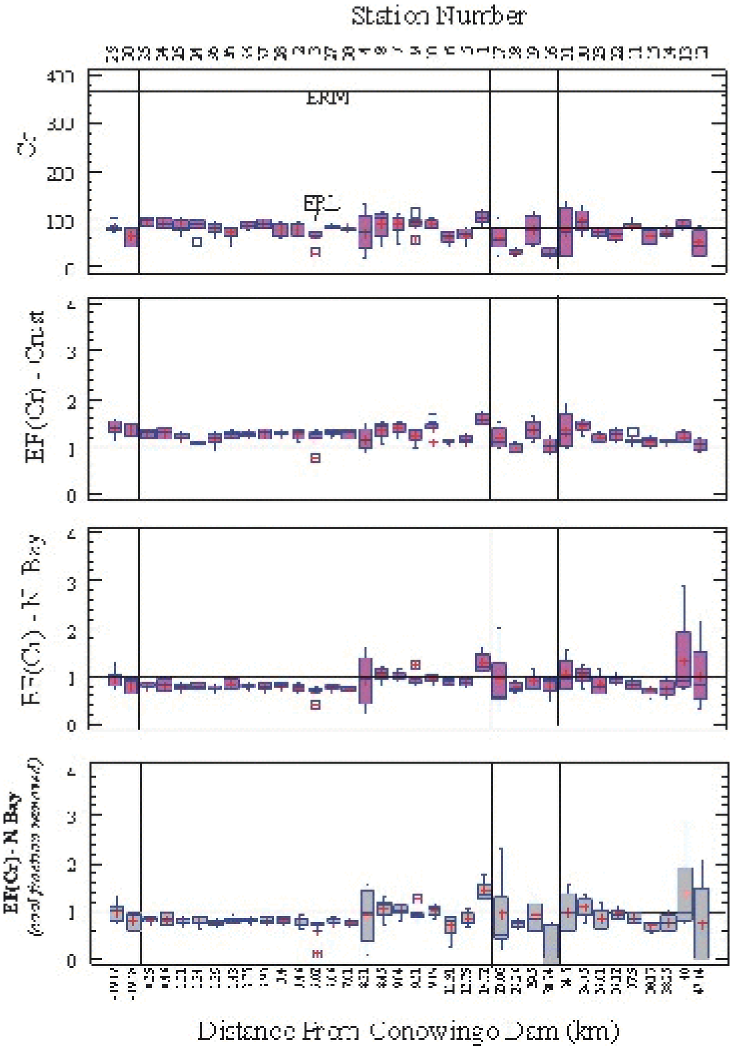

Figure 12: Distribution of Cr as a function of Distance from the Conowingo Dam (km)

Copper (Cu)

Of the metals analyzed, Cu is the one most strongly associated with coal; coal related Cu is 42% higher than the Cu in the silt fraction and is three times higher than that in the clay fraction. This is seen in all four graphs in Figure 13. The highest concentration of coal is in sediments located between Cores 4 through Core 11 (approximately 8 - 38 km from the Conowingo Dam), though high levels are also found in Cores 12 &13, the cores furthest from the Conowingo Dam. Similarly, the highest concentration of Cu in the sediments is found in this area, roughly tracking the coal concentrations. Crustal enrichment factors show a stronger relative influence in this region due to the difference of the Cu:Fe ratios between the average crustal rock and the average coal (Average Crust - 9.77: Average Coal - 38.1). This is also the case with the Northern Bay enrichment factors, with similar degrees of enrichment (note the change of scale between the Crustal and the Northern Bay enrichment factors). When the contribution of the coal is removed and the concentrations corrected, the mean of the analyses lowers and the range of the data fall within normal background levels and in some cases even lower. However the variability within some of the cores increases due to the uncertainty of the procedure.

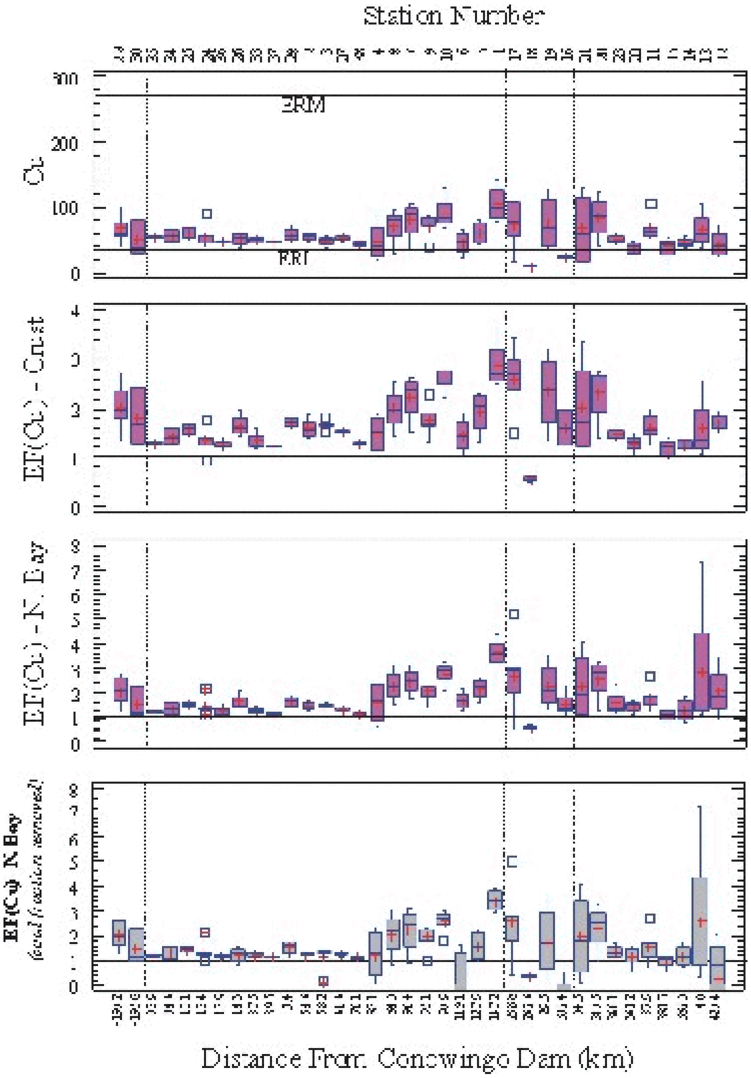

Figure 13: Distribution of Cu as a function of Distance from the Conowingo Dam (km)

Iron (Fe)

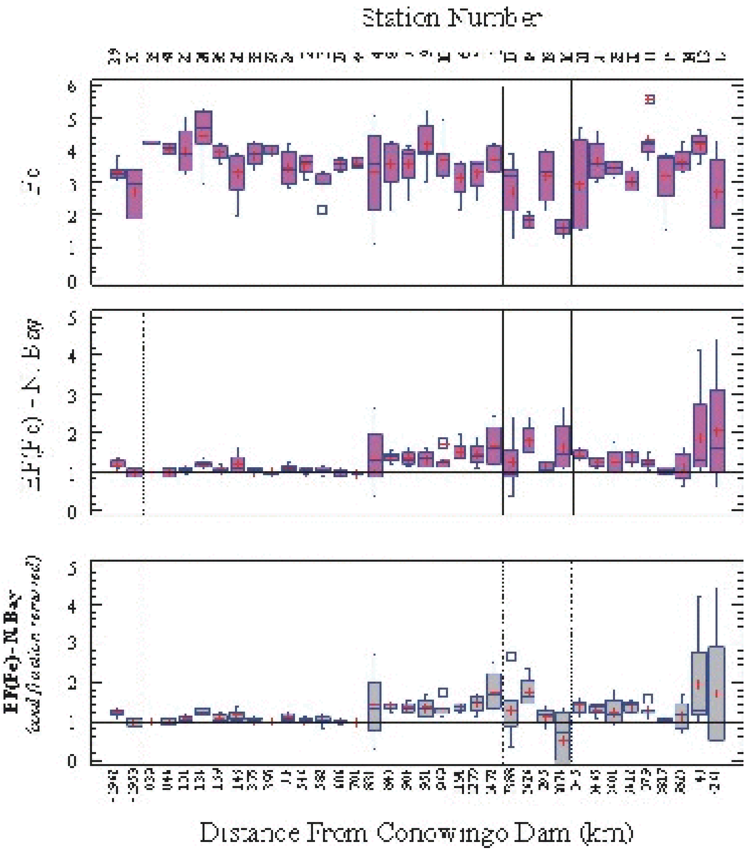

Figure 14: Distribution of Fe as a function of Distance from the Conowingo Dam (km)

There are two unique features of Figure 14. First there are no ERL and ERM values for Fe. Fe is an essential element to biological systems, and it is considered an environmentally benign element, so there are no limits set where Fe is considered to adversely influence benthic communities. The second feature to note is that there is no crustal enrichment graph. Fe is used as the element to reference other metal concentrations to as in Equation ( ); therefore it is meaningless to have an Fe crustal enrichment factor. However, there are the Northern Bay Enrichment Factors since these are based on grain size and coal content. Generally, in samples where coal is negligible the Northern Bay Enrichment Factors are one, that is the samples are indistinguishable from Northern Bay samples of the same grain size characteristics. When Coal is a significant component of the sediment, Fe is slightly enriched. This is due to the association of coal with the Silt and Sand fraction of the sediment. The Fe content of the average Coal is only lower than the average Silt, but it is 2.7 times more concentrated than the average Sand; thus if the coal content remains constant as the Sand content increases, the enrichment of Fe due to Coal increases Removing the predicted contribution of coal and correcting the concentration for the mass difference, lowers the enrichment factors closer to one, but this increases the apparent down core variability.

Manganese (Mn)

Based on the regression fit of the data, the average coal does not contain significant concentrations of Mn. Consequently, as the Coal content increases it dilutes the clastic portion of the sediment and lowers the overall Mn content of the sediment. This is seen most clearly in the absolute metals concentration and in the Crustal Enrichment Factors. The trend for Mn seen in Figure 15 is antithetic to the trend for Coal and Cu; Mn shows a general lowering of values between Cores 4 - 11. Note, Mn is considered another environmentally benign metal for which there are no ERL and ERM values.

In regard to the Northern Bay Enrichment Factors, Mn is very close to the Northern Bay Baseline level. Removal of the predicted coal contribution (dilution) slightly increases the enrichment, and variability of the data.

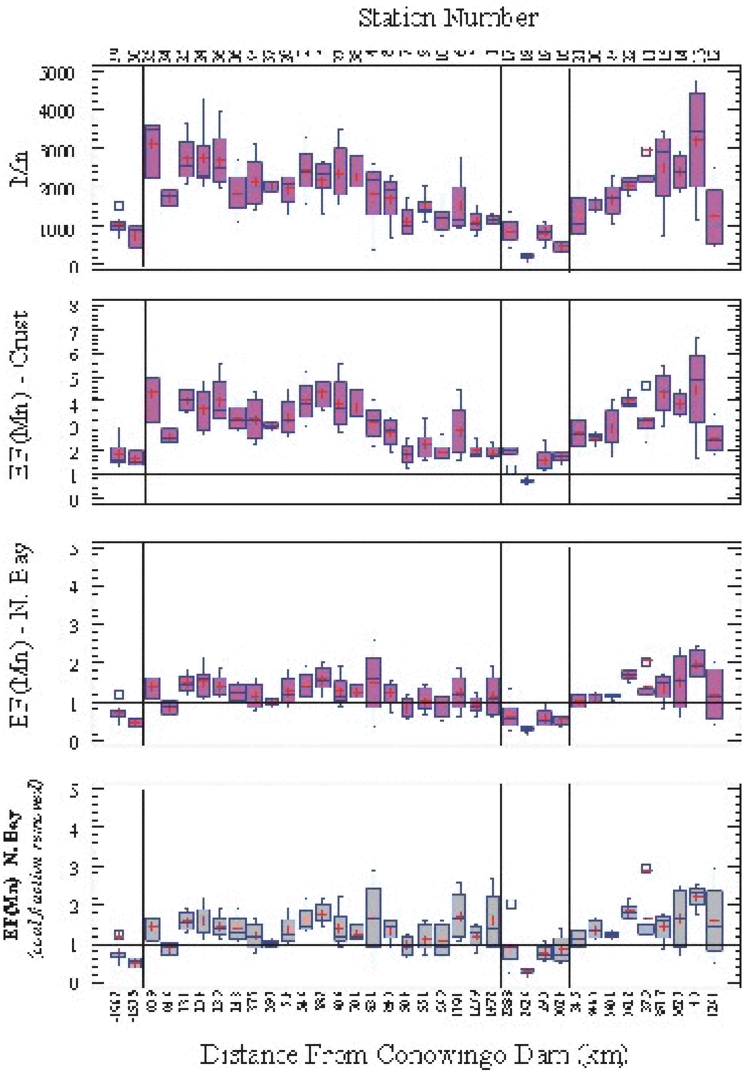

Figure 15: Distribution of Mn as a function of Distance from the Conowingo Dam (km)

Nickel (Ni)

Ni is similar to Mn in that the concentration of Ni in the Coal fraction are low, though not negligible as in the case of Mn. As a result, the antithetic trend is present in the absolute concentration and crustal enrichment factors, but not as pronounced as with Mn. Similarly, the samples are generally close to the Northern Bay Baseline level, and removal of the Coal fraction slightly increases the enrichment factors.

One interesting feature to note is that over 85% of all of the samples exceed the ERM value of 51.6 ug/g. Several things are to be kept in mind when looking at these numbers:

1. The ERL/ERM values are for marine or estaurine environments, not fresh water- so there is no direct comparability in terms of biological effects;
2. The ERL/ERM values do not take grain size variability into account, thus in material finer than the average that the values were determined from, the concentration will naturally exceed these values. This was demonstrated in Baltimore Harbor ( ), and;
3. The average crustal rock concentration of Ni is 75 ug/g, so the ERM value (51.6 ug/g) is well below the concentration of the average crustal rock, which is a reasonable approximation of the sediment sampled for this report..

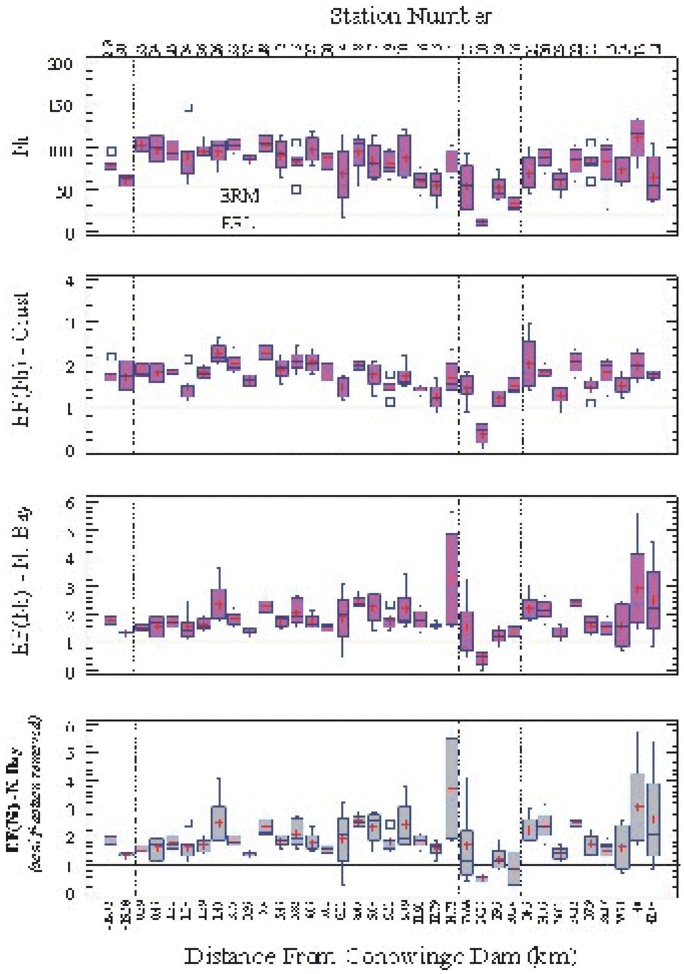

Figure 16: Distribution of Ni as a function of Distance from the Conowingo Dam (km)

Lead (Pb)

Pb is strongly associated with the Coal fraction though not as strongly as Cu. It is sub-equally distributed between the Silt and Coal fractions, in contrast to Cu where Coal is the fraction with the highest metal concentration. The distribution of Pb, shown in Figure 17, is similar to Cu though the excursion of the means from baseline levels and the range of variability is lower than Cu. Pb concentrations vary normally around the ERL value with ~45% above and ~55% below. The Crustal Enrichment Factors for Pb, and Zn, are the highest of the metals analyzed. However when compared to the Northern Bay Baseline, most of the cores are at the predicted baseline level. The correspondence is even better when the predicted contribution of Coal to the overall Pb concentration is removed and there is a direct comparison of clastic sediments of the Bay with the clastic portion of the river sediment.

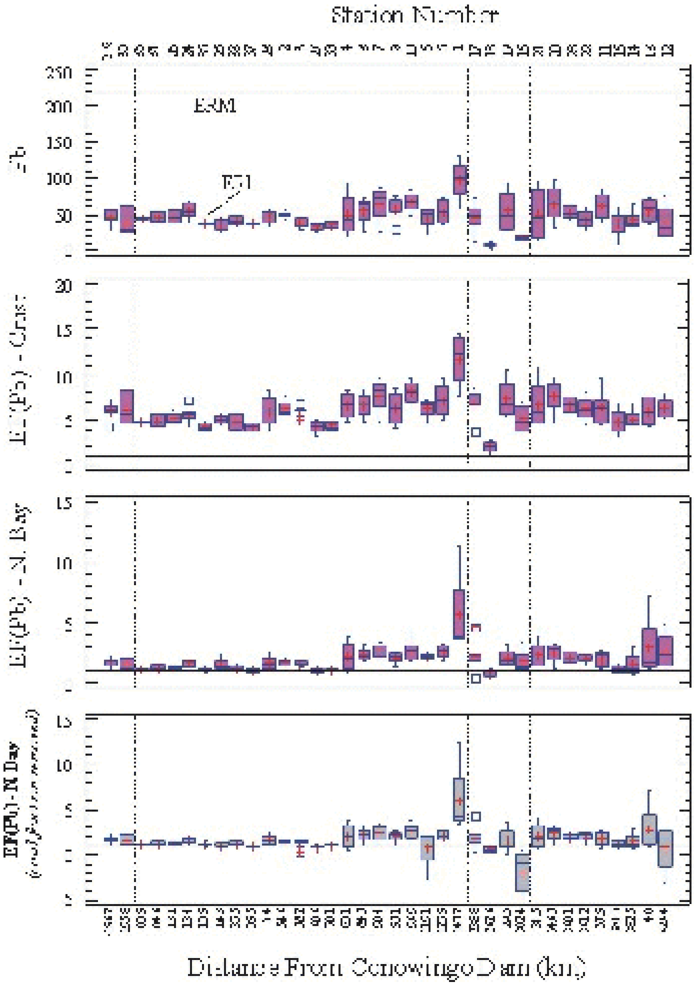

Figure 17: Distribution of Pb as a function of Distance from the Conowingo Dam (km)

Zinc (Zn)

Zn concentrations are strongly affected by the coal content as seen in Figure 18. The intra-core variability is relatively small in the cores where the coal content is minimal (Cores 35 -38), and significantly higher in the cores with high coal content (Cores 4- 12). The data for the cores are normally distributed around a mean value (Zn ~330ug/g; EF(Zn)-Crust ~7.7; EF(Zn)-N.B. ~2.3: EF(Zn)-N.B.(corrected) ~1.0). The normal/consistent distribution of the data is due to the average compositions of the Silt, Clay, and Coal fractions being comparable; similar to the behavior seen for Cr.

The levels for Zn are high with respect to the ERL and ERM; ~92% of the samples are greater than the ERL, and ~23% are greater than the ERM. They are also high with respect to the average crustal rock on average ~8X higher. However, when viewed in the context of the Northern Bay the river sediments are only ~2X higher than the uncorrected enrichment factor and with the coal fraction removed, the clastic portion is the same as to the Northern Bay Baseline level.

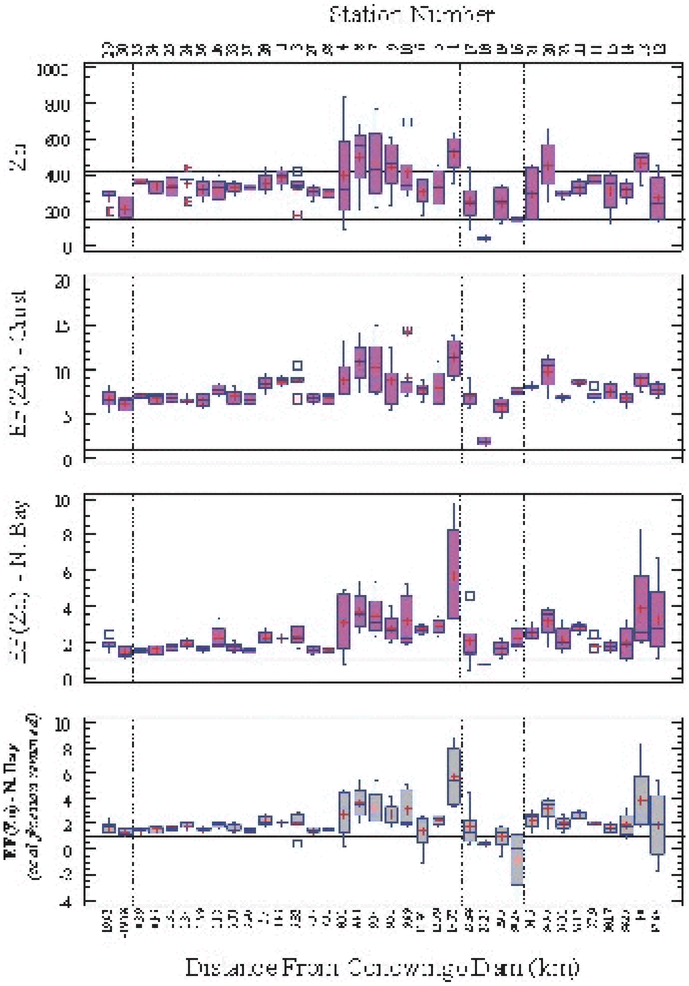

Figure 18: Distribution of Zn as a function of Distance from the Conowingo Dam (km)

The above graphs show variations due to spatial variability, and hint at temporal variability. Temporal changes in loading within the sediment column show up in these figures as extended ranges data within one site. The temporal variability is discussed later.

Arsenic (As) and Selenium (Se)

The metalloids do not show strong trends across the dams as found for some of the metals and there is both variability spatially and vertically. For some of the cores, the concentrations within the core are highly variable and likely reflect to some degree the contribution from As and Se in coal, although levels are generally lower than the average values for coal (see Table 4). However, given the high variability of the volatile compounds in coal (i.e. As, Se and Hg), an analysis similar to that done for the transition metals is not warranted. For example, the range in values for As are from 0.06 to 2200 ppm,

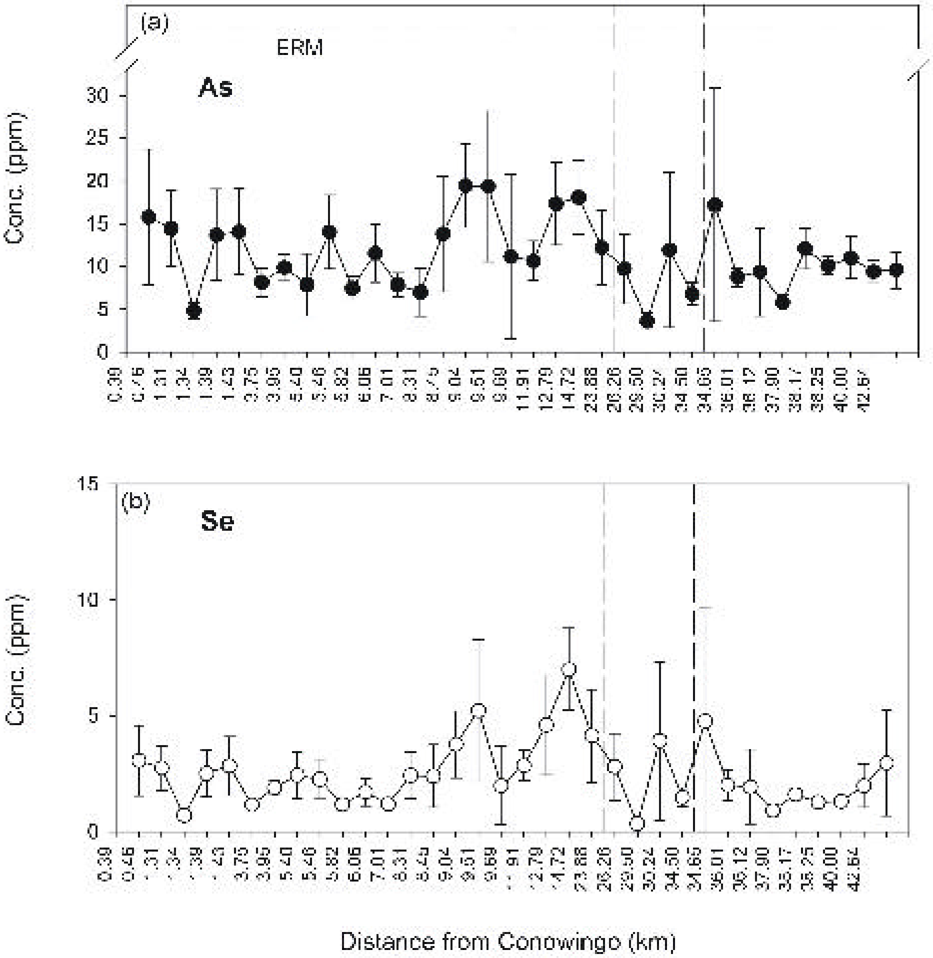

Figure 19 a&b: The average and standard deviation for all sites analyzed, plotted in terms of distance from the Conowingo Dam wall (x=0). The dotted lines reflect the location of the other two dams. Distances are in km. (a) arsenic and (b) selenium.

0.01-150 for Se and 0-64 ppm for Hg. Such a wide variability contrasts that of the other metals. For As, the range in concentration in coal mirrors a similar variable range in As concentrations is surface soils.

Focusing on the As distributions, it can be seen that there is a broad region of somewhat higher, but not statistically significant, concentration in the region from 8-14 km above the Conowingo Dam (Fig. 19a). Overall, however, there is as much or even more variability within a core as between cores. The 8-14 km region is the region where the concentration of metals such as Pb and Cu are also higher (see discussion above) and is the region where the fraction of the total sediment as coal is elevated, although the correspondence is not exactly the same for %coal and As concentration. For example, the concentrations of As are higher that other sediments at Stations 7 and 8 where the fraction as coal is relatively low (Fig. 5), but the concentration of various trace elements is relatively high. For example, Cd concentrations are also high at these sites. These locations are south of the Peach Bottom Nuclear Power plant but it is not known whether there is any significance in this as it is unlikely that the plant would be a source of these elements to the sediments. Thus, the reason for the somewhat higher values in this region is not known.

Table 4: Average concentrations of analytes in sediment from behind the Conowingo Dam (first 6 km) and from the Upper Chesapeake Bay (above the Bay Bridge). All concentrations are in ppm (mg/kg dry weight) except for PCBs (ppb; Fg/g dry). Data for metals in the upper Bay taken from Kim and Mason (unpublished); data for organic contaminants from Nakanishi (1996). Coal data from USGS.

Analyte	Conowingo Sediment	Average Coal	Upper Bay
As	3.60 ± 2.12	24.4 ± 58.4	6.33 ± 3.79
Se	0.74 ± 0.46	2.83 ± 2.97	1.31 ± 0.70
Ag	0.24 ± 0.15	0.075 ± 0.19	0.43 ± 0.31
Hg	0.057 ± 0.03	0.18 ± 0.94	0.14 ± 0.08
PAH	3.6 ± 0.94	-	1.61 ± 0.67
PCB	44.8 ± 10.7		46.3 ± 24.4

It should also be pointed out that the ERM value for As is much higher than that of any of the samples and the concentrations found here are reflective of relatively low "background" conditions (Fig. 19a), and thus the differences may just reflect differences in the sediment sources and not reflect any anthropogenic input. For example, the As concentrations in the sediments of the Susquehanna are about half that of the average values for the upper Chesapeake Bay (i.e. for sites north of the Bay Bridge; Table 4). In summary, therefore, while there is some variability in concentration of As between sites, the concentrations are low relative to those of the Chesapeake Bay, and much lower than those considered to have a significant biological impact.

For Se, the trends across the dams is similar to that for As although the differences are somewhat more pronounced (Fig. 19b). Overall, however, the concentrations of As and Se are strongly correlated (r^2 = 0.65 - note that a value for r^2 of >0.20 is significant at the >99% level for this dataset; Fig. R2a). Both the metalloids also correlate strongly with Hg (for As, r^2 = 0.27; for Se, r^2 = 0.61; Figs. R2a and R2b) and Pb (e.g., r^2 = 0.77 for As vs. Pb; Fig R2c). Thus, the factors controlling Pb, which were determined above to be strongly related to the presence of both coal and silt (Table 2) likely are also controlling the distribution of metalloids. For Se, the highest concentrations are found in the region of 8-14 km above the Conowingo Dam, similar to that of As.

There is not ERM value available for Se so it is difficult to compare this to any baseline value. Again, as shown in the Table 4, the concentrations of Se in the lower Conowingo Dam sediment are about half those of the sediments of the upper Chesapeake Bay. The concentrations of Se, and of As, on a per gram basis are no higher than those of suspended sediments in small streams in Western Maryland, for example (Castro et al., 2001) and likely of streams within the Susquehanna watershed. Thus, the sediment levels reflect the levels in the source material and do not reflect significantly elevated concentrations. The lack of a strong trend with either silt or with coal is due to the fact that the concentrations of As and Se in coal are of the same order as those of soils and sediments within the Appalachian mountains and surroundings i.e. these elements are not particularly enriched in coal relative to other matrices.

While for some of the other metals there was an increase in concentration with sediment depth this is not true for the metalloids. No distinct vertical trends are evident and it appears that for many of the sites the variability down core was small. Thus, there does not appear to be any historic enrichment in concentration that may have been expected, based on what was found for some of the heavy metals.

Silver (Ag)

The concentrations of silver in the sediments show a more significant trend with lower concentrations (generally <1 ppm) in the lower 7 km of the Conowingo Dam (Fig. 19c). Such levels are significantly lower than the ERM value, and are again about half those of the upper Chesapeake Bay (Table 4). There is a dramatic increase in concentration around 8 km and the region between 8-10 km appears to be a region of elevated Ag concentration. The high average, and large deviation, at 34.5 km represents one high value which may or may not reflect some contamination artifact in this sample. Indeed, all the elevated values for Ag reflect the fact that there is one high value in the core. In most cases, this is not the surface sediment sample, and in general it is the second sediment depth sample that has the highest concentration. There is the potential that these results indicate an input of Ag to the river for a confined period of time from a specific point source. Again, while the individual samples from these specific cores may exceed the ERM value - with the high value at depth for the Site 21 (34.5 km, directly behind the Safe Harbor Dam) being almost 12 ppm - the averages for each site are below this value.

It would be interesting to ascertain what is the source of the Ag, which appears to have been deposited at a specific period of time, and to be concentrated at two sites - one in the region of 8-10 km from the Conowingo Dam wall, and the other behind the Safe Harbor Dam. It is interesting to note that a paper by Turekian et al. (1967) predicted high Ag export from the Susquehanna River. These authors estimated a transport of around 4.5 tons of Ag per year to the Chesapeake Bay. While it is not possible to compare our data directly with surface sediment concentrations that were not measured at that time, such a load would correspond to Ag concentrations in the ppm range, comparable to those measured at depth in the sediments, and much higher than those of the current surface sediments (Fig. 19c). While Ag was not measured during the recent Fall Line Study for metals (Lawson et al., 2001), its relative flux can be estimated based on the ratio of Ag/Hg in surface sediments. Such a calculation yields a flux of 1-2 tons/yr, less than the value estimated by Turekian et al. (1967). Clearly, our sediment record data for Ag is compatible with the notion of much higher Ag concentrations and fluxes in the more recent past. However, current surface sediment levels are lower than those expected to impact aquatic organisms.

Given the unusual distribution of Ag in the sediment cores, there is not a strong correlation between its distribution and that of the other metals and metalloids, as shown in Fig. R2a for the correlation between Hg and Ag - the correlation coefficient (r^2 value) is 0.1. Thsi contrasts the upper bay, for example, where there is a strong correlation between metal concentration and sediment organic carbon for Ag, As, Cd, Hg and Pb i.e. Ag in this case tracks the distribution of the other metals and metalloids. Thus, while it does appear that the other metal's distributions can be accounted for by the combination of soil and sediment inputs from the watershed, coupled with the mixing in of coal, the sources of Ag are likely more directly influenced by point source inputs on the river at various times in the past. This conclusion is reinforced by the fact that the concentration of Ag in coal is actually lower, on average, than that of the surface sediments. Thus, Ag is in direct contrast to As, Se and Hg, and the other metals, where the opposite is true (Table 4). This confirms the notion derived from the sediment distribution that the Ag does not likely come from coal or from areal sources in the watershed, but from specific inputs.

Mercury (Hg)

The concentrations of Hg in the lower part of the river are low and comparable to that expected from relatively uncontaminated sediments (Fig. 19d). Mercury levels in coal are highly variable (range from the detection limit to 63 ppm for Pennsylvania coals; Table 4) but are elevated compared to background soils and therefore an elevation in concentration in coincidence with the

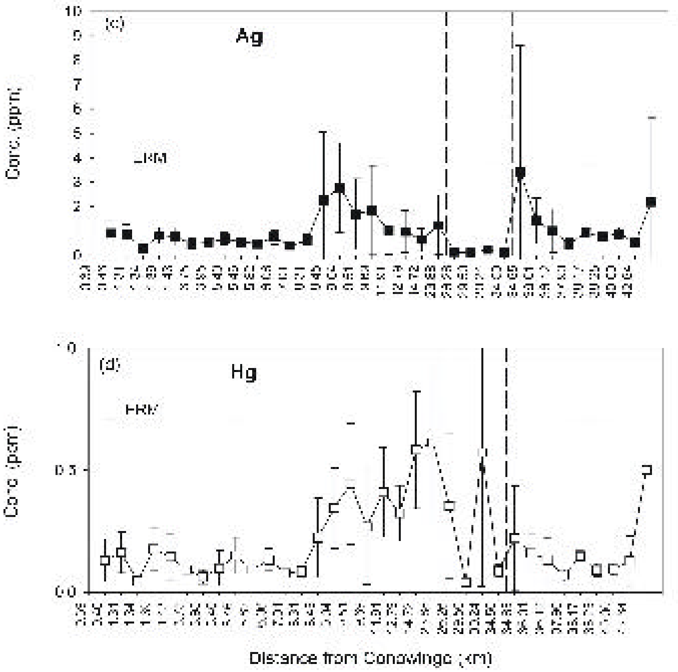

Figure 19 c&d: The average and standard deviation for all sites analyzed, plotted in terms of distance from the Conowingo Dam wall (x=0). The dotted lines reflect the location of the other two dams. Distances are in km. (c) silver and (d) mercury distribution elevation in coal in the sediment cores is expected. This is indeed the case as there is a region of higher Hg concentration from around 8 km to behind the Safe Harbor Dam which coincides strongly with the elevated levels of coal. However, Hg is also strongly bound up in silt, and has lower concentrations in sand and clay, so it is not surprising that overall Hg has a distribution similar to that of Pb. Indeed, the correlation is strong ($r^2 = 0.36$; Fig. 21). As mentioned above, the distribution of Hg also correlates with that of As and Se. For some of the other metals, there is not as strong a relationship (for Ag, $r^2 = 0.14$; for Cd, $r^2 = 0.10$; Fig. 20a&b). Again, this is consistent with the sources of material that constitute the sediments behind the three dams.

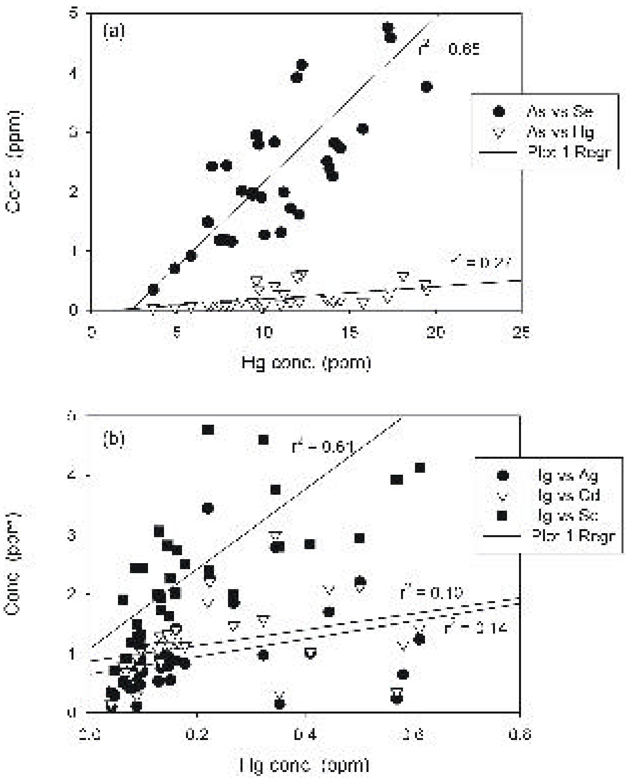

Figure 20: Correlations between Hg and different inorganic contaminants measured during the survey.

It is interesting to note, but expected, that the concentration of Hg in the surface sediments is lower than that of the suspended material that is passing over the Conowingo Dam wall, which is around 0.6 ppm (Lawson et al., 2001). The reason for this is that the fine material that is being transported over the wall tends to have a higher Hg concentration than the larger particulate size fractions that remain in the surface sediment. Therefore, given the much higher organic matter content of the upper Chesapeake Bay (excluding the coal contributions), it is not surprising that the levels of Hg in the lower Conowingo Dam sediments are much lower than those of the upper Bay. This is similar to what has been found for the other metals and metalloids as well.

Mercury levels are lowest in the surface sediments in most of the cores and there are less occasions of a single elevated concentration than for Ag, for example. This is indicated by the relatively smaller error bars for Hg, except for a few locations. There is the potential for Hg inputs from local sources into the river over time but as suggested above, the concentrations of Hg are not particularly elevated compared to the upper Bay, and are similar to those found in the lower Bay. In contrast to the Susquehanna, levels of Hg measured in Baltimore Harbor exceeded 2 ppm at some locations (Mason and Lawrence, 1999; Baker et al., 1997). Thus, overall, and given that the values for Hg are all below the ERM value, except for a few of the deeper samples, it is reasonable to conclude that these sediments do not constitute values in excess of the regional concentrations.

Organic Contaminants

The distributions of the organic contaminants across the reservoirs is shown in Figs. 20a-20c. Because of the difficulty in doing the analysis and the associated cost, in most cases only the surface samples was analyzed from a core, and in these cases, no standard deviation is shown on the graphs. For four of the cores, all the samples, in accordance with the trace metal analysis, were analyzed. Overall, these samples show relative consistency down core (i.e small deviations) suggesting that there

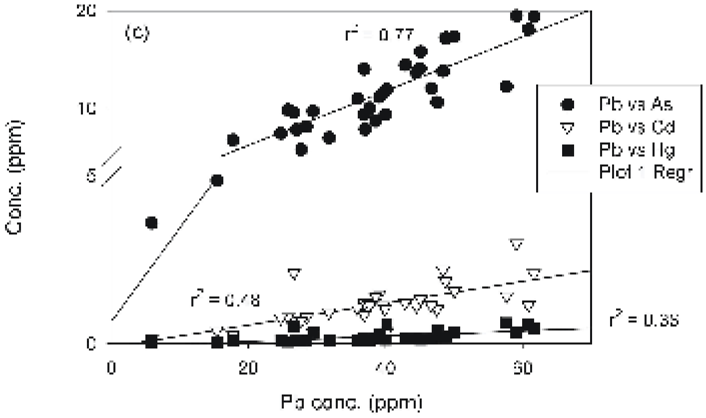

Figure 21: Correlations between Pb and different inorganic contaminants measured during the survey.

was indeed little variation with depth for the organic contaminants in these cores. It should be noted, however, that the cores analyzed in detail for organics also showed little variability in concentration for most of the trace metals as well - see previous figures, while other cores showed larger variability. Thus, it is likely that variability with depth for the organics is also likely in these regions, specifically above 8 km from the Conowingo Dam. If the potential variability is a concern, then more analyses of archived sediments should be completed. For PAHs, given their potential to be related to the amount of coal in the cores show increasing concentration with increasing amounts of coal in the core. For the PCBs, concentrations will likely reflect usage rates in the region, and their legacy. The same would be true for the individual pesticides.

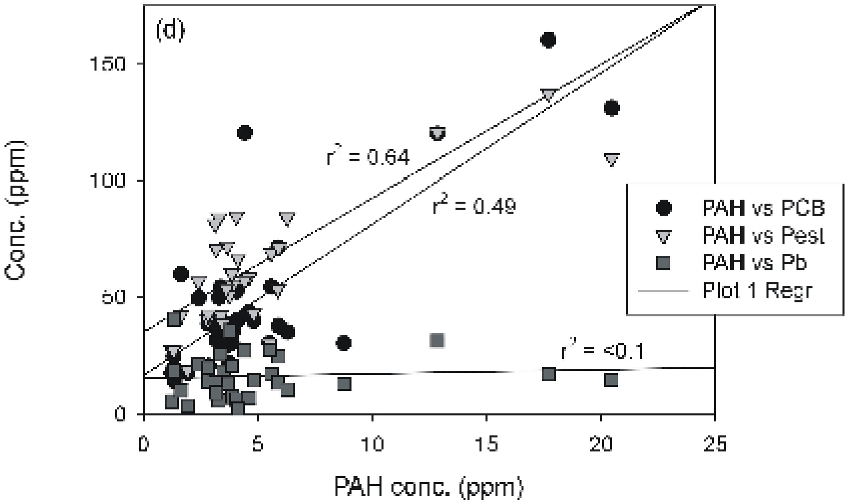

Figure 22: Correlations between the different inorganic and organic contaminants measured during the survey.

The distribution of the PAH compounds, as total PAH, is shown in Fig. 23a. Except for four sites, the total concentrations are less than 7 ppm, and most are significantly lower. In terms of the ERM, there is no value listed for total PAHs, but individual ERM values are in the 0.5-5 ppm range. Thus, the concentrations of the individual PAHs in most cases are well below the ERM values. More analysis of the data would be required to determine if any of the individual PAHs from any of the cores were to exceed the ERM values but a preliminary assessment of the whole dataset show this to be not the case. The relationship between the concentration of total PAHs and the other metals is weak, as shown in Fig. 22 for PAH and Pb ($r^2 < 0.1$). There did not appear to be significant correlations with the other metals and metalloids that show either a correlation with the fraction of the sediment as coal, or which show a strong relationship to grain size. Thus, we can conclude that the factors, and sources, controlling the PAH distribution are different from those of the coal-associated or grain size-associated metals. As mentioned above, while there is likely some relationship between PAH and coal, there are a myriad of other potential sources of PAHs to the watershed such as release from power plants, and

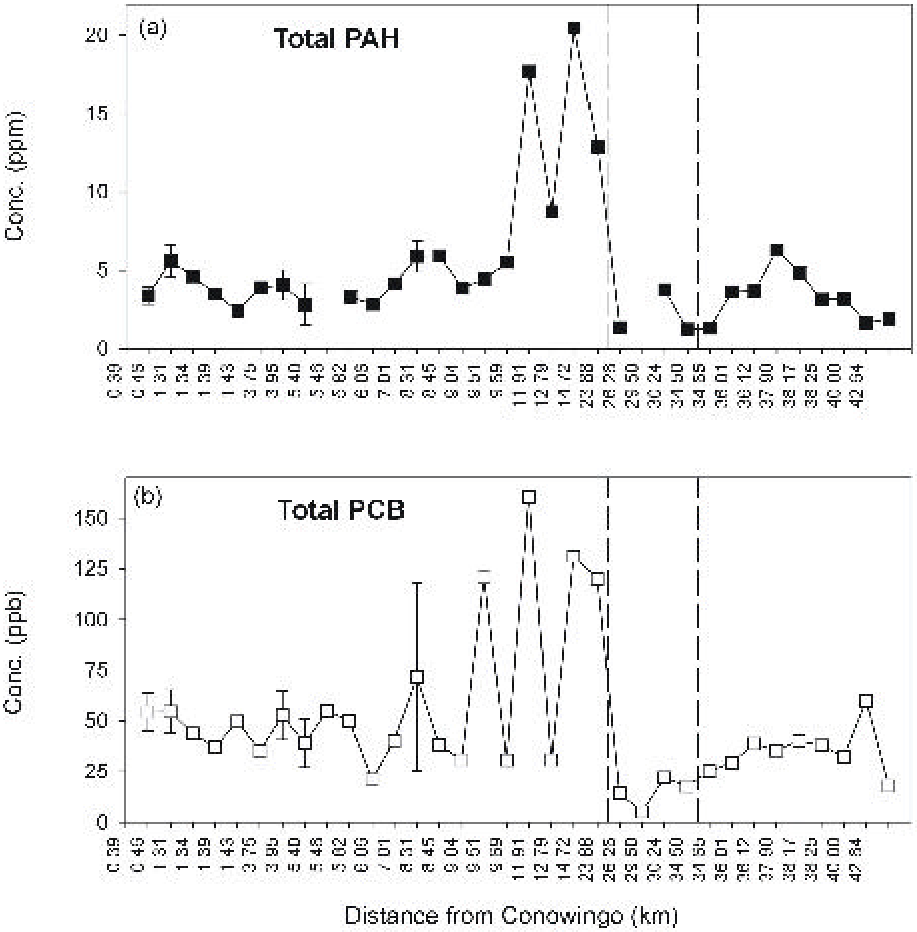

Figure 23: The average and standard deviation for all sites analyzed, plotted in terms of distance from the Conowingo Dam wall (x=0). The dotted lines reflect the location of the other two dams. Distances are in km. (a) polycyclic aromatic hydrocarbons and (b) polychlorinated biphenyls

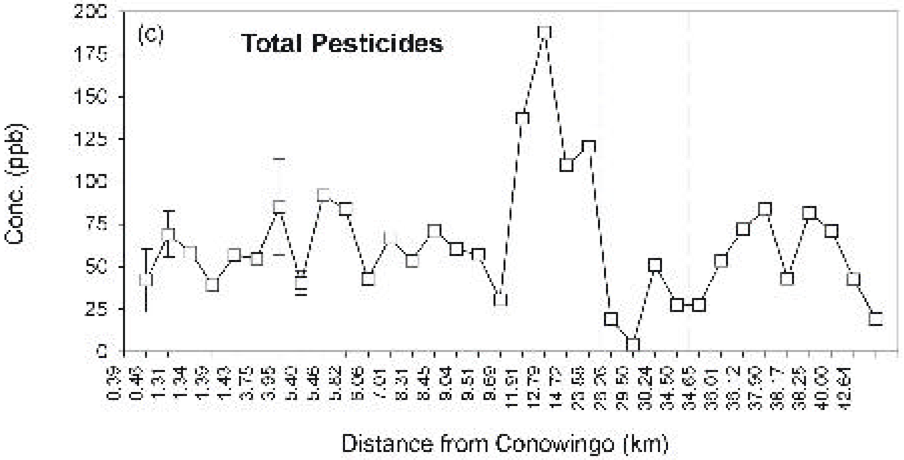

Figure 23c: The average and standard deviation for all sites analyzed, plotted in terms of distance from the Conowingo Dam wall (x=0). The dotted lines reflect the location of the other two dams. Distances are in km. chlorinated pesticides..

from vehicular emissions. These overlaying source signals would tend to smear any relationship between that of PAHs and the other contaminants measured. The PAH distribution does correlate reasonably well with that of the other organic contaminants - $r^2 = ^{0.49}$ for the correlation of total PAH and total PCB, and $r^2 = 0.64$ for PAH and total pesticides. These relationships suggest that the controls over the organic contaminants are similar, and likely reflect the overall trends in industrialization along the river i.e. even though the classes of organic contaminants do not have the same sources, their correlations reflect the factors controlling watershed runoff, and retention of the particles in the watershed. It is worth noting that the total PAH concentrations behind the dams is on average higher than that of the upper Chesapeake Bay sediments (Table 4). The difference is about a factor of two and there is a large standard deviation to each of the values but it is significant that in this case the sediments in the near proximity behind the Conowingo Dam, on average, are higher than those of the upper Bay, in contrast to most of the other contaminants listed in Table 4. This is surprising and suggests that the PAHs are being strongly retained behind the dams and not being released to a large degree to the upper Bay. Foster et al. (2000) measured organic contaminant levels in particulate material flowing over the Conowingo Dam wall. They found an average of 4 ppm total PAH (range 2-11 ppm) which is more comparable with the measured values for the surface sediments behind the dam than for those of the upper Bay. This results suggests that dilution of the Bay material is occurring, in terms of PAH, with material that does not originate from the Susquehanna or there are substantial other loss terms for PAHs in the system.

The concentration of PCBs in the sediments range from low values of around 10 ppb to high values above 100 ppb (Fig. 23b). The distribution of PCBs is more variable than that of the other organic contaminants measured and four locations have values over 100 ppb while the remainder of the sites generally have values of around 50 ppb or less. The ERM value for total PCBs is 180 ppb so none of the sites exceed this value although the four high sites tend to approach this value. In comparing the sediments directly behind the Conowingo Dam wall to the upper Bay (Table 4), it is evident that the sediment behind the dam has a lower concentration. This is what is found for most contaminants. Also, as mentioned above, PAH and PCB concentration tend to correlate well statistically although this is likely driven by the fact that for both sets of contaminants, the highest values occur at the same sites, and that these high values drive the regression.

The same is true for the relationship between PAH and pesticides (Fig. 22). Again, the pesticide concentrations are highest for the same four sites and this fact drives the correlation relationship (Fig. 23c). It is intriguing that these four sites are elevated in all the organic contaminants while for most of the other sites, the concentrations are much lower and fairly consistent. There must be some particular reason why these four sites are elevated in the organic contaminants. It should be remembered that these sites, on average, were also elevated in terms of the inorganic contaminants as well.

The concentrations of PCBs in the surface sediments behind the Conowingo Dam are comparable to those of the upper Bay. Thus, this contrasts the situation for PAHs. Also, the range in values measured in particulate flowing over the dam wall (range 29-107 ppb; average 62 ppm) are not substantially different. Thus, for PCBs, it does appear that the Susquehanna River is the main source contributing these compounds to the upper Chesapeake Bay.

Metal Concentration with Depth

Temporal variability in metals loading can be seen by examining the sedimentary records in the cores; the oldest sediments being found at the greatest depth, with the current deposits form at the sediment-water interface. A preliminary assessment of the temporal variability in the data, based on dividing the data into five depth intervals, shows that the metals fall into three categories of behavior:

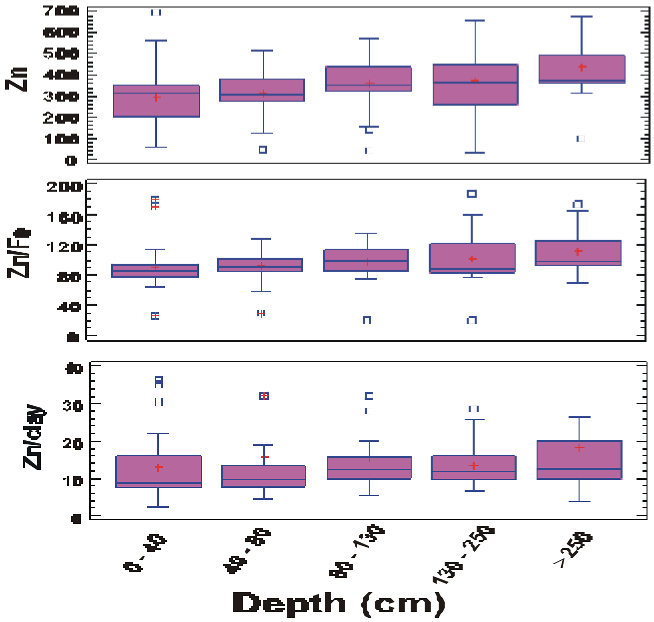

Figure 24. Zn, the ratios of Zn/Fe and Zn/Clay as a function of depth.

1- Elements that increase in concentration with depths that relate to grain size variability: Cr, Fe, Zn
, As, (Cd)

This behavior is exhibited in Figure 24 which shows the concentration of Zn in the bed sediments (top plot), the Zn/Fe ratio (middle plot) and Zn/Clay ratio (bottom plot). Zn concentrations generally increase with depth, however when normalized to Fe or Clay this trend is eliminated, showing a nearly constant ratio with depth. This relationship is borne out by the grain size behavior within the cores: the ratio of silt to is virtually constant with depth, showing that the fine grain fraction, the size fraction that holds most of the metals, is uniform throughout the cores. However, in the more recent sediments the fine grain material is diluted with sand, which becomes the dominant size fraction: sand has a lower metal content, thus lowering the total metals' concentration.

2- Elements that increase in concentration with depth, possibly related to changes in anthropogenic loading - Ag, Cu, Pb, Se

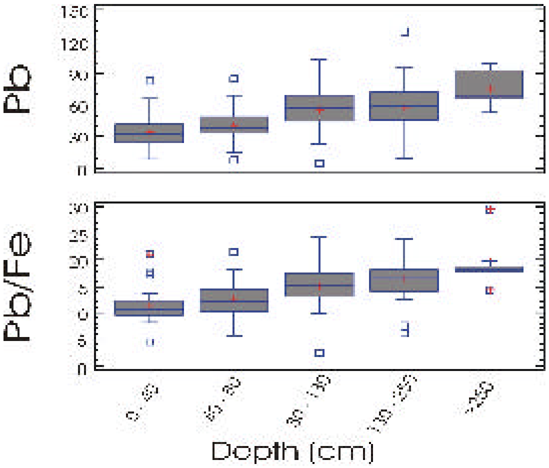

Figure 25

These elements exhibit increases in concentration, greater than what would be expected from grain size variability. This is shown in Figure25; where both the concentration of Pb and the ratio of Pb/Fe also increases with depth. It would be expected that the ratio would be constant with depth for normal background variability. For elements that are strongly influenced by anthropogenic loading, such as Pb, the introduction of these metals has decreased with time as environmental controls have been strengthened on the use and release of these metals into the environment; this produces the trend that is seen.

3- Elements that show no apparent concentration change with depth - Mn, Ni

This is similar to findings in the Northern Chesapeake Bay where these elements are strongly associated with oxy-hydroxide grain coatings, and are therefore less affected by grain size variability. No figure is given here because of the lack of variability with depth

SUMMARY

! ***The bed sediments contain a large amount of coal***

- All of the cores analyzed measured have a significant amount of coal
- 20 of the 28 cores have visually distinct layers of coal (ave. 26cm/m of core length)
- The sediments have a high carbon content as a result of the coal content

The large amount of coal in the sediments can affect the chemical and physical properties of the sediment and must be taken into account with any management decision.

! ***The sulfur concentrations are low in the bed sediments***.

-Sulfur concentrations are approximately 1/4 to ½ the concentrations found in the Northern Chesapeake Bay

The relatively low sulfur concentrations reduce the potential for acid leachate formation if the sediments are exposed to atmospheric oxygen, as in upland disposal.

! ***Generally the concentrations of metals analyzed are similar to concentrations found in the Northern Chesapeake Bay***

As a result, the level of biological influence and the expected toxicological effects of the metals would be similar to that found in the Northern Bay main stem sediments, and the handling of the Susquehanna sediments would be expected to be the same as the northern Bay sediments in this regard.

! ***Metals concentration varies with depth and geographical location due to natural grain size induced variations and changes in loading which include anthropogenic activities.***

- Grain size induced variations are exhibited spatially in sedimentation patterns within the river: areas of high velocity have coarse sediments with correspondingly low metals' levels. Conversely areas of low velocities have finer grain sediments with higher metals' loadings. Similarly, temporal changes, as reflected by changes with depth in the cores, reflect both depositional events, i.e. high energy depositional events such as storms and low flow quiescent periods, as well as long term changes in flow regimes due to infilling of the dams. It would be expected that as the reservoirs fill with sediment the water depths become shallower thus increasing the velocity of water flow in the river. This should be reflected in a coarsening of the sediments through time, this may result in the general coarsening up sequence seen in the cores.
- Changes in metals concentrations which exceed that explained by the grain size variability are the result of differences in the source of material to the sediment. Geographical variability is most likely the result of point sources or localized inputs which influence the sediment adjacent to the discharge points. These inputs can be either anthropogenic or natural (e.g. stream inflow which drains an area with a sediment load distinct from the average Susquehanna River). Temporal variability preserves the historic loading to the basin. Improvements in land use, the cessation of the use of certain heavy metals, such as Pb in gasoline, and changes in mining operations would produce lower levels at the surface with increasing concentrations with depth, as seen in the data. Hg, Pb, and Se show highly elevated levels and are known to be strongly influenced by anthropogenic loading.
- High silver (Ag) concentrations were found at depth which suggest that in the past Ag may have come from pollution sources within the river basin.
- Overall organic contaminant concentrations were comparable to those found in the Upper Chesapeake Bay. It appears that the Susquehanna River is the main source for PCB's to the Upper Chesapeake; on the other hand pesticides and PAH's appear to be trapped behind the dams.

The bed sediments of the Susquehanna river exhibit a complex behavior pattern, based on temporal and spatial loading variations. Although an overview of the data shows that the majority of the metals are present at levels near Northern Chesapeake Bay baseline levels, this is not true for all of the samples. Specific locations, and samples at greater depths have elevated metals' concentrations. For any management option that results in sediment movement or removal, it is important to evaluate the specific site and the depth to which the sediment may be disturbed in order to assess any potential problems associated with sediment associated metals toxicity.

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Appendix I

Station ID, Sample Locations, Core Length, Sub-sampled Intervals

ID	Lat	Long	Length	Intervals
1	39.78278	76.26417	331	10-20
1	39.78278	76.26417		120-130
1	39.78278	76.26417		230-240
1	39.78278	76.26417		310-320
2A	39.69556	76.21111	200	4-14
2A	39.69556	76.21111		56-66
2A	39.69556	76.21111		110-120
2A	39.69556	76.21111		180-190
3	39.69333	76.21611	160	8-18
3	39.69333	76.21611		47-57
3	39.69333	76.21611		82-92
3	39.69333	76.21611		107-117
3	39.69333	76.21611		122-142*
4	39.70583	76.23611	353	9-19
4	39.70583	76.23611		123-133
4	39.70583	76.23611		243-253
4	39.70583	76.23611		329-339
5	39.75611	76.25750	237	5-15
5	39.75611	76.25750		78-88
5	39.75611	76.25750		137-147
5	39.75611	76.25750		210-220
6	39.76222	76.24500	320	7-17
6	39.76222	76.24500		93-103
6	39.76222	76.24500		207-217
6	39.76222	76.24500		297-307
7	39.72500	76.23389	350	11-21
7	39.72500	76.23389		121-131
7	39.72500	76.23389		241-251
7	39.72500	76.23389		325-335
8	39.72472	76.22778	269	6-16
8	39.72472	76.22778		116-126
8	39.72472	76.22778		176-186
8	39.72472	76.22778		246-256
9	39.72389	76.23944	341	10-20
9	39.72389	76.23944		90-100
9	39.72389	76.23944		170-180
9	39.72389	76.23944		250-260
9	39.72389	76.23944		320-330*
10	39.74361	76.23111	410	3-13
10	39.74361	76.23111		103-113
10	39.74361	76.23111		215-225
10	39.74361	76.23111		337-347
10	39.74361	76.23111		387-397*

ID	**Lat**	**Long**	**Length**	**Intervals**
11	39.93694	76.43028	145	10-20
11	39.93694	76.43028		40-50
11	39.93694	76.43028		65-75
11	39.93694	76.43028		105-115
11	39.93694	76.43028		125-135*
12	39.96472	76.46611	142	4-14
12	39.96472	76.46611		40-50
12	39.96472	76.46611		90-100
12	39.96472	76.46611		120-130
13	39.94028	76.45083	114	5-15
13	39.94028	76.45083		40-50
13	39.94028	76.45083		70-80
13	39.94028	76.45083		103-113
14	39.93611	76.43444	125	5-15
14	39.93611	76.43444		40-50
14	39.93611	76.43444		80-90
14	39.93611	76.43444		115-125
15	39.93389	76.43472	165	5-15
15	39.93389	76.43472		40-50
15	39.93389	76.43472		80-90
15	39.93389	76.43472		155-165
16	39.88722	76.37472	119	0-10
16	39.88722	76.37472		40-50
16	39.88722	76.37472		70-80
16	39.88722	76.37472		109-119
17	39.83111	76.33639	175	3-13
17	39.83111	76.33639		60-70
17	39.83111	76.33639		93-103
17	39.83111	76.33639		129-139
17	39.83111	76.33639		159-169*
18	39.85500	76.34917	147	6-16
18	39.85500	76.34917		51-61
18	39.85500	76.34917		80-90
18	39.85500	76.34917		130-140
19	39.87750	76.37194	146	3-13
19	39.87750	76.37194		50-60
19	39.87750	76.37194		90-100
19	39.87750	76.37194		130-140
20	39.92556	76.40167	155	3-13
20	39.92556	76.40167		50-60
20	39.92556	76.40167		100-110

20	39.92556	76.40167		140-150
21	39.92250	76.40167	156	20-30

ID	Lat	Long	Length	Intervals
21	39.92250	76.40167		70-80
21	39.92250	76.40167		100-110
21	39.92250	76.40167		140-150
22	39.92778	76.41611	82	10-20
22	39.92778	76.41611		30-40
22	39.92778	76.41611		50-60
22	39.92778	76.41611		70-80
23	39.93028	76.41361	170	20-30
23	39.93028	76.41361		70-80
23	39.93028	76.41361		120-130
23	39.93028	76.41361		160-170
24	39.66917	76.18111	168	0-10
24	39.66917	76.18111		40-50
24	39.66917	76.18111		80-90
24	39.66917	76.18111		130-140
24	39.66917	76.18111		150-160*
25	39.66583	76.18250	154	23-33
25	39.66583	76.18250		56-66
25	39.66583	76.18250		96-106
25	39.66583	76.18250		136-146
26	39.66306	76.18528	83	10-20
26	39.66306	76.18528		30-40
26	39.66306	76.18528		50-60
26	39.66306	76.18528		70-80
27	39.68917	76.22083	92	7-17
27	39.68917	76.22083		27-37
27	39.68917	76.22083		47-57
27	39.68917	76.22083		67-77
28	39.69500	76.21083	155	10-20
28	39.69500	76.21083		60-70
28	39.69500	76.21083		100-110
28	39.69500	76.21083		140-150
29	39.54694	76.02194	109	10-20
29	39.54694	76.02194		30-40
29	39.54694	76.02194		60-70
29	39.54694	76.02194		80-90
29	39.54694	76.02194		90-100*
30	39.54722	76.02222	75	10-20
30	39.54722	76.02222		30-40

30	39.54722	76.02222		50-60
33	39.68306	76.19944	97	10-20
33	39.68306	76.19944		30-40
33	39.68306	76.19944		50-60

ID	**Lat**	**Long**	**Length**	**Intervals**
33	39.68306	76.19944		87-97
34	39.66611	76.17333	71	10-20
34	39.66611	76.17333		30-40
34	39.66611	76.17333		50-60
35	39.66250	76.17444	74	10-20
35	39.66250	76.17444		30-40
35	39.66250	76.17444		50-60
36	39.66167	76.18556	76	10-20
36	39.66167	76.18556		30-40
36	39.66167	76.18556		50-60
36	39.66167	76.18556		66-76*
37	39.67861	76.20389	58	10-20
37	39.67861	76.20389		40-50
38	39.70750	76.22139	69	10-20
38	39.70750	76.22139		30-40
38	39.70750	76.22139		59-69

Appendix II

Core Descriptions

Sediment Core 1

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/16/00	6/7/00	331	2		✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
1	1	00-15 cm	0	15	10-20	5Y4/2	mud
1	1	15-33 cm	15	33	10-20	5Y3/2	gassy mud
1	1	33-35 cm	33	35		10YR4/2	sand bed
1	1	35-52 cm	35	52		5Y4/2	mud with coarse sand lenses
1	1	52-54 cm	52	54		10YR4/2	sand bed
1	1	54-70 cm	54	70		5Y2/1	mud
1	1	70-72 cm	70	72		10YR4/2	sand bed
1	1	72-90 cm	72	90		5Y2/1	mud
1	1	90-99 cm	90	99		N2 | 10YR4/2	coal-sand;cross-bedding; scour-fill
1	1	99-157 cm	99	157	120-130	5Y2/1	homogeneous mud
1	2	157-180cm	157	180		N2 | 10YR4/2	sand-coal curved, non-parallel bedding; coring artifact
1	2	180-200 cm	180	200		10YR4/2	clay with sand laminae
1	2	200-212 cm	200	212		5Y2/1	sand with organic intrusions
1	2	212-218 cm	212	218		N2	coal bed; wavy, nonparallel
1	2	218-260 cm	218	260	230-240	5Y2/1	mud with parallel coal beds
1	2	260-269 cm	260	269		5GY4/1	mud
1	2	269-292 cm	269	292		5GY2/1	mud; methane bubbles
1	2	292-299 cm	292	299		10YR4/2	coal-sand cross-bedding
1	2	299-320 cm	299	320	310-320	5Y3/2	mud
1	2	320-331 cm	320	331		5Y2/1	mud

Sediment Core 2

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/16/00	6/8/00	200	2		✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
2	1	00-16 cm	0	16	4-14	5Y4/2	mud; organic rich (leaves)
2	1	16-20 cm	16	20		5Y3/2	mud; organic rich
2	1	20-28 cm	20	28		5Y5/2	mud; organic rich
2	1	28-38 cm	28	38		5Y3/2	mud; organic rich
2	1	38-41 cm	38	41		N2	interbedded coal and organics
2	1	41-62 cm	41	62	56-66	5Y5/2	mud; organic rich
2	1	62-68 cm	62	68	56-66	5Y3/2	mud; organic rich
2	1	68-72 cm	68	72		N2	interbedded coal, fine sand, and organics
2	1	72-78 cm	72	78		5Y4/2	mud; organic rich
2	2	78-96 cm	78	96		5Y4/2	mud; organic rich
2	2	96-110 cm	96	110		10YR4/2	mud
2	2	110-132 cm	110	132	110-120	10YR4/2 | 5Y3/2	banded mud
2	2	132-142 cm	132	164		5Y3/2	homogeneous mud
2	2	164-165 cm	164	165		N3	mud
2	2	165-182 cm	165	182	180-190	5Y4/2	mud
2	2	182-190 cm	182	190	180-190	5Y3/2	mud
2	2	190-200 cm	190	200			core catcher

Sediment Core 3

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/17/00	6/8/00	160	1		✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
3	1	00-26 cm	0	26	8-18	5Y4/2	mud; organic / sand laminae
3	1	26-43 cm	26	43		N2	26-32: coal-sand scour-fill structure; 32-43: parallel coal-sand bed
3	1	43-65 cm	43	65	47-57	5Y4/2	mud; organic matter; gassy
3	1	65-92 cm	65	92	82-92	5Y3/2	homogenous mud
3	1	92-117 cm	92	117	107-117	5Y4/2	mud; organic layers
3	1	117-142 cm	117	142	122-142	N2	parallel laminae > cross-bedding with mud intrusions; abrupt transition
3	1	142-160 cm	142	160		5Y3/2	core catcher; mud

Sediment Core 4

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/17/00	6/9/00	353	3		✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
4	1	00-39 cm	0	39	9-19	5Y4/2	mud; flat sand lenses; cracks; bioturbated
4	1	39-44 cm	39	44		N2	interbedded coal, organics, mud
4	1	44-58 cm	44	58		5Y4/2	interbedded organics and mud
4	1	58-59 cm	58	59		N2	organic layer
4	1	59-72 cm	59	72		5Y5/2	homogeneous mud
4	1	72-84 cm	72	84		5Y3/2	coal bed
4	1	84-98 cm	84	98		5Y3/2	organic rich mud
4	1	98-105 cm	98	105		5Y5/2	organic rich mud
4	1	105-117 cm	105	117		5Y4/2	gassy mud
4	2	117-123cm	117	123		5Y3/2	interbedded organics and mud
4	2	123-137 cm	123	137	123-133	5Y4/2	gassy mud
4	2	137-141 cm	137	141		5Y3/2	mud layer
4	2	141-161 cm	141	161		5Y4/2	mud; cracks
4	2	161-191 cm	161	191		5Y6/2	discontinuous, chaotic sand and coal bed; coring artifact
4	2	191-228 cm	191	228		N2	discontinuous, wavy to parallel sand and coal bed; coring artifact
4	3	228-278cm	228	278	243-253	N2	parallel, interbedded sand and coal
4	3	278-288 cm	278	288		N3	parallel, interbedded sand and coal; less coal
4	3	288-308 cm	288	308		5Y4/2	homogeneous mud
4	3	308-319 cm	308	319		5Y4/2	homogeneous mud
4	3	319-348 cm	319	348	329-339	5Y4/2	homogeneous mud
4	3	348-353 cm	348	353		5Y3/2	consolidated mud

Sediment Core 5

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo

Conowingo	5/18/00	6/12/00	237	2	✓	

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
5	1	00-28 cm	0	28	5-15	5YR2/1	mud with sand lenses
5	1	28-60 cm	28	60		N3	mud, wavy bedding
5	1	60-80 cm	60	80		N2	homogeneous mud
5	1	80-88 cm	80	88	78-88	5Y5/2	homogeneous mud
5	1	88-97 cm	88	97		N4	interbedded sand, coal, and mud
5	1	97-100 cm	97	100		N2	coal layer
5	2	100-114 cm	100	114		5Y3/2	homogeneous mud
5	2	114-136cm	114	136		5Y3/2	homogeneous mud with coal interspersed
5	2	136-185 cm	136	185	137-147	5Y6/4 | N2	interbedded sand, coal, organics into homogenous mud
5	2	185-189 cm	185	189		5Y5/2	consolidated mud
5	2	189-190 cm	189	190		N2	coal
5	2	190-199 cm	190	199		5Y3/2	homogeneous mud
5	2	199-200 cm	199	200		N2	coal
5	2	200-206 cm	200	206		5Y3/2	mud
5	2	206-210 cm	206	210		5Y6/4	consolidated mud
5	2	210-219 cm	210	219	210-220	N2	mud
5	2	219-226 cm	219	226		5Y3/2	mud with sand lenses
5	2	226-237 cm	226	237			core catcher

Sediment Core 6

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/18/00	6/12-13/00	320	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
6	1	00-28 cm	0	28	7-17	5Y/6 | N2	chaotic bedding of mud, coal, and fine to medium sand
6	1	28-56 cm	28	56		N3	compact mud with coal lamina
6	1	56-77 cm	56	77		N2	interlayered coal and mud
6	1	77-85 cm	77	85		5Y6/4	curved, interbedded sand and mud
6	1	85-87 cm	85	87		N1	coarse, coal layer
6	1	87-108 cm	87	108	93-103	5Y3/2	consolidated mud
6	1	108-125cm	108	125		5Y3/2|N1	intermixed sand and coal bed
6	1	125-129 cm	125	129		N1	coarse, coal layer
6	1	129-138cm	129	138		5Y3/2	intermixed sand and coal bed
6	1	138-154 cm	138	154		5Y3/2	consolidated mud, coal intrusion from mixing during coring
6	2	154-187 cm	154	187		N3	firm, homogeneous mud, coal/sand intrusion during coring
6	2	187-193cm	187	193		N2|5Y6/4	disrupted, sand, coal, mud fill
6	2	193-222cm	193	222	207-217	N3	less firm mud intermixed with coal
6	2	222-240 cm	222	240		N2	gassy mud
6	2	240-248 cm	240	248		5Y3/2	more homogeneous mud

6	2	248-252 cm	248	252		N2	coal layer
6	2	252-267 cm	252	268		N3	consolidated mud
6	2	267-275 cm	267	275		5Y3/2	mud
6	2	275-302 cm	275	302	297-307	N3	mud
6	2	302-312 cm	302	312	297-307	5Y3/2	mud
6	2	312-320 cm	312	320			core catcher

Sediment Core 7

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/24/00	6/13-14/00	350	3	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
7	1	00-21 cm	0	21	11-21	N4	sandy mud
7	1	21-30 cm	21	30		N3	mud
7	1	30-38 cm	30	38		N4	intermixed mud, coal, and organics
7	1	38-39 cm	38	39		N3	coal lamina
7	1	39-41 cm	39	41		5Y3/2	mud; organics
7	1	41-50 cm	41	50		N4	intermixed mud and coal
7	1	50-68 cm	50	68		5Y3/2	intermixed mud and coal
7	1	68-92 cm	68	92		N1	intermixed mud, sand, and coal
7	1	92-97 cm	92	97		5Y3/2 | N3	curved, interbedded sand and coal layers
7	2	97-107 cm	97	107		5Y3/2	firm mud
7	2	107-117 cm	107	117		5Y5/2	firm mud
7	2	117-122 cm	117	122		5Y3/2	mud
7	2	122-134 cm	122	134	121-131	5Y5/2	mud
7	2	134-150 cm	134	150		5Y3/2	mud
7	2	150-159 cm	150	159		5Y4/2	mud
7	2	159-183 cm	159	183		5Y5-3/2	banded mud
7	2	183-198 cm	183	198		5Y4/2	mud
7	2	198-201 cm	198	201		N2	mud
7	2	201-225 cm	201	225		N3	mud
7	3	225-231 cm	225	231		5Y3/2	mud
7	3	231-287 cm	231	287	241-251	N3	mud; organic rich
7	3	287-295 cm	287	295		5Y3/2	mud
7	3	295-309 cm	295	309		N4	mud
7	3	309-312 cm	309	312		N2	organic layer
7	3	312-336 cm	312	336	325-335	5Y4/2 | N4	mud
7	3	336-350 cm	336	350			core catcher

Sediment Core 8

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/24/00	6/14/00	269	3	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
8	1	00-12 cm	0	12	6-16	5Y3/2 | 5Y6/4	muddy sand
8	1	12-20 cm	12	20		N4	sandy mud
8	1	20-30 cm	20	30		N2	organic rich mud
8	1	30-39 cm	30	39		N3	interbedded coal and sand
8	1	39-52 cm	39	52		5Y3/2	homogeneous mud

8	1	52-64 cm	52	64		N2	coarse, coal layer
8	2	64-76 cm	64	76		5Y3/2 | N2	curved, wavy coal and sand bed
8	2	76-104 cm	76	104		5Y6/4|N2	chaotic, intermixed coal and sand bed
8	2	104-106cm	104	106		5Y6/2	coal layer; transitional surface
8	2	106-113 cm	106	113		5Y5/2	homogeneous mud
8	2	113-118 cm	113	118	116-126	5Y3/2	organic rich mud
8	2	118-138 cm	118	138		5Y5/6	homogeneous mud
8	2	138-152 cm	138	152		5Y3/2	firm mud
8	2	152-163 cm	152	163		N2	interbedded coal and sand
8	2	163-173 cm	163	173		5Y3/2	homogeneous mud
8	3	173-180 cm	173	180	176-186	5Y3/2	firm, homogeneous mud
8	3	180-191cm	180	191		N4	mud with slight organics and coal
8	3	191-203 cm	191	203		5Y3/2	firm, homogeneous mud
8	3	203-216 cm	203	216		N2	coal and sandy mud
8	3	216-257 cm	216	257	246-256	N3	firm, organic rich mud
8	3	257-269 cm	257	269			core catcher

Sediment Core 9

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/24/00	6/15/00	341	3	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
9	1	00-24 cm	0	24	10-20	5Y4/2	organic rich, firm mud
9	1	24-30 cm	24	30		N3	coal and sandy mud
9	1	30-35 cm	30	35		5Y5/2	intermixed sand and coal
9	1	35-55 cm	35	55		5Y4/2	intermixed sand and coal with organic layers
9	1	55-61 cm	55	61		5Y5/2	organic rich, sandy mud
9	1	61-72 cm	61	72		5Y3/2	organic rich, soft mud
9	1	72-76 cm	72	76		N2	intermixed mud, coal, and organics
9	1	76-82 cm	76	82		N4	intermixed coal and mud
9	2	82-142 cm	82	142	90-100	5Y4/2	gassy, firm mud
9	2	142-158 cm	142	158		5Y5/2	mud; thin organic layers
9	2	158-171 cm	158	171		5Y4/2	banded mud
9	2	171-188 cm	171	188	170-180	5Y5/2	mud
9	2	188-191 cm	188	191		N2	mud
9	2	191-200 cm	191	200		5Y4/2	mud
9	2	200-209 cm	200	209		5Y5/2	banded mud, coal rich
9	2	209-213 cm	209	213		5Y3/2	mud
9	3	213-222 cm	213	222		5Y5/2	mud
9	3	222-236 cm	222	236		5Y3/2	mud
9	3	236-244 cm	236	244		5Y5/2	mud
9	3	244-252 cm	244	252		5Y3/2	mud
9	3	252-276 cm	252	276	250-260	5Y4/2	mud
9	3	276-282 cm	276	282		5Y3/2	mud
9	3	282-285 cm	282	285		N3	mud
9	3	285-289 cm	285	289		5Y4/2	mud
9	3	289-320 cm	289	320		5Y3/2	mud

9	3	320-324 cm	320	324		5Y5/2	mud
9	3	324-342 cm	324	342	320-330		core catcher

Sediment Core 10

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	5/24/00	6/16/00	410	3	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
10	1	00-08 cm	0	8	3-13	5Y3/2	firm mud
10	1	08-22 cm	8	22		5Y5/2	mud
10	1	22-29 cm	22	29		5Y3/2	organic rich, coal mud
10	1	29-40 cm	29	40		5Y6/2	soft mud
10	1	40-51 cm	40	51		5Y5/2	soft mud
10	1	51-97 cm	51	97		N4	soft mud
10	1	97-101 cm	97	101		N3	mud
10	1	101-107 cm	101	107	103-113	5Y3/2	mud
10	1	107-126 cm	107	126		N3	coal layer
10	2	126-151 cm	126	151		N3	coal layer
10	2	151-157 cm	151	157		5Y4/2	mud
10	2	157-191 cm	157	191		N3	firm mud
10	2	191-204 cm	191	204		5Y3/2	mud
10	2	204-206 cm	204	206		N2	mud
10	2	206-245 cm	206	245	215-225	N4	mud
10	2	245-253 cm	245	253		5Y6/4 | 5Y3/2	banded mud
10	2	253-263 cm	253	263		N2 | 5Y5/2	interlayered coal and sand
10	2	263-271 cm	263	271		N3	coal rich mud
10	3	271-281 cm	271	281		5Y3/2	firm mud
10	3	281-303 cm	281	303		N3	firm mud
10	3	303-305 cm	303	305		N2	homogeneous mud
10	3	305-314 cm	305	314		N3	homogeneous mud
10	3	314-337 cm	314	337		N3 | 5Y6/4	interlayered sand and coal
10	3	337-383 cm	337	383	337-347	5Y3/2	mud
10	3	383-390 cm	383	390		5Y3/2 | 5Y6/4	interlayered sand and coal
10	3	390-400 cm	390	400	387-397	N2	mud
10	3	400-410 cm	400	410		N4	mud

Sediment Core 11

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	5/25/00	6/21/00	145	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
11	1	00-22 cm	0	22	10-20	10YR4/2	mixed, soupy, grayish brown mud
11	1	22-25 cm	22	25		5Y3/2	mud
11	1	25-57 cm	25	57	40-50	5Y4/2	mud with organic layer
11	1	57-59 cm	57	59		N2	sand bed
11	1	59-62 cm	59	62		N2	mud
11	1	62-65 cm	62	65		N2	organics (leaves, twigs), mud
11	1	65-72 cm	65	72	65-75	5Y5/2	mud with sand lens
11	1	72-75 cm	72	75		5Y4/2	mud
11	1	75-80 cm	75	80		5Y4/2 | N2	mud
11	1	80-83 cm	80	83		N2	sand/coal cross-bedding
11	1	83-130 cm	83	130	105-115	5Y5-3/2	mottled - banded mud

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
11	1	130-145 cm	130	145	125-135	5Y3/2	core catcher; mud

Sediment Core 12

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/14/00	7/17/00	142	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
12	1	00-19 cm	0	19	4-14	5Y4/1	interbedded sand and coal; wavy bedding
12	1	19-35 cm	19	35		N2 | 5Y4/1	interlaminated sand and coal bed; minor scour-fill structure
12	1	35-48 cm	35	48	40-50	5Y4/2	soupy, bioturbated mud bed
12	1	48-53 cm	48	53		N3	organic rich interbedded mud and fine sand
12	1	53-76 cm	53	76		N1	organic rich (acorns, twigs, leaves); intermixed mud, fine sand, coal
12	1	76-100 cm	76	100	90-100	N2 | 5Y4/1	abrupt transition; interlaminated, parallel coal and sand band
12	1	100-101 cm	100	101		N2	abrupt transition; solid-organics
12	1	101-110 cm	101	110		N2 | 5Y4/1	abrupt transition; interlaminated, parallel coal and sand band
12	1	110-114 cm	110	114		5Y5/2	firm mud
12	1	114-120 cm	114	120		5Y4/1	homogenous mud
12	1	120-124 cm	120	124		N4	mud
12	1	124-142 cm	124	142	120-130	5Y5/2	mud; mud cracks; organic layers

Sediment Core 13

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/14/00	7/25/00	114	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
13	1	00-07 cm	0	7		5Y4/1	firm mud
13	1	07-23 cm	7	23	5-15	5Y4/1	soupy mud
13	1	23-35 cm	23	35		5GY4/1	mud
13	1	35-49 cm	35	49	40-50	5Y4/1	mud
13	1	49-66 cm	49	66		5GY4/1	mud
13	1	66-91 cm	66	91	70-80	5Y4/1	mud
13	1	91-103cm	91	103		5Y4/1	abrupt transition; mixed coal and sand; gravel
13	1	103-114 cm	103	114	103-113	5GY2/1	organic rich mud

Sediment Core 14

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/14/00	7/17/00	125	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
14	1	00-13 cm	0	13	5-15	5Y5/2	bioturbated, firm mud
14	1	13-17 cm	13	17		5Y3/2	firm mud; organic layers

14	1	17-26 cm	17	26		5Y4/2	homogenous mud
14	1	26-31 cm	26	31		5Y3/2	homogenous mud
14	1	31-37 cm	31	37		5Y5/2	homogenous mud
14	1	37-41 cm	37	41		5Y3/2	homogenous mud
14	1	41-45 cm	41	45	40-50	5Y4/2	homogenous mud
14	1	45-50 cm	45	50		5Y5/2	homogenous mud; angular mud crack; gas bubbles
14	1	50-60 cm	50	60		5Y3/2	abrupt transition to firm mud with abundant mud cracks
14	1	60-65 cm	60	65		5Y5/6	interbedded sand and mud layers
14	1	65-90 cm	65	90	80-90	5Y3/2	homogenous mud; mud cracks; small sand lens
14	1	90-98 cm	90	98		5Y3/2	homogenous mud; mud cracks
14	1	98-125cm	98	125	115-125	5Y3/2	homogenous mud; mud cracks

Sediment Core 15

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/16/00	7/18/00	165	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
15	1	00-18 cm	0	18	5-15	5Y5/6	mud with plant matter
15	1	18-23 cm	18	23		N3	mud
15	1	23-37 cm	23	37		5Y3/2	mud
15	1	37-44 cm	37	44		5Y3/2	mud
15	1	44-48 cm	44	48	40-50	N4	mud
15	1	48-60 cm	48	60		5Y3/2	firm mud
15	1	60-65 cm	60	65		N4	mud
15	1	65-76 cm	65	76		5Y5/2	mud
15	1	76-80 cm	76	80		5Y6/4	mud
15	1	80-91 cm	80	91	80-90	5Y5/2	mud
15	1	91-99 cm	91	99		5Y3/2	mud
15	1	99-105 cm	99	105		N4	firm mud
15	1	105-119 cm	105	119		5Y5/2	mud
15	1	119-124 cm	119	124		5Y3/2	mud
15	1	124-144 cm	124	144		5Y5/2	mud
15	1	144-146 cm	144	146		5Y7/2	sand
15	1	146-149 cm	146	149		5Y3/2	mud
15	1	149-153 cm	149	153		5YR7/2	firm to very firm mud
15	1	153-159 cm	153	159		5Y6/4	coarse sand bed
15	1	159-165 cm	159	165	155-165	5Y3/2	very firm mud

Sediment Core 16

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Aldred	6/15/00	7/18/00	119	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
15	1	00-19 cm	0	19	0-10	5Y5/6 | N1	wavy, intermixed sand and coal into curved bedding
15	1	19-31 cm	19	31		N1	abrupt transition into coal bed; sand laminae, lenses
15	1	31-36 cm	31	36		N3	coal bed

15	1	36-44 cm	36	44		N3 | 5Y5/6	interlayered coal and sand; thin lamina to medium beds
15	1	44-54 cm	44	54	40-50	N3	interlayered coal and sand; thin lamina to medium beds; mostly coal
15	1	54-65 cm	54	65		5Y6/4	abrupt transition to fine to medium sand; several coal laminae
15	1	65-74 cm	65	74	70-80	N2 | 5Y5/6	interlayered coal and sand; thin lamina to medium beds
15	1	74-76 cm	74	76		N4	abrupt transition into clay bed
15	1	76-80 cm	76	80		5Y3/2	wavy, muddy sand, interlayered with coal
15	1	80-90 cm	80	90		N5 | 5Y5/2	sand bed; coarse sand and coal lenses
15	1	90-91 cm	90	91		N4	intermixed coal and sand
15	1	91-110 cm	91	110		5Y3/2	interlayered sand and coal; thin lamina to medium beds
15	1	110-119 cm	110	119	109-119	N1	coal bed

Sediment Core 17

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Aldred	6/15/00	7/19/00	175	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
17	1	00-18 cm	0	18	3-13	5Y6/4 | N2	intermixed coal and sand; mostly coal; chaotic bedding
17	1	18-27 cm	18	27		5Y6/4	abrupt transition to wavy then slanted beds; interlayered sand and coal
17	1	27-47 cm	27	47		N2	wavy, coal beds; plant matter at bottom of interval
17	1	47-61 cm	47	61		5Y6/2	sand with coal lamina
17	1	61-67 cm	61	67	60-70	5Y3/2	cohesive mud; coring artifact
17	1	67-74 cm	67	74		5Y5/2	muddy sand
17	1	74-78 cm	74	78		N1	coarse coal layer
17	1	78-83 cm	78	83		5Y3/2 | N4	intermixed coal and mud
17	2	83-86 cm	83	86		N5	cohesive mud
17	2	86-102 cm	86	102	93-103	5Y3/2	sandy mud; coal lamina
17	2	102-124 cm	102	124		N3	interbedded sand and coal
17	2	124-137cm	124	137	129-139	N4	abrupt transition to cohesive mud
17	2	137-138 cm	137	138		N2	coal bed
17	2	138-143 cm	138	143		5Y5/2	cohesive, firm mud
17	2	143-153 cm	143	153		N4	interbedded coal and sandy mud
17	2	153-175 cm	153	175	159-169	N3	sandy mud; intermixed coal

Sediment Core 18

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Aldred	6/15/00	7/20/00	147	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
18	1	00-05 cm	0	5		10YR4/2	firm, bioturbated muddy sand; oxidized

18	1	05-26 cm	5	26	6-16	10YR6/6	less firm, muddy sand; bioturbated; organic matter abundant
18	1	26-48 cm	26	48		10YR6/2	bioturbated, muddy sand
18	1	48-61 cm	48	61	51-61	10YR5/2	bioturbated, muddy sand
18	2	61-98 cm	61	98	80-90	5Y5/6	bioturbated, sand with organic layers
18	2	98-102 cm	98	102		5Y6/4	bioturbated, sand
18	2	102-105cm	102	105		5Y6/1	bioturbated, sand with blue-gray color
18	2	105-119 cm	105	119		5Y5/2	bioturbated, sand
18	2	119-127 cm	119	127		5Y6/1	bioturbated, muddy sand
18	2	127-147 cm	127	147	130-140	5B5/1	bioturbated, muddy sand

Sediment Core 19

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Aldred	6/15/00	7/19/00	146	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
19	1	00-09 cm	0	9	3-13	5Y6/4	sandy mud; organic matter
19	1	09-27 cm	9	27		N4 | 5Y6/4	banded mud
19	1	27-53 cm	27	53		N1	soupy mud
19	1	53-60 cm	53	60	50-60	N2 | 5Y5/2	interbedded sand, coal, and mud
19	1	60-107 cm	60	107	90-100	N2	homogeneous mud
19	1	107-119 cm	107	119		N4	homogeneous mud
19	1	119-137 cm	119	137	130-140	N3	homogeneous mud
19	1	137-146 cm	137	146		N4	homogeneous mud; coal

Sediment Core 20

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/16/00	7/24/00	155	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
20	1	00-04 cm	0	4		5Y5/6	intermixed coal and mud
20	1	04-06 cm	4	6		N3	homogeneous mud
20	1	06-12 cm	6	12	3-13	5Y6/1	homogeneous, sandy mud
20	1	12-16 cm	12	16		5YR5/6 | 5Y6/1	banded mud
20	1	16-29 cm	16	29		5Y4/1	cohesive mud
20	1	29-34 cm	29	34		N4	mud
20	1	34-48 cm	34	48		5Y6/1	mud
20	1	48-56 cm	48	56	50-60	N3	bioturbated, organic rich mud
20	1	56-76 cm	56	76		N4	intermixed mud, sand, coal
20	1	76-94 cm	76	94		N2	intermixed mud and coal
20	1	94-153 cm	94	153	100-110 140-150	N3	intermixed mud and coal
20	1	153-155 cm	153	155		N3	organic rich mud

Sediment Core 21

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/16/00	7/24/00	156	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
21	1	00-17 cm	0	17		5YR6/6	medium sand
21	1	17-26 cm	17	26	20-30	5Y4/1	interbedded sand and coal
21	1	26-34 cm	26	34		5Y6/1	interbedded sand and mud
21	1	34-54 cm	34	54		5Y4/1	firm, cohesive mud
21	1	54-61 cm	54	61		N3	intermixed mud and coal
21	1	61-77 cm	61	77	70-80	N4	sand
21	1	77-93 cm	77	93		N4	cohesive mud
21	1	93-110 cm	93	110	100-110	N4	homogeneous mud
21	1	110-117 cm	110	117		N4	homogeneous mud
21	1	117-127 cm	117	127		N3	homogeneous mud
21	1	127-156 cm	127	156	140-150	N2	homogeneous mud

Sediment Core 22

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/16/00	7/25/00	82	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
22	1	00-22 cm	0	22	10-20	5Y4/1	soupy, organic rich, sandy mud
22	1	22-30 cm	22	30		5GY2/1	muddy sand
22	1	30-45 cm	30	45	30-40	5Y4/1	muddy sand
22	1	45-50 cm	45	50		5GY2/1	muddy sand
22	1	50-58 cm	50	58	50-60	5Y4/1	muddy sand; organic layers
22	1	58-60 cm	58	60		5GY2/1	muddy sand
22	1	60-70 cm	60	70		5G4/1	muddy sand
22	1	70-82 cm	70	82	70-80	5G2/1	coal

Sediment Core 23

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/16/00	7/24/00	170	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
23	1	00-13 cm	0	13		5YR5/6 | N3	intermixed mud and coal
23	1	13-16 cm	13	16		N2	organic layer
23	1	16-39 cm	16	39	20-30	5Y6/1	homogeneous mud
23	1	39-49 cm	39	49		N2	coarse coal bed
23	1	49-51 cm	49	51		5Y6/1	cohesive mud
23	1	51-59 cm	51	59		N2	coal
23	1	59-68 cm	59	68		N1	intermixed coal, mud, organics
23	1	68-87 cm	68	87	70-80	5Y4/1	homogeneous mud
23	2	87-95 cm	87	95		N4	homogeneous mud
23	2	95-112 cm	95	112		5Y6/1	organic rich, homogeneous mud
23	2	112-120 cm	112	120		N5	cohesive mud
23	2	112-120 cm	120	132	120-130	5Y4/1	cohesive mud
23	2	132-141 cm	132	141		5Y6/1	cohesive mud
23	2	141-145 cm	141	145		N4	cohesive mud
23	2	145-149 cm	145	149		5Y6/1	cohesive mud
23	2	149-163 cm	149	163		5Y4/1	cohesive mud
23	2	163-167 cm	163	167	160-170	5Y6/1	cohesive mud
23	2	167-170 cm	167	170		N3	coal layer

Sediment Core 24

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	6/21/00	7/25/00	168	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
24	1	00-12 cm0	12	0-10		5Y4/1 | N3	bioturbated mud
24	1	12-21 cm12	21			5Y6/1	homogeneous mud
24	1	21-30 cm21	30			5Y4/1	homogeneous mud
24	1	30-49 cm30	49	40-50		5Y4/1 | N4	sandy mud, organic rich
24	1	49-64 cm49	64			N3	organic layer
24	1	64-79 cm64	79			N5 | 5Y4/1	mottled mud
24	2	79-100 cm	79	100	80-90	5Y4/1	firm mud
24	2	100-102 cm	100	102		5Y4/1	organic rich mud
24	2	102-146 cm	102	146	130-140	5Y4/1	organic rich mud
24	2	146-168 cm	146	168	150-160	5Y4/1	gassy, organic rich mud

Sediment Core 25

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	6/21/00	7/25/00	154	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
25	1	00-33 cm0	33	23-33		5Y4/1	soupy mud
25	2	33-46 cm33	46			N3	mud
25	2	46-58 cm46	58	56-66		N4	firm mud
25	2	58-73 cm58	73			N3	homogeneous mud
25	2	73-87 cm73	87			5Y4/1	homogeneous mud
25	2	87-107 cm	87	107	96-106	5Y6/1	homogeneous mud
25	2	107-124 cm	107	124		5Y4/1	homogeneous mud
25	2	124-154 cm	124	154	136-146	5Y5/1	homogeneous mud

Sediment Core 26

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	6/22/00	7/26/00	83	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
26	1	00-11 cm0	11			5Y4/1	soupy mud
26	1	11-17 cm11	17	10-20		5G4/1	mud
26	1	17-32 cm17	32			5Y4/1	organic rich, sandy mud
26	1	32-38 cm32	38	30-40		N3	coal laden, muddy sand
26	1	38-44 cm38	44			5Y4/1	organic rich, sandy mud
26	1	44-48 cm44	48			5Y5/1	intermixed coal, sand, and mud
26	1	48-57 cm48	57	50-60		5Y4/1	mud
26	1	57-63 cm57	63			N4	organic rich, mud
26	1	63-83 cm63	83	70-80		5Y4/1	mud

Sediment Core 27

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/22/00	7/26/00	92	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description

27	1	00-09 cm	0	9		5Y4/1	soupy mud
21	1	09-24 cm	9	24	7-17	5Y4/1	organic and coal rich, soupy mud
27	1	24-48 cm	24	48	27-37	5Y3/1	homogeneous mud
27	1	48-59 cm	48	59	47-57	5Y3/1	homogeneous mud
27	1	59-69 cm	59	69		5Y6/2	homogeneous mud
27	1	69-79 cm	69	79	67-77	N3	sandy mud
27	1	79-92 cm	79	92		5Y3/1	homogeneous mud

Sediment Core 28

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Lake Clarke	6/22/00	7//00	155	2	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
28	1	00-10 cm	0	10		5Y4/1	soupy mud
28	1	10-25 cm	10	25	10-20	5GY4/1	homogeneous mud interrupted by organic layers
28	1	25-40 cm	25	40		5Y4/1	homogeneous mud interrupted by organic layers
28	2	40-50 cm	40	50		5G4/1	firm, cohesive mud
28	2	50-60 cm	50	60		5G2/1	interbedded sand, mud, and coal
28	2	60-78 cm	60	78	60-70	5Y4/1	organic rich, sandy mud
28	2	78-85 cm	78	85		5Y4/1	cohesive mud
28	2	85-90 cm	85	90		5G4/1	cohesive mud
28	2	90-110 cm	90	110	100-110	5Y4/1	organic and coal rich mud
28	2	110-138 cm	110	138		5Y4/1	homogeneous mud
28	2	138-155 cm	138	155	140-150	5G4/1	firm, homogeneous mud

Sediment Core 29

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Flats	8/30/00	10/4/00	109	1	✓	

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
30	1	00-22 cm	0	22	10-20	5Y5/2	sandy mud
30	1	22-35 cm	22	35		5Y3/2	sandy mud
30	1	35-48 cm	35	48	30-40	5Y4/2	mud
30	1	48-52 cm	48	52		5Y3/2	coal layer
30	1	52-80 cm	52	80	60-70	N2 | 5Y5/2	banded sandy mud; coal present
30	1	80-83 cm	80	83		N3	intermixed sand, coal, mud
30	1	83-100 cm	83	100	80-90 90-100	N2	sandy mud
30	1	100-109 cm	100	109			core catcher

Sediment Core 30

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Flats	8/30/00	10/4/00	75	1	✓	

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
29	1	00-21 cm	0	21	10-20	5Y4/2	sandy mud

29	1	21-27 cm	21	27		5Y3/2 | N3	intermixed sand and coal
29	1	27-32 cm	27	32		5Y3/2 | N2	interbedded sand and coal
29	1	32-35 cm	32	35		N3	intermixed sand, coal, and mud
29	1	35-38 cm	35	38	30-40	5Y3/2	intermixed sand, coal, and mud
29	1	38-48 cm	38	48		5Y2/1	coal laden mud
29	1	48-67 cm	48	67	50-60	N3	homogeneous mud; organics
29	1	67-75 cm	67	75			core catcher

Sediment Core 31

Not used

Sediment Core 32

Not used

Sediment Core 33

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/2/00	97	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
33	1	00-14 cm	0	14		5Y5/2	soupy, highly disturbed mud
33	1	14-19 cm	14	19	10-20	5Y3/2	homogeneous mud
33	1	19-23 cm	19	23		5Y4/2	homogeneous mud
33	1	23-31 cm	23	31		5Y5/2	homogeneous mud
33	1	31-40 cm	31	40	30-40	5Y4/2	homogeneous mud
33	1	40-44 cm	40	44		5Y3/2	homogeneous mud
33	1	44-55 cm	44	55		5Y6/2	homogeneous mud
33	1	55-74 cm	55	74	50-60	N3	homogeneous mud interrupted by organic layers
33	1	74-80 cm	74	80		5Y5/2	intermixed coal, sand, and mud
33	1	80-86 cm	80	86		N3	organic layer
33	1	86-90 cm	86	90	87-97	5Y3/2	firm mud
33	1	90-93 cm	90	93		N3	organic layer
33	1	93-97 cm	93	97		5Y3/2	firm mud

Sediment Core 34

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/2/00	71	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
34	1	00-28 cm	0	28	10-20	5Y5/2	homogeneous mud
34	1	28-32 cm	28	32		5Y6/2	homogeneous mud
34	1	32-37 cm	32	37	30-40	5Y5/2	homogeneous mud
34	1	37-50 cm	37	50		5Y3/2 | N5	homogeneous mud
34	1	50-71 cm	50	71	50-60	5Y4/2	mud; organic matter

Sediment Core 35

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/2/00	74	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
35	1	00-30 cm	0	30	10-20	5Y5/2	homogeneous mud
35	1	30-36 cm	30	36		5Y3/2	homogeneous mud
35	1	36-57 cm	36	57	30-40	5Y4/2	homogeneous mud
35	1	57-59 cm	57	59	50-60	5Y3/2	homogeneous mud
35	1	57-74 cm	57	74		5Y5/2	homogeneous mud

Sediment Core 36

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/2/00	76	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
36	1	00-12 cm	0	12		5Y5/6	soupy mud
36	1	12-43 cm	12	43	10-20	5Y5/2	moderately firm mud with mud cracks
					30-40		
36	1	43-49 cm	43	49		5Y3/2	moderately firm mud
36	1	49-66 cm	49	66	50-60	5Y6/2	moderately firm mud
36	1	66-73 cm	66	73	66-76	5Y4/2	firm mud
36	1	73-76 cm	73	76		N2	mud; organic layers

Sediment Core 37

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/4/00	58	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
37	1	00-20 cm	0	20	10-20	5Y5/2	soupy, highly disturbed mud
37	1	20-28 cm	20	28		5Y3/2 | N1	slightly firm mud; coal veins
37	1	28-37 cm	29	37		5Y3/2	homogenous mud
37	1	37-58 cm	37	58	40-50	5Y5/2	homogenous mud

Sediment Core 38

Reservoir	Cored	Extruded	Length	Sections	X-Ray	Photo
Conowingo	9/8/00	10/4/00	69	1	✓	✓

Core	Section	Log Interval	Start	End	Sampled Interval	Color	Description
38	1	00-13 cm	0	13		5Y4/2	soupy grading to slightly firm mud
38	1	13-15 cm	13	15	10-20	5Y3/2	slightly firm mud
38	1	15-33 cm	15	33		5Y4/2	slightly firm mud
38	1	33-37 cm	33	37	30-40	5Y3/2	slightly firm mud
38	1	37-51 cm	37	51		5Y4/2	moderately firm mud
38	1	51-56 cm	51	56		5Y3/2	moderately firm mud, interspersed organic matter
38	1	56-66 cm	56	66	59-69	5Y5/2	moderately firm mud
38	1	66-69 cm	66	69		5Y3/2	sandy mud with coal

Appendix III

Physical Properties, % Sand, % Silt, % Clay, % Coal

ID	Intervals	%H20	Bulk Density	%Coal	%GRAVEL	%SAND	%SILT	CLAY	SHEP CLASS	PEJRUP CLASS
1	10-20	40.75	1.60	21.74	0.00	40.84	45.23	13.93	Sandy-Silt	C,III
1	120-130	45.93	1.52	27.60	0.00	11.54	55.88	32.59	Clayey-Silt	C,III
1	230-240	45.74	1.52	24.53	0.00	4.78	55.58	39.65	Clayey-Silt	D,III
1	310-320	38.57	1.64	28.75	0.00	25.84	68.76	5.40	Sandy-Silt	C,IV
2A	4-14	53.18	1.42	2.89	0.00	2.87	60.97	36.16	Clayey-Silt	D,III
2A	56-66	56.65	1.38	10.75	0.00	1.97	60.11	37.92	Clayey-Silt	D,III
2A	110-120	53.47	1.42	7.13	0.00	0.43	55.94	43.63	Clayey-Silt	D,III
2A	180-190	40.42	1.60	19.72	0.00	12.41	57.24	30.35	Clayey-Silt	C,III
3	8-18	52.57	1.43	6.47	0.00	15.36	61.99	22.65	Clayey-Silt	C,III
3	47-57	53.70	1.41	6.03	0.00	9.89	60.98	29.13	Clayey-Silt	D,III
3	82-92	50.16	1.46	2.64	0.00	1.33	60.12	38.55	Clayey-Silt	D,III
3	107-117	45.27	1.53	5.21	0.00	10.40	60.12	29.48	Clayey-Silt	C,III
3	122-142*	35.52	1.69	30.60	0.00	41.83	38.45	19.72	Silty-Sand	C,III
4	9-19	38.37	1.64	10.98	0.00	52.91	37.29	9.80	Silty-Sand	B,III
4	123-133	37.89	1.65	12.46	0.00	21.59	53.73	24.68	Sand-Silt-Clay	C,III
4	243-253	29.86	1.80	14.30	0.00	18.68	55.95	25.36	Clayey-Silt	C,III
4	329-339	45.84	1.52	2.58	0.00	5.50	53.02	41.48	Clayey-Silt	D,III
5	5-15	38.51	1.64	28.48	0.00	24.09	50.64	25.27	Sand-Silt-Clay	C,III
5	78-88	36.02	1.68	16.94	0.00	19.04	57.81	23.15	Clayey-Silt	C,III
5	137-147	31.33	1.77	26.35	0.00	54.46	38.69	6.85	Silty-Sand	B,IV
5	210-220	35.87	1.68	10.18	0.00	19.64	47.28	33.08	Clayey-Silt	C,III
6	7-17	28.30	1.83	45.97	0.00	70.72	23.52	5.76	Silty-Sand	B,IV

6	93-103	35.37	1.69	17.96	0.00	31.28	47.58	21.14	Sand-Silt-Clay	C,III

ID	Intervals	%H20	Bulk Density	%Coal	%GRAVEL	%SAND	%SILT	CLAY	SHEP CLASS	PEJRUP CLASS
6	207-217	31.55	1.76	40.97	0.00	48.07	24.44	27.49	Sand-Silt-Clay	C,II
6	297-307	34.48	1.71	5.68	0.00	29.00	42.10	28.91	Sand-Silt-Clay	C,III
7	11-21	32.30	1.75	18.44	0.00	57.58	31.94	10.48	Silty-Sand	B,III
7	121-131	43.88	1.55	5.07	0.00	4.65	65.25	30.10	Clayey-Silt	D,III
7	241-251	41.66	1.58	6.97	0.00	2.17	66.33	31.50	Clayey-Silt	D,III
7	325-335	40.15	1.61	8.75	0.00	4.06	62.21	33.73	Clayey-Silt	D,III
8	6-16	28.43	1.83	13.86	0.00	66.74	22.89	10.37	Silty-Sand	B,III
8	116-126	43.33	1.56	7.57	0.00	8.12	56.57	35.31	Clayey-Silt	D,III
8	176-186	38.82	1.63	11.42	0.00	12.97	55.92	31.11	Clayey-Silt	C,III
8	246-256	44.20	1.55	3.60	0.00	15.41	58.99	25.60	Clayey-Silt	C,III
9	10-20	43.02	1.56	11.65	0.00	36.04	43.07	20.89	Sand-Silt-Clay	C,III
9	90-100	42.96	1.56	3.63	0.00	11.85	59.09	29.06	Clayey-Silt	C,III
9	170-180	38.54	1.64	7.00	0.00	3.72	57.61	38.67	Clayey-Silt	D,III
9	250-260	41.54	1.59	6.50	0.00	2.19	61.03	36.77	Clayey-Silt	D,III
9	320-330*	39.08	1.63	5.09	0.00	4.74	59.18	36.08	Clayey-Silt	D,III
10	3-13	45.48	1.53	25.36	0.00	8.93	59.35	31.72	Clayey-Silt	D,III
10	103-113	41.66	1.58	22.01	0.00	17.74	70.20	12.06	Sandy-Silt	C,IV
10	215-225	35.90	1.68	16.91	0.00	11.74	59.65	28.62	Clayey-Silt	C,III
10	337-347	37.51	1.65	9.76	0.00	11.82	59.35	28.83	Clayey-Silt	C,III
10	387-397*	41.02	1.59	12.43	0.00	0.53	49.13	50.34	Silty-Clay	D,II
11	10-20	60.96	1.33	30.63	0.00	4.07	65.04	30.89	Clayey-Silt	D,III
11	40-50	55.69	1.39	8.34	0.00	0.83	53.31	45.86	Clayey-Silt	D,III

11	65-75	45.84	1.52	11.50	0.00	5.19	57.98	36.84	Clayey-Silt	D,III
ID	**Intervals**	**%H20**	**Bulk Density**	**%Coal**	**%GRAVEL**	**%SAND**	**%SILT**	**CLAY**	**SHEP CLASS**	**PEJRUP CLASS**
11	105-115	38.90	1.63	2.86	0.00	1.82	65.50	32.68	Clayey-Silt	D,III
11	125-135*	41.51	1.59	2.86	0.00	1.99	58.67	39.34	Clayey-Silt	D,III
12	4-14	26.75	1.86	41.97	0.00	89.07	7.23	3.69	Sand	B,III
12	40-50	48.24	1.49	31.63	0.00	89.97	8.29	1.74	Sand	B,IV
12	90-100	27.74	1.84	12.93	0.00	22.85	48.81	28.34	Sand-Silt-Clay	C,III
12	120-130	44.85	1.54	2.93	0.00	7.35	61.18	31.47	Clayey-Silt	D,III
13	5-15	54.86	1.40	25.37	0.04	39.58	27.30	33.07	Clayey-Sand	B,II
13	40-50	59.11	1.35	3.39	0.00	2.65	61.28	36.07	Clayey-Silt	D,III
13	70-80	55.83	1.39	7.52	0.00	3.53	46.09	50.38	Silty-Clay	D,II
13	103-113	26.21	1.87	6.11	25.97	53.34	13.10	7.59	Silty-Sand	B,III
14	5-15	53.76	1.41	4.11	0.00	12.69	50.53	36.78	Clayey-Silt	C,III
14	40-50	38.89	1.63	4.53	0.00	31.39	1.34	67.26	Sandy-Clay	C,I
14	80-90	48.44	1.48	8.03	0.00	16.26	55.78	27.97	Clayey-Silt	C,III
14	115-125	44.95	1.53	4.14	0.00	14.88	61.41	23.71	Clayey-Silt	C,III
15	5-15	57.97	1.36	2.58	0.00	8.72	47.14	44.13	Clayey-Silt	D,III
15	40-50	31.99	1.75	1.54	0.00	16.70	42.84	40.45	Clayey-Silt	C,III
15	80-90	51.23	1.45	6.34	0.00	12.07	42.82	45.11	Silty-Clay	C,II
15	155-165	49.06	1.48	2.77	0.00	74.85	15.66	9.49	Sand	B,III
16	0-10	8.87	2.36	23.16	0.00	89.22	3.78	6.99	Sand	B,II
16	40-50	25.10	1.90	35.23	0.00	84.35	6.49	9.16	Sand	B,II
16	70-80	8.35	2.38	12.20	0.00	82.33	4.77	12.91	Sand	B,II
16	109-119	28.48	1.83	53.60	0.00	100.00	0.00	0.00	Sand	A,IV
17	3-13	10.62	2.30	4.99	0.00	15.85	45.86	38.28	Clayey-Silt	C,III
17	60-70	28.27	1.83	8.39	0.00	51.92	26.07	22.01	Sand-Silt-Clay	B,III
17	93-103	26.44	1.87	34.95	0.00	69.49	17.06	13.45	Silty-Sand	B,III

17	129-139	38.29	1.64	7.30	0.00	35.22	43.18	21.59	Sand-Silt-Clay	C,III

ID	Intervals	%H20	Bulk Density	%Coal	%GRAVEL	%SAND	%SILT	CLAY	SHEP CLASS	PEJRUP CLASS
17	159-169*	39.06	1.63	38.81	0.00	21.20	42.55	36.26	Sand-Silt-Clay	C,III
18	6-16	18.86	2.05	5.62	0.00	69.27	20.55	10.18	Silty-Sand	B,III
18	51-61	16.08	2.13	2.91	0.00	76.28	18.75	4.98	Sand	B,III
18	80-90	15.01	2.16	3.51	0.00	89.33	7.94	2.73	Sand	B,III
18	130-140	14.72	2.17	1.86	0.00	73.77	22.78	3.45	Silty-Sand	B,IV
19	3-13	37.87	1.65	7.95	0.00	34.76	45.29	19.95	Sandy-Silt	C,III
19	50-60	30.81	1.78	34.45	0.00	53.78	28.63	17.60	Silty-Sand	B,III
19	90-100	42.10	1.58	30.44	0.00	2.92	63.59	33.48	Clayey-Silt	D,III
19	130-140	35.68	1.69	24.65	0.00	7.89	49.26	42.85	Clayey-Silt	D,III
20	3-13	37.90	1.65	9.74	0.00	20.67	51.15	28.18	Sand-Silt-Clay	C,III
20	50-60	36.62	1.67	19.83	0.00	13.12	58.12	28.75	Clayey-Silt	C,III
20	100-110	39.70	1.62	27.74	0.00	25.95	52.27	21.79	Sandy-Silt	C,IV
20	140-150	45.79	1.52	14.86	0.00	3.20	59.70	37.10	Clayey-Silt	D,III
21	20-30	22.12	1.97	14.06	0.00	84.04	8.24	7.72	Sand	B,III
21	70-80	31.01	1.77	3.29	0.00	87.89	7.55	4.56	Sand	B,III
21	100-110	47.31	1.50	3.91	0.00	2.82	62.12	35.07	Clayey-Silt	D,III
21	140-150	44.83	1.54	6.02	0.00	18.87	53.34	27.79	Clayey-Silt	C,III
22	10-20	44.77	1.54	14.82	0.00	43.36	38.05	18.59	Silty-Sand	C,III
22	30-40	43.92	1.55	2.38	0.00	39.79	37.91	22.30	Sand-Silt-Clay	C,III
22	50-60	34.08	1.71	5.93	0.00	25.99	45.48	28.53	Sand-Silt-Clay	C,III
22	70-80	49.59	1.47	4.04	0.00	54.70	30.62	14.68	Silty-Sand	B,III
23	20-30	51.63	1.44	2.18	0.00	8.91	61.37	29.72	Clayey-Silt	D,III
23	70-80	39.65	1.62	2.78	0.00	14.60	43.09	42.30	Clayey-Silt	C,III

23	120-130	42.99	1.56	6.29	0.00	16.84	52.87	30.28	Clayey-Silt	C,III
ID	**Intervals**	**%H20**	**Bulk Density**	**%Coal**	**%GRAVEL**	**%SAND**	**%SILT**	**CLAY**	**SHEP CLASS**	**PEJRUP CLASS**
23	160-170	18.24	2.07	21.18	0.00	33.81	49.14	17.04	Sandy-Silt	C,III
24	0-10	59.78	1.34	9.52	0.00	0.20	54.05	45.76	Clayey-Silt	D,III
24	40-50	47.40	1.50	6.34	0.00	21.70	56.27	22.03	Sand-Silt-Clay	C,III
24	80-90	51.36	1.44	3.50	0.00	0.38	51.39	48.22	Clayey-Silt	D,III
24	130-140	49.26	1.47	1.40	0.00	2.04	53.76	44.21	Clayey-Silt	D,III
24	150-160*	53.12	1.42	1.88	0.00	0.39	54.99	44.62	Clayey-Silt	D,III
25	23-33	52.98	1.42	5.35	0.00	5.83	60.63	33.54	Clayey-Silt	D,III
25	56-66	44.78	1.54	8.39	0.00	9.06	61.88	29.06	Clayey-Silt	D,III
25	96-106	53.05	1.42	1.11	0.00	0.54	47.18	52.28	Silty-Clay	D,II
25	136-146	50.28	1.46	5.08	0.00	0.52	49.33	50.14	Silty-Clay	D,II
26	10-20	60.88	1.33	9.32	0.00	7.01	53.53	39.45	Clayey-Silt	D,III
26	30-40	47.52	1.50	22.52	0.00	65.45	27.87	6.68	Silty-Sand	B,IV
26	50-60	49.80	1.47	3.95	0.00	19.38	44.44	36.18	Clayey-Silt	C,III
26	70-80	54.57	1.40	0.74	0.00	2.07	56.02	41.91	Clayey-Silt	D,III
27	7-17	63.43	1.30	4.82	0.00	6.21	56.11	37.68	Clayey-Silt	D,III
27	27-37	60.19	1.34	13.56	0.00	4.95	54.74	40.31	Clayey-Silt	D,III
27	47-57	56.99	1.37	1.35	0.00	2.60	49.32	48.08	Clayey-Silt	D,III
27	67-77	49.47	1.47	1.09	0.00	18.97	45.27	35.76	Clayey-Silt	C,III
28	10-20	60.74	1.33	1.01	0.00	0.85	61.81	37.35	Clayey-Silt	D,III
28	60-70	44.81	1.54	13.27	0.00	23.78	47.26	28.96	Sand-Silt-Clay	C,III

28	100-110	44.46	1.54	4.98	0.00	31.94	45.10	22.96	Sand-Silt-Clay	C,III
28	140-150	37.14	1.66	3.07	0.00	1.05	56.84	42.11	Clayey-Silt	D,III
ID	**Intervals**	**%H20**	**Bulk Density**	**%Coal**	**%GRAVEL**	**%SAND**	**%SILT**	**CLAY**	**SHEP CLASS**	**PEJRUP CLASS**
29	10-20	47.73	1.49	1.29	0.00	38.77	33.84	27.39	Sand-Silt-Clay	C,III
29	30-40	40.70	1.60	3.95	0.00	36.45	39.37	24.18	Sand-Silt-Clay	C,III
29	60-70	43.22	1.56	3.82	0.00	26.65	40.79	32.57	Sand-Silt-Clay	C,III
29	80-90	41.17	1.59	2.54	0.00	44.17	29.51	26.33	Sand-Silt-Clay	C,III
29	90-100*	40.15	1.61	19.77	0.00	4.21	60.95	34.84	Clayey-Silt	D,III
30	10-20	48.65	1.48	0.46	0.00	34.38	34.00	31.61	Sand-Silt-Clay	C,III
30	30-40	37.86	1.65	5.03	0.00	56.92	21.43	21.65	Sand-Silt-Clay	B,II
30	50-60	41.95	1.58	2.29	0.00	19.16	46.84	34.01	Clayey-Silt	C,III
33	10-20	62.91	1.31	4.24	0.00	0.36	55.05	44.59	Clayey-Silt	D,III
33	30-40	60.83	1.33	1.60	0.00	0.65	55.98	43.36	Clayey-Silt	D,III
33	50-60	52.04	1.44	0.64	0.00	7.55	52.67	39.78	Clayey-Silt	D,III
33	87-97	55.64	1.39	2.39	0.00	12.25	52.48	35.26	Clayey-Silt	C,III
34	10-20	55.56	1.39	1.47	0.00	0.74	48.78	50.48	Silty-Clay	D,II
34	30-40	57.26	1.37	0.27	0.00	1.11	56.79	42.10	Clayey-Silt	D,III
34	50-60	57.08	1.37	1.38	0.00	1.05	55.75	43.21	Clayey-Silt	D,III
35	10-20	68.41	1.25	2.31	0.00	0.31	49.04	50.65	Silty-Clay	D,II
35	30-40	60.82	1.33	0.26	0.00	0.48	51.19	48.34	Clayey-Silt	D,III
35	50-60	61.54	1.32	0.82	0.00	0.85	50.27	48.88	Clayey-Silt	D,III
36	10-20	61.80	1.32	0.72	0.00	1.39	51.16	47.45	Clayey-Silt	D,III
36	30-40	61.96	1.32	2.08	0.00	1.56	51.70	46.74	Clayey-Silt	D,III

36	50-60	52.88	1.42	0.90	0.00	2.48	55.68	41.84	Clayey-Silt	D,III
36	66-76*	41.69	1.58	6.25	0.00	22.00	47.46	30.54	Sand-Silt-Clay	C,III
37	10-20	63.61	1.30	1.84	0.00	0.36	52.99	46.65	Clayey-Silt	D,III
ID	**Intervals**	**%H20**	**Bulk Density**	**%Coal**	**%GRAVEL**	**%SAND**	**%SILT**	**CLAY**	**SHEP CLASS**	**PEJRUP CLASS**
37	40-50	59.85	1.34	0.47	0.00	1.33	53.89	44.78	Clayey-Silt	D,III
38	10-20	62.75	1.31	1.49	0.00	1.48	55.03	43.49	Clayey-Silt	D,III
38	30-40	50.01	1.46	2.20	0.00	10.62	51.80	37.58	Clayey-Silt	C,III
38	59-69	56.62	1.38	1.10	0.00	6.40	53.20	40.39	Clayey-Silt	D,III

Appendix IV

Maryland Geological Survey Metals Analytical Results
(Cd, Cr, Cu, Fe, Mn, Ni, Pb, & Zn)
[Note: All values are in ug/g unless otherwise noted]

ID	**Cr**	**Cu**	**Fe(%)**	**Mn**	**Ni**	**Cd**	**Pb**	**Zn**
1	86.48	79.54	3.30	1295.62	103.13	bdl	56.64	563.73
1	108.36	111.59	4.21	1150.66	77.84	bdl	102.86	522.37
1	118.92	143.53	4.02	1195.38	89.43	bdl	129.95	642.25
1	103.29	86.27	3.33	1055.35	62.87	bdl	99.24	361.10
2A	65.70	47.21	3.47	2412.41	87.43	bdl	42.20	373.54
2A	93.09	54.08	3.79	3336.44	99.00	bdl	48.80	410.50
2A	86.90	60.03	3.82	2385.66	113.62	bdl	49.81	440.97
2A	71.52	56.61	3.12	1615.02	64.30	bdl	53.99	313.15
3	64.96	43.08	2.93	2374.78	86.54	bdl	32.26	332.58
3	68.59	51.73	3.26	2678.86	105.70	bdl	44.63	417.90
3	74.13	53.81	3.29	2645.55	88.93	bdl	43.57	361.34
3	72.39	50.75	3.06	1968.81	78.18	bdl	45.44	327.00
3	29.27	38.04	2.14	1307.67	50.32	bdl	29.11	178.28
4	87.44	48.23	3.85	2179.65	65.31	bdl	48.77	343.63
4	58.61	31.50	3.25	2194.03	74.47	bdl	35.21	303.18
4	17.61	18.87	1.10	407.47	17.04	bdl	18.61	96.70
4	131.26	93.09	5.10	2638.58	114.94	2.07	92.54	839.31
5	83.35	80.24	3.70	1123.39	56.82	0.33	66.09	384.52
5	70.61	47.36	3.70	1517.49	62.01	0.36	40.65	277.91
5	46.31	44.15	2.41	727.31	27.21	bdl	33.94	195.91
5	71.53	75.22	3.40	1084.49	74.90	0.49	71.87	455.49
6	40.86	21.54	2.17	1052.46	42.19	bdl	22.76	173.96
6	62.00	42.72	3.25	1268.86	63.06	0.97	48.16	321.26
6	69.58	64.94	3.49	936.52	59.71	0.47	55.91	378.11
6	74.32	55.42	3.69	2810.75	75.29	0.40	52.77	361.74
7	50.41	35.99	2.43	801.54	61.40	0.29	26.22	218.09
7	111.98	106.18	4.13	1698.71	113.18	3.18	87.92	769.73
7	101.00	92.21	3.93	829.37	94.93	1.17	71.59	490.07
7	100.67	87.80	3.86	1164.43	66.73	0.49	69.19	375.11
8	40.30	30.37	2.15	691.66	54.56	0.53	23.28	203.61
8	105.86	79.73	4.08	2329.61	113.11	2.98	64.78	552.78
8	115.12	80.72	4.23	1889.44	105.98	2.88	61.27	570.86
8	96.08	95.77	3.91	1977.32	103.23	2.99	72.05	677.15
9	59.67	38.37	2.98	1659.55	61.69	bdl	26.94	225.02
9	114.54	76.15	4.74	2065.11	97.48	2.29	65.45	570.97
9	97.17	88.56	3.96	1433.34	94.17	2.25	68.80	614.50
9	92.19	71.43	3.85	1135.64	71.96	0.99	73.04	464.02
9	88.32	84.83	5.20	1388.48	76.35	0.29	52.93	360.69
10	101.53	104.30	3.91	1775.08	114.07	2.38	82.56	696.03
10	77.78	76.27	3.15	910.17	66.19	0.73	56.28	339.21
10	82.78	69.42	3.20	722.17	64.40	0.39	48.81	280.21
10	96.06	84.68	3.37	1217.46	69.40	bdl	68.19	314.64
10	95.62	132.03	4.95	1372.14	122.70	bdl	76.88	459.57

ID	Cr	Cu	Fe(%)	Mn	Ni	Cd	Pb	Zn
11	75.01	52.88	3.73	2950.02	79.49	bdl	35.73	337.79
11	82.67	53.83	4.27	2318.09	80.65	bdl	43.21	362.77
11	91.96	70.56	3.95	2251.94	87.45	1.41	84.45	401.13
11	85.26	63.67	4.18	1997.41	60.31	1.26	66.58	349.35
11	101.63	105.48	5.56	2163.26	105.22	1.99	76.59	443.17
12	26.09	24.86	1.56	491.55	38.16	bdl	17.68	134.06
12	67.71	47.05	3.18	1398.76	73.25	0.66	38.83	323.58
12	27.33	31.87	1.70	620.73	37.13	bdl	23.99	155.13
12	86.21	72.38	4.25	2494.29	105.73	2.67	74.10	453.60
13	77.88	37.67	3.58	2853.98	75.63	0.26	34.25	337.43
13	90.61	56.60	4.66	4037.96	132.08	0.52	47.10	514.96
13	82.66	60.01	4.28	4793.12	134.88	1.96	68.76	515.63
13	99.96	105.47	4.24	1152.96	101.73	0.28	71.68	497.66
14	65.82	37.52	3.28	1914.12	52.37	bdl	33.07	231.81
14	65.62	39.26	3.44	2025.92	67.70	0.42	33.15	303.55
14	71.49	47.30	3.64	2762.69	88.96	0.64	35.48	340.64
14	87.63	55.58	4.23	2919.25	85.83	0.94	63.33	372.63
15	76.73	41.34	3.71	3418.91	96.58	bdl	36.64	317.15
15	75.68	46.24	3.86	3080.03	109.93	0.64	41.79	413.99
15	83.70	51.90	3.80	2784.20	97.77	0.77	58.48	393.35
15	24.76	13.99	1.47	747.55	24.82	0.28	9.79	121.50
16	34.44	22.55	1.81	594.18	33.59	bdl	14.84	153.50
16	19.74	25.25	1.31	306.77	24.50	0.30	17.24	126.22
16	40.26	22.19	1.83	588.44	47.22	0.24	14.70	170.85
16	24.58	28.04	1.47	425.34	24.94	bdl	22.87	143.39
17	22.33	18.43	1.27	454.06	24.58	bdl	10.42	89.07
17	86.06	79.09	3.43	1149.26	79.07	0.29	49.66	312.10
17	103.38	110.50	3.85	1390.45	93.40	0.29	71.81	434.59
17	39.46	54.49	2.08	656.03	25.02	0.23	35.38	172.58
17	54.67	107.83	3.19	640.96	55.41	bdl	55.76	243.71
18	40.65	12.39	2.06	283.75	16.36	bdl	9.02	56.36
18	27.42	8.20	1.51	165.62	11.07	0.29	7.30	44.11
18	29.73	9.82	1.91	241.47	8.00	bdl	4.38	38.90
18	28.82	8.19	1.68	211.68	bdl	bdl	10.21	33.42
19	54.54	36.75	2.77	1130.40	40.28	bdl	32.19	190.96
19	47.31	43.15	2.09	421.47	37.65	bdl	27.76	120.79
19	117.38	126.21	4.04	871.80	74.27	bdl	93.74	344.76
19	95.91	97.90	3.80	887.42	49.58	bdl	63.24	311.31
20	66.19	40.72	3.01	1385.02	69.06	0.24	31.02	250.65
20	101.12	92.20	3.80	1637.18	88.29	3.03	69.26	475.59
20	82.98	83.29	3.27	1461.56	88.07	2.75	60.69	439.34
20	129.72	122.50	4.60	1702.85	107.80	5.12	97.43	657.79
21	29.19	18.44	1.53	943.17	43.76	bdl	16.69	154.54

ID	**Cr**	**Cu**	**Fe(%)**	**Mn**	**Ni**	**Cd**	**Pb**	**Zn**
21	25.25	17.93	1.50	648.66	58.54	0.35	14.98	147.23
21	117.80	100.26	4.67	2186.87	100.66	3.67	69.47	456.74
21	135.35	130.73	3.97	1260.38	73.69	0.57	95.27	423.24
22	59.72	28.64	2.78	2098.05	79.35	0.26	27.25	299.97
22	79.69	44.77	3.46	2237.51	93.34	0.79	47.05	374.86
22	82.27	47.69	3.28	2179.25	102.11	0.54	59.01	355.53
22	52.16	34.21	2.74	1765.92	60.40	0.45	37.91	278.84
23	63.52	43.75	3.16	1663.36	59.76	0.44	41.41	259.56
23	64.96	46.27	3.36	2318.55	63.77	0.49	57.12	288.17
23	79.75	48.11	3.69	1798.56	72.80	bdl	61.70	316.96
23	82.50	59.42	3.56	1058.31	39.72	1.21	45.64	313.32
24	97.17	46.45	5.15	2328.49	77.29	0.47	47.64	379.90
24	53.84	39.82	2.94	2048.83	57.46	0.48	36.12	246.01
24	90.40	57.64	4.69	2214.53	95.26	0.77	52.92	371.57
24	82.86	56.01	4.21	3088.16	69.28	1.08	65.18	372.69
24	98.49	89.55	5.26	4272.07	147.05	1.82	67.74	435.14
25	81.89	51.09	3.49	2102.83	82.44	0.16	35.78	259.59
25	67.57	52.22	3.23	2494.81	85.98	bdl	36.59	300.56
25	102.73	69.51	5.00	3666.89	116.94	bdl	50.58	420.43
25	88.19	68.84	4.19	2663.62	99.08	0.28	57.29	357.36
26	80.27	54.96	3.64	1800.59	95.68	0.47	34.97	319.26
26	47.23	37.47	1.96	1148.54	69.69	0.41	24.26	205.19
26	84.36	51.83	3.73	1763.31	108.67	bdl	38.49	336.17
26	80.47	62.08	3.85	2700.46	108.26	0.51	44.62	395.20
27	77.78	53.03	3.53	2036.52	90.85	bdl	38.72	303.88
27	89.30	56.38	3.76	3507.00	118.24	bdl	32.63	349.78
27	83.24	55.01	3.65	2473.22	102.25	bdl	37.02	308.15
27	79.94	48.83	3.34	1542.26	79.46	bdl	24.19	249.92
28	88.51	57.92	3.78	2217.49	106.67	0.51	32.09	343.60
28	62.32	47.08	2.87	1259.56	87.01	bdl	41.33	298.53
28	67.67	53.12	3.02	2299.30	103.74	bdl	54.54	353.34
28	92.63	72.35	4.14	2052.54	119.59	bdl	51.26	439.23
29	83.29	40.07	3.05	1117.41	72.46	bdl	28.26	199.44
29	78.10	59.96	3.14	1534.35	74.02	1.12	42.86	317.12
29	73.35	57.62	3.24	700.73	94.24	0.15	41.86	302.96
29	95.53	77.51	3.42	905.42	73.71	0.22	54.48	280.42
29	76.05	100.11	3.80	976.69	80.65	bdl	53.89	281.45
30	77.58	36.62	2.95	973.55	67.64	bdl	30.03	195.35
30	41.07	30.37	1.88	439.04	52.45	bdl	23.45	159.62
30	83.60	80.87	3.43	895.46	63.56	bdl	62.29	281.01
33	94.83	51.77	4.14	1819.37	99.23	0.28	48.98	337.71
33	93.02	48.61	4.24	3140.58	109.15	0.35	36.12	365.76
33	79.77	44.99	3.66	1411.83	92.77	0.46	33.45	274.89

ID	**Cr**	**Cu**	**Fe(%)**	**Mn**	**Ni**	**Cd**	**Pb**	**Zn**
33	76.97	53.35	3.40	2193.65	108.67	0.73	44.90	347.96
34	80.62	48.73	3.89	1512.63	81.52	bdl	39.90	301.30
34	91.45	55.15	4.05	1951.35	98.99	bdl	37.86	367.09
34	103.82	65.90	4.20	1756.54	112.17	0.97	52.51	367.65
35	102.23	54.87	4.28	3623.41	101.35	0.69	44.37	356.11
35	89.00	52.76	4.17	2238.17	95.26	0.45	44.85	356.67
35	95.55	52.00	4.17	3507.79	111.55	0.82	41.44	379.32
36	86.56	46.81	4.08	2304.78	91.31	0.90	37.74	352.58
36	94.35	48.92	4.17	3941.96	110.66	0.22	35.13	383.85
36	83.84	45.49	3.90	2644.09	88.47	0.97	35.39	296.26
36	60.09	49.52	3.61	1976.90	89.08	0.33	39.07	255.17
37	99.05	48.54	4.10	2168.32	82.61	0.82	34.60	311.76
37	80.94	47.88	3.87	1888.76	90.07	0.31	38.79	343.99
38	77.26	48.26	3.76	2854.29	93.39	bdl	40.29	324.68
38	82.45	43.53	3.50	1992.03	74.25	bdl	31.05	271.58
38	82.51	42.20	3.47	2013.28	93.34	0.24	31.81	317.43

Appendix V

Nutrients (total C, N, S, & P)

ID	Intervals	P(ug/g)	%N	%C	TS
1	10-20	857.90	0.256	13.775	0.230
1	120-130	826.53	0.300	12.894	0.187
1	230-240	816.00	0.303	9.801	0.206
1	310-320	702.84	0.322	21.495	0.284
2A	4-14	1250.81	0.363	4.684	0.109
2A	56-66	1593.87	0.377	4.929	0.104
2A	110-120	1581.55	0.371	4.338	0.101
2A	180-190	1088.81	0.249	6.469	0.098
3	8-18	1188.52	0.275	6.097	0.101
3	47-57	1438.19	0.337	6.330	0.110
3	82-92	1559.92	0.309	4.254	0.084
3	107-117	1320.50	0.249	4.390	0.069
3	122-142*	510.62	0.276	25.882	0.165
4	9-19	1128.80	0.266	7.502	0.107
4	123-133	1070.32	0.197	4.660	0.099
4	243-253	144.45	0.167	15.394	0.083
4	329-339	2049.64	0.374	18.668	0.192
5	5-15	696.03	0.276	17.536	0.237
5	78-88	698.71	0.212	9.760	0.103
5	137-147	369.23	0.221	15.808	0.141
5	210-220	641.28	0.286	25.342	0.224
6	7-17	571.43	0.224	23.634	0.159
6	93-103	1007.06	0.272	15.676	0.179
6	207-217	669.99	0.237	11.937	0.162
6	297-307	780.71	0.248	15.065	0.134
7	11-21	701.38	0.210	14.369	0.138
7	121-131	1212.54	0.328	11.212	0.149
7	241-251	874.96	0.284	10.914	0.198
7	325-335	811.23	0.231	7.737	0.139
8	6-16	571.35	0.208	22.509	0.188
8	116-126	1488.08	0.311	14.559	0.152
8	176-186	1306.78	0.281	17.692	0.000
8	246-256	1078.11	0.343	17.234	0.178
9	10-20	1050.36	0.284	14.038	0.163
9	90-100	1449.12	0.297	8.807	0.148
9	170-180	1208.95	0.294	6.270	0.121
9	250-260	1030.93	0.278	8.055	0.146
9	320-330*	840.54	0.293	14.652	0.162
10	3-13	1315.40	0.301	10.215	0.171
10	103-113	819.28	0.296	19.702	0.242
10	215-225	807.89	0.299	18.017	0.252
10	337-347	854.69	0.325	17.258	0.223
10	387-397*	811.64	0.289	13.862	0.204

ID	Intervals	P(ug/g)	%N	%C	TS
11	10-20	1348.15	0.382	6.123	0.087
11	40-50	1226.34	0.319	4.379	0.103
11	65-75	1424.57	0.326	7.114	0.123
11	105-115	1281.11	0.279	5.011	0.087
11	125-135*	1473.11	0.286	5.414	0.100
12	4-14	312.64	0.182	16.733	0.052
12	40-50	1081.41	0.287	11.666	0.190
12	90-100	296.58	0.192	19.366	0.060
12	120-130	1330.92	0.295	10.179	0.138
13	5-15	1175.68	0.345	10.338	0.133
13	40-50	1651.19	0.410	5.224	0.114
13	70-80	1652.58	0.449	4.882	0.127
13	103-113	784.19	0.353	14.626	0.242
14	5-15	1094.76	0.301	7.060	0.093
14	40-50	1076.95	0.260	5.024	0.137
14	80-90	1255.03	0.303	7.483	0.119
14	115-125	1461.35	0.329	5.581	0.119
15	5-15	1373.79	0.384	5.357	0.112
15	40-50	1418.70	0.343	4.738	0.152
15	80-90	1415.19	0.320	5.250	0.126
15	155-165	312.68	0.064	1.542	0.017
16	0-10	331.89	0.149	13.674	0.053
16	40-50	244.63	0.171	28.424	0.098
16	70-80	360.54	0.169	14.390	0.116
16	109-119	282.80	0.218	19.205	0.060
17	3-13	354.37	0.236	29.498	0.109
17	60-70	577.37	0.230	28.524	0.172
17	93-103	686.49	0.295	28.385	0.247
17	129-139	299.81	0.198	14.100	0.118
17	159-169*	432.66	0.294	25.470	0.166
18	6-16	345.82	0.040	3.293	0.010
18	51-61	151.91	0.020	0.213	0.000
18	80-90	224.98	0.017	0.115	0.000
18	130-140	184.08	0.015	0.137	0.000
19	3-13	906.94	0.298	15.029	0.137
19	50-60	341.06	0.211	20.943	0.109
19	90-100	703.24	0.361	26.914	0.285
19	130-140	690.02	0.324	24.556	0.210
20	3-13	869.94	0.253	9.217	0.109
20	50-60	942.80	0.307	13.895	0.206
20	100-110	790.99	0.337	21.708	0.223
20	140-150	1370.31	0.362	15.651	0.240
21	20-30	345.75	0.121	9.736	0.045

ID	Intervals	P(ug/g)	%N	%C	TS
21	70-80	291.84	0.071	2.396	0.000
21	100-110	1791.90	0.348	5.178	0.138
21	140-150	967.11	0.368	14.985	0.272
22	10-20	859.94	0.253	6.845	0.090
22	30-40	1191.11	0.230	6.024	0.080
22	50-60	1074.84	0.280	7.113	0.122
22	70-80	827.09	0.282	4.264	0.118
23	20-30	1071.91	0.320	18.999	0.143
23	70-80	1024.67	0.244	8.034	0.101
23	120-130	1079.47	0.260	8.491	0.171
23	160-170	776.60	0.259	12.688	0.115
24	0-10	1643.98	0.419	9.622	0.106
24	40-50	786.56	0.266	12.024	0.152
24	80-90	1772.21	0.359	4.180	0.120
24	130-140	1243.25	0.347	6.109	0.109
24	150-160*	1614.11	0.426	16.660	0.164
25	23-33	1158.05	0.324	7.018	0.106
25	56-66	1082.01	0.284	6.478	0.096
25	96-106	1841.40	0.367	4.055	0.085
25	136-146	1565.00	0.327	3.786	0.071
26	10-20	1435.36	0.349	6.193	0.123
26	30-40	684.66	0.319	20.465	0.256
26	50-60	1365.99	0.312	5.858	0.104
26	70-80	1476.66	0.359	5.216	0.102
27	7-17	1371.87	0.340	4.808	0.115
27	27-37	1441.35	0.353	5.606	0.107
27	47-57	1423.49	0.337	4.138	0.100
27	67-77	1151.29	0.272	9.286	0.099
28	10-20	1162.49	0.326	4.815	0.095
28	60-70	1140.51	0.314	12.457	0.139
28	100-110	1241.28	0.354	13.119	0.173
28	140-150	1922.14	0.375	4.268	0.114
29	10-20	771.08	0.198	7.690	0.182
29	30-40	874.79	0.200	11.045	0.162
29	60-70	720.82	0.237	12.653	0.378
29	80-90	719.92	0.243	19.003	0.277
29	90-100*	669.88	0.255	17.410	0.171
30	10-20	699.98	0.188	7.364	0.165
30	30-40	470.46	0.219	24.282	0.314
30	50-60	742.68	0.279	19.215	0.282
33	10-20	1466.74	0.357	4.493	0.095
33	30-40	1323.95	0.368	4.410	0.109
33	50-60	1099.37	0.352	7.505	0.133

ID	Intervals	P(ug/g)	%N	%C	TS
33	87-97	1102.39	0.468	12.368	0.194
34	10-20	1131.83	0.264	4.332	0.102
34	30-40	1312.47	0.306	4.873	0.109
34	50-60	1469.54	0.312	6.502	0.163
35	10-20	1714.93	0.445	4.809	0.100
35	30-40	1445.10	0.359	4.062	0.104
35	50-60	1450.77	0.388	4.478	0.090
36	10-20	1402.89	0.352	4.395	0.096
36	30-40	1433.50	0.366	4.865	0.072
36	50-60	1255.49	0.314	4.019	0.058
36	66-76*	865.56	0.290	9.373	0.118
37	10-20	1401.73	0.350	4.041	0.069
37	40-50	1345.06	0.321	3.926	0.086
38	10-20	1375.63	0.346	4.957	0.100
38	30-40	1167.55	0.332	11.341	0.121
38	59-69	1168.57	0.382	9.566	0.132

Appendix VI

University of Maryland - CBL Metal and Metaloid Analytical Results
(Ag, As, Cd, Hg, Pb, & Se; in ug/g)

ID	As	Se	Ag	Cd	Hg	Pb
1	15.749	5.181	3.01	3.314	0.73	83.723
1	9.369	3.168	0.724	0.632	0.24	33.245
1	16.072	6.32	0.985	1.395	0.99	86.179
1	7.725	1.878	0.243	0.347	0.49	27.424
2A	8.657	1.467	0.538	0.903	0.13	28.427
2A	6.215	1.01	0.387	0.668	0.078	19.733
2A	6.402	0.977	0.451	0.689	0.074	19.636
2A	8.59	1.27	0.53	0.8	0.09	31.09
3	8.39	1.07	0.4	0.61	0.08	24
3	9.26	1.37	0.63	0.87	0.11	34.3
3	12.97	2.05	1.04	1.41	0.18	42.43
3	15.7	2.38	0.94	1.64	0.16	57.82
4	6.43	0.96	0.34	0.57	0.08	23.3
4	15.39	2.6	0.95	1.64	0.19	49.04
4	19.69	3.63	5.5	4.41	0.4	72.89
5	22.5	9.08	1.32	1.32	0.49	70.05
5	12.99	6.24	0.27	0.63	0.61	46.7
5	16.32	4.99	0.46	1.17	0.33	50.11
5	20.64	7.71	0.53	1.49	0.9	76.57
6	12.5	2.62	0.39	0.84	0.18	30.83
6	21.65	3.46	2.22	2.98	0.28	59.17
6	21.41	7.56	0.94	1.31	0.4	57.69
6	13.9	4.74	0.35	1.15	0.43	52.37
7	6.42	1.05	0.32	0.47	0.09	20.82
7	22.01	4.85	3.69	4.16	0.66	80.47
7	25.84	7.2	1.75	2.34	0.49	72.34
7	23.35	7.77	1.02	1.4	0.54	72.97
8	12.16	1.65	0.48	0.9	0.1	28.76
8	21.86	4.23	4.98	3.84	0.4	72.09
8	21.89	4.32	2.91	3.54	0.42	62.92
8	22.03	4.85	2.78	3.67	0.46	72.58
9	5.08	0.75	0.26	0.44	0.06	20.56
9	24.48	4.29	2.98	3.79	0.43	72.17
9	12.1	2.26	3.84	1.43	0.51	51.58
9	3.06	0.66	0.32	0.24	0.07	12.13
10	11.64	2.56	2.47	2.29	0.5	67.37
10	7.17	2.07	0.62	0.56	0.19	26.3
10	11.55	3.21	0.55	0.65	0.34	43.25
10	12.26	3.52	0.39	0.62	0.61	53.21
11	10.62	1.42	0.59	0.77	0.12	32.5
11	10.6	1.43	0.63	0.94	0.14	38.95
11	11.53	1.74	0.95	1.58	0.17	65.8

11	15.61	1.86	1.59	1.28	0.16	49.57
ID	As	Se	Ag	Cd	Hg	Pb
12	9.99	1.92	0.41	0.2	0.12	21.42
12	6.98	1.02	0.73	0.76	0.12	27.96
12	12.18	6.2	7.39	7.05	1.65	30.18
12	9.22	2.67	0.29	0.46	0.12	26.95
13	7.76	1.14	0.4	0.81	0.06	27.37
13	9.27	1.75	0.63	1.03	0.08	36.66
13	9.42	1.73	0.6	1.61	0.09	45.19
13	11.16	3.32	0.49	0.76	0.28	50.65
14	9.2	1.07	0.65	0.7	0.07	26.26
14	14.46	1.5	0.8	1.04	0.08	30.92
14	11.2	1.39	1.09	1.21	0.11	38.97
14	9.23	1.29	1.11	1.3	0.12	47.4
15	10.74	1.27	0.54	0.9	0.08	30.27
15	10.62	1.46	0.81	1.3	0.1	38.72
15	10.45	1.43	0.88	1.47	0.12	56.52
15	8.47	0.94	0.77	0.93	0.06	25.19
16	5.88	1.07	0.07	0.19	0.06	11.87
16	5.52	1.44	0.07	0.19	0.08	14.46
16	7.96	1.38	0.21	0.49	0.09	21.18
16	7.79	2.06	0.08	0.24	0.12	23.57
17	6.49	1.38	0.1	0.17	0.09	12.06
17	9.64	3.66	0.1	0.25	0.33	25.5
17	7.31	1.79	0.1	0.27	0.22	23.88
17	15.48	4.35	0.27	0.64	0.77	56.22
18	3.3	0.33	0.1	0.05	0	6.16
18	2.85	0.36	0.1	0.36	-0.01	5.64
18	5.03	0.3	0.1	0.06	-0.01	5.48
18	3.21	0.38	0.1	0.11	-0.01	6.26
19	3.91	0.651	0.134	0.178	0.053	9.452
19	4.326	1.323	0.043	0.083	0.18	9.941
19	20.6	7.39	0.42	0.66	1.21	79.75
19	18.98	6.32	0.34	0.5	0.84	61.63
20	7.4	1.04	0.29	0.44	0.05	20.25
20	9.32	2.34	1.57	1.33	0.19	43.29
20	8.38	2.37	1.27	1.22	0.18	37.33
20	9.84	2.31	2.54	2.62	0.22	53.44
21	6.95	2.51	0.06	0.43	0.05	16.05
21	4.09	0.57	0.16	0.26	0.02	11.1
21	30.84	4.27	11.03	4.8	0.37	81.16
21	27.05	11.71	2.5	1.96	0.44	86.77
22	4.82	0.71	0.21	0.39	0.05	16.54

22	5.37	0.73	0.39	0.54	0.05	20.99
22	6.63	1.2	0.76	0.94	0.1	38.74
ID	As	Se	Ag	Cd	Hg	Pb
22	6.41	1.03	0.52	0.88	0.07	34.65
23	9.13	1.68	0.74	1	0.13	50.47
23	4.11	0.63	0.4	0.52	0.06	22.02
23	16.38	4.26	2.31	1.28	0.26	45.39
23	7.84	1.18	0.56	0.62	0.08	29.68
24	20.689	3.837	1.189	1.663	0.3	69.177
24	11.585	2.216	0.624	0.876	0.17	32.602
24	14.575	2.58	0.97	1.199	0.14	47.855
24	7.928	1.417	0.493	0.78	0.1	28.534
25	6.25	1.02	0.33	0.53	0.06	24.14
25	4.56	0.82	0.37	0.51	0.06	18.47
25	4.581	0.528	0.231	0.302	0.034	9.796
25	4.082	0.441	0.208	0.269	0.028	9.219
26	8.3	1.07	0.47	0.79	0.08	28.57
26	5.84	1.19	0.19	0.45	0.1	19.23
26	9.64	1.07	0.51	0.84	0.08	28.28
26	8.83	1.33	0.71	1.08	0.11	37.72
27	9.73	1.27	0.5	0.72	0.07	27.85
27	7.94	1.29	0.42	0.73	0.09	29.63
27	6.77	1.12	0.36	0.59	0.07	26.8
27	6.89	1.09	0.33	0.56	0.08	23.64
28	17.57	2.34	0.56	1.38	0.11	39.4
28	15.6	2.66	0.47	1.34	0.19	39.77
28	15.28	2.99	0.64	1.46	0.23	42.67
28	7.76	1.04	0.54	0.7	0.07	25.69
29	6.731	2.705	0.544	0.808	0.21	39.683
29	6.665	2.623	1.383	1.1	0.18	34.971
29	4.652	2.072	0.278	0.542	0.1	22.311
29	3.715	1.884	0.143	0.288	0.22	17.181
30	6.693	2.619	0.757	0.837	0.21	33.301
30	3.828	1.578	0.59	0.519	0.16	18.57
30	9.632	4.86	0.312	0.628	0.75	48.216
33	8.397	1.623	0.437	0.616	0.037	20.047
33	9.105	1.721	0.48	0.725	0.039	21.793
33	12.1	2.366	0.62	0.961	0.093	34.589
33	9.888	1.913	0.576	0.838	0.08	26.582
34	9.485	1.694	0.459	0.665	0.085	24.65
34	15.998	2.977	0.939	1.334	0.15	45.027
34	17.921	3.542	1.236	1.655	0.25	59.012
35	23.545	4.364	1.381	1.763	0.18	63.803

35	16.156	3.415	0.983	1.592	0.18	55.838
35	7.699	1.408	0.39	0.577	0.03	15.838
36	14.886	2.696	0.817	1.334	0.12	44.143
ID	As	Se	Ag	Cd	Hg	Pb
36	18.689	4.146	1.14	1.988	0.25	66.935
36	8.74	1.632	0.38	0.671	0.065	24.214
37	5.304	1.733	0.52	0.725	0.047	22.81
37	10.446	3.146	0.856	1.456	0.15	51.288
38	10.188	3.576	0.886	1.365	0.11	47.346
38	5.931	1.994	0.526	0.863	0.083	25.955
38	4.915	1.708	0.379	0.592	0.066	21.999

Appendix VII

Organic Contaminant Analytical Results

- Pesticides
- PCB
- PAH

PESTICIDES

Station	Depth	trifluralin	benfluralin (benefin)	alpha-BHC	hexachlorobenzene	gama-BHC (lindane)
1		0.000	1.742	1.940	0.726	0.699
2		0.725	0.168	0.035	0.199	0.111
3		0.340	0.000	0.224	0.091	0.052
4		0.034	0.000	0.547	0.177	0.129
5		1.323	0.049	0.080	0.640	0.261
6		1.793	0.000	0.089	0.199	0.266
7		0.874	0.797	0.456	0.224	0.509
8		1.323	1.122	0.674	0.136	0.363
9		0.336	0.000	0.421	0.326	0.162
10		3.955	0.861	1.579	0.880	3.601
11		0.853	0.122	0.000	0.491	0.084
12		0.825	0.421	0.070	0.249	0.120
13		1.836	1.407	0.213	0.318	0.254
14		1.268	0.978	0.171	0.339	0.257
15		1.711	1.321	0.242	0.470	0.451
16		0.964	1.188	0.156	0.062	0.374
17		0.615	0.521	0.157	0.048	0.181
18		0.627	0.000	0.017	0.015	2.395
19		0.485	0.325	0.000	0.000	3.063
20		0.000	1.397	0.079	0.073	2.910
21		0.000	0.800	0.000	0.000	2.390
22		0.363	0.292	0.082	0.028	2.686
23		1.082	0.653	0.165	0.392	0.223
24		1.375	0.536	0.108	0.223	0.031
25		0.576	0.338	0.057	0.111	0.091
26		1.741	0.974	0.218	0.299	0.281
27		1.402	0.618	0.148	0.222	0.089
28		2.140	0.909	0.161	0.268	0.103
29	10-20	0.743	0.000	0.051	0.062	0.145
29	30-40	1.138	0.154	0.186	0.254	0.488
29	80-90	0.945	0.083	0.056	0.151	0.133
30	10-20	1.056	0.196	0.107	0.102	0.197
30	50-60	1.034	0.239	0.076	0.191	0.181
33	10-20	2.401	0.353	0.258	0.342	0.496
33	30-40	2.681	0.572	0.254	0.355	0.186
33	50-60	2.371	0.419	0.242	0.329	0.390
33	87-97	2.001	0.190	0.157	0.303	0.317
34	10-20	0.816	1.068	0.951	0.482	0.319
34	30-40	0.922	0.000	0.101	0.326	0.202
35		0.904	0.524	0.100	0.323	0.180
36	10-20	0.581	0.457	0.035	0.392	0.106
36	50-60	0.556	0.265	0.065	0.166	0.068
37	10-20	0.342	0.412	0.357	0.162	0.129
37	40-50	1.376	0.297	0.153	0.279	0.269
38	10-20	0.996	0.495	0.092	0.412	0.152
38	30-40	0.854	0.237	0.105	0.162	0.306

38	59-69	0.980	0.257	0.160	0.277	0.100

Station	Depth	diazinon	hepteclor	aldrin	chlorpyrifos	dacthal (DCPA)
1		0.584	1.709	0.539	4.693	0.158
2		1.891	1.909	0.270	2.975	0.015
3		0.000	0.969	0.050	0.775	0.000
4		1.711	1.805	0.050	0.906	0.000
5		0.000	1.703	0.600	0.485	0.000
6		1.223	2.423	0.455	5.416	0.000
7		0.260	0.215	0.214	1.564	0.000
8		0.546	0.148	0.242	0.798	0.000
9		0.190	0.192	0.099	1.340	0.029
10		0.181	3.392	1.337	8.491	2.362
11		0.772	0.262	0.337	1.832	0.259
12		0.140	0.520	0.089	1.056	0.293
13		0.324	0.572	0.122	1.849	0.000
14		0.302	0.232	0.082	1.155	0.343
15		0.568	0.372	0.177	2.013	0.049
16		0.209	0.154	0.065	1.383	0.347
17		0.504	0.043	0.103	0.677	0.184
18		0.063	0.052	0.020	0.064	0.020
19		0.686	0.028	0.092	0.670	0.144
20		0.402	0.173	2.916	0.388	0.220
21		0.200	0.098	2.431	0.763	0.280
22		0.219	0.026	2.947	0.039	0.215
23		0.801	0.401	0.586	1.444	0.045
24		0.218	0.276	0.352	0.707	0.000
25		0.373	0.288	0.452	0.637	0.000
26		0.241	0.505	0.569	0.932	0.037
27		0.503	0.974	0.351	1.045	0.030
28		0.499	0.525	0.912	1.313	0.084
29	10-20	0.246	0.677	0.354	0.869	0.000
29	30-40	0.311	2.544	0.495	4.913	0.018
29	80-90	0.229	1.775	0.210	0.123	0.094
30	10-20	0.181	1.070	0.229	1.451	0.026
30	50-60	0.231	1.949	0.440	0.030	0.124
33	10-20	0.349	0.621	0.637	1.279	0.086
33	30-40	0.413	0.579	0.826	2.044	0.000
33	50-60	0.542	0.546	0.586	1.167	0.074
33	87-97	0.399	0.671	0.569	2.440	0.000
34	10-20	0.298	0.127	0.352	0.440	0.000
34	30-40	0.086	1.858	0.462	1.299	0.000
35		0.688	0.282	0.316	1.631	0.306
36	10-20	0.430	0.791	0.181	0.577	0.221
36	50-60	0.431	0.219	0.348	0.711	0.000
37	10-20	0.847	0.127	0.257	0.736	0.000
37	40-50	0.567	1.472	0.250	0.751	0.000
38	10-20	0.900	1.421	0.380	1.990	0.147
38	30-40	0.848	0.327	0.330	1.028	0.000
38	59-69	0.653	1.412	0.334	1.056	0.000

Station	Depth	heptachlor epoxide B	oxychlordane	heptachlor eposide A	oxyfluoren	trans-chlordane
1		1.012	1.227	3.491	0.543	3.751
2		0.193	0.976	1.154	0.688	2.175
3		0.107	0.341	0.843	0.044	1.055
4		0.183	0.709	1.636	0.085	2.063
5		0.481	0.795	1.828	0.764	1.128
6		0.126	2.187	3.910	1.337	1.306
7		0.000	0.568	0.930	0.267	1.430
8		0.129	0.554	0.969	0.080	1.636
9		0.080	0.447	0.782	0.134	1.083
10		1.632	2.212	3.710	1.322	1.398
11		0.099	0.557	1.078	0.346	1.581
12		0.059	0.400	0.647	0.000	0.373
13		0.080	1.020	1.180	0.741	0.713
14		0.117	0.641	0.934	0.000	0.823
15		0.206	0.524	0.803	0.000	1.337
16		0.246	0.554	0.771	0.285	0.554
17		0.173	0.446	0.237	0.000	0.707
18		0.035	0.000	0.049	0.064	0.034
19		0.215	0.362	0.540	0.000	0.954
20		0.243	0.259	0.641	4.334	1.256
21		0.247	0.053	0.324	4.523	0.467
22		0.292	0.089	0.856	3.402	1.011
23		0.145	0.791	1.149	0.286	1.846
24		0.078	0.592	0.667	0.000	0.412
25		0.085	0.493	0.640	0.334	1.792
26		0.233	0.985	0.998	0.485	1.598
27		0.094	0.622	0.852	0.452	0.911
28		0.190	0.942	1.274	0.445	1.305
29	10-20	0.061	0.622	1.069	0.203	0.625
29	30-40	0.162	2.482	4.028	0.413	1.023
29	80-90	0.161	0.797	2.575	0.180	0.858
30	10-20	0.092	0.718	1.345	0.286	0.518
30	50-60	0.109	0.453	1.168	0.082	0.897
33	10-20	0.171	0.828	1.093	0.462	1.417
33	30-40	0.136	0.972	1.236	0.644	1.340
33	50-60	0.093	0.715	0.891	0.413	1.236
33	87-97	0.178	1.242	1.633	0.300	1.403
34	10-20	0.059	0.972	0.270	0.000	0.852
34	30-40	0.116	1.059	1.850	0.173	0.714
35		0.205	0.708	1.031	0.116	1.343
36	10-20	0.122	0.220	0.572	0.000	0.512
36	50-60	0.107	0.404	0.862	0.114	1.144
37	10-20	0.141	0.223	0.456	0.508	0.000
37	40-50	0.135	0.518	0.948	0.522	0.795
38	10-20	0.147	0.758	1.353	0.218	1.186
38	30-40	0.163	0.703	1.190	0.231	1.059

38	59-69	0.137	0.627	1.155	1.374	1.106

Station	Depth	2,4-DDE	endosulfan I	cis-chlordane	trans-nonachlor	4,4-DDE
1		1.959	4.084	0.619	0.616	7.572
2		0.652	1.156	1.088	0.748	3.284
3		0.205	0.456	0.387	0.295	1.282
4		0.500	0.908	0.580	0.366	3.002
5		0.932	1.182	0.374	0.351	0.000
6		0.186	0.620	2.947	0.618	2.140
7		0.373	0.000	0.712	0.232	0.463
8		0.344	0.000	0.678	0.381	0.631
9		0.281	0.000	0.566	0.175	0.538
10		2.291	1.086	3.670	0.453	3.134
11		0.061	0.165	1.490	0.826	0.598
12		0.033	0.000	0.585	0.253	0.346
13		0.000	0.000	1.244	0.675	0.765
14		0.066	0.119	0.956	0.638	0.515
15		0.100	0.000	0.921	0.664	0.553
16		0.050	0.000	0.552	0.262	0.423
17		0.084	0.000	0.519	0.316	0.351
18		0.000	0.006	0.045	0.096	0.155
19		0.038	0.118	0.849	0.137	0.313
20		1.021	1.375	1.234	0.446	0.000
21		0.355	1.384	0.411	0.119	0.000
22		0.651	0.921	0.591	0.218	0.000
23		0.496	0.113	1.353	0.793	0.565
24		0.017	0.000	0.554	0.675	0.565
25		0.262	0.000	0.501	0.485	0.509
26		0.161	0.000	1.167	0.891	0.611
27		0.026	0.127	0.768	0.813	0.560
28		0.036	0.129	1.148	0.700	0.672
29	10-20	0.029	0.207	0.759	0.303	0.784
29	30-40	0.229	0.662	2.359	0.646	2.223
29	80-90	0.000	0.030	0.613	0.193	0.180
30	10-20	0.075	0.132	0.899	0.308	1.006
30	50-60	0.369	0.065	0.505	0.050	0.213
33	10-20	0.000	0.182	0.931	1.132	0.670
33	30-40	0.000	0.000	1.051	0.809	0.748
33	50-60	0.051	0.115	0.903	0.842	0.633
33	87-97	0.089	0.000	1.371	0.769	1.072
34	10-20	0.357	0.701	1.422	1.421	0.348
34	30-40	0.060	0.022	0.143	0.243	0.849
35		0.000	0.233	1.054	0.073	0.930
36	10-20	0.031	0.000	0.451	0.353	0.547
36	50-60	0.000	0.187	0.925	0.546	0.708
37	10-20	0.034	0.092	0.493	0.412	0.469
37	40-50	0.041	0.120	0.879	0.383	0.727
38	10-20	0.095	0.128	1.118	0.647	0.913
38	30-40	0.069	0.000	0.881	0.614	0.892

38	59-69	0.096	0.000	1.016	0.137	0.627

Station	Depth	dieldrin	2,4-DDD	endrin	endosulfan II	4,4-DDD + cis-nonachlor
1		2.115	11.459	5.854	3.610	20.470
2		1.368	3.926	2.031	10.558	3.238
3		0.390	1.739	0.833	5.990	1.635
4		0.751	3.464	1.809	4.824	2.295
5		1.066	1.246	0.609	6.573	4.012
6		9.606	11.240	0.000	3.070	5.070
7		2.223	2.293	0.470	3.427	2.741
8		2.654	2.843	0.561	3.653	3.453
9		2.532	2.441	0.080	1.035	1.141
10		11.497	17.137	8.968	1.666	15.809
11		6.268	3.630	1.833	0.957	3.416
12		1.634	1.965	0.603	0.937	1.846
13		3.209	3.827	1.487	1.011	1.798
14		2.773	2.733	1.751	1.432	1.223
15		3.172	2.700	1.407	1.107	1.487
16		1.170	1.863	0.582	0.489	0.676
17		1.378	1.902	0.580	0.560	2.560
18		0.000	0.116	0.097	0.000	0.121
19		2.100	1.318	0.920	1.215	1.665
20		1.056	1.338	1.561	1.079	3.946
21		0.524	0.959	2.075	0.000	0.679
22		0.765	0.677	1.060	0.484	1.135
23		8.782	4.453	1.699	4.423	6.591
24		3.593	2.375	0.045	0.599	0.566
25		2.976	2.187	0.212	0.608	4.077
26		4.905	4.384	1.567	0.714	7.845
27		3.830	2.866	1.286	0.706	2.023
28		4.222	3.611	1.840	0.457	1.687
29	10-20	3.277	3.000	1.410	0.284	1.439
29	30-40	13.302	11.544	3.164	0.297	8.330
29	80-90	0.373	0.393	0.798	0.510	0.636
30	10-20	4.419	4.134	2.413	0.000	2.057
30	50-60	0.113	0.091	0.485	0.576	0.382
33	10-20	4.618	3.387	1.467	0.500	2.011
33	30-40	3.574	3.800	2.001	0.864	2.760
33	50-60	4.447	3.044	1.805	0.461	1.649
33	87-97	6.988	5.882	0.221	0.735	5.483
34	10-20	6.939	5.105	0.217	0.817	3.175
34	30-40	6.691	4.519	0.250	0.876	2.921
35		4.909	3.818	1.972	1.014	2.437
36	10-20	2.077	2.098	1.011	0.389	0.841
36	50-60	4.116	3.029	2.604	0.735	1.959
37	10-20	1.798	1.809	0.956	0.000	0.759
37	40-50	3.796	2.966	0.134	0.300	1.458
38	10-20	5.363	4.163	0.189	1.002	1.931

38	30-40	3.815	3.911	2.003	0.489	1.885
38	59-69	4.194	3.654	2.155	0.637	1.474

Station	Depth	2,4-DDT	4,4-DDT	methoxychlor	mirex	Total Pesticides (ng/g)
1		0.617	33.769	3.956	1.323	120.836
2		0.822	29.247	11.215	1.303	84.120
3		0.296	20.115	3.306	0.895	42.712
4		0.544	34.403	6.504	1.518	71.503
5		0.399	69.787	11.032	1.817	109.519
6		1.306	87.866	41.729	0.884	188.013
7		0.319	30.583	4.312	0.814	57.267
8		0.451	27.568	7.333	1.068	60.338
9		0.197	9.478	5.627	0.818	30.530
10		0.651	28.028	4.171	1.938	137.412
11		0.545	11.541	1.736	1.315	43.053
12		0.153	3.920	1.009	0.406	18.956
13		0.618	13.219	2.273	1.575	42.331
14		0.328	9.988	40.047	0.737	70.951
15		0.417	50.847	6.605	1.465	81.685
16		0.190	11.998	1.388	0.636	27.590
17		0.124	4.647	1.220	0.280	19.117
18		0.042	0.207	0.000	0.005	4.344
19		0.522	29.429	4.227	0.457	50.870
20		0.596	17.975	6.012	0.842	53.770
21		0.181	6.831	0.856	0.611	27.561
22		0.303	52.485	10.822	1.584	84.239
23		0.902	25.494	4.732	1.579	71.986
24		0.290	19.696	3.904	0.455	38.911
25		0.332	26.818	11.898	1.410	58.543
26		0.252	14.645	6.545	1.114	54.897
27		0.579	28.295	15.644	1.038	66.876
28		0.545	41.886	22.207	1.582	91.791
29	10-20	0.248	16.286	11.722	0.667	46.139
29	30-40	0.517	14.590	21.081	0.882	98.436
29	80-90	0.201	27.509	10.714	1.234	51.753
30	10-20	0.283	9.946	12.758	0.620	46.626
30	50-60	0.121	19.722	7.285	0.998	38.173
33	10-20	0.594	29.440	14.707	1.439	71.872
33	30-40	0.558	65.548	28.662	2.015	124.628
33	50-60	0.489	21.199	12.281	1.605	59.538
33	87-97	0.628	25.905	20.885	1.365	83.195
34	10-20	0.301	22.618	7.966	1.275	59.669
34	30-40	0.430	30.354	20.450	1.644	78.621
35		0.656	19.764	8.541	1.283	55.338
36	10-20	0.236	10.384	4.176	1.084	28.874
36	50-60	0.450	23.441	11.377	1.176	56.716
37	10-20	0.259	17.515	5.582	0.494	35.367
37	40-50	0.396	11.494	13.638	1.009	45.675

38	10-20	0.548	16.021	10.968	1.626	55.359
38	30-40	0.418	16.163	14.796	2.180	55.659
38	59-69	0.586	12.657	12.153	1.004	50.015

PAH

Station	depth	Dry Weight to extract (g)	Total PAHs (ng/g)	Total PAHs (ug/g)
1	5-15	01/01	12853	12.853
2	4-14	01/01	3297	3.297
3	8-18	01/03	2843	2.843
4	0-10	01/01	5925	5.925
5	0-10	01/02	20461	20.461
6	0-10	01/01	8747	8.747
7	0-10	01/02	4427	4.427
8	0-10	01/02	3874	3.874
9	0-10	01/02	5516	5.516
10	0-10	01/01	17685	17.685
11	10-20	01/01	4817	4.817
12	4-14	01/02	1930	1.930
13	5-15	01/01	1644	1.644
14	5-15	01/01	3190	3.190
15	10-20	12/31	3137	3.137
16	0-10	01/03	1227	1.227
17	3-13	01/03	1339	1.339
18	6-16	01/03	0	0.000
19	3-13	01/01	3765	3.765
20	3-13	01/02	3631	3.631
21	20-30	01/02	1321	1.321
22	10-20	01/01	6293	6.293
23	20-30	01/01	3670	3.670
24	0-10	01/01	3489	3.489
25	37-47	01/01	4610	4.610
26	10-20	01/01	3898	3.898
27	10-20	01/01	4144	4.144
28	10-20	01/01	4031	4.031
33	10-20	12/31	3678	3.678
33	30-40	12/31	4564	4.564
33	50-60	01/01	2933	2.933
33	87-97	01/01	5093	5.093
34	10-20	01/01	5617	5.617
34	50-60	01/01	5757	5.757
35	10-20	12/31	3761	3.761
35	30-40	01/01	3009	3.009
36	10-20	01/01	2414	2.414
37	10-20	12/31	1893	1.893
37	40-50	01/01	3756	3.756
38	10-20	01/01	6503	6.503
38	30-40	01/01	6430	6.430
38	59-69	01/01	4752	4.752

Station	depth	Compound	Napthalene	Azulene	2Me Napthalene	1Me Napthalene	Ace napthylene	Biphenyl	Ace napthene
1	5-15		06/04	ND	08/21	11/10	05/21	05/07	03/22
2	4-14		03/06	ND	03/06	01/25	01/14	01/13	ND
3	8-18		01/25	ND	02/10	01/15	01/12	01/09	01/07
4	0-10		03/20	ND	03/13	01/28	01/11	01/13	01/17
5	0-10		07/26	ND	08/20	12/20	05/21	10/17	06/27
6	0-10		11/10	ND	10/24	04/16	02/26	02/19	02/06
7	0-10		05/25	ND	05/20	02/15	01/23	01/28	01/19
8	0-10		05/17	ND	05/13	02/15	01/23	01/24	01/16
9	0-10		03/16	ND	03/13	01/27	01/14	01/13	01/27
10	0-10		01/25	ND	01/15	11/22	05/10	05/01	03/15
11	10-20		03/09	ND	03/18	01/28	01/18	01/18	ND
12	4-14		05/10	ND	05/11	02/10	01/25	02/04	01/11
13	5-15		01/15	01/03	01/25	01/13	01/03	01/04	ND
14	5-15		01/16	ND	01/25	01/10	01/07	01/06	ND
15	10-20		02/09	ND	02/17	01/20	01/09	01/09	ND
16	0-10		06/09	ND	05/26	02/19	01/17	01/29	01/10
17	3-13		05/15	ND	04/21	02/10	01/13	01/26	01/13
18	6-16		ND	ND	ND	ND	ND	ND	ND
19	3-13		03/19	ND	03/02	01/28	01/29	01/12	01/18
20	3-13		03/31	ND	03/18	01/27	01/13	01/18	01/11
21	20-30		02/24	ND	02/15	01/14	01/06	01/12	ND
22	10-20		02/12	ND	02/20	01/20	01/11	01/11	01/23
23	20-30		05/01	ND	04/23	02/07	01/15	01/25	01/18
24	0-10		03/09	ND	03/09	01/25	01/14	01/13	ND
25	37-47		05/02	ND	05/03	02/16	01/29	01/24	01/19
26	10-20		03/08	ND	03/18	01/30	01/17	01/15	ND
27	10-20		02/10	ND	02/16	01/20	01/13	01/09	ND
28	10-20		06/05	ND	05/22	02/24	01/27	01/27	01/18
33	10-20		06/09	ND	05/06	02/17	01/19	01/29	01/25
33	30-40		06/12	ND	05/17	02/20	01/17	01/31	01/20
33	50-60		04/22	ND	04/09	02/03	01/09	01/24	ND
33	87-97		05/07	ND	07/10	03/08	02/22	02/07	01/31
34	10-20		06/23	ND	07/15	03/09	02/12	02/05	01/25
34	50-60		07/28	ND	08/02	03/17	01/24	02/11	01/31
35	10-20		03/09	ND	03/23	01/30	01/14	01/15	ND
35	30-40		05/03	ND	04/18	02/09	01/10	01/28	ND
36	10-20		05/07	ND	04/05	02/07	01/19	01/25	ND
37	10-20		03/20	ND	03/03	01/27	01/07	01/14	ND
37	40-50		05/05	ND	04/25	02/16	01/11	01/20	01/21
38	10-20		12/31	ND	10/13	04/04	01/30	02/11	01/25
38	30-40		09/21	ND	07/18	03/11	01/17	02/02	01/18
38	59-69		05/31	ND	04/30	02/17	01/24	01/24	01/18

Station	depth	Fluorene	Dibenzo benzo thiophene	Phen anthrene	Anthracene	1Me fluorene	4,5-Methylene phen anthrene	2Methyl phen anthrene	2Methyl anthracene
1	5-15	10/04	ND	08/01	03/02	04/25	ND	02/14	05/30
2	4-14	02/08	ND	08/24	02/20	01/25	ND	03/06	ND
3	8-18	01/29	ND	07/29	02/18	01/15	ND	02/26	01/14
4	0-10	02/18	ND	10/26	03/12	01/24	ND	03/25	01/21
5	0-10	11/06	ND	12/29	11/08	06/03	ND	08/02	10/23
6	0-10	05/19	ND	12/31	08/07	02/18	ND	07/26	03/13
7	0-10	03/05	ND	11/12	04/04	01/21	ND	03/16	01/25
8	0-10	02/28	ND	10/20	03/23	01/21	ND	03/12	01/21
9	0-10	03/01	ND	07/22	02/07	03/02	ND	05/08	01/31
10	0-10	10/25	ND	09/17	02/10	05/18	ND	09/21	06/28
11	10-20	02/08	ND	10/07	02/27	01/16	ND	03/02	ND
12	4-14	02/07	ND	10/12	03/05	01/14	ND	02/19	01/14
13	5-15	03/18	ND	07/16	03/24	01/10	ND	02/19	01/27
14	5-15	01/21	ND	08/08	02/23	01/07	ND	02/16	ND
15	10-20	01/26	ND	07/31	01/28	01/15	ND	02/23	ND
16	0-10	01/28	ND	08/26	02/21	01/15	ND	02/20	01/14
17	3-13	02/21	ND	08/25	02/27	01/16	ND	02/12	01/13
18	6-16	ND	ND	ND	ND	ND	ND	ND	ND
19	3-13	02/23	ND	12/05	04/09	01/21	ND	03/08	01/26
20	3-13	02/06	ND	09/18	02/24	01/13	ND	02/17	ND
21	20-30	01/14	ND	04/22	01/21	01/06	ND	01/24	ND
22	10-20	02/16	ND	04/21	04/16	01/18	ND	04/07	02/01
23	20-30	02/24	ND	11/04	02/07	01/17	ND	03/02	ND
24	0-10	02/06	ND	08/16	02/12	01/18	ND	02/22	ND
25	37-47	02/19	ND	12/03	03/04	01/25	ND	03/23	ND
26	10-20	02/08	ND	09/08	02/10	01/19	ND	02/27	ND
27	10-20	01/26	ND	08/22	02/02	01/17	ND	02/22	ND
28	10-20	02/23	ND	11/15	02/13	02/18	ND	03/12	01/19
33	10-20	02/04	ND	09/13	02/05	01/21	ND	02/24	ND
33	30-40	02/16	ND	10/19	02/01	01/26	ND	03/09	ND
33	50-60	02/10	ND	08/26	02/15	01/15	ND	02/22	ND
33	87-97	04/10	ND	11/02	07/29	02/15	ND	07/16	03/09
34	10-20	03/20	ND	05/02	05/24	02/07	ND	05/30	02/18
34	50-60	03/27	ND	06/01	05/05	02/04	ND	06/09	02/07
35	10-20	02/04	ND	10/29	03/05	01/19	ND	03/21	ND
35	30-40	01/20	ND	07/21	01/09	01/07	ND	02/19	ND
36	10-20	02/12	ND	07/29	01/22	01/27	ND	02/14	ND

37	10-20	01/12	ND	05/05	ND	ND	ND	01/27	ND
37	40-50	02/10	ND	09/02	02/22	02/13	ND	03/08	01/15
38	10-20	03/03	ND	12/09	02/15	01/20	ND	03/24	02/01
38	30-40	02/28	ND	11/14	02/20	01/24	ND	03/24	01/20
38	59-69	03/05	ND	12/03	02/19	01/26	ND	04/03	01/15

Station	depth	1Methyl anthracene	1Methyl phen anthrene	9Methyl anthracene	Fluor anthene	Pyrene	3,6Di methyl phen anthrene	9,10 dimethyl anthracene	Benzo[a]f luorene
1	5-15	02/03	09/14	01/21	01/19	09/26	02/26	ND	08/18
2	4-14	02/24	02/03	01/08	04/02	ND	ND	ND	01/08
3	8-18	02/18	02/01	02/25	08/14	09/06	01/08	ND	02/25
4	0-10	03/17	02/13	03/19	04/27	06/03	01/19	ND	04/25
5	0-10	08/04	12/27	01/26	11/16	05/13	03/08	01/12	03/15
6	0-10	07/09	04/28	07/25	07/23	10/28	01/31	ND	06/28
7	0-10	03/11	02/12	01/03	10/24	12/18	01/13	ND	03/18
8	0-10	03/10	02/11	03/14	12/09	02/23	01/14	ND	03/30
9	0-10	01/31	01/26	01/15	08/07	04/14	03/01	ND	09/06
10	0-10	06/08	11/24	07/18	11/07	06/05	05/30	02/01	05/25
11	10-20	02/25	02/08	ND	02/16	04/04	01/04	ND	02/02
12	4-14	02/13	01/29	01/03	06/02	01/10	01/01	ND	01/09
13	5-15	02/20	02/05	02/06	01/18	01/17	12/30	ND	ND
14	5-15	02/08	01/26	ND	01/26	03/27	01/06	ND	03/12
15	10-20	02/12	01/28	ND	10/04	08/21	01/16	ND	05/01
16	0-10	02/07	01/31	ND	01/24	01/27	ND	ND	01/03
17	3-13	02/06	01/25	01/05	04/06	04/02	01/08	ND	01/24
18	6-16	ND	ND	ND	ND	ND	ND	ND	ND
19	3-13	03/12	02/12	ND	04/18	03/25	01/09	ND	03/13
20	3-13	02/07	01/26	ND	06/26	07/25	01/13	ND	02/26
21	20-30	01/22	01/14	ND	05/17	05/18	01/05	ND	01/23
22	10-20	03/17	02/21	ND	10/06	07/18	01/19	ND	05/08
23	20-30	02/15	02/04	ND	12/20	01/08	01/07	ND	02/13
24	0-10	02/13	01/30	ND	03/01	02/22	01/09	ND	03/01
25	37-47	03/09	02/16	01/06	04/02	04/03	01/14	ND	03/11
26	10-20	02/20	02/03	ND	09/22	08/29	01/17	ND	04/05
27	10-20	02/16	01/31	ND	05/10	05/03	01/09	ND	02/28
28	10-20	03/08	02/12	ND	11/12	10/08	01/17	ND	02/07
33	10-20	02/19	01/31	ND	11/09	09/21	01/10	ND	02/22
33	30-40	02/24	02/07	ND	04/03	01/22	01/16	ND	04/05
33	50-60	02/15	01/29	ND	11/09	09/21	01/08	ND	02/20
33	87-97	07/10	04/20	ND	09/07	11/12	01/13	ND	03/16
34	10-20	05/20	03/22	07/22	08/20	09/29	01/10	ND	03/12
34	50-60	05/22	03/26	ND	09/12	10/31	01/11	ND	03/14

35	10-20	03/12	02/13	ND	08/19	09/01	01/06	ND	02/18
35	30-40	02/03	01/26	ND	06/22	04/18	01/02	ND	01/20
36	10-20	02/09	01/27	ND	03/16	03/09	12/31	ND	ND
37	10-20	01/19	01/16	ND	06/08	03/27	01/01	ND	01/14
37	40-50	03/24	02/04	01/07	09/09	07/08	01/07	ND	03/12
38	10-20	03/23	02/13	ND	12/23	08/11	01/10	ND	02/15
38	30-40	04/02	02/20	ND	03/12	12/31	01/20	ND	04/03
38	59-69	03/23	02/17	01/06	11/25	09/08	01/15	ND	02/20

Station	depth	Benzo[b] fluorene	Benz[a] anthracene	Chrysene + Triphenylene	Napth acene	Benzo[b] fluor anthene	Benzo[k] fluor anthene	Benzo[e] pyrene	Benzo[a] pyrene
1	5-15	07/10	06/26	08/07	03/15	02/20	08/13	02/08	03/06
2	4-14	02/06	02/19	02/02	06/05	07/27	06/11	06/18	07/19
3	8-18	02/06	06/09	07/13	ND	05/08	04/10	05/01	08/10
4	0-10	03/23	11/09	12/03	ND	03/03	02/17	11/10	04/22
5	0-10	11/07	03/02	02/26	06/13	06/21	05/13	04/14	08/15
6	0-10	05/11	01/29	04/11	03/23	10/12	08/09	09/08	05/07
7	0-10	02/22	06/06	07/07	ND	01/29	01/22	05/19	09/06
8	0-10	02/27	06/15	07/25	02/18	01/18	01/14	03/27	05/04
9	0-10	05/23	11/19	03/05	03/08	02/13	02/03	06/12	07/03
10	0-10	10/28	08/28	01/25	01/06	11/03	11/30	01/21	05/12
11	10-20	05/09	07/24	04/27	07/16	12/04	09/20	12/11	04/07
12	4-14	02/17	ND	02/05	05/09	01/21	01/16	03/11	02/15
13	5-15	ND	03/23	02/19	05/04	05/25	ND	04/27	04/26
14	5-15	02/11	06/10	06/28	ND	06/22	05/14	05/24	06/23
15	10-20	03/09	08/03	10/17	ND	02/02	01/26	04/26	04/27
16	0-10	01/13	ND	01/12	ND	02/12	01/11	01/27	02/28
17	3-13	01/12	ND	01/25	ND	03/06	01/24	02/15	02/10
18	6-16	ND	ND	ND	ND	ND	ND	ND	ND
19	3-13	02/24	07/06	07/20	ND	09/24	06/21	07/17	10/14
20	3-13	02/23	07/30	09/29	ND	06/09	07/07	05/15	07/17
21	20-30	01/19	03/04	03/09	ND	03/25	02/20	02/26	03/24
22	10-20	05/02	03/24	05/10	03/09	11/26	11/20	08/24	12/27
23	20-30	02/12	06/12	07/20	ND	09/25	08/20	06/19	08/03
24	0-10	02/16	06/16	08/08	ND	10/01	07/16	06/10	07/18
25	37-47	02/24	07/12	08/30	ND	09/15	09/03	08/10	08/20
26	10-20	03/09	08/22	10/12	ND	05/31	05/15	05/02	05/12
27	10-20	02/14	07/13	10/24	ND	09/09	10/22	07/26	03/10
28	10-20	02/27	07/07	06/28	ND	12/13	08/15	07/27	08/21
33	10-20	02/15	06/10	08/03	ND	09/29	07/17	06/25	07/14
33	30-40	02/25	08/06	11/25	ND	11/16	11/09	09/02	09/30
33	50-60	02/05	06/10	08/16	ND	06/26	05/18	04/29	05/10
33	87-97	03/15	09/30	08/24	ND	10/21	08/01	06/26	09/22
34	10-20	03/10	10/07	09/03	ND	10/16	08/23	06/25	11/16
34	50-60	03/11	10/23	09/27	ND	12/09	10/11	07/28	11/07

35	10-20	02/12	07/31	08/22	ND	12/24	10/31	07/20	11/14
35	30-40	01/15	05/20	07/14	ND	07/26	11/05	06/24	08/17
36	10-20	01/22	ND	ND	05/03	06/26	05/04	05/15	06/28
37	10-20	01/09	03/31	06/05	ND	07/01	07/24	05/27	05/06
37	40-50	02/08	06/23	12/07	ND	04/02	10/07	08/26	04/30
38	10-20	02/13	09/23	09/03	ND	01/15	10/01	06/11	09/17
38	30-40	02/26	01/25	07/26	ND	04/29	09/12	03/20	11/10
38	59-69	02/11	07/28	03/07	ND	07/30	12/03	11/16	07/24

Station	depth	Perylene	Dimethyl benz[a] anthracene	3Methyl chol anthrene	Indeno [1,2,3-c,d]pyrene	Benzo[g,h,i]perylene	Anth anthrene	Dibenz[a,h+a c]anthracene	Coronene
1	5-15	12/03	01/15	ND	08/01	09/11	02/05	01/29	02/17
2	4-14	10/01	ND	ND	01/24	11/23	01/21	02/05	01/30
3	8-18	07/27	ND	ND	07/26	07/22	01/18	01/24	01/13
4	0-10	12/18	ND	ND	11/06	11/05	01/12	02/17	01/17
5	0-10	12/18	ND	ND	07/11	10/31	03/12	03/08	03/02
6	0-10	04/16	01/18	ND	04/28	05/11	08/08	03/10	01/15
7	0-10	12/29	ND	ND	04/18	02/18	01/28	01/30	01/19
8	0-10	10/29	ND	ND	08/06	07/21	01/14	01/23	01/04
9	0-10	12/06	ND	ND	07/12	07/11	01/30	01/26	01/22
10	0-10	03/09	ND	ND	09/11	11/07	04/17	04/06	02/04
11	10-20	06/24	ND	ND	09/10	08/10	01/10	01/26	01/02
12	4-14	ND	ND	ND	01/24	11/25	01/18	02/09	01/19
13	5-15	04/06	02/07	ND	02/10	01/27	02/01	02/02	02/01
14	5-15	02/17	ND	ND	06/10	02/06	02/06	03/13	01/24
15	10-20	ND	ND	ND	06/14	05/12	01/15	01/04	01/04
16	0-10	ND	01/16	ND	01/10	02/06	01/08	01/08	01/08
17	3-13	01/12	01/13	ND	01/02	01/05	ND	01/01	01/01
18	6-16	ND	ND	ND	ND	ND	ND	ND	ND
19	3-13	03/16	ND	ND	05/09	04/16	01/31	01/24	02/07
20	3-13	06/09	ND	ND	04/23	04/24	01/27	01/18	02/08
21	20-30	02/06	ND	ND	03/03	02/27	01/16	01/08	01/21
22	10-20	06/16	ND	ND	08/22	07/15	02/16	01/23	02/15
23	20-30	06/19	ND	ND	05/12	05/13	06/06	01/20	02/23
24	0-10	08/26	ND	ND	05/23	05/16	02/01	01/25	02/22
25	37-47	12/07	ND	ND	08/11	07/12	08/16	01/27	03/02
26	10-20	09/21	ND	ND	06/28	05/11	01/20	01/25	03/01
27	10-20	10/11	ND	ND	06/26	07/21	01/25	01/21	02/16
28	10-20	02/14	ND	ND	06/25	04/29	01/29	02/08	01/30
33	10-20	10/03	01/26	ND	07/22	07/01	01/27	02/28	03/08
33	30-40	12/28	ND	ND	07/05	06/26	02/01	01/16	02/28
33	50-60	06/29	ND	ND	05/20	05/22	01/07	01/15	02/04
33	87-97	10/30	ND	ND	07/12	06/25	01/18	02/02	02/06

34	10-20	08/27	ND	ND	08/01	07/11	01/18	02/02	02/01
34	50-60	08/08	ND	ND	09/22	07/29	01/13	02/01	02/01
35	10-20	07/07	ND	ND	08/25	07/06	01/19	01/28	02/02
35	30-40	11/16	ND	ND	07/06	07/03	01/10	01/14	01/21
36	10-20	10/07	ND	ND	04/25	10/24	01/25	01/26	01/12
37	10-20	04/03	ND	ND	03/20	03/29	01/07	01/10	01/11
37	40-50	09/16	ND	ND	06/05	05/29	01/08	01/27	01/15
38	10-20	10/07	ND	ND	08/27	09/15	12/11	02/03	01/16
38	30-40	12/19	01/28	ND	09/02	08/03	01/20	02/14	01/17
38	59-69	01/27	ND	ND	07/10	07/03	01/10	02/03	01/22

PCB

Station	depth	Dry Weight to extract
1	5-15	2.826
2	4-14	2.193
3	8-18	4.037
4	0-10	2.734
5	0-10	3.335
6	0-10	2.690
7	0-10	3.967
8	0-10	3.447
9	0-10	3.782
10	0-10	2.810
11	10-20	2.060
12	4-14	3.969
13	5-15	2.402
14	5-15	2.502
15	10-20	1.908
16	0-10	4.374
17	3-13	4.417
18	6-16	4.255
19	3-13	2.991
20	3-13	3.163
21	20-30	3.742
22	10-20	2.719
23	20-30	2.540
24	0-10	2.195
25	37-47	2.434
26	10-20	2.130
27	10-20	2.671
28	10-20	2.063
29	10-20	3.189
29	30-40	3.353
29	80-90	2.941
30	10-20	2.999
30	50-60	3.021

33	10-20	1.915
33	30-40	1.838
33	50-60	2.303
33	87-97	2.346
34	10-20	2.340
34	50-60	2.819
35	10-20	1.651
35	30-40	2.691
36	10-20	2.031
37	10-20	1.945
37	40-50	2.503
38	10-20	2.041
38	30-40	2.095
38	59-69	2.454
	MDL_min	4.417
	MDL_max	1.651

Station	depth	Congener #	1	3	4,10	7,9	6	8,5	19
1	5-15		4.974	1.576	0.410	0.132	0.540	4.658	0.383
2	4-14		2.410	1.922	0.268	0.051	0.097	0.981	0.136
3	8-18		1.145	0.511	0.139	0.028	0.016	0.570	0.097
4	0-10		1.923	1.161	0.239	0.041	0.029	1.223	0.157
5	0-10		2.377	0.277	0.382	0.099	0.174	3.468	0.840
6	0-10		0.604	0.674	0.120	0.079	0.041	3.724	0.201
7	0-10		0.409	0.968	0.081	0.029	0.007	0.817	0.041
8	0-10		0.471	0.455	0.094	0.032	0.009	0.714	0.052
9	0-10		0.429	0.705	0.085	0.029	0.009	0.911	0.036
10	0-10		5.860	2.119	0.427	0.238	0.855	7.323	0.458
11	10-20		1.154	0.691	0.237	0.062	0.069	1.522	0.111
12	4-14		1.143	0.246	0.123	0.028	0.016	0.801	0.121
13	5-15		1.789	0.873	0.260	0.057	0.056	1.467	0.113
14	5-15		1.043	0.900	0.210	0.044	0.036	0.976	0.086
15	10-20		1.308	1.068	0.243	0.058	0.043	1.246	0.097
16	0-10		1.063	0.657	0.127	0.025	0.008	0.650	0.051
17	3-13		0.884	0.373	0.106	0.025	0.010	0.607	0.079
18	6-16		0.382	0.000	0.076	0.026	0.005	0.506	0.018
19	3-13		0.543	0.626	0.166	0.037	0.018	0.783	0.080
20	3-13		1.171	0.769	0.184	0.036	0.036	1.092	0.094
21	20-30		1.550	0.470	0.155	0.030	0.034	0.670	0.100
22	10-20		1.447	0.833	0.252	0.041	0.048	1.160	0.187
23	20-30		0.908	0.853	0.222	0.064	0.041	1.848	0.160
24	0-10		1.109	0.844	0.270	0.051	0.059	1.414	0.132
25	37-47		0.667	0.577	0.133	0.069	0.067	1.427	0.127
26	10-20		0.762	0.499	0.202	0.052	0.038	1.421	0.093
27	10-20		0.608	1.131	0.184	0.049	0.041	1.639	0.103
28	10-20		0.838	0.653	0.279	0.068	0.069	1.907	0.190
29	10-20		0.615	0.226	0.101	0.057	0.041	1.329	0.105
29	30-40		0.573	1.877	0.096	0.067	0.116	4.326	0.201
29	80-90		0.552	3.695	0.110	0.060	0.027	2.164	0.511
30	10-20		0.541	0.279	0.108	0.067	0.070	2.023	0.187
30	50-60		0.537	6.277	0.157	0.055	0.029	1.925	0.469

33	10-20		0.848	0.639	0.196	0.065	0.052	1.768	0.165
33	30-40		1.308	2.887	0.252	0.154	0.091	1.754	0.135
33	50-60		0.705	0.653	0.183	0.057	0.052	1.720	0.177
33	87-97		0.692	0.223	0.177	0.092	0.095	2.256	0.291
34	10-20		0.694	0.350	0.138	0.048	0.012	2.327	0.223
34	50-60		0.576	0.318	0.114	0.039	0.008	1.811	0.367
35	10-20		0.983	0.862	0.195	0.067	0.012	1.303	0.312
35	30-40		0.603	1.607	0.120	0.041	0.020	0.799	0.043
36	10-20		0.800	0.329	0.159	0.055	0.010	1.060	0.154
37	10-20		0.835	0.342	0.166	0.057	0.020	1.106	0.069
37	40-50		0.649	0.687	0.129	0.044	0.012	0.860	0.134
38	10-20		0.795	0.769	0.158	0.055	0.007	1.054	0.094
38	30-40		0.775	0.680	0.154	0.053	0.014	1.027	0.137
38	59-69		0.662	1.463	0.131	0.045	0.023	0.973	0.124
		MDL_min	0.368	0.000	0.073	0.025	0.000	0.487	0.017
		MDL_max	0.983	0.000	0.195	0.067	0.000	1.303	0.047

Station	depth	Congener #	12,13	18	17	24	16,32	29	26	25
1	5-15		0.198	1.195	0.520	0.380	1.412	0.131	1.716	0.424
2	4-14		0.134	0.256	0.253	0.083	0.461	0.034	0.096	0.052
3	8-18		0.005	0.058	0.053	0.045	0.164	0.008	0.006	0.013
4	0-10		0.012	0.102	0.119	0.131	0.319	0.011	0.041	0.019
5	0-10		0.042	0.371	0.238	0.092	1.374	0.051	0.124	0.140
6	0-10		0.104	0.703	0.477	0.784	0.760	0.034	0.382	0.178
7	0-10		0.015	0.070	0.103	0.046	0.168	0.006	0.019	0.022
8	0-10		0.010	0.051	0.074	0.053	0.135	0.007	0.051	0.026
9	0-10		0.008	0.057	0.085	0.048	0.141	0.007	0.022	0.114
10	0-10		0.310	2.255	1.095	0.673	2.472	0.057	2.728	0.611
11	10-20		0.034	0.229	0.191	0.129	0.399	0.018	0.046	0.065
12	4-14		0.010	0.120	0.102	0.046	0.194	0.007	0.014	0.019
13	5-15		0.020	0.183	0.221	0.076	0.538	0.021	0.055	0.089
14	5-15		0.010	0.161	0.156	0.073	0.280	0.015	0.040	0.040
15	10-20		0.006	0.110	0.140	0.096	0.339	0.016	0.020	0.057
16	0-10		0.005	0.135	0.114	0.042	0.226	0.006	0.011	0.020
17	3-13		0.010	0.136	0.087	0.041	0.170	0.008	0.026	0.023
18	6-16		0.007	0.000	0.007	0.043	0.078	0.006	0.000	0.021
19	3-13		0.009	0.090	0.075	0.061	0.234	0.010	0.021	0.043
20	3-13		0.016	0.198	0.145	0.093	0.375	0.014	0.039	0.028
21	20-30		0.026	0.149	0.147	0.049	0.188	0.010	0.018	0.028
22	10-20		0.013	0.135	0.127	0.067	0.395	0.012	0.016	0.025
23	20-30		0.041	0.299	0.215	0.202	0.532	0.014	0.082	0.080
24	0-10		0.021	0.208	0.224	0.083	0.385	0.015	0.025	0.032
25	37-47		0.025	0.243	0.157	0.075	0.478	0.024	0.107	0.410
26	10-20		0.014	0.116	0.137	0.086	0.343	0.015	0.029	0.038
27	10-20		0.044	0.166	0.159	0.068	0.423	0.025	0.069	0.053
28	10-20		0.031	0.299	0.273	0.088	0.717	0.031	0.075	0.065
29	10-20		0.018	0.125	0.096	0.057	0.151	0.011	0.086	0.084
29	30-40		0.053	0.870	0.489	0.575	0.800	0.027	0.266	0.272
29	80-90		0.000	0.178	0.007	0.075	0.113	0.013	0.034	0.285
30	10-20		0.050	0.229	0.155	0.222	0.266	0.016	0.153	0.125
30	50-60		0.000	0.137	0.007	0.064	0.110	0.009	0.017	0.161

33	10-20		0.027	0.193	0.203	0.095	0.504	0.016	0.029	0.050
33	30-40		0.076	0.254	0.317	0.099	0.680	0.026	0.061	0.126
33	50-60		0.024	0.199	0.182	0.079	0.365	0.014	0.023	0.034
33	87-97		0.051	0.389	0.282	0.078	0.662	0.026	0.086	0.112
34	10-20		0.029	0.232	0.163	0.078	0.372	0.012	0.000	0.091
34	50-60		0.020	0.199	0.156	0.065	0.234	0.009	0.070	0.222
35	10-20		0.042	0.121	0.157	0.110	0.239	0.016	0.060	0.183
35	30-40		0.022	0.011	2.205	0.068	0.123	0.009	0.010	0.017
36	10-20		0.006	0.040	0.049	0.090	0.179	0.012	0.033	0.049
37	10-20		0.007	0.023	0.057	0.094	0.170	0.013	0.014	0.023
37	40-50		0.026	0.059	0.074	0.073	0.156	0.016	0.067	0.082
38	10-20		0.012	0.091	0.112	0.089	0.218	0.012	0.055	0.058
38	30-40		0.021	0.103	0.081	0.087	0.202	0.012	0.016	0.067
38	59-69		0.017	0.036	0.168	0.074	0.193	0.014	0.022	0.035
		MDL_min	0.000	0.000	0.005	0.041	0.075	0.006	0.000	0.010
		MDL_max	0.000	0.000	0.013	0.110	0.200	0.015	0.000	0.026

Station	depth	Congener #	31	28	33,21,53	51	22	45	46	52
1	5-15		0.888	1.021	2.027	0.324	1.195	0.672	0.859	1.313
2	4-14		0.305	0.551	0.456	0.094	0.371	0.186	0.506	0.443
3	8-18		0.153	0.230	0.190	0.025	0.182	0.048	0.095	0.164
4	0-10		0.278	0.436	0.278	0.032	0.268	0.120	0.097	0.346
5	0-10		0.304	0.000	0.770	0.331	0.293	0.639	0.418	0.065
6	0-10		1.497	2.304	1.519	0.250	0.942	0.637	0.119	1.516
7	0-10		0.375	0.465	0.341	0.038	0.264	0.160	0.089	0.367
8	0-10		0.274	0.411	0.252	0.022	0.222	0.094	0.058	0.281
9	0-10		0.273	0.429	0.232	0.019	0.194	0.080	0.038	0.291
10	0-10		2.045	2.839	3.817	0.422	2.533	1.007	1.267	2.161
11	10-20		0.298	0.577	0.467	0.087	0.356	0.187	0.396	0.381
12	4-14		0.091	0.537	0.239	0.091	0.224	0.093	0.061	0.275
13	5-15		0.366	0.600	0.534	0.076	0.306	0.154	0.242	0.546
14	5-15		0.219	0.367	0.294	0.048	0.293	0.106	0.245	0.331
15	10-20		0.190	0.358	0.315	0.061	0.385	0.123	0.252	0.272
16	0-10		0.293	0.360	0.282	0.044	0.181	0.081	0.066	0.323
17	3-13		0.273	0.306	0.221	0.034	0.166	0.060	0.057	0.242
18	6-16		0.085	0.000	0.033	0.008	0.173	0.011	0.018	0.015
19	3-13		0.132	0.169	0.177	0.048	0.245	0.081	0.065	0.139
20	3-13		0.305	0.401	0.339	0.059	0.232	0.189	0.135	0.314
21	20-30		0.157	0.191	0.211	0.026	0.196	0.058	0.060	0.177
22	10-20		0.244	0.341	0.341	0.042	0.270	0.117	0.150	0.268
23	20-30		0.406	0.584	0.592	0.101	0.369	0.372	0.201	0.502
24	0-10		0.214	0.386	0.365	0.054	0.334	0.147	0.162	0.257
25	37-47		0.310	0.402	0.621	0.094	0.302	0.313	0.151	0.413
26	10-20		0.220	0.335	0.357	0.050	0.345	0.115	0.115	0.277
27	10-20		0.245	0.345	0.370	0.051	0.275	0.176	0.091	0.288
28	10-20		0.393	0.601	0.678	0.090	0.356	0.253	0.169	0.411
29	10-20		0.283	0.432	0.367	0.071	0.272	0.249	0.021	0.299
29	30-40		1.727	2.665	1.629	0.349	1.164	0.754	0.141	1.640
29	80-90		0.123	0.326	0.047	0.087	0.250	0.863	0.057	0.055
30	10-20		0.484	0.751	0.589	0.102	0.395	0.108	0.033	0.482
30	50-60		0.120	0.243	0.046	0.030	0.243	0.755	0.022	0.026

33	10-20		0.300	0.491	0.523	0.070	0.383	0.186	0.118	0.385
33	30-40		0.448	0.710	0.832	0.116	0.526	0.359	0.224	0.534
33	50-60		0.344	0.403	0.513	0.064	0.319	0.197	0.116	0.362
33	87-97		0.536	0.744	1.107	0.140	0.537	0.407	0.154	0.566
34	10-20		0.697	1.104	0.861	0.161	0.528	0.396	0.083	0.647
34	50-60		0.529	0.966	0.373	0.090	0.358	0.364	0.046	0.506
35	10-20		0.311	0.605	0.393	0.054	0.445	0.271	0.067	0.366
35	30-40		0.135	0.266	0.101	0.038	0.273	0.037	0.025	0.217
36	10-20		0.283	0.446	0.267	0.047	0.361	0.176	0.040	0.300
37	10-20		0.186	0.253	0.172	0.035	0.377	0.068	0.055	0.153
37	40-50		0.302	0.508	0.386	0.060	0.319	0.233	0.129	0.313
38	10-20		0.295	0.613	0.429	0.070	0.376	0.292	0.152	0.438
38	30-40		0.354	0.539	0.476	0.086	0.381	0.299	0.142	0.424
38	59-69		0.285	0.478	0.467	0.075	0.390	0.161	0.121	0.398
		MDL_min	0.082	0.000	0.032	0.000	0.166	0.003	0.015	0.000
		MDL_max	0.219	0.000	0.084	0.000	0.445	0.009	0.040	0.000

Station	depth	Congener #	49	47,48	44	37,42	41,64,71	40	100	63
1	5-15		0.769	1.014	1.071	0.821	1.004	1.218	0.331	0.431
2	4-14		0.607	0.171	0.322	0.245	0.449	0.123	0.124	0.164
3	8-18		0.330	0.077	0.124	0.097	0.154	0.049	0.025	0.033
4	0-10		0.487	0.098	0.285	0.199	0.323	0.105	0.024	0.040
5	0-10		0.399	0.202	0.152	0.137	0.381	0.342	0.207	0.402
6	0-10		1.359	1.130	1.557	1.246	1.471	0.547	0.259	0.274
7	0-10		0.336	0.257	0.332	0.303	0.344	0.107	0.063	0.027
8	0-10		0.386	0.125	0.262	0.208	0.259	0.099	0.056	0.027
9	0-10		0.352	0.123	0.265	0.194	0.379	0.113	0.077	0.026
10	0-10		1.430	2.332	1.947	1.510	1.946	1.954	0.430	0.734
11	10-20		1.075	0.257	0.330	0.256	0.460	0.095	0.111	0.054
12	4-14		0.440	0.241	0.206	0.190	0.263	0.043	0.118	0.125
13	5-15		0.732	0.207	0.379	0.307	0.620	0.146	0.088	0.116
14	5-15		0.532	0.221	0.206	0.147	0.277	0.075	0.095	0.050
15	10-20		1.095	0.113	0.210	0.129	0.302	0.031	0.052	0.061
16	0-10		0.304	0.116	0.254	0.154	0.274	0.070	0.068	0.031
17	3-13		0.301	0.105	0.207	0.139	0.271	0.065	0.063	0.040
18	6-16		0.313	0.022	0.010	0.017	0.135	0.008	0.007	0.004
19	3-13		0.445	0.227	0.135	0.090	0.192	0.042	0.024	0.030
20	3-13		0.421	0.250	0.259	0.205	0.337	0.066	0.063	0.068
21	20-30		0.356	0.194	0.149	0.106	0.197	0.026	0.015	0.014
22	10-20		0.490	0.137	0.202	0.153	0.234	0.098	0.036	0.112
23	20-30		0.524	0.429	0.460	0.361	0.560	0.179	0.102	0.156
24	0-10		0.803	0.198	0.206	0.181	0.290	0.095	0.045	0.031
25	37-47		1.983	0.404	0.387	0.265	0.628	0.194	0.043	0.035
26	10-20		0.677	0.273	0.227	0.193	0.273	0.103	0.031	0.031
27	10-20		0.498	0.359	0.281	0.230	0.364	0.113	0.038	0.067
28	10-20		0.923	0.450	0.417	0.324	0.545	0.176	0.043	0.078
29	10-20		0.417	0.112	0.331	0.322	0.436	0.160	0.098	0.406
29	30-40		1.282	0.462	1.687	1.237	1.966	0.656	0.213	0.208
29	80-90		0.453	0.024	0.042	0.082	0.196	0.032	0.092	1.335
30	10-20		0.477	0.368	0.519	0.448	0.683	0.238	0.142	0.458

30	50-60		0.441	0.022	0.014	0.037	0.191	0.009	0.111	0.905
33	10-20		0.695	0.382	0.322	0.237	0.357	0.130	0.045	0.101
33	30-40		0.837	0.577	0.322	0.253	0.409	0.225	0.081	0.228
33	50-60		0.652	0.428	0.294	0.238	0.390	0.137	0.052	0.097
33	87-97		0.755	0.679	0.560	0.456	0.872	0.264	0.097	0.250
34	10-20		0.933	0.521	0.616	0.514	0.882	0.304	0.164	0.006
34	50-60		0.568	0.292	0.497	0.421	0.620	0.213	0.051	0.453
35	10-20		0.806	0.225	0.339	0.374	0.374	0.089	0.027	0.256
35	30-40		0.495	0.033	0.169	0.090	0.214	0.070	29.303	0.012
36	10-20		0.656	0.172	0.228	0.170	0.298	0.085	4.215	0.246
37	10-20		0.684	0.161	0.162	0.115	0.296	0.056	0.028	0.116
37	40-50		0.532	0.116	0.289	0.262	0.443	0.162	0.103	0.373
38	10-20		0.652	0.189	0.393	0.325	0.530	0.135	0.088	0.289
38	30-40		0.636	0.187	0.396	0.303	0.549	0.173	0.086	0.375
38	59-69		0.638	0.191	0.345	0.263	0.487	0.169	0.107	0.323
		MDL_min	0.301	0.013	0.009	0.016	0.130	0.000	0.006	0.003
		MDL_max	0.806	0.034	0.025	0.043	0.349	0.000	0.017	0.008

Station	depth	Congener #	74	70,76	66,95	91	56,60	89	101
1	5-15		0.436	1.792	4.773	0.339	1.954	1.393	1.720
2	4-14		0.352	0.643	1.798	0.151	0.574	0.530	0.612
3	8-18		0.083	0.278	0.694	0.028	0.347	0.144	0.232
4	0-10		0.182	0.625	1.365	0.060	0.496	0.296	0.462
5	0-10		0.125	0.129	0.844	0.093	0.213	0.588	0.235
6	0-10		1.141	2.967	7.376	0.394	3.688	1.497	2.123
7	0-10		0.211	0.637	1.435	0.085	0.863	0.303	0.442
8	0-10		0.161	0.526	1.189	0.068	0.706	0.271	0.397
9	0-10		0.180	0.571	1.449	0.107	0.709	0.297	0.436
10	0-10		0.861	3.197	7.717	0.585	2.710	2.122	2.377
11	10-20		0.241	0.618	1.721	0.085	0.641	0.567	0.548
12	4-14		0.170	0.421	0.929	0.050	0.661	0.187	0.278
13	5-15		0.421	0.707	2.066	0.119	0.652	0.378	0.550
14	5-15		0.182	0.486	1.274	0.075	0.474	0.286	0.469
15	10-20		0.207	0.493	1.167	0.060	0.391	0.232	0.378
16	0-10		0.208	0.510	1.027	0.048	0.714	0.248	0.289
17	3-13		0.141	0.394	0.733	0.033	0.519	0.166	0.230
18	6-16		0.018	0.017	0.034	0.015	0.167	0.016	0.015
19	3-13		0.079	0.220	0.599	0.033	0.292	0.172	0.205
20	3-13		0.230	0.518	1.263	0.051	0.502	0.389	0.437
21	20-30		0.091	0.257	0.937	0.028	0.190	0.127	0.380
22	10-20		0.177	0.449	0.993	0.052	0.337	0.199	0.329
23	20-30		0.365	0.908	2.039	0.112	0.982	0.540	0.560
24	0-10		0.169	0.460	1.107	0.067	0.565	0.267	0.365
25	37-47		0.180	0.624	2.127	0.091	1.419	0.782	0.788
26	10-20		0.132	0.426	1.170	0.065	0.384	0.236	0.352
27	10-20		0.204	0.506	1.142	0.097	0.356	0.321	0.354
28	10-20		0.256	0.667	1.806	0.100	0.594	0.498	0.528
29	10-20		0.313	0.740	1.720	0.169	0.730	0.368	0.577
29	30-40		1.325	3.320	6.511	0.385	3.869	1.995	1.713
29	80-90		0.301	1.044	0.269	0.250	0.242	0.216	0.082
30	10-20		0.464	1.081	2.473	0.226	1.387	0.566	0.737

30	50-60		0.173	0.337	0.096	0.092	0.235	0.122	0.019
33	10-20		0.258	0.613	1.643	0.087	0.791	0.464	0.502
33	30-40		0.430	0.481	1.585	0.243	1.087	0.549	0.606
33	50-60		0.203	0.545	1.559	0.089	0.735	0.395	0.489
33	87-97		0.580	1.113	3.059	0.242	1.551	0.831	0.874
34	10-20		0.634	1.615	3.239	0.181	1.601	0.688	0.840
34	50-60		0.506	1.515	2.419	0.132	1.328	0.557	0.695
35	10-20		0.245	0.623	1.635	0.077	0.812	0.346	0.511
35	30-40		0.105	0.323	0.836	0.043	0.509	0.094	0.303
36	10-20		0.282	0.720	1.553	0.061	0.704	0.332	0.456
37	10-20		0.095	0.309	0.742	0.051	0.396	0.078	0.248
37	40-50		0.377	0.804	1.887	0.151	1.004	0.457	0.541
38	10-20		0.235	0.729	2.067	0.126	1.081	0.562	0.651
38	30-40		0.264	0.723	2.001	0.108	0.660	0.457	0.606
38	59-69		0.183	0.635	1.834	0.215	0.707	0.186	0.706
		MDL_min	0.006	0.000	0.009	0.005	0.161	0.000	0.006
		MDL_max	0.016	0.000	0.023	0.013	0.431	0.000	0.016

Station	depth	Congener #	99	119	83	97	81,87	85	136
1	5-15		0.839	0.090	0.143	0.454	0.865	0.461	0.429
2	4-14		0.373	0.175	0.066	0.211	0.343	0.188	0.147
3	8-18		0.111	0.049	0.012	0.073	0.158	0.068	0.064
4	0-10		0.216	0.072	0.021	0.132	0.262	0.115	0.064
5	0-10		0.055	0.059	0.039	0.132	0.368	0.049	0.251
6	0-10		1.013	0.139	0.145	0.499	1.043	0.632	0.493
7	0-10		0.178	0.049	0.027	0.100	0.266	0.120	0.094
8	0-10		0.174	0.057	0.026	0.094	0.252	0.133	0.068
9	0-10		0.192	0.052	0.032	0.111	0.265	0.125	0.089
10	0-10		1.235	0.111	0.232	0.605	1.233	0.684	0.561
11	10-20		0.398	0.190	0.027	0.132	0.289	0.107	0.089
12	4-14		0.198	0.049	0.021	0.058	0.195	0.109	0.033
13	5-15		0.350	0.095	0.050	0.187	0.374	0.245	0.105
14	5-15		0.239	0.114	0.023	0.106	0.245	0.126	0.134
15	10-20		0.210	0.138	0.019	0.100	0.274	0.123	0.114
16	0-10		0.114	0.045	0.015	0.069	0.198	0.079	0.044
17	3-13		0.104	0.044	0.014	0.052	0.168	0.068	0.029
18	6-16		0.009	0.046	0.013	0.008	0.035	0.007	0.004
19	3-13		0.108	0.108	0.013	0.052	0.141	0.062	0.048
20	3-13		0.234	0.101	0.030	0.104	0.227	0.094	0.070
21	20-30		0.097	0.052	0.012	0.058	0.143	0.059	0.130
22	10-20		0.173	0.072	0.016	0.098	0.230	0.112	0.083
23	20-30		0.329	0.160	0.052	0.128	0.303	0.128	0.075
24	0-10		0.202	0.101	0.022	0.108	0.242	0.119	0.105
25	37-47		0.241	0.187	0.058	0.153	0.506	0.176	0.270
26	10-20		0.155	0.092	0.027	0.106	0.221	0.104	0.096
27	10-20		0.165	0.114	0.024	0.117	0.222	0.120	0.112
28	10-20		0.273	0.095	0.037	0.157	0.292	0.173	0.154
29	10-20		0.305	0.067	0.050	0.135	0.394	0.194	0.137
29	30-40		0.904	0.110	0.163	0.477	1.009	0.581	0.345
29	80-90		0.028	0.067	0.021	0.021	0.117	0.212	0.003
30	10-20		0.376	0.070	0.065	0.191	0.475	0.230	0.158

30	50-60		0.006	0.065	0.006	0.011	0.084	0.087	0.003
33	10-20		0.204	0.143	0.032	0.137	0.312	0.164	0.102
33	30-40		0.325	0.137	0.082	0.201	0.345	0.188	0.181
33	50-60		0.203	0.120	0.035	0.114	0.259	0.125	0.126
33	87-97		0.516	0.135	0.077	0.284	0.516	0.347	0.220
34	10-20		0.433	0.084	0.075	0.245	0.544	0.288	0.189
34	50-60		0.366	0.070	0.069	0.198	0.432	0.262	0.174
35	10-20		0.235	0.119	0.027	0.134	0.380	0.189	0.142
35	30-40		0.147	0.073	0.018	0.061	0.252	0.114	0.090
36	10-20		0.191	0.097	0.030	0.120	0.323	0.188	0.141
37	10-20		0.133	0.101	0.015	0.080	0.227	0.105	0.066
37	40-50		0.300	0.134	0.065	0.186	0.370	0.182	0.161
38	10-20		0.345	0.149	0.042	0.189	0.418	0.232	0.166
38	30-40		0.295	0.101	0.040	0.156	0.382	0.179	0.126
38	59-69		0.289	0.080	0.050	0.182	0.314	0.200	0.171
		MDL_min	0.002	0.044	0.002	0.008	0.034	0.003	0.002
		MDL_max	0.007	0.119	0.004	0.020	0.091	0.009	0.006

Station	depth	Congener #	77110	82	151	135144	107	123149	118	134
1	5-15		2.844	0.279	0.870	0.569	0.322	2.433	1.614	0.374
2	4-14		0.937	0.323	0.357	0.214	0.093	1.004	0.658	0.230
3	8-18		0.394	0.073	0.178	0.093	0.027	0.501	0.245	0.125
4	0-10		0.801	0.126	0.268	0.195	0.083	0.858	0.535	0.184
5	0-10		0.243	0.160	0.198	0.132	0.205	0.506	0.120	0.151
6	0-10		3.290	0.358	1.372	0.933	0.286	3.989	1.725	0.622
7	0-10		0.704	0.118	0.262	0.159	0.075	0.739	0.459	0.127
8	0-10		0.665	0.110	0.215	0.139	0.078	0.637	0.440	0.146
9	0-10		0.710	0.118	0.267	0.179	0.078	0.824	0.424	0.133
10	0-10		4.017	0.388	1.023	0.732	0.502	2.904	2.319	0.430
11	10-20		0.823	0.289	0.408	0.209	0.069	1.048	0.673	0.244
12	4-14		0.532	0.050	0.113	0.081	0.055	0.356	0.393	0.127
13	5-15		1.066	0.181	0.325	0.184	0.107	0.983	0.765	0.210
14	5-15		0.686	0.186	0.416	0.212	0.049	1.096	0.484	0.201
15	10-20		0.635	0.226	0.281	0.152	0.069	0.791	0.492	0.264
16	0-10		0.505	0.052	0.106	0.068	0.039	0.340	0.274	0.115
17	3-13		0.418	0.050	0.096	0.072	0.045	0.279	0.282	0.114
18	6-16		0.023	0.008	0.014	0.009	0.007	0.026	0.015	0.118
19	3-13		0.332	0.089	0.148	0.080	0.025	0.452	0.259	0.168
20	3-13		0.700	0.196	0.327	0.187	0.071	0.852	0.510	0.159
21	20-30		0.444	0.076	0.444	0.222	0.032	1.101	0.227	0.156
22	10-20		0.577	0.206	0.252	0.136	0.063	0.739	0.379	0.185
23	20-30		0.915	0.355	0.322	0.175	0.065	0.891	0.661	0.198
24	0-10		0.666	0.249	0.295	0.180	0.067	0.842	0.513	0.229
25	37-47		1.057	0.241	0.623	0.375	0.123	1.660	0.767	0.207
26	10-20		0.587	0.188	0.290	0.163	0.064	0.758	0.418	0.236
27	10-20		0.647	0.157	0.304	0.170	0.067	0.801	0.435	0.188
28	10-20		0.917	0.309	0.454	0.241	0.085	1.158	0.634	0.244
29	10-20		0.908	0.083	0.362	0.246	0.126	1.169	0.579	0.158
29	30-40		3.063	0.328	0.697	0.501	0.300	2.015	1.693	0.312
29	80-90		0.104	0.036	0.031	0.015	0.015	0.048	0.032	0.171
30	10-20		1.167	0.149	0.403	0.281	0.123	1.260	0.666	0.184

30	50-60		0.025	0.016	0.015	0.007	0.014	0.019	0.021	0.167
33	10-20		0.861	0.235	0.354	0.211	0.121	0.961	0.585	0.263
33	30-40		0.960	0.198	0.421	0.242	0.099	1.083	0.522	0.274
33	50-60		0.766	0.169	0.376	0.201	0.050	0.955	0.546	0.219
33	87-97		1.563	0.212	0.530	0.317	0.146	1.510	1.133	0.301
34	10-20		1.494	0.189	0.473	0.289	0.123	1.388	0.930	0.304
34	50-60		1.319	0.133	0.406	0.254	0.120	1.189	0.803	0.179
35	10-20		0.916	0.229	0.417	0.233	0.088	1.151	0.631	0.305
35	30-40		0.584	0.086	0.234	0.137	0.039	0.730	0.374	0.187
36	10-20		0.783	0.163	0.403	0.213	0.070	1.055	0.521	0.248
37	10-20		0.442	0.191	0.187	0.116	0.035	0.580	0.324	0.259
37	40-50		0.883	0.322	0.386	0.232	0.096	1.046	0.578	0.201
38	10-20		1.134	0.388	0.429	0.262	0.105	1.337	0.807	0.247
38	30-40		0.944	0.314	0.417	0.249	0.100	1.200	0.682	0.240
38	59-69		1.092	0.250	0.551	0.320	0.105	1.652	0.657	0.205
		MDL_min	0.007	0.007	0.000	0.005	0.007	0.005	0.008	0.114
		MDL_max	0.018	0.020	0.000	0.013	0.019	0.013	0.021	0.305

Station	depth	Congener #	146	132153105	141	137130176	163138	158	129178
1	5-15		0.846	5.979	1.091	0.505	4.666	0.623	0.612
2	4-14		0.429	2.923	0.471	0.076	1.923	0.528	0.378
3	8-18		0.134	1.258	0.205	0.024	0.812	0.287	0.168
4	0-10		0.273	2.161	0.281	0.042	1.359	0.423	0.256
5	0-10		0.149	0.899	0.165	0.236	0.514	0.639	0.445
6	0-10		1.392	8.454	1.581	0.505	5.746	0.754	1.076
7	0-10		0.202	1.630	0.185	0.015	1.095	0.292	0.395
8	0-10		0.214	1.497	0.176	0.036	0.942	0.336	0.131
9	0-10		0.252	1.763	0.257	0.048	1.104	0.306	0.155
10	0-10		1.029	7.711	1.428	0.684	6.427	0.638	0.690
11	10-20		0.363	2.619	0.413	0.127	1.871	0.562	0.232
12	4-14		0.164	1.249	0.150	0.020	0.760	0.292	0.063
13	5-15		0.321	2.470	0.398	0.051	1.740	0.482	0.332
14	5-15		0.277	2.552	0.498	0.103	1.681	0.463	0.270
15	10-20		0.246	1.903	0.295	0.031	1.303	0.607	0.200
16	0-10		0.089	0.729	0.129	0.013	0.463	0.265	0.013
17	3-13		0.088	0.712	0.116	0.009	0.566	0.262	0.097
18	6-16		0.092	0.163	0.008	0.000	0.033	0.272	0.018
19	3-13		0.140	1.333	0.240	0.029	0.897	0.387	0.140
20	3-13		0.207	1.821	0.334	0.082	1.409	0.366	0.252
21	20-30		0.241	2.349	0.492	0.090	1.491	0.309	0.177
22	10-20		0.228	1.648	0.266	0.038	1.127	0.426	0.172
23	20-30		0.291	2.240	0.368	0.103	1.657	0.456	0.262
24	0-10		0.209	2.046	0.313	0.154	1.362	0.527	0.241
25	37-47		0.167	1.440	0.325	0.213	1.020	0.476	0.186
26	10-20		0.241	1.971	0.312	0.085	1.240	0.543	0.228
27	10-20		0.251	2.055	0.325	0.098	1.324	0.433	0.286
28	10-20		0.337	2.679	0.434	0.094	1.865	0.561	0.314
29	10-20		0.424	2.791	0.322	0.174	2.067	0.363	0.338
29	30-40		0.694	4.683	0.807	0.394	3.877	0.473	0.530
29	80-90		0.133	0.236	0.017	0.021	0.059	0.394	0.023
30	10-20		0.458	2.968	0.374	0.199	2.121	0.386	0.370

30	50-60		0.129	0.229	0.019	0.080	0.033	0.383	0.011
33	10-20		0.266	2.199	0.356	0.085	1.486	0.604	0.302
33	30-40		0.375	2.879	0.594	0.198	2.185	0.630	0.695
33	50-60		0.267	2.528	0.439	0.090	1.664	0.503	0.308
33	87-97		0.464	3.649	0.624	0.329	2.965	0.493	0.537
34	10-20		0.515	3.767	0.480	0.222	2.883	0.495	0.424
34	50-60		0.377	2.813	0.407	0.137	2.061	0.411	0.248
35	10-20		0.400	2.957	0.459	0.168	1.906	0.701	0.374
35	30-40		0.199	1.787	0.275	0.042	1.112	0.430	0.229
36	10-20		0.322	2.515	0.410	0.130	1.682	0.570	0.329
37	10-20		0.201	2.827	0.226	0.025	0.796	0.595	0.198
37	40-50		0.276	2.266	0.323	0.084	1.488	0.462	0.477
38	10-20		0.404	2.907	0.405	0.118	1.984	0.567	0.382
38	30-40		0.381	2.793	0.401	0.093	1.718	0.553	0.349
38	59-69		0.463	3.494	0.524	0.010	1.933	0.472	0.606
		MDL_min	0.088	0.157	0.000	0.000	0.005	0.262	0.007
		MDL_max	0.237	0.420	0.000	0.000	0.014	0.701	0.020

Station	depth	Congener #	187182	183	128	185	174	177	202171156	157200
1	5-15		1.962	1.112	0.445	0.186	1.548	0.902	1.229	0.736
2	4-14		0.982	0.459	0.230	0.072	0.587	0.575	0.853	0.333
3	8-18		0.508	0.179	0.055	0.036	0.288	0.249	0.356	0.115
4	0-10		0.849	0.304	0.123	0.064	0.466	0.491	0.640	0.188
5	0-10		0.738	0.370	0.098	0.102	0.726	0.295	1.296	1.447
6	0-10		2.998	1.645	0.679	0.380	2.025	1.552	1.252	0.534
7	0-10		0.631	0.194	0.131	0.040	0.280	0.326	0.373	0.122
8	0-10		0.561	0.219	0.116	0.037	0.226	0.255	0.320	0.075
9	0-10		0.602	0.255	0.157	0.049	0.314	0.299	0.350	0.120
10	0-10		2.296	1.435	0.668	0.230	1.782	1.084	1.464	0.779
11	10-20		0.877	0.400	0.184	0.074	0.533	0.459	0.583	0.167
12	4-14		0.286	0.116	0.063	0.020	0.113	0.108	0.155	0.037
13	5-15		0.941	0.356	0.161	0.070	0.507	0.493	0.725	0.300
14	5-15		0.838	0.480	0.136	0.089	0.603	0.442	0.438	0.133
15	10-20		0.000	0.248	0.105	0.054	0.404	0.325	0.438	0.163
16	0-10		0.202	0.089	0.037	0.006	0.117	0.080	0.123	0.045
17	3-13		0.226	0.121	0.044	0.014	0.105	0.074	0.130	0.032
18	6-16		0.036	0.017	0.024	0.000	0.017	0.014	0.028	0.025
19	3-13		0.662	0.336	0.073	0.066	0.388	0.349	0.374	0.070
20	3-13		0.648	0.330	0.131	0.053	0.410	0.325	0.466	0.116
21	20-30		0.670	0.486	0.132	0.114	0.598	0.402	0.355	0.100
22	10-20		0.623	0.252	0.104	0.045	0.384	0.297	0.538	0.181
23	20-30		0.830	0.374	0.165	0.053	0.521	0.429	0.785	0.080
24	0-10		0.757	0.274	0.116	0.058	0.463	0.422	0.612	0.229
25	37-47		0.563	0.332	0.075	0.058	0.386	0.311	0.748	0.212
26	10-20		0.734	0.294	0.102	0.054	0.431	0.383	0.690	0.139
27	10-20		0.818	0.398	0.109	0.068	0.468	0.368	0.664	0.151
28	10-20		1.101	0.563	0.152	0.076	0.667	0.565	0.941	0.355
29	10-20		0.929	0.468	0.347	0.276	0.609	0.448	0.461	0.227
29	30-40		1.402	0.812	0.565	0.112	0.967	0.675	0.973	0.448
29	80-90		0.048	0.048	0.031	0.023	0.017	0.025	0.061	0.000
30	10-20		0.918	0.499	0.294	0.104	0.615	0.459	0.534	0.263

30	50-60		0.028	0.005	0.009	0.008	0.009	0.011	0.032	0.021
33	10-20		0.817	0.426	0.123	0.055	0.435	0.422	0.764	0.191
33	30-40		1.154	0.559	0.171	0.084	0.559	0.731	1.108	0.164
33	50-60		0.947	0.409	0.125	0.079	0.601	0.483	0.672	0.151
33	87-97		1.279	0.691	0.309	0.113	0.931	0.687	0.975	0.406
34	10-20		1.328	0.630	0.308	0.091	0.773	0.592	0.700	0.351
34	50-60		0.959	0.404	0.154	0.059	0.624	0.423	0.529	0.189
35	10-20		1.123	0.458	0.142	0.087	0.695	0.564	0.848	0.283
35	30-40		0.717	0.266	0.083	0.041	0.398	0.288	0.450	0.169
36	10-20		0.971	0.424	0.121	0.076	0.630	0.501	0.811	0.273
37	10-20		0.542	0.188	0.054	0.043	0.329	0.236	0.322	0.098
37	40-50		0.855	0.432	0.165	0.064	0.501	0.512	0.738	0.260
38	10-20		1.146	0.502	0.258	0.078	0.565	0.542	0.851	0.252
38	30-40		1.008	0.460	0.223	0.069	0.541	0.522	0.714	0.158
38	59-69		1.574	0.640	0.228	0.103	0.749	0.594	0.755	0.279
		MDL_min	0.000	0.000	0.000	0.000	0.006	0.004	0.005	0.000
		MDL_max	0.000	0.000	0.000	0.000	0.017	0.010	0.014	0.000

Station	depth	Congener #	172197	180	193	191	199	170190	198	201
1	5-15		0.412	3.653	0.549	0.128	0.377	2.695	0.199	2.937
2	4-14		0.235	1.527	1.509	0.119	0.486	1.298	0.126	1.479
3	8-18		0.103	0.760	0.274	0.026	0.264	0.566	0.028	0.664
4	0-10		0.142	1.163	0.269	0.037	0.390	0.904	0.060	1.214
5	0-10		0.149	0.816	0.489	0.063	0.374	0.631	0.392	5.521
6	0-10		0.629	5.216	0.512	0.149	0.396	4.090	0.139	2.812
7	0-10		0.131	0.801	0.241	0.046	0.269	0.628	0.033	0.785
8	0-10		0.088	0.662	0.147	0.018	0.309	0.518	0.037	0.661
9	0-10		0.117	0.845	0.152	0.017	0.282	0.662	0.048	0.912
10	0-10		0.516	4.547	0.614	0.174	0.379	3.553	0.218	3.025
11	10-20		0.233	1.552	1.191	0.102	0.517	1.361	0.084	0.907
12	4-14		0.048	0.455	0.138	0.008	0.269	0.313	0.013	0.267
13	5-15		0.162	1.287	0.454	0.036	0.444	1.063	0.104	1.843
14	5-15		0.188	1.606	0.875	0.041	0.426	1.304	0.036	0.650
15	10-20		0.112	2.145	0.106	0.033	0.559	0.954	0.075	1.035
16	0-10		0.025	0.318	0.087	0.015	0.244	0.249	0.023	0.316
17	3-13		0.030	0.289	0.140	0.008	0.241	0.221	0.010	0.205
18	6-16		0.000	0.025	0.048	0.000	0.251	0.027	0.003	0.106
19	3-13		0.132	1.307	0.436	0.034	1.328	0.977	0.029	0.630
20	3-13		0.110	1.168	0.547	0.030	0.337	0.917	0.026	0.678
21	20-30		0.176	1.547	0.233	0.078	0.285	1.136	0.032	0.545
22	10-20		0.122	0.991	0.432	0.029	0.392	0.741	0.057	1.330
23	20-30		0.161	1.378	1.060	0.053	0.420	1.095	0.049	0.828
24	0-10		0.130	1.201	0.831	0.041	0.486	1.007	0.068	1.111
25	37-47		0.000	0.963	0.651	0.000	0.438	1.215	0.058	0.941
26	10-20		0.113	1.195	0.890	0.064	0.500	0.894	0.054	1.158
27	10-20		0.163	1.186	1.000	0.027	0.399	0.965	0.092	1.423
28	10-20		0.252	1.601	0.927	0.071	0.517	1.249	0.088	1.917
29	10-20		0.190	1.460	0.170	0.056	0.334	1.148	0.097	0.890
29	30-40		0.311	2.308	0.346	0.082	0.318	1.822	0.125	2.222
29	80-90		0.000	0.032	0.069	0.027	0.362	0.098	0.018	0.157
30	10-20		0.181	1.478	0.232	0.066	0.355	1.265	0.119	1.309

30	50-60		0.000	0.017	0.067	0.000	0.353	0.013	0.000	0.019
33	10-20		0.211	1.262	1.177	0.061	0.557	0.949	0.054	1.280
33	30-40		0.170	1.585	0.895	0.055	0.580	1.270	0.083	1.693
33	50-60		0.177	1.458	0.670	0.034	0.463	1.161	0.050	1.219
33	87-97		0.308	2.226	0.778	0.111	0.454	1.861	0.095	1.959
34	10-20		0.268	1.941	0.322	0.046	0.455	1.469	0.086	1.740
34	50-60		0.200	1.530	0.248	0.038	0.378	1.167	0.053	1.256
35	10-20		0.267	1.701	1.020	0.061	0.646	1.343	0.063	1.570
35	30-40		0.126	0.944	0.293	0.025	0.396	0.674	0.040	1.091
36	10-20		0.173	1.429	0.678	0.043	0.525	1.181	0.081	1.716
37	10-20		0.090	0.742	0.401	0.030	0.548	0.631	0.061	0.984
37	40-50		0.222	1.275	0.669	0.086	0.426	1.121	0.111	1.417
38	10-20		0.231	1.622	0.922	0.059	0.522	1.200	0.083	1.774
38	30-40		0.190	1.394	0.648	0.050	0.509	1.049	0.070	1.358
38	59-69		0.316	1.967	0.395	0.091	0.434	1.403	0.079	2.050
		MDL_min	0.000	0.000	0.046	0.000	0.241	0.000	0.000	0.000
		MDL_max	0.000	0.000	0.122	0.000	0.646	0.000	0.000	0.000

Station	depth	Congener #	203196	189	208195	207	194	205	206	209
1	5-15		2.876	0.088	6.924	0.742	0.872	0.306	8.814	7.516
2	4-14		1.288	0.146	0.013	0.389	0.402	0.065	4.849	2.956
3	8-18		0.586	0.023	1.584	0.147	0.161	0.007	2.007	0.223
4	0-10		1.042	0.042	3.235	0.305	0.272	0.012	4.155	0.459
5	0-10		4.094	0.065	22.708	3.002	0.515	0.065	30.343	33.924
6	0-10		2.915	0.138	3.972	0.394	1.115	0.105	3.734	2.497
7	0-10		0.661	0.048	2.087	0.213	0.160	0.011	2.732	1.867
8	0-10		0.567	0.017	1.493	0.168	0.145	0.026	1.838	1.269
9	0-10		0.761	0.015	2.315	0.275	0.183	0.021	2.844	2.108
10	0-10		3.115	0.137	6.325	0.690	1.047	0.101	7.844	7.459
11	10-20		0.999	0.101	1.257	0.107	0.346	0.035	1.299	0.968
12	4-14		0.264	0.015	0.342	0.044	0.073	0.008	0.461	0.278
13	5-15		1.475	0.097	5.659	0.646	0.379	0.062	7.867	7.705
14	5-15		0.816	0.045	0.695	0.045	0.318	0.047	0.641	0.446
15	10-20		0.941	0.084	2.573	0.292	0.341	0.010	3.505	3.208
16	0-10		0.283	0.295	0.647	0.093	0.078	0.013	0.830	0.654
17	3-13		0.185	0.011	0.319	0.033	0.052	0.008	0.474	0.323
18	6-16		0.069	0.000	0.474	0.043	0.011	0.005	0.574	0.050
19	3-13		0.733	0.039	0.883	0.056	0.288	0.016	0.910	0.099
20	3-13		0.734	0.037	1.053	0.096	0.265	0.014	1.192	0.098
21	20-30		0.640	0.031	0.555	0.033	0.261	0.028	0.479	0.045
22	10-20		1.048	0.027	3.876	0.349	0.225	0.010	5.158	0.519
23	20-30		0.897	0.061	0.942	0.064	0.362	0.020	0.952	0.097
24	0-10		0.973	0.034	2.957	0.241	0.307	0.021	3.955	0.457
25	37-47		0.759	0.015	3.260	0.207	0.344	0.109	4.138	0.406
26	10-20		0.889	0.032	3.196	0.236	0.294	0.012	4.284	0.511
27	10-20		1.187	0.030	4.041	0.331	0.323	0.019	5.545	0.697
28	10-20		1.603	0.037	5.595	0.444	0.452	0.033	7.618	0.750
29	10-20		1.182	0.054	1.877	0.249	0.335	0.116	2.046	1.553
29	30-40		1.984	0.131	5.336	0.517	0.562	0.059	6.497	4.254
29	80-90		0.142	0.174	0.476	0.038	0.019	0.026	0.562	0.442
30	10-20		1.418	0.117	3.288	0.441	0.313	0.049	3.933	2.653

30	50-60		0.024	0.074	0.056	0.007	0.008	0.006	0.068	0.092
33	10-20		1.087	0.048	3.909	0.297	0.330	0.027	5.377	0.667
33	30-40		1.343	0.088	5.094	0.359	0.397	0.013	7.129	0.729
33	50-60		1.127	0.039	3.078	0.229	0.348	0.021	4.057	0.437
33	87-97		1.831	0.065	4.803	0.426	0.554	0.024	6.071	0.672
34	10-20		1.566	0.075	0.012	0.355	0.467	0.045	5.858	4.812
34	50-60		1.110	0.047	2.885	0.230	0.308	0.012	3.624	0.430
35	10-20		1.436	0.122	3.629	0.268	0.420	0.027	4.411	0.496
35	30-40		0.898	0.016	2.895	0.247	0.202	0.013	3.796	0.409
36	10-20		1.409	0.053	4.951	0.414	0.355	0.022	6.375	0.854
37	10-20		0.813	0.077	3.381	0.272	0.197	0.022	4.483	0.476
37	40-50		1.197	0.058	3.774	0.401	0.313	0.098	5.039	4.432
38	10-20		1.647	0.061	3.941	0.376	0.450	0.033	5.407	3.388
38	30-40		1.183	0.039	3.490	0.313	0.322	0.020	4.729	3.100
38	59-69		1.945	0.077	4.300	0.449	0.475	0.034	5.628	3.354
		MDL_min	0.000	0.000	0.007	0.005	0.006	0.004	0.004	0.000
		MDL_max	0.000	0.000	0.017	0.013	0.015	0.011	0.011	0.000

APPENDIX B

Phosphate Geochemistry and Microbial Activity in Surface Sediments from the Conowingo Reservoir and Susquehanna Flats, Md.: Summary of Findings

Phosphate Geochemistry and Microbial Activity in Surface Sediments from the Conowingo Reservoir and Susquehanna Flats, MD: Summary of Findings

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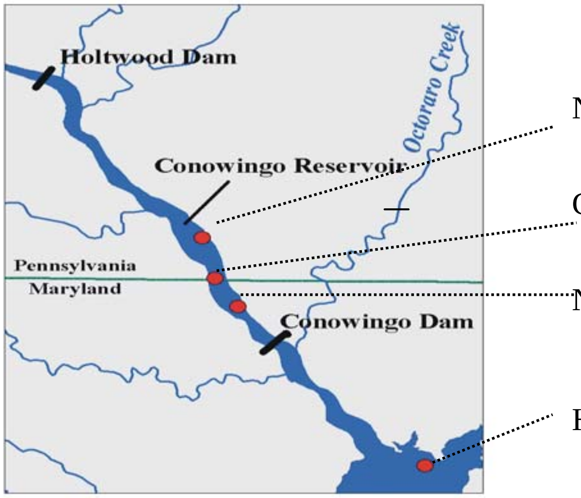
The transport of phosphate is directly related to the transport of sediment. As part of preliminary evaluation of the feasibility of dredging Conowingo Reservoir on the Susquehanna River, Pa., a characterization study was initiated that included a description of phosphorus biogeochemistry in the reservoir. Analyses included determination of total phosphorus and interstitial water phosphate concentrations, and phase association of phosphate from sequential extraction data. In addition, an evaluation was made of the antibiotic sensitivity of *in situ* bacteria.

Three box cores were collected in May 2000. To provide data for comparison of the characteristics of sediment that has been transported beyond the dam with the characteristics of sediment retained behind the dam, a fourth box core was collected at the mouth of the Susquehanna River, Md., near Havre de Grace in August 2000. The box corer collects surface material to a depth of 20 cm (8-inches) without compactions of the sediment.

Sampling locations are shown in Figure 1.

Sampling sites and characteristics of samples:
(1) Near the shoreline of the reservoir north of Peach Bottom. The water was approximately 0.5 meter deep. Sediment was very sandy. Centrifugation of sediment did not yield interstitial water.
(2) In the channel of the reservoir across from Broad Creek. Water was approximately 6 meters deep.
(3) North of Conowingo Creek near the shoreline of the reservoir. Water was approximately 6 meters deep.
And in August 2000:
(4) East of Havre de Grace near Furnace Bay, close to the shoreline of the Susquehanna River. Water was approximately 4 meters deep.



North of Peach Bottom - Shoreline Site

Channel at Broad Creek

North of Conowingo Creek – Shoreline Site

Havre de Grace – Shoreline Site near Furnace Bay

Figure 1. Map of Lower Susquehanna River showing Conowingo Reservoir and Sampling Sites.

Summary of the findings of this study.

- Geochemical phase associations and total phosphorus concentrations in the bottom sediments of the Conowingo Reservoir vary with location.

Sequential chemical extractions of sediment can determine how much of the total phosphorus is bound in each geochemical phase (component) in the sediment. Different combinations of chemical solutions indicate slightly different distributions of phosphorus, so the sequential extraction data is said to be 'operationally defined'. Table 1 lists the geochemical phases identified in the sediments collected for this study as determined by sequential extraction of sediment using a modified version of the method of Ruttenberg (1992) and shows the ranges of the percent of the total phosphorus found in the four geochemical phases. Table 1 also gives the conditions under which phosphorus could be released to water from these solid phases.

Figures 2 and 3 show the concentrations of phosphorus in four geochemical phases determined in one-to two-centimeter sections of cores collected at each study site. A bar missing from the sequence is the result of a lost sample. The total phosphorus concentrations in the sediment are the sums of phosphorus associated with all geochemical phases in the sediment. Examination of the graphs shows that the concentrations of total phosphorus are smaller in the core collected from the site in the Susquehanna River past the Conowingo Reservoir and Conowingo dam (Havre de Grace near Furnace Bay) than in sediment from the channel site at Broad Creek or in the sediment from the shoreline site south of Conowingo Creek. Granular coal is present in all of the samples and visual inspection indicates that the sediment from the site north of Peach Bottom contains the largest amount. The granular coal obscures the composition of sediment transported into the reservoir.

Table 1. Geochemical Phases of Phosphorus in Sediment Samples Collected in the Conowingo Reservoir, Pa., and Susquehanna Flats, Md.	**Percent of Total Phosphorus**
Exchangeable phosphate (PO_4): Can be released to water if replaced by another anion	2 to 4
Calcium (Ca)-bound phosphate: Slow release of phosphate if mineral is soluble. Can be transported with suspended solids or formed in bottom sediment.	2 to 20
Phosphate sorbed to Iron (Fe) oxides: Iron oxides release phosphate when: (a) oxidized iron is reduced, Fe^{3+} to Fe^{2+} (b) when hydrogen sulfide produced by bacterial sulfate reduction precipitates iron, or, when sediment is exposed to acidic conditions.	30 to 60
Organic Phosphorus (P) Available when microbes degrade organic matter	30 to 70

- Iron oxide associated phosphorus is the principal geochemical phase in the bottom sediments collected at shoreline sites within the Conowingo Reservoir.

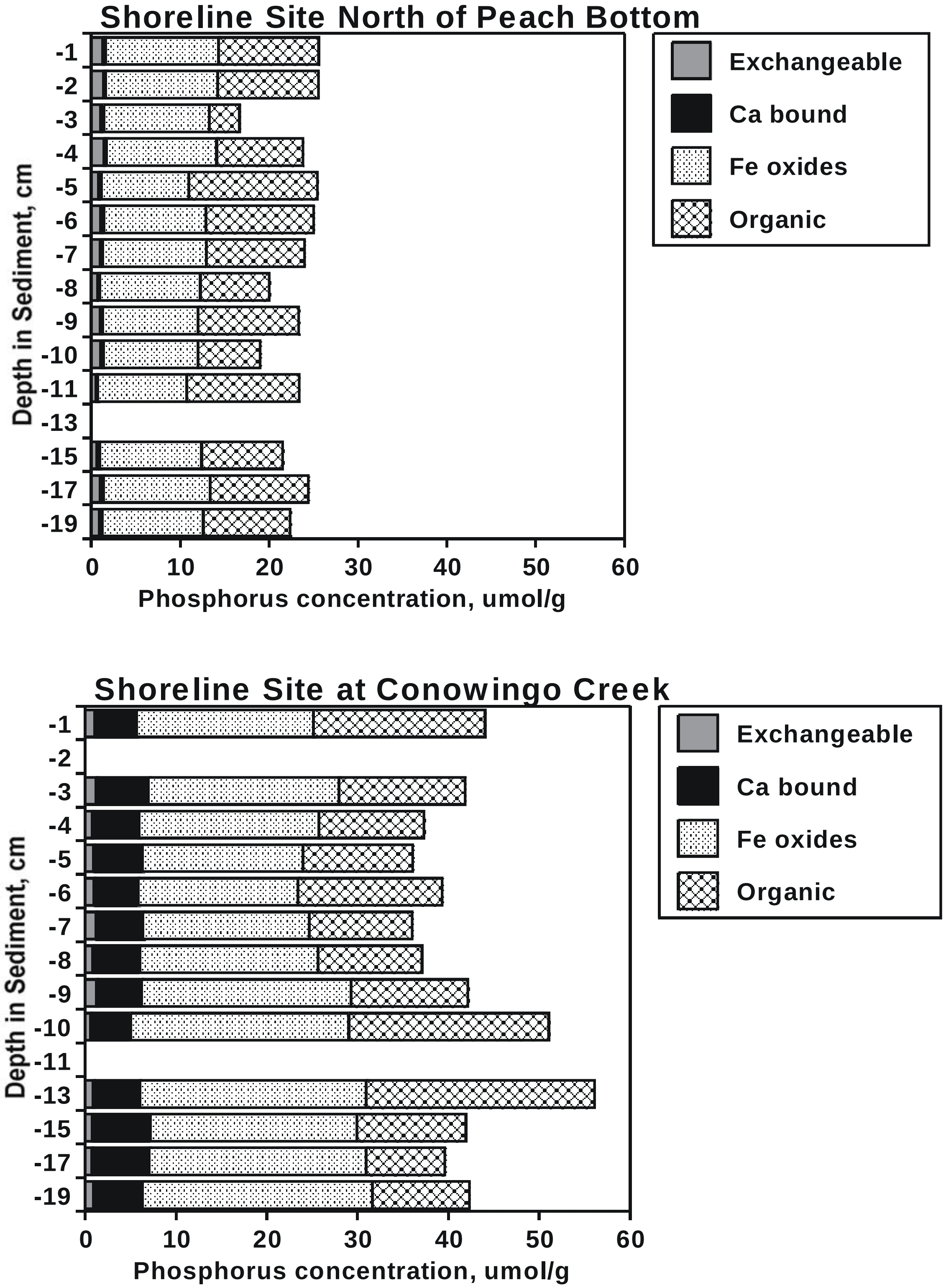


Figure 2. Geochemical Phases of Phosphorus in Sediment Cores Collected north of Peach Bottom and north of Conowingo Creek in the Conowingo Reservoir in May 2000.

- Both iron oxide associated phosphorus and organic phosphorus are important geochemical phases in bottom sediment collected in the channel of Conowingo Reservoir and in bottom sediment collected in the Susquehanna River. Some of the largest concentrations of organic phosphorus found in the samples collected for this study were those in bottom sediments from the channel of the Conowingo Reservoir.

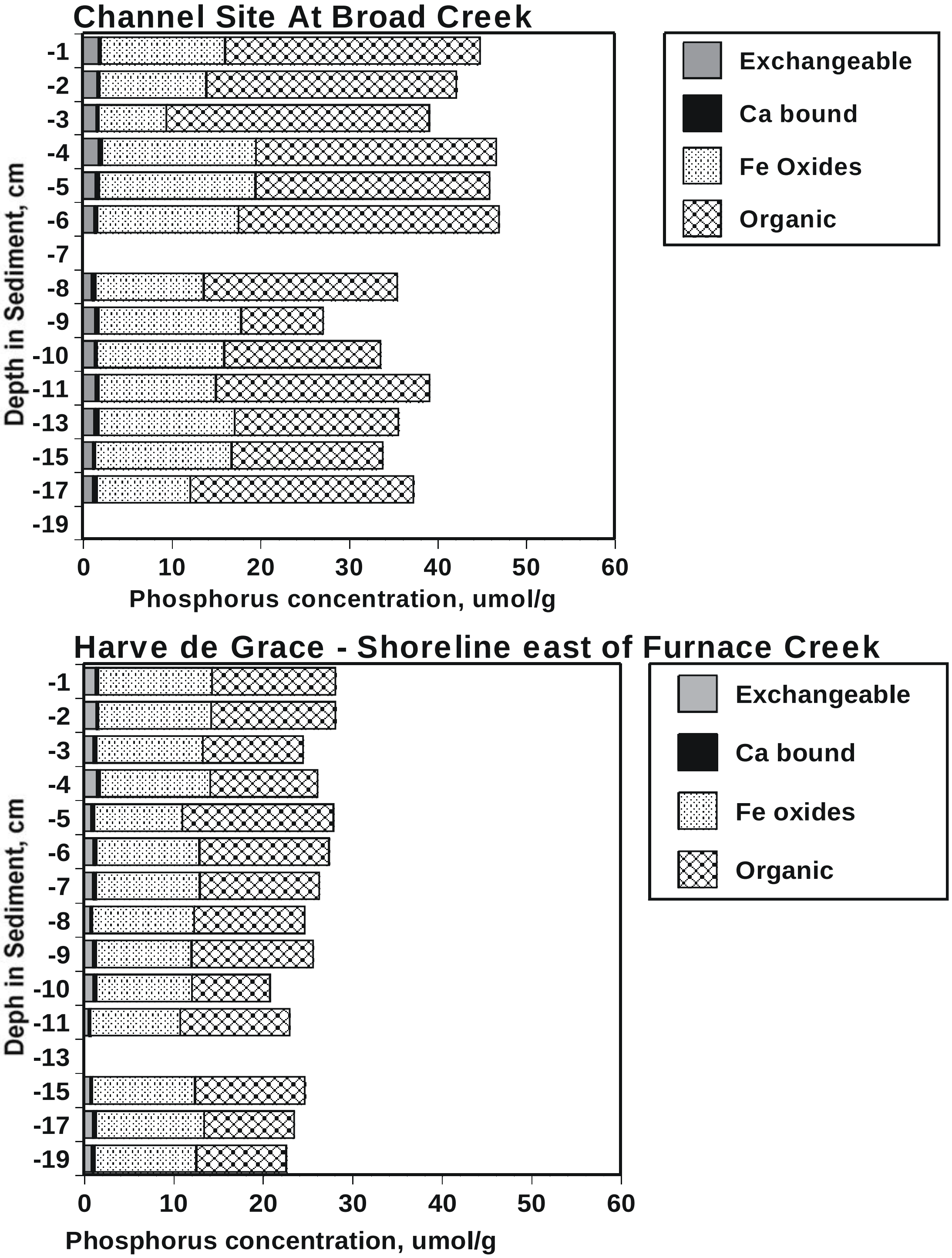


Figure 3. Geochemical Phases of Phosphorus in Sediment Cores collected in the channel of Conowingo Reservoir near Broad Creek and at a shoreline site in the Susquehanna River east of Havre de Grace in May and August 2000.

- The bottom sediments are not a source of dissolved reactive phosphate to the water column of the Conowingo Reservoir.

Water separated from the sediments (interstitial water) collected for this study contains small concentrations of phosphate. There is no increase in phosphate concentration in interstitial water with increase in depth from the sediment-water interface. A concentration gradient with increasing concentrations of phosphate with depth in the sediment indicates movement of dissolved phosphate toward the sediment-water interface and possible release of phosphate to the overlying water. The concentration profiles determined from interstitial water collected from the Conowingo Reservoir and Havre de Grace cores indicates that there is no release of phosphate by diffusive flux from the bottom sediments of Conowingo Reservoir or from the site near Havre de Grace which is in the Susquehanna River beyond the Conowingo Dam. Phosphate concentrations in interstitial water collected from a core taken in Susquehanna Flats approximately 10 kilometers south of Havre de Grace in 1973 are shown in with open circles in Figure 4. The concentrations of phosphate in the interstitial waters of the core collected near Havre de Grace in 2000 are smaller than the concentrations of phosphate in the interstitial waters of the core collected in Susquehanna Flats in 1973.

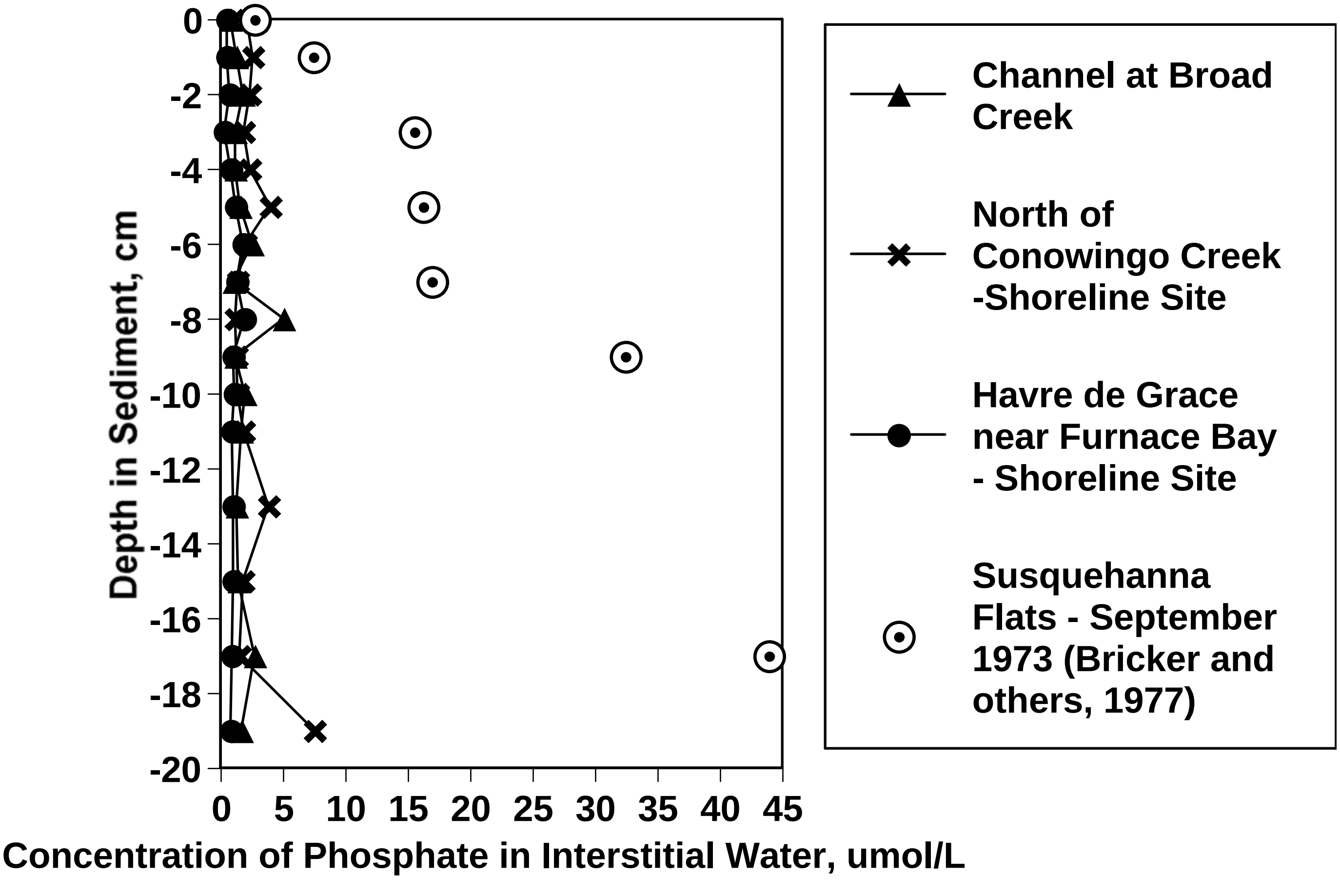


Figure 4. Phosphate concentrations, µmol/L, in sediment interstitial water. Conowingo Reservoir and Havre de Grace samples collected in 2000. Susquehanna Flats samples collected in 1973.

- Bacteria in the sediment that could be cultured in the laboratory were, in general, antibiotic resistant.

Native bacteria from sediment samples collected for this study were tested for sensitivity to five antibiotics. The bacteria in these cultures are mixed populations. Concentrations of antibiotics were the “normal” effective concentrations for inhibition of microbial growth, as well as a significantly higher antibiotic concentration (tetracycline at Havre de Grace – Furnace Bay).

North of Peach Bottom – Shoreline Site

Amoxicillin (33 µg/mL)	R
Penicillin (10 µg/mL)	R
Ampicillin (33 µg/mL)	R
Tetracycline HCl (10 µg/mL)	S
Sulfadimethoxine (250 µg/mL)	I

Broad Creek - Channel

Amoxicillin (33 µg/mL)	R
Penicillin (10 µg/mL)	R
Ampicillin (33 µg/mL)	R
Tetracycline HCl (10 µg/mL)	S
Sulfadimethoxine (250 µg/mL)	R

North of Conowingo Creek – Shoreline Site

Amoxicillin (33 µg/mL)	I
Penicillin (10 µg/mL)	R
Ampicillin (33 µg/mL)	R
Tetracycline HCl (10 µg/mL)	I
Sulfadimethoxine (250 µg/mL)	R

Havre de Grace – Furnace Bay – Shoreline Site

Amoxicillin (33 µg/mL)	R
Penicillin (10 µg/mL)	R
Ampicillin (33 µg/mL)	R
Tetracycline HCl (8 -100 µg/mL)	R
Sulfadimethoxine (250 µg/mL)	R

R = Resistant. Bacteria populations demonstrate similar growth increases in the presence or absence of antibiotic
S = Sensitive. Bacterial population does not increase in the presence of antibiotic.
I = Inhibited. Bacterial population increase was 2-3 orders of magnitude less than the increase of the bacterial population in the control (no antibiotic added to sample).

Bacteria from all sampling sites were resistant to penicillin and ampicillin at the concentrations used in the experiments. The native populations of bacteria in these sediments were sensitive to tetracycline at two of the reservoir sites (north of Peach Bottom and the channel at Broad Creek). Bacterial growth in the sediment collected north of Peach Bottom was inhibited by sulfadimethoxine. In sediment from the site north of Conowingo Creek, also a reservoir site, bacterial growth was inhibited in the presence of tetracycline and amoxicillin. Bacteria in the sediment from the site near Furnace Bay (in the area of Susquehanna Flats east of Havre de Grace) were resistant to all five of the antibiotics at the concentrations that were tested.

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APPENDIX C

Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River: Activities of Anthropogenic Gamma Emitting Isotopes

Characterization of Bed Sediment Behind the Lower Three Dams on the Susquehanna River: Activities of Anthropogenic Gamma Emitting Isotopes

Report to Susquehanna River Basin Commission

UMCES TS-507-06

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Introduction

Potential management actions regarding the rapid infilling of the lower Susquehanna River dams require a characterization of the chemical properties of the underlying sediments. Dams are important sites for the retention of sediments in fluvial ecosystems, often exhibiting high rates of sediment accumulation. Organic contaminants and trace metals are generally the main concerns with regard to contamination in most reservoirs. In the Susquehanna River basin, the presence of two nuclear power plants adds a second level of concern. Nuclides come from ongoing low level inputs and from accidental releases. The high rate of sediment input has lead to the concern that sediment retention by these dams will diminish in the future; this may lead to higher inputs of sediment to the downstream Chesapeake Bay. There appears to be considerable imprecision in the time frame of complete infill (i.e. Hermann et al. 2003), as will as in the estimate of the efficiency of particulate retention (i.e. < 25% from Donoghue et al. 1989 & McClean et al. 1991; >50% from Hermann et al. 2003).

Several key studies have investigated the distribution of reactor nuclides in the lower Susquehanna. Donoghue et al. (1989) and McClean et al. (1991) both used reactor nuclides to estimate sediment accretion and the retention of fine-grained sediment in the lower three reservoirs. Donoghue et al. (1989) used a combination of surface grabs and 6 core profiles to make estimates of retention; McClean et al. (1991) used several core profiles; of 5 cores collected, only 3 were useful for reactor nuclides other than ^{137}Cs. ^{134}Cesium was largely restricted to the top 5-10 cm of sediment.

The question asked by this measurement program is quite different than that of these other studies. This study is focused on the bulk sediment profiles from a contaminant perspective, rather than as a measure of accretion or particle retention efficiency. This is the perspective used in this overall larger study of contaminants (Hill et al. 2000). Thus, we are not doing "traditional" geochronology (i.e. McClean et al. 1991; Owens and Cornwell 1995), but rather are sampling these sediments to best characterize the bulk deposit that might conceivably be dredged. The advantage of this approach is relevance to dredging; the disadvantage, as shown by the metals and organic data, is that we do not develop a sense of time.

Background on Radionuclides

Radioactive decay is a key part of the solar system and has major effects on the present day earth. Primordial nuclides, formed at the "big bang", generate sufficient heat in the earth's core to keep the earth's mantle from solidifying. Substantial amounts of uranium-thorium series nuclides are found in the earth's crust, as well as other nuclides such as the gamma-emitting nuclide ^{40}K. Human exposure to radiation includes sources from space, soils, the atmosphere, and in more recent times, man's activities. Many radionuclides are occluded in minerals (i.e. ^{40}K) or are particle reactive (i.e. ^{137}Cs). The chemical behavior of radionuclides is identical to that of non-radioactive forms of the nuclide. In the case of radioactive metals, they often are strongly particle reactive and most of the metal is retained in particulate form. The accumulation of metals in reservoir sediments such as in the Susquehanna is a major sink for metals in that system. Testing of nuclear weapons in the 1950's and early 1960's spread radioactive isotopes of cesium, strontium, tritium and plutonium throughout the earth's atmosphere, with a fall out onto soils and water. Nuclear power plants can also be sources of radionuclides, even without catastrophic events such as Three Mile Island and Cherbonyl.

Donoghue et al. (1989) identified the nuclides of environmental interest in his paper (Table 1). In this study, we examined our counting data for all of these nuclides, with particular emphasis on ^{134}Cs, ^{137}Cs and ^{60}Co. The short half lives of the nuclides (except ^{137}Cs) results in their rapid decrease to levels below the detection limit. In Figure 1, the releases of nuclides in the late 1970's from the reactors is plotted, with the calculated decay of the nuclides shown over time. Clearly, in the 10 year time frame (i.e. ~15% of the time of existence of these dams) most of the nuclides disappear. Thus, the average deposit in these reservoirs should only have ^{137}Cs; this nuclide first appeared in the 1950's as a consequence of atmospheric testing of fusion weapons.

Table 1. Reactor nuclides (gamma only), half life, and gamma energies. The nuclides in bold have been observed in surface sediments (Donoghue et al. 1989). We checked for all these nuclides in our counting.

Nuclide	Half Life ($T_{1/2}$, days)	Gamma Energies (Kev)
^{110}Ag	252	885
^{58}Co	71	511
^{60}Co	1924	1173
^{134}Cs	752	796
^{137}Cs	11019	662
^{54}Mn	312	835
^{65}Zn	244	1115
^{95}Zr	64	724

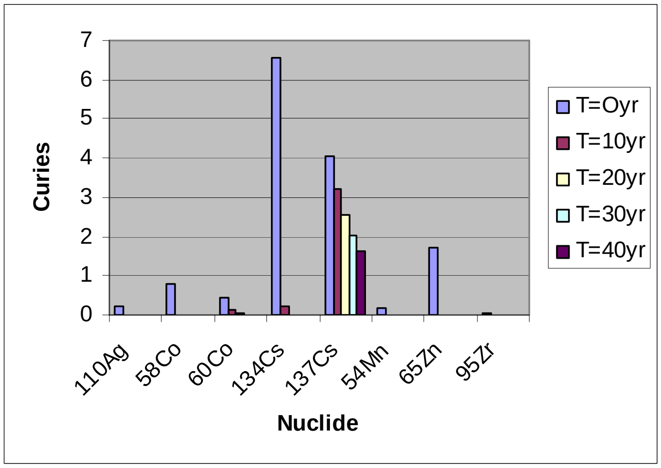
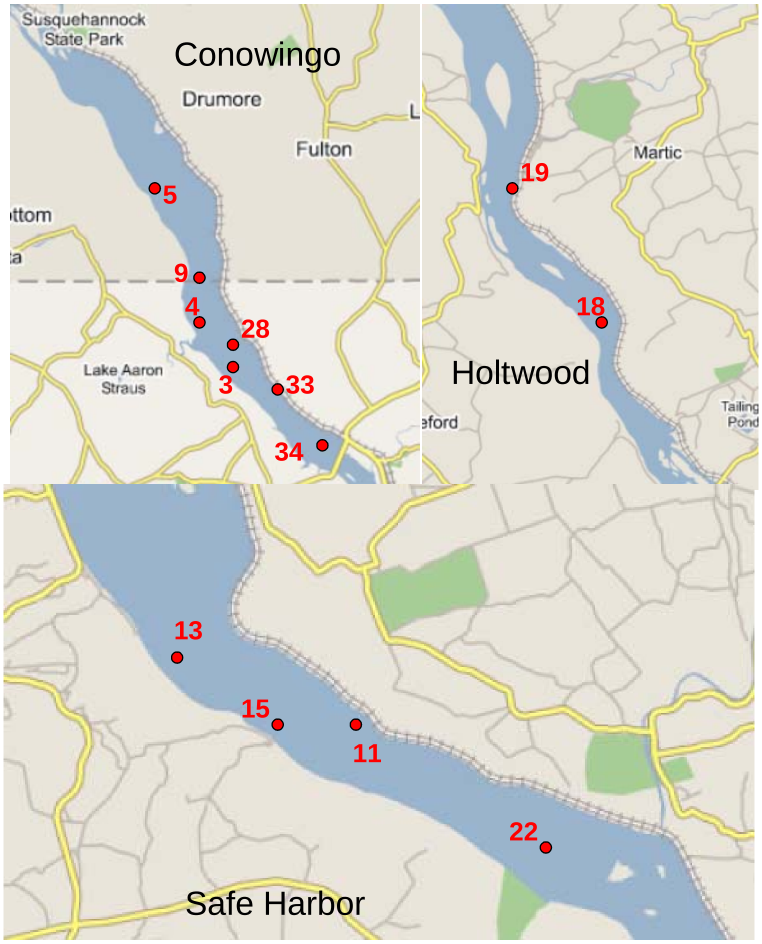


Figure 1. Inputs of reactor nuclides in the late 1990's, as well as their persistence after decay. Note that ^{137}Cs is the main persistent reactor nuclide.

Study Approach

For gamma analysis, I chose 13 sites, averaging 4 samples per site (Figure 2). Sites were chosen to cover a reasonable distribution of locations within each reservoir, with a somewhat greater density of sites in Conowingo because of the inputs from Peach Bottom Atomic Power Station, where somewhat higher activities have been found (McClean et al. 1989).



Methods

Sediment collection methods are detailed in Hill et al. (2000). Sediments were dried at 65°C and powdered using a mortar and pestle. Sediment (20 g) was placed in a plastic jar for counting. A Canberra germanium detector system (planar LeGe) was used for counting. This system was calibrated with a multi gamma source; sediment data were compared to our counts of NIST sediment SRM 4357, a low-level calibrated marine sediment. Samples were generally counted for 24 hours. We did not observe any reactor nuclides in these samples except ^{137}Cs; each spectra was examined for all nuclides in Table 1. In addition, we calibrated ^{226}Ra using the NIST standard. While ^{226}Ra was not of environmental concern, it's relatively constant activity in fine grained muds provided a secondary check of the counting system. We expected 20-30 mBq g^{-1} activities; in our Chesapeake Bay ^{210}Pb dating (i.e. Cornwell et al. 1996), we generally found ^{226}Ra activities of ~25 mBq g^{-1}. The detector we used was optimized for lower energy nuclides and could not measure the higher energy ^{40}K; Donoghue et al. (1979) have shown a relatively constant activity of this primordial nuclide and it does not have other chemical or radiological characteristics. A sediment ^{137}Cs peak is shown in Figure 3.

Counting statistics are shown with the data. We normalized our counting to 24 hour; with shorter counts, identifying the 137Cs peak was more difficult. At non-zero activities < 10 mBq g^{-1}, the counting error averaged 35% of the activity, for activities between 10 and 20 mBq g^{-1} the average counting error was 14% and at activities > 20 mBq g^{-1}, the average counting error decreased to 10%. Two recounts of the NIST SRM 4357 sediment standard for 24 hours yielded ^{137}Cs activities of 10.4±1.6 and 13.3±1.6 mBq g^{-1}, well within the 2.5-97.5% tolerance range (10.3-15.0 mBq g^{-1}). Results for recounts of NIST SRM 4357 for ^{226}Ra were at the high end of the tolerance range (16.3, 15.5 mBq g^{-1} for counts, NIST range = 10.3-15.0), we have not adjusted this data downward.

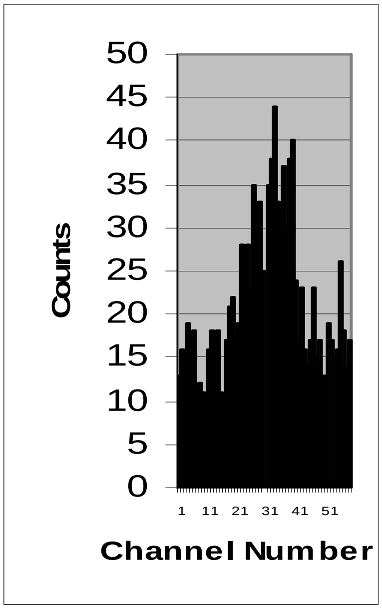


Figure 3. Spectra for ^{137}Cs; the MCA board in the gamma system has > 8,000 channels and this peak is centered at 662 Kev.

Results

The analysis showed a broad range of activities for ^{137}Cs and a limited range for ^{226}Ra (as expected). All data are shown in Table 1, with summary statistics in Table 2. Two histograms were generated from all 52 samples that were counted (Figure 4). We had no measurable 137 activity in 1/5 of the samples, with the most abundant activity range of 5-10 mBq g^{-1}; our sampling emphasized more samples near the sediment surface, so a truly random selection would have resulted in more non-detectable activities. The ^{226}Ra activities were similar in most cores sections, with the average (24±5 mBq g^{-1}) similar to the 25 mBq g^{-1} observed in fine-grained Chesapeake Bay sediments.

Our highest activities (Table 1) were found at SRC-4, near the Peach Bottom Atomic Power Station (PBAPS). This result is consistent with that of McClean et al. (1991) who found higher ^{137}Cs (and ^{134}Cs) near the reactor (their highest activities were ~ 350 mBq g^{-1} with most activities of their core A < 60 mBq g^{-1}). Our SRC-4 core location is further from Peach Bottom than their core and these ^{137}Cs activities are generally about half of the McClean et al. (1991) data. Core SRC-9 is located closer to PBAPS, and the top two sections analyzed have activities about 2/3 of that at SRC-4; the three deeper sections have no measureable activity. A plot of the ^{137}Cs activity versus depth (Figure 5) shows only modest down core change in SRC-3; core SRC-3 showed low activity in the surface and higher activity in deeper sections. Cores SRS-15 and SRH-19 had much lower activities with downcore decreases.

Table 2. Analytical results for ^{137}Cs and ^{226}Ra. The results are report as milli-bequerels per gram (NIST units); these may be converted to dpm per gram by multiplying by 0.060. To convert to pCi per gram, multiply these data by 0.00758. Standard errors are counting errors based on total net counts and background.

Core	Depth (cm)	^{137}Cs	^{137}Cs S.E.	^{226}Ra	^{226}Ra S.E.
		mBq g^{-1}			
SRC-3	0-8	4.14	1.18	24.0	2.0
	51-55	3.99	2.00	23.6	2.1
	70-80	15.77	0.08	31.3	2.1
	100-110	5.92	1.64	24.5	1.8
	125-130	9.47	2.81	33.4	2.7
SRC-4	0-10	29.9	2.9	24.0	1.1
	50-60	42.0	3.7	20.8	2.5
	158-188	36.5	2.9	18.3	1.8
	158-188	31.2	3.1	21.3	2.2
	100-110	28.8	2.5	26.6	2.4
	310-320	35.7	2.2	24.7	2.0
SRC-5	10-20	30.6	2.5	28.3	2.2
	60-73	0.0	0.0	23.7	2.2
	150-160	0.0	0.0	16.1	2.0
	203-313	0.0	0.0	26.0	2.8
SRC-9	10-20	23.18	1.90	20.0	1.6
	90-100	32.00	2.43	31.4	2.2
	170-180	0.00		23.5	1.7
	250-260	0.85	1.51	26.8	1.9
	310-320	0.00		26.8	2.0
SRS-11	10-20	7.0	1.5	24.5	2.2
	40-50	11.5	2.0	25.2	2.7
	75-85	2.7	1.3	21.7	2.0
	115-123	14.1	1.7	25.4	1.9
SRS-13	20-30	7.61	1.68	23.9	1.9
	50-60	11.87	1.85	24.2	1.8
	103-113	0.00		21.3	1.7
SRS-15	5-10	5.8	1.3	21.5	2.1
	40-50	12.2	1.9	26.2	2.8
	80-90	11.1	1.8	25.6	2.0
	120-130	8.6	1.0	22.7	1.6
	155-165	6.4	1.5	13.3	2.0
SRC-18	10-23	2.17	0.72	17.6	1.7
	40-81	0.00		20.2	2.1
SRH-19	3-13	2.1	1.8	21.9	2.7
	50-60	0.0	0.0	21.5	2.1
	90-100	0.0	0.0	24.4	1.6
	130-140	0.0	0.0	24.1	2.3
SRS-22	10-20	7.87	2.31	21.6	2.0
	40-50	6.32	1.38	22.4	1.9
	70-82	8.81	1.51	23.1	1.9
SRC-28	10-20	6.8	1.4	23.5	1.9
	60-70	8.0	1.4	22.9	1.6
	100-110	0.0	0.0	25.0	2.0
	140-150	6.6	1.4	22.2	2.0
SRC-33	10-20	14.9	3.8	44.4	4.1
	40-50	8.0	1.7	23.9	2.0
	50-60	3.5	1.7	26.1	1.9
	87-98	4.8	1.6	22.6	2.1
SRC-34	10-20	5.5	1.7	26.3	2.2
	30-40	9.7	1.9	27.2	2.7
	50-60	9.6	1.9	27.1	2.1

Table 2. Data statistics.

Nuclide	Low	High	Median	Average	Standard Deviation
	Activity (mBq g^{-1})				
^{137}Cs	0	42	7	10	11
^{226}Ra	13	44	24	24	4

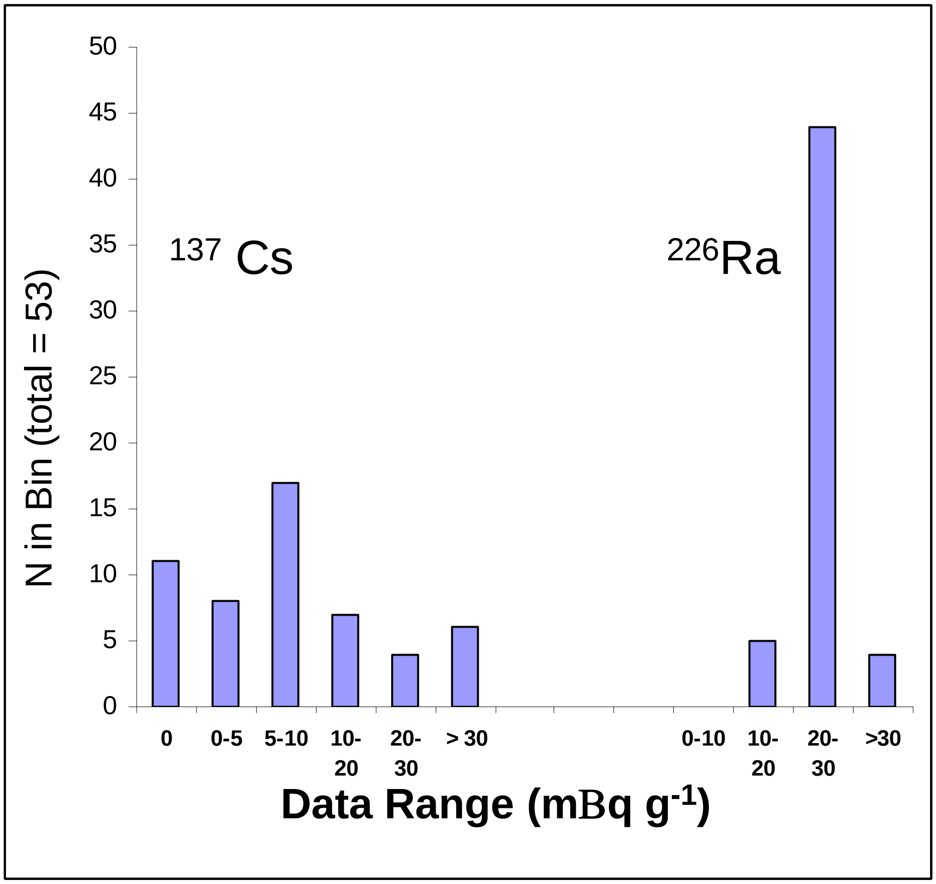


Figure 4. Histogram of ^{137}Cs and ^{226}Ra in Susquehanna reservoir samples (n=50).

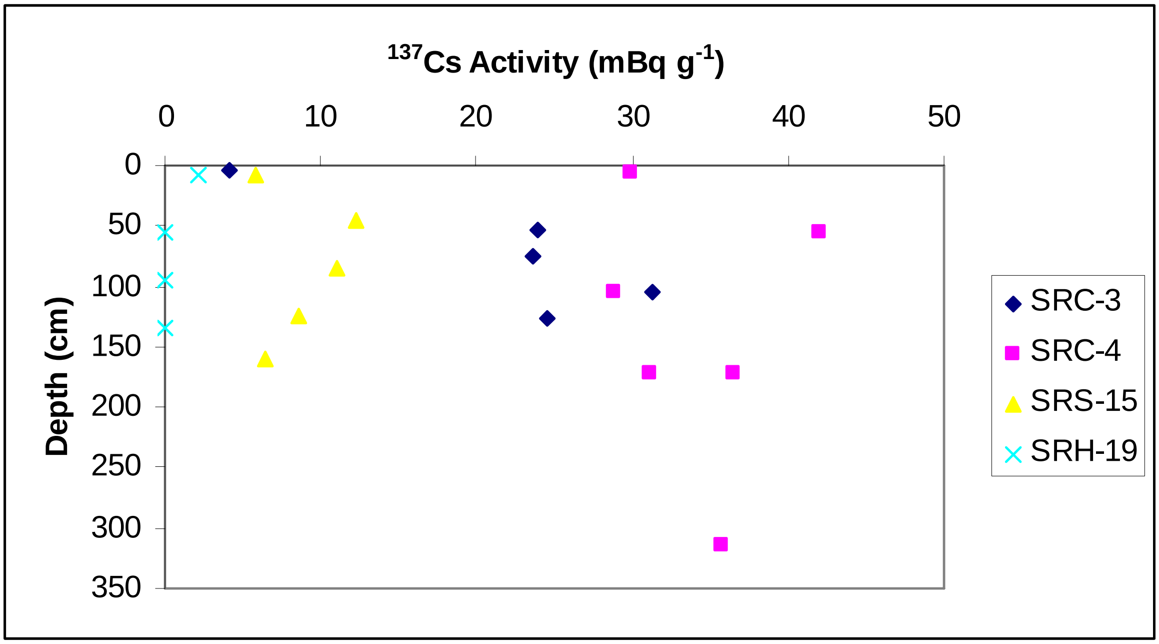


Figure 5. Representative Depth Profiles of ^{137}Cs.

Discussion

The activities of ^{137}Cs found in these reservoir sediments are generally lower than that observed in surficial grabs (Donoghue et al.1989) and lower than the core data from near Peach Bottom (McClean et al. 1991). I did not observed any hot spots of high activity of any other nuclides, suggesting that radionuclide "contamination" is not a likely issue with these sediments. Overall activities are somewhat lower than peaks found in slowly accumulating sediments (i.e. as in lakes; Robbins et al. 1978). A comparison of 137Cs activity with other aquatic systems shows that these numbers are not extraordinary. In two reservoir studies, Van Metre and Callender (1997) and Callender (1997) found maximum137Cs activity of 180 and 60 mBq g^{-1} respectively. In New England softwater lakes, Davis et al. (1984) found peak core ^{137}Cs activity of 800-5,300 mBq g^{-1}; such high activity sediment result from low particulate inputs relative to the atmospheric input of ^{137}Cs. In higher sedimentation sites such as in this study, the overall ^{137}Cs activity on a per gram basis in not especially high because of dilution by the high inputs of particulates.

It would appear that the higher activities near Peach Bottom are a consistent feature of that region (i.e. from this study and others). It is unlikely that such modest activities would have any environmental consequences for sediment placement. Any future sampling for radionuclides in conjunction with dredging assessment would do well to focus on the region near PBAPS.

The issue of mobility of ^{137}Cs in dredge sediment placement is beyond the scope of this report because of the wide range of placement options and unknown nature of the ^{137}Cs-sediment association. Unlike many metals, ^{137}Cs can be somewhat mobile in anaerobic sediments (i.e. Evans et al. 1983; Comans et al. 1989) because of displacement by NH_4^+. Leaching of ^{137}Cs into hydrological systems may be important in highly contaminated systems, but the low activity of these sediments suggest this would not be an issue. Although only of modest relevance to this situation, work on ^{137}Cs contaminated soils at the Idaho National Engineering and Environmental Laboratory have as a goal an activity of ~ 300 mBq g^{-1} before fitting into "residential onsite" criteria. Overall activity from our work, assuming about half of the reservoir sediment is uncontaminated (i.e. deposited before major ^{137}Cs inputs) would be ~5 mBq g^{-1}, a level considerably below what DOE is concerned about at their sites (http://c2d2.eml.doe.gov/ap.cfm?target=ap.cfm&medium=soil&contami=cesium-137&instl=INEL)

Conclusions

- Activities of 110Ag, ^{58}Co, ^{60}Co, ^{134}Cs, ^{54}Mn, ^{65}Zn, and ^{95}Zr were below the limit of detection due to the short half lives of these nuclides.

- The highest activities of ^{137}Cs were found near the Peach Bottom Atomic Power station. These results are consistent with other studies conducted near the reactor.

- It is unlikely that higher activities near Peach Bottom would have any environmental consequences for sediment placement.

- When compared to measured results in other studies (Donoghue et al.1989; McClean et al. 1991), the activities of ^{137}Cs found in this investigation of reservoir sediments were generally lower than activities observed in core data from near Peach Bottom and in surficial grab samples.

- The range of ^{226}Ra activities of 20-30 mBq g^{-1} were similar to ^{226}Ra activities found in other studies in the Chesapeake Bay.

- Hot spots of high activity were not observed suggesting that radionuclide contamination was not a likely issue with these sediments.

Recommendations

In future assessments of contaminants associated with dredging, it would be valuable to composite samples at 50 cm increments (or more), to capture the whole profile. The approached used in this study is useful to identify potential hot spots, but especially with hydraulic dredging, the most relevant number is that which is likely to end up in placement. Dredging will homogenize these profiles and result in a dilution of the higher ^{137}Cs activity sediment with low ^{137}Cs activity sediment. Such compositing is less important for trace metal or trace organic sampling because of the longer record of such contamination. However, the overall low ^{137}Cs activity found in the most enriched samples in this study suggests that the conclusions from the work would be unaffected.

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