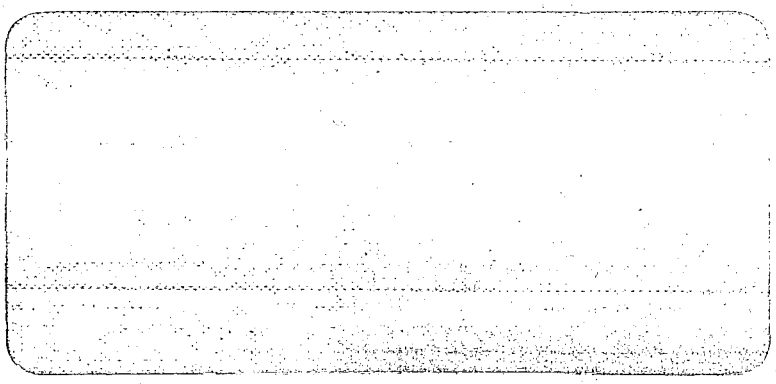
CDM Camp Dresser & McKee

Report



Draft Report

PCB CONGENER-BASED ESTIMATES OF THE LOCAL CONTRIBUTION OF PCBs TO THE HAMILTON POND PORTION OF CEDAR CREEK

November 1998

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1. SUMMARY

This report describes the results of a study to quantitatively evaluate the relative contributions of two potential sources to the mass of polychlorinated biphenyls (PCBs) in the sediments of Hamilton Pond, an impoundment in Cedar Creek, Cedarburg, Wisconsin. One source is from upstream industrial discharges by Mercury Marine (and perhaps others) who discharged PCBs into one or two upstream impoundments in Cedar Creek: Ruck and Columbia Ponds. The PCBs in these impoundments have been carried downstream over the years, principally by transport of contaminated sediments. Some of the upstream PCBs that were transported downstream were trapped in the sediment beds behind the Hamilton Pond dam (recently breached and removed). The other potential source is the Amcast plant in Cedarburg which is connected to a storm sewer that discharges to Cedar Creek near the upstream end of Hamilton Pond. An earlier (historic) discharge location for this pipe is just upstream of the current outfall. Other minor sources of PCB may have existed in the past, including the Cedarburg sewage treatment plant which discharges to Cedar Creek just downstream of the Amcast-related storm sewer pipe.

To evaluate the contributions of the two sources, a program was carried out that involved the analysis of PCBs by congener in sediment samples from the three areas of concern:

- The "upstream" source - represented by 3 sediment samples from areas of Cedar Creek that are at least 200 feet upstream of the Amcast-related discharges, both current and historic.

- The Amcast source - represented by 2 sediment samples taken from the sewer pipe directly outside the Amcast plant (accessed via a manhole).

- Hamilton Pond sediments - represented by 6 samples taken from the major sediment beds near the former dam. One of these sediment samples was subsequently found to have insufficient PCB concentration for use in the analysis.

PCB congener analyses use high resolution gas chromatography to separately identify and quantify almost every congener present in a sample; in some cases, groups of 2 or 3 congeners coelute and are collectively quantified. The resulting data can be considered a "fingerprint" of the PCB mixture present. Industrial sources that used different commercial PCB products would, after discharge, yield contaminated media (e.g., soils, sediments) that would show distinctly different fingerprint patterns in the data from a PCB congener analysis. As expected -- based on significant differences in the commercial Aroclors associated with the two sources (principally Aroclor 1260 for the "upstream" source and Aroclor 1242 for the Amcast plant) -- the PCB congener fingerprints of the two sources were easily distinguished by simple visual inspection.

The mathematical analysis of the data -- i.e., the PCB congener data from the samples in the

three areas described above -- assumed that all of the PCBs in the Hamilton Pond sediments came from one of the two identified sources. The congener concentration data used were in units of weight percent (not mg/kg) since only the congener pattern, not the absolute PCB concentration, is important in the fingerprint. A simple mixing equation was used to predict concentrations for individual congeners in Hamilton Pond sediments assuming different combinations of the two sources. The predicted concentrations, on a sample-by-sample basis, were compared with actual measured congener data. A least squares routine -- using the sum of the squares of the difference between predicted and measured concentrations -- was used to find the mixing ratio that gave the best fit of the predicted and measured congener patterns. This analysis directly yields the estimate of the relative contributions of the "upstream" and Amcast sources.

The fingerprinting analysis was carried out for the five Hamilton Pond sediments that had significant PCB concentrations. The percentage of PCBs determined to have come from the Amcast source ranged from 7 to 21% and averaged 12%. The standard deviation of the data set was 6%. Comparisons of the predicted and measured PCB congener patterns for the 5 samples showed acceptable fits for 4 samples and a poor fit for one sample. Overall, the analysis is considered to have provided reliable information on the relative contribution of the "upstream" and Amcast sources. The analysis indicates the most likely allocation is 12 ± 6% for Amcast and 88 ± 6% for the "upstream" sources. Additional accuracy in the allocation could be achieved by conducting similar analyses on additional Hamilton Pond sediment samples.

2. INTRODUCTION

In September 1996, Camp Dresser & McKee (CDM) undertook a preliminary analysis of the available data on polychlorinated biphenyls (PCBs) in Cedar Creek, Cedarburg, WI (CDM, 1996). The area of interest for the Creek includes a series of ponds or impoundments: Ruck Pond, Columbia Pond, Wire and Nail Pond, and Hamilton Pond (listed in order of downstream flow). The objective was to determine if the data would support a determination of the relative contribution -- between Amcast Corporation and other potentially responsible parties (primarily Mercury Marine) -- of the sediment-bound PCBs present in the Hamilton Pond portion of Cedar Creek. The data in the reports reviewed generally indicated that the Amcast contribution to the PCBs of Hamilton Pond was a minor one. However, this initial review could only support a qualitative conclusion. To provide a quantitative estimate of the potential Amcast contribution, CDM recommended that additional studies be conducted involving: (1) mathematical modeling of PCB and sediment transport; and (2) a "fingerprint" type analysis using PCB congener analyses of sediment samples (CDM, 1996). This report describes the results of the fingerprinting type analysis that was conducted. The modeling results are provided in a separate report (CDM, 1998).

The essence of the fingerprinting work conducted involved the analysis (for PCBs by congener) of sediment samples from three basic locations:

1) The storm sewer leading from Amcast's Cedarburg plant to Cedar Creek;

2) Cedar Creek upstream of the location where the Amcast-related storm sewer discharges to the Creek; and

3) Hamilton Pond, focusing on the area of deepest sediment deposition just upstream of the former Hamilton Pond dam.

The "Amcast sewer" and "upstream" samples comprise the two potential source fingerprints for the PCBs present in Hamilton Pond sediments. By means of mathematical analysis, it was determined what combination of these two fingerprints best matched the fingerprint of the PCBs in the Hamilton Pond samples. This led directly to the quantitative estimate of the fraction of sediment-bound PCBs in Hamilton Pond that were of local origin, i.e., likely came from Amcast and/or the Cedarburg sewage treatment plant (which also discharges to the Creek near the Amcast-related outfall).

This work was carried out primarily by CDM, with assistance in sample collection from Blasland Bouck & Lee (BBL, Syracuse, NY), and with sample analyses by Northeast Analytical (NEA, Schenectady, NY). BBL's sampling work was done at the same time they were collecting sediment samples for the further characterization of Cedar Creek, as required by the State of

Wisconsin, Department of Natural Resources. BBL played no other role in the planning or execution of this project.

This project was initiated in April 1997, and has involved the following events:

- Site visit - On July 24, 1997, CDM (Warren Lyman and Dylan Keenan) visited the site to identify sampling locations at the Amcast plant and in Cedar Creek.

- Sampling and analysis plan - A plan was prepared (in September 1997) that described the sampling and analytical protocols to be used. (The Plan is provided in **Appendix A** of this report.)

- Sampling of Amcast sewer - CDM collected these samples on October 16, 1997. The samples were immediately submitted to Northeast Analytical for analysis.

- Initial sampling of sediments in Cedar Creek and Hamilton Pond - BBL initially collected 8 samples for CDM on May 14, 1998. CDM immediately submitted these samples to NEA for analysis. (The sampling event was documented in an internal CDM memo which is provided in **Appendix B** of this report.)

- Initial data analysis - An initial data analysis showed that, due to uncommonly low PCB concentrations in some samples, there were insufficient data for the fingerprinting analysis.

- Obtain additional sediment samples - With the logistical assistance of BBL, CDM requested (June, 1998) and received (August, 1998) 4 additional sediment samples, collected in 1998 by BBL, that had been archived by ITS Environmental Laboratories (Richardson, TX). These samples were submitted to NEA for analysis.

- Completion of data analysis - CDM completed its data analysis using data from the combined data sets.

Section 3 of this report provides additional details on the sampling and analytical methods used. In **Section 4**, the data from NEA are simply presented in tables and figures for visual inspection. In **Section 5**, we present the specialized data analysis that constitutes the fingerprint evaluation and the estimate of the local contribution of PCBs to Hamilton Pond sediments.

Tables and figures called out in a section have been placed after the text in that section.

3. SAMPLE COLLECTION AND ANALYSIS

Overview

In total, CDM obtained, for analysis, sediment samples as follows:

- Amcast sewer - Two samples from the Amcast storm sewer.
- "Upstream" samples - Three samples from Cedar Creek in areas at least 200 feet upstream of the Amcast-related discharge point to Cedar Creek.
- "Middle" samples - Two samples from the short segment of Cedar Creek between the current Amcast-related outfall (to Cedar Creek) and the Cedarburg sewage treatment plant outfall.
- "Downstream" samples - Six samples from the Hamilton Pond sediment deposits in an area near the former Hamilton Pond dam. All of these sample locations are well downstream of the Amcast-related storm sewer outfall. (A duplicate was collected for one of these samples.)

The locations of the Cedar Creek and Hamilton Pond samples are shown on **Figure 1**. The subsections below briefly describe each of the sampling and analysis events.

Amcast Sewer

The sampling at Amcast's Cedarburg plant was done in conformance with CDM's Sampling and Analysis Plan (see Appendix A). The samples were collected by Dylan Keenan (CDM) on October 16, 1997. The sampling was observed by Mr. Gary Scholl (Amcast). The samples were collected from a manhole located behind the Amcast plant (see photo in Appendix A). This manhole was identified as the one providing access to the storm sewer that carries storm water from the Amcast plant to Cedar Creek based on a review of a storm water site plan for the plant (Triad Engineering, 1995) and a discussion with the plant's project engineer, Noel Schuster.

Prior to sampling, it was necessary to remove approximately 6 inches of sand and gravel which had fallen into the manhole as a result of recent grading activities in the area. This material was removed until what appeared to be pre-existing sediments were exposed. As planned, two sediment samples were collected from the bottom of the manhole providing access to the storm sewer; they are designated SS-01 and SS-02. Sample SS-01 was collected from the northeast portion of the bottom of the manhole, while SS-02 was taken from the southwest portion of this area. The samples were taken from the groove between the bottom and side of the storm sewer basin. The samples were placed on ice and shipped via Airborne Express to Northeast Analytical

(NEA), Schenectady, NY. NEA analyzed the samples for PCBs by Aroclor, PCBs by congener and total organic carbon (TOC).

Initial Cedar Creek/Hamilton Pond Sampling

Initial samples were collected on May 14, 1998. Blasland Bouck & Lee (BBL) personnel (Todd Merrel and Rick Pierce) collected the samples at locations, and in a manner, specified by CDM. A CDM professional (Amy Sansone) was on-site to verify sample locations, oversee sample collection, take possession of the sediment samples, and ship the samples to NEA for analysis of PCBs by congener and TOC. Sediment samples were collected from approximately the first foot of sediment using a 2-inch Lexan tube driven manually into the sediment. Each sample was removed from the tube, placed on a clean sheet of aluminum foil, mixed by hand, and then a portion of the mixture placed in the sampling bottle. The samples were placed on ice for shipment to NEA by Airborne Express. The samples collected at this time were designated A1-1, A1-2, A2-3, A2-4, A3-5, A3-6, A3-7 and A3-8. Locations are shown in Figure 1. Sample A3-8 was a duplicate (split sample) for sample A3-7. Additional details on this sampling event are provided in the sampling event memo prepared by Ms. Sansone (see Appendix B).

Additional Archived Samples Provided by ITS Environmental Services

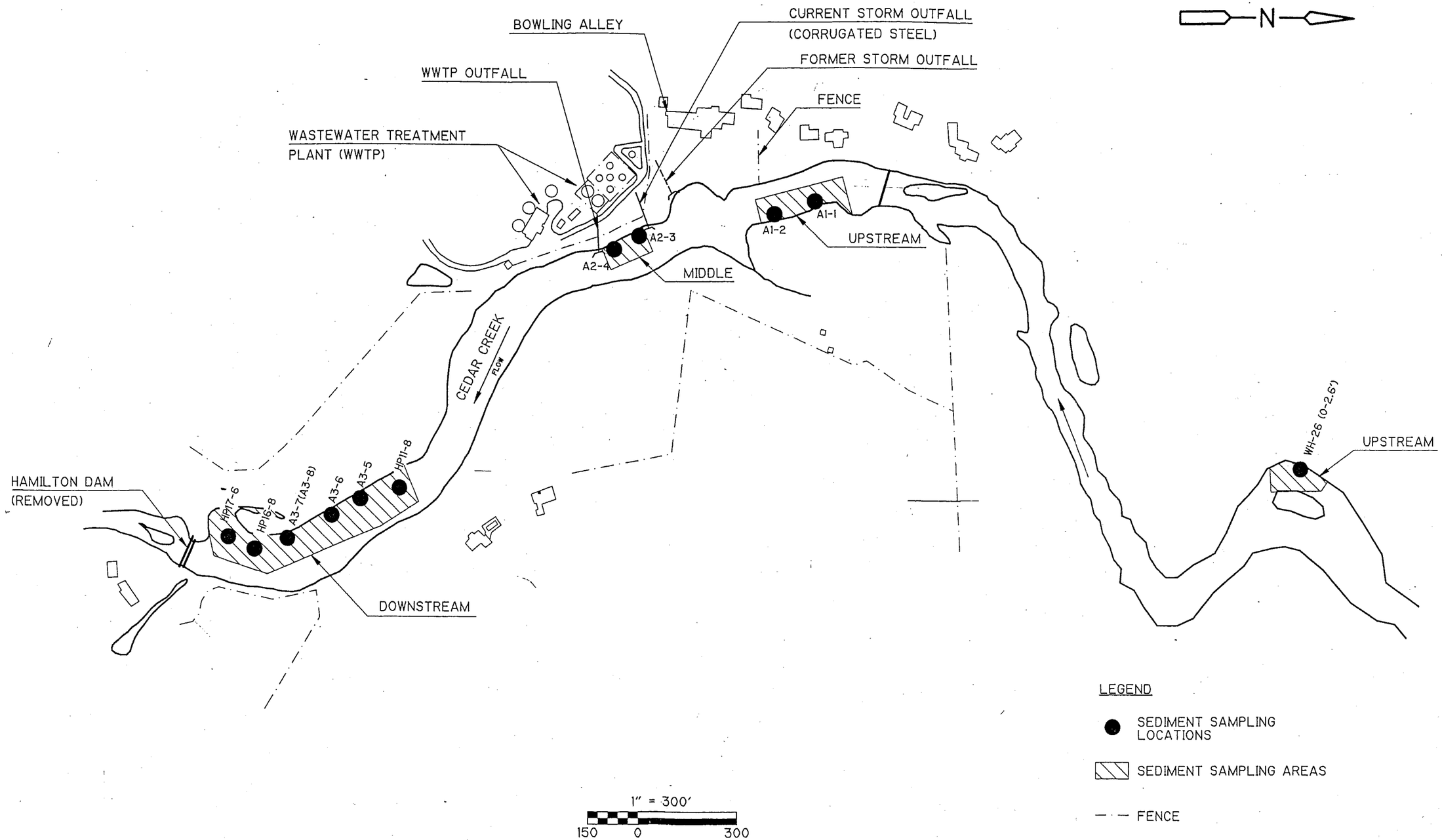
After determining that additional sediment samples would be required, and learning that ITS Environmental Services (Richardson, TX) had archived unused sediment sample material from previous BBL sampling in Cedar Creek, CDM requested portions of four archived sediment samples. The BBL sample codes for these four samples were: WH-26 (0-2.6'), HP11-8 (0-1'), HP16-8 (0-1'), and HP17-6 (0-1'). Their locations are also shown on Figure 1. In identifying archived samples to request, CDM focused on samples containing between 1 and 20 mg/kg total PCBs. As indicated in the above samples codes, all of the three Hamilton Pond samples (HP code) came from the 0-1' sample depth. The upstream sample (WH-26) came from the 0-2.6' depth.

The three HP samples had initially been collected by BBL from Hamilton Pond on May 4 or 5, 1998. The WH sample was collected on June 30, 1998. The archived samples were shipped directly from ITS to NEA where they were received on August 6, 1998. NEA analyzed the samples for PCBs by congener and TOC, as directed by CDM.

Analytical Methods

Total organic carbon (TOC) was analyzed by EPA Method 9060. The analysis of PCBs by congener was done by the Green Bay Method. The analysis of PCBs by congener (the two Amcast sewer samples) was by EPA Method 8081. In the Aroclor analysis, NEA looks for detectable concentrations of Aroclors 1016, 1221, 1232, 1242, 1248, 1254 and 1260. In the congener method, NEA looks to quantify up to 118 different PCB congeners or congener groups. For convenience, they are referred to by the sequential peak numbers for the peaks seen in the

gas chromatogram. Thus, for example, an analytical result for a given sediment sample might contain individual results for as many as 118 PCB "congeners", but more likely has results for only 40-90 congeners. The sum of the concentrations for each congener provides a total PCB concentration for the sample. The different congeners may be divided into subsets representing homolog groups, i.e., all congeners with the same number of chlorines on the biphenyl structure. The homolog groups are referred to by appropriate prefixes: e.g., "mono" for monochlorobiphenyls, "di" for dichlorobiphenyls, "tri" for trichlorobiphenyls, etc. Some of the analytical results shown in this report are in the form of congener and homolog histograms. In the figures displaying the data, the congeners are identified by peak number (1 to 118) and the homologs are identified by the appropriate prefix (mono to nona). The vertical scale in these histograms is commonly in units of weight percent in order to provide focus on the congener or homolog pattern (i.e., the "fingerprint") rather than on the absolute concentration. The absolute concentration does not play an important part in the fingerprint analysis.



CDM
environmental engineers, scientists, planners, & management consultants

SEDIMENT SAMPLING LOCATIONS: HAMILTON POND PORTION OF CEDAR CREEK

FIGURE 1

4. DATA PRESENTATION AND REVIEW

Table 1 presents a summary of the data for total PCBs, total organic carbon (TOC) and extent of chlorination for each of the sediment samples analyzed. Data for three laboratory blanks are also provided. Except where noted, the data for total PCBs are derived from the congener analyses. Aroclor analyses were only requested for the two Amcast sewer samples. In this case, the Aroclor and congener values for total PCBs are seen to be similar.

The TOC analyses had been requested in order to have a basis for understanding any major differences in total PCB concentrations. (To a first approximation, total PCB and TOC values should be roughly correlated due to the strong tendency of PCBs to sorb to organic matter.) The TOC data are not used for any other purpose in this project.

The data on number of chlorines per biphenyl, given in the right-hand columns of Table 1, are derived from the PCB congener analyses. The data are displayed here to provide one indication of the significant difference between the "upstream" samples (avg. total = 5.69 chlorines/biphenyl), the Amcast sewer samples (avg. total = 3.64 chlorines/biphenyl) and the "downstream" Hamilton Pond samples (avg. total = 5.2 chlorines/biphenyl). Clearly, the "upstream" samples are much more chlorinated than the Amcast samples; the difference, on average, is 2 chlorines/biphenyl.[1] The "downstream" Hamilton Pond samples are seen to have a degree of chlorination that is in between the "upstream" and Amcast values, but closer (on average) to the "upstream" value. Already, this analysis suggests that most of the PCBs in the Hamilton Pond sediments are derived from upstream sources rather than local (i.e., Amcast) sources. There are also differences in the ring positions of the chlorines: e.g., 42% in the ortho position for the Amcast sewer samples versus 39% in the ortho position for the "upstream" samples. This information on differences in degree of chlorination and chlorination location is strongly indicative of different PCB mixtures in the designated areas.

Figures 2, 3, 4 and 5 present, respectively, PCB congener and homolog histograms for the Amcast, "upstream", "middle" and "downstream" sediment samples. A visual inspection of these diagrams shows a distinct difference between the Amcast and "upstream" samples; i.e., they have distinctly different fingerprints. The diagrams for the "middle" and "downstream" samples are quite varied, but generally can be seen to be comprised of a mixture of the "upstream" and Amcast patterns. By way of example of the pattern differences, note the significant difference in the major homolog groups for the Amcast samples (Figure 2) and the "upstream" samples (Figure 3); tri- and tetra-chlorobiphenyls dominate the Amcast samples while penta-, hexa- and hepta-chlorinated biphenyls dominate the "upstream" samples.

1. This chlorination difference is consistent with the historic use of the more highly chlorinated Aroclor 1260 by Mercury Marine, the primary upstream PCB discharger, and the historic use of the lesser chlorinated Aroclor 1242 by Amcast, the primary "local" PCB discharger.

Because of the high degree of similarity in the diagrams (histograms) for the two Amcast samples (Figure 2), an average value was calculated to represent this source. The second page of Figure 2 shows the congener and homolog histograms for this average sample. For similar reasons, an average was calculated for the congener and homolog values for the three "upstream" samples; the combined (averaged) histograms are shown in the last panel on Figure 3. Because of the significant variability in the "downstream" samples, no calculation was undertaken to obtain an average sample.

As may be seen by the data on total PCBs in Table 1, one of the "downstream" samples, A3-6, had an anomalously low PCB concentration (0.015 mg/kg). This value is only marginally above the highest laboratory blank (0.011 mg/kg). It is concluded that this sample either: (1) contains no significant amount of PCBs; or (2) was compromised somewhere in the sampling and analytical process. It should be noted that, finding non-detect levels of PCBs in samples from Hamilton Pond sediments is quite common. For example, BBL's 1998 survey found that one third of the samples (18 of 54) had non-detect levels of PCBs, although with a higher detection level (0.12 to 0.26 mg/kg) (BBL, 1998). Because of the above, the results from sample A3-6 cannot be used in the fingerprinting analysis.

The two "middle" samples, A2-3 and A2-4, were collected in order to provide a rough check on the potential contribution of the Cedarburg sewage treatment plant to the PCB load in Hamilton Pond sediments. Had the PCB fingerprints for these samples been essentially identical to the "upstream" samples (which they were not -- compare Figures 3 and 4), then the sewage treatment plant would have been considered a more significant contributor. These two samples were collected in a region of Cedar Creek that is not considered to be part of the Hamilton Pond study area in that; (1) it is not a part of the actual Pond; and (2) there are no substantial sediment deposits in the area that are likely to be required to be remediated. For these reasons, these two samples are not used in the fingerprinting analysis.

As noted in Table 1, sample A3-8 is a split sample with A3-7, i.e., a duplicate sample. Thus, the results from A3-7 and A3-8 were averaged prior to use in the fingerprinting analysis. The averaged data, essentially representing a single sample, is referred to as sample A3-7/8.

Table 1
Summary of Sample Analyses for Amcast Sewer and Hamilton Pond

Sample Number	NEA Lab Number	General Location	Total Organic Carbon (mg/kg)	Total PCB Concentration (mg/kg)	Number of Chlorines per Biphenyl		
					Ortho	Meta + Para	Total
Amcast Sewer							
SS-1	AA07929	Sewer	10,000	63.6 (55.0)[1]	1.54	2.05	3.59
SS-2	AA07930	Sewer	5,900	27.1 (20.2)[1]	1.57	2.13	3.70
Hamilton Pond							
A1-1	AB02935	Upstream	18,000	0.95	2.20	3.33	5.53
A1-2	AB02936	Upstream	16,000	2.79	2.29	3.58	5.87
WH-26 (0 - 2.6')	AB04946	Upstream	3,900	0.75	2.19	3.47	5.66
A2-3	AB02937	Middle	30,000	8.47	2.11	3.05	5.16
A2-4	AB02938	Middle	8,700	3.46	1.91	2.77	4.68
A3-5	AB02939	Downstream	11,000	3.88	2.16	3.41	5.57
A3-6	AB02940	Downstream	17,000	0.015	1.72	2.44	4.16
A3-7	AB02941	Downstream	13,000	0.11	2.14	3.38	5.52
A3-8 *	AB02942	Downstream	9,800	0.12	2.02	2.72	4.74
HP11-8 (0 - 1')	AB04947	Downstream	21,000	3.10	1.77	2.98	4.75
HP16-8 (0 - 1')	AB04948	Downstream	15,000	13.2	2.18	3.48	5.66
HP17-6 (0 - 1')	AB04949	Downstream	20,000	18.3	2.14	3.42	5.56
Lab Blanks							
Lab Blank 1	AA7734B	Laboratory	-	0.003	2.08	1.68	3.76
Lab Blank 2	AB2936B	Laboratory	-	0.005	1.83	2.16	3.99
Lab Blank 3	AB04949B	Laboratory	-	0.011	1.34	2.19	3.53

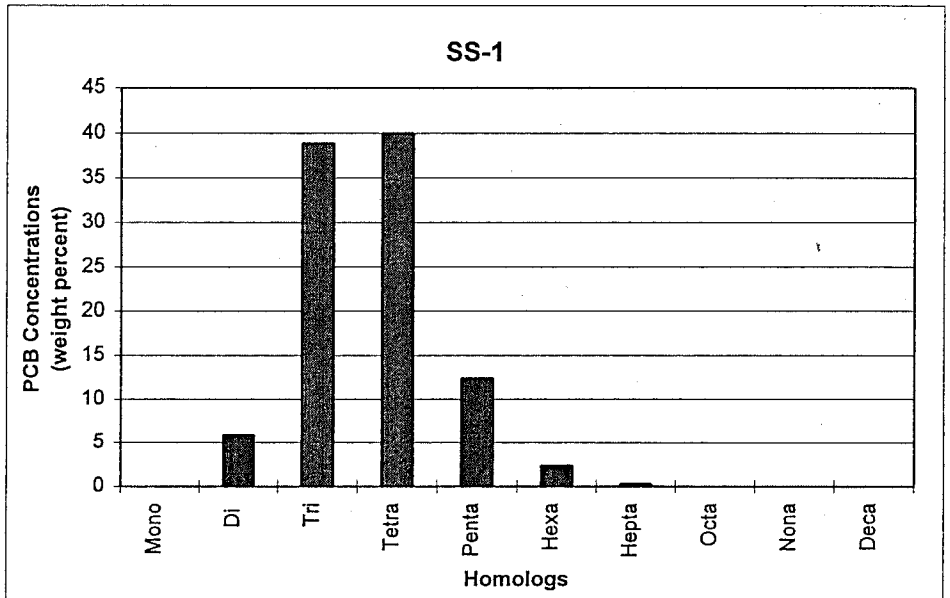
Notes:

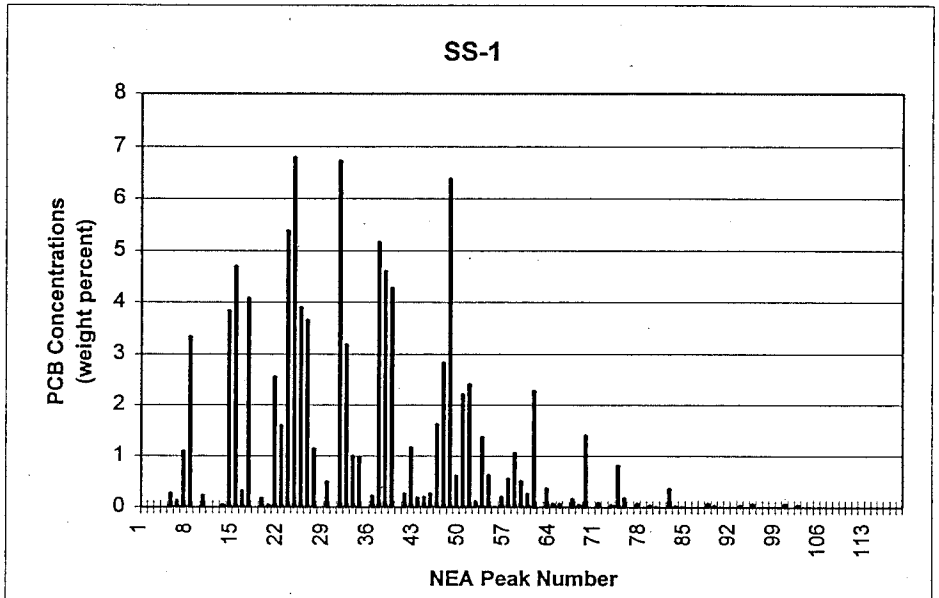
* A3-8 is a duplicate sample of A3-7

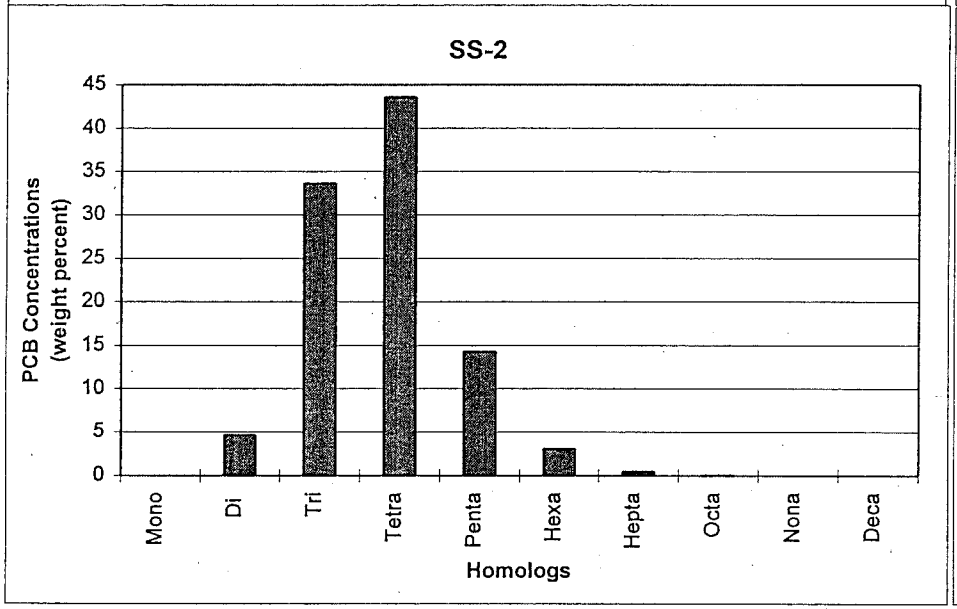
- Not analyzed

1. Total PCBs by Aroclor. All reported as Aroclor 1242. No other Aroclors detected.

Figure 2
Congener and Homolog Weight Percentages for PCBs in Amcast Sewer Samples







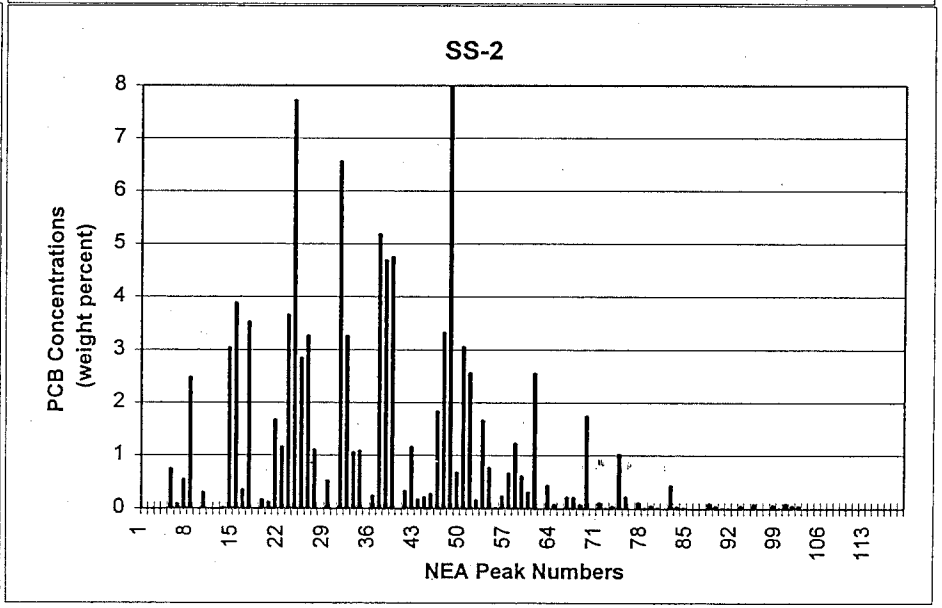
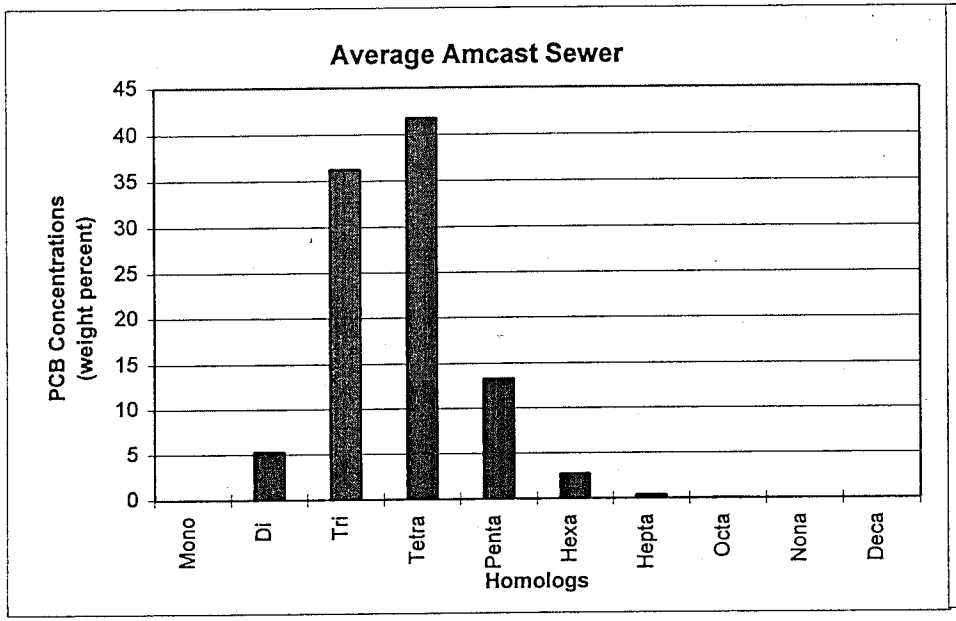


Figure 2

Congener and Homolog Weight Percentages for PCBs in Amcast Sewer Samples



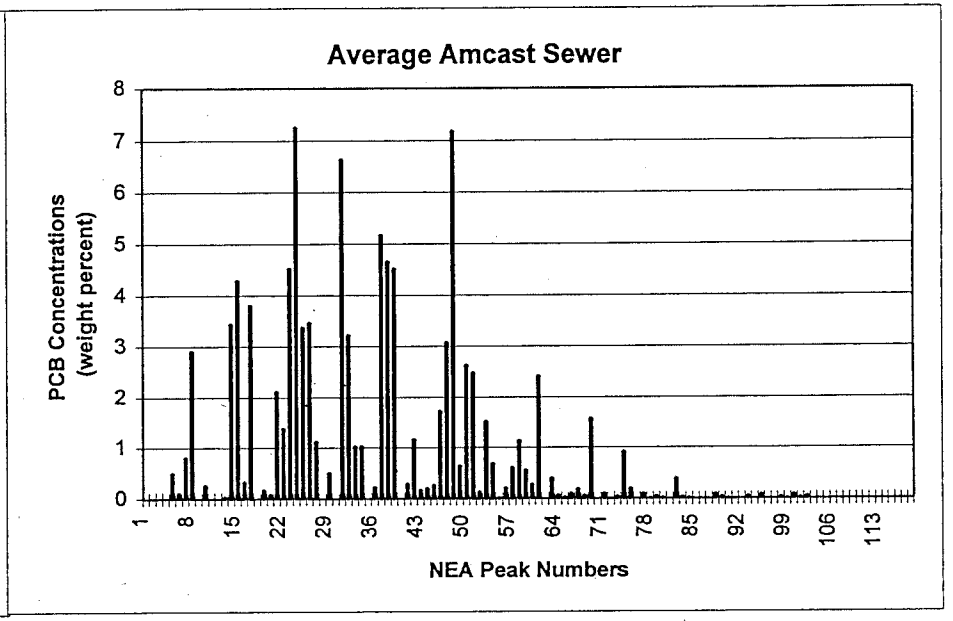
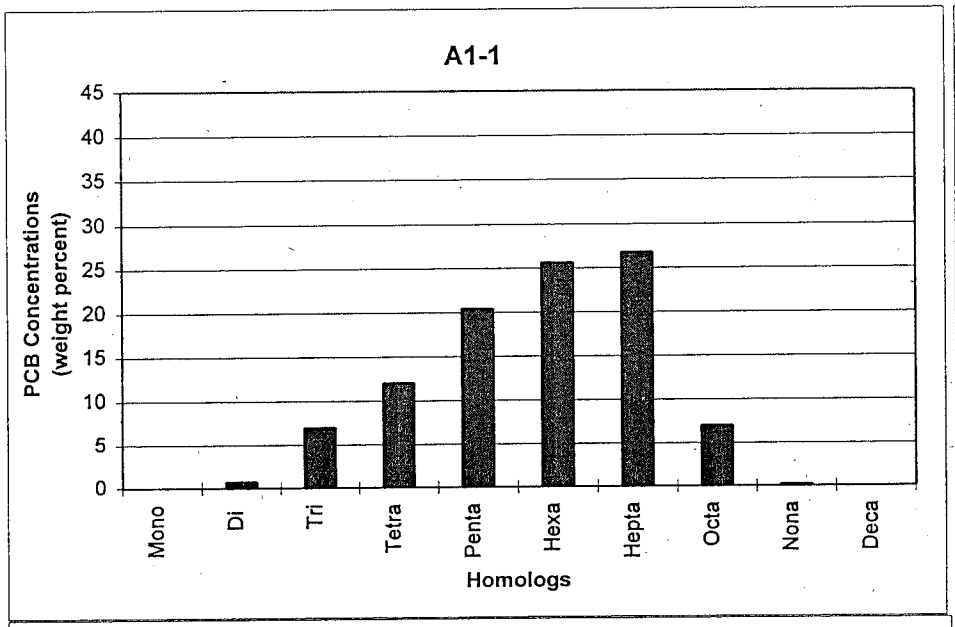
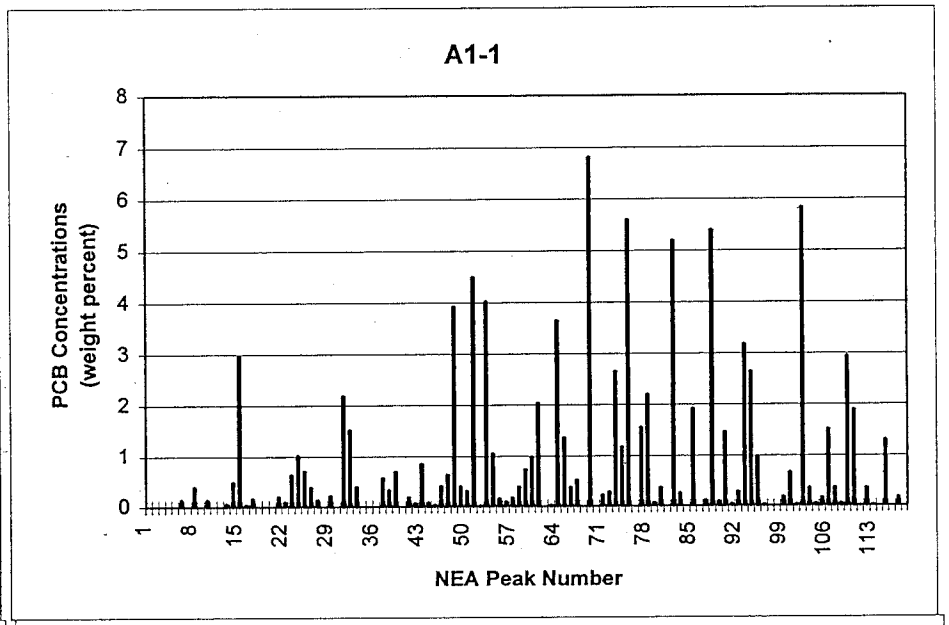
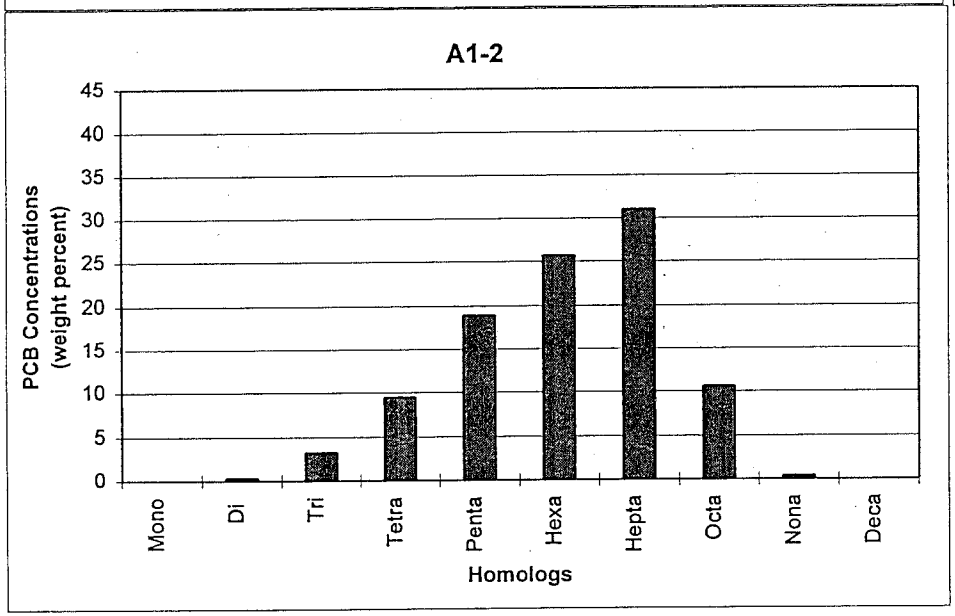


Figure 3
Congener and Homolog Weight Percentages for PCBs in Upstream Samples







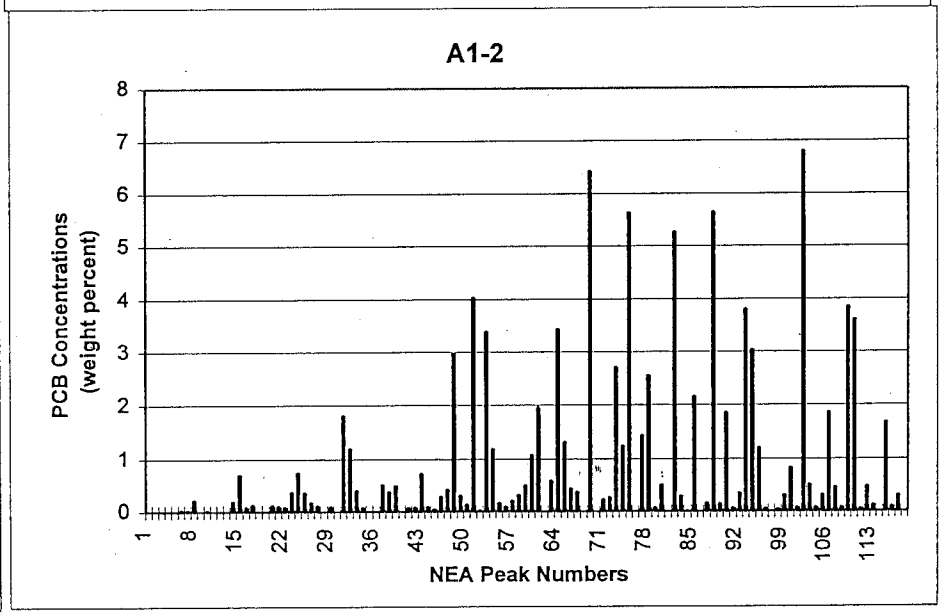
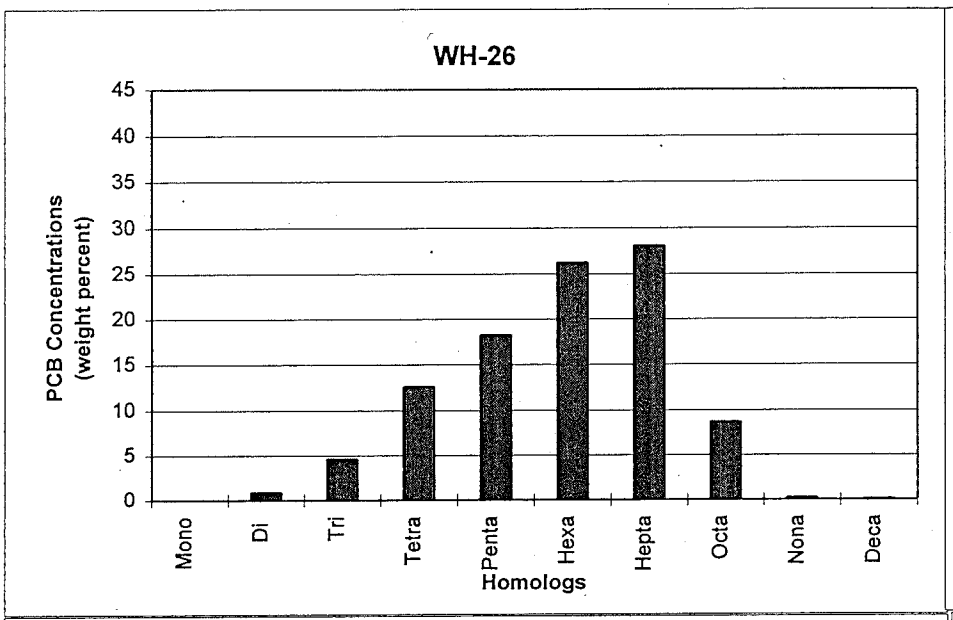
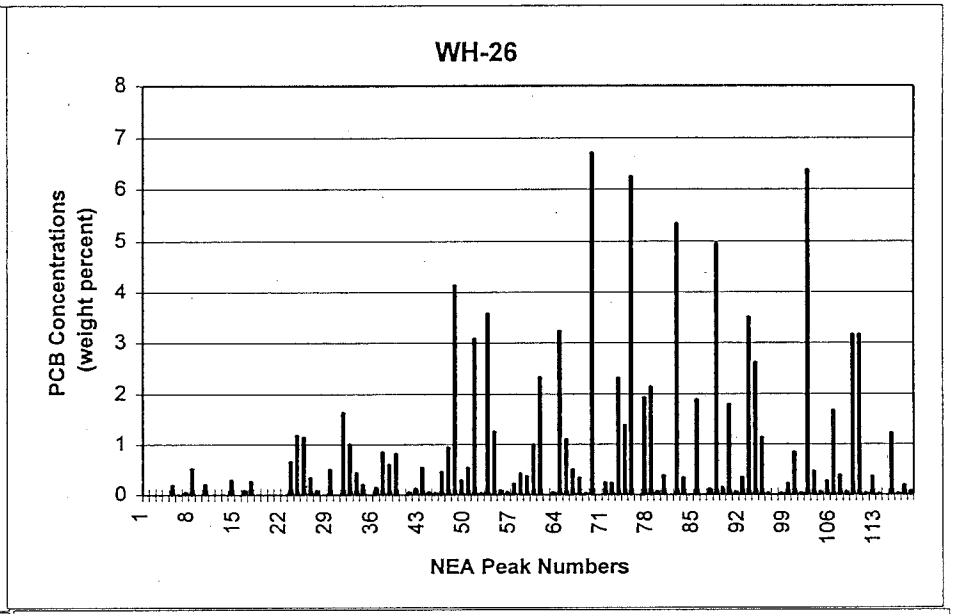
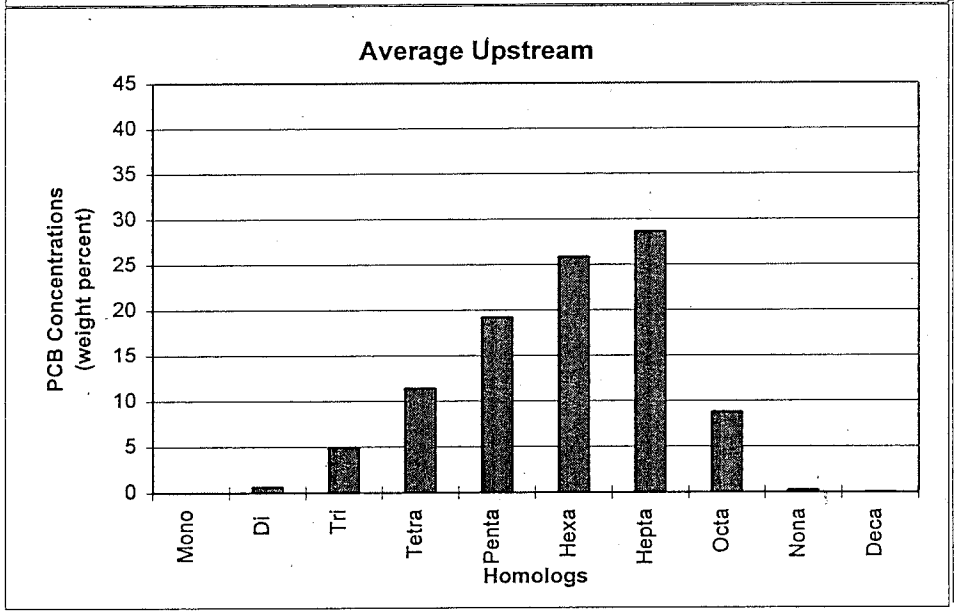


Figure 3
Congener and Homolog Weight Percentages for PCBs in Upstream Samples







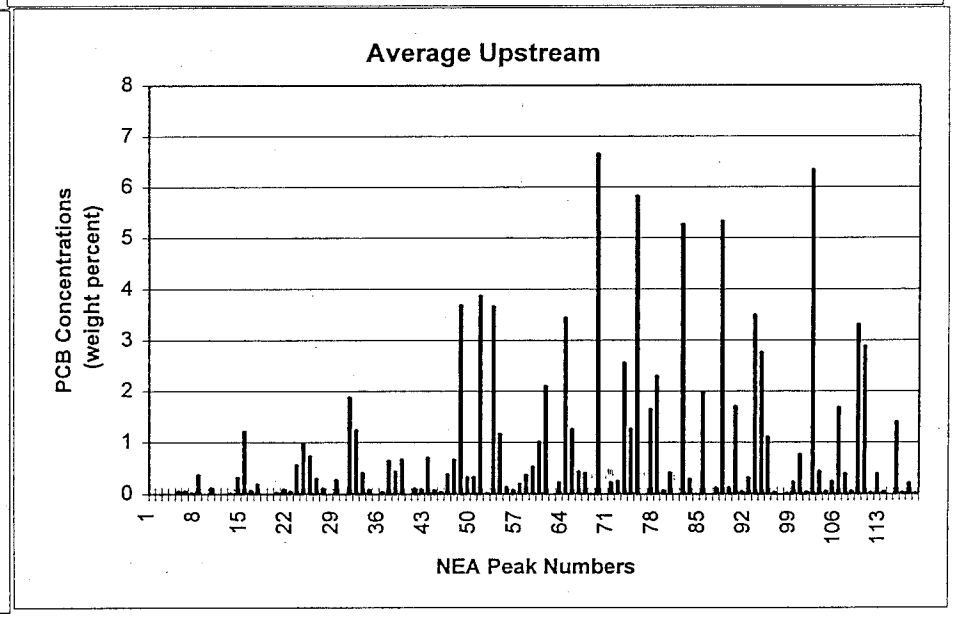


Figure 4
Congener and Homolog Weight Percentages for PCBs in Middle Samples

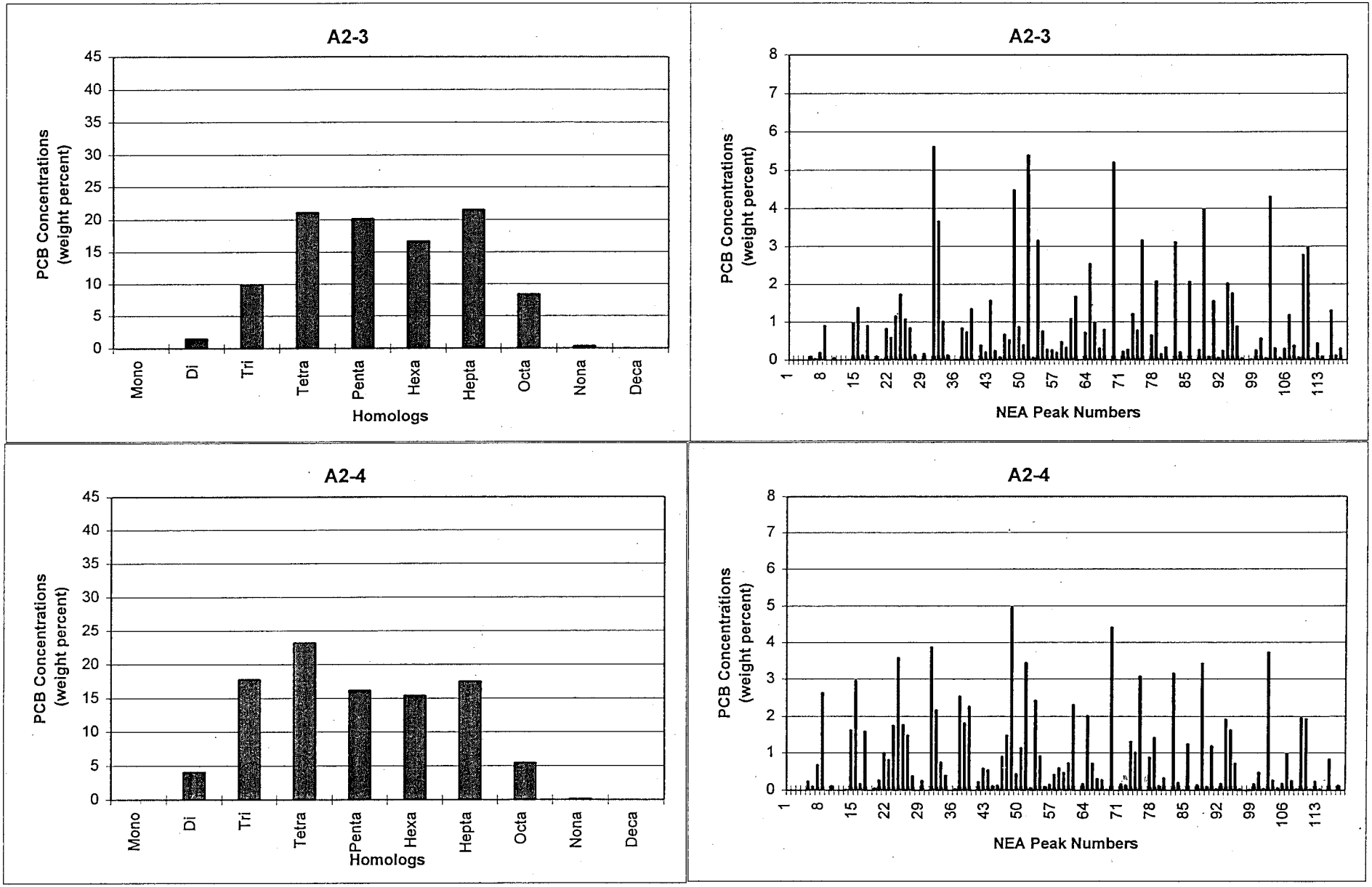


Figure 5
Congener and Homolog Weight Percentages for PCBs in Downstream Samples

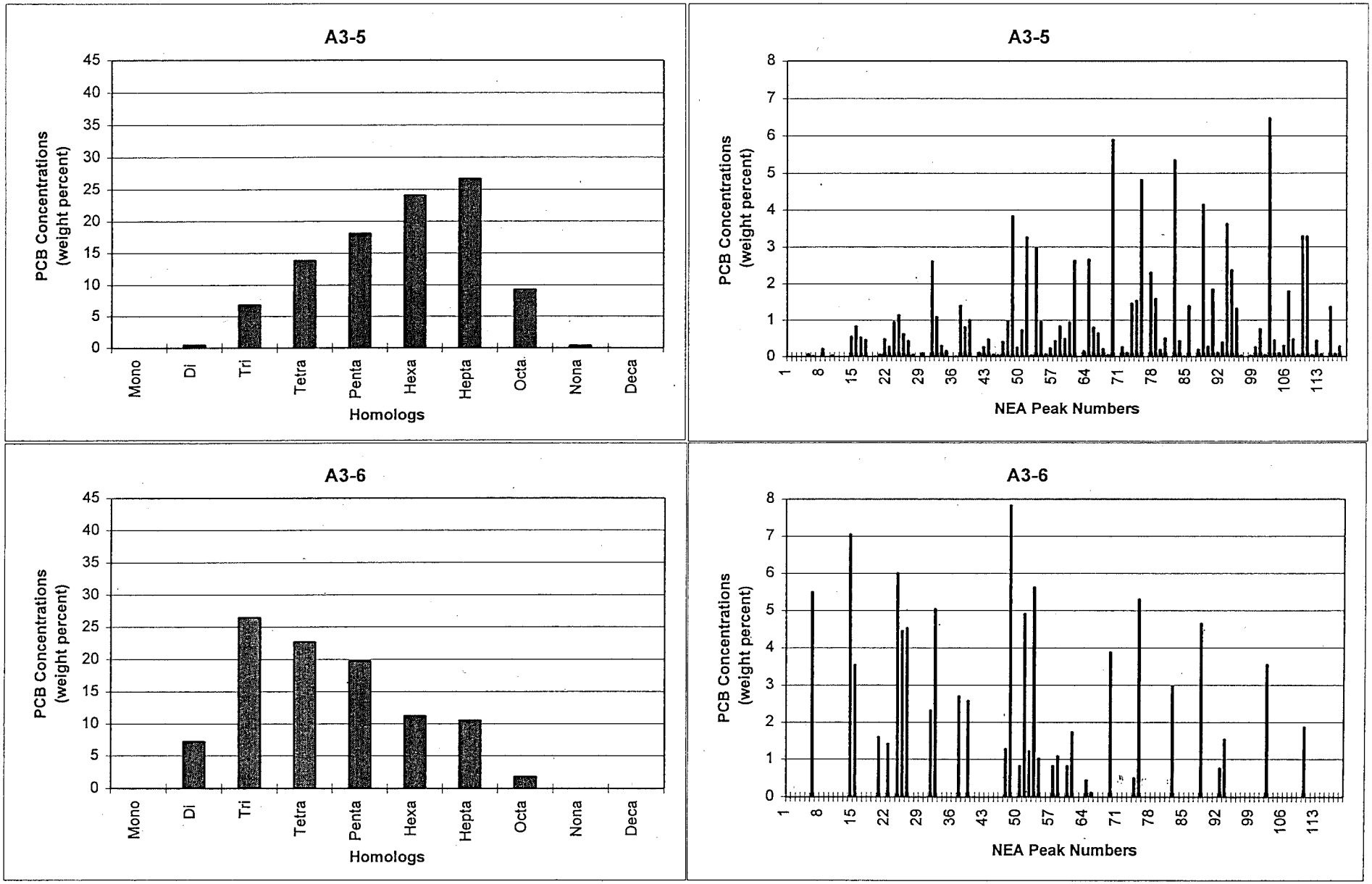
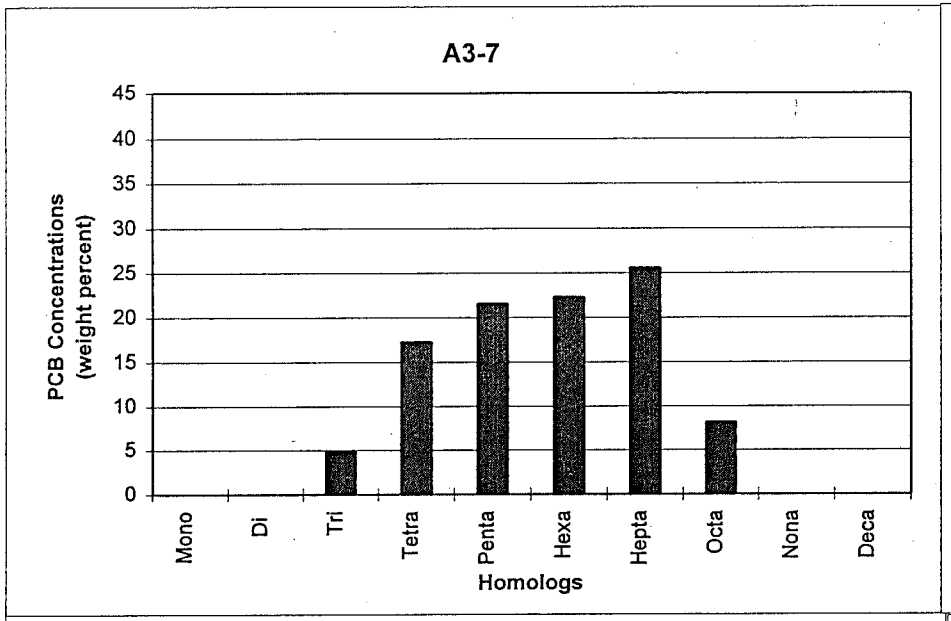
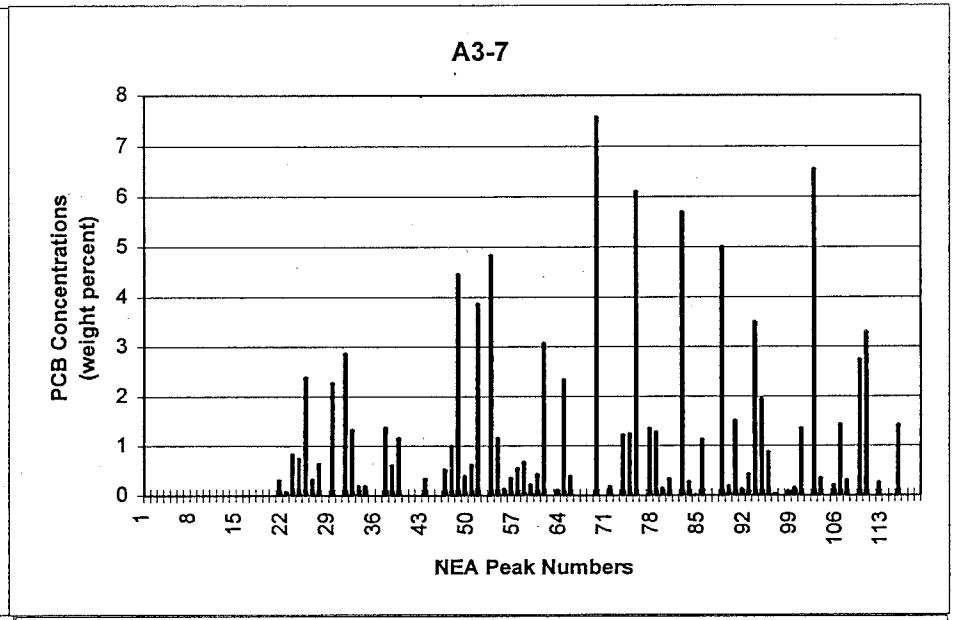
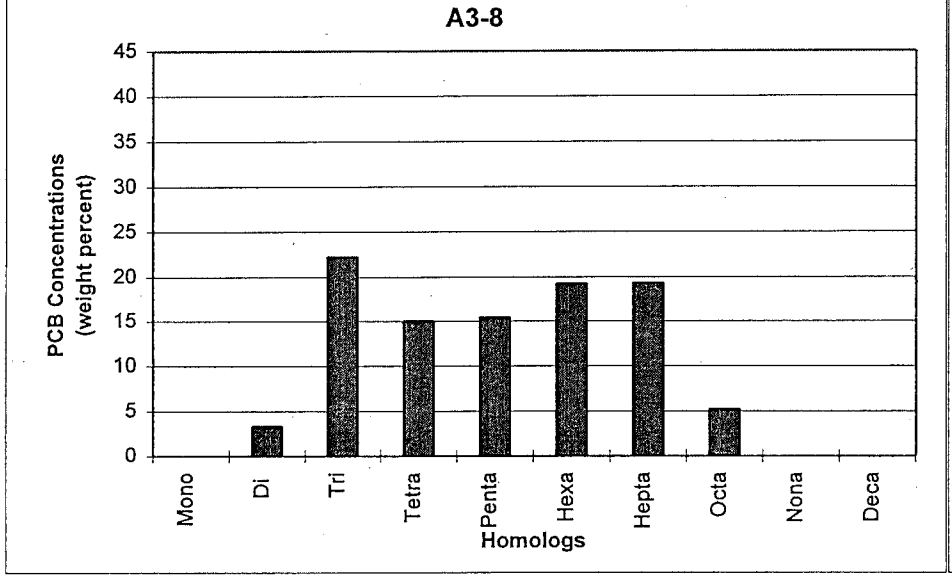


Figure 5
Congener and Homolog Weight Percentages for PCBs in Downstream Samples







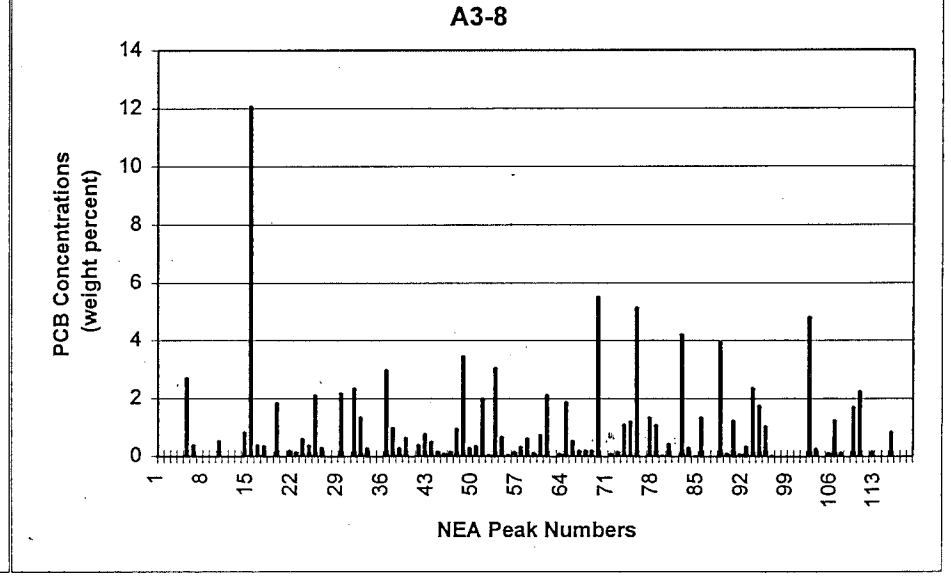


Figure 5
Congener and Homolog Weight Percentages for PCBs in Downstream Samples

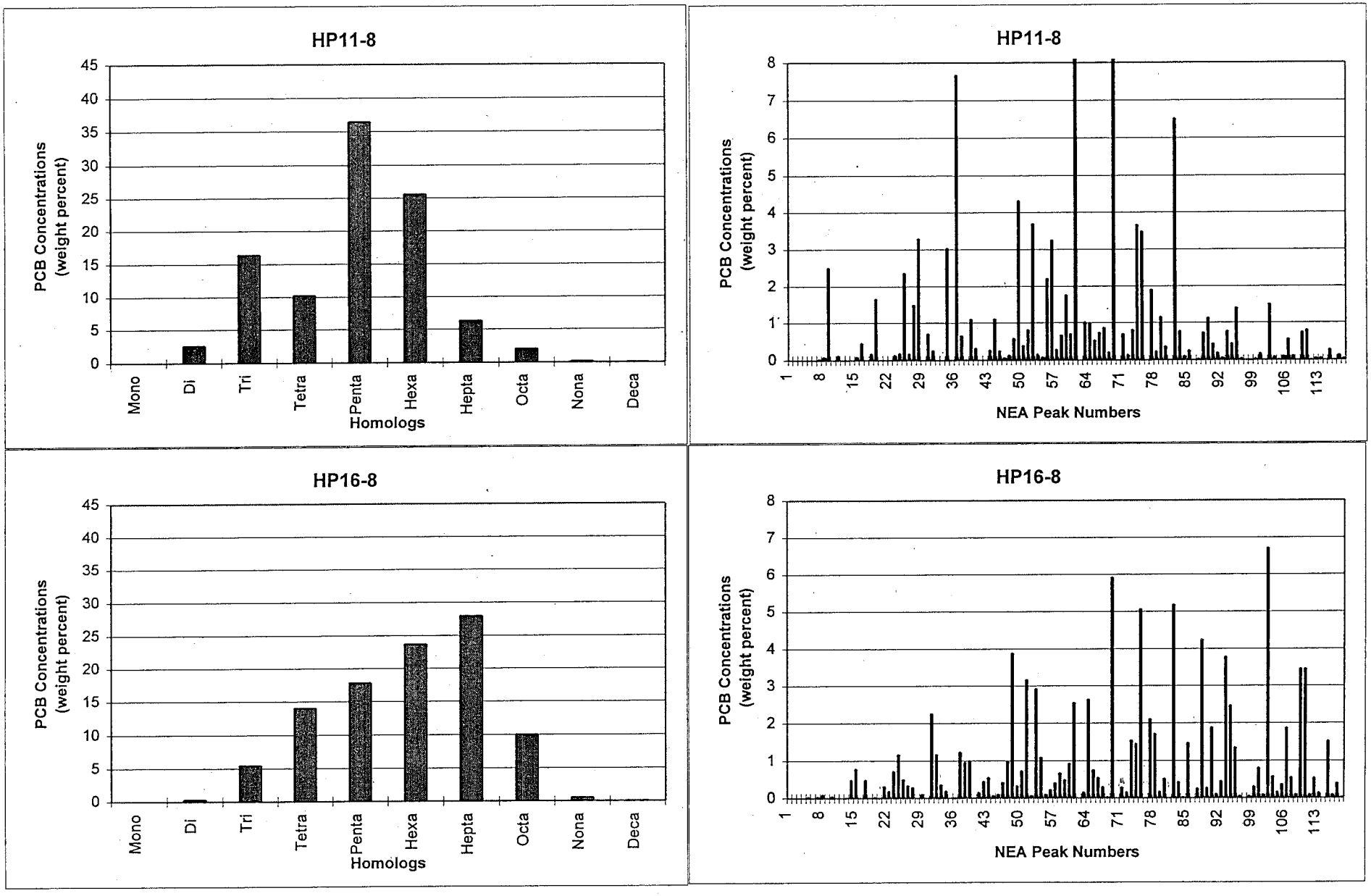
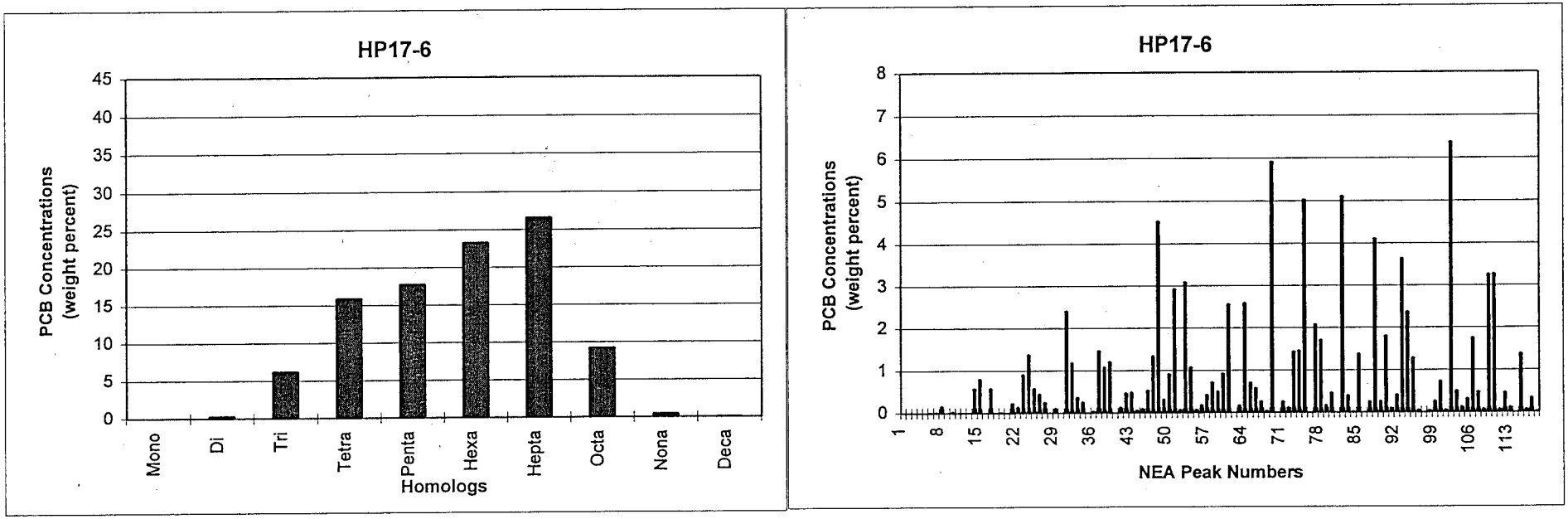


Figure 5
Congener and Homolog Weight Percentages for PCBs in Downstream Samples



5. DATA ANALYSIS

The fingerprinting analysis of the data is described in this section. The basic question addressed is: "What fraction of the PCBs in the 'downstream' Hamilton Pond sediments came from local sources?" Local sources here are taken to be only the discharges from Amcast via the storm sewer connecting their Cedarburg plant with Cedar Creek; i.e., we ignore the likely small contribution from the Cedarburg sewage treatment plant. In the mathematical analysis, it is thus assumed that all PCBs in the Hamilton Pond sediments came either from the local source (i.e., the Amcast-related storm sewer) or from "upstream" sources (presumed to be primarily from Mercury Marine).

With the assumptions given above, we first define a mixing equation for predicting the concentration of PCB congeners (on a weight fraction basis) in Hamilton Pond sediment samples:

$$C_H = X\,C_U + (1 - X)\,C_A \qquad (1)$$

where:

- C_H = predicted concentration (wt. %) of a PCB congener in each Hamilton Pond sediment sample (i.e., considering only one sample at a time)
- C_U = average concentration (wt. %) of the PCB congener in "upstream" portion of Cedar Creek (i.e., upstream of Hamilton Pond)
- C_A = average concentration (wt. %) of the PCB congener in Amcast sewer sample
- X = fraction of PCBs coming from "upstream" sources ($X = 0 \rightarrow 1$)
- $1-X$ = fraction of PCBs coming from "local" sources (i.e., Amcast)

Note that the values of C_U and C_A come from actual measurements made in this project.

For each "downstream" sediment sample, a best fit value of X (and thus 1-X) is obtained by minimizing the sum of the squares of the differences, on a congener-by-congener basis, of the predicted (i.e., eqn. 1) and actual values of the congener concentrations. The sum-of-squares equation is as follows:

$$SS = \sum (C_H - C_H')^2 \qquad \text{(Sum over all congeners)} \qquad (2)$$

where:

- SS = sum of squares
- C_H = predicted concentration (wt. %) of PCB congener in each Hamilton Pond sediment sample (i.e., predicted from equation 1)
- C_H' = measured concentration (wt. %) of PCB congener in each Hamilton Pond sediment sample

The Solver program in Microsoft Excel® was used to find the value of X that minimized SS for each "downstream" sediment sample. The local contribution is then simply obtained from 1-X. The results of this analysis are shown in **Table 2**. The local contributions are seen to range from 0.07-0.21 (7 to 21%) for the 5 "downstream" samples. For this data set, the average local contribution is 0.12 on a fraction basis (i.e., 12%) with a standard deviation of 0.06 (6%).

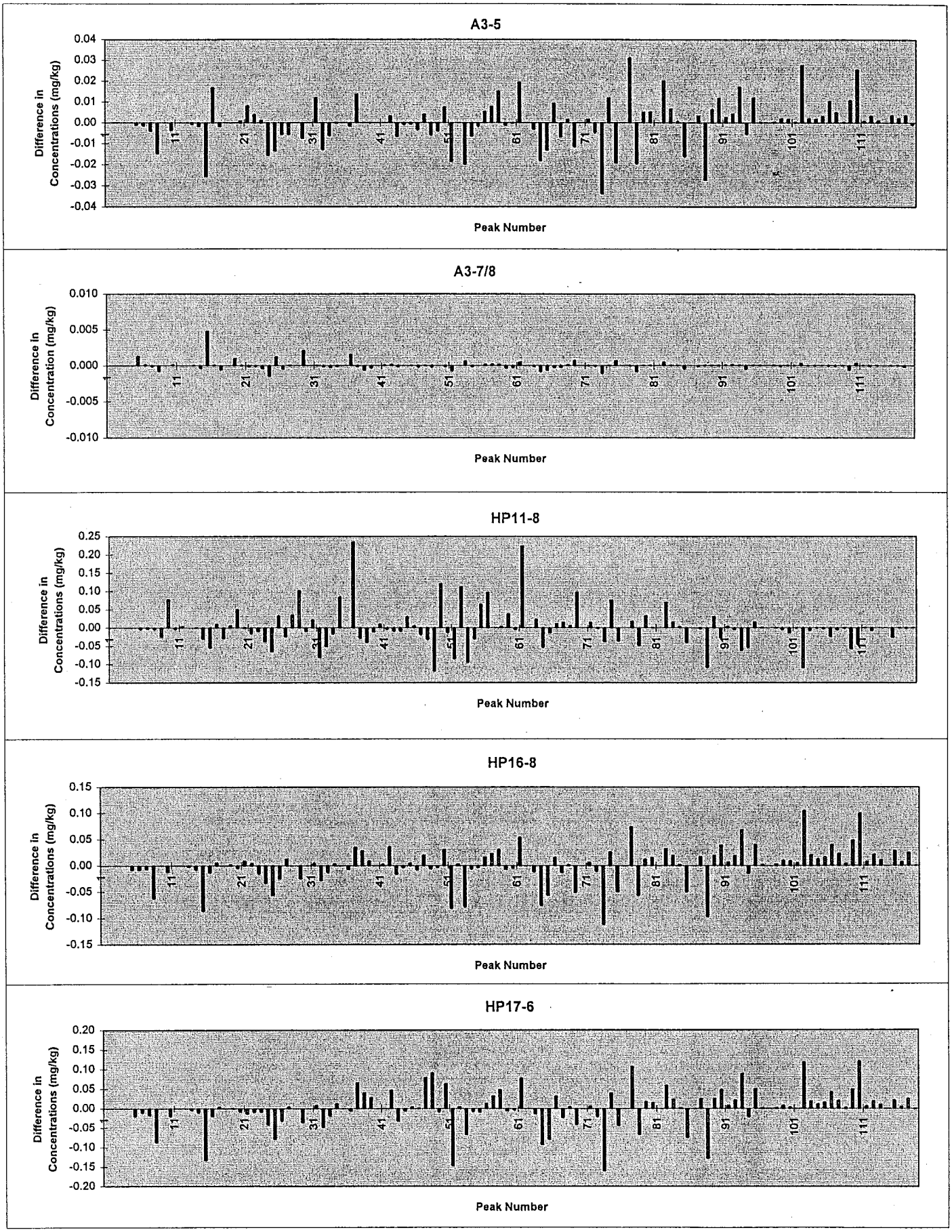
To evaluate the quality of the fit between the actual and predicted congener histograms for each of the "downstream" samples, difference plots were created and are shown in **Figure 6**. The values plotted are $C_H' - C_H$ on a congener-by-congener basis (and converted from units of wt. % to mg/kg), with a separate plot for each sample. Note that there are significant differences in the vertical scales for the 5 samples. These plots indicate reasonably good agreement between the calculated and actual congener histograms. The relatively random pattern of positive and negative differences, and the lack of any significant pattern in the plots, suggests a successful fit. As a final check, the absolute value of the differences was summed (i.e., sum = $\sum|C_H' - C_H|$). These sums are shown in Table 2, both in absolute values (mg/kg) as well as a percent of the total concentration shown in Table 1. Except for sample HP11-8, all of the percentages are reasonably small; i.e., for the 4 other samples, the fit was so good that only a small portion (19-32%) of the measured congener concentrations was not properly accounted for by the best fit mix of the Amcast and "upstream" samples. The high sum of differences for sample HP11-8 can not be explained at this time.

Table 2
Source Allocation for PCBs in Sediments of Hamilton Pond

Downstream Sample Location	Estimated Local Contribution (1-X)	Sum of Absolute Differences Between Actual and Calculated Congener Concentrations	
		(mg/kg)	[%][1]
A3-5	0.09	0.75	19
A3-7/8*	0.15	0.035	32
HP11-8	0.21	3.6	116
HP16-8	0.07	2.5	19
HP17-6	0.10	3.4	19
Average (all samples)	0.12		
Standard Deviation (all samples)	0.06		

Notes:
X = fraction of PCBs in Hamilton Pond from upstream sources.
1 - X = fraction of PCBs in Hamilton Pond from local sources.
* Average of A3-7 and A3-8.
1. Sum of absolute differences expressed as percent of total PCB concentration for sample (from Table 1).

Figure 6
Difference Between Actual and Calculated PCB Congner Concentrations in Hamilton Pond Sediments



6. REFERENCES

BBL, 1998. "Cedar Creek - Sediment Characterization Data." Letter, with data attachments, from Kendrick Jaglal, Blasland Bouck & Lee, to Mark Thimke (Foley & Lardner) and Timothy Hoffman (Coolidge, Wall, Womsley & Lombard), dated July 24, 1998.

Camp Dresser & McKee (CDM), "Initial Review of Data Relevant to Source Allocation of PCBs in Cedar Creek Sediments," report prepared for Katten Muchin & Zavis, Chicago, IL, September 1996.

Camp Dresser & McKee (CDM), "Model-Based Estimates of the Local Contribution of PCBs to the Hamilton Pond Portion of Cedar Creek," draft report prepared for Coolidge, Wall, Womsley & Lombard, Dayton, Ohio, November 1998.

APPENDIX A

SAMPLING AND ANALYSIS PLAN

DRAFT SAMPLING AND ANALYSIS PLAN

FOR EVALUATION OF PCB CONGENER PATTERNS IN SEDIMENT FROM THE HAMILTON POND PORTION OF CEDAR CREEK CEDARBURG, WISCONSIN

SEPTEMBER 1997

Prepared for:

Amcast Industrial Corporation

Prepared by:

Camp Dresser & McKee Inc.
5215 North Ironwood Road, Suite 250
Milwaukee, Wisconsin 53217

Confidential
Attorney Client Privileged

CDM Project No. 10464-21890-RT.PLG

Introduction

Cedar Creek is located in the City of Cedarburg in Ozaukee County, Wisconsin. The Hamilton Pond portion, as shown in Attachment A, is located on Cedar Creek between Spring Court and Green Bay Road in Section 35 of Township 10 North, Range 21 East of the USGS Cedarburg Quadrangle, Wisconsin - Ozaukee County, 7.5 Minute Series (Topographic).

This Sampling and Analysis Plan (SAP) describes sample location, method of collection and analysis of sediment samples. Sediment samples will be taken from:

- the storm sewer located at the Amcast Plant (N39 W5789 Hamilton Road) that drains to Cedar Creek,
- the creek sediments located upstream of the historic Amcast storm sewer,
- the creek sediments between the current Amcast outfall and the City of Cedarburg Wastewater Treatment Plant (WWTP) outfall, and
- the creek sediments located in the Hamilton Pond area above the Hamilton Dam.

A total of ten sediment samples will be taken which will include eight sediment samples and two quality control samples (duplicates).

Sampling related to the Hamilton Pond portion of Cedar Creek will be coordinated between Camp Dresser & McKee Inc. (CDM), Blasland, Bouck & Lee, Inc. (BBL) and Northeast Analytical Laboratory (NEA). CDM will collect samples related to the Amcast storm sewer and locate and oversee Cedar Creek sediment samples taken by BBL. NEA will provide analytical services for CDM samples.

Site Reconnaissance

CDM personnel (W. Lyman and D. Keenan) conducted a site reconnaissance on Thursday, July 24, 1997. The site reconnaissance included verifying the location of the Amcast storm sewer on Amcast property and visually observing the current conditions of the Hamilton Pond portion of Cedar Creek. CDM personnel walked north of the WWTP on the west bank of Cedar Creek and canoed south of the WWTP to the area of the removed Hamilton Dam. Landmarks observed included the area believed to be the historic Amcast storm sewer outfall, the current Amcast storm sewer outfall, the WWTP outfall and the area of the removed Hamilton Dam.

During this site reconnaissance, CDM identified the general areas to be targeted for sediment sampling. CDM noted that stream width appeared significantly smaller than indicated on historic areal photographs.

Sampling Plan

Amcast Storm Sewer

CDM personnel will sample the sediment in the Amcast storm sewer located on Amcast property northwest of the Amcast Plant. Attachment B includes a photograph identifying the manhole of the storm sewer to be sampled. Based on review of a storm water site plan for the Plant (Triad Engineering, 1995) and discussion with the Plant's project engineer (Noel Schuster), this manhole was identified as the storm sewer that carries storm water from the Amcast Plant to Cedar Creek.

A total of two samples will be taken from the storm sewer - one grab sample and one duplicate grab sample. Sampling equipment will be decontaminated in a solution of Alconox and distilled water and rinsed in distilled water between samples.

The storm sewer sediment sample will be collected through the manhole by scraping the deposited material from the bottom and side of the storm sewer catch basin. Samples will be placed in laboratory grade containers supplied by NEA, placed on ice and shipped overnight to NEA for analysis.

CDM anticipates storm sewer sampling to be completed in September 1997.

Hamilton Pond Portion Sampling

CDM personnel will locate and oversee the sampling of creek sediments from the Hamilton Pond Portion of Cedar Creek. A total of eight samples will be taken in the following locations as indicated on Attachment C:

- Two samples at least 120-feet upstream of the historic Amcast storm sewer outfall (Area 1). Based on available maps (Strand Associates, Inc., 1992, Figure 2.04-4), this historic outfall was located approximately 120-feet upstream and to the west of the current Amcast storm sewer outfall, and located on the same (west) bank. For reference purposes, these samples will be taken from the creek sediments near the east bank approximately opposite of a wooden residential fence north of Ceddars Bowling Alley. Samples will be taken and composited from the top foot of sediment.
- Two samples between the current Amcast outfall and the WWTP outfall (Area 2). These samples will be taken from the creek sediments near the west bank. Samples will be taken and composited from the top foot of sediment.
- Three samples from the lower portion of Hamilton Pond in the areas containing deeper sediments (Area 3). These samples will be taken from the historic footprint of the creek bed near the west bank. Samples will be taken and composited from the top foot of sediment.
- One duplicate sample from the lower portion of Hamilton Pond (Area 3).

BBL will conduct the sampling in conjunction with sampling events for the Hamilton Pond sediments on behalf of both Amcast and Mercury Marine. Prior to sampling, CDM will coordinate and refine sample locations with BBL. During sampling, CDM will provide sample location verification and sample collection oversight. It is CDM's understanding that BBL will provide other necessary sampling services (sampling procedures, sampling equipment and decontamination equipment).

Samples collected by BBL for CDM will be placed in laboratory grade containers supplied by NEA, placed on ice and shipped overnight by CDM to NEA for analysis.

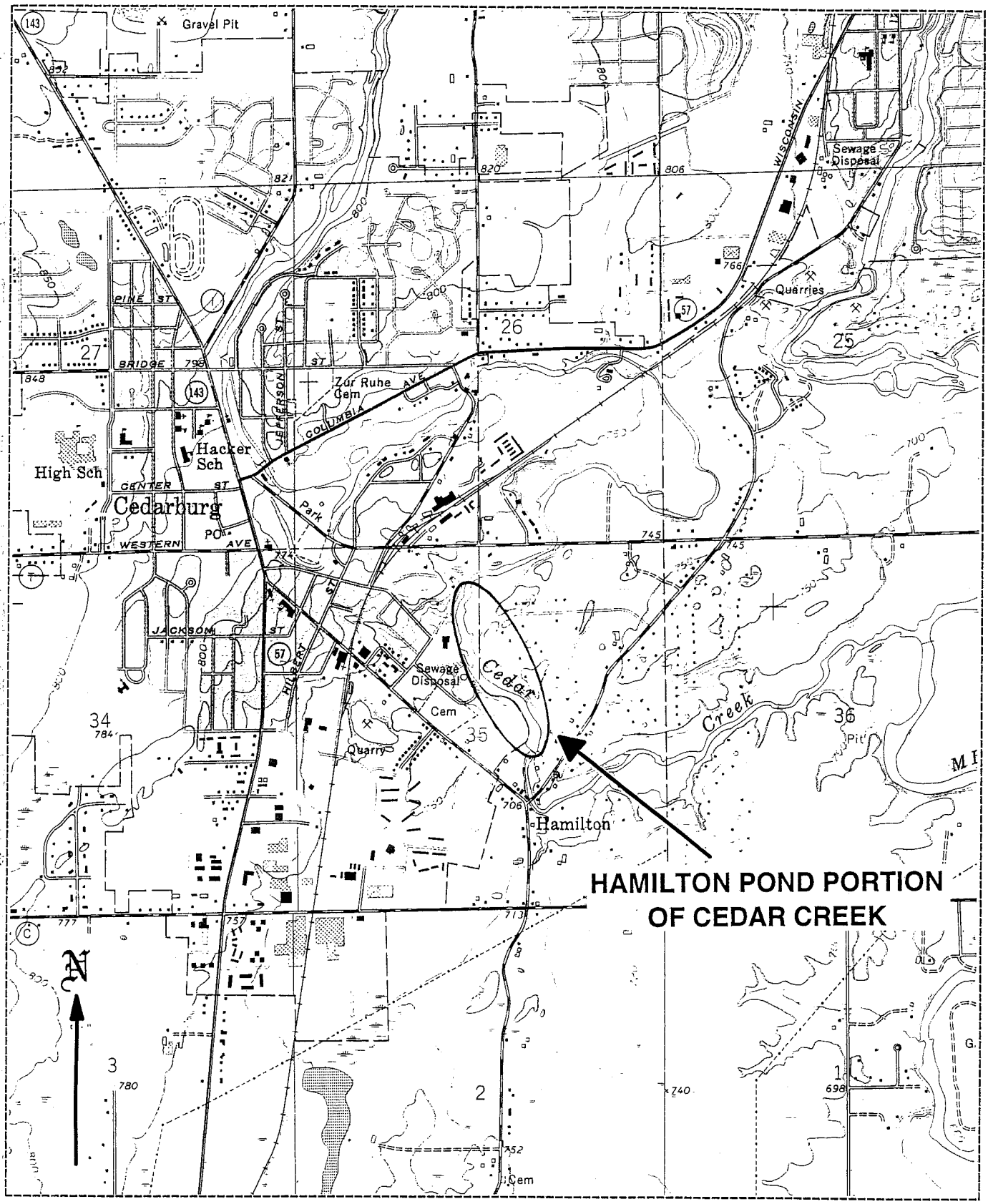
No date has been established for BBL's sampling.

Sample Analysis

Sediment samples will be sent to NEA located in Schenectady, New York and will be analyzed for polychlorinated biphenyls (PCBs) by congener by the Green Bay Method and total organic carbon (TOC) by EPA Method 9060.

The samples from the Amcast storm sewer will be also be analyzed for PCB Aroclors by EPA Method 8080. PCB Aroclors analysis will be from the same extract prepared for the PCBs by congener analysis.

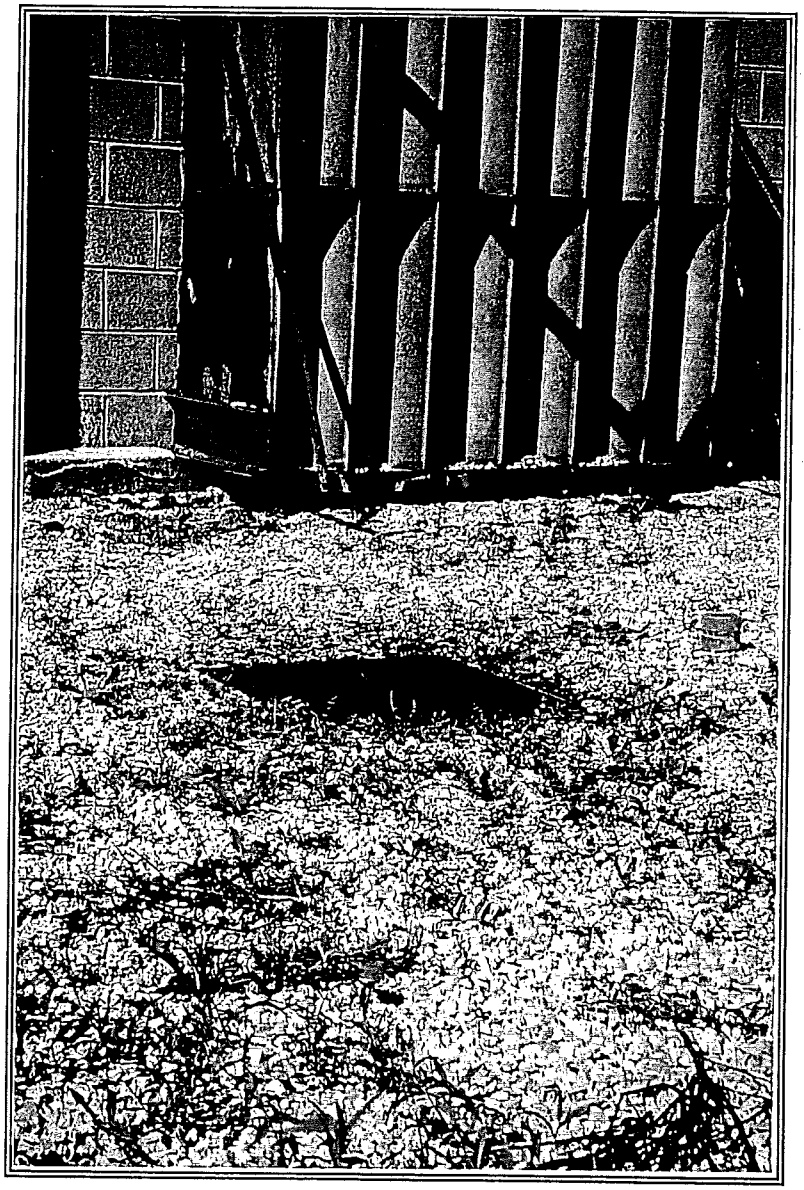
Analytical results for PCBs by congener will be expressed in terms of mass/mass and weight percent, for TOC in terms of mass/mass, and for PCB Aroclors in terms of mass/mass (by Arochlor).



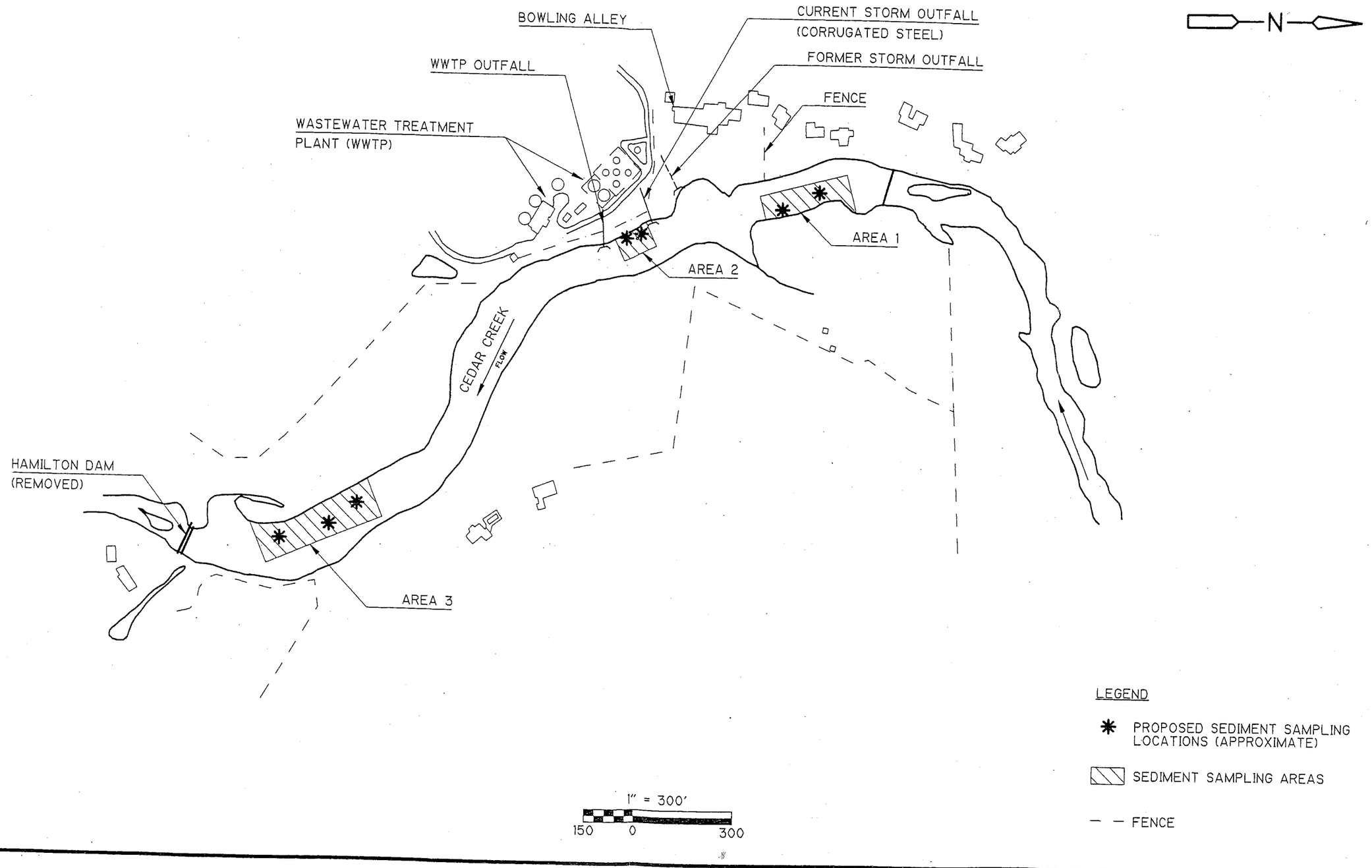
Attachment A
Hamilton Pond Portion of Cedar Creek
USGS Cedarburg Quadrangle - Ozaukee County

Camp Dresser & McKee

Date: July 24,1997
Photographed by: Dylan T. Keenan



Description: Amcast Storm Sewer to be Sampled



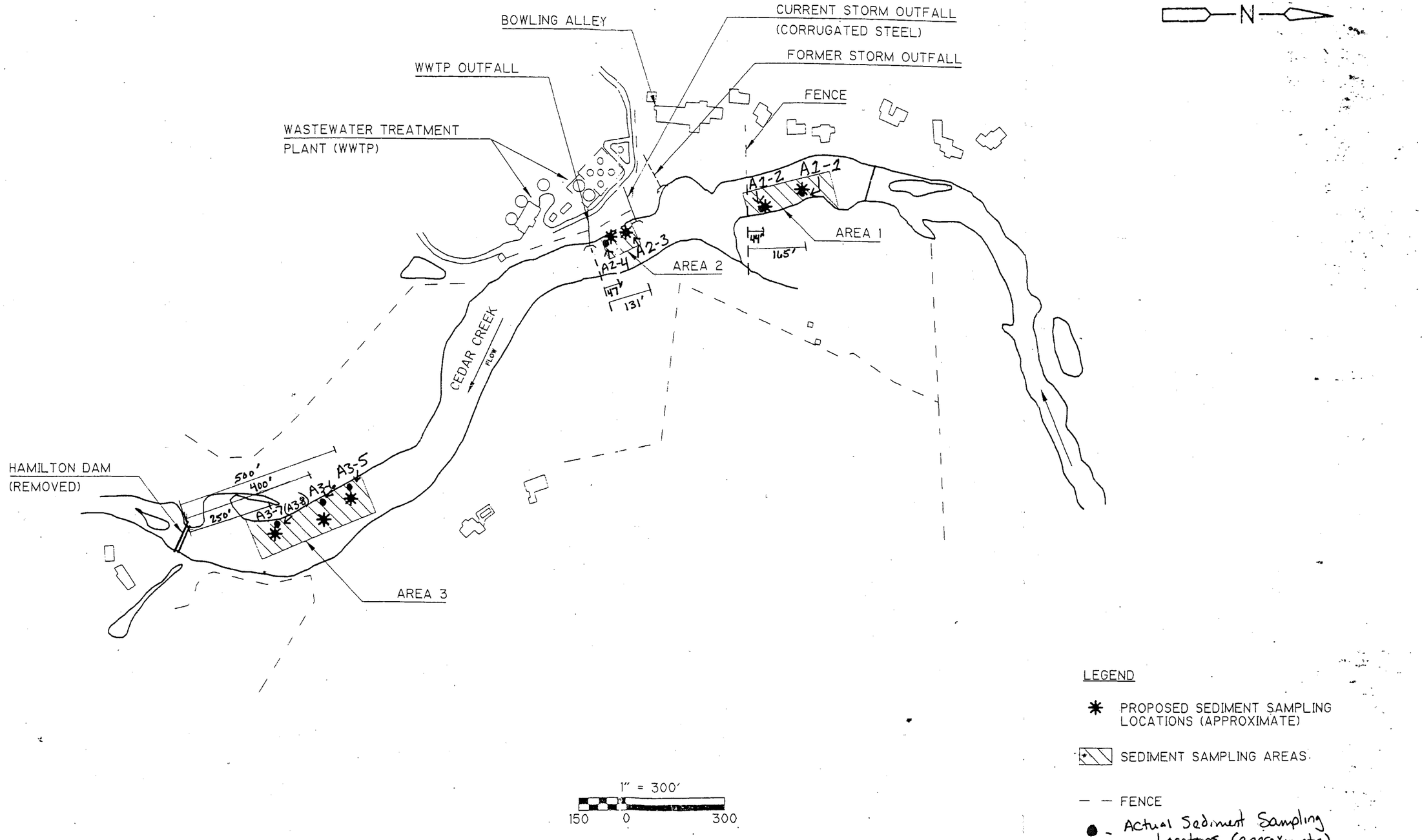
CDM
environmental engineers, scientists, planners, & management consultants

SEDIMENT SAMPLING LOCATIONS: HAMILTON POND PORTION OF CEDAR CREEK

ATTACHMENT C

Camp Dresser & McKee
09/04/97 10:56:55
4:15:54
Fig6
V:\CAM_int\W\1046\x2690\

ATTACHMENT A



CDM
environmental engineers, scientists, planners, & management consultants

SEDIMENT SAMPLING LOCATIONS:
HAMILTON POND PORTION OF CEDAR CREEK

ATTACHMENT C

Comp Dresser & McKee
09/04/97 10:56:55
4:15:54
FIG1
O:\CAM 111W\10-164\21890\

APPENDIX B

SEDIMENT SAMPLING EVENT MEMORANDUM

CDM Camp Dresser & McKee Inc.

consulting engineering construction operations

312 East Wisconsin Avenue, Suite 500
Milwaukee, Wisconsin 53202
Tel: 414 291-5100 Fax: 414 291-2765

Memorandum

To: *Warren J. Lyman, Ph.D., Camp Dresser & McKee Inc. (Cambridge, Massachusettes)*

Date: *May 18, 1998*

From: *Amy Sansone, Camp Dresser & McKee Inc. (Milwaukee, Wisconsin)* ALS

Subject: *Sediment Sampling Event Memorandum*

OVERVIEW

Cedar Creek flows through the City of Cedarburg in Ozaukee County, Wisconsin. The Hamilton Pond portion is located on Cedar Creek between Spring Court and Green Bay Road in Section 35 of Township 10 North, Range 21 East of the USGS Cedarburg Quadrangle, Wisconsin - Ozaukee County, 7.5 Minute Series (Topographic).

This memorandum discusses the Hamilton Pond portion sediment sampling event conducted on May 14, 1998 on the portion of Cedar Creek located in the City of Cedarburg. Sediment samples were collected by Blasland Blouck and Lee, Inc. (BBL) for Camp Dresser and McKee, Inc. (CDM). BBL personnel (Todd Merrel and Rick Pierce) performed the sediment sampling while CDM personnel (Amy Sansone) was on-site to verify sample location, oversee sample collection and ship the collected samples to Northeast Analytical (NEA) for laboratory analysis.

As discussed in the Draft Sampling and Analysis Plan (CDM, September 1997) sediment samples were taken from the following areas:

Area 1 (samples A1-1 through A1-2)

- Two samples at least 120-feet upstream of the historic Amcast storm sewer outfall. For reference purposes, these samples will be taken from the creek sediments near the east bank approximately opposite of a wooden residential fence north of Ceddars Bowling Alley. Samples will be taken and composited from the top foot of sediment.

Area 2 (samples A2-3 through A2-4)

- Two samples between the current Amcast outfall and the WWTP outfall. These samples will be taken from the creek sediments near the west bank. Samples will be taken and composited from the top foot of sediment.

Area 3 (A3-5 through A3-8)

- Three samples from the lower portion of Hamilton Pond in the areas containing deeper sediments. These samples will be taken from the historic footprint of the creek bed near the west bank. Samples will be taken and composited from the top foot of sediment.
- One duplicate sample from the lower portion of Hamilton Pond (Area 3).

PROCEDURE

BBL Personnel

The sampling areas and points were located on-site from the Sediment Sampling Location Map (CDM, September 1997) using a tape measure. Sediment samples were collected from approximately the first foot of sediment by using 2-inch Lexan tubing manually driven into the sediment. A more detailed description of the sampling technique is discussed in the Draft Sediment Characterization Program (BBL, January 1998). Each sample was removed from the sampling tube, placed on a clean sheet of aluminum foil, and hand mixed using clean latex gloves by BBL. A portion of each composited sample was then placed in a 250-milliliter container provided by NEA and given to the CDM personnel. The sediment sampling points were then surveyed.

CDM Personnel

CDM labeled the sediment container and stored in a cooler on ice. Once all of the samples were collected they were placed in a cooler with crushed ice and packing material along with the signed chain-of-custody form. The cooler was sealed with duct tape and packing tape and shipped overnight via Airborne Express to Northeast Analytical in Schenectady, New York to be analyzed for total organic carbon (TOC) by the EPA Method 9060 and for polychlorinated biphenyls (PCBs) by congener by the Green Bay Method.

SAMPLE INFORMATION

A map of the proposed and actual sampling point locations is shown in Attachment A. The locations on the attached map were estimated by BBL personnel using a measuring tape and may not correspond exactly with the more accurate surveyed locations.

All samples collected are composite with sample A3-8 as a duplicate split sample of A3-7. The duplicate sample was taken from the same composited sample as A3-7. The sampling point information is summarized below.

Sample I.D.	Date	Time	Depth of Water (ft)	Location	Depth Penetrated (ft)	Depth Recovered (ft)
A1-1	5-14-98	8:50 am	0.3	Area 1	1.3	0.9
A1-2	5-14-98	8:40 am	0.3	Area 1	1.0	0.8
A2-3	5-14-98	9:10 am	0.2	Area 2	0.8	0.7
A2-4	5-14-98	9:20 am	0.2	Area 2	0.7	0.6
A3-5	5-14-98	10:45 am	0.7	Area 3	1.3	1.3
A3-6	5-14-98	10:40 am	1.3	Area 3	1.0	0.9
A3-7	5-14-98	10:30 am	0.7	Area 3	1.3	1.0
A3-8	Duplicate Sample of A3-7					

Each sediment sample collected was described by BBL personnel and is summarized below.

Sample I.D.	Sediment Description
A1-1	shells/fine to medium sand over dark grey silt/ organic matter over dark grey coarse sand/ small gravel
A1-2	brown/dark brown silt, some fine sand, trace organic matter, trace gravel
A2-3	dark brown silt/some fine sand/organic matter over dark brown fine sand with silt and trace coarse sand/small gravel
A2-4	brown fine sand/trace coarse sand/small gravel over dark grey silt/some fine sand over small gravel
A3-5	dark brown silt/fine sand over fine to medium sand/trace coarse sand/silt
A3-6	dark grey fine sand over silt with fine sand over coarse sand/gravel
A3-7	dark brown fine sand with some medium sand/trace organic matter over dark grey fine sand with some silt/trace medium sand
A3-8	Duplicate of Sample A3-7

The sampling event field notes and chain-of-custody form filled out by CDM personnel are included as Attachments B and C, respectively.

REFERENCES

BBL- Sediment Characterization Program, "Cedar Creek-Cedarburg, Wisconsin (Draft). Blasland Balck and Lee, Inc. Syracuse, New York, January 1998.

CDM- Draft Sampling and Analysis Plan; For Evaluation of PCB Congener Patterns In Sediment From The Hamilton Pond Portion of Cedar Creek - Cedarburg, Wisconsin. Camp Dresser & McKee, Inc., Milwaukee, Wisconsin September 1997.

cc: Dan Buss, P.E.

ATTACHMENT B

(1)

PROJECT NAME: HAMILTON POND PORTION OF CEDAR CREEK
PROJECT #: 10464-21890
DATE: 5-14-98
TIME ON-SITE: 7:45 am @ Mercury Plant
TIME OFFSITE: 11:20 am
WEATHER: 70°F, Sunny
PURPOSE: Sediment Sampling
CDM PERSONNEL: AMY SANSONE

SUBCONTRACTOR PERSONNEL: BLASLAND, BOUCK + LEE INC.
TODD MERREL, RICK PIERCE
SAMPLING TECHNIQUE: Lexon tubing - 2" diameter manual driven
: Empty sediment onto aluminum foil, hand mixed w/ latex gloves

Area 2: hard bottom, will not be able to penetrate full foot possibly
9:30 am: finished sampling Areas 1 and 2. BBL is surveying. CDM personnel labeling bottles and putting on ice.
10:00 am: left for Area 3
10:50 am: BBL surveying points in Area 3
11:20 am: offsite

SAMPLE ID	SAMPLER	TIME	DEPTH OF H_2O	SAMPLING LOCATION	COMMENTS
A1-1	TODD	8:50am	3/10 foot	Area 1	penetrated 1.3 ft, 9/10 ths recovered; shells, fine to medium sand over dark gray silt, organic matter over dark gray silt
A1-2	TODD	8:40am	3/10 foot	Area 1	1st 6/10 ths foot recovered, penetrated 1 ft; (2nd) used this sample 8/10 ths foot; dark brown silt, some fine sand, trace sand, trace silt, organic
A2-4 A.D.	TODD	9:20am	2/10 foot	Area 2	pen. 7/10 ths recovered 6/10 ths; br. f. sand, tr. c sand, small gr. over dark grey silt, some f. sand over small gravel
A2-3 A.S.	TODD	9:10am	(1) 2/10 foot (2)	Area 2	used 6/10 ths ft penetrated, recovered 3/10; *8/10 ft penetrated, recovered 7/10; dark br. silt, some f. sand, organic matter over d. br. fine sand w/ silt + tr. c. sand + sm. gravel
A3-7 A.S.	TODD	10:30am	7/10 foot	Area 3	penetrate 1.3 ft, recovered 1 ft; dark brown fine sand w/ some med. sand, tr organic matter over dark grey fine sand w/ some silt, tr. med sand
A3-6	TODD	10:40am	1.3 ft	Area 3	1 ft penetrated, recovered 9/10 ths foot; dark grey fine sand over silt w/ fine sand, over coarse sand + gravel
A3-5 A.D.	TODD	10:45am	7/10 foot	Area 3	1.3 penetrated, 1.3 recovered; didn't include bottom 3/10 in composite. dark br. silt, f. sand over f-med sand, tr. crse sand + silt
A3-8	Duplicate	10:35am of	A3-7	Area 3	

5-14-98 [signature] 11:20 am

(2)

NORTHEAST ANALYTICAL, INC.

301 Nott Street, Schenectady, N.Y. 12305
(518)346-4592 Fax (518)381-6055

CHAIN OF CUSTODY RECORD

*NOTE: Send Data To Warren Lyman, Camp Dresser & McKee, 10 Cambridge Center, Cambridge, MA 02142

CLIENT: Camp Dresser & McKee, Inc.
PROJECT#/PROJECT NAME: 10464-21890 / Hamilton Pond
CLIENT CONTACT: Warren Lyman
LOCATION (CITY/STATE) ADDRESS: CEDARBURG, WI
DUE DATE: PHONE#: 617-252-8000
REQUIRED TURN AROUND TIME: As discussed w/ Dr. Warren Lyman

SAMPLE ID	DATE	TIME	MATRIX	GRAB/COMP	NEA USE ONLY	# OF CONTAINERS	1 TOC by EPA Method 9060	2 PCB by Coroner by Green Bay Method	3	4	5	6	7	REMARKS
A1-1	5-14-98	8:50am	SEDIMENT	COMP		1-250 ml	X	X						
A1-2		8:40am												
A2-3		9:10am												
A2-4		9:20am												
A3-5		10:45am												
A3-6		10:40am												
A3-7		10:30am												
A3-8		10:35am												

PARAMETER AND METHOD	SAMPLE BOTTLE:	TYPE	SIZE	PRES.
1 TOC by EPA Method 9060	A1-1, A1-2, A2-3, A2-4 A3-5 A3-6 A3-7 A3-8	COMP	250ml	NONE
2 PCB by coroner by Green Bay Method	A1-1,2, A2-3,4 A3-5,6,7,8	COMP	250ml	NONE
3				
4				
5				
6				
7				

NOTE: THE NUMBERED COLUMNS ABOVE CROSS REFERENCE THE NUMBERED COLUMNS FROM TOP RIGHT OF SHEET

SAMPLED BY (PRINT): Amy Sansone
COMPANY: CDM, Inc.
NAME OF COURIER (IF USED):

RELINQUISHED BY: [signature]
DATE: 5-14-98 TIME: 1:15pm
RECEIVED BY:
DATE: TIME:

RELINQUISHED BY:
DATE: TIME:
RECEIVED BY:
DATE: TIME:

RELINQUISHED BY:
DATE: TIME:
RECEIVED BY:
DATE: TIME:

AMBIENT OR CHILLED TEMP _____
PROPERLY PRESERVED: Y N NOTE:
COC TAPE Y N NOTE:
RECEIVED BROKEN OR LEAKING YES NO NOTE:
RCVD W/I HOLDING TIMES: Y N NOTE:
COC DISCREPANCIES Y N NOTE:

ATTACHMENT C

WHITE COPY TO LABORATORY YELLOW COPY TO GENERATOR PINK COPY TO SAMPLER