DELAWARE RIVER

PHILADELPHIA TO THE SEA PROJECT

HIGH RESOLUTION PCB ANALYSIS

OF CHANNEL SEDIMENTS

Prepared for

U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, PA 19107

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Contract No. DACW61-95-D-0011
Delivery Order No. 0030

March 1997

FOREWORD

This report, *Delaware River Philadelphia to the Sea Project, High Resolution PCB Analysis of Channel Sediments,* was prepared by Versar, Inc., for Jerry Pasquale, Environmental Resources Branch, U.S. Army Corps of Engineers, Philadelphia District, under Contract No. DACW61-95-D-0011. Assistance with study design and statistical analyses was provided by Rick Greene, Delaware Natural Resources and Environmental Control. Statistical analyses conducted by Rick Greene is presented in Appendix F.

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1.0 INTRODUCTION

1.1 BACKGROUND

The Philadelphia District of the U.S. Army Corps of Engineers (USACOE) is responsible for maintenance of the existing Delaware River, Philadelphia to the Sea, Federal navigation channel. This project provides a channel from deep water in Delaware Bay to a point in the bay, near Ship John Light, that is 40 feet deep at mean low water (mlw) and 1,000 feet wide. From this point in Delaware Bay to the Philadelphia Naval Base the channel is 40 feet deep mlw and 800 feet wide. From the Naval Base to Allegheny Avenue, Philadelphia, Pennsylvania, the channel is 40 feet deep mlw and 500 feet wide through Horseshoe Bend, and 40 feet deep mlw, and 400 feet wide through Philadelphia Harbor, along the west side of the channel. The east side of the channel in Philadelphia Harbor has a depth of 37 feet mlw and a width of 600 feet.

There are wide variations in the amount of dredging required to maintain the Philadelphia to the Sea project. Some ranges are nearly self maintaining and others experience rapid shoaling. The entire project requires average annual maintenance dredging in the amount of 4,888,000 cubic yards. Of this amount, the majority of the material is removed from the Marcus Hook, Deepwater Point and New Castle ranges. The remaining material is spread throughout the other 37 channel ranges. In the riverine section of the project area, dredged material is placed in seven upland dredged material disposal sites located between Artificial Island, New Jersey and National Park, New Jersey. Material dredged from Delaware Bay is placed in an approved open water dredged material disposal site known as the Buoy 10 site.

In addition to maintenance of the existing project, the USACOE has been authorized by Congress to construct the Delaware River Main Channel Deepening Project. This project was authorized by Congress in October 1992 as part of the Water Resources Development Act of 1992. This project would modify the existing depth in the navigation channel from 40 to 45 feet at mean low water. As part of this project, material dredged from Delaware Bay during initial construction would be used for wetland restoration/protection at Egg Island Point, New Jersey and Kelly Island, Delaware, and for stockpiling sand for beach nourishment of Slaughter and Broadkill beaches in Delaware (sites MS-19 and L-5). The USACOE released a Draft Supplemental Environmental Impact Statement for this project in January 1997 (USACOE 1997).

1.2 NEED FOR STUDY

The PCB content of the sediments to be dredged from the Philadelphia to the Sea project were investigated by the USACOE in 1991, 1992 and 1994; however, the laboratory analyses were based on the traditional Arochlor method of determining PCB content in

sediments which had detection limits averaging about 0.21 mg/kg (or 210 ppb) dry weight. Recent advances in PCB analyses have developed state-of-the-art techniques which can detect congener-specific PCBs in parts per billion and coplanar PCBs in parts per trillion. In 1994, the Delaware Estuary Program conducted PCB tests using these high resolution techniques on sediments collected at 16 shallow stations from areas ranging from Egg Island Point, New Jersey to Neshaminy Creek, Pennsylvania (Arthur D. Little 1994). This study indicated that PCB contaminants were widespread throughout the estuary and suggested concentrations were highest in upper industrialized portions of the river. In addition, high resolution tissue testing conducted by Greene and Miller (1994) revealed that striped bass contained PCBs ranging from 0.499 to 2.25 ppm. In an earlier study between the Schuylkill River and Burlington Island the Delaware River Basin Commission (DRBC 1988, as cited by Greene and Miller 1994) reported PCB contamination in channel catfish above the FDA limit of 2.0 ppm and concentrations ranging from 0.1 to 1.4 ppm for white perch. Health advisories on the consumption of channel catfish, all bottom feeding fish, and striped bass have been issued for the estuary.

Because of concern over PCB contamination in Delaware estuary sediments and finfish, additional sampling using high resolution PCB analyses was conducted within the Delaware River, Philadelphia to the Sea, Federal navigation channel. The purpose of these tests was to address two environmental concerns related to dredging and dredged material disposal activities. The first issue relates to the use of hopper dredges in the navigation channel. A hopper dredge is a mobile vessel equipped with a side arm that hydraulically dredges material from the bottom into an on-board hopper (or holding tank). The hydraulically dredged slurry that enters the hopper is typically a mixture of 75 percent water and 25 percent sediment. Hopper dredges are frequently used when there is a significant distance between the dredging site and the disposal site. Because of the time required for the hopper dredge to travel between these locations, it is most efficient to allow excess water to overflow the holding tank until the hopper dredge is completely full of sediment, thus maximizing the amount of material transported per trip. Depending upon the concentration of PCBs in bottom sediments, this practice could release PCBs in sediment pore water into the water column at levels that could be harmful to aquatic biota. The second issue involves the proposed use of material dredged from the lower portion of Delaware Bay, for initial construction of the deepening project, for wetland restoration/protection and the stockpiling of sand for future beach nourishment projects. If the channel sediments contain high concentrations of PCBs, the use of this material for habitat creation could potentially expose humans and wildlife to harmful PCB levels.

1.3 STUDY OBJECTIVES

The purpose of this study was therefore to:

- evaluate the longitudinal and vertical distribution of PCB congeners in the navigational channel sediments using state-of-the-art analytical methods,

- compare channel concentrations to shoal concentrations observed in the Delaware Estuary Program study,
- determine whether use of sediments designated for placement at Kelly Island, Egg Island Point, and lower bay sand stockpile areas pose any risks to ecological resources, and
- assess potential PCB releases to the water column if a hopper dredge is allowed to spill excess water during dredging operations.

1.4 OVERVIEW OF PCB CHEMISTRY

PCBs are a class of synthetic organic compounds used primarily in the electronic industry. The class is comprised of 209 individual compounds, more commonly referred to as congeners. Individual congeners are identified by the number and position of insertion of chlorine atoms on a biphenyl group. The biphenyl group is the framework for the PCB molecule and is comprised of two linked benzene rings. PCBs are extremely stable compounds, and degrade slowly in the environment. Microbial decomposition of PCBs occurs in natural environments, but the rate depends on the degree of chlorination and the position of the atoms on the biphenyl molecule. PCBs with four or fewer chlorine atoms decompose at a greater rate than those with more atoms. PCBs have very low solubilities in water, and in natural conditions, they typically adsorb to suspended particles or in bottom sediments. Adsorption rates among PCB congeners increase with the degree of chlorination. Most of the PCBs used in industry are termed Arochlor groups. Arochlor groups are mixtures of PCB congeners created by the partial chlorination of the biphenyl molecule. Arochlor groups are identified by a four digit number that defines their composition. The first two digits identify the Arochlor as a mixture of PCBs and the last two digits express the percentage of chlorine content by weight. For example, Arochlor 1260 is a PCB mixture with an average chlorine content of 60%.

The toxicity of PCBs is directly related to the reactivity of the chlorine atoms inserted on the biphenyl group. The reactivity of the atoms is determined by their position on the two benzene rings. Chlorine atoms in the outer portions of the rings (e.g., meta and para positions) are more reactive, and thus more toxic than those in the inner part. The inner positions are closer to the bond that joins the two benzene rings, which limits their reactivity. Another factor that determines PCB toxicity is molecular geometry. Current research indicates that non-ortho substituted coplanar congeners, where both benzene rings basically lie in the same plane, are the most toxic forms of PCB. The toxicity of PCB coplanar congeners is generally regarded as comparable to that of dioxin.

2.0 METHODS

2.1 FIELD METHODS

Sediment samples were collected at 15 sites ranging from 10 miles north of Cape May, New Jersey to Penn's Landing, Philadelphia, PA during the first week of October 1996 (Fig. 2-1). All collections were conducted in the navigational ranges at stations identified for sampling by the USACOE. At each station, four separate 5 foot cores were taken with a vibracore (a hydraulically activated boring device) containing a 3 inch diameter plexiglass liner. The plexiglass liner allowed the core to be removed from the device intact for sectioning. Alpine Ocean Survey, Inc. was subcontracted to conduct the vibracoring aboard the Atlantic Twin survey vessel. Sample locations for the four cores taken at each station were randomized using the following procedures: 1) the vessel anchored at the coordinates supplied by the USACOE; 2) four random numbers between 0 and 250 feet were selected (250 feet was the maximum anchor line length the vessel could deploy after the initial setting of the anchor); and 3) the anchor line was deployed for the number feet selected for each sample. At each sampling location the coordinates were recorded with a Trimble NT200D Differential Global Positioning System (DGPS) which has an accuracy of less than 30 feet. After positioning the vessel on station, a laptop computer recorded at least 180 position fixes from the DGPS. The position fixes were averaged to calculate a sampling station location. The coordinates of 15 primary stations are summarized in Table 2-1; the coordinates of each of the four cores taken near the primary stations are summarized in Table 2-2.

After retrieving the core, the plastic liners were cut longitudinally. Each core was then split into two separate samples. The top three inches of the core was separated from the remaining sub-surface portion of the core. Sediment from the top portion of the core was removed using pre-cleaned stainless steel knives and spoons and placed in a pre-cleaned stainless steel bowl. The bowl was placed on ice in a closed cooler to reduce the temperature of the sample and to prevent contamination. In a similar manner, sediment for the sub-surface portion of the core was removed using a second set of pre-cleaned stainless steel utensils and bowl. Between collections the surface and sub-surface collection bowls were stored in separate coolers. Only sediment from the inner portion of the core was sampled. Sediment sampling for the lower sub-surface core was conducted uniformly along its entire length so that all layers would be equally represented in the sample.

Sediment subsampling procedures were repeated for all four cores taken at each station. After each coring, the surface and sub-surface sediments were added to their respective bowls. After all four cores were collected, the surface and sub-surface bowls were thoroughly homogenized and transferred into factory sealed 500 ml I-Chem Jars for a total of 30 samples. Sediments remaining in the bowls were transferred to whirl-pacts for grain size and total organic carbon analysis. All samples for chemical testing and TOC were stored in the dark at 4°C until analysis.

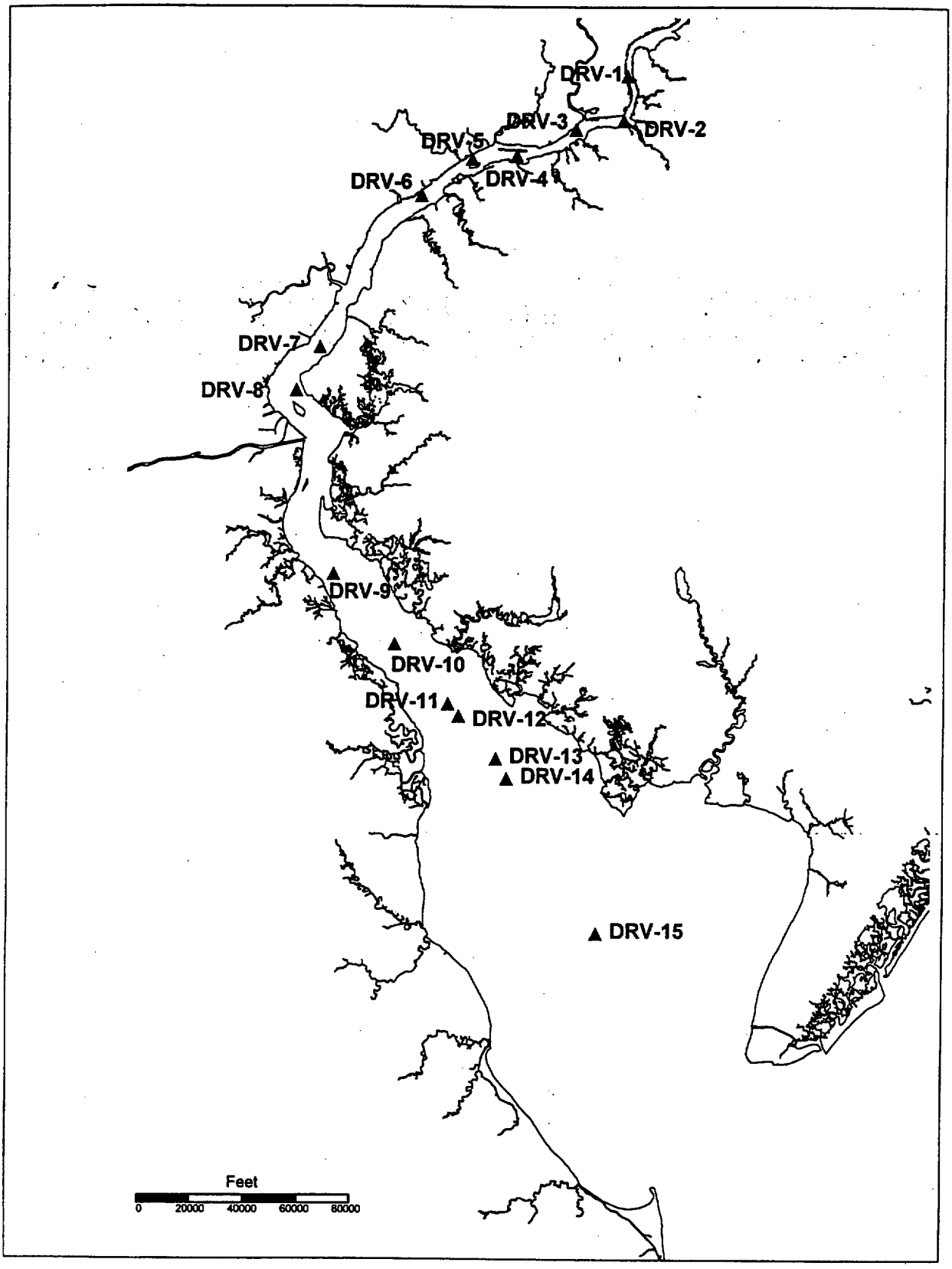

Figure 2-1. Locations of primary sampling stations for the PCB sediment cores collected in the Delaware River, Philadelphia to the Sea Federal Navigation Project in October 1996

Table 2-1. Station coordinates for the high resolution PCB analysis of sediment cores for the Delaware River, Philadelphia to the Sea Federal Navigation Project conducted in October 1996

Station	River Range	Latitude		Longitude		Type of Material (from USACOE)
		Degrees	Minutes	Degrees	Minutes	
DRV-1	Reach M	39	55.70	75	8.27	Sand
DRV-2	Horseshoe Bend	39	53.02	75	8.55	Sand
DRV-3	Mifflin	39	52.50	75	12.28	Sand
DRV-4	Tinicum	39	50.90	75	17.02	Sand
DRV-5	Eddystone	39	50.68	75	20.57	Sand
DRV-6	Marcus Hook	39	48.52	75	24.58	Silt
DRV-7	Deepwater Point	39	39.33	75	32.68	Silt
DRV-8	New Castle	39	36.68	75	34.57	Sand
DRV-9	Liston	39	25.52	75	31.50	Silt
DRV-10	Liston	39	21.22	75	26.53	Sand
DRV-11	Liston	39	17.55	75	22.28	Sand
DRV-12	Liston	39	16.82	75	21.43	Silt
DRV-13	Liston	39	14.23	75	18.45	Silt
DRV-14	Crossledge	39	13.05	75	17.58	Sand
DRV-15	Brandywine	39	3.67	75	10.38	Silt

Table 2-2. Cont'd

Station	Latitude		Longitude	
	Degrees	Minutes	Degrees	Minutes
9C	39	25.54	75	31.51
9D	39	25.53	75	31.48
10A	39	21.25	75	26.54
10B	39	21.26	75	26.53
10C	39	21.27	75	26.54
10D	39	21.27	75	26.54
11A	39	17.55	75	22.28
11B	39	17.52	75	22.28
11C	39	17.52	75	22.25
11D	39	17.56	75	22.19
12A	39	16.83	75	21.41
12B	39	16.79	75	21.40
12C	39	16.78	75	21.41
12D	39	16.77	75	21.42
13A	39	14.26	75	18.50
13B	39	14.27	75	18.49
13C	39	14.28	75	18.49
13D	39	14.26	75	18.49
14A	39	13.06	75	17.61
14B	39	13.06	75	17.61
14C	39	13.08	75	17.61
14D	39	13.08	75	17.60
15A	39	3.65	75	10.29
15B	39	3.58	75	10.34
15C	39	3.60	75	10.39
15D	39	3.63	75	10.39

2.2 LABORATORY METHODS

Laboratory analyses of the 30 sediment samples were conducted by Midwest Research Institute (MRI) using High Resolution Gas Chromatography (HRGC) and High Resolution Mass Spectrometry (HRMS). The HRGC/HRMS analytical method used by MRI was developed as a modification of EPA SW-846 Method 8290. Appendix A reproduces the analytical report submitted by MRI for this study and provides a detailed description of the laboratory methods used in this study. The analytical approach to the 30 sediment samples included analyses for 75 PCB congeners at a detection limit of 2 to 5 ng/g (ppb; Appendix A). Additionally, all

samples were analyzed for five of the more toxic, non-ortho substituted coplanar PCB congeners (IUPAC numbers 77, 81, 126, 127, and 169) using HRGC/HRMS to a detection limit of 1 pg/g (parts per trillion; Appendix A). All sediment PCB congener concentrations are reported on a dry weight basis.

In addition to the PCB analysis, all the sediment samples were analyzed for Total Organic Carbon (TOC) using the combustion analytical technique outlined in EPA method SW-846 Method 9060. TOC analyses were included because of the tendencies of PCBs to absorb to organic particles which may help explain some of the patterns observed in the PCB distribution in the estuary. Bulk sediment analysis for TOC was conducted within 14 days of sample collection.

Sediment grain size was determined for all 30 samples (15 upper and lower core sections) using ASTM method number D422. As with the TOC analysis, data on the sediment particle size may be correlated to PCB concentrations as fine grained material will trap more organics than coarser sediments. The sieve analysis was taken down to the U.S. Standard Sieve No. 200 and the hydrometer portion of the test was not performed.

2.3 DATA ANALYSIS METHODS

Total PCBs were calculated by summing the concentrations of all congeners found in each sample. Non-detects were treated as zeros for all analyses. To evaluate potential sediment toxicity, total PCB concentrations were compared to Long et al.'s (1995) Effects Range-Low (ERL) and Effects Range-Median (ERM) marine and estuarine sediment guideline values (22.7 and 180 ng/g, respectively). The ERL concentration is the threshold at which biological effects of PCBs begin to occur while the ERM concentration is the point at which biological effects are likely to occur. Sediment concentrations were also compared to draft guidelines of the protection of human health (33.8 ng/g) recently developed by Rick Greene from Delaware Natural Resources and Environmental Control (Appendix B). The human health guideline is a biomagnification-based sediment quality criteria where no increase in cancer at a rate of 1 in 100,000 would be expected for humans consuming fish.

The distribution of PCB homologs in each sediment sample was calculated by dividing the homolog concentrations by the total PCBs and expressing the result as a percentage. Overall chlorination of PCBs was calculated by multiplying the percent of each homolog by corresponding mass fraction of chlorine (Table 2-3) and summing all the partial homolog concentrations. Total coplanar PCBs were calculated as the sum of the non-ortho, mono-ortho, and di-ortho congeners in a sediment sample. Among the coplanar PCBs the percentage of congeners found in the non, mono, and di-ortho form was also calculated. Total coplanar PCBs were computed as a percentage of the sum of all congeners. Linear regressions were used to determine the degree of correlation between total PCBs and coplanar PCBs.

Table 2-3. Molecular weight of PCB homologs and their corresponding chlorine mass fractions (source: Greene and Miller 1994)

PCB Homolog Group	Formula	Molecular Weight	Mass Fraction of Chlorine
Mono	$C_{12}H_9Cl$	188.65	0.1879
Di	$C_{12}H_8Cl_2$	223.10	0.3177
Tri	$C_{12}H_7Cl_3$	257.54	0.4130
Tetra	$C_{12}H_6Cl_4$	291.99	0.4856
Penta	$C_{12}H_5Cl_5$	326.43	0.5430
Hexa	$C_{12}H_4Cl_6$	360.88	0.5893
Hepta	$C_{12}H_3Cl_7$	395.32	0.6277
Octa	$C_{12}H_2Cl_8$	419.77	0.6598
Nona	$C_{12}HCl_9$	464.21	0.6873
Deca	$C_{12}Cl_{10}$	498.63	0.7108

The non-parametric Spearman's correlation test was conducted to determine the relationship between sediment organic content, grain size, and total PCB concentration. Analysis of variance tests (ANOVA) and Duncan's mean separation tests were conducted to determine if concentration differences between the surface and sub-surface samples were significant. Separate tests were conducted using unadjusted PCB concentrations and organic content adjusted PCB concentrations. In the adjusted test, total PCB concentrations were divided by the sample's respective percent organic carbon. ANOVAs were also used to evaluate the significance of navigational channel concentrations and concentrations found in shoal habitats during a study conducted for the Delaware Estuary Program (Arthur D. Little 1994). Station locations used in the present study were categorized into the Arthur D. Little study zones and separate ANOVAs comparing channel and shoal concentrations were conducted for each of three estuary reaches.

Toxicity Equivalent Factors (TEF) have been developed which can estimate the toxic response for a coplanar PCB congener relative to that of 2,3,7,8-tetrachlorodibenzo-p-dioxin (Safe 1990). The premise for the development of TEFs is that the molecules of coplanar PCB congeners are similar in shape to dioxins. The biochemical response used for estimating a TEF is the degree of induction of the liver enzyme aryl hydrocarbon hydrozylase (AHH). Dioxin is the most potent and is assigned a TEF of 1.0. TEF for individual congeners are therefore assigned a value of less than one based on their lower toxicity. A toxicity equivalent is the product of the congener concentration and the toxicity factor. Table 2-4 lists the toxicity

Table 3-1. Frequency of detection, minimum, maximum, and average concentration (ng/g) of 32 PCB congeners detected in sediments collected from the Philadelphia to Sea navigational channel during October 1996

Homolog Group	ICUPAC	Detect	Min	Max	Ave
Tetra	42	1	12	12	12
Tetra	44	1	14.4	14.4	14.4
Tetra	47	1	6.21	6.21	6.21
Tetra	49	2	2.81	5.45	4.13
Tetra	52	3	4.57	21.8	13.09
Tetra	66	1	10.6	10.6	10.6
Tetra	70	1	11.8	11.8	11.8
Tetra	77	29	0.00238	1.604	0.197768
Tetra	80	1	10.4	10.4	10.4
Tetra	81	13	0.000656	0.01372	0.005412
Penta	118	1	8.48	8.48	8.48
Penta	126	12	0.00296	0.0282	0.013348
Penta	127	5	0.000932	0.0031	0.002366
Penta	84/101	1	13.4	13.4	13.4
Penta	95	2	2.45	5.58	4.015
Penta	97/86	2	2.56	6.97	4.765
Penta	99	2	2.75	3.74	3.245
Hexa	138	3	4.03	13.2	9.71
Hexa	149	7	2.56	10.2	5.562857
Hexa	153	5	2.83	9.44	5.708
Hexa	168	1	3.61	3.61	3.61
Hexa	169	13	0.000204	0.00848	0.003641
Hepta	170,190	1	5.47	5.47	5.47
Hepta	174	2	3.58	4.46	4.02
Hepta	180	5	2.76	5.62	3.948
Hepta	187	4	2.77	3.47	3.0875
Hepta	189	1	3.25	3.25	3.25
Octa	194	1	3.18	3.18	3.18
Octa	205	1	2.45	2.45	2.45
Nona	206	4	3.12	4.82	4.09
Nona	208	2	3.1	3.15	3.125
Deca	209	7	2.63	7.14	5.174286

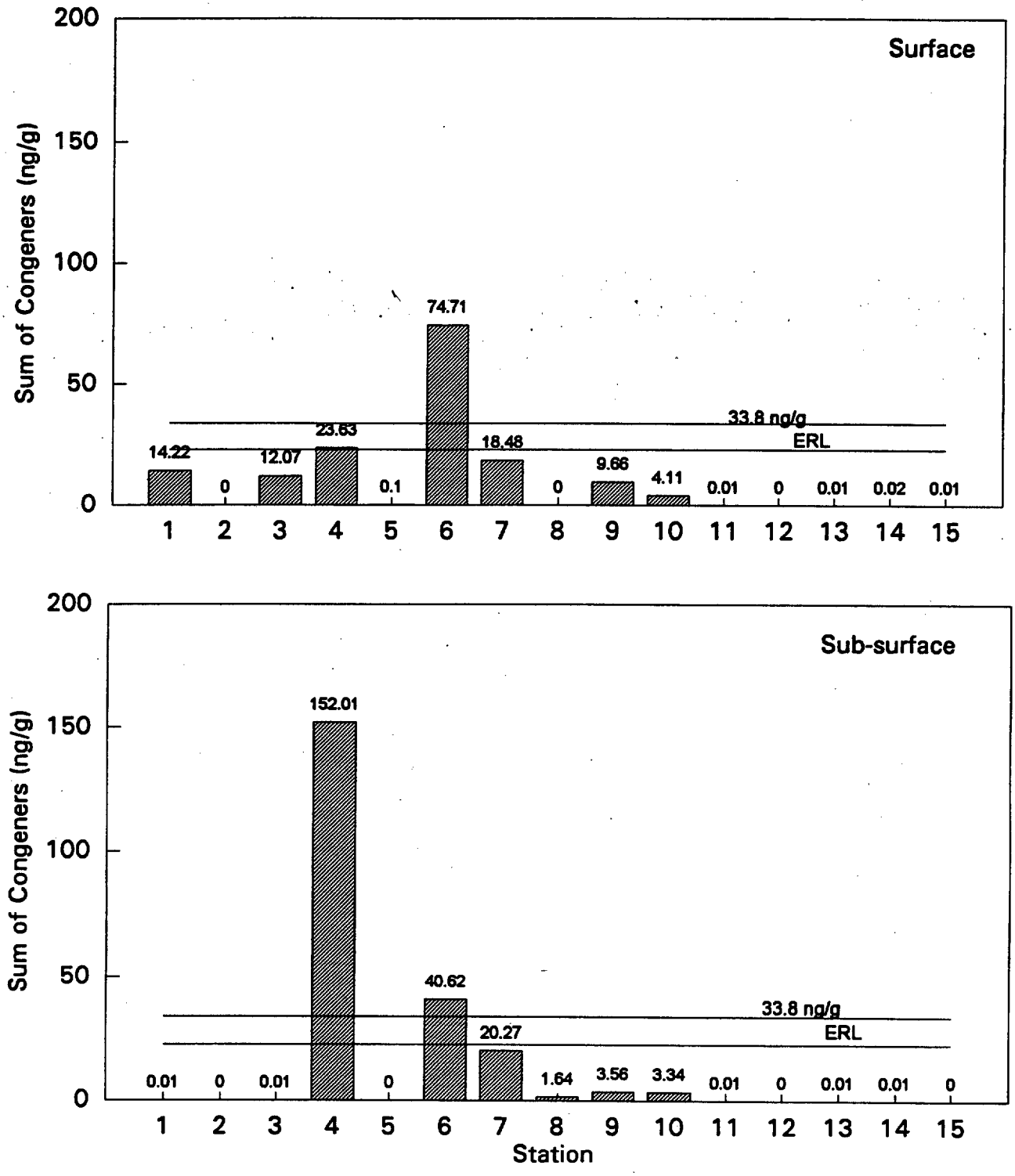

Figure 3-1. Concentrations of total PCBs (ng/g) in surface (0-3") and sub-surface (3" to 5') sediments collected in the Delaware River, Philadelphia to the Sea Federal navigational channel in October 1996

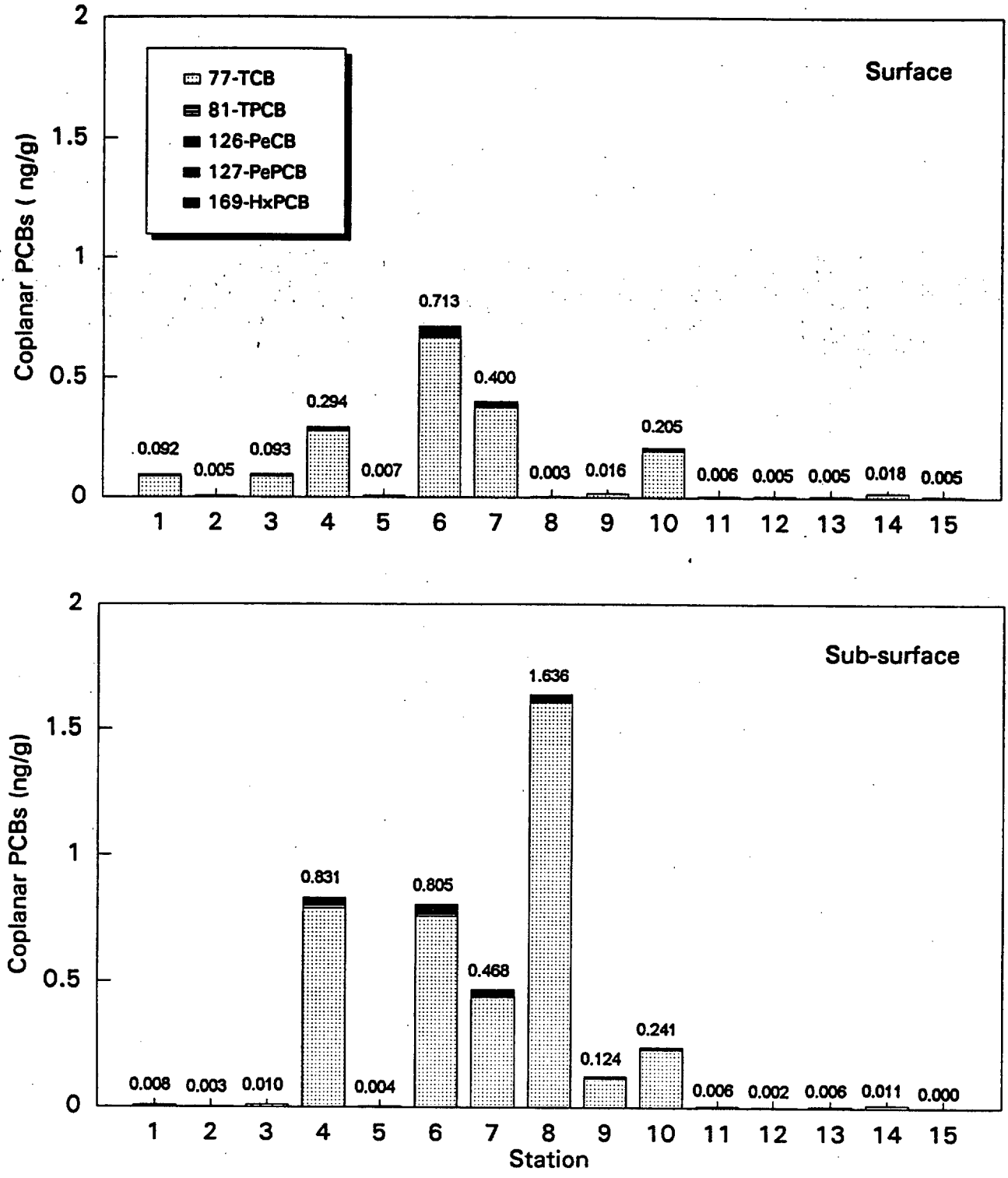

Figure 3-2. Concentrations of coplanar non-ortho substituted PCBs (ng/g) in surface (0-3") and sub-surface (3" to 5') sediments collected in the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

Tinicum Range), and intermediate levels from the Mifflin Range (DRV-4) to Reach M near downtown Philadelphia (Fig. 3-2). A regression analysis of total PCBs (excluding the five coplanar forms) versus total coplanar concentrations was significant (R^2 =0.80) indicating that the coplanar PBCs were correlated well with total PCBs as would be expected (Fig. 3-3). The PCB congener IUPAC 77 (3,3',4,4'-Tetrachlorobiphenyl) was the most common coplanar congener found comprising over 99% of the five coplanar PCBs tested in the study. Average coplanar PCB concentrations among all surface sediments (0.133 ng/g) were generally lower than sub-surface concentrations which averaged about 0.277 ng/g. The greatest concentration of coplanar PCBs in surface sediments was observed in the Marcus Hook Range sample (DRV-6) where the total concentration among the four composited samples was 0.713 ng/g. In contrast, the sub-surface sediments from the New Castle Range station (DRV-8) showed the greatest coplanar PCB concentration at 1.635 ng/g.

No congener specific sediment guidelines currently exist through which the toxicity of these non-ortho substituted coplanar PCBs can be placed into an environmental context. However, toxicity equivalent factors (TEF) were calculated to relate the coplanar PCB concentrations to dioxin toxicity (Table 3-2). A maximum toxicity equivalent of 0.0041 ng/g was observed in the sub-surface sample at station DRV-6 in the Marcus Hook range. All other TEFs were substantially lower, particularly at the lower bay stations. Although no dioxin guidelines have been established for estuarine sediments, EPA has issued a residential soil ingestion Risk Based Concentration of 0.0041 ng/g for the protection of human health. EPA risk-based levels establish soil cleanup criteria where no increase in cancer at a rate of 1 in 1,000,000 would be expected for humans ingesting the soils. With the exception of perhaps the sub-surface sediments in the Marcus Hook range, the dry weight sediment concentrations found in the navigational channel were well below the maximum concentrations established by the EPA for the incidental ingestion (100 mg/day for adults, 200 mg/day for ages 1-6) of soil by humans living in a residential area. In addition, DNREC has drafted biomagnification-based toxicity equivalent sediment guidelines of 0.32 ng/g for adults and 0.007 ng/g for children (Appendix B), both of which are much higher than the maximum toxicity equivalent observed during the present study.

The percent of PCB homologs found in each sample was analyzed to determine the relative contribution of each homolog group to the total PCBs found within the sediment samples. Recall that PCB homologs with four or less chlorine molecules attached to the benzene rings (tetra and less) are more readily degraded by bacteria and other forces while PCBs with the greatest number of chlorines (e.g., deca) are slowest to degrade. The results of this analysis are presented in Figures 3-4 and 3-5 for the surface and sub-surface collections, respectively. In the lower Delaware Estuary (stations DRV-11 through DRV-15) nearly 100% of the PCBs detected were in the tetra homolog group (i.e., four chlorines) for both surface and sub-surface samples. Thus, the concentrations of PCBs were not only low in the lower bay channel sediments, the species of PCB that was present was in a relatively degradable form. No mono, di, or tri homologs were found in any of the samples. In contrast, the PCBs at the Liston Range (DRV-9 and 10), Deepwater Point (DRV-7), and Marcus Hook (DRV-6) stations had relatively high percentages of the less degradable nona and deca

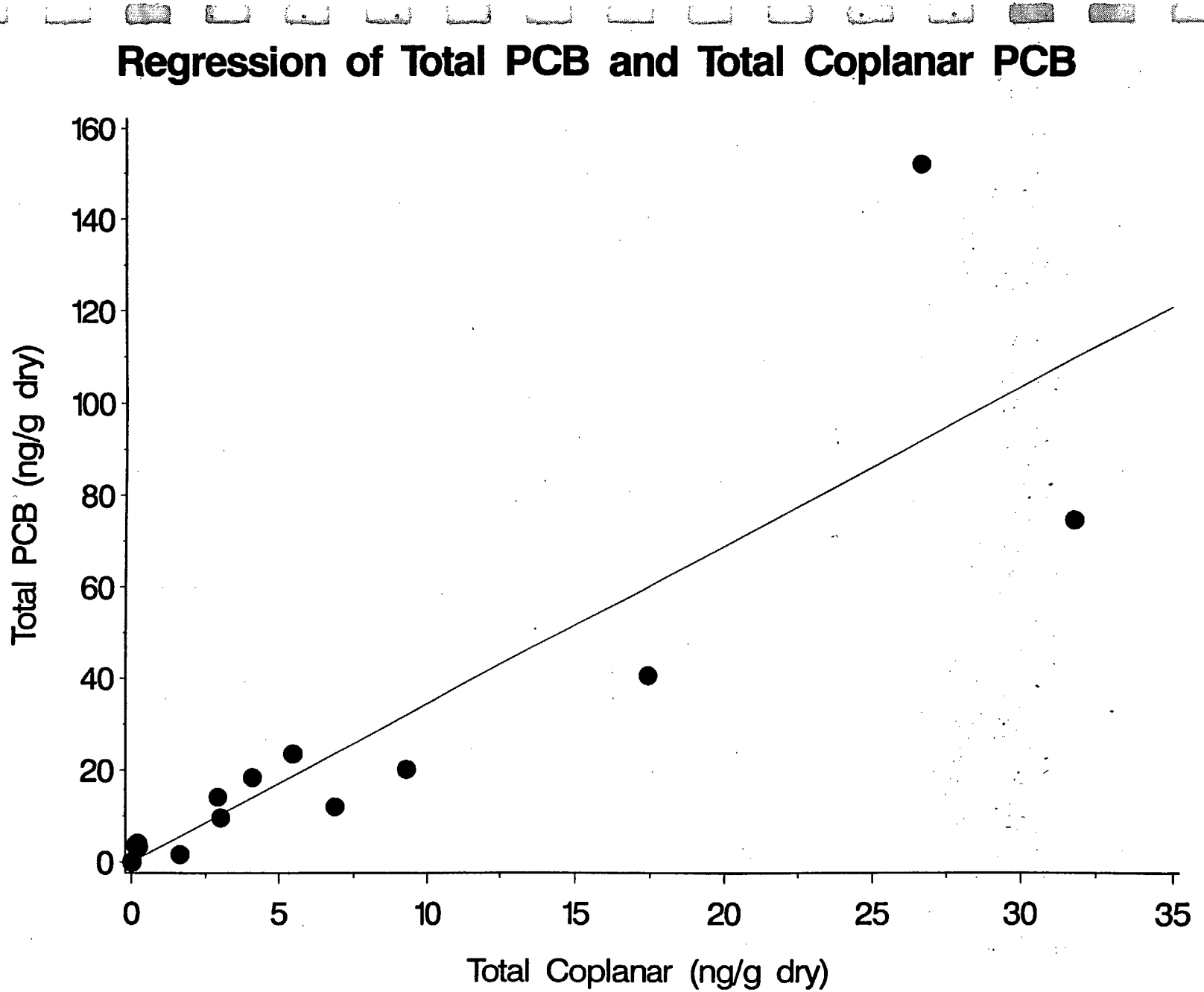

Figure 3-3. Regression of total PCBs versus total coplanar PCBs for all samples collected in the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

Table 3-2. Toxicity equivalents (ng/g) calculated for dioxin-like PCBs found in sediments collected in surface and sub-surface sediments for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996. The shaded value is at the EPA Risk Based Level for ingestion of residential soils.

Station	Surface	Sub-surface
1	0.00035140	0.00000391
2	0.00000198	0.00000144
3	0.00042208	0.00000510
4	0.00112448	0.00269280
5	0.00000362	0.00000220
6	0.00380540	0.00409690
7	0.00181040	0.00241590
8	0.00000172	0.00293780
9	0.00000805	0.00038520
10	0.00058880	0.00058300
11	0.00000478	0.00000291
12	0.00000243	0.00000119
13	0.00000261	0.00000324
14	0.00000883	0.00000559
15	0.00000257	0.00000000

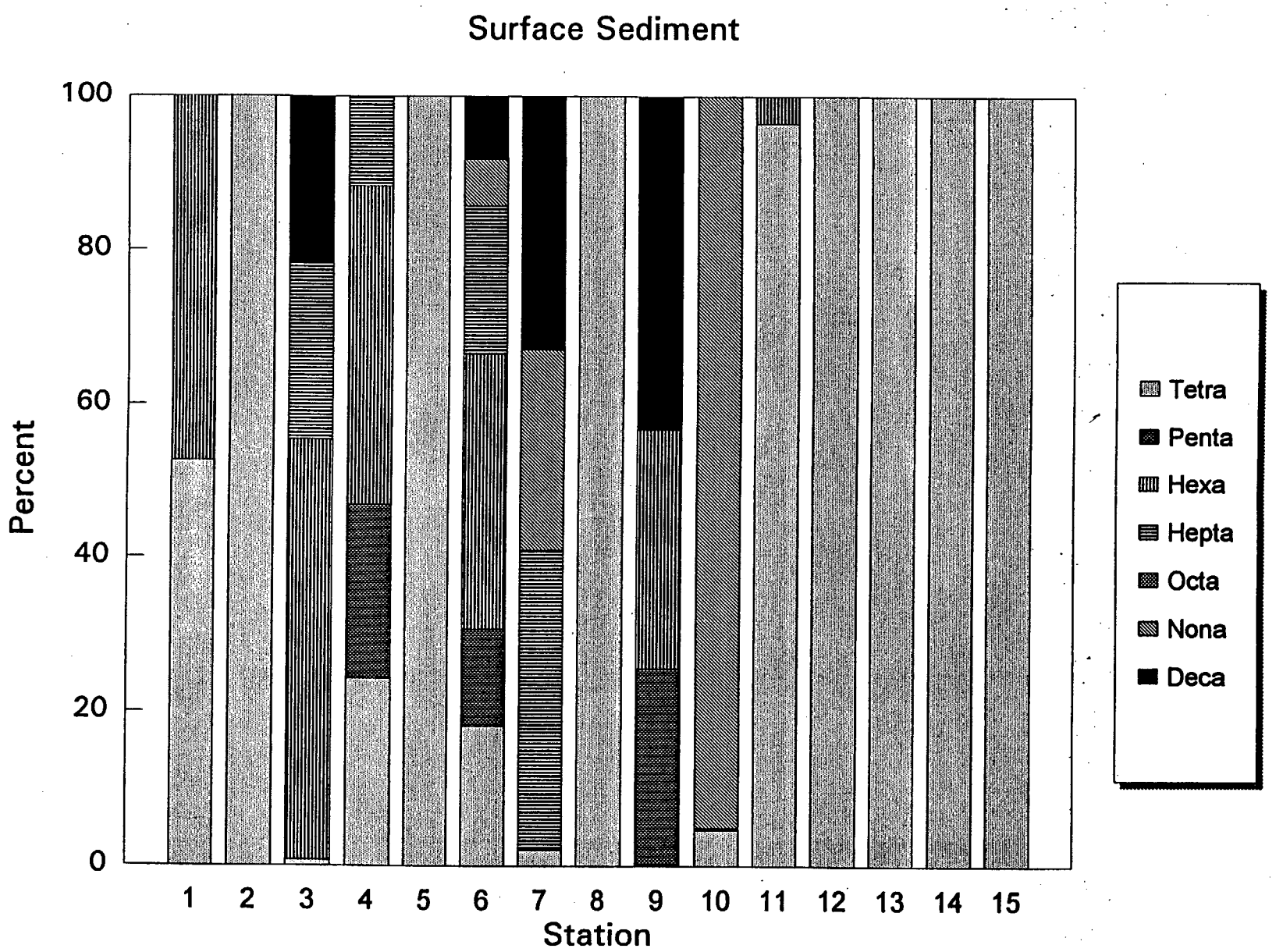

Figure 3-4. PCB homolog distribution (as percent of total) found in surface sediment collection for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

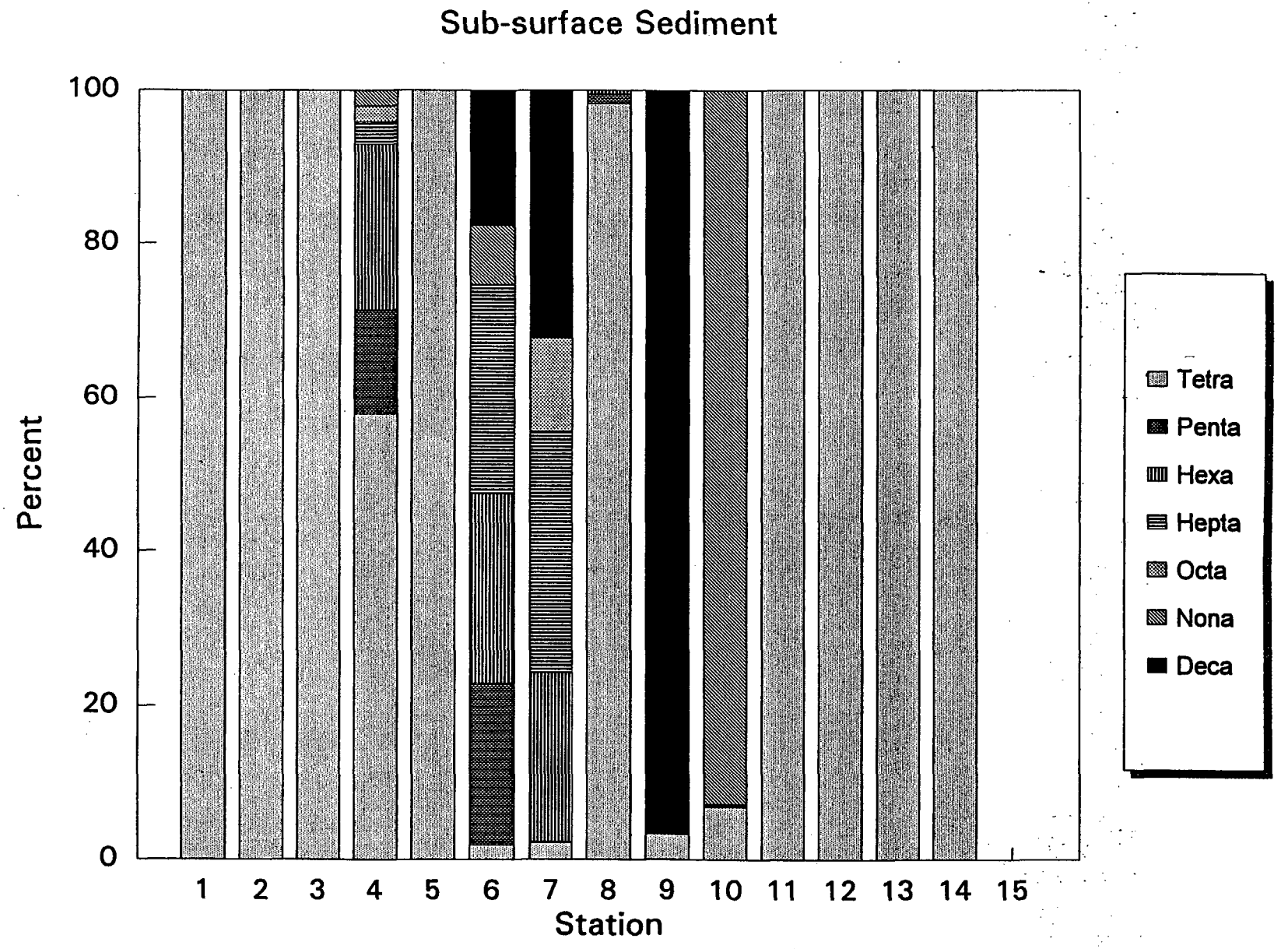

Figure 3-5. PCB homolog distribution (as percent of total) found in sub-surface sediment collections for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

homologs in both the surface and sub-surface sediments. In the middle portion of the estuary, PCBs in the New Castle Range (DRV-8) and Eddystone Range (DRV-5) were comprised of nearly 100% tetra homologs for both the surface and subsurface sediments. Surface sediments, in the upper portion of the navigational channel at Reach M near Philadelphia (DRV-1), Mifflin Range (DRV-3), and Tinicum Range (DRV-4) had PCBs that comprised relatively long-lived deca, hepta, hexa, and penta homologs. With the exception of the Tinicum Range samples (DRV-4) 100% of the sub-surface sediments in the upper estuary were comprised of the degradable tetra homolog.

The percent chlorination of the PCBs found in the surface and sub-surface sediments is presented in Figure 3-6. Among all 15 stations, average percent chlorination was slightly higher in the surface sediments (54.5%) relative to the sub-surface sediments which averaged 50.3%. A reference line is included on the plot to denote the lowest chlorination level of the 100% tetra homolog based samples.

3.2 NON-ORTHO, MONO-ORTHO, AND DI-ORTHO SUBSTITUTED COPLANAR PCBs

The non-ortho, mono-ortho, and di-ortho substituted coplanar PCB congeners are more toxic and were therefore analyzed separately to evaluate concentrations and relative distributions within the surface and sub-surface samples. Non-ortho substituted coplanar PCBs were detected in all samples except the sub-surface sample at station DRV-15 (Tables 3-3 and 3-4). Mono-ortho substituted PCBs were not detected in any of the sediments except for those in sub-surface sediments collected at stations DRV-6 (Marcus Hook) and DRV-7 (Deepwater Point; Table 3-4). Di-ortho substituted PCBs were detected in most surface sediment samples from Reach M near Philadelphia to station DRV-9 in Liston Range. Di-ortho substituted PCBs were not detected in surface sediment samples from the lower bay stations DRV-10 through 15 (Table 3-3) or in samples collected at stations DRV-2, 5, and 8. Sub-surface samples from stations DRV-8 through 15 contained no detectable concentrations of di-ortho substituted PCBs as well as up river stations DRV-1, 2, 3, and 5 (Table 3-4). The maximum concentration observed for non-ortho substituted PCBs was 1.6 ng/g while a maximum of 8.5 and 13.2 ng/g was observed for the mono and di-ortho substituted congeners, respectively.

An analysis of the relative contributions of non, mono, and di-ortho substituted coplanar PCBs indicated that at stations DRV-2, DRV-5, and DRV-8 through 15 in the lower bay all were in the non-ortho substituted form (Figure 3-7). Among the sub-surface samples, all coplanar PCBs were comprised of 100% non-ortho substituted species with the exception of stations DRV-4, 6, and 7 (Fig. 3-8). Although it appears that most of the coplanar PCBs were found in the more toxic form, the analysis was biased as the detection limit for the non-ortho substituted form was much lower (1 part per trillion) than the mono and di-ortho substituted forms (2 parts per billion).

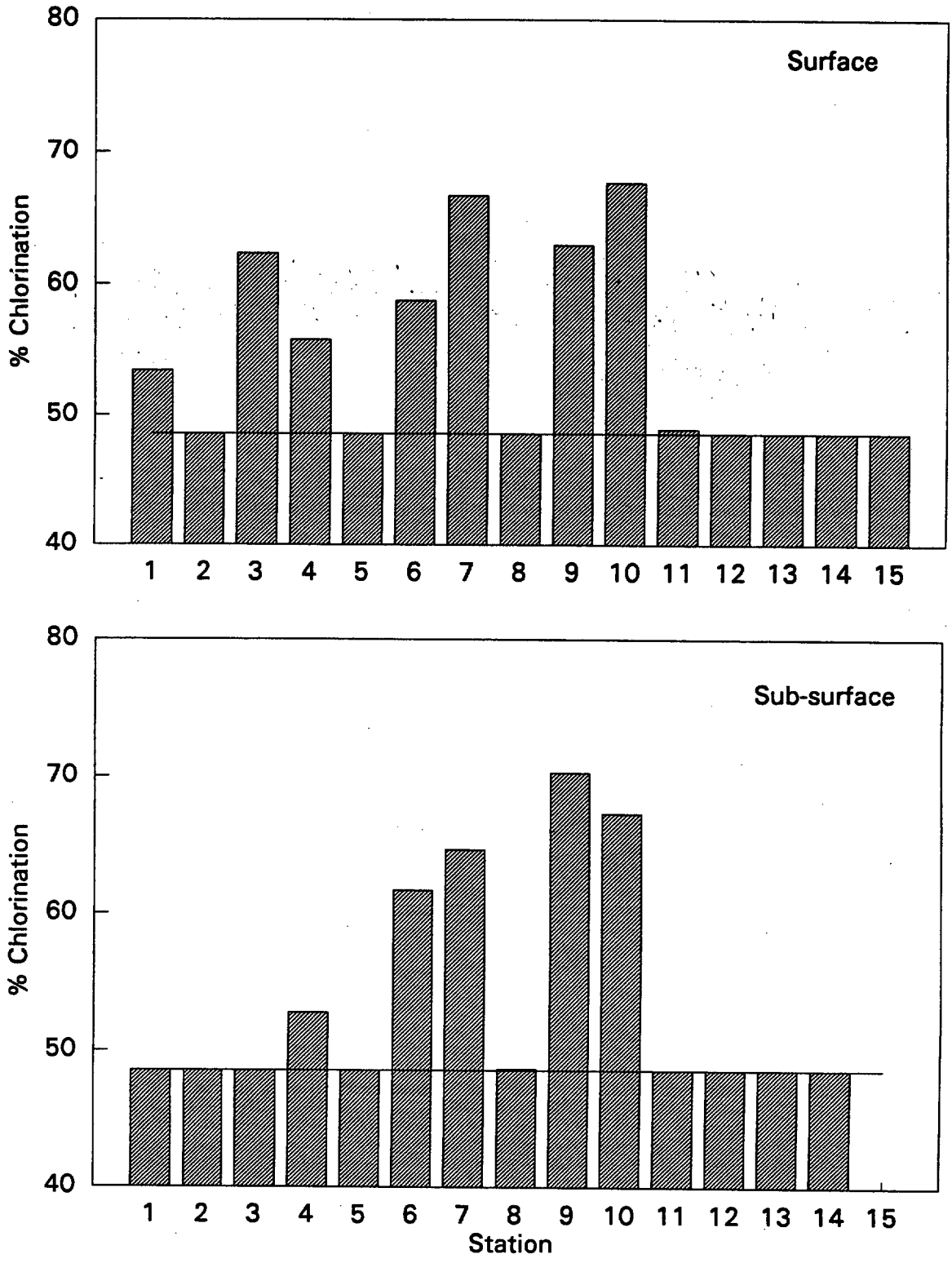

Figure 3-6. Percent PCB chlorination for the surface and sub-surface sediments collected for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

Table 3-3. Concentrations of non-ortho, mono-ortho, and di-ortho substituted PCBs (ng/g) in surface sediments collected from the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

	IUPAC	Station														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Non-ortho	77	0.0852	0.00396	0.0854	0.278	0.00724	0.664	0.374	0.00344	0.0161	0.192	0.00548	0.00486	0.00522	0.01766	0.00514
Non-ortho	81	0.00274	0.00073	0.0033	0.00526	0	0.01276	0.0071	0	0	0.00082	0	0	0	0	0
Non-ortho	126	0.00306	0	0.0034	0.00974	0	0.0282	0.01552	0	0	0.00408	0	0	0	0	0
Non-ortho	127	0.00093	0	0	0	0	0.0031	0	0	0	0	0	0	0	0	0
Non-ortho	169	0.00028	0	0.00078	0.00115	0	0.00502	0.00344	0	0	0.00848	0.0002	0	0	0	0
Mono-ortho	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	128/ 167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	128/ 167	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	138	0	0	4.03	0	0	11.9	0	0	0	0	0	0	0	0	0
Di-ortho	153	2.83	0	0	5.16	0	8.1	0	0	3.01	0	0	0	0	0	0
Di-ortho	158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	168	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	170/ 19	0	0	0	0	0	5.47	0	0	0	0	0	0	0	0	0
Di-ortho	180	0	0	2.76	0	0	5.62	3.7	0	0	0	0	0	0	0	0
Di-ortho	191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	205	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Coplanar PCB		2.92	0.00	6.88	5.45	0.01	31.80	4.10	0.00	3.03	0.21	0.01	0.00	0.01	0.02	0.01
% Non-ortho		3.16	100.00	1.35	5.39	100.00	2.24	9.76	100.00	0.53	100.00	100.00	100.00	100.00	100.00	100.00
%Mono-ortho		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Di-ortho		96.84	0.00	98.65	94.61	0.00	97.76	90.24	0.00	99.47	0.00	0.00	0.00	0.00	0.00	0.00
Total PCB		14.22	0.00	12.07	23.63	0.01	74.71	18.48	0.00	9.66	4.11	0.01	0.00	0.01	0.02	0.01
% Coplanar		20.55	100.00	57.01	23.08	100.00	42.57	22.19	100.00	31.34	5.00	100.00	100.00	100.00	100.00	100.00

Table 3-4. Concentrations of non-ortho, mono-ortho, and di-ortho substituted PCBs (ng/g) in sub-surface sediments collected from the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

	IUPAC	Station														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Non-ortho	77	0.00782	0.00288	0.0102	0.79	0.0044	0.76	0.436	1.604	0.1164	0.23	0.00582	0.00238	0.00648	0.01118	0
Non-ortho	81	0.000656	0	0	0.01372	0	0.01108	0.00756	0.00338	0.001248	0	0	0	0	0	0
Non-ortho	126	0	0	0	0.0228	0	0.0278	0.01804	0.0206	0.00296	0.00394	0	0	0	0	0
Non-ortho	127	0	0	0	0.00302	0	0.0021	0.00268	0	0	0	0	0	0	0	0
Non-ortho	169	0	0	0	0.00178	0	0.00436	0.00376	0.00758	0.0031	0.0074	0	0	0	0	0
Mono-ortho	105	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	118	0	0	0	0	0	8.48	0	0	0	0	0	0	0	0	0
Mono-ortho	123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	128/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	156	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	157	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mono-ortho	189	0	0	0	0	0	0	3.25	0	0	0	0	0	0	0	0
Di-ortho	128/16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	137	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	138	0	0	0	13.2	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	153	0	0	0	9.44	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	158	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	166	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	168	0	0	0	0	0	3.61	0	0	0	0	0	0	0	0	0
Di-ortho	170/19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	180	0	0	0	0	0	4.53	3.13	0	0	0	0	0	0	0	0
Di-ortho	191	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	194	0	0	0	3.18	0	0	0	0	0	0	0	0	0	0	0
Di-ortho	205	0	0	0	0	0	0	2.45	0	0	0	0	0	0	0	0
Total Coplanar PCB		0.01	0.00	0.01	26.65	0.00	17.43	9.30	1.64	0.12	0.24	0.01	0.00	0.01	0.01	0.00
% Non-ortho		100.00	100.00	100.00	3.12	100.00	4.62	5.03	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0.00
% Mono-ortho		0.00	0.00	0.00	0.00	0.00	48.66	34.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Di-ortho		0.00	0.00	0.00	96.88	0.00	46.71	60.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total PCB		0.01	0.00	0.01	152.01	0.00	40.62	20.27	1.64	3.56	3.34	0.01	0.00	0.01	0.01	0.00
% Coplanar		100.00	100.00	100.00	17.53	100.00	42.90	45.88	100.00	3.47	7.22	100.00	100.00	100.00	100.00	0.00

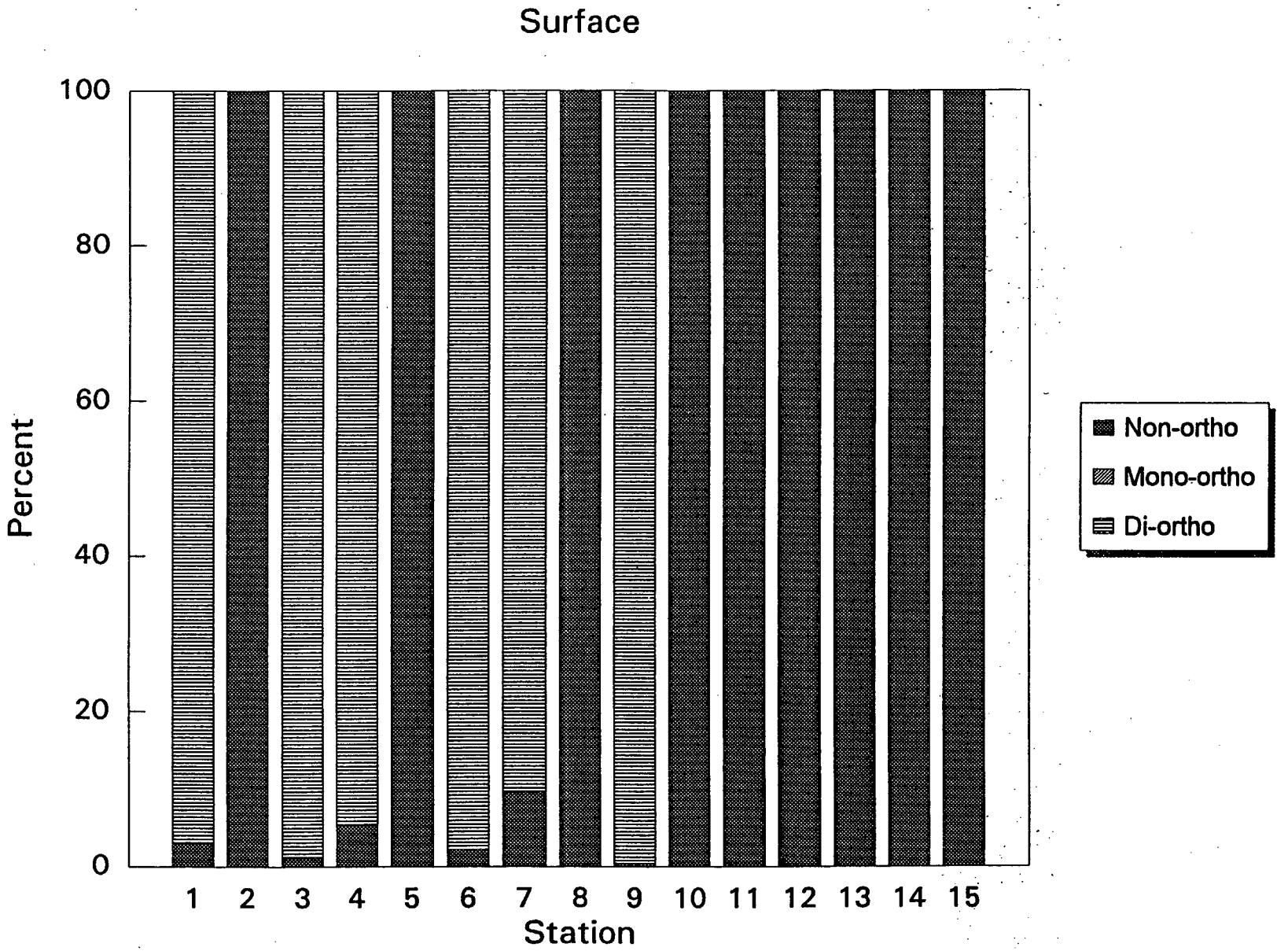

Figure 3-7. Contributions of non, mono, and di-ortho substituted coplanar PCB congeners (as percent of total coplanar) found in surface collections for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

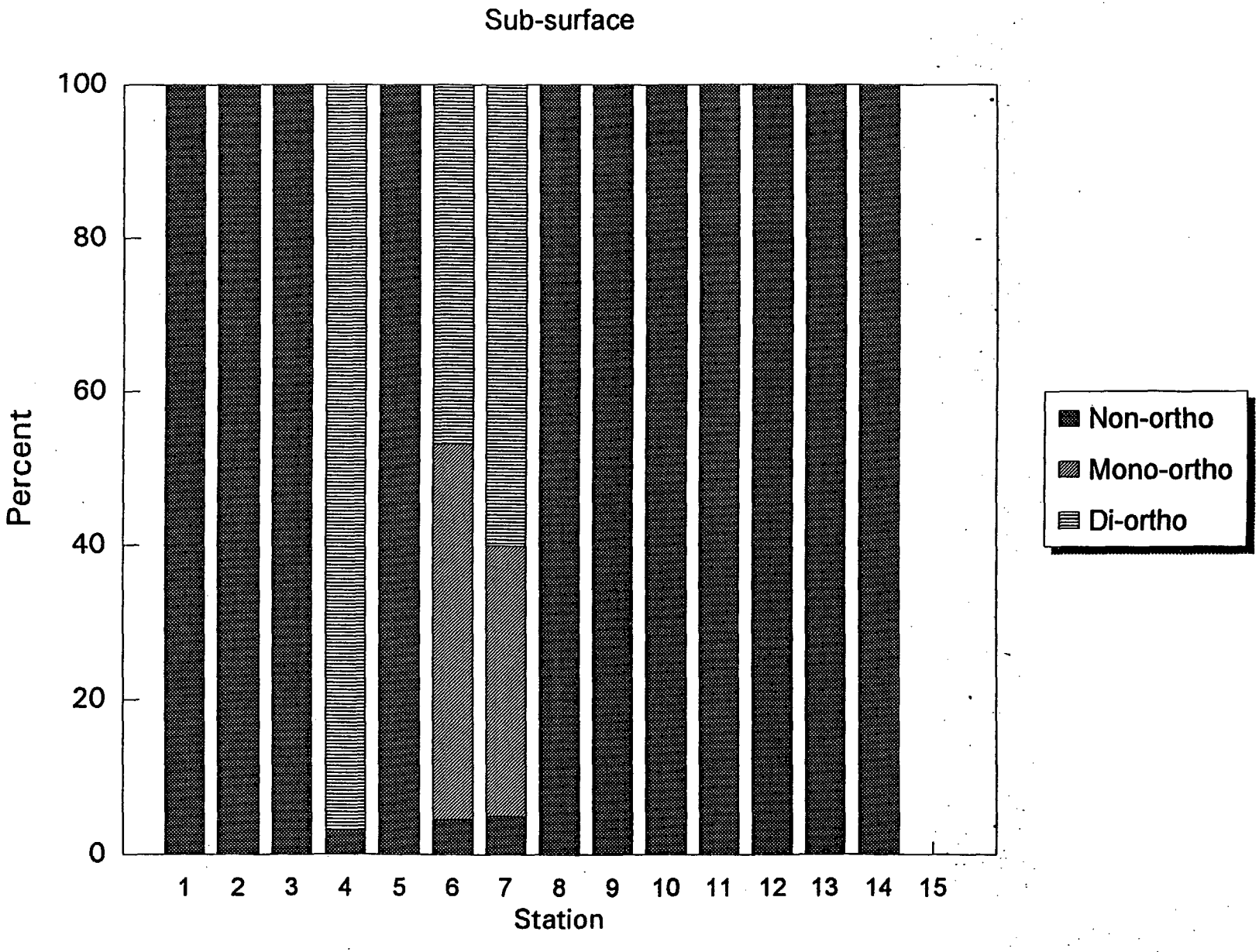

Figure 3-8. Contributions of non, mono, and di-ortho substituted coplanar PCB congeners (as percent of total coplanar) found in sub-surface collections for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

3.3 PCB CORRELATIONS WITH TOC AND GRAIN SIZE

Because PCBs are known to attach to organics and fine grained material, total organic carbon levels and sediment grain size can be used to predict or explain observed distributions of PCBs. In addition, if either parameter correlates with PCBs, the concentrations of PCBs can be adjusted for statistical comparisons. Carbon levels in the sediments from stations DRV-11 to 15 had the lowest percent carbon averaging 0.3 %, while mid-estuary stations DRV-6 to 10 averaged 2.4% and the upper estuary stations DRV-1- 5 averaged 1.5% (Fig. 3-9). Grain size distributions of the <63 μm (e.g., fine silt) fraction among the stations showed a similar pattern of less fine grained material in the lower bay, highest levels in the mid-estuary, and intermediate levels in the upper estuary (Fig. 3-10).

The relationship between the total percent organic carbon and the percentage of total sediment sample that comprised the $<$ 63 μm fraction for all 30 composite samples was evaluated using Spearman's Correlation coefficients. The analysis indicated that a significant positive correlation existed between TOC and total PCB concentrations ($p<0.005$). However, no correlation was indicated for the <63 μm fraction of the sediment grain size ($p<0.378$). Spearman's Correlations for all other sediment size fractions were also not significant.

3.4 DIFFERENCES BETWEEN SURFACE AND SUB-SURFACE CONCENTRATIONS

Differences between PCB concentrations found in the surface sediments and sub-surface sediments were tested using Analysis of Variance Models. Among all surface and sub-surface concentrations, no significant differences were detected (Table 3-5). Because the Spearman's test indicated a positive correlation between PCB concentration and sediment TOC, an additional analysis was conducted based on TOC adjusted concentrations. The concentrations were adjusted by dividing the sum of congeners found in each sample by its corresponding TOC levels. Based on the adjusted PCB concentrations, no significant differences were detected between surface and sub-surface samples.

Table 3-5. Analysis of variance results for differences between surface and sub-surface concentrations of total PCBs in sediments collected from the Delaware River, Philadelphia to the Sea Federal navigation project in October 1996

	Corrected Total Degrees of Freedom	F Value	P > F
Unadjusted concentrations	29	0.21	0.6486
TOC adjusted concentrations	29	0.17	0.6839

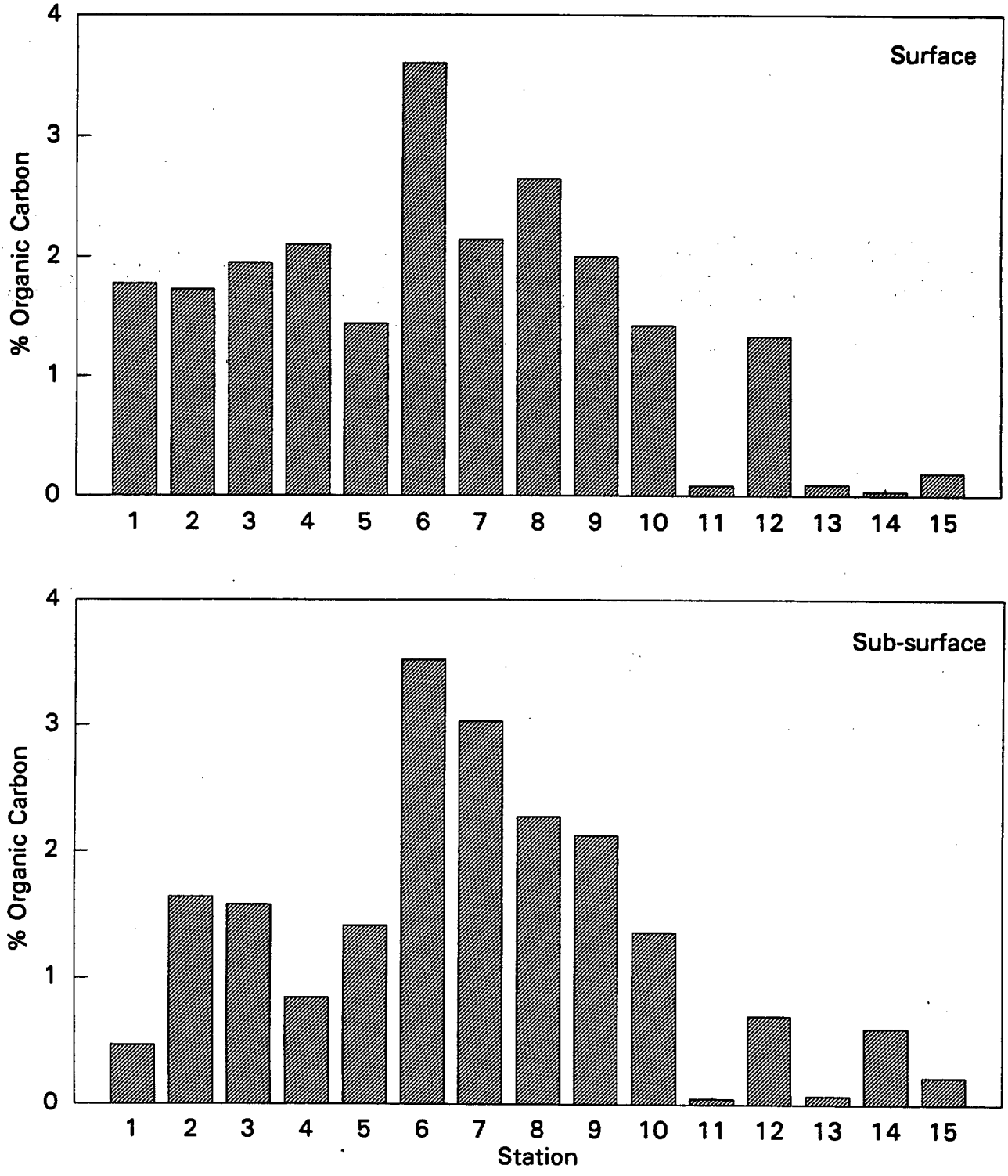

Figure 3-9. Sediment Total Organic Carbon (%) observed in surface and sub-surface collections for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

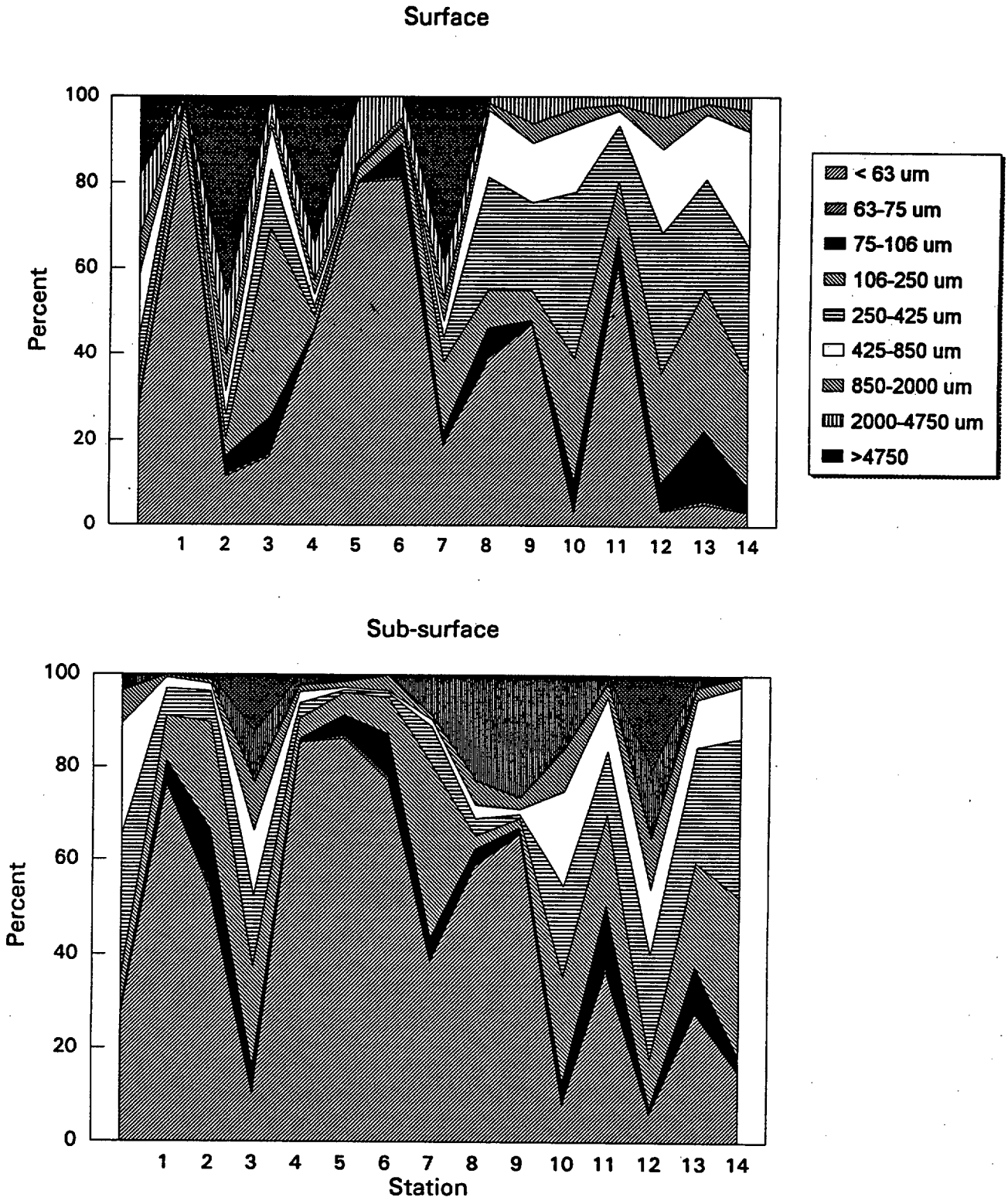

Figure 3-10. Sediment grain size (%) observed in surface and sub-surface collections for the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996

3.5 COMPARISON OF NAVIGATIONAL CHANNEL DATA TO SHOAL DATA

Surface PCB concentrations observed in the navigational channel during the present study were compared to surface PCB concentrations observed in a recent study conducted by Arthur D. Little for the Delaware Estuary Program (Arthur D. Little 1994). Only the surface concentrations from the present study were compared because the Arthur D. Little study only conducted surface grab samples. The Arthur D. Little study used the same high resolution methods; thus, the data are directly comparable. All of the sediments for the Arthur D. Little study were taken from shoal habitats and at stations which were often located in the mouths of major tributaries to the Delaware River. Table 3-6 summarizes the Arthur D. Little sampling locations while Figure 3-11 shows the position of each station relative to samples collected for the present study. The Arthur D. Little study also partitioned the contaminant results into four estuary reaches (A through D) for data analysis. Reach A was located up river and included an area ranging from the mouth of Neshaminy Creek to north of the Ben Franklin Bridge. Reach B ranged from the mouth of Mantua Creek to Raccoon Creek, Reach C ranged from Stone Creek to just north of the C&D Canal, and Reach D was located in the lower bay and ranged from south of Artificial Island to Egg Island Point, New Jersey. Data from the present study were categorized into approximately the same reaches (Table 3-6) and the mean concentrations of the sum of the congeners were compared. No comparisons of shoal and channel concentrations were available for Reach A as no sampling was conducted north of Philadelphia during the present study.

The results of this comparison suggests that PCB concentrations in the navigational channel are much lower than concentrations observed in the shoal habitats sampled by Arthur D. Little (Fig. 3-12). Mean concentrations in the up river shoal areas (177.8 ng/g) were more than eight times greater than those observed in the channel sediments (21.9 ng/g). Lower concentrations were observed in the shoal samples from Reaches C and D relative to Reach B. However, average total PCB concentrations in the navigational channel in Reaches C and D were 9 and 28 times lower than the respective shoal concentrations. Analysis of variance tests indicated the these differences were significant suggesting that the accumulation of PCBs in the estuary occurs primarily in shoal areas outside the navigational channel.

Table 3-6. Arthur D. Little sampling locations for the May 1993 PCB survey conducted in the Delaware River and the corresponding stations for each reach sampled in the navigational channel in October 1996

Reach	Station	Location Description	Latitude	Longitude	Corresponding Philadelphia to Sea Station
D	1	NOAA NS&T Mussel Watch Site 29, off False Egg Island Point	39° 12.77'	75° 11.42'	DRV- 9
	2	South of Money Island, EMAP-NC VA90-008	39° 16.42'	75° 14.62'	DRV-10 DRV-11
	3	NOAA NS&T Mussel Watch Site 31, Arnold's Point Shoal	39° 23.10'	75° 25.87'	DRV-12 DRV-13 DRV-14
	4	North of Bombay Hook Point, EMAP-NC VA90-10	39° 20.20'	75° 26.10'	
C	5	At mouth of Mill creek at Goose Pond entrance	39° 35.42'	75° 30.10'	
	6	At mouth of Miles Creek	39° 38.45'	75° 32.28'	DRV- 7 DRV- 8
	7	Off mouth of Whooping John Creek, downriver from mouth of Christina River, on east bank of Delaware River	39° 42.22'	75° 33.10'	
	8	At mouth of Stoney Creek	39° 46.42'	75° 28.58'	
B	9	Just off mouth of Raccoon Creek	39° 48.53'	75° 23.38'	
	10	At mouth of Danby Creek and railroad drawbridge	39° 51.62'	75° 18.85'	DRV- 6 DRV- 5
	11	At mouth of Mantua Creek, just upstream of pipeline trestle	39° 51.47'	75° 13.37'	DRV- 4 DRV- 3 DRV- 2
	12	Just inside mouth of Big Timber Creek	39° 53.10'	75° 07.98'	
A	13	North of Ben Franklin Bridge	39° 57.20'	75° 07.87'	
	14	At mouth of Pensauken Creek, Just north of the Betsy Ross Bridge	39° 59.53'	75° 03.42'	None
	15	Inside mouth of Dredge Harbor, near Plum Point	40° 01.90'	74° 59.22'	
	16	At mouth of Neshaminy Creek, near Logan Point	40° 04.37'	74° 54.78'	

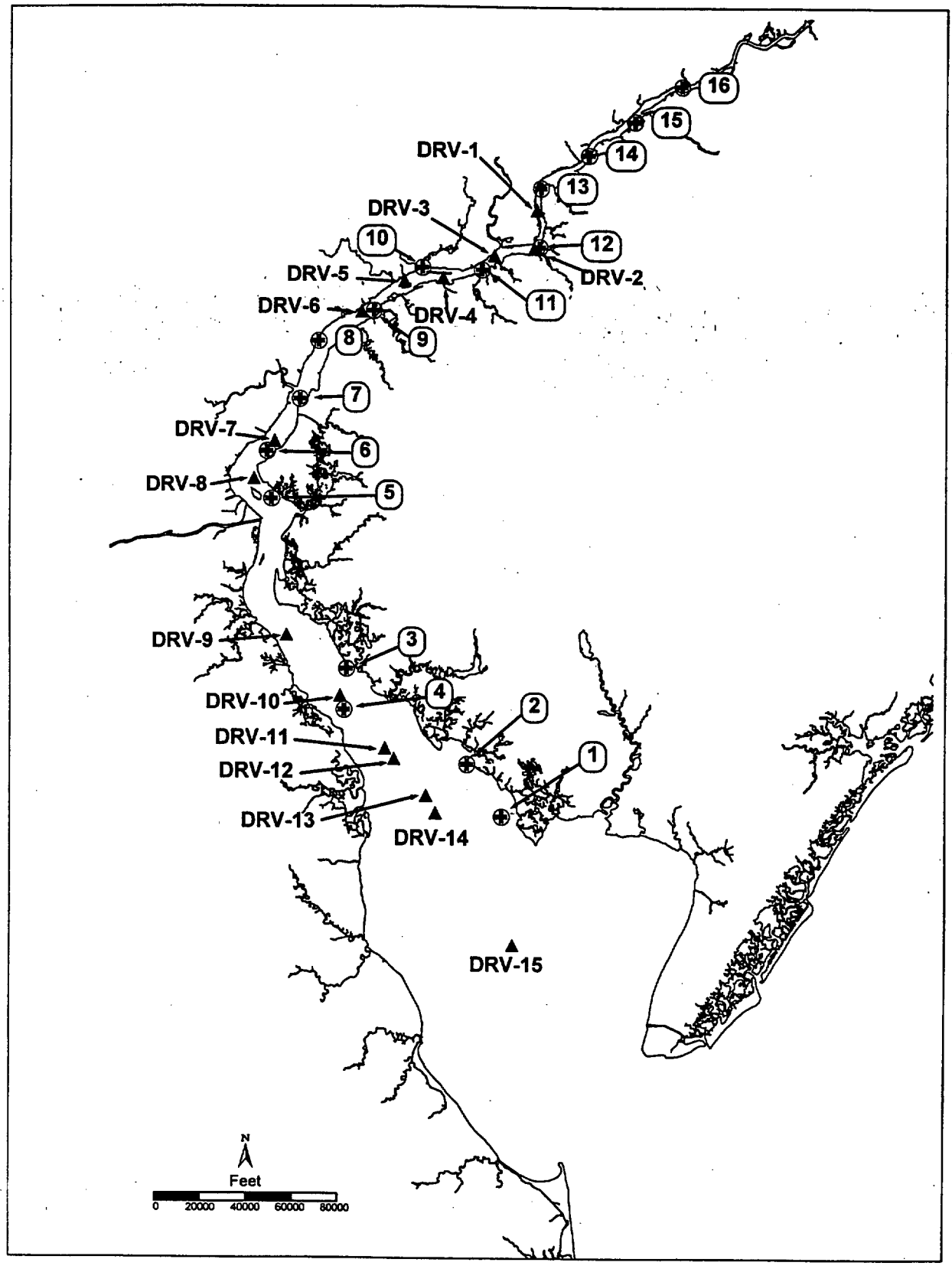

Figure 3-11. Comparison of station locations for the primary stations sampled in the Delaware River, Philadelphia to the Sea Federal navigation channel in October 1996 and stations sampled by the Arthur D. Little study in May 1993

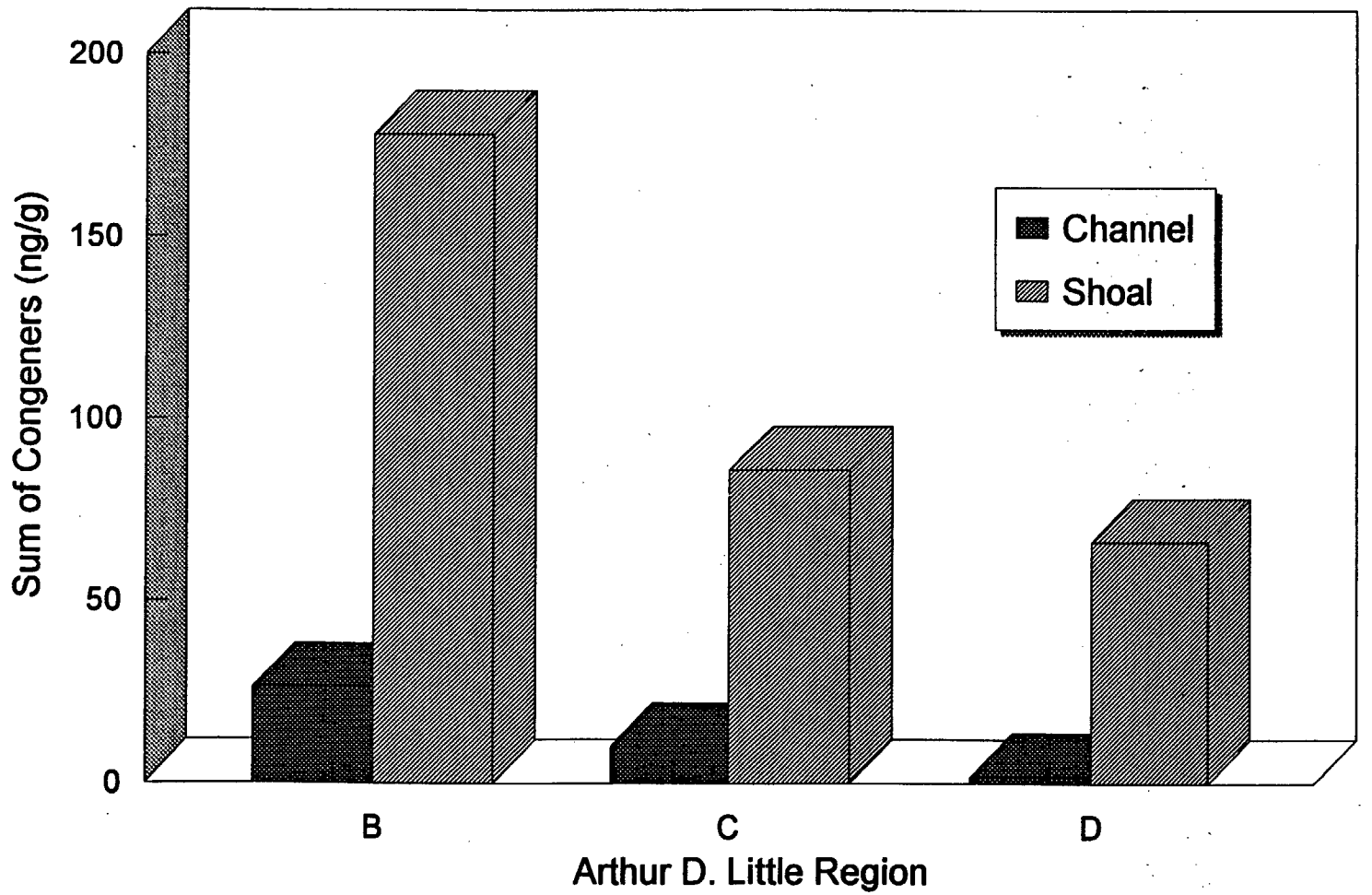

Figure 3-12. Comparison of total PCB concentrations (ng/g) observed in the navigational channel to concentrations observed in the shoal sampling conducted by Arthur D. Little in May 1993

4.0 IMPACT ANALYSIS OF DREDGING ACTIVITIES

4.1 POTENTIAL EFFECTS OF USING DREDGED MATERIAL FOR BENEFICIAL USE PROJECTS IN THE LOWER DELAWARE BAY

The dredged material disposal plan for the Delaware River, Philadelphia to the Sea main channel deepening project includes using dredged material from the lower portion of the estuary (Liston Range to Crossledge Range) for the creation of shallow marsh habitat around Egg Island Point in New Jersey, and Kelly Island in Delaware. In addition, some of the sediments will be stockpiled in the lower Delaware Bay at sites L-S and MS-19 for use in future beach replenishment activities along the Delaware shoreline. A major environmental concern expressed by the State of Delaware was that placement of material containing high levels of PCBs could expose aquatic and terrestrial natural resources to toxic concentrations and potentially increase the biomagnification of PCBs through the food chain.

The results of this study indicate that these concerns are unwarranted as the sediments slated for the beneficial projects contain only trace concentration of PCBs (Figs. 3-1 and 3-2). Sediments for the wetland creation and sand stockpile projects will be taken from sampling areas DRV-11, 12, 13, 14, and 15. These particular areas had the lowest concentration of PCBs found in the entire study region. Furthermore, the results of the comparison of channel concentrations and shoal concentrations reported by Arthur D. Little (1994) indicated that PCB contamination in the navigational channel is significantly lower than levels observed in shallower non-channel areas (Fig. 3-12). Thus, use of channel sediments for construction of wetlands and beach nourishment projects may have an added benefit by capping shallow water sediments known to have higher PCB concentrations. PCB levels reported by Arthur D. Little at the stations closest to the Egg Island project area (station 1; Figure 3-11) had a total concentration of 36.9 ng/g while this study suggests that the navigational channel sediments that will be placed there may only have an average concentration of 0.003 ng/g.

4.2 MOBILIZATION OF PCBs FROM UPLAND DISPOSAL SITES

One mechanism where dredging activities can potentially mobilize PCBs in the estuary is through the discharge of water from upland disposal sites. In the riverine portion of the project area, dredged material is placed in seven upland disposal sites located between Artificial Island and the Schuylkill River. Discharge water from these sites may contain PCBs dissolved in the pore water of the dredged sediments. In addition, the process of dredging and pumping the dredge slurry to the upland disposal sites may increase dissolved PCB concentrations due to changes in sediment/interstial water equilibrium. However, PCB solubilities are known to be extremely low ranging from 0.00009 mg/l for nonachlorobiphenyl to 0.17 mg/l for some tetrachlorobiphenyls (EPA 1987). PCBs are also known to firmly attach to organic particles and fine grained sediments. Thus, only a very small percentage of the

PCBs in dredged material will be discharged in the dissolved phase. The specific percentage of PCBs that will be released will depend on the solubilities and concentrations of the various congeners in the material. This is usually measured for a particular sediment in elutriate tests. Elutriate tests were conducted for the Philadelphia to the Sea project which resulted in no PCB detections (USACOE 1997). However, these tests used lower resolution techniques and measured PCBs as Arochlors. Although no high resolution sediment tests were conducted in conjunction with high resolution elutriate tests, a recent study conducted in Wilmington Harbor, Delaware suggested PCB discharges from upland disposal sites pose no appreciable risk to aquatic biota in the Delaware River (Greeley-Polhemus Group 1994, Appendix C).

Using high resolution tests the Greeley-Polhemus Group (1994) quantified the concentration of PCB congeners in the sediments and in the weir discharge of the upland disposal site which received the material dredged for maintenance of the harbor (the same contract lab used for the present study conducted the PCB analysis). A total of 12 congeners were detected in two composite samples of the sediments prior to dredging, the sum of which averaged 23.1 ng/g (ppb). Two separate 24 hour composite samples of the weir discharge waters were collected during the dredging operations and only one congener (ICUPAC 77) was detected in extremely low concentrations which averaged only 0.00004 μg/l (ppb).

Efficient operation of upland disposal sites can reduce the mobilization of PCBs in the estuary by removing the majority of the suspended material. Maintenance of the proper ponding levels (by adjusting the weir height) increases the retention time of water within the upland site allowing suspended material more time to settle out. In addition, many of the upland sites used in the Delaware River contain large stands of Phragmites and other upland vegetation. Typically the dredged slurry is pumped into the site as far inland as possible and upgradient of the vegetation. This effectively maximizes the distance a parcel of water must traverse to the discharge weir. In addition, the flows of turbid water discharged from the dredge pipe is further detained by the plant material increasing the removal of suspended solids. In recent monitoring of weir discharges for the Wilmington Harbor and Salem River dredging projects, TSS levels at the weir were often much less than background concentrations measured in the river (Versar 1996a, 1996b).

4.3 POTENTIAL MOBILIZATION OF PCBS FROM HOPPER DREDGES USING ECONOMIC LOADING

Efficient use of hopper dredges is dependent on the ability of the dredge operators to completely fill the vessel's holding tanks with sediment before traveling to the disposal site. Because the typical sediment to water ratio in the hydraulic dredge slurry is 25% sediment to 75% water, much of water portion of the dredge slurry will need to be discharged overboard (through two on-board sluiceways) during the dredging operation to practice economic loading. Sediment elutriate tests for the material to be dredged were conducted for the Philadelphia to the Sea project (USACOE 1997) which suggested that no PCBs will be released into the dissolved phase during the operation (the detection limits ranged from 0.6

to 5.8 μg/l). However, PCB concentrations were reported as Arochlors and the tests were conducted using relatively low resolution techniques.

Although no high resolution congener specific elutriate tests were conducted for the Philadelphia to the Sea project (USACOE 1997), partitioning coefficients can be used to estimate the release of PCBs based on the high resolution results generated by the present study. PCBs are known to have extremely low solubilities which is one of the reasons they are persistent in the environment. The solubilities of organic molecules are expressed using the octanol-water partition coefficient (K_{ow}) which is a measure of how a pure chemical will partition in an octanol/water medium. For PCB homologs this coefficient ranges from $10^{4.3}$ for the biphenyl molecule to $10^{8.3}$ for the deca homolog (homologs with fewer chlorines have lower coefficients than more chlorinated PCBs). Thus, for tetra homologs and higher, only about 1 part in over 100,000 parts of PCBs will be dissolved in the water of an octanol/water mix. Recent studies have shown that the organic carbon portion is almost entirely responsible for the sorbing capacity of sediments (Karickhoff 1981, Mackay 1991). In addition, Karickhoff (1991) showed that the partition coefficient between sediment and water, expressed in terms of an organic carbon coefficient (K_{oc}) was closely related to the octanol/water partition coefficient. He established the following relationship:

$$K_{oc} = 0.41\ K_{ow}$$

This relationship was based on experiments where the soil/water partition coefficient was measured for a variety of soils with different carbon content (y). The ratio of the soil and water concentrations (K_p) was shown to have a near linear relationship to organic content y (g/g), suggesting the following relationship:

$$K_p = y\ K_{oc}$$

Thus by calculating K_p for each sample (we measured TOC in each collection) and multiplying the inverse of the resulting K_p times the total PCB concentration found in the sediments, we estimated the concentration of dissolved PCB in the sediment pore water. Using the conservative assumption that 10% of the sediment is water, and adjusting for a four fold dilution in the dredge slurry (25% sediments to 75% water), we estimated the concentration of PCBs in the overflow water of a hopper dredge. Although, many of our samples contained PCB homologs with more than 4 chlorines (tetra) we used a K_{ow} of 10^5 which was much lower than the K_{ow} of $10^{5.9}$ reported for the tetra PCB homolog (Kathy Boggs, MRI personal communication). In this analysis we have assumed that changes in the sediment/water PCB equilibrium will be insignificant due the low solubility of PCBs. We have also assumed that the environmental effects of suspended sediments in the overflow water containing sorbed PCBs will be minimal as the material will quickly settle back to the bottom.

The results of these calculations suggests that the overflow water from a hopper dredge will not have dissolved PCB concentrations greater than EPA chronic water quality criteria for freshwater (0.014 μg/L; Table 4-1). Concentrations near the chronic criteria for

the sub-surface sediments at Tinicum Range (DRV-4) were indicated (0.011 μg/L). However, predicted concentrations at all other sites were orders of magnitude lower than the most stringent criteria, as well as EPA's 2 μg/L acute criteria for freshwater. In addition to the low concentrations predicted for the hopper dredge overflow, dissolved PCBs will be rapidly diluted when the 60,000 gallons per minute overflow water enters Delaware River surface water. Given that the water within a hopper dredge may have PCB concentrations below chronic criteria, concentrations in the turbidity plume several meters away from the vessel will be substantially lower.

Table 4-1. Estimated PCB concentrations in hopper dredge overflows using organic carbon partitioning estimates of sediment pore water concentrations and a dredge slurry sediment/water ratio of 1 to 4

	Sediment Concentration (ng/g)	TOC (%)	K_p	Pore Water Concentration (μg/L)	Overflow Concentration (μg/L)
Surface Stations					
1	14.22	1.78	729.8	0.019	0.0005
2	0	1.73	709.3	0	0
3	12.07	1.95	799.5	0.015	0.0004
4	23.63	2.1	861	0.027	0.0007
5	0.1	1.44	590.4	0.0002	0.000004
6	74.71	3.6	1476	0.05	0.0013
7	18.48	2.14	877.4	0.021	0.0005
8	0	2.65	1087	0	0
9	9.66	2	820	0.012	0.00029
10	4.11	1.42	582.2	0.0071	0.00018
11	0.01	0.082	33.62	0.0003	0.000007
12	0	1.33	545.3	0	0
13	0.01	0.092	37.72	0.0003	0.000007
14	0.02	0.034	13.94	0.0014	0.00004
15	0.01	0.19	77.9	0.0001	0.000003

Table 4-1. Cont'd

	Sediment Concentration (ng/g)	TOC (%)	K_p	Pore Water Concentration (μg/L)	Overflow Concentration (μg/L)
Sub-surface Stations					
1	0.01	0.47	192.7	0.00005	0.000001
2	0	1.64	672.4	0	0
3	0.01	1.58	647.8	0.00002	0
4	152.01	0.85	348.5	0.436	0.011
5	0	1.41	578.1	0	0
6	30.62	3.52	1443	0.021	0.0005
7	20.27	3.03	1242	0.016	0.0004
8	1.64	2.28	934.8	0.0018	0.00004
9	3.56	2.13	873.3	0.0041	0.0001
10	3.34	1.36	557.6	0.0059	0.0001
11	0.01	0.047	19.27	0.0005	0.00001
12	0	0.71	291.1	0	0
13	0.01	0.071	29.11	0.0003	0.000009
14	0.01	0.61	250.1	0.00004	0
15	0	0.22	90.2	0	0

ASSUMPTIONS:
$K_{oc} = 0.41 K_{ow}$ (Mckay 1991)
$K_p = y\ K_{oc}$ (Mckay 1991
y = g/g = percent carbon (Mckay 1991)
Assume K_{ow} for PCBs is 10^5 (conservative)
K_{oc} = 41000
Multiply inverse of K_p times sediment concentration to estimate pore water concentration

APPENDIX A

MRI REPORT

MRI REPORT

Analysis of Sediment Samples for Mono-ortho, Di-ortho, and Coplanar Congener-Specific PCBs

Draft Final Report

For Versar, Inc.
9200 Rumsey Road
Columbia, Maryland 21045

Attn: William H. Burton
Program Manager

MRI Project No. 4615-01

January 3, 1997

MIDWEST RESEARCH INSTITUTE 425 Volker Boulevard, Kansas City, MO 64110-2299 • (816) 753-7600

Preface

This draft final report provides the results of the analysis of 30 samples of Delaware estuary sediments in support of a Philadelphia Corps of Engineers study to determine trace levels (parts per trillion and parts per billion) of congener specific polychlorinated biphenyls (PCBs) in navigational channel sediments. The samples were collected from 15 locations within the Delaware River, Philadelphia to the Sea navigation channel, from Philadelphia Harbor to Delaware Bay. Midwest Research Institute (MRI) performed the PCB analyses through a subcontract with Versar, Inc. under purchase order number 04978.

The samples were prepared for analysis under the supervision of Mr. Mark Davis. The HRGC/LRMS analyses for mono-ortho and di-ortho congener specific PCBs were performed by Mr. Mike Molloy, and the HRGC/HRMS coplanar PCB analyses were performed by Mr. John Wagner. Ms. Kathy Boggess reviewed the analytical data and prepared this report.

MIDWEST RESEARCH INSTITUTE

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January 3, 1997

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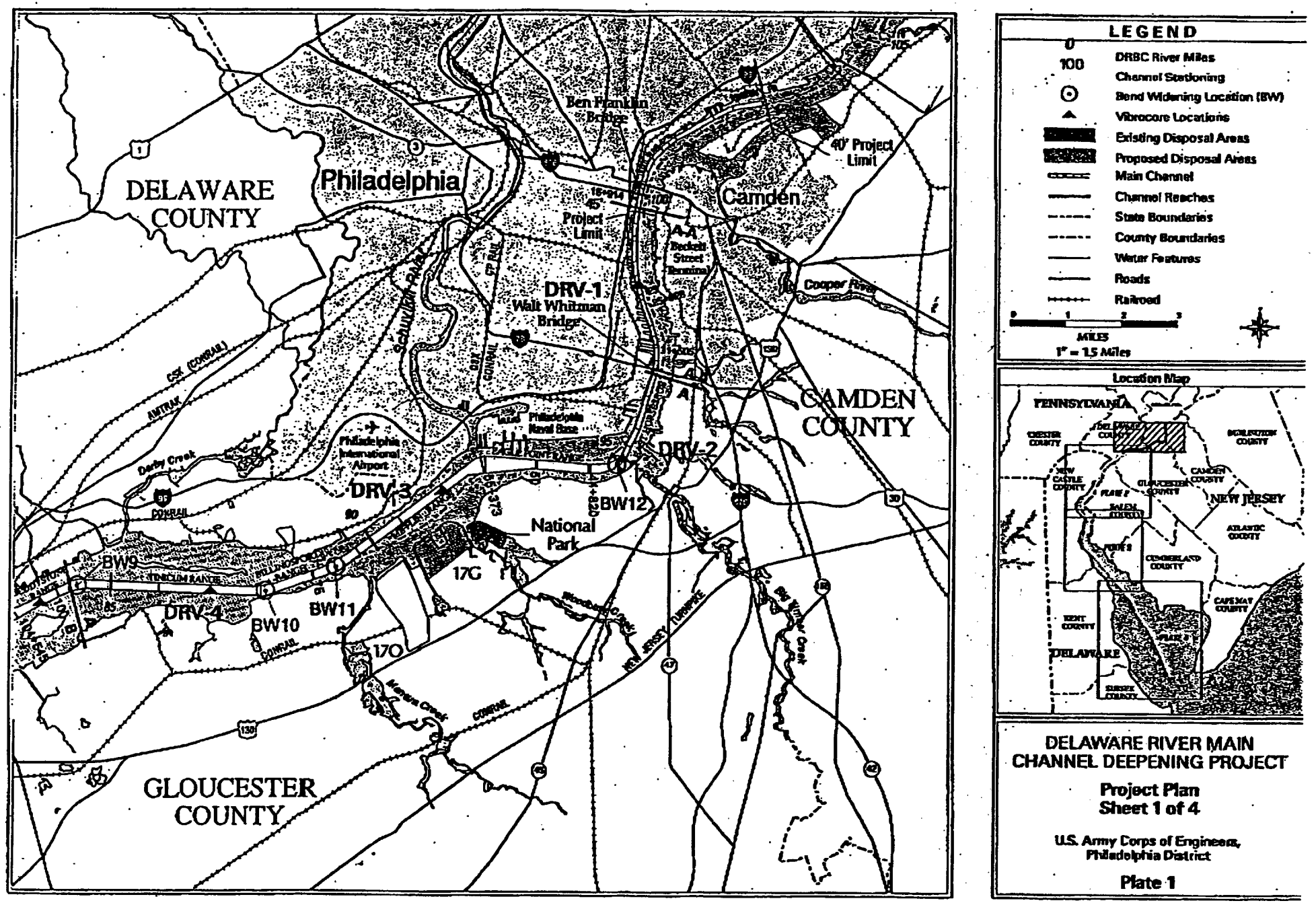


Figure 1. DRV1-DRV4 Sampling Locations

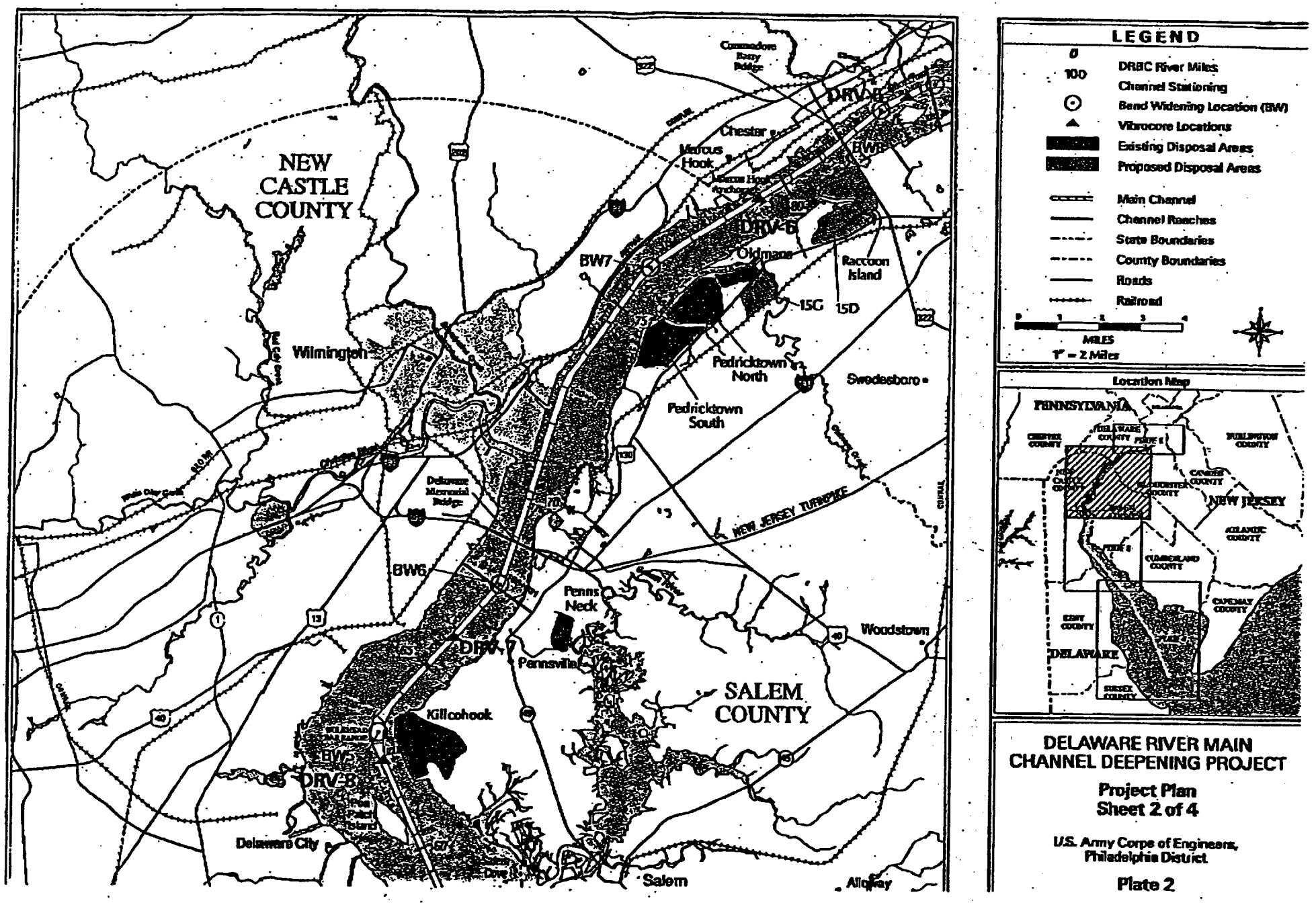


Figure 2. DRV5-DRV8 Sampling Locations

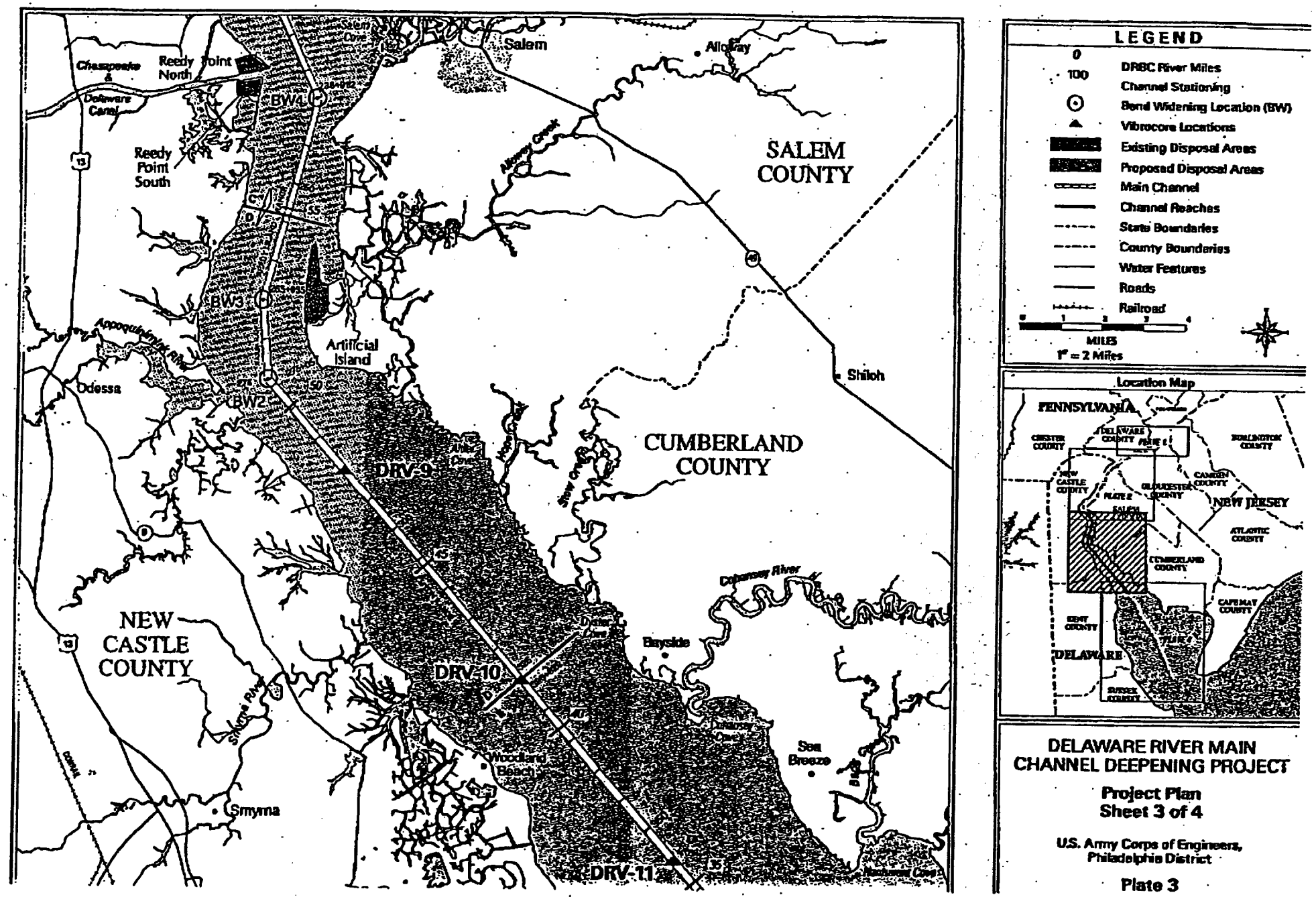


Figure 3. DRV9-DRV11 Sampling Locations

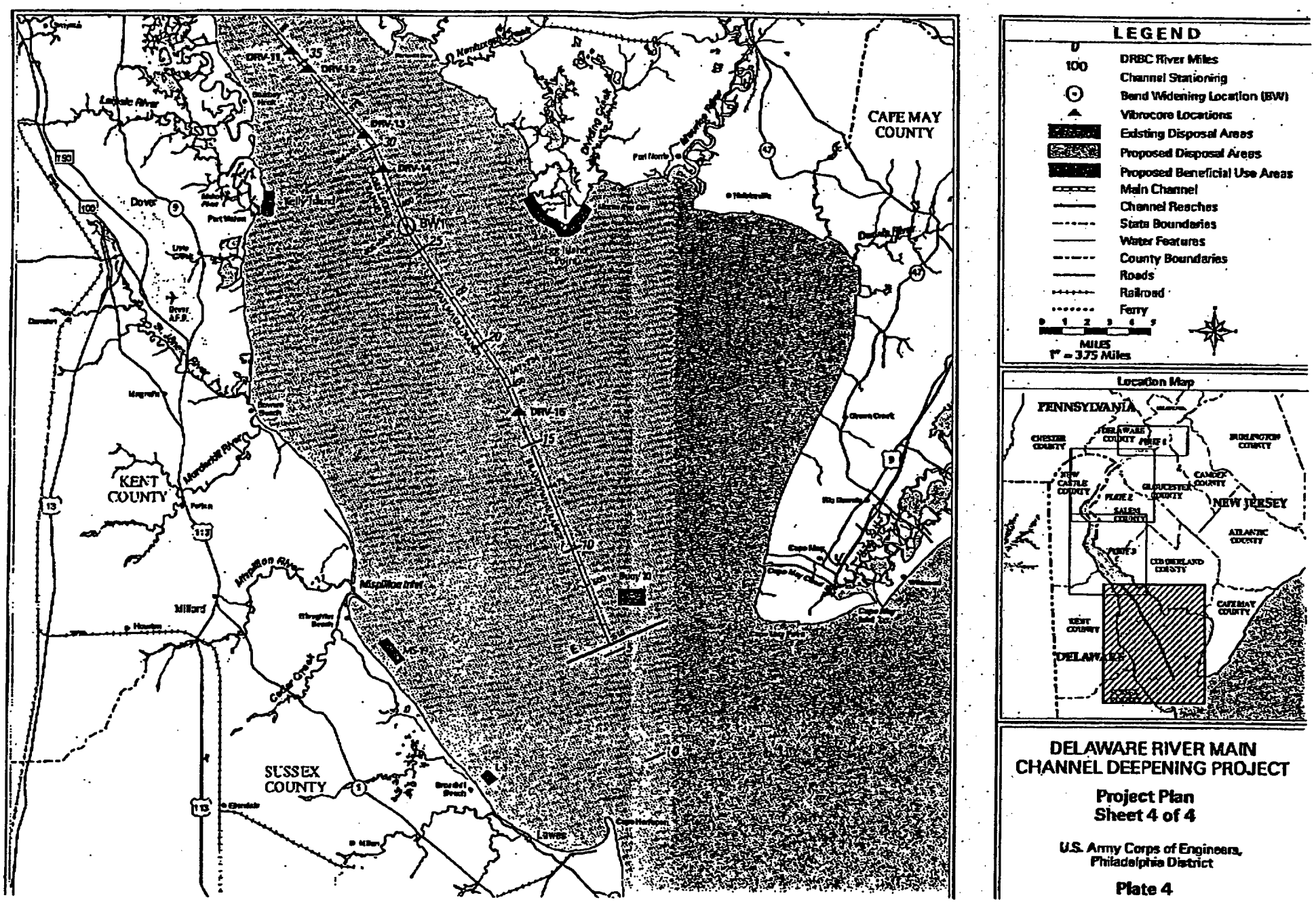


Figure 4. DRV11-DRV15 Sampling Locations

Section 2
Experimental

This section describes sample receipt, analytical standards, sample preparation procedures, instrumental analysis, and data reduction.

2.1 Sample Receipt

The sample collection study design and shipment of samples to MRI were coordinated by Mr. William Burton, Versar Program Manager. The samples were received at MRI cold and in good condition on October 8, 1996. MRI's sample receipt documentation including a sample receipt checklist and sample transaction log provided by Mr. Brad Deck, MRI Sample Custodian, are provided in Appendix A along with the chain-of-custody record for sample shipment. Samples were refrigerated until sample preparation was initiated.. The samples were identified by their field number and by a unique MRI barcode number for identification during sample preparation and analysis. The extract split for HRGC/HRMS analysis was assigned a different barcode number than the split for HRGC/LRMS analysis.

2.2 Analytical Standards

Analytical standards were prepared for the target analytes requested in the scope of work, shown in Tables 1 and 2. Individual stock solutions were purchased from Cambridge Isotope Laboratories, Woburn, Massachusetts; Ultra Scientific, Hope, Rhode Island; and Accustandard, New Haven, Connecticut.

Isotopically labeled analogs of selected analytes were used as internal quantitation standards, surrogates, and internal standards.

Thee analytical standards discussed in this section are presented as HRMS standards and LRMS standards.

2.2.1 Coplanar PCBs Analytical Standards (HRMS)

The coplanar PCB standards include native standards for two tetra-coplanar PCBs (Congeners 77 and 81), two penta-PCBs (Congeners 126 and 127), and one hexa-PCB (Congener 169). Corresponding $^{13}C_{12}$-isotopes for each homolog group include $^{13}C_{12}$-3,3′,4,4′ Tetra-PCB (Congener 77), $^{13}C_{12}$-3,3′,4,4′5 Penta-PCB (Congener 126), and $^{13}C_{12}$-3,3′,4,4′,5,5′ Hexa-PCB (Congener 169). Native spiking solutions, surrogate spiking solutions, and instrument calibration solutions were prepared from mixed stock

solutions. The calibration standards include native PCBs over a concentration range from 5.0 to 500 pg/μL with the concentration of isotopes constant at 100 pg/μL shown in Table 3. Retention time standards were analyzed to determine qualitative identification for tetra PCB congeners 81 and penta congener 127. Quantitation for these congeners was performed relative to the tetra PCB 77 and Penta PCB 126 standards, respectively.

2.2.2 Congener-Specific PCBs (LRMS)

Aliquots of the individual stock solutions of native PCBs were combined to prepare a mixed stock spiking solution. A mixed surrogate spiking solution was prepared by combining aliquots of the individual ^{13}C-PCBs. The ^{13}C-PCBs include congeners from the mono-, di-, tetra-, hexa-, octa-, and deca-substituted homologs. Aliquots of the chlorinated native PCB congeners shown in Table 2, the ^{13}C-PCB surrogates, and an internal standard solution containing d_{10}-phenanthrene and d_6-tetra PCB were combined to prepare instrument calibration standards over the concentration range shown in Table 4. The accuracy of the calibration standards was verified through an analysis of a 20 congener EPA reference standard.

2.3 Sample Preparation

The analytical procedures used for extraction of the sediment samples have been extensively evaluated at MRI through previous studies. The procedures used for sample preparation included Soxhlet extraction techniques presented in SW-846 methods. The cleanup procedures used were modifications of procedures specified in EPA Method 8290. The sample amount used for extraction was increased to provide at least 10-g dry sample. In addition to the field samples, a sample of the coring pipe material was prepared for analysis to determine the effect of small amounts of this material (< 1 g) that may have come in contact with the sample during collection. A 1-g sample of the coring material was cut into fine particles and extracted for PCB analysis using the same procedures used for the sediment samples.

After extraction, the samples were put through a sulfuric acid partitioning cleanup followed by acid/neutral silica gel chromatography cleanup described in Method 8290. Then, the extracts were split into two equal portions. The coplanar PCB split was put through additional chromatography cleanup procedures including neutral alumina and AX-21 carbon.

2.3.1 Mono-ortho and Di-ortho PCBs

The sediment samples were prepared for HRGC/LRMS PCB analysis using Soxhlet extraction followed by sulfuric acid and acid/neutral silica gel chromatography cleanup

procedures. The 30 samples were prepared in two batches. Quality control samples prepared with each batch included a sodium sulfate method blank, a laboratory control method spike, and duplicate matrix spikes of a randomly selected sediment sample.

Aliquots of the sediment samples, matrix spike, and matrix spike duplicate equivalent to at least 10 g on a dry weight basis, were weighed into 250-mL beakers and mixed with sodium sulfate. The field samples and quality control samples were fortified with ^{13}C surrogate standards shown in Table 5. In addition to the $^{13}C_{12}$ surrogate standards, the control spike and duplicate matrix spike samples were spiked with native target analytes at a concentration equivalent to 10 ng/g based on a 10-g sample.

The samples and quality control samples were placed in Soxhlet extractors and extracted for at least 16 hr with toluene. The extracts were cooled to ambient temperature, filtered through a bed of sodium sulfate, and solvent exchanged to hexane. The hexane extract (~15 mL) was subjected to sulfuric acid partitioning. The recovered hexane extract was then put through a sulfuric acid modified silica gel/neutral silica gel chromatography cleanup procedure. Three samples, contained visible concentrations of sulfur interference during the concentration step. These samples were put through a mercury cleanup procedure to remove the sulfur interference.

After cleanup was completed, each hexane sample extract was concentrated to 10 mL and split into two 5-mL portions. The 5-mL split for mono- and di-ortho PCB analysis was concentrated to 1.0 mL hexane, and an internal standard solution containing d_6 tetra PCB and phenanthrene-d_{10} was added to a final concentration of 200 ng/mL. The extracts were stored in the refrigerator until ready for HRGC/LRMS analysis.

2.3.2 Coplanar PCBs

The samples for HRGC/HRMS analysis required the same extraction procedures as used for HRGC/LRMS analysis, but clean-up steps were more extensive. The samples were prepared for analysis using the same procedures discussed in Section 2.3.1 except additional spiking solutions were used. Each sample was fortified with $^{13}C_{12}$ coplanar PCB internal quantitation standards (IQS) shown in Table 5. In addition to the $^{13}C_{12}$ PCBs, the matrix spike samples were spiked with native coplanar PCBs at a concentration equivalent to 100 pg/g based on a 10-g sample.

After extraction, the samples were subjected to the same sulfuric acid partitioning and neutral/acid silica gel chromatography column cleanup described in Section 2.3.1. After the extract split, the half designated for coplanar PCB analysis was put through additional column chromatography cleanup steps including neutral alumina and AX21-carbon/Celite.

Following the final cleanup, the extracts were concentrated under prepurified nitrogen to 100 µL, and 10 µL of a recovery standard solution containing $^{13}C_{12}$-1,2,3,4-TCDD and $^{13}C_{12}$-1,2,3,7,8,9-HxCDD in tridecane was added. The evaporation was continued until a

volume of 10 µL was reached. The recovery standard was used to calculate absolute recoveries of the PCB IQS standards. Sample extracts were transferred to refrigerated storage (4 °C) until ready for HRGC/HRMS analysis.

2.4 HRGC/LRMS Analysis—Mono-ortho and Di-ortho PCBs

The HRGC/LRMS analyses for mono- and di-ortho PCBs, pesticides were performed using a Fisons MD 800-E quadrupole mass spectrometer operated in the full scan mode. The instrument was tuned according to manufacturer's specifications, and decafluoro-triphenyl phosphate (DFTPP) was analyzed at the beginning of each 12-hr day that samples were analyzed to ensure proper mass assignments. A PCB window defining mix, containing the first and last eluting congeners for each homolog group, was analyzed to determine appropriate quantitation windows for total PCB analysis.

Initial calibration of the instrument was performed with the analytical standards described in Section 2.2 over a minimum of five points. Continuing calibration included a beginning-of-the-day and end-of-the-day standard to ensure stable instrument performance. Calibration criteria included an average response factor precision of less than 20% relative standard deviation (RSD) for the initial curve. Daily calibration response factors were required to be within ± 25% of the initial curve. Initial and continuing calibration standards met the performance criteria.

2.5 HRGC/HRMS Analysis—Coplanar PCBs

The coplanar PCBs are typically detected at concentrations much lower than the more prevalent mono- and di-ortho-substituted PCBs. Because of these differences in concentrations, it was necessary to conduct an analysis for coplanar PCBs separate from the other PCB analysis. The analysis of the sediment samples for coplanar PCBs was performed using analytical conditions evaluated at MRI through previous studies using an Autospec Ultima HRMS instrument operated with mass resolution > 10,000.

The instrument was tuned according to manufacturer's specifications, and a mass resolution check was performed at the beginning of each 12-hr day that samples were analyzed. Initial calibration of the instrument was performed with the analytical standards described in Section 2.2 over a minimum of five points. Continuing calibration included a beginning-of-the-day standard followed by a tridecane blank to ensure no carryover in the analytical system. An end-of-the-day standard was analyzed to ensure stable instrument performance. Calibration criteria included an average response factor precision of less than 20% relative standard deviation (RSD) for the initial curve. Daily calibration response factors were required to be within ± 20% of the initial curve for native isomers and ± 25% for internal quantitation standards. The initial and continuing calibration criteria were met.

2.6 Congener-Specific PCBs LRMS Data Reduction

The data from the congener-specific PCB and total PCB analyses were reduced using a high-speed computer program that filters noise and calculates the responses of analytes in the appropriate mass windows with ion abundance ratios at ± 20% of the theoretical ratios. The PCB quantitation and theoretical ion abundance ratio criteria are specified in EPA Method 680.

For qualitative identification, detected peaks were required to meet the ion ratio criteria and to fall within established relative retention time windows. Retention time ratios of analytes relative to the internal standard were established from the analysis of the calibration standards. The order of elution for congener-specific PCBs has been determined during previous MRI studies and from the literature.[1]

For peaks positively identified as pesticides or congener-specific PCBs, the computer program calculates an extract concentration, and then the sample weights, extract volumes, and dilution factors are taken into account to arrive at a final sample concentration.

The calculation formulas are shown in the following equations:

$$\text{relative response factor} = \text{RRF} = \frac{\text{Area}_{STD} \times \text{Conc}_{IS}}{\text{Conc}_{STD} \times \text{Area}_{IS}} \qquad \text{Eq. (1)}$$

where: area = sum of the area for the primary and secondary masses characteristic of the analyte standard or internal standard, and
conc = the concentration (ng/mL) of internal standard or standard.

$$\text{ng/g Sample} = \left[\frac{\text{Area}_{sample} \times \text{Conc}_{IS}}{\text{Area}_{IS} \times \text{RRF}}\right] \times \frac{\text{final vol}}{\text{wt}} \times \text{split} \qquad \text{Eq. (2)}$$

where: final vol = final volume of extract (mL), and
wt = is weight of sample (g).
split factor = 2

Total homolog PCB results were determined in addition to the congener-specific data. Quantitation windows for the mono- through deca-PCB homologs were established from the analysis of a window defining standard that contains the first and last eluting congener for each homolog. As a result of the extensive target congener analyte list, all responses observed were identified as specific congeners. For each homolog group, the individual

[1] Erickson, M. D., *Analytical Chemistry of PCBs*, Lewis Publishers, Inc. (1992).

congeners detected above the lowest calibration standard were summed. Total PCBs were calculated by summing the mono through deca homolog concentrations.

Limits of detection for analytes not positively identified were based on the lowest calibration standard (12.5 ng/mL). The estimated maximum possible concentration (EMPC) was calculated for background interferences that masked response for the target analyte, resulting in a qualitative ion ratio that was outside the theoretical ratio acceptance limits.

The concentrations of the isotopically labeled surrogate compounds added to each sample were determined the same as for the native analytes. The amount found was compared to the amount spiked and the percent recovery was calculated. The native concentrations were not adjusted for surrogate recovery.

2.7 Coplanar PCBs, PCDDs, and PCDFs Data Reduction

The OPUSquan software, accompanying the Autospec HRMS system was used to calculate the concentrations of coplanar PCBs.. The coplanar PCBs are calculated based on the isotope dilution approach which adjusts the concentration of the native analyte for recovery of the internal quantitation standards (IQS) from the sample matrix. Qualitative identification requires the target analyte response to be within a specific retention time and the quantitation ions must be within ±20% theoretical ratio criteria. Exact masses for HRMS analysis were determined through previous studies.

The instrument was calibrated with the series of calibration standards given in Tables 3. Relative response factors (RRFs) were determined for each native compound relative to the corresponding ^{13}C-labeled internal quantitation standard (IQS) (Equation 3) and for each IQS relative to the recovery standard (RS) (Equation 4). The mean RRFs from all standards were then used in subsequent calculations to determine sample amounts for each specific isomer or IQS. The RRF for analytes is calculated using the following equation:

$$RRF = \frac{A_{STD} \times C_{IS}}{A_{IS} \times C_{STD}} \qquad \text{Eq. (3)}$$

where: A_{STD} = the sum of the area responses for the two characteristic ions of the native standard;

A_{IS} = the sum of the area responses for the two characteristic ions of the corresponding internal quantitation standard;

C_{IS} = concentration (pg/μL) of the internal quantitation standard; and

C_{STD} = concentration (pg/μL) of the native standard.

The RRF for internal standards, RRF_{IS} is calculated as:

$$RRF_{IS} = \frac{A_{IS} \times C_{RS}}{A_{RS} \times C_{IS}} \qquad \text{Eq. (4)}$$

where A_{IS} and C_{IS} are defined as in Equation 3 and

C_{RS} = concentration (pg/μL) of the internal recovery standard, and

A_{RS} = the sum of the area responses for the two characteristic ions corresponding to the recovery standard.

The coplanar PCB detection limits were based on 2.5 times the instrumental noise, adjusted for sample weight and extract volume.

As discussed in the Sample Preparation Section, known amounts of IQS are added to the samples before extraction, and the IQS concentration in the final extract is used to calculate the concentration of the native analytes in the final extract as an isotope dilution calculation technique. This calculation procedure (Equation 5) adjusts for recovery from the sample matrix.

$$C_{WT} = \frac{A_{sample} \times Q_{IS} \times V_e}{A_{IS} \times RRF \times Wt} \qquad \text{Eq. (5)}$$

where:

C_{WT} = (pg/g) concentration of the PCB congener;

A_{sample} = sum of the area responses for the two characteristic ions of the PCB congener;

Q_{IS} = concentration (pg/μL) of the internal quantitation standard added to the sample;

V_e = final extract volume (μL);

A_{IS} = sum of the area responses for the two characteristic ions of the respective internal quantitation standard;

RRF = the average of the initial calibration relative response factors from Equation 3; and

Wt = dry weight for sediment.

$$\text{Recovery (\%)} = \frac{A_{IS} \times Q_{RS}}{A_{RS} \times RRF_{IS} \times Q_{IS}} \times 100 \qquad \text{Eq. (6)}$$

where: A_{RS} = sum of the area responses for the two characteristic ions of the internal recovery standard;

Q_{RS} = amount of the internal recovery standard added to the final extract; and

RRF_{IS} = the average of initial calibration response factors from Equation 4.

The recovery standards which are added to the sample at the final concentration step are used to establish the absolute recovery of the carbon-13 internal standards (Equation 6). The IQS recoveries are used to access overall method performance and adjust the results for native compounds.

Table 1. Non-Ortho Coplanar PCB Congeners Substituted in Both Para and Two or More META Positions

IUPAC number	Structure	Homolog group	Target detection limit (pg/g)
77	3,3′,4,4′	Tetra-CB	1
81	3,4,4′,5	Tetra-CB	1
126	3,3′,4,4′,5	Penta-CB	1
169	3,3′,4,4′,5,5′	Hexa-CB	1

Table 2. Mono-ortho and Di-ortho Targeted PCB Congeners for LRMS

IUPAC number	Structure	Homolog group	Target detection limit (ng/g)
8	2,4′	Di-CB	2
18	2,2′,5	Tri-CB	2
28	2,4,4′	Tri-CB	2
37	3,4,4′	Tri-CB	2
42	2,2′, 3,4′	Tetra-CB	2
44	2,2′,3,5′	Tetra-CB	2
47	2,2′,4,4′	Tetra-CB	2
49	2,2′,4,5′	Tetra-CB	2
52	2,2′,5,5′	Tetra-CB	2
60	2,3,4,4′	Tetra-CB	2
64	2,3,4′,6	Tetra-CB	2
66	2,3′,4,4′	Tetra-CB	2
70	2,3′,4′,5	Tetra-CB	2
74	2,4,4′,5	Tetra-CB	2
80	3,3′,5,5′	Tetra-CB	2
82	2,2′,3,3′,4	Penta-CB	2
84	2,2′,3,3′,6	Penta-CB	2
86	2,2′,3,4,5	Penta-CB	2
87	2,2′,3,4,5′	Penta-CB	2
91	2,2′,3,4′,6	Penta-CB	2
92	2,2′,3,5,5′	Penta-CB	2
95	2,2′,3,5′,6	Penta-CB	2
97	2,2′,3′,4,5	Penta-CB	2
99	2,2′,4,4′,5	Penta-CB	2
101	2,2′,4,5,5′	Penta-CB	2
105	2,3,3′,4,4′	Penta-CB	2
110	2,3,3′,4′,6	Penta-CB	2
114	2,3,4,4′,5	Penta-CB	2
118	2,3′,4,4′,5	Penta-CB	2
119	2,3′,4,4′,6	Penta-CB	2
120	2,3′,4,5,5′	Penta-CB	2
123	2′,3,4,4′,5	Penta-CB	2
127	3,3′,4,5,5′	Penta-CB	2
128	2,2′,3,3′,4,4′	Hexa-CB	2
137	2,2′,3,4,4′,5	Hexa-CB	2
138	2,2′,3,4,4′,5′	Hexa-CB	2
141	2,2′,3,4,5,5′	Hexa-CB	2
146	2,2′,3,4′,5,5′	Hexa-CB	2
149	2,2′,3,4′,5′,6	Hexa-CB	2
151	2,2′,3,5,5′,6	Hexa-CB	2
153	2,2′,4,4′,5,5′	Hexa-CB	2

Table 2 (Continued)

IUPAC number	Structure	Homolog group	Target detection limit (ng/g)
156	2,3,3′,4,4′,5	Hexa-CB	2
157	2,3,3′,4,4′,5′	Hexa-CB	2
158	2,3,3′,4,4′,6	Hexa-CB	2
166	2,3,4,4′,5,6	Hexa-CB	2
167	2,3′,4,4′,5,5′	Hexa-CB	2
168	2,3′,4,4′,5′,6	Hexa-CB	2
170	2,2′,3,3′,4,4′,5	Hepta-CB	3
171	2,2′,3,3′,4,4′,6	Hepta-CB	3
174	2,2′,3,3′,4,5,6′	Hepta-CB	3
177	2,2′,3,3′,4′,5,6	Hepta-CB	3
179	2,2′,3,3′,5,6,6′	Hepta-CB	3
180	2,2′,3,4,4′,5,5′	Hepta-CB	3
183	2,2′,3,4,4′,5′,6	Hepta-CB	3
185	2,2′,3,4,5,5′,6	Hepta-CB	3
187	2,2′,3,4′,5,5′,6	Hepta-CB	3
189	2,3,3′,4,4′,5,5′	Hepta-CB	3
190	2,3,3′,4,4′,5,6	Hepta-CB	3
191	2,3,3′,4,4′,5′,6	Hepta-CB	3
194	2,2′,3,3′,4,4′,5,5′	Octa-CB	3
195	2,2′,3,3′,4,4′,5,6	Octa-CB	3
196	2,2′,3,3′,4,4′,5′,6	Octa-CB	3
198	2,2′,3,3′,4,5,5′,6	Octa-CB	3
200	2,2′,3,3′,4,5′,6,6′	Octa-CB	3
201	2,2′,3,3′,4′,5,5′,6	Octa-CB	3
203	2,2′,3,4,4′,5,5′,6	Octa-CB	3
205	2,3,3′,4,4′,5,5′,6	Octa-CB	3
206	2,2′,3,3′,4,4′,5,5′,6	Nona-CB	4
207	2,2′,3,3′,4,4′,5,6,6′	Nona-CB	4
208	2,2′,3,3′,4,5,5′,6,6′	Nona-CB	4
209	2,2′,3,3′,4,4′,5,5′,6,6′	Deca-CB	5

Table 3. HRMS Coplanar PCBs Calibration Standard Concentrations

PCB Congener	Cal 1 pg/uL	Cal 2 pg/uL	Cal 3 pg/uL	Cal 4 pg/uL	Cal 5 pg/uL
77 Tetra	5	20	100	250	500
126 Penta	5	20	100	250	500
169 Hexa	5	20	100	250	500
Interal Quantitation Standards					
$^{13}C_{12}$ 77 Tetra	100	100	100	100	100
$^{13}C_{12}$ 126 Penta	100	100	100	100	100
$^{13}C_{12}$ 169 Hexa	100	100	100	100	100
Recovery Standard					
$^{13}C_{12}$ 1,2,3,4 TCDD	100	100	100	100	100

Table 4. LRMS PCBs Calibration Standard Concentrations

PCB Congener	Cal 1 ng/mL	Cal 2 ng/mL	Cal 3 ng/mL	Cal 4 ng/mL	Cal 5 ng/mL	Cal 6 ng/mL
8 Di	12.5	25	50	100	200	400
18 Tri	12.5	25	50	100	200	400
28 Tri	12.5	25	50	100	200	400
37 Tri	12.5	25	50	100	200	400
52 Tetra	12.5	25	50	100	200	400
49 Tetra	12.5	25	50	100	200	400
47 Tetra	12.5	25	50	100	200	400
44 Tetra	12.5	25	50	100	200	400
42 Tetra	12.5	25	50	100	200	400
64 Tetra	12.5	25	50	100	200	400
74 Tetra	12.5	25	50	100	200	400
70 Tetra	12.5	25	50	100	200	400
66 Tetra	12.5	25	50	100	200	400
80 Tetra	12.5	25	50	100	200	400
60 Tetra	12.5	25	50	100	200	400
95 Penta	12.5	25	50	100	200	400
91 Penta	12.5	25	50	100	200	400
92 Penta	12.5	25	50	100	200	400
84 Penta	12.5	25	50	100	200	400
101 Penta	12.5	25	50	100	200	400
99 Penta	12.5	25	50	100	200	400
119 Penta	12.5	25	50	100	200	400
97 Penta	12.5	25	50	100	200	400
86 Penta	12.5	25	50	100	200	400
87 Penta	12.5	25	50	100	200	400
120 Penta	12.5	25	50	100	200	400
110 Penta	12.5	25	50	100	200	400
82 Penta	12.5	25	50	100	200	400
123 Penta	12.5	25	50	100	200	400
118Penta	12.5	25	50	100	200	400
114 Penta	12.5	25	50	100	200	400
105 Penta	12.5	25	50	100	200	400
151 Hexa	12.5	25	50	100	200	400
149 Hexa	12.5	25	50	100	200	400
146 hexa	12.5	25	50	100	200	400
153 Hexa	12.5	25	50	100	200	400
168 hexa	12.5	25	50	100	200	400
141 Hexa	12.5	25	50	100	200	400
137 Hexa	12.5	25	50	100	200	400
138 Hexa	12.5	25	50	100	200	400
158 Hexa	12.5	25	50	100	200	400

Table 4. (Continued)

PCB Congener	Cal 1 ng/mL	Cal 2 ng/mL	Cal 3 ng/mL	Cal 4 ng/mL	Cal 5 ng/mL	Cal 6 ng/mL
128 Hexa	12.5	25	50	100	200	400
167 Hexa	12.5	25	50	100	200	400
156 Hexa	12.5	25	50	100	200	400
157 Hexa	12.5	25	50	100	200	400
179 Hepta	12.5	25	50	100	200	400
187 Hepta	12.5	25	50	100	200	400
183 Hepta	12.5	25	50	100	200	400
185 Hepta	12.5	25	50	100	200	400
174 Hepta	12.5	25	50	100	200	400
177 Hepta	12.5	25	50	100	200	400
171Hepta	12.5	25	50	100	200	400
180 Hepta	12.5	25	50	100	200	400
191 Hepta	12.5	25	50	100	200	400
170 Hepta	12.5	25	50	100	200	400
190 Hepta	12.5	25	50	100	200	400
189 Hepta	12.5	25	50	100	200	400
200 Octa	12.5	25	50	100	200	400
198 Octa	12.5	25	50	100	200	400
201 Octa	12.5	25	50	100	200	400
196 Octa	12.5	25	50	100	200	400
203 Octa	12.5	25	50	100	200	400
195 Octa	12.5	25	50	100	200	400
194 Octa	12.5	25	50	100	200	400
205 Octa	12.5	25	50	100	200	400
208 Nona	12.5	25	50	100	200	400
207 Nona	12.5	25	50	100	200	400
206 Nona	12.5	25	50	100	200	400
209 Deca	12.5	25	50	100	200	400
Surrogates						
13C Mono(3)	12.3	25	49	98	197	394
13C Di (15)	12.3	25	49	98	197	394
13C Tetra (52)	24.5	49	98	196	392	784
13C Hexa (153)	24.5	49	98	196	392	784
13C Octa (202)	50.6	101	202	405	810	1619
13C Deca (209)	57.1	114	228	457	914	1827
Internal Standards						
d6-Tetra (77)	200	200	200	200	200	200
d10-phenanthrene	200	200	200	200	200	200

Table 5. Laboratory Surrogates and Internal Quantitation Standard Spiking Solutions

Compound	Amount spiked (ng)
Laboratory Surrogates for HRGC/LRMS Analysis	
PCB surrogates	
$^{13}C_6$-Mono (3)[a]	244
$^{13}C_{12}$-Di (15)	244
$^{13}C_{12}$-Tetra (47)	489
$^{13}C_{12}$-Hexa (138)	489
$^{13}C_{12}$-Octa (202)	1,011
$^{13}C_{12}$-Deca (209)	1,141
Internal Quantitation Standard for HRGC/HRMS Analysis	Amount spiked (pg)
$^{13}C_{12}$-3,3′,4,4′,-PCB (77)	2,000
$^{13}C_{12}$-3,3′,4,4′,5-PCB (126)	2,000
$^{13}C_{12}$-3,3′4,4′,5,5′-PCB (169)	2,000

[a] Ballschmitter congener number shown in parentheses.

Section 3
Results

This section provides the field sample and quality control sample results. Field sample results include coplanar PCBs, mono-ortho and di-ortho congener specific PCBs and total PCBs. Quality control sample results including method blanks, laboratory control spikes, matrix spikes, surrogate recoveries, and internal quantitation standard recoveries are also presented.

3.1 Coplanar PCB Results

The coplanar PCB field results are summarized in Table 6 and quality control results are presented in Tables 7, 8, and 9.

3.1.1 Coplanar PCB Field Sample Results

The coplanar PCB results are summarized in Table 6 in pg/g concentration units or parts per trillion (ppt) on a dry weight basis. The field ID and MRI extract ID are cross-referenced in the sample results column along with the MS filename and the batch number. The samples are reported by sampling location. For each sampling location, the S code sample, indicating sediment core surface, is reported first, followed by the corresponding B code sample for the bottom or subsurface core sample.

3.1.2 Coplanar PCB Quality Control Sample Results

The method blank results for the coplanar PCBs are presented in Table 6 for comparison to sample results. Some PCB 77 sample results are close to the 5 pg/g concentration in the method blank. Values near this level should be considered as background. The laboratory control spike and matrix spike recovery results are presented in Tables 7 and 8. A high recovery for Tetra PCB 77 (i.e., recovery greater than 400%) was consistent for all laboratory control spikes and matrix spikes. Acceptable recoveries (i.e., 50%-150% objective) were shown for the Penta PCB 126 and Hexa PCB 169 analytes.

An investigation of the high bias for Tetra PCB 77 was conducted, and no apparent reason for high recoveries was discovered. Because the precision measurements are very good between replicate samples spiked with the same standard solutions, the source of error may be in the LRMS native spiking solutions. The LRMS and HRMS spiking solutions were added to the same quality control samples. Then the samples were split for separate analysis as discussed in Section 2.3. A cross contamination of the LRMS spiking

solution with PCB 77 may have occurred. No difficulties were observed with the $^{13}C_{12}$ spiking solutions used to spike field samples and QC samples because the method blanks were acceptable. Overall, the precision between the duplicate matrix spikes was very good, with relative percent difference < 10%.

Other quality control sample results include the absolute recoveries of the $^{13}C_{12}$ IQS added to each field sample and quality control sample before extraction. Table 9 summarizes the recoveries and shows the mean recovery and relative standard deviation (RSD) precision of 39 samples prepared in two batches. The three samples with high IQS recoveries were those having difficulties with sulfur interferences. The high recoveries are attributed to suppression of the $^{13}C_{12}$ 1,2,3,4 TCDD internal recovery standard used to calculate IQS absolute recoveries. The chromatographic response for the $^{13}C_{12}$ PCB IQS and the native PCBs were not affected as much by the sulfur interference as the $^{13}C_{12}$ 1,2,3,4 TCDD recovery standard. The native PCB concentrations are not believed to be affected by the high IQS recoveries. The IQS recoveries for these samples, DRV-13-C-S, DRV-13-C-B, and DRV-15-C-B are not included in the mean and RSD calculations.

Statistical performance charts for the three internal quantitation standards, $^{13}C_{12}$ PCB 77, $^{13}C_{12}$ PCB 126, and $^{13}C_{12}$ 169, are provided in Appendix B. The mean recovery and method performance limits based on 1 and 2 standard deviation from the mean are shown for each sample. With the exception of the three off scale results, most of the 39 data points are within 2 standard deviation of the mean recovery.

3.2 HRGC/LRMS PCBs

The mono- and di-ortho PCB field results are summarized in Table 10 and the total homologs are presented in Table 11. Quality control results are presented in Tables 12 through 15.

3.2.1 Field Sample Results

The results for the mono-ortho and di-ortho congener-specific PCBs are presented in Table 10. For compounds not detected, the detection limit based on matrix background, estimated maximum possible concentration (EMPC) or the lowest calibration standard is shown in parentheses. The percent moisture for the sample is shown in the sample results header for each sample along with the field ID, MRI barcode, and the instrumental analysis MS file.

In cases where two congeners were not completely resolved chromatographically, the calibration was based on the sum of the coeluting congeners and the results are shown as a congener pair.

Total homolog PCB concentrations are presented in Table 11. A PCB window defining mix that contains the first and last eluting congener for each homolog was used to establish retention time windows for mono through deca homologs. The total homologs include the sum of all PCB congeners detected above the lowest calibration standard for mono through deca PCB homolog groups. As a result of the extensive target list, all peaks detected in a specific homolog were identified as a target congener. Therefore, homolog results are shown as the sum of the specific congeners within each respective homolog..

3.2.2 Quality Control Sample Results

The quality control samples included method blanks, control spikes, and duplicate matrix spikes of selected samples. The method blank sample results and the coring sample results are shown in Table 12. No significant levels of PCBs were detected in the method blanks or the coring blank sample. Laboratory control spike samples are presented in Table 13 and matrix spike results are shown in Table 14. The mean recoveries for the two LCS samples were within the 50 to 150% method performance objective. Lower recoveries for the batch 2 LCS were observed for some di, tri, and some tetra homologs.

Matrix sample recovery results are presented in Table 14. Background in the unspiked sample precluded recovery calculations for some of the batch 1 matrix spike congeners. The matrix spike duplicate results for batch 1 sample DRV-06-C-S (MRI Code 36148) showed better method performance than sample DRV-06-C-S matrix spike (MRI Code 36147). The difficulties with the matrix spikes are attributed to the low spike level (10 ng/g) compared to background in the unspiked sample. The overall method performance for the batch 1 samples was judged acceptable because of good recoveries for the batch 1 LCS and because surrogate recoveries were good for the batch 1 field samples. Most of the batch 2 recoveries were detected well within the 50 to 150 % method performance objective, and precision for the batch 2 MS and MSD samples was very good with relative percent difference < 20 %.

The surrogate recoveries for each of the field sample and quality control samples are summarized in Table 15. The mean recoveries for 39 samples ranged from 67 to 77% recovery and the precision ranged from 21 to 36 RSD. Individual recoveries were evaluated statistically relative to 1 and 2 standard deviations from the mean recovery for each surrogate. Method performance charts are provided in Appendix C.

Table 6. Concentrations of Coplanar PCBs in Sediment Samples (pg/g) Dry Weight Basis

Compound	Field ID	MB b1	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-B
	Extract ID	36109	36091	36092	36093	36094	36095	36096
	MS Filename	H96K021-3	H96K021-4	H96K021-5	H96K021-6	H96K021-7	H96K021-8	H96K021-9
	Batch	1	1	1	1	1	1	1
77-TCB		5.08	85.2	7.82	3.96	2.88	85.4	10.2
81-TPCB		U(0.367)	2.74	0.656	0.726	U(0.413)	3.3	U(0.435)
126-PeCB		U(0.542)	3.06	U(0.376)	U(0.612)	U(0.828)	3.44	U(0.447)
127-PePCB		U(0.542)	0.932	U(0.376)	U(0.612)	U(0.828)	U(0.983)	U(0.447)
169-HxPCB		U(0.101)	0.28	U(0.0598)	U(0.0115)	U(0.177)	0.778	U(0.0157)

U=Undetected with instrumental noise based detection limit shown in parentheses

Table 6. (Continued)

Compound	Field ID Extract ID MS Filename Batch	DRV-04-C-S 36097 H96K021-10 1	DRV-04-C-B 36098 H96K021-11 1	DRV-05-C-S 36099 H96K021-14 1	DRV-05-C-B 36100 H96K021-15 1	DRV-06-C-S 36101 H96K021-16 1	DRV-06-C-B 36102 H96K021-17 1	DRV-07-C-S 36103 H96K021-18 1
77-TCB		278	790	7.24	4.4	664	760	374
81-TPCB		5.26	13.72	U(0.269)	U(0.264)	12.76	11.08	7.1
126-PeCB		9.74	22.8	U(0.643)	U(0.243)	28.2	27.8	15.52
127-PePCB		U(2.83)	3.02	U(0.643)	U(0.243)	3.1	2.1	U(1.98)
169-HxPCB		1.148	1.78	U(0.107)	U(0.117)	5.02	4.36	3.44

Table 6. (Continued)

Compound	Field ID Extract ID MS Filename Batch	DRV-07-C-B 36104 H96K021-19 1	DRV-08-C-S 36105 H96K021-20 1	MB b2 36128 H96K072-2 2	DRV-08-C-B 36110 H96K072-3 2	DRV-09-C-S 36111 H96K072-4 2	DRV-09-C-B 36112 H96K072-5 2	DRV-10-C-S 36113 H96K072-6 2
77-TCB		436	3.44	3.04	1604	16.1	116.4	192
81-TPCB		7.56	U(0.425)	U(0.641)	3.38	U(0.531)	1.248	0.822
126-PeCB		18.04	U(0.359)	U(1.35)	20.6	U(0.609)	2.96	4.08
127-PePCB		2.68	U(0.359)	U(1.35)	U(1.62)	U(0.609)	U(0.874)	U(0.840)
169-HxPCB		3.76	U(0.113)	U(0.0255)	7.58	U(0.0920)	3.1	8.48

Table 6. (Continued)

Compound	Field ID Extract ID MS Filename Batch	DRV-10-C-B 36114 H96K072-7 2	DRV-11-C-S 36115 H96K072-8 2	DRV-11-C-B 36116 H96K072-9 2	DRV-12-C-S 36117 H96K072-10 2	DRV-12-C-B 36118 H96K072-11 2	DRV-13-C-S 36119 H96K072-14 2	DRV-13-C-B 36120 H96K072-15 2	DRV-14-C-S 36121 H96K072-16 2
77-TCB		230	5.48	5.82	4.86	2.38	5.22	6.48	17.66
81-TPCB		U(0.419)	U(0.415)	U(0.392)	U(0.493)	U(0.962)	U(0.768)	U(2.40)	U(0.382)
126-PeCB		3.94	U(0.695)	U(0.416)	U(0.831)	U(0.856)	U(1.06)	U(7.15	U(0.603)
127-PePCB		U(0.971)	U(0.695)	U(0.416)	U(0.831)	U(0.856)	U(1.06)	U(7.15)	U(0.603)
169-HxPCB		7.4	0.204	U(0.0894)	U(0.104)	U(0.147)	U(0.0715)	U(0.432)	U(0.0216)

Table 6. (Continued)

Compound	Field ID Extract ID MS Filename Batch	DRV-14-C-B 36122 H96K072-17 2	DRV-15-C-S 36123 H96K072-18 2	DRV-15-C-B 36124 H96K081-1 2	CORRING PIPE 36206 H96K082-2 2
77-TCB		11.18	5.14	U(1.31)	32
81-TPCB		U(0.158)	U(0.368)	U(1.31)	U(3.14)
126-PeCB		U(0.363)	U(0.328)	U(1.33)	U(4.48)
127-PePCB		U(0.363)	U(0.328)	U(1.33)	U(4.48)
169-HxPCB		U(0.0258)	U(0.0978)	U(0.482)	U(1.62)

Table 7. Concentrations of Coplanar PCBs in Quality Control Samples

Compound	Field ID Extract ID MS Filename Batch	MB b1 36109 H96K021-3 1	MB b2 36128 H96K072-2 2	CORING PIPE 36206 H96K082-2 2	LCS Spike Level pg/g (a)	LCS b1 36108 H96K021-25 % Recovery	LCS b2 36127 H96K081-4 % Recovery
77-TCB		5.08	3.04	32	100	468 c	450 c
81-TPCB		U(0.367)	U(0.641)	U(3.14)	NA (b)	NA	NA
126-PeCB		U(0.542)	U(1.35)	U(4.48)	100	130	107
127-PePCB		U(0.542)	U(1.35)	U(4.48)	NA	NA	NA
169-HxPCB		U(0.101)	U(0.0255)	U(1.62)	100	122	108

a- LCS Spike concentrations based on typical sample size of 10 g dry sediment
b-NA=Not applicable; compound not spiked
c-High bias for PCB 77 recovery for unknown reason
U= Undetected with instrumental noise based detection limit shown in parentheses

Table 8. Coplanar PCB Matrix Spike Samples Results

Coplanar PCB	Field ID Extract ID MS Filename Batch	DRV-06-C-S 36101 H96K021-16 1	MS,MSD Nominal Spike Level (a)	DRV-06-C-S(MS) 36106 H96K021-21 1	DRV-06-C-S(MSD) 36107 H96K021-22 1	DRV-06-C-S(MS) 36106 H96K021-21 1	DRV-06-C-S(MSD) 36107 H96K021-22 1	Mean	RPD
		pg/g	pg/g	pg/g	pg/g	% Recovery	% Recovery	% Recovery	
77-TCB		664	100	1040	1060	399	404	401	1.3
126-PeCB		28.2	100	129	141	106	115	111	7.6
169-HxPCB		5.02	100	107	114	108	111	110	2.8

Table 8. (Continued)

Coplanar PCB	Field ID Extract ID MS Filename Batch	DRV-12-C-B 36118 H96K072-11 2	MS,MSD Nominal Spike Level (a)	DRV-12-C-B(MS) 36125 H96K081-2 2	DRV-12-C-B(MSD) 36126 H96K081-3 2	DRV-12-C-B(MS) 36125 H96K081-2 2	DRV-12-C-B(MSD) 36126 H96K081-3 2	Mean	RPD
		pg/g	pg/g	pg/g	pg/g	% Recovery	% Recovery	% Recovery	
77-TCB		2.38	100	450	426	450	426	438	5.5
126-PeCB		U(0.856)	100	102	100	102	100	101	2.0
169-HxPCB		U(0.147)	100	101	93.2	101	93.2	97.1	8.0

Table 9. Coplanar PCB's Internal Quantitation Standards Recoveries (%)

Compound	MB b1 36109 H96K021-3	DRV-01-C-S 36091 H96K021-4	DRV-01-C-B 36092 H96K021-5	DRV-02-C-S 36093 H96K021-6	DRV-02-C-B 36094 H96K021-7	DRV-03-C-S 36095 H96K021-8	DRV-03-C-B 36096 H96K021-9	DRV-04-C-S 36097 H96K021-10	DRV-04-C-B 36098 H96K021-11
13C-77-TCB	54.1	70.7	65.8	62.5	85.4	98.6	76.2	86.8	90.1
13C-126-PeCB	58.9	69.0	71.0	61.7	82.2	80.0	66.9	59.8	81.7
13C-169-HxCB	60.6	70.9	75.1	61.4	76.1	74.3	73.2	99.7	81.6

a - J = Recovery outside criteria of 25-130%; high recoveries attributed to suppression of 13C12 1,2,3,4 TCDD recovery standard response due to sulfur interferences even after mercury cleanup

High recoveries for three samples not included in Mean and relative standard deviation (RSD) precision measurements

Table 9 (Continued)

Compound	DRV-05-C-S 36099 H96K021-14	DRV-05-C-B 36100 H96K021-15	DRV-06-C-S 36101 H96K021-16	DRV-06-C-B 36102 H96K021-17	DRV-07-C-S 36103 H96K021-18	DRV-07-C-B 36104 H96K021-19	DRV-08-C-S 36105 H96K021-20	DRV-06-C-S(MS) 36106 H96K021-21
13C-77-TCB	101	99.9	75.3	78.5	57.6	62.9	66.6	33.1
13C-126-PeCB	89.9	83.5	70.1	75.9	55.6	62.9	63.9	32.8
13C-169-HxCB	84.0	71.4	70.6	79.9	54.2	64.5	65.1	31.6

Table 9 (Continued)

Compound	DRV-06-C-S(MSD) 36107 H96K021-22	LCS b1 36108 H96K021-25	MB b2 36128 H96K072-2	DRV-08-C-B 36110 H96K072-3	DRV-09-C-S 36111 H96K072-4	DRV-09-C-B 36112 H96K072-5	DRV-10-C-S 36113 H96K072-6	DRV-10-C-B 36114 H96K072-7
13C-77-TCB	52.4	60.7	60.3	98.3	89.9	80.7	87.3	77.0
13C-126-PeCB	50.3	62.5	61.4	84.7	87.2	80.2	81.9	75.8
13C-169-HxCB	53.4	64.1	66.6	94.5	97.8	84.7	91.2	84.8

Table 9 (Continued)

Compound	DRV-11-C-S 36115 H96K072-8	DRV-11-C-B 36116 H96K072-9	DRV-12-C-S 36117 H96K072-10	DRV-12-C-B 36118 H96K072-11	DRV-13-C-S 36119 H96K072-14	DRV-13-C-B 36120 H96K072-15	DRV-14-C-S 36121 H96K072-16	DRV-14-C-B 36122 H96K072-17
13C-77-TCB	66.4	63.6	106	33.8	311(J)	487(J)	76.3	95.0
13C-126-PeCB	68.8	64.2	102	42.6	267(J)	403(J)	77.3	76.6
13C-169-HxCB	78.8	68.9	107	51.5	294(J)	423(J)	96.1	92.7

Table 9 (Continued)

Compound	DRV-15-C-S 36123 H96K072-18	DRV-15-C-B 36124 H96K081-1	DRV-12-C-B(MS) 36125 H96K081-2	DRV-12-C-B(MSD) 36126 H96K081-3	LCS b2 36127 H96K081-4	CORING PIPE 36206 H96K082-2	Mean	RSD
13C-77-TCB	69.7	302(J)	93.6	79.6	67.0	63.6	74.6	23.8
13C-126-PeCB	70.9	275(J)	89.2	85.3	73.1	64.4	71.2	19.6
13C-169-HxCB	92.3	238(J)	77.6	79.5	69.8	69.1	75.4	20.7

Table 10. Concentrations of PCBs in Sediment Samples (ng/g) Dry Weight

PCB Congener	Field ID	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-B	DRV-04-C-S	DRV-04-C-B	DRV-05-C-S
	Extract ID	36132	36133	36134	36135	36136	36137	36138	36139	36140
	MS File	K12F6.RPT	K12F7.RPT	K13F1.RPT	K13F2.RPT	K13F3.RPT	K13F4.RPT	K13F5.RPT	K13F6.RPT	K13F7.RPT
	% Moisture	34.7	18.4	37.7	34.3	35.1	32.0	35.4	19.7	40.3
	Batch	1	1	1	1	1	1	1	1	1
8 Di		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(9.13 EMPC)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
18 Tri		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
28 Tri		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
37 Tri		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
52 Tetra		4.57	U(2.38)	U(2.46)	U(2.46)	U(3.66 EMPC)	U(2.3)	U(9.66 EMPC)	21.8	U(2.32)
49 Tetra		2.81	U(2.38)	U(2.46)	U(2.46)	U(4.11 EMPC)	U(2.3)	5.45	U(10.7 EMPC)	U(2.32)
47 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(3.72 EMPC)	U(2.3)	U(3.19 EMPC)	6.21	U(2.32)
44 Tetra		U(4.82 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(4.34 EMPC)	U(2.3)	U(8.74 EMPC)	14.4	U(2.32)
42 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(3.45 EMPC)	U(2.3)	U(5.98 EMPC)	12	U(2.32)
64 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(3.29 EMPC)	U(2.3)	U(6.71 EMPC)	U(16.2 EMPC)	U(2.32)
74 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(9.69 EMPC)	U(2.32)
70 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(8.2 EMPC)	U(2.3)	U(2.57 EMPC)	11.8	U(2.32)
66 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(7.41 EMPC)	U(2.3)	U(2.36)	10.6	U(2.32)
80 Tetra		U(3.92 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.95 EMPC)	U(2.3)	U(7.43 EMPC)	10.4	U(2.32)
60 Tetra		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(3.61 EMPC)	U(2.3)	U(6.4 EMPC)	U(12.1 EMPC)	U(2.32)
95 Penta		U(3.67 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.43 EMPC)	U(2.3)	U(3.85 EMPC)	U(8.58 EMPC)	U(2.32)
91 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(3.29 EMPC)	U(2.32)
92 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(3.13 EMPC)	U(2.32)
84/101 Penta		U(8.07 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.99 EMPC)	U(2.3)	U(7.99 EMPC)	13.4	U(2.32)
99 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.41 EMPC)	U(2.3)	2.75	U(5.51 EMPC)	U(2.32)
119 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
97/86 Penta		U(2.53 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	2.56	6.97	U(2.32)
87 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(4.46 EMPC)	U(2.3)	U(3.51 EMPC)	U(6.01 EMPC)	U(2.32)
120 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
110 Penta		U(4.31 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.91 EMPC)	U(2.3)	U(5.91 EMPC)	U(9.45 EMPC)	U(2.32)
82 Penta		U(2.42)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(3.19 EMPC)	U(10.8 EMPC)	U(2.32)
123 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.44 EMPC)
118Penta		U(3.84 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(3.46 EMPC)	U(2.3)	U(5.14 EMPC)	U(15.7 EMPC)	U(2.32)
114 Penta		U(2.64 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(9.07 EMPC)	U(2.32)
105 Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(4.4 EMPC)	U(2.3)	U(2.36)	U(12.8 EMPC)	U(2.32)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 10 (Continued)

PCB Congener	Field ID / Extract ID / MS File	DRV-01-C-S 36132 K12F6.RPT	DRV-01-C-B 36133 K12F7.RPT	DRV-02-C-S 36134 K13F1.RPT	DRV-02-C-B 36135 K13F2.RPT	DRV-03-C-S 36136 K13F3.RPT	DRV-03-C-B 36137 K13F4.RPT	DRV-04-C-S 36138 K13F5.RPT	DRV-04-C-B 36139 K13F6.RPT	DRV-05-C-S 36140 K13F7.RPT
151 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
149 Hexa		3.92	U(2.38)	U(2.46)	U(2.46)	2.56	U(2.3)	4.65	10.2	U(2.32)
146 hexa		U(2.92 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
153 Hexa		2.83	U(2.38)	U(2.46)	U(2.46)	U(3.49 EMPC)	U(2.3)	5.16	9.44	U(3.07 EMPC)
168 hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(4.64 EMPC)	U(2.32)
141 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(4.1 EMPC)	U(3.02 EMPC)	U(2.32)
137 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
138 Hexa		U(4.15 EMPC)	U(2.38)	U(2.46)	U(2.46)	4.03	U(2.3)	U(6.78 EMPC)	13.2	U(2.32)
158 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
166 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(6.15 EMPC)	U(2.32)
128/167 Hexa		U(5.24 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(4.47 EMPC)	U(2.3)	U(3.59 EMPC)	U(8.45 EMPC)	U(2.32)
156 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.97 EMPC)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
157 Hexa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
179 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
187 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	2.77	U(4.59 EMPC)	U(2.32)
183 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
185 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
174 Hepta		U(2.35)	U(2.62 EMPC)	U(2.46)	U(2.46)	U(2.71 EMPC)	U(2.31)	U(2.99 EMPC)	4.46	U(2.32)
177 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
171Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
180 Hepta		U(2.53 EMPC)	U(2.38)	U(2.46)	U(2.46)	2.76	U(2.3)	U(5.41 EMPC)	U(6.33 EMPC)	U(2.32)
191 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
170,190 Hepta		U(4.64 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(3.24 EMPC)	U(5.55 EMPC)	U(2.32)
189 Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(4.12 EMPC)	U(2.32)
200 Octa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
198 Octa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(5.79 EMPC)	U(2.36)	U(5.42 EMPC)	U(7.75 EMPC)
201 Octa		U(5.66 EMPC)	U(2.38)	U(2.49 EMPC)	U(2.46)	U(2.35)	U(6.06 EMPC)	U(2.36)	U(5.67 EMPC)	U(8.11 EMPC)
196,203Octa		U(2.35)	U(2.38)	U(2.46)	U(11.5 EMPC)	U(2.35)	U(7.03 EMPC)	U(6.37 EMPC)	U(8.82 EMPC)	U(6.07 EMPC)
195 Octa		U(4.04 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(3.73 EMPC)	U(4.12 EMPC)	U(2.42)	U(2.32)
194 Octa		U(2.35)	U(3.05 EMPC)	U(2.46)	U(7.61 EMPC)	U(2.35)	U(4.71 EMPC)	U(2.36)	3.18	U(2.32)
205 Octa		U(3.55 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
208 Nona		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.59 EMPC)	U(2.32)
207 Nona		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
206Nona		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	3.12	U(2.32)
209 Deca		U(2.35)	U(2.38)	U(2.46)	U(2.46)	2.63	U(2.3)	U(3.5 EMPC)	U(3.76 EMPC)	U(2.32)
Sum of Congeners		14.1	U(2.38)	U(2.46)	U(2.46)	12.0	U(2.3)	23.3	151	U(2.32)

Table 10 (Continued)

PCB Congener	DRV-05-C-B 36141 K13F8.RPT 39.0 1	DRV-06-C-S 36142 K12F5.RPT 70.8 1	DRV-06-C-B 36143 K13F9.RPT 63.9 1	DRV-07-C-S 36144 K13F10.RPT 69.1 1	DRV-07-C-B 36145 K13F11.RPT 59.7 1	DRV-08-C-S 36146 K13F12.RPT 23.5 1	DRV-08-C-B 36151 K14F7.RPT 22.8 2	DRV-09-C-S 36152 K14F8.RPT 39.0 2	DRV-09-C-B 36153 K14F9.RPT 45.0 2	DRV-10-C-S 36154 K14F10.RPT 43.9 2
8 Di	U(2.2)	U(2.43)	U(4.96)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
18 Tri	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(14.3)	U(2.36)	U(2.27)
28 Tri	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(9.17)	U(2.36)	U(2.27)
37 Tri	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(7.67)	U(2.36)	U(2.27)
52 Tetra	U(2.2)	12.9	U(8.39 EMPC)	U(7.43 EMPC)	U(11 EMPC)	U(2.27)	U(2.46)	U(7.02 EMPC)	U(2.97 EMPC)	U(2.45 EMPC)
49 Tetra	U(2.2)	U(2.43)	U(5.66)	U(2.45)	U(3.22 EMPC)	U(2.27)	U(2.46)	U(4.19 EMPC)	U(2.4 EMPC)	U(2.27)
47 Tetra	U(2.2)	U(2.43)	U(4.75)	U(2.45)	U(2.32)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
44 Tetra	U(2.2)	U(2.43)	U(13.3 EMPC)	U(2.69)	U(3.81 EMPC)	U(2.27)	U(2.46)	U(7.15 EMPC)	U(3.3 EMPC)	U(2.27)
42 Tetra	U(2.2)	U(2.43)	U(6.15)	U(7.55 EMPC)	U(8.02 EMPC)	U(2.27)	U(2.46)	U(2.86 EMPC)	U(2.36)	U(2.27)
64 Tetra	U(2.2)	U(2.43)	U(11.4 EMPC)	U(4.88 EMPC)	U(7.35 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
74 Tetra	U(2.2)	U(2.43)	U(4.35)	U(2.45)	U(15.4 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.75 EMPC)	U(2.27)
70 Tetra	U(2.2)	U(2.43)	U(15.8 EMPC)	U(4.47 EMPC)	U(14.5 EMPC)	U(2.27)	U(2.46)	U(3.39 EMPC)	U(2.36)	U(2.27)
66 Tetra	U(2.2)	U(2.43)	U(7.66 EMPC)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.46 EMPC)	U(2.27)
80 Tetra	U(2.2)	U(2.43)	U(7.47 EMPC)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(4.77 EMPC)	U(2.4 EMPC)	U(2.27)
60 Tetra	U(2.2)	U(2.43)	U(10.2 EMPC)	U(2.45)	U(3.43 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.63 EMPC)	U(2.27)
95 Penta	U(2.2)	5.58	U(6.33 EMPC)	U(3.27)	U(2.92)	U(2.39)	U(2.46)	2.45	U(2.36)	U(2.27)
91 Penta	U(2.2)	U(2.65 EMPC)	U(2.38)	U(2.82)	U(2.53)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
92 Penta	U(2.2)	U(2.43)	U(4.4 EMPC)	U(2.51)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
84/101 Penta	U(2.2)	U(9.49 EMPC)	U(8.09 EMPC)	U(5.22 EMPC)	U(6.11 EMPC)	U(2.27)	U(2.46)	U(3.51 EMPC)	U(2.75 EMPC)	U(2.27)
99 Penta	U(2.2)	3.74	U(3.72 EMPC)	U(2.94 EMPC)	U(3.4 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.47 EMPC)	U(2.27)
119 Penta	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
97/86 Penta	U(2.2)	U(2.43)	U(2.98 EMPC)	U(3.49 EMPC)	U(2.49)	U(2.27)	U(2.46)	U(4.24 EMPC)	U(2.36)	U(2.27)
87 Penta	U(2.2)	U(2.43)	U(2.42)	U(3.07)	U(2.75)	U(2.27)	U(2.46)	U(3.64 EMPC)	U(2.36)	U(2.27)
120 Penta	U(2.2)	U(2.43)	U(4.84 EMPC)	U(2.45)	U(2.4 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
110 Penta	U(2.2)	U(11.1 EMPC)	U(8.04 EMPC)	U(8.99 EMPC)	U(5.76 EMPC)	U(2.27)	U(2.46)	U(3.28 EMPC)	U(2.36)	U(2.27)
82 Penta	U(2.2)	U(5.83 EMPC)	U(4.42 EMPC)	U(3.45)	U(3.08)	U(2.52)	U(2.46)	U(2.41)	U(3.47 EMPC)	U(2.27)
123 Penta	U(2.2)	U(2.43)	U(4.74 EMPC)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
118Penta	U(2.2)	U(13.5 EMPC)	8.48	U(6.55 EMPC)	U(5.09 EMPC)	U(2.27)	U(2.46)	U(2.72 EMPC)	U(3.17 EMPC)	U(3.66 EMPC)
114 Penta	U(2.2)	U(5.66 EMPC)	U(3.34 EMPC)	U(2.82)	U(13.9 EMPC)	U(2.46 EMPC)	U(2.46)	U(3.29 EMPC)	U(6.62 EMPC)	U(3.51 EMPC)
105 Penta	U(2.2)	U(8.04 EMPC)	U(6.9 EMPC)	U(4.92 EMPC)	U(13.3 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(12.8 EMPC)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 10 (Continued)

PCB Congener	DRV-05-C-B 36141 K13F8.RPT	DRV-06-C-S 36142 K12F5.RPT	DRV-06-C-B 36143 K13F9.RPT	DRV-07-C-S 36144 K13F10.RPT	DRV-07-C-B 36145 K13F11.RPT	DRV-08-C-S 36146 K13F12.RPT	DRV-08-C-B 36151 K14F7.RPT	DRV-09-C-S 36152 K14F8.RPT	DRV-09-C-B 36153 K14F9.RPT	DRV-10-C-S 36154 K14F10.RPT
151 Hexa	U(2.2)	U(2.43)	U(3.74 EMPC)	U(4.17 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
149 Hexa	U(2.2)	6.79	6.39	U(5.37 EMPC)	4.43	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
146 hexa	U(2.2)	U(3.28 EMPC)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.47 EMPC)	U(2.36)	U(2.27)
153 Hexa	U(2.2)	8.1	U(8.58 EMPC)	U(4.95 EMPC)	U(4.88 EMPC)	U(2.27)	U(2.46)	3.01	U(2.36)	U(2.27)
168 hexa	U(2.2)	U(2.43)	3.61	U(4.87 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
141 Hexa	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.45 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
137 Hexa	U(2.2)	U(2.43)	U(3.55 EMPC)	U(3.73 EMPC)	U(6.29 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
138 Hexa	U(2.2)	11.9	U(13.1 EMPC)	U(9.69 EMPC)	U(8.43 EMPC)	U(2.27)	U(2.46)	U(3.57 EMPC)	U(2.36)	U(2.27)
158 Hexa	U(2.2)	U(4.07 EMPC)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
166 Hexa	U(2.2)	U(2.43)	U(2.38)	U(2.57 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
128/167 Hexa	U(2.2)	U(10.6 EMPC)	U(11.9 EMPC)	U(9.62 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(3.48 EMPC)	U(2.36)	U(2.27)
156 Hexa	U(2.2)	U(2.43)	U(9.24 EMPC)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
157 Hexa	U(2.2)	U(2.43)	U(6.72 EMPC)	U(2.82 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(3.74 EMPC)	U(3.98 EMPC)
179 Hepta	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
187 Hepta	U(2.2)	3.18	2.93	3.47	U(2.81 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
183 Hepta	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
185 Hepta	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
174 Hepta	U(2.2)	U(5.07 EMPC)	3.58	U(2.53 EMPC)	U(2.98 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
177 Hepta	U(2.2)	U(2.43)	U(2.82 EMPC)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
171Hepta	U(2.2)	U(2.43)	U(2.38)	U(3.75 EMPC)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
180 Hepta	U(2.2)	5.62	4.53	3.7	3.13	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
191 Hepta	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
170,190 Hepta	U(2.2)	5.47	U(2.38)	U(5.1 EMPC)	U(2.7 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
189 Hepta	U(2.2)	U(2.73 EMPC)	U(2.38)	U(2.45)	3.25	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
200 Octa	U(2.2)	U(2.43)	U(2.38)	U(2.81)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
198 Octa	U(2.72 EMPC)	U(2.43)	U(3.39 EMPC)	U(3.93)	U(4.58 EMPC)	U(3.28 EMPC)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
201 Octa	U(2.84 EMPC)	U(2.43)	U(3.55 EMPC)	U(4.12)	U(4.8 EMPC)	U(3.44 EMPC)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
196,203Octa	U(8.95 EMPC)	U(2.43)	U(4.95 EMPC)	U(7.27 EMPC)	U(5.73 EMPC)	U(7.56 EMPC)	U(2.46)	U(2.41)	U(3.04 EMPC)	U(3.38 EMPC)
195 Octa	U(2.5 EMPC)	U(2.43)	U(3.96 EMPC)	U(3.33)	U(2.31)	U(2.27)	U(2.46)	U(3.97 EMPC)	U(2.36)	U(2.27)
194 Octa	U(2.2)	U(2.43)	U(3.63 EMPC)	U(3.73 EMPC)	U(3.15 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.97 EMPC)	U(2.27)
205 Octa	U(2.2)	U(2.43)	U(2.47 EMPC)	U(3.02 EMPC)	2.45	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
208 Nona	U(2.2)	U(3.42 EMPC)	3.15	U(2.45)	U(6.52 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(3.29 EMPC)
207 Nona	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
206Nona	U(2.2)	4.52	U(4.22 EMPC)	4.82	U(11.5 EMPC)	U(2.27)	U(2.46)	U(2.41)	U(2.76 EMPC)	3.9
209 Deca	U(2.2)	6.2	7.14	6.09	6.54	U(2.6 EMPC)	U(2.46)	4.18	3.44	U(7.29 EMPC)
Sum of Congeners	U(2.2)	74.0	39.8	18.1	19.8	U(2.27)	U(2.46)	9.6	3.4	3.9

Table 10 (Continued)

PCB Congener	DRV-10-C-B 36155 K14F11.RPT 51.4 2	DRV-11-C-S 36156 K14F12.RPT 14.7 2	DRV-11-C-B 36157 K14F13.RPT 18.4 2	DRV-12-C-S 36158 K15F1.RPT 48.2 2	DRV-12-C-B 36159 K14F5.RPT 40.0 2	DRV-13-C-S 36160 K15F2.RPT 20.3 2	DRV-13-C-B 36161 K15F3.RPT 17.8 2	DRV-14-C-S 36162 K15F4.RPT 20.4 2	DRV-14-C-B 36163 K15F5.RPT 27.6 2	DRV-15-C-S 36164 K15F6.RPT 20.5 2	DRV-15-C-B 36165 K15F7.RPT 19.9 2
8 Di	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(3.14)	U(2.28)	U(2.42)
18 Tri	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
28 Tri	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
37 Tri	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
52 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
49 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
47 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
44 Tetra	U(6.4 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
42 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
64 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
74 Tetra	U(3.55 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
70 Tetra	U(3.34 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
66 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
80 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
60 Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
95 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
91 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
92 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
84/101 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
99 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
119 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
97/86 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
87 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
120 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
110 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
82 Penta	U(2.48)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
123 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
118Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
114 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
105 Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 10 (Continued)

PCB Congener	DRV-10-C-B 36155 K14F11.RPT	DRV-11-C-S 36156 K14F12.RPT	DRV-11-C-B 36157 K14F13.RPT	DRV-12-C-S 36158 K15F1.RPT	DRV-12-C-B 36159 K14F5.RPT	DRV-13-C-S 36160 K15F2.RPT	DRV-13-C-B 36161 K15F3.RPT	DRV-14-C-S 36162 K15F4.RPT	DRV-14-C-B 36163 K15F5.RPT	DRV-15-C-S 36164 K15F6.RPT	DRV-15-C-B 36165 K15F7.RPT
151 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
149 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
146 hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
153 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
168 hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
141 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
137 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
138 Hexa	U(3.99 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
158 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
166 Hexa	U(2.41 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
128/167 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
156 Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
157 Hexa	U(3.01 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
179 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
187 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
183 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
185 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
174 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
177 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
171Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
180 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
191 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
170,190 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
189 Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
200 Octa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
198 Octa	U(2.4)	U(2.73 EMPC)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
201 Octa	U(2.83 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
196,203Octa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(6.56 EMPC)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
195 Octa	U(2.4)	U(2.47)	U(2.36)	U(2.66 EMPC)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
194 Octa	U(3.54 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
205 Octa	U(2.76 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
208 Nona	3.1	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
207 Nona	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
206Nona	U(5.25 EMPC)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
209 Deca	U(7.39 EMPC)	U(2.7 EMPC)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
Sum of Congeners	3.1	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)

Table 11. Concentrations of PCB Homologs in Sediment Samples (ng/g) Dry Weight Basis

PCB Homolog	Field ID	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-B	DRV-04-C-S	DRV-04-C-B	DRV-05-C-S
	Extract ID	36132	36133	36134	36135	36136	36137	36138	36139	36140
	MS File	K12F6.RPT	K12F7.RPT	K13F1.RPT	K13F2.RPT	K13F3.RPT	K13F4.RPT	K13F5.RPT	K13F6.RPT	K13F7.RPT
	% Moisture	34.7	18.4	37.7	34.3	35.1	32.0	35.4	19.7	40.3
	Batch	1	1	1	1	1	1	1	1	1
Mono		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
Di		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
Tri		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
Tetra		7.38	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	5.45	87.21	U(2.32)
Penta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	5.31	20.37	U(2.32)
Hexa		6.75	U(2.38)	U(2.46)	U(2.46)	6.59	U(2.3)	9.81	32.84	U(2.32)
Hepta		U(2.35)	U(2.38)	U(2.46)	U(2.46)	2.76	U(2.3)	2.77	4.46	U(2.32)
Octa		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	0	3.18	U(2.32)
Nona		U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	0	3.12	U(2.32)
Deca		U(2.35)	U(2.38)	U(2.46)	U(2.46)	2.63	U(2.3)	U(3.5 EMPC)	U(3.76 EMPC)	U(2.32)
Sum of Homologs		14.1	U(2.38)	U(2.46)	U(2.46)	12.0	U(2.3)	23.3	151.2	U(2.32)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 11. (Continued)

PCB Homolog	DRV-05-C-B 36141 K13F8.RPT 39.0 1	DRV-06-C-S 36142 K12F5.RPT 70.8 1	DRV-06-C-B 36143 K13F9.RPT 63.9 1	DRV-07-C-S 36144 K13F10.RPT 69.1 1	DRV-07-C-B 36145 K13F11.RPT 59.7 1	DRV-08-C-S 36146 K13F12.RPT 23.5 1	DRV-08-C-B 36151 K14F7.RPT 22.8 2	DRV-09-C-S 36152 K14F8.RPT 39.0 2	DRV-09-C-B 36153 K14F9.RPT 45.0 2	DRV-10-C-S 36154 K14F10.RPT 43.9 2
Mono	U(2.2)	U(2.43)	U(4.96)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Di	U(2.2)	U(2.43)	U(4.96)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Tri	U(2.2)	U(2.43)	U(2.38)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Tetra	U(2.2)	12.9	U(4.35)	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Penta	U(2.2)	9.32	8.48	U(2.45)	U(2.31)	U(2.27)	U(2.46)	2.45	U(2.36)	U(2.27)
Hexa	U(2.2)	26.79	10	U(2.45)	4.43	U(2.27)	U(2.46)	3.01	U(2.36)	U(2.27)
Hepta	U(2.2)	14.27	11.04	7.17	6.38	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Octa	U(2.2)	U(2.43)	U(2.38)	U(2.81)	2.45	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)
Nona	U(2.2)	4.52	3.15	4.82	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	3.9
Deca	U(2.2)	6.2	7.14	6.09	6.54	U(2.6 EMPC)	U(2.46)	4.18	3.44	U(7.29 EMPC)
Sum of Homologs	U(2.2)	74.0	39.8	18.1	19.8	U(2.27)	U(2.46)	9.6	3.4	3.9

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 11. (Continued)

	DRV-10-C-B	DRV-11-C-S	DRV-11-C-B	DRV-12-C-S	DRV-12-C-B	DRV-13-C-S	DRV-13-C-B	DRV-14-C-S	DRV-14-C-B	DRV-15-C-S	DRV-15-C-B	Coring pipe
PCB	36155	36156	36157	36158	36159	36160	36161	36162	36163	36164	36165	36206
Homolog	K14F11.RPT	K14F12.RPT	K14F13.RPT	K15F1.RPT	K14F5.RPT	K15F2.RPT	K15F3.RPT	K15F4.RPT	K15F5.RPT	K15F6.RPT	K15F7.RPT	K14F6.RPT
	51.4	14.7	18.4	48.2	40.0	20.3	17.8	20.4	27.6	20.5	19.9	NA
	2	2	2	2	2	2	2	2	2	2	2	2
Mono	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Di	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(3.14)	U(2.28)	U(2.42)	U(25)
Tri	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Tetra	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Penta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Hexa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Hepta	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Octa	U(2.4)	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Nona	3.1	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Deca	U(7.39 EMPC)	U(2.7 EMPC)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)
Sum	3.1	U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)	U(25)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 12. Method Blank Quality Control Samples Results

PCB Congener	Field ID	Coring Pipe	Blank Batch 1	Blank Batch 2
	Extract ID	36206	36150	36169
	MS File	K14F6.RPT	K12F1.RPT	K14F1.RPT
	Units	ng/g	ng/g	ng/g
	Batch	2	1	2
8 Di		U(25)	U(2.5)	U(2.5)
18 Tri		U(25)	U(2.5)	U(2.5)
28 Tri		U(25)	U(2.5)	U(2.5)
37 Tri		U(25)	U(2.5)	U(2.5)
52 Tetra		U(25)	U(2.5)	U(2.5)
49 Tetra		U(25)	U(2.5)	U(2.5)
47 Tetra		U(25)	U(2.5)	U(2.5)
44 Tetra		U(25)	U(2.5)	U(2.5)
42 Tetra		U(25)	U(2.5)	U(2.5)
64 Tetra		U(25)	U(2.5)	U(2.5)
74 Tetra		U(25)	U(2.5)	U(2.5)
70 Tetra		U(25)	U(2.5)	U(2.5)
66 Tetra		U(25)	U(2.5)	U(2.5)
80 Tetra		U(25)	U(2.5)	U(2.5)
60 Tetra		U(25)	U(2.5)	U(2.5)
95 Penta		U(25)	U(2.5)	U(2.5)
91 Penta		U(25)	U(2.5)	U(2.5)
92 Penta		U(25)	U(2.5)	U(2.5)
84/101 Penta		U(25)	U(2.5)	U(2.5)
99 Penta		U(25)	U(2.5)	U(2.5)
119 Penta		U(25)	U(2.5)	U(2.5)
97/86 Penta		U(25)	U(2.5)	U(2.5)
87 Penta		U(25)	U(2.5)	U(2.5)
120 Penta		U(25)	U(2.5)	U(2.5)
110 Penta		U(25)	U(2.5)	U(2.5)
82 Penta		U(25)	U(2.5)	U(2.5)
123 Penta		U(25)	U(2.5)	U(2.5)
118Penta		U(25)	U(2.5)	U(2.5)
114 Penta		U(25)	U(2.5)	U(2.5)
105 Penta		U(25)	2.56	U(2.5)
151 Hexa		U(25)	U(2.5)	U(2.5)
149 Hexa		U(25)	U(2.5)	U(2.5)
146 hexa		U(25)	U(2.5)	U(2.5)
153 Hexa		U(25)	U(2.5)	U(2.5)
168 hexa		U(25)	U(2.5)	U(2.5)
141 Hexa		U(25)	U(2.5)	U(2.5)
137 Hexa		U(25)	U(2.5)	U(2.5)
138 Hexa		U(25)	U(2.5)	U(2.5)
158 Hexa		U(25)	U(2.5)	U(2.5)
166 Hexa		U(25)	U(2.5)	U(2.5)
128/167 Hexa		U(25)	3.48	U(2.5)
156 Hexa		U(25)	U(2.5)	U(2.5)
157 Hexa		U(25)	U(2.5)	U(2.5)
179 Hepta		U(25)	U(2.5)	U(2.5)
187 Hepta		U(25)	U(2.5)	U(2.5)

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight

U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

Table 12 (Continued)

PCB Congener	Field ID / Extract ID / MS File	Coring Pipe 36206 K14F6.RPT	Blank Batch 1 36150 K12F1.RPT	Blank Batch 2 36169 K14F1.RPT
183 Hepta		U(25)	U(2.5)	U(2.5)
185 Hepta		U(25)	U(2.5)	U(2.5)
174 Hepta		U(25)	U(2.5)	U(2.5)
177 Hepta		U(25)	U(2.5)	U(2.5)
171Hepta		U(25)	U(2.5)	U(2.5)
180 Hepta		U(25)	U(2.5)	U(2.5)
191 Hepta		U(25)	2.53	U(2.5)
170,190 Hepta		U(25)	6.98	U(2.5)
189 Hepta		U(25)	U(5.36 EMPC)	U(2.5)
200 Octa		U(25)	U(2.5)	U(2.5)
198 Octa		U(25)	2.54	U(2.5)
201 Octa		U(25)	2.66	U(2.5)
196,203Octa		U(41.4 EMPC)	5.13	U(2.5)
195 Octa		U(25)	4.39	U(2.5)
194 Octa		U(25)	5.94	U(2.5)
205 Octa		U(25)	5.98	U(2.5)
208 Nona		U(25)	U(2.5)	U(2.5)
207 Nona		U(25)	2.88	U(2.5)
206Nona		U(25)	U(6.48 EMPC)	U(2.5)
209 Deca		U(25)	5.85	U(2.5)

Table 13. Laboratory Control Spike (LSC) Quality Control Samples Results

PCB Congener	Spike Level ng/g	Field ID Extract ID MS File Units Batch	LCS Bat 1 36149 K12F2.RPT ng/g 1	LCS Bat 2 36168 K14F2.RPT ng/g 2	LCS Bat 1 36149 K12F2.RPT % Recovery 1	LCS Bat 2 36168 K14F2.RPT % Recovery 2	Mean % Recovery	RPD
8 Di	10		6.26	4.15	62.6	41.5	52.1	41
18 Tri	10		7.00	4.75	70	47.5	58.8	38
28 Tri	10		6.77	4.69	67.7	46.9	57.3	36
37 Tri	10		6.13	4.89	61.3	48.9	55.1	23
52 Tetra	10		7.73	4.73	77.3	47.3	62.3	48
49 Tetra	10		6.84	4.5	68.4	45	56.7	41
47 Tetra	10		6.78	4.77	67.8	47.7	57.8	35
44 Tetra	10		7.21	5.08	72.1	50.8	61.5	35
42 Tetra	10		7.14	4.6	71.4	46	58.7	43
64 Tetra	10		6.99	4.98	69.9	49.8	59.9	34
74 Tetra	10		7.17	5.22	71.7	52.2	62.0	31
70 Tetra	10		6.27	5.08	62.7	50.8	56.8	21
66 Tetra	10		6.19	5.84	61.9	58.4	60.2	6
80 Tetra	10		7.92	4.9	79.2	49	64.1	47
60 Tetra	10		7.3	5.57	73	55.7	64.4	27
95 Penta	10		8.39	6.31	83.9	63.1	73.5	28
91 Penta	10		7.88	5.31	78.8	53.1	66.0	39
92 Penta	10		6.51	5.15	65.1	51.5	58.3	23
84/101 Penta	20		14.9	12	74.5	60	67.3	22
99 Penta	10		7.22	5.85	72.2	58.5	65.4	21
119 Penta	10		7.08	5.69	70.8	56.9	63.9	22
97/86 Penta	20		16.1	11.7	80.5	58.5	69.5	32
87 Penta	10		8.84	6.43	88.4	64.3	76.4	32
120 Penta	10		8.93	6.48	89.3	64.8	77.1	32
110 Penta	10		8.95	6.11	89.5	61.1	75.3	38
82 Penta	10		8.62	6.29	86.2	62.9	74.6	31
123 Penta	10		7.39	6.31	73.9	63.1	68.5	16
118Penta	10		7.52	5.39	75.2	53.9	64.6	33
114 Penta	10		8.94	6.04	89.4	60.4	74.9	39
105/127 Penta	20		17.4	13.1	87	65.5	76.3	28
151 Hexa	10		8.3	5.89	83	58.9	71.0	34
149 Hexa	10		8.86	6.4	88.6	64	76.3	32
146 hexa	10		8.88	5.96	88.8	59.6	74.2	39
153 Hexa	10		8.12	6.11	81.2	61.1	71.2	28
168 hexa	10		7.95	5.91	79.5	59.1	69.3	29
141 Hexa	10		8.59	6.34	85.9	63.4	74.7	30
137 Hexa	10		9.48	5.79	94.8	57.9	76.4	48
138 Hexa	10		8.85	8.2	88.5	82	85.3	8
158 Hexa	10		8.78	6.59	87.8	65.9	76.9	28
166 Hexa	10		8.43	5.73	84.3	57.3	70.8	38
128/167 Hexa	20		17.5	12.5	87.5	62.5	75.0	33
156 Hexa	10		8.58	6.98	85.8	69.8	77.8	21
157 Hexa	10		8.87	6.79	88.7	67.9	78.3	27
179 Hepta	10		8.35	5.89	83.5	58.9	71.2	35
187 Hepta	10		9.39	6.71	93.9	67.1	80.5	33
183 Hepta	10		8.62	6.48	86.2	64.8	75.5	28
185 Hepta	10		9.5	6.81	95	68.1	81.6	33
174 Hepta	10		8.44	6.18	84.4	61.8	73.1	31
177 Hepta	10		5.78	3.82	57.8	38.2	48.0	41
171Hepta	10		8.89	6.34	88.9	63.4	76.2	33

Table 13 (Continued)

PCB Congener		Field ID Extract ID Units	LCS Bat 1 36149 ng/g	LCS Bat 2 36168 ng/g	LCS Bat 1 36149 % Recovery	LCS Bat 2 36168 % Recovery	Mean % Recovery	RPD
180 Hepta	10		8.39	6.29	83.9	62.9	73.4	29
191 Hepta	10		9.48	6.59	94.8	65.9	80.4	36
170,190 Hepta	20		18.4	12.9	92	64.5	78.3	35
189 Hepta	10		9.77	6.46	97.7	64.6	81.2	41
200 Octa	10		9.61	7.06	96.1	70.6	83.4	31
198 Octa	10		7.55	4.23	75.5	42.3	58.9	56
201 Octa	10		7.9	2.6	79	26	52.5	101
196,203Octa	20		20.3	8.93	101.5	44.65	73.1	78
195 Octa	10		10.8	8.54	108	85.4	96.7	23
194 Octa	10		8.66	8.84	86.6	88.4	87.5	2
205 Octa	10		10.5	6.89	105	68.9	87.0	42
208 Nona	10		9.38	6.01	93.8	60.1	77.0	44
207 Nona	10		9.89	6.62	98.9	66.2	82.6	40
206Nona	10		10.8	6.19	108	61.9	85.0	54
209 Deca	10		10.6	6.72	106	67.2	86.6	45

Table 14. Matrix Spike Quality Control Samples Results

PCB Congener	Spike Level Dry Basis ng/g	Field ID Extract ID MS File QC Code % Moisture Units	DRV-06-C-S 36142 K12F5.RPT Field Sample 70.8 ng/g	DRV-06-C-S 36147 K12F3.RPT MS Batch 1 71.5 ng/g	DRV-06-C-S 36148 K12F4.RPT MSD Batch 1 72.1 ng/g	DRV-06-C-S 36147 K12F3.RPT MS Batch 1 71.5 % Recovery	DRV-06-C-S 36148 K12F4.RPT MSD Batch 1 72.1 % Recovery	MS,MSD Mean % Recovery	RPD
8 Di	10		U(2.43)	4.17	5.86	41.7	58.6	50.2	34
18 Tri	10		U(2.43)	2.39	6.8	23.9	68	46.0	96
28 Tri	10		U(2.43)	4.01	9.33	40.1	93.3	66.7	80
37 Tri	10		U(2.43)	3.32	6.14	33.2	61.4	47.3	60
52 Tetra	10		12.9	9.53	13	-	-	-	-
49 Tetra	10		U(2.43)	5.61	12.2	56.1	122	89.1	74
47 Tetra	10		U(2.43)	5.35	10.3	53.5	103	78.3	63
44 Tetra	10		U(2.43)	10.7	14.6	107	146	127	31
42 Tetra	10		U(2.43)	5.89	12.7	58.9	127	93.0	73
64 Tetra	10		U(2.43)	6.21	10.6	62.1	106	84.1	52
74 Tetra	10		U(2.43)	5.83	12	58.3	120	89.2	69
70 Tetra	10		U(2.43)	4.73	10.1	47.3	101	74.2	72
66/80 Tetra	20		U(2.43)	9.5	17.6	47.5	88	67.8	60
60 Tetra	10		U(2.43)	6.2	12.2	62	122	92.0	65
95 Penta	10		5.58	3.76	11.5	-	59.2	-	-
91 Penta	10		U(2.65 EMPC)	5.04	8.39	50.4	83.9	67.2	50
92 Penta	10		U(2.43)	4.93	8.23	49.3	82.3	65.8	50
84/101 Penta	20		U(9.49 EMPC)	13.5	25.4	67.5	127	97.3	61
99 Penta	10		3.74	3.23	4.63	-	-	-	-
119 Penta	10		U(2.43)	2.58	8.32	25.8	83.2	54.5	105
97/86 Penta	20		U(2.43)	11.1	18.7	55.5	93.5	75	51
87 Penta	10		U(2.43)	6.56	11.6	65.6	116	90.8	56
120 Penta	10		U(2.43)	3.88	9.2	38.8	92	65.4	81
110 Penta	10		U(11.1 EMPC)	8.1	13.1	81	131	106	47
82 Penta	10		U(5.83 EMPC)	3.95	20.1	39.5	201	120	134
123 Penta	10		U(2.43)	7.41	11.9	74.1	119	96.6	47
118Penta	10		U(13.5 EMPC)	7.68	12.3	76.8	123	99.9	46
114 Penta	10		U(5.66 EMPC)	10.6	12.4	106	124	115	16
105/127 Penta	20		U(8.04 EMPC)	11.2	24.1	56	121	88	73

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight
U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification
"-"= Not calculated; for some PCB congeners, concentration in unspiked sample precluded MS recovery

Table 14 (Continued)

PCB Congener	Spike Level Dry Basis ng/g	Field ID Extract ID QC Code Units	DRV-06-C-S 36142 Field Sample ng/g	DRV-06-C-S 36147 MS Batch 1 ng/g	DRV-06-C-S 36148 MSD Batch 1 ng/g	DRV-06-C-S 36147 MS Batch 1 % Recovery	DRV-06-C-S 36148 MSD Batch 1 % Recovery	MS,MSD Mean % Recovery	RPD
151 Hexa	10		U(2.43)	4.19	9.83	41.9	98.3	70.1	80
149 Hexa	10		6.79	6.75	13.5	-	67.1	-	-
146 hexa	10		U(3.28 EMPC)	3.85	7.4	38.5	74	56.3	63
153 Hexa	10		8.1	6.47	12.5	-	44	-	-
168 hexa	10		U(2.43)	4.77	7.77	47.7	77.7	62.7	48
141 Hexa	10		U(2.43)	4.83	11	48.3	110	79.2	78
137 Hexa	10		U(2.43)	4.69	9.33	46.9	93.3	70.1	66
138 Hexa	10		11.9	7.44	13.8	-	-	-	-
158 Hexa	10		U(4.07 EMPC)	4.26	11.9	42.6	119	80.8	95
166 Hexa	10		U(2.43)	8.21	11	82.1	110	96.1	29
128/167 Hexa	20		U(10.6 EMPC)	11.3	14.1	56.5	70.5	63.5	22
156 Hexa	10		U(2.43)	4.78	10.7	47.8	107	77.4	76
157 Hexa	10		U(2.43)	4.69	10.7	46.9	107	77.0	78
179 Hepta	10		U(2.43)	3.88	7.03	38.8	70.3	54.6	58
187 Hepta	10		3.18	4.27	7.84	10.9	46.6	28.8	124
183 Hepta	10		U(2.43)	3.55	6.69	35.5	66.9	51.2	61
185 Hepta	10		U(2.43)	3.15	5.92	31.5	59.2	45.4	61
174 Hepta	10		U(5.07 EMPC)	4.02	7.43	40.2	74.3	57.3	60
177 Hepta	10		U(2.43)	2.66	5.39	26.6	53.9	40.3	68
171Hepta	10		U(2.43)	3.51	7.61	35.1	76.1	55.6	74
180 Hepta	10		5.62	4.67	9.04	-	34.2	-	-
191 Hepta	10		U(2.43)	3.39	5.54	33.9	55.4	44.7	48
170,190 Hepta	20		5.47	7.27	14	9	42.7	25.8	130
189 Hepta	10		U(2.73 EMPC)	5	6.73	50	67.3	58.7	29
200 Octa	10		U(2.43)	2.82	7.04	28.2	70.4	49.3	86
198 Octa	10		U(2.43)	3.72	7.25	37.2	72.5	54.9	64
201 Octa	10		U(2.43)	3.89	7.59	38.9	75.9	57.4	64
196,203Octa	20		U(2.43)	6.24	13.2	31.2	66	48.6	72
195 Octa	10		U(2.43)	3.78	7.17	37.8	71.7	54.8	62
194 Octa	10		U(2.43)	4.07	8.96	40.7	89.6	65.2	75
205 Octa	10		U(2.43)	3.54	5.66	35.4	56.6	46.0	46
208 Nona	10		U(3.42 EMPC)	3.74	6.71	37.4	67.1	52.3	57
207 Nona	10		U(2.43)	2.71	5.51	27.1	55.1	41.1	68
206Nona	10		4.52	4.66	9.4	1.4	-	-	-
209 Deca	10		6.2	5.99	10.3	-	41	-	-

Table 14 (Continued)

PCB Congener	Spike Level Dry Basis ng/g	Field ID Extract ID MS File QC Code % Moisture Units	DRV-12-C-B 36159 K14F5.RPT Field Sample 40.0 ng/g	DRV-12-C-B 36166 K14F3.RPT MS Batch 2 39.3 ng/g	DRV-12-C-B 36167 K14F4.RPT MSD Batch 2 35.9 ng/g	DRV-12-C-B 36166 K14F3.RPT MS Batch 2 % Recovery	DRV-12-C-B 36167 K14F4.RPT MSD Batch 2 % Recovery	MS,MSD Mean % Recovery	RPD
8 Di	10		U(2.45)	6.02	6.87	60.2	68.7	64.5	13.2
18 Tri	10		U(2.45)	6.88	8.14	68.8	81.4	75.1	16.8
28 Tri	10		U(2.45)	6.42	7.06	64.2	70.6	67.4	9.5
37 Tri	10		U(2.45)	9.13	9.25	91.3	92.5	91.9	1.3
52 Tetra	10		U(2.45)	7.04	7.98	70.4	79.8	75.1	12.5
49 Tetra	10		U(2.45)	6.58	7.5	65.8	75	70.4	13.1
47 Tetra	10		U(2.45)	6.47	7.31	64.7	73.1	68.9	12.2
44 Tetra	10		U(2.45)	7.65	8.19	76.5	81.9	79.2	6.8
42 Tetra	10		U(2.45)	6.54	7.49	65.4	74.9	70.2	13.5
64 Tetra	10		U(2.45)	6.85	7.44	68.5	74.4	71.5	8.3
74 Tetra	10		U(2.45)	7.24	8.31	72.4	83.1	77.8	13.8
70 Tetra	10		U(2.45)	6.77	7.81	67.7	78.1	72.9	14.3
66/80 Tetra	20		U(2.45)	15.4	16.8	77	84	80.5	8.7
60 Tetra	10		U(2.45)	7.41	8.28	74.1	82.8	78.5	11.1
95 Penta	10		U(2.45)	6.9	8.42	69	84.2	76.6	19.8
91 Penta	10		U(2.45)	7.6	8.1	76	81	78.5	6.4
92 Penta	10		U(2.45)	6.53	7.36	65.3	73.6	69.5	12.0
84/101 Penta	20		U(2.45)	15.4	17.8	77	89	83.0	14.5
99 Penta	10		U(2.45)	7.4	8.32	74	83.2	78.6	11.7
119 Penta	10		U(2.45)	7.48	8.65	74.8	86.5	80.7	14.5
97/86 Penta	10		U(2.45)	15.7	16.8	78.5	84.	81.3	6.8
87 Penta	10		U(2.45)	8.3	9.21	83	92.1	87.6	10.4
120 Penta	10		U(2.45)	8.11	9.53	81.1	95.3	88.2	16.1
110 Penta	10		U(2.45)	8.14	8.77	81.4	87.7	84.6	7.5
82 Penta	10		U(2.45)	7.52	8.71	75.2	87.1	81.2	14.7
123 Penta	10		U(2.45)	7.87	9.5	78.7	95	86.9	18.8
118Penta	10		U(2.45)	7.65	7.86	76.5	78.6	77.6	2.7
114 Penta	10		U(2.45)	7.5	9.69	75	96.9	86.0	25.5
105/127 Penta	20		U(2.45)	16.3	18.6	81.5	93	87.3	13.2

U (#)= Compound Not detected. Number in parentheses is the reporting limit based on the lowest calibration standard, adjusted for final volume and dry sample weight

U(# EMPC)= Compound not detected. Value in parentheses is the estimated maxiumum possible concentration (EMPC) for a peak detected at the expected retention time that did not meet the qualitative ion ratio criteria for PCB identification

"-"= Not calculated; for some PCB congeners, concentration in unspiked sample precluded MS recovery

Table 14 (Continued)

PCB Congener	Spike Level Dry Basis ng/g	Field ID Extract ID QC Code Units	DRV-12-C-B 36159 Field Sample ng/g	DRV-12-C-B 36166 MS Batch 2 ng/g	DRV-12-C-B 36167 MSD Batch 2 ng/g	DRV-12-C-B 36166 MS Batch 2 % Recovery	DRV-12-C-B 36167 MSD Batch 2 % Recovery	MS,MSD Mean % Recovery	RPD
151 Hexa	10		U(2.45)	7.66	8.75	76.6	87.5	82.1	13.3
149 Hexa	10		U(2.45)	8.31	9.07	83.1	90.7	86.9	8.7
146 hexa	10		U(2.45)	7.95	9.13	79.5	91.3	85.4	13.8
153 Hexa	10		U(2.45)	7.8	8.58	78	85.8	81.9	9.5
168 hexa	10		U(2.45)	7.71	8.97	77.1	89.7	83.4	15.1
141 Hexa	10		U(2.45)	7.1	8.62	71	86.2	78.6	19.3
137 Hexa	10		U(2.45)	7.45	8.04	74.5	80.4	77.5	7.6
138 Hexa	10		U(2.45)	7.54	8.9	75.4	89	82.2	16.5
158 Hexa	10		U(2.45)	8.37	8.44	83.7	84.4	84.1	0.8
166 Hexa	10		U(2.45)	7.65	8.6	76.5	86	81.3	11.7
128/167 Hexa	20		U(2.45)	16	17.5	80	87.5	83.8	9.0
156 Hexa	10		U(2.45)	7.06	8.2	70.6	82	76.3	14.9
157 Hexa	10		U(2.45)	7.62	9	76.2	90	83.1	16.6
179 Hepta	10		U(2.45)	7.8	8.18	78	81.8	79.9	4.8
187 Hepta	10		U(2.45)	7.37	8.34	73.7	83.4	78.6	12.3
183 Hepta	10		U(2.45)	7.59	8.13	75.9	81.3	78.6	6.9
185 Hepta	10		U(2.45)	7.36	9.28	73.6	92.8	83.2	23.1
174 Hepta	10		U(2.45)	7	8.5	70	85	77.5	19.4
177 Hepta	10		U(2.45)	4.5	5.02	45	50.2	47.6	10.9
171Hepta	10		U(2.45)	6.77	8.57	67.7	85.7	76.7	23.5
180 Hepta	10		U(2.45)	6.54	8.2	65.4	82	73.7	22.5
191 Hepta	10		U(2.45)	7.34	8.55	73.4	85.5	79.5	15.2
170,190 Hepta	20		U(2.45)	15.1	16.2	75.5	81	78.3	7.0
189 Hepta	10		U(2.45)	8.41	9.14	84.1	91.4	87.8	8.3
200 Octa	10		U(2.45)	7.3	8.71	73	87.1	80.1	17.6
198 Octa	10		U(2.45)	8.19	8.91	81.9	89.1	85.5	8.4
201 Octa	10		U(2.45)	6.16	5.72	61.6	57.2	59.4	7.4
196,203Octa	20		U(6.56 EMPC)	15.5	18.8	77.5	94	85.8	19.2
195 Octa	10		U(2.45)	7.6	9.29	76	92.9	84.5	20.0
194 Octa	10		U(2.45)	10.5	8.58	105	85.8	95.4	20.1
205 Octa	10		U(2.45)	9.49	9.6	94.9	96	95.5	1.2
208 Nona	10		U(2.45)	6.63	8.15	66.3	81.5	73.9	20.6
207 Nona	10		U(2.45)	7.8	8.62	78	86.2	82.1	10.0
206Nona	10		U(2.45)	7.86	7.7	78.6	77	77.8	2.1
209 Deca	10		U(2.45)	7.71	8.88	77.1	88.8	83.0	14.1

Table 15. PCB Surrogate Recoveries (%)

PCB Surrogate	Field ID	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-B	DRV-04-C-S	DRV-04-C-B
	Extract ID	36132	36133	36134	36135	36136	36137	36138	36139
	MS File	K12F6.RPT	K12F7.RPT	K13F1.RPT	K13F2.RPT	K13F3.RPT	K13F4.RPT	K13F5.RPT	K13F6.RPT
	Batch No.	1	1	1	1	1	1	1	1
13C6 (3)		96.6	74.3	85.9	81.4	151	78.4	127	74.6
13C12(15)		93.5	76.1	77.1	87.2	77.2	80.1	96.6	80.5
13C12(47)		93.2	80.4	75.8	85.9	71.2	87.1	91.3	80.4
13C12 (138)		105	97.1	84	94.2	68.4	96.4	83.9	73.3
13C12(202)		109	104	89.6	99.8	68	102	84.8	72.2
13C12 (209)		78.4	112	79.1	89.5	55.9	89.1	64.5	54

Ballschmiter Number for PCB Surrogate is shown in parentheses

Table 15 (Continued)

PCB Surrogate	DRV-05-C-S 36140 K13F7.RPT 1	DRV-05-C-B 36141 K13F8.RPT 1	DRV-06-C-S 36142 K12F5.RPT 1	DRV-06-C-B 36143 K13F9.RPT 1	DRV-07-C-S 36144 K13F10.RPT 1	DRV-07-C-B 36145 K13F11.RPT 1	DRV-08-C-S 36146 K13F12.RPT 1	DRV-06-C-S-MS 36147 K12F3.RPT 1	DRV-06-C-S-MSD 36148 K12F4.RPT 1
13C6 (3)	79.1	113	83	91.8	44.4	88.5	65	23	66.1
13C12(15)	82.2	77.6	76.3	92.6	48.5	76.4	66.5	22.4	62.5
13C12(47)	84	81.1	69.3	74.9	53.5	68	75.5	28.5	51.4
13C12 (138)	99.7	89.1	61.1	60.9	57.8	66.1	95.5	27.3	51.5
13C12(202)	106	93.1	55.7	56.6	56.5	61.8	103	26.3	50.1
13C12 (209)	89.1	81.7	39.6	45.3	38.9	46.1	99	20.9	35.3

Ballschmiter Number for PCB Surrogate is shown in parentheses

Table 15 (Continued)

PCB Surrogate	LCS 36149 K12F2.RPT 1	M.Blank 36150 K12F1.RPT 1	DRV-08-C-B 36151 K14F7.RPT 2	DRV-09-C-S 36152 K14F8.RPT 2	DRV-09-C-B 36153 K14F9.RPT 2	DRV-10-C-S 36154 K14F10.RPT 2	DRV-10-C-B 36155 K14F11.RPT 2	DRV-11-C-S 36156 K14F12.RPT 2	DRV-11-C-B 36157 K14F13.RPT 2
13C6 (3)	60.5	60.6	81.4	42.7	134	86.3	92.7	104	113
13C12(15)	58.6	66.5	65.2	40.6	75.2	84.1	76	76.2	74.2
13C12(47)	62.1	62.9	66	39.4	73.1	83	76.9	72	71
13C12 (138)	77.6	76.9	72.4	37.4	74.9	83.9	81.8	86.6	88
13C12(202)	85	86.6	75.9	36.2	76.4	85.4	81.6	93.4	95.9
13C12 (209)	93.9	111	72.4	29.3	55.8	66.9	63.3	97.3	96.3

Ballschmiter Number for PCB Surrogate is shown in parentheses

Table 15 (Continued)

PCB Surrogate	DRV-12-C-S 36158 K15F1.RPT 2	DRV-12-C-B 36159 K14F5.RPT 2	DRV-13-C-S 36160 K15F2.RPT 2	DRV-13-C-B 36161 K15F3.RPT 2	DRV-14-C-S 36162 K15F4.RPT 2	DRV-14-C-B 36163 K15F5.RPT 2	DRV-15-C-S 36164 K15F6.RPT 2	DRV-15-C-B 36165 K15F7.RPT 2	DRV-12-C-B-MS 36166 K14F3.RPT 2
13C6 (3)	66.7	45	69.8	71.1	93.3	67.2	65.2	17	70.5
13C12(15)	52.4	44.6	61.9	59.4	77.2	56	56.8	47.8	62.2
13C12(47)	53	46.6	60	59.7	79.1	63	61.6	58.2	63.9
13C12 (138)	63.2	55.1	77.9	77.1	91.7	73.4	80.8	81.5	74
13C12(202)	63.4	56.4	81.4	82.4	95.6	75.8	84.5	87.1	76.3
13C12 (209)	54.9	57	80	79.3	83.5	68	76.9	88.2	72.4

Ballschmiter Number for PCB Surrogate is shown in parentheses

Table 15 (Continued)

PCB Surrogate	DRV-12-C-B-MSD 36167 K14F4.RPT 2	LCS 36168 K14F2.RPT 2	M.Blank 36169 K14F1.RPT 2	Coring Pipe 36206 K14F6.RPT 2	Mean	RSD
13C6 (3)	88.2	48.7	54.8	60.9	77.4	35.6
13C12(15)	73.2	44.9	50.8	60.7	67.6	23.8
13C12(47)	72.6	45.8	51	55.1	67.4	21.7
13C12 (138)	83.7	57.8	71.5	57.6	75.3	22.3
13C12(202)	85.4	63.1	74.2	57.3	77.9	24.8
13C12 (209)	81.2	66.3	77.6	57.9	70.5	31.1

Ballschmiter Number for PCB Surrogate is shown in parentheses

Appendix A

Sample Receipt Records

SAMPLE RECEIPT CHECKLIST

MRI Project No. 4615

Instructions are on the back of the checklist.
Samples Received by: BTDeal Date: 10/8/96
Airbill No. UPS 0930 6902 191, 6207 Chain-of-Custody No. _____
AIRBILLS STUCK TO COOLERS

Yes/No

Y 1. Is the shipping container intact?
What kind of container is it? 2 COOLERS
Y 2. Chain-of-custody form present? Record number above.
Y 3. Chain-of-custody form properly filled out?
Y 4. Airbill present? Record number above.
N 5. Were samples under some kind of custody seal?
What kind of custody seals were used:
____ a. Bottle sealed?
____ b. Bag sealed?
____ c. Cooler sealed?
____ d. Other? Specify_____
If there are custody seal numbers verify them versus the chain-of-custody form or if they are not on the form, record them on the form or versus the sample number.
NA 6. Were the custody seals intact?
Y 7. All sample containers intact, none broken or leaking?
Y 8. Does the chain-of-custody form or sample inventory indicate the type of sample and the sample container? If not, indicate on the form or below.
Y 9. Ice packs or ice still frozen?
____ If no, are samples still cold? Contact project leader to see if the sample temperature needs to be measured.
Y 10. All samples on chain-of-custody form, sample inventory, or packing list accounted for? Do the actual sample labels or tags match all the paperwork? If not, describe on the form or below any discrepancies by listing the numbers on the containers versus the numbers on the chain-of-custody form.
Y 11. Sample labels permanently affixed? If not, affix the label permanently.
Y 12. Did you sign, date, and complete all areas of every form received with the samples?
Y 13. Did you store samples as indicated by the project leader?
NA 14. Did you indicate where samples are stored on the chain-of-custody form?

COMMENTS AND ANY REMARKS AS SPECIFIED ABOVE:
THE LID ON SAMPLE DRV-15-C-B WAS CRACKED BUT NO SAMPLE WAS LOST. WE WILL USE THE DUPLICATE FOR ANALYSIS. BTD 10-8-96

SAMPLES WERE STORED IN 330-E. BTD 10-8-96

Attach any additional pages needed for comments.

oject ID	Lab Sample ID	Received Date	Sample Description	Field Site ID/ Sample ID	Sampled Date	Sample Tech.	Lab	PO No.	EPA Case/ SAS
15	961738	10/08/96	DRV-01-C-S		10/05/96		MRI		
	Required Analyses: 680V								
	961739	10/08/96	DRV-01-C-B		10/05/96		MRI		
	Required Analyses: 680V								
	961740	10/08/96	DRV-02-C-S		10/05/96		MRI		
	Required Analyses: 680V								
	961741	10/08/96	DRV-02-C-B		10/05/96		MRI		
	Required Analyses: 680V								
	961742	10/08/96	DRV-03-C-S		10/05/96		MRI		
	Required Analyses: 680V								
	961743	10/08/96	DRV-03-C-B		10/05/96		MRI		
	Required Analyses: 680V								
	961744	10/08/96	DRV-04-C-S		10/05/96		MRI		
	Required Analyses: 680V								
	961745	10/08/96	DRV-04-C-B		10/05/96		MRI		
	Required Analyses: 680V								

VERIFIED By BTS 10-8-96

roject ID	Lab Sample ID	Received Date	Sample Description	Field Site ID/ Sample ID	Sampled Date	Sample Tech.	Lab	PO No.	EPA Case/ SAS
15	961746	10/08/96	DRV-05-C-S		10/04/96		MRI		
			Required Analyses: 680V						
	961747	10/08/96	DRV-05-C-B		10/04/96		MRI		
			Required Analyses: 680V						
	961748	10/08/96	DRV-06-C-S		10/03/96		MRI		
			Required Analyses: 680V						
	961749	10/08/96	DRV-06-C-B		10/03/96		MRI		
			Required Analyses: 680V						
	961750	10/08/96	DRV-07-C-S		10/04/96		MRI		
			Required Analyses: 680V						
	961751	10/08/96	DRV-07-C-B		10/04/96		MRI		
			Required Analyses: 680V						
	961752	10/08/96	DRV-08-C-S		10/02/96		MRI		
			Required Analyses: 680V						
	961753	10/08/96	DRV-08-C-B		10/02/96		MRI		
			Required Analyses: 680V						

VERIFIED BY B-Deal 10-8-96

roject ID	Lab Sample ID	Received Date	Sample Description	Field Site ID/ Sample ID	Sampled Date	Sample Tech.	Lab	PO No.	EPA Case/ SAS
515	961754	10/08/96	DRV-09-C-S		10/02/96		MRI		
	Required Analyses: 680V								
	961755	10/08/96	DRV-09-C-B		10/02/96		MRI		
	Required Analyses: 680V								
	961756	10/08/96	DRV-10-C-S		10/02/96		MRI		
	Required Analyses: 680V								
	961757	10/08/96	DRV-10-C-B		10/02/96		MRI		
	Required Analyses: 680V								
	961758	10/08/96	DRV-11-C-S		10/02/96		MRI		
	Required Analyses: 680V								
	961759	10/08/96	DRV-11-C-B		10/02/96		MRI		
	Required Analyses: 680V								
	961760	10/08/96	DRV-12-C-S		10/01/96		MRI		
	Required Analyses: 680V								
	961761	10/08/96	DRV-12-C-B		10/01/96		MRI		
	Required Analyses: 680V								

VERIFIED BY BT 10-8-96

oject ID	Lab Sample ID	Received Date	Sample Description	Field Site ID/ Sample ID	Sampled Date	Sample Tech.	Lab---	PO No.----	EPA Case/ SAS
15	961762	10/08/96	DRV-13-C-S		10/01/96		MRI		
			Required Analyses: 680V						
	961763	10/08/96	DRV-13-C-B		10/01/96		MRI		
			Required Analyses: 680V						
	961764	10/08/96	DRV-14-C-S		10/01/96		MRI		
			Required Analyses: 680V						
	961765	10/08/96	DRV-14-C-B		10/01/96		MRI		
			Required Analyses: 680V						
	961766	10/08/96	DRV-15-C-S		10/01/96		MRI		
			Required Analyses: 680V						
	961767	10/08/96	DRV-15-C-B		10/01/96		MRI		
			Required Analyses: 680V						

VERIFIED BY BTDch 10-8-96

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name:
DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 1 of 1
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description MRF #	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-01-C-S	961738	10/5/96 1019	1	PCB as per	Y
DRV-01-C-S	(Backup)	10/5/96 1019	1	scope of work	Y
DRV-01-C-B	961739	10/5/96 1017	1		Y
DRV-01-C-B	(Backup)	10/5/96 1017	1		Y
DRV-02-C-S	961740	10/5/96 0847	1		Y
DRV-02-C-S	(Backup)	10/5/96 0847			Y
DRV-02-C-B	961741	10/5/96 0845	1		Y
DRV-02-C-B	(Backup)	10/5/96 0845			Y
DRV-03-C-S	961742	10/5/96 0838			Y
DRV-03-C-S	(Backup)	10/5/96 0838	1		Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment: UPS
Date of Shipment: 10/7/96 Airbill No.

Laboratory Name: MRI
Received by: Dorothy Dent Date/Time: 10-8-96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. **Note:** Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10/7/96	1500				

Comments: THERE WERE EVIDENCE TAPE SEALS ON COOLER OR JARS.
10-8-96 BTD

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name:
DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 2 of 6
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-03-C-B	961743	10/5/96 0708	1		Y
DRV-03-C-B	(Backup)	10/5/96 0708	1		Y
DRV-04-C-S	961744	10/5/96 1234	1		Y
DRV-04-C-S	(Backup)	10/5/96 1234			Y
DRV-04-C-B	961745	10/5/96 1234			Y
DRV-04-C-B	(Backup)	10/5/96 1234			Y
DRV-05-C-S	961746	10/4/96 1616			Y
DRV-05-C-S	(Backup)	10/4/96 1616			Y
DRV-05-C-B	961747	10/4/96 1616			Y
DRV-05-C-B	(Backup)	10/4/96 1616			Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment:
Date of Shipment: Airbill No.

Laboratory Name: MRI
Received by: Bradley Ward Date/Time: 10-8-96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. **Note:** Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10/7/96	1500				

Comments:
THERE WERE NO SEALS ON THE COOLER OR SAMPLES. BTC
10-8-96

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name: DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 3 of 6
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-06-C-S	961748	10/3/96 1330	1		Y
DRV-06-C-S	(BackUp)	10/3/96 1330	1		Y
DRV-06-C-B	961749	10/3/96 1330	1		Y
DRV-06-C-B	(BackUp)	10/3/96 1330	1		Y
DRV-07-C-S	961750	10/4/96 1215	1		Y
DRV-07-C-S	(BackUp)	10/4/96 1215	1		Y
DRV-07-C-B	961751	10/4/96 1215	1		Y
DRV-07-C-B	(BackUp)	10/4/96 1215	1		Y
DRV-08-C-S	961752	10/5/96 1430	1		Y
DRV-08-C-S	(BackUp)	10/5/96 1430	1		Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment:
Date of Shipment: Airbill No.

Laboratory Name: MRI
Received by: Bradley Hall Date/Time: 10.8.96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. **Note:** Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10.7.96	1500				

Comments: THERE WERE NO SEALS ON THE COOLER OR THE SAMPLES.

BTO
10-8-96

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name: DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 4 of 6
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description MRI #	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-08-C-B	961753	10/2/96 1630	1		Y
DRV-08-C-B	(Backup)	10/2/96 1630	1		Y
DRV-09-C-S	961754	10/2/96 1401	1		Y
DRV-09-C-S	(Backup)	10/2/96 1401	1		Y
DRV-09-C-B	961755	10/2/96 1401	1		Y
DRV-09-C-B	(Backup)	10/2/96 1401	1		Y
DRV-10-C-S	961756	10/2/96 1033	1		Y
DRV-10-C-S	(Backup)	10/2/96 1033			Y
DRV-10-C-B	961757	10/2/96 1032	1		Y
DRV-10-C-B	(Backup)	10/2/96 1032	1		Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment:
Date of Shipment: Airbill No.

Laboratory Name: MRI
Received by: Bradley Dull Date/Time: 10-8-96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. Note: Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10/7/96	1500				

Comments: THERE WERE NO SEALS ON COOLER OR SAMPLES. BD 10-8-96

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name: DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 5 of 6
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-11-C-S	961758	10/2/96 0742	1		Y
DRV-11-C-S	(BacKup)	10/2/96 0742	1		Y
DRV-11-C-B	961759	10/2/96 0742	1		Y
DRV-11-C-B	(BacKup)	10/2/96 0742	1		Y
DRV-12-C-S	961760	10/1/96 1641			Y
DRV-12-C-S	(BacKup)	10/1/96 1641			Y
DRV-12-C-B	961761	10/1/96 1641			Y
DRV-12-C-B	(BacKup)	10/1/96 1641			Y
DRV-13-C-S	961762	10/1/96 1301			Y
DRV-13-C-S	(BacKup)	10/1/96 1301			Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment:
Date of Shipment: Airbill No.

Laboratory Name: MRI
Received by: Bradley Dail Date/Time: 10-8-96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. **Note:** Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10/7/96	1500				

Comments: THERE WERE NO SEALS ON COOLERS OR SAMPLES. BTJ 10-8-96

CHAIN OF CUSTODY RECORD FOR SAMPLE SHIPMENT

Sampling Firm: VERSAR, Inc.
Address: 9200 Rumsey RD Columbia, MD 21045
Sampling Location/Address/Site Name:
DELAWARE River Navigational Channel
Project No./ID 3353-011 Sheet 6 of 6
Sampled By: NH CB Bottles Supplied by: MRI
NOTE: When samples are received, return this form to sampling firm:
Name: William Burton at the above address.

Sample I.D.	Sample Description	Collection Date/Time	# of Bottles	Analyses Requested	Received Intact
DRV-13-C-B	961763	10/1/96 1301	1		Y
DRV-13-C-B	(BackUp)	10/1/96 1301	1		Y
DRV-14-C-S	961764	10/1/96 1016	1		Y
DRV-14-C-S	(BackUp)	10/1/96 1016	1		Y
DRV-14-C-B	961765	10/1/96 1016	1		Y
DRV-14-C-B	(BackUp)	10/1/96 1016			Y
DRV-15-C-S	961766	10/1/96 0720			Y
DRV-15-C-S	(BackUp)	10/1/96 0720			Y
DRV-15-C-B	961767	10/1/96 0720			Y *
DRV-15-C-B	(BackUp)	10/1/96 0720			Y

Samples packed by: Craig Date: 10/7/96
Cooler/Box Identifier: Method of Shipment:
Date of Shipment: Airbill No.

Laboratory Name: MRI
Received by: Bradley Hill Date/Time: 10-8-96 0945
Seals Intact (Y/N): N Containers Intact (Y/N): Y
If not describe in comments section. **Note:** Laboratory's chain of custody procedures are in effect from receipt through analysis.

SAMPLES RELINQUISHED BY:			SAMPLES RECEIVED BY:			SAMPLES INTACT
Signature	Date	Time	Signature	Date	Time	
[signature]	10/7/96	1500				

Comments: * THERE WAS A CRACK IN THE LID OF DRV-15-C-B, BUT NO SAMPLE LEAKED OUT. WE WILL USE THE DUPLICATE FOR ANALYSIS. BH 10-8-96

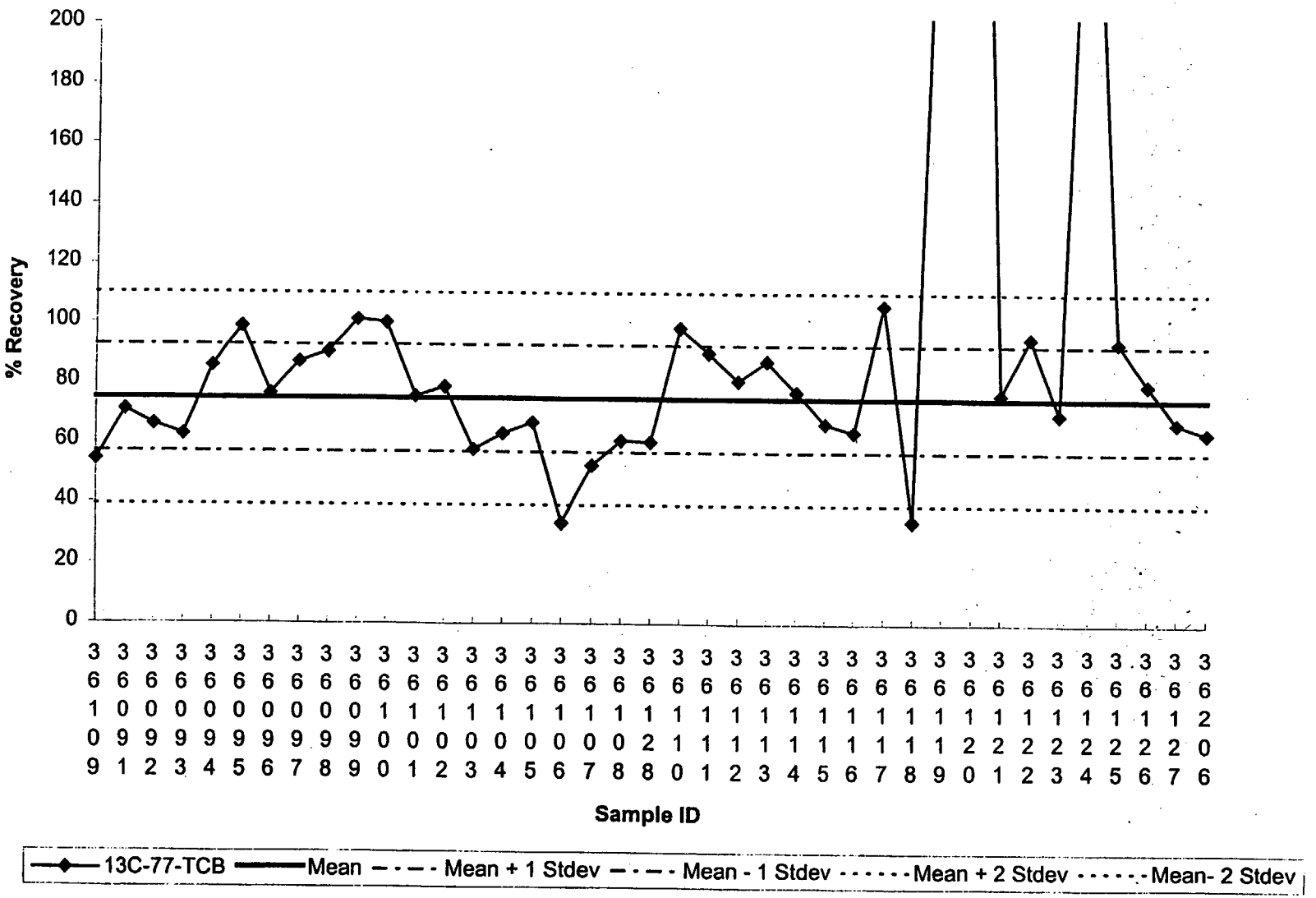
THERE WERE NO SEALS ON COOLERS OR SAMPLES BH 10-8-96

Record#	PROJ_SMPL		SMPL_DESC
503	4615	961738	DRV-01-C-S
504	4615	961739	DRV-01-C-B
505	4615	961740	DRV-02-C-S
506	4615	961741	DRV-02-C-B
507	4615	961742	DRV-03-C-S
508	4615	961743	DRV-03-C-B
509	4615	961744	DRV-04-C-S
510	4615	961745	DRV-04-C-B
511	4615	961746	DRV-05-C-S
512	4615	961747	DRV-05-C-B
513	4615	961748	DRV-06-C-S
514	4615	961749	DRV-06-C-B
515	4615	961750	DRV-07-C-S
516	4615	961751	DRV-07-C-B
517	4615	961752	DRV-08-C-S
518	4615	961753	DRV-08-C-B
519	4615	961754	DRV-09-C-S
520	4615	961755	DRV-09-C-B
521	4615	961756	DRV-10-C-S
522	4615	961757	DRV-10-C-B
523	4615	961758	DRV-11-C-S
524	4615	961759	DRV-11-C-B
525	4615	961760	DRV-12-C-S
526	4615	961761	DRV-12-C-B
527	4615	961762	DRV-13-C-S
528	4615	961763	DRV-13-C-B
529	4615	961764	DRV-14-C-S
530	4615	961765	DRV-14-C-B
531	4615	961766	DRV-15-C-S
532	4615	961767	DRV-15-C-B

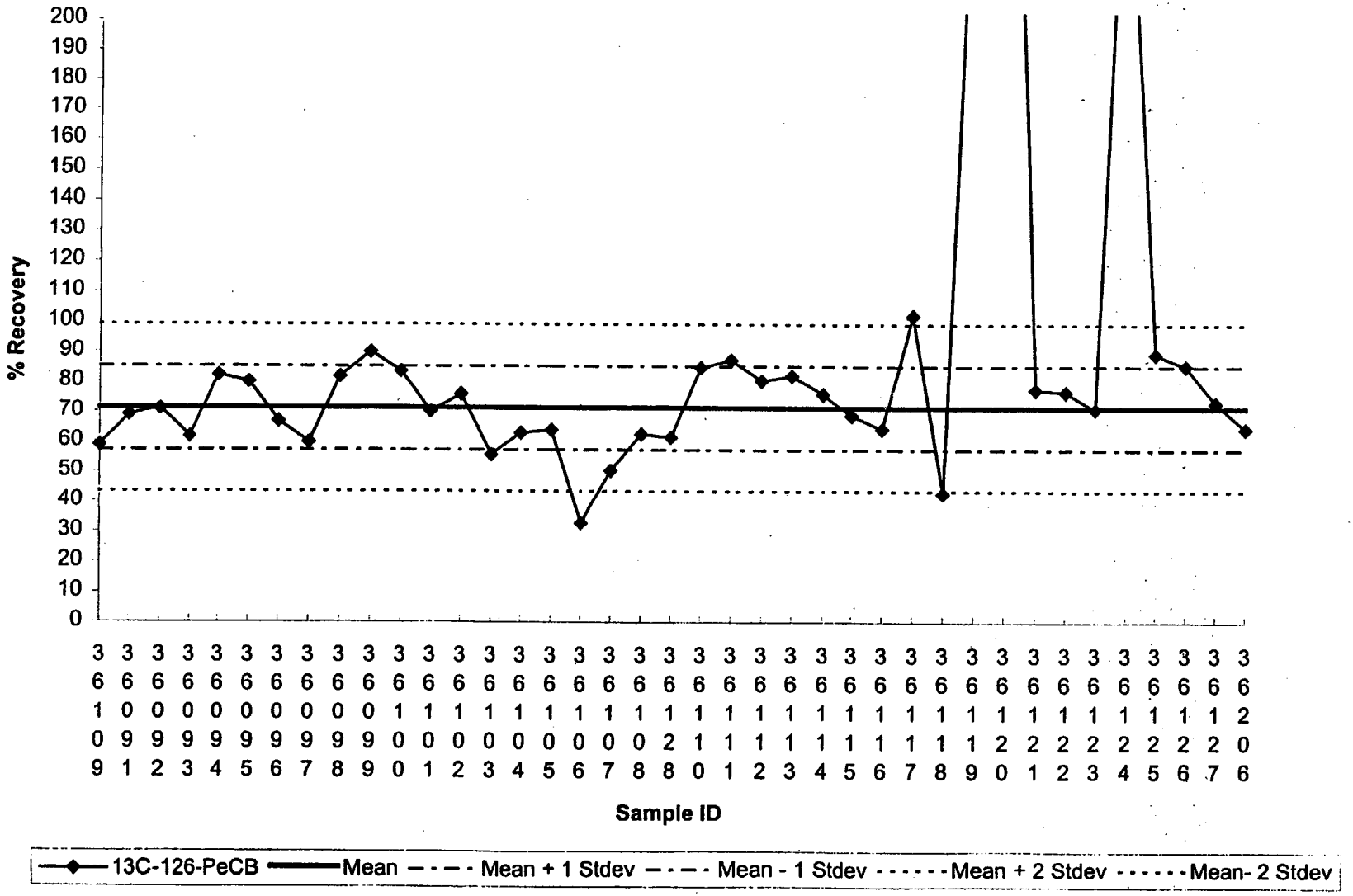
Appendix B

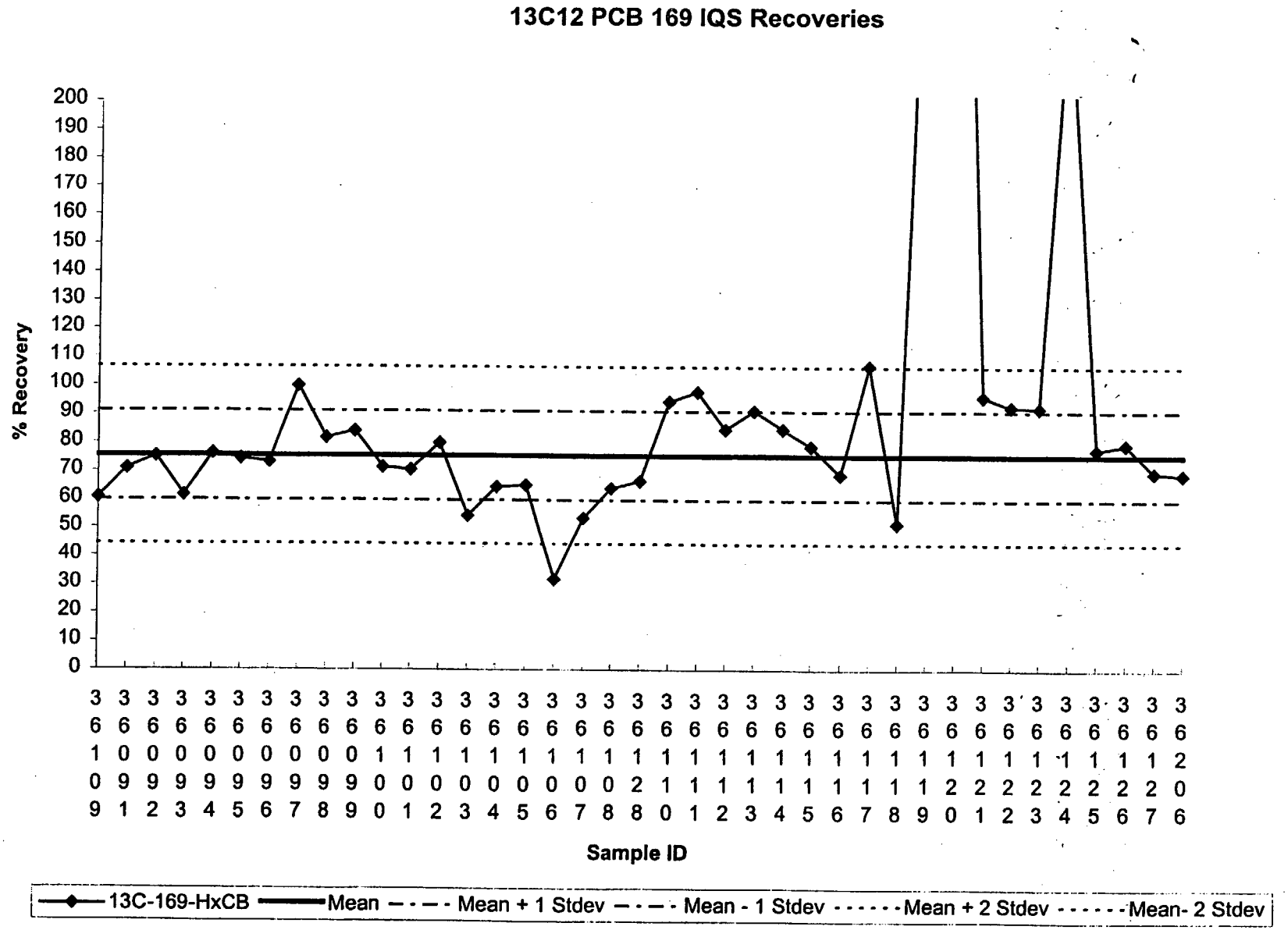
Performance Charts for $^{13}C_{12}$ Coplanar PCB Internal Quantitation Standards

13C12 PCB 77 IQS Recoveries



13C12 PCB 126 IQS Recoveries

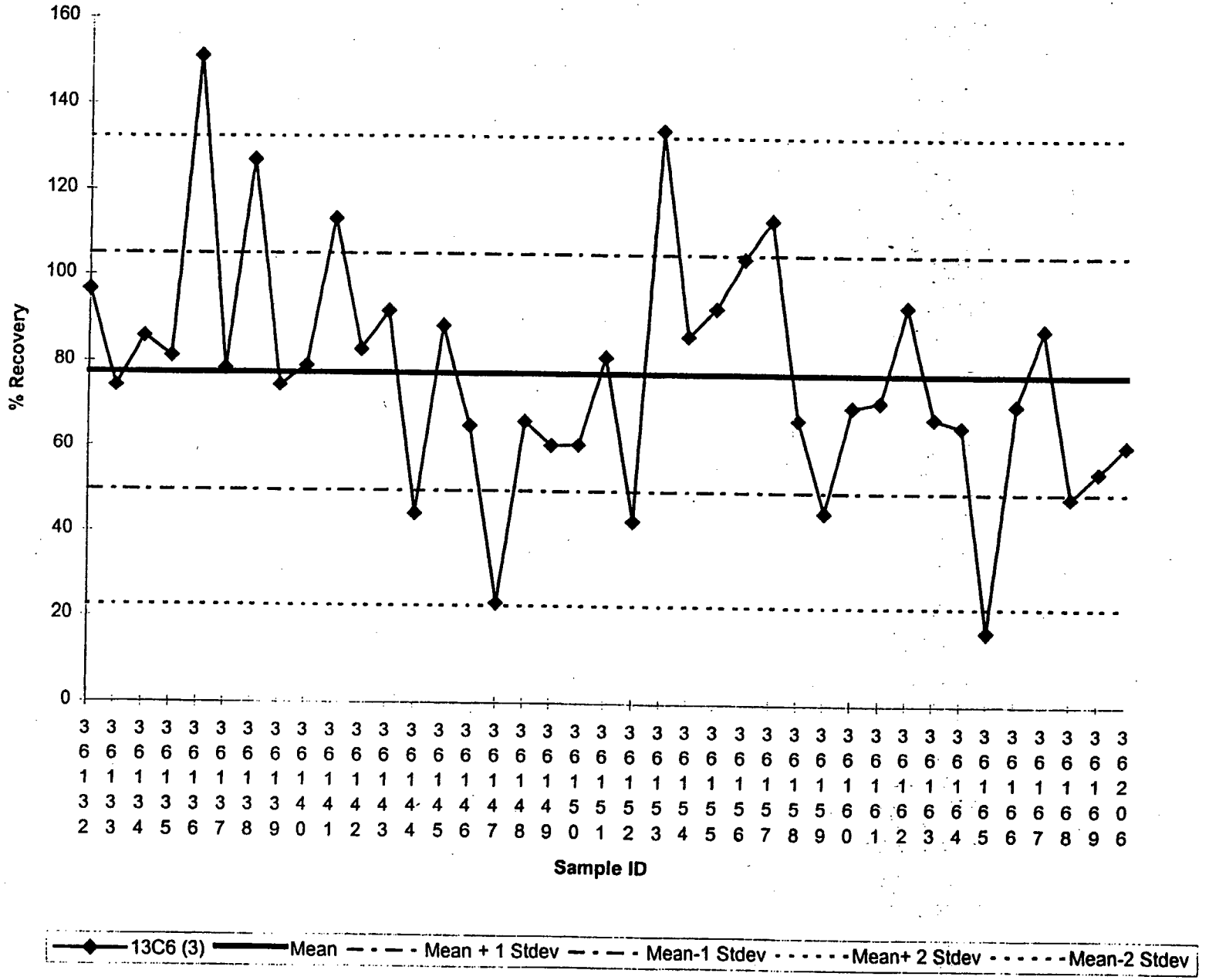



13C12 PCB 169 IQS Recoveries
% Recovery
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
Sample ID
13C-169-HxCB
Mean
Mean + 1 Stdev
Mean - 1 Stdev
Mean + 2 Stdev
Mean- 2 Stdev

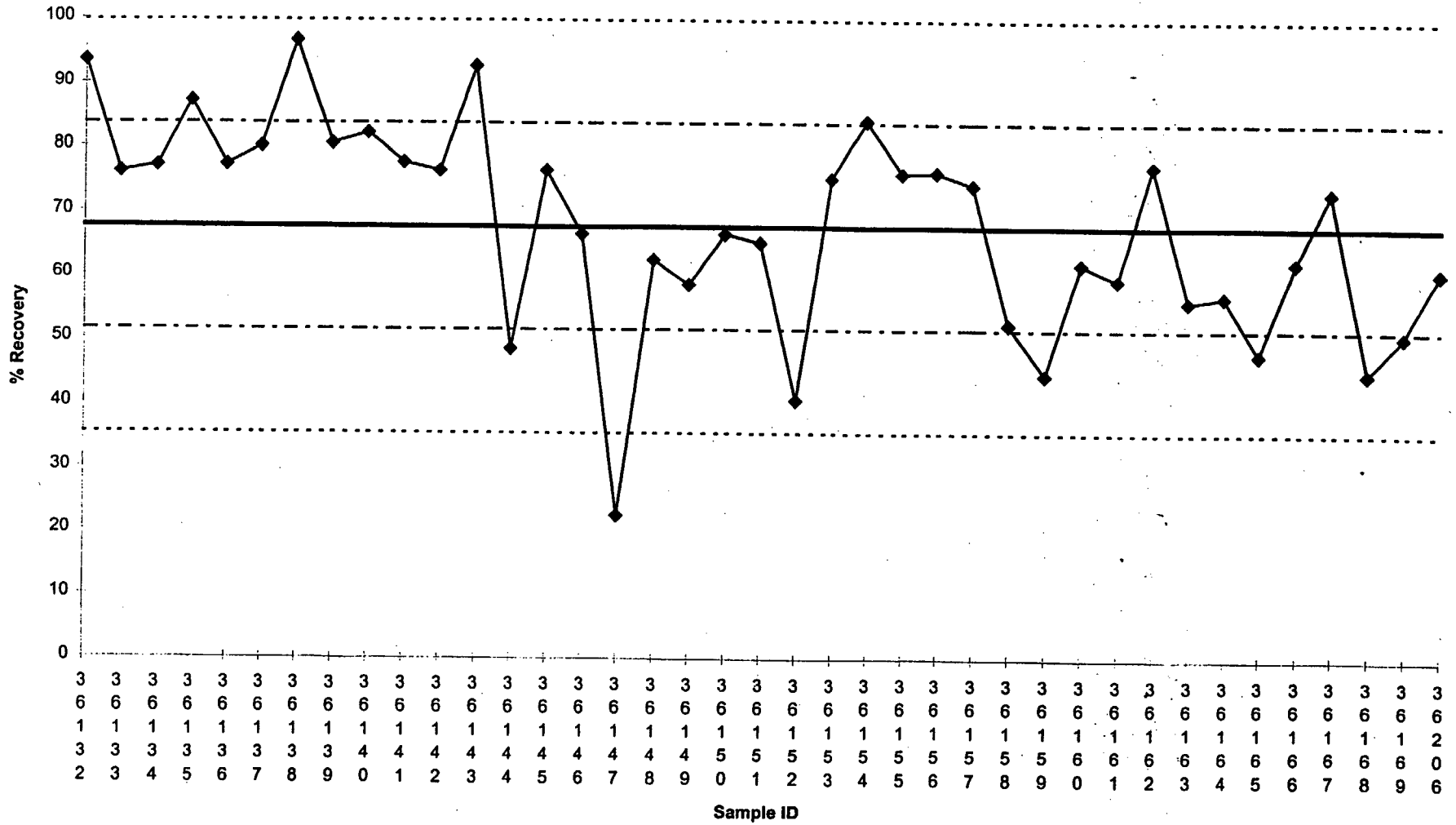
Appendix C

Performance Charts for $^{13}C_{12}$ PCB Surrogate Recoveries

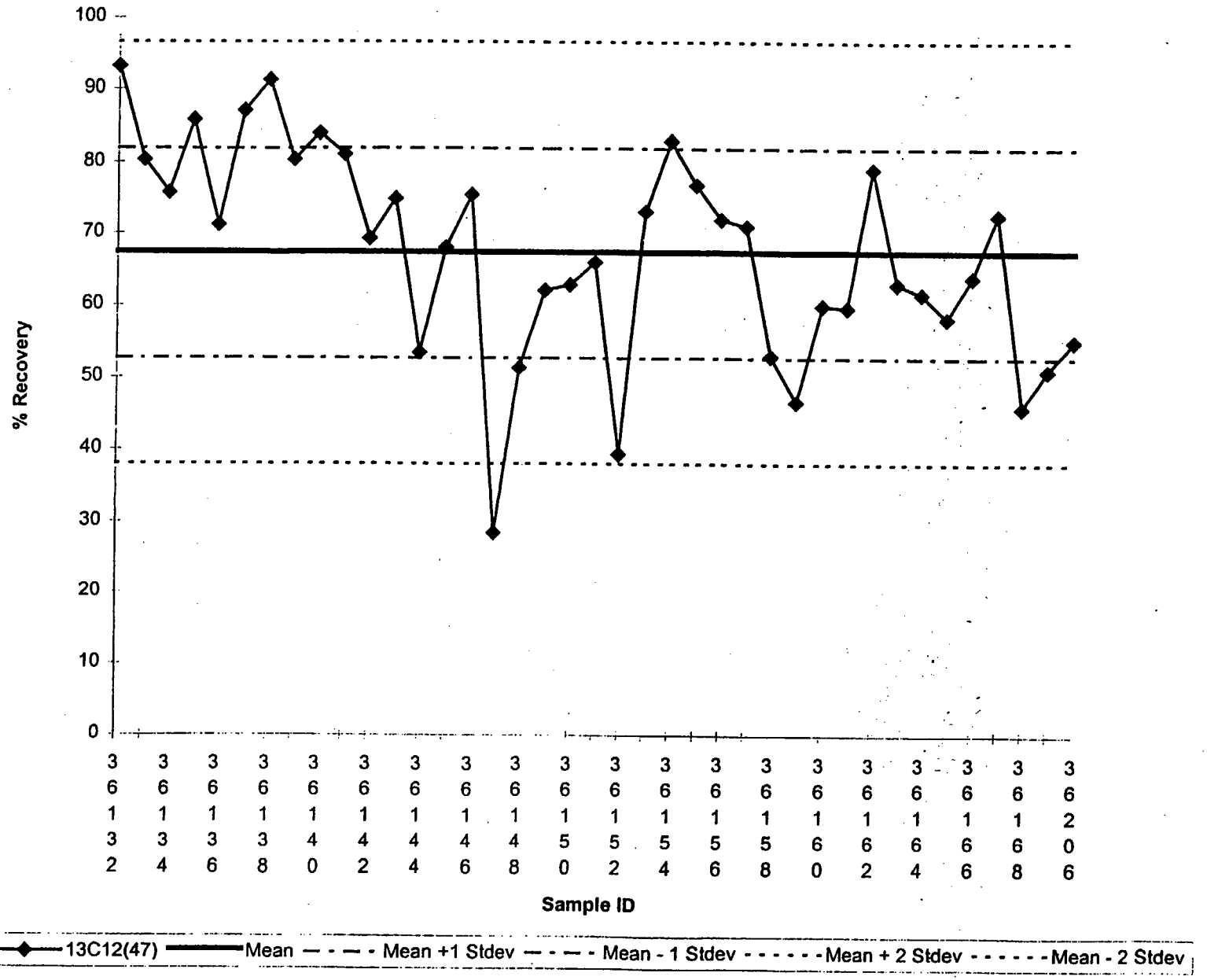
13C6 Mono PCB Surrogate Recoveries

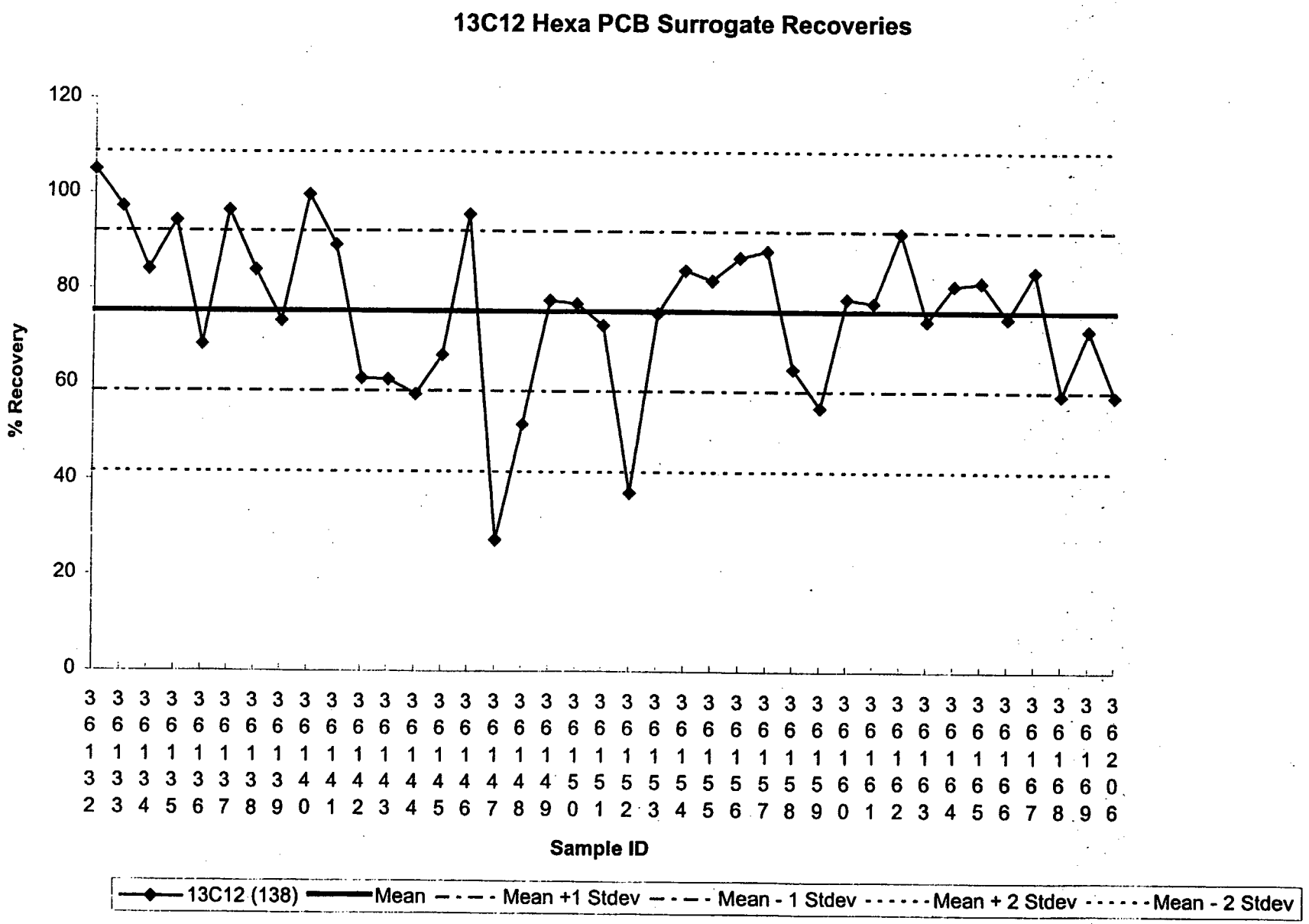


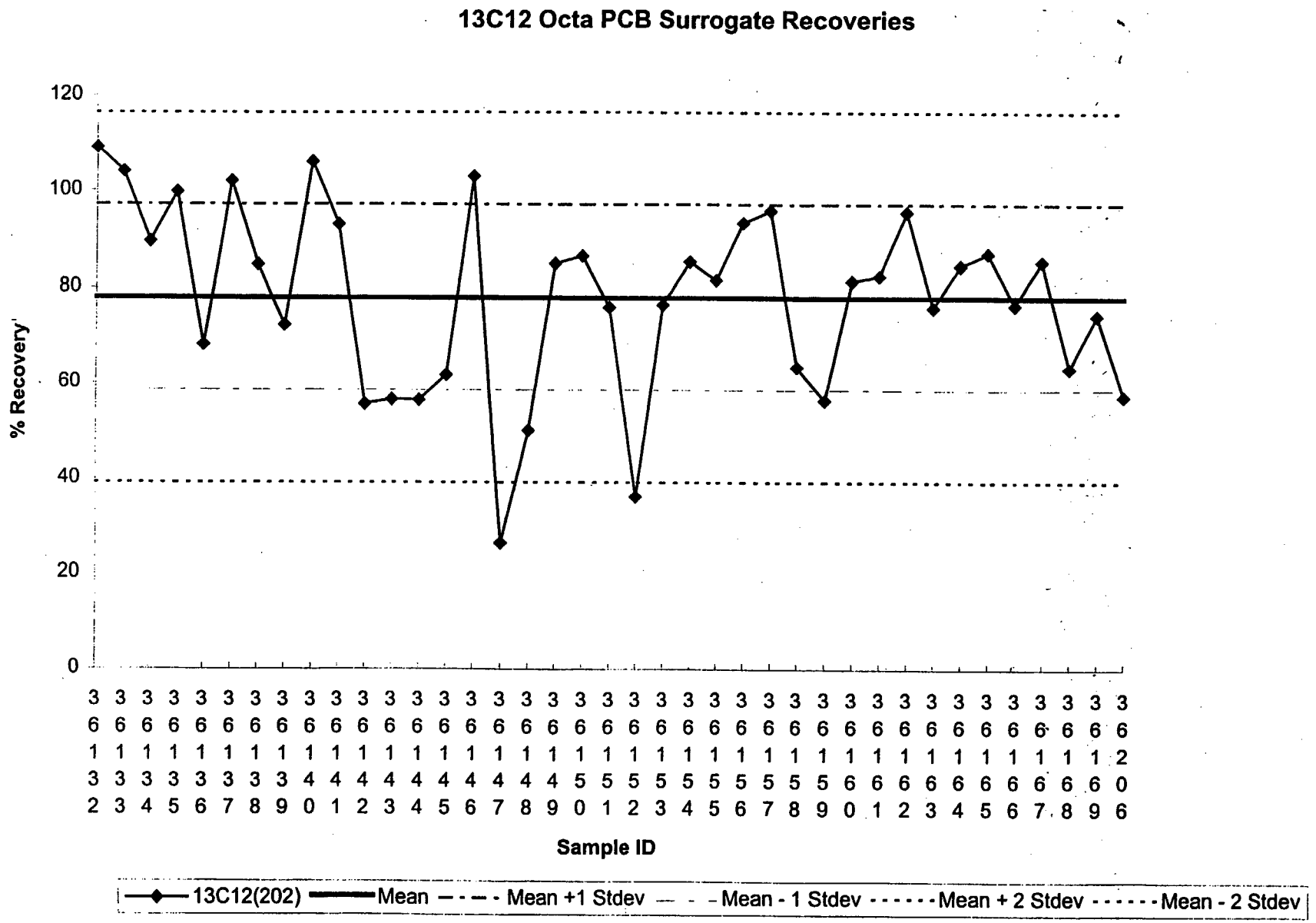
13C12 Di PCB Surrogate Recoveries



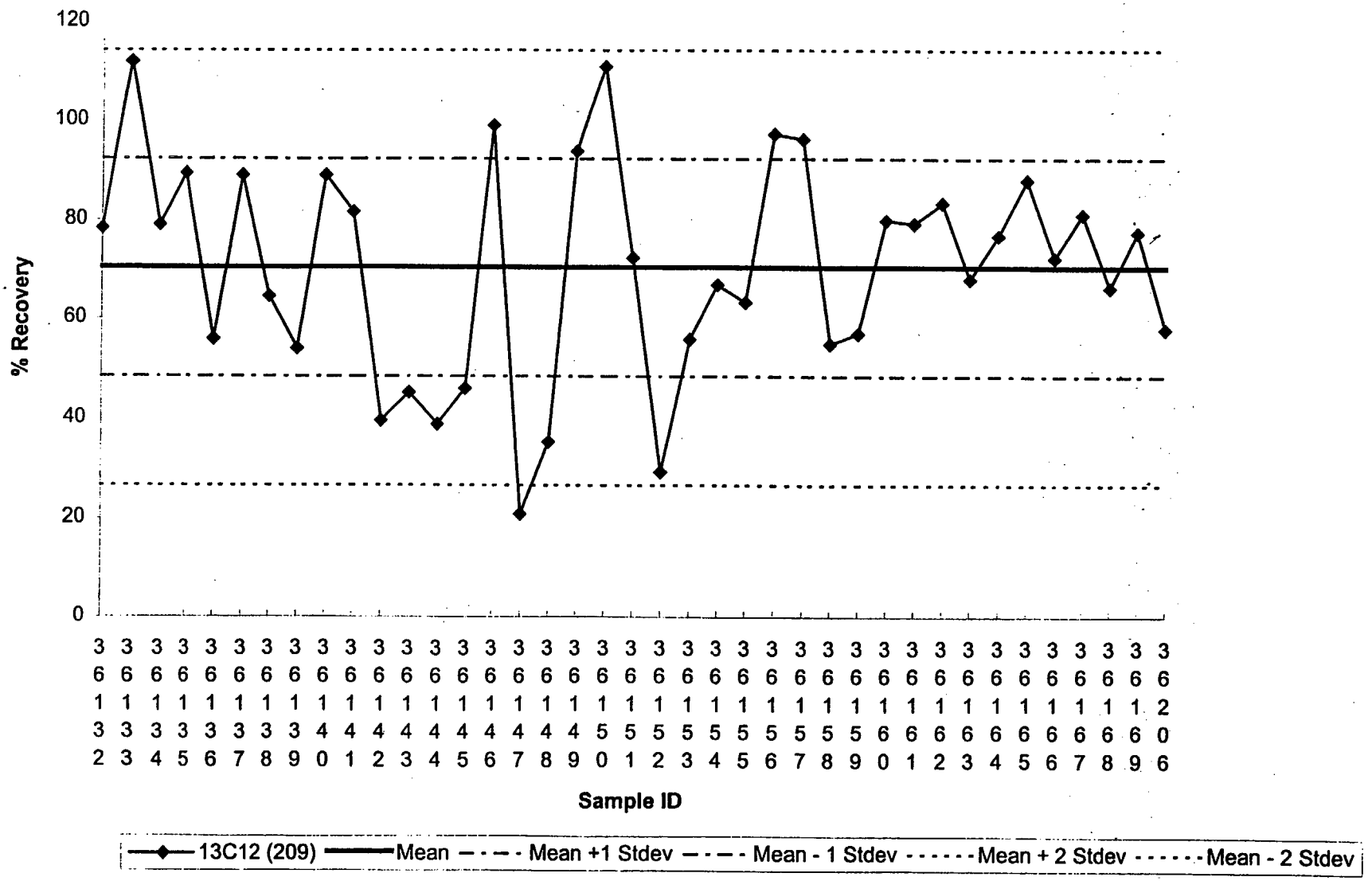
13C12 Tetra PCB Surrogate Recoveries




13C12 Hexa PCB Surrogate Recoveries
120
100
80
60
40
20
0
% Recovery
Sample ID
13C12 (138)
Mean
Mean +1 Stdev
Mean - 1 Stdev
Mean + 2 Stdev
Mean - 2 Stdev


13C12 Octa PCB Surrogate Recoveries
% Recovery
120
100
80
60
40
20
0
Sample ID
13C12(202)
Mean
Mean +1 Stdev
Mean - 1 Stdev
Mean + 2 Stdev
Mean - 2 Stdev

13C12 Deca PCB Surrogate Recoveries



APPENDIX B

DNREC WHITE PAPER - BIOACCUMULATION-BASED SEDIMENT QUALITY CRITERIA FOR THE PROTECTION OF HUMAN HEALTH

BIOACCUMULATION-BASED SEDIMENT QUALITY CRITERIA FOR THE PROTECTION OF HUMAN HEALTH

Prepared by: R. Greene, DNREC, DWR, Watershed Assessment Branch
January, 1997

I. References:

1. R. Greene. 1996. Bioaccumulation-based Sediment Quality Criteria for the Protection of Human Health.
2. EPA. 1996 draft. The National Sediment Quality Survey (EPA-823-D-96-002).
3. EPA. 1997. The Integrated Risk Information System (EPA-600/8-86-032a and b).
4. EPA. 1989. Exposure Factors Handbook (EPA/600/8-89/043).
5. KCA Research Division. 1994. Fish Consumption Patterns of Delaware Recreational Fishermen and their Households.

II. Toxicological and Bioaccumulation Data:

Contaminant	Cancer Potency 1/(mg/kg-d)	Reference Dose (mg/kg-d)	BSAF
Total PCB	2	2E-05	1.85
Total DDT	0.34	0.0005	7.7
Total Chlordane	1.3	6E-05	4.77
Dieldrin	16	5E-05	1.8
Dioxin TEQs	156000		0.025

III. Risk Level and Exposure Factor Assumptions:

Risk Level:	1E-05
GI Adsorption Factor:	1
Reduction for Trimming/Cooking	0

Receptor	Body Weight (kg)	Exposure Duration (yrs)	Lifetime (yrs)	Fish Consumption Rate (kg/d)
General Adult	70	30	75	0.0175
Woman	64	30	75	0.0159
Child (0-6 yrs)	14.5	6	75	0.0059

IV. Bioaccumulation-Based Sediment Quality Criteria (ng/g, ug/kg, or ppb):

Fraction of Organic Carbon: 0.025
Lipid Content of Fish Fillet: 0.02
(Note: Criteria increase as foc increases and as lipid content decreases)

A. Carcinogenic Effects

Contaminant	Average Adult	Women of Child-Bearing Age	Child (0-6 yrs)
Total PCB	33.8	34.0	7.7
Total DDT	47.7	48.0	10.9
Total Chlordane	20.2	20.3	4.6
Dieldrin	4.3	4.4	1.0
Dioxin TEQs	0.032	0.032	0.007

B. Non-Carcinogenic Effects

Contaminant	Average Adult	Women of Child-Bearing Age	Child (0-6 yrs)
Total PCB	54.1	54.4	33.2
Total DDT	324.7	326.7	199.5
Total Chlordane	62.9	63.3	38.6
Dieldrin	138.9	139.8	85.3
Dioxin TEQs	na	na	na

APPENDIX C

DNREC WHITE PATER - SCREENING CALCULATIONS TO DETERMINE ALLOWABLE PCB CONCENTRATIONS AND MASS LOADING FROM DREDGE SPOIL DISPOSAL BASINS

DELAWARE ESTUARY DEEPENING PROJECT

SCREENING CALCULATIONS TO DETERMINE ALLOWABLE PCB CONCENTRATION AND MASS LOADING FROM DREDGE SPOIL DISPOSAL BASINS

JANUARY, 1996

Richard W. Greene
Delaware DNREC, Division of Water Resources
Watershed Assessment Branch

PROBLEM STATEMENT

1. What is the maximum allowable concentration of total PCB in a discharge if an acute aquatic life criterion of 10 ppb on a dissolved basis must be met at the edge of the zone of initial dilution?

2. What is the maximum allowable mass loading of total PCB to Zone 5 of the Delaware Estuary if a chronic aquatic life criterion of 0.03 ppb on a dissolved basis must be met upon complete mix?

ASSUMPTIONS

Assume a range of effluent total suspended solids (TSS) values between 100 mg/l and 500 mg/l and that the dilution at the edge of the zone of initial dilution is 10:1. Also assume that the critical net advective flow in Zone 5 of the Delaware Estuary is 4500 cfs. Further, assume that near-field PCB and TSS concentrations are dominated by the effluent so that background levels of PCB and TSS can be ignored for purposes of evaluating near-field acute effects. Finally, assume that background levels of PCB and TSS away from the immediate influence of the discharge are zero and 20 mg/l, respectively.

NEAR-FIELD ACUTE ANALYSIS

The concentration of total PCB at the edge of the zone of initial dilution (ZID) can be determined by dividing the concentration of total PCB in the effluent by the dilution factor at the edge of the ZID:

$$C_{T_{mix}} = \frac{C_{T_{eff}}}{df} \qquad (1)$$

Similarly, the suspended solids concentration at the edge of the mixing zone can be determined by dividing the TSS level in the effluent by the dilution factor at the edge of the ZID:

$$TSS_{mix} = \frac{TSS_{eff}}{df} \qquad (2)$$

The fraction of PCB at the edge of the ZID which is in the dissolved phase is the ratio between the dissolved PCB concentration and the total (i.e., dissolved + particulate) PCB concentration. This ratio is often expressed in terms of a partition coefficient, K_d, and TSS as follows:

$$f_d = fraction\ dissolved = \frac{C_{d_{mix}}}{C_{T_{mix}}} = \frac{1}{1 + K_d \times TSS_{mix}} \qquad (3)$$

The partition coefficient for total PCB is of the order 10^5 liters per kilogram. Converting this value to units of liters per day, we obtain 0.1 l/mg.

We begin our solution by first solving equation 1 for $C_{T\,eff}$:

$$C_{T_{eff}} = C_{T_{mix}} \times df \tag{4}$$

Next, solve equation 3 for $C_{T\,mix}$:

$$C_{T_{mix}} = C_{d_{mix}} \times [1 + K_d \times TSS_{mix}] \tag{5}$$

Now, substitute equation 5 into equation 4:

$$C_{T_{eff}} = C_{d_{mix}} \times [1 + K_d \times TSS_{mix}] \times df \tag{6}$$

Then substitute equation 2 into equation 6 and simplify:

$$C_{T_{eff}} = C_{d_{mix}} \times [df + K_d \times TSS_{mix}] \tag{7}$$

Finally, set $C_{d\,mix}$ in equation 7 above equal to CMC, which is shorthand notation for the criterion maximum concentration, otherwise known as the acute aquatic life criterion:

$$C_{T_{eff}} = CMC \times [df + K_d \times TSS_{eff}] \tag{8}$$

Substituting CMC = 10 ppb, K_d = 0.1 l/mg, df = 10, and TSS_{eff} equal to a range between 100 mg/l and 500 mg/l into equation 8, the maximum allowable concentration of total PCB in a typical weir overflow, $C_{T\,eff}$, is computed as shown in the table below.

TSS_{eff} (mg/l)	$C_{T\,eff}$ (ppb)
100	200
250	350
500	600

FAR-FIELD CHRONIC ANALYSIS

The concentration of total PCB after complete mixing of a discharge with the net advective flow of an tidal river can be estimated as follows:

$$C_{T_{mix}} = \frac{(C_{T_{eff}} \times Q_{eff}) + (C_b \times Q_r)}{Q_{eff} + Q_r} \qquad (9)$$

, where the variables in the above equation are defined as:

$C_{T\,eff}$ = concentration of total PCB in effluent discharge
Q_{eff} = volumetric flow rate of effluent discharge
C_b = background concentration of total PCB in river
Q_r = net advective flowrate in tidal river

If the background concentration of PCB is small, and if the net advective flow of the river is very large relative to the effluent discharge flow, equation 9 simplifies to:

$$C_{T_{mix}} = \frac{C_{T_{eff}} \times Q_{eff}}{Q_r} \qquad (10)$$

Setting the product in the numerator equal to WLA_c (i.e., the waste load allocation that should not be exceeded in order to avoid chronic aquatic life impacts), and then solving for WLA_c, equation 10 becomes:

$$WLA_c = C_{T_{mix}} \times Q_r \qquad (11)$$

Now, substituting equation 5 into equation 11, we obtain the following expression:

$$WLA_c = C_{d_{mix}} \times [1 + K_d \times TSS_{mix}] \times Q_r \qquad (12)$$

This time, however, we let TSS_{mix} be approximated by the background TSS concentration in the tidal river away from the immediate vicinity of any discharges, which we have assumed to be equal to 20 mg/l.

The final step in the formulation is to set $C_{d\,mix}$ in equation 12 equal to the chronic aquatic life criterion, which is abbreviated as CCC. Making this substitution, the final equation used to compute the maximum allowable mass loading of PCB to Zone 5 of the Delaware Estuary is as follows:

$$WLA_c = CCC \times [1 + K_d \times TSS_{mix}] \times Q_r \qquad (13)$$

Substituting CCC = 0.03 ppb, K_d = 0.1 l/mg, TSS_{mix} = 20 mg/l, and Q_r = 4500 cfs into equation 13 above and making the proper unit conversions, WLA_c is computed as 1 kg/d, which is approximately equal to 2.2 pounds per day. This is the total PCB mass loading that can discharged into Zone 5 of the Delaware Estuary during critical flow conditions without risking chronic aquatic life impacts. This is a cumulative loading from all spoils sites combined.

In order to evaluate the feasibility of meeting this mass loading cap, you can divide the load by the effluent concentrations derived under the acute analysis to determine a volumetric flowrate. If the flowrate is very small, it would mean that it may be difficult to meet the mass loading requirements. Conversely, a high flowrate would equate to ease in meeting the loading requirement. The results of this calculation appear in the table that follows.

$C_{T,eff}$ (ppb)	Q_{eff} (gal/d)
200	1320
350	760
600	440

The above effluent flows are quite small and might suggest that it would be very difficult to meet the mass loading cap of 2.2 #/d for Zone 5. However, this projection assumes that the effluent PCB concentrations in the overflows from the spoil basins are no better than 200 to 600 ppb. If, however, the basins perform more like what we saw in the case of the Wilmington Harbor dredging project (e.g., total PCB levels in the effluent of, say, 0.0004 ppb), then the corresponding flowrate balloons to 660 million gallons per day (MGD). It would be hard to imagine that the combined volumetric flowrate from the basins could ever approach this magnitude, (which is of the same order as the flowrate of all NPDES discharges to the Estuary combined). The bottom line is that I would expect the mass loading cap of 2.2 #/d to be met without much difficulty.

SUMMARY

Based upon the simplified analysis presented above, there appears to be little to no appreciable risk of acute or chronic aquatic life impacts due to PCB release from dredge spoil sites in the Delaware Estuary. Health risks to potential human receptors were not addressed within the above analysis and may represent a more critical consideration than the ecological risks.

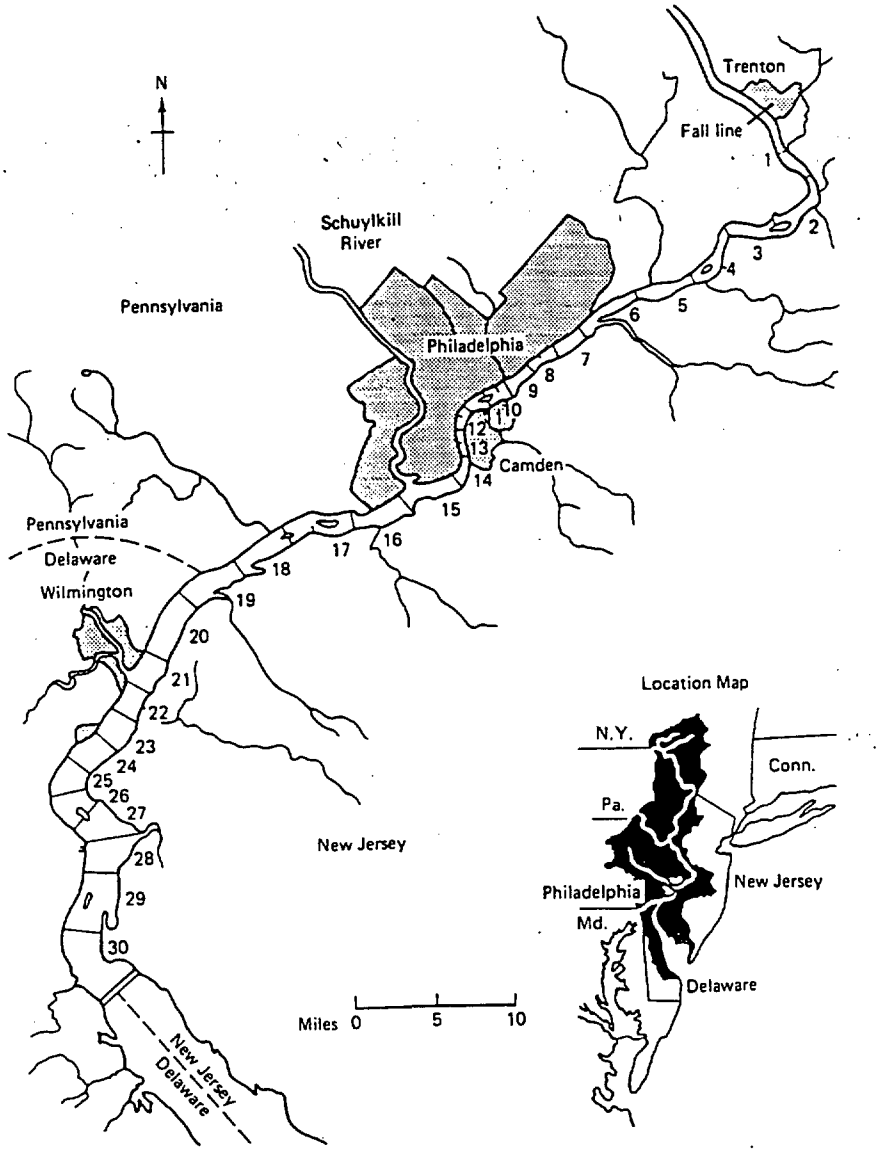


Figure 6.26 Finite segment model of Delaware Estuary. From Thomann (1972).

It should be noted that for the finite segment approach, there is no distinction between point and distributed sources or sinks. Thus for DO deficit inputs such as SOD (see Eq. 6.49) that are expressed in $g/m^2 \cdot day$, the input for the finite section model is

$$S_b(\text{lb/day}) = \frac{S_b(\text{g/m}^2 \cdot \text{day})}{H(m)} V(\text{MG})\ (8.34)\ (\text{lb/MG-mg/l})$$

TABLE 6.8 SYSTEM PARAMETERS FOR DELAWARE ESTUARY (inflow at Trenton = 3000 cfs)

Section	Length (ft)	Volume (10^6 ft^3)	Average tidal velocity (ft/hr)	Cross-sectional area, i, $i+1$ (10^3 ft^2)	Freshwater flow, i, $i+1$ (cfs)	Dispersion coefficient i, $i+1$ (smpd)	Decay coefficient (day^{-1})	Reaeration coefficient (day^{-1})
0	—	—	—	6.5	3000	4.0	—	—
1	21,000	242	1500	15.8	3040	4.0	0.40	0.31
2	20,000	364	1500	21.4	3140	4.0	0.40	0.23
3	20,000	460	1500	24.6	3150	4.0	0.40	0.18
4	20,000	532	1500	28.5	3180	4.0	0.40	0.20
5	20,000	636	2000	34.1	3220	4.0	0.40	0.20
6	20,000	756	2000	41.4	3420	4.0	0.40	0.25
7	10,000	455	2000	49.6	3150	4.0	0.40	0.20
8	10,000	504	2000	51.2	3170	5.0	0.40	0.19
9	10,000	533	2000	55.4	3180	5.0	0.40	0.23
10	10,000	582	2000	60.9	3390	5.0	0.40	0.16
11	10,000	630	2500	65.0	3420	5.0	0.40	0.18
12	10,000	655	2500	66.0	3420	5.0	0.40	0.10
13	10,000	694	2500	72.7	3470	5.0	0.40	0.09
14	10,000	805	2500	88.3	3660	5.0	0.40	0.11
15	20,000	1860	2500	98.0	4060	5.0	0.40	0.11
16	20,000	2030	3000	104.9	4250	5.0	0.40	0.13
17	20,000	2184	3000	113.4	4380	5.0	0.40	0.13
18	20,000	2396	3000	126.3	4440	5.0	0.40	0.13
19	20,000	2692	3000	142.8	4460	5.0	0.40	0.13
20	20,000	2932	3000	150.4	4460	5.0	0.40	0.13
21	10,000	1512	3500	151.9	4650	5.0	0.40	0.13
22	10,000	1574	3500	162.9	4650	5.0	0.40	0.13
23	10,000	1698	3500	176.8	4660	5.0	0.40	0.18
24	10,000	1792	3500	181.7	4660	7.0	0.40	0.18
25	10,000	1850	3500	188.4	4660	7.0	0.40	0.28
26	10,000	1924	4000	196.4	4670	7.0	0.40	0.38
27	10,000	2054	4000	214.5	4670	7.0	0.40	0.35
28	10,000	2248	4000	235.0	4720	7.0	0.40	0.35
29	20,000	4896	4000	254.5	4750	7.0	0.40	0.25
30	20,000	5620	4000	307.4	4780	7.0	0.40	0.24

Source: From Thomann (1972).

PRINCIPLES OF SURFACE WATER QUALITY MODELING AND CONTROL

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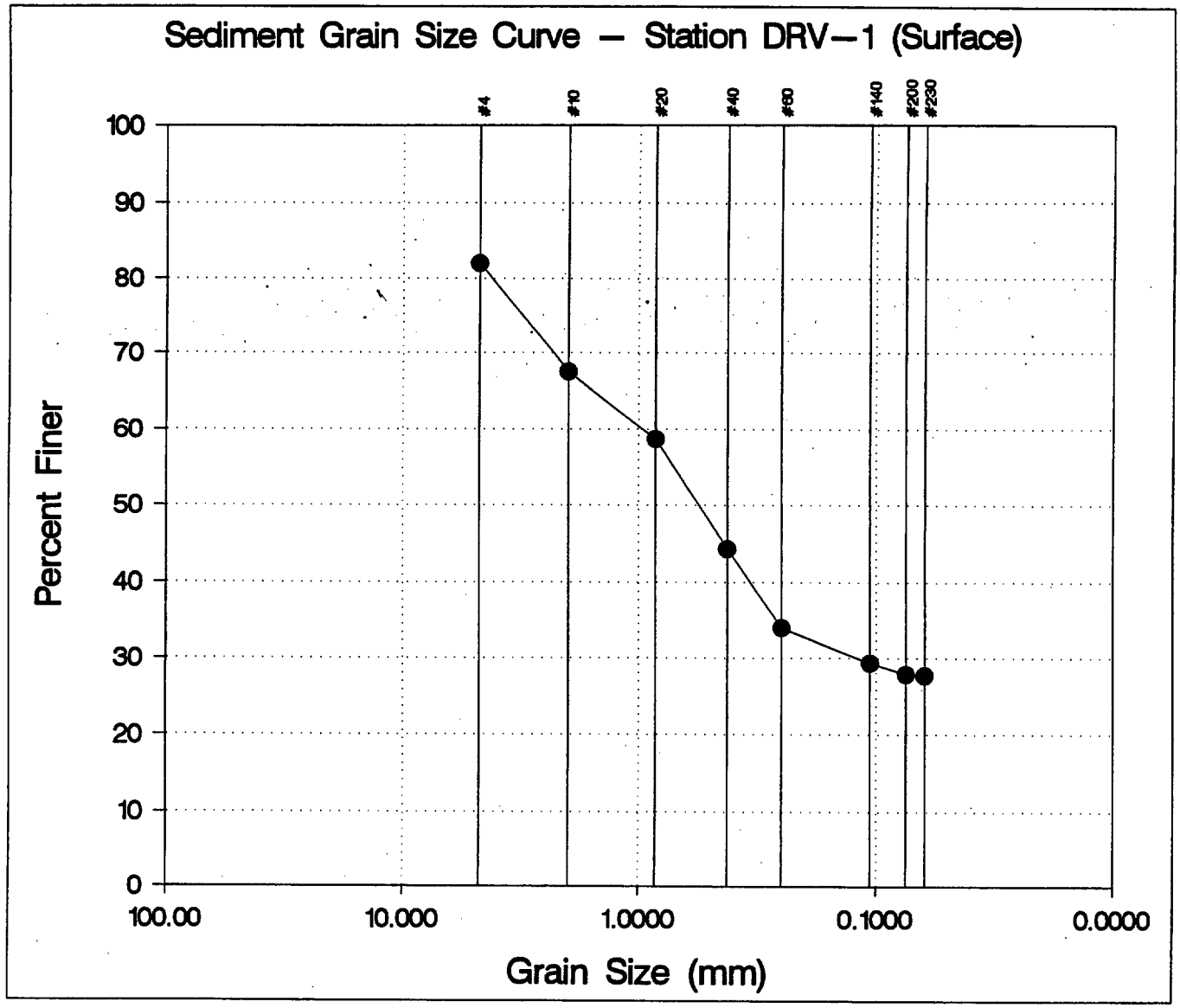
Manhattan College

HARPER & ROW, PUBLISHERS, New York
Cambridge, Philadelphia, San Francisco, Washington,
London, Mexico City, São Paulo, Singapore, Sydney

APPENDIX D

SEDIMENT GRAIN SIZE CURVES


Sediment Grain Size Curve — Station DRV—1 (Surface)
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#20
#40
#60
#140
#200
#230
100
90
80
70
60
50
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20
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Percent Finer
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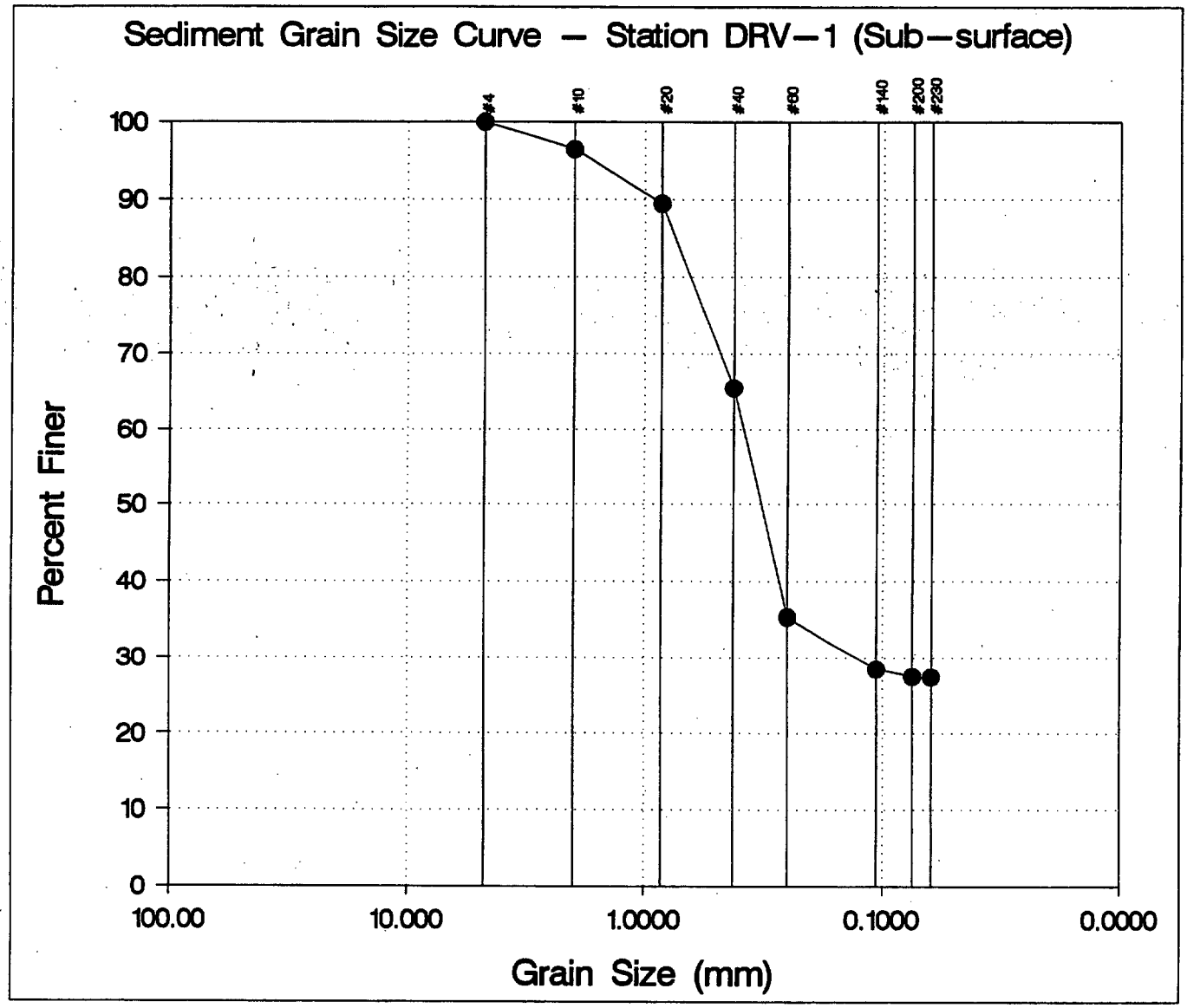
Grain Size (mm)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#40
#60
#140
#200
#230
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Percent Finer
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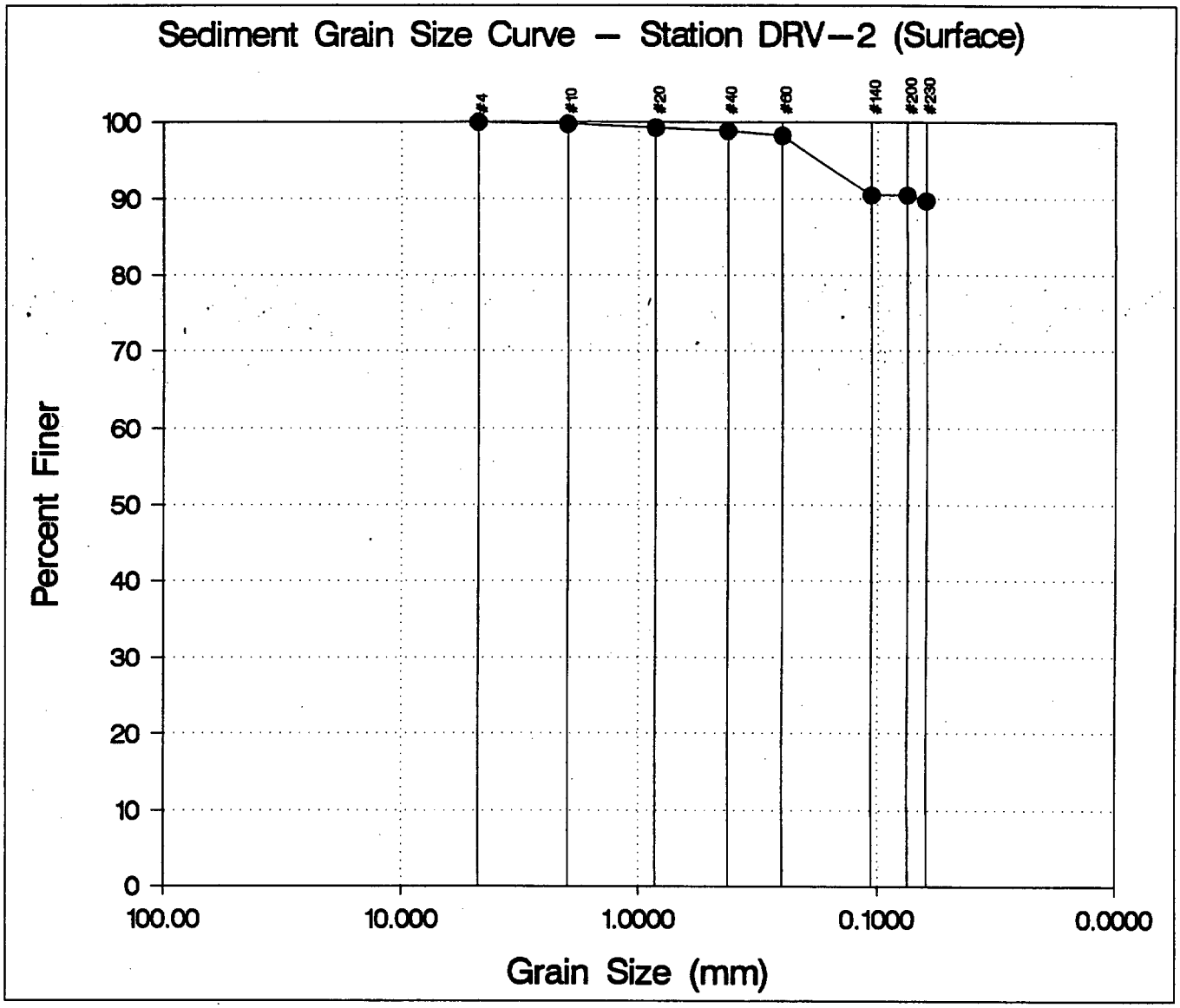
Grain Size (mm)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#60
#140
#200
#230
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Percent Finer
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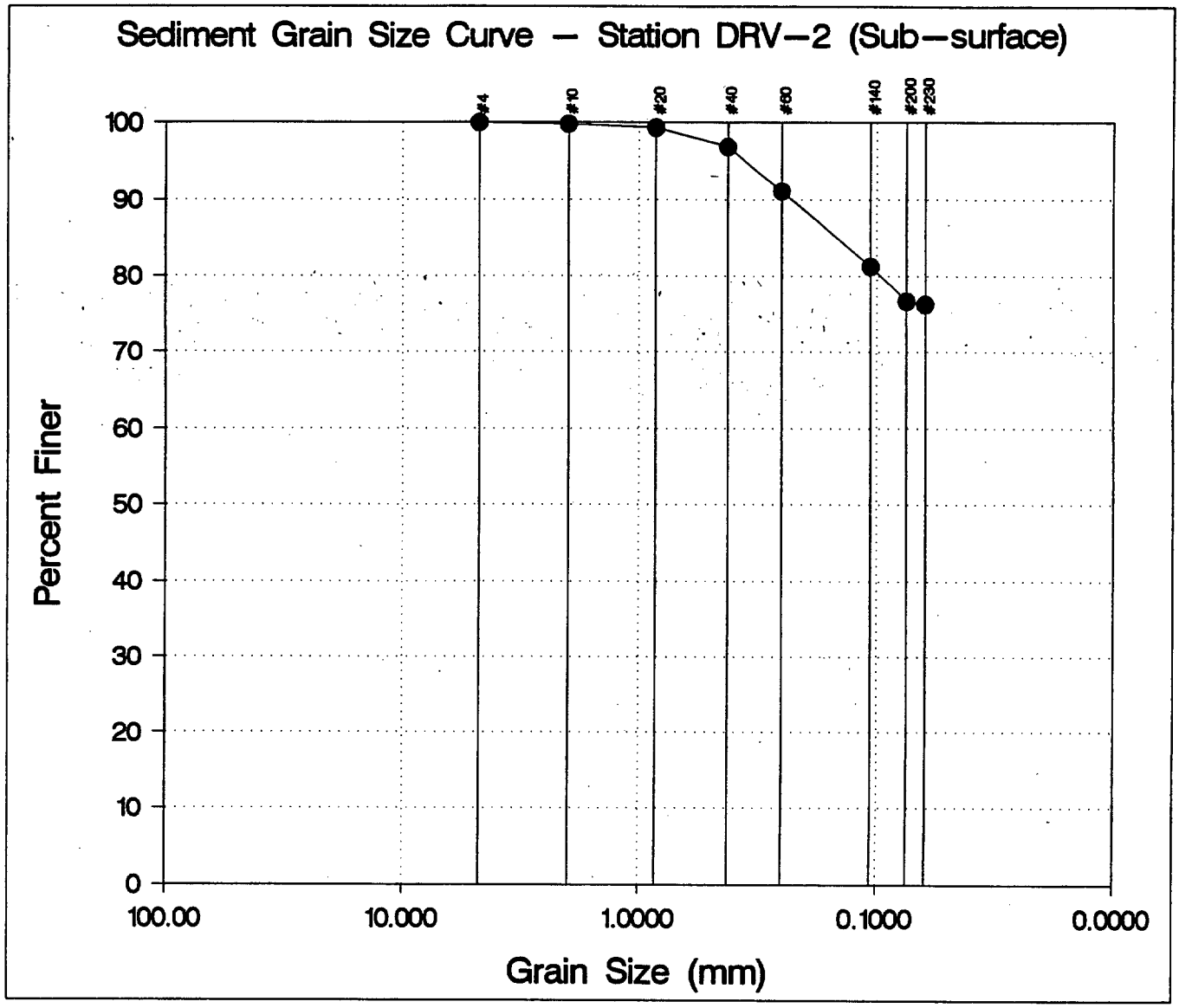
Grain Size (mm)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#200
#230
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Percent Finer
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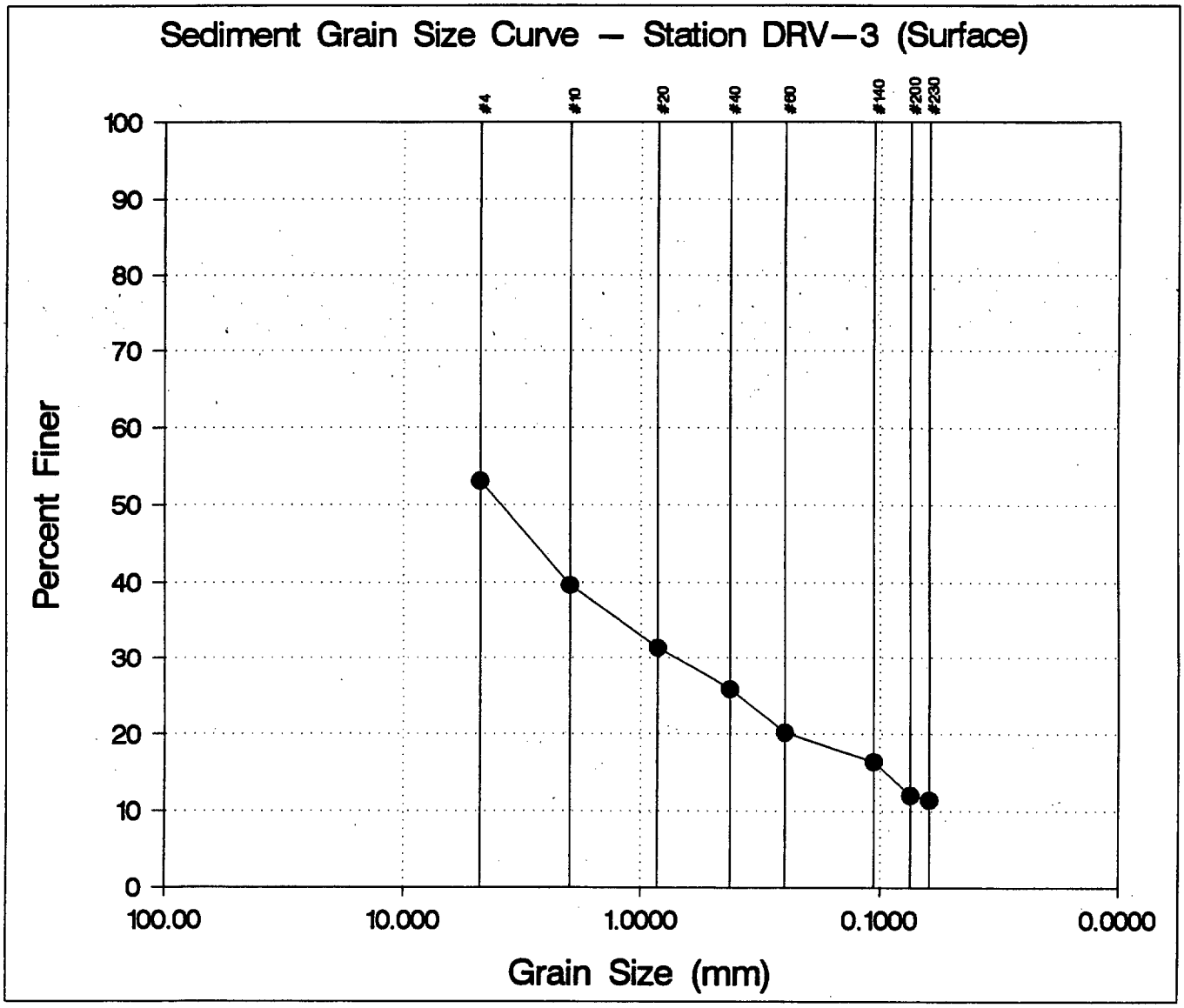
Grain Size (mm)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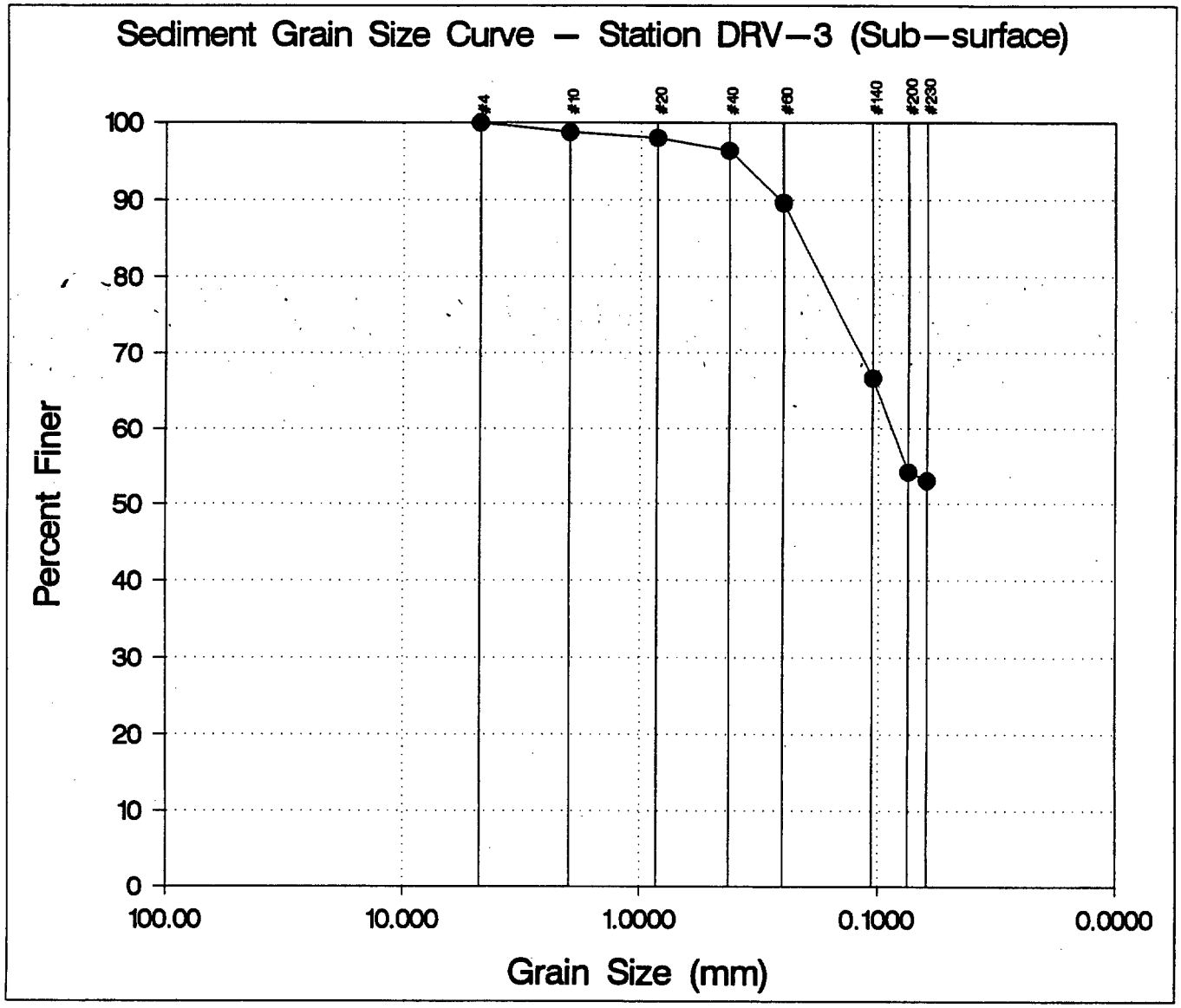
Grain Size (mm)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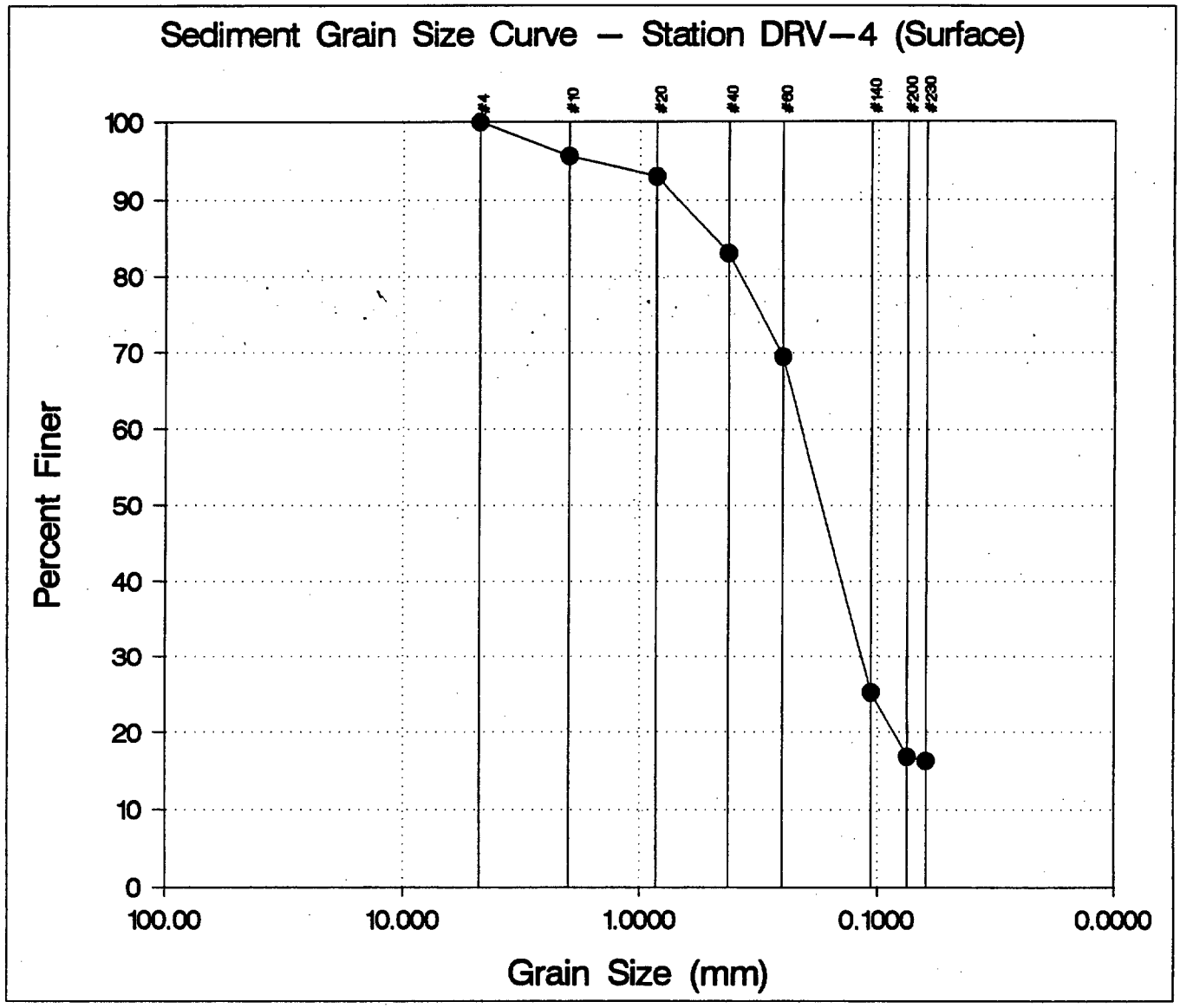
Grain Size (mm)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Percent Finer
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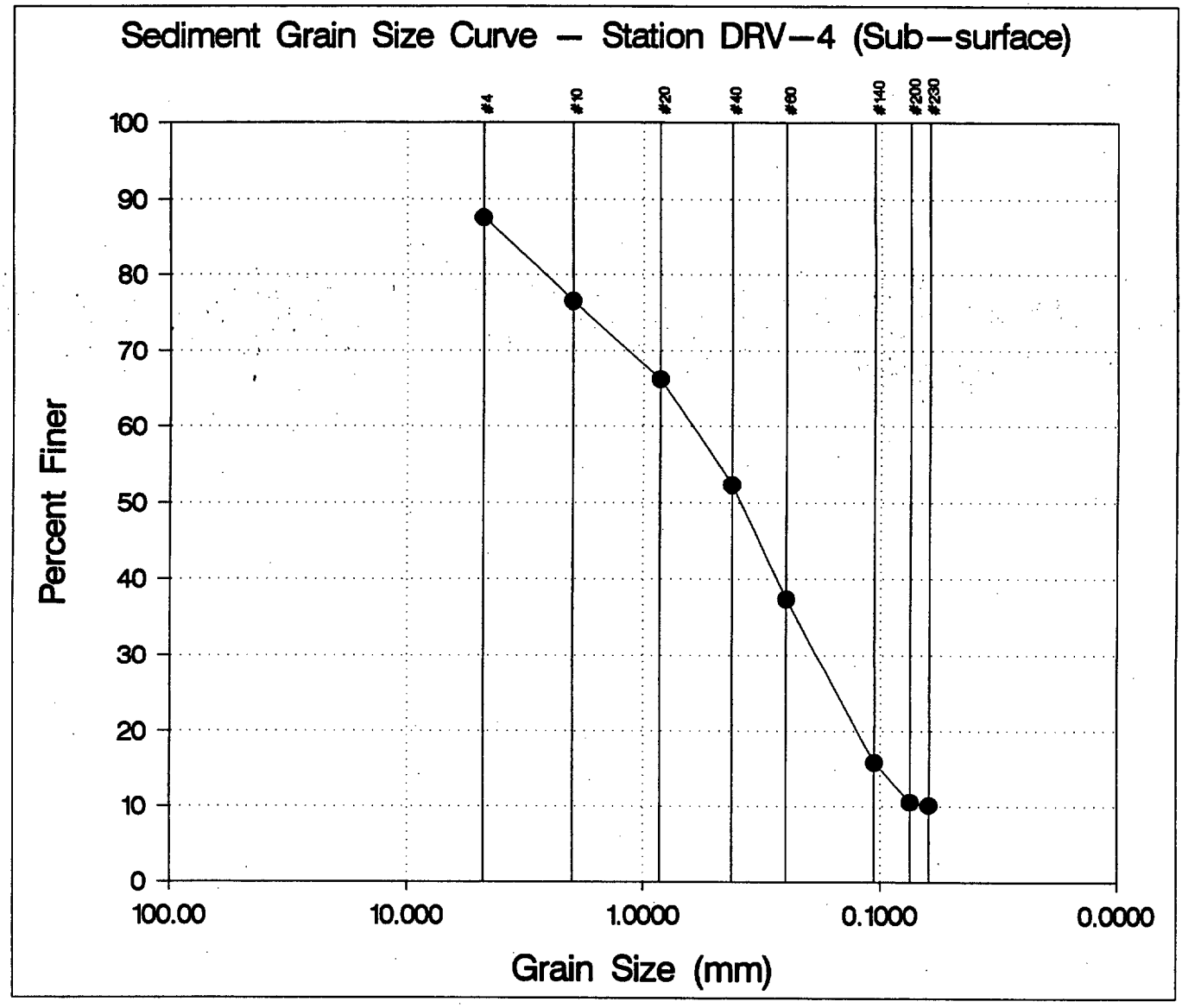
Grain Size (mm)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Percent Finer
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10.000
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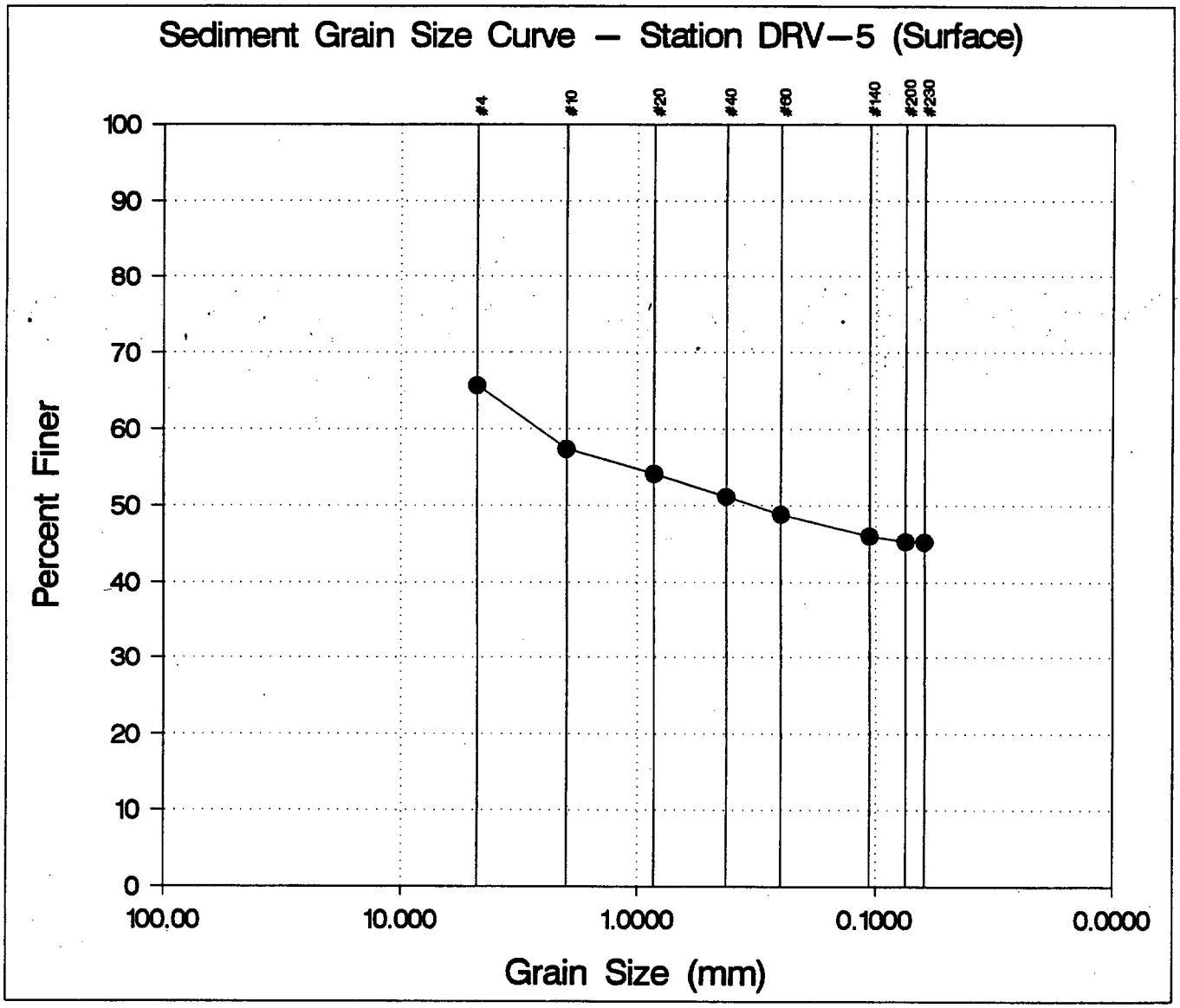
0.0000
Grain Size (mm)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Percent Finer
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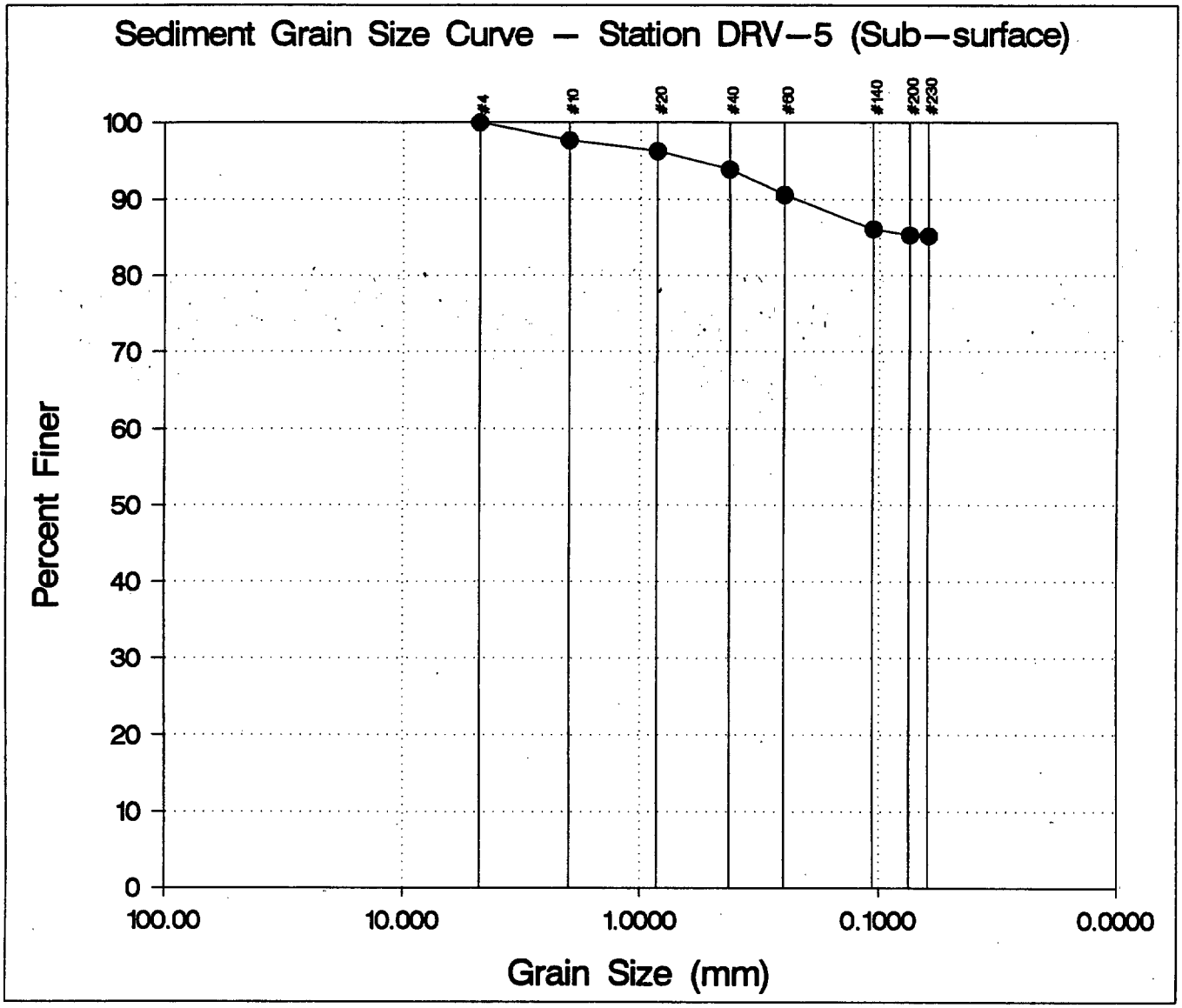
Grain Size (mm)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Percent Finer
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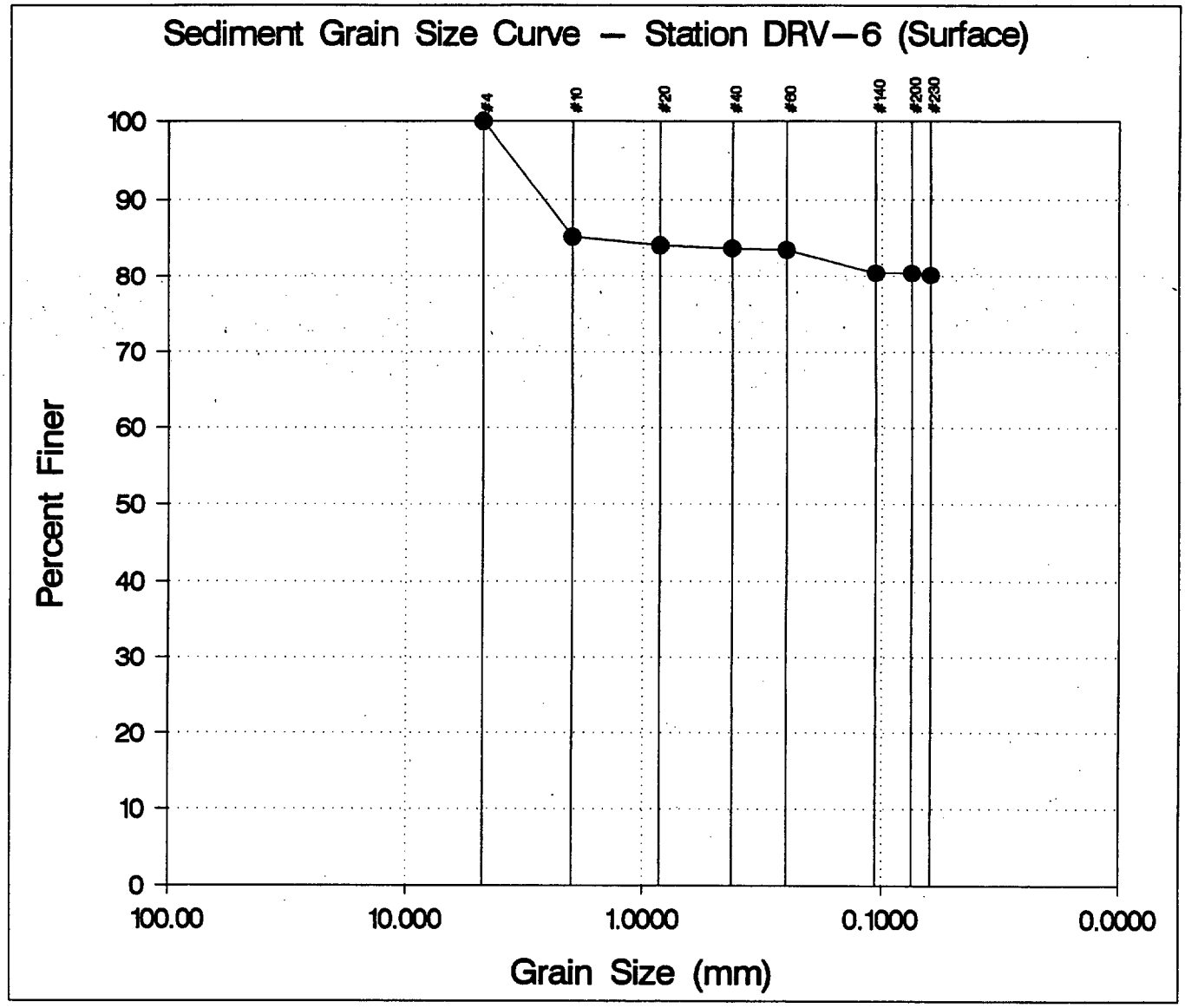
Grain Size (mm)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Percent Finer
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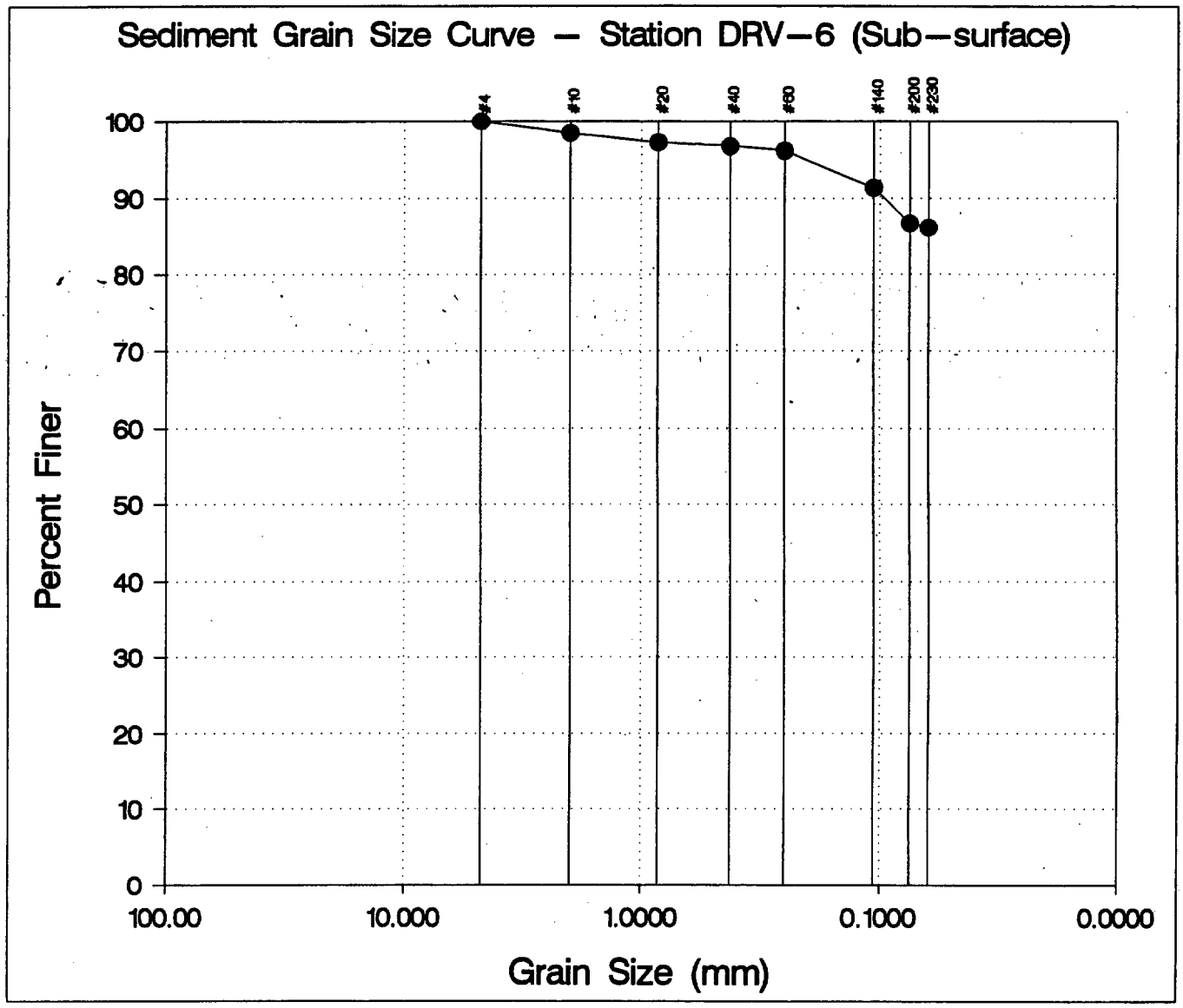
0.0000
Grain Size (mm)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Percent Finer
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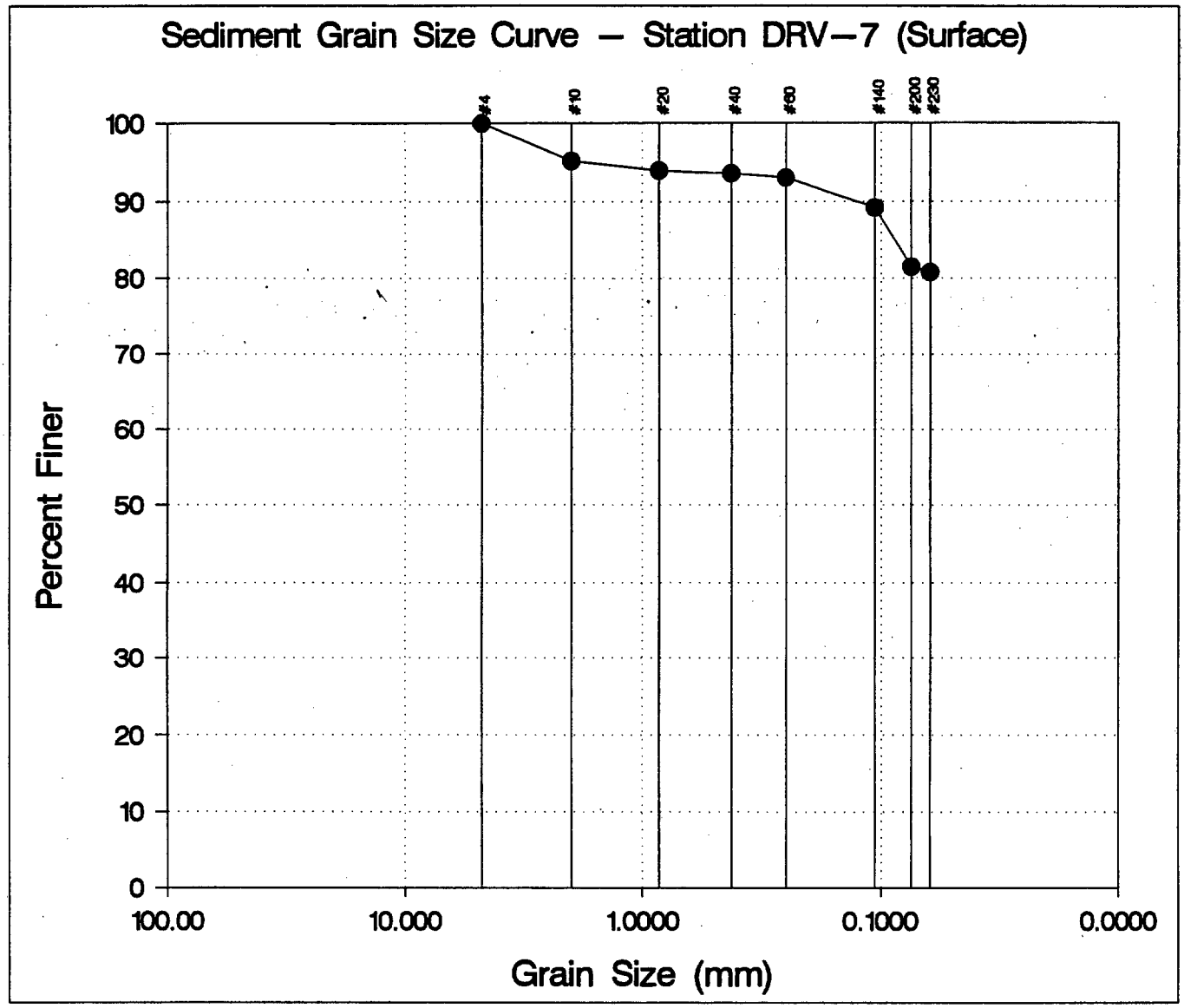
Grain Size (mm)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#20
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#140
#200
#230
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Percent Finer
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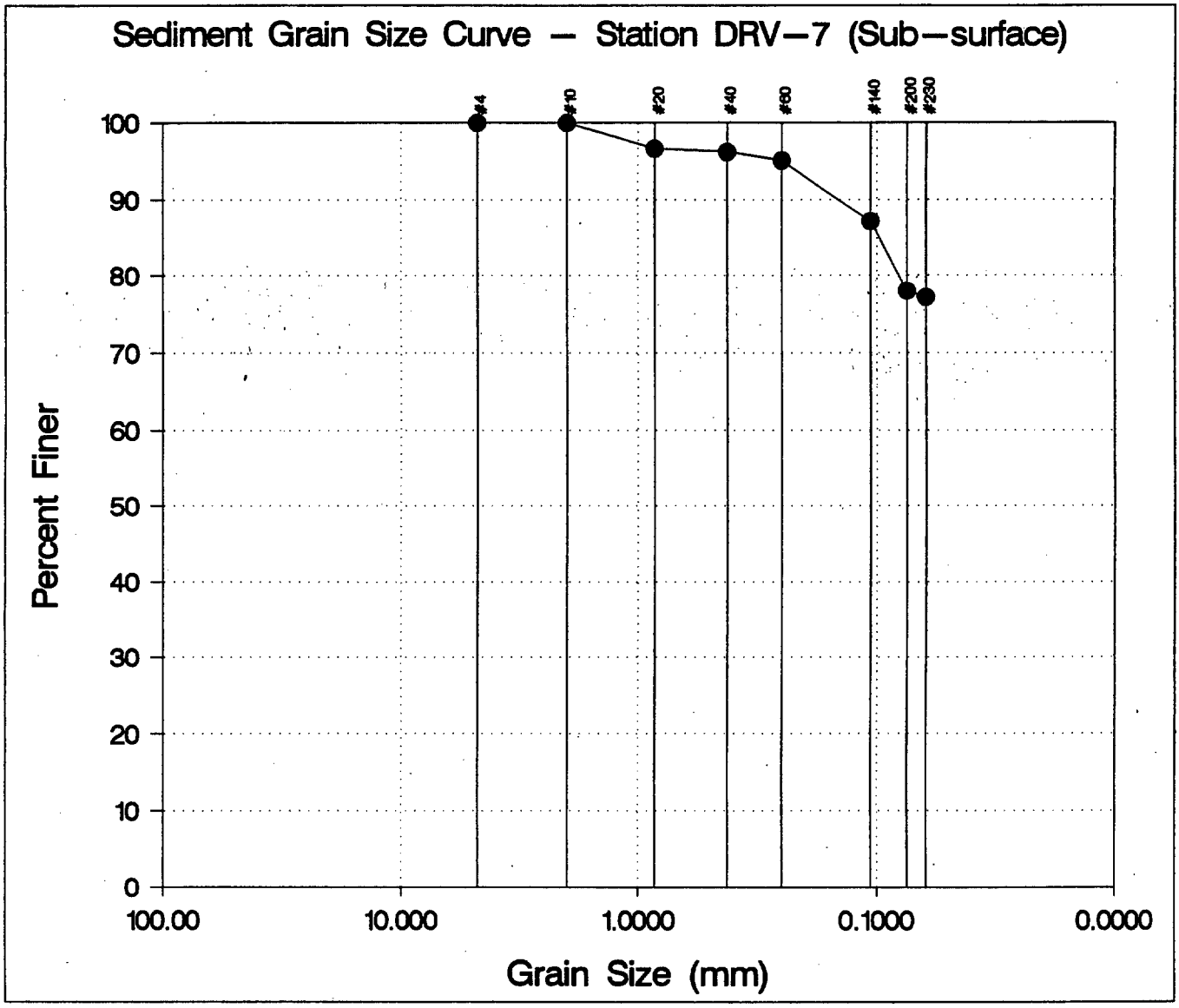
0.0000
Grain Size (mm)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30
20
10
0
Percent Finer
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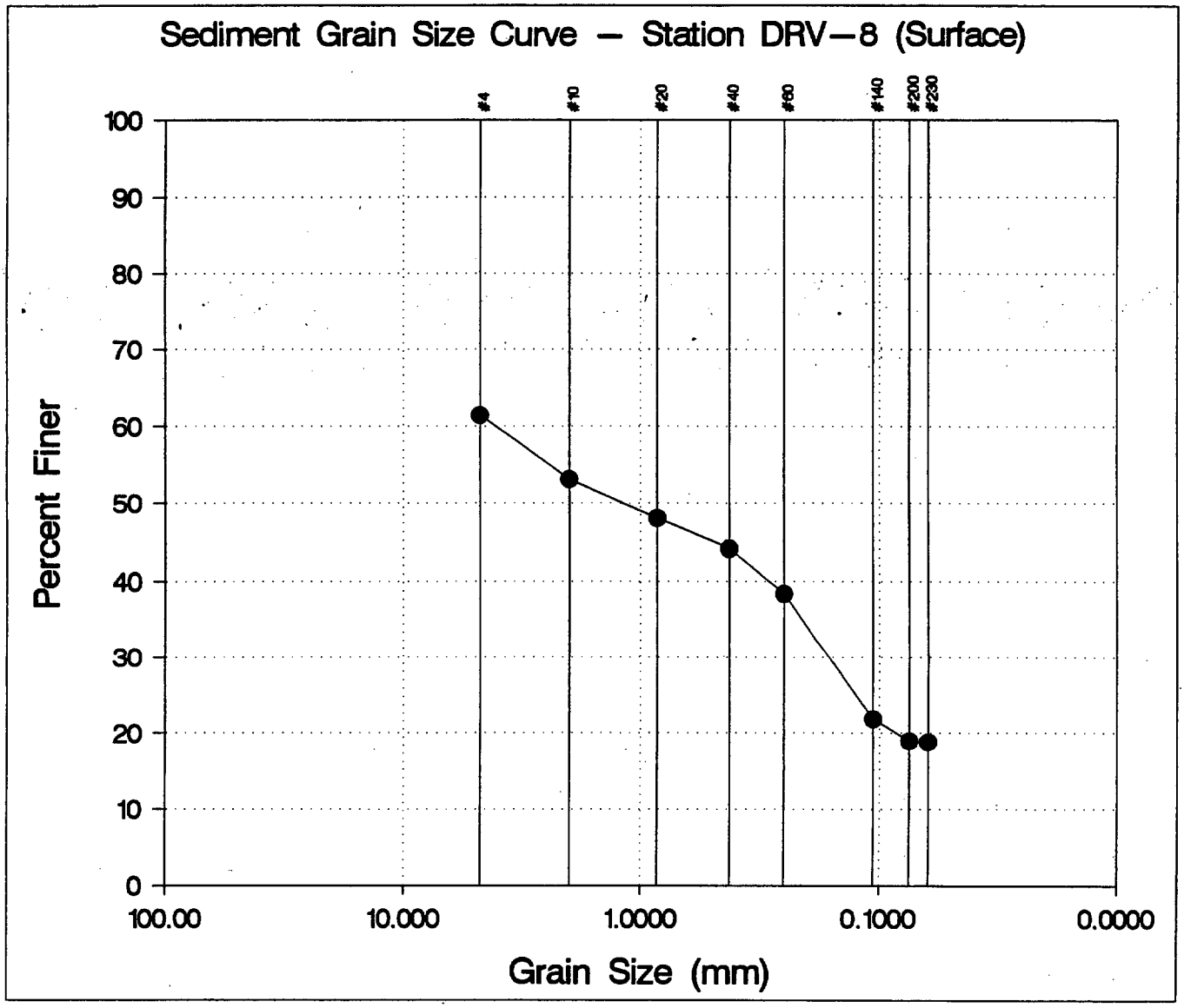
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—8 (Surface)
#4
#10
#20
#40
#60
#140
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#230
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Percent Finer
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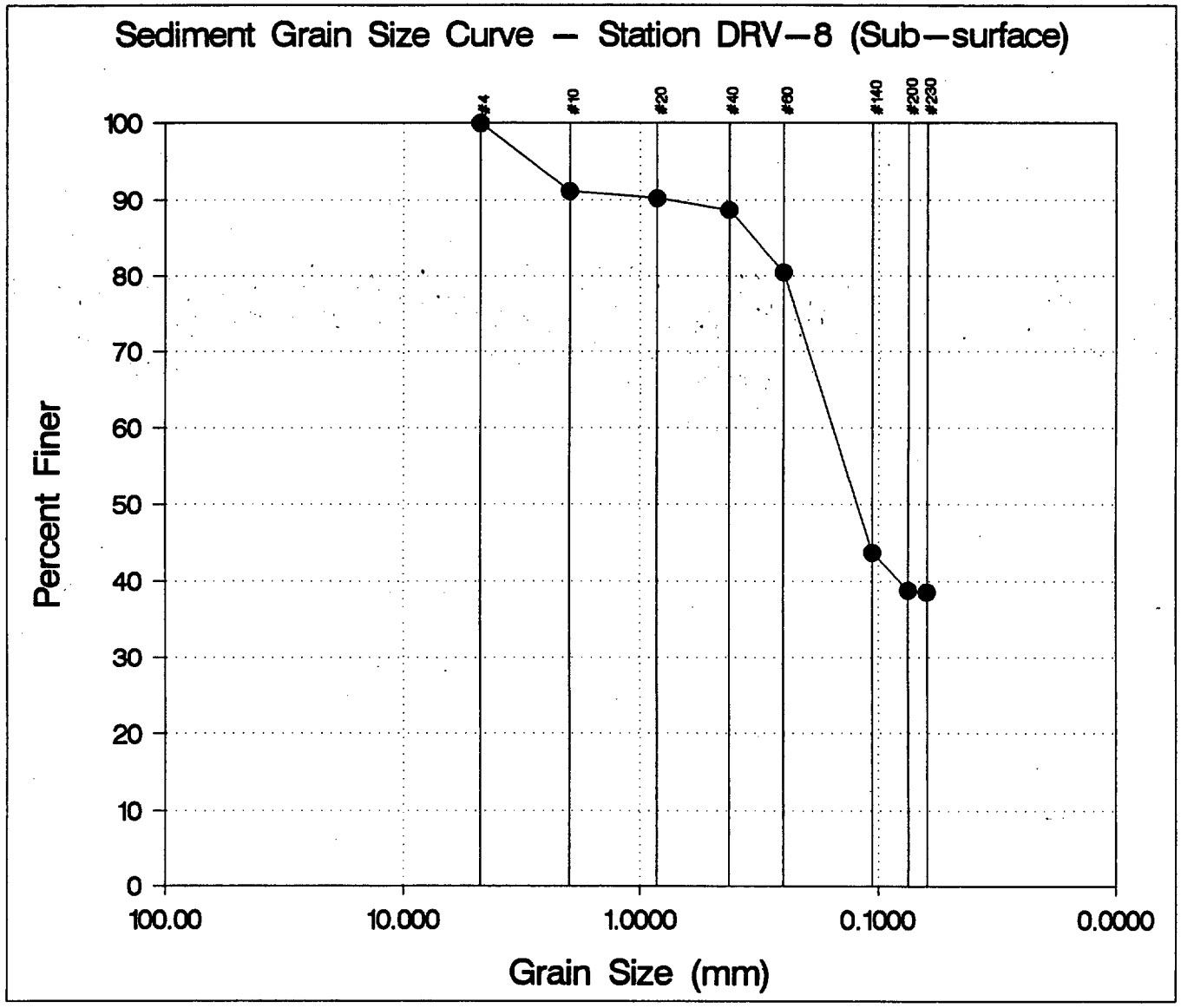
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—8 (Sub—surface)
#4
#10
#20
#40
#60
#140
#200
#230
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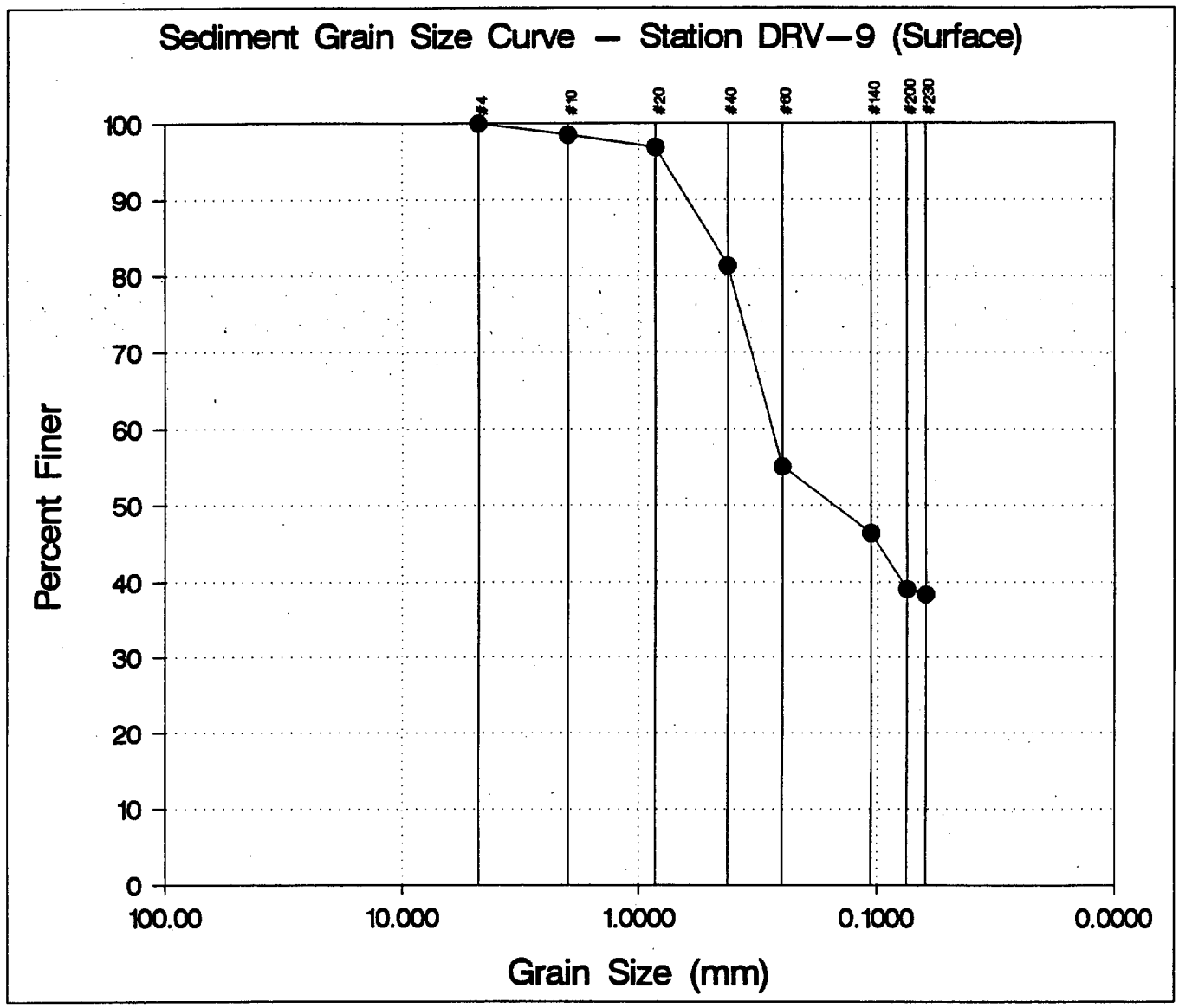
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—9 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
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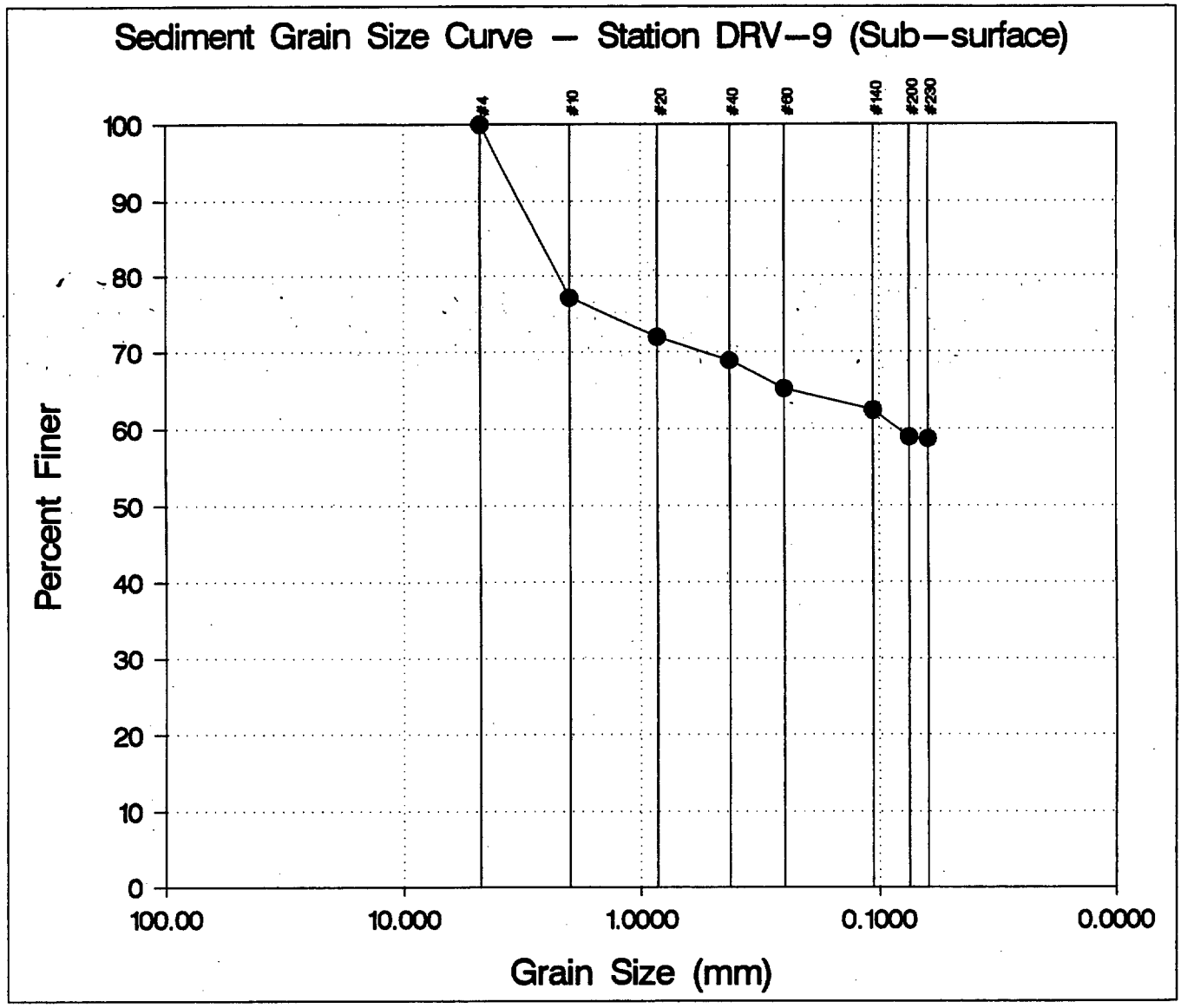
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV-9 (Sub-surface)
#4
#10
#20
#40
#60
#140
#200
#230
100
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80
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10
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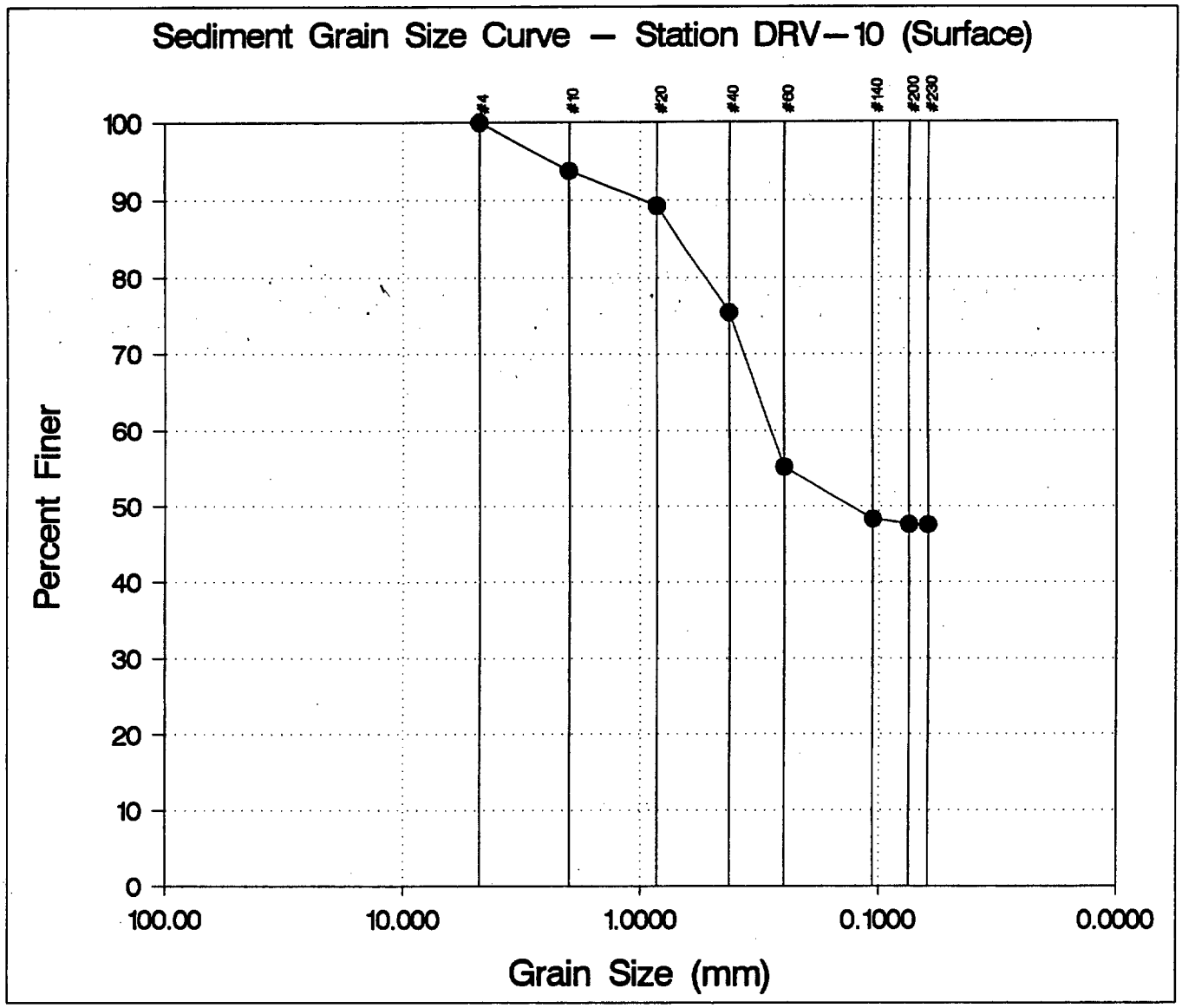
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—10 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
100
90
80
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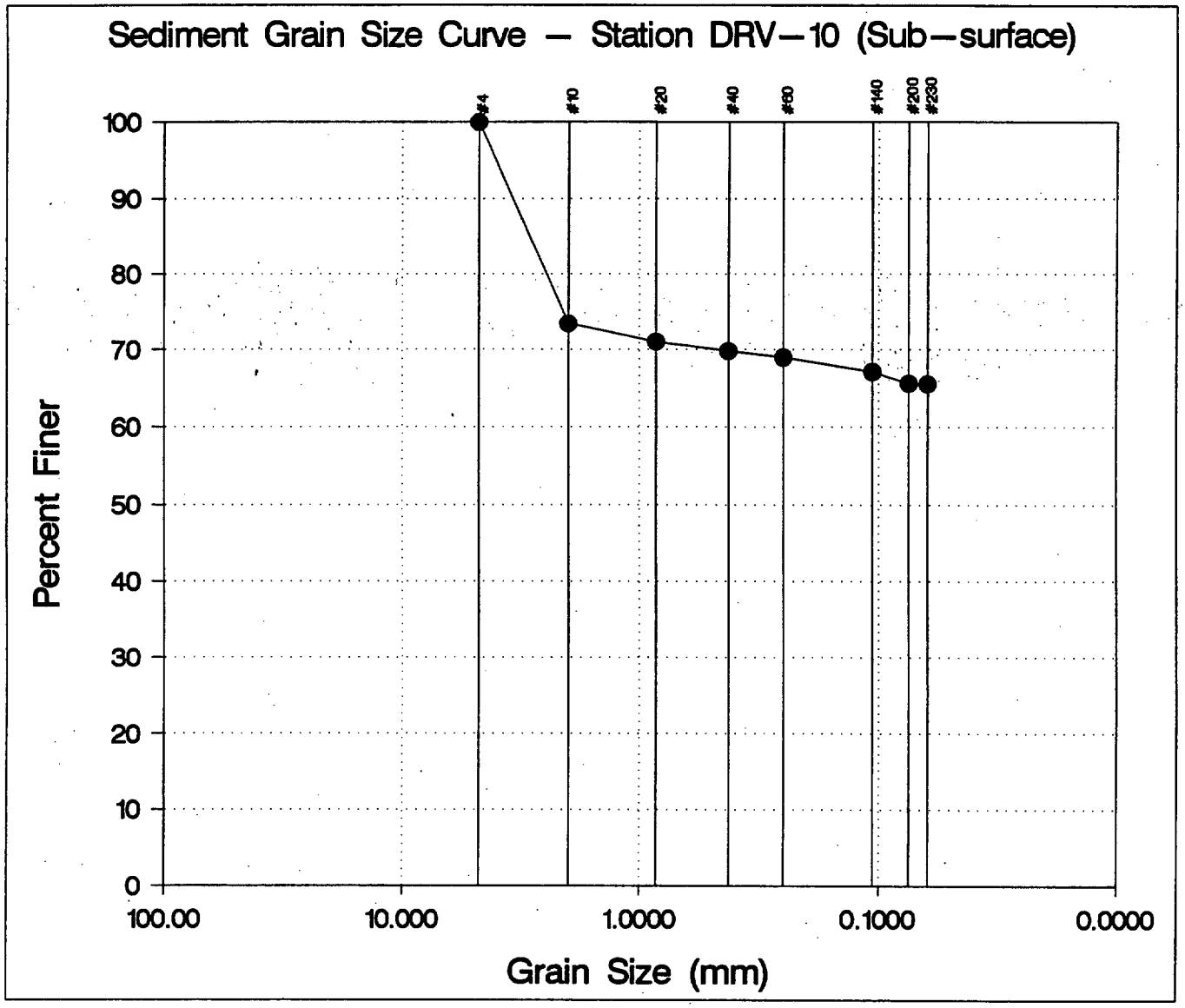
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—10 (Sub—surface)
#4
#10
#20
#40
#60
#140
#200
#230
100
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Percent Finer
100.00
10.000
1.0000
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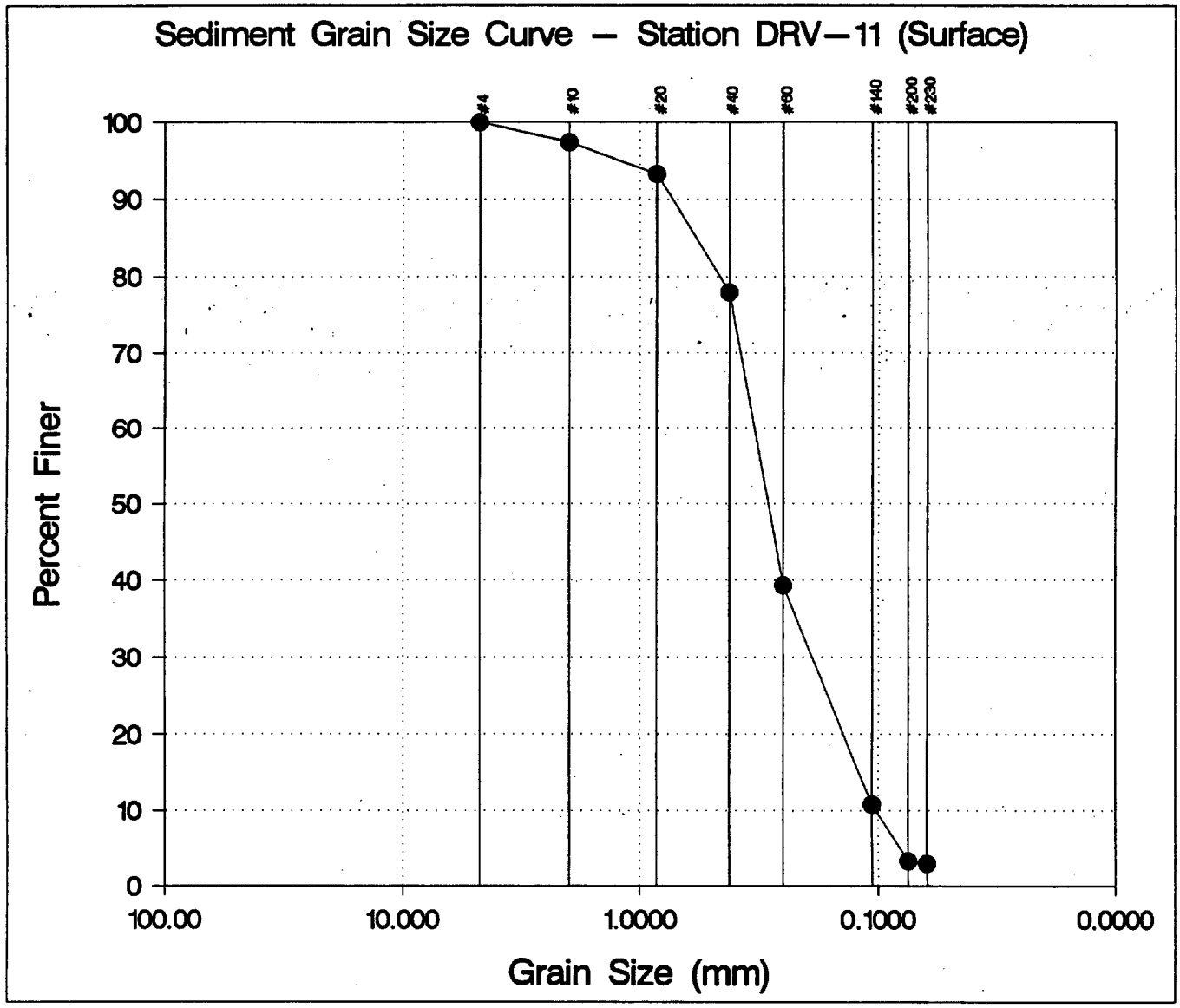
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—11 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
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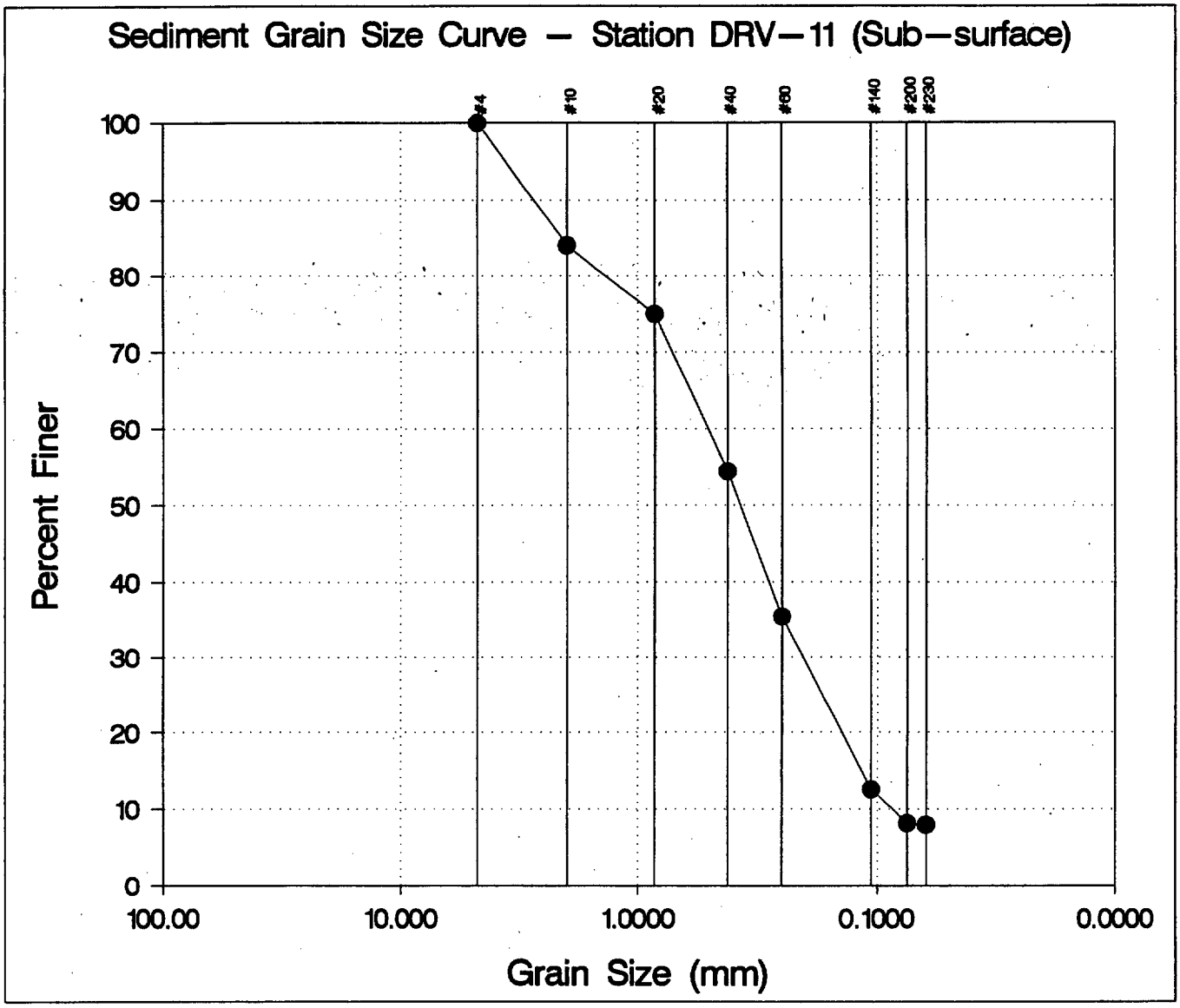
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—11 (Sub—surface)
#4
#10
#20
#40
#60
#140
#200
#230
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90
80
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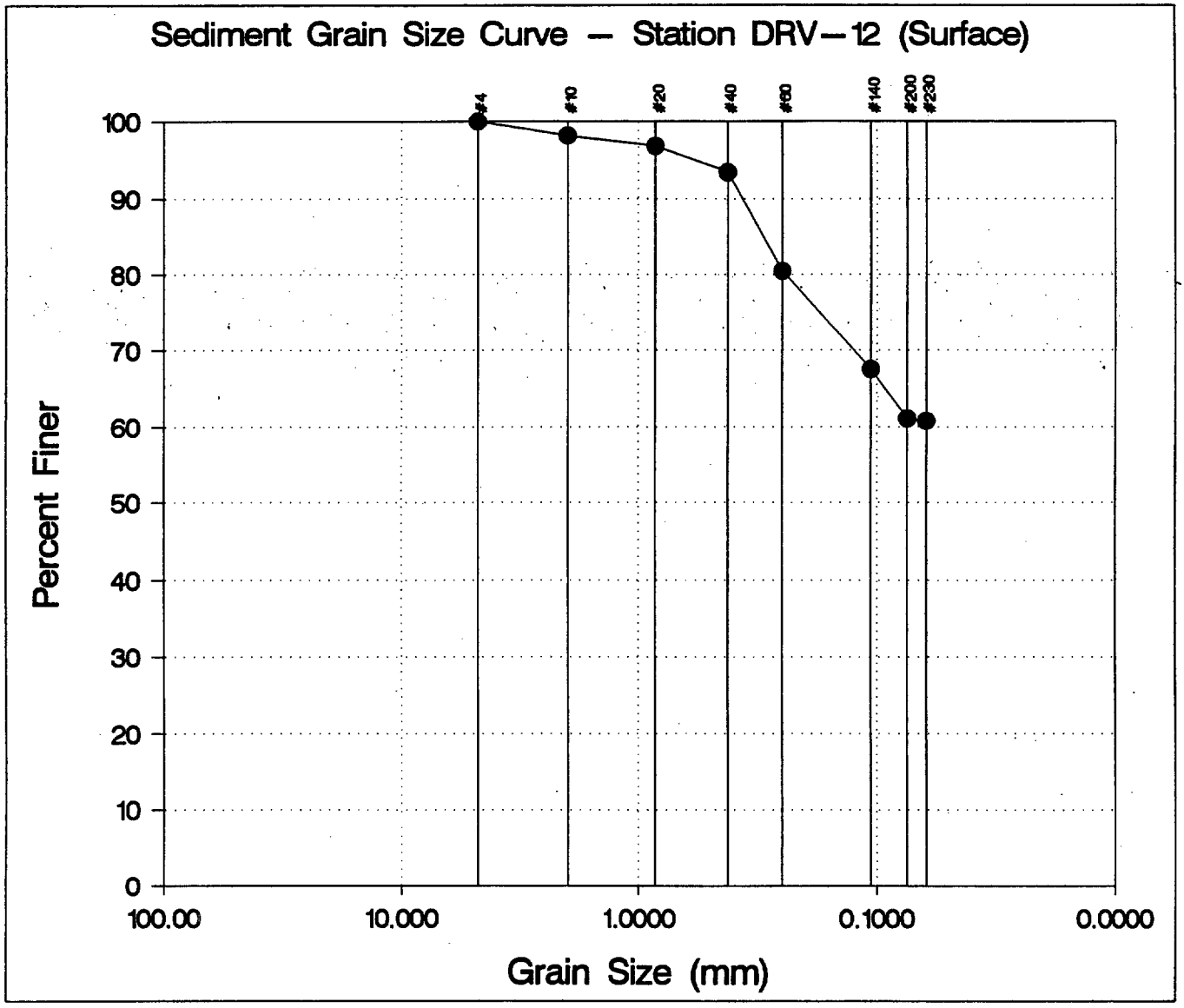
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—12 (Surface)
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#10
#20
#40
#60
#140
#200
#230
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Percent Finer
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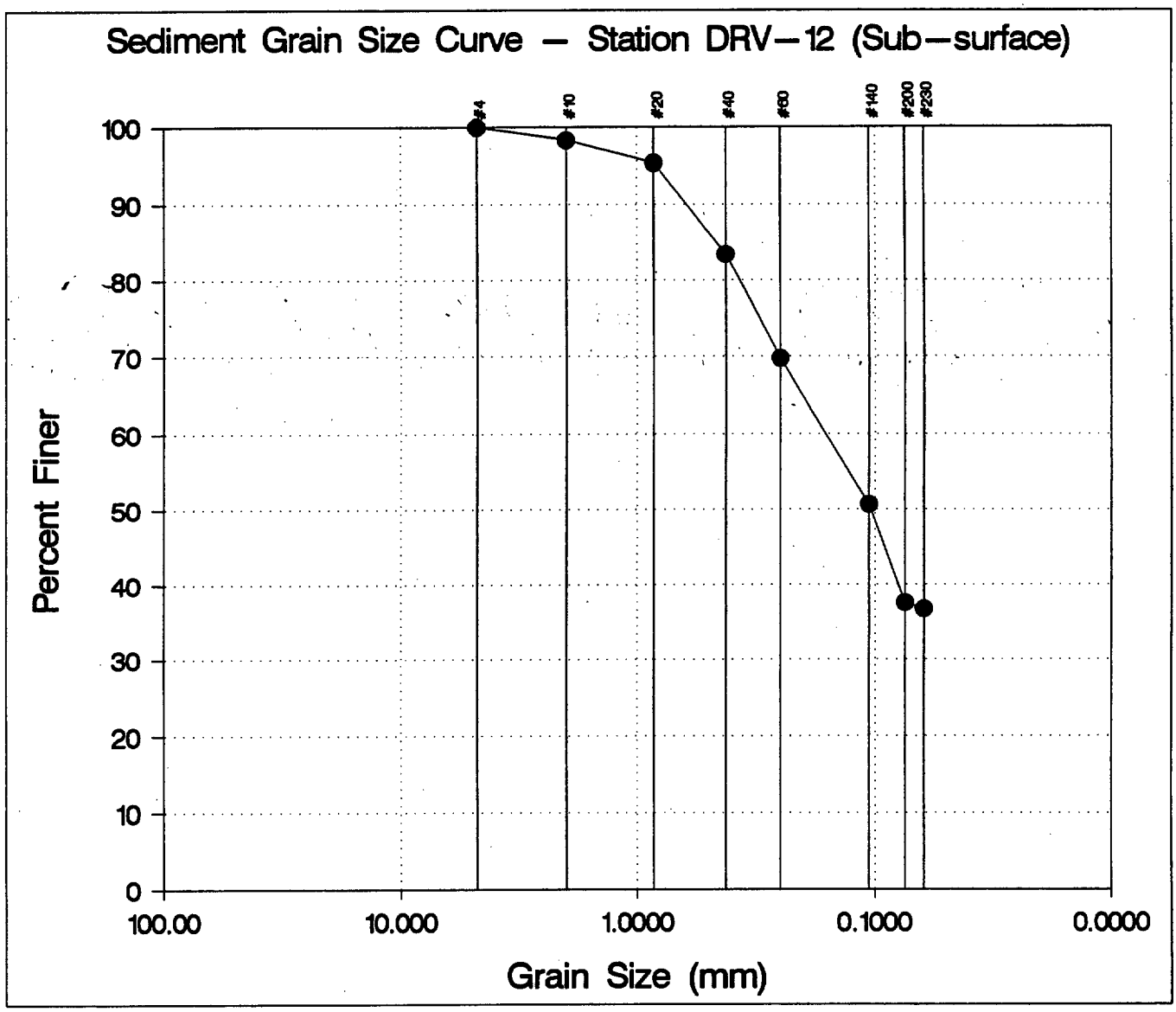
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—12 (Sub—surface)
#4
#10
#20
#40
#60
#140
#200
#230
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Percent Finer
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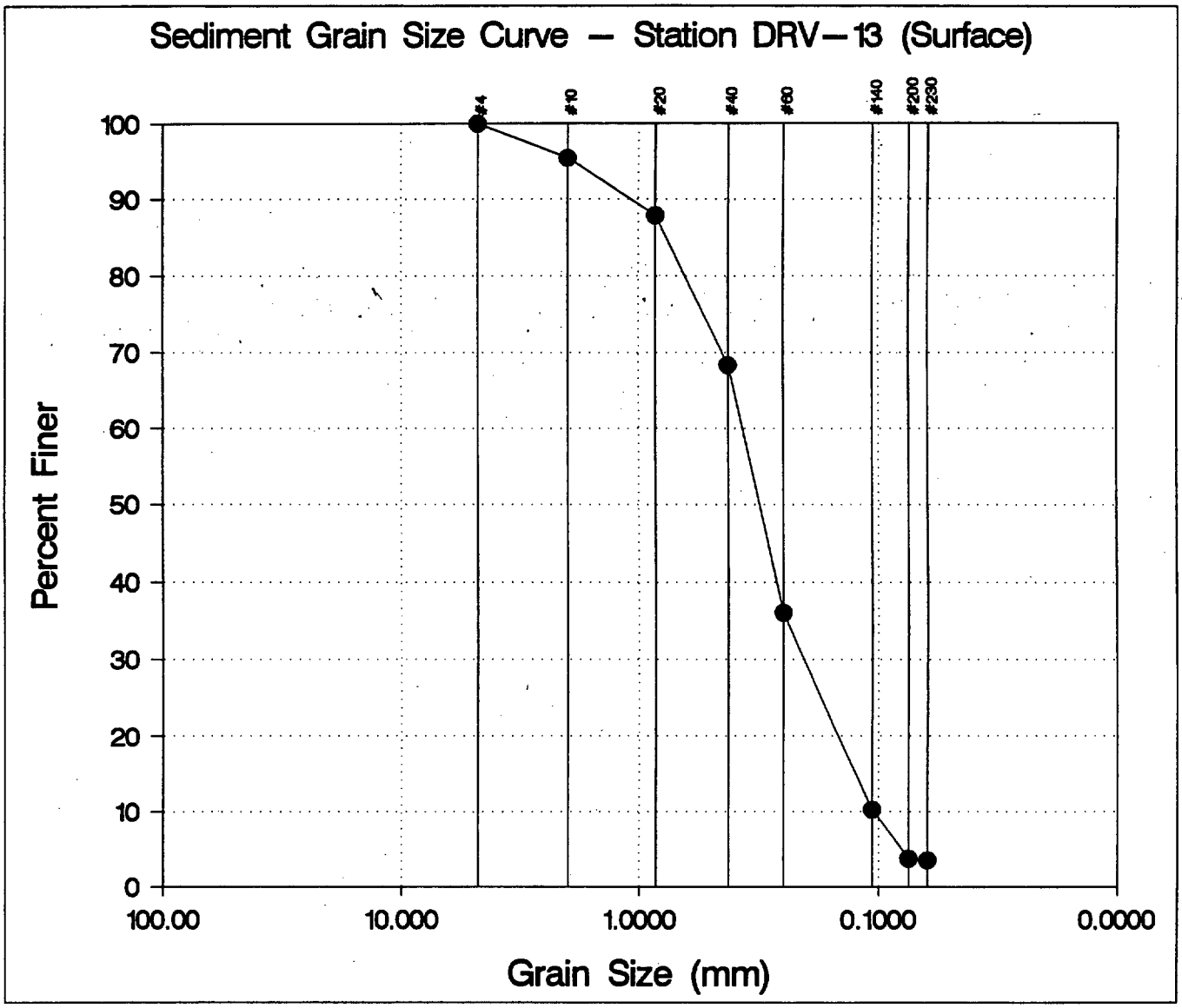
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—13 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
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Percent Finer
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1.0000
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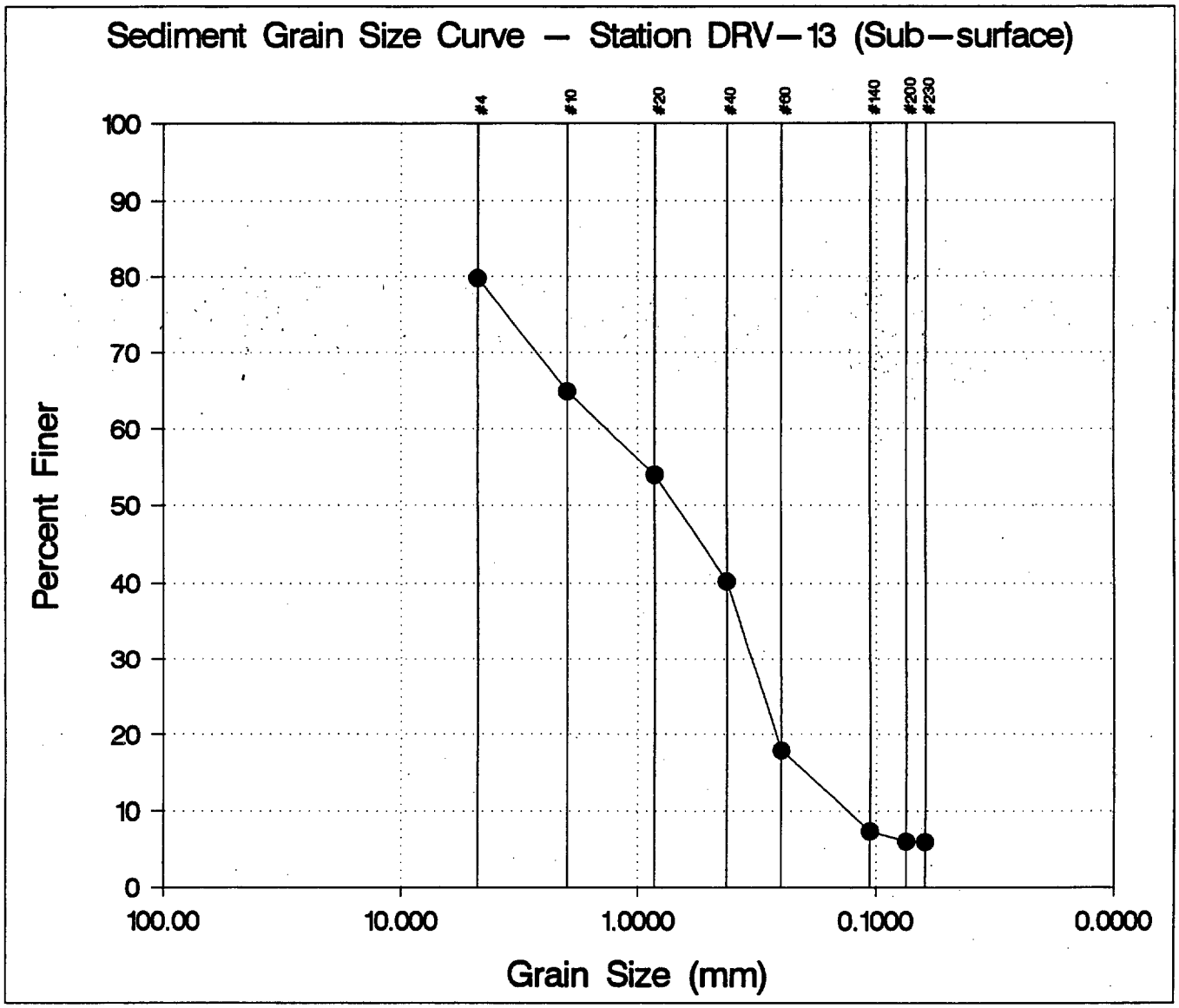
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—13 (Sub—surface)
#4
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Percent Finer
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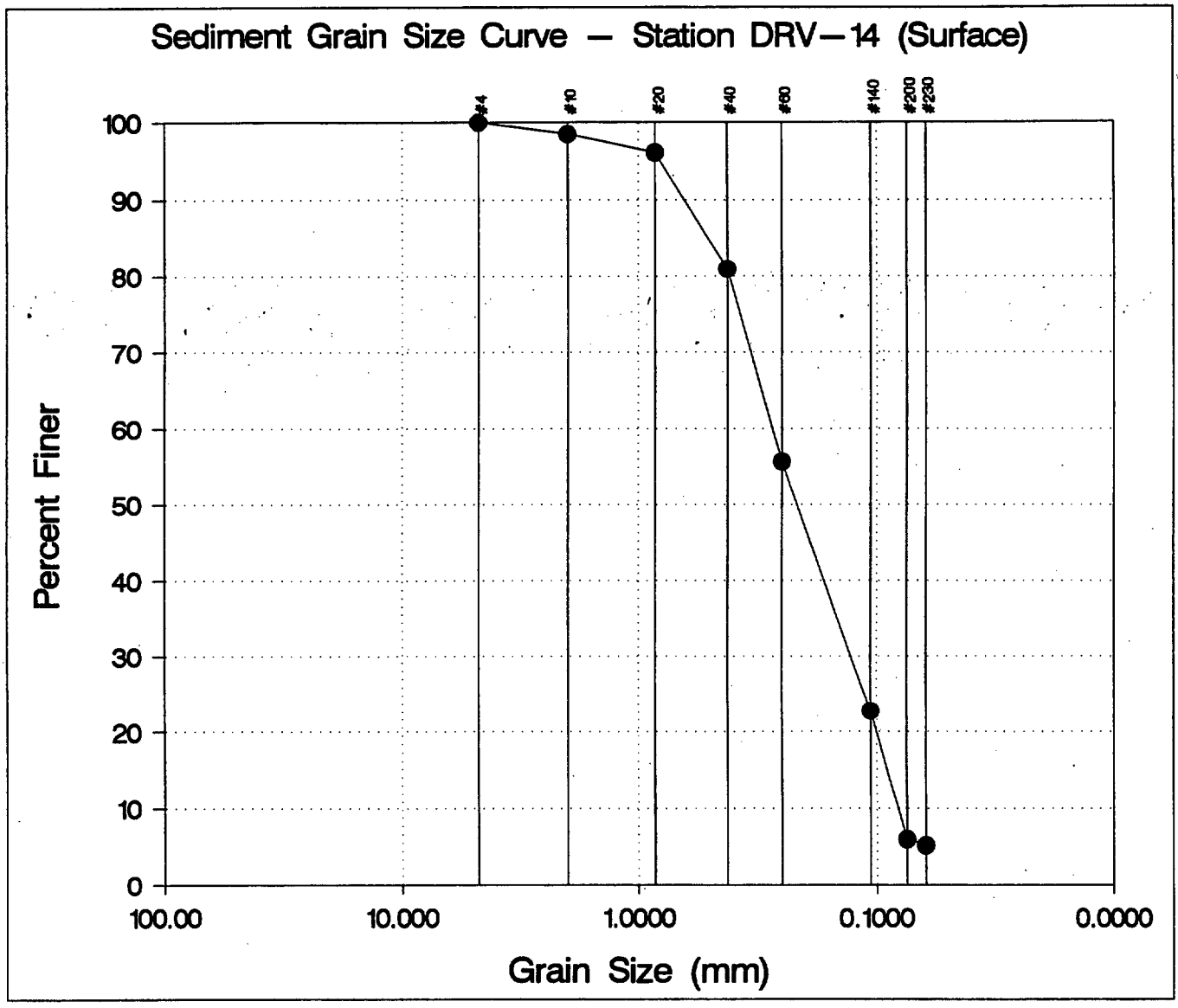
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—14 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
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Percent Finer
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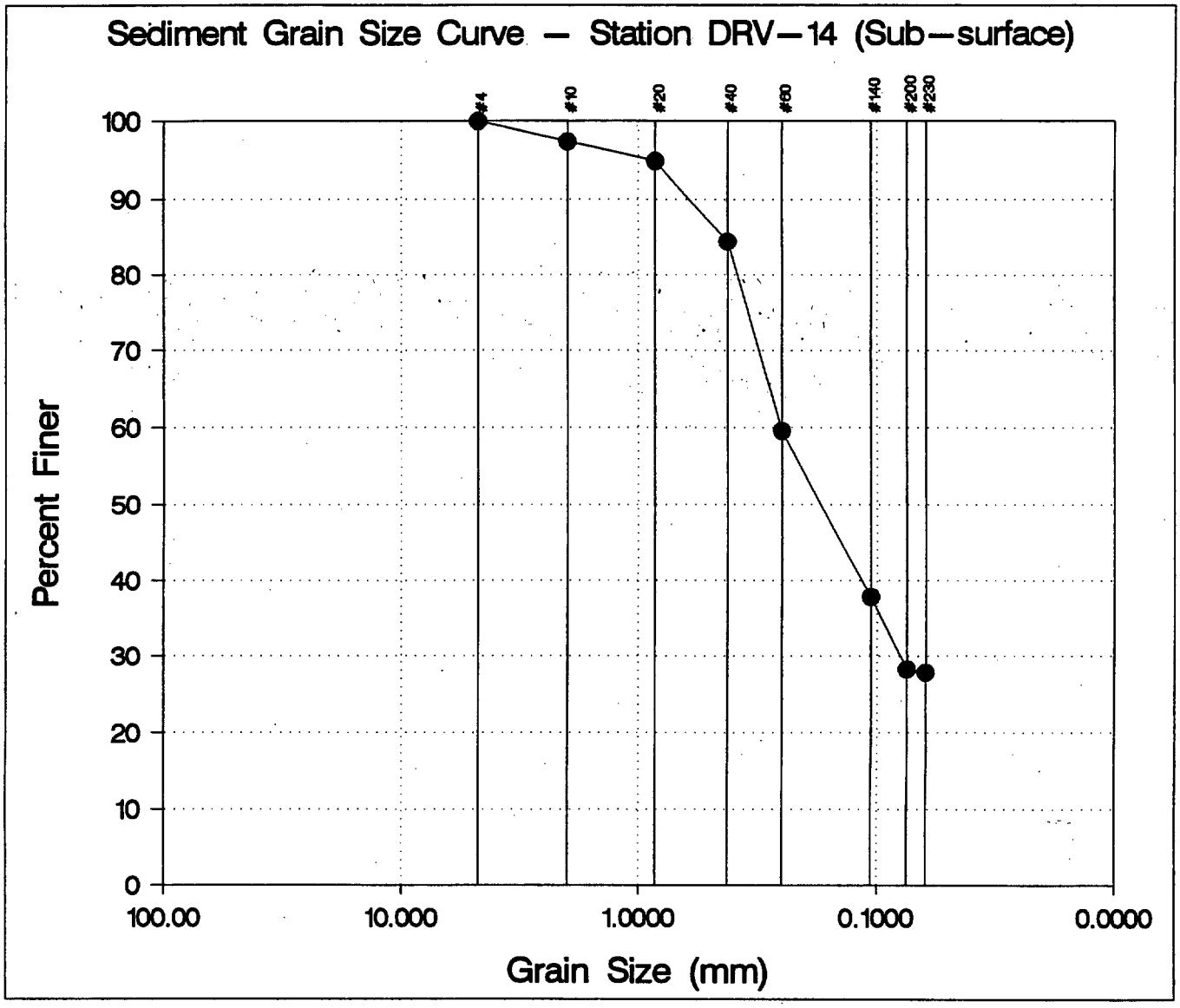
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—14 (Sub—surface)
#4
#10
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#40
#60
#140
#200
#230
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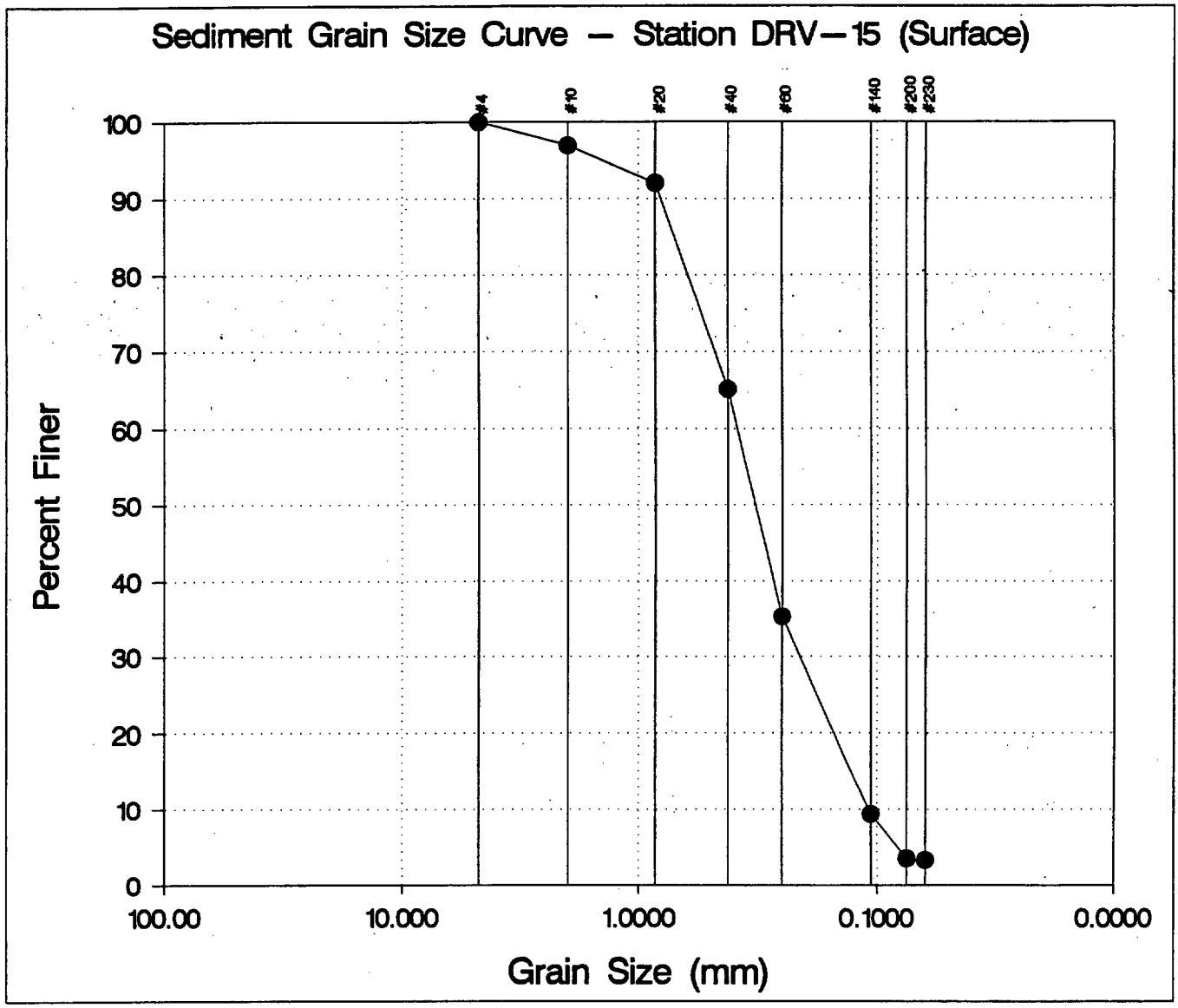
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—15 (Surface)
#4
#10
#20
#40
#60
#140
#200
#230
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80
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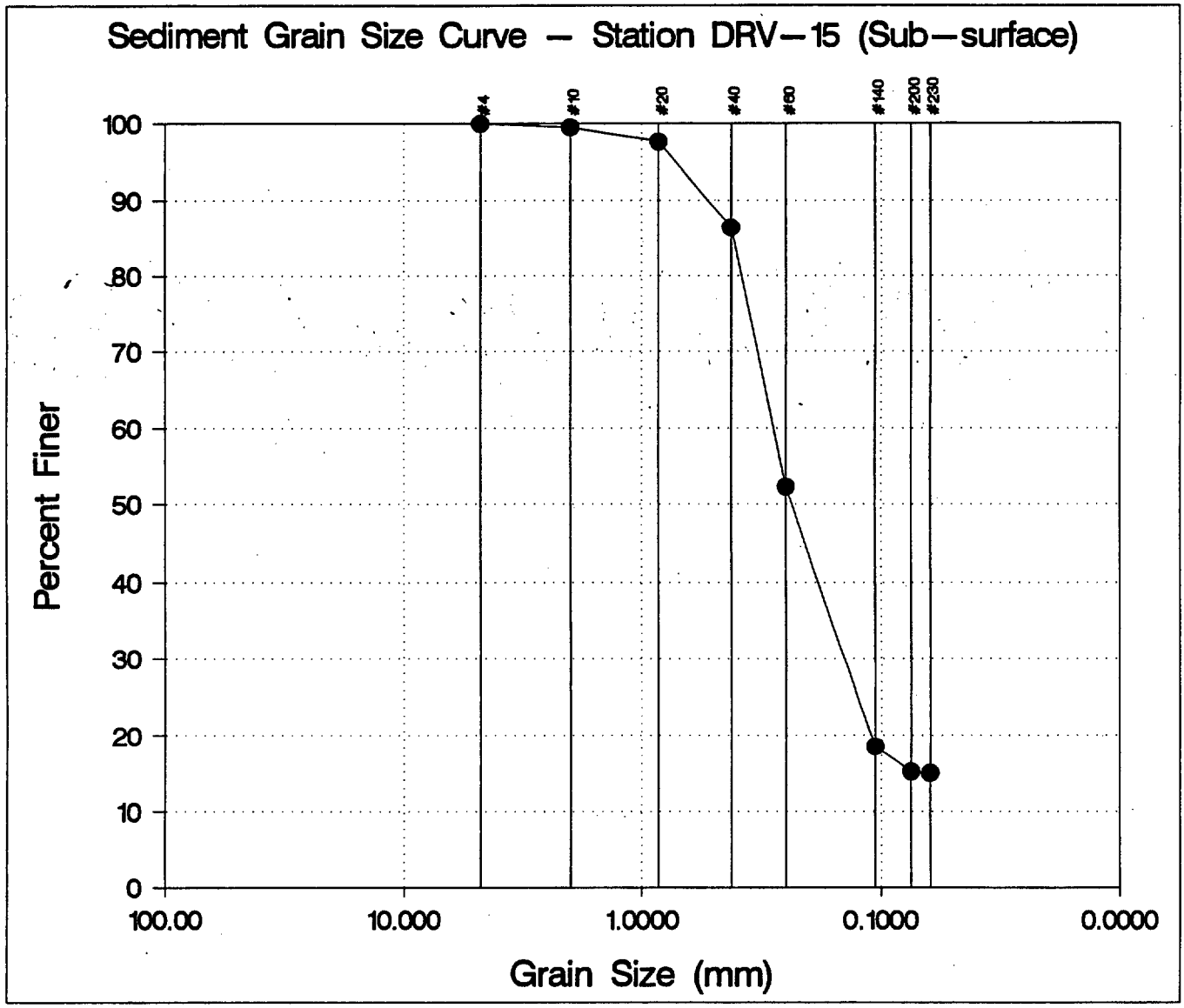
Percent Finer
100.00
10.000
1.0000
0.1000
0.0000
Grain Size (mm)


Sediment Grain Size Curve — Station DRV—15 (Sub—surface)
#4
#10
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#40
#60
#140
#200
#230
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Percent Finer
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0.0000
Grain Size (mm)

APPENDIX E

SOW

PCBSED

FY-96 SCOPE OF WORK
DELAWARE RIVER
PHILADELPHIA TO THE SEA PROJECT
PCB ANALYSIS OF CHANNEL SEDIMENTS

I. Scope of Work

The work under this contract includes collecting sediment samples from 60 vibrocore holes, and conducting specific PCB congener and homolog analyses, TOC analyses and geotechnical analyses on 30 composited samples. The sediment samples shall be collected from 15 locations within the Delaware River, Philadelphia to the Sea navigation channel, from Philadelphia Harbor to Delaware Bay. The project area is shown on Plates 1 through 4.

A. Vibrocore Sample Collection and Sample Preservation

A1. The 15 approximate vibrocore sample locations are shown on Plates 1 through 4; the coordinates are listed in Table 1. Four vibrocore samples will be collected at each location. The four vibrocores will be randomly distributed around the coordinate location provided. All vibrocores will be collected within the navigation channel.

A2. Mobilization and Demobilization

a. Mobilization - Mobilization shall consist of the delivery at the project site of all plant, equipment, materials and supplies to be furnished by the Contractor; the complete assembly in satisfactory working order of all such plant and equipment on the job; and the satisfactory storage at the project site of all materials and supplies.

b. Demobilization - Demobilization shall consist of the removal from the project site of all plant and equipment after completion of the work.

A3. Order of Work

The order in which the vibrocores are drilled will be at the Contractor's discretion.

A4. Vibrocore Sample Collection

a. Positioning - Vessel positioning will be accomplished with a Trimble NT200D GPS unit with differential capability built-in. To record station locations, the Contractor will take 180 position fixes with a precision of thousandths of a minute (1 per second) using differential corrections and an on-board lap-top computer. These 180 fixes will be averaged in order to report station position. Government-furnished control descriptions are available if required to establish horizontal control on land.

b. Core Borings - Cores comprising the surface of the bottom and sub-bottom shall be obtained by a pneumatically or hydraulically activated boring device having a minimum diameter of 3 inches, and shall be representative of the relative position of the bottom and sub-bottom strata. A transparent plastic

rigid tube of appropriate size that permits visual inspection of the cored material will be placed inside the coring tool prior to operation. The same tube shall be removed from the coring tool when the operation at a site has been completed. If necessary, packing will be inserted at both ends of the tube to prevent disturbance of the core during handling and shipping. The plastic tube shall be cut into 5-foot length segments for ease of handling and appropriately marked as to the sequence of segments and sample location. Both ends of the segments will be sealed with plastic caps and plastic pressure sensitive tape. The plastic segments will be identified as to top and bottom of core sample and the sample designation with a water proof marking ink. Cores shall be kept in the dark and at 4 degrees C to preserve the samples until laboratory analysis is conducted. Cores shall not be frozen.

The coring device shall recover a minimum of 80 percent of the unconsolidated strata through which it has penetrated. Depth of penetration beneath the surface of the bottom must be known to within plus or minus 2 percent of actual penetration. The desired depth of penetration is 7 feet. It is recognized, however, that maximum penetration may not be achieved at all sample locations. When located over a boring site, the Contractor shall make every reasonable effort to reach the required depth or to reach penetration refusal. Penetration refusal shall be completed when less than 1-foot of advance is accomplished after 5 minutes of vibration with the vibrating type coring tool. Sample penetration of less than 5 feet of penetration will not be accepted as a complete sample. When refusal is met at less than 5 feet of penetration, the Contractor will remove the sampled portion from the pipe, and a new liner will be inserted into the core pipe. A jet pump hose shall be attached to the top of the core pipe just below the vibrator. The rig shall be lowered to the bottom and jetted down to a depth where the first part met refusal. The jet will then be turned off and the vibrator turned on, taking the additional part of the core. Retries will be accomplished until penetration has reached at least 5 feet, or until two retries have been attempted, whichever occurs first.

c. The Contractor shall provide transportation for a Government Inspector and any other related personnel to and from the boring site. The departure and return location will be at a convenient local docking area.

A5. Sediment Sample Handling

a. Core Logs - Subsequent to collection of the sediment cores the sediments will be extruded from the plastic tubes and visually inspected to identify distinct sediment strata. For each core, a written core log based on visual inspection shall be completed. The log shall include the date, location, core number, water depth, elevations of the top and bottom of each core (depths) and percent recovery. In addition, the top and bottom depths within the core of all strata greater than 6 inches, a general description of these strata, and the position and labels of sediment samples taken from the core will be noted.

b. Sediment Samples - Each core will be split into two separate samples. The top three (3) inches of the core will be separated from the remaining (subsurface) portion of the core. Sediment from the top portion of the core shall be removed from the tube using pre-cleaned stainless steel knives and spoons and placed in a pre-cleaned stainless steel bowl. The bowl shall be placed on ice in a closed cooler to reduce the temperature of the sample and prevent accidental contamination. In a similar manner, sediment from the subsurface portion of the core shall be removed using a second set of pre-

cleaned stainless steel knives and spoons and placed in a separate pre-cleaned stainless steel bowl. Sediment from the entire subsurface portion of the core does not need to be placed in the bowl. Only sediment from the interior of the core needs to be removed and placed in the bowl. In so doing, sediment should be removed uniformly along the entire length so that all areas of the subsurface sample are equally represented. Once the subsurface sample has been placed in the bowl, the bowl should be placed on ice in a separate cooler and closed.

The above procedure shall be repeated for all four cores at the site. After each coring, the surface sample will be added to the bowl designated for the surface samples and the subsurface sample will be added to the bowl designated for the subsurface samples. After the four surface samples and the four subsurface samples have been accumulated in their respective bowls, the surface samples will be thoroughly homogenized in their bowl and the subsurface samples will be homogenized in their bowl. The surface homogenate will be transferred to two factory sealed 500 ml widemouth I-Chem jars equipped with teflon lids. The subsurface homogenate will likewise be transferred to two 500 ml I-Chem jars. In each case, the second of the two jars will serve as a backup in the event the first jar is inadvertently broken en route from the field to the laboratory or if additional sample volume is needed for all analyses. The backup samples will carry the designator "BACKUP" in addition to all other applicable labelling for the sample. The entire procedure just described will be repeated at each of the fifteen sites.

After sediment from an individual core is taken, the knives and spoons shall be cleaned in the following sequence: non-phosphate detergent and tap water rinse, tap water rinse, deionized water rinse, 10 percent nitric acid rinse, deionized water rinse, hexane rinse, deionized water rinse, acetone rinse, and a final deionized water rinse.

Sediment samples for chemical analysis will be kept in the dark and at ≤ 4 degrees C prior to analysis. Storage temperature is not a factor for the sediment samples that will undergo geotechnical analysis.

c. Core and Sample Labeling - Identification codes for the 15 sample locations are provided in Table 1. These identification codes shall be followed by a C or G designation to indicate the type of analysis, chemical or geotechnical, for each sample. This will be followed by an S (surface) or B (bottom or subsurface) to indicate the portion of the core represented by the sample. Thus, the surface sample from location DRV-1 that will undergo chemical analysis shall be labeled as: DRV-1-C-S.

A6. Records

a. The Contractor shall maintain records of all work performed in this contract. The originals shall be furnished to the Contracting Officer upon completion of the work.

b. Records maintained for position location shall include date, record number, range number, targets (on shore) showing locations thereof, and position number. Position results for each of the four cores collected at each vibrocore location shall be reported in latitude and longitude.

c. In addition to the above records, daily records shall be maintained on the operation and shall include the date, operating port area, times of departure from the dock, times the work commences, state of the river and remarks.

d. Vibrocore logs that include an entry for each hole drilled shall be maintained on the operation and delivered to the Contracting Officer at the completion of the work. The logs shall include the date, location, core number, water depth relative to mean low water, elevations of the top and bottom of each core, and percent recovery. Penetrometer charts that show the rate of penetration, coupled with vibratory energy output, for the entire depth of each core shall be delivered with the logs.

A7. Government Furnished Material

a. The 15 approximate vibrocore sample locations are shown on Plates 1 through 4; coordinates are provided in Table 1.

b. Vertical control point and bench mark descriptions - Contractor may obtain control points by contacting Mr. Doug Moore, Philadelphia District Survey Branch, (215) 656-6754.

B. Chemical and Geotechnical Analysis of Sediment Samples

B1. Order of Work

The order in which the sediment samples are analyzed will be at the Contractor's discretion.

B2. Sample Preservation

a. Bulk Sediment Samples - Sediment samples for chemical analysis will be stored in the dark and at $\leq$ 4 degrees C until sample analyses are initiated.

b. Geotechnical Analysis - Storage temperature is not a factor for the sediment samples that will undergo geotechnical analysis.

c. Sample Holding Times - Chemical analyses will be conducted based on the following maximum sample holding times.

Bulk sediment analysis for specific PCB congeners shall be conducted within 14 days of sample collection.

Bulk sediment analysis for total organic carbon (TOC) shall be conducted within 14 days of sample collection.

B3. Chemical Analysis

a. Sample Compositing - From the 60 vibrocores collected in the field, 30 composited samples will be prepared for PCB congener and TOC analyses, and 30 composited samples will be prepared for grain size analyses. The 30 samples will consist of one surface and one subsurface sample from each of the 15 vibrocore sample locations. For each of the 15 locations, equal aliquots of

sediment will be taken from the four surface and four subsurface samples, and composited to produce one surface and one subsurface sample per sample location. Sample compositing shall conform to the procedure described in Section A5.b., above.

b. All 30 composited sediment samples will be analyzed for the 75 specific PCB congeners listed in Tables 2 and 3. The four non-ortho coplanar congeners listed in Table 2 fall into a special class based upon their structure/activity and required method of analysis. These four congeners will be tested using high resolution GC/high resolution MS with EPA SW-846 Method 8290. Detection levels will be in the 2 parts per trillion range. The following list of labs can provide the PCB analyses described above:

Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110
POC: Ms. Kathy Boggess (816) 753-7600

Arthur D. Little, Inc.
Acorn Park
Cambridge, Massachusetts 02140-2390
POC: Ms. Helder Costa (617) 498-5322

Triangle Labs, Inc.
4915 Prospectus Drive
Suite F
Research Triangle Park, North Carolina 27709
POC: Mr. Ed Marti (919) 544-5729

The remaining 71 congeners listed in Table 3 will be analyzed using high resolution GC/low resolution MS with EPA SW-846 Method 8270. Detection levels will be at the 1 to 10 parts per billion range. In addition to the 75 congeners, total PCB, determined through the analysis of mono- through deca-chlorobiphenyl homologs will be analyzed using high resolution GC/low resolution MS with EPA SW-846 Method 8270, or EPA Method 680. Detection levels for each homolog group will be at the 1 to 10 parts per billion range.

In addition to the PCB analyses, all sediment samples will be analyzed for total organic carbon (TOC) using the combustion analytical technique (EPA SW-846 Method 9060). Maximum holding times prior to all chemical analyses will not exceed those specified in Section B2, above.

c. Reporting Requirements - The following information shall be included on the laboratory data sheets:

1. test method;
2. appropriate holding time;
3. date sample was collected;
4. date of analysis;
5. testing result (reported on a dry weight basis);
6. detection level; and
7. an explanation of any data qualifiers.

All laboratory data sheets will be submitted to the Contracting Officer prior to completion of this contract.

B4. Geotechnical Sediment Classification Testing - Sediment samples for geotechnical classification will be analyzed using ASTM D2487. A total of 30 sediment samples will be tested. Classification will be taken down to the U.S. Standard Sieve No. 200; the hydrometer portion of the ASTM test will not be run. A log of each core shall be recorded. A grain size curve shall be prepared for each sample tested.

B5. All procedures required under this scope of work will conform to a viable analytical quality assurance/quality control program, which shall include:

a. analytical test procedures for chemical analysis of sediment will follow those specified in Section B3, above;

b. use of a sample labeling system to ensure proper tracking of samples from collection through analysis to listing in the final report;

c. use of standard quality assurance protocols, including method blanks, control spikes, duplicate matrix spikes, and percent recoveries for internal quantitation standards and surrogate standards; and

d. maintenance of accurate quality control records including at least daily analytical instrument calibration data.

Results from quality assurance analyses will be reported along with the results for the sediment samples.

B6. All excess sediment will be appropriately preserved for a period of 60 days subsequent to the initial analyses. This sediment will be used for additional testing, if necessary.

II. Reporting Results

A report will be prepared that describes all methodology and data obtained. Maps will be included that show the location of all sediment sample locations. Data will be compiled on the ARC/INFO DOS operated Geographic Information System (GIS). The horizontal grid will be based on the NAD 83, Delaware State Plan Coordinate System. Data will be delivered on a high density 3 1/2" floppy disk. Such procedures will facilitate data analysis as well as generation of graphics that clearly present pertinent information.

Draft Report - Three copies of a draft report will be submitted to the Corps by December 13, 1996. The draft report must be a polished product and an accurate representation of the content of the final report. The draft must be clean-typed, complete with all figures, tables and sections of the report. All graphics will appear in the same format, and general location in the report as they will be in the final report.

Final Report - Subsequent to a 3-week review period the Corps will provide the Contractor with comments on the draft report. The Contractor will then have an additional 2 weeks to revise and submit the final report. The Contractor shall submit one unbound, reproducible original and 10 bound copies of the final report.

III. Report Format and Content

Draft and final copies of the report of investigation will reflect and report the analysis outlined in this scope of work. Draft and final reports must contain the following features:

a. If the report has been written by someone other than the contract principal investigator, the cover and title page of the publishable report must bear the inscription Prepared Under the Supervision of (name), Principal Investigator. The principal investigator is required to sign the original copy of the report. In addition, the principal investigator must at least prepare a forward describing the overall research context of the report, the significance of the work, and any other related background circumstances relating to the manner in which the work was undertaken.

b. The TITLE PAGE will include the date (month and year) the report was submitted, the project name, the author, Prepared for the U.S. Army Corps of Engineers, Philadelphia District, and the contract number.

c. An EXECUTIVE SUMMARY that provides a brief description of the study's purpose, finding, conclusions and recommendations.

d. A TABLE OF CONTENTS that includes a list of all tables, figures and appendices presented in the report.

e. An INTRODUCTION section stating the purpose of the study with background information on the Delaware River, Philadelphia to the Sea Federal navigation project.

f. A METHODOLOGY section that describes the sampling and analysis equipment and methodologies.

g. A RESULTS section that presents collected data in tabular and graphic form, and details applicable statistical analyses used to evaluate the data.

h. A DISCUSSION section that collates statistical data with published literature and draws inferences regarding sediment contamination within the navigation channel.

i. A CONCLUSIONS section that emphasizes the main points articulated in the body of the report, and provides pertinent recommendations.

j. A LIST OF REFERENCES that includes literature cited and agencies/ individuals consulted.

k. Include APPENDICES for data sheets, records, and other pertinent information.

1. PAGE SIZE AND FORMAT. Each report will be produced on 8 1/2 " x 11" paper, singled spaced, with double spacing between paragraphs. Figures should not exceed 11" in height nor 12" in length in most circumstances. Larger figures may be produced, but an 8 1/2" x 11" version must be included in the report. All text pages (including appendices) must be consecutively numbered. Text print quality must at least be letter quality.

IV. Period of Performance

a. The Contractor will submit the required number of copies of the draft report by December 13, 1996.

b. The Corps will provide review comments to the Contractor within 3 weeks of receipt of the draft report.

c. The Contractor will furnish the required number of copies of the final report within 2 weeks of receipt of review comments on the draft report. The final report will be due on January 17, 1997.

d. When the Corps accepts the final report the Contract will be complete.

V. Options for Increased or Decreased Quantity

The Government may increase or decrease the quantities specified under sections IA and IB called for herein by the amount stated in the schedule and at the unit price specified therein. The Contracting Officer may exercise this option, at any time within the period of contract performance, by giving written notice to the Contractor. Delivery/performance of the item added by the excise of this option shall continue immediately after, and at the same rate as delivery of like items called for under this contract unless the parties otherwise agree.

VI. Inspection

The work will be conducted under the general discretion of the Contracting Officer and shall be subject to inspection by his appointed inspectors to insure strict compliance with the terms of the contract, but the presence of the inspector shall not relieve the contractor of responsibility for the proper execution of the work in accordance with the specifications.

Table 1. Delaware River, Philadelphia to the Sea Federal Navigation Project - PCB Analysis of Channel Sediments - Vibrocore Hole Locations.

Vibrocore Number	River Range	Vibrocore Location	Channel Station	Type of Material
DRV-1	Reach M	Plate 1	24+000	Sand
DRV-2	Horseshoe Bend	Plate 1	41+217	Sand
DRV-3	Mifflin	Plate 1	60+000	Sand
DRV-4	Tinicum	Plate 1	85+000	Sand
DRV-5	Eddystone	Plate 2	102+000	Sand
DRV-6	Marcus Hook	Plate 2	125+000	Silt
DRV-7	Deepwater Point	Plate 2	195+000	Silt
DRV-8	New Castle	Plate 2	215+000	Sand
DRV-9	Liston	Plate 3	290+000	Silt
DRV-10	Liston	Plate 3	325+000	Sand
DRV-11	Liston	Plate 4	355+000	Sand
DRV-12	Liston	Plate 4	361+000	Silt
DRV-13	Liston	Plate 4	382+000	Silt
DRV-14	Crossledge	Plate 4	390+500	Sand
DRV-15	Brandywine	Plate 4	457+000	Silt

TABLE 2

NON-ORTHO COPLANAR PCB CONGENERS SUBSTITUTED IN BOTH PARA AND TWO OR MORE META POSITIONS

IUPAC NUMBER	STRUCTURE	HOMOLOG GROUP
77	3,3',4,4'	Tetra-CB
81	3,4,4',5	Tetra-CB
126	3,3',4,4',5	Penta-CB
169	3,3',4,4',5,5'	Hexa-CB

TABLE 3

TARGETED PCB CONGENERS OTHER THAN NON-ORTHO PCBs

IUPAC NUMBER	CHLORINE POSITIONING	HOMOLOG GROUP
8	2,4'	Di-CB
18	2,2',5	Tri-CB
28	2,4,4'	Tri-CB
37	3,4,4'	Tri-CB
42	2,2',3,4'	Tetra-CB
44	2,2',3,5'	Tetra-CB
47	2,2',4,4'	Tetra-CB
49	2,2',4,5'	Tetra-CB
52	2,2',5,5'	Tetra-CB
60	2,3,4,4'	Tetra-CB
64	2,3,4',6	Tetra-CB
66	2,3',4,4'	Tetra-CB
70	2,3',4',5	Tetra-CB
74	2,4,4',5	Tetra-CB
80	3,3',5,5'	Tetra-CB
82	2,2',3,3',4	Penta-CB
84	2,2',3,3',6	Penta-CB
86	2,2',3,4,5	Penta-CB
87	2,2',3,4,5'	Penta-CB
91	2,2',3,4',6	Penta-CB

IUPAC NUMBER	CHLORINE POSITIONING	HOMOLOG GROUP
92	2,2',3,5,5'	Penta-CB
95	2,2',3,5',6	Penta-CB
97	2,2',3',4,5	Penta-CB
99	2,2',4,4',5	Penta-CB
101	2,2',4,5,5'	Penta-CB
105	2,3,3',4,4'	Penta-CB
110	2,3,3',4',6	Penta-CB
114	2,3,4,4',5	Penta-CB
118	2,3',4,4',5	Penta-CB
119	2,3',4,4',6	Penta-CB
120	2,3',4,5,5'	Penta-CB
123	2',3,4,4',5	Penta-CB
127	3,3',4,5,5'	Penta-CB
128	2,2',3,3',4,4'	Hexa-CB
137	2,2',3,4,4',5	Hexa-CB
138	2,2',3,4,4',5'	Hexa-CB
141	2,2',3,4,5,5'	Hexa-CB
146	2,2',3,4',5,5'	Hexa-CB
149	2,2',3,4',5',6	Hexa-CB
151	2,2',3,5,5',6	Hexa-CB
153	2,2',4,4',5,5'	Hexa-CB
156	2,3,3',4,4',5	Hexa-CB
157	2,3,3',4,4',5'	Hexa-CB

IUPAC NUMBER	CHLORINE POSITIONING	HOMOLOG GROUP
158	2,3,3',4,4',6	Hexa-CB
166	2,3,4,4',5,6	Hexa-CB
167	2,3',4,4',5,5'	Hexa-CB
168	2,3',4,4',5',6	Hexa-CB
170	2,2',3,3',4,4',5	Hepta-CB
171	2,2',3,3',4,4',6	Hepta-CB
174	2,2',3,3',4,5,6'	Hepta-CB
177	2,2',3,3',4',5,6	Hepta-CB
179	2,2',3,3',5,6,6'	Hepta-CB
180	2,2',3,4,4',5,5'	Hepta-CB
183	2,2',3,4,4',5',6	Hepta-CB
185	2,2',3,4,5,5',6	Hepta-CB
187	2,2',3,4',5,5',6	Hepta-CB
189	2,3,3',4,4',5,5'	Hepta-CB
190	2,3,3',4,4',5,6	Hepta-CB
191	2,3,3',4,4',5',6	Hepta-CB
194	2,2',3,3',4,4',5,5'	Octa-CB
195	2,2',3,3',4,4',5,6	Octa-CB
196	2,2',3,3',4,4',5',6	Octa-CB
198	2,2',3,3',4,5,5',6	Octa-CB
200	2,2',3,3',4,5',6,6'	Octa-CB
201	2,2',3,3',4',5,5',6	Octa-CB
203	2,2',3,4,4',5,5',6	Octa-CB

IUPAC NUMBER	CHLORINE POSITIONING	HOMOLOG GROUP
205	2,3,3',4,4',5,5',6	Octa-CB
206	2,2',3,3',4,4',5,5',6	Nona-CB
207	2,2',3,3',4,4',5,6,6'	Nona-CB
208	2,2',3,3',4,5,5',6,6'	Nona-CB
209	2,2',3,3',4,4',5,5',6,6'	Deca-CB

APPENDIX F

STATISTICAL ANALYSES CONDUCTED BY RICK GREENE (DNREC)

SUMMARY OF DETECTION FREQUENCIES
PCBs IN DELAWARE ESTUARY SEDIMENTS

	% Detected by HRGC/LRMS (reporting limit 2.2 ppb to 5 ppb)	% Detected by HRGC/LRMS (reporting limit 0.01 ppt to 7.2 ppt)
All Surface + Subsurface Samples, Main Channel	12/30 = 40.0%	29/30 = 96.7%
All Surface Samples, Main Channel	7/15 = 46.7%	15/15 = 100%
All Subsurface Samples, Main Channel	5/15 = 33.3%	14/15 = 93.3%
All Surface Samples, Shallows[1]	16/16 = 100%	NA
Surface + Subsurface Samples DRV-11 through DRV-15, Main Channel	0/10 = 0%	9/10 = 90%

[1] These samples were analyzed by GC/ECD with a target detection limit of 1 ppb for individual congeners.

SUMMARY OF EXCEEDANCE FREQUENCIES
PCBs IN DELAWARE ESTUARY SEDIMENTS

	Total PCB		PCB TEQs	
	% > BBSQC	% > ERL	% > BBSQC	% > ERL
All Surface + Subsurface Samples, Main Channel	4/30 = 13.3%	5/30 = 16.7%	0/30 = 0%	NA
All Surface Samples, Main Channel	1/15 = 6.7%	2/15 = 13.3%	0/15 = 0%	NA
All Subsurface Samples, Main Channel	3/15 = 20%	3/15 = 20%	0/15 = 0%	NA
All Surface Samples, Shallows	14/16 = 87.5%	14/16 = 87.5%	1/16 = 0.06%	NA
Surface + Subsurface Samples DRV-11 through DRV-15, Main Channel	0/10 = 0%	0/10 = 0%	0/10 = 0%	NA

CATEGORICAL STATISTICAL COMPARISONS
PCBs IN DELAWARE ESTUARY SEDIMENTS

Categories Being Compared	Hypotheses		Result of Mann-Whitney (Wilcoxon) W Test
	H_o	H_1	
Total PCB in Main Channel Surface Sediments vs. Total PCB in Main Channel Subsurface Sediments	medians are equal	medians not equal	Accept H_o, Reject H_1 ($p = 0.74$)
Total PCB in Main Channel Surface Sediments vs. Total PCB in Shallows	medians are equal	median for main channel < median for shallows	Accept H_1, Reject H_o ($p = 0.0000063$)
PCB TEQs in Main Channel Surface Sediments vs. PCB TEQs in Main Channel Subsurface Sediments	medians are equal	medians not equal	Accept H_o, Reject H_1 ($p = 0.93$)
PCB TEQs in Main Channel Surface Sediments vs. PCB TEQs in Shallows	medians are equal	median for main channel < median for shallows	Accept H_1, Reject H_o ($p = 0.0000063$)
Total PCB Main Channel Samples DRV-1 thru DRV-10 vs. Total PCB Main Channel DRV-11 thru DRV-15	medians are equal	median for DRV-1 thru DRV-10 > median for DRV-11 thru DRV-15	Accept H_1, Reject H_o ($p = 0.0034$)
Total PCB Main Channel Samples DRV-1 thru DRV-7 vs. Total PCB Main Channel DRV-8 thru DRV-15	medians are equal	median for DRV-1 thru DRV-7 > median for DRV-8 thru DRV-15	Accept H_1, Reject H_o ($p = 0.018$)
PCB TEQ Main Channel Samples DRV-1 thru DRV-10 vs. PCB TEQ Main Channel DRV-11 thru DRV-15	medians are equal	median for DRV-1 thru DRV-10 > median for DRV-11 thru DRV-15	Accept H_1, Reject H_o ($p = 0.005$)
PCB TEQ Main Channel Samples DRV-1 thru DRV-7 vs. PCB TEQ Main Channel DRV-8 thru DRV-15	medians are equal	median for DRV-1 thru DRV-7 > median for DRV-8 thru DRV-15	Accept H_o, Reject H_1 ($p = 0.12$)

STATISTICAL COMPARISONS TO SEDIMENT SCREENING CRITERIA
PCBs IN DELAWARE ESTUARY SEDIMENTS

Category	Hypotheses		Result of Sign Test
	H_o	H_1	
Total PCB in Main Channel Sediments	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Sediments	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.01
Total PCB in Shallows	median = 33.8 ppb	median > 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Shallows	median = 22.7 ppb	median > 22.7 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Surface Sediments	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Surface Sediments	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Subsurface Sediments	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.05 but not at 0.01
Total PCB in Main Channel Subsurface Sediments	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.05 but not at 0.01
Total PCB in Main Channel Sediments DRV-1 thru DRV-10	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Sediments DRV-1 thru DRV-10	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.05 but not at 0.01
Total PCB in Main Channel Sediments DRV-11 thru DRV-15	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Sediments DRV-11 thru DRV-15	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Sediments DRV-1 thru DRV-7	median = 33.8 ppb	median < 33.8 ppb	Accept H_o at alpha = 0.01 and 0.05

Category	Hypotheses		Result of Sign Test
	H_o	H_1	
Total PCB in Main Channel Sediments DRV-1 thru DRV-7	median = 22.7 ppb	median < 22.7 ppb	Accept H_o at alpha = 0.01 and 0.05
Total PCB in Main Channel Sediments DRV-8 thru DRV-15	median = 33.8 ppb	median < 33.8 ppb	Accept H_1 at alpha = 0.01
Total PCB in Main Channel Sediments DRV-8 thru DRV-15	median = 22.7 ppb	median < 22.7 ppb	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Sediments	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Shallows	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Surface Sediments	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Suburface Sediments	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Sediments DRV-1 thru DRV-10	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Sediments DRV-11 thru DRV-15	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Sediments DRV-1 thru DRV-7	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01
PCB TEQs in Main Channel Sediments DRV-8 thru DRV-15	median = 32 pptr	median < 32 pptr	Accept H_1 at alpha = 0.01

SPREADSHEET TO COMPUTE 2378-TCDD TOXICITY EQUIVALENTS FOR COPLANAR PCBs
PROJECT: COE DEL RIVER MAIN CHANNEL DEEPENING
DATA SOURCE: MRI (1997)

CONC. (ppb) OF AHH-ACTIVE PCBs IN DEL RIVER MAIN CHANNEL SEDIMENTS

	IUPAC	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-	DRV-04-C-S	DRV-04-C-B	DRV-05-C-S
Non-ortho	77	0.0852	0.00782	0.00396	0.00288	0.0854	0.0102	0.278	0.79	0.00724
	126	0.00306	U(0.376)	U(0.612)	U(0.828)	0.00344	U(0.447)	0.00974	0.0228	U(0.643)
	169	0.00028	U(0.0598)	U(0.0115)	U(0.177)	0.000778	U(0.0157)	0.001148	0.00178	U(0.107)
Mono-orth	105	U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(4.4 EMPC)	U(2.3)	U(2.36)	U(12.8 EM	U(2.32)
	114	U(2.64 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(9.07 EM	U(2.32)
	118	U(3.84 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(3.46 EMPC)	U(2.3)	U(5.14 EMPC	U(15.7 EM	U(2.32)
	123	U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.44 EMP
	156	U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.97 EMPC)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
	157	U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(2.42)	U(2.32)
	167	U(5.24 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(4.47 EMPC)	U(2.3)	U(3.59 EMPC	U(8.45 EM	U(2.32)
	189	U(2.35)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(2.36)	U(4.12 EM	U(2.32)
Di-ortho	170/190	U(4.64 EMPC)	U(2.38)	U(2.46)	U(2.46)	U(2.35)	U(2.3)	U(3.24 EMPC	U(5.55 EM	U(2.32)
	180	U(2.53 EMPC)	U(2.38)	U(2.46)	U(2.46)	2.76	U(2.3)	U(5.41 EMPC	U(6.33 EM	U(2.32)

DRV-05-C-B	DRV-06-C-	DRV-06-C-B	DRV-07-C-S	DRV-07-C-B	DRV-08-C-S	DRV-08-C-B	DRV-09-C-S	DRV-09-C-B	DRV-10-C-S	DRV-10-C-B
0.0044	0.664	0.76	0.374	0.436	0.00344	1.604	0.0161	0.1164	0.192	0.23
U(0.243)	0.0282	0.0278	0.01552	0.01804	U(0.359)	0.0206	U(0.609)	0.00296	0.00408	0.00394
U(0.117)	0.00502	0.00436	0.00344	0.00376	U(0.113)	0.00758	U(0.0920)	0.0031	0.00848	0.0074
U(2.2)	U(8.04 EM	U(6.9 EMPC)	U(4.92 EMP	U(13.3 EMP	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(12.8 EMP	U(2.4)
U(2.2)	U(5.66 EM	U(3.34 EMP	U(2.82)	U(13.9 EMP	U(2.46 EMP	U(2.46)	U(3.29 EMP	U(6.62 EMP	U(3.51 EMP	U(2.4)
U(2.2)	U(13.5 EM	8.48	U(6.55 EMP	U(5.09 EMP	U(2.27)	U(2.46)	U(2.72 EMP	U(3.17 EMP	U(3.66 EMP	U(2.4)
U(2.2)	U(2.43)	U(4.74 EMP	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)	U(2.4)
U(2.2)	U(2.43)	U(9.24 EMP	U(2.45)	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)	U(2.4)
U(2.2)	U(2.43)	U(6.72 EMP	U(2.82 EMP	U(2.31)	U(2.27)	U(2.46)	U(2.41)	U(3.74 EMP	U(3.98 EMP	U(3.01 EMP
U(2.2)	U(10.6 EMP	U(11.9 EMP	U(9.62 EMP	U(2.31)	U(2.27)	U(2.46)	U(3.48 EMP	U(2.36)	U(2.27)	U(2.4)
U(2.2)	U(2.73 EMP	U(2.38)	U(2.45)	3.25	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)	U(2.4)
U(2.2)	5.47	U(2.38)	U(5.1 EMP	U(2.7 EMPC	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)	U(2.4)
U(2.2)	5.62	4.53	3.7	3.13	U(2.27)	U(2.46)	U(2.41)	U(2.36)	U(2.27)	U(2.4)

DRV-11-C-S	DRV-11-C-B	DRV-12-C-	DRV-12-C-B	DRV-13-C-S	DRV-13-C-B	DRV-14-C-S	DRV-14-C-B	DRV-15-C-S	DRV-15-C-B
0.00548	0.00582	0.00486	0.00238	0.00522	0.00648	0.01766	0.01118	0.00514	U(1.31)
U(0.695)	U(0.416)	U(0.831)	U(0.856)	U(1.06)	U(7.15	U(0.603)	U(0.363)	U(0.328)	U(1.33)
0.000204	U(0.0894)	U(0.104)	U(0.147)	U(0.0715)	U(0.432)	U(0.0216)	U(0.0258)	U(0.0978)	U(0.482)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)
U(2.47)	U(2.36)	U(2.41)	U(2.45)	U(2.34)	U(2.27)	U(2.28)	U(2.35)	U(2.28)	U(2.42)

DRV-05-C-B	DRV-06-C-	DRV-06-C-B	DRV-07-C-S	DRV-07-C-B	DRV-08-C-S	DRV-08-C-B	DRV-09-C-S	DRV-09-C-B	DRV-10-C-S	DRV-10-C-B
0.0044	0.664	0.76	0.374	0.436	0.00344	1.604	0.0161	0.1164	0.192	0.23
0	0.0282	0.0278	0.01552	0.01804	0	0.0206	0	0.00296	0.00408	0.00394
0	0.00502	0.00436	0.00344	0.00376	0	0.00758	0	0.0031	0.00848	0.0074
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	8.48	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	3.25	0	0	0	0	0	0
0	5.47	0	0	0	0	0	0	0	0	0
0	5.62	4.53	3.7	3.13	0	0	0	0	0	0

CONC. (ppb) OF AHH-ACTIVE PCBs IN DELAWARE RIVER MAIN CHANNEL SEDIMENTS WITH NON-DETECTS SET EQUAL TO ZERO.

	IUPAC	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-S	DRV-03-C-	DRV-04-C-S	DRV-04-C-B	DRV-05-C-S
Non-ortho	77	0.0852	0.00782	0.00396	0.00288	0.0854	0.0102	0.278	0.79	0.00724
	126	0.00306	0	0	0	0.00344	0	0.00974	0.0228	0
	169	0.00028	0	0	0	0.000778	0	0.001148	0.00178	0
Mono-orth	105	0	0	0	0	0	0	0	0	0
	114	0	0	0	0	0	0	0	0	0
	118	0	0	0	0	0	0	0	0	0
	123	0	0	0	0	0	0	0	0	0
	156	0	0	0	0	0	0	0	0	0
	157	0	0	0	0	0	0	0	0	0
	167	0	0	0	0	0	0	0	0	0
	189	0	0	0	0	0	0	0	0	0
Di-ortho	170/190	0	0	0	0	0	0	0	0	0
	180	0	0	0	0	2.76	0	0	0	0

DRV-11-C-S	DRV-11-C-B	DRV-12-C-	DRV-12-C-B	DRV-13-C-S	DRV-13-C-B	DRV-14-C-S	DRV-14-C-B	DRV-15-C-S	DRV-15-C-B
0.00548	0.00582	0.00486	0.00238	0.00522	0.00648	0.01766	0.01118	0.00514	0
0	0	0	0	0	0	0	0	0	0
0.000204	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

TEQs FOR DIOXIN-LIKE PCBs IN DELAWARE RIVER MAIN CHANNEL SEDIMENTS

	IUPAC	TEF	DRV-01-C-S	DRV-01-C-B	DRV-02-C-S	DRV-02-C-B	DRV-03-C-	DRV-03-C-B	DRV-04-C-S	DRV-04-C-B
Non-ortho	77	0.0005	4.26E-05	3.91E-06	1.98E-06	1.44E-06	4.27E-05	5.1E-06	0.000139	0.000395
	126	0.1	0.000306	0	0	0	0.000344	0	0.000974	0.00228
	169	0.01	2.8E-06	0	0	0	7.78E-06	0	1.148E-05	1.78E-05
Mono-orth	105	0.0001	0	0	0	0	0	0	0	0
	114	0.0005	0	0	0	0	0	0	0	0
	118	0.0001	0	0	0	0	0	0	0	0
	123	0.0001	0	0	0	0	0	0	0	0
	156	0.0005	0	0	0	0	0	0	0	0
	157	0.0005	0	0	0	0	0	0	0	0
	167	1E-05	0	0	0	0	0	0	0	0
	189	0.0001	0	0	0	0	0	0	0	0
Di-ortho	170	0.0001	0	0	0	0	0	0	0	0
	180	1E-05	0	0	0	0	2.76E-05	0	0	0
		PCB TEQ (ppb)	0.0003514	3.91E-06	1.98E-06	1.44E-06	0.0004221	5.1E-06	0.00112448	0.0026928
		PCB TEQ (pptr)	0.3514	0.00391	0.00198	0.00144	0.42208	0.0051	1.12448	2.6928

NOTE: TEFs FOR DIOXIN-LIKE PCBs BASED ON AHLBORG, et al, 1994.

DRV-05-C-S	DRV-05-C-	DRV-06-C-S	DRV-06-C-B	DRV-07-C-S	DRV-07-C-B	DRV-08-C-S	DRV-08-C-B	DRV-09-C-S	DRV-09-C-B	DRV-10-C-S
3.62E-06	2.2E-06	0.000332	0.00038	0.000187	0.000218	1.72E-06	0.000802	8.05E-06	5.82E-05	9.6E-05
0	0	0.00282	0.00278	0.001552	0.001804	0	0.00206	0	0.000296	0.000408
0	0	5.02E-05	4.36E-05	3.44E-05	3.76E-05	0	7.58E-05	0	3.1E-05	8.48E-05
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0.000848	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0.000325	0	0	0	0	0
0	0	0.000547	0	0	0	0	0	0	0	0
0	0	5.62E-05	4.53E-05	3.7E-05	3.13E-05	0	0	0	0	0
3.62E-06	2.2E-06	0.0038054	0.0040969	0.0018104	0.0024159	1.72E-06	0.0029378	8.05E-06	0.0003852	0.0005888
0.00362	0.0022	3.8054	4.0969	1.8104	2.4159	0.00172	2.9378	0.00805	0.3852	0.5888

DRV-10-C-B	DRV-11-C-S	DRV-11-C-	DRV-12-C-S	DRV-12-C-B	DRV-13-C-S	DRV-13-C-B	DRV-14-C-S	DRV-14-C-B	DRV-15-C-S	DRV-15-C-B
0.000115	2.74E-06	2.91E-06	2.43E-06	1.19E-06	2.61E-06	3.24E-06	8.83E-06	5.59E-06	2.57E-06	0
0.000394	0	0	0	0	0	0	0	0	0	0
7.4E-05	2.04E-06	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0.000583	4.78E-06	2.91E-06	2.43E-06	1.19E-06	2.61E-06	3.24E-06	8.83E-06	5.59E-06	2.57E-06	0
0.583	0.00478	0.00291	0.00243	0.00119	0.00261	0.00324	0.00883	0.00559	0.00257	0