Upper Hudson River PCB Trackdown Using PISCES

by

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Abstract

Passive water samplers (PISCES, Passive In-Situ Chemical Extraction Samplers) were used in an extensive survey of polychlorinated biphenyl (PCB) contamination of the upper Hudson River primarily between Hudson Falls and Stillwater, NY., during the years 1997-1998 and 2000-2001. The main purpose of the investigation was for track down of secondary PCB sources to and adjacent to the River, which is well known to have been heavily contaminated by PCBs discharged by General Electric Co. plants at Hudson Falls and Fort Edward. Consequently, the River immediately upstream from Hudson Falls was sampled along with a number of tributaries, and areas around several landfills along or near the Hudson. Some of the early sampling was followed up with additional sampling during the latter part of the study.

All PISCES data were converted to estimated PCB water concentrations for ease of comparison. Water concentrations are expressed in terms of the PCB analysis originally specified and used in 1997 which encompassed 84 peaks representing 101 PCB congeners.

The highest PCB level found was 466 ng/L, immediately downstream from the GE Ft. Edward Capacitor Plant's original 004 outfall. Main stream Hudson River PCB levels, downstream from Ft. Edward, were found in the range of 12-138 ng/L.

Introduction

This project was initiated in 1997 using passive in-situ chemical extraction samplers (PISCES) as the sampling tool. The work was undertaken to address concerns regarding potential PCB contributions to the River from remnant deposits, landfills and tributaries.

Sampling in 1997 targeted the River between Hudson Falls and Ft. Edward encompassing Remnant Areas 1-5. Sampling was expanded in subsequent years (1998, 2000 and 2001) to include an area near the Ft. Edward and Kingsbury Landfills, the mouth area of several tributaries, the River downstream to Stillwater, the Thompson Island Pool and inshore areas upstream from Bakers Falls on both sides of the River. Sampling locations are summarized by year in Tables 1-4. In all, 80 stations were sampled with ten sites being sampled twice and one (Station 38) being sampled three times.

Results are summarized on a yearly and area basis. Pertinent information is presented in the accompanying Tables and Figures. In order to report findings as concisely as possible Figures 1-15, in addition to showing sampling locations and estimated PCB water concentrations, also summarize general information and total amounts of PCBs found in the samples. They are meant to serve as a concise summary of the entire study.

Methods

Sampling Procedures

Sampling methodology generally followed techniques outlined in Spodaryk *et al* (1999), which have been used in a number of trackdown studies conducted by the Bureau of Habitat's Environmental Disturbance Investigation Unit (EDIU) starting in 1994. The general methodology was adapted from Litten (1997).

Pairs of the same type of sampler (duplicates) were used at each sampling site as much as possible. Vented Hassett type samplers were primarily used but bag samplers were also employed (Fig. 16) since the number of Hassetts available was limited. Bags were also used in order to obtain some comparative data and because exposure conditions favored their use. At some sites one of each type of sampler was used.

Most samplers were deployed conventionally using an anchor block and float. In very shallow water (Station 21) samplers were tied directly to a block. In order to obtain near bottom samples in the River during the 2000 survey a float (white PVC sponge, 5"OD x 11"long, buoyancy approx. 105 oz.) was affixed to the anchor rope to keep the bottom sampler(s) about three feet above the substrate. In 2001 most samplers were tied to a stake driven into the substrate in 2-3 feet of water (Fig. 17) in order to keep them about 12-15 inches above the bottom. At Station 38B samplers were only several inches off the bottom and Station 66 was set conventionally (Fig. 18).

At deployment all samplers were spiked with FL aliquots of one or two spike solutions. The EDIU has routinely used a spike solution, prepared in-house by the Analytical Services Unit (ASU), containing mirex and trans-nonachlor. This was the only spike material used in 1997 and 1998. In 2000 and 2001 the primary spike solution, which contained three labeled PCB congeners, was furnished by the analytical laboratory, Axys Analytical Services Ltd.

Water temperatures were normally measured at all sampling sites at the time of PISCES deployment and retrieval. Temperatures were also measured if the samplers were checked at any time during the exposure period. Temperature measurements were made with an NIST traceable hand-held electronic thermometer unless equipment failure necessitated using a glass pocket thermometer. During each Hudson River survey temperature loggers (Optic StowAway™, WTA08-05+37, Onset Computer Corp.) were also deployed at two or more stations.

Chemical Analyses

All PISCES samples were submitted to Axys Analytical Services Ltd. (Sidney, BC, Canada) for analysis of PCB congeners and spike materials. Analyses were performed using HRGC/LRMS essentially as outlined by Colman (2001). However, the 2001 PISCES samples were quantified with a longer list of surrogates (IUPAC Nos. 3L, 15L, 37L, 54L, 118L, 167L, 180L, 202L, 206L and 209L) versus the previously used suite of five congeners (101L, 105L, 118L, 180L and 209L).

During the first two years of the study 84 peaks representing 101 congeners were quantified and reported (Table 5). During the last two years of the study all 209 PCB congeners were quantified. They are represented by 160 peaks.

Data evaluation

All PISCES sample PCB congener data were inspected and concentrations that did not meet laboratory quantification criteria were not included in the total (3) PCB levels reported herein. In order to compare PISCES PCB results from all four years of the study, the 2000 and 2001 results were adjusted for comparison with the results reported for 1997 and 1998. Table 5 lists those congeners used for calculating equivalent data. The list was developed following consultation with the analytical laboratory. All equivalent PISCES PCB data are expressed as an estimated (ng/L) water concentration (Litten et al 1993, Litten 1997) in order to make the final results easily understandable.

One or both of two types of PCB homolog plots were employed to screen data from closely grouped stations. One type plots the percent or fraction of each homolog (relative abundance) found at a site versus the corresponding homolog number (i. e., number of chlorine atoms; 1-10) (Litten et al 1993, Litten 1997, Luckey 2001, Rowell et al 2003). With the other type of homolog plot, sample results are grouped into just two homolog fractions, those having three or less (#3) chlorine atoms and those having four or more ($4) chlorine atoms (McCarthy et al 2000). This type of plot provides a gross distribution and comparison between lighter and heavier PCBs in a sample.

For paired samplers relative percent differences (RPD) for the amounts of recovered solvent and total PCBs were calculated. Also for paired samplers the root mean square difference (RMSD) was calculated to compare congener patterns (Colman 2001). For this statistic, congener results from paired samplers are compared after all congener pairs involving flagged results (those that do not meet laboratory quantification criteria) and nondetectable results (ND) are eliminated. The RMSD is determined as the square root of the sum of the squared differences between normalized congener concentrations in the two samples divided by the number of congener pairs compared. The result is multiplied by 100 to express RMSD as a percent. Higher RMSDs (>1.0) indicate greater differences between compared samples. Samples with relatively low amounts of PCBs (<100 ng) tend to produce high RMSDs.

RMSD comparisons between adjacent sampling stations were also made and the t-test (two sample, assuming equal variances) was used to test for significant differences (" =0.05) between the means.

Results & Discussion

QA/QC

Most of the information and data relative to each PISCES sample collected during this study is summarized in Appendix I. Italicized data generally denote some type of nonconformance with QA/QC criteria. However, it does not necessarily mean the data are compromised, as in the case of low volume solvent recovery, and unuseable. On the contrary, in a number of cases where solvent and spike recovery are good, but where PCB data show a high RPD, it may be indicative of an actual site problem (i. e. a source) rather than an analytical problem.

A summary of solvent and field spike recovery data for the entire study is presented in Table 6 with results grouped by sampler type and year. Solvent recovery (to the closest 5 mL) for each sample was estimated on return to the Hale Creek Field Station by comparing sample bottle volumes with calibrated bottles. This was done as a check against sample volume measurements done by Axys Analytical before sample processing. Agreement between HCFS solvent volume estimates and the analytical laboratory measurements was excellent with all seven data set correlation coefficients $0.9.

The solvent recovery and field spike recovery data for the last three years of the study (1998, 2000 & 2001) can generally be characterized as consistent and acceptable. In 1997 several samplers were recovered with no useable amount of solvent (Stations 09 & 12, see Fig. 2) and a number of others were recovered with low solvent volumes (see Figures 1 & 2). Fast flowing water and turbulence in the area of the River sampled seems to be the primary reason for solvent and spike material loss (Rowell et al 2003).

As is normal practice in EDIU PISCES work (Spodaryk et al 1999) samplers were filled with approximate amounts of solvent using a graduated beaker. Normally, a Hassett sampler is filled with 180-200 mL of hexane and a bag sampler is filled with 70-80 mL of trimethylpentane (TMP). Ideally, minimum solvent volumes recovered should not be less than about 100 mL hexane for Hassetts and 50 mL TMP for bags or roughly about 60% of the original amount added to the sampler. Other investigators (Rowell et al 2003) use a volumetric dispenser to add more exact amounts of solvent.

In a study using duplicate Hassett samplers involving five sampling sites Luckey (2001) obtained a mean (±SD) solvent recovery of 142 mL (±41, n=10, range 42-178). One sample had a low solvent amount of only 42 mL but the amount of PCBs recovered from it was comparable to its paired sampler which had a solvent recovery of 176 mL. In a larger study (Colman 2001), solvent recovery from Hassett samplers averaged 173 mL (±17, n=66) which approximates solvent recovery from Hassetts during the last three years of this study.

In addition to calculating relative percent difference (RPD) for the amounts of PCBs found in duplicate samplers (Appendix I), RPD was also calculated for solvent recovery from paired samplers. Figure 19 is a plot of recovered solvent RPD versus PCB (analytical) RPD for all types of paired samplers from the entire study. Ideally, all data points representing similar paired samplers (i.e. two Hassetts or two bags) should fall in the box (bounded by 50% RPD) in the lower left corner of the plot since acceptable analytical RPD is 50% (Litten 1997, Luckey 2001, Rowell et al 2003). As can be seen virtually all duplicate Hassett and duplicate bag points fall in the box.

Solvent RPD for paired Hassett and bag samplers (Fig. 19, circles) would be expected to be about 80-90% considering the initial amounts of solvent used in each or the amounts normally recovered. All circles representing these sixteen sample pairs fall close to the 100% solvent RPD line. The five triangles in this area represent Hassett duplicates from 1997 where low volume samples were recovered (see Figures 1 & 2; Stations 03, 16, 11, 06 and 19).

Excluding the above samples (represented by circles and triangles) that leaves seven data points (diamonds) outside the box. One of these data points has a high recovered solvent RPD (55%). This represents Station 10 from 1997 (Appendix I) where one sampler had a hexane volume of only 100 mL but PCB recovery was good. The other six data points lie to the right of the box. They have high PCB (analytical) RPDs. The three outliers farthest to the right each represent a duplicate pair obtained at or near Station 38 (Tables 2-4, Figures 5 & 11). The two data points having PCB RPDs of about 60% represent Stations 32 and 33 (1998, Table 2, Fig. 4) which are upstream on the west side of the River above Bakers Falls. These five data points represent stations at or near suspected PCB sources. The remaining data point (RPD = 51.6) outside the box represents Station 49 from 2000. This station is located above the dam at Stillwater. Two of the data points located inside the box but close to the analytical RPD 50% line also represent stations located behind dams.

Analytical RPD (ng PCBs) for pairs of similar samplers (both Hassetts or both bags) was generally better than that reported by other PISCES investigators and is summarized by year and sampler type in Table 7. Litten (1997) indicated obtaining a median RPD of 25% for 27 pairs of PISCES (probably Litten type). He also indicated that six RPDs exceeded 50% but that there was no association between RPD and average concentration (i. e. estimated PCB water concentration). Luckey (2001) also calculated RPD from estimated water concentrations and obtained a mean RPD of 22.7% (±19.4, range = 0.5-48.3) for just five Hassett pairs. Colman (2001) obtained an RPD of 27% for 23 Hassett pairs based on total PCBs. The three outlying Hassett pairs obtained at/near Station 38 were excluded from the data presented in Table 7 but even with these anomalous samples (which will be discussed further) included, the mean RPDs for this study would still be equivalent to those obtained by other PISCES investigators.

Figure 20 shows a plot of RMSD versus calculated PCB water levels for paired samplers. The five low sample volume pairs from 1997 (triangles in Fig. 19) are not included in this data set. For convenience and to better illustrate the data mean estimated PCB water concentrations are shown on a log scale x axis (rather than using nanograms of PCBs per sample and a linear scale). Colman (2001) illustrated the tendency of RMSD to increase when accumulated total PCB amounts per sample were < 100ng. In Figure 20 the 100ng level per sampler generally equates to < 3 ng/L.

Excluding the three outliers obtained at/near Station 38, which are obvious to the upper right in Figure 20, most RMSDs > 1 found in this study are also associated with low PCB samples and/or with sampler pairs consisting of a Hassett and a bag. Although substantial differences in PCB sample composition (i. e. congener distribution) would probably not be expected because of sampler differences, the tendency for higher RMSDs seems obvious with this sampler pairing, especially at low PCB levels. RMSDs also tend to be high where the number of congener pairs compared (i.e. used in the RMSD calculation) are relatively low.

It is noteworthy that the two Hassett pair data points (x,y) reflecting PCB water concentrations >10 with RMSDs >1 closest to the anomalous Station 38 outliers (Fig. 20) also represent sites near Station 38. Data point (15.8,1.02) represents Station 65 sampled in 2000 and data point (11.6,1.13) represents Station 38B sampled in 2001. These findings are consistent with the sample dissimilarity (high RMSDs) found at Station 38 and further point to a PCB source in the vicinity of Station 38.

During the course of the study 15 solvent blanks (13 hexane and 2 TMP) were submitted to Axys for analysis. The level of any detectable PCB congener in blank samples was very low. All blanks were considered uncontaminated and no corrections to sample data were made because of blank results.

Water temperature data obtained during the study are summarized in Appendix II. Simple manually obtained temperature readings approximate the data obtained by temperature loggers (Optic StowAway™, WTA08-05+37) (Rowell et al 2003) and were used in the calculation of estimated PCB water concentrations.

Weather conditions were monitored closely prior to PISCES exposures. Rain events are not conducive to ease of deployment and retrieval. Streamflow in the upper Hudson at Ft. Edward was checked using the USGS website prior to PISCES exposures. Moderate precipitation and flow conditions optimize aquatic monitoring using passive samplers. Upper Hudson River flow conditions during exposure periods were relatively uniform during the four years of the study. Streamflow averaged around 3000 cfs in both 1997 and 1998. Streamflow was slightly higher in 2000, generally ranging between 3500-4000 cfs, and it was slightly lower in 2001 when it was generally over 2000 cfs. Appendix III shows the daily mean discharge (cfs) at the USGS gauging station at Ft. Edward during and approximately two weeks prior to each exposure period.

1997 - Remnant Areas between Hudson Falls & Ft. Edward

The first year's work (July 1997) was the most problematic from several viewpoints. The area surveyed (Figures 1 & 2), between Hudson Falls and Ft. Edward, was difficult to access and sampling was affected by fast River flow. Nineteen stations (Table 1) were set with at least duplicate Hassett samplers. For QC purposes and sampler comparison Station 17 was set with an additional Hassett pair and three stations (nos. 10,15 & 17) were set with pairs of bag samplers. Good duplicate Hassett samples were recovered at only ten stations. All samples, including low solvent volume ones, recovered at 17 stations were submitted for analysis.

Along the west bank (Fig. 1) there are gaps in the results because of low sample volume recovery at two stations (3 & 16) where minimum estimated PCB water concentrations were calculated. These minimum estimates could easily only be half of actual levels at that time. Along the east bank (Fig. 2) no samples were recovered at two stations (9 & 12) and at several others (5, 6, 11, 13 & 19) only a partial sample or one good sample was recovered. Fast flows, turbulence and warm temperatures (Appendix IIA) are considered the primary causes of solvent loss (Rowell et al 2003).

It should be noted that the farthest upstream site sampled in 1997 at Station 1 (Fig. 1, Table 1) above Bakers Falls was in the west channel in deeper water closer to the island than the west bank. It was set by boat away from shore to avoid possible vandalism of the only upstream station being sampled.

A preliminary assessment of the 1997 PISCES sampling results was provided by Rowell (1997). His assessment was based on total PCBs recovered, estimated water concentrations and inspection of line graphs comparing sample homolog composition (homolog no. vs. % composition). He concluded (1) that GE's ongoing sampling was apparently not detecting the high PCB input from the outfall 004 area, (2) that two distinct PCB congener patterns were observed in the area (one dominating upstream of the original 004 outfall and along the west shore and the "old 004 outfall pattern" dominating close-in along the east shore) and (3) that any PCB contributions to the River from the remnant areas (nos. 2-5) are masked by the PCBs from upstream.

The data presented here (Figures 21 & 22) confirm Rowell's (1997) conclusions. Figure 21 compares PISCES sample homolog composition based on lighter (#3 chlorine atoms per molecule) and heavier ($4 chlorine atoms per molecule) PCB content. Figure 22 provides a schematic of the 1997 sampling stations (Figures 1 & 2) and shows results of significance testing between RMSD means at adjacent stations. These data primarily indicate a major source of PCB contamination between Stations 6 and 7, which bracket GE's original 004 outfall.

Similarity of PCB composition is indicated across the River (Fig. 21; Stations 3, 11, 5 & 6) below the plunge pool (Station 2) and this similarity extends along the west side of the River except at Station 16. Even Station 13, which was off the east bank about 50 ft. (not 15 ft. as indicated by Rowell (1997)) shows this similarity. The east side of the River is dominated by heavier PCBs, entering above Station 7, which persist downstream to

Station19. Significance testing (Fig. 22) was inhibited along the east side because only one sample was recovered and analyzed from Stations 5 and 13. Significance testing pinpoints the PCB source (original GE outfall 004) between Stations 6 & 7 and also shows a significant difference in PCB composition on opposite sides of the River at Stations 4W & 14E but not downstream from that point.

The survey could not substantiate PCB input from the Remnant Areas (nos. 2-5). Careful re-sampling with PISCES might be able to accomplish this but collection and analysis of aquatic organisms is deemed easier in this area and has already been accomplished (Sloan et al 2002). The distance of PISCES placement from shore seems critical in this area. The high PCB input above Station 7 on the east side along with fast stream flow complicates sampling. The PCB plume tends to hug the east bank. PCB concentration (ng/L) differences between Stations 7(466) ö 8(152) ö 10(369), 10(369) ö 13(46) and 15(125) ö 18(38) ö 19(53) along the east bank, where the middle and offshore stations have lower PCB levels, are probably due to how far offshore those stations were sited. With Stations 10 ö 13 this is obvious. At the lower end of the sampling area Stations 15 and 19 were 4-6 feet from shore (Table 1) whereas Station 18 was about 20 feet from shore. On the west side of the River the composition anomaly at Station 16 (Fig. 21) may be partly due to River morphology. Station 16 was set about 20 feet from shore and both samplers had a low level of recovered solvent. The set may have been far enough out in the River for the Station to be influenced by flow and its velocity coming around Remnant Area 3 from the east side of the River.

In addition to normal QA/QC, four samples (2 Hassetts and 2 bags) from Station 17 were analyzed in-house. Total PCB results (Fig. 1; Appendix I) for the Hassett samples are comparable to those reported by the contract laboratory. Total PCB results for the bag samplers are somewhat low. Total PCB results for the other bag samplers exposed during the 1997 survey (Stations 10 & 15, Fig. 2) are also low relative to Hassetts. This is surprising considering that membrane surface area on bag samplers is at least twice as great as on Hassetts. Fast stream flow is again thought to be a complicating factor. Significance testing of sample pair RMSD means comparing the Hassett and bag results at both Stations 10 and 15 indicates no significant difference in sample composition between the different types of samplers.

1998

The 1998 PISCES trackdown survey basically explored five different areas along the upper Hudson. These areas included the River upstream from Bakers Falls (Figures 3 & 4), the Canals east of Hudson Falls in proximity to the

Kingsbury and Ft. Edward Landfills (Figures 4 & 5), the area around Rogers Island (Fig. 5), a number of tributaries (Figures 6, 8 & 9) and lastly, Hot Spot 28 (Fig. 7) and several other River stations further downstream (Figures 8 & 9). A total of 33 stations (nos. 20 - 52) were set (Table 2).

All samplers but one (at Station 28) were recovered in good condition with good solvent recovery (Table 6). All samples (49 Hassett and 18 bag) were submitted to Axys Analytical for analysis. The samples represented 18 similar sampler pairs (duplicates; 17 Hassetts and 1 bag) and 14 Hassett and bag pairs. Recovery of spike material (mirex and trans-nonachlor) was good (Table 6). In fact solvent and spike recovery was not a problem after 1997. During the last three years of the study, fast stream flow and turbulence were not a concern, and temperatures were generally lower (Appendix II).

1998 - Upstream

The farthest upstream River samples obtained during the study produced the lowest PCB levels (Fig. 3). Stations 27 & 28 bracketed the Sherman Island Power Plant and no PCB input was indicated although the Niagara Mohawk Queensbury site lies just upstream from Station 27.

Sampling above Bakers Falls produced generally increasing PCB levels proceeding downstream between Stations 30 & 31 (Fig. 4). PCB levels found at Stations 29 & 30 can be considered background for the area and are similar to the upstream result obtained in 1997. However, PCB levels are elevated at Stations 31-33. Additionally, all three of these “upstream” stations show relatively high analytical RPDs even though solvent and spike recoveries are normal. (This phenomenon will be encountered again.) It should also be noted that Station 31 on the east side of the River is relatively close to a dam and that Stations 32 & 33 on the west side were set close to the west bank (unlike Station 1 in 1997). Both sides of the River above Bakers Falls were subsequently re-surveyed. The east side was done in 2000 and the west side in 2001.

Figure 23 summarizes PISCES sample composition from stations in this area on the basis of lighter and heavier homolog fractions. Increasing amounts of PCBs were accumulated proceeding downstream. Changes in PCB composition are evident especially at Station 31 where the heavier fraction dominates. The lighter/heavier PCB composition at Stations 29, 30 & 33 resembles those found at 1997 Stations 1 & 2 (Fig. 21). The composition at Station 31 approximates those found across the River at Stations 3, 11, 5 and 6 in 1997 (Fig. 21). Testing of RMSD means among adjacent stations in this area did not produce any pairings showing significant differences.

1998 - Canals/Landfills

PCB levels in the Canals (Feeder, Old Champlain and Champlain) just east of Hudson Falls are well above background (Figures 4 & 5). Levels tend to generally increase proceeding downstream in the system. Cutter Pond, located below the Kingsbury Landfill, is contaminated. The highest PCB level in the area was found at Station 26 in the Old Champlain Canal downstream from the Kingsbury Landfill. Station 26 reflects the actively flowing water from the Feeder Canal.

All sampler pairs in this area, except for the outlet of Cutter Pond (Station 21), consisted of a Hassett and a bag. Therefore no significance testing of sampler pairs was done.

1998 - Rogers Island Area

Six sites were sampled in the area adjacent to and just downstream from Rogers Island (Fig. 5). On the east side of the River Stations 34 and 35 bracket Area 518. On the west side sampling was focused on bracketing the Moreau Sites and Special Area 13. Results seemed straightforward except at Station 38.

At the "upstream" Stations (34 & 36) PCB levels were higher on the east side of the River than on the west side as was found to be the case just upstream in 1997 at Stations 19 and 17. In the east channel the PCB level found at Station 35 was about 2½ times as high as that found upstream at Station 34. In the west channel there was also an increase in PCB levels from upstream to downstream at Stations 36 and 37. Although the PCB increases in both channels bracket known landfilled areas the increases may also be due to PCBs in sediment deposits.

At Station 38 along the west shore just downstream from Rogers Island anomalous results were obtained. The Hassett pair not only had amounts of PCB that were divergent (analytical RPD = 108) but the composition of the pair was divergent (RMSD = 1.95). Solvent and spike material recoveries for the pair were normal. Initially it was theorized that the sampler with the very high amount of PCB (5447 ng) might have come in contact with highly contaminated sediment from resting on the bottom during at least part of the exposure period. The other sampler, whose lower amount of recovered PCB (1616 ng) was more comparable to adjacent stations, also had a homolog composition similar to adjacent stations. Figure 24 compares the homolog composition of the Hassett pair obtained at Station 38 in 1998. The sample with the most PCBs has a much heavier homolog profile. Even with the above noted differences in the duplicates at Station 38 their data were processed like all other duplicates.

Results at Station 39, just downstream from Station 38, appear rather normal in comparison with adjacent stations. Figure 25 compares 1998 Rogers Island area stations in terms of lighter/heavier PCB composition. All the stations seem fairly similar with the exception of Station 38, which is dominated by the heavier PCBs.

Significance testing of RMSD means among adjacent stations showed some interesting results which are summarized in Figure 26. Although it appears that gross PCB composition among the stations is fairly uniform except for Station 38, significant differences were found, but not where they were expected. Perhaps least surprising is that stations on opposite sides of the River, separated by Rogers Island, showed significant differences. Perhaps most surprising is that no significant differences were found between Station 38 and adjacent stations. What is particularly interesting, however, is that on the east side, no significant difference was found between Stations 34 and 35, while on the west side a significant difference was found between Stations 36 and 37. In any case, preliminary indications are that at least one PCB source exists in this area.

1998 - Tributaries

Five tributaries were sampled in 1998. These included the Snook Kill (Station 40, Fig. 6), the Moses Kill (Stations 41 & 42, Fig. 6), the Batten Kill (Station 44, Fig. 8), Fish Creek (Stations 51 & 52, Fig. 8) and the Hoosic River (Station 50, Fig. 9). Black House Creek was also inspected but this small stream was shallow and backflow from the River was evident in the lower part of the stream where sampling was projected. Samplers were exposed at the mouth of Black House Creek (Station 43, Fig. 6) but these reflect River conditions.

All tributaries had generally low but varying levels of PCBs. The Snook Kill is a very low gradient stream and backflow was evident in the lower part of it. In the Moses Kill an attempt was made to bracket the old Ft. Miller Landfill. Backflow was evident in the area sampled. The situation was investigated further in 2000. The Batten Kill (Station 44, Fig. 8) showed PCBs slightly greater than background. There is a known PCB source upstream at Battenville. The Fish Creek upstream site (Station 51, Fig. 8) had background level PCBs. The downstream site (Station 52) below the STP was twice as high. The Hoosic River showed a relatively high level of PCBs (4.8 ng/L, Station 50, Fig. 9). It has at least one known source further upstream at the former Sprague Electric plant site in North Adams, MA.

1998 - Hot Spot 28 & Downstream

Hot Spot 28 lies on the east side of the River below the Champlain Canal's Lock No. 6 at Ft. Miller. Three stations (nos. 45 - 47) were set in the area (Fig. 7) in an attempt to determine whether Hot Spot 28 contributed PCB loading to the River. Station 45 was set just upstream from Hot Spot 28 and it had the highest PCB level of the three sites. In fact PCBs decreased at the two succeeding sites set over Hot Spot 28. Although the middle site (Station 46) shows a little increase in the lighter PCB fraction, which then decreases slightly at the downstream station (no. 47), testing of RMSD means at adjacent stations did not show significant differences between the sites.

Station 45 had the highest mean PCB level (138 ng/L) found during the 1998 and subsequent surveys. It is located immediately downstream from the Ft. Miller Dam. In the upper Hudson PCBs appear to increase down through long pools with the highest levels found just above or below dams. Perhaps contaminated sediment accumulated in relatively quiescent areas in the lower parts of pools and behind the dams contribute to this phenomenon.

Two other River stations were set in 1998. Station 48 at Northumberland (Fig. 8) is about 2.2 mi. downstream from Station 47. PCB levels decreased to 44 ng/L. The PCB composition at Stations 47 and 48 is not significantly different. Samples were also obtained at Station 49 (Fig. 9) above the dam at Stillwater where PCB levels were high (106 ng/L). There are about 15 stream miles between Stations 48 and 49 so it is not surprising that there is a significant difference in composition with a shift to heavier PCBs.

2000

The 2000 PISCES trackdown survey also keyed on five different areas of the upper Hudson. Broader, followup surveys were carried out in three areas including on the east side of the River upstream from Bakers Falls (Fig. 10), in the area around Station 38 south of Rogers Island near the upper end of the Thompson Island Pool (Fig. 11) and in the Moses Kill (Fig. 12). Additionally, the lower parts of two River pools were sampled including the Thompson Island Pool (Fig. 13) and the Stillwater Pool (Fig. 14). A total of 30 stations was sampled including eight that were previously sampled in 1998.

All samplers were recovered in good condition with good solvent and spike material recovery (Table 6). All samples (56 Hassett and 12 bag) were submitted to Axys Analytical for analysis which included all 209 PCB congeners. Results comparable to those obtained in 1997/98 were estimated. Hassett samplers were used at all River stations. Because of limited sampler availability individual Hassetts were used for all bottom sets and at several surface sites. Duplicate bag samplers were used at all six Moses Kill stations.

Sampling took place during Aug./Sept. as in 1998. Water temperatures were comparable to those obtained in 1998 (Appendix II) but River flow was slightly higher, ranging about 3500 - 4000 cfs (Appendix III).

2000 - Upstream - East Side

In the upstream area on the east side of the River above Bakers Falls (Fig. 10) Stations 29 and 31 were re-sampled and four other stations were set in an attempt to determine if localized PCB sources are present. The old Hudson Falls STP was located just upstream from Station 55 and GE's Pump House is located just above the dam near Station 53.

Both Stations 29 and 31 had PCB levels similar to those found previously in 1998 (Fig. 4). Upstream Stations 29 and 54, along with the offshore Station 56, showed similar, low PCB levels, #2 ng/L. The inshore Station 55 below the old STP had elevated PCBs at 4.8 ng/L. It also has a much different congener profile. Figure 27 summarizes data from area stations in terms of lighter and heavier PCB fractions. Just downstream at Station 31 PCBs decrease slightly and composition shifts to a lighter makeup, probably reflecting the mixing of upstream water. At Station 53, which is adjacent to GE's Pump House, PCB levels rise considerably.

Results of significance testing on RMSD means from available duplicate samples are summarized in Figure 28. They show a PCB source upstream from Station 55 along with a significant difference between Stations 55 and 53 indicating a second source.

2000 - Station 38 Area

In 2000 seven sites were sampled near Station 38 at the north end of the Thompson Island Pool just below Rogers Island (Fig. 11). Stations 37-39, previously sampled in 1998, were re- sampled, and Stations 65-68 were set to gain additional information in the area. Sampling conditions (dates, flow, temperatures) were similar to those in 1998. Results again seemed straightforward except at Station 38.

Along the west side of the River (Fig. 11) PCB levels generally decreased with the exceptions of Stations 38 and 66. At Station 38 anomalous results were obtained again! Station 66 was set just a little further offshore adjacent to Station 38. At Station 68, the only station set on the east side of the River, PCB levels were again found to be higher than on the west side.

At Station 38 results from the duplicate Hassetts were again divergent in terms of PCB amounts and composition. Figures 29A & B summarize results from the area based on lighter and heavier PCB fractions. Station 38 shows a much heavier PCB homolog composition than surrounding stations. Figure 30 compares sample composition at Station 38 as both total PCBs and 1997/98 equivalents. As in 1998 (Fig. 24, sample 045) the sample (068) with the most

PCBs also has a heavier PCB profile. The 1997/98 composition results (3rd & 4th columns Fig. 30) show essentially the same sample correspondence and distribution as found in 1998 (Fig. 24).

Significance testing of RMSD means among adjacent stations is summarized in Figure 31. Results are again similar to 1998's (Fig. 26) in that no significant differences were found between Station 38 and adjacent stations but some significant differences were found across the River and along the west side. At this point it should be obvious that Station 38 represents a very peculiar situation.

2000 - The Moses Kill

A more complete survey of the Moses Kill (Fig. 12) relative to the Ft. Miller Landfill was done in 2000. Stations 41 and 42 were re-sampled and Stations 57-60 were also set. Because of limited Hassett sampler availability all six Moses Kill stations were set using duplicate bag samplers. Backflow was observed in the Moses Kill beyond the entry of Dead Creek. This is about 1½ miles upstream from the mouth of the Moses Kill. PCB levels were found to decrease proceeding upstream.

Figure 32 summarizes results in terms of lighter and heavier PCB fractions. Based on total PCBs (3rd & 4th station columns) essentially no change in composition is seen except at the farthest upstream station (no. 57) when a shift to heavier PCBs is observed. Comparing sites on the basis of equivalent 1997/98 results (1st & 2nd station columns) shows essentially the same pattern. Significance testing of RMSD means, using all combinations of adjacent stations, did not show any significant differences between Moses Kill stations.

The PCB concentration and composition profiles through the area sampled, including opposite sides of the lower part of the stream, implicate backflow from the Hudson as the apparent contamination source in the Moses Kill.

2000 - Thompson Island Pool

Stations were set down through the Thompson Island Pool (Fig. 13) to obtain information on the levels and dynamics of PCBs in a large River pool. There are about 4½ stream miles between Stations 39 and 68 (Fig. 11) near the north end of the Pool and the Thompson Island Dam. PCB levels increased somewhat from the head of the Pool down into the middle of the Pool above Griffin Island (Stations 69 & 70). From there down to above the Moses Kill (Stations 71 &72) PCB levels appear homogeneous on the west side of the River and decreased somewhat on the east side. Further down toward the Dam at Stations 73 and 74 PCB levels decreased on the west side and increased on the east side.

In terms of gross composition (homolog distribution) stations down through the Pool appear fairly homogeneous. Figure 33 compares lighter and heavier PCB fractions at area stations using 1997/98 comparable data. The heavier PCB fraction is more prevalent than in the Moses Kill (Fig. 32). In actuality, on the basis of the total PCB analysis, PCB composition in the Thompson Island Pool is dominated by the lighter PCB fraction. In fact, throughout the Pool, roughly 65-70% of the PCB mass is due to the mono- and di- homologs.

Testing of RMSD means for significance between adjacent stations showed differences in the upper and middle areas of the Pool which are not obvious from inspecting homolog composition graphs. Results are summarized in Figure 34.

2000 - Stillwater Pool

The lower (southern) end of the Stillwater Pool (Fig. 14) was sampled for several reasons. It was desired to re-sample Station 49 and to obtain more information on PCB distribution in the Pool. According to Department maps there is a long hot spot along the east bank upstream from the Washington/Rensselaer Co. line. This hot spot was essentially bracketed by Stations 62 and 64 (Fig. 14) to determine if it was contributing to the high PCB level previously found at Station 49 (Fig. 9). As can be seen from the PCB concentration levels shown in Figure 14 some surprising results were obtained.

Station 49 results were not surprising. PCB levels found in 2000 were nearly identical to that found in 1998 (Fig. 9). Also, mean sample composition (homolog distribution) for the two years (on the basis of comparable analyses) is virtually the same.

At the Pool stations (nos. 61-64) upstream from Station 49, however, the exact opposite of what was expected was found. PCB levels were lower on the east side of the River than on the west side and they decreased, from upstream to downstream, on both sides of the River in both surface and bottom samples.

In terms of gross composition (homolog distribution), stations in the Stillwater Pool, as in the Thompson Island Pool (Fig. 33), appear relatively homogeneous. Figure 35 compares lighter and heavier PCB fractions at area stations using 1997/98 comparable data. Composition is dominated by the lighter PCB fraction but not to quite the extent found further upstream (approx. 20 miles) in the Thompson Island Pool. On the basis of total PCB analysis PCB composition in the Stillwater Pool is also dominated by the lighter PCB fraction. About 50% of the PCB mass in the Stillwater Pool is due to the mono- and di- homologs.

Because of limited Hassett sampler availability, duplicate samplers could not be deployed at most sites in the area. Only the surface sets at Stations 62, 64 and 49 along the east side of the River had duplicate samplers. Therefore, significance testing of RMSD means was limited to those sets and significant differences were not found.

2001

The 2001 PISCES trackdown survey was done to obtain additional information in two areas previously sampled along the west side of the upper Hudson. The upstream area above Bakers Falls (Fig. 15) was sampled and the area around Station 38 (Fig. 11) south of Rogers Island was sampled for the third time. Station locations are outlined in Table 4.

A total of 10 stations was sampled using duplicate Hassett samplers. In this survey all samplers, except those at Station 66, were exposed using a stake set (Fig. 17) in order to assure that samplers did not come in direct contact with the bottom sediments. All samplers were recovered in good condition with good solvent and spike material recovery (Table 6). All samples (20 Hassetts) were submitted to Axys Analytical for analysis of 209 PCB congeners. Results comparable to those obtained in 1997/98 were estimated.

Sampling was done later in the season (Oct.) than previous surveys. Water temperatures were somewhat cooler, averaging about 16E ± 2EC (Appendix IID), and River flows were lower, ranging just above 2000 cfs (Appendix IIID).

2001 - Upstream - West Side

In the upstream area on the west side of the River above Bakers Falls (Fig. 15) Stations 32 and 33 were re-sampled and three other stations (nos. 75-77) were set in an attempt to determine if localized PCB sources are present.

PCB levels at Stations 32 and 33 were lower than those found in 1998 (Fig. 4) but levels at all 2001 upstream area stations sampled were higher than those found at upstream stations on the east side of the River in both 1998 (Fig. 4, Stations 29 & 30) and 2000 (Fig. 10, Stations 29 & 54). The slightly lower PCB levels found along the west side in 2001, as compared with 1998, probably reflect lower flow conditions and the later sampling period. PCB levels again increased between Stations 32 and 33 although the increase in 2001 was very slight.

The most revealing results obtained in this area in 2001 are the level at Station 75 and the increase between Stations 76 and 77. The PCB level (2.7 ng/L) found at the farthest upstream station (no. 75) is higher than levels previously found at “upstream” stations on the opposite side of the River and is slightly higher than those found at the next two downstream stations (nos. 32

& 76). This indicates a low level PCB source exists upstream from Station 75. Likewise, the increase in PCBs between Stations 76 and 77 indicates a low level source between those stations.

In 1997 young-of-the-year fish samples were obtained along several of the Remnant Areas and upstream in this area. PCB results for the "upstream" fish were comparable to those found in samples obtained around Remnant Area 4 (Fig. 1) (Spodaryk 1998). Fish sampling in 1999 also showed samples from this area to be contaminated (Sloan et al 2002).

The preponderance of evidence points to the existence of at least one, and probably two, low level sources in this area. However, testing of RMSD means between stations could not confirm this. One problem is that Station 75 was the farthest upstream station sampled and another is the generally low amounts of PCBs accumulated during the exposure. A comparison of PCB homolog distribution or of lighter and heavier homolog fractions (Fig. 36) at area sites does not appear to be very informative except for the trend reversal between Stations 77 and 33. However, Figure 36 is included for comparison with other "upstream" station results (Figures 21, 23 & 27).

2001- Station 38 Area

In the Station 38 area on the west side of the River below Rogers Island another PISCES deployment was carried out but in a very closely grouped arrangement (Table 4, Fig. 18). Stations 38 and 66 were re-sampled and three additional stations (nos. 38N, 38B & 38S) were set around and in close proximity to Station 38.

Anomalous results were obtained again! However, this time the Station 38S samples proved to be very different. Figure 37 compares area results from 2001 on the basis of lighter and heavier PCB homolog fractions. Station 38S shows the obvious increase in the heavier PCB fraction as was found at Station 38 in 1998 (Fig. 25) and 2000 (Fig. 29). However, the PCB composition at Station 38S (Fig. 38) is somewhat different than was found at Station 38 in 1998 (Fig. 24) and 2000 (Fig. 30). Generally, there is an increase in the lightest (mono- and di-) and heaviest (hexa-, hepta- and octa-) homologs, a decrease in the tetra- homolog, variable results in the tri- homolog, while the penta- homolog fractions are fairly similar. The slight shift in location of the divergent sample pair was likely due to generally drier, lower flow conditions in 2001. In any case, for the third time, sampling in this area produced an anomalous pair of samples.

Significance testing was done on RMSD means of all adjacent station pairs and no significant differences were found. This seems surprising except for the fact that no previously tested pairings involving Station 38 (Figures 26 & 31) had showed a significant difference.

Key Findings

1997

PCBs in the River between Hudson Falls and Ft. Edward were dominated by inputs at/above the plunge pool (Station 02, Fig. 1) and from the area of the original GE Ft. Edward Plant Outfall 004 (Station 07, Fig. 2). Based on this investigation PCB input from the remnant areas is uncertain because of incomplete sample recovery on the west side of the River and the high PCB input found above Station 07 on the east side.

1998

Slightly elevated PCB levels were found on both sides of the River just upstream from Bakers Falls (Fig. 4). Findings were followed up and substantiated in 2000 on the east side and in 2001 on the west side.

Elevated PCB levels were found in the Canals (Feeder, Old Champlain and Champlain) and Cutter Pond east of Hudson Falls especially down gradient and downstream from the Kingsbury Landfill.

PCB inputs were documented adjacent to and just downstream from Rogers Island pointing to possible input from the Moreau Landfills, Site 518, and near the upstream end of Special Area 13 at Station 38 (Fig. 5).

Higher PCB levels were found at the downstream site in the Moses Kill (Station 42) below the Ft. Miller Landfill (Fig. 6). This area was further investigated in 2000 (Fig. 12).

Very high PCB levels were found below the Ft. Miller Dam at Lock 6 (Station 45, 138 ng/L, Fig. 7) and above the Stillwater Dam (Station 49, 106 ng/L, Fig. 9).

2000

Elevated PCB levels on the east side of the River above Bakers Falls were documented at two sites (Fig. 10); adjacent to the old Hudson Falls STP at Station 55 and just upstream from the Dam at Station 53.

The initial 1998 finding regarding anomalous results (sample pair PCBs vary greatly both quantitatively and qualitatively) at Station 38 was substantiated and higher PCB levels were again found on the east side of the River at the head of the Thompson Island Pool (Fig. 11).

PCBs in the Moses Kill in the area of the Ft. Miller Landfill are apparently largely due to back flow of Hudson River water (Fig. 12).

Relatively uniform PCB levels and gross congener distributions were found throughout the Thompson Island Pool (Fig. 13).

High PCB levels (-110 ng/L) at Station 49 above the Stillwater Dam were substantiated. Higher PCB levels were found on the west side of the River than on the east side in the lower part of the Stillwater Pool (Fig. 14).

2001

Low level PCB input along the west bank upstream from Bakers Falls was substantiated. Two sources are possible; upstream from Station 75 and at/upstream from Station 77 (Fig. 15).

For the third time anomalous results at/near Station 38 (Figures 5 & 11) were found. In 1998, 2000 and 2001 sample pairs at or near this station included one sample with PCB quantity and quality similar to adjacent stations and the other sample with much different results.

Summary

High water-borne PCB levels were found to be pervasive in the main stem of the Hudson from below the Bakers Falls Dam at Hudson Falls (Station 02, 57 ng/L) downstream to behind the dam at Stillwater (Station 49, >100 ng/L), an area encompassing approximately 28 river miles. Main stream PCB levels ranged from about 10 ng/L (Station 17W, downstream from Remnant Area 4 opposite Ft. Edward) to 466 ng/L (Station 7E, downstream from GE's original 004 outfall). Elevated PCB levels were also found at several tributary and canal stations.

The initial PISCES survey in 1997 could not substantiate PCB input from the Remnant Areas between Hudson Falls and Ft. Edward. Subsequent surveys documented a number of PCB sources. These included areas on both sides of the River just upstream from Bakers Falls. On the west side low level sources were evident upstream from Station 75 and in the vicinity of Station 77. On the east side there is a low level source adjacent to the old Hudson Falls STP at Station 55 and another source upstream from the Bakers Falls Dam at Station 53.

Downstream from Bakers Falls PCB input was evident below GE's original 004 outfall at Station 7. Elevated PCBs were also evident on both sides of the River opposite the south end of Rogers Island. On the west side (Station 37) this may be due to the Moreau Sites and on the east side (Station 35) it may be due to Area 518 and/or sediment deposits in the east channel. South of Rogers Island a PCB source is also evident at/near Station 38 located opposite the north end of Special Area 13.

Apart from the main stem of the Hudson significant PCB contamination was also documented in the area of the Ft. Edward and Kingsbury Landfills. Cutter Pond is contaminated along with the Canals near it including the Feeder, Old Champlain and Champlain Canals.

Low PCB levels were generally found in the six tributaries sampled in the survey. The influence of the Hudson River can be profound in low gradient streams such as the Moses Kill. In 2000, back flow in the Moses Kill was obvious at Station 57 located about 1.7 mi. upstream from the River. The Batten Kill and Hoosic River are contaminated by upstream sources on those streams. Heavier PCBs dominate the profile in the Hoosic.

PISCES gave consistent estimates of PCB water concentrations during the study. Inspection of the data shows that sample composition (congener profile) was also generally comparable at re-sampled sites during the study.

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References

Colman JA. 2001. Source identification and fish exposure for polychlorinated biphenyls using congener analysis from passive water samplers in the Millers River Basin, Massachusetts. U. S. Geological Survey Water-Resources Investigations Report 00-4250. 44p.

Litten S, B Mead, J Hassett. 1993. Application of passive samplers (PISCES) to locating a source of PCBs on the Black River, New York. Environ. Contam. Toxicol. 12(4):639-647.

Litten S. 1997. PCBs - What they are, what they do, and how to find them - A manual for field staff. Bureau of Assessment and Research, Division of Water, New York State Department of Environmental Conservation, Albany, NY. 63p.

Luckey F. 2001. Evaluation of toxic contaminants in West Carthage/Carthage municipal wastewaters. Division of Water, New York State Department of Environmental Conservation, Albany, NY. 34p.

McCarthy JF, GR Southworth, KD Ham, JA Palmer. 2000. Time-integrated, flux-based monitoring using semipermeable membrane devices to estimate the contribution of industrial facilities to regional polychlorinated biphenyl budgets. Environ. Contam. Toxicol. 19(2):352-359.

Rowell HC. 1997. Upper Hudson River PISCES sampling/source trackdown results - Remnant deposits and GE #004 outfall area (Bakers Falls to Remnant deposit #5). Memorandum to: L. Skinner, B. Ports; dated December 19, 1997. Division of Water, New York State Department of Environmental Conservation, Albany, NY. 12p.

Rowell HC, J Eldred, K Konow, E Stevenson, B Ruppel, JP Hassett, JM Polito, DJ Hughes. 2003. Hudson River toxics trackdown project - Contaminant identification and source trackdown utilizing passive sampling techniques. Division of Water, New York State Department of Environmental Conservation, Albany, NY. 53p.

Sloan RJ, MW Kane, LC Skinner. 2002. 1999 as a special spatial year for PCBs in Hudson River fish. Bureau of Habitat, Division of Fish, Wildlife & Marine Resources, New York State Department of Environmental Conservation, Albany, NY. 107p.

Spodaryk J. 1998. 1997 upper Hudson River PISCES and fish sampling results – Remnant deposits and GE #004 outfall area. Memorandum to: C. Rowell; dated January 7, 1998. Division of Fish, Wildlife and Marine Resources, New York State Department of Environmental Conservation, Gloversville, NY. 7p.

Spodaryk JG, TL Preddice, SJ Jackling. 1999. Contaminant trackdown studies - Standard operating procedures. Bureau of Habitat, Division of Fish, Wildlife & Marine Resources, New York State Department of Environmental Conservation, Gloversville, NY. 21p.

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34. Schematic of 2000 Upper Hudson River PISCES stations (N 8) in the Thompson Island Pool showing results of significance testing (t-test, " =0.05) between RMSD means at adjacent surface stations (dashed line - not significantly different, solid line - significantly different). Estimated PCB water concentrations (ng/L) given in parentheses. Refer to Figure 13.

35. Comparison of PCB homolog chlorine content at Upper Hudson River PISCES stations in the Stillwater Pool, 2000. Refer to Figure 14.

36. Comparison of PCB homolog chlorine content at Upper Hudson River PISCES stations upstream above Bakers Falls on the west side of the River, 2001. Refer to Figure 15.

37. Comparison of PCB homolog chlorine content at Upper Hudson River PISCES stations adjacent to Station 38, 2001. Refer to Figure 11.

38. Comparison of PCB homolog composition in PISCES samples at Station 38S, Oct. 2001.

Table 1. Upper Hudson River PISCES Stations - 1997

Station No.	Í River Mile	Location[1]
01 -	196.3	Upstream, above Fenimore Bridge. In west channel near west side of island just upstream from bridge.
02 -		Plunge Pool. Opposite Hudson Falls GE plant.
03 -	196.0	North end of Remnant Area #2.
04 -	195.5	South end of Remnant Area #2.
05 -		Upstream from new Outfall 004 (onshore, about 20 ft. from shore).
06 -		Upstream from old Outfall 004 (onshore, about 10-15 ft. from shore).
07 -		Downstream from old Outfall 004 (onshore, about 20 ft. from shore).
08 -		About halfway between old Outfall 004 and junk yard.
09 -		At south/downstream end of junk yard (about 6 ft. from shore).
10 -	195.6	Upstream end of Remnant Area #3 (onshore, about 10-15 ft. from shore).
11 -		Upstream from new Outfall 004 (offshore, about 45 ft. from shore).
12 -		Upstream from old Outfall 004 (offshore, about 40-45 ft. from shore).
13 -	195.6	Upstream end of Remnant Area #3 (offshore, about 50 ft. from shore).
14 -	195.4	Middle of Remnant Area #3 (onshore, about 6 ft. from shore).
15 -	195.3	Downstream end of Remnant Area #3 (onshore, about 6 ft. from shore).
16 -	195.0	North end of Remnant Area #4 (about 20 ft. from shore).
17 -	194.4	South end of Remnant Area #4.
18 -	194.3	Upstream end of Remnant Area #5 (about 20 ft. from shore).
19 -	194.1	Downstream end of Remnant Area #5 (about 4 ft. from shore).

[1]All Stations on Hudson Falls USGS quad map.

Table 2. Upper Hudson River PISCES Stations - 1998

Station No.		Location (USGS quad map)
20	-	Upstream in Glens Falls Feeder Canal, about 250 ft. above the Burgoyne Ave. dam. (Hudson Falls quad).
21	-	In the downstream end of the overflow culvert from Cutter Pond.
22	-	North side of Feeder Canal just above junction with Old Champlain Canal.
23	-	South side of Feeder Canal just above junction with Old Champlain Canal. On side nearer Ft. Edward Landfill.
24	-	East side of Champlain Canal about 1 mi. up Dike Rd. north of Rt. 196. About 150 yds. before bend in road.
25	-	West side of Champlain Canal about 100 yds up Lock 8 Rd. north of East St.
26	-	On the east side of the Old Champlain Canal about ¾ mi. downstream from (north of) the entry of the Feeder Canal.
27	-	Upstream from Sherman Island Dam about 600+ yds. on the north side of the river about 50 ft. from shore. (Glens Falls quad)
28	-	In bay on north side of river about 350 yds. downstream from the Sherman Island Power Plant.
29	-	Downstream from Washington Co. Incinerator. Just upstream from intermittent trib (H327). (Hudson Falls quad)
30	-	Upstream from Washington Co. Incinerator. About 50 ft. downstream from concrete and block wall.
31	-	East side of river just downstream from the old Fenimore Bridge above Baker's Falls.
32	-	On west side of river above island above Baker's Falls in between old stone bridge abutment(s) and small steep boat launch.
33	-	On west side of river about 50 yds. upstream from (new) Fenimore Bridge.
34	-	Upstream from Area 518. Upstream from Ft. Edward STP and just downstream from intermittent trib (H319, Bond Creek at river).
35	-	Downstream from Area 518. About 100 ft. above Lock 7 wall.
36	-	Upstream from old and new Moreau sites. West side of river about 125 yds. downstream from RR

cont'd

Table 2. Upper Hudson River PISCES Stations - 1998 continued pg. 2

Station No.		Location (USGS quad map)
37	-	Downstream from old and new Moreau sites. West side of river opposite downstream end of Rogers Island.
38	-	Upstream from Special Area 13. West side of river about 50 yds. downstream from West River Rd. Marina dock and about 100 yds. upstream from green channel buoy.
39	-	Downstream from Special Area 13. About 25 yds. from the west bank under the power lines crossing the river. (Ft. Miller quad)
40	-	Snook Kill (H318) just upstream from the Clark Rd. bridge.
41	-	Moses Kill (H314) upstream from Ft. Miller Landfill. Along east bank about 100 ft. downstream from where stream narrows and deepens.
42	-	Moses Kill (H314) downstream from Ft. Miller Landfill. At upstream side of old aqueduct.
43	-	Black House Creek (H317) at downstream side of culvert under Rt. 4.
44	-	Batten Kill (H301) at Hollingsworth and Vose Co. water intake on the east side of Co. Rt. 113. (Schuylerville quad)
45	-	Upstream from Hot Spot 28. East side of river about 150 ft. from shore downstream from dam adjacent to Lock No. 6. (Ft. Miller quad)
46	-	On Hot Spot 28. About 250 yds. below entrance to Champlain Canal Lock 6 and about 65 yds. from east bank.
47	-	Downstream from Hot Spot 28. About 100 yds. from east bank off north end of small island upstream from the mouth of the Slocum Creek.
48	-	At Northumberland upstream from the entrance to Champlain Canal Lock No. 5. (Schuylerville quad)
49	-	At Stillwater about 25 ft. from east bank about midway between Rt. 67 bridge and USGS gauging station above dam. (Mechanicville quad)
50	-	Hoosic River (H264) off Knickerbocker Rd. off north end of island.
51	-	Fish Creek (H299) upstream from Schuylerville (V). Along south shore about 350 ft. upstream from dam near village line. (Schuylerville quad)
52	-	Fish Creek (H299) downstream from Schuylerville STP and just upstream from Old Champlain Canal aqueduct and towpath.

Table 3. Upper Hudson River PISCES Stations – 2000

Station No.		Location (USGS quad map) Latitude/Longitude[1]
29[2]	-	Downstream from Washington Co. Incinerator. Just upstream from intermittent trib (H327). (Hudson Falls quad) 43E18'15.7"/73E35'24.3"
31[2]	-	East side of river just downstream from the old Fenimore Bridge above Baker's Falls. 43E17'49.8"/73E35'19.0"
37[2]	-	Downstream from old and new Moreau sites. West side of river opposite down-stream end of Rogers Island. 43E15'24.0"/73E35'13.4"
38[2]	-	Upstream from Special Area 13. West side of river about 50 yds. downstream from West River Rd. Marina dock and about 100 yds. upstream from green channel buoy 219. 43E15'12.6"/73E35'18.6"
39[2]	-	Downstream from Special Area 13. About 25 yds. from the west bank under the power lines crossing the river. (Ft. Miller quad) 43E14'55.9"/73E35'37.1"
41[2]	-	Moses Kill (H314) upstream from Ft. Miller Landfill. Along east bank about 100 ft. downstream from where stream narrows and deepens. 43E12'30.0"/73E34'24.2"
42[2]	-	Moses Kill (H314) downstream from Ft. Miller Landfill. At upstream side of old aqueduct. 43E12'11.4"/73E34'43.1"
49[2]	-	At Stillwater about 25 ft. from east bank about midway between Rt. 67 bridge and USGS gauging station above dam. (Mechanicville quad) 42E56'12.3"/73E39'03.6"
53	-	Just above Baker's Falls Dam on east (south) side about 25 ft. above abutment and old walkway. (Hudson Falls quad) 43E17'46.2"/73E35'25.0"
54	-	East side of river upstream from old Hudson Falls STP at middle of cove. 43E17'58.6"/73E35'15.2"
55	-	East side of river immediately downstream from old Hudson Falls STP and adjacent to red marker. 43E17'52.5"/73E35'17.4"
56	-	Adjacent to Station 55 but further offshore (-75' vs. -20'). 43E17'52.4"/73E35'18.4"
57	-	Moses Kill (H314) adjacent to power line -100 ft. downstream from junction with Dead Creek. (Ft. Miller quad) 43E12'54.4"/73E34'01.8"
58	-	East side of Moses Kill (H314) about halfway between Stations 41 & 42. 43E12'18.1"/73E34'32.6"
59[1]	-	On west side of Moses Kill (H314) opposite Station 58.
60[1]	-	On west side of Moses Kill (H314) opposite Station 42.

cont'd.

Table 3. Upper Hudson River PISCES Stations – 2000

continued pg. 2

Station No.		Location (USGS quad map) Latitude/Longitude[1]
61	-	West side of river about 225 ft. downstream from green buoy 89 and opposite point on east side. (Mechanicville quad) 42E57'29.5"/73E37'48.4"
62	-	East side of river just downstream from point opposite Station 61. 42E57'27.5"/73E37'42.4"
63	-	West side of river opposite (west of) green buoy 85. 42E56'42.0"/73E38'01.6"
64	-	East side of river opposite Station 63 in line with green buoy 85 (west) and white outhouse (east). About 10 ft. west of water chestnut along east shore. 42E56'38.7"/73E37'55.5"
65	-	West side of river opposite silver maple at upstream end of dock mooring block and power pole for West River Rd. Marina. (Hudson Falls quad) 43E15'16.4"/73E35'15.0"
66	-	West side of river adjacent Station 38 about 30-35 ft. (east) out in deeper water. 43E15'12.2"/73E35'18.2"
67	-	West side of river adjacent green buoy 219. 43E15'09.4"/73E35'22.4"
68	-	East side of river under power lines opposite Station 39 and adjacent shore marker for red buoy 218. (Ft. Miller quad) 43E14'52.6"/73E35'33.0"
69	-	West side of river across and slightly downstream from red buoy 200. 43E13'06.6"/73E34'56.4"
70[1]	-	East side of river just upstream from red buoy 200 and about 100 ft. from shore. 43E13'09.2"/73E34'52.9"
71	-	West side of river below Griffin (Billings) Island about midway between green buoy 189 and red buoy 192. 43E12'03.0"/73E35'01.8"
72	-	East side of river about 80 ft. from shore opposite and slightly upstream from Station 71. 43E12'03.8"/73E34'57.5"
73	-	West side of river about halfway between dam (N end Thompson Island) and north entrance to Champlain Canal (Lock 6, Ft. Miller). About 100 ft. from shore. 43E11'32.0"/73E35'10.8"
74	-	East side of river opposite Station 73. 43E11'31.6"/73E35'04.8"

[1]N Latitude/W Longitude data are the means of two readings obtained at sampler deployment and retrieval with a Garmin GPS 12 XL (S/N35336447). Exceptions: Station 70, one reading at deployment; Stations 59 and 60, readings not taken.
[2]Station also sampled in 1998.

Table 4. Upper Hudson River PISCES Stations - 2001

Station No.	Location[1] Latitude/Longitude[2]
	Stations on the west side of the river upstream from Fenimore Bridge.
75 -	About 20 ft. from shore, about midway between old stone bridge abutment and dam at incinerator. 43E18'09.0"/73E35'33.7"
32[3] -	About 20-25 ft. from shore, upstream from canoe launch above Fenimore Bridge and about 30 ft. downstream from old stone bridge abutment. 43E18'05.0"/73E35'31.0"
76 -	About 20-25 ft. from shore, opposite the north end of the island above Fenimore bridge. 43E17'59.9"/73E35'29.7"
77 -	About 7 ft. from shore, about 150 ft. upstream from Station 33. 43E17'55.9"/73E35'29.3"
33[3] -	About 12-15 ft. from shore, about 150 ft. upstream from the (new) Fenimore Bridge. 43E17'54.5"/73E35'29.2"
	Stations on the west side of the river south of Rogers Island adjacent to Special Area 13 and PISCES Station 38.
38N -	About 60 ft. upstream from Station 38, about 20 ft. from shore in about 2.5 ft. of water.
38[4] -	About 150 yds. downstream from where the West River Rd. Marina docks used to be, about 15 ft. from shore in about 3 ft. of water. 43E15'12.5"/73E35'18.8"
38B -	Adjacent to Station 38 in closer to shore, about 10 ft. from shore with samplers only a few inches off the bottom.
38S -	About 60 ft. downstream from Station 38, about 20 ft. from shore in about 2.5 ft. of water.
66[5] -	Adjacent to Station 38 out farther from shore in water about 12 ft. deep.

[1]All Stations on Hudson Falls USGS quad map.
[2]N Latitude/W Longitude data are the means of two readings obtained at sampler deployment and retrieval with a Garmin GPS 12 XL (S/N35336447).
[3]Station also sampled in 1998.
[4]Station also sampled in 1998 & 2000.
[5]Station also sampled in 2000.

	Table 5. List of PCB congeners (IUPAC Nos.) determined in Upper Hudson River PISCES trackdown studies.											
	1997/98			**2000/01**						**Used for comparison with 97/98 data**		
	8/5	90/101	179	1	38	78	114	153	186	5/8	85/120	171
	15	99	176	2	39	79	119	154	188	15	86/97	172/192
	19	83	178	3	40	81	122	155	189	16/32	87/115/116	174/181
	18	97	175	4/10	41/64/68/71	82	123	156	191	17	91	175
	17	87	187/182	5/8	42/59	83/108	124	157	193	18	93/95	176
	24/27	85	183	6	43/49	84	125	158/160	194	19	99	177
	16/32	110	185	7/9	44	85/120	126	159	195	20/21/33	105/127	178
	26	107	174	11	45	86/97	128	161	196/203	22	106/118	179
	25	118	177	12/13	46	87/115/116	129	162	197	24/27	107/109	180
	31/28	114	171	14	47/48/75	88/121	130	165	198	25	110	183
	33	105	172	15	50	89/90/101	131/142	166	199	26	114	185
	22	136	180	16/32	51	91	132/168	167	200	28	128	189
	45	151	193	17	52/73	92	133	169	201	31	129	191
	46	144/135	191	18	53	93/95	134/143	170/190	202	40	130	193
	52	149	170/190	19	54	94	135/144	171	204	41/64/68/71	131/142	194
	49	134	189	20/21/33	55	96	136	172/192	205	42/59	134/143	195
	47/48	131	201	22	56/60	98/102	137	173	206	43/49	136	196/203
	44	146	197	23/34	57	99	138/163/164	174/181	207	44	137	197
	42	153	198	24/27	58	100	139/149	175	208	45	138/163/164	198
	41/71/64	141	199	25	61/74	103	140	176	209	46	139/149	199
	40	130	196/203	26	62/65	104	141	177		47/48/75	141	201
	74	137	195	28	63	105/127	145	178		52/73	146	205
	70/76	138/163/164	194	29	66/80	106/118	146	179		56/60	151	206
	66	158	205	30	67	107/109	147	180		61/74	153	207
	56/60	129	208	31	69	110	148	182/187		66/80	156	208
	95	128	207	35	70/76	111/117	150	183		70/76	157	209
	91	156	206	36	72	112	151	184		83/108	158/160	
	84/89	157	209	37	77	113	152	185		84	170/190	
Domains		84				160					82	
Congeners		101				209					118	

TABLE 6. Upper Hudson River PISCES Trackdown - QA/QC Summary								
Year		**1997**		**1998**		**2000**		**2001**
No. Stations		19		33		30		10
Sample Type		Hassett	Bag	Hassett	Bag	Hassett	Bag	Hassett
Duplicate pairs[1]		15	2	17	1	20	6	10
Solvent recovery	No. Samples	32	4	49	18	56	12	20
	r (correlation coeff.)[2]	0.998	0.986	0.953	0.896	0.970	0.964	0.975
HCFS data	Mean (mL)	134	46	168	61	170	64	178
	Std. Dev. +/-	55	9	12	5	11	8	11
	Range	30 - 190	35 - 55	135 - 190	55 - 70	135 - 190	50 - 75	145 - 190
	Approx. Mean % Recovery[3]	67	58	84	76	85	80	89
DEC field spike	No. Samples	32	4	49	18	9	0	20
% Recovery, Mean	**trans-Nonachlor**	NR[4]	NR[4]	98	100	96		111
	Std. Dev. +/-			13	14	8		11
	Range			71 - 137	78 - 120	88 - 105		84 - 123
	Mirex	66	54	88	77	85		95
	Std. Dev. +/-	44	14	13	6	21		9
	Range	ND[5] - 152	46 - 76	63 - 120	68 - 87	60 - 122		72 - 106
AXYS field spike	No. Samples	0	0	0	0	56	12	20
% Recovery, Mean	**13C-24'5-TriCB**					67	69	76
	Std. Dev. +/-					9	12	6
	Range					49 - 85	49 - 99	61 - 86
	13C-22'35'6-PeCB					89	86	92
	Std. Dev. +/-					9	12	7
	Range					71 - 109	63 - 108	71 - 101
	13C-22'44'55'-HxCB					93	95	95
	Std. Dev. +/-					14	13	8
	Range					54 - 117	73 - 127	73 - 104
Notes:	[1]See Table 7 & Appendix I for RPD & RMSD results for duplicates.							
	[2]Correlation coefficient between AXYS sample volume measurement and HCFS volume estimate.							
	[3]Assuming initial solvent volumes of 200 mL hexane (Hassett) & 80 mL TMP (Bag).							
	[4]No trans- Nonachlor results reported.							
	[5]ND = not detected. Equated to 0.							

Table 7. Upper Hudson River PISCES trackdown - Analytical relative percent difference (RPD, ng total PCBs) for similar sampler pairs (Hassetts or bags).

Year	Sampler Type	No. Sampler Pairs	Mean RPD	± SD	Range
1997	Hassett	10[1]	13	8.7	0.5 - 28
	combined[2]	12	15	11	0.5 - 38
1998	Hassett	16[3]	24	20	1.4 - 60
	combined[4]	17	22	20	1.0 - 60
2000	Hassett	19[3]	22	16	2.1 - 52
	bag	6	10	6.2	4.1 - 22
	combined	25	19	15	2.1 - 52
2001	Hassett	9[3]	20	7.9	2.4 - 27

[1]Excludes data for the five low solvent volume sample pairs recovered.
[2]Includes data for two bag pairs.
[3]Excludes data for sampler pairs at Station 38 (1998 & 2000) and Station 38S (2001).
[4]Includes data for one bag pair.