The 2009

Pottersburg Creek/Walker Drain

PCB Blood Survey

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EXECUTIVE SUMMARY

This document reports the results of the Pottersburg PCB Study, commissioned by the Middlesex-London Health Unit in 2008 in response to community concerns regarding the proposed decommissioning of the Pottersburg PCB storage site located at Clarke Road and Huron Streets in London. A blood monitoring study of area residents was carried out and the concentration of PCB-congeners was quantified in adult men and women who worked at the Westinghouse/ABB plant, lived in the Pottersburg Creek community, or used the Pottersburg Creek/Walker Drain area for recreational purposes, as well as a reference population. All blood samples were coded and sent to the Centres for Disease Control in Atlanta, Georgia for analysis. Coded results were subsequently analyzed with investigators blinded to any identifying characteristics of study participants. Results were compared with the PCB levels of a reference population who also participated in this study as well as reference populations found in the published literature. Results indicate that the concentrations of PCBs measured in the plasma of individuals who lived in close proximity to Pottersburg Creek/Walker Drain or used the area for recreational purposes are low and not different from the reference population. However, those individuals who worked at the Westinghouse/ABB plant and had handled PCB-containing fluids as part of their occupational activities had plasma PCB-congener concentrations profoundly higher than the reference population. Therefore, in general, area residents who did not work at the Westinghouse/ABB plant with PCB containing fluids can be reassured that their PCB levels are no different from those of members of the reference population.

INTRODUCTION

Polychlorinated biphenyls (PCBs) are chlorinated organic chemicals that are produced by the chlorination of biphenyl. PCBs found industrial application in dielectric and heat-exchange fluids such as electrical transformers and insulators. Their wide-spread use led to entry to the environment where they have been found to be highly resistant to degradation. PCBs are highly lipophilic (fat loving) chemicals that accumulate in body fat and bioaccumulate in the food chain. There are a total of 209 possible congeners that can be formed by the variable chlorination of the biphenyl structure (**Fig. 1**). However, fewer than 25 PCB congeners account for most of the tissue burden in fish, birds and mammals (McFarland and Clarke 1989). Production and use of PCBs was banned in the 1977 owing to persistence of these chemicals in the environment and biological tissues along with possible health effects (IARC, 1978).

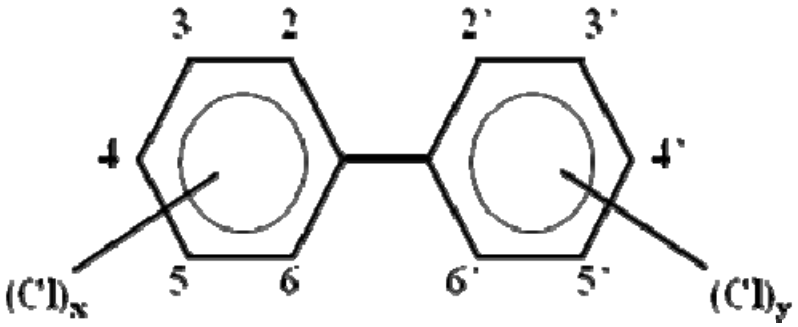


Figure 1. Schematic structure of the PCB ring structure. There are 209 different possible PCB congeners formed by addition of chlorine atoms (Cl^-) in the different Cl_x or Cl_y positions.

Human exposure to PCBs occurs primarily through ingestion of contaminated food or through occupational exposure. There are numerous studies in the literature that have documented background concentrations of PCB congeners in adipose (fat) and blood in different populations throughout the world (Axelrad *et al.* 2009; Cerna *et al.* 2008; Cole *et al.* 2002; Den Hond *et al.* 2009; Deutch *et al.* 2007; Ferriby *et al.* 2007; Koppen *et al.* 2001; LaKind *et al.* 2009; Mari *et al.*

2009; Mari *et al.* 2007; Minh *et al.* 2006; Scott *et al.* 2008; Tsuji *et al.* 2006). PCB congener concentrations have also been quantified in at risk populations owing to consumption of diets thought to be contaminated with PCBs (Ayotte *et al.* 2005; Ayotte *et al.* 2003; Cole *et al.* 2002; Kiviranta *et al.* 2002; Mari *et al.* 2007; Mari *et al.* 2009; Nadon *et al.* 2002; Rylander *et al.* 2009; Sandanger *et al.* 2007), residence in a contaminated region (Wong *et al.* 2008) or potential occupational exposure (Domingo *et al.* 2001; Mari *et al.* 2007; Schuhmacher *et al.* 2002; Wingfors *et al.* 2006; Zamir *et al.* 2009). Concern over exposure to PCBs has arisen in several communities with heavy industrial activity and release of these chemicals into the environment (Wong *et al.* 2008). Recently, public concern regarding potential past exposure to PCBs which had contaminated soil and sediment of the Pottersburg Creek/Walker Drain in London, Ontario from the late 1950s to the mid-1980s resurfaced following announcement that the Ontario Ministry of the Environment had a plan to decommission the Pottersburg PCB storage site located at Clarke Road and Huron Streets, the site of a former Westinghouse/ABB plant. The Westinghouse/ABB plant was established on the site in 1957. Between 1984 and 1987, a major site cleanup was undertaken by the Ontario Ministry of the Environment. Through this process the Ministry removed contaminated materials from the Westinghouse/ABB property and the nearby Walker Drain and Pottersburg Creek. Since that time the contaminated material has been stored on site and monitored regularly for release of contaminants. At the time of the original site cleanup, area residents raised some concerns about their potential exposure to PCBs and potential associated health effects. In response to these concerns a blood survey was undertaken of local residents and concentrations of PCBs measured. Results indicated that levels of PCBs in the blood of local area residents were not higher than expected. At the time of the announcement of the decommissioning in 2008, similar concerns were raised by both area residents and former

employees of the plant. In response to these concerns the Pottersburg PCB study was commissioned by the Middlesex-London Health Unit (MLHU). The MLHU established a Community Liaison Committee (CLC) to represent community concerns regarding the implementation of the PCB blood testing survey and to provide input into strategies for communicating with the community regarding the PCB blood testing survey and its findings. The objectives of the study were to: (1) quantify PCB specific congener concentrations in the plasma of former Westinghouse/ABB employees, residents of the Pottersburg Creek/Walker Drain community, people who used the Pottersburg Creek/Walker Drain for recreational purposes, and a reference population of residents from London Ontario without known exposure to PCBs; and (2) communicate the activities and results to the community and individual participants.

MATERIALS AND METHODS

PCB Blood Survey Recruitment: An Information Drop-In session was held on April 14, 2009 to raise awareness of the study and to allow community members an opportunity to have questions answered about the Blood Survey. Individuals who were interested in participating in the Pottersburg Creek/Walker Drain PCB blood survey had the opportunity to leave their contact information with MLHU's PCB Blood Survey Team. The formal recruitment period for the blood survey was between April 24 and June 3, 2009. During this time, a recruitment flyer was emailed to the members of the CLC and sent to 81 local community agencies for posting and recruitment ads were placed on MLHU's website and published in the London Free Press newspaper. Interested participants were asked to contact the health unit to volunteer for participation and provide contact information to the MLHU PCB Blood Survey Team. Inclusion criteria included any Pottersburg Creek/Walker Drain resident who

- Live or lived in the area of interest identified on a map (**Fig. 2**);
- Worked at the Westinghouse/ABB plant;
- Played in Pottersburg Creek as a child or used the area for recreation;
- Were part of the 1985 PCB blood survey;
- Live in another part of London and had no known previous exposure to PCBs and were willing to serve as part of the "reference" group for this study.

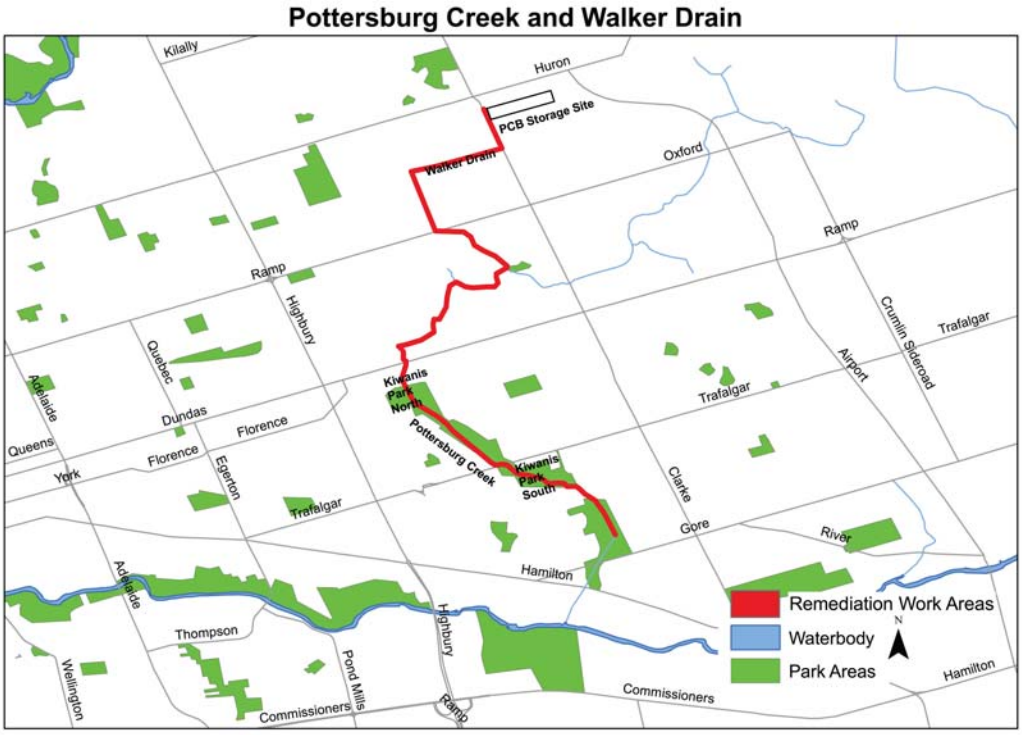


Figure 2. Map of the Pottersburg Creek/Walker Drain area showing the PCB storage site.

Participant Screening: A screening tool was developed by the McMaster Researcher Team to collect background information that would allow the research team to assign participants to either the reference group or one of the study groups. Anticipating that a sufficient sample size for the reference group may not be included within the individuals who contacted the MLHU PCB Survey Team, questions 18 and 19 were added to the screening tool to identify 100 additional potential study subjects through snowball sampling (i.e. it was administered to all who volunteered for the survey who had potential residential or occupational exposures and at the end of the survey, respondents were asked if there was another adult in the household who met the following criteria: they did NOT live in the Pottersburg Creek/Walker Drain area between 1957 and 1987, they did NOT make any recreational use of the Creek area between 1957 and 1987, and they NEVER worked at the Westinghouse/ABB plant). A Survey consulting firm (CCI Research) was contracted to administer the screening tool to all volunteer participants over the

telephone. The screening tool was piloted and screening interviews took place between May 12 and June 14, 2009.

Blood Sample Collection: During July and August 2009, study subjects completed an informed consent following which a blood sample was collected from the antecubital vein into red-toped Vacutainer® tubes (two 10 ml tubes for PCBs measurements). The vacutainers were stored for one hour at 4ºC before centrifugation (1,500 X g) and the serum decanted into pre-cleaned vials and stored frozen at -20ºC until required for analyses. All serum samples were shipped frozen to the analytical laboratory (Center for Disease Control, Atlanta, GA). All procedures were approved by the McMaster University Research Ethics Board.

The concentration of PCB congeners in serum samples collected from participating study subjects were determined by standard analytical methods. The concentration of PCB congeners identified by their IUPAC number as follows: 28, 52, 49, 44, 74, 66, 87, 99, 101, 105, 110, 118, 151, 149, 146, 153, 138-158, 128, 167, 156, 157, 178, 187, 183, 177, 172, 180, 170, 189, 199, 196-203, 195, 194, 206, 209, 114, and 123 were quantified.

Analytical methods: PCB residue concentrations in serum were quantified using high-resolution gas chromatography/ mass spectroscopy (GC/MS) using a modification of previously described methods (Mes *et al.* 1990). Briefly, plasma samples (2 ml) were extracted on a solid phase extraction column. The extracts were purified on a Florisil column, concentrated to a final volume of 100 μL, and analyzed by GC/MS operated in the electronic impact ionisation mode. The precision of the analytical methods were monitored through the use of in-house reference

material analyzed with each analytical run. Routine checks of accuracy were accomplished using certified reference serum from the US National Institute of Science and Technology.

PCBs are lipophilic chemicals whose concentration in plasma can be influenced by circulating lipid levels. Since the blood samples collected from study subjects were a random sample and plasma lipid levels were measured. The total lipid concentration of each sample was calculated by summing the measured concentrations of plasma lipid components. Total cholesterol (TC), free cholesterol (FC), triglycerides (TG) and phospholipids (PL) were measured by standard enzymatic methods and the total lipid (TL) concentration calculated using the following formula: TL = (2.27 * TC + TG + 0.623) (Phillips *et al.* 1989). Since random as opposed to fasting blood samples were collected in this blood survey the concentration of PCBs in serum are reported on a lipid-adjusted basis.

Statistical Analysis: Summary statistics including sample size, age of study subjects, LOD, and % of observations above LOD, were calculated using SigmaStat (v.3.1, SPSS, Chicago, IL) and reported for all PCB congeners studied. The range, arithmetic mean, standard error of the mean (SEM), median, 95% confidence interval, and 25^{th} and 75^{th} percentiles were also determined. Comparisons between exposed and non-exposed study subjects were made for each congener where the percent of observations above LOD (**Table I**) was greater than 70%. For all PCB congeners studied the concentrations were not normally distributed and could not be transformed to a normal distribution using conventional methods. Therefore, differences in the concentration of PCB congeners between study groups were made using unpaired t-test and the Mann-Whitney

Rank Sum test on ranks. The data are presented as the mean (± SEM) as well as the median concentration and a $p<0.05$ was used to detect statistical differences.

Table I. Limits of detection (LOD) for PCB-specific congeners measured.

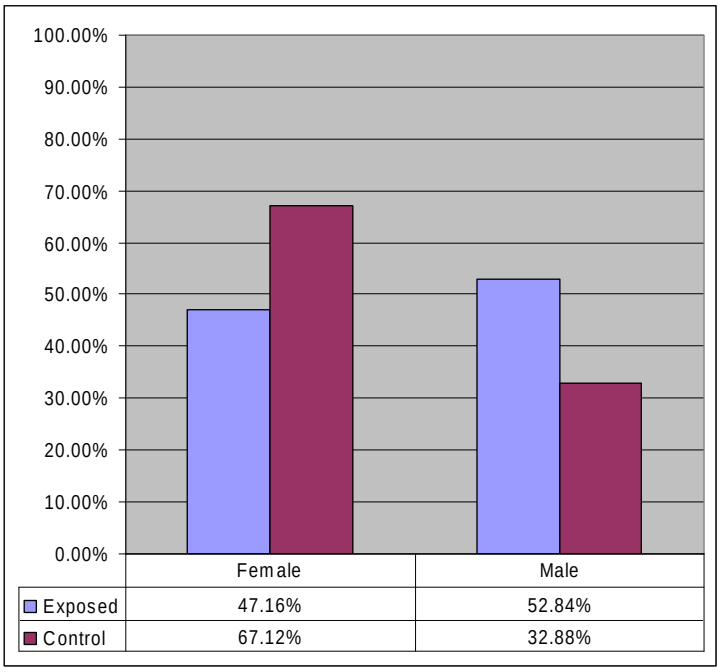
	PCB congener (IUPAC number)	LOD (ppt)
	PCB-28	10
	PCB-52	4.5
	PCB-49	2.5
	PCB-44	2.5
	PCB-74	2.5
	PCB-66	2.7
	PCB-101	2.5
	PCB-99	2.5
	PCB-87	2.5
	PCB-110	2.5
	PCB-118	2.5
	PCB-105	2.5
	PCB-151	2.5
	PCB-149	2.5
	PCB-146	2.5
	PCB-153	2.5
	PCB-138-158	2.5
	PCB-128	2.5
	PCB-167	2.5
	PCB-156	2.5
	PCB-157	2.5
	PCB-178	2.5
	PCB-187	2.5
	PCB-183	2.5
	PCB-177	2.5
	PCB-172	2.5
	PCB-180	2.5
	PCB-170	2.5
	PCB-189	2.5
	PCB-199	2.5
	PCB-196-203	2.5
	PCB-195	2.5
	PCB-194	2.5
	PCB-206	2.5
	PCB-209	2.5
	PCB-114	2.5
	PCB-123	2.5

RESULTS

Characteristics of the Study Participants: A total of 620 individuals completed the survey undertaken by the survey consultants. Of these, 541 provided a blood sample and were included in the PCB analyses. All of the individuals in the study were divided into discrete groups of exposed and reference categories. The reference or control category included a total of n=74 individuals who had NOT experienced ANY exposure to PCBs either through their occupation, their residence being in close proximity to the Creek, or having had any recreational exposure to the Pottersburg Creek/Walker Drain area. The individuals in the sample who were NOT part of the reference group (n=467) were further divided into three ***primary*** exposure groups: occupational exposure (n=153), residential exposure (n=318), and recreational exposure (n=59). Note that a dietary exposure group was eliminated from the analysis due to very low numbers. It is important to note that each of these groups was mutually exclusive. The occupational exposure group was further divided into 5 sub-groups: (1) worked with PCB containing fluids/materials at Westinghouse/ABB only (n=63); (2) worked at Westinghouse/ABB but did not handle PCB containing fluids or materials (n= 56); (3) did not work at Westinghouse/ABB but did work elsewhere with PCB containing fluids/materials (n=30); (4) worked at Westinghouse/ABB but did not handle PCB containing fluids/materials but did elsewhere (n=4); and (5) worked with PCB containing fluids/materials at Westinghouse/ABB and elsewhere (0).

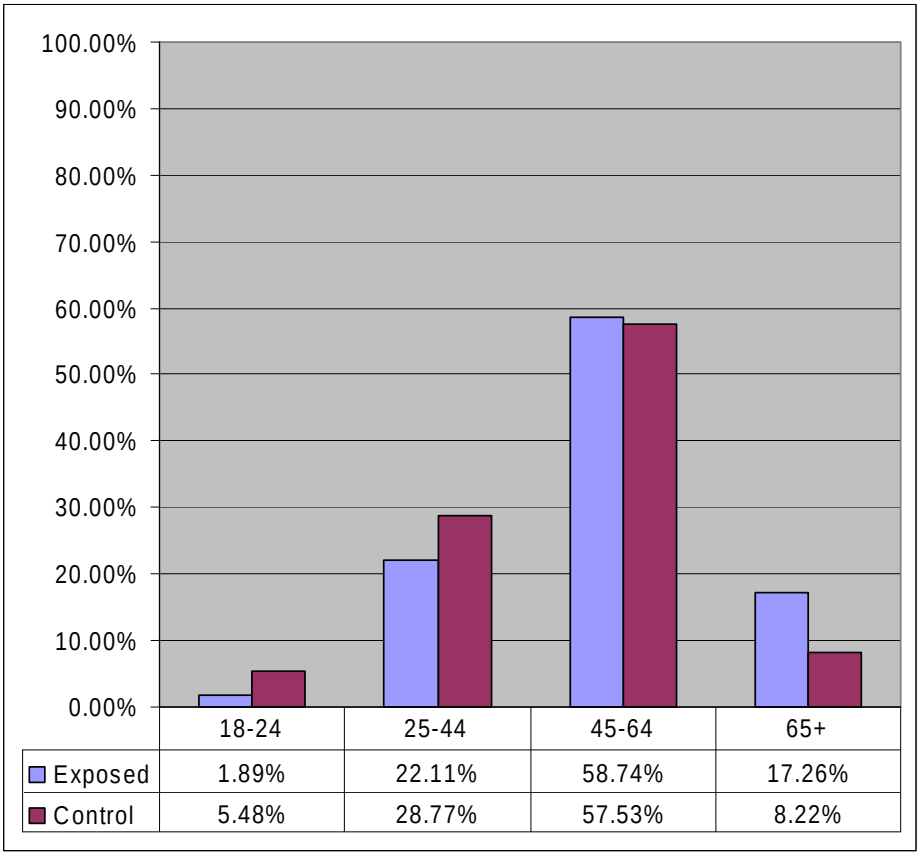
Overall, 541 men (n=274) and women (n=267) from the Pottersburg Creek community provided completed demographic and occupational history questionnaire and provided a blood sample for PCB specific residue analysis. In this population 251 men (52.8%) and 224 women (47.2%) reported that they had some form of exposure to PCBs (**Fig. 3**). The mean age of male and

female study subjects was 60.2 ± 11.2 and 64.8 ± 5.3 years, respectively; with the majority of study subjects between the ages of 45 and 64 years of age (**Fig. 4**).



		Female	Male	***Row Total***
Exposed	N	224	251	475
	Row %	47.2	52.8	100.0
Control	N	49	24	73
	Row %	67.1	32.9	100.0
Column Total	N	273	275	**548**

Figure 3. Distribution of all study subjects by gender in the exposed (O) vs. reference (R) populations who completed questionnaires. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.



		18-24	25-44	45-64	65+	***Row Total***
Exposed	N	9	105	279	82	475
	Row %	1.9	22.1	58.7	17.3	100.0
Control	N	4	21	42	6	73
	Row %	5.5	28.8	57.5	8.2	100.0
Column Total	N	13	126	321	88	**548**

Figure 4. Distribution of study subjects in age groups in the exposed (O) vs. reference (R) population. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.

Of note, only 13 study subjects (2.7%) who reported that they worked with PCBs have previously had their blood tested for PCBs. Only 1.0% report that they do not know if they have had their blood tested for PCBs previously. Of the study subjects who self-report exposure to PCBs 358 (75.4%) did not work at the Westinghouse/ABB plant whereas 53 (11.2%) held at least one job at the Westinghouse/ABB plant. Of study subjects 64 (13.5%) held more than one

job at the Westinghouse/ABB plant. Of the study subjects that worked at the Westinghouse/ABB plant 44 (9.3%) held at least one job and 19 (4.0%) held more than one job handling PCB containing fluids or materials. By comparison 74 (100%) of the reference population studied self-reported that they did not have occupational exposure to PCBs and did not work at the Westinghouse/ABB plant. Of the study subjects that worked elsewhere, 19 (4.0%) reported at least one job and a small group reported more than one job (9; 1.9%) working with PCB containing capacitors, condensers, transformers, or light ballasts. To account for possible changes in employment we also captured those study subjects that worked at both the Westinghouse/ABB plant and elsewhere in jobs with exposure to PCBs. There were 63 (13.3%) of the study subjects who worked both at the Westinghouse/ABB plant and elsewhere and were exposed to PCB containing fluids or materials. As expected not many study subjects (28; 5.9%) reported more than one job at both the Westinghouse/ABB plant and elsewhere.

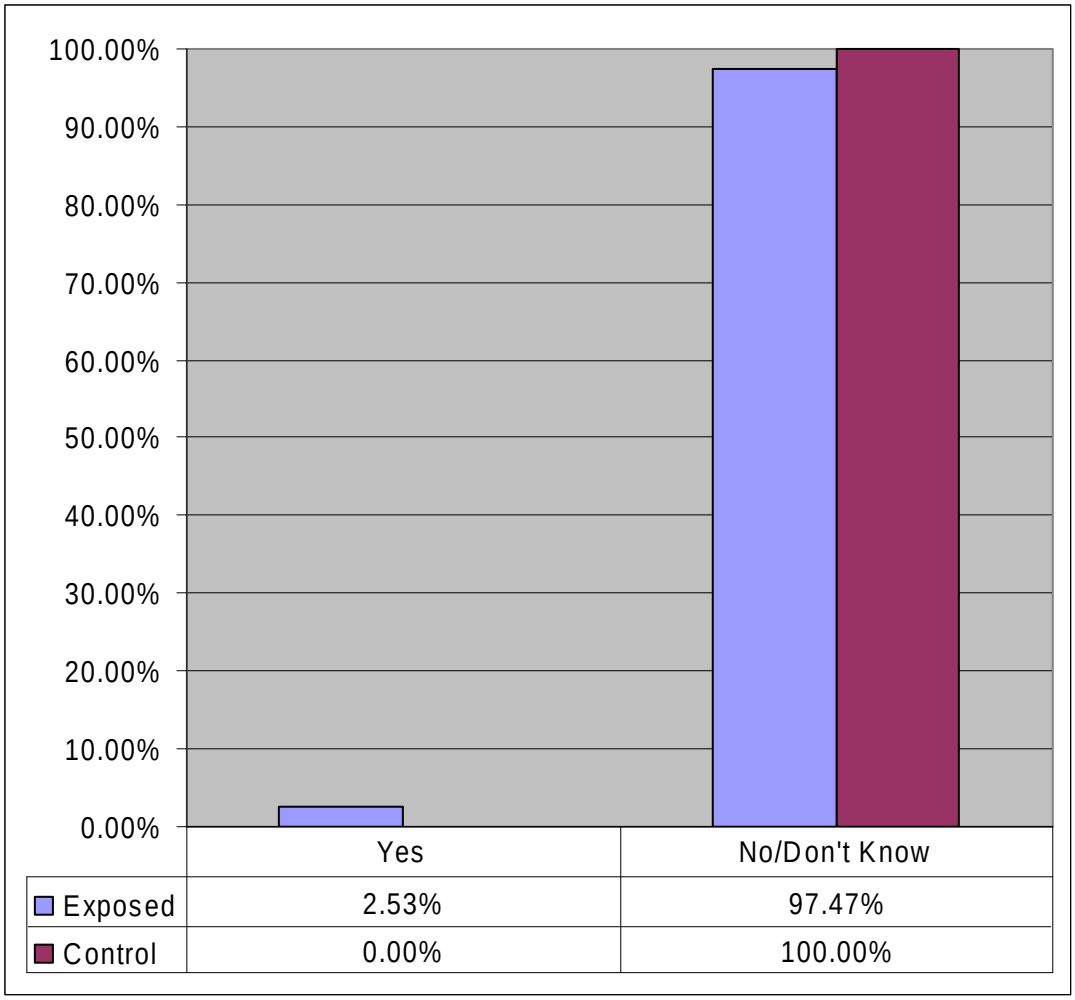
To assess other potential sources of PCB exposure data was collected on proximity of study subject residence to the Pottersburg Creek, recreational use of the Creek, sport fishing, and consumption of wild game. Of the study subjects who report occupational exposure to PCBs 350 (73.7%) occupied a residence that was within 1-2 blocks of Pottersburg Creek/Walker Drain compared to 175 (26.3%) whose residence was outside this distance or did not know the proximity of their residence to the Pottersburg Creek/Walker Drain. Study subjects in the reference population did not live within 1-2 blocks of Pottersburg Creek/Walker Drain.

Potential PCB exposure through the use of Pottersburg Creek/Walker Drain soil or water on the property of study subjects was reported in a minority of cases (55; 11.6%). Sparingly few study

subjects (11; 2.3%) reported multiple exposures via this route. While a large percentage of study subjects with occupational exposure also report potential PCB exposure through proximity to the Pottersburg Creek/Walker Drain and recreational use of the Creek, no participant from the reference population reported use of Pottersburg Creek/Walker Drain water or soil on their property or exposure through recreational use. Indeed, 381 (80.2%) study subjects with occupational exposure to PCBs also reported recreational use of Pottersburg Creek/Walker Drain whereas 94 (19.8%) did not or do not know if they have been exposed through this route. The Pottersburg Creek/Walker Drain was used for multiple different recreational purposes by study subjects with occupational exposure but not members from the reference population.

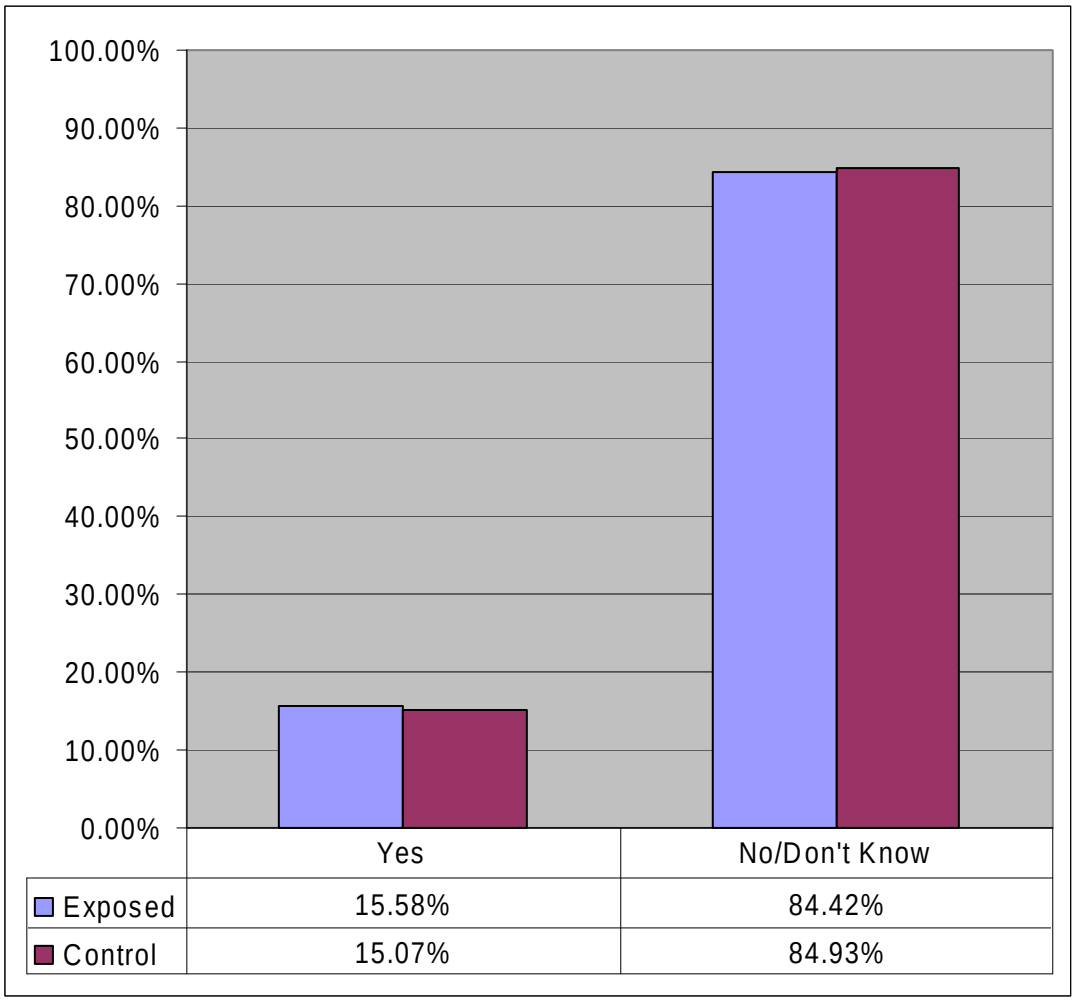
In addition to occupational exposure dietary sources of PCBs are another potentially important route of exposure that was assessed. Specifically, consumption of sport fish and wild game was assessed through the questionnaire. The majority of study subjects with occupational PCB exposure (463; 97.5%) and reference population (74; 100%) did not report consumption of sport fish caught in the Pottersburg Creek/Walker Drain compared to 12 (2.5%) study subjects who also reported occupation exposure to PCBs (**Fig 5a**). Similarly, the numbers of study subjects in the occupationally exposed group that also consumed sport fish caught elsewhere (**Fig. 5b**) and wild game (**Fig. 5c**) was small. A minority of study subjects (n=108; 20.8%) with occupational exposure also reported consuming any sport caught fish or wild game (**Fig. 5d**). In comparison 411 (79.2%) reported that they did not consume sport caught fish or wild game. The reference population was similar to the exposed group.

Figure 5a. Consumption Exposure – Ever eaten fish from the Pottersburg Creek. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.

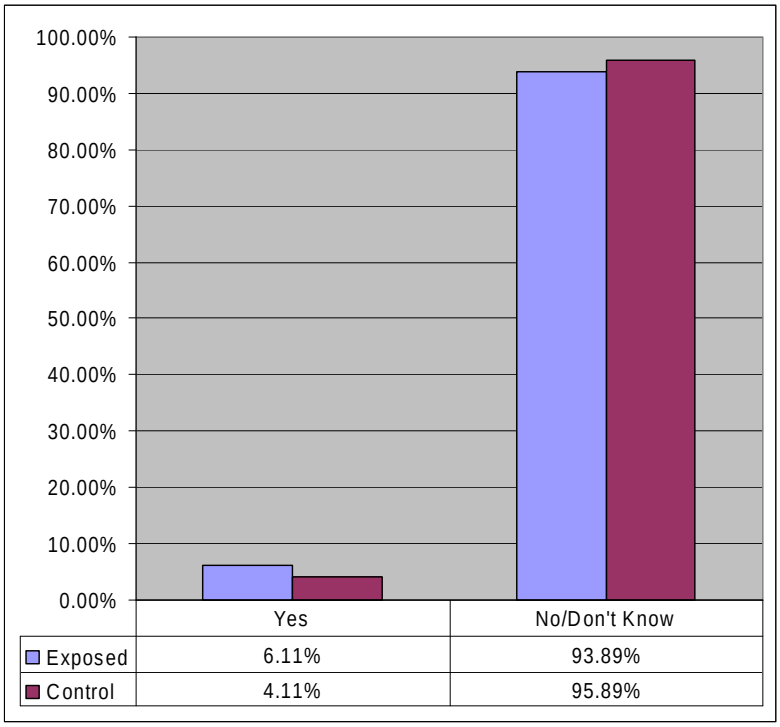


		Yes	No/Don't Know	***Row Total***
Exposed	N	12	463	475
	Row %	2.5	97.5	100
Control	N	0	73	73
	Row %	0	100.0	0
Column Total	N	12	536	**548**

Figure 5b. Consumption Exposure – Ever eaten sport fish from elsewhere. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.

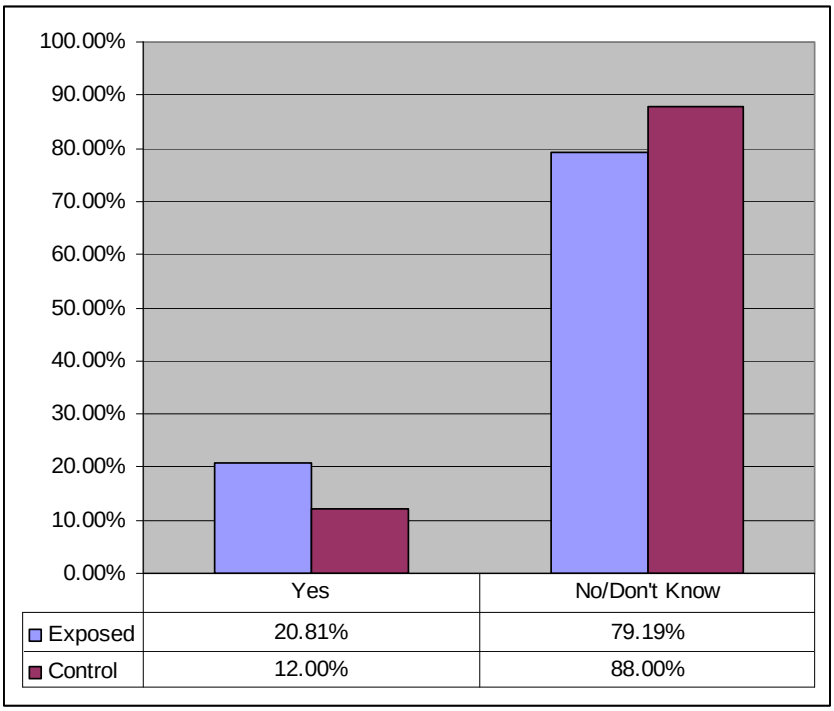


		Yes	No/Don't Know	***Row Total***
Exposed	N	74	401	475
	Row %	15.6	84.4	100
Control	N	11	62	73
	Row %	15.1	84.9	100
Column Total	N	85	463	**548**



		Yes	No/Don't Know	***Row Total***
Exposed	N	29	446	475
	Row %	6.1	93.9	100
Control	N	3	70	73
	Row %	4.1	95.9	100
Column Total	N	32	516	**548**

Figure 5c. Consumption Exposure – Ever eaten wild game. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.



		Yes	No/Don't Know	***Row Total***
Exposed (type = "O")	N	108	411	519
	Row %	20.8	79.2	100.0
Control (type = "R")	N	12	88	100
	Row %	12.0	88.0	100.0
Column Total	N	120	499	**619**

Figure 5d. Consumption Exposure – Ever eaten any sport fish or wild game. Note that seven subjects did not provide a blood sample or were excluded from the study for other reasons.

PCB Residue Concentrations: PCB specific congeners were quantified in the serum of all men (n=274) and all women (n=267). The PCB specific congeners -74, 99, 118, 105, 146, 153, 138-158, 167, 156, 157,178, 187,183, 180, 170, 199, 196-203, 195, 194, 206, 209, and 114 were quantified in the serum of more than 70% of both the male and female study subjects studied (**Table II and III**). Of note the concentration of all PCB congeners were below the limit of detection for one study subject and thus was removed from further analysis. PCB-177 was detected in the plasma of 73.7% of males compared to 62.9% of females whilst PCB-172 was measured in 70.8% of male subjects vs. 54.7% of the serum samples from female participants.

PCB congeners that were below the level of detection in greater than 30% of the serum samples studied in both men and women (PCB-28, 52, 49, 44, 66, 101, 87, 110, 151, 149, 128, 189, and 123) were excluded from further statistical analysis.

Serum concentrations of PCB specific congeners were compared amongst several distinct study groups. Specifically, we compared the serum concentrations of PCB congeners in study subjects who reported exposure to PCBs through their employment at the Westinghouse/ABB plant vs. a reference population. Comparisons were also made between study subjects who worked with PCB containing fluids and materials in the Westinghouse/ABB plant vs. those that did not handle such materials. We also compared male subjects who handled PCB containing fluids or materials and worked in the Westinghouse/ABB plant vs. those that worked elsewhere. The serum concentrations of PCB-congeners were also quantified in study subjects who resided within two city blocks of the Pottersburg Creek/Walker Drain or reported that they used these waters for recreational purposes. Serum concentrations of PCB-congeners for study subjects residing with close proximity to the Pottersburg Creek/Walker Drain or reported recreational use of the waters were compared with the concentrations measured in study subjects from the reference population. Although diet is recognized as a potentially important source of PCB exposure, there were too few study subjects who reported consuming sport caught fish from the Pottersburg Creek/Walker Drain. Moreover, data on type of fish consumed and methods of meal preparation could not be ascertained and thus no further analyses were carried out.

Table II. Concentration of PCB specific congeners in the serum (ng/g lipid) for male study participants (n=274). The instrument value was used for samples with PCB concentrations below the level of detection.

Lipid adjusted	**PCB-28**	**PCB-52**	**PCB-49**	**PCB-44**	**PCB-74**	**PCB-66**	**PCB-101**	**PCB-99**	**PCB-87**	**PCB-110**	**PCB- 118**	**PCB-105**	**PCB-151**
N with detectable PCB levels (%)	71 (25.9)	72 (26.3)	1 (0.4)	39 (14.2)	274 (100)	139 (50.7)	73 (26.6)	270 (98.5)	52 (18.9)	92 (33.6)	273 (99.6)	255 (93.1)	10 (3.7)
Mean ± SEM	1.5 ± 0.2	0.4 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	17.8 ± 4.6	0.8 ± 0.1	0.4 ± 0.0	6.5 ± 0.7	0.1 ± 0.0	0.2 ± 0.0	10.1 ± 1.3	2.0 ± 0.3	0.1 ± 0.0
Median	0.8	0.2	0.0	0.2	4.5	0.5	0.2	3.5	0.0	0.2	4.6	1.0	0.0
95% CI	0.32	0.05	0.02	0.03	9.04	0.13	0.08	1.31	0.05	0.04	2.52	0.53	0.02
25th percentile	0.4	0.1	0.0	0.0	2.6	0.3	0.0	2.0	0.0	0.0	2.9	0.6	0.0
75th percentile	1.5	0.5	0.1	0.3	9.0	0.8	0.5	6.2	0.2	0.3	9.3	1.9	0.1
Lipid adjusted	**PCB-149**	**PCB-146**	**PCB-153**	**PCB-138-158**	**PCB-128**	**PCB-167**	**PCB-156**	**PCB-157**	**PCB-178**	**PCB-187**	**PCB-183**	**PCB-177**	
N with detectable PCB levels (%)	12 (4.8)	263 (96.0)	274 (100)	272 (99.3)	14 (5.1)	83 (69.7)	273 (99.6)	239 (87.2)	244 (89.1)	267 (97.5)	241 (88.0)	202 (73.7)	
Mean ± SEM	0.1 ± 0.0	5.3 ± 0.6	40.3 ± 3.4	24.2 ± 2.7	0.1 ± 0.0	1.7 ± 0.2	8.5 ± 1.2	2.1 ± 0.3	2.5 ± 0.2	9.0 ± 0.6	2.8 ± 0.2	1.8 ± 0.2	
Median	0.0	2.9	27.3	13.9	0.0	0.8	4.3	1.0	1.8	5.7	2.0	1.1	
95% CI	0.03	1.13	6.72	5.33	0.04	0.45	2.40	0.59	0.33	1.17	0.32	0.30	
25th percentile	0.0	1.4	13.6	7.3	0.00	0.2	2.0	0.5	0.9	3.1	1.0	0.4	
75th percentile	0.1	5.2	42.2	24.1	0.00	1.7	7.0	1.7	3.0	10.7	3.7	2.1	
Lipid adjusted	**PCB-172**	**PCB-180**	**PCB-170**	**PCB-189**	**PCB-199**	**PCB-196-203**	**PCB-195**	**PCB-194**	**PCB-206**	**PCB-209**	**PCB-114**	**PCB-123**	
N with detectable PCB levels (%)	194 (70.8)	274 (100)	273 (99.6)	172 (62.8)	264 (96.4)	272 (99.3)	221 (80.7)	264 (96.4)	264 (96.4)	262 (95.6)	204 (74.5)	54 (31.0)	
Mean ± SEM	1.8 ± 0.2	35.9 ± 2.1	14.2 ± 1.0	0.1 ± 0.1	8.4 ± 0.7	7.4 ± 0.5	1.4 ± 0.1	8.7 ± 0.5	4.1 ± 0.4	1.8 ± 0.1	1.6 ± 0.3	0.2 ± 0.1	
Median	1.2	25.4	9.7	0.4	4.6	5.0	1.0	6.0	2.1	1.0	0.5	0.0	
95% CI	0.31	4.15	1.98	0.11	1.41	0.92	0.16	1.00	0.77	0.26	0.52	0.09	
25th percentile	0.0	13.3	5.0	0.0	2.4	2.6	0.6	3.3	1.2	0.6	0.3	0.0	
75th percentile	2.1	45.2	16.6	0.8	8.7	8.7	1.8	10.9	4.1	2.2	0.9	0.1	

Table III. Concentration of PCB specific congeners in the serum (ng/g lipid) for female study participants (n=267). The instrument value was used for samples with PCB concentrations below the level of detection.

Lipid adjusted	**PCB-28**	**PCB-52**	**PCB-49**	**PCB-44**	**PCB-74**	**PCB-66**	**PCB-101**	**PCB-99**	**PCB-87**	**PCB-110**	**PCB- 118**	**PCB-105**	**PCB-151**
N with detectable PCB levels (%)	82 (30.7)	64 (24.0)	3 (1.1)	38 (14.2)	266 (99.6)	148 (55.4)	72 (27.0)	255 (95.5)	35 (13.1)	75 (28.1)	265 (99.3)	244 (91.4)	4 (1.5)
Mean ± SEM	1.7 ± 0.2	0.4 ± 0.1	0.1 ± 0.0	0.3 ± 0.0	9.3 ± 1.0	0.9 ± 0.1	0.5 ± 0.1	5.4 ± 0.9	0.1 ± 0.0	0.3 ± 0.1	0.98 ± 1.3	2.0 ± 0.3	0.0 ± 0.0
Median	0.9	0.2	0.0	0.2	4.8	0.5	0.2	3.0	0.0	0.1	4.8	0.9	0.0
95% CI	0.37	0.10	0.03	0.05	1.94	0.14	0.21	1.68	0.07	0.11	2.51	0.52	0.02
25th percentile	0.4	0.1	0.0	0.0	3.0	0.3	0.0	1.8	0.0	0.0	3.0	0.6	0.0
75th percentile	1.8	0.4	0.1	0.3	8.4	1.0	0.5	5.2	0.1	0.3	9.2	1.8	0.0
Lipid adjusted	**PCB-149**	**PCB-146**	**PCB-153**	**PCB-138-158**	**PCB-128**	**PCB-167**	**PCB-156**	**PCB-157**	**PCB-178**	**PCB- 187**	**PCB-183**	**PCB-177**	
N with detectable PCB levels (%)	13 (4.9)	246 (92.1)	266 (99.6)	262 (98.1)	8 (3.0)	190 (71.1)	259 (97.0)	219 (82.0)	223 (83.5)	255 (95.5)	233 (87.3)	168 (62.9)	
Mean ± SEM	0.1 ± 0.0	3.4 ± 0.5	28.8 ± 3.2	18.4 ± 3.1	0.1 ± 0.0	1.3 ± 0.3	5.0 ± 0.9	1.2 ± 0.2	1.5 ± 0.1	5.6 ± 0.4	2.1 ± 0.2	1.1 ± 0.1	
Median	0.0	2.0	20.7	11.5	0.0	0.8	3.2	0.8	1.1	4.1	1.7	0.7	
95% CI	0.04	1.01	6.35	6.18	0.07	0.52	1.74	0.45	0.23	0.75	0.32	0.25	
25th percentile	0.0	1.3	12.1	6.8	0.0	0.1	1.8	0.4	0.6	2.4	0.9	0.0	
75th percentile	0.1	3.6	31.5	18.9	0.0	1.3	4.7	1.2	1.9	6.7	2.7	1.4	
Lipid adjusted	**PCB-172**	**PCB-180**	**PCB-170**	**PCB-189**	**PCB-199**	**PCB-196-203**	**PCB-195**	**PCB-194**	**PCB-206**	**PCB-209**	**PCB-114**	**PCB-123**	
N with detectable PCB levels (%)	146 (54.7)	266 (99.6)	263 (98.5)	137 (51.3)	255 (95.5)	257 (96.3)	208 (77.9)	246 (92.1)	245 (91.7)	235 (88.0)	203 (76.0)	51 (19.1)	
Mean ± SEM	1.2 ± 0.2	22.8 ± 1.4	9.2 ± 0.9	0.4 ± 0.1	4.0 ± 0.3	4.4 ± 0.2	0.9 ± 0.1	4.8 ± 0.3	2.1 ± 0.1	1.1 ± 0.1	0.9 ± 0.1	0.2 ± 0.0	
Median	0.6	18.1	7.0	0.3	3.1	3.7	0.8	3.9	1.6	0.7	0.5	0.0	
95% CI	0.42	2.84	1.67	0.08	0.50	0.44	0.10	0.50	0.24	0.14	0.26	0.05	
25th percentile	0.0	10.8	4.0	0.0	1.6	2.0	0.4	2.1	0.9	0.4	0.3	0.0	
75th percentile	1.3	27.5	10.8	0.5	4.6	5.5	1.2	6.1	2.6	1.4	0.9	0.1	

i. ***Occupational exposure vs. reference population:*** We compared serum concentrations of PCB congeners in men (n=55) and women (n=8) who directly handled PCBs through their employment at Westinghouse/ABB vs. a reference population of men (n=24) and women (n=50) who did not have occupational exposure to PCBs. The serum concentration for all PCB congeners were significantly higher ($p<0.001$) for study subjects with exposure compared to men from the reference population (**Table IV**). Similarly, in female participants, the serum concentrations for all PCB congeners were significantly higher for study subjects with exposure compared to women from the reference population (**Table V**). The mean concentration of PCB congeners in the serum of men with exposure to PCBs were between 2.1 (PCB-195) and 6.4 (PCB-74) times higher than the levels measured in the serum of men from the reference population. In the female participants, the mean serum concentration of PCB congeners were between 2.9 (PCB-138-158 and 195) and 8.4 (PCB-74) times higher than the concentration measured in the serum of women from the reference population. However, note that men in the occupational exposure group (60.2 ± 1.2 yrs) were significantly older ($p<0.001$) than men in the reference population (51.1 ± 2.5 yrs). Similarly, women in the occupational exposure group (64.8± 5.3 yrs) were significantly older ($p<0.001$) than women in the reference population (47.8 ± 2.0 yrs).

Table IV. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men who self-report occupational exposure to PCB vs. men from a reference population without exposure to PCBs. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational exposure (n=55)	Reference population (n=24)	*p* value
PCB-74	62.5 ± 21.8 (21.0)	9.7 ± 5.2 (4.3)	<0.001
PCB-99	14.8 ± 2.6 (7.9)	4.9 ± 1.7 (3.0)	<0.001
PCB-118	21.3 ± 3.3 (12.6)	5.4 ± 0.9 (4.1)	<0.001
PCB-105	4.2 ± 0.7 (2.5)	1.1 ± 0.2 (0.9)	<0.001
PCB-146	11.9 ± 2.3 (6.1)	3.6 ± 0.8 (3.0)	<0.001
PCB-153	82.4 ± 13.0 (48.4)	30.6 ± 5.4 (24.5)	<0.001
PCB-138/158	53.3 ± 11.1 (29.1)	17.7 ± 4.4 (13.9)	<0.001
PCB-156	21.6 ± 5.2 (9.0)	5.4 ± 1.2 (4.2)	<0.001
PCB-157	5.4 ± 1.3 (2.4)	1.3 ± 0.3 (1.1)	<0.001
PCB-178	5.0 ± 0.5 (3.6)	2.0 ± 0.4 (1.8)	<0.001
PCB-187	17.7 ± 1.9 (12.2)	6.4 ± 1.2 (5.3)	<0.001
PCB-183	4.9 ± 0.5 (3.8)	2.2 ± 0.4 (1.7)	<0.001
PCB-172	3.5 ± 0.5 (2.5)	1.2 ± 0.3 (1.1)	<0.001
PCB-180	66.2 ± 6.6 (47.4)	28.7 ± 4.2 (24.8)	<0.001
PCB-170	27.9 ± 3.5 (19.0)	10.9 ± 1.7 (9.6)	<0.001
PCB-199	19.2 ± 2.7 (9.9)	5.8 ± 1.3 (4.2)	<0.001
PCB-196/203	14.2 ± 1.6 (8.2)	5.7 ± 1.1 (4.8)	<0.001
PCB-195	2.5 ± 0.2 (2.0)	1.2 ± 0.2 (1.1)	<0.001
PCB-194	15.7 ± 1.4 (11.9)	6.7 ± 1.1 (4.8)	<0.001
PCB-206	10.1 ± 1.6 (5.4)	2.7 ± 0.6 (2.1)	<0.001
PCB-209	3.8 ± 0.5 (2.4)	1.3 ± 0.2 (1.0)	<0.001
PCB-114	4.9 ± 1.2 (1.7)	0.8 ± 0.3 (0.6)	<0.001

Table V. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of women who self-report occupational exposure to PCB vs. women from a reference population without exposure to PCBs. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational exposure (n=8)	Reference population (n=50)	*p* value
PCB-74	56.3 ± 20.9 31.6	6.7 ± 1.0 4.4	0.004
PCB-99	9.8 ± 3.6 (3.9)	3.6 ± 0.4 (2.9)	0.043
PCB-118	30.1 ± 15.0 (15.3)	7.6 ± 1.2 (4.4)	0.032
PCB-105	5.8 ± 3.3 (2.4)	1.5 ± 0.2 (0.9)	0.049
PCB-146	9.7 ± 3.8 (5.9)	2.3 ± 0.3 (1.8)	0.007
PCB-153	74.3 ± 27.3 (40.6)	21.0 ± 2.0 (16.5)	0.010
PCB-138/158	35.4 ± 12.9 (19.3)	12.4 ± 1.3 (9.4)	0.026
PCB-156	15.2 ± 6.9 (9.6)	3.0 ± 0.4 (2.5)	0.004
PCB-157	3.5 ± 1.7 (2.0)	0.7 ± 0.1 (0.5)	0.003
PCB-178	5.9 ± 2.0 (4.3)	1.2 ± 0.2 (1.1)	0.008
PCB-187	17.9 ± 5.7 (10.9)	4.5 ± 0.5 (3.6)	0.008
PCB-183	4.1 ± 1.2 (2.2)	1.8 ± 0.2 (1.4)	0.046
PCB-172	3.2 ± 1..1 (2.5)	0.8 ± 0.1 (0.5)	0.036
PCB-180	65.1 ± 19.4 (48.3)	17.7 ± 1.9 (15.5)	0.005
PCB-170	27.5 ± 9.2 (17.6)	6.6 ± 0.7 (6.4)	0.004
PCB-199	15.0 ± 4.2 (12.8)	3.4 ± 0.4 (3.3)	0.002
PCB-196/203	12.6 ± 3.2 (10.4)	3.7 ± 0.4 (3.0)	0.003
PCB-195	2.3 ± 0.6 (2.0)	0.8 ± 0.1 (0.7)	0.005
PCB-194	13.9 ± 3.6 (13.3)	4.0 ± 0.5 (3.3)	0.004
PCB-206	7.3 ± 1.9 (6.5)	1.8 ± 0.2 (1.4)	0.002
PCB-209	3.0 ± 0.8 (2.8)	0.9 ± 0.1 (0.7)	0.008
PCB-114	3.8 ± 1.8 (2.2)	0.6 ± 0.1 (0.4)	0.004

We further sought to determine if there were differences in the mean serum concentration of PCB-congeners in study subjects who worked with PCB containing fluids and materials in the Westinghouse/ABB plant compared to those that worked in the plant but did not handle contaminated fluids or materials. There were no significant differences in the mean age of men

(60.2 ± 1.2 vs. 60.5 ± 2.0 yrs, p=0.906; respectively) or women (64.5 ± 5.3 vs. 63.5 ± 2.2 yrs, p=0.877; respectively) in either group. The mean serum concentrations of PCB-congeners in study subjects who reported working in the Westinghouse/ABB plant and handling PCB containing fluids or materials were significantly higher for some PCB congeners (PCB-74, 99, 118, 105, 146, 153, 138-158, 156,157, 178, 183, 170, 195, 206, 209, and 114) than the concentrations measured in the serum of men who also worked in the plant but reported that they did not handle PCB containing fluids or materials (**Table VI**). The concentration of several PCB-congeners (PCB-187, 172, 180, 199, 196-203, and 194) were not significantly different between the two groups. Although statistically higher the serum concentrations in the two groups differed by 1.3 to 2.2 times for the majority of the PCB-congeners studied. Only the PCB-congeners 74, 99, 156, 157, and 114 were markedly higher (2.7 to 4.3 times higher).

Serum concentrations of PCB congeners from male study subjects who worked with PCB containing fluids or materials at the Westinghouse/ABB plant or elsewhere were compared. Comparisons were restricted to male study subjects since only one female participant reported working elsewhere with PCB containing fluids and materials but did not work at the Westinghouse/ABB plant. Study subjects who worked with PCB containing fluids and materials at the Westinghouse/ABB plant had markedly higher serum concentrations for all PCB-congeners (p<0.001) studied compared to male participants that worked with PCBs elsewhere (**Table VII**).

Table VI. Mean (± SEM) and median (in parentheses)serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men with occupational exposure to PCB containing fluids/materials (Westinghouse/ABB plant employment only) vs. men who worked in the plant but did not handle PCB containing fluids or materials. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational exposure (n=55)	Non-occupational exposure (n=34)	*p* value
PCB-74	62.5 ± 21.8 (21.0)	14.7 ± 2.2 (8.7)	<0.001
PCB-99	14.8 ± 2.6 (7.9)	5.6 ± 0.7 (3.4)	<0.001
PCB-118	21.3 ± 3.3 (12.6)	9.5 ± 1.1 (8.3)	0.002
PCB-105	4.2 ± 0.7 (2.5)	1.9 ± 0.3 (1.3)	<0.001
PCB-146	11.9 ± 2.3 (6.1)	6.0 ± 0.7 (4.6)	0.012
PCB-153	82.4 ± 13.0 (48.4)	45.1 ± 4.5 (35.5)	0.014
PCB-138/158	53.3 ± 11.1 (29.1)	23.8 ± 2.5 (18.3)	0.005
PCB-156	21.6 ± 5.2 (9.0)	8.1 ± 0.9 (6.1)	0.008
PCB-157	5.4 ± 1.3 (2.4)	1.9 ± 0.2 (1.4)	0.003
PCB-178	5.0 ± 0.5 (3.6)	3.5 ± 0.4 (2.6)	0.04
PCB-187	17.7 ± 1.9 (12.2)	12.6 ± 1.4 (9.4)	0.06 (NS)
PCB-183	4.9 ± 0.5 (3.8)	3.5 ± 0.4 (2.7)	0.042
PCB-172	3.5 ± 0.5 (2.5)	2.5 ± 0.3 (1.9)	0.147 (NS)
PCB-180	66.2 ± 6.6 (47.4)	48.7 ± 5.1 (36.1)	0.055 (NS)
PCB-170	27.9 ± 3.5 (19.0)	17.9 ± 1.7 (14.3)	0.040
PCB-199	19.2 ± 2.7 (9.9)	11.8 ± 1.5 (8.7)	0.090 (NS)
PCB-196/203	14.2 ± 1.6 (8.2)	10.3 ± 1.0 (9.0)	0.223 (NS)
PCB-195	2.5 ± 0.2 (2.0)	1.9 ± 0.2 (1.6)	0.029
PCB-194	15.7 ± 1.4 (11.9)	12.7 ± 1.5 (10.1)	0.120 (NS)
PCB-206	10.1 ± 1.6 (5.4)	5.2 ± 0.6 (4.4)	0.024
PCB-209	3.8 ± 0.5 (2.4)	2.6 ± 0.4 (1.8)	0.040
PCB-114	4.9 ± 1.2 (1.7)	1.3 ± 0.2 (1.2)	0.001

Table VII. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men with occupational exposure to PCB containing fluids/materials (Westinghouse/ABB plant employment only) vs. men who worked elsewhere and handled PCB containing fluids or materials. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational Westinghouse/ABB exposure (n=55)	Occupational Elsewhere exposure (n=30)	*p* value
PCB-74	62.5 ± 21.8 (21.0)	3.8 ± 0.5 (3.1)	<0.001
PCB-99	14.8 ± 2.6 (7.9)	3.0 ± 0.4 (2.5)	<0.001
PCB-118	21.3 ± 3.3 (12.6)	4.3 ± 0.6 (3.7)	<0.001
PCB-105	4.2 ± 0.7 (2.5)	0.9 ± 0.1 (0.9)	<0.001
PCB-146	11.9 ± 2.3 (6.1)	2.6 ± 0.4 (2.0)	<0.001
PCB-153	82.4 ± 13.0 (48.4)	21.8 ± 2.9 (18.6)	<0.001
PCB-138/158	53.3 ± 11.1 (29.1)	12.1 ± 1.6 (9.8)	<0.001
PCB-156	21.6 ± 5.2 (9.0)	3.8 ± 0.6 (3.5)	<0.001
PCB-157	5.4 ± 1.3 (2.4)	0.8 ± 0.2 (0.6)	<0.001
PCB-178	5.0 ± 0.5 (3.6)	1.4 ± 0.3 (1.2)	<0.001
PCB-187	17.7 ± 1.9 (12.2)	5.1 ± 1.1 (3.6)	<0.001)
PCB-183	4.9 ± 0.5 (3.8)	1.9 ± 0.3 (1.7)	<0.001
PCB-172	3.5 ± 0.5 (2.5)	0.9 ± 0.2 (0.9)	<0.001
PCB-180	66.2 ± 6.6 (47.4)	22.9 ± 3.6 (18.8)	<0.001
PCB-170	27.9 ± 3.5 (19.0)	9.0 ± 1.5 (7.3)	<0.001
PCB-199	19.2 ± 2.7 (9.9)	4.5 ± 1.0 (3.3)	<0.001
PCB-196/203	14.2 ± 1.6 (8.2)	4.8 ± 0.9 (4.3)	<0.001
PCB-195	2.5 ± 0.2 (2.0)	0.8 ± 0.2 (0.7)	<0.001
PCB-194	15.7 ± 1.4 (11.9)	6.0 ± 1.1 (5.1)	<0.001
PCB-206	10.1 ± 1.6 (5.4)	2.1 ± 0.3 (1.8)	<0.001
PCB-209	3.8 ± 0.5 (2.4)	1.0 ± 0.1 (1.0)	<0.001
PCB-114	4.9 ± 1.2 (1.7)	0.4 ± 0.1 (0.4)	<0.001

Serum concentrations of PCB specific congeners were also compared between men who worked in the Westinghouse/ABB plant but did not directly handle or have exposure to PCBs with men from the reference population (**Table VIII**). Similar comparisons were made for women who

worked in the Westinghouse/ABB plant but did not directly handle or have exposure to PCBs with women in the reference population (**Table IX**). In both cases the serum concentration for the majority of the PCBs measured in the serum were significantly greater than the levels quantified in the serum of the reference population. Of note there was no difference for PCB-138/158 and 153 between men in both groups whereas the concentration for these marker PCBs were significantly higher in women who worked in the Westinghouse/ABB plant but did not directly handle or have exposure to PCBs with women in the reference population.

ii. ***Proximity to Pottersburg Creek/Walker Drain:*** Serum concentrations of PCB specific congeners in study subjects who reported residing within one to two blocks of the Pottersburg Creek/Walker Drain were compared with the serum levels of the reference population. We postulated that there would be no differences between these two groups for either gender. The serum concentrations of PCB-congeners were not significantly different between men living in close proximity to the Pottersburg Creek/Walker Drain and those of the reference population with the exception of PCB-157 (**Table X**). The serum concentration of PCB-157 was 1.2 times higher (p=0.014) in males from the reference population compared to males living in close proximity of Pottersburg Creek/Walker Drain. The serum concentration of PCB-congeners measured in women who resided within close proximity of the Pottersburg Creek/Walker Drain were not significantly higher than those measured in the serum of females in the reference population with the exception of PCB-156 (**Table XI**). The concentration of PCB-156 was 1.7 times higher (p=0.032) in the serum of women living in close proximity to Pottersburg Creek/Walker Drain compared to the reference population.

Table VIII. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men who worked at Westinghouse/ABB but did not have exposure to PCBs vs. men from a reference population without exposure to PCBs. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational exposure (n=34)	Reference population (n=24)	*p* value
PCB-74	13.8 ± 2.6 (8.2)	9.9 ± 5.5 (4.1)	0.003
PCB-99	5.5 ± 0.8 (3.5)	5.0 ± 1.8 (3.0)	0.286 (NS)
PCB-118	8.8 ± 1.2 (7.1)	5.4 ± 1.0 (4.1)	0.022
PCB-105	1.8 ± 0.3 (1.3)	1.1 ± 0.2 (0.9)	0.100 (NS)
PCB-146	5.7 ± 0.9 (4.6)	3.6 ± 0.8 (2.7)	0.062 (NS)
PCB-153	43.2 ± 5.2 (33.1)	31.0 ± 5.6 (24.5)	0.054 (NS)
PCB-138/158	22.8 ± 2.9 (18.3)	18.2 ± 4.6 (13.9)	0.065 (NS)
PCB-156	7.6 ± 1.0 (5.6)	5.5 ± 1.2 (3.8)	0.053 (NS)
PCB-157	1.8 ± 0.3 (1.3)	1.3 ± 0.3 (1.1)	0.182 (NS)
PCB-178	3.5 ± 0.5 (2.5)	2.0 ± 0.4 (1.5)	0.038
PCB-187	12.3 ± 1.8 (8.9)	6.4 ± 1.3 (4.9)	0.012
PCB-183	3.4 ± 0.4 (2.7)	2.2 ± 0.5 (1.7)	0.045
PCB-172	2.4 ± 0.4 (1.9)	1.3 ± 0.3 (1.3)	0.016
PCB-180	46.7 ± 6.0 (32.5)	28.5 ± 4.4 (23.7)	0.017
PCB-170	17.1 ± 2.1 (13.0)	10.9 ± 1.8 (8.6)	0.026
PCB-199	11.5 ± 1.9 (7.3)	5.8 ± 1.4 (3.9)	0.007
PCB-196/203	9.9 ± 1.2 (7.2)	5.7 ± 1.1 (4.4)	0.004
PCB-195	1.8 ± 0.3 (1.5)	1.2 ± 0.2 (1.2)	0.137 (NS)
PCB-194	12.2 ± 1.7 (9.1)	6.7 ± 1.2 (4.5)	0.004
PCB-206	5.0 ± 0.8 (4.4)	2.7 ± 0.6 (2.0)	0.005
PCB-209	2.4 ± 0.4 (1.8)	1.3 ± 0.2 (1.0)	0.011
PCB-114	1.2 ± 0.2 (1.1)	0.8 ± 0.3 (0.6)	0.028

Table IX. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of women who worked at Westinghouse/ABB but did not handle PCB containing fluids vs. women from a reference population without exposure to PCBs. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Occupational exposure (n=16)	Reference population (n=49)	*p* value
PCB-74	20.2 ± 5.1 (12.2)	6.8 ± 1.0 (4.5)	0.001
PCB-99	8.9 ± 2.4 (4.1)	3.7 ± 0.4 (2.9)	0.021
PCB-118	17.3 ± 6.5 (5.8)	7.7 ± 1.2 (4.5)	0.044
PCB-105	3.7 ± 1.7 (1.2)	1.5 ± 0.2 (0.9)	0.348 (NS)
PCB-146	5.8 ± 1.2 (3.9)	2.3 ± 0.3 (1.7)	0.001
PCB-153	44.3 ± 7.9 (34.0)	21.0 ± 2.1 (15.9)	0.002
PCB-138/158	27.0 ± 6.5 (17.7)	12.5 ± 1.3 (9.6)	0.017
PCB-156	7.7 ± 1.6 (5.0)	3.0 ± 0.4 (2.4)	<0.001
PCB-157	1.8 ± 0.4 (1.3)	0.7 ± 0.1 (0.5)	0.008
PCB-178	2.9 ± 0.5 (2.3)	1.2 ± 0.2 (1.0)	0.002
PCB-187	10.3 ± 1.8 (7.9)	4.5 ± 0.5 (3.5)	0.001
PCB-183	3.6 ± 0.7 (2.8)	1.8 ± 0.2 (1.4)	0.011
PCB-172	1.8 ± 0.4 (1.7)	0.8 ± 0..1 (0.5)	0.020
PCB-180	38.9 ± 5.9 (31.7)	17.7 ± 1.9 (15.4)	<0.001
PCB-170	15.2 ± 2.3 (12.7)	6.6 ± 0.7 (6.3)	<0.001
PCB-199	8.2 ± 1.5 (6.1)	3.4 ± 0.4 (2.9)	<0.001
PCB-196/203	8.1 ± 1.2 (6.7)	3.7 ± 0.4 (3.2)	<0.001
PCB-195	1.7 ± 0.2 (1.6)	0.8 ± 0.1 (0.7)	<0.001
PCB-194	9.1 ± 1.4 (6.8)	4.0 ± 0.5 (3.2)	<0.001
PCB-206	4.0 ± 0.7 (3.3)	2.0 ± 0.2 (1.4)	<0.001
PCB-209	1.9 ± 0..3 (1.5)	0.9 ± 0.1 (0.6)	0.002
PCB-114	1.8 ± 0.4 (1.1)	0.6 ± 0.1 (0.4)	<0.001

Table X. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men who lived within 1-2 blocks of the Pottersburg Creek/Walker Drain vs. men in the reference population. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Proximity to Pottersburg Creek/Walker Drain (n=111)	Reference population (n=24)	*p* value
PCB-74	5.0 ± 0.7 (3.1)	9.7 ± 5.2 (4.3)	0.063 (NS)
PCB-99	4.2 ± 0.7 (2.7)	4.9 ± 1.7 (3.0)	0.519 (NS)
PCB-118	8.4 ± 2.5 (3.8)	5.4 ± 0.9 (4.1)	0.182 (NS)
PCB-105	1.7 ± 0.5 (0.8)	1.1 ± 0.2 (0.9)	0.250 (NS)
PCB-146	3.3 ± 0.6 (2.0)	3.6 ± 0.8 (3.0)	0.059 (NS)
PCB-153	27.5 ± 3.8 (18.4)	30.6 ± 5.4 (24.5)	0.141 (NS)
PCB-138/158	16.0 ± 2.8 (10.1)	17.7 ± 4.4 (13.9)	0.242 (NS)
PCB-156	4.7 ± 1.1 (2.7)	5.4 ± 1.2 (4.2)	0.054 (NS)
PCB-157	1.1 ± 0.3 (0.7)	1.3 ± 0.3 (1.1)	0.014
PCB-178	1.6 ± 0.2 (1.1)	2.0 ± 0.4 (1.8)	0.082 (NS)
PCB-187	6.0 ± 0.6 (3.7)	6.4 ± 1.2 (5.3)	0.193 (NS)
PCB-183	2.0 ± 0.2 (1.4)	2.2 ± 0.4 (1.7)	0.553 (NS)
PCB-172	1.3 ± 0.2 (0.8)	1.2 ± 0.3 (1.1)	0.686 (NS)
PCB-180	24.8 ± 2.3 (16.9)	28.7 ± 4.2 (24.8)	0.152 (NS)
PCB-170	9.6 ± 1.2 (6.7)	10.9 ± 1.7 (9.6)	0.145 (NS)
PCB-199	4.6 ± 0.5 (3.0)	5.8 ± 1.3 (4.2)	0.169 (NS)
PCB-196/203	4.8 ± 0.4 (3.4)	5.7 ± 1.1 (4.8)	0.204 (NS)
PCB-195	0.9 ± 0.1 (0.7)	1.2 ± 0.2 (1.1)	0.086 (NS)
PCB-194	6.0 ± 0.6 (4.2)	6.7 ± 1.1 (4.8)	0.263 (NS)
PCB-206	2.1 ± 0.2 (1.5)	2.7 ± 0.6 (2.1)	0.093 (NS)
PCB-209	1.1 ± 0.1 (0.7)	1.3 ± 0.2 (1.0)	0.055 (NS)
PCB-114	0.7 ± 0.2 (0.4)	0.8 ± 0.3 (0.6)	0.082 (NS)

Table XI. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of women who lived within 1-2 blocks of the Pottersburg Creek/Walker Drain vs. women in the reference population. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Proximity to Pottersburg Creek/Walker Drain (n=167)	Reference population (n=50)	*p* value
PCB-74	7.0 ± 0.7 (4.6)	6.7 ± 1.0 4.4	0.483 (NS)
PCB-99	5.6 ± 1.3 (3.0)	3.6 ± 0.4 (2.9)	0.647 (NS)
PCB-118	9.1 ± 1.7 (4.6)	7.6 ± 1.2 (4.4)	0.907 (NS)
PCB-105	1.8 ± 0.4 (0.9)	1.5 ± 0.2 (0.9)	0.754 (NS)
PCB-146	3.4 ± 0.8 (2.0)	2.3 ± 0.3 (1.8)	0.346 (NS)
PCB-153	28.5 ± 4.8 (19.8)	21.0 ± 2.0 (16.5)	0.256 (NS)
PCB-138/158	19.3 ± 4.9 (11.5)	12.4 ± 1.3 (9.4)	0.275 (NS)
PCB-156	5.1 ± 1.4 (3.2)	3.0 ± 0.4 (2.5)	0.032
PCB-157	1.3 ± 0.4 (0.8)	0.7 ± 0.1 (0.5)	0.068 (NS)
PCB-178	1.3 ± 0.1 (1.1)	1.2 ± 0.2 (1.1)	0.846 (NS)
PCB-187	5.0 ± 0.4 (3.8)	4.5 ± 0.5 (3.6)	0.474 (NS)
PCB-183	2.0 ± 0.2 (1.5)	1.8 ± 0.2 (1.4)	0.565 (NS)
PCB-172	1.2 ± 0.3 (0.5)	0.8 ± 0.1 (0.5)	0.356 (NS)
PCB-180	21.2 ± 1.7 (17.8)	17.7 ± 1.9 (15.5)	0.130 (NS)
PCB-170	8.8 ± 1.2 (6.8)	6.6 ± 0.7 (6.4)	0.101 (NS)
PCB-199	3.4 ± 0.2 (3.1)	3.4 ± 0.4 (3.3)	0.649 (NS)
PCB-196/203	3.9 ± 0.2 (3.6)	3.7 ± 0.4 (3.0)	0.468 (NS)
PCB-195	0.8 ± 0.1 (0.8)	0.8 ± 0.1 (0.7)	0.852 (NS)
PCB-194	4.2 ± 0.2 (3.8)	4.0 ± 0.5 (3.3)	0.236 (NS)
PCB-206	1.8 ± 0.1 (1.5)	1.8 ± 0.2 (1.4)	0.483 (NS)
PCB-209	1.0 ± 0.1 (0.7)	0.9 ± 0.1 (0.7)	0.552 (NS)
PCB-114	0.9 ± 0.2 (0.5)	0.6 ± 0.1 (0.4)	0.157 (NS)

iii. ***Recreational use of the Pottersburg Creek/Walker Drain:*** The possibility that people using Pottersburg Creek/Walker Drain for recreational purposes may be at increased risk of higher exposure to PCBs was evaluated by comparing serum concentrations in this group with those of the reference population. No statistically significant differences were found in the serum concentration for any PCB-congener studied between people using Pottersburg Creek/Walker Drain for recreational purposes and the reference population in either gender (**Table XII and XIII**).

iv. ***Occupational vs. non-exposed:*** The mean age of men and women with occupational exposure to PCBs were significantly older than men and women in the reference population. However, there were no significant differences in age between the groups without occupational exposure to PCBs and the reference population. Therefore, the exposure data for the reference population and the non-exposed groups were collapsed for comparison with those occupationally exposed to PCBs (analysis in progress).

Table XII. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of men who used Pottersburg Creek/Walker Drain for recreational purposes vs. men in the reference population. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Recreational use of Pottersburg Creek/Walker Drain (n=24)	Reference population (n=24)	*p* value
PCB-74	3.8 ± 0.4 (3.1)	9.7 ± 5.2 (4.3)	0.099 (NS)
PCB-99	4.4 ± 1.0 (2.9)	4.9 ± 1.7 (3.0)	0.812 (NS)
PCB-118	4.9 ± 0.7 (3.7)	5.4 ± 0.9 (4.1)	0.348 (NS)
PCB-105	1.0 ± 0.1 (0.8)	1.1 ± 0.2 (0.9)	0.812 (NS)
PCB-146	3.2 ± 0.7 (2.3)	3.6 ± 0.8 (3.0)	0.483 (NS)
PCB-153	27.4 ± 5.0 (21.2)	30.6 ± 5.4 (24.5)	0.550 (NS)
PCB-138/158	16.1 ± 3.7 (10.2)	17.7 ± 4.4 (13.9)	0.821 (NS)
PCB-156	4.6 ± 1.3 (3.4)	5.4 ± 1.2 (4.2)	0.293 (NS)
PCB-157	1.1 ± 0.3 (0.7)	1.3 ± 0.3 (1.1)	0.136 (NS)
PCB-178	1.6 ± 0.2 (1.2)	2.0 ± 0.4 (1.8)	0.409 (NS)
PCB-187	5.6 ± 0.7 (4.4)	6.4 ± 1.2 (5.3)	0.643 (NS)
PCB-183	2.1 ± 0.3 (1.8)	2.2 ± 0.4 (1.7)	0.695 (NS)
PCB-172	1.0 ± 0.2 (0.8)	1.2 ± 0.3 (1.1)	0.644 (NS)
PCB-180	23.1 ± 2.4 (20.3)	28.7 ± 4.2 (24.8)	0.445 (NS)
PCB-170	8.7 ± 1.2 (7.1)	10.9 ± 1.7 (9.6)	0.375 (NS)
PCB-199	4.0 ± 0.4 (3.4)	5.8 ± 1.3 (4.2)	0.496 (NS)
PCB-196/203	4.4 ± 0.5 (4.0)	5.7 ± 1.1 (4.8)	0.529 (NS)
PCB-195	1.0 ± 0.2 (0.8)	1.2 ± 0.2 (1.1)	0.331 (NS)
PCB-194	5.4 ± 0.7 (5.3)	6.7 ± 1.1 (4.8)	0.599 (NS)
PCB-206	1.9 ± 0.2 (1.7)	2.7 ± 0.6 (2.1)	0.445 (NS)
PCB-209	1.0 ± 0.1 (1.0)	1.3 ± 0.2 (1.0)	0.309 (NS)
PCB-114	0.6 ± 0.2 (0.4)	0.8 ± 0.3 (0.6)	0.191 (NS)

Table XIII. Mean (± SEM) and median (in parentheses) serum concentrations (ng/g lipid) for PCB-congeners that were quantified in 70% or more of the samples studied of women who used Pottersburg Creek/Walker Drain for recreational purposes vs. women in the reference population. Differences between exposure group medians were determined using Mann-Whitney rank sum test.

Congener	Recreational use of Pottersburg Creek/Walker Drain (n=26)	Reference population (n=50)	*p* value
PCB-74	7.5 ± 1.6 (5.2)	6.7 ± 1.0 4.4	0.576 (NS)
PCB-99	4.1 ± 0.7 (3.2)	3.6 ± 0.4 (2.9)	0.630 (NS)
PCB-118	8.0 ± 1.3 (4.3)	7.6 ± 1.2 (4.4)	0.772 (NS)
PCB-105	1.5 ± 0.2 (0.9)	1.5 ± 0.2 (0.9)	0.645 (NS)
PCB-146	2.4 ± 0.4 (2.0)	2.3 ± 0.3 (1.8)	0.848 (NS)
PCB-153	22.8 ± 3.3 (21.9)	21.0 ± 2.0 (16.5)	0.874 (NS)
PCB-138/158	13.5 ± 1.9 (10.9)	12.4 ± 1.3 (9.4)	0.738 (NS)
PCB-156	3.5 ± 0.6 (3.4)	3.0 ± 0.4 (2.5)	0.338 (NS)
PCB-157	0.9 ± 0.1 (0.8)	0.7 ± 0.1 (0.5)	0.222 (NS)
PCB-178	1.4 ± 0.2 (1.2)	1.2 ± 0.2 (1.1)	0.622 (NS)
PCB-187	4.6 ± 0.7 (3.8)	4.5 ± 0.5 (3.6)	0.793 (NS)
PCB-183	2.0 ± 0.3 (1.7)	1.8 ± 0.2 (1.4)	0.430 (NS)
PCB-172	0.7 ± 0.2 (0.7)	0.8 ± 0.1 (0.5)	0.685 (NS)
PCB-180	20.1 ± 2.9 (18.7)	17.7 ± 1.9 (15.5)	0.501 (NS)
PCB-170	7.6 ± 1.1 (7.1)	6.6 ± 0.7 (6.4)	0.447 (NS)
PCB-199	3.3 ± 0.5 (2.8)	3.4 ± 0.4 (3.0)	0.961 (NS)
PCB-196/203	4.1 ± 0.6 (3.8)	3.7 ± 0.4 (3.3)	0.595 (NS)
PCB-195	0.9 ± 0.1 (0.9)	0.8 ± 0.1 (0.7)	0.754 (NS)
PCB-194	4.2 ± 0.7 (4.0)	4.0 ± 0.5 (3.3)	0.645 (NS)
PCB-206	1.9 ± 0.3 (1.6)	1.8 ± 0.2 (1.4)	0.638 (NS)
PCB-209	1.0 ± 0.2 (0.8)	0.9 ± 0.1 (0.7)	0.653 (NS)
PCB-114	0.7 ± 0.1 (0.7)	0.6 ± 0.1 (0.4)	0.162 (NS)

DISCUSSION

The Westinghouse/ABB plant operated in the Pottersburg Creek community for approximately 20 years before ceasing operations in the mid 1980s. During the operation of the Westinghouse/ABB plant PCBs were used in the manufacture of electrical transformers. Subsequently PCBs were found in the Pottersburg Creek and Walker Drain leading to an environmental cleanup action in the late 1980s. The Ontario Ministry of the Environment now proposes decommissioning of the Pottersburg PCB storage site which has led to community concern for potential exposure to contaminated material. Therefore the present blood survey was conducted to document current PCB specific congener residue levels in the serum of Pottersburg Creek residents including former employees of the Westinghouse/ABB plant. A reference population of study subjects was recruited from London and included people who: (1) did not knowingly have previous exposure to PCB containing fluids or materials and did not use the Pottersburg Creek/Walker Drain for recreational purposes. Our results demonstrate that serum residue levels for several PCB congeners are markedly higher in individuals who previously worked with PCB containing fluids and materials compared to the reference population as well as individuals who worked in the plant but did not work with PCB containing fluids or materials. However, plasma concentrations of PCBS are known to be associated with age (Hue *et al.* 2007) and the age of the occupationally exposed group in the current study was greater than that of the reference population, exposure levels would be expected to be greater. Of note, the serum concentrations of PCB-congeners in individuals who lived in close proximity to or used Pottersburg Creek/Walker Drain for recreational purposes are not different from the levels quantified in the serum of the reference population. Hence, the data from all non-exposed groups and the reference population was combined to form a new reference population/control group

whose age matched that of the exposed group. Moreover, the serum concentration of PCBs were modestly higher in men and women who worked at the Westinghouse/ABB plant but did not handle PCB containing fluids or materials compared to men and women from the reference population. Taken together these data suggest that PCB residue levels remain higher in the serum of individuals with occupational exposure compared to the general population of London although the plant ceased operations more than 25 years ago. Moreover, results of the present study show that serum concentrations of some PCB congeners are elevated in men and women who worked at Westinghouse/ABB but did not handle PCB containing fluids or materials compared to the reference population.

The PCB congeners targeted measured are representative of historical exposure (PCB 138, 153 and 180), include PCB congeners present in commercial PCB mixtures and permit comparison with other contemporary North American biomonitoring studies (LaKind *et al.* 2008; Nichols *et al.* 2007a). PCB residue levels were detected in the serum of study participants; however, for many PCB-congeners the frequency of detection was very low. For example, fewer than 10% of the study subjects have measurable levels of PCB-49, 151, 149, and 128 in their serum and more than 50% of study subjects had values below the level of detection for several other PCB-congeners (PCB-28, 52, 44, 66, 101, 87, 110,151, and 123) of which PCB-28, 52 and 101 are frequently used additional markers of historical exposure. A large percentage of samples with values below the level of detection prevent meaningful statistical comparisons. Hence, our analyses focused on PCB-congeners where the percentage of study subjects whose serum concentrations were above the limit of detection was 70% or greater. The percentage of samples above the level of detection in the present study are consistent with those reported previously for

PCB-105, 118, 156, 157, and 167 in a population from two separate Louisiana parishes (Wong *et al.* 2008) although PCB-189 was detected in a greater proportion of study subjects in the present study. For the purposes of statistical analysis we elected to use the analytical equipment generated number for values below the LOD which has recently been shown to produce results harmonious with replacement of non-detect values with an imputed value using the calculation concentration = LOD/$\sqrt{2}$ (Axelrad *et al.* 2009) (Scott et al. 2008), and thus is a valid approach. The highly chlorinated PCBs (PCB-138/158, 153 and 180) accounted for the majority of PCBs measured in the serum of both the exposed and non-exposed study subjects. This indicates that dietary sources are responsible for a significant proportion of the total PCB body burden measured. Marker PCB congeners are also frequently reported in exposure studies and include PCB-28, 52, 101, 138, 153 and 180 (Domingo *et al.* 2001; Mari *et al.* 2007; Mari *et al.* 2009; Schuhmacher *et al.* 2002; Tsuji *et al.* 2006). In the present study PCB-28, 52, and 101 were quantified in a small proportion of the study subjects (25.9, 26.3, and 26.6 % of men and 30.7, 24.0, and 27.0 % of women, respectively). By comparison PCB-153, and 180, markers of historical exposure to PCBs, were successfully quantified in the serum of 100% of the study subjects. PCB-138 is also a marker of historical exposure; however, it cannot be separated from PCB-158 although it is thought to represent the overwhelming majority of the level reported. PCB-138/158 was measured in 99.3% of males and 98.1% of the female participants in this study.

In the present blood monitoring survey the entire population can be divided by exposure into those exposed via employment at Westinghouse/ABB and handling PCB containing fluids and materials vs. employment at Westinghouse/ABB but did not handle PCB containing fluids and

materials vs. the combination of residents around the Pottersburg Creek/Walker Drain and the reference population. In those with occupational exposure we found that the serum concentration of all PCB-congeners measured were profoundly higher in both male and female participants who self-reported working with PCB containing fluids or materials at the Westinghouse/ABB plant compared to workers who did not handle these chemicals and the reference population. It is difficult to compare PCB exposure across studies owing to differences in study design, method of analysis, PCB-congeners measured, approach to dealing with non-detectable results, and reporting of results as: wet weight vs. lipid adjusted basis; a measure of 2,3,7,8 tetrachlorodibenzo-*p*-dioxin (TCDD) toxic equivalence; and the sum of PCB congeners measured. The concentrations of PCBs reported in the present study are substantially lower compared to other studies of men occupationally exposed to PCBs at a waste incinerator (Domingo *et al.* 2001; Schuhmacher *et al.* 2002) or lower (PCB-153 and 180) or similar to (PCB-138) the concentrations measured in another study of male waste incinerator workers (Mari *et al.* 2007) but higher than the concentrations measured in the follow-up study (Mari *et al.* 2009). The concentrations in the men with occupational exposure in the present study are similar to those reported for men from different occupational groups in Bangladesh (Zamir *et al.* 2009). A major difference between the results of the present study and other reports in the literature is the interval exposure and measurement of serum PCB concentration. The Westinghouse/ABB plant completed operations more than 20 years ago whereas reports in the literature largely reflect men with contemporary exposure. Thus it is not surprising that the concentrations measured in the men with occupational exposure in the present study are lower than those from contemporary studies. Comparable reports for women with occupational exposure are not available.

In general, the serum PCB concentrations measured in the reference population and the non-occupationally exposed individuals in the present study were low and are markedly lower than the concentrations measured in adult men and women from Hamilton, Ontario and First Nations people from the Western James Bay region of Northern Ontario (Tsuji *et al.* 2006). The serum concentrations in women from both the reference population and without occupational exposure to PCBs were also lower than the comparable marker PCBs in a convenience sample of 110 postmenopausal women from Quebec City (Sandanger et al. 2007) and substantially lower than the serum concentration of marker PCB-138, 153 and 180 in adult Czech men and women (Cerna et al. 2008). Furthermore, the concentrations of PCB congeners measured in the present study are also lower than those reported for the NHANES 2001-2002 Survey (Nichols *et al.* 2007b), the most recent national survey for which serum PCB concentrations are available for comparison. Indeed, the concentration of PCB-153, the PCB which accounted for most of the PCBs measured in the serum of study subjects in the present study, was approximately half the concentration reported in the NHANES 2001-2002 Survey (Axelrad et al. 2009). Similarly, the concentrations of PCBs measured in the current study are lower in the serum of men and women from the community compared to another community with industrial exposure to environmental contaminants including PCBs (Wong *et al.* 2008). Finally, consumption contaminated fish has been associated with PCB exposure in adult men and women (Ayotte et al. 2005; 2003; Sandager et al. 2006; Kiviranta et al. 2002; Rylander et al. 2009; Nadon et al. 2002; Cole et al. 2002) and in all cases the concentrations measured are higher than the levels measured in the present study.

A strength of the current study is the robust sample size employed and the overall positive community response and participation in this blood survey. There are however a number of important limitations to the present study. The age of the study participants is narrow with under representation from young adults and seniors but over represented by adults between 45 and 64 which accounted for between 57 and 59% of exposed and non-exposed study subjects, respectively. The retrospective nature of the study precluded our ability to determine duration of exposure for those who self-reported working with PCB containing fluids or materials. For example, while study subjects provided information on their employment and handling of PCB containing fluids or materials, we were unable to obtain information on length of employment, the length of time study subjects were exposed to PCBs, and the concentration of PCB at the time of exposure. Although, a previous blood survey in this community was conducted only 2.7% of the study subjects recruited reported having had their blood tested previously. Moreover, we were unable to obtain results of previous blood monitoring in these subjects and thus it is not possible to determine if serum concentrations are changing or the direction of any change if present. Duration of residence in proximity to the Westinghouse/ABB plant and direct measures of exposure that resulted from flooding from Pottersburg Creek/Walker Drain or use of soil sediments from these sites was not determined.

In summary, serum PCB concentrations measured in this study are profoundly higher in those individuals who worked at the Westinghouse/ABB plant compared to the reference population; however, the concentrations of PCBs measured in the serum of individuals who lived in close proximity to Pottersburg Creek/Walker Drain and used these waters for recreational purposes are low and not different from the reference population. Hence, we conclude that the residents of the

Pottersburg Creek community are not more exposed to PCBs than members of the reference population.

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