ATMOSPHERIC DEPOSITION OF TOXIC SUBSTANCES TO THE GREAT LAKES: IADN RESULTS THROUGH 1998

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Executive Summary

The Integrated Atmospheric Deposition Network (IADN) was established in 1990 to determine the magnitude and trends of atmospheric loadings of toxic contaminants to the Great Lakes. By maintaining a master station on each of the Great Lakes, IADN is able to monitor the atmospheric deposition of selected pollutants. These data have been used to calculate loadings estimates to the Great Lakes from 1992 to 1996. IADN incorporates three atmospheric deposition processes into its loadings estimates: wet deposition, dry particle deposition, and net gas exchange which combines the processes of gas absorption (air to water) and volatilization (water to air). This document reports the biennial loadings to the Great Lakes for 1997 and 1998.

A subset of the substances measured at the IADN master stations are used in the loadings calculations. These substances are the pesticides α- and γ-hexachlorocyclohexane (HCH), dieldrin, *p,p′*-DDE, *p,p′*-DDD, *p,p′*-DDT, *trans*-nonachlor, *trans*- and *cis*-chlordane, α-endosulfan, and endosulfan sulfate; hexachlorobenzene (HCB) and polychlorinated biphenyl (PCB) congeners 18, 44, 52, and 101, as well as a sum of 56 PCB congeners and coeluting congener groups expressed as "suite-PCB"; the individual polycyclic aromatic hydrocarbons (PAHs) phenanthrene, pyrene, benzo[*k*]fluoranthene, benzo[*b*]fluoranthene, indeno[1,2,3-*cd*]pyrene and benzo[*a*]pyrene as well as a the total of four of these PAHs expressed as sum-PAH; and the trace metals lead, arsenic, selenium, and cadmium.

The 1997-1998 loadings presented in this report were calculated in a manner consistent with the 1995-1996 loadings. The estimates are presented here as flows (kg/yr) to better understand the amount of the substances being deposited to the lakes, and as fluxes (ng/m^2/day) to account for differences in lake areas and to facilitate spatial trend analysis.

Downward fluxes for pesticides in 1997 and 1998 ranged from 0.01 ng/m^2/day to 40 ng/m^2/day, with in-use pesticides such as γ-HCH accounting for the highest fluxes. Volatilization fluxes for those pesticides banned from use were almost 10 times greater than those for currently used pesticides, reaching –37 ng/m^2/day at their highest. PCB and HCB downward fluxes ranged from 0.02 ng/m^2/day to 11 ng/m^2/day across the basin. Volatilization fluxes for these banned commercial chemicals were on the same order as those for banned pesticides. Suite-PCB volatilization fluxes increased from west to east across the basin. Downward fluxes for PAHs ranged from 0.3 ng/m^2/day to 530 ng/m^2/day with volatilization fluxes ranging from –0.00001 to –240 ng/m^2/day. Where water concentration data are available, volatilization of PAHs was almost always less than net inputs. Fluxes for metals ranged from 13 to 840 ng/m^2/day for dry deposition and from 130 to 5400 ng/m^2/day for wet deposition. Since the metals analyzed by IADN are nonvolatile, they are not measured in the gas phase. The PAHs and metals measured by IADN are currently emitted through anthropogenic means into the atmosphere and thus have downward (air to water) fluxes much greater than those of the pesticides and PCBs that have been banned from use.

Current (1997-1998) fluxes (ng/m^2/day) were compared across time and space to better understand loadings trends in the Great Lakes. Pesticide wet deposition fluxes seem to be generally decreasing over time except for γ-HCH at Lakes Huron and Ontario. Since γ-HCH is still in use, this trend is expected. Volatilization of dieldrin from Lake Ontario is the largest pesticide flux observed. The magnitude of PCB wet deposition fluxes is similar for Lakes Superior, Erie, and Michigan. Lake Erie, however, seems unique in that all PCBs measured there reached peak fluxes around 1994 and 1995 and then decreased in the following three years. Gas exchange of PCBs has been, for the most part, in the direction of net volatilization consistently over time with only Lake Michigan showing signs of nearing air-water equilibrium. Wet and dry deposition of PAHs shows no real temporal trend, but spatial analysis indicates that fluxes have increased from west to east across the basin. Gas exchange fluxes for Lakes Superior and Erie for all PAHs show net absorption over time. Metal fluxes for Lakes Huron and Ontario are similar over the years with dry deposition showing no real trend and wet deposition decreasing from 1992-1996 for Cd and Pb, then increasing in 1997 and 1998.

All of the flows and fluxes mentioned above are based on IADN master station data. These stations are remote sites, one on each lake, which measure what are considered to be Great Lakes background contaminant levels. However, spatial differences exist across each lake for many of the compounds we monitor, particularly near urban areas, where atmospheric deposition from cities can be much greater than that from remote sites. In an attempt to assess the impact of urban areas on lakewide loadings, and in accordance with the 1995-1996 loadings report, depositional data from IADN's Chicago site were extrapolated onto Lake Michigan loadings. The impact of Chicago pollution on a small sub-area of Lake Michigan was then compared to loadings calculated at the remote master station. Results demonstrate that urban inputs have a minor lakewide effect for most pesticides. There does, however, seem to be a large effect on *cis*- and *trans*-chlordane, drastically changing lakewide volatilization and markedly increasing total mass loadings. Urban inputs also have a strong effect on the net gas exchange of PCBs. PAHs, currently emitted urban pollutants, show consistently large urban effects in all deposition categories.

In an attempt to explore a more tangible means of examining the loadings results, estimates were investigated on a Great Lakes basin-wide basis by summing the total deposition flow (kg/yr) of each substance over all five lakes for each year. These sums give a good approximation of the larger, regional atmospheric deposition to the Great Lakes. Total deposition for α-HCH showed a decreasing trend, going from 950 kg/yr in 1992 to –210 kg/yr in 1998. Dieldrin and *p,p′*-DDE, two organochlorine pesticides banned from use, had negative total deposition across time, indicating that the lakes are acting as a source of these chemicals to the atmosphere. Sum-PCB total deposition across the basin also showed net volatilization for all years. Even so, PCB flows out of the Great Lakes have decreased dramatically over time, with the largest drop occurring between 1994 and 1995 when total PCB flows went from –3100 kg/yr to –940 kg/yr. PAHs and metals had the largest regional deposition. PAH flows have, for the most part, remained stable across time. While total loads of metals to the Great Lakes basin have decreased over time, the region was still receiving 78000 kg of lead in 1998.

Table D1. IADN annual flows (kg/yr) from 1992 to 1998 for Lake Superior

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	78	1.1	390	470
	1993	33	5.6	450	490
	1994	38	12	710	760
	1995	28	4.7	-230	-200
	1996	71	-	-240	-170
	1997	35	2.9	-290	-250
	1998	6.5	1.9	-470	-460
γ-HCH	1992	62	0.65	140	200
	1993	14	2.7	47	64
	1994	19	2.4	95	120
	1995	9.5	1.9	65	76
	1996	38	-	43	81
	1997	27	4.2	69	100
	1998	10	2.2	-4.6	7.6
dieldrin	1992	21	7.4	-500	-470
	1993	62	6.3	-540	-470
	1994	11	25	-500	-460
	1995	34	15	-240	-190
	1996	20	-	-200	-180
	1997	18	15	-220	-190
	1998	11	18	-280	-250
p,p'-DDD	1992	-	6.1	-	-
	1993	17	0.1	-	-
	1994	10	-	-	-
	1995	0.89	0.5	-9.3	-7.9
	1996	0.8	-	4.3	5.1
	1997	0.32	1.1	6	7.4
	1998	0.74	0.64	5	6.4
p,p'-DDE	1992	2.6	0.39	-	-
	1993	3.8	1.2	-	-
	1994	4	-	-	-
	1995	4.6	0.96	-18	-12
	1996	2.1	-	-14	-12
	1997	2.5	-	1.9	4.4
	1998	2.3	-	-4	-1.7
p,p'-DDT	1992	6.2	1.6	21	29
	1993	59	1.9	12	73
	1994	48	-	-	-
	1995	1.7	2.4	2	6.1
	1996	3.2	-	7.8	11
	1997	3.9	1.4	2.6	7.9
	1998	3.8	1.8	1.5	7.1
HCB	1992	5.3	0.67	47	53
	1993	25	19	15	59
	1994	1.2	0.37	16	18
	1995	1.5	0.42	24	26
	1996	1.2	-	22	23
	1997	1	-	18	19
	1998	0.6	-	25	26
PCB18	1992	0.92	0.26	-71	-70
	1993	3.1	0.39	-74	-71
	1994	1.6	2.9	-71	-67
	1995	2	1.9	-14	-10
	1996	3.4	-	14	17
	1997	2.3	-	-5	-2.7
	1998	1.1	-	-5.5	-4.4
PCB44	1992	1.4	0.45	-19	-17
	1993	9.1	0.92	-14	-4
	1994	1.7	2.8	-7.3	-2.8
	1995	2.2	1.7	-8.3	-4.4
	1996	1.9	-	51	53
	1997	2.7	-	-0.57	2.1
	1998	5.3	-	-2.3	3
PCB52	1992	1.1	0.31	-13	-12
	1993	1.8	0.56	-8	-5.6
	1994	2.1	3.1	5	10
	1995	2.6	2.4	-9.9	-4.9
	1996	2.6	-	34	37
	1997	3.1	-	1.5	4.6
	1998	1.6	-	0.54	2.1

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.7	0.45	-42	-40
	1993	1.6	0.74	-39	-37
	1994	1.6	2.3	-25	-21
	1995	3.1	1.4	-0.94	3.6
	1996	2.6	-	22	25
	1997	3	-	3.9	6.9
	1998	3.5	-	3.2	6.7
ΣPCB	1992	58	27	-1300	-1200
	1993	110	25	-1200	-1100
	1994	63	86	-1000	-850
	1995	70	47	-300	-180
	1996	90	-	-380	-290
suite-PCB	1997	75	-	-210	-140
suite-PCB	1998	70	-	-230	-160
phenan-threne	1992	260	100	-5500	-5100
	1993	180	60	-6800	-6600
	1994	130	310	-6800	-6400
	1995	500	59	5700	6300
	1996	190	100	2200	2500
	1997	270	96	1600	2000
	1998	110	75	830	1000
pyrene	1992	160	120	980	1300
	1993	140	74	67	280
	1994	210	220	-58	370
	1995	460	54	2600	3100
	1996	120	91	210	420
	1997	170	76	61	310
	1998	83	71	28	180
B(k)F	1992	120	52	140	310
B(k)F	1993	130	13	20	160
B(k)F	1994	92	58	70	220
B(b+k)F	1995	640	159	190	990
B(b+k)F	1996	219	152	98	470
B(b+k)F	1997	229	170	99	500
B(b+k)F	1998	149	143	100	390
B(a)P	1992	140	58	22	220
	1993	160	14	21	200
	1994	92	39	35	170
	1995	170	17	76	260
	1996	49	35	34	120
	1997	72	39	35	150
	1998	49	36	33	120
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	26000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
As	1992	-	-	-	-
	1993	-	5600	-	-
	1994	-	2900	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Se	1992	-	-	-	-
	1993	-	1800	-	-
	1994	-	3100	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	2100	-	-
	1994	-	4400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-

Table D2. IADN annual flows (kg/yr) from 1992 to 1998 for Lake Michigan

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	62	1.5	52	120
	1993	44	4	81	130
	1994	98	6.3	120	220
	1995	56	4.5	350	410
	1996	15	-	300	320
	1997	40	3.4	300	340
	1998	17	0.91	200	220
γ-HCH	1992	65	1.1	870	940
	1993	120	2	250	370
	1994	47	1.4	490	540
	1995	26	2.2	190	220
	1996	6.6	-	110	120
	1997	31	2.3	150	180
	1998	13	1.9	190	200
dieldrin	1992	58	8	-	-
	1993	55	7.2	-	-
	1994	62	23	-	-
	1995	47	20	-	-
	1996	30	-	-	-
	1997	24	15	-	-
	1998	31	18	-	-
p,p'-DDD	1992	-	3.8	-	-
	1993	6.4	0.98	-	-
	1994	16	-	-	-
	1995	1.6	1.9	-	-
	1996	1.8	-	-	-
	1997	0.36	0.76	3.5	4.6
	1998	2.9	0.99	5.3	9.2
p,p'-DDE	1992	3.8	0.48	-	-
	1993	11	1.4	-	-
	1994	3.5	-	-	-
	1995	7.4	1.4	-	-
	1996	3.9	-	-	-
	1997	2.5	-	-1.5	1
	1998	2.7	-	-12	-9.3
p,p'-DDT	1992	22	2.3	44	68
	1993	56	6.2	35	97
	1994	58	-	-	-
	1995	9.7	0.67	-	-
	1996	9	-	-	-
	1997	4.3	1.1	13	18
	1998	3	2	14	19
HCB	1992	2.6	0.38	24	27
	1993	13	13	1.2	27
	1994	1.1	0.19	-10	-8.7
	1995	1.4	0.35	8.3	10
	1996	0.91	-	8.3	9.2
	1997	0.75	-	16	17
	1998	0.83	-	26	27
PCB18	1992	0.91	0.18	-69	-68
	1993	1.3	0.46	-74	-72
	1994	1.6	1.2	-75	-72
	1995	2.6	1.1	-24	-20
	1996	1.7	-	-24	-22
	1997	0.82	-	-6.2	-5.4
	1998	1.4	-	-5.5	-4.1
PCB44	1992	1.4	0.32	-44	-42
	1993	1.2	0.67	-42	-40
	1994	9.1	1.4	-52	-42
	1995	1.8	1.1	-20	-17
	1996	0.97	-	-22	-21
	1997	1.3	-	-8.2	-6.9
	1998	2.8	-	-11	-8.2
PCB52	1992	1.2	0.24	-56	-55
	1993	1.1	0.55	-55	-53
	1994	2.3	1.4	-60	-56
	1995	3	2	3	8
	1996	2.2	-	2.2	4.4
	1997	1.7	-	7.1	8.8
	1998	1.9	-	11	13

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.4	0.33	-26	-24
	1993	0.81	0.66	-23	-22
	1994	1.7	1.1	-29	-26
	1995	2.1	1.6	-9.3	-5.6
	1996	1.4	-	-9.1	-7.7
	1997	1.1	-	-3.79	-2.7
	1998	1.7	-	-4.3	-2.6
ΣPCB	1992	52	16	-1300	-1200
	1993	86	24	-1200	-1100
	1994	71	39	-1400	-1300
	1995	78	41	-330	-210
	1996	48	-	-320	-270
suite-PCB	1997	25	-	-51.4	-26
suite-PCB	1998	38	-	-34	4
phenan-threne	1992	350	110	-	-
	1993	230	100	-	-
	1994	160	160	-	-
	1995	360	82	-	-
	1996	220	100	-	-
	1997	320	97	-	-
	1998	180	120	-	-
pyrene	1992	220	140	-	-
	1993	220	140	-	-
	1994	130	170	-	-
	1995	340	95	-	-
	1996	140	110	-	-
	1997	220	99	-	-
	1998	130	150	-	-
B(k)F	1992	130	56	-	-
B(k)F	1993	110	43	-	-
B(k)F	1994	73	63	-	-
B(b+k)F	1995	480	198	-	-
B(b+k)F	1996	258	197	-	-
B(b+k)F	1997	338	183	-	-
B(b+k)F	1998	278	288	-	-
B(a)P	1992	170	77	-	-
	1993	170	42	-	-
	1994	77	63	-	-
	1995	160	37	-	-
	1996	84	41	-	-
	1997	120	48	-	-
	1998	89	86	-	-
Pb	1992	-	-	-	-
	1993	-	16000	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
As	1992	-	-	-	-
	1993	-	820	-	-
	1994	-	1300	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Se	1992	-	-	-	-
	1993	-	910	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	4500	-	-
	1994	-	-	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-

Table D3. IADN annual flows (kg/yr) from 1992 to 1998 for Lake Huron

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	170	-	-	-
	1993	140	-	-500	-360
	1994	150	-	-490	-340
	1995	220	-	-50	170
	1996	160	-	-63	97
	1997	72	-	-15	57
	1998	40	-	-82	-42
γ-HCH	1992	-	-	-	-
	1993	260	-	-34	230
	1994	120	-	-19	100
	1995	110	-	32	140
	1996	93	-	29	120
	1997	100	-	56	160
	1998	130	-	37	170
dieldrin	1992	-	-	-	-
	1993	13	-	-760	-750
	1994	15	-	-720	-710
	1995	19	-	-	-
	1996	41	-	-	-
	1997	26	-	-	-
	1998	17	-	-	-
p,p' -DDD	1992	-	-	-	-
	1993	-	-	-	-
	1994	1.8	-	-	-
	1995	3.8	-	-	-
	1996	6.7	-	-	-
	1997	27	-	0.91	28
	1998	6.1	-	0.79	6.9
p,p' -DDE	1992	10	-	-	-
	1993	-	-	-	-
	1994	3.4	-	-	-
	1995	9.6	-	-	-
	1996	7.8	-	-	-
	1997	21	-	-5	16
	1998	6	-	-5	1
p,p' -DDT	1992	22	-	-	-
	1993	-	-	2.5	-
	1994	4.1	-	2.5	6.6
	1995	10	-	-	-
	1996	18	-	-	-
	1997	45	-	5.7	51
	1998	2.8	-	4	6.8
HCB	1992	5.8	-	-35	-29
	1993	11	-	-14	-3
	1994	3.3	-	-18	-15
	1995	3.6	-	-35	-31
	1996	1.3	-	-28	-27
	1997	3.6	-	-16	-12
	1998	0.92	-	-17	-16
PCB18	1992	17	-	-	-
	1993	4	-	-28	-24
	1994	0.94	-	-29	-28
	1995	-	-	-14	-
	1996	-	-	-15	-
	1997	-	-	-0.18	-
	1998	-	-	-4.9	-
PCB44	1992	20	-	-	-
	1993	5.2	-	-10	-4.8
	1994	2.5	-	-10	-7.5
	1995	-	-	-17	-
	1996	-	-	-15	-
	1997	-	-	-6.3	-
	1998	-	-	-6.6	-
PCB52	1992	7.6	-	-	-
	1993	11	-	-6.8	4.2
	1994	2.6	-	-6.7	-4.1
	1995	-	-	-7.3	-
	1996	-	-	-5.5	-
	1997	-	-	2	-
	1998	-	-	0.72	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	11	-	-	-
	1993	6	-	0.77	-
	1994	1.9	-	0.74	-
	1995	-	-	-7.7	-
	1996	-	-	-6.1	-
	1997	-	-	-2.7	-
	1998	-	-	-3.4	-
ΣPCB	1992	180	-	-	-
	1993	130	-	-490	-360
	1994	110	-	-460	-350
	1995	-	-	-240	-
	1996	-	-	-230	-
suite-PCB	1997	-	-	-23	-
suite-PCB	1998	-	-	-24	-
phenan-threne	1992	-	-	-	-
	1993	640	90	-	-
	1994	320	71	-	-
	1995	250	63	-	-
	1996	390	110	-	-
	1997	760	140	-	-
	1998	730	59	-	-
pyrene	1992	-	-	-	-
	1993	350	130	-	-
	1994	190	77	-	-
	1995	220	61	-	-
	1996	350	130	-	-
	1997	680	160	-	-
	1998	380	94	-	-
B(k)F	1992	-	-	-	-
B(k)F	1993	-	83	-	-
B(k)F	1994	-	48	-	-
B(b+k)F	1995	610	-	-	-
B(b+k)F	1996	-	257	-	-
B(b+k)F	1997	600	215	-	-
B(b+k)F	1998	420	158	-	-
B(a)P	1992	-	-	-	-
	1993	-	110	-	-
	1994	-	56	-	-
	1995	350	-	-	-
	1996	-	100	-	-
	1997	280	86	-	-
	1998	210	56	-	-
Pb	1992	100000	11000	-	110000
	1993	64000	8000	-	72000
	1994	47000	11000	-	58000
	1995	15000	7600	-	23000
	1996	18000	13000	-	31000
	1997	61000	12000	-	73000
	1998	28000	7300	-	35000
As	1992	11000	2200	-	13000
	1993	7500	1700	-	9200
	1994	6500	1200	-	7700
	1995	2200	710	-	2900
	1996	2700	2900	-	5600
	1997	-	1500	-	-
	1998	-	1200	-	-
Se	1992	17000	2700	-	20000
	1993	12000	2400	-	14000
	1994	10000	2600	-	13000
	1995	2700	110	-	2800
	1996	3100	1100	-	4200
	1997	-	590	-	-
	1998	-	570	-	-
Cd	1992	6600	470	-	7100
	1993	2900	310	-	3200
	1994	2300	410	-	2700
	1995	1400	170	-	1600
	1996	2000	310	-	2300
	1997	2900	490	-	3400
	1998	4100	280	-	4400

Table D4. IADN annual flows (kg/yr) from 1992 to 1998 for Lake Erie

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	84	1.2	140	230
	1993	35	2	290	330
	1994	19	3.4	300	320
	1995	29	0.9	120	150
	1996	6.3	-	44	50
	1997	5.4	0.25	81	87
	1998	1.5	0.2	93	95
γ-HCH	1992	46	0.45	60	110
	1993	23	1.3	83	110
	1994	22	0.83	68	91
	1995	13	0.6	45	59
	1996	1.7	-	47	49
	1997	5.3	1.3	41	48
	1998	0.51	0.51	38	39
dieldrin	1992	28	5.6	-300	-270
	1993	32	3.7	-120	-84
	1994	8.9	18	-110	-83
	1995	12	11	-110	-87
	1996	9.4	-	-110	-100
	1997	9.2	8.4	-82	-64
	1998	2.4	7.7	-80	-70
p,p' -DDD	1992	1.9	2	-	-
	1993	3.4	0.21	-	-
	1994	1.4	-	-	-
	1995	1.7	1.2	-	-
	1996	2	-	-	-
	1997	0.75	0.72	-	-
	1998	0.72	0.79	-	-
p,p' -DDE	1992	4.6	0.53	-	-
	1993	4.6	0.65	-	-
	1994	3.6	-	-	-
	1995	7.8	1.2	-	-
	1996	2.6	-	-	-
	1997	1.8	-	-26	-24
	1998	0.37	-	-25	-25
p,p' -DDT	1992	34	4.3	20	58
	1993	98	2.1	30	130
	1994	15	-	14	-
	1995	14	1.5	-	-
	1996	4.9	-	-	-
	1997	2.3	1.2	-9.9	-6.4
	1998	0.38	0.64	-12	-11
HCB	1992	0.88	0.2	-17	-16
	1993	5.4	6.4	0.76	13
	1994	0.4	0.21	-7	-6.4
	1995	0.73	0.22	-1	-0.05
	1996	0.34	-	-5.7	-5.4
	1997	0.3	-	-2.8	-2.5
	1998	0.23	-	-0.97	-0.74
PCB18	1992	0.34	0.12	-17	-17
	1993	0.57	0.21	-15	-14
	1994	0.56	0.74	-15	-14
	1995	1.4	0.6	-22	-20
	1996	0.43	-	-26	-26
	1997	0.35	-	-13	-13
	1998	0.1	-	-10	-9.9
PCB44	1992	0.55	0.23	-5.4	-4.6
	1993	0.81	0.43	-1.1	0.14
	1994	1.6	0.83	-5.2	-2.8
	1995	0.96	1.2	-11	-8.8
	1996	0.32	-	-16	-16
	1997	0.43	-	-3.4	-3
	1998	0.37	-	-6.3	-5.9
PCB52	1992	0.42	0.28	-5.8	-5.1
	1993	0.729	0.33	-2.2	-1.1
	1994	1	0.85	-5.2	-3.4
	1995	1.7	1.3	-8.6	-5.6
	1996	0.65	-	-13	-12
	1997	0.6	-	9	9.6
	1998	0.21	-	7.6	7.8

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	0.48	0.28	-2.2	-1.4
	1993	0.81	0.37	1	2.2
	1994	1.1	0.73	-2.6	-0.77
	1995	1.4	1.4	-5.2	-2.4
	1996	0.51	-	-6.6	-6.1
	1997	0.54	-	-1.1	-0.56
	1998	0.25	-	-0.74	-0.49
ΣPCB	1992	21	16	-200	-160
	1993	26	14	-100	-60
	1994	41	29	-200	-130
	1995	58	32	-220	-130
	1996	18	-	-310	-290
suite-PCB	1997	13	-	-160	-150
suite-PCB	1998	4.6	-	-120	-120
phenan-threne	1992	500	86	-	-
	1993	360	100	-	-
	1994	210	190	-	-
	1995	530	160	1600	2300
	1996	91	190	-770	-490
	1997	290	160	3600	4100
	1998	89	140	3600	3800
pyrene	1992	330	110	-	-
	1993	310	130	-	-
	1994	160	250	-	-
	1995	360	210	290	860
	1996	58	260	-80	240
	1997	210	180	370	760
	1998	50	170	350	570
B(k)F	1992	150	60	-	-
B(k)F	1993	140	84	-	-
B(k)F	1994	81	100	-	-
B(b+k)F	1995	560	580	52	1200
B(b+k)F	1996	158	430	15	600
B(b+k)F	1997	305	376	37	720
B(b+k)F	1998	93	441	39	570
B(a)P	1992	180	63	-	-
	1993	190	57	-	-
	1994	97	98	-	-
	1995	190	100	-0.75	290
	1996	50	120	-8	160
	1997	120	100	5.1	230
	1998	27	98	3.3	130
Pb	1992	-	-	-	-
	1993	-	13000	-	-
	1994	-	13000	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
As	1992	-	-	-	-
	1993	-	1500	-	-
	1994	-	1400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Se	1992	-	-	-	-
	1993	-	2800	-	-
	1994	-	2400	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-
Cd	1992	-	-	-	-
	1993	-	1100	-	-
	1994	-	1500	-	-
	1995	-	-	-	-
	1996	-	-	-	-
	1997	-	-	-	-
	1998	-	-	-	-

Table D5. IADN annual flows (kg/yr) from 1992 to 1998 for Lake Ontario

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
α-HCH	1992	52	-	-80	-28
	1993	32	-	-54	-22
	1994	33	-	-23	10
	1995	21	-	-5.7	15
	1996	31	-	-11	20
	1997	25	-	-18	7
	1998	21	-	-44	-23
γ-HCH	1992	50	-	-8.2	42
	1993	37	-	-1.5	36
	1994	24	-	7.9	32
	1995	13	-	12	25
	1996	26	-	17	43
	1997	50	-	6.8	57
	1998	33	-	3.4	36
dieldrin	1992	11	-	-330	-320
	1993	5.4	-	-200	-190
	1994	3	-	-180	-180
	1995	3.9	-	-230	-230
	1996	4.5	-	-210	-210
	1997	6	-	-110	-100
	1998	4.5	-	-120	-120
p,p' -DDD	1992	2.9	-	-	-
	1993	0.36	-	-	-
	1994	0.49	-	-	-
	1995	0.42	-	-	-
	1996	0.59	-	-	-
	1997	2.3	-	-	-
	1998	2	-	-	-
p,p' -DDE	1992	4.4	-	-96	-92
	1993	2	-	-99	-97
	1994	0.61	-	-80	-79
	1995	5.3	-	-	-
	1996	2	-	-	-
	1997	11	-	-21	-10
	1998	3.9	-	-24	-20
p,p' -DDT	1992	3.3	-	4.4	7.7
	1993	7.2	-	5.5	13
	1994	1.1	-	8.2	9.3
	1995	14	-	-	-
	1996	4.1	-	-	-
	1997	13	-	5.7	19
	1998	1.3	-	3.9	5.2
HCB	1992	6.1	-	-170	-160
	1993	3	-	-190	-190
	1994	0.62	-	-150	-150
	1995	0.73	-	-32	-31
	1996	0.87	-	-28	-27
	1997	0.87	-	-24	-23
	1998	0.56	-	-22	-21
PCB18	1992	2.5	-	-19	-17
	1993	0.28	-	-22	-22
	1994	0.35	-	-19	-19
	1995	0.81	-	-18	-17
	1996	0.71	-	-16	-15
	1997	-	-	-8.7	-
	1998	-	-	-10	-
PCB44	1992	3.6	-	-19	-15
	1993	5.7	-	-21	-15
	1994	0.66	-	-18	-17
	1995	2	-	-20	-18
	1996	1.4	-	-19	-18
	1997	-	-	-10	-
	1998	-	-	-10	-
PCB52	1992	1.6	-	-18	-16
	1993	1.4	-	-22	-21
	1994	0.93	-	-18	-17
	1995	2.5	-	-11	-8.5
	1996	2.5	-	-9.5	-7
	1997	-	-	-0.2	-
	1998	-	-	-2.1	-

		Wet Deposition	Dry Deposition	Net Gas Exchange	Total Deposition
PCB101	1992	1.7	-	-1.6	0.1
	1993	2.3	-	-2.4	-0.1
	1994	0.62	-	-0.84	-0.22
	1995	1.8	-	-6.2	-4.4
	1996	1.3	-	-5.4	-4.1
	1997	-	-	-2.4	-
	1998	-	-	-2.9	-
ΣPCB	1992	56	-	-450	-390
	1993	89	-	-570	-480
	1994	15	-	-450	-440
	1995	38	-	-230	-190
	1996	26	-	-230	-200
suite-PCB	1997	-	-	-19	-
suite-PCB	1998	-	-	-18	-
phenan-threne	1992	70	41	-510	-400
	1993	540	25	-	-
	1994	380	44	-	-
	1995	110	28	-	-
	1996	250	63	-	-
	1997	390	51	-630	-190
	1998	340	52	-410	-18
pyrene	1992	64	88	-46	110
	1993	470	55	-	-
	1994	220	48	-	-
	1995	130	46	-	-
	1996	260	83	-	-
	1997	450	72	-110	410
	1998	210	100	3.6	310
B(k)F	1992	33	92	-9.7	120
B(k)F	1993	-	79	-	-
B(k)F	1994	-	29	-	-
B(b+k)F	1995	173	105	-	-
B(b+k)F	1996	311	249	-	-
B(b+k)F	1997	210	225	3.5	440
B(b+k)F	1998	259	315	41	620
B(a)P	1992	54	86	-	-
	1993	-	79	-	-
	1994	-	43	-	-
	1995	63	29	-	-
	1996	110	60	-	-
	1997	81	60	-7.6	130
	1998	76	69	-8	140
Pb	1992	40000	4500	-	45000
	1993	27000	5300	-	32000
	1994	15000	6100	-	21000
	1995	7600	3300	-	11000
	1996	5000	5100	-	10000
	1997	21000	5100	-	26000
	1998	37000	5800	-	43000
As	1992	2900	570	-	3500
	1993	3100	720	-	3800
	1994	2100	630	-	2700
	1995	970	210	-	1200
	1996	580	610	-	1200
	1997	-	650	-	-
	1998	-	1000	-	-
Se	1992	5500	1000	-	6500
	1993	5000	1600	-	6600
	1994	3900	1800	-	5700
	1995	1300	150	-	1500
	1996	1100	340	-	1400
	1997	-	600	-	-
	1998	-	460	-	-
Cd	1992	2600	96	-	2700
	1993	1300	99	-	1400
	1994	550	130	-	680
	1995	530	49	-	580
	1996	390	100	-	490
	1997	1100	170	-	1300
	1998	1600	170	-	1800