Concentrations of contaminants in Dorchester Bay and Boston Harbor sediments collected in the vicinity of CSO discharges and comparison to 1990 concentrations

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FINAL REPORT

Concentrations of Contaminants in Dorchester Bay and Boston Harbor Sediments Collected in 1994 in the Vicinity of CSO Discharges and Comparison to 1990 Concentrations

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SUMMARY

The main goals of this study were to assess the effects of specific CSOs on the concentrations of pollutants in the sediments around the CSOs and to determine if concentrations of these contaminants have declined in Dorchester Bay sediment at specific sampling sites between 1990 and 1994. Two areas of Dorchester Bay were studied: (1) the Old Harbor area, which may receive direct discharge from seven CSOs (BOS-81 through BOS-87), and (2) the area near the Fox Point (BOS-89) and Commercial Point (BOS-90) CSOs, which may receive direct discharge from these two CSOs, BOS-88 and indirect discharge from CSOs upstream of the Neponset River. Several other Boston Harbor sites, outside the Dorchester Bay area, were included in the 1994 sampling. Although the possible sources of pollutants are numerous, pollutant concentrations relative to sites expected to be free of point-source contamination from specific CSO(s) can be used to help determine if certain CSOs are contributing significant amounts of pollutants to the local environment. However, pollutant discharge data for potential sources and reliable Harbor contaminant transport data are necessary to perform definitive assessment of the impact of specific CSOs on the local sedimentary environment.

Bacterial contamination is generally considered to be the primary pollution problem associated with CSOs, and microbiological parameters are most often monitored for assessing pollution from wastewater treatment plants and CSOs, although elevated concentrations of toxic compounds and low dissolved oxygen concentrations are recognized as additional potential problems. In this study, *Clostridium perfringens* spores, sewage tracer organic compounds (LAB and coprostanol), and toxic chemical pollutants (selected organic and metal contaminants) in sediments were studied in relation to specific CSOs. CSOs are never the sole source of any of these pollutants and it is impossible to accurately determine the exact proportion of a pollutant originating from a specific CSO, although relative magnitudes of a pollutant originating at a source may be determined if sufficient information is available. Other potential sources of these pollutants include

- Stormwater not associated with CSOs
- Illegal connections to what should be otherwise uncontaminated storm drains
- Street runoff and runoff/discharge from nearby industrial and commercial activities
- Flow upstream of CSOs
- Sediment release of toxics
- Transport and deposition of pollutants originating elsewhere in the Harbor

The data generated in this study were also compared to data generated in a similar study performed four years ago, and to other historical data to assess if contaminant concentrations have changed in recent years. When reviewing the statistical analysis results, along with the site-mean concentration data, it is surprising how few sites and parameters show statistically significant differences in contaminant concentrations. The low number of sites with significant differences is the result of either (1) lack of "real" differences in parameter values, (2) large intrasite variability for many sites and parameters, and/or (3) relatively high general "background" concentrations.

Organic Contaminants

Elevated concentrations of PAH were measured in the sediment at site DB14, which is located near the Commercial Point CSO (BOS-90). The PAH concentrations were lower at all other sites, including sites nearest to DB14. The PAH concentrations measured at the study sites in 1994 sediment samples were

generally comparable to the concentrations measured in 1990 samples, and were in line with other Boston Harbor sediments that are not influenced by nearby point source. The exception are site DB14 where sediment concentrations were clearly higher in 1994 than in 1990, and site DB01 where lower PAH concentrations were measured in the 1994 sediments.

The data suggest that the sediment at DB14 is, or has recently been, subject to point-source PAH pollution. However, other studies have suggested that this part of Dorchester Bay is an area of significant deposition of pollutants transported from other parts of the Harbor (Gallagher *et al.*, 1992; Stolzenbach *et al.,* 1993; Eganhouse and Sherblom, 1990; Wallace *et al.*, 1991; MDC, 1979; MDEQE, 1986), which may in part explain the elevated PAH concentrations in the sediment. Although CSO BOS-90 may be a major contributor of PAH to the sediment at site DB14, it is also possible that a significant proportion of the elevated PAH concentrations is unrelated to the CSO and originates with activities at the nearby yacht club, local runoff and unidentified discharges, or the result of pollutant transport from other parts of the Harbor. There is insufficient pollutant transport and hydrodynamic information for the area to completely interpret the data with respect to possible sources and to irrefutably identify BOS-90 as a primary source of PAH.

The data suggest that the LAB concentrations at a few sites (CO19, T2, DB13, and DB14) and the coprostanol concentrations at some sites (DB06, DB14, and T2) may be slightly elevated relative to the rest of the Harbor, but the data do not clearly implicate any individual CSO as a likely source. The LAB and coprostanol concentrations in the 1994 samples were generally similar to what had been determined in 1990 and other earlier studies. Slight decreases were observed in LAB and coprostanol at site DB12 and in coprostanol at DB13. The relatively uniform LAB and coprostanol concentrations suggest that the major source(s) of these contaminants are not local CSO point-source(s). Eganhouse and Sherblom (1990) determined that the distribution of organic sewage tracer compounds (LAB and coprostanol) in the Savin Hill Cove area was different from the distribution in discharge from the nearby Fox Point CSO (BOS-89), and suggested that these tracer organic compounds originate in releases from the Nut Island wastewater treatment plant. The data generated in this study are consistent with the Eganhouse and Sherblom observations in that there appear to be important sources of LAB and coprostanol outside of Dorchester Bay. However, the LAB and coprostanol data in this study are insufficient to thoroughly evaluate Dorchester Bay CSO contributions to total LAB and coprostanol in the sediment.

PCB and pesticide (as represented by the DDT compounds) are slightly elevated in the Fox Point/Commercial Point area, as compared to other study site locations. However, the magnitude of the elevation is small and does not implicate any specific CSO as a likely point source. The sediment transport and depositional characteristics of this area that were discussed above may explain the observed results. The concentrations of DDT in the sediment samples collected during the 1994 survey were comparable to historical concentrations, while the data suggest that PCB concentrations have been declining in the past 5 to 10 years.

Metal Contaminants

Elevated concentrations of zinc and lead were measured in the sediment at site DB14 and, to a lesser degree, the concentration of copper was also slightly elevated at this site. The mercury concentrations at site DB03 were slightly higher than at other study sites. Concentrations of most other metals were consistent with what could be expected for Dorchester Bay and Boston Harbor sediments and do not reflect a nearby point source. The data suggest that CSO BOS-90 may contribute to the elevated concentrations of zinc, lead, and copper in the sediment at DB14. However, as with PAH, pollutant transport may be a significant factor contributing to these elevated concentrations. Without an understanding of the transport and deposition of contaminants in the Old Harbor area, definitive conclusions cannot be drawn. The concentrations of several metals apparently declined in the sediment in the Old Harbor area between 1990 and 1994, particularly at site DB01, while concentrations of metals at the other sites are comparable to recent historical data.

The concentrations of metals are slightly higher in the Fox Point/Commercial Point area than at the other studied locations. Wallace *et al.* (1988c) found that sites in this area had the highest particulate cadmium, zinc, lead, and copper concentrations in water samples collected throughout Boston Harbor. Wallace *et al.* (1991) found that concentrations of cadmium, zinc, lead, and copper in sediment from Savin Hill Cove, adjacent to the Fox Point CSO, were among the highest in Boston Harbor. They concluded that the local CSOs contributed little to the elevated metal concentrations and attributed the elevated concentrations to transport from elsewhere in the Harbor. Although the concentrations of certain metals at site DB14 appear to be elevated, the magnitude of the concentration difference is not large enough to confidently identify the Commercial Point CSO as a primary source of these pollutants. Pollutant transport from other parts of the Harbor may be a major factor.

Clostridium perfringens
Densities of *Clostridium perfringens* were slightly elevated at site DB12 — a site expected to be free of point-source pollution — but no data implicate any CSO(s) as the source of this pollutant at any site. The overall data show relatively small differences in *Clostridium perfringens* densities among the study sites, and indicate that the primary source of this contamination is remote to the site locations. The data also indicate that *Clostridium perfringens* densities have generally declined between 1990 and 1994 throughout Dorchester Bay, particularly at site DB14 (near CSO BOS-90 — the Commercial Point CSO), DB13 (near CSO BOS-89 — the Fox Point CSO), and DB04 (near CSO BOS-83). These reductions in *Clostridium perfringens* are likely the result of CSO facility improvements, and the cessation of sludge discharges at the Deer Island and Nut Island treatment plants.

Of the CSOs investigated, the Commercial Point CSO (BOS-90) is the CSO that can be linked to sediment pollution with the greatest degree of confidence. The heightened concentrations of PAH, slightly elevated concentrations of zinc and lead, and possibly also copper, LAB, and coprostanol concentrations suggest that BOS-90 (Commercial Point CSO) may have contributed to the sediment concentrations of these contaminants. However, the Commercial Point CSO cannot be conclusively identified as the primary source of the contaminants. Other possible local sources include the nearby yacht club and street runoff or runoff from nearby industrial activities. Additionally, it is important to bear in mind that the organic and metal contaminants measured in the sediments may have been deposited over several years, and may not necessarily represent contamination from current CSO discharges. It is known that changes in sediment contaminant concentration are a function of a number of variables including, source strength, deposition rates, and proximity to source, and because sediments typically take years to respond to decreases in contaminant loading it is not surprising that the 1994 data are not fully definitive. Furthermore, without reliable Harbor pollutant transport data and hydrodynamic information for the area, one cannot conclusively implicate the CSO as the primary source of these pollutants because earlier investigations have suggested that this is an area where significant amounts of contaminants originating in other parts of the Harbor are deposited.

With the possible exception of PAH at site DB14, the contaminant concentrations measured in the 1994 sediments are mostly similar to, or slightly below, those measured in sediments collected at the same sites in the 1990 Dorchester Bay CSO study or in other previous studies. The data suggest that the sediment PCB concentrations have declined in the past 10 years. The contaminant concentrations in sediment in the Old Harbor area have declined for several parameters (e.g., PAH and metals), and the densities of *Clostridium perfringens* appear to be lower throughout Dorchester Bay, and possibly throughout Boston Harbor, than they were four years ago. The observed sediment quality improvements, particularly with respect to

Clostridium perfringens, can probably be attributed to improvements that have been made at CSO facilities, and the termination of sludge discharges at the Deer Island and Nut Island treatment plants. A decline in the general usage and ubiquity of certain contaminants (e.g., PCB) has probably also contributed to improved sediment quality.

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1.0 INTRODUCTION

During heavy rains, when the extra burden of storm runoff overloads the sewerage systems, combined sewer overflows (CSOs) contribute significantly to the pollution of Boston Harbor and the tributaries flowing into the Harbor. CSO discharge is a mixture of sewage and storm runoff, and can include debris of many types and sizes, as well as microbiological and chemical contaminants. Chemical contaminants may include those from lawn, park, agricultural, and street runoff and from raw sewage.

In November 1990, Battelle conducted a sediment survey to assess the potential impact of CSOs on the sediment quality at selected Dorchester Bay locations (Durell *et al.*, 1991). In August 1994, a second survey was performed in the same general area, with most sites being re-visited. Data were generated to assess changes in sediment quality from 1990 to 1994. In both surveys, sediments were collected close to and remote from known CSO outfalls to determine if the CSOs are likely to significantly impact the local sediment quality.

MWRA proposed to focus on sediments for the sampling and analysis of toxic metals and organic pollutants for this study, as was done in the 1990 CSO survey (Durell *et al.*, 1991). Battelle coordinated and carried out the field work, and conducted and/or coordinated analyses of sediment samples for chemical, microbiological, and physical parameters. This report presents the results from the 1994 survey, considers the apparent impact of the studied CSOs on the local sediment quality, and discusses changes in contaminant concentrations between 1990 and 1994. The study of changes in contaminant concentrations between 1990 and 1994 was of particular interest because significant facility improvements were made to the CSOs in the study area between 1990 and 1994, and because sludge discharges from the wastewater treatment plants ceased in December 1991.

Background Information and Regulatory Context

As part of their monitoring requirements for National Pollutant Discharge Elimination System (NPDES) permits, municipalities and agencies that own CSOs are required to measure the effects of the CSOs on receiving waters. MWRA is charged with the responsibility of overseeing NPDES monitoring of the local municipalities that have CSOs (Boston, Cambridge, Somerville, and Chelsea). To facilitate an integrated approach to monitoring the quality of waters receiving CSO input from several different municipalities, MWRA has agreed to perform the receiving-water monitoring component of the NPDES permit (MWRA, 1989) for the entire CSO receiving-water area.

In the summer of 1989, MWRA began intensive, ongoing water quality surveys of Boston Harbor and its tributary rivers (Rex, 1991; 1993). The water quality monitoring focused on measuring densities of sewage indicator bacteria as well as dissolved oxygen, water temperature, and salinity during wet- and dry-weather conditions. This approach was taken because data collected during 1988 for the MWRA CSO Facilities Plan, and data previously collected by the Department of Environmental Protection (DEP) and the Metropolitan District Commission (MDC) indicated that the most severe CSO-related pollution problem in the water column was contamination with human pathogens present in raw sewage, based on the high numbers of sewage indicator bacteria (fecal coliform and *Enterococcus*).

In the spring of 1990, MWRA and the Boston Water and Sewer Commission (BWSC) began a coordinated monitoring program to measure the flows and pollutant loadings from the BWSC CSOs, and the effects of overflows on nearfield and farfield receiving waters (BWSC, 1990a,b). Substantial system improvements that affects CSO discharges have been made by both MWRA and BWSC in the past five years. These improvements include rigorous tide-gate inspection programs that essentially eliminated dry weather overflows and increases in pumping capacity that allow more of the storm flow to reach the treatment plants, decreasing choking times and, therefore, reducing CSO discharges (MWRA, 1994b). Additional system improvements include the construction of CSO treatment facilities (for bar screening and chlorination) at Fox Point (CSO BOS-89) and Commercial Point (CSO BOS-90); these became operational in the winter of 1989 (before the 1990 survey) and 1990 (after the 1990 survey), respectively. Furthermore, sludge discharges to Boston Harbor from the Deer Island and Nut Island sewage treatment plants ceased in December of 1991; sludge from Nut Island had previously been implicated as one source of linear alkyl benzenes (LABs) and other contaminants to the sediments in Savin Hill Cove in particular (near Fox Point) and in the Dorchester Bay area in general (Gallagher *et al.*, 1992; Egenhouse and Sherblom, 1990; Wallace *et al.*, 1991).

Recent metering improvements and model predictions have increased the understanding of the total system flow of CSOs. Recent predictions estimate an annual CSO volume of approximately 1.1 billion gallons, with approximately 60% being untreated, after the currently planned system improvements, for example improved pumping to the Deer Island treatment facility, have been implemented. This annual volume is substantially lower than the 5 billion gallons predicted for the 1990 Facilities Plan, and also suggests that actual CSO volumes at the present time are substantially lower than predicted earlier (Metcalf & Eddy, 1993).

OBJECTIVES

The primary objectives of this study were to

- Generate data on the sediment quality at specific Dorchester Bay locations in 1994
- Evaluate the potential impact of CSOs on sediment contamination
- Assess changes in sediment contaminant concentrations between 1990 and 1994

These objectives were met by measuring levels of selected contaminants in sediments at sites that were expected to be affected by CSOs and at sites in the same general area that were expected to be relatively free of CSO impact. Data from the 1990 survey (Durell *et al.*, 1991) and the 1994 survey, which are first presented in this report, were compared to determine if sediment contaminant levels have changed in the past four years. This report is intended to be primarily a Dorchester Bay sediment contamination data report with limited data analysis — not an exhaustive contaminant impact assessment study.

2.0 TECHNICAL APPROACH

The information and data presented in Sections 2 and 3 are for the 1994 CSO sediment survey. In Section 4 these data are discussed and compared to data from a survey conducted at the same locations in 1990 (Durell *et al.*, 1991).

Sediment samples were collected from 14 sites, most of which were in the Dorchester Bay region of Boston Harbor. Sample collection, transport, storage, and analysis procedures are described in the applicable survey and work/quality assurance project plan (Battelle, 199; Kropp and Peven, 1993). These 1994 procedures are the same as those used in the field and laboratory for the 1990 CSO survey (Durell *et al.*, 1991). The technical procedures are only briefly summarized in this report; detailed technical descriptions can be found in the referenced survey and work plan.

Sediment samples were analyzed for a number of environmentally important chemical and microbiological parameters. The data were reviewed to determine the differences in sediment quality among sites predicted to have significant CSO input and sites remote from CSO sources. Additionally, the data were compared against data from the earlier 1990 survey to determine if contaminant concentrations have changed.

2.1 SITE SELECTION — RATIONALE AND OBJECTIVES

The locations of the 14 sampling sites selected for this study are indicated in Table 2-1 and Figure 2-1. These sites represent areas expected to be impacted as well as areas unimpacted with respect to the CSOs chosen for investigation. The study focused on the Old Harbor (sites DB01, DB04, and DB06) and Fox Point/Commercial Point (sites DB10, DB11, DB13, and DB14) areas of Dorchester Bay (Figure 2-2).

The entire Old Harbor study area has a depth of less than 6 m at low tide, and most of the Old Harbor has a depth of less than 3 m. Carson Beach, on the northern side of Old Harbor in the Dorchester Bay region of Boston Harbor, has a number of CSOs that discharge into the shallow subtidal zone after heavy rain. The CSO in this area that has the largest discharge volume according to a recent sewer system modeling study is BOS-86 (BWSC, 1991). The second largest discharge volume is from BOS-87 followed by BOS-82, BOS-84, BOS-81, BOS-85, and BOS-83. It is believed that BOS-87 discharges primarily stormwater runoff and little combined sewage (MWRA personal communication). The BOS-87 regulator is located on the west side

Table 2-1. 1994 Sampling Site Locations

Site	Latitude	Longitude	Depth (m)
T1	42°20.95′ N	70°57.81′ W	4.0
T2	42°20.57′ N	71°00.12′ W	6.0
T8	42°17.12′ N	70°54.75′ W	11.0
DB01	42°19.48′ N	71°02.75′ W	1.5
DB03	42°19.30′ N	71°00.86′ W	5.2
DB04	42°19.68′ N	71°02.22′ W	2.7
DB06	42°19.39′ N	71°02.25′ W	2.0
DB10	42°17.50′ N	71°02.33′ W	1.2
DB11	42°17.32′ N	71°02.05′ W	2.4
DB12	42°18.97′ N	71°01.29′ W	6.4
DB13	42°18.60′ N	71°02.50′ W	5.5
DB14	42°17.92′ N	71°02.73′ W	2.0
C019	42°21.55′ N	71°02.71′ W	9.0
SWEX3	42°19.76′ N	71°59.56′ W	8.0

of interstate highway I-93 (Southeast Expressway), and it is relatively high in elevation and rarely allows sewage to overflow. It is, therefore, thought that most of the discharge from BOS-87 is stormwater runoff from the relatively large drainage area (including Day Boulevard and Columbus Park) between the CSO regulator and the point of discharge. The southern side of Old Harbor (sites DB06) receives no direct CSO input and was sampled, along with site DB03, to represent Old Harbor areas relatively free of CSO impact.

The Fox Point/Commercial Point, like the Old Harbor area, generally has a depth of less than 3 m at low tide. This area is affected by two large CSOs — the Fox Point CSO (BOS-89) and the Commercial Point CSO (BOS-90) which handled 37 and 77 million gallons in 1993, respectively (MWRA, 1994a). Two smaller CSOs in this area (BOS-88 and BOS-93) discharge significantly lower volumes. Site DB13 was located near the discharge from the Fox Point CSO. The waste stream from the Fox Point CSO has been screened and chlorinated since 1989. Site DB14 was selected to provide information on the effect of the effluent from BOS-90 (Commercial Point) on nearby sediments. A CSO treatment facility that screens and chlorinates the BOS-90 effluent became operational in the winter of 1990. As part of the monitoring study near Commercial Point, MWRA has located sites near Pine Neck Creek (site DB10) and the mouth of the Neponset River (site DB11) to assess the relative contributions of these potential sources of pollution to the Commercial

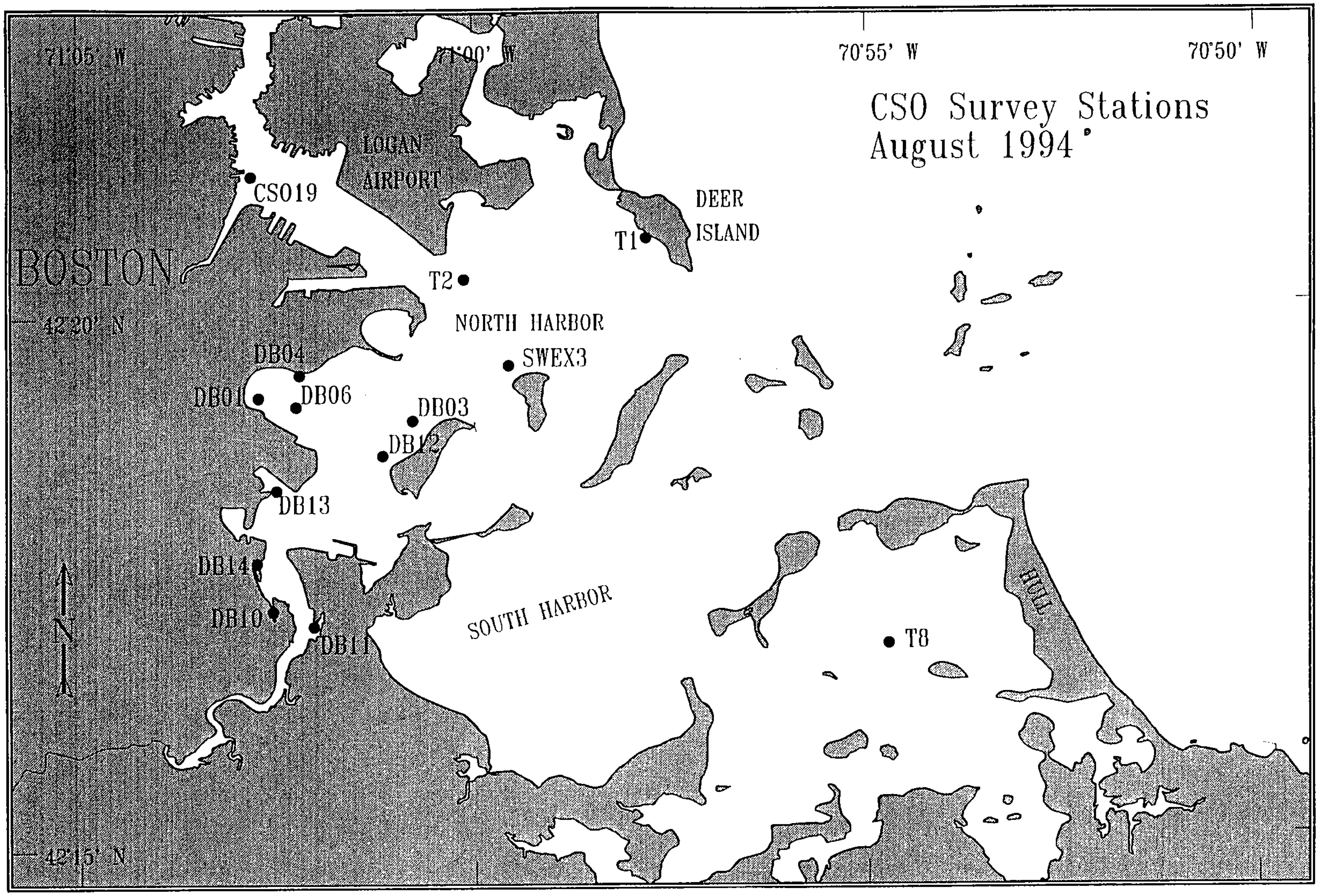


Figure 2-1. Boston Harbor Study Area and Approximate Locations of Sampling Sites

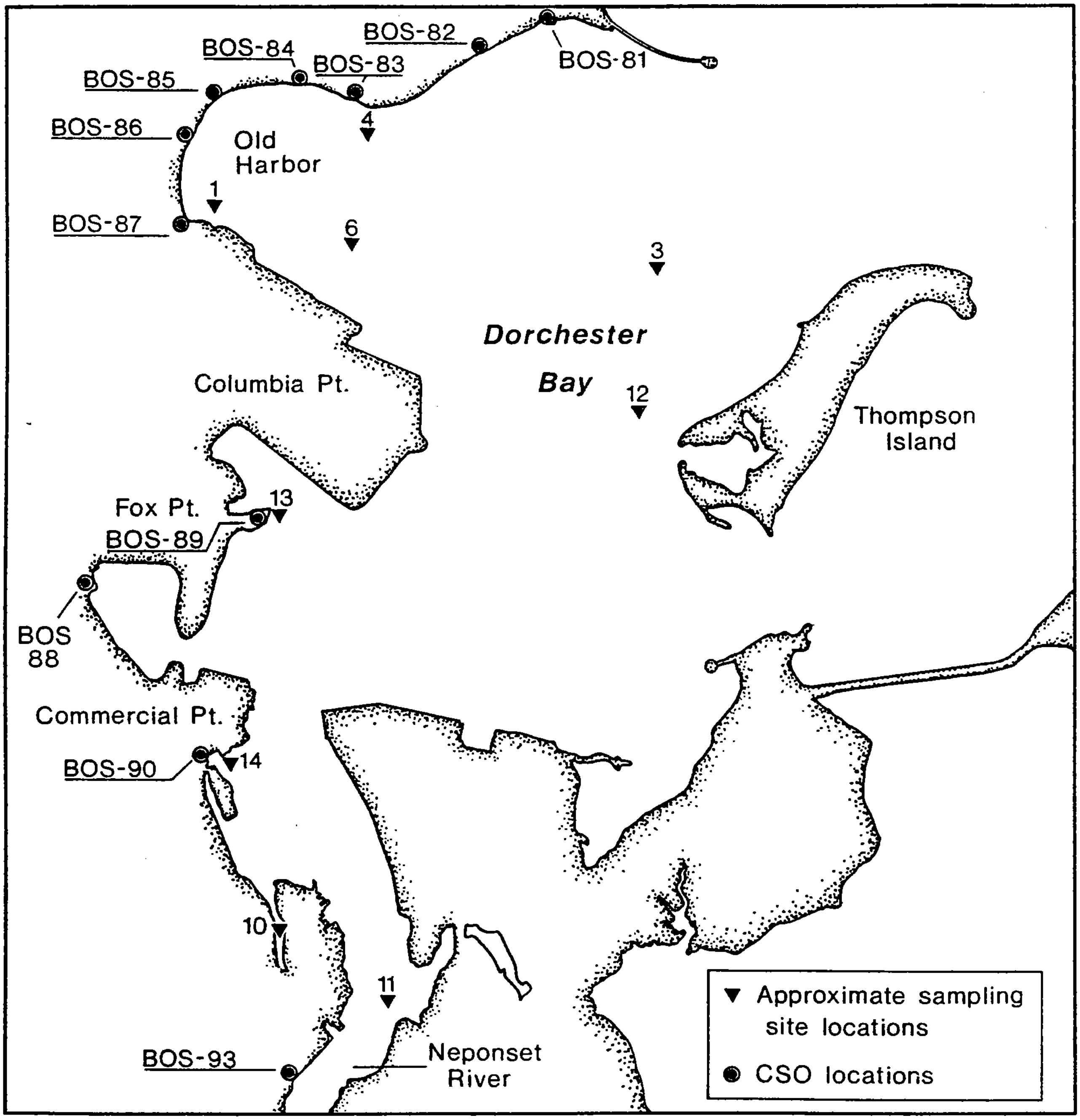


Figure 2-2. Dorchester Bay Study Area with CSO and Sampling Site Locations
Numbers indicate site IDs; 13 = site DB13.

Point/Tenean Beach area. Site DB12 was sampled to represent Fox Point/Commercial Point areas relatively free of CSO impact.

Five sites outside of Dorchester Bay (sites T1, T2, T8, CO19, and SWEX3) were included in the 1994 survey. One of these sites is located just outside the mouth of the Fort Point Channel (CO19), while the other four are in different parts of the North Harbor. Site T1 is relatively distant from any CSO discharge but is adjacent to Deer Island, site T2 is roughly equidistant from major CSOs (and other runoff sources) in the Inner Harbor and the effluent discharges of Deer Island, and site T8 is in Hingham Bay, distant from any point sources. Site SWEX3 was sampled in 1990 as part of a separate study of the effects of CSOs on contaminant transport and deposition. Sites DB03 and DB12 were initially intended to be used as reference locations for the Old Harbor and Fox Point/Commercial Point areas, respectively. However, other sites were also considered for this purpose, and through discussions with MWRA, it was decided that T2 would best represent Harbor background levels. Thus, this site was used as the reference site for all other study sites when performing the statistical data analysis.

One of the most difficult problems in environmental monitoring is to measure the relative impact of different sources of pollution. In Boston Harbor, the effects of CSO input are confounded by input from such sources as treatment plants, upstream river sources, boats, stormwater (including street runoff), atmospheric deposition, and others. In addition, all of these inputs can be dispersed and reconcentrated in depositional areas not necessarily near the original source. In this study the intent was to, when applicable, use microbial indicators to help discriminate among some of these sources at sites located near and distant from the CSOs, and to relate measured toxic pollutants to probable sources.

2.2 SAMPLE COLLECTION AND FIELD PROCEDURES

Battelle conducted the field work for this study between August 12 and 16, 1994. The exact location of each sampling site is shown in Table 2-1. The field team collected surface sediment grab samples from each of the 14 sampling sites. To improve accuracy and to evaluate the degree of intrasite variability in contaminant loading, three replicate sediment samples were collected at each site, for a total of 42 field sediment samples.

The sediment samples were collected by using a clean Kynar®-coated 0.04-m^2 Young (modified van Veen) grab sampler. The grab sampler and sampling scoops were cleaned by rinsing with dichloromethane, methanol, and deionized water prior to each sample collection. Sediment from the top 2 cm of the grab sampler was removed with a clean Kynar-coated scoop. Sediment in contact with the sides of the grab was not used. The samples for bacteriological analysis were removed directly from the grab and placed in sterilized containers. The collected surface sediment was placed in a pre-cleaned wide-mouth glass jar (I-Chem, Inc.). The sample was subsequently stirred with a Teflon spatula, and subsampled for grain size and chemical analyses. Sample homogenate was removed using a clean Teflon spatula and placed in pre-cleaned, prelabeled glass vials [total organic carbon (TOC) samples], glass jars [organic contaminants (I-Chem, Inc.)], Teflon jars (metal contaminants), and WhirlPak® bags (grain size samples).

The samples were stored on ice in coolers until arrival at Battelle. TOC, grain size and *Clostridium perfringens* samples were later packaged and shipped, on ice, to Battelle subcontractors for subsequent analysis. TOC analysis was performed by Global Geochemistry, Canoga Park, California. Grain size analysis was performed by Geo/Plan Associates, Hingham, Massachusetts. *Clostridium perfringens* analysis was performed by MTH Environmental Associates, Marston Mills, Massachusetts. The samples for organic and metal contaminant analysis were placed in a freezer at Battelle and stored at, or below, -20°C until laboratory processing could begin.

Navigation

The precise site locations were determined using a Northstar 800 GPS/LORAN system aboard the 30 ft. R/V *Una Mas*. During survey operations, the vessel's position was tracked using the Battelle Ocean Sampling System (BOSS) navigation software which automatically recorded sampling site locations, date, time, depth, site and sample identifications, and other site-specific sampling information. The site information was stored electronically for subsequent use and the relevant information was printed onto sample labels and sample collection forms. The navigation system was checked for accuracy at the beginning and end of each day.

2.3 LABORATORY SAMPLE ANALYSIS PROCEDURES

The surface-sediment samples were analyzed for selected physicochemical and environmentally important organic, trace metal, and microbiological parameters (Table 2-2). Table 2-2 also presents the approximate method detection limits for the analyses. Battelle performed the polycyclic aromatic hydrocarbon (PAH),

Table 2-2. Sediment Target Analytes and Approximate Detection Limits

Polycyclic Aromatic Hydrocarbons (PAH)[b]	Approximate Detection Limit (dry weight)[a]
naphthalene*	0.48
C_1-naphthalenes*	0.87
C_2-naphthalenes*	1.19
C_3-naphthalenes*	1.35
C_4-naphthalenes	2
biphenyl*	1.15
acenaphthylene*	1.36
dibenzofuran	1
acenaphthene*	1.05
fluorene*	0.83
C_1-fluorenes	1
C_2-fluorenes	2
C_3-fluorenes	2
phenanthrene*	1.41
anthracene*	1.32
C_1-phenanthrenes/anthracenes*	1.74
C_2-phenanthrenes/anthracenes	2
C_3-phenanthrenes/anthracenes	2
C_4-phenanthrenes/anthracenes	2
dibenzothiophene	1
C_1-dibenzothiophenes	1
C_2-dibenzothiophenes	1
C_3-dibenzothiophenes	1
fluoranthene*	2.70
pyrene*	2.42
C_1-fluoranthenes/pyrenes	2
benzo(a)anthracene*	1.49
chrysene*	1.83
C_1-chrysene	2
C_2-chrysene	2
C_3-chrysene	2
C_4-chrysene	2
benzo[b]fluoranthene*	1.40
benzo[k]fluoranthene*	1.67
benzo[e]pyrene*	1.51
benzo[a]pyrene*	0.99
perylene*	4.63
indeno[1,2,3-cd]pyrene*	2.36
dibenzo[a,h]anthracene*	1.39
benzo[g,h,i]perylene*	2.56

Table 2-2 (cont.). Sediment Target Analytes and Approximate Detection Limits

Polychlorinated Biphenyl (PCB)	
Cl_2(8)	0.87
Cl_3(18)	0.48
Cl_3(28)	0.23
Cl_4(52)	0.26
Cl_4(44)	0.67
Cl_4(66)	0.43
Cl_5(101)	0.60
Cl_4(77)	0.60
Cl_5(118)	0.45
Cl_6(153)	0.82
Cl_5(105)	0.60
Cl_6(138)	0.45
Cl_5(126)	0.60
Cl_7(187)	0.58
Cl_6(128)	0.34
Cl_7(180)	0.49
Cl_7(170)	0.67
Cl_8(195)	0.61
Cl_9(206)	0.96
Cl_{10}(209)	0.63
Pesticides	
Hexachlorobenzene	0.28
Lindane	0.20
Heptachlor	0.54
Aldrin	0.42
Heptachlorepoxide	0.46
cis-Chlordane	0.39
trans-Nonachlor	0.42
Dieldrin	0.40
Endrin	1.14
Mirex	0.49
2,4-DDE	0.32
2,4-DDD	0.49
2,4-DDT	0.37
4,4-DDE	0.25
4,4-DDD	0.58
4,4-DDT	0.62

Table 2-2 (cont.). Sediment Target Analytes and Approximate Detection Limits

Metals	
Aluminum	5400
Cadmium	0.005
Chromium	10
Copper	5
Lead	5
Mercury	0.025
Nickel	6
Iron	20
Silver	0.004
Zinc	3
Linear Alkyl Benzenes	
C_{10}-LAB through C_{14}-LAB homologues	5
Coprostanol[c]	1
Bacteriology	
Clostridium perfringens	Not applicable
Other Analyses	
Total organic carbon (TOC)	100
Grain size	Not applicable

[a] Organic (PAH, PCB, pesticide, LAB, and coprostanol) MDLs are in nanograms per gram (ng/g) dry weight, and metals and TOCMDLs are in micrograms per gram (µg/g) dry weight.

[b] The asterisked (*) PAH compounds were used to compare to the 1990 CSO survey total PAH data, and the summed concentration is referred to as "Total 24 PAH" — the two metylnaphthalene isomers in the 1990 work are considered part of the C_1-naphthalene homologous series in this work, which is why only 23 PAH analytes are asterixed. The **bolded** PAH compounds represent the 16 priority pollutant PAH.

[c] Coprostanol was determined as coprostanol (5β-cholestan-3β-ol) plus epicoprostanol (5β-cholestan-3α-ol).

linear alkyl benzene (LAB), polychlorinated biphenyl (PCB), chlorinated pesticide, coprostanol, and metal contaminant analyses. The TOC, grain size, and *Clostridium perfringens* analyses were performed by Battelle subcontractors, as listed in Section 2.2. The laboratory analytical methods are described in the Combined Work/Quality Assurance Plan (CW/QAPP) for soft-bottom benthic monitoring (Kropp and Peven, 1993), which is a component of the MWRA outfall monitoring program, and they are briefly described below. The laboratory methods are the same as those used in the National Status and Trends Mussel Watch project (Battelle, 1990b) and in the 1990 CSO study performed by Battelle (Durell *et al.* 1991).

2.3.1 Sample Analysis for Organic Analytes

Sediment samples processed for organic contaminant analysis were spiked with the PAH surrogates d_8-naphthalene, d_{10}-acenaphthene, d_{12}-perylene, d_{12}-benz[*a*]pyrene; the LAB surrogate 1-phenyl nonane; the

PCB/pesticide surrogates dibromo-octafluoro-biphenyl (DBOFB), $Cl_5(103)$, and $Cl_5(112)$; and the coprostanol surrogate androstanol (5α-androstan-3β-ol). Samples were solvent-extracted, purified using high-performance liquid chromatography (HPLC), concentrated, and submitted for instrumental analysis. Samples were quantified by the method of internal standards using the surrogate compounds as quantification internal standards (i.e., the data were automatically corrected for surrogate recovery). D_{10}-biphenyl, d_{10}-phenanthrene, and d_{12}-benzo[*e*]pyrene were added as recovery internal standard for determination of PAH and LAB surrogate recoveries, and tetrachloro-*m*-xylene (TCMX) and $Cl_6(166)$ was added to determine PCB/ pesticide surrogate recoveries, and androstane (5α-androstane) was added as an internal standard for the determination of the coprostanol surrogate recovery.

Instrumental analysis for PAH and LAB was performed by gas chromatography/mass spectrometry (GC/MS). Coprostanol analysis was performed by gas chromatography/flame ionization detection (GC/FID), and the PCB and pesticides analysis was performed by gas chromatography/electron capture detection (GC/ECD). The PAH analyte list was comprised of 40 PAH parameters, including PAH alkyl homologue groups that represent PAH contamination of both petrogenic and pyrogenic nature. The LABs were quantified as the five major LAB groups, as designated by the number of carbons in the alkyl chain (e.g., the individual phenyl decanes were summed and reported as C_{10}-LAB). The C_{10}-, C_{11}-, C_{12}-, C_{13}-, and C_{14}-LAB were determined and reported separately, and the total LAB concentration was calculated as the sum of the five LAB groups. The coprostanol analysis does not distinguish between coprostanol (5β-cholestan-3β-ol) and epicoprostanol (5β-cholestan-3α-ol), and these two isomers are reported together as one coprostanol value. The PCB congener and chlorinated pesticide analytes were those included in the NOAA National Status and Trends Mussel Watch Program and in other recent Boston Harbor/Massachusetts Bay sediment surveys for MWRA.

2.3.2 Sample Analysis for Metal Analytes

All metals except silver, cadmium, and mercury were analyzed by x-ray fluorescence (XRF). Silver and cadmium analysis was performed by inductively coupled plasma/mass spectrometry (ICP/MS). The analysis for mercury was performed by cold vapor atomic absorption (CVAA). Samples prepared for silver, cadmium, and mercury analysis were digested using a combination of nitric acid and hydrochloric acid. No chemical digestion was performed prior to XRF analysis.

2.3.3 Sample Analysis for TOC, Grain Size, and *Clostridium perfringens*

TOC analysis was performed with a LECO carbon analyzer. TOC concentrations were based on the measurement of oxidized carbon (the procedure does not measure any inorganic carbon that may be present). Grain size analysis was performed by the standard sieve/pipette method to determine the weight percent distribution of gravel/sand/silt/clay of the sample. This method includes the use of a deflocculant and mechanical disaggregation of the wet sample, and wet sieving to separate the coarse (gravel/sand) portion from the fine (silt/clay) portion. The *Clostridium perfringens* analysis employed an aqueous suspension and membrane filtration method. All *Clostridium perfringens* analyses were performed in duplicate.

2.4 LABORATORY QUALITY CONTROL PROCEDURES

Data quality is assessed by determinations of comparability, representativeness, completeness, accuracy, and precision in field and laboratory activities. Comparability between this project and earlier studies was ensured by using standard methods consistent with those used for other MWRA studies. Representativeness was addressed through the design of the field sampling program, and by the proper preservation and storage of samples to ensure that the samples analyzed accurately represent the materials collected. In the field, representativeness and precision were addressed by collecting three site replicates. Completeness, which is defined as the measure of data collected versus the amount expected under ideal conditions, was 100%. The Quality Control (QC) samples and data requirements for accuracy and precision are summarized below.

The QC program for organic contaminant analyses included the processing of one procedural blank, one matrix spike, one matrix spike duplicate, and one standard reference material (SRM) sample for each batch of approximately 20 field samples. Analysis of procedural blanks (containing all reagents used in sample processing, carried through all steps and treated as samples) ensures that there are no significant levels of laboratory contamination. The matrix spike (field sample spiked with the respective analytes), matrix-spike sample duplicates, blank spike, field sample duplicates, and SRMs were used to demonstrate laboratory accuracy and precision. Recoveries of internal standards were monitored for every sample to provide data on the efficiency of the sample extraction and other sample-processing manipulations. For metal contaminant analysis, the QC program included the processing of a procedural blank, a matrix spike, a field sample duplicate, and an SRM sample for a minimum of every 20 samples. The data quality objectives for the organic and metal contaminant QC analyses are summarized in Table 2-3.

Quality control of TOC analysis was monitored by analyzing one standard material sample for every 10 samples (within 5% of true value); precision was determined by performing duplicate analyses after every 10 samples (within 5% of each other) and by analyzing one procedural blank for every 50 samples (no significant levels of interference or contamination; blank signal needed to be less than five times the MDL).

Sediment grain size QC included determination of precision by analyzing two sets of triplicates with the 42 field samples. The percent relative standard deviation for the three replicate determinations was to be less than 20% for sand, silt, and clay to meet the data quality objectives.

Table 2-3. Quality Control Sample Data Quality Objectives

Organic QC Sample Analysis	
Surrogate recovery	50%-150%[a]
Matrix spike analyte relative recovery	50%-150%[b]
Matrix spike/spike duplicate precision	30% RPD[c]
SRM quantification accuracy	±30% DIFF vs. certified value[d]
Procedural blank	<5× MDL
Organics Instrument Calibration	
Initial Calibration	Calibration correlation coefficient >0.995 or ≤25 %RSD in analyte RFs with the average RSD being ≤10%
Calibration Check	±25% DIFF from true value or ≤25 %RPD in analyte RFs with the average RPD being ≤10%
Metals QC Sample Analysis	
Matrix spike analyte relative recovery	70%-130%
Matrix spike/spike duplicate precision	30% RPD
Field sample duplicate precision	30% RPD
SRM quantification accuracy	±30% DIFF vs. certified value
Method blank	<5× MDL
Metals Instrument Calibration	
Initial Calibration	Calibration correlation coefficient >0.99
Calibration Check	±15% DIFF from true value

[a] One PAH SIS may be outside data quality objective limits.
[b] Relative recovery is determined relative to the surrogate compound.
[c] Relative percent difference in the MS/MSD duplicate determinations.
[d] Accuracy of determinations of target analytes for which certified values exist.

Quality control for the *Clostridium perfringens* analyses included ensuring the media quality by conducting growth promotion and sterility analyses on all lots of media prepared and used. Control samples were also included with each set of field samples to verify that the test system was free of contamination. Duplicate analysis was performed on all samples, and triplicate analysis was performed on approximately one in every 20 samples.

A rigorous laboratory quality control QC program (Kropp and Peven, 1993) was implemented to ensure that accurate and precise data were obtained that could, with a high degree of confidence, be used to assess the current sediment quality of Dorchester Bay and to compare the data with other studies. It is beyond the scope of this report to compile, present, or discuss the results of the QC sample analyses. However, the organic contaminant, metal contaminant, and subcontractor analysis QC data were carefully reviewed with generally very good results; any deviations from the data quality objectives that were observed were minor, and there was no indication of any significant impact on the quality of the field sample analysis data. The analytical objectives of the program were met.

2.5 DATA ANALYSIS PROCEDURES

MWRA conducted the statistical analyses reported in this document. Statistical tests were conducted to determine if there were significant differences in contaminant loading among CSO-impacted sites and sites expected to be relatively unimpacted by CSOs and to determine if contaminant concentrations have changed in the four years since the previous CSO survey. The results were tabulated for inclusion in this report.

Two-sample *t*-tests were performed to compare differences in concentrations between potentially CSO-impacted sites and a reference site; site T2 was used as the reference site for all test sites because it was considered representative of overall Harbor "background" levels and was not expected to have any significant local point-source contributions. One-way analysis of variance (ANOVA) was performed to test for differences between two groups of sites, and the Student-Newman-Keuls multiple comparison test was used to determine differences and similarities in concentrations among sites. The one-way ANOVA was run by comparing two groups of sites; the "adjacent to CSOs" group, which was comprised of sites DB01, DB04, DB13, DB14, and CO19, and the "distant from CSOs" group, which was comprised of the other nine sites. The Student-Newman-Keuls test was then run to determine how the sites "group" in terms of similarity and differences in contaminant concentrations. In addition, two-way ANOVA analysis was performed to determine if there were statistically significant differences in the contaminant concentrations measured in the sediments collected in 1990 and 1994, for the parameters and site locations that were common to both studies.

Statistical analyses were conducted using the program SPSS (v 4.1) operating on a VAX/VMS computer. Organic contaminant data were typically analyzed both non-normalized and normalized to TOC; the results using the TOC normalized data were generally the most useful. Metal contaminant data were analyzed non-normalized, normalized to aluminum, and normalized to grain size (percent mud); the statistical analysis results based on the aluminum-normalized data were typically most useful. *Clostridium perfringens* data were analyzed statistically using non-transformed and log-transformed data, and TOC normalization was also applied during the data evaluation; log-transformed data were usually most useful. The ANOVA analyses included Bartlett's Box-F test for violation of the assumption of homogeneity in variance. Analyses where violations were evident were repeated on log-transformed data. If heteroscedasticity remained following log-transformation, the parameter was removed from consideration. Raw printouts from the statistical analyses are available from MWRA (ENQUAD).

3.0 RESULTS

3.1 LABORATORY ANALYSIS RESULTS — 1994 SAMPLES

The analytical results of all laboratory analyses conducted on the samples collected during the 1994 survey for this study are presented in Section 3.1. The presentation of these data is divided into results from the organic contaminant analyses (Section 3.1.1), metal contaminant analyses (Section 3.1.2), and the *Clostridium perfringens*, TOC, and grain size analyses (Section 3.1.3). The site average data (i.e., the average of the three stations that were the site replicates) are presented in Section 3.1, while the complete data sets, with results for each individual station, are presented in the Appendices.

3.1.1 TOC, Grain Size and *Clostridium perfringens* Analysis Results

The data from the 1994 sediment analyses that Battelle subcontracted to other laboratories — analysis for total organic carbon (TOC), grain size, and *Clostridium perfringens* — are summarized in Table 3-1. The TOC data are presented as weight percent, dry weight. The grain size data are presented as percent distribution of gravel, sand, silt, and clay, with the calculated percent mud value (as the sum of the silt and clay components) also listed. The data are presented as the average site data in this section. The complete TOC, grain size, and *Clostridium perfringens* data set, with results for each individual station, is presented in Appendix D (*Clostridium perfringens*, TOC, and Grain Size Data for 1994 Sediment Field Samples).

The sediment grain size was highly variable; 2 (DB06 and T8) of the 14 sites had a composition of more than 90% sand and gravel, and 5 of the 14 sites had more than 60% mud (silt plus clay). Figure 3-1 shows the grain size distribution by each of the four classes [Figure 3-1(a)] and as percent mud [Figure 3-1(b)]. The TOC content of the samples was also quite variable (Figure 3-2), ranging from 0.2 (site DB06) to 5.1% dry weight (site DB14). As expected, the coarse sediments generally had a low TOC content, and the TOC content increased with percent fines (Figure 3-3). An exception to this relationship was site DB14 which had a higher TOC content than would have been expected based on the grain size, possibly due to organic matter being discharged from the Commercial Point CSO.

The *Clostridium perfringens* data (Table 3-1) are presented as spores per gram dry weight. The sediment densities of *Clostridium perfringens* ranged from approximately 1,300 (site DB06) to approximately 16,500

Table 3-1. ***Clostridium perfringens*****, TOC, and Grain Size Data Summary—1994 Samples**

	Clostridium perfringens			Grain Size				
Site ID	**(spores/g)**	**log10 (spores/g)**	**TOC (%)**	**%Gravel**	**%Sand**	**%Silt**	**%Clay**	**%Mud***
DB01	3037	3.48	2.8	0.0	25.6	58.9	15.5	74.4
DB03	5283	3.72	1.1	10.3	71.2	12.0	6.6	18.6
DB04	5117	3.71	2.4	0.4	38.9	48.0	12.8	60.8
DB06	1283	3.11	0.2	0.0	92.5	5.0	2.5	7.4
DB10	11967	4.08	4.1	0.0	12.1	65.3	22.6	87.9
DB11	3340	3.52	1.1	2.3	58.1	31.7	7.9	39.6
DB12	16500	4.22	2.6	7.7	46.7	30.7	14.9	45.6
DB13	10483	4.02	3.2	0.0	14.3	59.3	26.5	85.7
DB14	7287	3.86	5.1	0.7	47.5	39.5	12.4	51.9
T1	4833	3.68	1.8	10.0	53.7	28.1	8.3	36.4
T2	12100	4.08	1.6	2.8	59.4	26.5	11.3	37.9
T8	2567	3.41	1.1	3.8	90.1	3.2	2.9	6.1
CO19	12643	4.10	2.8	0.0	4.0	66.1	29.9	95.9
SWEX3	12433	4.09	2.6	0.2	45.8	33.9	20.0	54.0

* Percent mud is defined as percent silt plus percent clay.

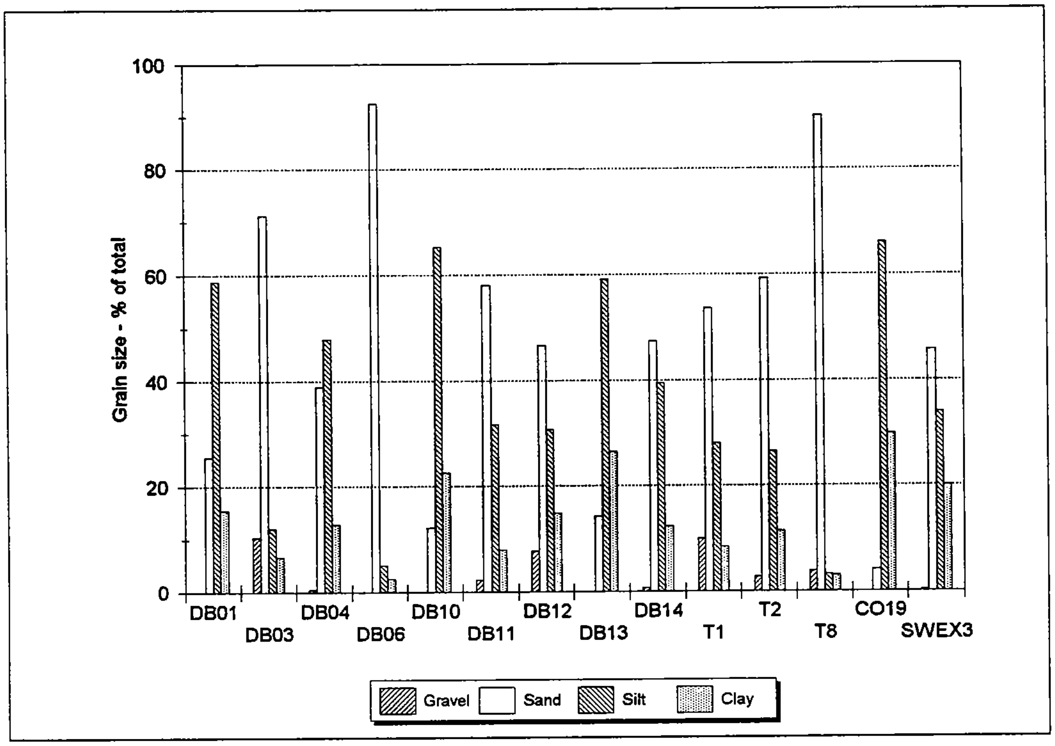
spores per gram (site DB12). The *Clostridium perfringens* data were also $\log_{10}$-transformed for data analysis and interpretation (Table 3-1).

3.1.2 Organic Contaminant Analysis Results

In 1994, sediment samples were analyzed for PAH, PCB, chlorinated pesticides, LAB, and coprostanol. The analytical parameters, and their respective approximate detection limits, are presented in Table 2-2. All sediment concentration data presented in Section 3.1.2 are reported in nanograms per gram (ng/g) dry weight, and the data are presented as the site average data. The complete organic contaminant data set, with results for each individual sample, is presented in Appendix B.

3.1.2.1 PAH Results

Sediment samples were analyzed for 40 individual polycyclic aromatic hydrocarbon (PAH) compounds or alkylated PAH homologous. The total PAH values reported in this section are defined as the sum of these 40 analytes. The 24 PAH analytes that were determined in 1990 (asterisked in Table 2-2) have been summed for these new 1994 data, and reported as "Total 24 PAH", to be better able to compare the 1994 and 1990



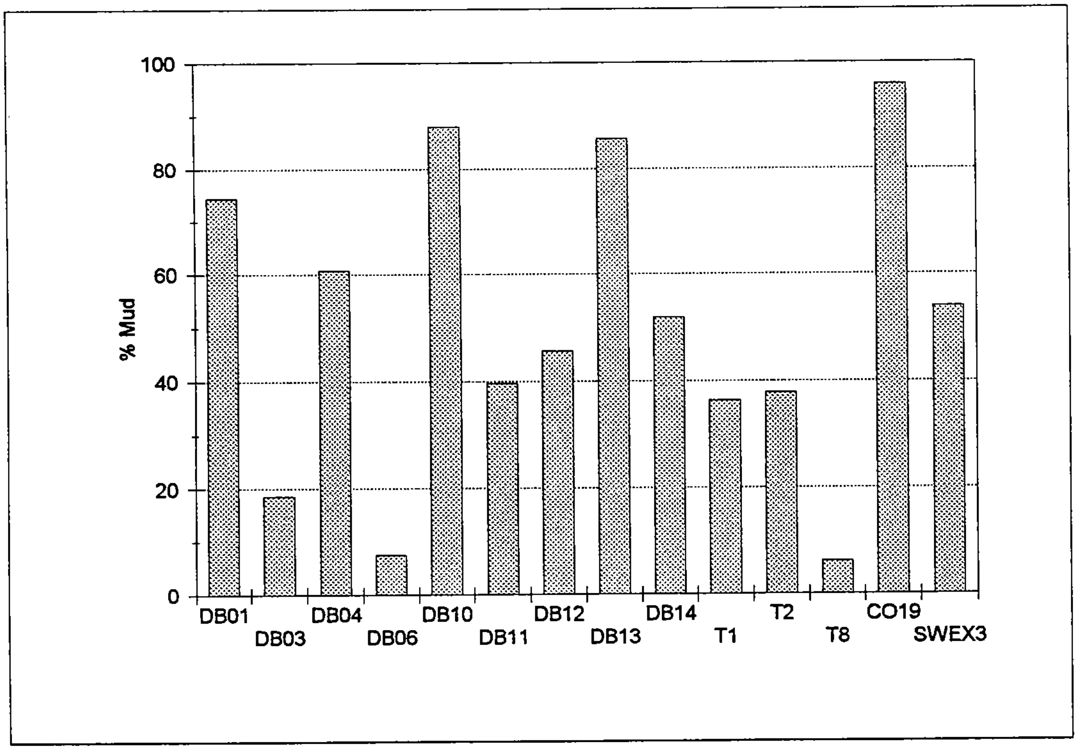


Figure 3-1. Sediment Grain Size Data—1994 Samples
(a) Percent Gravel, Sand, Silt, and Clay Distribution (b) Percent Mud

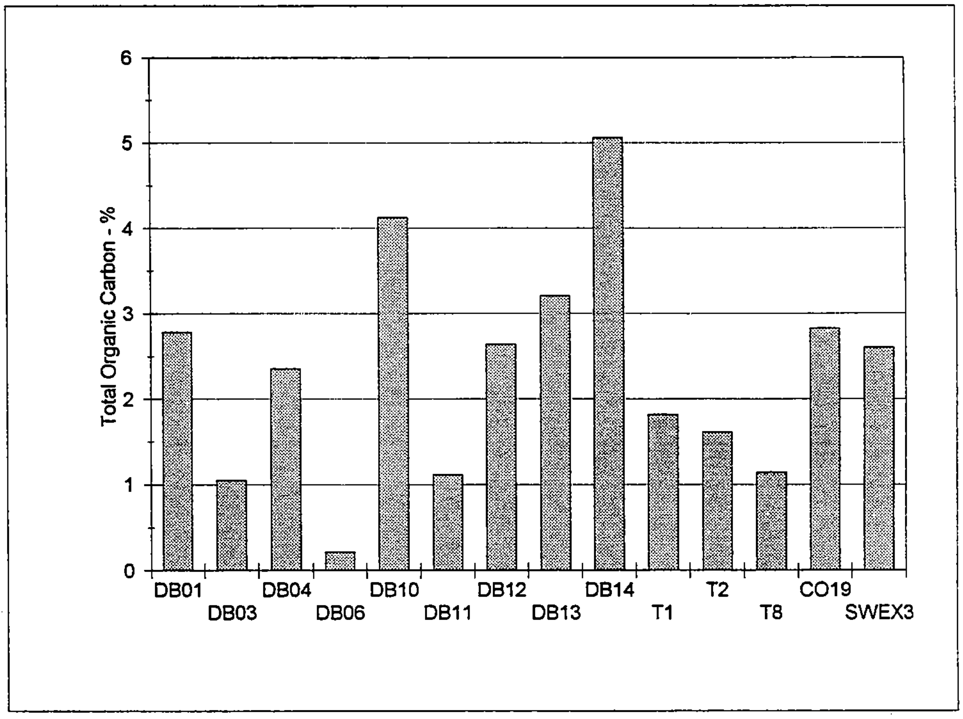


Figure 3-2. Sediment TOC Concentrations—1994 Samples

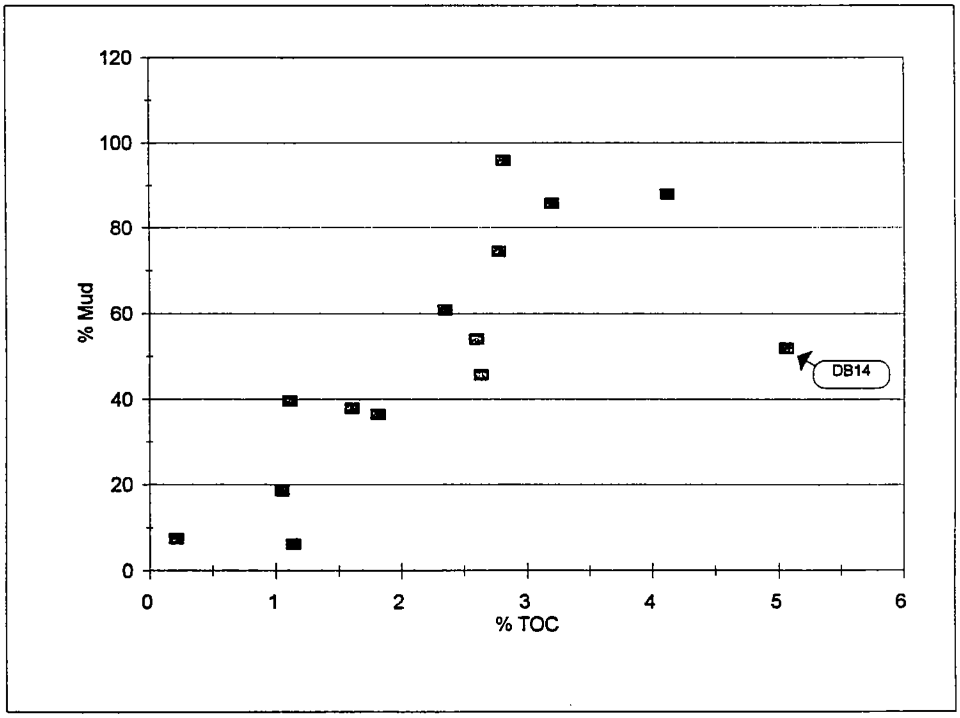


Figure 3-3. Sediment Percent Mud versus Percent TOC—1994 Samples.

study's PAH concentrations. Additionally, for presentation and discussion purposes, the 40 PAH analytes have been divided into two groups based on their predominant origin: (1) petrogenic (petroleum related) and (2) pyrogenic (combustion and creosote/coal-tar related). The petrogenic (Petro-PAH) are mostly found in refined and unrefined petroleum products, and are primarily the lighter-molecular-weight PAH. The pyrogenic compounds (Pyro-PAH) are primarily derived from the combustion of fossil fuels or as principal components of creosote and coal-tar mixtures, and are primarily the heavier-molecular-weight PAH. The Petro-PAH are, for the purposes of this study, defined as the PAH in Table 2-2 from naphthalene through C_3-dibenzothiophene, while the Pyro-PAH are defined as fluoranthene through benzo[*g,h,i*]perylene. Although PAH compounds cannot exclusively be attributed to one of these two discrete source types (e.g., varying concentrations of chrysenes are present in various petroleum products), this classification represents a good general approximation of the relative proportion of petrogenic and pyrogenic PAH. The PAH data are presented as the site average data only in the text, by these four summed categories. The analytical results for all samples and all 40 individual PAH analytes are given in Appendix B (Organic Contaminant Data for 1994 Sediment Field Samples).

A summary of the 1994 sediment organic contaminant concentrations is presented in Table 3-2. Non-normalized data are presented in Table 3-2(a) while Table 3-2(b) presents the data normalized to TOC. As indicated in Table 3-2(a), PAH concentrations in the sediment samples varied greatly, with total PAH concentrations ranging from 495 (site DB06) to 128,000 ng/g (site DB14). The Petro-PAH (the low-molecular-weight petroleum-related PAH) range in concentration from approximately 96 to 41,000 ng/g and the Pyro-PAH (higher-molecular-weight combustion and creosote/coal-tar related PAH) cover a concentration range of approximately 400 to 88,000 ng/g. The concentration of the Pyro-PAH was, on average, between two and three times higher than the concentration of the Petro-PAH, although a few individual sites deviated from this relationship.

The site-to-site sediment PAH concentrations are less variable once the PAH data are normalized to sediment TOC content [Table 3-2(b)]. The TOC-normalized total PAH concentrations varied by a factor of ten, ranging from approximately 2,500 (site DB06) to 25,000 ng/g/%TOC (site DB14). The difference in concentration for the raw PAH data from these two sites was a factor of approximately 250. Much of the variability in the raw sediment PAH concentrations can thus be attributed to variability in the TOC content.

Table 3-2. Sediment Organic Contaminant Data Summary—1994 Samples
(a) PAH, PCB, and DDT Concentrations

Non-normalized (ng/g, dry weight)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T2	T8	CO19	SWEX3
Total PAH	26280	10391	39792	495	20791	8400	19365	22588	128354	7616	7580	2999	19559	9960
Total 24 PAH	21184	8253	31813	424	16007	6317	14599	17329	100149	5007	5749	2343	14834	7304
Petro-PAH	6979	3855	12826	96.5	5385	2190	6444	6145	40848	3126	2179	1226	5009	3173
Pyro-PAH	19300	6536	26966	399	15406	6210	12921	16443	87506	4490	5401	1772	14550	6788
% Pyro-PAH of Total PAH	73.4	62.9	67.8	80.5	74.1	73.9	66.7	72.8	68.2	59.0	71.3	59.1	74.4	68.1
PCB Sum	88.1	45.7	62.2	7.2	373	127	266	417	348	28.8	55.8	7.9	186	90.6
DDTs Sum	25.8	9.7	29.3	1.3	151	23.1	50.6	71.8	164	10.9	14.1	2.9	39.8	23.6

(b) PAH, PCB, and DDT Concentrations—Normalized to TOC

TOC Normalized (ng/g/%TOC)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T2	T8	CO19	SWEX3
Total PAH	9386	9447	16580	2475	5071	7636	7448	7059	25168	4231	4738	2726	6985	3831
Total 24 PAH	7566	7503	13255	2122	3904	5743	5615	5415	19637	2781	3593	2130	5298	2809
Petro-PAH	2493	3505	5344	483	1313	1991	2478	1920	8010	1737	1362	1115	1789	1220
Pyro-PAH	6893	5942	11236	1993	3758	5645	4970	5138	17158	2495	3376	1611	5196	2611
PCB Sum	31.5	41.5	25.9	36.0	90.9	116	102	130	68.2	16.0	34.8	7.2	66.6	34.9
DDTs Sum	9.2	8.8	12.2	6.4	37.0	21.0	19.5	22.4	32.1	6.0	8.8	2.7	14.2	9.1

Table 3-2. Sediment Organic Contaminant Data Summary—1994 Samples
(c) LAB-Group, Total LAB, Coprostanol, and *Coprostanol perfringens* Concentrations

Non-normalized (ng/g, dry weight)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T2	T8	CO19	SWEX3
Phenyl Decanes	39.6	0	49.6	0	88.6	18.4	0	120	313	21.1	75.8	11.1	169	69.6
Phenyl Undecanes	149	56.1	203	0	342	77.6	154	464	865	88.2	290	77.8	606	279
Phenyl Dodecanes	250	90.0	321	19.3	456	159	258	537	870	103	385	106	778	377
Phenyl Tridecanes	191	68.0	229	13.0	362	104	166	432	643	89.5	302	95.3	573	285
Phenyl Tetradecanes	163	50.1	172	0	285	66.4	103	387	505	41.4	219	69.9	446	176
Total LAB	792	264	974	32.2	1533	425	681	1939	3197	343	1272	360	2572	1187
Coprostanol	5604	1612	6061	2815	5683	2135	2825	9263	32232	4195	9798	1765	10726	6726
Total LAB/Coprostanol Ratio	0.14	0.16	0.16	0.01	0.27	0.20	0.24	0.21	0.10	0.08	0.13	0.20	0.24	0.18
Clostridium perfringens	3037	5283	5117	1283	11967	3340	16500	10483	7287	4833	12100	2567	12643	12433
Log10 Clostridium perfringens	3.48	3.72	3.71	3.11	4.08	3.52	4.22	4.02	3.86	3.68	4.08	3.41	4.10	4.09

(d) LAB-Group, Total LAB, and Coprostanol Concentrations—Normalized to TOC

TOC Normalized (ng/g/%TOC)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T2	T8	CO19	SWEX3
Phenyl Decanes	14.1	0.0	20.7	0.0	21.6	16.7	0.0	37.5	61.5	11.7	47.4	10.1	60.4	26.8
Phenyl Undecanes	53.1	51.0	84.6	0.0	83.4	70.5	59.4	145	170	49.0	182	70.7	216	107
Phenyl Dodecanes	89.3	81.9	134	96.3	111	145	99.2	168	171	57.1	240	96.7	278	145
Phenyl Tridecanes	68.0	61.8	95.2	64.9	88.3	94.1	63.7	135	126	49.7	189	86.6	205	110
Phenyl Tetradecanes	58.2	45.6	71.6	0.0	69.6	60.4	39.7	121	99.1	23.0	137	63.6	159	68
Total LAB	283	240	406	161	374	386	262	606	627	191	795	328	919	456
Coprostanol	2001	1465	2525	14075	1386	1941	1087	2895	6320	2331	6124	1605	3831	2587

3.1.2.2 PCB and Pesticide Results

Sediment samples were analyzed for the 20 individual PCB congeners and 16 chlorinated pesticides listed in Table 2-2. The PCB and pesticide data are summarized as "PCB Sum" and "DDTs Sum" in Tables 3-2(a) and (b). The "PCB Sum" values represent the sum of the 20 individual PCB congeners, while the "DDTs Sum" values are the sum of the 6 DDT compounds (2,4- and 4,4-isomers of DDT, DDD, and DDE). PCB and pesticides are presented only as the site average data. The analytical results for all samples and all individual PCB congeners and chlorinated pesticides (including the 10 non-DDT pesticides) are given in Appendix B (Organic Contaminant Data for 1994 Sediment Field Samples).

The "PCB Sum" concentrations in the sediment samples ranged from approximately 7 (site DB06 and T8) to 420 ng/g (site DB13). The "DDTs Sum" concentrations ranged from approximately 1 (site DB06) to 160 ng/g (site DB14; DB10 had similar concentrations at 150 ng/g).

The PCB and pesticide concentrations are less variable once the data are normalized to sediment TOC content [Table 3-2(b)]. The TOC-normalized PCB concentrations ranged from approximately 7 (site T8) to 130 ng/g/%TOC (site DB13). The sum of the DDT compound concentrations ranged from approximately 3 (site T8) to 37 ng/g/%TOC (site DB10). The concentration *range* (i.e., ratio between the highest and lowest site concentrations) for the TOC normalized PCB and pesticide data was approximately half that of the non-normalized data. Much of the variability in the raw PCB and pesticide data is clearly due to differences in the TOC content.

3.1.2.3 LAB and Coprostanol Results

Linear alkyl benzene (LAB) was determined as the five major environmentally relevant LAB groups: phenyldecanes (C_{10}-LAB), phenylundecanes (C_{11}-LAB), phenyldodecanes (C_{12}-LAB), phenyltridecanes (C_{13}-LAB), and phenyltetradecanes (C_{14}-LAB). The individual phenyl-substituted alkanes in each LAB group were determined together as one analyte and reported as one value for the LAB group. The total LAB, defined as the sum of the C_{10}-, C_{11}-, C_{12}-, C_{13}-, and C_{14}-LAB, was also calculated. The coprostanol data represent the total concentration of two coprostanol isomers, coprostanol (5β-cholestan-3β-ol) and epicoprostanol (5β-cholestan-3α-ol).

The 1994 LAB and coprostanol concentrations are summarized in Tables 3-2(c) and (d). The non-normalized total LAB concentration in the sediment samples ranged from approximately 32 (site DB06) to 3,200 ng/g (site DB14). When normalized to TOC, the total LAB concentrations ranged from approximately 160 (site DB06) to 920 ng/g/%TOC (site CO19). All five LAB groups were identified in most samples. The C_{12}-LAB group was consistently present at the highest level, followed by C_{11}- and C_{13}-LAB, C_{14}-LAB, and C_{10}-LAB. The coprostanol concentrations ranged from approximately 1,700 (sites DB03 and T8) to 32,000 ng/g (site DB14). The TOC-normalized coprostanol concentrations ranged from approximately 1,100 (site DB12) to 14,000 ng/g/%TOC (site DB06); 10 of the 14 sites had concentrations below 2,900 ng/g/%TOC. Interestingly, site DB06 had the lowest TOC-normalized LAB concentration but the highest coprostanol level, but the TOC content of this sample was so low that normalizing to TOC may be of limited value and reduce the accuracy of the data.

3.1.3 Metal Contaminant Analysis Results

The site means for the ten metals in the sediment samples are summarized in Tables 3-3(a) through (c). All sediment metals data are presented in micrograms per gram (µg/g) dry weight, except for the aluminum and iron data which are presented as percent dry weight. The complete set of metal contaminant data, with results for each individual sample, is presented in Appendix C (Metal Contaminant Data for 1994 Sediment Field Samples).

The concentrations of aluminum ranged from approximately 3.0% (site T8) to approximately 7.2% (site CO19), and from approximately 1.4% (site DB06) to approximately 4.3% (site CO19) for iron. Chromium, copper, lead, and zinc were present at intermediate levels; concentrations ranged from 35 (site DB06) to 250 µg/g (site DB13) for chromium, 12 (site DB06) to 200 µg/g (site DB10) for copper, 26-28 (sites T8 and DB06) to 350 µg/g (site DB14) for lead, and 33 (site DB06) to 340 µg/g (site DB14) for zinc. Nickel concentrations ranged from approximately 9 (site DB06) to 34-37 µg/g (sites DB01, DB10, DB12, DB13, CO19, and SWEX3), while the silver concentrations ranged from 0.4 (site DB06) to 5.6 µg/g (site DB13). Cadmium and mercury were present at the lowest concentrations, with concentration ranges of approximately 0.07 (site DB06) to 2.1 µg/g (site DB13) and 0.08 (site DB06) to 1.2-1.3 µg/g (sites DB03, DB10, and DB13), respectively.

Table 3-3. Sediment Metal Contaminant Data Summary—1994 Samples
(a) Metal Contaminant Concentrations

Non-normalized (ug/g, dry weight)*

Site ID	Ag ICP-MS	Al (%) XRF	Cd ICP-MS	Cr XRF	Cu XRF	Fe (%) XRF	Hg CVAA	Ni XRF	Pb XRF	Zn XRF	Mud* (%)
DB01	3.48	5.70	0.844	157	134	3.72	0.741	34.5	152	233	74.4
DB03	0.885	4.63	0.228	65.2	27.9	1.99	1.348	15.3	54.6	69.5	18.6
DB04	2.97	5.47	0.820	139	87.0	2.94	0.617	28.2	159	168	60.8
DB06	0.359	3.64	0.065	34.8	12.1	1.35	0.075	9.10	28.4	33.3	7.4
DB10	5.05	6.17	1.69	218	198	4.22	1.177	37.8	182	273	87.9
DB11	1.20	4.19	0.585	77.0	41.2	1.95	0.402	13.5	63.5	95.5	39.6
DB12	3.76	5.33	1.13	209	98.5	3.14	0.810	33.9	130	172	45.6
DB13	5.59	6.71	2.12	254	158	3.79	1.243	37.1	199	266	85.7
DB14	2.18	4.25	1.48	119	126	2.84	0.771	25.5	347	344	51.9
T1	0.895	6.49	0.307	78.2	26.8	2.60	0.260	20.7	32.8	67.6	36.4
T2	2.50	5.66	0.485	126	59.2	2.63	0.373	23.2	63.1	101	37.9
T8	0.530	3.02	0.101	48.9	15.8	2.03	0.101	13.3	25.9	47.2	6.1
CO19	4.76	7.20	1.14	215	146	4.34	0.812	37.2	137	218	95.9
SWEX3	4.03	6.95	0.423	194	95.7	3.95	0.581	35.9	108	156	54.0

* Aluminum and iron are reported as percent. Percent mud is defined as percent silt plus percent clay.

(b) Metal Contaminant Concentrations—Normalized to Grain Size

Grain Size Normalized (ug/g/%mud)*

Site ID	Ag ICP-MS	Al (%) XRF	Cd ICP-MS	Cr XRF	Cu XRF	Fe (%) XRF	Hg CVAA	Ni XRF	Pb XRF	Zn XRF
DB01	0.047	0.077	0.011	2.11	1.80	0.050	0.010	0.463	2.04	3.13
DB03	0.048	0.249	0.012	3.51	1.50	0.107	0.073	0.822	2.94	3.74
DB04	0.049	0.090	0.013	2.28	1.43	0.048	0.010	0.464	2.62	2.76
DB06	0.048	0.489	0.009	4.68	1.63	0.182	0.010	1.22	3.83	4.48
DB10	0.057	0.070	0.019	2.48	2.26	0.048	0.013	0.429	2.07	3.11
DB11	0.030	0.106	0.015	1.95	1.04	0.049	0.010	0.340	1.60	2.41
DB12	0.082	0.117	0.025	4.59	2.16	0.069	0.018	0.743	2.85	3.77
DB13	0.065	0.078	0.025	2.96	1.84	0.044	0.014	0.433	2.32	3.10
DB14	0.042	0.082	0.029	2.30	2.43	0.055	0.015	0.492	6.68	6.63
T1	0.025	0.178	0.008	2.15	0.736	0.071	0.007	0.570	0.901	1.86
T2	0.066	0.149	0.013	3.32	1.56	0.069	0.010	0.614	1.67	2.67
T8	0.086	0.492	0.017	7.98	2.58	0.331	0.017	2.17	4.22	7.70
CO19	0.050	0.075	0.012	2.24	1.52	0.045	0.008	0.388	1.43	2.27
SWEX3	0.075	0.129	0.008	3.60	1.77	0.073	0.011	0.665	2.00	2.89

* Aluminum and iron are reported as %/g/%mud. Percent mud is defined as percent silt plus percent clay.

Table 3-3. Sediment Metal Contaminant Data Summary—1994 Samples (c) Metal Contaminant Concentrations—Normalized to Aluminum

Aluminum Normalized (ug/g/%aluminum)*

Site ID	Ag ICP-MS	Al (%) XRF	Cd ICP-MS	Cr XRF	Cu XRF	Fe (%) XRF	Hg CVAA	Ni XRF	Pb XRF	Zn XRF
DB01	0.610	1.00	0.148	27.6	23.5	0.652	0.130	6.04	26.7	40.9
DB03	0.191	1.00	0.049	14.1	6.0	0.430	0.291	3.30	11.8	15.0
DB04	0.543	1.00	0.150	25.4	15.9	0.538	0.113	5.16	29.0	30.7
DB06	0.099	1.00	0.018	9.57	3.34	0.372	0.021	2.50	7.82	9.17
DB10	0.819	1.00	0.274	35.3	32.2	0.684	0.191	6.12	29.5	44.3
DB11	0.286	1.00	0.140	18.4	9.83	0.465	0.096	3.21	15.2	22.8
DB12	0.706	1.00	0.213	39.3	18.5	0.590	0.152	6.36	24.4	32.2
DB13	0.834	1.00	0.315	37.9	23.5	0.565	0.185	5.53	29.6	39.6
DB14	0.514	1.00	0.349	28.1	29.7	0.669	0.182	6.00	81.6	80.9
T1	0.138	1.00	0.047	12.1	4.13	0.400	0.040	3.20	5.06	10.4
T2	0.441	1.00	0.086	22.2	10.5	0.464	0.066	4.11	11.1	17.8
T8	0.175	1.00	0.034	16.2	5.23	0.673	0.034	4.42	8.57	15.6
CO19	0.661	1.00	0.159	29.8	20.3	0.602	0.113	5.17	19.0	30.3
SWEX3	0.580	1.00	0.061	28.0	13.8	0.569	0.084	5.17	15.5	22.5

* Aluminum and iron are reported as %/g/%aluminum.

The sediment metal concentrations are less variable once the data are normalized to sediment grain size [Table 3-3(b)] or to aluminum [Table 3-3(c)]. The grain size normalization generally resulted in a greater reduction in the site-to-site variability than the aluminum normalization. For example, the grain-size-normalized copper concentration in the sediment samples ranged from 0.74 to 2.58 µg/g/% mud, a ratio of approximately 3.5 difference in concentration between the high and the low sites. The aluminum-normalized copper concentration ranged from 3.34 to 32.2 µg/g/% aluminum, a ratio of approximately 9.6 between the high and the low sites. The raw copper data showed a high-to-low site concentration ratio of 16.4. For cadmium, the concentration ratios between the highest and lowest sites were 32.2, 3.6, and 19.4 for raw, grain-size-normalized, and aluminum-normalized data, respectively. Similar reductions in variability by normalizing to grain size and aluminum were observed for most other metals.

3.2 STATISTICAL ANALYSIS RESULT — 1994 SAMPLES

To determine contamination differences between a potentially impacted site and a reference site, each individual site was tested (t-test) versus site T2. In the one-way ANOVA to determine general CSO impact, the sites were separated into two groups: (1) the "adjacent to CSOs" group, which was comprised of sites DB01, DB04, DB13, DB14, and CO19, and (2) the "distant from CSOs" group, which was comprised of the other nine sites. Additionally, the Student-Newman-Keuls test was run on all sites together in one test to determine how the sites "group" in terms of similarity and differences in contaminant concentrations.

The data presented in this section are summaries of the statistical analysis and are presented as site data. However, individual sample data (the three replicates from each site) were used to perform all the statistical analyses. The individual site replicate data can be found in Appendices B, C, and D, respectively, for the organic contaminants, metals contaminants, and the subcontracted analyses (*Clostridium perfringens*, TOC, and grain size). The summary statistics (e.g., site average and standard deviation data) for the sites and parameters that were determined for both the 1990 and 1994 surveys' samples are compiled in Appendix E. These data give an indication of the intra-site precision for the sites and parameters that were determined in both surveys, and it is clear that poor site replicate precision frequently hampered the statistical analysis (e.g., for the three DB11 site replicates the % mud ranged from 12 to 79% and the TOC content ranged from 0.3 to 2.3%).

3.2.1 Organic Contaminant and *Clostridium perfringens* Data Analysis Results

The probability values (*p* values) from the *t*-test of difference among test sites and a reference site (T2) are presented in Table 3-4 for comparisons that resulted in a p value ≤ 0.10 ($\geq 90\%$ probability of difference in the means of the test site and the reference site). The table shows both results for higher (indicated with a "+") and lower (indicated with a "–") levels than the reference site. In addition to comparing the means, this statistical analysis considers the variability in each site value for determination of significant differences. The results indicate that there are several sites with concentrations of organic contaminants that are significantly higher than concentrations at the reference site (T2). For instance, sites DB01, DB10, DB12, DB13, DB14, and CSO19 had PAH, PCB, and/or DDT levels that were higher than the reference site. No sites had elevated counts of *Clostridium perfringens*, relative to T2. Several sites had statistically significant lower levels of some organic contaminants and *Clostridium perfringens* than at the reference site.

Table 3-5 presents the results of the one-way ANOVA analysis that compares data for sites located near CSOs with data from sites located away from CSOs for selected contaminants (LAB, *Clostridium perfringens*, and metals). The listed parameters were the only ones that could be tested by this statistical analysis method; the other parameters did not meet the required assumptions of homoscedasticity, even after log-transformation and/or the standard normalization procedures were performed.

Table 3-4. Observed Significance Levels (*p* Values) for Statistical Comparison (t-test) of Test Sites with a Reference Site (T2) for Organic Contaminants and *Clostridium perfringens*—1994 Samples

	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T8	CSO19	SWEX3
Non-normalized Organic Contaminants													
Total PAH	+ 0.000			- 0.001	+ 0.000		+ 0.006	+ 0.017	+ 0.001		- 0.036	+ 0.000	+ 0.043
PAH 24	+ 0.000			- 0.001	+ 0.000		+ 0.010	+ 0.014	+ 0.066		- 0.040	+ 0.000	+ 0.067
Total PCB	+ 0.004			- 0.000	+ 0.000		+ 0.000		+ 0.009	- 0.094	- 0.000	+ 0.002	+ 0.000
Total DDT	+ 0.004			- 0.000	+ 0.000		+ 0.000		+ 0.003		- 0.002	+ 0.005	+ 0.007
Total LAB	- 0.006	- 0.002		- 0.000		- 0.033	- 0.001	+ 0.002	+ 0.001	- 0.009	- 0.007	+ 0.003	
Coprostanol	- 0.029	- 0.003		- 0.000		- 0.007	- 0.005		+ 0.001	- 0.060	- 0.004		
TOC-normalized Organic contaminants													
Total PAH	+ 0.001			- 0.037		+ 0.029	+ 0.037	+ 0.086	+ 0.001		- 0.058	+ 0.001	- 0.008
PAH 24	+ 0.001			- 0.092	+ 0.094	+ 0.026	+ 0.063	+ 0.069			- 0.099	+ 0.001	- 0.004
Total PCB			- 0.051		+ 0.000	+ 0.018	+ 0.003		+ 0.013	- 0.004	- 0.000	+ 0.008	
Total DDT					+ 0.000	+ 0.044	+ 0.001		+ 0.000	- 0.056	- 0.002	+ 0.041	
Total LAB	- 0.002	- 0.002	- 0.024	- 0.005	- 0.005	- 0.089	- 0.001	- 0.056	- 0.072	- 0.001	- 0.003		- 0.010
Coprostanol	- 0.001	- 0.000	- 0.012		- 0.001	- 0.021	- 0.000	- 0.070		- 0.001	- 0.001	- 0.007	- 0.028
Clostridium perfringens spore counts													
Raw	- 0.002	- 0.013	- 0.010	- 0.001		- 0.004				- 0.002	- 0.004		
Log transformed	- 0.004	- 0.031	- 0.025	- 0.000		- 0.009				- 0.001	- 0.021		
TOC norm./Log transf.	- 0.002		- 0.013		- 0.006			- 0.013	- 0.017	- 0.044	- 0.003		- 0.051
Grain size norm./Log transf.	- 0.001		- 0.040	- 0.001	- 0.001	- 0.021		- 0.011	- 0.066	- 0.001			- 0.075
Total Organic Carbon and Grain Size													
TOC	+ 0.002		+ 0.014	- 0.001	+ 0.000		+ 0.007	+ 0.002	+ 0.002			+ 0.002	+ 0.004
Silt/Clay	+ 0.001			- 0.002	+ 0.000			+ 0.000			- 0.002	+ 0.000	+ 0.096

Numbers are 2-tailed probabilities for difference between T2 and test site. Only results where p is less than 0.1 are tabulated.

\+ Indicates site mean significantly greater than mean for that contaminant at T2.

\- Indicates site mean significantly less than mean for that contaminant at T2.

Table 3-5. Results of One-Way ANOVA Analysis for Selected Contaminants to Statistically Compare Sites Near CSOs to Sites Away from CSOs—1994 Samples

		Main Effect		Contrast	
Parameter	**Log***	**F ratio****	**Probability**	**Result**	**Probability**
Ag		7.1093	< 0.0001	CSO > non-CSO	< 0.001
Cr		3.022	0.007	CSO > non-CSO	0.016
Cu		11.132	< 0.0001	CSO > non-CSO	< 0.001
Fe	Y	1.78	> 0.05, NS	NS	
Hg	Y	2.52	0.0197	CSO > non-CSO	0.004
Ni		1.75	> 0.05, NS	NS	
Pb	Y	9.903	< 0.0001	CSO > non-CSO	< 0.001
Zn	Y	9.21	< 0.0001	CSO > non-CSO	< 0.001
LABs		11.5671	< 0.0001	CSO > non-CSO	< 0.001
C. perfringens	Y	4.9204	0.0002	CSO > non-CSO	< 0.001

* "Y" in LOG column indicates data were log-transformed to meet ANOVA assumptions
** F-ratios are based upon 13 & 28 degrees of freedom.
Aluminum-normalized data were used for metals. TOC nomalized data were used for LABs.

Table 3-6 presents the results of the multiple comparison test (Student-Newman-Keuls) of differences and similarities in contaminant concentrations among the 14 study sites. These data were generated using a probability of difference criterion of 95% or greater (α=0.05). LABs, *Clostridium perfringens*, and the listed metals were the only parameters that could be tested by this statistical analysis method; the other parameters did not meet the required assumptions of homoscedasticity, even after log-transformation and/or data normalization. The letters in the table indicate the site grouping by statistically significant difference/similarity, and by level of contamination. The letter “A” is for the site(s) that group with the lowest concentration level, the letter “B” indicates the next highest, and so on. A test result of a “B” alone means that site has a significantly higher level of the given parameter than sites with a test result of “A” only. A result of “A, B” indicates that the level is not statistically different from those in group A or B.

3.2.2 Metal Contaminant Data Analysis Results

Table 3-7 presents the probability values (*p* values) from the *t*-test of difference among test sites and site T2 that resulted in a *p* value ≤0.10 (≥90% probability of difference in the means of the test site and the reference site). The table shows both results for higher (indicated with a “+”) and lower (indicated with a “–”) levels than the reference site. In addition to comparing the means, this statistical analysis considers the variability

Table 3-6. Multiple Comparisons (Student-Newman-Keuls) among Test Sites for Selected Contaminants—1994 Samples

Parameter	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T2	T8	CSO19	SWEX3
Ag	C,D,E	A,B,C	B,C,D,E	A	E	A,B,C,D	E	E	B,C,D,E	A,B	A,B,C,D,E	A,B,C	D,E	C,D,E
Cr	A,B	A	A,B	A	A,B	A,B	B	A,B	A,B	A	A,B	A,B	A,B	A,B
Cu	C,D	A	A,B,C	A	D	A,B	B,C	B,C,D	D	A	A,B,C	A	B,C	A,B,C
Pb	C	A,B,C	C	A,B	C	B,C	C	C	D	A,B	A,B,C	A,B,C	B,C	B,C
Zn	C	AB	B,C	A	C	A,B,C	B,C	C	D	A	A,B,C	A,B,C	B,C	A,B,C
LABs	A	A	A,B,C	A	A,B,C	A,B,C	A	B,C,D	C,D	A	D,E	A,B	E	A,B,C
C. perfringens	A	B	A,B	B	A,B	A,B	B	A,B	A	A, B	B	A,B	A,B	B

For each parameter, "A" is the homogenous group with the lowest concentrations, followed by "B", etc.

Aluminum normalized data were used for metals and TOC normalized LABs and C. perfringens data were used.

Table 3-7. Observed Significance Levels (*p* Values) for Statistical Comparison (t-test) of Test Sites with a Reference Site (T2) for Selected Metal Contaminants—1994 Samples

	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14	T1	T8	CSO19	SWEX3
Non-normalized Metals													
Ag	+ 0.004	- 0.016		- 0.000	+ 0.001	- 0.091	+ 0.005	+ 0.057		- 0.014	- 0.001	+ 0.000	+ 0.006
Al												+ 0.094	
Cd	+ 0.002	- 0.042	+ 0.000	- 0.000	+ 0.002				+ 0.006	- 0.034	- 0.000	+ 0.000	- 0.044
Cr		- 0.020		- 0.001	+ 0.001		+ 0.033			- 0.041	- 0.007	+ 0.001	+ 0.004
Cu	+ 0.004	- 0.039		- 0.002	+ 0.000		+ 0.039	+ 0.029	+ 0.017	- 0.027	- 0.009	+ 0.000	+ 0.006
Fe	+ 0.031	- 0.044		- 0.002	+ 0.001			+ 0.005				+ 0.001	+ 0.003
Hg	+ 0.003		+ 0.021	- 0.001	+ 0.000		+ 0.007	+ 0.048	+ 0.056		- 0.004	+ 0.001	+ 0.082
Ni	+ 0.018	- 0.083		- 0.008	+ 0.008		+ 0.023	+ 0.026				+ 0.014	+ 0.010
Pb	+ 0.000		+ 0.062	- 0.003	+ 0.008		+ 0.013	+ 0.020	+ 0.006	- 0.032	- 0.006	+ 0.000	+ 0.002
Zn	+ 0.002	- 0.072	+ 0.010	- 0.001	+ 0.000		+ 0.040	+ 0.024	+ 0.008	- 0.043	- 0.014	+ 0.000	+ 0.003
Al-normalized Metals													
Ag		- 0.088		- 0.017	+ 0.023			+ 0.065		- 0.035	- 0.085	+ 0.077	
Cd	+ 0.098		+ 0.039	- 0.020	+ 0.007				+ 0.009	- 0.091	- 0.066	+ 0.015	
Cr					+ 0.075		+ 0.078			- 0.098			
Cu	+ 0.032			- 0.074	+ 0.006		+ 0.099	+ 0.038	+ 0.018	- 0.087		+ 0.034	
Fe													
Hg	+ 0.005		+ 0.086	- 0.012	+ 0.001		+ 0.051	+ 0.029	+ 0.005			+ 0.009	
Ni													
Pb	+ 0.008		+ 0.073		+ 0.024		+ 0.023	+ 0.013	+ 0.004	- 0.066		+ 0.029	
Zn	+ 0.022				+ 0.006		+ 0.062	+ 0.025	+ 0.006			+ 0.045	

Numbers are 2-tailed probabilities for difference between T2 and test site. Only results where p is less than 0.1 are tabulated.

\+ Indicates site mean significantly greater than mean for that contaminant at T2.

\- Indicates site mean significantly less than mean for that contaminant at T2.

in each site value for determination of significant differences. The results indicate that there are several sites with concentrations of metal contaminants that are significantly higher than concentrations at the reference site (T2). Some site/parameter combinations show lower concentrations of the metal contaminant than the reference site.

Results of the one-way ANOVA analysis for metals contaminants, comparing the data for sites that are located near CSOs with those that are located away from CSOs, are presented in Table 3-5, as discussed in Section 3.2.1. Table 3-6 presents the results of the multiple comparison test of differences and similarities in contaminant concentrations among the 14 study sites. These data were generated using a probability of difference criterion of 95% or greater (α=0.05). As presented in the previous section, the letters in Table 3-6 indicate the site grouping by statistically significant difference/similarity and by level of contamination.

3.3 COMPARISON RESULTS — 1994 VERSUS 1990 DATA

An important aspect of this study was to compare the sediment contaminant concentrations measured in sediments collected in the 1990 survey with concentrations in sediments collected in 1994. This comparison could only be performed for the sites and analytical parameters that were common to both studies. For example, PCB and pesticides were not determined in the 1990 samples and are, therefore, not included in the comparison sections, and the data presentation is limited to the nine sites that were sampled both years. The 1994 data presented in this section are therefore a subset of the data presented in Section 3. The 1990 data are a subset of the data presented in Durell *et al.* (1991); that report includes detailed information on that study and the associated data (including all the site replicate and individual analyte data).

3.3.1 Organic Contaminant Concentrations and *Clostridium perfringens* Densities

The comparison of the 1990 and 1994 organic contaminant and *Clostridium perfringens* data is presented in Table 3-8; Table 3-8(a) is a compilation of the non-normalized data while the TOC-normalized organic contaminant data are listed in Table 3-8(b). The PAH data are presented as the sum of the 24 PAH analytes asterisked in Table 2-2 because these were the only PAH compounds determined in the previous CSO study. In the previous study, PAH, LAB, and/or coprostanol were not determined at all of the sites, as indicated by the "NA" comment in the 1990 data segment of the table. Table 3-9 summarizes *Clostridium perfringens* data that were generated in other studies for selected Boston Harbor sites. The organic contaminant and

Table 3-8. Sediment Organic Contaminant and *Clostridium perfringens* Data Comparison—1994 and 1990 Samples

(a) PAH, LAB, Coprostanol, and *Clostridium perfringens* Concentrations

Non-normalized (ng/g, dry weight)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14
				1994					
Total 24 PAH	21184	8253	31813	424	16007	6317	14599	17329	100149
Total LAB	792	264	974	32.2	1533	425	681	1939	3197
Coprostanol	5604	1612	6061	2815	5683	2135	2825	9263	32232
Total LAB/Coprostanol Ratio	0.14	0.16	0.16	0.01	0.27	0.20	0.24	0.21	0.10
Clostridium perfringens	3037	5283	5117	1283	11967	3340	16500	10483	7287
Clostridium perfringens - log10	3.48	3.72	3.71	3.11	4.08	3.52	4.22	4.02	3.86
				1990					
Total 24 PAH	65840	2440	8030	550	18140	NA	4490	9010	35720
Total LAB	1350	NA	1170	NA	NA	NA	1230	2430	3210
Coprostanol	4220	NA	5160	NA	NA	NA	4860	16770	31030
Total LAB/Coprostanol Ratio	0.32	NA	0.23	NA	NA	NA	0.25	0.14	0.10
Clostridium perfringens	27033	12963	45533	1990	34567	25400	27800	53400	115400
Clostridium perfringens - log10	4.43	4.11	4.66	3.30	4.54	4.40	4.44	4.73	5.06

(b) PAH, LAB, and Coprostanol Concentrations—Normalized to TOC

TOC Normalized (ng/g/%TOC)

Site ID:	DB01	DB03	DB04	DB06	DB10	DB11	DB12	DB13	DB14
				1994					
Total 24 PAH	7566	7503	13255	2122	3904	5743	5615	5415	19637
Total LAB	283	240	406	161.0	374	386	262	606	627
Coprostanol	2001	1465	2525	14075	1386	1941	1087	2895	6320
				1990					
Total 24 PAH	10540	2570	2540	2160	4000	NA*	2470	2380	8300
Total LAB	220	NA	370	NA	NA	NA	670	640	750
Coprostanol	650	NA	1640	NA	NA	NA	2560	4440	7240

* NA: Not applicable. Sample not analyzed for this parameter.

Table 3-9. ***Clostridium perfringens*** **Data for Selected Boston Harbor Sites from Other Studies**

Sampling Date	T-1	T-2	T-3	T-4	T-6	T-7	T-8
09/91	11700	22900	207000	30000	29400	13700	7330
08/92	4300	14800	938	3330	7000	7500	3890
04/93	3870	3690	12500	10500	10300	13700	3420
08/93	7030	9090	20200	5750	13800	7100	1580
04/94	6180	18500	14600	12000	11900	10600	5230
08/94	7460	13600	20300	9080	7110	7290	933

Sites T-1 through T-8 are sites within Boston Harbor, not Massachusetts Bay, that are part of ongoing monitoring.
09/91 through 04/94 data from Kropp and Diaz, 1994. 08/94 data from Battelle survey for MWRA in August 1994.

Clostridium perfringens data presented in Tables 3-8 and 3-9 are discussed in Sections 4-2 and 4-4, respectively.

3.3.2 Metal Contaminant Concentrations

The comparison of the 1990 and 1994 metal contaminant data is presented in Table 3-10; Table 3-10(a) is a compilation of the non-normalized data, while the grain-size-normalized metal contaminant data are listed in Table 3-10(b) and the aluminum normalized data are presented in Table 3-10(c). The metal contaminant data presented in Table 3-10 are discussed in Section 4-3.

3.3.3 Statistical Data Analysis Results

Two-way ANOVA analyses were performed to determine if there were statistically significant differences in the contaminant levels measured in the sediments collected in 1990 and 1994, for the parameter and site location that were common to both studies. Organic contaminant data were typically analyzed with and without TOC normalization; metal contaminant data were analyzed nonnormalized, normalized to aluminum, and normalized to grain size (percent mud); and the *Clostridium perfringens* data were analyzed using nontransformed and log-transformed data, with and without TOC normalization. Log transformation of organic and metal contaminant data was also attempted before performing the two-way ANOVA to obtain homoscedasticity. However, this ANOVA analysis was not very effective in discriminating between year differences and yielded only three parameters with clear statistical differences for one or more sites.

Table 3-10. Sediment Metal Contaminant Data Comparison—1994 and 1990 Samples
(a) Metal Contaminant Concentrations

Non-normalized (ug/g, dry weight)*

Site ID	Al (%)	Cd	Cr	Cu	Fe (%)	Ni	Pb	Zn	Mud* (%)
				1994					
DB01	5.70	0.844	157	134	3.72	34.5	152	233	74.4
DB03	4.63	0.228	65.2	27.9	1.99	15.3	54.6	69.5	18.6
DB04	5.47	0.820	139	87.0	2.94	28.2	159	168	60.8
DB06	3.64	0.065	34.8	12.1	1.35	9.10	28.4	33.3	7.4
DB10	6.17	1.69	218	198	4.22	37.8	182	273	87.9
DB12	5.33	1.13	209	98.5	3.14	33.9	130	172	45.6
DB13	6.71	2.12	254	158	3.79	37.1	199	266	85.7
DB14	4.25	1.48	119	126	2.84	25.5	347	344	51.9
				1990					
DB01	6.52	8.28	116	215	2.82	73.4	469	1472	30.1
DB03	5.31	0.600	82.8	48.5	2.09	19.3	59.7	97.6	18.5
DB04	7.44	1.50	196	156	3.70	47.9	150	275	63.8
DB06	5.11	0.250	34.2	18.6	1.39	13.8	36.7	46.7	6.1
DB10	7.14	2.29	218	215	4.62	51.5	427	473	62.7
DB12	6.44	1.06	168	103	3.07	34.0	110	156	44.1
DB13	7.41	2.01	212	182	4.01	44.3	192	342	77.7
DB14	6.97	2.46	160	183	3.70	44.3	523	433	64.1

* Aluminum and iron are reported as percent. Percent mud is defined as percent silt plus percent clay.

Table 3-10. Sediment Metal Contaminant Data Comparison—1994 and 1990 Samples
(b) Metal Contaminant Concentrations—Normalized to Grain Size

Grain Size Normalized (ug/g/%mud)*

Site ID	Al (%)	Cd	Cr	Cu	Fe (%)	Ni	Pb	Zn
1994								
DB01	0.077	0.011	2.11	1.80	0.050	0.463	2.04	3.13
DB03	0.249	0.012	3.51	1.50	0.107	0.822	2.94	3.74
DB04	0.090	0.013	2.28	1.43	0.048	0.464	2.62	2.76
DB06	0.489	0.009	4.68	1.63	0.182	1.22	3.83	4.48
DB10	0.070	0.019	2.48	2.26	0.048	0.429	2.07	3.11
DB12	0.117	0.025	4.59	2.16	0.069	0.743	2.85	3.77
DB13	0.078	0.025	2.96	1.84	0.044	0.433	2.32	3.10
DB14	0.082	0.029	2.30	2.43	0.055	0.492	6.68	6.63
1990								
DB01	0.217	0.275	3.85	7.14	0.094	2.439	15.6	48.9
DB03	0.287	0.032	4.48	2.62	0.113	1.043	3.23	5.28
DB04	0.117	0.024	3.07	2.45	0.058	0.751	2.35	4.31
DB06	0.838	0.041	5.61	3.05	0.228	2.262	6.02	7.66
DB10	0.114	0.037	3.48	3.43	0.074	0.821	6.81	7.54
DB12	0.146	0.024	3.81	2.34	0.070	0.771	2.49	3.54
DB13	0.095	0.026	2.73	2.34	0.052	0.570	2.47	4.40
DB14	0.109	0.038	2.50	2.85	0.058	0.691	8.16	6.76

* Aluminum and iron are reported as %/g/%mud. Percent mud is defined as percent silt plus percent clay.

(c) Metal Contaminant Concentrations—Normalized to Aluminum

Aluminum Normalized (ug/g/%aluminum)*

Site ID	Al (%)	Cd	Cr	Cu	Fe (%)	Ni	Pb	Zn
1994								
DB01	1.00	0.148	27.6	23.5	0.652	6.04	26.7	40.9
DB03	1.00	0.049	14.1	6.0	0.430	3.30	11.8	15.0
DB04	1.00	0.150	25.4	15.9	0.538	5.16	29.0	30.7
DB06	1.00	0.018	9.57	3.34	0.372	2.50	7.82	9.17
DB10	1.00	0.274	35.3	32.2	0.684	6.12	29.5	44.3
DB12	1.00	0.213	39.3	18.5	0.590	6.36	24.4	32.2
DB13	1.00	0.315	37.9	23.5	0.565	5.53	29.6	39.6
DB14	1.00	0.349	28.1	29.7	0.669	6.00	81.6	80.9
1990								
DB01	1.00	1.27	17.8	33.0	0.433	11.3	71.9	225.8
DB03	1.00	0.113	15.6	9.1	0.394	3.63	11.2	18.4
DB04	1.00	0.202	26.3	21.0	0.497	6.44	20.2	37.0
DB06	1.00	0.049	6.69	3.64	0.272	2.70	7.18	9.14
DB10	1.00	0.321	30.5	30.1	0.647	7.21	59.8	66.2
DB12	1.00	0.165	26.1	16.0	0.477	5.28	17.1	24.2
DB13	1.00	0.271	28.6	24.6	0.541	5.98	25.9	46.2
DB14	1.00	0.353	23.0	26.3	0.531	6.36	75.0	62.1

* Aluminum and iron are reported as %/g/%aluminum.

The results indicated a statistically significant decline in zinc at site DB01, in LAB at site DB12, and in *Clostridium perfringens* at sites DB04, DB13, and DB14. Many site/parameter data sets clearly had no apparent concentration changes, while for others the lack of statistically significant differences between 1990 and 1994 data may be because the required assumption of homogeneity of variance could not be attained due to less-than-ideal precision for the site replicate samples that were collected.

4.0 DISCUSSION

The primary goals of this study were to assess the current impact of specific CSOs on contamination of sediments in the Dorchester Bay area and to determine if there have been changes in the sediment contaminant concentrations between 1990 and 1994. The discussion presented in Section 4 is based on the data generated in this study (1994 samples), relevant historical data where appropriate, and the comparison with the 1990 study data. A brief compilation of selected historical data is presented in Section 4.1, followed by a discussion of the organic (Section 4.2), metal (Section 4.3), and microbiological (Section 4.4) sediment contaminant concentrations that were determined for Dorchester Bay in this (1994) and the previous (1990) CSO study. The 1994 data are also compared with other historical data in sections 4.2 through 4.4.

4.1 HISTORICAL DATA

Data from other studies that may be useful for comparison with this study are limited. Sediment, water-column, and CSO and treatment-plant discharge data from a variety of studies and monitoring programs have been reviewed. Most of this previous work was not useful for comparison with this study either because of the lack of site, parameter, and/or sample-matrix overlap with this study, or because the analytical methods were not comparable or not sufficiently well documented. Additionally, an exhaustive review of the literature was beyond the scope of this report. Historical data that were considered useful are summarized below.

4.1.1 Studies of Contaminant Fate and Transport in Boston Harbor

Transport and deposition of pollutants has been shown to be important in regulating contaminant concentrations in Boston Harbor (Gallagher *et al.*, 1992; MDC, 1979; Wallace *et al.*, 1988a,b,c). Studies have shown concentrations of most metals to be relatively uniform in the water column within much of Boston Harbor. However, Wallace *et al.* (1988c) found that the Dorchester Bay sites generally had among the highest particulate-phase water-column metal concentrations, but had dissolved-phase concentrations that were comparable with most other Harbor sites. Wallace *et al.* (1991) determined the metal concentrations in the Fox Point CSO discharge and in water and sediment samples collected near the CSO. They concluded that, although the CSO effluent elevates the concentrations of several metals in the water column near the point of discharge during and shortly after the time of discharge, the elevated levels found in the sediment were due primarily to transport from elsewhere in the Harbor and not from the Fox Point discharge. Similar conclusions were drawn by Eganhouse and Sherblom (1990) for organic pollutants in the Fox Point area.

Deer Island and Nut Island wastewater treatment plants discharge into Boston Harbor. Historically, sludge, untreated effluent, and treated effluent have been discharged, but sludge discharges to Boston Harbor from the Deer Island and Nut Island sewage treatment plants ceased in December 1991. Up until then the sludge discharges occurred predominantly with outgoing tides, while the effluent discharges have been continuous. The sewage outfalls from these two plants account for approximately 50% of the total freshwater input into Boston Harbor (Wallace *et al.*, 1988). Other sources of fresh water to the Harbor are the Mystic, Charles, and Neponset Rivers. The treatment plant discharges do not completely disperse into Massachusetts Bay, but reenter the Harbor through President Roads and other routes such as Nantasket Roads. Transport back into the Harbor by either of these routes is supported by known tidal-current patterns, and measured water and sediment contaminant distribution patterns (Gallagher *et al.,* 1992; MDC, 1979; MDEQE, 1986; Wallace *et al.,* 1988; Wallace *et al.* 1991). The data from these studies suggest that there is a plume of elevated concentrations of contaminants that extends from the Deer Island/President Roads area up into the Fox Point/Commercial Point area of Dorchester Bay. Additionally, Kelly (1993) estimated that approximately 10% of the nitrogen input to the Harbor remains in the Harbor, while roughly 90% is exported to western Massachusetts Bay. Furthermore, sludge from Nut Island had been implicated as one source of LAB and other contaminants to the sediments in Savin Hill Cove, in particular, (near Fox Point) and Dorchester Bay area, in general. Tracking of the Nut Island plume in 1990 (McDowell *et al.*, 1991) also suggested that this discharge may be a likely source of contaminants into Dorchester Bay. These historical chemistry data suggest that this may be the main route of transport into Dorchester Bay for most toxic chemicals, and that most of the chemicals have historically originated in Deer Island and Nut Island discharges.

The elimination of Deer Island and Nut Island sludge discharges in December 1991 was expected to significantly reduce the amount of contaminants transported into Dorchester Bay. Furthermore, the substantial CSO system improvements that have been made in the past five years are expected to reduce the locally contributed contaminant inputs to Dorchester Bay. These improvements include rigorous tide-gate inspection programs that essentially ceased dry weather overflows and pumping increases that allow more of the storm flow to reach the treatment plants, decreasing choking times and, therefore, reducing the number and volume of CSO discharges (MWRA, 1994b). Additional system improvements include the construction of CSO treatment facilities (for bar screening and chlorination) at Fox Point (CSO BOS-89) and Commercial

Point (CSO BOS-90); these went into operation in the winter of 1989 (before the 1990 survey) and 1990 (after the 1990 survey), respectively.

4.1.2 Contaminant Concentrations in Boston Harbor and Massachusetts Bay

The NOAA Mussel Watch Program is one source of Massachusetts Bay data that were generated using analytical methods comparable to the ones used in this study. Table 4-1 lists metal, PAH, PCB, and DDT concentrations found in sediment samples collected between 1985 and 1990 at eight Mussel Watch sites from Cape Ann to Cape Cod (there has not been any more recent sediment sample collection for this area in the Mussel Watch program). Two sites, the Deer Island and Dorchester Bay sites, are of particular interest for comparison purposes because of their proximity to the area investigated in this study. The Deer Island site is located on the western shore of Point Shirley, a short distance north of site T1 in this study. The Dorchester Bay site is located on the north shore of Squantum Point, which is approximately half-way between sites DB13 and DB14 and on the opposite side of the Neponset River. These Mussel Watch data will be used as reference data in the discussion sections that follow.

PAH

The mean sediment PAH concentrations (as the sum of the 24 asterisked PAH in Table 2-2) for the Deer Island and Dorchester Bay Mussel Watch sites (sampled 1986 and 1987) were 3,300 and 7,700 ng/g, respectively (Hillman *et al.*, 1990). The concentrations, as the sum of these 24 PAH, ranged from 550 to 66,000 ng/g for the 10 sites for which PAH were determined in the 1990 Dorchester Bay CSO survey (Durell *et al.*, 1991). The total PAH concentrations measured in the Mystic and Charles River sediment ranged from 30,000 to 99,000 ng/g for the five sites sampled in an earlier study conducted by Battelle for MWRA (Battelle, 1990a). Although other work on PAH concentrations in Boston Harbor and Massachusetts Bay sediments was reviewed (e.g., Shiaris and Jambard-Sweet, 1986; EPA, 1988a, 1988b; MDEQE, 1986), they were not useful for comparison purposes for a variety of reasons, including noncomparable analytical methods, high detection limits, insufficient overlap in analyte lists, noncomparable site locations, and insufficient information on how data were generated and what they represented.

PCB and DDT

The mean sediment total PCB concentrations (as the sum of the PCB congeners listed in Table 2-2) for the Deer Island and Dorchester Bay Mussel Watch sites were 230 and 640 ng/g, respectively (Hillman *et al.*,

Table 4-1. Massachusetts Bay Reference Sediment Data from the Mussel Watch Program

	Analyte Concentration[a]										
	Ag	Hg	Cu	Pb	Cd	Cr	Ni	Zn	ΣPAH_{24}[b]	ΣPCB	ΣDDTs
Site Location											
Cape Ann, Gap Head	0.08	0.07	9.0	28.3	0.13	33.7	10.9	40.3	~1,840[d]	20.1	4.5
Salem Harbor, Folger Point	1.04	0.68	58.0	133	1.95	6.0	31.7	150	~5,120[d]	80.6	57.9
Massachusetts Bay, Nahant Bay	0.12	0.04	7.5	24.1	0.11	52.0	NA[c]	NA	883	9	1
Boston Harbor, Deer Island	3.10	0.69	103	110	1.13	191	29.2	145	~3,320[d]	233[e]	24.4
Boston Harbor, Dorchester Bay	3.12	0.83	118	132	1.43	192	30.8	183	~7,670[d]	644[e]	45.2
Boston Harbor, Hingham Bay	1.13	0.21	25.0	35.5	0.27	56.8	14.5	58.5	~814[d]	66.2	6.9
Massachusetts Bay, North River	0.33	0.17	13.3	32.5	0.24	26.9	NA	NA	1,230	17	9
Duxbury Bay, Clarks Island	0.28	0.01	4.8	11.1	0.04	18.5	6.5	19.7	156	13	2.2

[a] Concentration in sediment samples collected between 1986 and 1989. Mean concentration if site was analyzed more than one time.
Metals concentrations are in micrograms per grams (μg/g) dry weight while PAH, PCB, and DDT concentrations are in ng/g dry weight.
Data for Massachusetts Bay, Nahant Bay and Massachusetts Bay, North River are from Battelle (1991b). All other data are from Battelle (1990c).

[b] ΣPAH_{24}: Sum of the 24 individual PAH analytes asterixed in table 2-2.

[c] NA: Not readily available.

[d] Approximate ΣPAH_{24} determined by multiplying the sum of the "low" and "high" molecular weight PAH reported in Battelle (1990c) by 1.1 — expected to be within 10% of true value.

[e] PCB data for Deer Island and Dorchester Bay sites are average of data for samples collected in 1986 and 1987. Concentrations were 247 and 219 ng for Deer Island for 1986 and 1987, respectively. Concentrations were 602 and 685 ng for Dorchester Bay for 1986 and 1987, respectively. The TOC content of the 1986 samples was 1.01 and 1.73% for Deer Island and Dorchester Bay, respectively, and the grain size was 48.9 and 68.8% mud for these same samples.

1990). The sum of the six DDT compounds was approximately 24 and 45 ng/g for the Deer Island and Dorchester Bay Mussel Watch sites, respectively, during the same survey period.

LAB and Coprostanol

Linear alkylbenzenes (LAB) are aromatic compound byproducts produced during industrial synthesis of LAB sulfonates, which are widely used anionic surfactants in detergents (Eganhouse and Sherblom, 1990; Takada and Ishiwatari, 1990). Sources of LAB in Boston Harbor include waste from industrial production and household and commercial cleaning activities. Coprostanol (5β-cholestan-3β-ol) is a sterol that is found in human feces and can be used as an indicator of sewage-derived organic material (Brown and Wade, 1984; Hatcher and McGillivary, 1979). It is particularly useful as a tracer because its concentration is generally unaffected by chlorination and aeration, and because it persists in anoxic sediments (Vankatesan and Kaplan, 1990). Coprostanol data are frequently the sum of coprostanol and epicoprostanol (as is the case in both of Battelle's Dorchester Bay CSO studies).

The sediment total LAB and coprostanol concentrations ranged from 1,200 to 3,200 ng/g and from 4,200 to 31,000 ng/g, respectively, for the five sites for which these parameters were determined in the 1990 Dorchester Bay CSO survey (Durell *et al.*, 1991); the LAB/coprostanol ratios for the five samples ranged from 0.10 to 0.32. Deer Island and Nut Island sludge and effluent were analyzed in that same study. The Deer Island sludge and effluent LAB concentrations were 0.98 and 0.015 mg/L, respectively, while the coprostanol concentrations were 43.4 (sludge) and 0.13 mg/L (effluent). This resulted in LAB/coprostanol ratios of 0.02 and 0.13 for Deer Island sludge and effluent, respectively. The Nut Island sludge and effluent LAB concentrations were 1.7 and 0.023 mg/L, respectively, while the coprostanol concentrations were 22.7 (sludge) and 0.19 mg/L (effluent). This yielded LAB/coprostanol ratios of 0.08 and 0.12 for Deer Island sludge and effluent, respectively.

In a previous study in Dorchester Bay, Eganhouse and Sherblom (1990) found that total LAB concentrations in the sediment ranged from 280 to 2,340 ng/g (eight stations) and that coprostanol concentrations ranged from 260 to 11,500 ng/g (seven stations). The LAB/coprostanol ratios for five sites located in Savin Hill Cove, near Thompson Island, and at the mouth of the Neponset River ranged from 0.20 to 0.55. They also report coprostanol values from a six station survey of Boston Harbor in which a mean sediment concentration of 4,800 ng/g was determined. In an earlier study, Eganhouse *et al.* (1988) reported LAB concentrations of 3.22 and 0.82 mg/L in Nut Island and Deer Island sludge, respectively. In the same study, coprostanol concentrations were determined to be 15.3 and 38.6 mg/L in Nut Island and Deer Island sludge, respectively. This yielded an LAB/coprostanol ratio of 0.21 for Nut Island sludge and 0.021 for Deer Island sludge.

Metal Contaminants

Several studies have been conducted to determine the metal concentrations in Boston Harbor waters (MDEQE, 1986; Wallace *et al.*, 1988) and sediment (MDC, 1979; MDEQE, 1986; Battelle, 1990a; Wallace *et al.*, 1991). Although some of these data were useful, much of the data could not be used for comparison for the same reasons stated above.

The concentrations of cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc at the eight Massachusetts Bay Mussel Watch sites are given in Table 4-1. The Dorchester Bay and Deer Island sites, the sites closest to the two areas examined in this study, generally have, along with the Salem Harbor site, the highest metal concentrations. The metal concentrations averaged approximately 1.3 µg/g for cadmium, 190 µg/g for chromium, 110 µg/g for copper, 120 µg/g for lead, 0.76 µg/g for mercury, 30 µg/g for nickel, 3.1 µg/g for silver, and 160 µg/g for zinc for the Dorchester Bay and Deer Island sites. The ranges of metal concentrations that were determined for the 10 sites in the 1990 Dorchester Bay CSO sediment survey were 0.25 to 8.3 µg/g for cadmium, 25 to 220 µg/g for chromium, 16 to 220 µg/g for copper, 33 to 520 µg/g for lead, 10 to 73 µg/g for nickel, and 33 to 1,500 µg/g for zinc (Durell *et al.*, 1991).

Wallace *et al.* (1991) determined that the Savin Hill Cove overall intertidal and subtidal surface sediment metal concentrations ranged from approximately 1.6 to 2.2 µg/g for cadmium, 190 to 220 µg/g for chromium, 130 to 180 µg/g for copper, 210 to 230 µg/g for lead, 32 to 38 µg/g for nickel, and 190 to 280 µg/g for zinc. The metal concentrations were slightly lower at reference sites near Thompson Island and lower yet at sites near the mouth of the Neponset River.

Microbiology

Limited data are available on the microbiology of Boston Harbor sediment. Site-to-site variability has been high for total and fecal coliform concentrations measured in the water column within Boston Harbor, with sites in the Inner Harbor generally having the highest concentrations, but with highly elevated densities occasionally measured in the mouth of the Neponset River and other scattered sites (MDEQE, 1984, 1986). The concentrations in sediments at individual sites were found to be highly variable from one sampling time to another, with the same sites having among the highest densities in samples collected on one survey and among the lowest densities of coliforms in a survey that was conducted only a few weeks later. Sediment concentrations of microbiological pollutants were not measured in these past studies. There are only limited data on CSO discharge, and the density data from these analyses are of limited value because of the large variability in the few data that are available. There are particularly few data on the Dorchester Bay CSOs relevant to this study.

However, *Clostridium perfringens* densities were reported by Durell *et al.* (1991) for 14 sites in the 1990 Dorchester Bay CSO sediment survey and ranged from approximately 2,000 spores/gram dry weight on the low end to approximately 115,000 spores/gram dry weight for the site near the Commercial Point CSO (DB14). Additionally, *Clostridium perfringens* densities were determined in sediment for other Boston Harbor sites between 1991 and 1994, and are summarized in Table 3-9 (Kropp and Diaz, 1994). *Clostridium perfringens* densities ranging from 930 to 207,000 spores/gram dry weight were measured at the seven reported Boston Harbor sites over the three-year period, with the majority of the sites having concentrations of 5,000 to 15,000 spores/gram. Furthermore, decreases in fecal coliform concentrations in water near the Fox Point and Commercial Point CSOs have been reported for samples collected after 1991 (after CSO treatment upgrades), as compared with samples collected before the CSO treatment upgrades were made (MWRA, 1993). Furthermore, some of the CSO reports suggest that the Old Harbor CSOs do not frequently overflow (BWSC, 1990a). CSO BOS-85 has a history of occasionally discharging, and high fecal coliform concentrations have been measured at such times, with densities over 100,000 col/100 mL measured in the discharge (BWSC, 1990a). However, because elevated concentrations of fecal coliforms generally are obtained only with recent pollution, and their longevity/survivability is highly variable and dependent on the local environment, data on "background," or even elevated Harbor densities are not particularly useful because they can vary dramatically within a small area without necessarily indicating significant pollution differences. *Enterococcus* has longer survivability in marine sediments than fecal coliform, and *Clostridium perfringens* spores persist even longer. *Clostridium perfringens* spores are, therefore, the better indicator of long-term, chronic sewage pollution.

4.2 ORGANIC CONTAMINANT CONCENTRATIONS

4.2.1 PAH Concentrations

Figures 4-1(a) and (b) present the total PAH concentrations as raw data and normalized for TOC content, respectively, for all 14 sites analyzed. These data are also summarized in Table 3-1. PAH concentrations in the sediment samples varied greatly, with total PAH concentrations ranging from 495 (site DB06) to 128,000 ng/g (site DB14). The highest PAH concentration was measured for site DB14, located near CSO BOS-90 (Commercial Point CSO). The PAH concentrations at this location were clearly elevated compared to the other sites; TOC-normalized concentrations were approximately three to four times higher than at other sites in the same general area. The PAH concentrations at site DB04, located near CSO BOS-83 in the Old Harbor, appear to be slightly elevated. However, only one of the three DB04 site replicates has PAH levels that are clearly elevated (producing a slightly elevated site average) over the other Old Harbor area sites (e.g., DB01 and DB03) — the data for the individual station replicates are presented in Appendix B.

Figure 4-2 presents the PAH composition, as primarily petroleum product originating PAH (Petro-PAH) and primarily combustion product and/or creosote/coal-tar originating PAH (Pyro-PAH). The PAH makeup was fairly consistent among all sites, and primarily pyrogenic in nature; the PAH at most sites was comprised of approximately 65 to 75% Pyro-PAH and 25 to 35% Petro-PAH. Exceptions were site T1 and T8 which had approximately 41% Petro-PAH and site DB03 (37% Petro-PAH), possibly due to local runoff or other sources that, relative to the other sites, were slightly enriched in petroleum products (although petroleum products were clearly not the primary source of PAH even at these sites). Site DB06 was relatively more enriched in pyrogenic PAH than the other sites (20% Petro-PAH), possibly due to minor contributions from local source(s) of creosote or coal tar or a higher level of combustion product runoff.

The statistical analysis indicates that the PAH concentrations at DB01, DB12, DB13, DB14, and CO19, are significantly different, and higher, than those at the reference site T2 (Table 3-4) for both raw and TOC-normalized total PAH data. The data suggest that there may be a local source(s) of PAH contamination at or near sites DB14 and DB04. Site DB14 appears to have been impacted by localized input of PAH, as evidenced by the lower concentrations found at nearby sites. High variability in the site replicate data for site DB04 makes it difficult to draw any conclusions for this site. The slightly elevated concentrations at sites

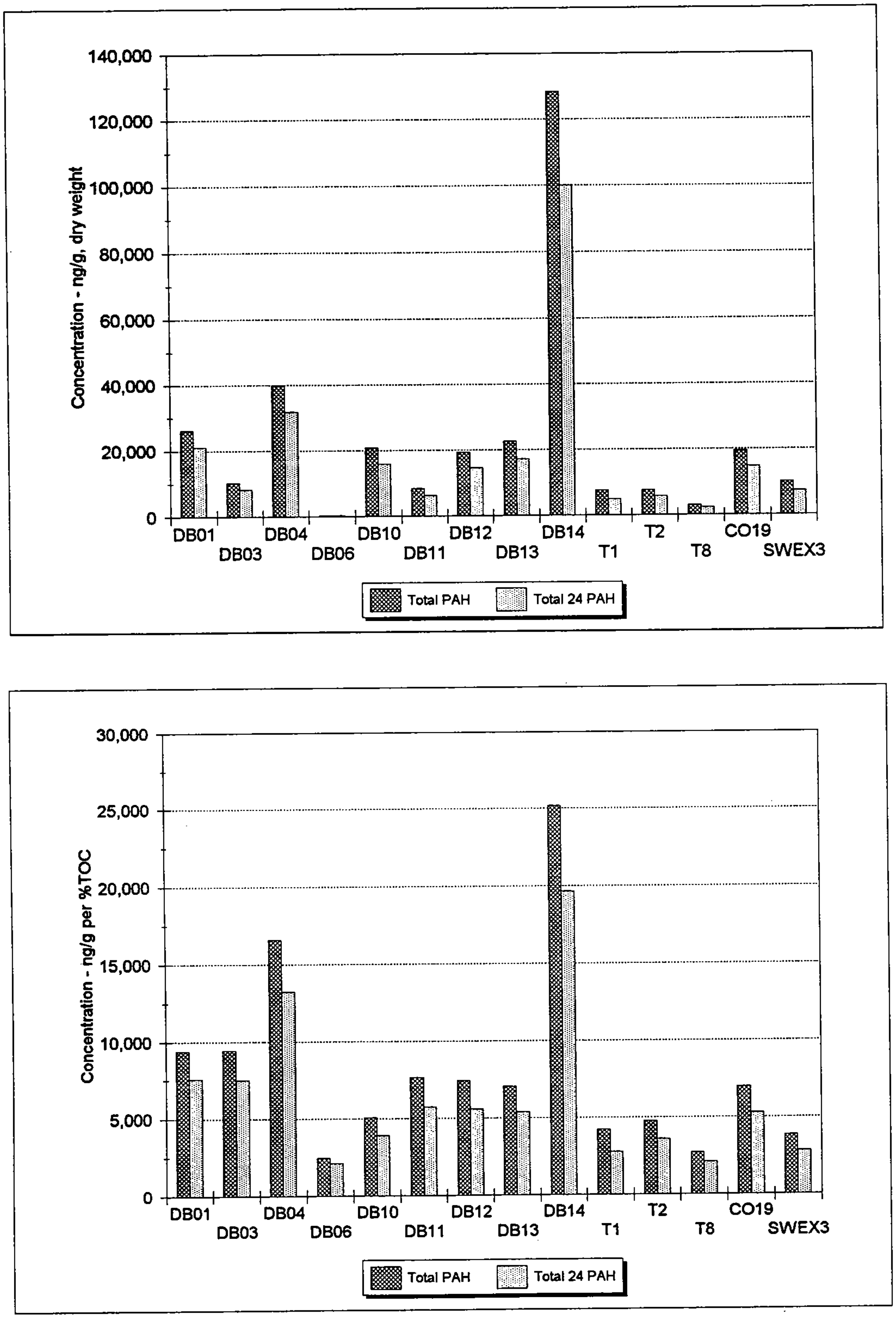


Figure 4-1. Sediment PAH Concentrations—1994 Samples
(a) Non-normalized (b) Normalized to TOC

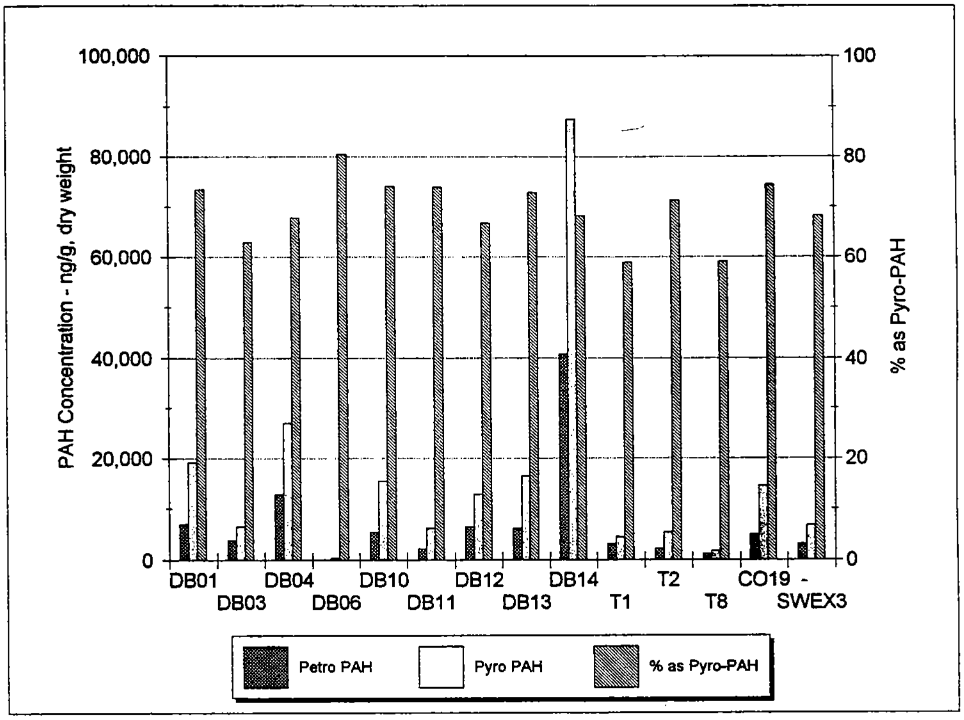


Figure 4-2. Sediment Petrogenic and Pyrogenic PAH Concentration Distribution—1994 Samples

DB12 and DB13 may originate in the same material that was responsible for the higher levels at DB14. However, the data are insufficient to attribute the elevated concentrations at site DB14 to discharges from CSO-90, as PAH could also be contributed by sources at the nearby yacht club, localized runoff and discharges, or sediment deposition.

The TOC content at site DB14, and TOC and percent mud at sites DB10, DB13, and CO19 are among the highest of all the sites in this study. This may be due to discharge from the CSOs near these sites but can also be the result of sediment focusing in a depositional environment. It should be cautioned that it may be inappropriate to focus strictly on TOC-normalized data when analyzing the PAH or other organic contaminant analytical results. It is possible and likely that, along with the discharge from a CSO, the sediment TOC and percent mud content will increase because sewage waste (and most CSO discharge) is high in organic carbon content and the solids are small particulates compared to most Harbor sediments. The sites with the highest TOC and mud content are likely either areas of CSO discharge or depositional areas. Site DB06, for example, which is the site nearest DB01 and DB04, has among the lowest TOC and mud content, while sites DB01 and DB04 have similar and significantly higher concentrations of TOC and fines.

This significant difference in TOC and mud content in a very short distance may suggest that much of the surface sediment at DB01 and DB04 originate in CSO discharge, but it may also be contributed by sediment focusing. Reliable hydrodynamic data for the area are needed to gain a better understanding of the depositional environment at these sites and the origin of the surface sediment.

EPA published draft sediment quality criteria for three PAH compounds in 1993 (U.S. EPA, 1993). Criteria at which "saltwater benthic organisms should not be affected unacceptably" were set at 230, 300, and 240 $\mu g/g_{oc}$ for acenaphthene, fluoranthene, and phenanthrene, respectively. No sediment samples collected in this study exceeded the acenaphthene criteria; the highest site average was 18.6 $\mu g/g_{oc}$ for site DB14. Two samples (one DB04 and one DB14 site replicate) exceeded the criteria for both fluoranthene and phenanthrene, but the fluoranthene concentration for site DB14 was the only site average value that exceeded criteria (313 $\mu g/g_{oc}$ versus a criteria of 300 $\mu g/g_{oc}$). The organic carbon normalized data are summarized in Appendix F for comparison to sediment quality criteria.

The sum of the concentrations of the 24 PAH that are asterisked in Table 2-2 ranged from 424 to 100,000 ng/g; this PAH analyte list (Total 24 PAH) is equivalent to that used by Battelle in previous CSO surveys for MWRA and in the Mussel Watch Program. The "Total 24 PAH" data can be compared to a range of 30,000 to 99,000 ng/g for five Mystic River and Charles River sites sampled and analyzed in an earlier study by Battelle for MWRA (Battelle, 1990a), and a range of 156 to 7,670 ng/g for the eight Boston Harbor/Massachusetts Bay Mussel Watch sites (Table 4-1). PAH concentrations at several sites in this study were higher than those measured in sediments from the two nearby Mussel Watch sites sampled in 1986 and 1987 (PAH concentrations of 3,320 and 7,670 ng/g for the Deer Island and Dorchester Bay Mussel Watch sites, respectively). However, the concentrations were, for the most part, comparable to those measured at the same Dorchester Bay study locations in the 1990 CSO survey.

The PAH concentrations for the sites at which these parameters were determined in both 1994 and 1990 are shown in Figure 4-3. These data are also summarized in Table 3-8. The PAH concentrations appear to have increased at five study sites (DB03, DB04, DB12, DB13, and DB14) between 1990 and 1994, decreased a one site (DB01), and remained about the same at two sites (DB06 and DB10). Of the sites that appear to have increased PAH concentrations, the concentrations at DB04 and DB14 are the most noteworthy; the concentrations at DB03, DB12, and DB13, although higher than in 1990, are within the range that could be expected for those areas and do not suggest local point-source pollution near the sites. The PAH data for

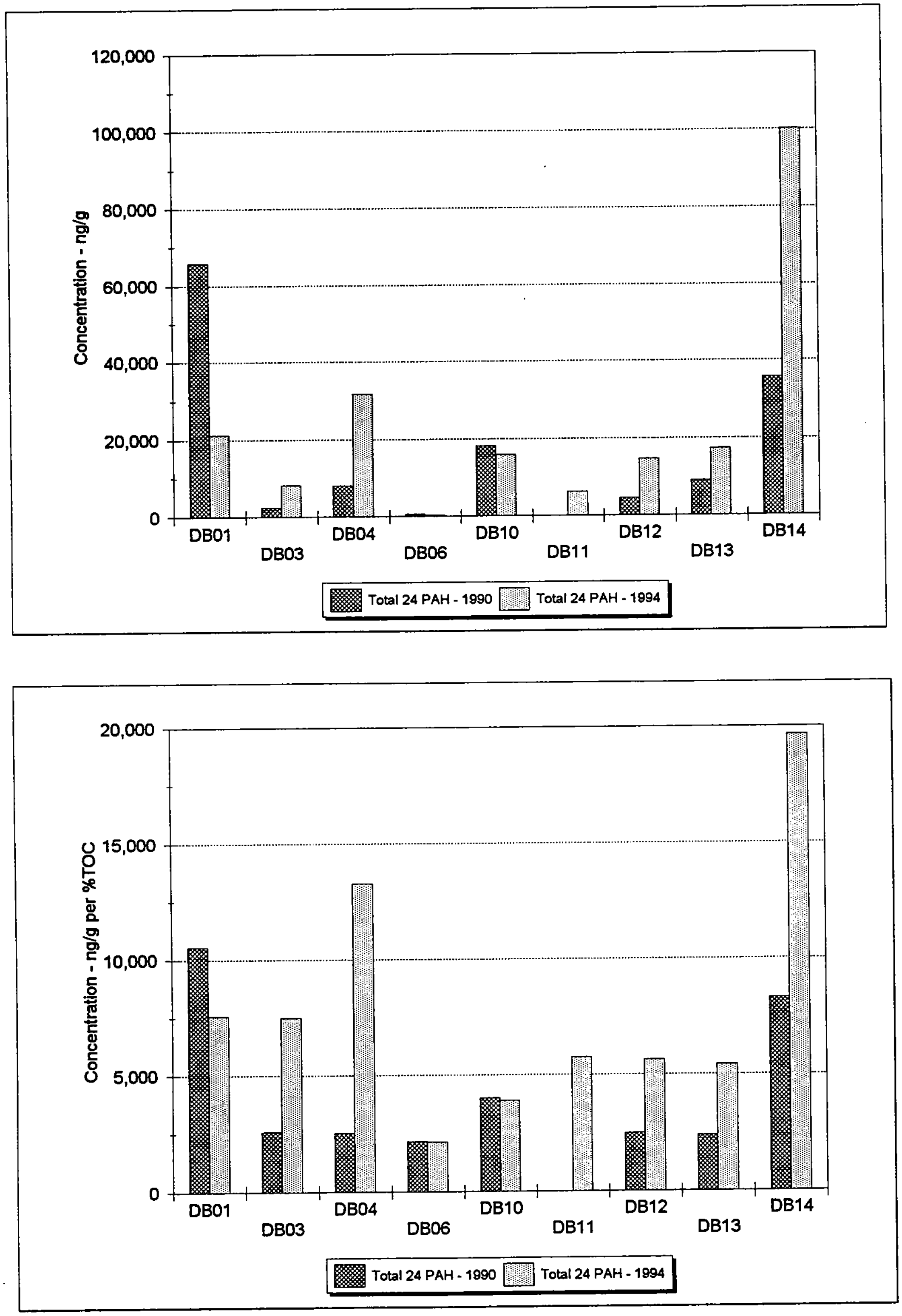


Figure 4-3. Sediment PAH Data Comparison—1994 and 1990 Samples (a) Non-normalized (b) Normalized to TOC

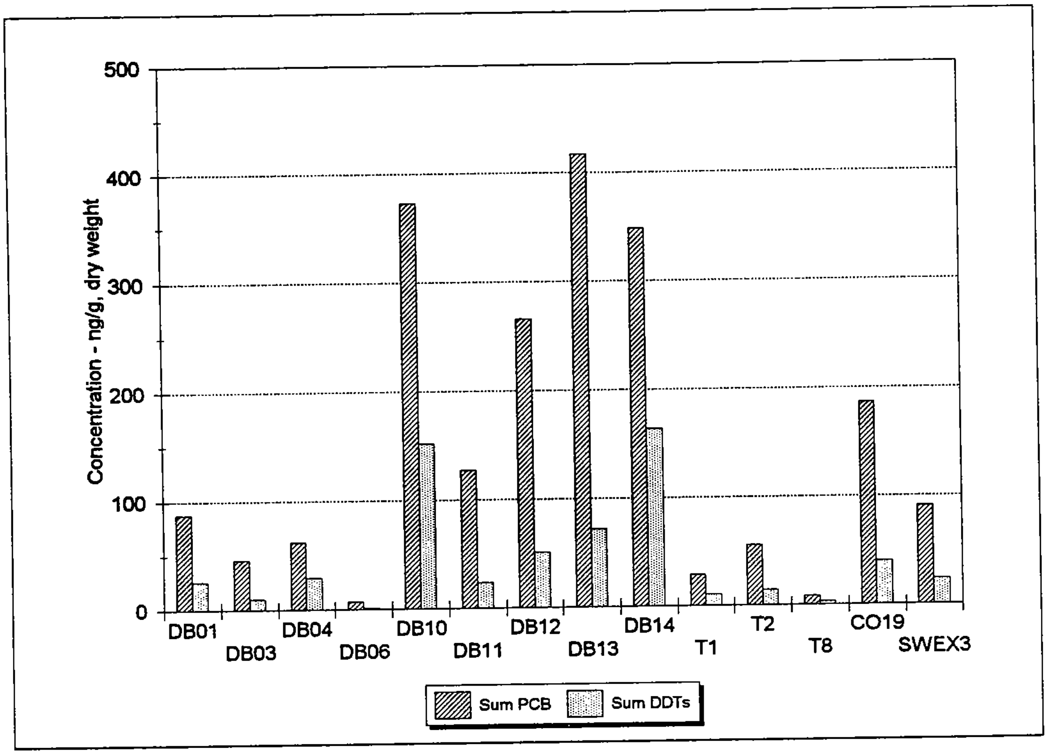
DB04, located near CSO BOS-83 in the Old Harbor, show high site replicate variability; one of the three site replicates is responsible for the slightly elevated site average, making the data for this site of limited value. The 1994 PAH concentrations at DB14, however, are approximately twice as high as those measured in 1990 sediment, and appear elevated as compared with the other study sites.

These data suggest that the Commercial Point CSO has been and/or is contributing amounts of PAH to the nearby sediment and that, except for the area near the Commercial Point CSO, PAH concentrations measured in 1994 sediment were generally similar to measurements made four years ago. The PAH may be originating in storm water, which can include street runoff, from the drainage area served by this CSO. Other possible sources of PAH to site DB14 include the nearby yacht club and runoff from industrial activities on Commercial Point. However, without reliable information on the erosional and depositional conditions of the study areas, it is not possible to rule out that some sites may receive significant pollutant deposition originating from elsewhere in the Harbor. Unfortunately, this area has not been thoroughly studied in the past, and it is not possible to completely assess the impact of the CSOs without comprehensive sediment transport and hydro-dynamic data.

4.2.2 PCB and Pesticide Concentrations

Figures 4-4(a) and (b) present the raw and TOC-normalized sediment PCB and DDT concentrations. These data are also summarized in Table 3-1. The highest PCB and DDT concentrations were measured at the Fox Point/Commercial Point area sites (DB10 through DB14); DB13 and DB10 had the highest TOC-normalized PCB and DDT concentrations, respectively. However, the TOC-normalized concentrations for these sites are only approximately two to three times higher than at most other study sites and one of the site replicates for DB13 is responsible for most of the elevation in the average PCB site data (the three site replicates had concentrations of 180, 210, and 860 ng/g). The statistical analysis indicates that the PCB and DDT concentrations at DB10, DB12, DB14, and CO19 are significantly different, and higher, than those at the reference site T2 (Table 3-4) for both raw and TOC-normalized PCB data.

The EPA draft sediment quality criteria set in 1993 included the two pesticides dieldrin and endrin (U.S. EPA, 1993). The criteria were set at 20 and 0.76 $\mu g/g_{oc}$ for dieldrin and endrin, respectively, and no sediment samples collected in this study exceeded these values (See Appendix F for the complete data set).



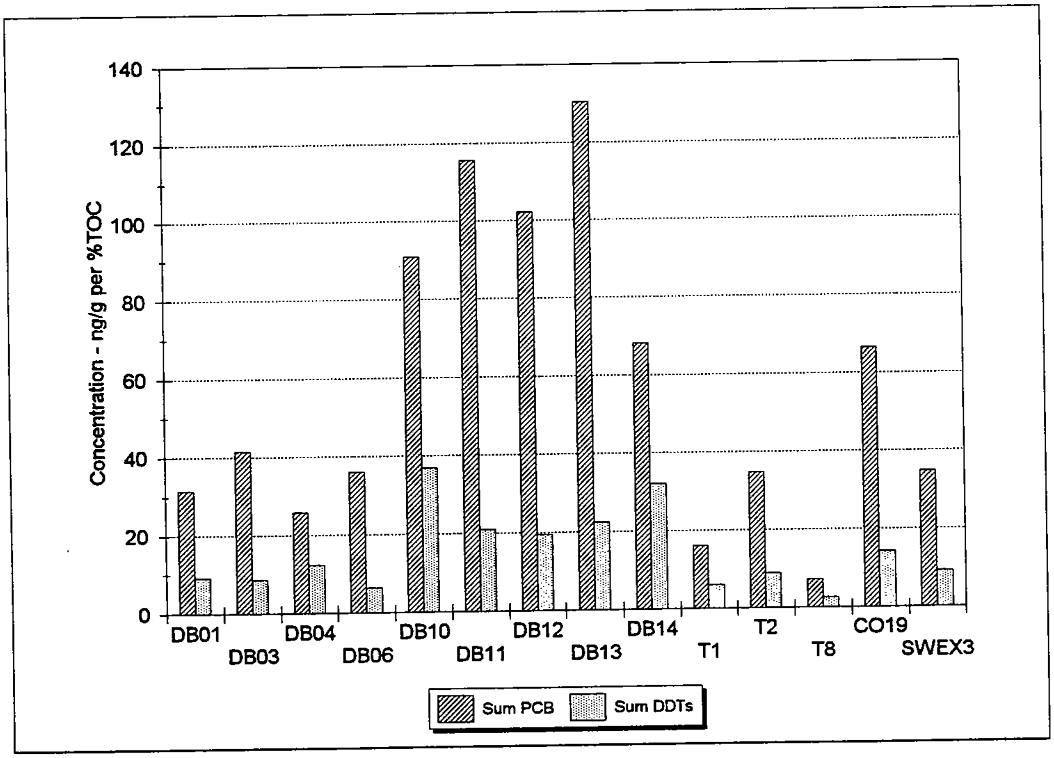


Figure 4-4. Sediment ΣPCB Congener and ΣDDTs Concentrations—1994 Samples (a) Non-normalized (b) Normalized to TOC

These data suggest that the PCB and DDT concentrations are elevated in the Fox Point/Commercial Point area. The data do, however, not indicate that any particular CSO is the primary source of these contaminants. The PCB and DDT may be originating in any of a number of possible sources, such as the Neponset River, Pine Neck Creek, or local land runoff. Other possible sources may be other areas of the Harbor, with the contaminants being transported to and deposited in the Fox Point/Commercial Point area. Therefore, as with the site DB14 PAH, the elevated PCB and DDT concentrations may be due to point-source pollution or deposition of contaminated sediment transported from another area and deposited here, or both.

The non-normalized total PCB concentrations ranged from 7 to 350 ng/g for the 14 sediment sites in this study. The PCB concentrations measured in this 1994 study are comparable to, or lower than, those measured in Boston Harbor in the 1980s. This compares to a range of 9 to 640 ng/g for the eight Boston Harbor/Massachusetts Bay Mussel Watch sites, and 230 and 640 ng/g PCB for the Deer Island and Dorchester Bay Mussel Watch sites, respectively. The Boston Harbor sediment PCB concentrations appear to have declined in the past 5 to 10 years; the TOC-normalized PCB data ranged from 7 to 116 ng/g/%TOC in this study and the 1986 sediment concentrations were 245 and 348 ng/g/%TOC in sediment from the Deer Island and Dorchester Bay Mussel Watch sites (Table 4-1). Gardner and Pruell (1987) determined that total PCB concentrations ranged from 132 to 1,220 ng/g at 19 Quincy Bay sites; Boehm *et al.* (1984) measured PCB concentrations between 15 and 330 ng/g for six Boston Harbor sites. Eganhouse and Sherblom (1990) measured total PCB concentrations ranging from 99 to 806 ng/g at eight Dorchester Bay sites. In that study, total PCB concentrations were 610 to 806 ng/g at three Savin Hill cove sites (in the vicinity of site DB13), 201 ng/g for a Neponset River site (near site DB11), and 114 and 527 ng/g for two Thompson's Island sites (near site DB12). Eganhouse and Sherblom (1990) analyzed significantly more PCB congeners than in this study and, based on the congener selections, the sum of the congeners that comprised their "total PCB" is typically about two times the sum of the PCB congeners that comprise the "total PCB" in this CSO study, further suggesting decreases in PCB levels in the sediment.

The DDT concentrations at the study sites (1 to 160 ng/g) were generally comparable to those measured earlier at the nearby Mussel Watch sites. DDT concentrations of 24 and 45 ng/g had been determined for the Deer Island and Dorchester Bay Mussel Watch sites, respectively, and a range of 1 to 58 ng/g was measured for the eight Boston Harbor/Massachusetts Bay Mussel Watch sites (Table 4-1). After TOC normalization the DDT concentrations at study sites DB10 and DB14 (150 and 160 ng/g) are clearly less elevated, and more comparable to other parts of the study area [Figure 4-4(b)].

4.2.3 LAB and Coprostanol Concentrations

Figure 4-5(a) and (b) present the raw and TOC-normalized sediment LAB and coprostanol concentrations. The LAB distribution by LAB group is presented in Figure 4-6. These LAB and coprostanol data are also summarized in Table 3-1. The total LAB concentrations in the sediment samples ranged from approximately 32 (site DB06) to 3,200 ng/g (site DB14). The coprostanol concentrations ranged from approximately 1,700 (sites DB03 and T8) to 32,000 ng/g (site DB14). When normalized to TOC, the total LAB concentrations ranged from approximately 160 (site DB06) to 920 ng/g/%TOC (site CO19) and the coprostanol concentrations ranged from approximately 1,100 (site DB12) to 14,000 ng/g/%TOC (site DB06); concentrations at 10 of the 14 sites were below 2,900 ng/g/%TOC.

The non-normalized LAB and coprostanol concentrations were quite variable, with highest concentrations of both LAB and coprostanol at site DB14. LAB concentrations also appeared to be slightly elevated for sites DB10, DB13, and CO19 — all of which are near CSOs (or suspected CSO discharge, as is the case for DB10). However, after TOC normalization the LAB and coprostanol concentrations were more uniform. The TOC-normalized LAB concentrations at sites CO19, T2, DB14, and DB13 were elevated by no more than two times the concentrations of most other sites. The TOC-normalized coprostanol concentrations at site DB06 were apparently elevated, and the DB14 and T2 concentrations were slightly elevated. However, with the exception of DB06, these sites have no more than twice the concentrations measured at other sites. The apparently elevated TOC-normalized coprostanol concentrations at DB06 is more a reflection of a low sediment TOC content at this site (0.2%, while all other sites had more than 1% TOC); the non-normalized coprostanol concentration for site DB06 was among the lowest (approximately 2,800 ng/g). Additionally, the site replicate data for site DB06 were highly variable, and one sample was responsible for most of the site average value (concentrations were 1,000, 850, and 6,600 ng/g for the three DB06 site replicates).

Statistical analysis indicates that there are no sites with LAB or coprostanol concentrations significantly higher than those at the reference site T2 (Table 3-4). The data do, however, indicate that several sites (e.g., DB01, DB03, DB11, DB12, T1, T8) had significantly *lower* LAB and coprostanol concentrations than the reference site; site T2 may have been an inappropriate reference site for these two contaminants if the goal is to have a reference site that represents Harbor background levels. The one-way ANOVA test indicated that, as a group, sites located near CSOs (DB01, DB04, DB13, and DB14) had higher TOC-normalized sediment LAB concentrations than other sites (Table 3-5). The multiple comparison test (Table 3-6) shows that CO19

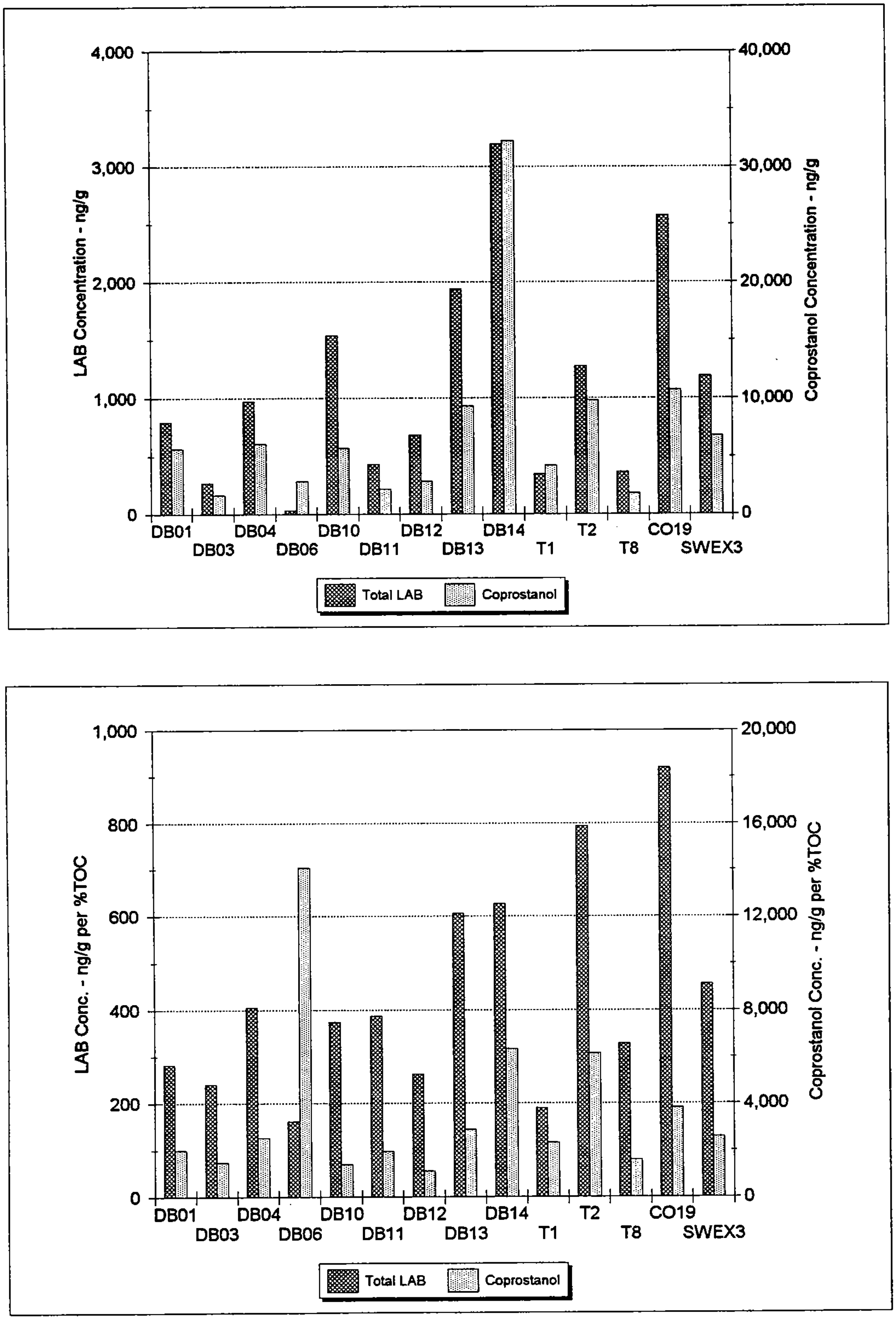


Figure 4-5. Sediment Total LAB and Coprostanol Concentrations—1994 Samples (a) Non-normalized (b) Normalized to TOC

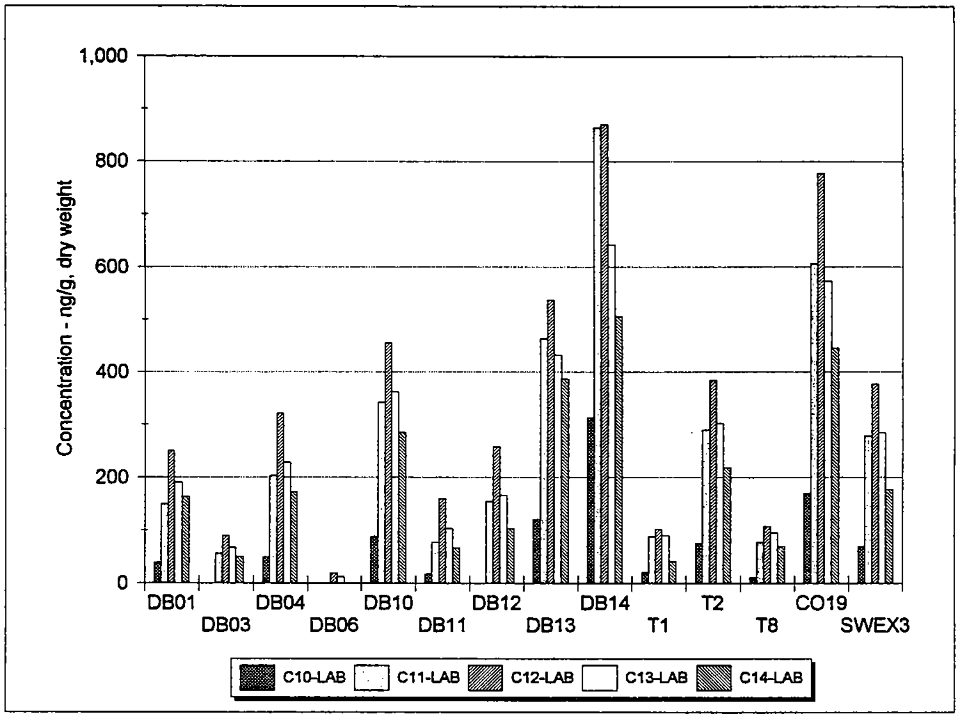


Figure 4-6. Sediment LAB Concentration Distribution by LAB Group—1994 Samples

"groups" (grouping letter E) as the site with the highest LAB concentration and has TOC-normalized LAB concentrations that are statistically higher than at all sites except T2 (grouping letters D,E). The higher concentrations at T2 may reflect historical input from sludge discharges because of the proximity of this site to Deer Island.

The LAB-group distribution (Figure 4-6) is very similar from site to site; C_{12}-LABs are predominant, followed by C_{13}- and C_{11}-LABs, and then by C_{14}- and C_{10}-LABs. This LAB composition is consistent with the composition observed in the previous Dorchester Bay CSO study (Durell *et al.*, 1991). The LAB/coprostanol concentration ratios ranged from 0.08 to 0.27 [Table 3-1(c)], except for site DB06 which had such low LAB concentrations that a ratio could not accurately be determined. LAB/coprostanol ratios have been used by other investigators to suggest possible sources of these contaminants in Dorchester Bay sediment (Eganhouse *et al.*, 1988; Eganhouse and Sherblom, 1990) because the LAB/coprostanol ratios were very different in the sludge discharged from Nut Island and Deer Island treatment plants; the sludge discharges were implicated as the primary source of these contaminants. The LAB/coprostanol ratio is no longer a useful measure to distinguish between these two possible sources because the plants no longer discharge sludge, and the LAB/coprostanol ratio in the effluent from the two plants was earlier found to be similar (Durell *et al.*, 1991); 0.12 and 0.13 for Nut Island and Deer Island, respectively. The ratios may provide some indication of local sources/contribution of these two contaminants. For example, the LAB/coprostanol ratio at DB10 was 0.27, which was higher than at other sites, and higher than in the treatment plant effluent from Deer Island and Nut Island. This suggests that the source of these contaminants to the sediment at DB10 is either enriched in LAB *or* "deficient" in coprostanol, relative to the source(s) for other sites.

The LAB and coprostanol concentrations for the study sites at which these parameters were determined in both 1994 and 1990 are shown in Figures 4-7 and 4-8, respectively. The sediment LAB/coprostanol ratios for both years for the same sites are presented in Figure 4-9. These data are also summarized in Table 3-8. The LAB and coprostanol concentrations measured in the 1994 sediment samples are, for the most part, similar to those measured at the tested sites in 1990. Site DB12, at which both LAB and coprostanol concentrations decreased, is the only site with notable changes for both LAB and coprostanol; the apparent reduction in LAB at site DB12 was supported by the two-way ANOVA results showing a statistically significant difference in 1994 and 1990 TOC-normalized LAB concentrations at this site. The LAB concentrations have remained fairly constant for the other four sites (DB01, DB04, DB13, and DB14). Sediment concentrations of coprostanol at DB13 (Fox Point CSO) have declined since 1990, while the concentrations at DB14 (Commercial Point CSO) are similar to those measured four years ago. It appears that the coprostanol concentrations at DB01 and DB04 have increased slightly in the past four years, but the concentrations are comparable to what could be expected for a Dorchester Bay location without a local source of the contaminant.

The LAB and coprostanol concentrations measured in this study are also comparable to those determined by other investigators. In a previous study in Dorchester Bay, Eganhouse and Sherblom (1990) determined sediment total LAB concentrations ranging from 280 to 2,340 ng/g and coprostanol concentrations ranging from 260 to 11,500 ng/g (seven stations). They also reported coprostanol values from a six-station survey of Boston Harbor in which a mean sediment concentration of 4,800 ng/g was determined. The C_{12}-LAB predominance that was observed in all samples was also noted in the 1990 Dorchester Bay CSO survey and has been documented in several municipalities worldwide (Eganhouse and Sherblom, 1990) and is likewise expected in most coastal sediments (Takada and Ishiwatari, 1990). The sediment LAB/coprostanol ratios determined in this study were comparable to those determined by Eganhouse and Sherblom (1990) for

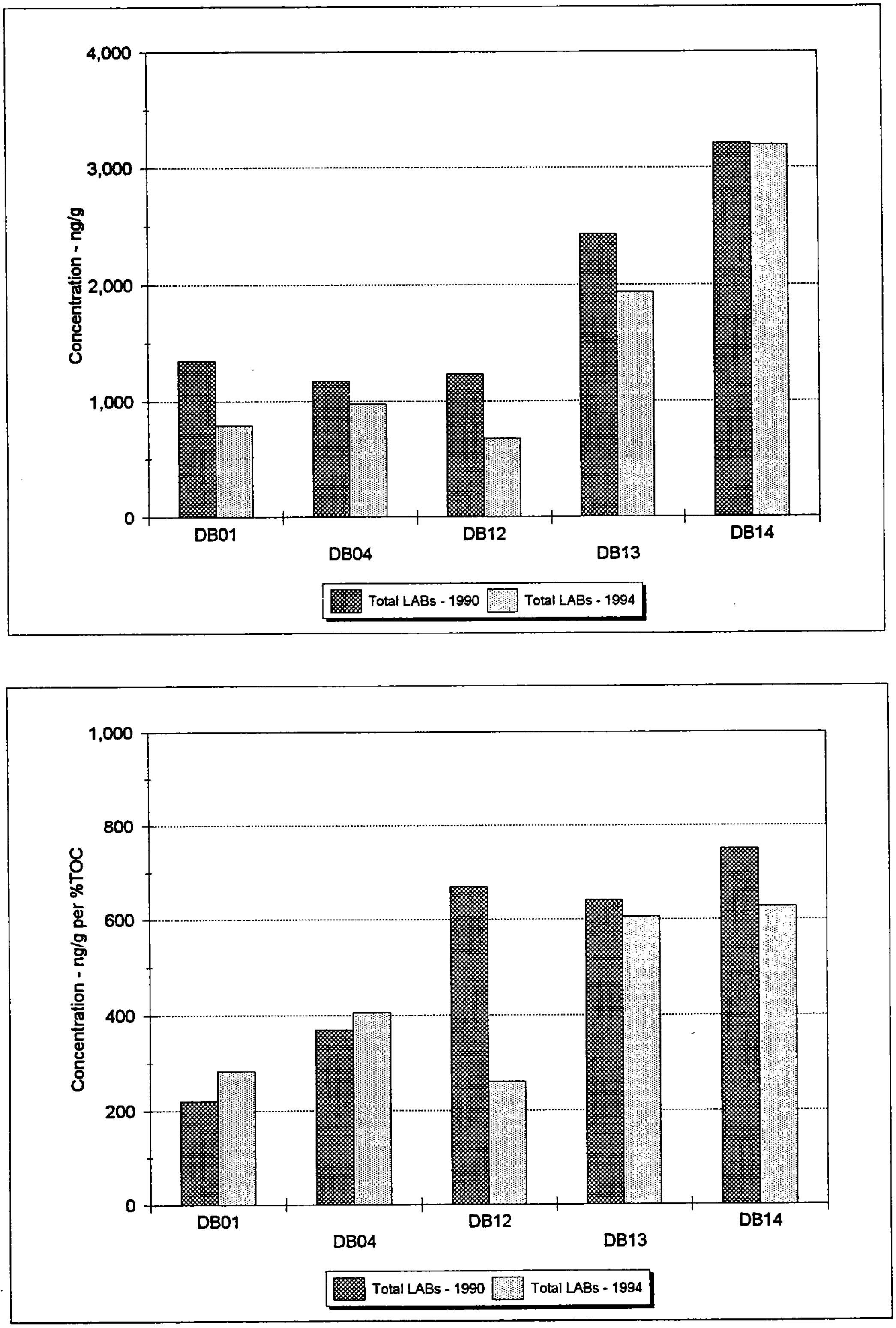


Figure 4-7. Sediment Total LAB Data Comparison—1994 and 1990 Samples (a) Non-normalized (b) Normalized to TOC

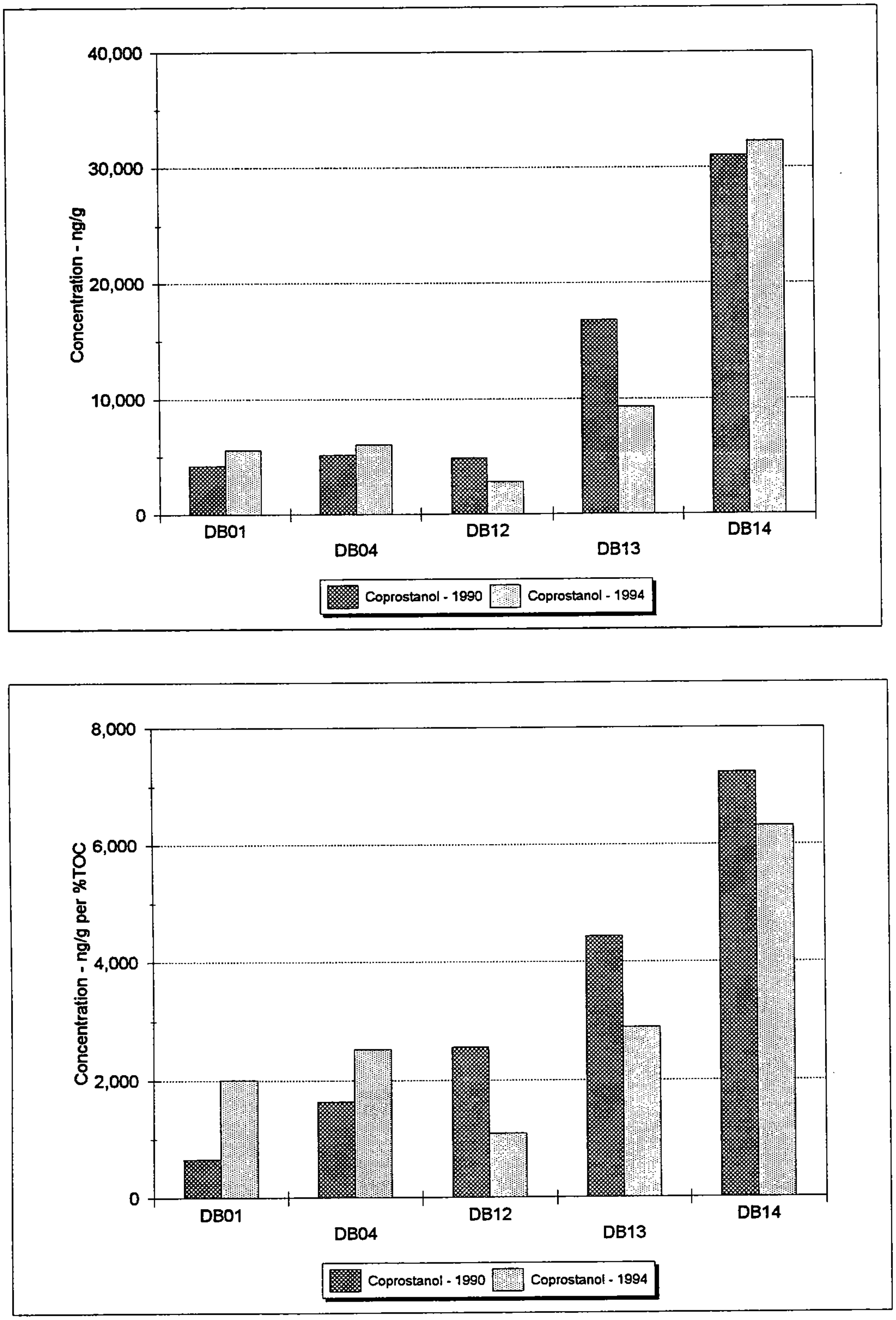


Figure 4-8. Sediment Coprostanol Data Comparison—1994 and 1990 Samples (a) Non-normalized (b) Normalized to TOC

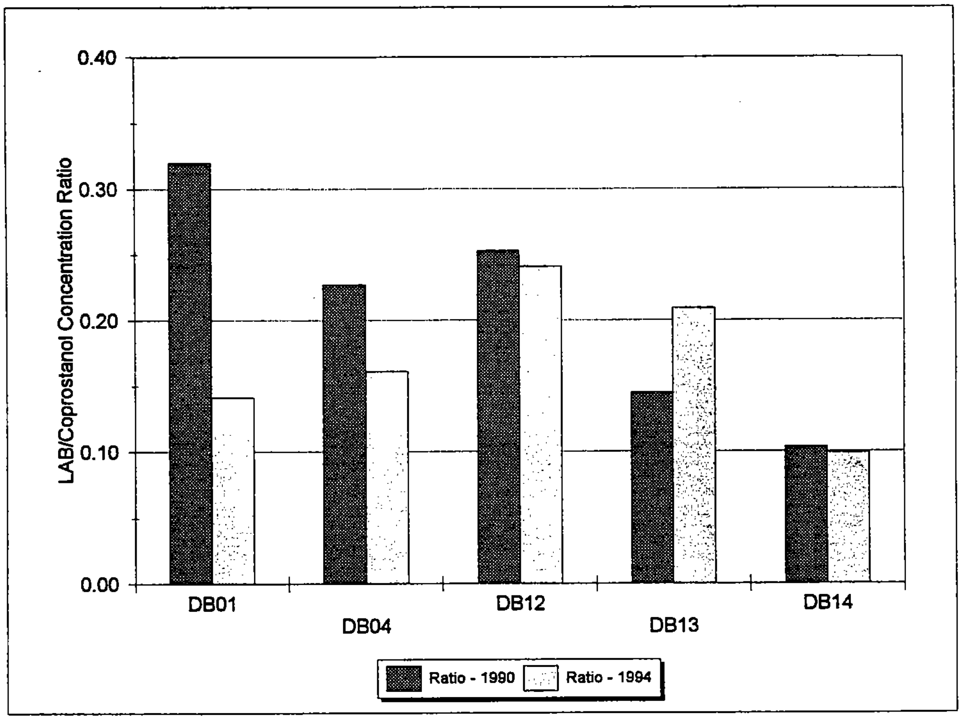


Figure 4-9. Sediment Total LAB/Coprostanol Ratio Data Comparison—1994 and 1990 Samples

sediment samples from the same general area and, for the most part, are comparable to those determined in the 1990 CSO survey (Figure 4-9). The lower 1994 ratio at site DB01 appears to be primarily the result of lower LAB concentrations in 1994 than earlier, possibly due to the elimination/reduction of a local source of LAB (the LAB/coprostanol ratio was higher at this site than at other locations in the 1990 study), but also contributed to by slightly higher coprostanol concentrations.

The overall similarity in LAB and coprostanol concentrations throughout Dorchester Bay, and at sites outside the Bay, indicates that the primary source of these contaminants may be remote and that they may be transported into the Bay from outside source(s). It is possible that the discharges from the Deer Island and Nut Island treatment plants, as well Harbor CSOs in general, are responsible for maintaining the relatively evenly distributed background concentrations of LAB and coprostanol. The LAB and coprostanol concentrations measured in 1994 sediment were generally similar to measurements made four years ago.

4.3 METAL CONTAMINANT CONCENTRATIONS

The sediment metal concentrations are presented non-normalized, normalized to grain size, and normalized to aluminum in Figures 4-10 through 4-13. These data are also summarized in Table 3-2. The metals data for the sites and parameters that were determined in both 1994 and 1990 are shown in Figures 4-14 through 4-19, and are also summarized in Table 3-10. In reviewing the metals data, the normalized data are given the greatest weight for determining possible sources of pollution because of its utility for identifying and interpreting metal concentrations above regional background concentrations — concentration elevations that are due to anthropogenic activity. Normalizing to aluminum and grain size often provide similar results and TOC content has also been used as a normalizer when assessing sediment contamination for certain metals.

Cadmium, Copper, Lead, and Zinc

Cadmium, copper, lead, and zinc are the four primary metals of concern that previously data have suggested there may be anthropogenic sources in Dorchester Bay and Boston Harbor. A cursory review of the data suggests that the Fox Point/Commercial Point area (sites DB10 through DB14) has slightly elevated cadmium, copper, lead, and zinc concentrations, as compared with other parts of the Harbor (Figures 4-10, 4-11, and 4-12). However, normalization of the concentrations removes the appearance of regional trends. For example, the grain-size-normalized cadmium, copper, lead, and zinc data are generally comparable (within a factor of two) for most study sites. Of these four metals, only the zinc and lead concentrations at site DB14 were consistently elevated. However, even the lead and zinc concentrations are no more than approximately twice the study average grain-size-normalized concentrations.

The non-normalized and aluminum-normalized cadmium, copper, lead, and zinc concentrations were statistically significantly higher at sites DB01, DB10, DB12 (except cadmium), DB13 (except cadmium), DB14, and CO19 than at the reference site (Table 3-7). The one-way ANOVA results show that, as a group, the sites located near CSOs (DB01, DB04, DB13, and DB14) have higher aluminum-normalized sediment copper, lead, and zinc concentrations than the other sites (Table 3-5). The multiple comparison test (Table 3-6) indicates that site DB14 "groups" as the site with the highest aluminum-normalized copper, lead, and zinc concentrations (grouping letter D), typically followed by sites DB13, DB01, and DB12 in concentrations of contamination, based on this test.

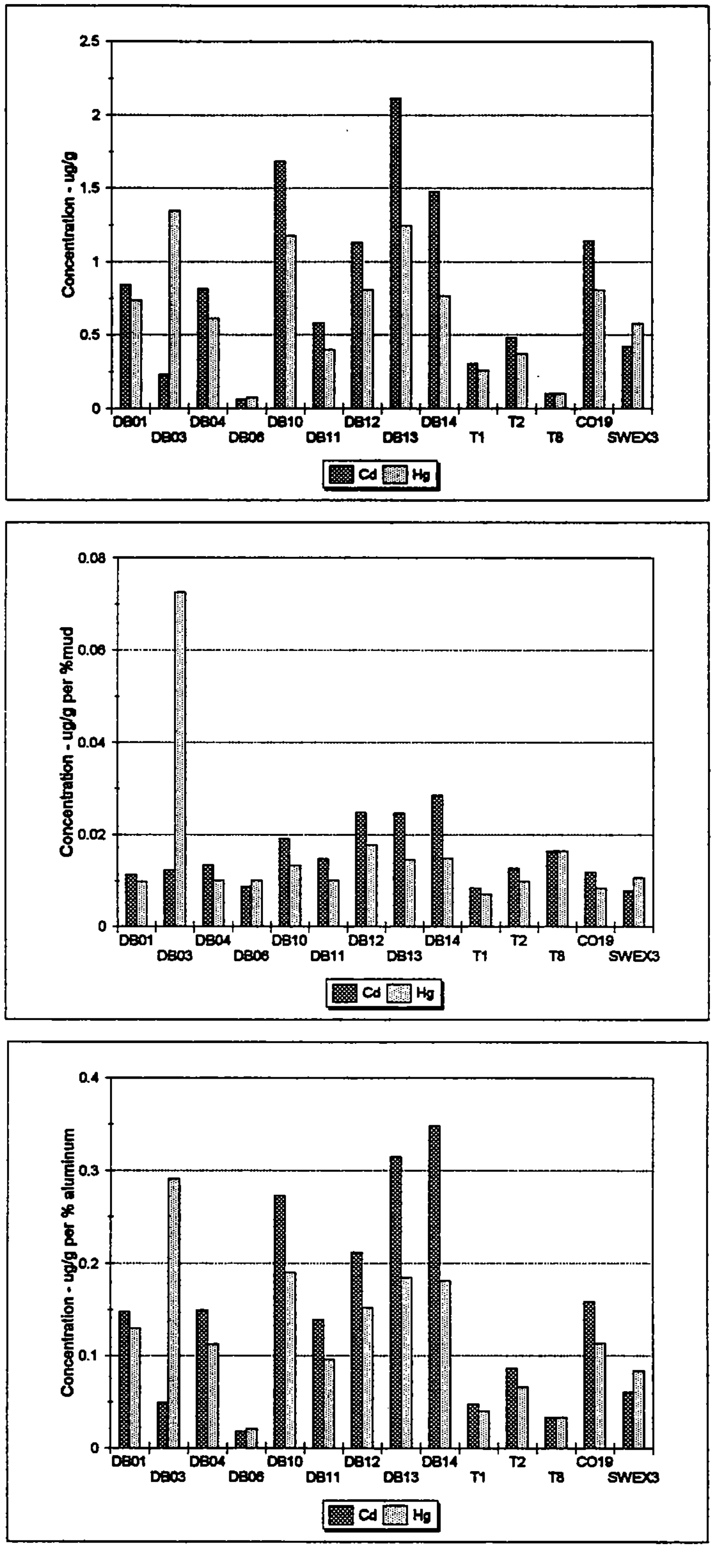


Figure 4-10. Sediment Cadmium and Mercury Concentrations—1994 Samples (a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

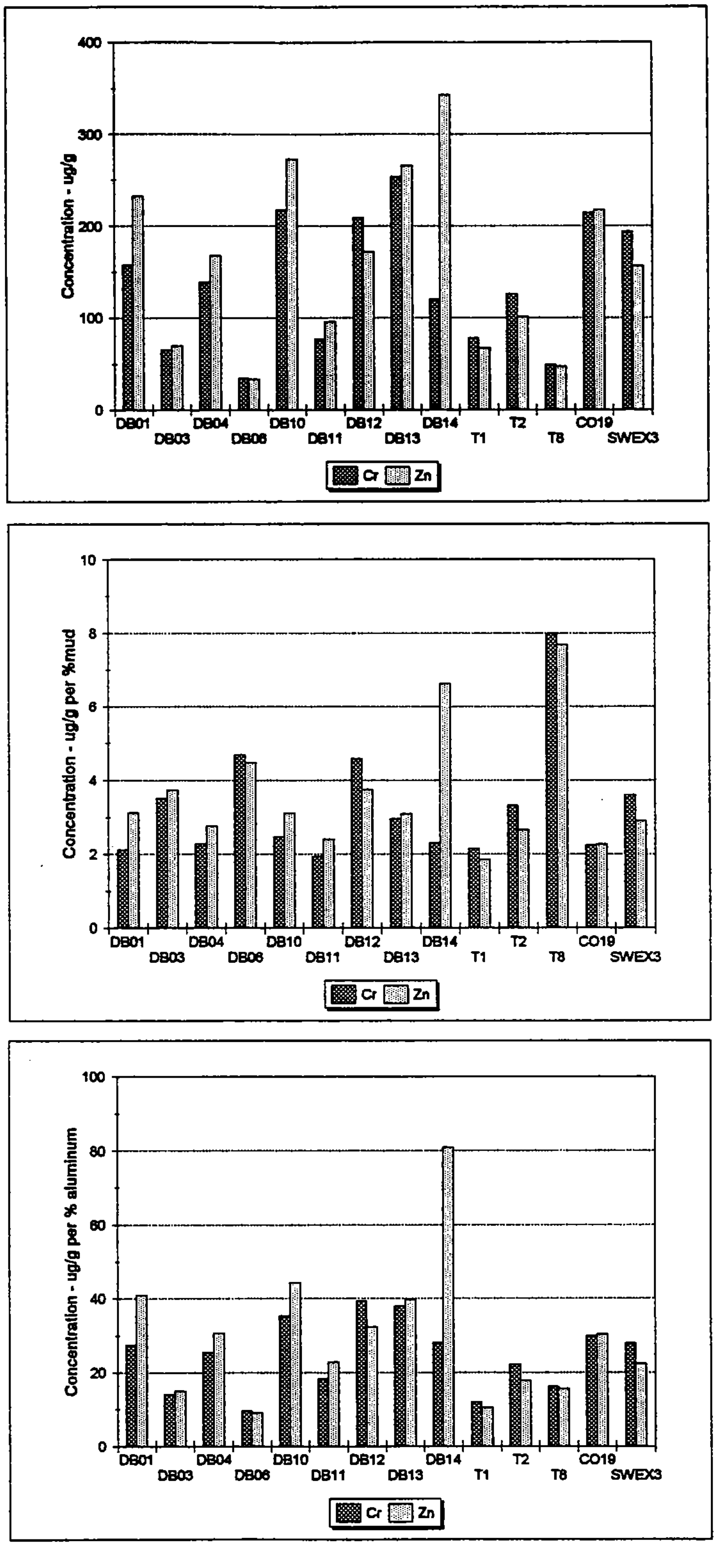


Figure 4-11. Sediment Chromium and Zinc Concentrations—1994 Samples (a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

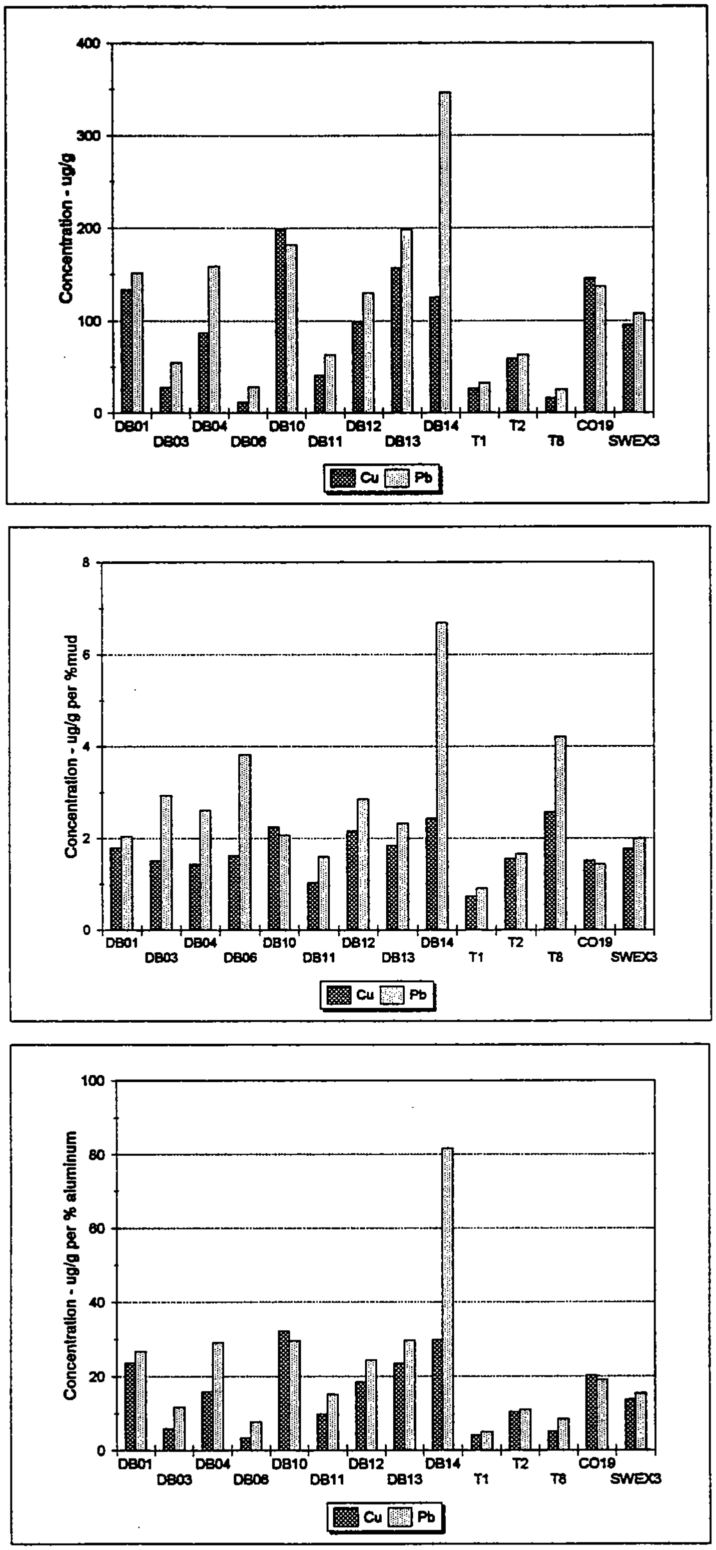


Figure 4-12. Sediment Copper and Lead Concentrations—1994 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

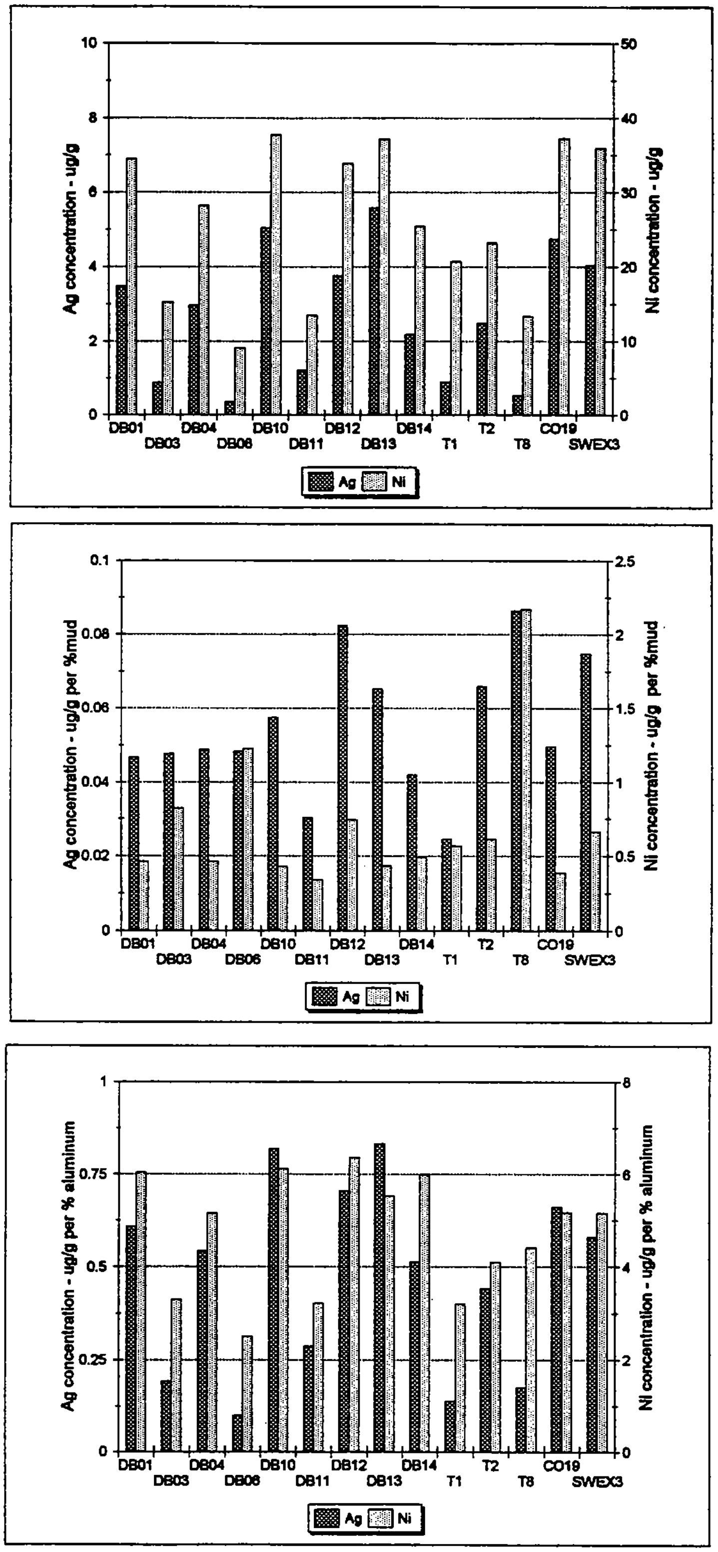


Figure 4-13. Sediment Silver and Nickel Concentrations—1994 Samples (a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

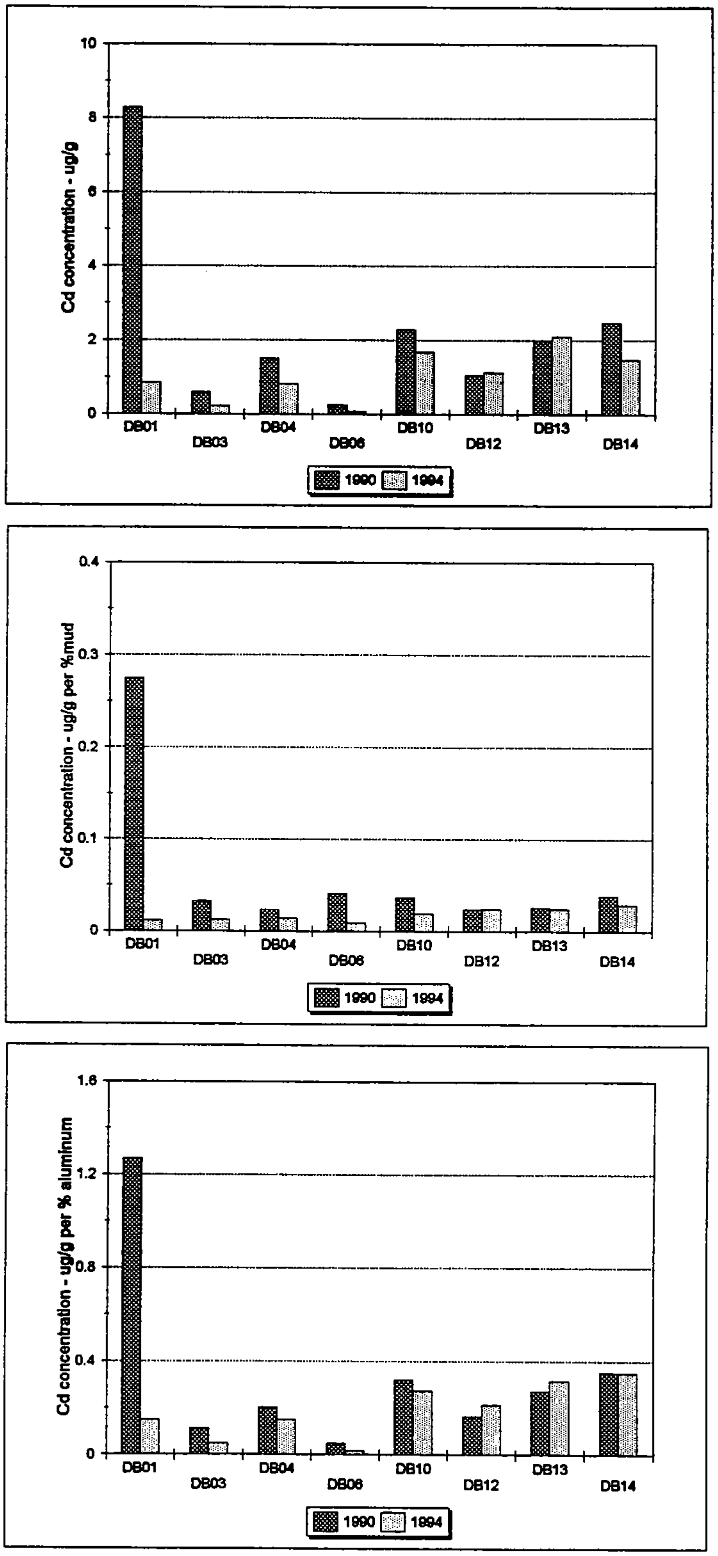


Figure 4-14. Sediment Cadmium Data Comparison—1994 and 1990 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

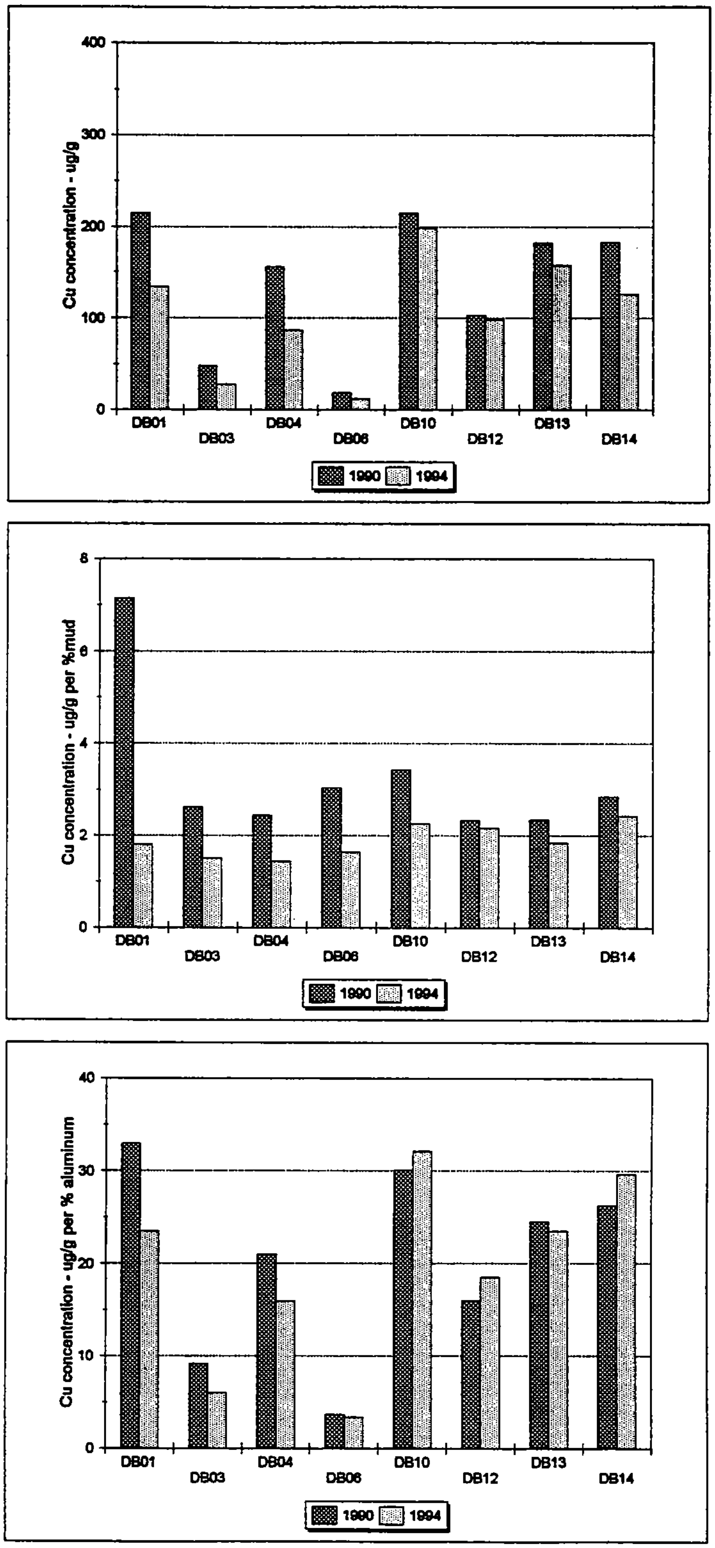


Figure 4-15. Sediment Copper Data Comparison—1994 and 1990 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

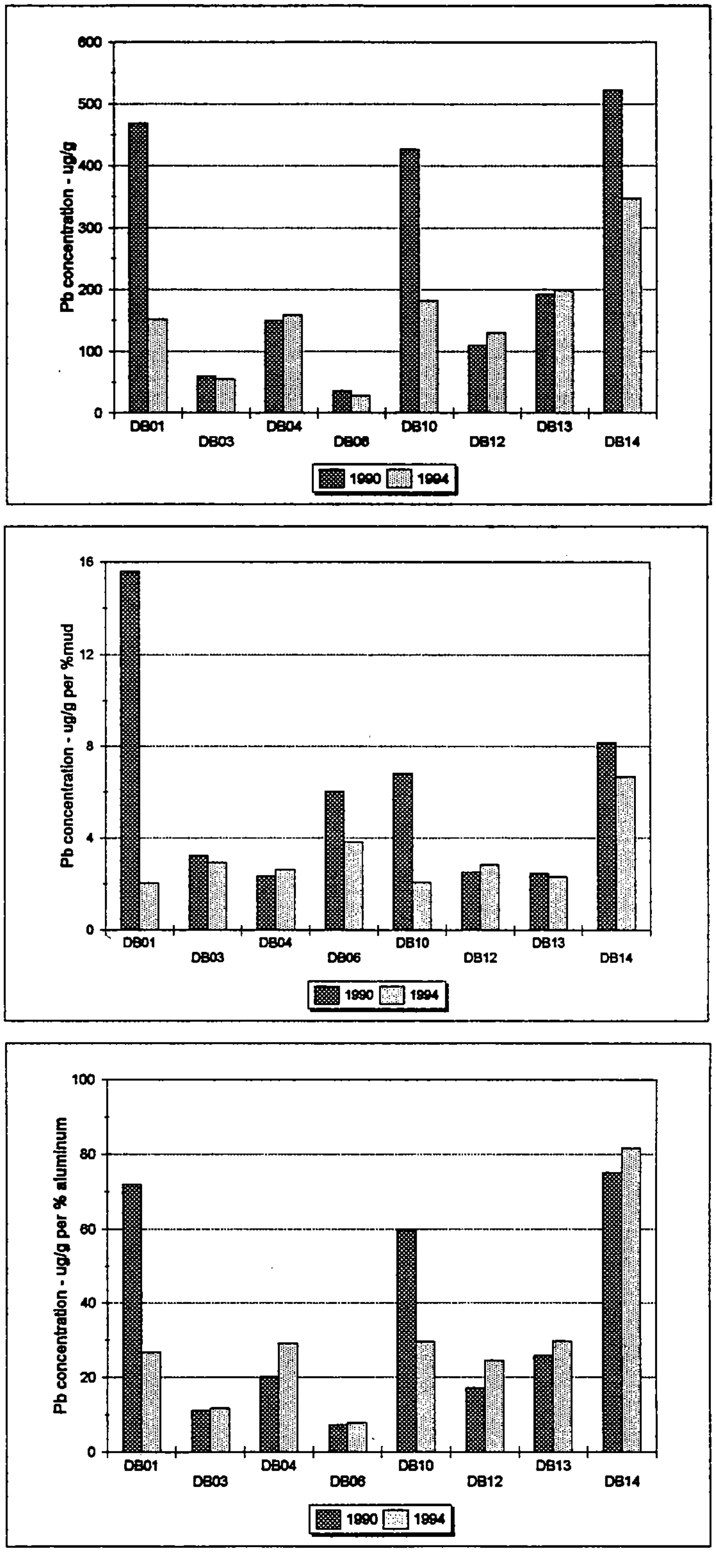


Figure 4-16. Sediment Lead Data Comparison—1994 and 1990 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

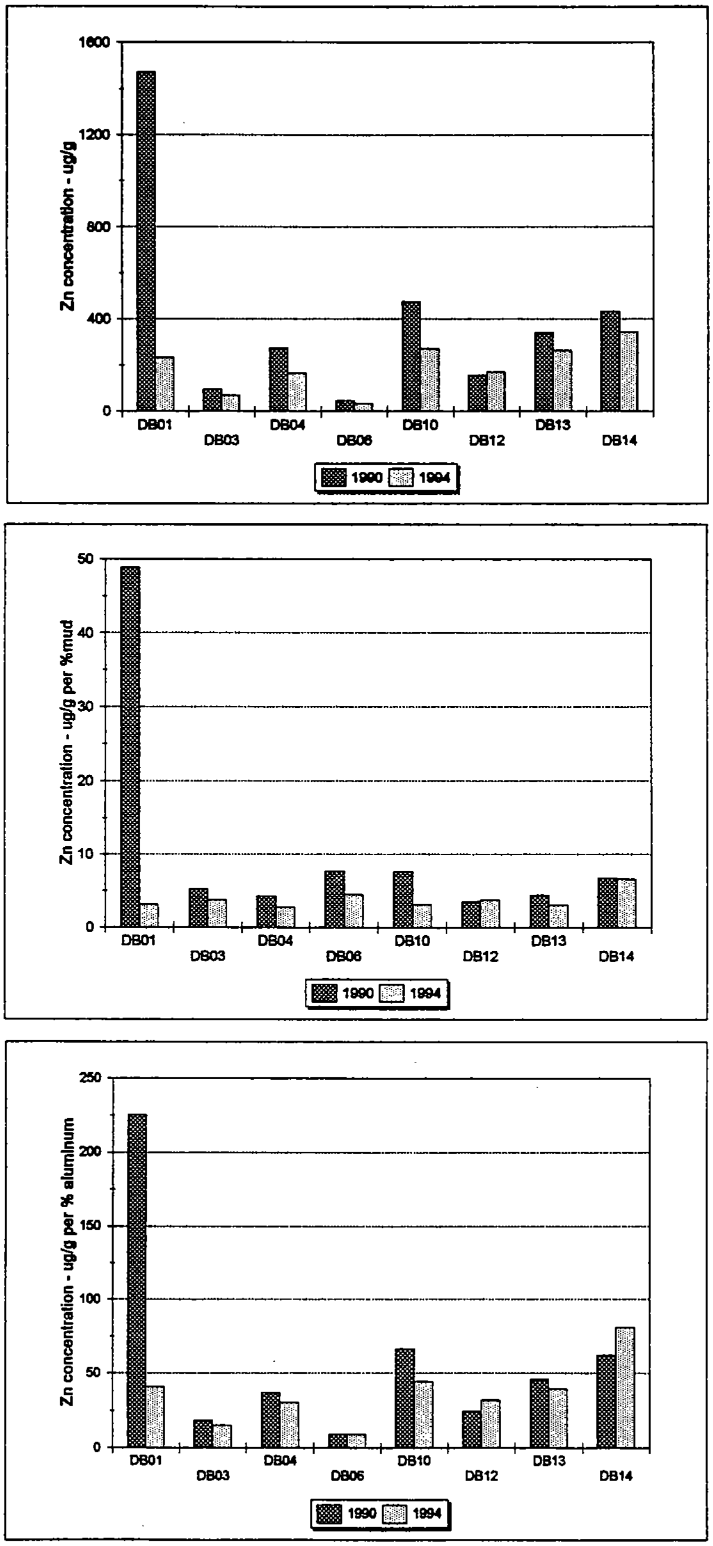


Figure 4-17. Sediment Zinc Data Comparison—1994 and 1990 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

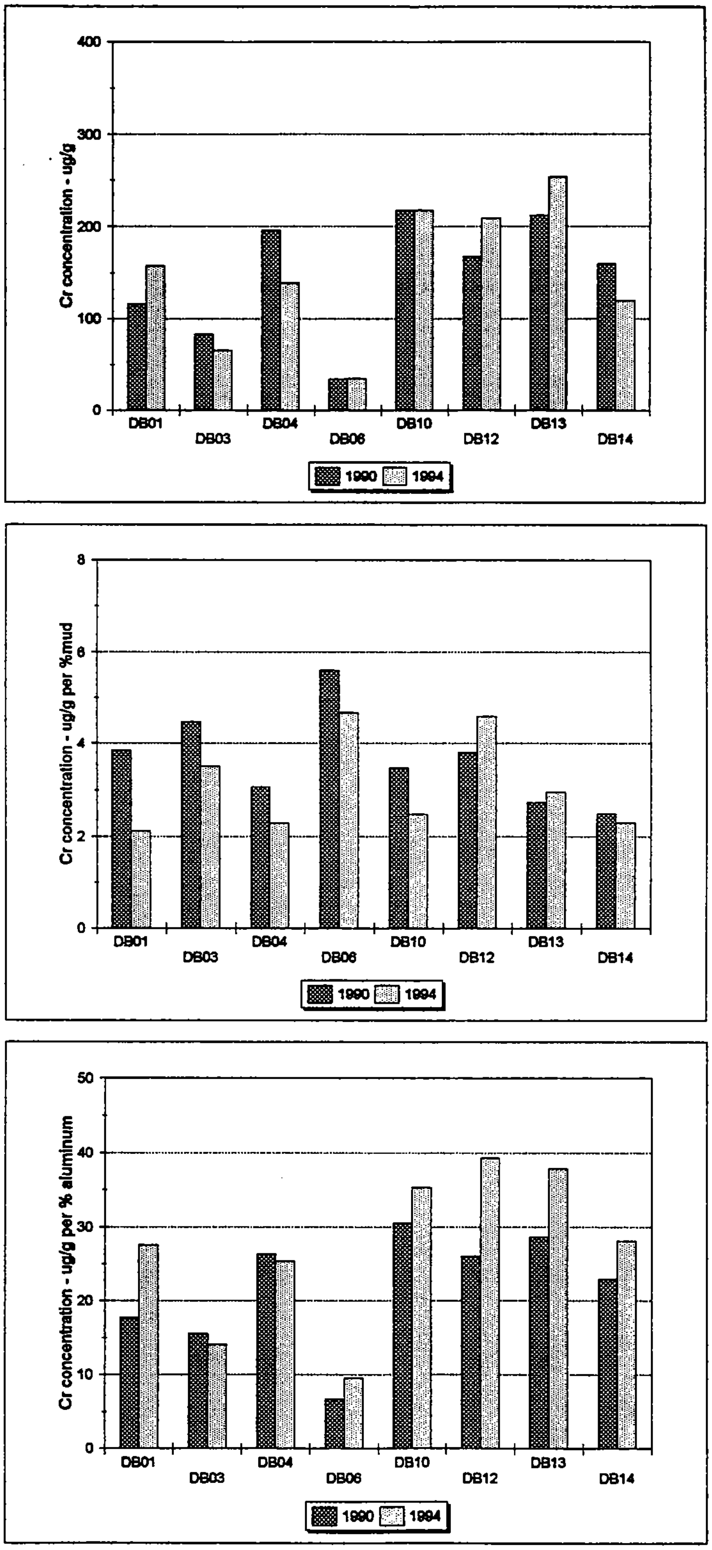


Figure 4-18. Sediment Chromium Data Comparison—1994 and 1990 Samples (a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

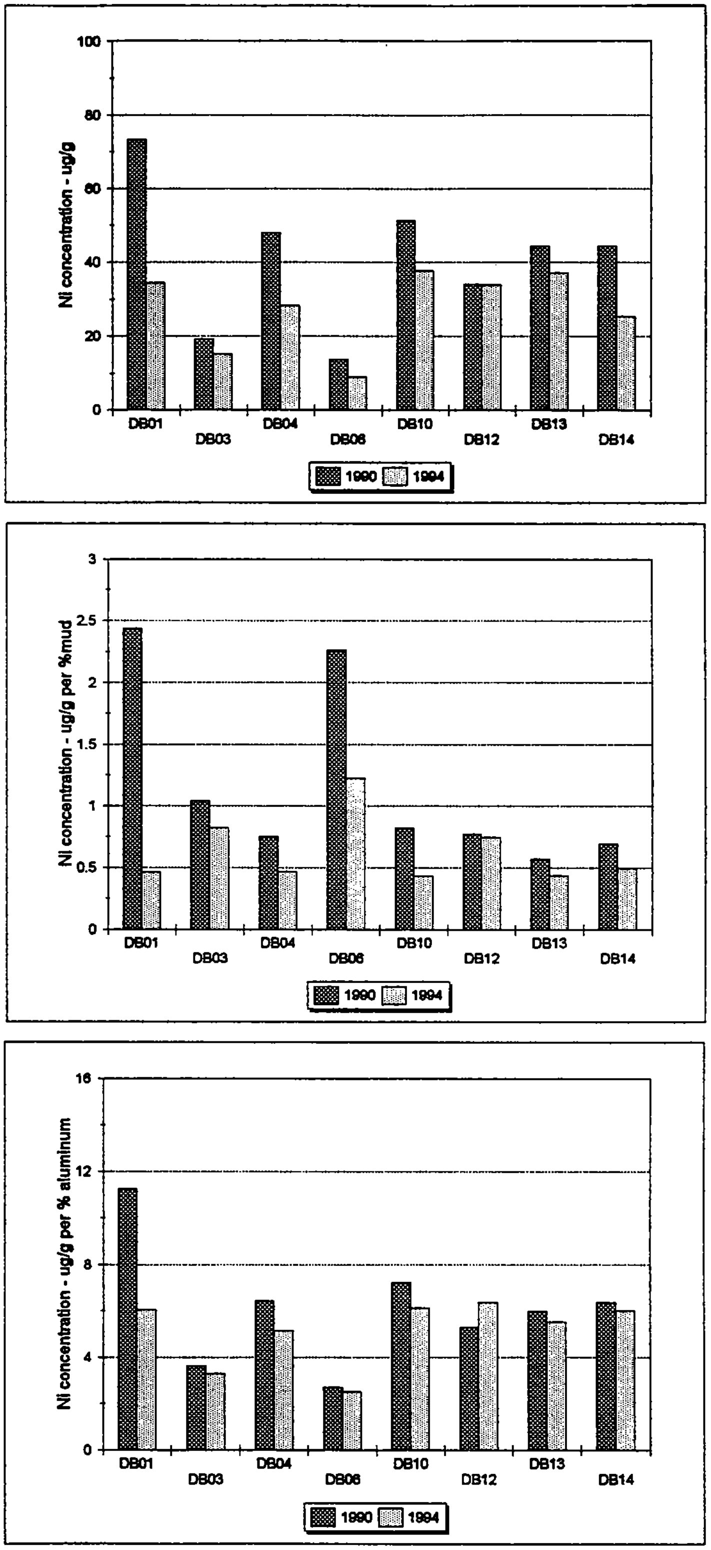


Figure 4-19. Sediment Nickel Data Comparison—1994 and 1990 Samples
(a) Non-normalized (b) Normalized to Grain Size (c) Normalized to Aluminum

In this study, the concentrations of cadmium ranged from 0.07 (site DB06) to 2.1 μg/g (site DB13). The concentrations at all sites were within two times the average of approximately 1.3 μg/g determined for the two nearby Boston Harbor Mussel Watch sites (1.13 and 1.43 μg/g for the Deer Island and Dorchester Bay Mussel Watch sites) and all were comparable to, or below, the Savin Hill Cove concentrations (1.6 to 2.2 μg/g) determined by Wallace *et al.* (1991). Cadmium concentrations at 11 of the 14 sites were below both the average for the two Mussel Watch sites and the concentrations previously determined for Savin Hill Cove. The cadmium concentrations apparently declined slightly in the surface sediment in the Old Harbor area (sites DB01 through DB06) between 1990 and 1994 (a significant decline can be noted for site DB01), while the concentrations remained nearly constant at the other sites.

The concentrations of copper ranged from 12 (site DB06) to 200 μg/g (site DB10) in this study. These concentrations were up to twice the average concentration of 110 μg/g determined for the two Deer Island and Dorchester Bay Mussel Watch sites, but comparable to the Savin Hill Cove concentrations (130 to 180 μg/g) determined by Wallace *et al.* (1991). For 9 of the 14 sites, copper concentrations were below both the average for the two Mussel Watch sites and the concentrations determined for Savin Hill Cove. The graphical presentation of the copper concentrations suggests that they may have declined slightly in sediments of the Old Harbor area between 1990 and 1994, while they appear to have remained relatively constant at the other locations. The highest concentrations occurred at site DB10 in both 1990 and 1994.

The concentrations of lead ranged from about 26 (site T8 and DB06) to 350 μg/g (site DB14). The lead concentrations at DB14 were approximately three times higher than the mean of 120 μg/g determined at the two Boston Harbor Mussel Watch sites, but this is the only site at which concentrations were higher than the Savin Hill Cove concentrations (210 to 230 μg/g) determined by Wallace *et al.* (1991). At 7 of the 14 sites, lead concentrations were below both the average for the two Mussel Watch sites and the concentrations determined for Savin Hill Cove. The sediment lead concentrations have, for the most part, remained relatively constant at the study sites, with a decline in concentration evident for only DB01 and DB10. The highest lead concentrations were measured at site DB14 in both sampling years.

The concentrations of zinc ranged from 33 (site DB06) to 340 μg/g (site DB14). At seven sites, concentrations were higher than the average of approximately 160 μg/g determined for the two Boston Harbor Mussel Watch sites and, at one site (DB14), concentrations were higher than the Savin Hill Cove concentrations (190 to 280 μg/g) determined by Wallace *et al.* (1991). At 7 of the 14 sites, zinc concentrations were below both the average for the two Mussel Watch sites and the concentrations determined for Savin Hill Cove. The sediment zinc concentrations apparently declined slightly at the Old Harbor sites (a large decline at site DB01) and at DB10 between 1990 and 1994, while the concentrations at DB12, DB13, and DB14 were similar in both years. However, DB01 was the only site with statistically significant differences in the 1994 and 1990 zinc concentrations (aluminum normalized), as determined by the two-way ANOVA analysis, supporting the observation of a decline in zinc concentrations at this site.

Chromium, Mercury, Nickel, and Silver

The chromium, mercury, nickel, and silver concentrations are variable, with large differences in the highest and lowest values for the non-normalized data (Figures 4-10, 4-11, and 4-13). There are, however, no sites with chromium, nickel, or silver concentrations that are consistently elevated over the other sites when the data have been normalized. The grain-size-normalized mercury concentrations appear to be elevated at site DB03, while the non-normalized and aluminum-normalized concentrations appear only slightly elevated. However, poor precision in the site replicates for DB03 (non-normalized concentrations of 0.039, 0.254, and 3.75 μg/g were determined for the three DB03 field replicates) makes it difficult to draw definitive conclusions about the mercury concentrations at this site.

The non-normalized and aluminum-normalized chromium concentrations were statistically higher at sites DB10 and DB12 than at the reference site (Table 3-7). Similarly, the mercury concentrations were elevated at sites DB01, DB10, DB12, DB13, DB14, and CO19; silver concentrations were elevated at sites DB10, DB13, and CO19. Nickel concentrations were not significantly elevated over the reference site at any of the test sites. The one-way ANOVA results show that, as a group, the sites that are located near CSOs (DB01, DB04, DB13, and DB14) have higher aluminum-normalized sediment chromium, mercury, and silver concentrations (but not nickel) than the other sites (Table 3-5). The multiple comparison test (Table 3-6) shows that site DB12 "groups" as the site with the highest aluminum-normalized chromium and silver concentrations, but that the concentrations at this site are not statistically different from those measured at several other sites (e.g., DB01, DB04, DB10, DB13, DB14, T2, CO19, and SWEX3).

The chromium concentrations ranged from 35 (site DB06) to 250 µg/g (site DB13). These concentrations were near or below the approximately 190 µg/g determined at the two Boston Harbor Mussel Watch sites closest to the study area, and the 190 to 220 µg/g concentrations determined by Wallace *et al.* (1991) for

Savin Hill Cove sites. The sediment chromium concentrations remained fairly constant at the study sites between 1990 and 1994.

The concentrations of nickel ranged from 9 (site DB06) to about 37 µg/g (sites DB01, DB10, DB12, DB13, CO19, and SWEX3). These concentrations were generally comparable to the approximately 30 µg/g concentrations determined at the two Boston Harbor Mussel Watch sites and the Savin Hill Cove concentrations (32 to 38 µg/g) determined by Wallace *et al.* (1991). For 8 of the 14 sites, nickel concentrations were below both the average for the two Mussel Watch sites and the concentrations determined for Savin Hill Cove. The nickel concentrations in the sediment at the test sites remained fairly constant between 1990 and 1994, with the exception of site DB01 where the concentrations have clearly declined.

The approximate concentrations of mercury and silver ranged from 0.08 (site DB06) to 1.3 µg/g (site DB03) and 0.4 (site DB06) to 5.6 µg/g (site DB13), respectively. These concentrations were generally comparable to the approximately 0.75 µg/g (mercury) and 3.1 µg/g (silver) determined at the two Boston Harbor Mussel Watch sites. For 8 of the 14 sites, mercury and silver concentrations were below the average concentration measured for the two Mussel Watch sites. Mercury and silver data were not included in Wallace *et al.* (1991) and were not determined in the previous Dorchester Bay CSO study in 1990 (Durell *et al.*, 1991).

Metals Summary

The average site data suggest that there may be significant contributions of lead and zinc from BOS-90 (by site DB14). The multiple comparison test supports the findings that site DB14 does have higher lead and zinc concentrations than any other site (Table 3-6), suggesting that there is a local source — the Commercial Point CSO is a possible source. The data also suggest that CSOs may contribute chromium, mercury, and silver to the sediment; slight elevations of one or more of these metals may be detected at sites DB01, DB10, DB12, DB13, DB14, and CO19. However, the relative increases in the concentrations of these metals at these sites are so small that CSOs cannot be conclusively identified as the primary source. Pollutant transport and deposition from other parts of the Harbor is also a possibility that must be considered; it is possible that other discharges, such as the Deer Island and Nut Island treatment plants, Harbor CSOs in general, and various non-point source pollution are responsible for maintaining the relatively evenly distributed concentrations of these metals. Without complete hydrodynamic information for the area, the Commercial Point CSO (BOS-90), or other CSOs, cannot be conclusively identified as a significant source of the elevated pollutant levels. Generally, the concentrations measured in 1994 sediment were comparable to Dorchester Bay concentrations determined in the CSO study four years ago and by other investigators in earlier Boston Harbor studies. A slight decline in concentrations of several metals was observed for the Old Harbor area — in particular at site DB01.

4.4 *Clostridium perfringens* DENSITIES

The 1994 *Clostridium perfringens* data are presented in Figure 4-20 and are also summarized in Table 3-3. The data are presented non-transformed as well as log-transformed but, for evaluating relative differences in microbiological pollution, log-transformed data are most commonly used. The *Clostridium perfringens* data, for the sites for which this parameter was determined in both 1994 and 1990, are shown in Figure 4-21. These data are tabulated in Table 3-8.

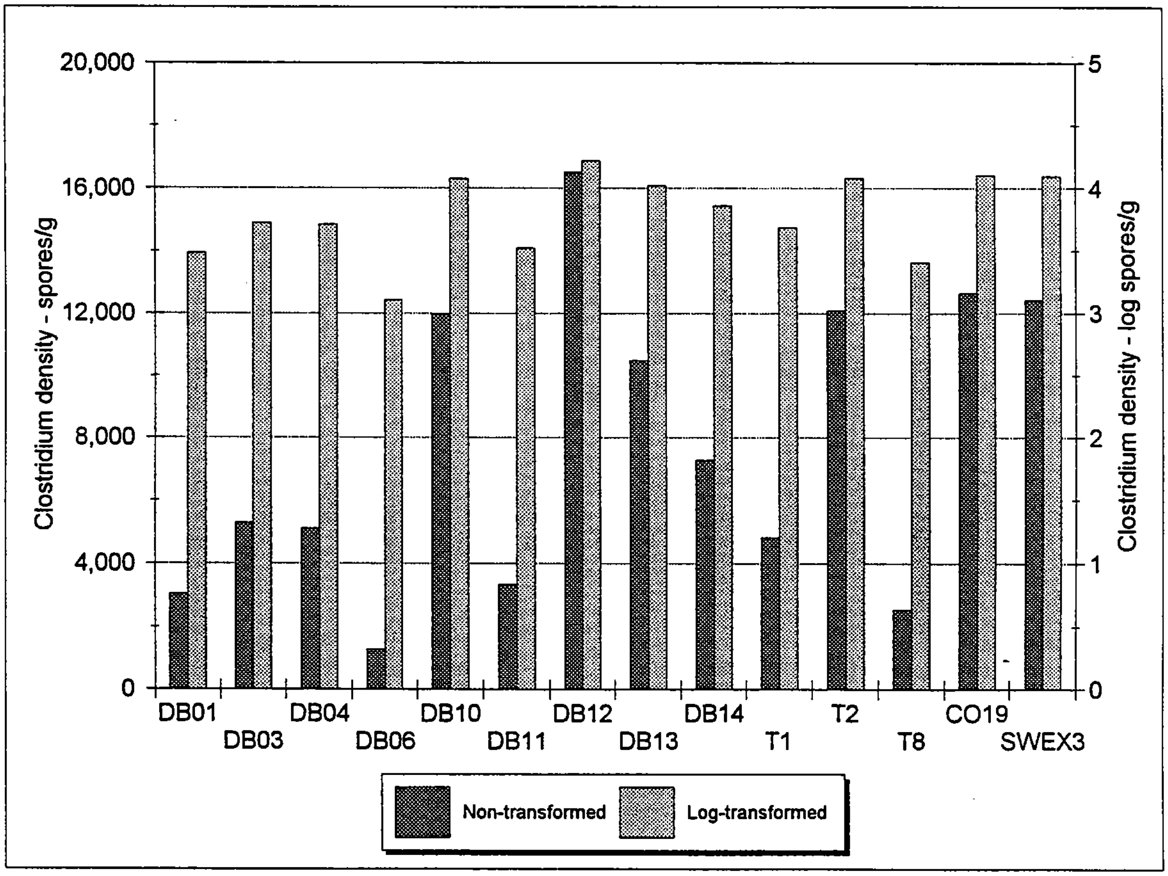


Figure 4-20. Sediment *Clostridium perfringens* Densities—1994 Samples

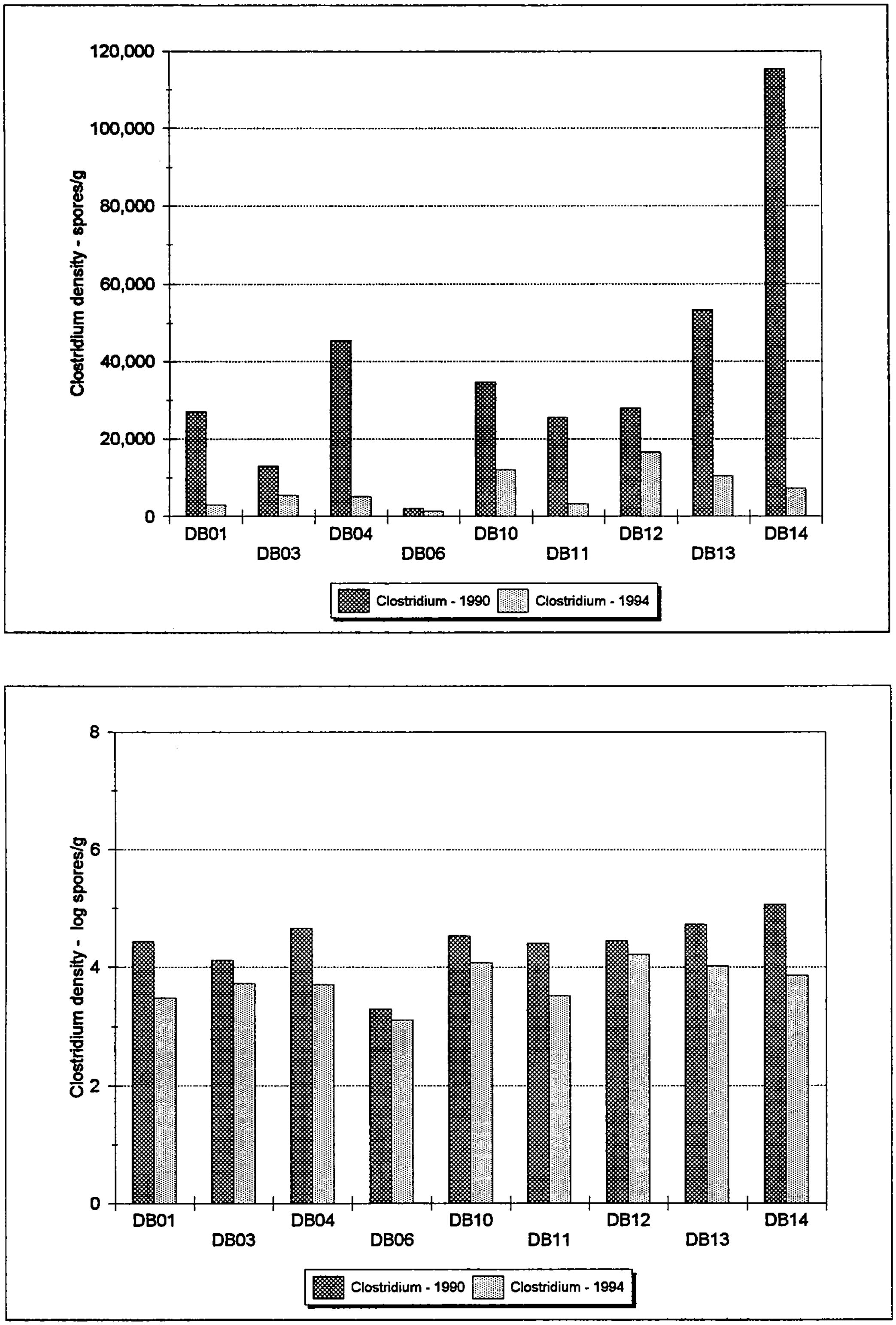


Figure 4-21. Sediment *Clostridium perfringens* Data Comparison—1994 and 1990 Samples (a) Nontransformed (b) Log_{10}-transformed

The densities of *Clostridium perfringens* at the study sites ranged from approximately 1,300 (site DB06) to 16,500 spores per gram dry weight (site DB12). The log-transformed data do not reveal any obvious elevations in *Clostridium perfringens* at any site and the non-transformed densities at DB12 are no more than three times the densities at the "reference site" (T2); the overall data show small relative density differences between the sites. Additionally, DB12 is not a site with a known nearby source of sewage and would not be expected to be impacted by discharges from any of the Dorchester Bay CSOs.

The statistical analysis data indicate that there are no sites with *Clostridium perfringens* densities that are significantly higher than those at the reference site T2 (Table 3-4). The data do, however, indicate that several sites (e.g., DB01, DB03, DB04, DB06, DB11, and T8) had significantly lower *Clostridium perfringens* densities than the reference site; site T2 may not have been an ideal reference site for this contaminant because it does not seem to represent typical Harbor background levels. The one-way ANOVA test indicated that, as a group, the sites that are located near CSOs (DB01, DB04, DB13, and DB14) have higher *Clostridium perfringens* densities than the other sites (Table 3-5). The multiple comparison test (Table 3-6) shows no distinct "grouping" of a site, or a few sites, with significantly higher *Clostridium perfringens* densities than most sites.

The *Clostridium perfringens* densities apparently declined at all tested sites between 1990 and 1994 (Figure 4-21). The largest reductions in *Clostridium perfringens* counts were observed at DB14 (near CSO BOS-90 — the Commercial Point CSO), DB13 (near CSO BOS-89 — the Fox Point CSO), and DB04 (near CSO BOS-83). The reductions observed at these three sites were supported by results from the two-way ANOVA analysis which indicated a statistically significant difference (and decline) in the 1990 and 1994 *Clostridium perfringens* densities.

Figure 4-22 (and Table 3-9) presents *Clostridium perfringens* densities generated in other studies of selected Boston Harbor sites. Some of these sites (T1, T2, and T8) were also sampled in this study. The data from these other studies of Boston Harbor sediments are consistent with the observations made during this CSO study; *Clostridium perfringens* densities appear to have declined in recent years in Boston Harbor sediments. However, it should be pointed out that these data were generated by three different microbiological testing laboratories; the data from 09/91 (which is of particular importance for concluding that a reduction in *Clostridium perfringens* has occurred) was generated by one laboratory, the 08/92 data were generated by another laboratory, and the data for the subsequent four sampling events were generated by a third laboratory.

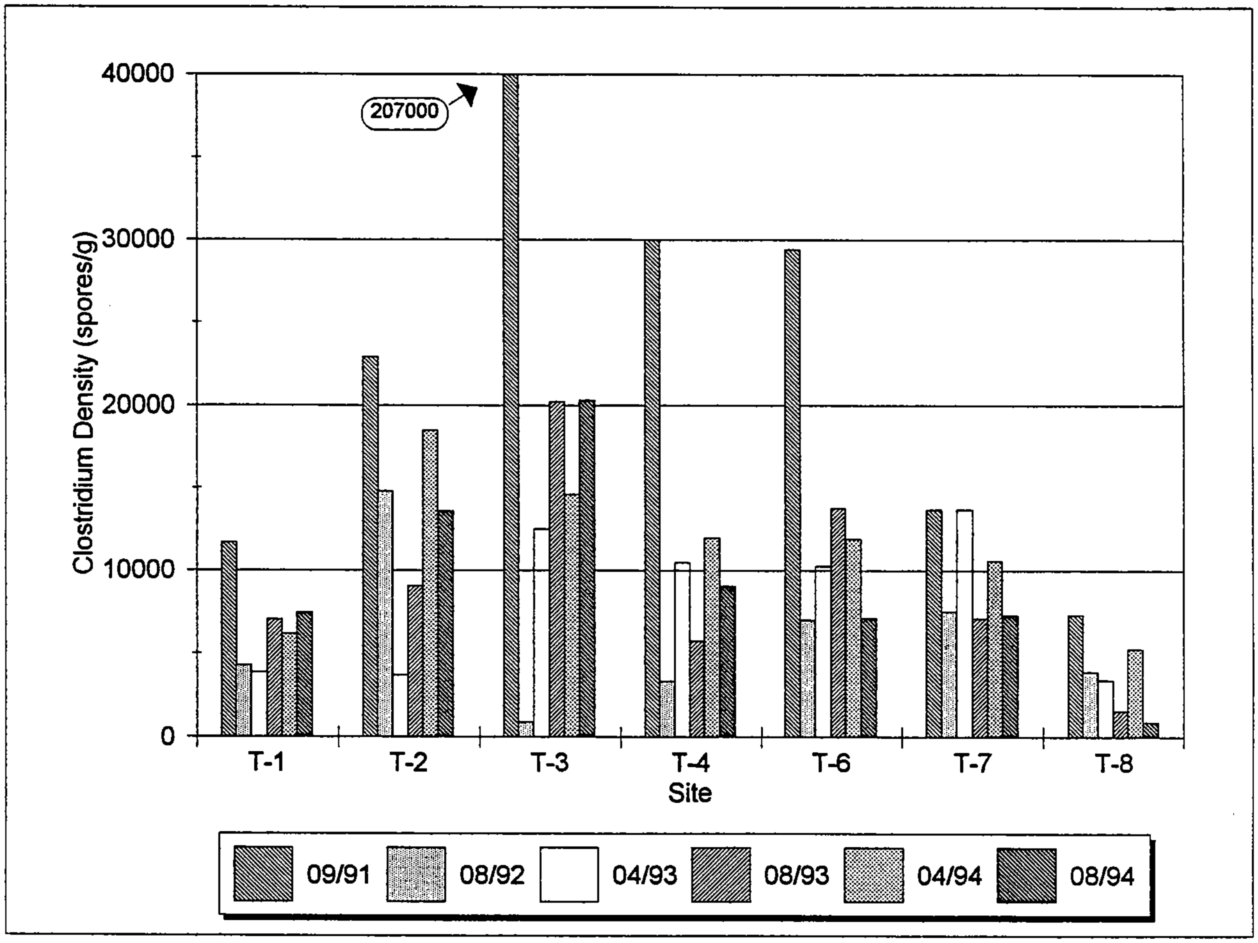


Figure 4-22. ***Clostridium perfringens*** **Data for Selected Boston Harbor Sites from Other Studies**

The event-to-event variability in these data suggests that there may also be inter-laboratory procedural differences, which makes it difficult to accurately compare data; the 08/92 data in particular (which were generated by a laboratory used for only that event) appear to be uncharacteristically low for several sites. However, all laboratories reported meeting the data quality objectives of their surveys and much of the variability may be "natural" fluctuations due to weather patterns and other phenomena.

The overall similarity in *Clostridium perfringens* densities throughout Dorchester Bay, and for the other Harbor sites, do not indicate the presence of any significant local source in Dorchester Bay. The primary source of these contaminants may be remote and the contaminants may be transported into Dorchester Bay. The relatively uniform, evenly distributed, levels of *Clostridium perfringens* may be because it deposits slowly, is effectively redistributed, and/or associate with many sources. It is possible that the discharges from the Deer Island and Nut Island treatment plants, as well Harbor CSOs in general, are responsible for maintaining the relatively evenly distributed background concentrations of *Clostridium perfringens*. The *Clostridium perfringens* densities determined in 1994 were consistently lower than those measured at the same locations four years ago. The largest reductions were observed for sediment collected near the Commercial Point and Fox Point CSOs. These reductions may be the result of CSO facility improvements that have occurred in recent years, and the elimination of sludge discharge from Deer Island and Nut Island.

5.0 CONCLUSIONS

Of the CSOs investigated, the Commercial Point CSO (BOS-90) is the CSO that can be linked to sediment pollution with the greatest degree of confidence. The heightened concentrations of PAH, slightly elevated concentrations of zinc and lead, and possibly also copper, LAB, and coprostanol concentrations suggest that BOS-90 (Commercial Point CSO) may have contributed to the sediment concentrations of these contaminants. However, the Commercial Point CSO cannot be conclusively identified as the primary source of the contaminants. Other possible local sources include the nearby yacht club and street runoff or runoff from nearby industrial activities. Additionally, it is important to bear in mind that the organic and metal contaminants measured in the sediments may have been deposited over several years, and may not necessarily represent contamination from current CSO discharges. It is known that changes in sediment contaminant concentration are a function of a number of variables including, source strength, deposition rates, and proximity to source, and because sediments typically take years to respond to decreases in contaminant loading it is not surprising that the 1994 data are not fully definitive. Furthermore, without reliable Harbor pollutant transport data and hydrodynamic information for the area, one cannot conclusively implicate the CSO as the primary source of these pollutants because earlier investigations have suggested that this is an area where significant amounts of contaminants originating in other parts of the Harbor are deposited.

The Commercial Point CSO may be a source of certain pollutants to nearby sediments. However, the site near this CSO was the site with highest TOC concentration. This is consistent with common knowledge of the behavior of organic and, to some degree, also metal contaminants, and with findings by Wallace *et al.* (1991) who found a correlation between elevated organic carbon and elevated metal concentrations in Dorchester Bay samples, including the metals that were elevated in this study. The data are insufficient to determine, with a high degree of confidence, if (1) these TOC concentrations are independent of the source of the pollutants and the sediments concentrate these pollutants from the overlying waters, (2) the TOC is discharged along with the pollutants from local CSOs, or (3) the TOC, particulates, and pollutants are transported from elsewhere in the Harbor and deposited at these locations. These questions might be answered with more CSO-specific discharge data and with reliable hydrodynamic data, including an understanding of the transport, deposition, and erosion of the areas.

The Fox Point/Commercial Point area had, on average, slightly higher contaminant concentrations than the Old Harbor area, as has been observed by other investigators. Gallagher *et al.* (1992), who performed work in the Fox Point area, and summarized the work of Eganhouse and Sherblom (1990) and of Wallace *et al.* (1991), concluded that the data available were insufficient to attribute the increased concentrations of organic and metal contaminants in this area to the Fox Point CSO. Elevated contaminant concentrations were attributed to transport and deposition of pollutants from other parts of the Harbor, and the data in this study suggest that this may indeed be the case for some of the pollution concentrations measured in the Fox Point/Commercial Point area.

With the possible exception of PAH at site DB14, the contaminant concentrations measured in the 1994 sediments are mostly similar to, or slightly below, those measured in sediments collected at the same sites in the 1990 Dorchester Bay CSO study or in other previous studies. The data suggest that the sediment PCB concentrations have declined in the past 10 years. The contaminant concentrations in sediment in the Old Harbor area have declined for several parameters (e.g., PAH and metals), and the densities of *Clostridium perfringens* appear to be lower throughout Dorchester Bay, and possibly throughout Boston Harbor, than they were four years ago. The observed sediment quality improvements, particularly with respect to *Clostridium perfringens*, can probably be attributed to improvements that have been made at CSO facilities, and the termination of sludge discharges at the Deer Island and Nut Island treatment plants. A decline in the general usage and ubiquity of certain contaminants (e.g., PCB) has probably also contributed to improved sediment quality.

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Appendix A

SITE LOCATION AND SAMPLE COLLECTION INFORMATION FOR 1994 SEDIMENT FIELD SAMPLES

Summary of Benthic Collections for the Boston Harbor CSO Survey S9402

Site	MWRA Sample ID	Date	Time (EDT)	Latitude	Longitude	Depth (m)	Protocol/ Replicate
SWEX3	S94020097	08-12-1994	17:28:19	42°19.73'N	70°59.57'W	8	CSO/CHE/1
SWEX3	S94020100	08-12-1994	17:36:54	42°19.74'N	70°59.55'W	8	CSO/CHE/2
SWEX3	S94020102	08-12-1994	17:47:44	42°19.76'N	70°59.53'W	8	CSO/CHE/3
T8	S94020143	08-13-1994	10:45:42	42°17.11'N	70°54.74'W	10	CSO/CHE/1
T8	S94020146	08-13-1994	10:55:59	42°17.12'N	70°54.75'W	10	CSO/CHE/2
T8	S94020152	08-13-1994	11:19:05	42°17.13'N	70°54.72'W	11	CSO/CHE/3
T1	S94020223	08-13-1994	17:45:38	42°20.96'N	70°57.79'W	7	CSO/CHE/1
T1	S94020225	08-13-1994	17:57:11	42°20.95'N	70°57.78'W	7	CSO/CHE/2
T1	S94020227	08-13-1994	18:07:20	42°20.94'N	70°57.81'W	7	CSO/CHE/3
DB11	S94020253	08-14-1994	09:30:01	42°17.32'N	71°02.05'W	2	CSO/CHE/1
DB11	S94020255	08-14-1994	09:40:31	42°17.30'N	71°02.07'W	2	CSO/CHE/2
DB11	S94020258	08-14-1994	09:50:05	42°17.32'N	71°02.06'W	2	CSO/CHE/3
DB13	S94020262	08-14-1994	10:27:32	42°18.58'N	71°02.49'W	4	CSO/CHE/1
DB13	S94020265	08-14-1994	10:42:10	42°18.56'N	71°02.50'W	4	CSO/CHE/2
DB13	S94020268	08-14-1994	10:53:58	42°18.58'N	71°02.51'W	3	CSO/CHE/3
DB12	S94020284	08-14-1994	12:24:56	42°18.97'N	71°01.28'W	5	CSO/CHE/1
DB12	S94020286	08-14-1994	12:35:19	42°18.97'N	71°01.29'W	5	CSO/CHE/2
DB12	S94020288	08-14-1994	12:47:33	42°18.96'N	71°01.28'W	5	CSO/CHE/3
DB03	S94020295	08-14-1994	13:15:24	42°19.30'N	71°00.87'W	5	CSO/CHE/1
DB03	S94020297	08-14-1994	13:25:57	42°19.31'N	71°00.85'W	5	CSO/CHE/2
DB03	S94020301	08-14-1994	13:38:25	42°19.32'N	71°00.87'W	5	CSO/CHE/3
T2	S94020365	08-15-1994	11:37:17	42°20.56'N	71°00.10'W	6	CSO/CHE/1
T2	S94020368	08-15-1994	11:46:09	42°20.57'N	71°00.12'W	6	CSO/CHE/2
T2	S94020370	08-15-1994	11:53:45	42°20.57'N	71°00.12'W	6	CSO/CHE/3
CS019	S94020398	08-15-1994	14:20:53	42°21.55'N	71°02.68'W	12	CSO/CHE/1
CS019	S94020403	08-15-1994	15:06:50	42°21.55'N	71°02.73'W	9	CSO/CHE/2
CS019	S94020405	08-15-1994	15:17:49	42°21.55'N	71°02.71'W	9	CSO/CHE/3
DB04	S94020409	08-15-1994	16:07:07	42°19.68'N	71°02.23'W	4	CSO/CHE/1
DB04	S94020411	08-15-1994	16:14:51	42°19.68'N	71°02.22'W	4	CSO/CHE/2
DB04	S94020413	08-15-1994	16:24:28	42°19.68'N	71°02.23'W	4	CSO/CHE/3

Summary of Benthic Collections for the Boston Harbor CSO Survey S9402

Site	MWRA Sample ID	Date	Time (EDT)	Latitude	Longitude	Depth (m)	Protocol/ Replicate
DB01	S94020417	08-15-1994	16:38:01	42°19.48'N	71°02.75'W	3	CSO/CHE/1
DB01	S94020420	08-15-1994	16:45:06	42°19.47'N	71°02.76'W	3	CSO/CHE/2
DB01	S94020423	08-15-1994	16:56:07	42°19.47'N	71°02.76'W	3	CSO/CHE/3
DB06	S94020433	08-16-1994	09:22:47	42°19.40'N	71°02.24'W	2	CSO/CHE/1
DB06	S94020435	08-16-1994	09:31:18	42°19.41'N	71°02.23'W	2	CSO/CHE/2
DB06	S94020437	08-16-1994	09:40:17	42°19.41'N	71°02.24'W	2	CSO/CHE/3
DB10	S94020442	08-16-1994	10:32:21	42°17.49'N	71°02.33'W	2	CSO/CHE/1
DB10	S94020445	08-16-1994	10:40:14	42°17.51'N	71°02.34'W	2	CSO/CHE/2
DB10	S94020449	08-16-1994	10:53:18	42°17.50'N	71°02.32'W	2	CSO/CHE/3
DB14	S94020454	08-16-1994	11:12:13	42°17.93'N	71°02.73'W	2	CSO/CHE/1
DB14	S94020456	08-16-1994	11:21:27	42°17.91'N	71°02.73'W	2	CSO/CHE/2
DB14	S94020458	08-16-1994	11:30:40	42°17.92'N	71°02.74'W	2	CSO/CHE/3

Appendix B

ORGANIC CONTAMINANT DATA FOR 1994 SEDIMENT FIELD SAMPLES

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PAH and LAB Data in ng/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station ID:	DB01-REP1	DB01-REP2	DB01-REP3	DB03-REP1	DB03-REP2	DB03-REP3	DB04-REP1	DB04-REP2	DB04-REP3	DB06-REP1	DB06-REP2	DB06-REP3	DB10-REP1	DB10-REP2
MWRA Sample ID:	S94020417	S94020420	S94020423	S94020295	S94020297	S94020301	S94020409	S94020411	S94020413	S94020433	S94020435	S94020437	S94020442	S94020445
BOS Lab ID:	PB32	PB31	PB40	PA98	PB01	PA78	PB29	PB35	PB33	PA79	PA73	PB27	PA88	PB02
NAPHTHALENE	171.57	185.15	142.76	14.69	50.57	348.74	116.74	180.78	806.57	7.49	7.83	11.45	177.19	175.12
C1-NAPHTHALENES	89.01	100.20	78.22	9.33	25.48	187.80	59.45	103.67	459.50	3.91	a	4.54	104.95	109.88
C2-NAPHTHALENES	163.17	171.06	145.22	25.56	52.76	271.94	103.85	175.35	656.70	a	a	a	156.24	165.63
C3-NAPHTHALENES	160.03	153.31	130.11	30.42	53.31	226.54	89.04	167.86	560.23	a	a	a	134.25	145.37
C4-NAPHTHALENES	82.10	81.36	70.85	16.08	25.10	82.69	44.24	89.47	281.26	a	a	a	83.34	91.68
BIPHENYL	33.11	36.26	28.71	3.78	10.39	56.60	22.63	35.37	128.68	a	a	a	42.44	62.81
ACENAPHTHYLENE	113.38	98.17	92.48	8.41	34.38	84.32	76.85	91.37	118.48	3.38	2.13	4.30	137.48	145.64
ACENAPHTHENE	158.27	147.53	151.31	14.48	33.81	342.14	71.52	212.73	929.01	1.79	a	2.21	77.09	71.65
DIBENZOFURAN	107.28	104.66	101.46	11.39	25.66	246.60	62.12	136.53	690.03	1.72	a	2.47	74.91	65.31
FLUORENE	198.44	185.28	188.95	25.96	45.97	373.68	103.02	255.99	927.90	2.42	2.33	3.55	116.86	106.23
C1-FLUORENES	97.85	95.37	91.03	17.32	33.59	143.38	52.38	108.89	319.49	a	a	a	72.51	70.86
C2-FLUORENES	130.43	144.00	118.87	22.08	55.91	134.54	84.47	131.51	435.77	a	a	a	126.64	138.62
C3-FLUORENES	359.08	346.49	278.26	29.26	78.06	332.74	213.96	328.56	1198.77	a	a	a	339.99	319.52
PHENANTHRENE	2139.41	1936.24	1945.70	227.19	385.74	2952.36	1004.79	2422.08	8346.19	30.17	25.79	33.26	1132.35	995.17
ANTHRACENE	470.67	403.18	429.14	80.26	117.76	570.28	335.94	476.17	1474.95	6.94	4.33	7.67	297.39	251.79
C1-PHENANTHRENES/ANTHRACENE	958.62	848.08	850.69	130.31	217.46	999.94	505.03	1014.57	3542.54	19.31	16.56	20.94	610.51	560.05
C2-PHENANTHRENES/ANTHRACENE	551.73	521.83	476.22	76.46	153.83	484.62	347.02	580.40	1763.27	17.30	a	19.28	452.86	465.51
C3-PHENANTHRENES/ANTHRACENE	252.29	310.06	233.12	38.74	95.04	223.62	189.67	317.82	762.88	10.09	a	a	324.26	323.85
C4-PHENANTHRENES/ANTHRACENE	704.58	676.33	627.12	57.35	145.92	444.25	371.25	613.42	1572.65	a	a	a	563.42	610.13
DIBENZOTHIOPHENE	132.17	121.89	122.17	12.79	27.62	165.31	63.80	148.09	589.55	2.35	2.17	2.29	75.89	71.58
C1-DIBENZOTHIOPHENES	93.34	93.38	83.74	11.86	25.47	80.58	51.70	98.09	361.54	2.87	3.05	3.75	67.04	67.50
C2-DIBENZOTHIOPHENES	117.01	117.17	105.66	14.77	36.80	88.89	77.52	119.30	335.00	a	a	a	117.13	139.15
C3-DIBENZOTHIOPHENES	99.57	101.12	84.49	11.51	36.99	67.26	67.14	87.67	207.34	a	a	a	139.12	155.41
FLUORANTHENE	3459.94	3218.40	3117.28	269.50	600.73	2648.36	1759.30	3315.72	8794.66	67.19	53.92	70.75	2275.67	2181.49
PYRENE	4003.78	3654.39	3249.69	327.09	702.33	3048.88	2008.28	3705.24	9139.88	75.54	55.78	77.13	2662.07	2611.35
C1-FLUORANTHENES/PYRENES	1492.02	1385.72	1356.14	160.45	328.44	1049.42	843.19	1483.88	3643.36	39.07	31.71	36.09	1098.32	1094.53
BENZ(A)ANTHRACENE	1340.61	1260.50	1178.44	97.98	218.37	901.28	746.83	1215.97	3667.30	26.25	18.10	22.75	866.34	970.01
CHRYSENE	1517.37	1431.11	1300.76	112.24	254.58	989.48	895.99	1350.33	3934.65	35.48	22.41	34.45	1087.54	1223.97
C1-CHRYSENE	490.10	489.54	404.06	50.47	115.43	340.45	318.02	465.83	1339.72	14.48	9.36	14.05	390.39	427.84
C2-CHRYSENE	342.73	374.52	304.76	50.65	97.91	297.73	251.97	356.11	995.33	a	a	a	368.74	367.58
C3-CHRYSENE	162.78	155.79	149.51	24.24	47.08	159.55	117.57	169.87	476.35	a	a	a	243.72	219.88
C4-CHRYSENE	101.76	113.93	128.48	18.01	a	120.64	99.53	136.00	338.51	a	a	a	166.03	171.46
BENZO(B)FLUORANTHENE	2030.42	2004.00	1786.31	128.48	346.10	1186.58	1188.43	1780.26	5095.92	47.85	31.36	48.29	1635.42	1663.56
BENZO(K)FLUORANTHENE	709.23	684.65	641.52	45.07	123.94	470.91	393.30	615.12	1612.72	17.04	14.82	17.63	499.16	590.96
BENZO(E)PYRENE	995.37	977.50	882.20	67.73	178.22	609.41	570.39	884.87	2413.86	23.39	16.78	23.01	807.23	900.33
BENZO(A)PYRENE	1333.27	1263.79	1166.19	95.97	234.89	890.77	735.67	1139.08	3231.12	29.89	20.10	29.11	973.67	1023.90
PERYLENE	346.49	348.15	309.19	22.55	63.02	236.95	196.39	302.22	909.68	15.86	5.70	8.02	263.52	285.11
INDENO(1,2,3-CD)PYRENE	1055.29	1041.85	940.25	62.25	171.02	665.06	577.54	895.14	2534.57	26.72	16.69	25.46	853.46	917.34
DIBENZO(A,H)ANTHRACENE	243.26	236.02	221.82	14.24	37.08	138.08	129.85	220.38	612.35	4.83	2.85	5.11	191.80	203.57
BENZO(G,H,I)PERYLENE	871.98	855.28	772.91	56.36	152.26	578.83	479.97	739.17	2071.88	21.45	15.63	23.50	726.28	802.80
Total PAH	27880	26473	24486	2493	5439	23241	15426	26671	77280	555	379	551	20533	20964
Total 24 PAH	22563	21240	19750	1870	4110	18779	12171	21299	61969	467	333	473	15829	16164
PETRO-PAH	7383	6978	6576	890	1768	8909	4114	7896	26468	110	64	116	5424	5308
PYRO-PAH	20496	19495	17910	1603	3671	14332	11312	18775	50812	445	315	435	15109	15656
1-PHENYL DECANES	37.71	47.01	33.99	a	a	a	30.97	46.04	71.88	a	a	a	63.99	104.98
1-PHENYL UNDECANES	135.71	166.04	144.12	a	65.53	102.69	121.18	209.94	278.34	a	a	a	236.53	416.37
1-PHENYL DODECANES	231.51	283.11	235.74	21.53	103.48	145.14	226.31	317.72	418.66	a	22.86	34.93	327.23	592.63
1-PHENYL TRIDECANES	199.67	215.20	156.66	13.52	80.53	109.82	181.50	202.15	302.14	a	13.63	25.33	260.46	414.50
1-PHENYL TETRADECANES	171.33	181.83	135.45	a	52.82	97.54	140.59	186.70	188.39	a	a	a	231.44	332.01
Total LAB	776	893	706	35.0	302	455	701	963	1259	0.0	36.5	60.3	1120	1860

a = Not Detected

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PAH and LAB Data in ng/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station ID:	DB10-REP3	DB11-REP1	DB11-REP2	DB11-REP3	DB12-REP1	DB12-REP2	DB12-REP3	DB13-REP1	DB13-REP2	DB13-REP3	DB14-REP1	DB14-REP2	DB14-REP3	T1-REP1A
MWRA Sample ID:	S94020449	S94020253	S94020255	S94020258	S94020284	S94020286	S94020288	S94020262	S94020265	S94020268	S94020454	S94020456	S94020458	S94020223
BOS Lab ID:	PA44	PA67	PB25	PA95	PA81	PA94	PA93	PA70	PA72	PA29	PB09	PA32	PB26	PA37
NAPHTHALENE	174.34	33.41	121.36	119.53	268.87	192.40	154.38	141.54	177.92	196.93	649.21	447.90	615.59	32.11
C1-NAPHTHALENES	109.03	14.84	72.51	66.31	135.79	110.12	68.63	98.78	110.37	124.68	610.50	323.13	434.40	30.48
C2-NAPHTHALENES	163.70	24.08	113.87	97.70	208.47	169.27	123.17	187.57	226.71	176.48	1513.90	805.01	805.56	97.20
C3-NAPHTHALENES	149.55	26.81	104.30	76.17	220.29	131.96	116.12	233.60	419.41	207.16	3040.63	1724.06	1345.22	137.34
C4-NAPHTHALENES	82.75	19.01	72.51	54.85	91.06	96.70	80.92	a	357.23	a	2901.68	1384.03	988.43	67.36
BIPHENYL	50.23	5.60	27.67	18.87	48.73	42.50	24.73	31.91	43.08	50.91	194.24	110.83	132.16	7.55
ACENAPHTHYLENE	156.81	21.05	113.27	59.41	125.98	85.25	137.20	166.68	171.83	178.31	455.27	328.08	314.56	41.09
ACENAPHTHENE	69.03	8.42	46.74	15.77	160.91	190.01	59.38	55.00	106.72	75.30	1048.18	651.82	1060.15	22.75
DIBENZOFURAN	68.47	9.22	45.04	26.32	150.65	223.23	46.20	52.44	94.81	74.55	668.34	437.99	710.26	19.36
FLUORENE	101.75	13.60	70.48	31.36	217.33	337.96	79.01	79.76	147.60	110.02	1215.94	800.92	1242.50	58.06
C1-FLUORENES	68.90	10.71	51.08	28.77	137.94	103.01	75.36	76.75	111.34	92.15	731.47	450.35	490.25	59.86
C2-FLUORENES	131.29	27.55	89.47	58.85	203.35	134.55	137.58	a	258.96	a	1248.72	1003.23	812.19	110.87
C3-FLUORENES	293.97	49.38	214.31	100.38	308.70	206.28	229.31	a	a	a	2350.70	1824.81	a	a
PHENANTHRENE	1061.14	149.28	766.07	265.53	1932.71	2269.18	765.43	934.79	1661.89	1074.46	12146.98	7967.79	11036.10	370.95
ANTHRACENE	266.31	36.04	176.66	78.81	375.93	753.03	201.33	272.56	425.68	354.20	2936.40	1781.39	2523.28	137.78
C1-PHENANTHRENES/ANTHRACENE	584.41	100.49	407.49	179.70	960.25	759.63	576.68	642.04	984.55	733.16	6825.98	4189.24	4854.89	390.06
C2-PHENANTHRENES/ANTHRACENE	472.14	87.61	321.31	178.74	647.54	447.10	477.61	606.31	946.62	665.70	5181.12	3425.74	3207.22	334.19
C3-PHENANTHRENES/ANTHRACENE	395.85	58.78	234.21	134.92	322.73	253.93	281.40	326.07	585.01	470.70	2476.33	1701.38	1674.23	148.31
C4-PHENANTHRENES/ANTHRACENE	627.77	85.49	421.63	212.10	486.79	368.21	473.49	a	645.61	a	2719.28	a	a	a
DIBENZOTHIOPHENE	72.34	10.46	50.48	21.39	123.57	177.01	52.46	68.90	126.20	86.13	930.99	573.13	774.98	25.32
C1-DIBENZOTHIOPHENES	58.95	10.92	50.90	24.69	109.75	82.91	69.05	115.60	161.09	123.81	1139.38	638.05	664.37	45.01
C2-DIBENZOTHIOPHENES	124.27	20.04	87.59	48.94	153.74	98.20	129.42	227.98	370.39	263.96	1771.55	1210.35	983.37	67.47
C3-DIBENZOTHIOPHENES	139.35	23.60	95.20	69.80	111.65	87.89	149.15	215.39	346.57	362.25	1467.64	1062.55	809.57	33.74
FLUORANTHENE	2183.38	332.87	1595.89	573.06	2211.95	2105.35	1220.87	2373.95	4107.26	2331.50	17276.81	14144.82	15445.93	570.03
PYRENE	2621.37	400.55	1950.88	803.69	2886.12	2593.10	2109.15	2142.06	3204.72	2252.90	14740.18	11317.28	12819.95	509.48
C1-FLUORANTHENES/PYRENES	1123.90	207.95	809.49	483.67	1333.15	1143.10	1096.32	1254.01	1727.49	1386.04	7891.30	5496.41	6353.66	468.63
BENZ(A)ANTHRACENE	898.76	133.74	664.22	260.78	904.94	936.69	682.57	780.30	1392.54	1068.06	8764.61	5772.84	6789.91	233.64
CHRYSENE	1158.64	171.48	784.29	334.44	1066.06	941.30	770.47	933.65	1733.68	1208.71	9726.22	6726.19	7457.35	238.20
C1-CHRYSENE	439.09	71.14	349.94	198.77	447.96	375.13	411.33	453.59	741.38	663.75	3916.03	2626.29	3162.54	200.31
C2-CHRYSENE	381.09	69.54	278.38	172.62	423.11	337.15	378.53	309.70	482.91	471.83	2091.93	1346.27	1464.65	149.63
C3-CHRYSENE	229.36	36.58	155.29	91.32	254.87	189.11	166.74	162.56	291.10	a	a	1190.04	a	63.91
C4-CHRYSENE	139.39	26.24	127.11	64.71	181.57	133.85	96.89	a	a	a	a	664.38	a	a
BENZO(B)FLUORANTHENE	1639.26	238.34	1231.39	502.13	1293.05	1194.99	978.84	1235.92	2198.35	1620.13	10684.88	7742.10	8453.35	246.88
BENZO(K)FLUORANTHENE	600.77	85.32	387.63	165.46	431.85	409.03	313.92	448.77	759.83	558.50	3739.39	2659.25	3112.69	92.08
BENZO(E)PYRENE	884.94	135.19	618.20	308.81	686.82	587.77	535.08	634.58	1088.02	840.98	4945.41	3778.91	4177.69	121.21
BENZO(A)PYRENE	1017.23	161.09	735.89	358.36	945.96	857.43	729.37	746.02	1262.11	968.49	6677.46	4653.82	5187.54	163.64
PERYLENE	281.56	41.46	205.62	106.95	241.64	216.17	169.25	189.87	323.79	270.99	1680.32	1229.53	1386.93	68.41
INDENO(1,2,3-CD)PYRENE	877.18	126.82	642.60	268.92	663.41	600.89	511.12	524.36	939.27	707.83	4644.22	3484.58	3744.07	91.48
DIBENZO(A,H)ANTHRACENE	192.86	28.08	143.79	60.35	150.63	154.16	128.54	123.77	225.21	175.82	1128.72	860.09	906.23	27.58
BENZO(G,H,I)PERYLENE	785.08	116.12	553.12	259.72	611.83	492.28	461.78	494.83	859.61	658.75	4041.80	3096.09	3317.36	78.36
Total PAH	20876	3229	14988	6983	22238	20588	15269	17342	29817	20605	156174	109631	119259	5560
Total 24 PAH	16027	2405	11534	5012	16750	16130	10917	13472	22570	15944	118687	84596	97163	3766
PETRO-PAH	5422	846	3754	1969	7503	7320	4508	4534	8480	5421	54224	32842	35479	2237
PYRO-PAH	15454	2382	11234	5014	14735	13267	10761	12808	21337	15184	101949	76789	83780	3323
1-PHENYL DECANES	96.87	a	55.18	a	a	a	a	112.67	132.82	114.62	393.76	344.97	201.66	a
1-PHENYL UNDECANES	372.99	55.98	176.71	a	136.39	189.84	137.01	392.17	504.98	493.70	965.95	878.63	750.16	42.51
1-PHENYL DODECANES	447.19	67.32	328.55	81.74	302.54	241.00	230.46	515.36	601.01	494.51	931.39	982.18	697.90	56.41
1-PHENYL TRIDECANES	411.05	47.29	213.48	49.83	147.69	186.50	162.76	435.98	467.84	392.44	624.99	747.01	557.27	47.76
1-PHENYL TETRADECANES	292.03	40.37	158.79	a	106.27	93.03	110.12	413.89	360.83	385.37	471.17	525.00	520.17	a
Total LAB	1620	211	933	132	693	710	640	1870	2067	1881	3387	3478	2727	147

a = Not Detected

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PAH and LAB Data in ng/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station ID:	T1-REP2A	T1-REP3	T2-REP1	T2-REP2	T2-REP3	T8-REP1	T8-REP2	T8-REP3	CO19-REP1	CO19-REP2	CO19-REP3	SWEX3-REP1	SWEX3-REP2	SWEX3-REP3
MWRA Sample ID:	S94020225	S94020227	S94020365	S94020368	S94020370	S94020143	S94020146	S94020152	S94020398	S94020403	S94020405	S94020097	S94020100	S94020102
BOS Lab ID:	PA31	PB08	PB36	PB39	PB30	PA34	PB23	PB15	PB41	PB38	PB37	PA27	PA38	PA42
NAPHTHALENE	34.92	84.71	94.15	113.98	121.57	63.11	62.97	12.65	281.52	373.46	365.64	147.81	132.65	146.77
C1-NAPHTHALENES	34.92	104.96	65.37	81.19	68.15	42.99	41.79	a	112.47	132.14	108.34	148.38	138.28	147.12
C2-NAPHTHALENES	91.81	265.31	87.73	135.54	93.13	61.03	88.85	a	165.04	188.07	180.90	186.41	190.31	204.15
C3-NAPHTHALENES	128.55	305.78	104.13	138.07	106.77	46.23	156.51	a	182.24	206.70	197.32	164.68	171.86	180.44
C4-NAPHTHALENES	80.63	a	a	a	54.66	a	a	a	184.04	142.89	a	55.48	118.71	75.90
BIPHENYL	10.50	41.98	15.89	19.66	20.47	11.42	14.48	a	51.80	55.84	49.58	36.63	40.23	45.39
ACENAPHTHYLENE	27.89	79.33	55.93	78.25	80.67	10.48	32.17	7.49	194.21	230.28	222.89	97.36	105.14	119.64
ACENAPHTHENE	55.07	21.99	17.63	19.46	25.00	58.42	32.74	a	52.86	62.80	55.99	29.33	24.84	28.77
DIBENZOFURAN	32.36	20.60	18.31	19.56	30.03	49.99	27.74	a	70.67	81.54	69.83	33.35	29.20	34.94
FLUORENE	65.34	60.90	27.50	34.37	45.76	63.93	61.05	a	91.18	101.98	93.09	47.57	44.61	53.25
C1-FLUORENES	71.45	140.31	a	36.85	41.26	27.81	70.21	a	81.94	76.83	91.72	53.30	56.65	55.84
C2-FLUORENES	100.39	246.90	a	a	a	a	a	a	a	a	a	73.21	80.09	103.36
C3-FLUORENES	a	a	a	a	a	a	a	a	a	a	a	a	a	a
PHENANTHRENE	551.92	479.00	326.55	395.52	425.75	571.55	376.76	35.93	809.63	798.88	840.11	477.03	392.43	500.61
ANTHRACENE	147.90	158.74	108.48	127.53	133.95	135.40	117.64	7.61	343.03	364.37	360.64	155.46	134.44	167.61
C1-PHENANTHRENES/ANTHRACENE	477.38	684.20	243.73	302.02	337.25	236.46	304.78	49.25	587.17	586.93	616.55	388.54	386.55	430.08
C2-PHENANTHRENES/ANTHRACENE	387.11	756.46	239.04	292.44	315.45	164.26	360.27	52.30	606.96	554.66	604.15	365.97	374.76	404.63
C3-PHENANTHRENES/ANTHRACENE	167.43	420.57	155.96	211.46	198.36	a	a	a	371.62	455.05	515.95	198.02	211.95	197.48
C4-PHENANTHRENES/ANTHRACENE	a	a	a	a	a	a	a	a	a	a	a	278.28	a	a
DIBENZOTHIOPHENE	39.26	45.87	24.09	31.26	33.38	35.52	28.36	a	68.48	68.17	67.79	39.31	36.52	40.00
C1-DIBENZOTHIOPHENES	64.12	122.53	38.92	52.67	49.18	a	49.56	a	82.05	80.56	92.30	62.66	66.27	67.35
C2-DIBENZOTHIOPHENES	86.16	217.30	87.79	106.74	113.26	a	65.78	a	235.19	208.68	248.78	120.87	143.63	129.21
C3-DIBENZOTHIOPHENES	49.04	178.97	101.68	120.34	112.88	a	43.50	a	309.67	275.98	318.69	109.15	119.32	117.99
FLUORANTHENE	713.46	924.10	740.31	993.75	1016.17	550.52	534.52	53.55	2395.49	2195.48	2441.33	1113.86	929.66	1138.09
PYRENE	623.77	1030.33	714.11	924.18	919.26	410.62	462.97	54.52	2157.86	1906.58	2177.83	1031.68	928.90	1086.83
C1-FLUORANTHENES/PYRENES	529.38	990.67	488.15	608.89	660.11	233.20	324.56	64.88	1440.17	1309.92	1436.48	687.96	747.34	753.56
BENZ(A)ANTHRACENE	229.83	400.15	255.30	330.80	432.28	154.27	153.96	18.19	972.87	967.45	835.56	439.43	438.10	440.96
CHRYSENE	236.18	461.11	300.43	391.21	486.57	158.68	181.72	26.13	1132.12	1216.62	1083.88	516.33	496.03	502.69
C1-CHRYSENE	168.07	426.52	173.13	261.73	335.17	81.03	115.74	21.06	631.53	759.75	501.32	273.85	356.25	317.08
C2-CHRYSENE	122.36	327.92	120.90	150.75	208.74	51.34	98.92	a	431.61	462.80	381.98	212.82	215.10	180.83
C3-CHRYSENE	70.37	171.65	a	a	a	a	a	a	278.43	326.27	251.08	131.74	137.59	a
C4-CHRYSENE	a	a	a	a	a	a	a	a	a	a	a	101.11	a	a
BENZO(B)FLUORANTHENE	249.34	464.37	398.34	512.29	631.81	183.66	207.73	31.30	1530.32	1607.71	1441.34	675.16	630.50	660.33
BENZO(K)FLUORANTHENE	90.20	155.37	145.01	193.56	228.54	64.41	74.13	11.89	556.40	567.96	507.31	245.91	209.17	224.19
BENZO(E)PYRENE	125.72	271.17	212.50	267.78	328.39	91.16	108.47	17.85	791.13	810.00	720.08	347.44	336.29	344.81
BENZO(A)PYRENE	174.03	358.64	260.57	334.34	404.44	133.09	138.52	20.34	902.29	932.50	849.18	429.99	419.77	432.63
PERYLENE	56.01	102.84	68.50	84.92	106.32	34.23	37.15	5.02	225.88	238.75	209.43	118.33	104.32	118.69
INDENO(1,2,3-CD)PYRENE	97.72	200.31	175.44	229.72	278.50	79.94	94.43	14.92	610.63	659.33	589.53	292.61	276.08	300.58
DIBENZO(A,H)ANTHRACENE	28.64	56.42	44.04	56.31	68.89	20.21	23.03	4.12	155.07	165.82	142.97	71.26	71.81	73.03
BENZO(G,H,I)PERYLENE	89.23	201.21	183.35	220.46	257.50	73.51	83.67	14.30	559.82	627.63	553.93	264.86	262.94	275.04
Total PAH	6308	10979	6093	7878	8770	3898	4575	523	19653	19800	19223	10223	9558	10100
Total 24 PAH	4340	6913	4645	5985	6617	3255	3390	385	14861	14997	14643	7426	6865	7622
PETRO-PAH	2704	4436	1813	2317	2407	1579	1935	165	4882	5046	5100	3269	2998	3251
PYRO-PAH	3604	6543	4280	5561	6363	2320	2640	358	14772	14755	14123	6954	6560	6849
1-PHENYL DECANES	a	63.19	65.05	87.03	75.34	a	33.19	a	180.66	154.90	172.19	76.54	67.61	64.79
1-PHENYL UNDECANES	54.68	167.48	245.32	340.55	285.38	54.86	135.32	43.08	645.88	560.49	611.15	317.51	250.46	268.09
1-PHENYL DODECANES	66.24	185.70	344.50	395.79	413.87	87.87	174.68	56.63	916.43	717.89	700.70	439.05	322.31	370.40
1-PHENYL TRIDECANES	51.57	169.12	250.86	346.85	309.47	56.61	175.58	53.66	697.57	502.38	519.94	333.92	256.60	264.68
1-PHENYL TETRADECANES	a	124.11	244.37	221.09	190.46	45.79	164.05	a	498.09	341.09	498.07	221.59	125.62	181.44
Total LAB	172	710	1150	1391	1275	245	683	153	2939	2277	2502	1389	1023	1149

a = Not Detected

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PCB/Pesticide Data in ng/g, Coprostanol in ug/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station Description: MWRA Sample ID: BOS Lab ID:	DB01-REP1 S94020417 PB32	DB01-REP2 S94020420 PB31	DB01-REP3 S94020423 PB40	DB03-REP1 S94020295 PA98	DB03-REP2 S94020297 PB01	DB03-REP3 S94020301 PA78	DB04-REP1 S94020409 PB29	DB04-REP2 S94020411 PB35	DB04-REP3 S94020413 PB33	DB06-REP1 S94020433 PA79	DB06-REP2 S94020435 PA73	DB06-REP3 S94020437 PB27	DB10-REP1 S94020442 PA88	DB10-REP2 S94020445 PB02
CL2(08)	1.23	1.32	0.91	a	0.95	1.93	0.96	0.81	a	a	a	a	10.05	13.73
HEXACHLOROBENZENE	2.69	0.55	0.42	a	0.15	1.70	1.71	0.29	a	a	a	a	0.50	0.51
LINDANE	0.97	0.83	0.77	a	a	a	3.42	1.00	a	a	a	a	1.52	1.64
CL3(18)	1.39	1.60	1.21	0.32	0.86	3.22	0.66	1.22	0.75	a	0.03	a	11.80	15.59
CL3(28)	2.64	3.19	2.69	0.56	2.03	3.16	2.17	2.32	2.32	0.20	0.19	0.30	34.71	34.56
HEPTACHLOR	1.21	1.07	0.82	a	a	a	0.67	0.85	1.53	a	a	a	a	a
CL4(52)	4.76	5.72	3.63	0.93	4.03	3.78	3.42	1.55	0.93	0.29	0.20	0.37	29.91	37.05
ALDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(44)	2.95	2.72	1.71	0.59	2.01	2.20	1.61	1.82	1.49	0.21	0.21	0.36	21.01	22.97
HEPTACHLOREPOXIDE	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(66)	4.45	5.88	4.54	0.99	4.28	4.23	4.41	3.77	3.53	0.36	0.43	0.70	30.05	36.80
2,4-DDE	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(101)	7.80	8.54	6.61	1.78	8.04	5.60	6.06	6.79	5.83	0.53	0.61	0.76	19.92	22.44
CIS-CHLORDANE	1.20	1.29	1.35	0.33	0.58	0.75	0.83	1.44	16.34	0.11	0.12	0.12	2.32	2.97
TRANS-NONACHLOR	0.92	0.93	0.80	0.28	0.45	0.39	0.66	0.80	1.38	0.10	0.14	0.14	1.89	2.02
DIELDRIN	4.06	4.23	3.60	a	a	1.42	2.62	4.00	11.89	0.09	0.58	a	4.43	6.04
4,4-DDE	4.98	5.34	4.18	0.77	2.79	3.69	4.57	4.51	12.33	0.29	0.24	0.34	11.90	11.28
CL4(77)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
2,4-DDD	7.43	7.11	6.69	0.59	1.78	4.35	4.51	8.56	24.15	0.26	0.24	0.27	31.69	40.67
ENDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(118)	7.79	9.61	7.41	1.37	7.47	5.48	6.95	6.66	5.70	0.65	0.69	0.95	34.97	41.76
4,4-DDD	8.42	8.80	7.48	1.09	4.49	3.88	6.26	5.69	7.43	0.55	0.60	0.53	81.82	101.50
2,4-DDT	3.05	2.52	2.33	0.38	1.27	1.70	1.89	3.74	a	a	a	0.24	3.12	3.36
CL6(153)	12.45	15.07	14.66	0.78	10.68	7.84	11.63	10.66	8.12	1.05	1.04	1.24	35.75	40.72
CL5(105)	4.27	4.87	2.88	a	3.43	3.13	3.31	3.65	3.66	0.41	0.30	0.33	15.24	17.94
4,4-DDT	4.96	2.29	1.97	0.30	0.64	1.31	2.51	1.81	a	0.13		0.17	4.56	3.28
CL6(138)	12.02	12.65	11.53	2.25	10.79	8.32	10.30	10.01	7.43	1.00	0.83	1.20	61.28	48.55
CL5(126)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL7(187)	4.30	4.29	4.14	0.43	2.00	2.44	3.30	3.50	3.51	0.30	0.31	0.37	7.78	8.77
CL6(128)	4.72	4.19	3.88	0.60	2.46	3.12	3.67	4.45	3.02	0.28	0.25	0.32	8.24	8.53
CL7(180)	5.21	5.28	3.82	0.77	3.36	3.00	4.32	4.10	2.80	0.40	0.24	0.29	14.84	16.03
MIREX	3.46	2.57	2.56	a	a	0.80	2.20	2.45	5.72	a	a	a	a	a
CL7(170)	MI	MI	MI	MI	MI	MI	MI	MI	MI	1.33	2.14	MI	MI	MI
CL8(195)	1.46	1.70	1.79	a	0.59	0.87	1.22	1.54	a	a	a	a	2.39	4.83
CL9(206)	2.12	2.50	1.96	a	0.76	1.03	1.33	1.04	a	a	a	a	3.09	MI
CL10(209)	7.51	8.67	6.14	a	1.00	1.61	3.78	4.67	a	a	a	a	2.90	MI
PCB Sum	87.1	97.8	79.5	11.3	64.7	61.0	69.1	68.6	49.1	7.0	7.5	7.2	344	370
DDTs Sum	28.8	26.0	22.6	3.1	11.0	14.9	19.7	24.3	43.9	1.2	1.1	1.5	133	160
COPROSTANOL (ug/g)	5.80	6.03	4.98	0.64	1.84	2.36	5.03	4.51	8.64	1.00	0.85	6.60	5.96	2.79

MI - matrix interference, data not quantifiable.
a - not detected

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PCB/Pesticide Data in ng/g, Coprostanol in ug/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station Description:	DB10-REP3	DB11-REP1	DB11-REP2	DB11-REP3	DB12-REP1	DB12-REP2	DB12-REP3	DB13-REP1	DB13-REP2	DB13-REP3	DB14-REP1	DB14-REP2	DB14-REP3	T1-REP1A
MWRA Sample ID:	S94020449	S94020253	S94020255	S94020258	S94020284	S94020286	S94020288	S94020262	S94020265	S94020268	S94020454	S94020456	S94020458	S94020223
BOS Lab ID:	PA44	PA67	PB25	PA95	PA81	PA94	PA93	PA70	PA72	PA29	PB09	PA32	PB26	PA37
CL2(08)	9.43	2.24	9.18	3.22	2.18	2.03	2.58	3.80	5.05	16.40	5.21	4.49	4.23	a
HEXACHLOROBENZENE	0.67	0.12	0.29	1.02	0.33	0.12	0.15	0.72	1.38	0.47	5.81	1.82	2.14	a
LINDANE	1.57	0.39	0.83	a	0.67	0.76	0.81	1.24	1.64	1.83	4.59	2.52	1.43	0.86
CL3(18)	11.45	2.59	9.91	3.61	4.10	4.68	2.54	4.91	4.97	76.70	9.11	9.22	6.52	0.28
CL3(28)	35.93	6.99	28.62	9.53	7.25	9.36	5.45	11.41	13.28	122.23	15.96	17.55	12.89	0.53
HEPTACHLOR	a	a	a	a	a	0.70	a	a	a	a	a	a	1.12	a
CL4(52)	30.93	6.44	25.15	9.41	15.83	19.56	17.84	14.56	16.56	2.06	12.96	27.60	23.44	0.72
ALDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(44)	22.68	4.34	16.70	5.93	8.68	11.69	7.71	8.26	10.56	1.82	10.39	11.55	8.52	0.52
HEPTACHLOREPOXIDE	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(66)	54.20	7.19	23.56	9.20	13.76	18.69	14.01	17.84	18.34	121.78	11.94	18.82	15.16	0.99
2,4-DDE	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(101)	23.12	4.86	15.47	7.55	28.43	30.18	35.61	16.66	18.84	1.44	23.69	22.20	15.72	1.98
CIS-CHLORDANE	2.73	0.56	2.02	0.83	2.22	2.15	2.50	1.97	3.49	5.74	45.85	9.94	7.00	0.25
TRANS-NONACHLOR	1.74	0.45	1.34	0.52	1.22	1.35	0.93	1.82	1.95	2.67	7.15	4.18	2.27	0.21
DIELDRIN	6.13	0.64	3.22		8.83	6.27	2.99	4.43	6.35	16.58	14.31	8.16	23.41	0.59
4,4-DDE	11.89	1.50	6.75	3.48	12.24	12.33	13.97	5.94	9.37	36.13	20.02	20.43	14.34	1.12
CL4(77)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
2,4-DDD	37.57	1.35	5.79	3.50	8.02	6.74	7.46	8.95	10.26	18.15	44.70	46.88	37.13	1.24
ENDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(118)	45.86	4.51	27.66	6.57	29.78	41.35	47.51	16.54	19.84	120.26	18.78	23.75	17.84	1.51
4,4-DDD	97.14	3.60	16.41	14.68	21.80	20.33	22.87	15.69	22.62	62.60	86.88	60.41	48.50	2.71
2,4-DDT	6.78	1.43	4.27	2.30	3.34	3.71	3.66	3.03	4.16	9.49	41.52	19.38	20.77	0.54
CL6(153)	48.50	4.98	31.29	7.63	38.34	41.77	45.26	30.06	37.67	114.49	27.45	40.40	25.84	2.27
CL5(105)	17.29	2.35	11.82	3.03	12.11	15.33	15.16	7.97	6.97	48.40	17.34	13.98	12.99	0.87
4,4-DDT	7.94	0.46	1.48	2.18	5.50	6.17	3.63	2.47	3.32	3.34	13.45	10.07	6.42	0.36
CL6(138)	52.00	3.27	19.88	6.86	39.13	42.93	45.19	20.92	26.17	110.16	283.35	68.79	109.70	2.42
CL5(126)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL7(187)	10.16	1.06	4.85	1.42	7.67	8.77	8.50	7.07	5.73	28.40	4.88	9.03	6.67	0.53
CL6(128)	10.47	1.36	6.54	2.47	9.15	11.47	12.66	6.56	5.57	18.66	5.77	7.00	4.89	1.22
CL7(180)	18.21	1.67	9.47	2.25	12.17	14.48	15.52	9.66	11.67	55.10	14.36	20.89	13.93	0.89
MIREX	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL7(170)	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
CL8(195)	3.41	0.99	1.78	0.46	1.84	2.15	2.26	1.87	3.56	7.43	9.17	a	a	a
CL9(206)	2.99	a	0.81	0.74	1.70	1.93	2.04	1.79	2.29	4.90	a	a	a	a
CL10(209)	7.51	a	3.47	0.91	3.12	2.82	3.44	2.26	6.45	5.49	a	a	a	a
PCB Sum	404	54.8	246	80.8	235	279	283.3	182	214	856	470	295	278	14.7
DDTs Sum	161	8.3	34.7	26.1	50.9	49.3	51.6	36.1	49.7	130	207	157	127	6.0
COPROSTANOL (ug/g)	8.30	1.28	4.01	1.12	3.12	2.58	2.78	7.33	17.0	3.43	35.4	32.7	28.6	2.27

MI - matrix interference, data not quantifiable.
a - not detected

MWRA Sediment Chemistry - August '94 CSO Survey (Survey S9402), G2360-1222
PCB/Pesticide Data in ng/g, Coprostanol in ug/g (dry weight)
File Name: ORG_REP1.WB1

Site/Station Description:	T1-REP2A	T1-REP3	T2-REP1	T2-REP2	T2-REP3	T8-REP1	T8-REP2	T8-REP3	CO19-REP1	CO19-REP2	CO19-REP3	SWEX3-REP1	SWEX3-REP2	SWEX3-REP3
MWRA Sample ID:	S94020225	S94020227	S94020365	S94020368	S94020370	S94020143	S94020146	S94020152	S94020398	S94020403	S94020405	S94020097	S94020100	S94020102
BOS Lab ID:	PA31	PB08	PB36	PB39	PB30	PA34	PB23	PB15	PB41	PB38	PB37	PA27	PA38	PA42
CL2(08)	a	a	a	a	a	a	a	a	1.44	1.42	2.19	1.44	1.89	0.96
HEXACHLOROBENZENE	a	0.32	a	a	a	a	a	a	0.30	0.57	1.42	0.25	0.21	0.14
LINDANE	0.84	1.13	a	a	0.72	a	a	a	1.16	1.33	2.05	1.13	1.25	1.09
CL3(18)	0.41	1.02	1.19	0.82	0.55	a	a	a	1.33	1.82	2.15	1.41	1.88	1.13
CL3(28)	0.64	1.78	2.05	1.45	1.35	a	0.42	a	2.97	3.21	3.38	2.49	3.26	2.57
HEPTACHLOR	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(52)	1.13	3.40	2.34	2.21	1.20	a	0.44	a	6.70	9.82	9.77	3.21	3.85	3.35
ALDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL4(44)	0.61	1.67	1.96	1.47	0.96	a	a	0.24	3.20	4.60	5.30	2.48	2.26	1.72
HEPTACHLOREPOXIDE	a	a	a	a	a	a	a	a	a	a	a	a	a	1.03
CL4(66)	1.11		3.16	2.66	1.82	a	1.29	0.28	7.33	8.26	11.28	4.13	4.53	5.01
2,4-DDE	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(101)	2.62	6.97	4.75	4.96	4.44	0.81	1.44	0.37	13.87	18.40	20.30	5.29	6.48	6.48
CIS-CHLORDANE	0.46	1.58	1.11	1.21	1.03	0.19	0.32	0.15	2.39	2.49	2.64	1.03	1.19	1.30
TRANS-NONACHLOR	0.40	1.55	1.20	0.96	1.15	0.16	0.37	0.08	1.40	1.97	2.14	0.81	1.15	1.33
DIELDRIN	0.64	2.08	1.72	1.41	2.03	a	0.79	0.25	4.25	3.57	a	3.00	3.72	3.21
4,4-DDE	1.42	3.60	3.42	3.55	3.62	0.66	1.77	0.40	7.39	8.51	6.97	5.57	5.40	4.89
CL4(77)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
2,4-DDD	1.50	2.80	2.89	2.73	3.22	0.80	1.46	0.18	6.74	7.28	6.81	4.14	3.97	4.13
ENDRIN	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL5(118)	2.03	5.56	5.56	5.33	5.88	0.77	2.07	0.36	16.49	21.95	15.91	10.04	9.41	9.11
4,4-DDD	1.99	8.35	5.14	5.11	4.23	0.65	1.54	0.31	13.00	21.13	15.77	7.92	8.32	7.50
2,4-DDT	0.30	2.03	1.33	1.90	0.70	0.21	0.69	0.16	3.08	4.75	3.21	4.32	2.54	1.97
CL6(153)	3.15	9.06	9.37	10.39	10.67	1.05	2.63	0.51	42.07	37.02	35.90	17.13	15.97	15.58
CL5(105)	1.20	2.36	2.27	1.97	2.92	0.33	0.89	0.19	6.84	8.14	5.96	4.85	5.52	4.64
4,4-DDT	0.45	4.23	0.81	2.11	1.62	a	a	a	4.07	7.11	3.48	5.18	2.07	3.00
CL6(138)	2.98	8.41	7.77	7.55	9.41	0.91	2.60	0.40	22.98	57.46	24.11	13.56	13.15	15.21
CL5(126)	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL7(187)	0.62	2.03	2.81	3.02	3.96	0.44	0.80	0.19	9.62	9.58	7.70	4.88	4.52	4.66
CL6(128)	1.16	5.91	3.51	3.63	5.05		1.12	0.22	7.33	8.65	7.08	5.19	6.17	5.75
CL7(180)	0.97	2.87	4.34	5.19	5.40	0.39	1.07	0.20	15.66	20.14	10.46	6.71	6.59	7.18
MIREX	a	a	a	a	a	a	a	a	a	a	a	a	a	a
CL7(170)	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI	MI
CL8(195)	a	0.53	0.88	0.80	1.30	a	0.28	a	2.57	2.61	1.79	1.44	1.92	1.48
CL9(206)	a	0.46	0.73	0.88	1.55	a	0.22	a	2.95	3.45	2.16	1.62	1.93	1.37
CL10(209)	a	1.14	1.82	1.77	2.18	a	0.82	a	5.35	5.68	3.08	3.48	3.26	3.74
PCB Sum	18.6	53.2	54.5	54.1	58.7	4.7	16.1	3.0	169	222	169	89.3	92.6	89.9
DDTs Sum	5.7	21.0	13.6	15.4	13.4	2.3	5.5	1.0	34.3	48.8	36.2	27.1	22.3	21.5
COPROSTANOL (ug/g)	2.55	7.76	7.41	10.6	11.3	1.37	2.95	0.97	10.7	11.8	9.68	1.73	8.88	9.58

MI - matrix interference, data not quantifiable.
a - not detected

Appendix C

METAL CONTAMINANT DATA FOR 1994 SEDIMENT FIELD SAMPLES

MASSACHUSETTS WATER RESOURCES AUTHORITY
Metals in Sediments - 1994 CSO Study (S9402)
File Name: MET_REP1.WB1

Site/Station ID	MWRA Sample ID	BOS Lab ID	Ag ICP-MS	Al (%) XRF	Cd ICP-MS	Cr XRF	Cu XRF	Fe (%) XRF	Hg CVAA	Ni XRF	Pb XRF	Zn XRF
DB01-REP1	S94020417	PB32	3.21	4.74	0.939	101	118	3.28	0.688	32.8	144	213
DB01-REP2	S94020420	PB31	3.49	5.44	0.816	187	155	4.27	0.694	36.7	156	264
DB01-REP3	S94020423	PB40	3.73	6.93	0.778	184	130	3.61	0.841	33.9	156	222
DB03-REP1	S94020295	PA98	0.136	4.92	0.0581	42.8	14.4	1.80	0.039	11.9	37.2	55.2
DB03-REP2	S94020297	PB01	1.04	4.33	0.321	66.3	27.4	1.91	0.254	14.5	47.7	64.7
DB03-REP3	S94020301	PA78	1.48	4.64	0.305	86.5	41.9	2.26	3.751	19.4	79.0	88.5
DB04-REP1	S94020409	PB29	3.34	4.40	0.766	186	107	3.72	0.683	35.4	126	192
DB04-REP2	S94020411	PB35	3.22	6.58	0.846	147	90.0	3.09	0.667	28.8	118	157
DB04-REP3	S94020413	PB33	2.35	5.44	0.847	83.3	64.1	2.02	0.501	20.5	233	155
DB06-REP1	S94020433	PA79	0.320	4.49	0.0435	31.6	11.5	1.37	0.071	9.10	28.8	32.7
DB06-REP2	S94020435	PA73	0.338	4.19	0.0677	32.5	11.3	1.31	0.078	7.40	23.7	30.7
DB06-REP3	S94020437	PB27	0.418	2.23	0.0841	40.3	13.6	1.38	0.076	10.8	32.8	36.6
DB10-REP1	S94020442	PA88	4.69	6.43	1.56	213	183	4.24	1.117	38.6	138	260
DB10-REP2	S94020445	PB02	5.51	5.85	2.00	230	219	4.26	1.270	39.6	220	293
DB10-REP3	S94020449	PA44	4.96	6.22	1.50	210	193	4.15	1.144	35.1	188	267
DB11-REP1	S94020253	PA67	0.481	4.76	0.317	33.4	16.9	1.28	0.147	7.50	31.9	49.9
DB11-REP2	S94020255	PB25	2.35	3.64	0.918	143	77.8	2.89	0.732	23.7	113	160
DB11-REP3	S94020258	PA95	0.766	4.17	0.519	54.6	28.9	1.67	0.327	9.20	46.0	77.1
DB12-REP1	S94020284	PA81	3.38	3.10	0.128	168	78.2	2.64	0.723	31.5	101	132
DB12-REP2	S94020286	PA94	4.13	6.64	1.59	252	117	3.57	0.970	35.9	150	208
DB12-REP3	S94020288	PA93	3.77	6.24	1.68	208	101	3.22	0.738	34.3	140	175
DB13-REP1	S94020262	PA70	4.46	6.45	1.19	192	127	3.66	0.940	32.7	157	215
DB13-REP2	S94020265	PA72	4.40	6.16	1.24	185	131	3.70	0.931	35.8	169	226
DB13-REP3	S94020268	PA29	7.92	7.52	3.92	385	215	4.01	1.857	42.9	271	357
DB14-REP1	S94020454	PB09	1.83	4.27	1.71	99.2	141	2.70	0.710	29.6	419	407
DB14-REP2	S94020456	PA32	2.82	6.07	1.62	144	142.9	3.31	1.050	28.2	380	378
DB14-REP3	S94020458	PB26	1.90	2.40	1.11	115	94.5	2.51	0.554	18.7	241	246
T1-REP1A	S94020223	PA37	0.464	6.87	0.280	75.7	20.3	2.62	0.101	24.0	23.8	63.3
T1-REP2A	S94020225	PA31	0.580	6.49	0.232	57.8	19.7	2.22	0.181	16.8	25.7	57.0
T1-REP3	S94020227	PB08	1.64	6.10	0.410	101	40.4	2.95	0.498	21.4	48.9	82.5
T2-REP1	S94020365	PB36	2.47	6.20	0.472	106	49.1	2.31	0.437	19.0	53.7	84.8
T2-REP2	S94020368	PB39	2.38	6.51	0.463	133	56.9	2.68	0.337	22.5	68.2	105
T2-REP3	S94020370	PB30	2.64	4.26	0.519	138	71.5	2.89	0.344	28.2	67.3	113
T8-REP1	S94020143	PA34	0.402	5.05	0.109	47.7	11.7	2.83	0.089	9.90	23.5	43.6
T8-REP2	S94020146	PB23	0.914	2.64	0.115	69.2	28.0	2.01	0.160	21.6	35.4	65.9
T8-REP3	S94020152	PB15	0.274	1.37	0.0797	29.9	7.70	1.26	0.055	8.50	18.7	32.1
CO19-REP1	S94020398	PB41	4.39	7.23	1.08	219	138	4.39	0.760	40.8	131	209
CO19-REP2	S94020403	PB38	4.96	7.29	1.19	213	154	4.38	0.879	36.9	137	223
CO19-REP3	S94020405	PB37	4.93	7.08	1.16	212	146	4.24	0.797	34.0	144	222
SWEX3-REP1	S94020097	PA27	4.13	7.03	0.445	202	97.1	4.01	0.749	34.8	113	158
SWEX3-REP2	S94020100	PA38	3.52	7.05	0.403	182	92.4	3.73	0.484	35.8	101	152
SWEX3-REP3	S94020102	PA42	4.45	6.77	0.421	199	97.5	4.12	0.510	37.1	110	159

Appendix D

CLOSTRIDIUM PERFRINGENS, TOC, AND GRAIN SIZE DATA FOR 1994 SEDIMENT FIELD SAMPLES

MASSACHUSETTS WATER RESOURCES AUTHORITY
Clostridium, TOC, grain size analysis of Sediments - 1994 CSO Study (S9402)
File name: SUB_REP1.WB1

Site/Station	MWRA	BOS Lab			Grain Size				
ID	Sample ID	ID	Clostridium (spores/g)	TOC (%)	%Gravel	%Sand	%Silt	%Clay	%Mud*
DB01-REP1	S94020417	PB32	2120	2.75	0.0	30.7	55.9	13.5	69.4
DB01-REP2	S94020420	PB31	2460	2.69	0.0	22.8	60.8	16.4	77.2
DB01-REP3	S94020423	PB40	4530	2.91	0.0	23.2	60.1	16.6	76.7
DB03-REP1	S94020295	PA98	3030	0.37	18.2	77.8	2.7	1.4	4.1
DB03-REP2	S94020297	PB01	5640	1.19	6.8	81.5	8.3	3.5	11.8
DB03-REP3	S94020301	PA78	7180	1.60	5.9	54.3	25.0	14.8	39.8
DB04-REP1	S94020409	PB29	5770	2.49	0.5	17.2	64.7	17.7	82.4
DB04-REP2	S94020411	PB35	2990	2.40	0.7	32.9	52.6	13.9	66.5
DB04-REP3	S94020413	PB33	6590	2.17	0.0	66.5	26.6	6.9	33.5
DB06-REP1	S94020433	PA79	1490	0.17	0.0	91.0	6.1	2.9	9.0
DB06-REP2	S94020435	PA73	1130	0.11	0.0	93.6	3.9	2.5	6.4
DB06-REP3	S94020437	PB27	1230	0.36	0.1	93.0	4.9	2.0	6.9
DB10-REP1	S94020442	PA88	12900	3.89	0.0	12.8	63.5	23.7	87.2
DB10-REP2	S94020445	PB02	12700	4.25	0.0	8.6	70.3	21.2	91.5
DB10-REP3	S94020449	PA44	10300	4.23	0.0	15.0	62.2	22.9	85.1
DB11-REP1	S94020253	PA67	2220	0.30	5.0	83.0	8.7	3.3	12.0
DB11-REP2	S94020255	PB25	5330	2.30	0.0	21.4	64.2	14.5	78.7
DB11-REP3	S94020258	PA95	2470	0.75	1.9	70.0	22.1	5.9	28.0
DB12-REP1	S94020284	PA81	14300	2.85	16.4	46.2	24.9	12.6	37.5
DB12-REP2	S94020286	PA94	20700	2.40	1.5	46.3	36.1	16.1	52.2
DB12-REP3	S94020288	PA93	14500	2.67	5.1	47.7	31.1	16.0	47.1
DB13-REP1	S94020262	PA70	7050	2.86	0.0	12.0	63.6	24.4	88.0
DB13-REP2	S94020265	PA72	10700	3.29	0.0	13.7	60.4	25.9	86.3
DB13-REP3	S94020268	PA29	13700	3.46	0.0	17.1	53.8	29.1	82.9
DB14-REP1	S94020454	PB09	15100	5.77	0.0	38.5	47.4	14.1	61.5
DB14-REP2	S94020456	PA32	4500	5.23	0.0	45.7	41.1	13.2	54.3
DB14-REP3	S94020458	PB26	2260	4.19	2.0	58.2	30.0	9.8	39.8
T1-REP1A	S94020223	PA37	5040	1.36	2.6	59.1	30.6	7.8	38.4
T1-REP2A	S94020225	PA31	4840	1.21	9.6	57.6	24.2	8.7	32.9
T1-REP3	S94020227	PB08	4620	2.88	17.8	44.3	29.5	8.4	37.9
T2-REP1	S94020365	PB36	11700	1.37	5.1	62.8	21.8	10.3	32.1
T2-REP2	S94020368	PB39	14100	1.58	0.0	54.8	31.9	13.3	45.2
T2-REP3	S94020370	PB30	10500	1.89	3.2	60.5	25.9	10.4	36.3
T8-REP1	S94020143	PA34	1710	0.96	4.2	88.9	3.2	3.7	6.9
T8-REP2	S94020146	PB23	4980	2.08	2.2	89.0	4.7	4.1	8.8
T8-REP3	S94020152	PB15	1010	0.39	4.9	92.4	1.7	1.0	2.7
CO19-REP1	S94020398	PB41	3030	2.70	0.0	6.7	66.3	27.0	93.3
CO19-REP2	S94020403	PB38	18200	2.87	0.0	1.3	66.1	32.5	98.6
CO19-REP3	S94020405	PB37	16700	2.90	0.0	4.0	65.8	30.1	95.9
SWEX3-REP1	S94020097	PA27	12000	2.59	0.0	35.0	39.7	25.3	65.0
SWEX3-REP2	S94020100	PA38	10500	2.49	0.7	56.3	27.5	15.5	43.0
SWEX3-REP3	S94020102	PA42	14800	2.73	0.0	46.1	34.6	19.3	53.9

* %Mud defined as %Silt+%Clay.

Appendix E

SUMMARY STATISTICS FOR THE 1990 AND 1994 STATION REPLICATE SEDIMENT FIELD SAMPLES

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          - - Description of Subpopulations - -

Summaries of    AL        Aluminum
By levels of    YEAR
                SITE

Variable      Value  Label              Mean   Std Dev   Cases

For Entire Population                  5.8900   1.3495     48

YEAR         1990                      6.5433    .9304     24
 SITE       DB01                       6.5200    .3407      3
 SITE       DB03                       5.3133    .6435      3
 SITE       DB04                       7.4367    .5559      3
 SITE       DB06                       5.1133    .3427      3
 SITE       DB10                       7.1433    .3275      3
 SITE       DB12                       6.4433    .4400      3
 SITE       DB13                       7.4067    .3950      3
 SITE       DB14                       6.9700    .2458      3

YEAR         1994                      5.2367   1.4018     24
 SITE       DB01                       5.7033   1.1185      3
 SITE       DB03                       4.6300    .2951      3
 SITE       DB04                       5.4733   1.0904      3
 SITE       DB06                       3.6367   1.2274      3
 SITE       DB10                       6.1667    .2937      3
 SITE       DB12                       5.3267   1.9387      3
 SITE       DB13                       6.7100    .7163      3
 SITE       DB14                       4.2467   1.8351      3

  Total Cases = 48
```

```
              - - Description of Subpopulations - -

Summaries of    CD        Cadmium
By levels of    YEAR
                SITE

Variable       Value  Label           Mean   Std Dev   Cases

For Entire Population              1.67677   1.91524     48

YEAR       1990                    2.30688   2.43257     24
 SITE     DB01                     8.27633    .55350      3
 SITE     DB03                      .59733    .15383      3
 SITE     DB04                     1.50333    .08905      3
 SITE     DB06                      .25433    .11875      3
 SITE     DB10                     2.29267    .02159      3
 SITE     DB12                     1.05767    .11853      3
 SITE     DB13                     2.00833    .05465      3
 SITE     DB14                     2.46500    .21145      3

YEAR       1994                    1.04667    .86589     24
 SITE     DB01                      .84433    .08416      3
 SITE     DB03                      .22800    .14744      3
 SITE     DB04                      .81967    .04648      3
 SITE     DB06                      .06533    .02013      3
 SITE     DB10                     1.68667    .27301      3
 SITE     DB12                     1.13267    .87123      3
 SITE     DB13                     2.11667   1.56193      3
 SITE     DB14                     1.48000    .32357      3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    CR        Chromium
By levels of    YEAR
                SITE


Variable     Value  Label          Mean     Std Dev   Cases

For Entire Population            149.0625   73.8277    48

YEAR        1990                 148.5417   63.6300    24
 SITE      DB01                  116.6667    5.8595     3
 SITE      DB03                   83.0000   36.4280     3
 SITE      DB04                  195.6667    6.6583     3
 SITE      DB06                   34.3333    7.5056     3
 SITE      DB10                  218.0000    5.2915     3
 SITE      DB12                  168.3333    9.4516     3
 SITE      DB13                  212.0000     .0000     3
 SITE      DB14                  160.3333    6.6583     3

YEAR        1994                 149.5833   84.1943    24
 SITE      DB01                  157.3333   48.8092     3
 SITE      DB03                   65.3333   22.0076     3
 SITE      DB04                  138.6667   52.0032     3
 SITE      DB06                   35.0000    4.3589     3
 SITE      DB10                  217.6667   10.7858     3
 SITE      DB12                  209.3333   42.0159     3
 SITE      DB13                  254.0000  113.5033     3
 SITE      DB14                  119.3333   22.8108     3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of   CU      Copper
By levels of   YEAR
               SITE

Variable     Value  Label          Mean     Std Dev   Cases

For Entire Population            122.7042   69.7486     48

YEAR        1990                 140.2042   72.5181     24
 SITE     DB01                   215.0667   18.1197      3
 SITE     DB03                    48.5333   20.4167      3
 SITE     DB04                   156.3333    8.5008      3
 SITE     DB06                    18.5333    7.1059      3
 SITE     DB10                   215.2000    6.6551      3
 SITE     DB12                   103.1667    3.3561      3
 SITE     DB13                   181.7667    4.5325      3
 SITE     DB14                   183.0333    9.4002      3

YEAR        1994                 105.2042   63.5865     24
 SITE     DB01                   134.1000   18.6615      3
 SITE     DB03                    27.9000   13.7568      3
 SITE     DB04                    87.0333   21.6033      3
 SITE     DB06                    12.1333    1.2741      3
 SITE     DB10                   198.3333   18.5831      3
 SITE     DB12                    98.5000   19.3357      3
 SITE     DB13                   157.6000   49.7462      3
 SITE     DB14                   126.0333   27.3308      3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    FE        Iron
By levels of    YEAR
                SITE


Variable      Value  Label            Mean    Std Dev   Cases

For Entire Population               3.0252     .9855     48

YEAR        1990                    3.0508    1.0093     24
 SITE      DB01                     2.8233     .2122      3
 SITE      DB03                     2.0867     .4244      3
 SITE      DB04                     3.6967     .1922      3
 SITE      DB06                     1.3867     .2888      3
 SITE      DB10                     3.6233    1.5936      3
 SITE      DB12                     3.0733     .0950      3
 SITE      DB13                     4.0133     .0306      3
 SITE      DB14                     3.7033     .2173      3

YEAR        1994                    2.9996     .9821     24
 SITE      DB01                     3.7200     .5041      3
 SITE      DB03                     1.9900     .2402      3
 SITE      DB04                     2.9433     .8594      3
 SITE      DB06                     1.3533     .0379      3
 SITE      DB10                     4.2167     .0586      3
 SITE      DB12                     3.1433     .4697      3
 SITE      DB13                     3.7900     .1916      3
 SITE      DB14                     2.8400     .4180      3

  Total Cases = 48
```

```
            - - Description of Subpopulations - -

Summaries of    NI
By levels of    YEAR
                SITE


Variable      Value  Label          Mean    Std Dev   Cases

For Entire Population             34.3750   19.9297     48

YEAR       1990                   41.0792   24.5565     24
 SITE     DB01                    73.4000   55.8605      3
 SITE     DB03                    19.3000    6.5046      3
 SITE     DB04                    47.8667    4.3409      3
 SITE     DB06                    13.8333    2.8919      3
 SITE     DB10                    51.5667    1.9140      3
 SITE     DB12                    34.0333    1.1372      3
 SITE     DB13                    44.3333    2.4542      3
 SITE     DB14                    44.3000    1.3892      3

YEAR       1994                   27.6708   10.7160     24
 SITE     DB01                    34.4667    2.0108      3
 SITE     DB03                    15.2667    3.8083      3
 SITE     DB04                    28.2333    7.4661      3
 SITE     DB06                     9.1000    1.7000      3
 SITE     DB10                    37.7667    2.3629      3
 SITE     DB12                    33.9000    2.2271      3
 SITE     DB13                    37.1333    5.2291      3
 SITE     DB14                    25.5000    5.9304      3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of   PB       Lead
By levels of   YEAR
               SITE


Variable      Value  Label          Mean      Std Dev   Cases

For Entire Population            201.1667   155.9653     48

YEAR          1990               245.7917   187.6773     24
  SITE        DB01               468.6667    20.4287      3
  SITE        DB03                59.6667    21.1266      3
  SITE        DB04               149.6667     8.0829      3
  SITE        DB06                36.6667     5.5076      3
  SITE        DB10               427.3333    31.0215      3
  SITE        DB12               109.6667     4.1633      3
  SITE        DB13               192.0000     1.7321      3
  SITE        DB14               522.6667    25.0067      3

YEAR          1994               156.5417   101.6327     24
  SITE        DB01               152.0000     6.9282      3
  SITE        DB03                54.6667    21.7792      3
  SITE        DB04               159.0000    64.2106      3
  SITE        DB06                28.6667     4.5092      3
  SITE        DB10               182.0000    41.3280      3
  SITE        DB12               130.3333    25.8908      3
  SITE        DB13               199.0000    62.6418      3
  SITE        DB14               346.6667    93.5646      3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    ZN        Zinc
By levels of    YEAR
                SITE


Variable      Value  Label          Mean   Std Dev   Cases

For Entire Population           303.3958  332.8473      48

YEAR        1990                411.9167  436.1303      24
 SITE     DB01                 1471.6667   91.5769       3
 SITE     DB03                   97.6667   21.7792       3
 SITE     DB04                  275.3333   62.1798       3
 SITE     DB06                   46.6667   19.7569       3
 SITE     DB10                  472.6667   32.6548       3
 SITE     DB12                  155.3333    4.0415       3
 SITE     DB13                  342.3333    8.0829       3
 SITE     DB14                  433.6667    7.5056       3

YEAR        1994                194.8750  107.7228      24
 SITE     DB01                  233.0000   27.2213       3
 SITE     DB03                   69.6667   17.4738       3
 SITE     DB04                  168.0000   20.8087       3
 SITE     DB06                   33.6667    3.0551       3
 SITE     DB10                  273.3333   17.3877       3
 SITE     DB12                  171.6667   38.1095       3
 SITE     DB13                  266.0000   79.0000       3
 SITE     DB14                  343.6667   85.8157       3

 Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    PAH24      PAHs, 24 congeners
By levels of    YEAR
                SITE

Variable     Value  Label          Mean       Std Dev    Cases

For Entire Population          22123.8125   27239.1397     48

YEAR          1990             18027.9167   22207.9408     24
 SITE       DB01               65843.3333   18941.6904      3
 SITE       DB03                2443.3333     446.5796      3
 SITE       DB04                8033.3333    1766.5031      3
 SITE       DB06                 553.3333     104.0833      3
 SITE       DB10               18136.6667    6082.9790      3
 SITE       DB12                4490.0000    1630.0920      3
 SITE       DB13                9006.6667    1285.0811      3
 SITE       DB14               35716.6667     523.1953      3

YEAR          1994             26219.7083   31432.4178     24
 SITE       DB01               21184.3333    1407.3260      3
 SITE       DB03                8253.0000    9184.3294      3
 SITE       DB04               31813.0000   26511.6644      3
 SITE       DB06                 424.3333      79.1539      3
 SITE       DB10               16006.6667     168.4231      3
 SITE       DB12               14599.0000    3203.7389      3
 SITE       DB13               17328.6667    4704.3998      3
 SITE       DB14               100148.667   17240.4966      3

  Total Cases = 48
```

```
111  0  means tables = lab coprost by year by site

            - - Description of Subpopulations - -

Summaries of    LAB        Total LABs
By levels of    YEAR
                SITE


Variable       Value  Label             Mean     Std Dev   Cases

For Entire Population              1447.6667   1013.4144      39

YEAR         1990                  1881.3333    903.0889      15
 SITE      DB01                    1356.6667    283.6077       3
 SITE      DB04                    1170.0000    190.7878       3
 SITE      DB12                    1233.3333    343.1229       3
 SITE      DB13                    2433.3333    482.9424       3
 SITE      DB14                    3213.3333    566.5980       3

YEAR         1994                  1176.6250   1000.5266      24
 SITE      DB01                     791.6667     94.4793       3
 SITE      DB03                     264.0000    212.5629       3
 SITE      DB04                     974.3333    279.1726       3
 SITE      DB06                      32.0000     30.1993       3
 SITE      DB10                    1533.3333    377.5359       3
 SITE      DB12                     681.0000     36.5103       3
 SITE      DB13                    1939.3333    110.6993       3
 SITE      DB14                    3197.3333    409.8540       3

  Total Cases = 48
 Missing Cases = 9 or  18.8 Pct
```

```
        - - Description of Subpopulations - -

Summaries of     COPROST    Coprostanol
By levels of     YEAR
                 SITE


Variable      Value  Label          Mean      Std Dev    Cases

For Entire Population            9857.3590  10539.4694     39

YEAR          1990              12410.0000  11335.1545     15
  SITE        DB01               4226.6667   2127.8236      3
  SITE        DB04               5163.3333    610.0273      3
  SITE        DB12               4856.6667   1281.4965      3
  SITE        DB13              16773.3333   3437.2421      3
  SITE        DB14              31030.0000   8223.6184      3

YEAR          1994               8261.9583   9920.1785     24
  SITE        DB01               5604.3333    556.8136      3
  SITE        DB03               1611.6667    882.3437      3
  SITE        DB04               6060.6667   2248.7333      3
  SITE        DB06               2815.0000   3277.9446      3
  SITE        DB10               5683.0000   2762.2113      3
  SITE        DB12               2824.6667    272.6432      3
  SITE        DB13               9263.6667   7002.9565      3
  SITE        DB14              32232.6667   3413.4653      3

  Total Cases = 48
Missing Cases = 9 or  18.8 Pct
```

```
          - - Description of Subpopulations - -

Summaries of    CLOSTRID   Clostridium
By levels of     YEAR
                 SITE

Variable       Value  Label              Mean        Std Dev    Cases

For Entire Population                23727.7083   30696.7535     48

YEAR          1990                   39835.8333   36789.5679     24
  SITE      DB01                     27033.3333   13285.0793      3
  SITE      DB03                     12963.3333    5348.8348      3
  SITE      DB04                     45533.3333   11712.1020      3
  SITE      DB06                      1990.0000     680.2206      3
  SITE      DB10                     34566.6667    6091.2506      3
  SITE      DB12                     27800.0000    6873.8635      3
  SITE      DB13                     53400.0000    3704.0518      3
  SITE      DB14                    115400.000    49980.7963      3

YEAR          1994                    7619.5833    5529.2019     24
  SITE      DB01                      3036.6667    1304.3900      3
  SITE      DB03                      5283.3333    2097.8640      3
  SITE      DB04                      5116.6667    1886.8316      3
  SITE      DB06                      1283.3333     185.8315      3
  SITE      DB10                     11966.6667    1446.8356      3
  SITE      DB12                     16500.0000    3638.6811      3
  SITE      DB13                     10483.3333    3330.2903      3
  SITE      DB14                      7286.6667    6858.6102      3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    TOC      Total Organic Carbon
By levels of    YEAR
                SITE

Variable     Value  Label          Mean    Std Dev   Cases

For Entire Population             2.9144   1.7648    48

YEAR        1990                  3.1496   1.9837    24
  SITE     DB01                   6.2567   1.6551     3
  SITE     DB03                    .9733    .2386     3
  SITE     DB04                   3.1533    .0451     3
  SITE     DB06                    .2633    .0451     3
  SITE     DB10                   4.5400    .4223     3
  SITE     DB12                   1.8800    .2800     3
  SITE     DB13                   3.8233    .2483     3
  SITE     DB14                   4.3067    .2203     3

YEAR        1994                  2.6792   1.5212    24
  SITE     DB01                   2.7833    .1137     3
  SITE     DB03                   1.0533    .6263     3
  SITE     DB04                   2.3533    .1650     3
  SITE     DB06                    .2133    .1305     3
  SITE     DB10                   4.1233    .2023     3
  SITE     DB12                   2.6400    .2265     3
  SITE     DB13                   3.2033    .3092     3
  SITE     DB14                   5.0633    .8031     3

  Total Cases = 48
```

```
          - - Description of Subpopulations - -

Summaries of    MUD       % Silt + Clay
By levels of    YEAR
                SITE


Variable     Value  Label          Mean      Std Dev   Cases

For Entire Population              49.9646   27.5070    48

YEAR          1990                 45.8833   24.6857    24
  SITE     DB01                    30.1333    4.3016     3
  SITE     DB03                    18.4667    3.9829     3
  SITE     DB04                    63.7667   11.0120     3
  SITE     DB06                     6.0667     .3215     3
  SITE     DB10                    62.7000    3.2512     3
  SITE     DB12                    44.1333     .8145     3
  SITE     DB13                    77.7000    5.8078     3
  SITE     DB14                    64.1000    2.1932     3

YEAR          1994                 54.0458   30.0338    24
  SITE     DB01                    74.4333    4.3662     3
  SITE     DB03                    18.5667   18.7873     3
  SITE     DB04                    60.8000   24.9433     3
  SITE     DB06                     7.4333    1.3796     3
  SITE     DB10                    87.9333    3.2624     3
  SITE     DB12                    45.6000    7.4639     3
  SITE     DB13                    85.7333    2.5968     3
  SITE     DB14                    51.8667   11.0528     3

  Total Cases = 48
```

Appendix F

CONTAMINANT DATA FOR 5 ORGANIC COMPOUNDS FOR COMPARISON TO SEDIMENT QUALITY CRITERIA

MASSACHUSETTS WATER RESOURCES AUTHORITY

Sediment Quality Criteria Comparison - 1994 CSO Study (S9402)

File name: SED_QUAL.WB2

Site/Station ID	MWRA Sample ID	BOS Lab ID	TOC (%)	Concentration (ng/g)					Concentration (ug/g-oc)				
				Acenaphthene	Fluoranthene	Phenanthrene	Dieldrin	Endrin	Acenaphthene	Fluoranthene	Phenanthrene	Dieldrin	Endrin
DB01-REP1	S94020417	PB32	2.75	158.27	3459.94	2139.41	4.06	a	5.76	125.82	77.80	0.15	a
DB01-REP2	S94020420	PB31	2.69	147.53	3218.40	1936.24	4.23	a	5.48	119.64	71.98	0.16	a
DB01-REP3	S94020423	PB40	2.91	151.31	3117.28	1945.70	3.60	a	5.20	107.12	66.86	0.12	a
DB03-REP1	S94020295	PA98	0.37	14.48	269.50	227.19	a	a	3.91	72.84	61.40	a	a
DB03-REP2	S94020297	PB01	1.19	33.81	600.73	385.74	a	a	2.84	50.48	32.42	a	a
DB03-REP3	S94020301	PA78	1.60	342.14	2648.36	2952.36	1.42	a	21.38	165.52	184.52	0.09	a
DB04-REP1	S94020409	PB29	2.49	71.52	1759.30	1001.79	2.62	a	2.87	70.65	40.23	0.11	a
DB04-REP2	S94020411	PB35	2.40	212.73	3315.72	2422.08	4.00	a	8.86	138.16	100.92	0.17	a
DB04-REP3	S94020413	PB33	2.17	929.01	8794.66	8346.19	11.89	a	42.81	405.28	384.62	0.55	a
DB06-REP1	S94020433	PA79	0.17	1.79	67.19	30.17	0.09	a	1.05	39.52	17.75	0.05	a
DB06-REP2	S94020435	PA73	0.11	a	53.92	25.79	0.58	a	a	49.02	23.45	0.53	a
DB06-REP3	S94020437	PB27	0.36	2.21	70.75	33.26	a	a	0.61	19.65	9.24	a	a
DB10-REP1	S94020442	PA88	3.89	77.09	2275.67	1132.35	4.43	a	1.98	58.50	29.11	0.11	a
DB10-REP2	S94020445	PB02	4.25	71.65	2181.49	995.17	6.04	a	1.69	51.33	23.42	0.14	a
DB10-REP3	S94020449	PA44	4.23	69.03	2183.38	1061.14	6.13	a	1.63	51.62	25.09	0.14	a
DB11-REP1	S94020253	PA67	0.30	8.42	332.87	149.28	0.64	a	2.81	110.96	49.76	0.21	a
DB11-REP2	S94020255	PB25	2.30	46.74	1595.89	766.07	3.22	a	2.03	69.39	33.31	0.14	a
DB11-REP3	S94020258	PA95	0.75	15.77	573.06	265.53	a	a	2.10	76.41	35.40	a	a
DB12-REP1	S94020284	PA81	2.85	160.91	2211.95	1932.71	8.83	a	5.65	77.61	67.81	0.31	a
DB12-REP2	S94020286	PA94	2.40	190.01	2105.35	2269.18	6.27	a	7.92	87.72	94.55	0.26	a
DB12-REP3	S94020288	PA93	2.67	59.38	1220.87	765.43	2.99	a	2.22	45.73	28.67	0.11	a
DB13-REP1	S94020262	PA70	2.86	55.00	2373.95	934.79	4.43	a	1.92	83.01	32.68	0.15	a
DB13-REP2	S94020265	PA72	3.29	106.72	4107.26	1661.89	6.35	a	3.24	124.84	50.51	0.19	a
DB13-REP3	S94020268	PA29	3.46	75.30	2331.50	1074.46	16.58	a	2.18	67.38	31.05	0.48	a
DB14-REP1	S94020454	PB09	5.77	1048.18	17276.81	12146.98	14.31	a	18.17	299.42	210.52	0.25	a
DB14-REP2	S94020456	PA32	5.23	651.82	14144.82	7967.79	8.16	a	12.46	270.46	152.35	0.16	a
DB14-REP3	S94020458	PB26	4.19	1060.15	15445.93	11036.10	23.41	a	25.30	368.64	263.39	0.56	a
T1-REP1A	S94020223	PA37	1.36	22.75	570.03	370.95	0.59	a	1.67	41.91	27.28	0.04	a
T1-REP2A	S94020225	PA31	1.21	55.07	713.46	551.92	0.64	a	4.55	58.96	45.61	0.05	a
T1-REP3	S94020227	PB08	2.88	21.99	924.10	479.00	2.08	a	0.76	32.09	16.63	0.07	a
T2-REP1	S94020365	PB36	1.37	17.63	740.31	326.55	1.72	a	1.29	54.04	23.84	0.13	a
T2-REP2	S94020368	PB39	1.58	19.46	993.75	395.52	1.41	a	1.23	62.90	25.03	0.09	a
T2-REP3	S94020370	PB30	1.89	25.00	1016.17	425.75	20.30	a	1.32	53.77	22.53	1.07	a
T8-REP1	S94020143	PA34	0.96	58.42	550.52	571.55	a	a	6.09	57.35	59.54	a	a
T8-REP2	S94020146	PB23	2.08	32.74	534.52	376.76	0.79	a	1.57	25.70	18.11	0.04	a
T8-REP3	S94020152	PB15	0.39	a	53.55	35.93	0.25	a	a	13.73	9.21	0.06	a
CO19-REP1	S94020398	PB41	2.70	52.86	2395.49	809.63	4.25	a	1.96	88.72	29.99	0.16	a
CO19-REP2	S94020403	PB38	2.87	62.80	2195.48	798.88	3.57	a	2.19	76.50	27.84	0.12	a
CO19-REP3	S94020405	PB37	2.90	55.99	2441.33	840.11	a	a	1.93	84.18	28.97	a	a
SWEX3-REP1	S94020097	PA27	2.59	29.33	1113.86	477.03	3.00	a	1.13	43.01	18.42	0.12	a
SWEX3-REP2	S94020100	PA38	2.49	24.84	929.66	392.43	3.72	a	1.00	37.34	15.76	0.15	a
SWEX3-REP3	S94020102	PA42	2.73	28.77	1138.09	500.61	3.21	a	1.05	41.69	18.34	0.12	a
EPA's saltwater benthic organism sediment criteria value (September 1993):									230	300	240	20	0.76

a = not detected.