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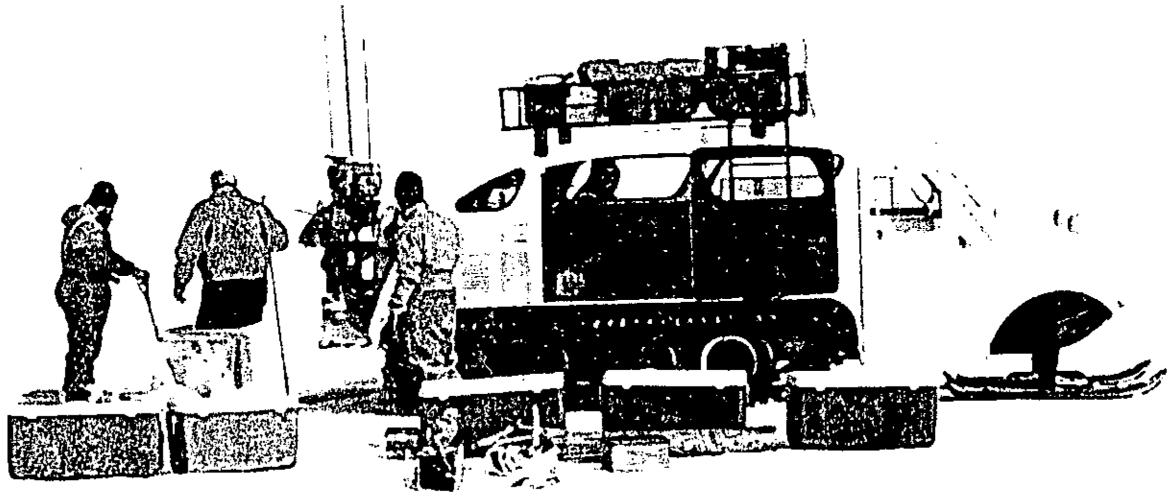
INFLUENCE OF THE 1997 RED RIVER FLOOD ON CONTAMINANT TRANSPORT AND FATE IN SOUTHERN LAKE WINNIPEG



Prepared for:

International Red River Basin Task Force

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February, 1999

1. ACKNOWLEDGMENT

This report is the result of a combination of efforts from numerous individuals.

- Gord Jacobson (Gimli, MB) provided safe transport to all of our sites on Lake Winnipeg in late February - early March and assisted with sampling.
- Terry Simcox, John Bartley, Brian Sparks, Frank Gnitzinger and Warren Magnusson of the Canadian Coast Guard (Gimli) crew of the Wabuno, transported us to our summer sampling sites and assisted with sampling.
- Hedy Kling, Cory Anema, Don Cobb, Bob Herzog, Alex Salki and Margret Friesen helped with summer sampling.
- Rick Wastle determined the ages of our fish.
- Bill Franzin arranged the collection of the October 1997 fish.
- Flow rate data was provided by Environment Canada
- Information on Herbicide use was provided by Manitoba Agriculture
- Pre-flood organochlorine data in fish was generously provided by Karen Kidd (Department of Fisheries and Oceans) and Derek Muir (Environment Canada).
- Ray Hesslein, Karen Kidd, Bill Last, and Paul Wilkinson provided scientific advice.
- Michael Stainton wrote nutrient sections.
- Alex Salki wrote zooplankton sections.

We greatly appreciate the assistance offered by Dwight Williamson (Water Quality Management, Manitoba Environment) in the preparation of the report and as a contact for the International Red River Basin Task Force.

2. EXECUTIVE SUMMARY

In response to the devastating effects of the 1997 Red River flood the International Joint Commission formed the International Red River Basin Task Force (RRBTF) to study aspects of the flood and make recommendations on ways to reduce the impacts of future floods. The present study sponsored by the RRBTF has been conducted to evaluate in detail the contaminant impacts of the flood, particularly the transport of contaminants in the Red River and their fate in the south basin of Lake Winnipeg.

Scientists with the Department of Fisheries and Oceans in Winnipeg began the study of contaminant transport during the flood event and collected water samples from sites upstream of Winnipeg (Floodway), downstream of Winnipeg (Selkirk), on the Assiniboine River, and at the north and south perimeters of the city. These flood samples along with water, sediment and biological samples collected from the south basin of the Lake Winnipeg in the year following the flood form the basis of this report. The objectives of this report are to: 1) quantify contaminant levels in flood samples – nutrients, metals, hydrocarbons, organochlorine pesticides and herbicides; 2) describe the relationship between contaminant transport and the flood event; 3) determine if any new sources of technical toxaphene were released into the Red River during the flood and subsequently transported into Lake Winnipeg; 4) describe the fate and source of loadings of contaminants in the south basin of Lake Winnipeg; 5) identify any contaminant issues related to the flood that would benefit from further study.

The following is a summary of the study's major findings.

Nutrients

- Unprecedented recorded mass of N and P was exported out of the Red River valley to the south basin of Lake Winnipeg by the flood of 1997.
- Regression analyses show that Red River watershed yield for N is as predicted by Brunskill et al. (1980) but is approximately 20% higher than predicted for P.
- The flushing rate for the south basin of Lake Winnipeg is the highest ever reported.
- In 1998 concentrations of total N and total P in the south basin of Lake Winnipeg were the highest on record.

- Algal biomass was diminished by an order a magnitude below previous years in the south basin of Lake Winnipeg in the summer of 1998.
- There is no obvious explanation for diminished algal productivity although light attenuation by re-suspended sediments is consistent with this event.
- Elevated levels of atrizine during the summer of 1998 warrant additional assessment

Zooplankton

- Zooplankton abundance in the south basin of Lake Winnipeg during July and August of 1998 averaged 198 individuals per litre, more than double (2.0 – 2.3X) levels detected in 1969 and 1994.
- Crustacean community structure in 1998 was consistent with the trend originating decades ago in response to eutrophication of the lake.
- The decreasing proportion of herbivorous calanoid species is consistent with limitation of primary production by light attenuation, particularly evident in the south basin in 1998.
- The increasing fraction of predatory cyclopoids and facultative cladocerans reflects rich food reserves of protozoan, ciliates, rotifers, bacteria and detritus that are increasingly available in Lake Winnipeg.
- The major impact of the 1997 Red River flood to south basin biota of Lake Winnipeg appears to be related to delivery of excessive nutrients and organic materials from its watershed.

Contaminants

Accurate identification of all flood related contaminant impacts requires a detailed analysis of all contaminant and ancillary data that has not been afforded in the time allocated for this report. In the meantime, the following are some preliminary conclusions and observations.

- Suspended sediment metal concentrations fell within 12% of their seasonal means during the flood, except for copper, mercury and cadmium, which were elevated over seasonal means on several occasions. Suspended sediment Cu, Zn, Hg and Cd concentrations were negatively correlated with total suspended solids, suggesting that these metals were diluted by high particle concentrations during the flood. Significant longitudinal and latitudinal gradients in surface sediment concentrations were found in the south basin of Lake Winnipeg. Lead, Cr, Ni, Fe and Ti concentrations were significantly lower at the southern sites than at the northern sites and Cd and Se concentrations tended to be higher at the southern sites than the northern sites. Differences in carbonate concentrations may be a factor in determining the distribution of Cd and Se.

- Concentrations of the herbicide tricyclopyr, triallate, ethalfluralin, trifluralin and the organophosphate insecticide chlorpyrifos followed the hydrograph of the flood. The post-frost and early spring application periods for these compounds make them susceptible to remobilization during a flood event.
- Maximum OC and PCB concentrations in water at Selkirk generally occurred at peak flow between May 2 and 7 and returned to background levels shortly after. Total dieldrin and chlordane followed the hydrograph closely, remaining elevated for a longer period of time. Results for both water and surface sediment samples for the south basin of Lake Winnipeg suggest that the Red River is an important source of ∑DDT and the Winnipeg River may be a source of ∑PCBs and other OCs. Multivariate congener analysis will be required to confirm these hypotheses.
- Concentrations of ∑chlordane, ∑DDT and ∑PCBs in walleye from Winnipeg Beach after the flood appear to be higher than in walleye collected from Riverton prior to the flood. Further statistical analysis is required to confirm that this increase is due to increased exposure and not differences in size or lipid content of the fish.
- Hydrocarbon concentrations in surface sediments in the south basin of Lake Winnipeg decrease from the mouth of the Red River northward, suggesting the Red River to be a primary source of the hydrocarbons. Significant transport and deposition of the PAHs are not likely related to the flood event.
- Technical toxaphene was released as a pulse during the flood, and was identified in Red River suspended sediments and water at Selkirk and the Floodway and in surface sediments from the south basin of Lake Winnipeg. Significantly higher

concentrations of toxaphene (lipid-adjusted) were found in walleye, sauger and burbot collected after the flood compared to walleye collected pre-flood. Initial analyses of the toxaphene congener profiles suggest that the post-flood fish may have been exposed to a new source of technical toxaphene.

3. TABLE OF CONTENTS

4. LIST OF TABLES

5. LIST OF FIGURES

6.0 INTRODUCTION

6.1 Flood of the century

In 1997, the Red River valley experienced its worst flood in over 100 years. A number of factors contributed to the severity of the flood including above average snow accumulation, a blizzard during the snowmelt period and high soil moisture conditions. At the peak of the flood discharge was estimated to be 793 m^3/s on April 17, 1997 at Fargo, ND, 3,850 m^3/s on April 18, 1997 at Grand Forks ND, 3,740 m^3/s on May 2, 1997 at Emerson MB, and 4,587 m^3/s on May 4, 1997 at Winnipeg MB (Currie et al. 1998). Peak flows at Winnipeg reached levels 2.5 times those recorded for the Nelson River at the same time of year. The flood resulted in the evacuation of over 103,000 people (75,000 in the US and 28,000 in Manitoba), destruction of physical property and potentially short-term and long-term impacts on water quality, particularly from contaminants mobilized during the flood (Currie et al. 1998).

6.2 Project Objectives

In response to the devastating effects of the 1997 Red River flood the International Joint Commission formed the International Red River Basin Task Force (RRBTF) to study aspects of the flood and make recommendations on ways to reduce the impacts of future floods. While the primary focus of the RRBTF was directed towards safeguarding human life and physical structures through flood preparedness, response, recovery, and mitigation efforts, some resources were allocated to assess contaminant impacts on the aquatic environment. A preliminary assessment of environmental impacts of the flood on water quality has been published by Currie et al. (1998). The present study sponsored by the RRBTF has been conducted to evaluate in detail the contaminant impacts of the flood, particularly the transport of contaminants in the Red River and their fate in the south basin of Lake Winnipeg.

Scientists with the Department of Fisheries and Oceans in Winnipeg began the study of contaminant transport during the flood event and collected water samples from sites upstream of Winnipeg (Floodway), downstream of Winnipeg (Selkirk), on the Assiniboine River, and at the north and south perimeters of the city. These flood samples along with water, sediment and biological samples collected from the south basin of the Lake Winnipeg in the year following the flood form the basis of this report. The objectives of this report are to: 1) quantify contaminant levels in flood samples – nutrients, metals, hydrocarbons, organochlorine pesticides and herbicides; 2) describe the relationship between contaminant transport and the flood event; 3) identify sources of technical toxaphene released during the flood; 4) describe the fate and source of loadings of contaminants in the south basin of Lake Winnipeg; 5) identify any potential impacts of the flood that would benefit from further study.

6.3 Physicochemical characteristics of Lake Winnipeg

A detailed description of the physicochemical characteristics of Lake Winnipeg can be found in Brunskill et al. (1980). A summary of the most pertinent characteristics is shown in Table 1. Lake Winnipeg is the 11th largest lake in the world by surface area with the south basin contributing approximately 12% of the surface area. Historically the south basin has a water renewal time of 0.4 to 0.8 yr., whereas the whole lake flushes once every 2.9 to 4.3 yr. (Brunskill et al. 1980). The Winnipeg and Red Rivers are the two main rivers flowing into the south basin. From the east the Winnipeg River drains a watershed composed of Precambrian Shield deposits overlain by glacial Lake Agassiz sediments. The Red River drains the predominantly prairie watershed to the south that is composed of sedimentary rock overlain by glacial Lake Agassiz sediments. Despite its relatively low concentrations of major and nutrient elements, the Winnipeg River contributes as much or more N, Ca, K, HCO_3 and Si to the south basin of Lake Winnipeg than the Red River, which has higher elemental concentrations (Brunskill et al. 1980). This is due to the large contribution of the Winnipeg River (75%) (Brunskill et al. 1980) to the annual water budget of the south basin. The Red River contributes a considerably higher proportion of P and SO_4^{2-} to the south basin than the Winnipeg River. What is unknown and probably highly variable is the extent to which these two water masses mix before exiting the south basin through the narrows.

The south basin of Lake Winnipeg is shallow (mean depth 9.7 m) and has little or no vertical stratification of temperature, oxygen, or dissolved elements. The basin is considered to be well mixed, however the plume of the Red River remains distinct and in variable locations throughout the summer (Brunskill et al. 1979). Horizontal gradients have been observed in many elements, suspended sediment, algae, zooplankton, and benthic biomass. Circulation patterns in the south basin are not well understood at this time. One theory is that water entering the south basin from the Red splits and flows north along the west and east shores until level with the mouth of the Winnipeg River where the water then turns inward forming eddies. Water entering the south basin from the Winnipeg River is thought to curl around Elk Island and move southward.

6.3 Sources of Contamination to the Red River and Lake Winnipeg

There are numerous sources that may have contributed to the contamination described in this report. Some sources can be directly related to the flood event while others may be related to anthropogenic activities in the region.

The Red River basin is unusually flat with the average change in elevation of the Red River of one-half foot per mile (0.15 m per 1.6 km) between Wahpeton, ND and the Manitoba border (International Red River Basin Task Force 1997). This makes the region susceptible to flooding without any natural barriers to keep the water back. During the 1997 flood the Red River exceeded its banks, spreading to a maximum width of 40 km in Manitoba, flooding farm properties, urban households, a rural town (St. Agathe), and farmland; each with their own retinue of contamination. A similar situation occurred south of the international border resulting in a potentially large input of contaminants into the Red River. Currie et al. (1998) reported the retrieval of over 550 containers from the Red River holding a variety of contaminants including solvents, propane, pesticides, fertilizer, and diesel fuel. Home heating fuel oil tanks were pulled from the Red River both in North Dakota and Manitoba and may have contributed hydrocarbons to the Red River. Other potential sources of contamination include two agricultural storage facilities in Grand Forks ND that were compromised during the flood. The basement of the AGSCO facility filled with water contaminated with toxaphene and lindane (γ-HCH) and a layer of sunflower oil containing heating oil, toxaphene and lindane (US EPA 1997). Toxaphene is an insecticide banned in the USA in 1982, but use of existing stocks was allowed until 1986. In Canada, toxaphene has not been registered for use since 1983. Lindane is presently registered in both Canada and the USA. Advanced analytical techniques were used by the Department of Fisheries and Oceans to detect and identify sources of toxaphene transported into the south basin of Lake Winnipeg.

The Red River basin is largely agricultural and there is seasonal use of pesticides that may enter the Red River during spring run-off or precipitation events. Within Lake Winnipeg itself there are several contaminant issues that have been identified. The large fetch and shallow depth of the south basin results in the re-suspension of previously deposited sediments that may reintroduce contaminants back into the water column; no estimates of reflux into the water column from sediments exist at this time. Mercury pollution has been a serious problem for the fishery in the Lake Winnipeg watershed. Earlier polluting incidents having resulted in closures of fisheries in at least two major tributaries, the English Wabigoon system draining into Traverse Bay in the South Basin and the Saskatchewan system draining through Cedar Lake to the North Basin. The Lake Winnipeg fishery itself was closed in 1970 because mercury levels in fish exceeded levels established to protect human health. On the Winnipeg River, the Pine Falls Pulp Mill and Manitoba Hydro's Great Falls generating station may be sources of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs), respectively, to the south basin of Lake Winnipeg. The radioactive isotope cesium-137 released by Atomic Energy of Canada Ltd. during the mid-1970s to the mid-1980s may be useful in understanding the distribution of PAHs and PCBs in the south basin of Lake Winnipeg (Lockhart et al. 1999; Winnipeg Red River Task Force 1995).

7. METHODS

This report presents information based on samples taken along the Red River during the flood and the following summer of 1997 and at sample sites in the south basin of Lake Winnipeg in winter (under ice) and summer of 1998.

7.1 Sampling of flood waters

Samples were collected during the 1997 flood at various points on the Red River, Assiniboine River and Winnipeg Floodway both upstream and downstream from Winnipeg (Figure 1). For purposes of this analysis we have used only data collected from the Selkirk sampling point for nutrients. Organic contaminants and metals were measured in samples from only two of the sites, Selkirk and the Floodway, due to cost restrictions.

Selkirk is located upstream of Lake Winnipeg, but downstream of Winnipeg and all major tributaries; water quality at this point reflects an integration of basin-wide processes. Samples were collected at varying frequency with the intent of accurately characterizing the chemical composition of the mass of water entering Lake Winnipeg during the flood. This varied from daily at the peak to bi-weekly as flows returned to normal. A total of 84 samples were collected, 22 from the Selkirk station (Appendix I, Table 1).

7.1.1 **Nutrient and Major Ions**

In the spring and summer of 1997 water samples for the analysis of nutrients and major ions were collected using a 2-L wide-necked polyethylene bottle held in a weighted frame and dropped by rope from the centre of the downstream side of various bridges spanning the Rivers and Floodway. Two 2-L samples were collected from each site and were returned to laboratories at the Freshwater Institute within 1/2 hour of sampling for processing and analysis. Samples were filtered and analyzed for perishable constituents on the day of collection as outlined in Appendix I, Table 2. All methods are described in Stainton et al. 1977 and their recent updates.

7.1.2 **Organic Contaminants and Metals**

Samples for contaminants were collected from the floodway and Selkirk a minimum of every 2-3 days from April 28, 1997 until June 2, 1997, then weekly at the Selkirk site for the month of June and monthly until the middle of October. Collections of river water were made from the center of a bridge by pumping water from 1 m below the surface into an 18-L stainless steel container. On several occasions when water levels had dropped in the river water samples were obtained by lowering the 18-L cans by a rope into the river and hauling up the filled cans. Suspended sediments were allowed to settle to the bottom of the 18-L cans and surface water was siphoned off the top, filtered, and extracted using an XAD column (Axys Environmental Systems, Sidney BC). Extracted water was then analyzed for OC contaminants and herbicides. Approximately halfway through the extraction of the floodwater samples it was realized that the XAD columns would not extract the acid-herbicides (e.g. 2,4-D, dicamba) and an alternative extraction process was adopted. A 2L-herbicide sample was taken off the top of the 18-L cans and extracted using solid phase extraction (SPE) to ensure removal of the acid-herbicides. The suspended sediment was then centrifuged to remove the remaining water and stored at 4°C until analysis for OCs, hydrocarbons and metals.

Flow rate data was obtained from Environment Canada at stations best corresponding to our sampling sites (Figure 1). These stations included the Red River near Lockport MB, Floodway near the gates, Red River at St. Norbert, Red River at St. Agathe, and the Assiniboine River.

7.2 Sampling of Lake Winnipeg Surface Sediment and Water

Samples were collected from sites in the south basin of Lake Winnipeg during the period of 23 February to 6 March 1998 and in the summer of 1998. Sites were visited during the winter by bombadier through a contract with Mr. Gordon Jacobson, a local fisherman from Gimli MB. There were 11 sites on 3 transects extending 52 km north from the mouth of the Red River to the latitude of Hnansa (Figure 2). Sites were separated in latitude by 4 km for sites 1 to 9, by 10 km for sites 10 and 11 and separated in longitude by 4 to 7 km (distance increased towards the northern sites). The sites were located on the ice using a global positioning system (GPS) (Appendix I, Table 3). The ice thickness and water depth at each site at the time of sampling are shown in Appendix I, Table 4).

7.2.1 Nutrient and Major Ions

In the winter of 1998 samples of water from the south basin of Lake Winnipeg were collected under ice from 33 stations on three transects (Figure 2). Again in the summer of 1998 surface samples were collected along these same transects. As with floodwaters, samples were returned to the Freshwater Institute on the day of collection for processing and analysis.

In all 84 samples of Red, Assiniboine and Floodway water and 50 samples of water from the south basin of Lake Winnipeg were collected and analyzed for the constituents in Appendix I, Table 2. Data is stored in dBase format along with longitudes and latitudes and various physical parameters and is available by contacting the authors.

7.2.2 Organic Contaminants and Metals

At each of the 33 sites, the top 0.5 cm of sediment of a grab sample (using an Eckman dredge sampler) was placed in a whirl-pak and kept at 4°C until analyzed for organic contaminants. At sites 4B, 9A, 9B, and 9C large volume (100L) water samples for OC analyses were collected along with zooplankton samples for taxonomy and biomass analysis. Water was filtered and extracted in the field using high volume water sampling system and XAD column from Axys Environmental Systems (Sidney BC). Gravity cores were also collected at these sites and sliced for radioisotopic dating and contaminant analysis. Results of those analyses will be published elsewhere.

Lake Winnipeg sites on latitudinal transects near Winnipeg Beach (4A, 4B, 4C), Gimli (7A, 7B, 7C) and Hnausa (11A, 11B, 11C) were revisited during the summer of 1998 on July 14 and 16, August 16 and 21, and September 15. On each occasion, water samples were collected for OC contaminant and nutrient analysis and zooplankton samples were collected for OC contaminant, stable isotope, taxonomic and biomass analysis. Plankton samples for contaminants and stable isotopes were collected using a 0.5-m diameter net with 160-μm netting. Sub-samples of plankton were taken to determine the percentage of algae to zooplankton in the sample. Taxonomic samples were taken using methods described below. Water samples for OC contaminants and nutrients were collected by pumping water from 1 m below the water surface into an 18-L stainless steel container or into a 1-L Nalgene® bottle, respectively.

7.3 Sampling of Biota

7.3.1 **Fish**

Several species of fish representing different feeding groups caught in the southern region (Winnipeg Beach) and northern region of the basin (Riverton) were purchased from fishermen in October 1997, June 1998 and September 1998. Fish were dissected and muscle tissue, plus liver in case of the burbot, was analyzed for OC compounds and metals. Individual fish were aged using otoliths or opercula, depending on the species. Whenever possible sexes were assigned, which was difficult due to the immature state of many of the fish.

Contaminant concentration in fish can be influenced by biological factors such as size, age, sex and lipid that should be considered when comparing different groups of fish within a given species. Morphological information for the fish collected from Lake Winnipeg is shown in Table 2. Within species comparisons indicated that burbot, freshwater drum, sauger and walleye were significantly different in size and age ($P<0.05$) among the sample times (Oct 97, July 98 and Sept 98). The size of yellow perch did not vary significantly among sample times. The ages of freshwater drum, sauger and walleye differed significantly among sample times ($P<0.05$), but the ages of the burbot and yellow perch did not.

7.3.2 **Zooplankton**

Field and laboratory procedures used in the RRBTF study followed methods detailed in Patalas and Salki (1992). During the March winter survey, zooplankton were collected from 7 stations in the South Basin of Lake Winnipeg (Figure 3), and in July, August and September from 9 stations using a Wisconsin net of 25 cm mouth diameter and 72 μm mesh netting. At each station, the net was drawn once from the bottom to the surface and the samples were preserved in a 5% formalin solution. Zooplankton samples were examined at 63X with all specimens identified to species and a minimum of 200 animals enumerated. Entire samples were scanned for larger and rare specimens.

7.3.3 **Mayflies**

Mayflies have been shown to serve as effective biomonitoring organisms for a variety of contaminants (Arnold et al. 1997; Corkum et al. 1997). For this reason mayflies were sampled at several locations on the Red River and around the south basin of Lake Winnipeg in the summer of 1998. Unfortunately, mayfly emergence was low or non-existent at many of those sites. There are several possible explanations for the poor mayfly recruitment including an unusually early emergence that was missed, unsuitable temperature conditions for emergence, changes in sediment composition that impacts the burrowing behavior of the larvae, or toxicological impacts. Further study of the biology of mayflies in the south basin would be required to determine the actual cause of the limited emergence. Sufficient individuals for analysis were collected at the Bridge-Drive In (BDI) in Winnipeg on July 17, 1998 at Selkirk on July 19, 1998 and at Gimli on July 8, 1998. Individuals were separated by sex and molt stage and analyzed separately for OC contaminants and for metals, when there was sufficient material.

7.4 Analytical Methodology

7.4.1 **Metals**

Methods for metals analysis are described elsewhere (Lockhart et al. 1993). Detection limits and instrumentation for individual elements and matrices are shown in Appendix I, Table 5.

7.4.2 **Herbicides**

Herbicides were analyzed according to methods described in Rawn (1998). A list of method detection limits and information on the use of herbicides in Manitoba are shown in Appendix I, Table 6. The organophosphate insecticide chlorpyrifos is included with the herbicides since it is analyzed using the same methodology.

7.4.3 **Organochlorine pesticides**

The list of organochlorine compounds measured in this study is shown in Appendix I, Table 7. Methods for organochlorine compounds have been described in elsewhere (Appendix I, Table 7).

7.4.4 **Toxaphene**

Samples were analyzed using high resolution gas chromatography electon capture negative ion high resolution mass spectrometry (HRGC/ECNI/HRMS) in the selected ion mode on a Kratos Concept high resolution mass spectrometer (EBE geometry) controlled using a Mach 3 data system. Selected ion ECNIMS was performed at a resolving power of M/ M ~12000. Argon (UHP) was used as the moderating gas and perflurokerosene (PFK) as the mass calibrant. Optimum sensitivity was obtained at a gas pressure of ~2 x 10^{-4} torr as measured by the source ion gauge. The electron energy was adjusted for maximum sensitivity (~180 eV), the accelerating voltage was 5.3 kV and the ion source temperature was 120°C. The following characteristic ions were monitored from the $(M-Cl)^-$ isotopic cluster of the hexa- to nonachlorobornane homolog groups; Cl_6 308.9352, 310.9323; Cl_7 342.8962, 344.8933; Cl_8 376.8573, 378.8543; Cl_9 410.8183, 412.8154. Four groups were set up to monitor the different homologue groups. The hexa- and heptachlorinated components were monitored in the first group, the hexa-, hepta- and octachlorinated components in the second, the hepta-, octa- and nonachlorinated components in the third and the nonachlorinated components along with the m/z 409.7747 and 411.7718 ions from the $(M-4Cl)^-$ isotopic cluster of $^{13}C_8$-Mirex in the fourth group. The ions used for quantification, underlined above, in the chlorine homolog classes are summed for a total toxaphene area, which is quantified against the area of a toxaphene standard (Radian Corporation) calculated in the same manner. $^{13}C_8$-Mirex was monitored to correct for any variation in source performance of the mass spectrometer between runs.

GC separations were performed on a Hewlett Packard model 5890 Series II gas chromatograph using a 60 m x 0.25 mm i.d. DB-5ms fused silica column (film thickness 0.24 μm) which was connected directly to the ion source of the mass spectrometer. Helium was used as the carrier gas. Samples were run using splitless injection with the injector temperature set at 260°C. The initial column temperature was 80°C; at 2 minutes the oven was ramped at 20°C min^{-1} to 200°C, then at 2°C min^{-1} to 230°C then at 10°Cmin^{-1} to a final temperature of 300°C and held for 8 minutes. Electronic pressure programming was used to increase the pressure during the injection cycle and then to maintain a constant flow of 1-ml min^{-1} during the remainder of the run. All injections were made by a CTC A200SE autosampler under data system control.

7.4.5 **Hydrocarbons**

The analysis of polycyclic aromatic hydrocarbons (PAH), alkylated PAH, and alkanes in environmental samples was performed by high-resolution gas chromatography and mass selective detection in sim mode. Instrument and method detection limits for hydrocarbons are shown in Appendix I, Table 6. Details of the methods are also shown in Appendix I, Table 8.

7.4 Statistical Analysis

Statistical relationships were determined using SAS v.6.12. Statistical significance was accepted at $p=0.05$.

8. RESULTS AND DISCUSSION

8.1 Red River

8.1.1 **Nutrient Loadings (N and P) from the Flood of 1997**

The 1997 flood provided a unique opportunity to both monitor the characteristics of an unpredictable event and to calibrate models of nutrient yield and impact in the Red River - Lake Winnipeg system at the high extreme of discharge and loading.

A flood events of this magnitude in the Red River- Lake Winnipeg system would be expected to be linked to or to cause several occurrences:

- The magnitude of the area flooded, the duration of flooding and the discharge rate all serve to deliver a large mass of nitrogen, phosphorus and suspended solids to the South Basin of Lake Winnipeg.
- Increases in the use of N and P fertilizers and livestock populations in the last 25 years would be expected to increase the yield of N and P per km^2 over values estimated by Brunskill et al. (1980).
- The same conditions, which caused the flooding of the Red River Valley also, generated extraordinary discharge from the Winnipeg River. These combined flows would significantly decrease the residence time of water in the south basin.
- Red River waters have a very low N/P ratio and are the dominant source of phosphorus in the south basin. Extreme loadings from the Red would lower the N/P ratio of the south basin creating a more favorable regime for dominance by blue-green algae.
- The elevated loading of suspended solids from the Red River into the south basin would decrease light penetration and further light limit algal productivity.

Data Analysis

Total nitrogen and total phosphorus data produced by this study and discharge data provided by Environment Canada were used to compute daily and annual loadings. Total nitrogen is the sum of dissolved nitrogen and particulate nitrogen. Total phosphorus is the sum of dissolve phosphorus and suspended phosphorous. Daily mass transports of N and P and discharges were computed using linearly interpolated flows and concentrations to define both the peak and base flow periods and were summed to give annual loadings (Figs. 4-6). Loadings for N and P for 1997 along with results reported by Brunskill et al. (1980) appear in Table 3.

The 1997 Flood was extreme in both water discharged and mass of N and P delivered to the South Basin of Lake Winnipeg and provides and opportunity to further calibrate N and P yield regressions estimated by Brunskill et al. (1980) and examine some of their predictions regarding increases in N and P loading.

Brunskill et al.1980 calculated yields of N and P on a per km^2 basis for the Red River basin and derived a linear relationship between yield and discharge.

P Flux (moles/km^2/yr) = -18.2+(3.87*10^{-8})*Q(m^3/yr) where Q = Discharge $R^2 = 0.96$
(Without 1970 data)

N Flux (Moles/Km^2/yr) =-1.46*10^3+(8.24*10^{-7})*Q(M^3/yr) $R^2 = 0.79$
(With 1970 data)

The regression for P yield was calculated by Brunskill et al. (1980) omitting data for 1970, apparently because the 1970 P load was considered erroneously high. The regression for N yield however included the value for N. We have recalculated the regression derived by Brunskill et al (1980) omitting 1970 data to obtain:

N Flux (moles/km^2/yr) =-1.46*10^3+(5.80*10^{-7})*Q(m^3/yr) $R^2 = 0.79$
(Without 1970 data)

We have recalculated these relationships (using an area of 287,500 km^2 for basin area) and including 1997 data and find an excellent linear fit for both N ($R^2 = 0.98$) and P ($R^2 = 0.96$) (Figs 7a-b).

P Flux (moles/km^2/yr) = -74.7+(4.74*10^{-8})*Q(m^3/yr) where Q = Discharge $R^2 = 0.96$

$$N\ Flux\ (moles/km^2/yr) = -5.82*10^2 + (6.29*10^{-7})*Q(m^3/yr) \qquad R^2 = 0.98$$

Table 4 shows 1997 predicted (Brunskill et al (1980)) and observed N and P yields from the Red River drainage basin.

It appears that, in spite of increases in Nitrogen fertilizer application and the inundation of previously unflooded land, the N yield relationship observed by Brunskill (1980) still holds at extraordinarily high discharge rates. This may in part be due to a change in the form of N being applied from more mobile (NO_3) to less mobile NH_3.

The same is not the case for phosphorus, however, which shows a 20% increase in yield per km^2 over the early 70s. Whether this change in P yield reflects a true increase in human impact or is simply a demonstration that P yield is not linearly related to discharge will require further analysis of data from the years intervening 1974 to 1997.

At this writing 1997 discharge data for the Winnipeg River was not available. We have used the strong linear relationship between Red and Winnipeg River annual discharges to estimate Winnipeg River discharge for 1997. Using the sum of Red and Winnipeg river waters and the assumption of 0.5 m of evaporation, the residence time of water in the South basin in 1997 was calculated to be 0.34 years or 18 weeks, which is significantly shorter that the range reported by Brunskill et al. (1980) of 0.43 to 0.83 years. With perfect mixing of Red and Winnipeg river waters, most of the 1997 Flood water and it's soluble conservative constituents would have left the south basin by the summer of 1998.

8.1.2 **Contaminants in water and suspended sediment**

8.1.2.1 <u>Metals</u>[1]

For most metals, concentrations in suspended sediment at the Floodway and Selkirk sampling sites fluctuated over the flood period, but did not deviate significantly from concentrations recorded in the fall (October 15, 1997) (Fig. 8, Appendix II, Table 1). The coefficients of variations (CV = standard deviation/mean x 100) for the metals

[1] All metal concentrations are reported on a dry weight basis unless otherwise specified.

were within 12% except for manganese, copper, mercury and cadmium. Manganese concentrations were lower than fall concentrations during the flood, possibly due to dilution, and tended to become more variable near the end of the flood period in June. On three occasions near the end of the flood, copper concentrations were elevated over all other sample days (Floodway – 557 μg/g), but otherwise were within ambient concentration ranges of copper for Manitoba surficial lake sediments (Environment Canada 1997a). If the three elevated copper concentrations are removed, the mean copper concentrations for the Selkirk and Floodway sites is 70 μg/g, which is twice the interim freshwater sediment quality guideline for copper (35.7 μg/g). Mercury concentrations peaked with flow (floodway - 0.147 μg/g) and then declined to concentrations recorded in the fall (mean 0.07 μg/g). At no time did mercury concentrations exceed the recommended interim freshwater sediment quality guideline for mercury of 0.17 μg/g (Environment Canada 1997b). Interim sediment quality guidelines for zinc (123 μg/g) (Environment Canada 1997c) and chromium (37.3 μg/g) (Environment Canada 1997d) were exceeded by their seasonal means for 1997 (148 μg/g and 99 μg/g, respectively). Despite having exceeded the suggested guideline, zinc concentrations in the Red River fell within the range of background levels recorded for Manitoba. Chromium concentrations in the Red River fell just outside the range for background concentrations (35 – 90 μg/g) in sediments considered uncontaminated by human activities (Environment Canada 1997d).

Metal loadings for both the Floodway and Selkirk sites (Fig. 9) closely follow loadings of total solids or particles at each site (Fig. 10) with minor deviations for manganese, copper, and mercury. These deviations could indicate that some factor other than particulate concentration might be influencing the transport of these metals in the Red River. Organic carbon concentrations closely follow the pattern for total solids, but carbonate concentrations do not. Carbonate appeared to be diluted by the high particle loads resulting in a trend in concentration that is the inverse of that observed for total solids (r^2=-0.60, p<0.05). Copper, Zn, Hg, and Cd concentrations were negatively correlated with total solids concentrations (p<0.05) and therefore, likely diluted by increased particle load during the flood. Factors such as changes in particle mineralogy and source input (sewage versus agricultural run-off) or differences in leaching potential of the metals might explain variations in concentrations and loadings among metals.

8.1.2.2 Herbicides and Organophosphate insecticide

Herbicide concentrations detected in water from the Red River at the Floodway and at Selkirk during the spring and summer of 1997 are provided in Appendix II, Table 2. Minimum concentrations in the Red River during the spring flood and summer of 1997 were below the method detection limits for virtually all the herbicides except for atrazine at Selkirk and the Floodway, dacthal at Selkirk, metolachlor at the Floodway and triallate at the Floodway (Table 5). Herbicide concentrations in the Red River at Selkirk tended to peak during mid-June to mid-July corresponding to application periods and did not follow the hydrograph of the flood (Fig. 11). Herbicides such as tricyclopyr, triallate, ethalfluralin, and trifluralin and the organophosphate insecticide chlorpyrifos were elevated during the flood and tended to follow the hydrograph. These compounds are usually applied after first frost in the fall, or during pre-plant in May or early June and could be easily mobilized during spring run-off or a flood-event. The Canadian water quality guideline for chlorpyrifos was exceeded once at the Floodway and three times at Selkirk (CCREM 1987). All other herbicides remained below suggested Canadian water quality guidelines.

8.1.2.3 OC Pesticides, PCBs and other industrial OC contaminants

Concentrations of organochlorine pesticides and PCBs in water and suspended sediments collected from the Floodway and the Red River at Selkirk are shown in Appendix II, Table 3 and Table 4, respectively. Maximum concentrations of OC contaminants in water at Selkirk occurred at peak flow between May 2 and 7 (Figure 12). Several compounds such as the ΣCBZ, DDT, ΣPCB, and PCB 153 were elevated over a very short period of time during the peak flow and then returned to background levels. Chlordane and dieldrin followed the hydrograph more closely and remained elevated for a longer period of time prior to and after peak flows. Total HCH (predominantly γ-HCH) concentrations fluctuated over the season between <0.01 and 3 ng/L, but reached a level of 5.3 ng/L on the May16, 1997. Total toxaphene reached maximum concentrations several days after peak flow on May 20, 1997. The fact that these two compounds reached maximum concentrations several days after the other OC compounds may correspond to the release of toxaphene and lindane from the AGSCO storage facility in Grand Forks ND, based on information provided by the U.S. EPA (Al Lang, Denver CO, personal communication). When the toxaphene contaminated oil and water was discovered in the basement of the storage facility on April 29, 1997 the concentrations of toxphene and lindane in the oil were 170,000 μg/L and 21,000 μg/L, respectively. This occurred 8 days after peak flow occurred in the area (April 21, 1997) and therefore, flushing of the contaminated oil into the floodwater may have occurred up until action was taken to contain the contaminated water. Contaminated water was found in a nearby drainage ditch, suggesting that the toxaphene and lindane were being removed from the basement.

Suspended sediment OC concentrations also reached a maximum during peak flow and followed a similar trend to organic carbon (Fig. 13). A second smaller peak was found for ΣChlordane, ΣCBZ, ΣHCH, ΣDDT, ΣPCB, and dieldrin near May 20 that lasted several days for some compounds. A second peak was found for total suspended solids, but not for organic carbon. Suspended sediment concentrations were higher than water concentrations for all of the OCs except for the more hydrophilic compounds ΣCBZ and ΣHCH, which were lower than maximum levels found in water.

Toxaphene by HRMS

The delayed peak in toxaphene concentrations in water at the Floodway and Selkirk determined by GC-ECD was confirmed by HRMS (Figs. 14-15, Appendix II, Table 5) along with a similar delay in the peak of toxaphene concentration in suspended sediments (Fig. 16-17, Appendix II, Table 6). To determine if the toxaphene in the water and suspended sediment samples consisted of a new or old source, the toxaphene congeners Hx-sed and Hp-sed concentrations were plotted as a percent of total toxaphene in the sample over the flood period. The Hx- and Hp-sed congeners are consider to be the dead-end metabolites of technical (new) toxaphene in the environment and, therefore, a lower ratio of Hx-sed + Hp-sed to total toxaphene should indicate a newer source (undegraded). This is in fact what was found. The ratio ranged from 4 to 13 during the flood period and 16 to 22 during the summer and fall after the flood. The higher ratio after peak flow suggested that an older source of toxaphene was being remobolized and probably represented a typical summer loading. The lower ratio indicates that a new source of toxaphene was released as a pulse during the flood, possibly from the compromised storage facility in Grand Forks ND. Suspended sediment ratios for these congeners were also lower during the flood period (~3-6) relative to the ratios measured in late June to mid-July (~10-13). Selected ion chromatograms of chlorinated bornanes (Cl_6 - Cl_9) in Lake Winnipeg and Red River water at Selkirk also suggested that a new source of toxaphene was released during the flood. The chromatograms for water collected during the flood was very similar to the technical toxaphene mixture showing an increase in the predominance of higher chlorinated congener peaks and a corresponding decreased presence of the Hp-sed and Hx-sed congeners (Fig. 18). Profiles for Red River water at Selkirk in mid-July 1997 and in Lake Winnipeg water in September 1998 show a shift to the lower chlorinated congeners with Hx-sed and Hp-sed peaks predominating. This result indicates that the toxaphene in these samples represent an older toxaphene source. Chlorinated bornane chromatograms for suspended sediment in Red River water on April 30, 1997 and July 15, 1997 and in surficial sediment in the south basin of Lake Winnipeg do show a shift toward the lower chlorinated congeners and an increase in the Hx-sed and Hp-sed peaks (Fig. 19). Surficial sediments taken in March 1998 after the flood show the Hx-sed and Hp-sed peaks as well as some of the higher chlorinated congener peaks, in contrast to surface sediments taken prior to the flood that show Hx-sed and Hp-sed as the predominant congeners.

8.1.2.4 Hydrocarbons (PAH and Alkanes)

Concentrations of 47 hydrocarbon compounds measured in suspended sediments in the Red River at the Floodway and at Selkirk are shown in Appendix II, Table 7. Total PAH (napthalene to benzo(e)pyrene and phenanthrene to benzo(e)pyrene) on suspended particles at Selkirk followed each other closely and tended to be lower in concentration than the total alkylated PAHs. Due to limited sample material, values for the PAHs are only available from May 9, 1997. Concentrations of total PAH decreased from approximately 260 ng/g to ~150 ng/g and then peaked again at slightly higher concentrations 298 ng/g on May 29, 1997 after which they begin to decrease (Figs. 20a-b). The alkylated compounds also show a similar peak followed by a decrease and another peak around May 29, 1997, although the second peak continues to climb for several weeks until June 19, 1997. A similar peak was observed for the OCs.

8.2 Lake Winnipeg

8.2.1 **Nutrients**

Impact of N and P Loading on Lake Winnipeg

We have compared nutrient and algal data obtained from two post flood south basin surveys, conducted in the spring (under ice) and summer of 1998, with similar data sets for 1969 (Brunskill - unreported data), 1992 (Manitoba Environment), 1994 (Stainton - Namao Cruise -Unreported data) and 1996 (Stainton - Namao Cruise - Unreported data). With the exception of 1992 all data have been produced by the analytical unit of the Freshwater Institute using consistent methodology and analysts. Data from 1992 were produced by the Manitoba Department of the Environment Laboratory. With the exception of 1992, total N and total P are the sum of dissolved and particulate N and P. For 1992, data are from a singular analysis for total N and total P each. Where annual average values are reported these are simple arithmetic means of data from all stations in the south basin (between Lattitudes 50.5 and 51.5) from June to September (with the exception of samples from the spring of 1998).

Chlorophyll levels in 1998 were surprisingly low given the immense loading of dissolved and particulate nutrients delivered to the basin in 1997. The mean of 1.74 μg/L under ice and 4.98 μg/L during open water are at the low end of the historic record for the south basin. Figure 21 also shows that the variance in 1998 is also considerably lower than in past. Variance in previous years is both spatial (depending on the position of the Red River plume) and temporal (elevated values in August when bloom conditions for nitrogen fixing algae often develop). From the 1998 chlorophyll data it appears that algal growth was constrained to a low and consistent level.

Water delivered to the south basin of Lake Winnipeg from the Red River has a very low N/P molar ratio (5- 14 during the flood period). At molar ratios below 22 algal growth is constrained by nitrogen limitation giving nitrogen fixing species (blue-greens) a competitive advantage over other algal species. Many of these nitrogen fixing species produce toxins that are implicated in fish kills, livestock poisonings and acute and chronic health problems in humans. In Figure 22 the historic range and means of N/P ratio in particulates is shown. Again 1998 is extraordinary both for the lowest N/P ratio and the lowest variance of that ratio. In previous years (particularly 1994 and 1996) there is a wide variance of N/P ratio which tends to increase throughout the summer months as blue-green algae come to dominance, begin fixing nitrogen and raise the N/P ratio. This did not happen in 1998.

Figures 23a and 23b shows the historic record of total N and total P in waters of the south basin. As can be seen, 1998 is again extraordinary having the highest levels of total N and total P and the least variance in these levels. There also appears to be an increasing trend in total N levels over time but not of total P. Certainly nutrient limitation was not a factor constraining chlorophyll levels and by inference algal productivity.

We assume that the high levels of total N and total P observed in the south basin in the summer of 1998 represent contributions from decomposition and resuspension of sediments deposited in the summer of 1997. While little is known of mixing in the south basin it is assumed that the flushing rate of 18 weeks computed for the summer of 1997 would remove dissolved N and P before the summer of 1998.

Figures 24 and 25 show the relationship between Chlorophyll and total N and P. For total N, the relationship to Chlorophyll is surprisingly strong ($R^2 = 0.990$) while that for total P is non existent ($R^2 = 0.09$). These figures demonstrate clearly a nitrogen limitation to algal growth normally found in the south basin. However, Figure 24 also shows dramatically an extraordinary limitation to algal growth in 1998 not previously observed in the south basin.

While low chlorophyll (and by inference low productivity) of under ice samples can be explained by severe light limitation and lack of mixing this is more difficult to explain in mid summer. Algal growth in the south basin is limited initially by nitrogen availability but ultimately by light by attenuation. While algal communities can overcome nitrogen limitation via a shift to nitrogen fixing blue-greens, growth is ultimately limited by the light attenuation of high levels of suspended sediments in south basin waters. Light attenuation normally limits algal biomass to 2-5 mg/L (H. Kling personal communication) with chlorophyll values ranging from 5- 100 μg/L Algal biomass from late August in 1998 was less than 400 μg/L with chlorophyll values ranging from 2 – 11 μg/l, an order of magnitude lower than the historic norm.

While there is some anecdotal information indicating a decrease in Secchi depth in 1998 (A. Salki, Freshwater Institute, personal communication) from 0.75 metres in 1969 and 1994 to 0.35 metres in 1998 it is not clear that this decrease (and the increase in light attenuation it indicates) is enough to explain the large inhibition to algal growth seen in Figure 24. Preliminary analysis of selected algal samples indicate they are largely made up of resuspended cell remains and large numbers of bacteria. (H. Kling personal communication). Consistent with these observations of detrital remains and high levels of bacteria are results of measurements of pCO_2 taken in the summer of 1998 (Fig. 26a), which were 2x higher than atmospheric (350 ppm) and indicate that the south basin water column was strongly dominated by respiration. (Stainton unpublished data)

Observations of resuspension of sediments (elevated nutrient levels and algal remains) provide some link between the sediment loading of the 1997 flood and potential light limitation of productivity in the summer of 1998. However data for suspended carbon (Fig. 26b) a surrogate for suspended solids, seems to counter -indicate light limitation as the source of inhibition, as levels of particulate carbon are at the low end of the historic range. We therefor cannot discount other sources of explanation for the decrease in algal productivity in 1998. Figure 29 shows elevated levels of atrazine and de-ethyl atrazine in waters of the south basin during the summer of 1998. The source of this herbicide and its impact on algal productivity warrant further study.

What is required, and we have not been able to do, is to correlate algal biomass and community structure with water chemistry and the zooplankton community structure observed in the summer of 1998 in an attempt to identify factors and relationships that were constraining algal biomass. As noted above those few samples that have been analyzed were dominated by resuspended algal remains and bacteria. Although sufficient samples exist to answer some of these questions they have yet to be analyzed.

It would also seem important to conduct follow up studies related to these observations in 1999. In the south basin, the extent to which low productivity in 1998 impacts higher trophic levels (benthos - whitefish) should be determined and in the north basin the impact of high N and P levels concentrations that apparently were unused in and exported from the south basin should be monitored.

Summary

- Unprecedented recorded mass of N and P exported out of the Red River valley to the south basin of Lake Winnipeg by the flood of 1997
- Regression analysis shows that Red River watershed yield for N is as predicted by Brunskill et al. (1980) but is approximately 20% higher than predicted for P.
- The flushing rate for the south basin of Lake Winnipeg is the highest reported.
- In 1998 concentrations of total N and total P in the south basin of Lake Winnipeg were the highest on record.
- Algal biomass was diminished by an order a magnitude below previous years in the south basin of Lake Winnipeg in the summer of 1998.
- There is no obvious explanation for diminished algal productivity although light attenuation by re-suspended sediments is consistent with this event.
- Elevated levels of atrizine during the summer of 1998 warrant additional assessment

8.2.2 Zooplankton

The crustacean plankton community of the south basin of Lake Winnipeg one year after the 1997 Red River Flood.

Crustacean plankton, typical inhabitants of lakes and other bodies of standing water, are usually well buffered from environmental change by the physical, chemical and thermal inertia of their habitat. However, the 1997 Red River flood was such a massive hydraulic event that concerns were expressed about its impact on the ecosystem of Lake Winnipeg. The load of contaminants and sediment transported by floodwaters into the south basin represented a potential threat to components of the food web including crustacean zooplankton whose feeding and grazing activities could be impaired. Delay of biological sampling until 1998 introduced some complication into the assessment of biotic responses to the flood. Given the significantly shortened water residence time, approximately 18 weeks, in 1997 and the relatively rapid turnover time of some planktonic populations, several generations of algae and zooplankton would be produced and flushed out of the south basin before possible flood induced changes could be evaluated. This necessitated reliance on longer-term responses in zooplankton such as the bioaccumulation of persistent organic contaminants and changes in species composition, abundance and distribution patterns, to provide clues about the effect of 1997 flood.

Zooplankton are an important source of food for all commercially valuable Lake Winnipeg fish species. Consequently, they serve as (1) vectors to transfer contaminants such as mercury and PCBs to fish, and (2) sensitive indicators of the health of the fishery. One year after the flood, elevated levels of PCB, DDT and toxaphene were detected in south basin bulk zooplankton samples in July and August (see section 8.2.5.1). The burden of xenobiotics in zooplankton likely resulted from ingestion of contaminated algal cells, detritus and sediment particles. The affect of long-term sub-lethal exposure to these substances on planktonic development is unknown. In addition, the influence of sediment bound contaminants on benthic phases of crustacean development requires study. Copepods normally diapause or lay eggs in epilimnetic sediments. Exposure to toxic chemicals during this portion of their life cycle could result in high rates of mortality or deformity in succeeding generations. Certain species of cyclopoid copepods are known to continue feeding during diapause (Krylov *et al.* 1996) so contaminants may be ingested for most of their life cycle. Zooplankton, particularly longer-lived, larger species preferred by planktivorous fish, could accumulate organic contaminants and transfer them to fish for extended periods, particularly in the shallow well mixed south basin where sedimentary particles are continuously re-suspended.

Finally, diapausing copepods could be buried by an impenetrable layer of sediment swept into Lake Winnipeg by the flood. High sediment loads would also reduce light levels to the impairment of visual predators, interfere with filtering activity of grazers, or reduce primary production. These cumulative impacts on zooplankton could be detected in succeeding years by a reduction in abundance or diversity resulting from decreased survivorship and fecundity.

This section documents the results of research conducted on crustacean plankton in the south basin of Lake Winnipeg during March, July, August and September of 1998, the objective of which was to characterize zooplankton abundance, species composition and distribution for comparison with previous studies on the lake by Bajkov (1930), Patalas and Salki (1992) and Salki (1996). Abnormal changes in the zooplankton community might signify environmental consequences of the 1997 flood.

Winter survey

The first post-flood glimpse of Lake Winnipeg zooplankton came from samples collected in March 1998 (Table 6). Crustacean abundance and species diversity in the south basin were low compared to the summer community that year but similar to winter aggregations in other lakes. Total abundances ranged from 4.3 to 8.9 per litre in the southern half of the basin with slightly lower values, from 2.8 to 4.2 individuals per litre at stations along the northern transect (Fig. 3). Chandler (1940) found, during the period January to May 1939, 2.1 copepods per litre, on average, in the western basin of Lake Erie, an area morphologically similar to the South Basin of Lake Winnipeg. Thus, winter zooplankton abundance in Lake Winnipeg during March 1998 was 2 – 3x that reported for Lake Erie.

Only three species, *Diacyclops bicuspidatus thomasi*, *Diaptomus ashlandi*, and *Bosmina longirostris* inhabited the water column in the south basin during March 1998. *D. ashlandi* adults and nauplii dominated the plankton throughout the basin. Gravid females were found at all stations and accounted for 30% of total females while males represented 50% of all mature specimens. Such high proportions of males and gravid females usually indicate favorable environmental conditions (Davis 1961). *Diacyclops b. thomasi* females with eggs, however, were not detected and males comprised only 30% of the adult population. This species produced eggs continuously from January to July in smaller, shallower prairie lakes (Salki 1981). The lack of *D. b. thomasi* egg-bearing females in Lake Winnipeg is currently unexplainable. Of the three species of zooplankton found in the south basin in March 1998, *D. ashlandi* was reported as a principal form in the lake during winter 1928/29 (Bajkov 1930). *Diaptomus ashlandi* also occured in Lake Erie during March (Robertson 1966). *Diaptomus sicilis* and several cyclopoid species were other chief components of the south basin winter community in 1929. The absence of *D. sicilis* in March 1998 is not likely a consequence of the 1997 flood because this species was not found in the south basin during the open water seasons of 1969 (Patalas and Salki 1992), 1994 (Salki 1996) or 1998. It now appears to be restricted to the north basin in low numbers during the open water season. The presence of a single cyclopoid species, *D.b. thomasi*, in March 1998 instead of several as in 1928/29 could be related to sampling location. Stations in 1928 may have been located closer to shore where littoral cyclopoid species are more common.

Summer Surveys

Zooplankton were extremely numerous and diverse in the south basin of Lake Winnipeg during July, August and September of 1998. Mean total crustacean abundance reached 198 per litre in July and August and 130 per litre in September (Table 6). These levels were approximately 2.3 and 2 x higher than averages obtained from comparable sets of stations during 1969 and 1994, respectively (Figs. 3 and 27). They also surpassed zooplankton abundance recorded in eutrophic Lake Erie in 1968 prior to implementation of phosphorus controls when densities reached between 128 and 184 individuals per litre (Patalas 1972). Total crustacean abundances above 300 individuals per litre seen at Transect 4 stations in August are comparable to zooplankton densities observed in hypereutrophic prairie ponds (Salki 1981).

Remarkably high total abundances were encountered in most stations throughout the 1998 study (Table 7, Appendix III Tables 1-4). Western and eastern stations in each transect were usually richer in plankton than central stations. The southern Transect 4 exhibited the highest mean seasonal values, 222.08 individuals per litre, with abundance decreasing to 134.5 individuals per litre at northern Transect 11. Temporally, crustacean abundance peaked at all transect 4 stations in August, at all Transect 11 stations in July and at some intermediate time at Transect 7 stations. While this spatial and temporal pattern was generally visible in Lake Winnipeg during midsummer 1969, an obvious distinction in 1998 was the enrichment of plankton in the central area of the south basin. In 1969, densities higher than 200 individuals per litre were limited to littoral areas near the western shores of the south basin. In 1998, levels of this magnitude extended throughout the entire mid-lake area.

Changes in zooplankton abundance are usually related to, among other things, the amount of nutrients available for primary production and water temperature in a particular lake. Patalas and Salki (1992) found a good correlation ($r^2 = 0.86$) between midsummer crustacean density and annual mean total phosphorus concentration in inflowing waters for the Laurentian Great Lakes and 1969 values in Lake Winnipeg. A multiple regression with epilimnion temperature and phosphorus concentration in inflowing water used as independent variables gave a high correlation coefficient, $r^2 = 0.97$. For 1997, calculations indicated that the mean concentration of total phosphorus in the Red and Winnipeg Rivers was 105 mg/m^3, a level corresponding closely to the mean concentration of total phosphorus of 117 mg/m^3 observed in the south basin during 1998 (see section 8.2.1 Nutrients). According to the relationship defined by Patalas and Salki (1992), this amount of total P should result in approximately 120 to 130 crustaceans per litre during 1998. Undoubtedly, water temperatures also played an important role in stimulating zooplankton growth. The summer of 1998 was the warmest on record for much of Canada and water column temperatures in the south basin of Lake Winnipeg, averaging 19.0 C° during September 1998, were 2-3 C higher than values in September 1969. On the basis of mean air temperatures recorded at the Experimental Lakes Area meteorological site during 1998 (M. Lyng, personal communication), summer water temperatures in the south basin probably attained an average of 21.0 C° during 1998. Applying the water temperature and phosphorus concentration values to the multiple regression described by Patalas and Salki (1992) predicts a zooplankton abundance of 136 individuals per litre. The much higher zooplankton abundance observed in 1998 suggests additional factors are now promoting crustacean development.

The species composition of the crustacean community in 1998 was similar to that found in previous years (Table 6). Of the 14 to 15 species found in each open water survey in 1998, cyclopoids accounted for 2 or 3 species, calanoids for 5 or 6 species, and cladocerans for 5 or 7 species. A similar composition was found in the 1969 and 1994 surveys. However, one important exception was the capture of *Mysis relicta* in September 1998 samples. This species had not been previously detected in 300 samples collected throughout the entire lake during 1969 or 1994 nor in 6 net hauls taken in the north basin in 1996. *Mysis*, a negatively phototactic crustacean, was originally found in the benthos of Lake Winnipeg mainly in the north basin and described as a common whitefish prey item (Bajkov 1930). Between 1929 and 1969, the lake mean abundance of *M. relicta* declined from 2.8 to 0.3 individuals per m^2 (Flannagan and Cobb 1994). The appearance of *Mysis* in 1998 matches the response of this species in Southern Indian Lake where decreased water transparency, associated with impoundment and shoreline erosion, led to an upward shift in the daily position of *Mysis* so that it was captured in plankton nets (Patalas and Salki 1984). In September 1998, secchi disc visibility ranged between 0.25 and 0.4 m (mean 0.35 m) among 7 south basin stations while in 1994 water transparency readings ranged from 0.3 to 1.3 (mean 0.75 m) among similar locations. Bajkov (1930) reported a mean secchi depth of 1.5 in the south basin during 1928/29. Very low water transparencies in September 1998 apparently altered the light regime sufficiently for *Mysis* to migrate into the water column. The decreased light levels may be related to the 1997 flood event that carried sediments and nutrients into the south basin.

The summer zooplankton community of Lake Winnipeg appears to be undergoing a structural modification that was likely enhanced by the 1997 flood. Comparison of the relative abundance of the three crustacean groups in 1998 with the two previous studies revealed a doubling of cyclopoids, from 17.4% to 37.6%, accompanied by a decline in calanoids, from 71.2% to 46.9%, between 1969 and 1998 (Figure 28). Cladocerans exhibited a moderate upward trend from 11.4% in 1969 to 15.5% in 1998. The nature of this trend is identical to that observed in the Laurentian Great Lakes by Patalas (1972) who found a diminishing significance of calanoids accompanied by increasing predominance of cyclopoids and cladocerans in the lake series progressing from oligotrophic Lake Superior to eutrophic Lake Erie. During the past 70 years, Lake Winnipeg has received increasing amounts of dissolved and particulate nitrogen and phosphorus as rates of agricultural activity, industrialization and urbanization climb in the Red River drainage basin. In 1997, total N and total P supplied by the Winnipeg and Red Rivers to the south basin reached unprecedented levels, 14.4 g TN/m^2 and 2.5 gTP/m^2 of lake surface area. Despite the large supply of nutrients, surprisingly low levels of chlorophyll in the south basin in 1998 (see section 8.2.1 Nutrients). As shown in section 8.2.1 and Brunskill (1979), primary production in the south basin appears to be limited by light attenuation resulting mainly from sediment re-suspension. While calanoids, the dominant group of phytoplankton grazers in Lake Winnipeg, declined relative to cyclopoids and cladocerans, the two main species *D. ashlandi* and *D. siciloides*, were twice as abundant in 1998 as in 1969 (Table 8). It is quite likely that higher calanoid grazing rates reduced algal standing crops, ultimately controlled by light, thereby lowering chlorophyll levels in Lake Winnipeg during 1998. Further, the significantly higher proportion of predatory cyclopoids and increasing numbers of large cladocerans (*Daphnia* and *Leptodora*) in the south basin clearly reflects an increased supply of detritus, rotifers, protozoans and bacteria, i.e. food items that abound in eutrophic conditions. The enrichment of cyclopoid and cladoceran food resources is supported by evidence from a comparison of pCO^2 levels in the south basin in 1994 and 1998 that indicates a predominance of respiration over primary production during 1998 and a balance between production and respiration in 1994 (section 8.2.1 Nutrients).

Comparison of the midsummer abundance of individual species in 1969,1994, and 1998 revealed several trends that were possibly related to the 1997 Red River flood. The appearance of *Mesocyclps edax* in the open water pelagic zone of the south basin demonstrated the physical capacity of inflowing Red River floodwaters to influence species distributions. In 1969, *Mesocyclops* was only found in September in littoral areas near the mouths of inflowing rivers (Patalas and Salki 1992). During 1998, it was identified in all sampled transects in the south basin from July to September. *Mesocyclops* was likely transported by the intensified 1997 Red River plume to mid-lake locations where reproduction and egg deposition allowed population development in 1998. In a similar fashion, the Winnipeg River, also with higher flows during 1997, may have transported *Holopedium gibberum* into the middle of the south basin. This species was found at station 11B in August 1998 although in 1969 it was restricted to the Traverse Bay area.

Several species exhibited large increases in abundance between 1969 and 1994: cyclopidae copepodids (mainly *A. vernalis*) (29.7x), *Daphnia galeata mendotae* (5.3x), *Leptodora kindtii* (4.7x), cyclopidae nauplii (4.4x), *Diaphanosoma leuchtenbergianum* (4.2X) and *Daphnia retrocurva* (3.1x) (Table 8). In contrast, four of six calanoid species declined to levels that were only 20 - 30 % of former numbers in 1969. *D. ashlandi* and *D. siciloides* essentially doubled in abundance between 1969 and 1998.

The dramatic rise of *C. vernalis*, *D. ashlandi*, and *D. siciloides* in 1998 is closely tied to the continuing eutrophication of Lake Winnipeg. *Diaptomus. siciloides* was not found by Bajkov (1930) in Lake Winnipeg although it did occur in other lakes within the watershed. *Cyclops. vernalis* and *D. ashlandi* were the dominant cyclopoid and calanoid species, respectively, in the eutrophic western basin of Lake Erie (Patalas 1975). The species composition of both lakes exhibits a high degree of overlap (Table 9). *Diaptomus. siciloides* was rare or absent in Lake Erie between 1928 and 1930 (Wilson 1929, 1960; Wright 1955), but by 1956-1957 it had become the second most common diaptomid in Lake Erie (Davis 1962). It appears to be duplicating this increase in Lake Winnipeg. The disappearance of *D. sicilis* from the south basin of Lake Winnipeg and the subsequent replacement by *D. siciloides* mimics the species change that occurred during the eutrophication of Lake Erie (Davis 1966).

Substantial increases in large *Daphnia* in 1998 were likely related to food web changes accompanying the eutrophication of Lake Winnipeg. . Daphnia normally graze on edible phytoplankton but are known to utilize bacteria and detritus as food items in sewage oxidation ponds (Daborn et al. 1978, Peterson et al. 1978). *Daphnia retrocurva* and *D. g. mendotae* were more abundant in the eutrophic western basin of Lake Erie than in its' mesotrophic eastern basin (Patalas 1975, Table 9). The high proportion of gravid females found throughout the south basin in summer 1998 (Appendices 1B - 1E) indicates that food was plentiful and grazing activity was not impaired. Adverse environmental conditions in 1997 may have prompted development of large numbers of ephippia for recruitment in 1998. Salki (1981) observed polycyclic production of ephippia by Daphnia in eutrophic prairie lakes subject to frequent algal bloom collapses and anoxia.

Leptodora kindtii, a large predatory cladoceran, was found in unusually high concentrations, approaching 2 individuals per litre, in some samples in 1998. The increases in *Leptodora* and *Daphnia*, species that are preferred food items of many Lake Winnipeg fish species, may also signify reduced predation pressure from planktivores.

Finally, the fact that *Cyclops vernalis*, a cyclopoid that diapauses in the sediment during winter, increased significantly would suggest that sediment entrapment did not play an inhibitory role in the life cycle of this and similar species. Long-term population and community effects of contaminant bioaccumulation, however, require further investigation.

Summary

Although immediate impacts of the 1997 Red River flood on south basin Lake Winnipeg zooplankton could not be investigated, findings of the Task Force study suggest that some remnant effects could be detected in the midsummer crustacean community of 1998. Further research will be required to determine if these changes are permanent or reversible.

Responses of Lake Winnipeg zooplankton to the 1997 flood are consistent with changes initiated earlier this century when increased human activity in the Red River Basin began to alter nutrient loadings from the watershed. A major effect of the flood was to amplify the delivery of nutrients, contaminants, sediments and perhaps bacteria that were scavenged from inundated farmlands, manure piles, livestock feedlots, retention ponds, and chemical and fuel storage facilities, to the south basin of Lake Winnipeg. Structural changes in the crustacean community observed in 1998 compliment the modification of the resource base associated with eutrophication of the lake. Nutrients and bacteria have contributed to increased rates of respiration in the south basin of the lake that ultimately stimulate secondary production by cyclpoids and cladocerans. In the year following the 1997 flood, crustacean abundances in the south basin rose to levels above those found at any other time in the past and have exceeded densities common in eutrophic Lake Erie prior to phosphorus controls. Since utilization of nutrients by primary producers in the south basin appears to be constrained by light availability (Brunskill 1979), excess nutrients, if transferred to the north basin, may ultimately disrupt the ecosystem in the northern part of this reservoir.

8.2.3 **Contaminants in Water**

8.2.3.1 Herbicides

Herbicide concentrations in water samples taken from sites in the south basin of Lake Winnipeg under the ice in March 1998 and in July and September 1998 are shown in Figure 29 (Values are provided in Appendix II, Table 2). Under ice herbicide concentrations are well below summer concentrations with only atrazine, triallate, alachlor, metolachlor and dacthal being detected. Concentrations are generally higher at site 4B and 9C, which are near the mouths of the Red and Winnipeg Rivers, respectively. In July during peak application periods for most of the herbicides, concentrations were elevated at sites 4B and 11B relative to site 7B. Concentrations of MCPA and 2,4-D were higher at site 11B than at site 4B while the reverse was found for alachlor and metolachlor. Equivalent concentrations of atrazine and de-ethyl atrazine were detected at sites 4B and 11B. Similar patterns in September are observed for MCPA and 2,4-D, but the other herbicides showed some changes. Concentrations higher than level measured during the flood period of de-ethyl atrazine and atrazine were found at site 7B and 11B in September. In contrast to trends observed in July, elevated levels of alachlor and metolachlor were detected at site 7B relative to sites 4B and 11B.

8.2.3.2 OC Pesticides, PCBs and other industrial OC contaminants

Concentrations of OCs in water collected from sites in the south basin of Lake Winnipeg under ice in March and in the summer in July and September 1998 are shown in Figure 30, Appendix II, Table 3. Concentrations varied over season and site with higher concentrations obtained in March. Concentrations of ΣDDT tended to be higher at sites nearest the mouth of the Red River corresponding to results obtained for surface sediments. Site 4B was elevated in most of the OC compounds relative to the other sites in March, but not in the summer months, thus indicating potential accidental contamination of the sample.

8.2.4 Contaminants in Surficial sediment

8.2.4.1 Metals

Metal concentrations in surface sediment grabs collected from the south basin of Lake Winnipeg in the winter of 1998 are shown in Table 10. Interim freshwater sediment guidelines were exceeded for Zn and Cr at all of the sites (Environment Canada 1997c and d). Statistically significant differences in sediment metal concentrations were found among sites (1 - 11) extending south to north and transects (A, B and C) spanning west to east. Sediment Pb, Cr, Ni, Fe and Ti concentrations were significantly lower at the southern sites than at the northern sites ($p<0.05$). Cadmium and Se concentrations showed the reverse trend and tended to be higher at the southern sites than the northern sites ($p<0.05$). Differences among transects were observed for several metals ($P<0.05$), whereby Hg concentrations tended to be higher along the shorelines (transects A and C), Cd, Zn, Al and As tended to increase from west to east (A<C), V and Mn tended to decrease from west to east (A>C).

Several factors might be responsible for the longitudinal and latitudinal trends in sediment metal concentrations including particle size or mineralogy, carbonate or organic carbon content of the sediment and sources of metal contamination. Concentrations of total N and organic carbon did not vary significantly among longitudinal sites or latitudinal transects (Table 11). Phosphorus concentrations were higher along the westerly transect than the middle or east transect ($p<0.05$). Carbonate concentrations were significantly different among longitudinal sites with concentrations at the southern sites tending to be higher than at the northern sites. Carbonate concentrations tended to be higher on the west side of the basin than the east similar to the Cd trends. Overall, Cd concentrations were highly dependent on carbonate concentrations ($R^2=0.998$, $p=0.0002$), suggesting that the Cd may be associated with the carbonate (Fig. 31). However, initial analyses of Paleozoic carbonates have found undetectable concentrations of Cd (William Last, University of Manitoba, Winnipeg MB personal communication). To resolve this issue Cd should be analyzed in each of the discrete size fractions. Selenium was also dependent on sediment carbonate ($R^2=0.987$, $p=0.016$).

8.2.4.2 <u>OC Pesticides, PCBs and other industrial OC contaminants</u>

Organochlorine concentrations in surface sediments from the south basin of Lake Winnipeg are shown in Figure 32 and Appendix III, Table 5. Chlorinated benzene, ΣHCH, ΣCHLOR, and ΣPCB show elevated concentrations at sites near the mouth of the Winnipeg River and may indicate the river as a source of contaminants to the south basin of Lake Winnipeg. Radioisotope signals for Cs^{137} originating from AECL in Pinawa indicate that sediments are transported around Elk Island and then get deposited to the south. In contrast ΣDDT shows a prominent decrease in concentration from the mouth of the Red River northward suggesting that the Red River is the source of DDT to the south basin. Dieldrin does not show any particular pattern to suggest a source of the compound.

Toxaphene by HRMS

Toxaphene concentrations in surface sediments collected from sites in the south basin of Lake Winnipeg show elevated concentrations of toxaphene near the mouth of the Red River and at the mouth of the Winnipeg River (sites 7-10) with levels higher in the middle transect (B) than the west transect (A) (Fig. 33). The ratio of Hx-sed and Hp-sed to total toxaphene concentrations ranged from 15 to 35 and appear to decline from the mouth of the Red River northward with peaks at sites 5 and 6 and at site 11 (Fig. 34).

The elevated toxaphene concentrations and lower ratio of Hx-sed and Hp-sed near the mouth of the Winnipeg River are puzzling, given that the source of the new toxaphene was the Red River. The ion chromatograms for the chlorinated bornanes (Cl_6-Cl_9) for surface sediment collected at sites 9B indicate that the toxaphene in the sediments collected one year after the flood consists of a mixture of the degraded toxaphene present in pre-flood sediment (7A) and the new technical toxaphene introduced via the Red River during the flood (Fig. 19).

8.2.4.3 Hydrocarbons (PAHs and Alkanes)

Hydrocarbons in surface sediments in the south basin of Lake Winnipeg show a consistent decrease in concentrations from the mouth of the Red River northward (Figs. 35-36, Appendix II, Table 6). Transect C on the west side of the basin tended to have higher concentrations than the east for both the non-alkylated parent compounds and combustion products as well as the alkylated compounds. A peak in concentrations in nearly all of the PAHs was found at site 9A suggesting a possible point source. Site 9A is situated north of Gimli. Retene an indicator of wood smoke was elevated at sites 9, 10 and 11, which might be expected given the influence of the Pine Falls Pulp mill on the Winnipeg River. Suspended sediment concentrations did not exceed interim sediment quality guidelines developed for 13 PAHs (Environment Canada 1997e)

8.2.5 **Contaminants in Biota**

8.2.5.1 Mayflies and Zooplankton

Contaminant concentrations in mayflies for Winnipeg (BDI), Selkirk and Gimli are shown in Appendix II, Table 7. Considerable variability in OC concentration among sexes and molt stage was found (Fig. 37). Female sub-imagos tended to have higher concentrations than other sex and molt stage combinations. Comparisons among female sub-imago samples indicate the highest concentrations were in mayflies from the BDI. Mayflies from Selkirk were intermediate, and Gimli had the lowest concentrations of ΣCBZ, Σchlordane, ΣDDT and ΣPCB. Chlordane concentrations in female sub-imagos at Selkirk (~3-4.5 ng/g) were higher than at the BDI or Gimli.

Organochlorine concentrations in zooplankton samples collected from sites in the south basin of Lake Winnipeg in 1998 are shown in Figure 38 and Appendix II, Table 8. Organochlorine concentrations varied in both time and space. Total DDT concentrations were marginally higher at sites nearest the Red River and lowest at Hnausa (sites 11). In July and September ∑DDT concentrations were elevated at site 7B, which is in the middle of the basin on the same latitude as Gimli. Total PCB concentrations were considerably lower in September than in July and August. Peaks in ∑PCBs were found at 7B and at 11A and 11B in August. The peaks at 11A and 11B may reflect the influence of the Winnipeg River, although further investigation would be required.

Toxaphene by HRMS

Toxaphene concentrations were determined in mayflies (female, sub-imago) collected at sites in the Red River at Winnipeg and Selkirk and at Gimli in the south basin of Lake Winnipeg. Concentrations are compared to mayflies collected prior to the flood in 1996 at Grand Beach, Winnipeg Beach, and Hussavik in the south basin (Fig. 39, Appendix III, Table 9). Toxaphene concentrations were higher in mayflies collected from the Red River than at Gimli in 1998. Mayflies collected from the south basin of Lake Winnipeg after the flood had overall lower toxaphene concentrations that may be comprised of a newer source of the toxaphene compared to pre-flood mayflies. The toxaphene concentration in the mayflies did not appear to vary according to lipid content in pre- and post-flood mayflies. The Degree of Chlorination Index (DCI) calculated for mayflies (female, sub-imago) collected after the flood were slightly lower (0.62-0.65) than the DCI for mayflies collected prior to the flood (0.69-0.84). Assuming that the bioaccumulation of toxaphene is consistent between these mayflies, the lower DCI suggests that the post-flood mayflies were exposed to a new toxaphene source. Overall, the DCIs calculated for all the post-flood mayflies were lower than the pre-flood mayflies (Appendix III, Table 10).

Toxaphene concentrations in plankton samples, predominantly zooplankton were similar across sample sites in July with elevated concentrations at sites 4A, 7A, and 7B (Fig. 40). Concentrations decreased from July to August and there was an increasing trend from west to east in August plankton. The DCI for August samples (0.89) was very similar to July samples (0.91).

8.2.5.2 Fish

8.2.5.2.1 **Metals**

Mercury concentrations in fish were similar among species and sample times except for burbot and freshwater drum, which had considerably lower concentrations in October 1997 and September 1998, respectively (Fig. 41 Appendix III, Table 11). Selenium concentrations were also found to be similar among the fish species and time with the lower concentrations in the burbot and walleye.

8.2.5.2.2 **OC Pesticides, PCBs and other industrial OC contaminants**

Organochlorine concentrations in fish collected near Winnipeg Beach in October 1997 and September 1998 and Riverton in July 1998 are shown in Fig. 42 and Appendix III, Table 12. Concentrations of OCs in walleye collected from Riverton prior to the flood in 1996 are also shown (Fig. 42). Organochlorine concentrations varied among sample times and species and tended to correspond to percent lipid, but not in all cases. For example, walleye collected from Riverton in July 1998 had higher ΣDDT, Σchlordane, and ΣHCH and comparatively lower percent lipid than walleye caught in October 1997 or October 1996. Further statistical analysis to determine the relationship of fish size and lipid content to OC concentration is required before it can be determined if the 1997 flood had an impact on the bioaccumulation of OCs.

Toxaphene concentrations in fish varied among species and date of collection, primarily due to differences in lipid content (Fig. 43, Appendix III, Table 13). Fish collected from Riverton in July had lower percent lipid concentrations than fish caught the previous fall at Winnipeg Beach. As pointed out in the methods section the fish collected are different in both size and age and those factors may also influence toxaphene concentrations. Burbot livers had the highest toxaphene87 concentration (179±42) and perch muscle had the lowest (1.5±0.5). Toxaphene concentrations were significantly related to lipid content and so concentrations were lipid adjusted using analysis of covariance (ANCOVA). Burbot (liver), sauger and walleye caught at Winnipeg Beach in October 1997 were higher in toxaphene concentration than pre-flood walleye from Riverton (Fig. 44). Site of collection may be a factor in the higher toxaphene concentrations measured in the Winnipeg Beach fish, particularly for the burbot, which tend to be bottom feeders and thus have a narrower feeding range. The lower ratio of Hx-sed and Hp-sed to total toxaphene and the lower DCI in the post-flood fish relative to the pre-flood fish suggest that the fish may have been exposed to technical toxaphene (Figs. 45-46).

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10. LIST OF APPENDICES

Table 1. Physicochemical characteristic of Lake Winnipeg (Brunskill et al. 1980).

Parameter	South Basin	Whole Lake
Surface Area (km^2)	2780	23750
Volume (km^3)	27	284
Mean Depth (m)	9.7	12
Maximum Depth (m)	14	36
Inflow (m^3/yr. x 10^9)[a]		
Winnipeg R.	39	na
Red R.	8.1	na
Total to south basin	50.6	na

[a] mean of years 1969-1979

Table 2. Morphological characteristics of fish collected from Lake Winnipeg. Lipid is determined in muscle tissue for all fish except for burbot, which there is an additional value for the liver. M – muscle. L – Liver.

Date	Location	Species	Length	Weight	Age	Lipid
Oct. 97	Winnipeg Beach	Walleye	278 ± 5	200 ± 11	4.4 ± 0.5	3.6 ± 0.5
Oct. 97	Winnipeg Beach	Burbot	384 ± 11	388 ± 31	5.6 ± 0.3	1.0 ± 0.1 M
						42 ± 3.9 L
Oct. 97	Winnipeg Beach	Sauger	266 ± 3	210 ± 51	2.0 ± 0.0	2.5 ± 0.3
July 98	Riverton	Walleye	343 ± 6	372 ± 17	3.0 ± 0.0	1.5 ± 0.1
July 98	Riverton	Sauger	322 ± 3.0	306 ± 5.6	3.0 ± 0.0	1.8 ± 0.1
July 98	Riverton	Freshwater Drum	363 ± 11	722 ± 66	12.7 ± 2.0	7.7 ± 1.5
July 98	Riverton	Yellow Perch	230 ± 6	176 ± 12	5.7 ± 0.4	1.2 ± 0.1
Sept. 98	Winnipeg Beach	Walleye	333 ± 10	316 ± 20	3.3 ± 0.2	1.6 ± 0.2
Sept. 98	Winnipeg Beach	Burbot	491 ± 26	768 ± 107	6.5 ± 1.4	-
Sept. 98	Winnipeg Beach	Freshwater Drum	239 ± 11	191 ± 24	3.0 ± 0.3	7.2
Sept. 98	Winnipeg Beach	Yellow Perch	223 ± 8.9	157 ± 16	5.3 ± 0.7	1.2
Oct 96	Riverton	Walleye	314 ± 6.8	358 ± 28	2.8 ± 0.2	3.9 ± 0.5

Table 3. Loadings of N and P for 1997 and those reported by Brunskill et al. (1980).

Year	Total N tonnes	Total P tonnes	Total N moles$\times10^6$	Total P moles$\times10^6$	Total N moles/ $km^2\times10^6$	Total P moles/ $km^2\times10^6$	Discharge $M^3\times10^9$/ yr.
1969	22500	3475	1607	112	5590	390	9.99
1971	11116	1426	794	46	2762	160	5.83
1972	14658	2139	1047	69	3642	246	7.09
1973	5880	1159	420	37	1461	130	2.89
1974	31598	4101	2257	132	7850	460	12.2
1997	40045	7023	2860	227	9949	780	17.2

Table 4. Predicted and observed N and P yields from the Red River drainage basin.

	Predicted (Brunskill et al. 1980)	Observed (this work)	Difference
Nitrogen (moles/km^2)	9967	9949	< 0.5%
Phosphorous (moles/km^2)	647	788	+ 22%

Table 6. Crustacean plankton species composition and abundance (individuals per liter) in the South Basin of Lake Winnipeg.

DATA SOURCE	Patalas and Salki 1992				Salki 1996	Salki RRBTF Study				
YEAR	1969				1994	1998				
MONTH	July 9-16	July 24-Aug1	Sep 2-10	summer	Aug 26-28	March 5	July 16	Aug 12	Sept14	summer
STATIONS	(n = 8)	(n = 6)	(n = 8)	mean	(n=8)	(n=7)	(n=9)	(n=9)	(n=7)	mean
SPECIES										
Eucyclops agilis	0.39			0.13						
Diaclops bicuspidatus	0.23	0.17		0.13	0.27	0.31	0.07		0.28	0.12
Acanthocyclops vernalis	3.27	2.29	9.95	5.17	2.42		12.44	6.81	2.72	7.33
Mesocyclops edax							0.08	0.001	0.01	0.03
Cyclopidae copepodids	1.16	1.09	0.07	0.77	7.73		23.14	28.21	17.39	22.92
Cyclopoid nauplii	4.51	4.36	15.16	8.01	18.99	0.28	48.28	29.99	28.36	35.54
Total Cyclopoida	9.56	7.91	25.17	14.21	29.41	0.59	84.12	65.01	48.77	65.97
Diaptomus oregonensis	1.50	1.20	1.83	1.51	1.11		0.28	0.35	0.24	0.29
Diaptomus ashlandi	12.67	17.34	32.75	20.92	20.02	2.51	39.89	40.42	42.96	41.09
Diaptomus siciloides		0.12	3.08	1.07	0.18		0.03	4.35	1.37	1.92
Limnocalanus macrurus	0.001		0.003	0.001	0.005		0.0004	0.0003		0.0002
Epischura lacustris	1.16	1.93	0.50	1.20	0.26		0.87	0.12	0.19	0.39
Epischura nevadensis	0.96	5.73	0.35	2.34	0.39		1.80	0.33	0.28	0.81
Calanoid nauplii	36.56	34.13	22.85	31.18	36.63	2.35	33.01	53.41	26.65	37.69
Total Calanoida	52.84	60.43	61.37	58.21	58.59	4.86	75.88	98.98	71.70	82.19
Daphnia retrocurva	9.04	4.66	0.79	4.83	1.09		24.86	18.32	1.07	14.75
Daphnia galeata mendotae		0.05	3.59	1.21	9.05		9.68	6.88	2.59	6.38
Daphnia pulex		0.08		0.03						
Daphnia schoedleri	0.003			0.001						
Bosmina longirostris	4.34	1.86	0.34	2.18	2.71	0.01	0.11	0.71	3.42	1.42
Diaphanosoma leuchtenbergianum	0.09	1.14	1.97	1.07	1.92		2.63	8.31	2.39	4.44
Holopedium gibberum								0.01		0.002
Leptodora kindtii	0.01	0.11	0.03	0.05	0.0009		0.39	0.24	0.07	0.23
Ceriodaphnia quadrangula			0.004	0.001	0.001			0.013		0.004
Latona setifera					0.0004					
Total Cladocera	13.48	7.89	6.73	9.36	14.77	0.01	37.68	34.48	9.54	27.23
Total Crustaceans Individuals/Litre	75.88	76.23	93.26	81.79	102.77	5.46	197.68	198.46	130.01	175.38
Mysis relicta									0.001	0.001
Total No. Species	13	13	13		15	3	14	15	14	

Table 7. Seasonal mean crustacean abundance at each sampling station. Monthly means for each transect also shown.

	Site 4				Site 7				Site 11			
Transect	A	B	C	Mean	A	B	C	Mean	A	B	C	Mean
July 16	273.6	217.5	176.4	222.5	317.7	88.0	196.5	200.7	230.2	144.4	134.7	169.8
Aug 12	382.3	221.7	318.0	307.3	211.7	149.2	204.5	188.5	99.6	113.0	86.1	99.6
Sept14	124.6	88.1	196.5	136.4	165.2	121.6	87.4	124.7		126.7		126.7
Mean	260.2	175.8	230.3	222.1	231.6	119.6	162.8	171.3	164.9	128.1	110.4	134.5

Table 8. Comparison of 1998 and 1969 mean summer zooplankton species abundance.

YEAR	1969	1998	Ratio
MONTH	summer mean	summer mean	98/69
SPECIES			
Eucyclops agilis	0.13		
Diaclops bicuspidatus thomasi	0.13	0.12	0.9
Acanthocyclops vernalis	5.17	7.33	1.4
Mesocyclops edax		0.03	
Cyclopidae copepodids	0.77	22.92	29.7
Cyclopoid nauplii	8.01	35.54	4.4
Total Cyclopoida	14.21	65.97	4.6
Diaptomus oregonensis	1.51	0.29	0.2
Diaptomus ashlandi	20.92	41.09	2.0
Diaptomus siciloides	1.07	1.92	1.8
Limnocalanus macrurus	0.001	0.0002	0.2
Epischura lacustris	1.20	0.39	0.3
Epischura nevadensis	2.34	0.81	0.3
Calanoid nauplii	31.18	37.69	1.2
Total Calanoida	58.21	82.19	1.4
Daphnia retrocurva	4.83	14.75	3.1
Daphnia galeata mendotae	1.21	6.38	5.3
Daphnia pulex	0.03		
Daphnia schoedleri	0.001		
Bosmina longirostris	2.18	1.42	0.6
Diaphanosoma leuchtenbergianum	1.07	4.44	4.2
Holopedium gibberum		0.002	
Leptodora kindtii	0.05	0.23	4.7
Ceriodaphnia quadrangula	0.0013	0.004	3.6
Total Cladocera	9.36	27.23	2.9
Total Crustaceans Individuals/L	81.79	175.38	2.1
Mysis relicta		0.001	

Table 9. Relative abundance of crustacean species in the South Basin of Lake Winnipeg in 1998 and the West (W) and East (E) basin of Lake Erie in 1968.

Author	Salki	Patalas	Patalas
Publication Year	1999	1975	1975
Lake	Winnipeg	Erie	Erie
Year	1998	1968	1968
Month	Jul-Sept	Aug	Aug
Basin	S	W	E
	%	%	%
Diaclops bicuspidatus thomasi	0.58	9.40	72.8
Acanthocyclops vernalis	36.85	27.90	0.04
Mesocyclops edax	0.16	7.10	2.2
Tropocyclops prasinus mexicanus	A	*	0.01
Diaptomus oregonensis	0.31	<0.01	5.9
Diaptomus ashlandi	43.28	9.10	<0.1
Diaptomus siciloides	2.02	1.40	1.1
Limnocalanus macrurus	0	*	*
Epischura lacustris	0.41	*	
Epischura nevadensis	0.85		
Diaptomus minutus	NB	*	0.1
Diaptomus sicilis	NB	*	*
Daphnia retrocurva	8.41	16.10	5.6
Daphnia galeata mendotae	3.64	10.60	5.9
Daphnia longiremis	NB	A	5.0
Bosmina longirostris	0.81	0.80	3.4
Diaphanosoma leuchtenbergianum	2.53	0.40	*
Holopedium gibberum	<0.01		*
Leptodora kindtii	0.13	0.01	0.01
Ceriodaphnia sps	<0.01		*
Eubosmina sps	#	17.40	0.2

* indicates inhabitant during other months

NB indicates present in North Basin of Lake Winnipeg

A indicates absent

# indicates recent invader in low abundance

Table 10. Metal and trace element concentrations in surface sediments at sites in the south basin of Lake Winnipeg.

Site	Aluminum mg/g	Chromium µg/g	Manganese µg/g	Iron mg/g	Nickel µg/g	Copper µg/g	Zinc µg/g	Mercury µg/g	Cadmium µg/g	Lead µg/g	Vanadium µg/g	Titanium µg/g	Arsenic µg/g	Selenium µg/g
Transect A														
1	86	96	2200	32.2	43.4	34.9	151	0.086	0.467	20.4	193	3.39	10.5	0.76
2	117	98	2117	34.4	44.6	32.5	160	0.070	0.430	17.3	200	3.43	9.7	0.73
3	85	92	2450	34.5	41.7	28.8	160	0.071	0.360	19.8	195	3.46	9.5	0.62
4	97	100	2775	38.4	45.0	28.8	157	0.075	0.325	19.7	203	3.66	12.9	0.61
5	88	100	2517	38.0	46.4	28.5	156	0.073	0.292	21.3	206	3.58	12.5	0.51
6	85	104	3289	39.6	48.3	28.5	160	0.077	0.307	20.4	207	3.63	14.9	0.54
7	91	99	3877	39.7	49.1	30.2	174	0.074	0.303	24.1	214	3.76	15.0	0.54
8	85	109	4318	43.7	51.5	33.3	154	0.080	0.286	21.2	229	3.80	15.1	0.54
9	91	104	4813	41.3	48.2	30.7	176	0.082	0.274	22.0	206	3.74	20.6	0.50
10	95	106	4581	41.1	50.9	29.9	161	0.073	0.267	19.1	200	3.78	20.6	0.48
11	90	103	2456	39.2	48.7	33.8	167	0.076	0.261	22.8	192	3.79	12.9	0.58
Transect B														
1	74	87	1772	30.2	37.3	31.9	142	0.071	0.559	13.5	181	3.26	8.7	0.74
2	82	89	1864	30.6	36.5	28.6	142	0.062	0.532	16.7	187	3.39	9.2	0.65
3	88	98	2063	33.4	41.9	28.0	160	0.061	0.451	15.6	196	3.63	8.9	0.62
4	84	102	2227	34.4	41.3	27.9	160	0.066	0.426	18.1	205	3.57	10.9	0.63
5	83	105	2172	36.4	45.7	27.7	165	0.062	0.381	19.0	206	3.67	11.8	0.57
6	90	102	2253	37.1	46.5	28.8	165	0.069	0.361	20.3	209	3.59	11.2	0.56
7	99	112	2851	38.4	46.8	29.3	181	0.069	0.328	21.7	210	3.80	12.8	0.48
8	88	110	3198	37.8	48.7	29.1	163	0.071	0.294	19.1	198	3.65	13.0	0.46
9	90	110	3381	39.2	49.8	31.4	169	0.070	0.324	18.7	203	3.73	13.9	0.47
10	114	110	2760	38.4	49.1	31.1	150	0.065	0.284	18.7	192	3.71	10.7	0.56
11	101	114	2128	39.0	51.2	32.8	162	0.078	0.298	21.8	194	3.86	8.9	0.49

Table 10. Metal and trace element concentrations in surface sediments at sites in the south basin of Lake Winnipeg.

Site	Aluminum mg/g	Chromium µg/g	Manganese µg/g	Iron mg/g	Nickel µg/g	Copper µg/g	Zinc µg/g	Mercury µg/g	Cadmium µg/g	Lead µg/g	Vanadium µg/g	Titanium µg/g	Arsenic µg/g	Selenium µg/g
Transect C														
1	81	102	1811	32.9	38.9	34.2	154	0.084	0.653	16.8	187	3.37	9.9	0.77
2	74	100	2162	32.4	37.2	29.0	146	0.072	0.580	15.0	177	3.40	9.3	0.67
3	70	99	2299	32.8	39.6	34.7	136	0.100	0.669	18.3	168	3.27	10.0	0.70
4	78	105	2112	35.1	41.9	30.2	149	0.081	0.526	19.0	187	3.53	10.0	0.62
5	80	102	2108	37.1	44.1	28.5	149	0.074	0.451	19.7	198	3.52	10.7	0.60
6	78	112	2152	38.2	46.0	28.9	161	0.075	0.400	21.7	205	3.64	9.4	0.59
7	92	111	2247	38.5	47.0	29.7	148	0.069	0.338	21.0	200	3.71	9.5	0.55
8	82	113	2087	39.1	47.3	31.0	158	0.065	0.315	20.0	196	3.65	9.5	0.54
9	81	111	2109	38.2	49.6	30.6	147	0.068	0.312	20.3	182	3.84	11.2	0.54
10	81	114	3099	40.2	52.0	32.7	142	0.082	0.327	20.4	189	3.81	11.0	0.54
11	79	110	2853	40.2	52.3	32.8	152	0.085	0.316	22.0	197	3.74	10.1	0.59

Table 11. Total concentrations of N, P, C, carbonate and organic carbon in surface sediment grabs from the south basin of Lake Winnipeg.

Site	Total N mg/g	Total C mg/g	Total P mg/g	Carbonate mg/g	Org. Carbon mg/g
Transect A					
1	2.4	34	1.04	11.2	22.8
2	2.2	29	0.97	10.0	19.0
3	2.1	27	1.04	9.4	17.6
4	3.5	43	1.26	6.5	36.5
5	2.2	24	1.12	5.8	18.2
6	2.3	23	1.22	4.4	18.6
7	2.4	22	1.24	3.4	18.6
8	2.6	23	1.26	2.9	20.1
9	2.5	23	1.29	3.0	20.0
10	2.6	23	1.53	3.9	19.1
11	2.6	23	1.34	4.0	19.0
Transect B					
1	3.5	50	1.03	12.3	37.7
2	1.9	29	1.03	10.9	18.1
3	1.8	25	0.96	8.3	16.7
4	2.0	25	1.09	7.3	17.7
5	2.0	24	1.01	5.7	18.3
6	2.2	23	1.02	5.3	17.7
7	2.0	23	1.07	4.1	18.9
8	2.3	21	1.11	3.2	17.8
9	2.4	22	1.07	3.1	18.9
10	2.4	22	1.29	2.5	19.5
11	2.5	21	1.01	3.0	18.0
Transect C					
1	2.3	33	1.06	11.4	21.6
2	1.9	31	1.0	12.6	18.4
3	2.3	34	1.02	10.7	23.3
4	2.1	27	1.02	9.3	17.7
5	1.9	25	1.1	7.3	17.7
6	2.1	24	1.0	5.9	18.1
7	2.2	23	1.09	4.5	18.5
8	2.2	22	0.97	4.4	17.6
9	2.2	23	1.01	4.7	18.3
10	2.4	22	1.02	3.1	18.9
11	2.5	24	1.07	2.3	21.7

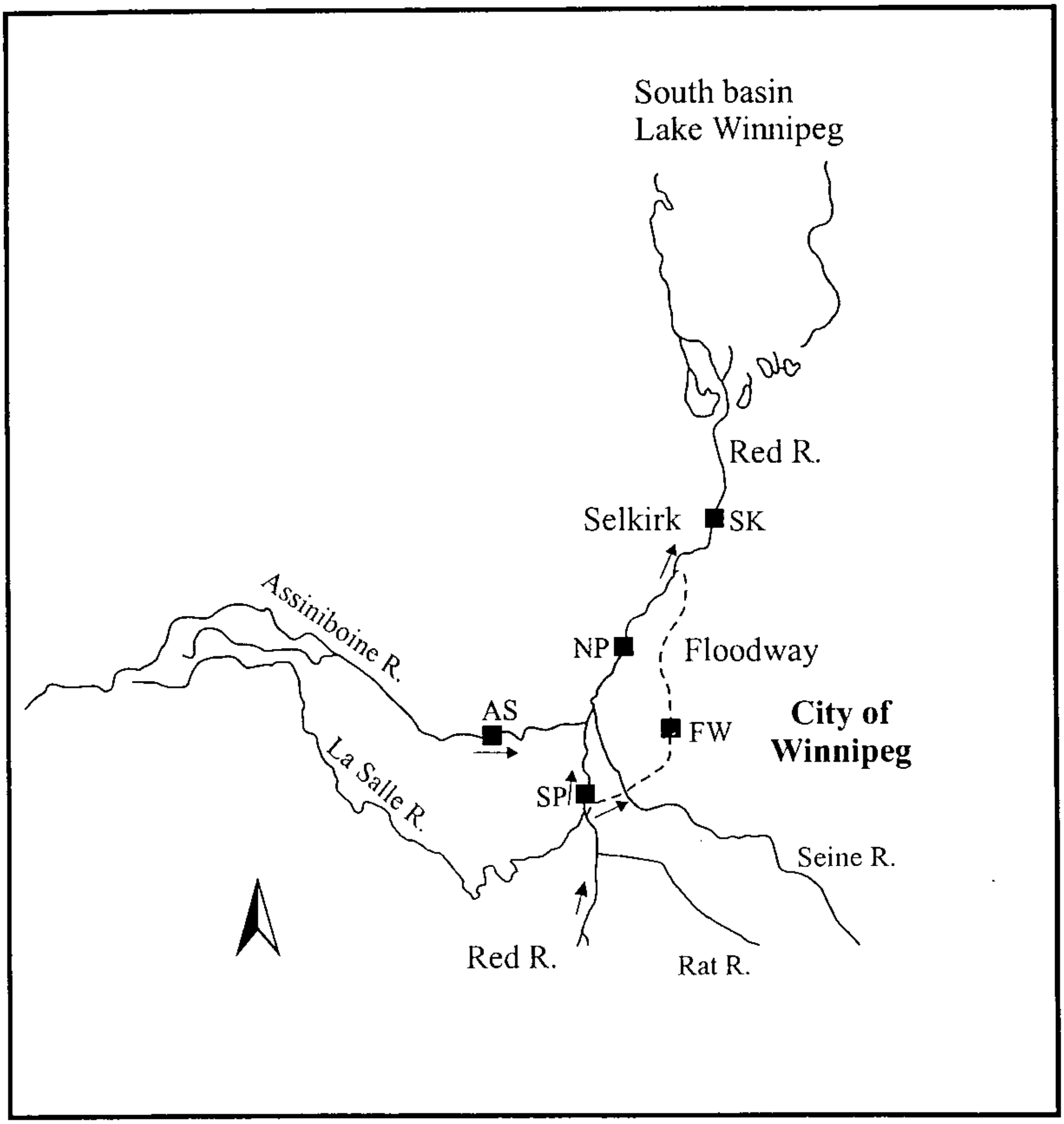


Figure 1. Red River sampling sites. SP - South Perimeter. NP- North Perimeter. AS - Assiniboine River. FW - Floodway. SK - Selkirk. Arrows point to sites where flow rate data was obtained from Environment Canada.

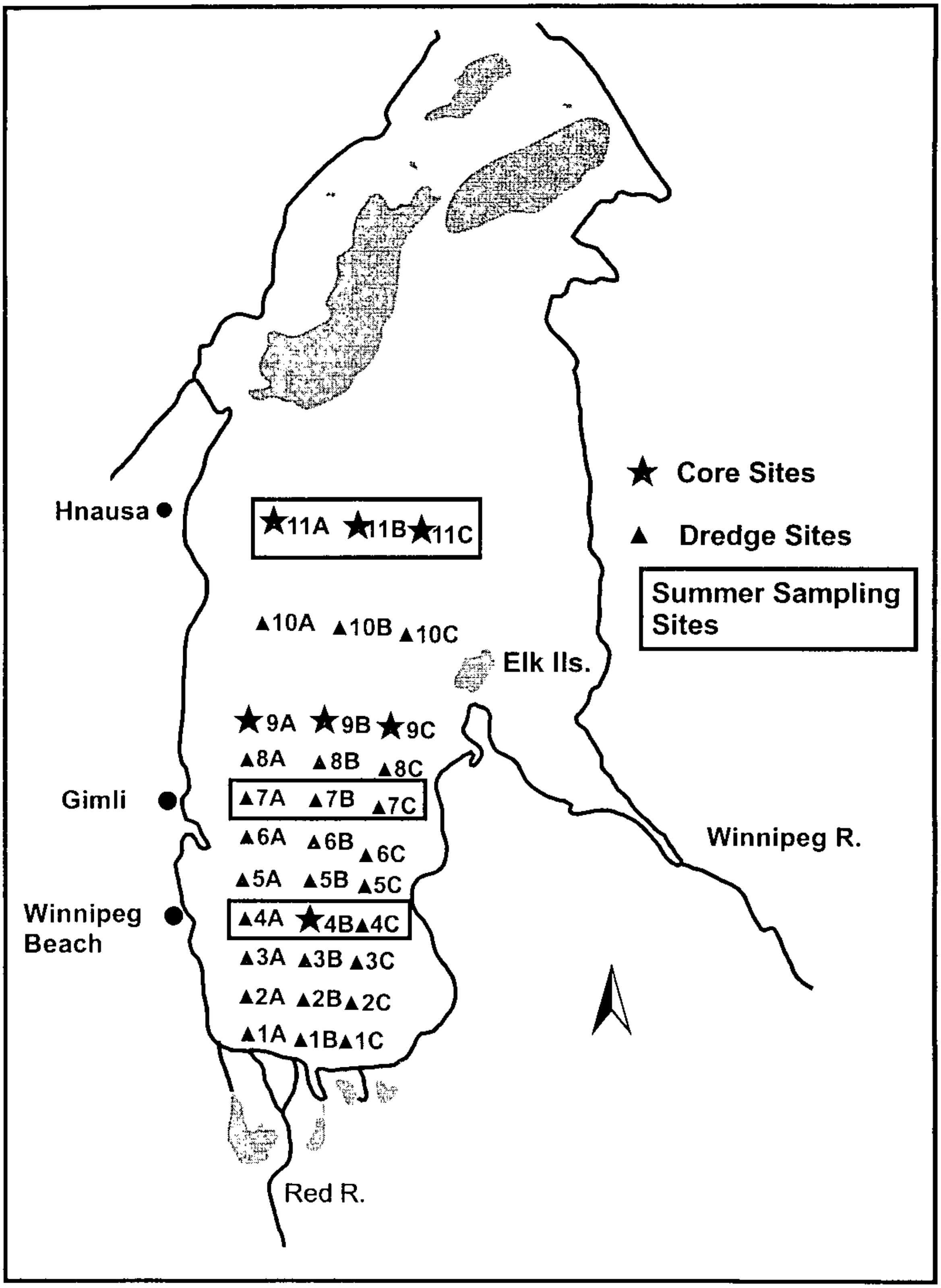


Figure 2. Lake Winnipeg south basin sampling sites.

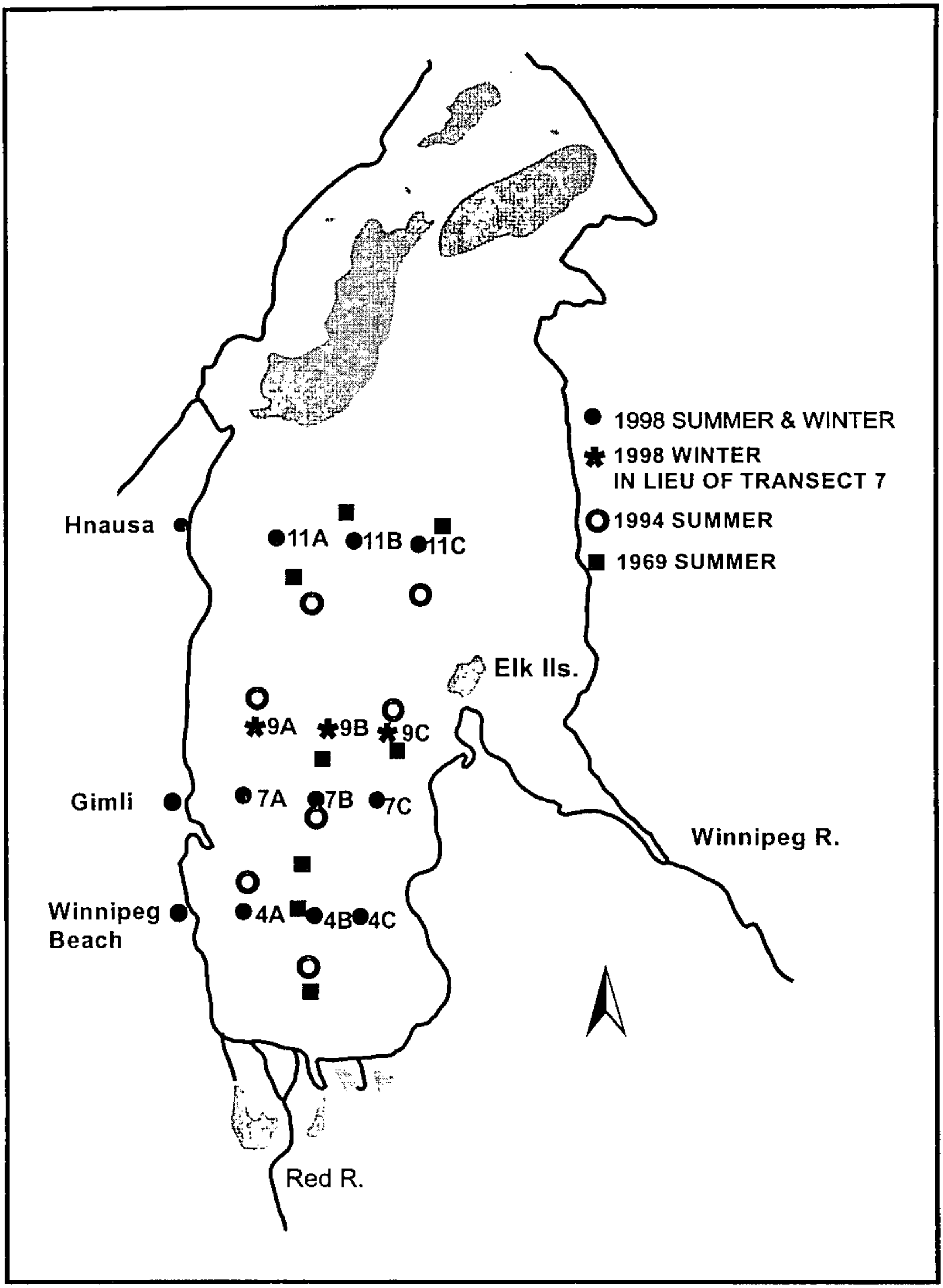


Figure 3. Lake Winnipeg south basin zooplankton sampling sites.

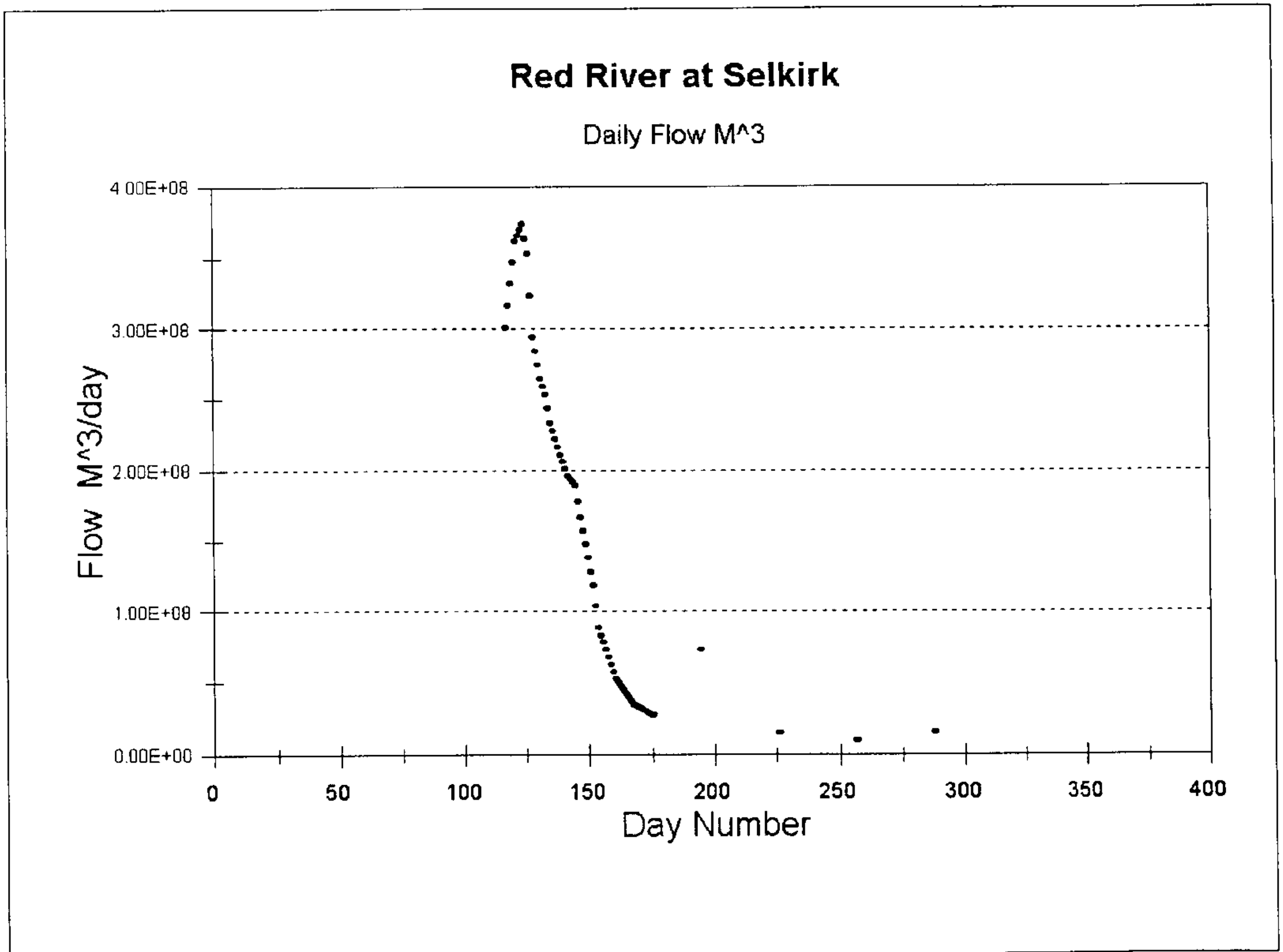


Figure 4. Daily flow (m^3/day) of the Red River at Selkirk 1997

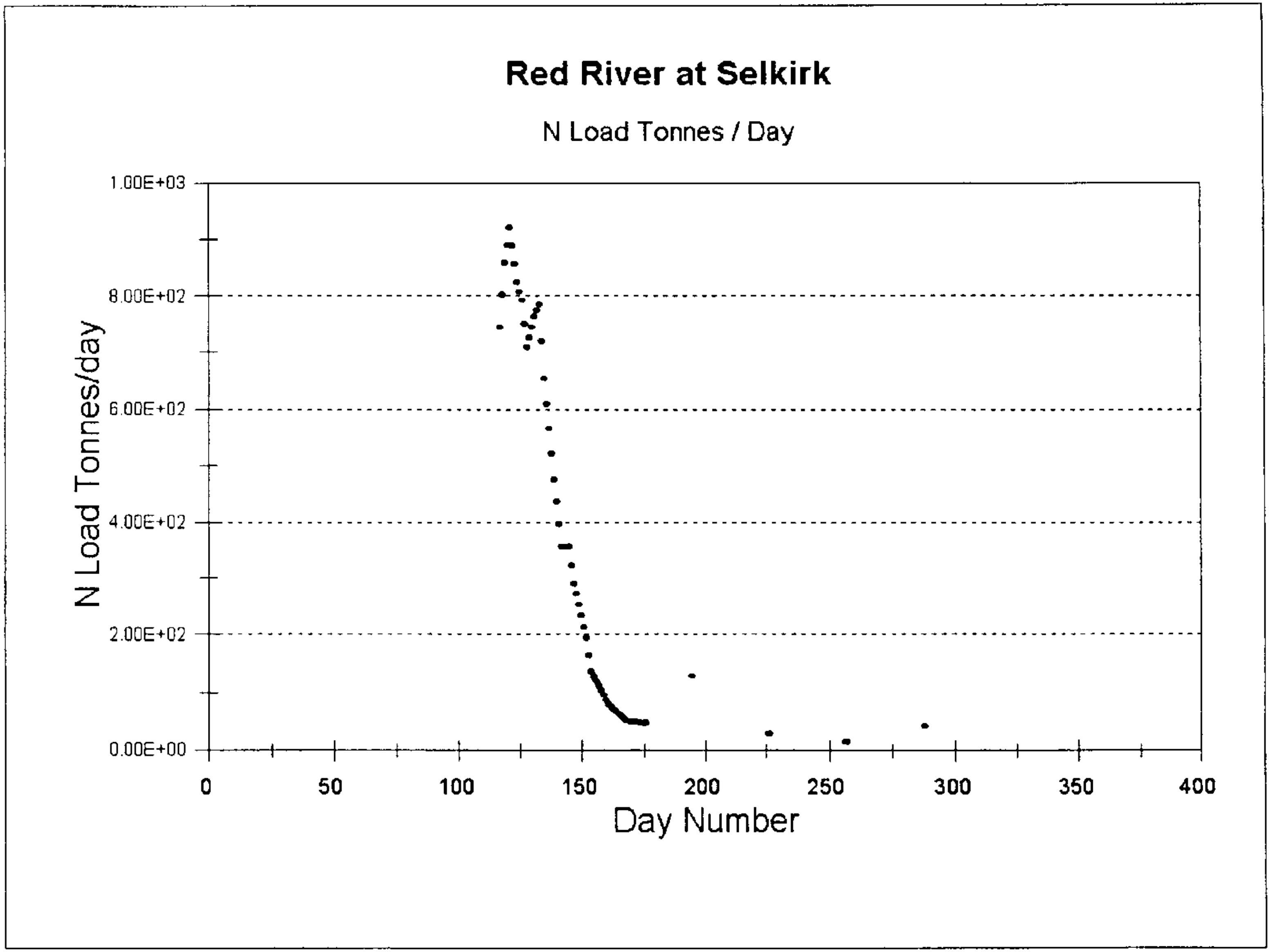


Figure 5. Nitrogen Loading (tonnes/day) in the Red River at Selkirk during 1997.

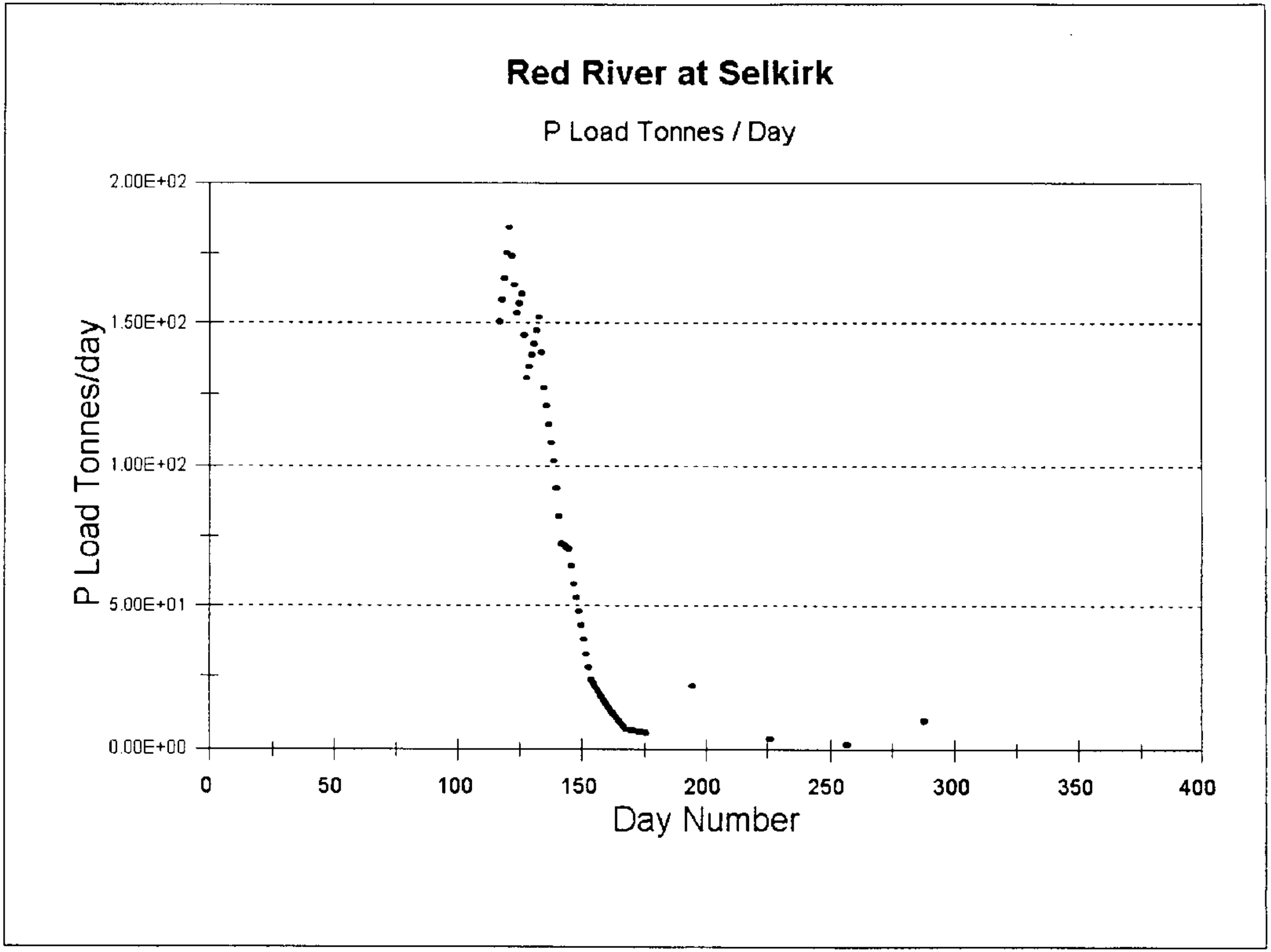


Figure 6. Phosphorus Loading (tonnes/day) in the Red River at Selkirk during 1997

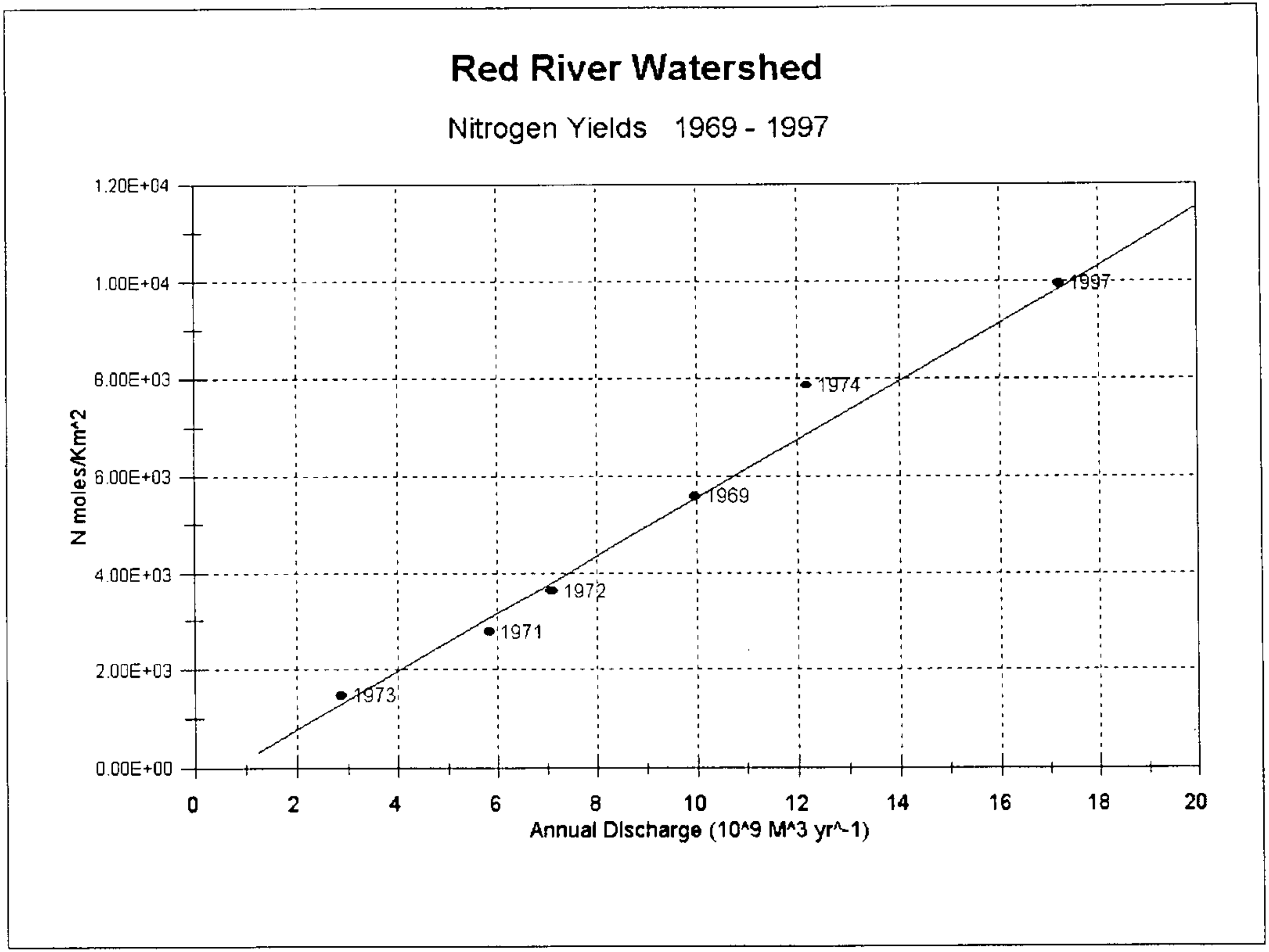


Figure 7A. Nitrogen yields from the Red River watershed 1969 - 1997

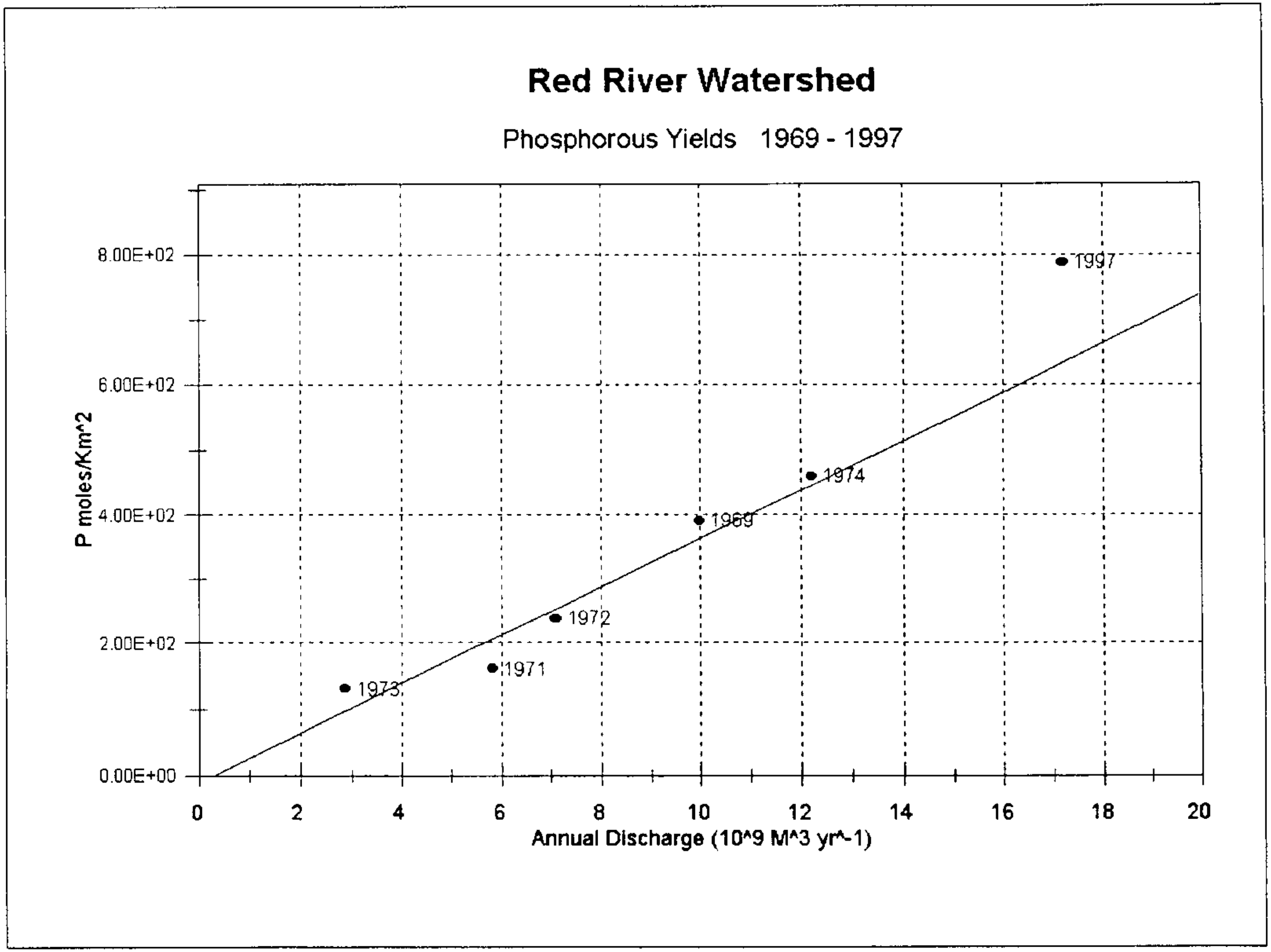


Figure 7B. Phosphorus yields from the Red River watershed 1969 - 1997

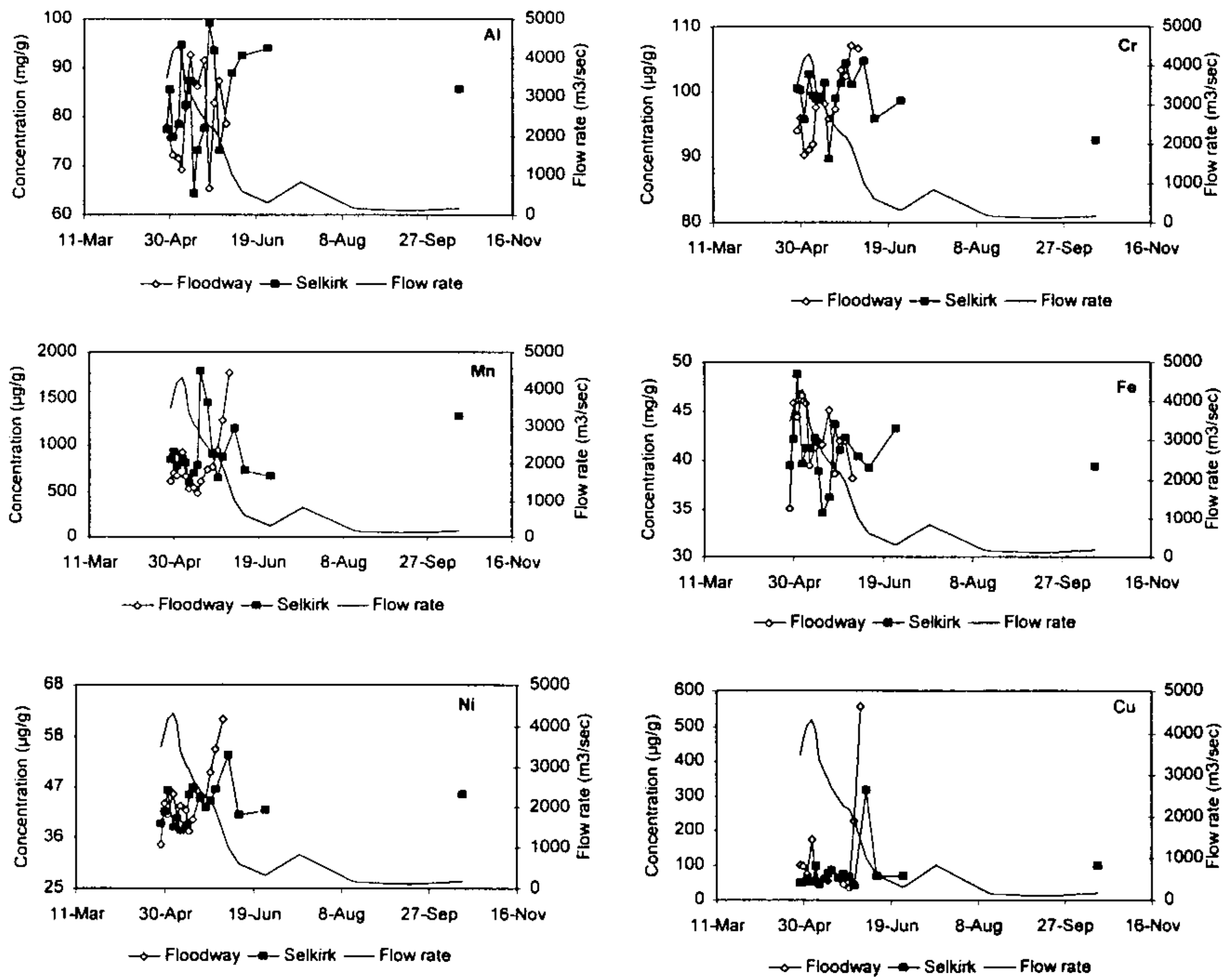


Figure 8. Metal concentrations in suspended sediments at the Floodway and Selkirk during 1997.

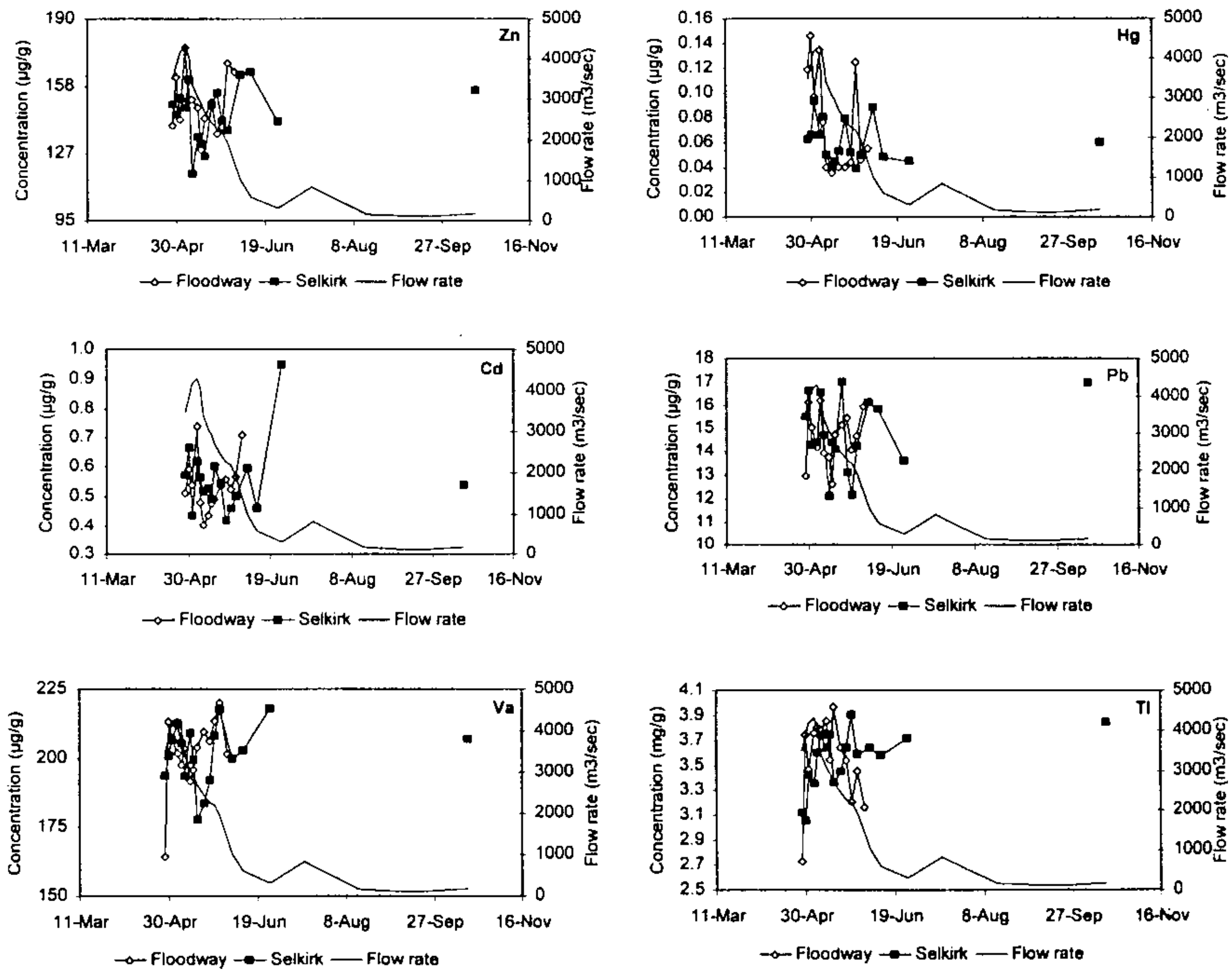


Figure 8. Metal concentrations in suspended sediments at the Floodway and Selkirk during 1997.

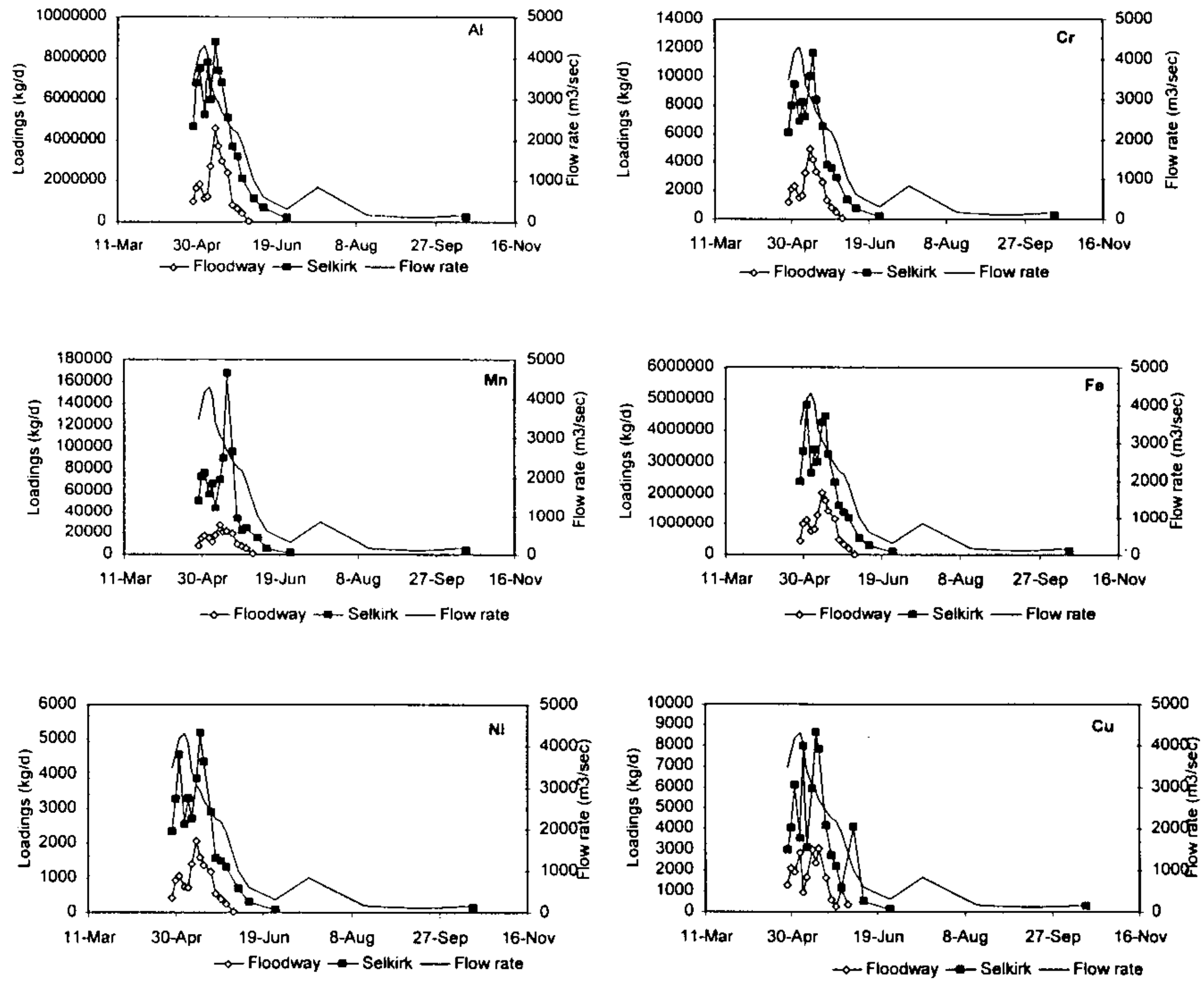


Figure 9. Loadings of metals and trace elements in the Red River at the Floodway and Selkirk during 1997.

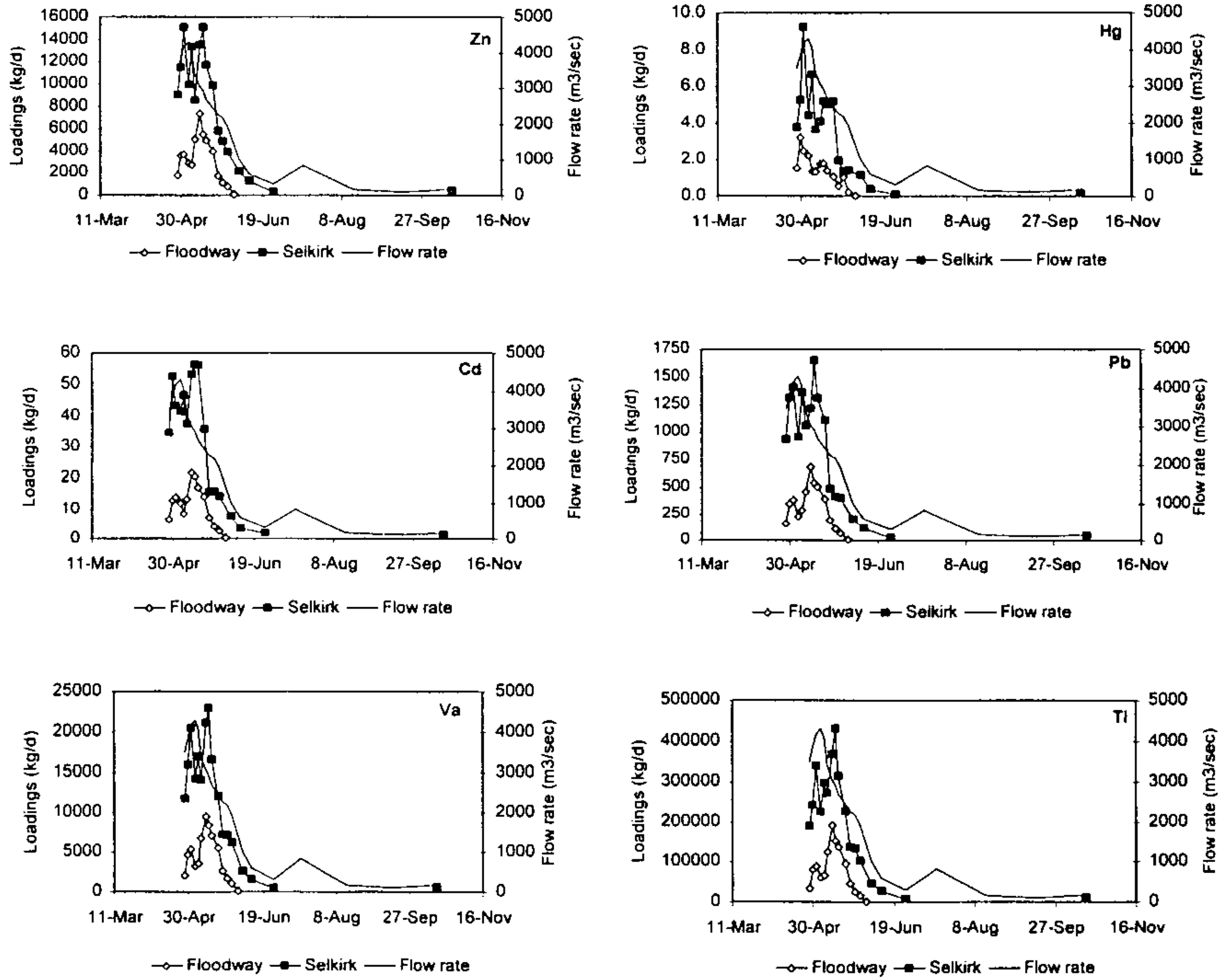


Figure 9. Loadings of metals and trace elements in the Red River at the Floodway and Selkirk during 1997.

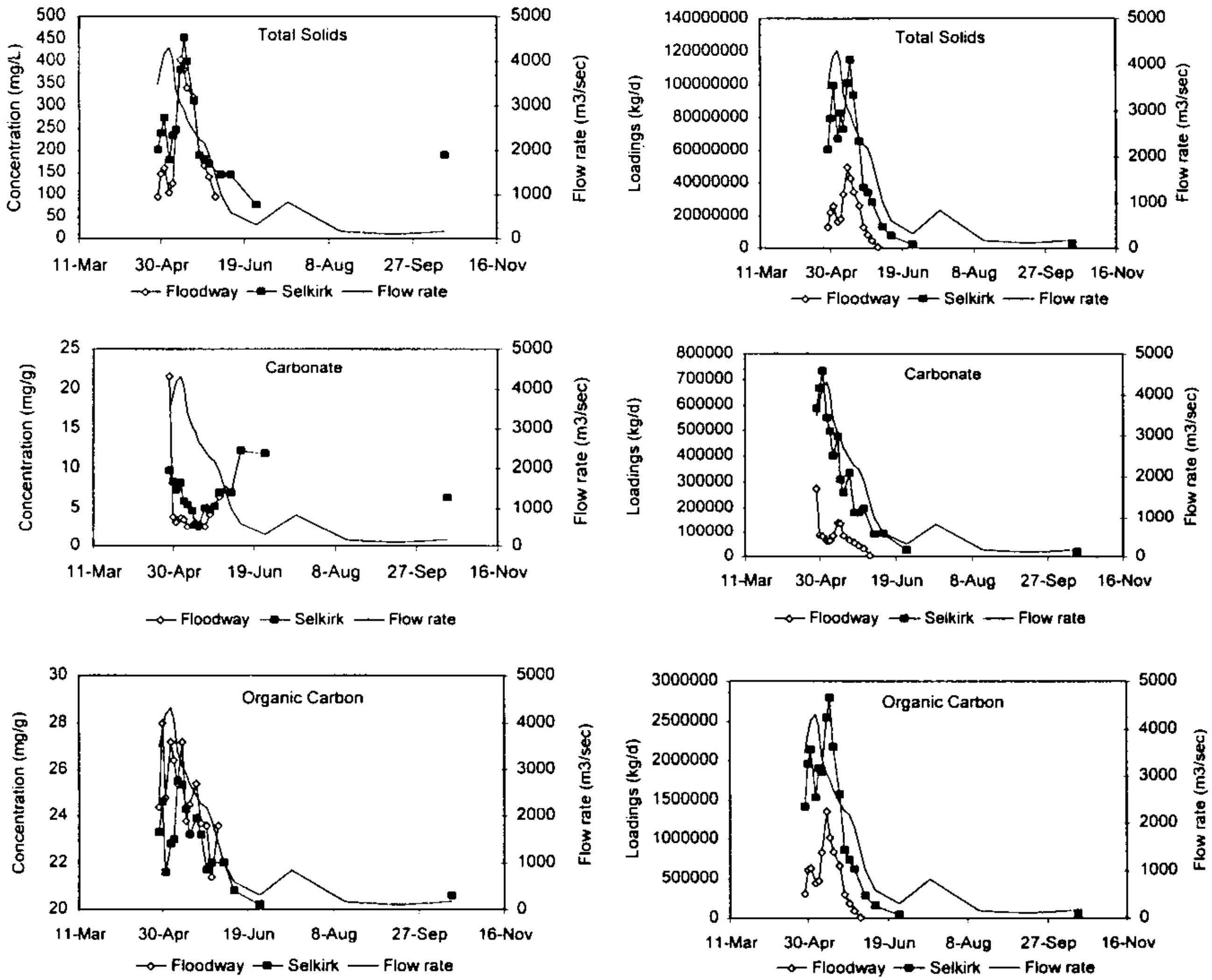


Figure 10. Concentrations and loadings of suspended solids, suspended sediment carbonate and suspended sediment organic matter in the Red River at the Floodway and Selkirk during 1997.

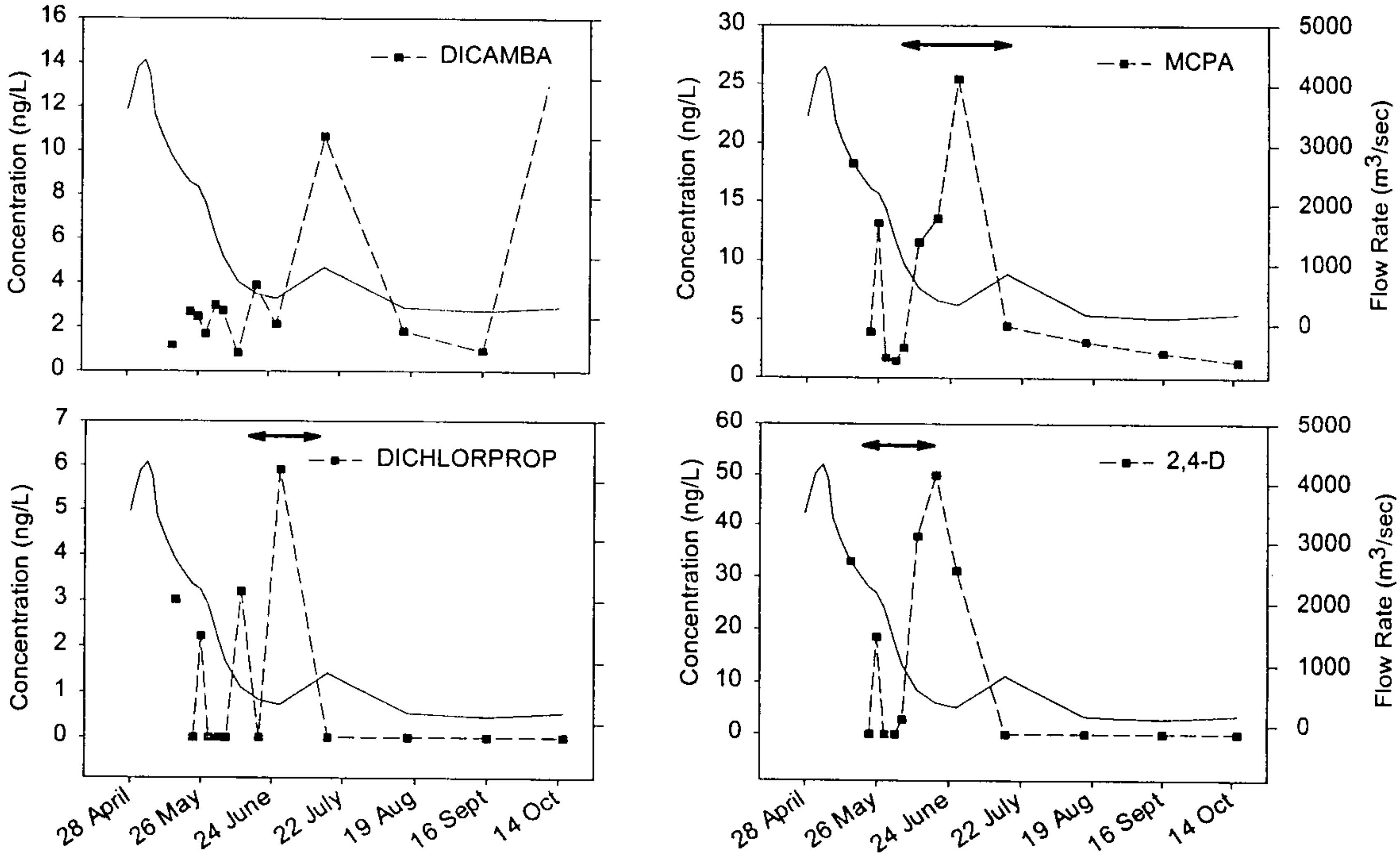


Figure 11. Herbicide concentrations (ng/L) in water at Selkirk from early spring to the fall of 1997. Typical application period indicated by ↔. Flow rate is shown in a solid line.

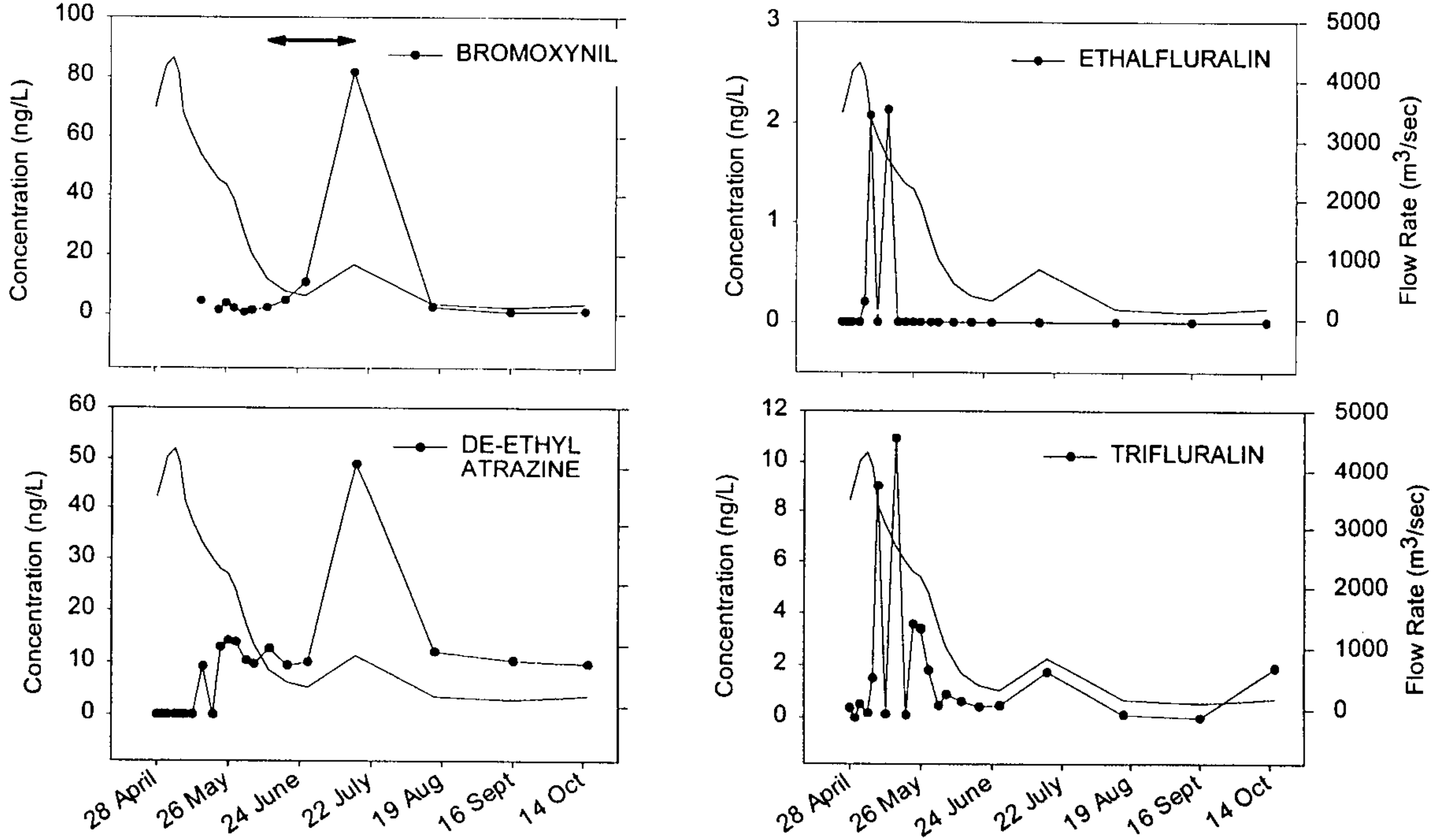


Figure 11. Herbicide concentrations (ng/L) in water at Selkirk from early spring to the fall of 1997. Application period indicated by ↔. Flow rate is shown in a solid line.

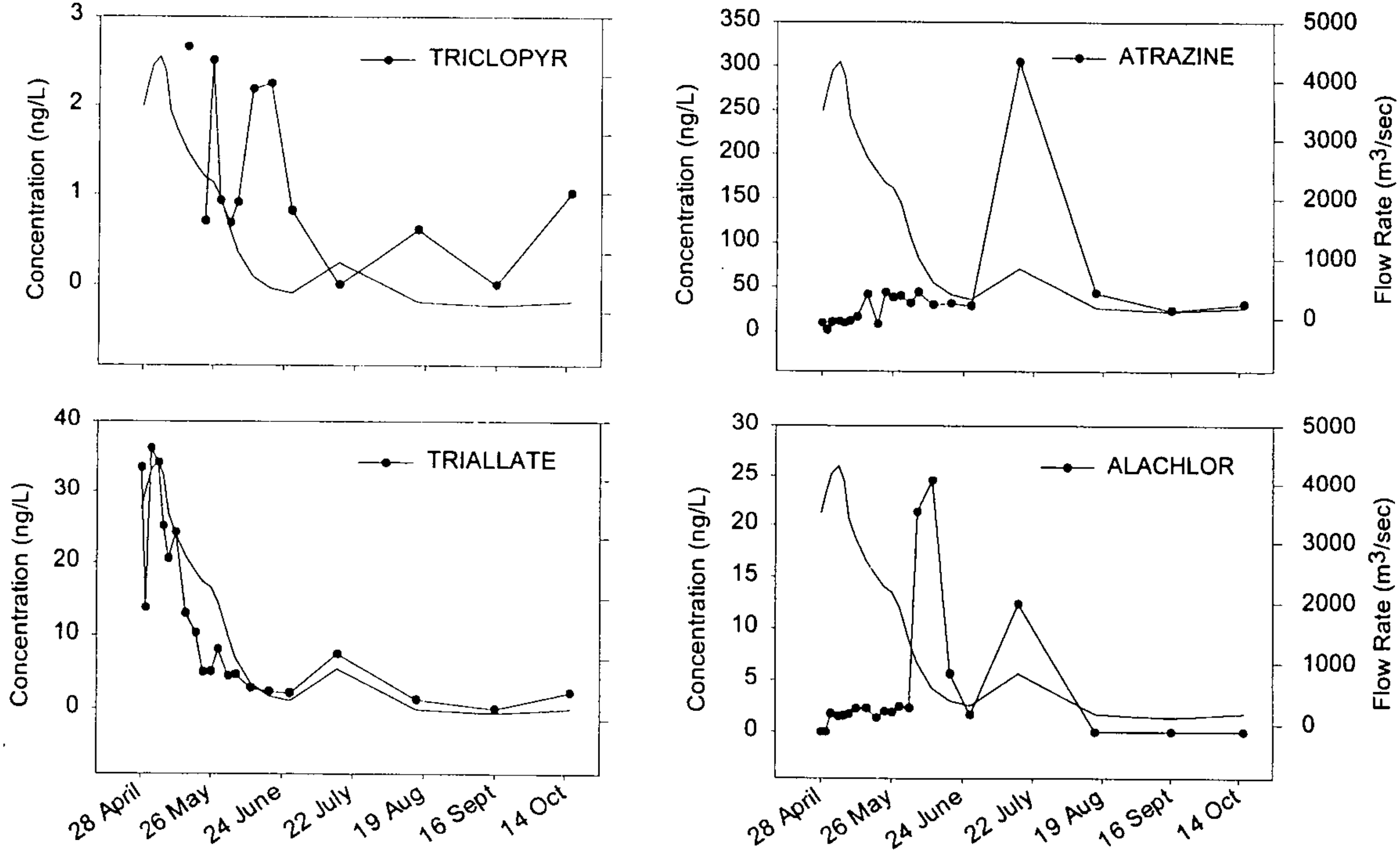


Figure 11. Herbicide concentrations (ng/L) in water at Selkirk from early spring to the fall of 1997. Flow rate is shown in a solid line.

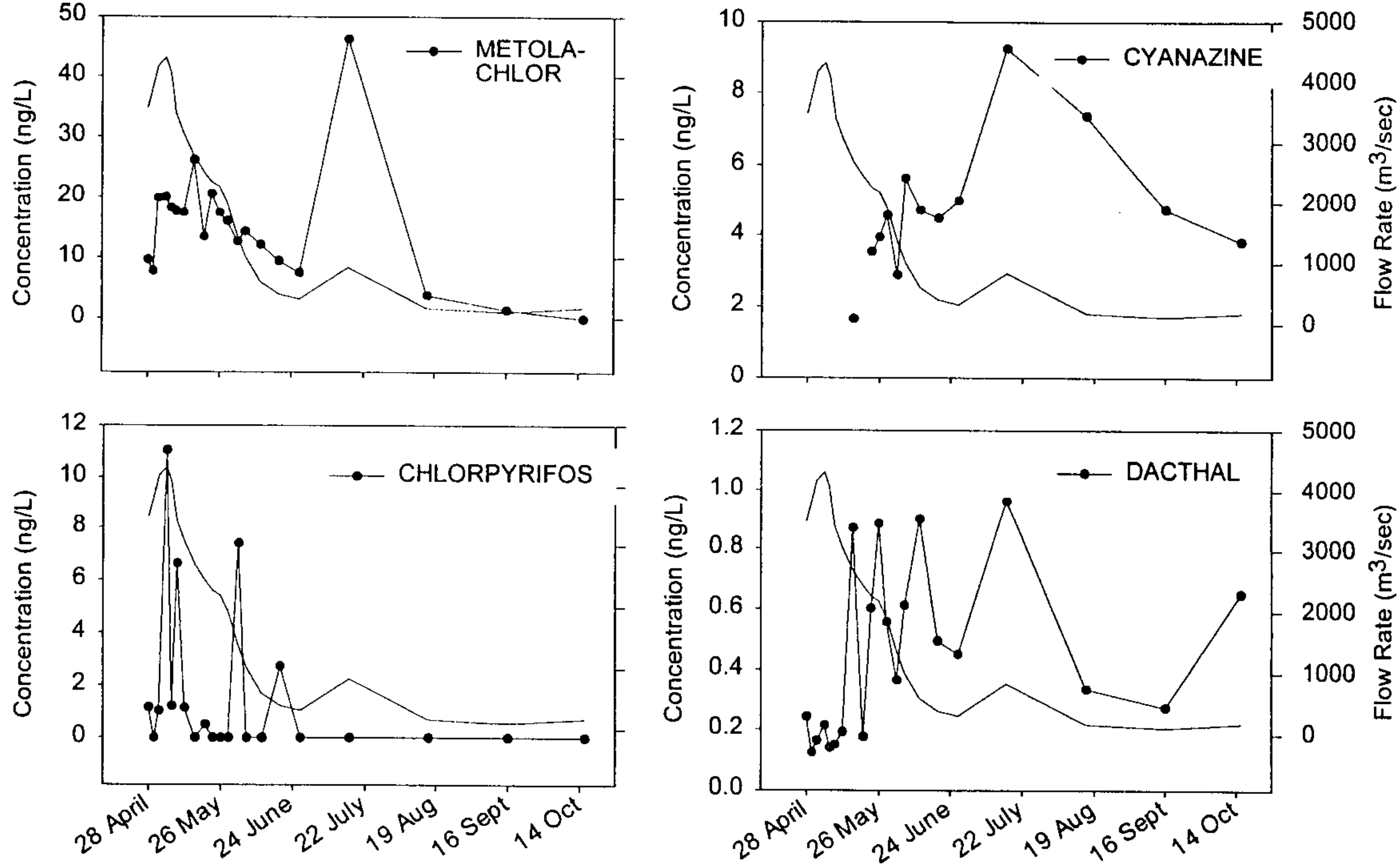


Figure 11. Herbicide concentrations (ng/L) in water at Selkirk from early spring to the fall of 1997. Flow rate is shown in a solid line.

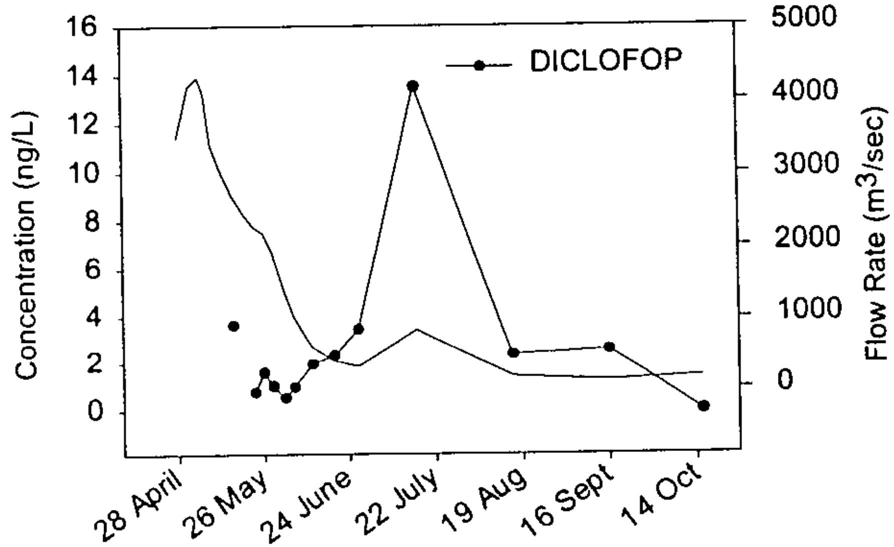


Figure 11. Herbicide concentrations (ng/L) in water at Selkirk from early spring to the fall of 1997. Flow rate is shown in a solid line.

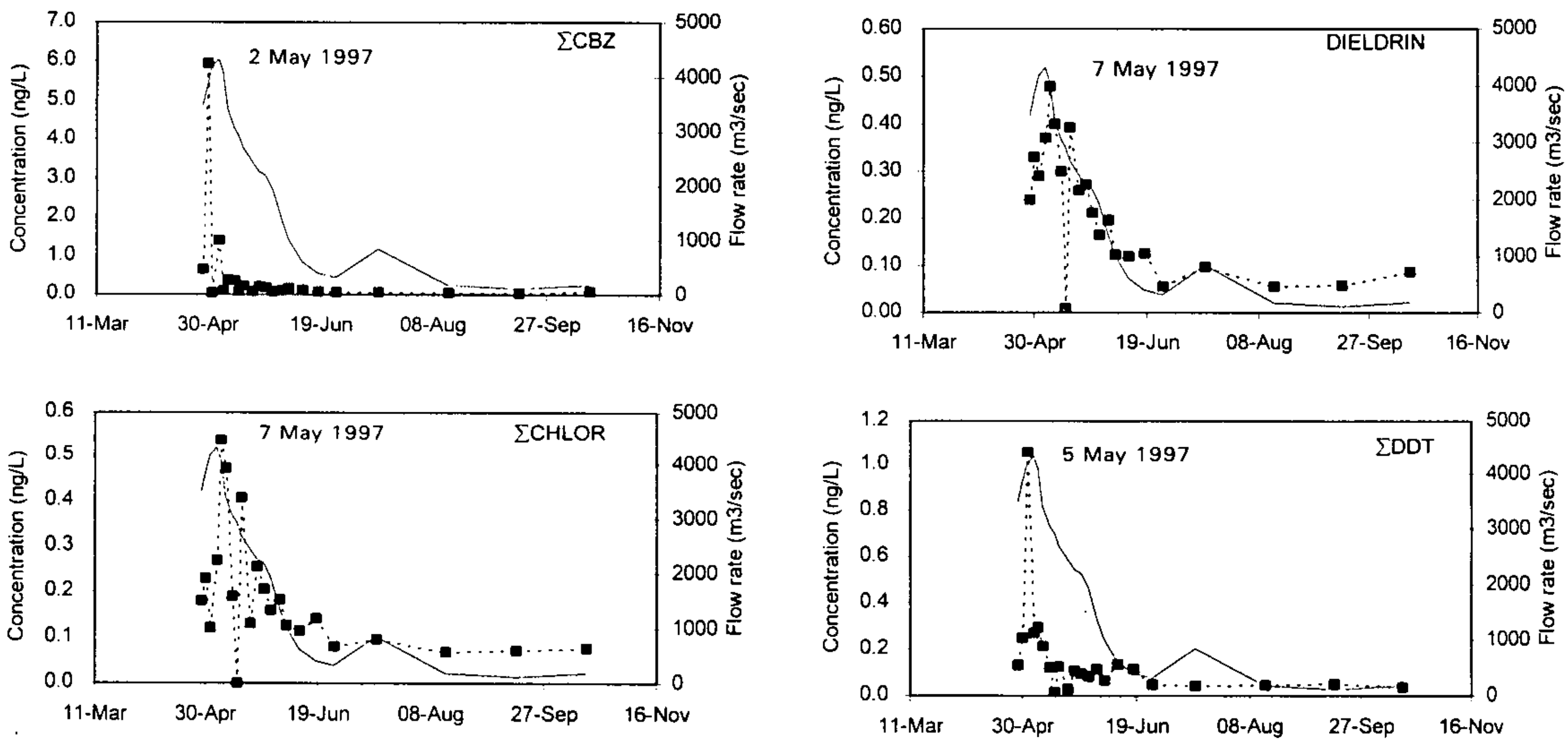


Figure 12. Organochlorine concentrations in water collected at Selkirk during 1997. Flow rate is shown by the solid black line.

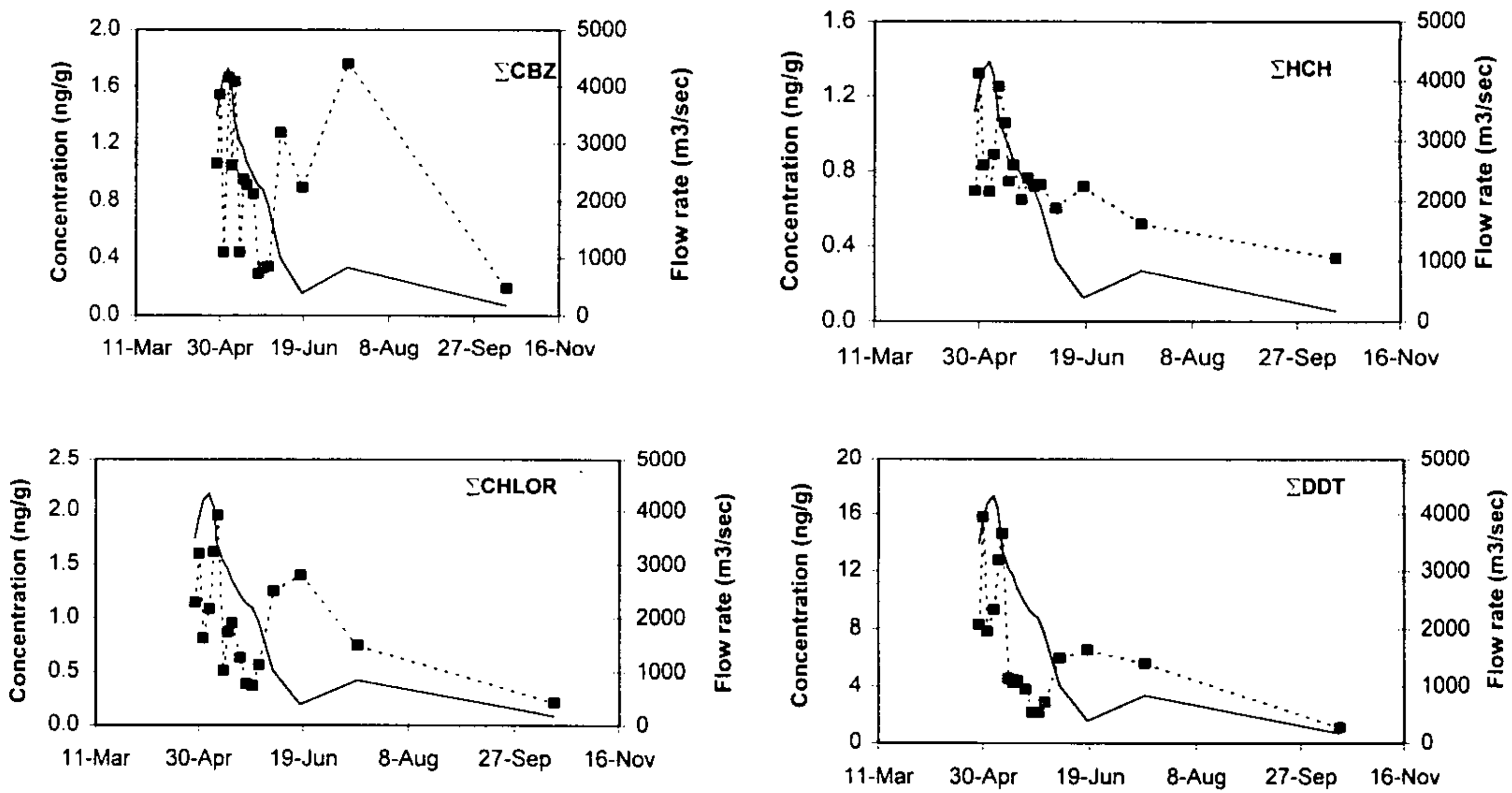


Figure 13. Organochlorine concentrations in suspended sediments collected from the Red River at Selkirk in 1997. Flow rate is shown in the solid black line.

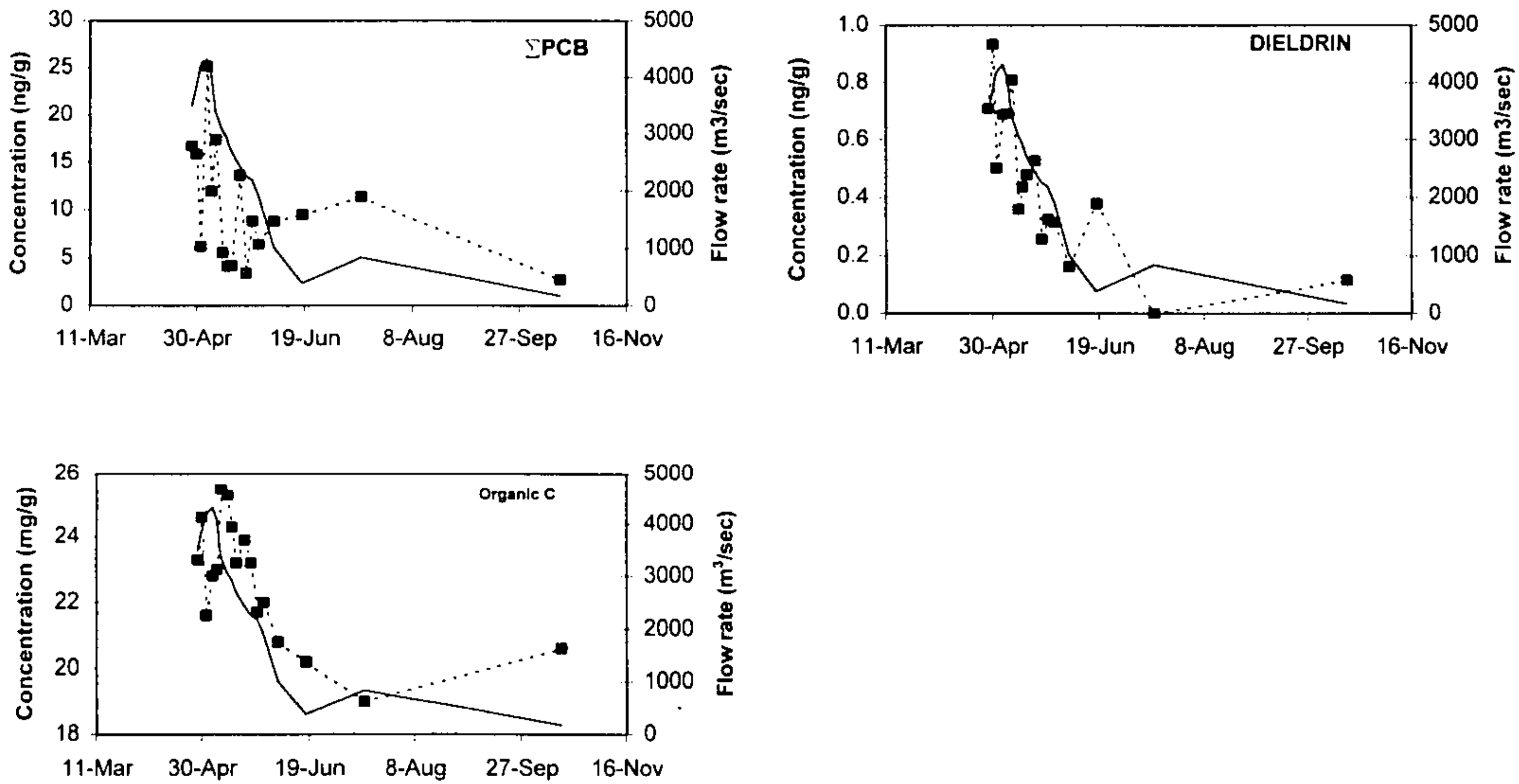


Figure 13. Organochlorine concentrations in suspended sediments collected from the Red River at Selkirk in 1997. Flow rate is shown in the solid black line.

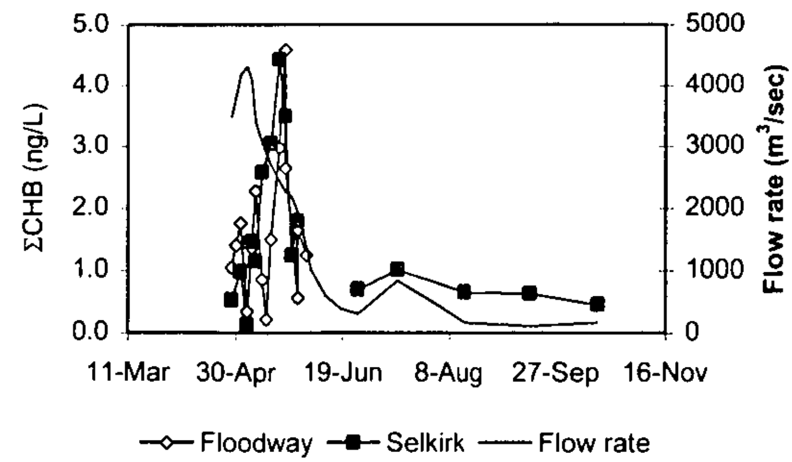


Figure 14. Concentrations of total toxaphene in water collected from the Red River at Selkirk and the Floodway in 1997 plotted against flow rate.

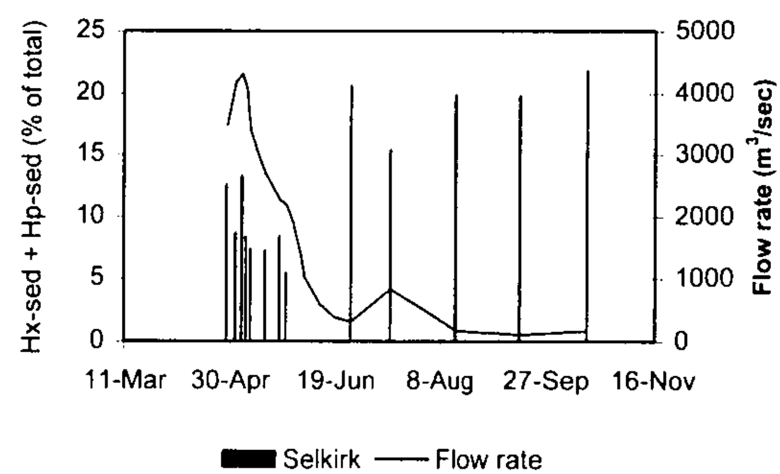


Figure 15. Concentrations of Hx-sed and Hp-sed toxaphene congeners as a ratio of total toxaphene in water samples collected from the Red River at Selkirk and the Floodway in 1997 plotted against flow rate.

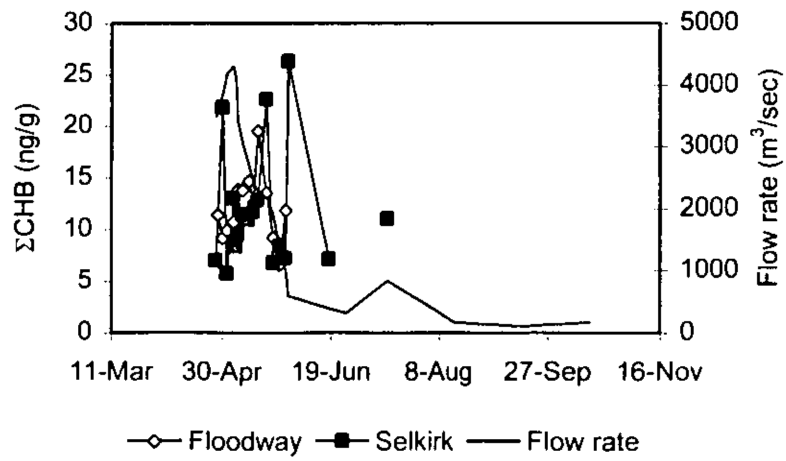


Figure 16. Concentrations of total toxaphene on suspended sediments in the Red River at Selkirk and the Floodway in 1997 plotted against flow rate.

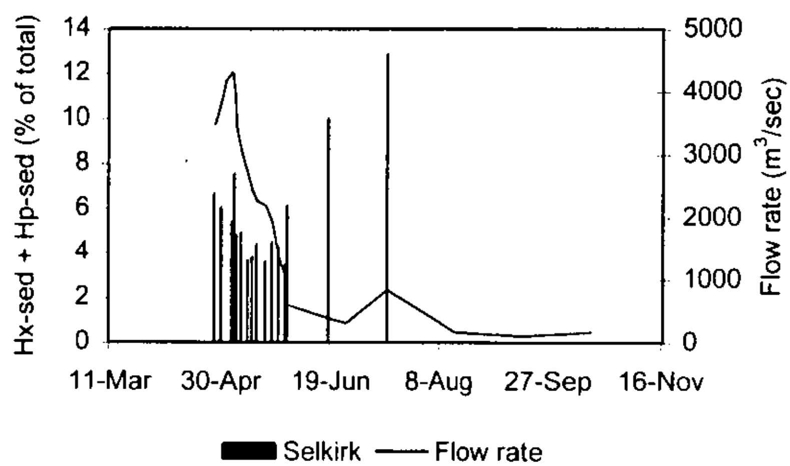


Figure 17. Concentrations of Hx-sed and Hp-sed toxaphene congeners as a ratio of total toxaphene on suspended sediments collected from the Red River at Selkirk and the Floodway in 1997 plotted against flow rate.

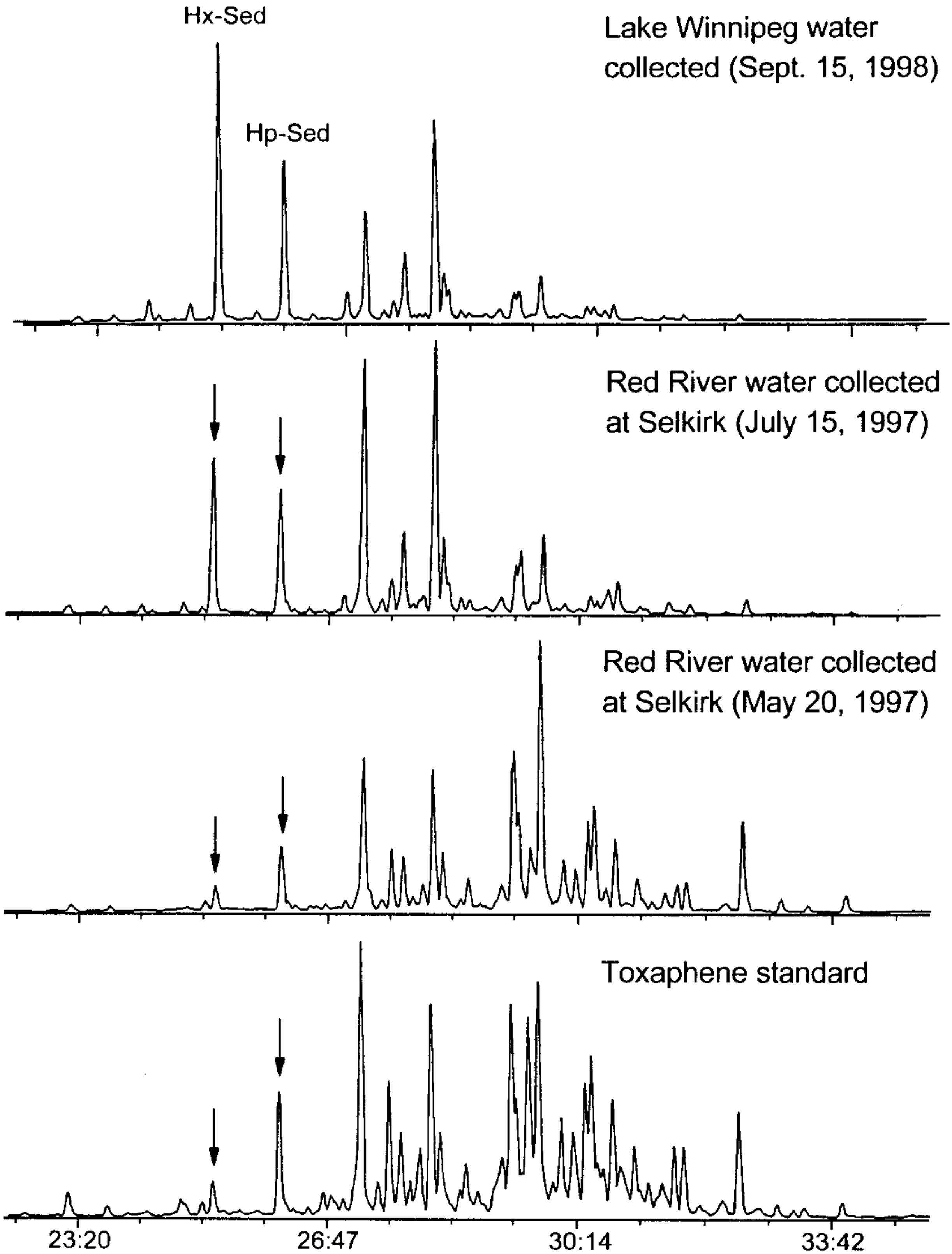


Figure 18. Electron capture negative ion selected ion chromatograms of chlorinated bornanes (sum of Cl_6-Cl_9) in Lake Winnipeg and Red River (at Selkirk) water and technical toxaphene.

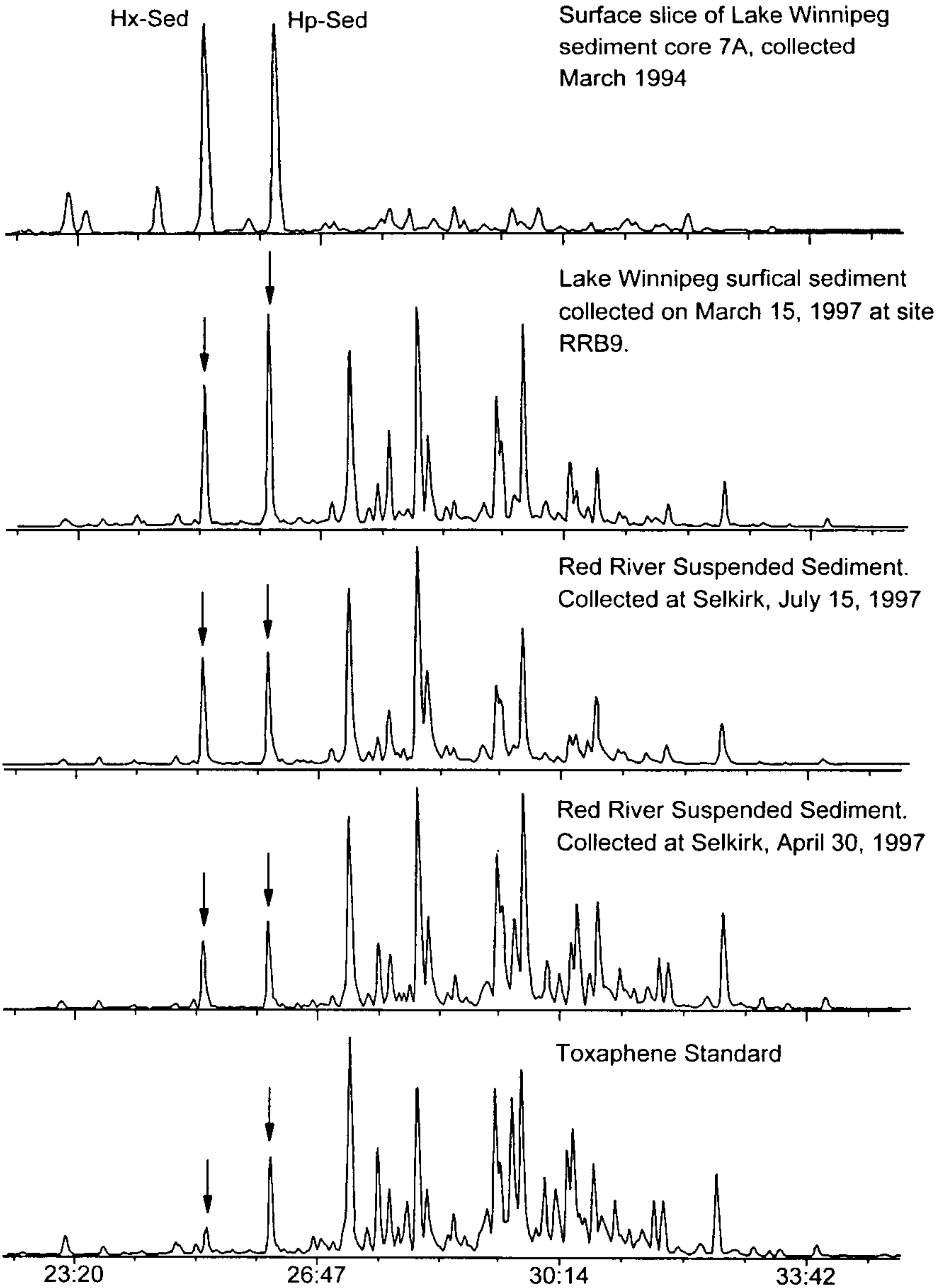


Figure 19. Electron capture negative ion selected ion chromatograms of chlorinated bornanes (sum of Cl_6-Cl_9) in Lake Winnipeg surficial sediment, Red River suspended sediment and technical toxaphene.

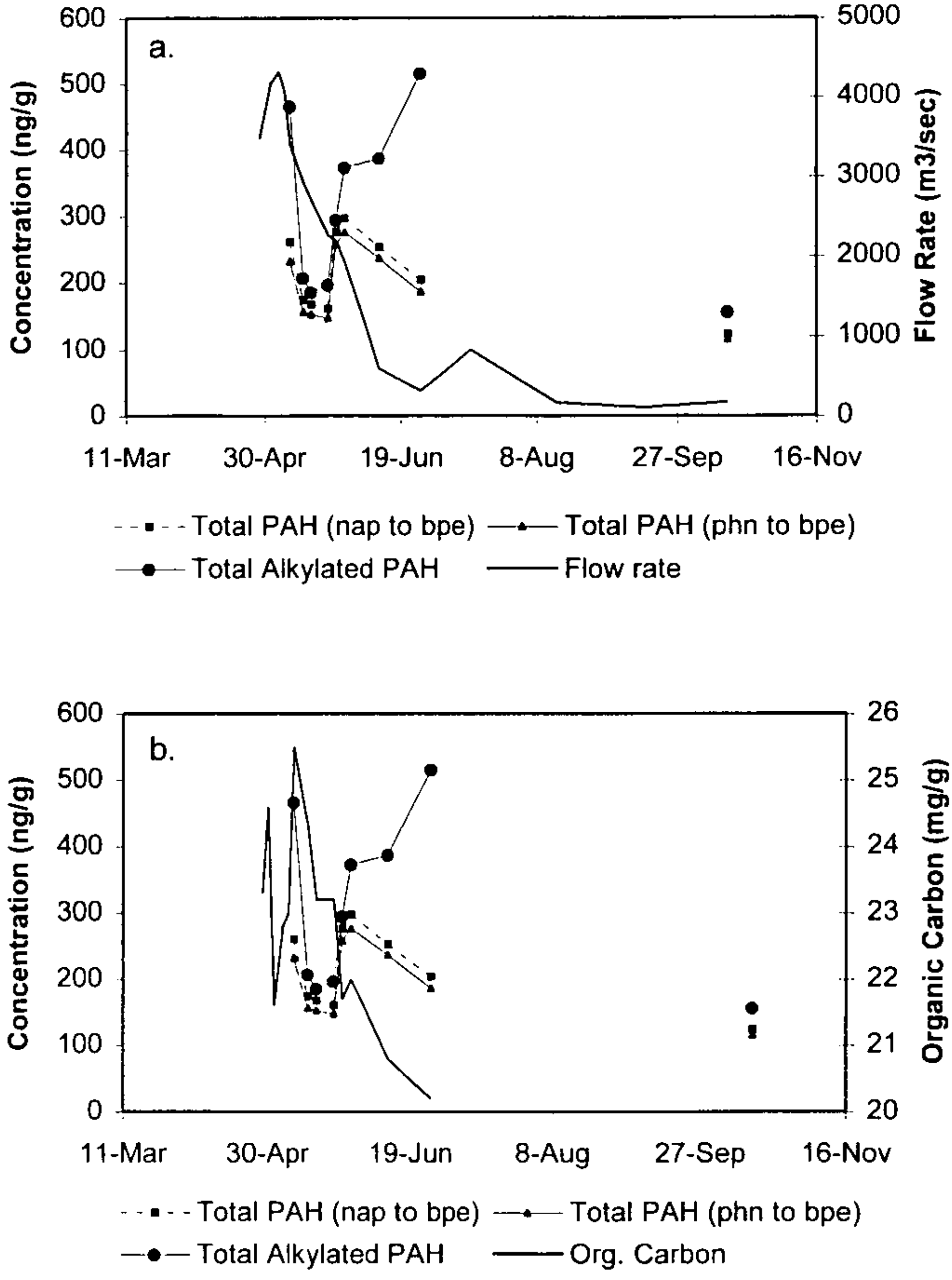


Figure 20. Concentrations of classes of Polyaromatic hydrocarbons in water samples at Selkirk during 1997. a. Graphed against flow rate. b. Graphed against organic carbon content of suspended sediment.

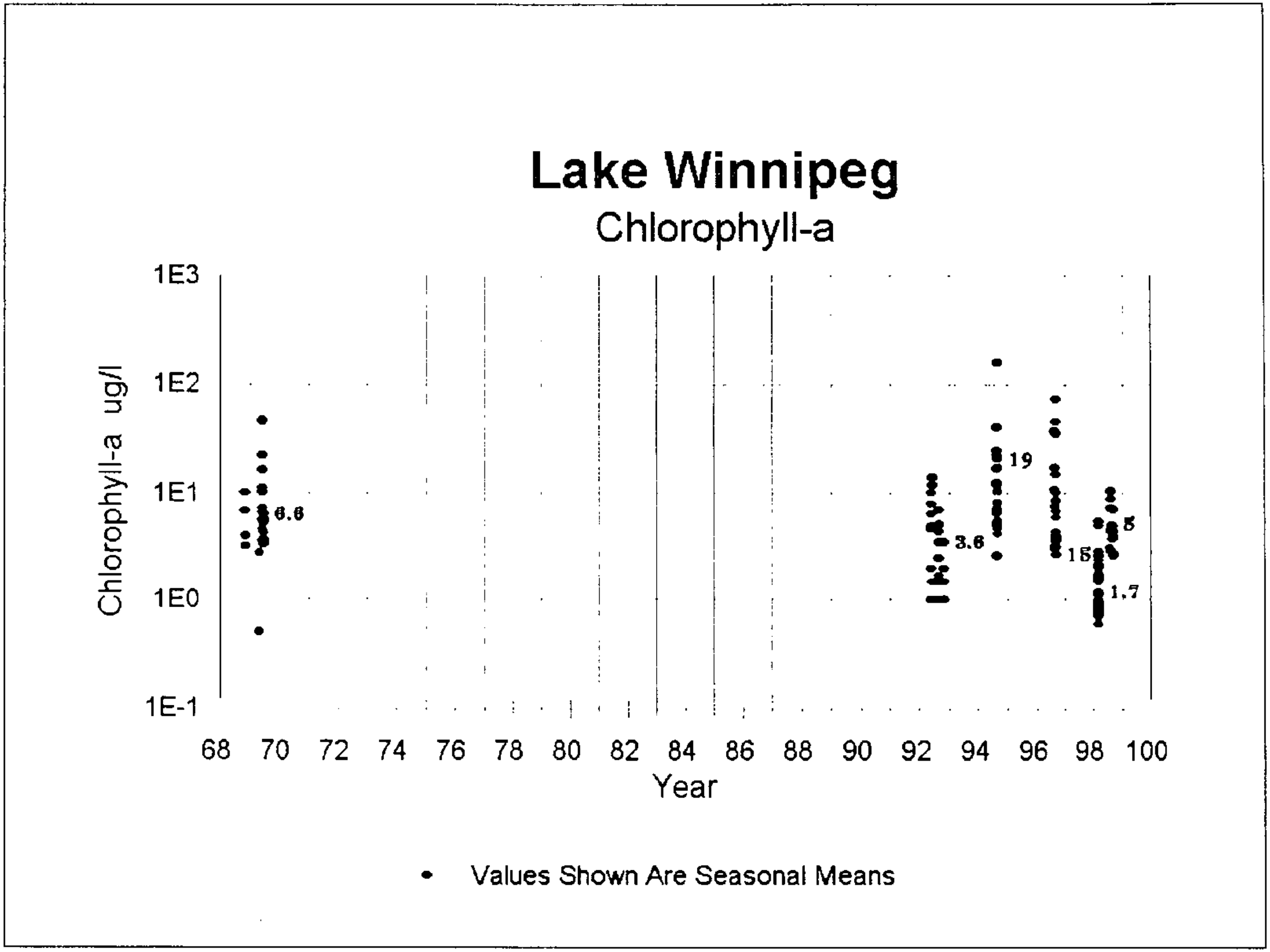


Figure 21. Historical Chlorophyll-a concentrations in the South Basin of Lake Winnipeg

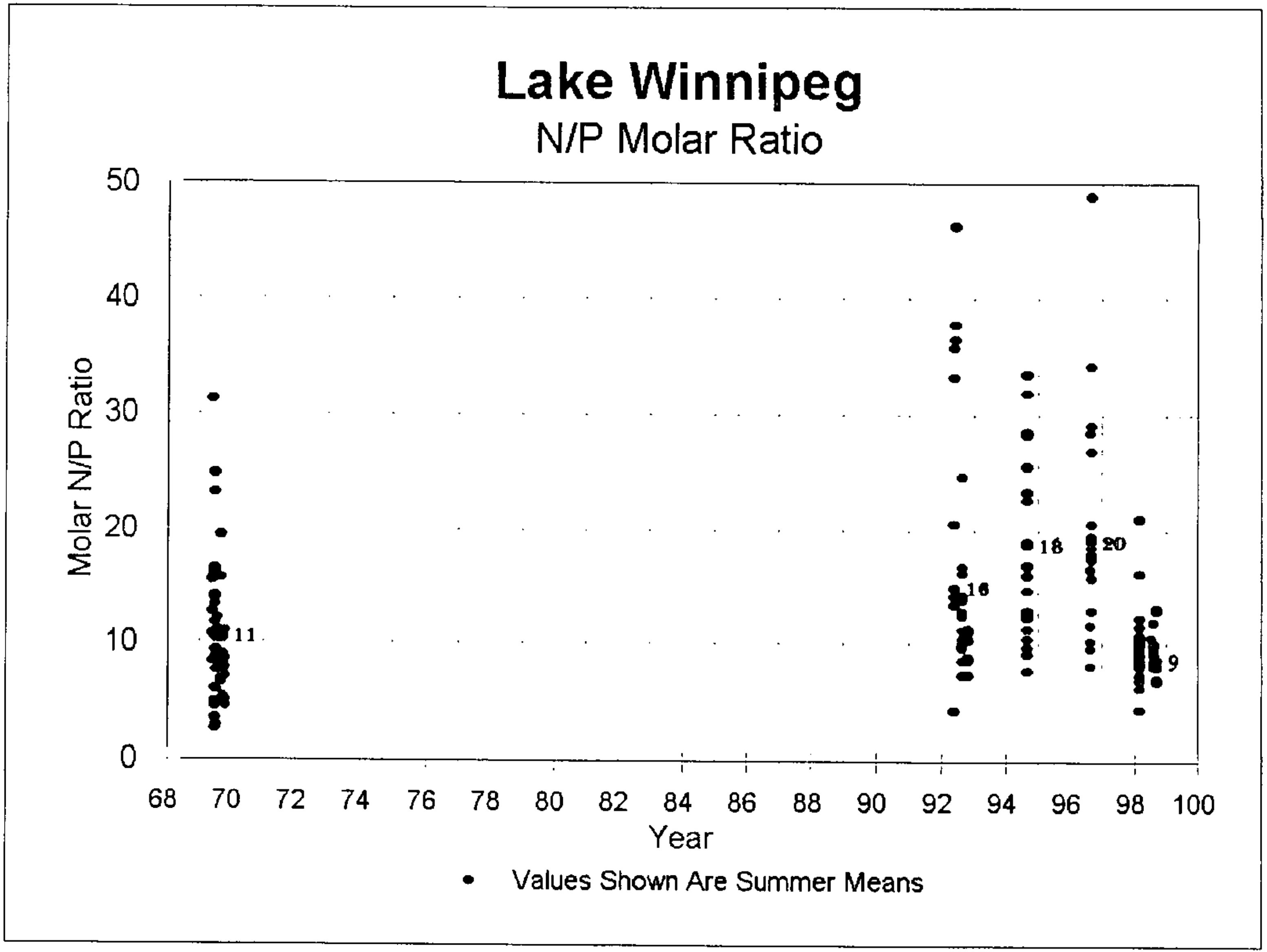


Figure 22. Historical N/P molar ratios in the South Basin of Lake Winnipeg

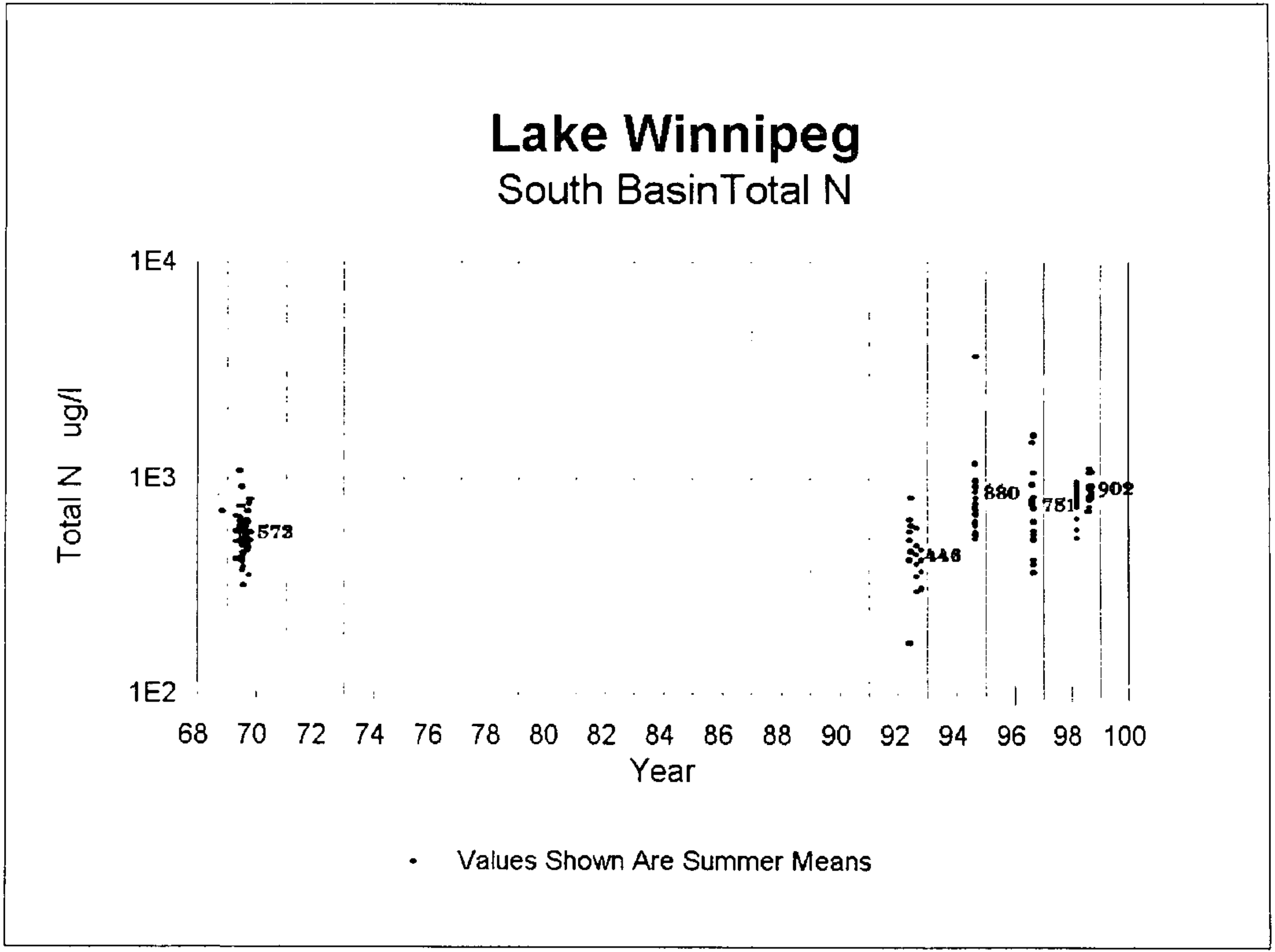


Figure 23A. Historical record of Total Nitrogen in waters of the South Basin of Lake Winnipeg

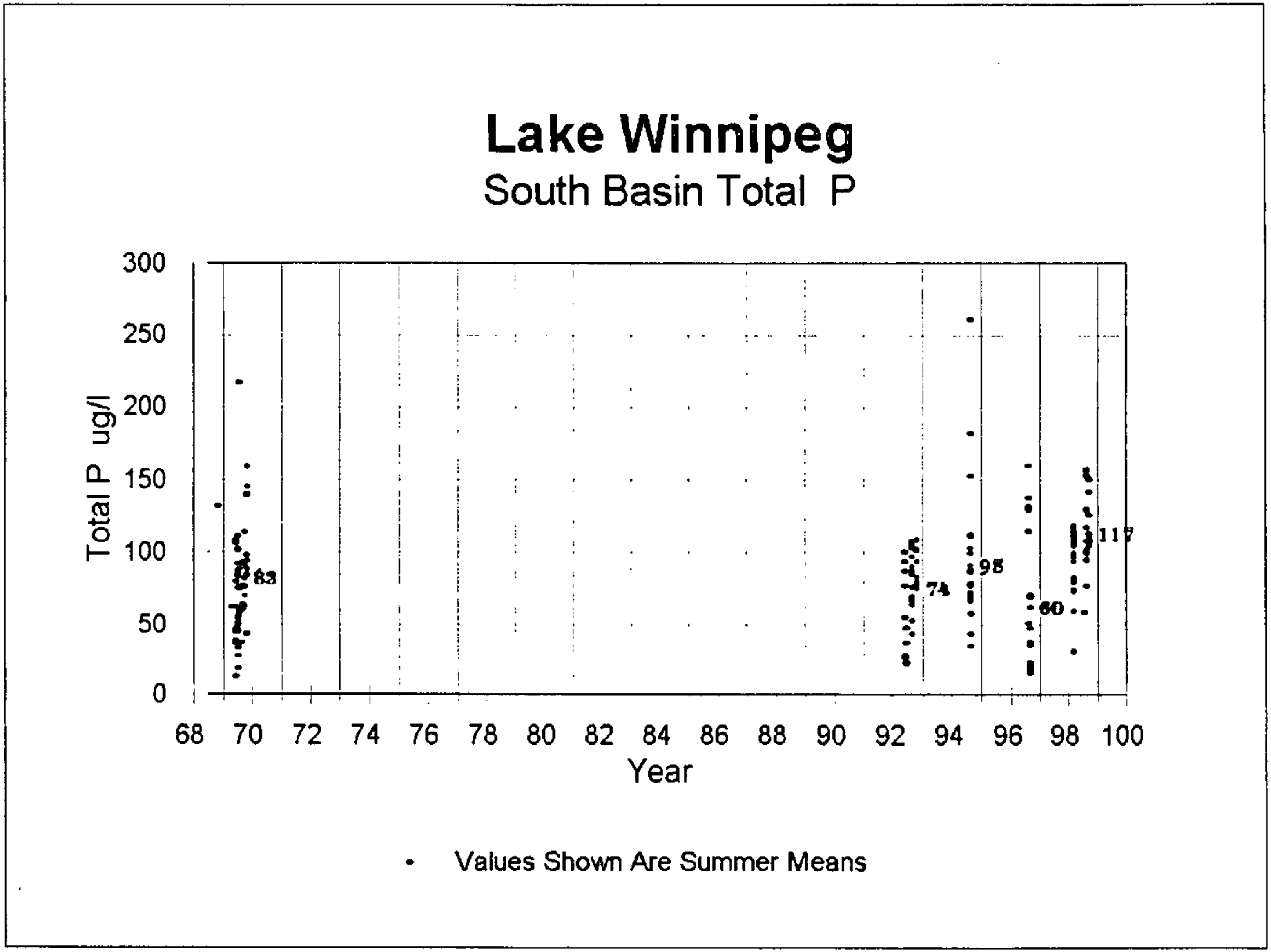


Figure 23B. Historical record of Total Phosphorus in waters of the South Basin of Lake Winnipeg

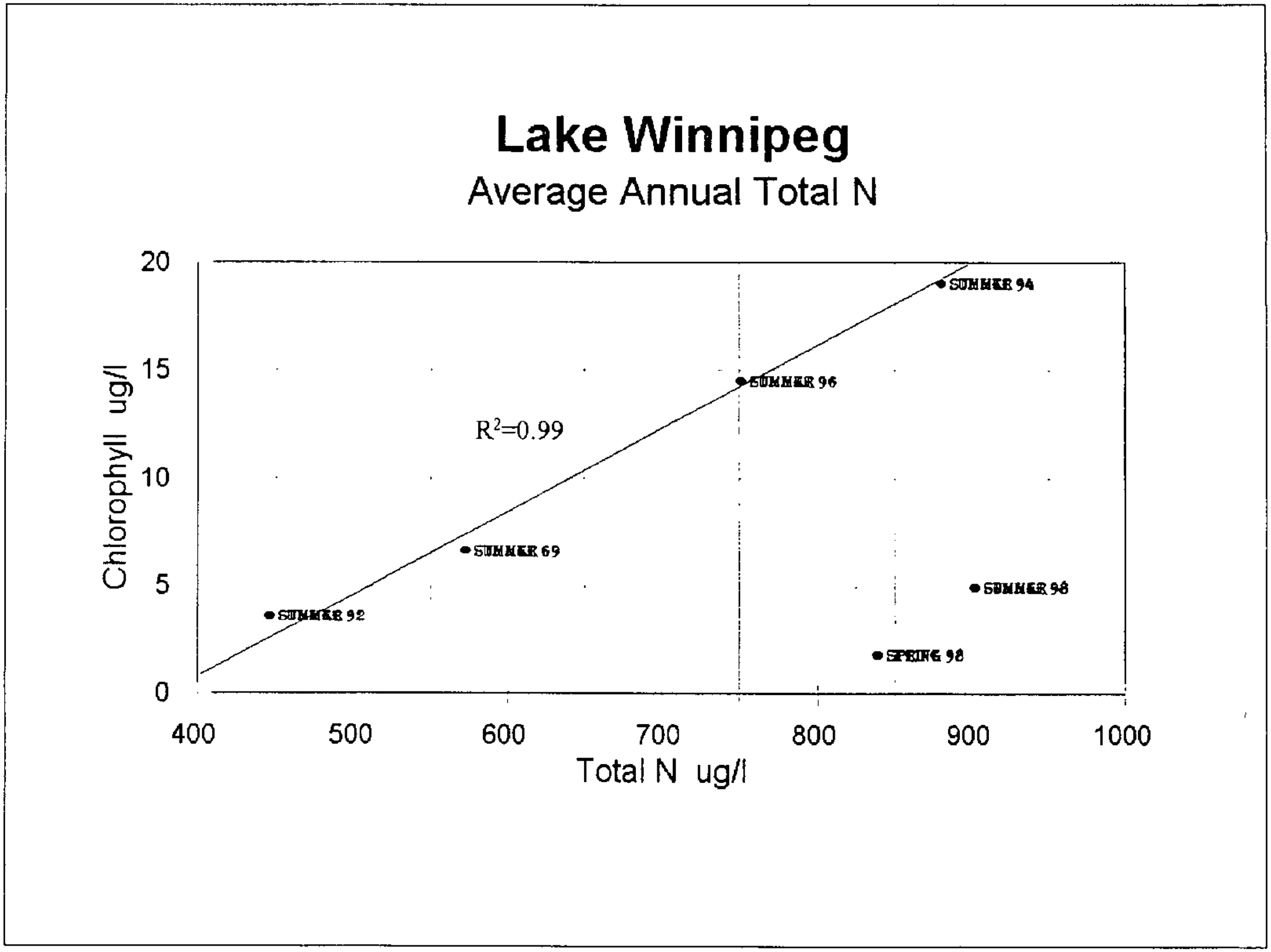


Figure 24. Average annual Total N and Chlorophyll in waters of the South Basin of Lake Winnipeg

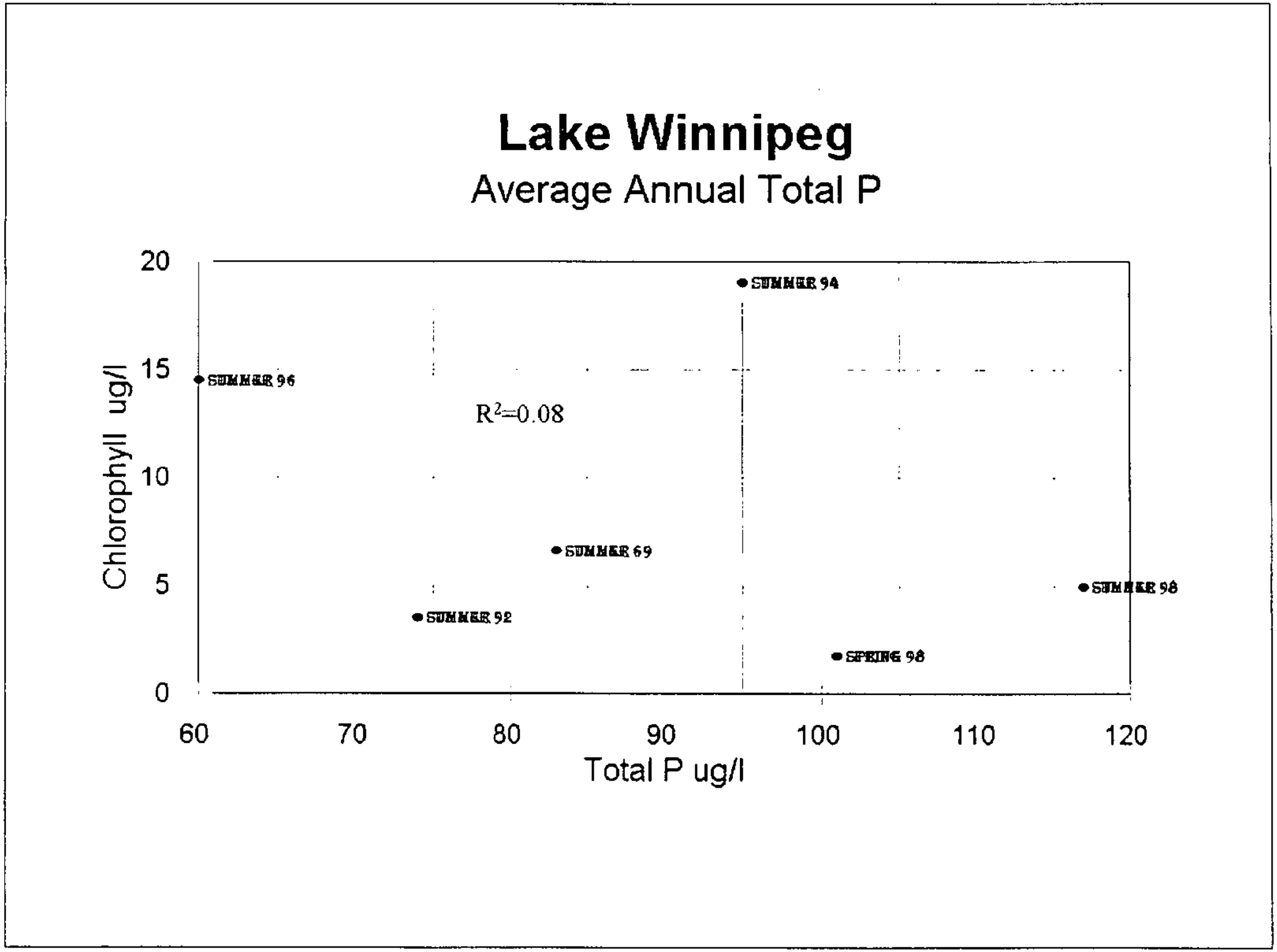


Figure 25. Average annual Total P and Chlorophyll in waters of the South Basin of Lake Winnipeg

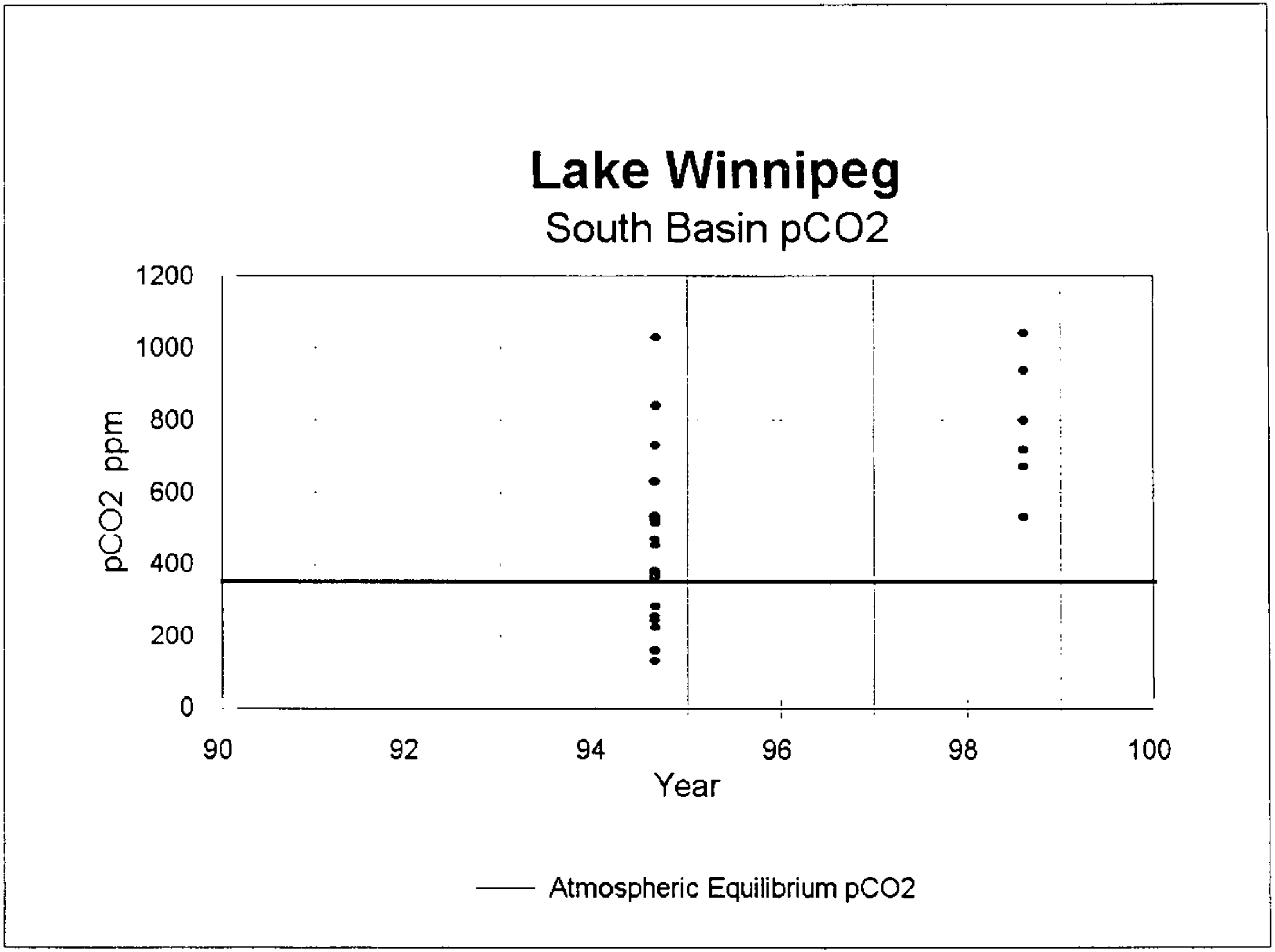


Figure 26A. pCO2 in waters of the South Basin of Lake Winnipeg

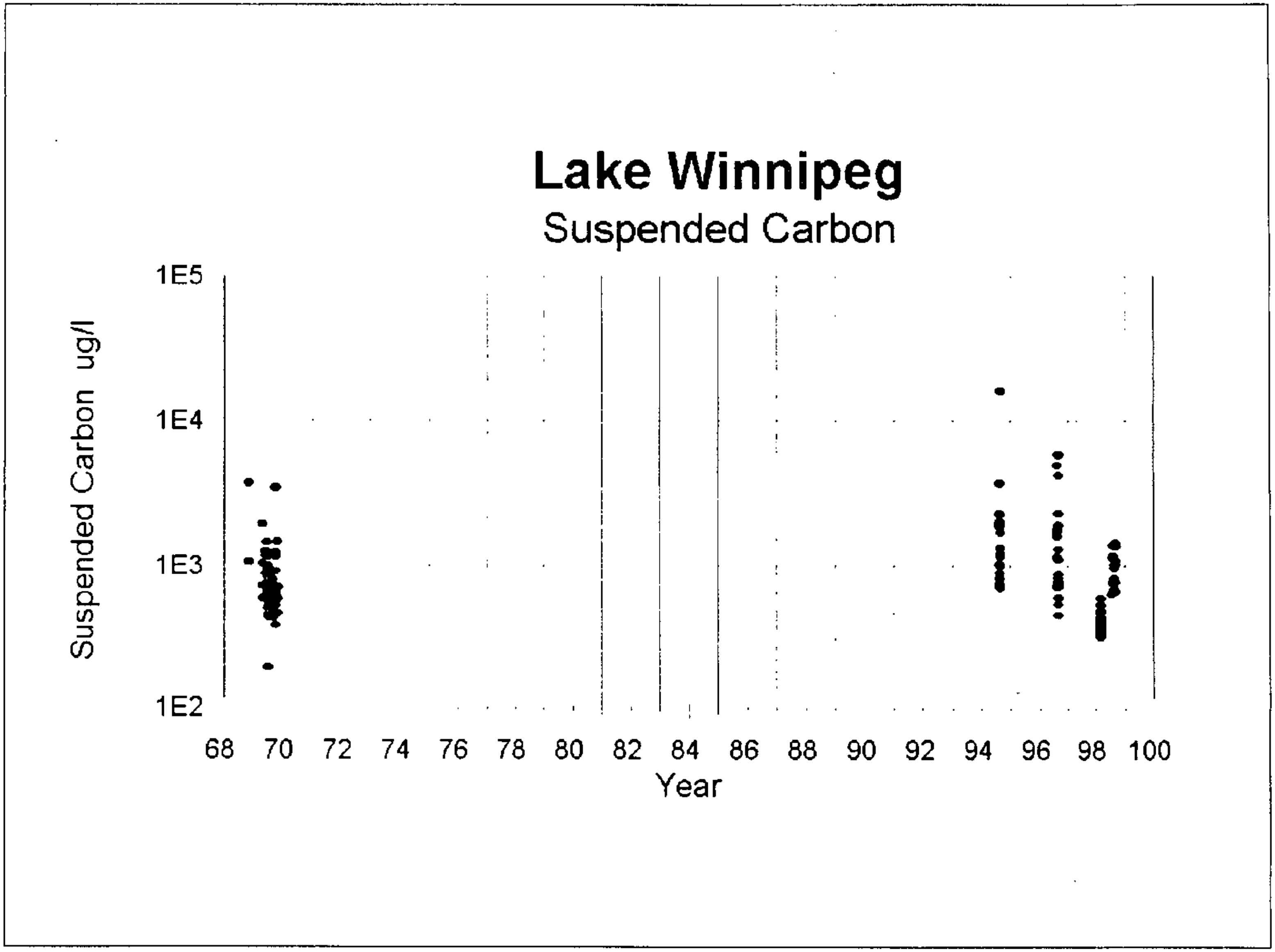


Figure 26B. Suspended Carbon in waters of the South Basin of Lake Winnipeg

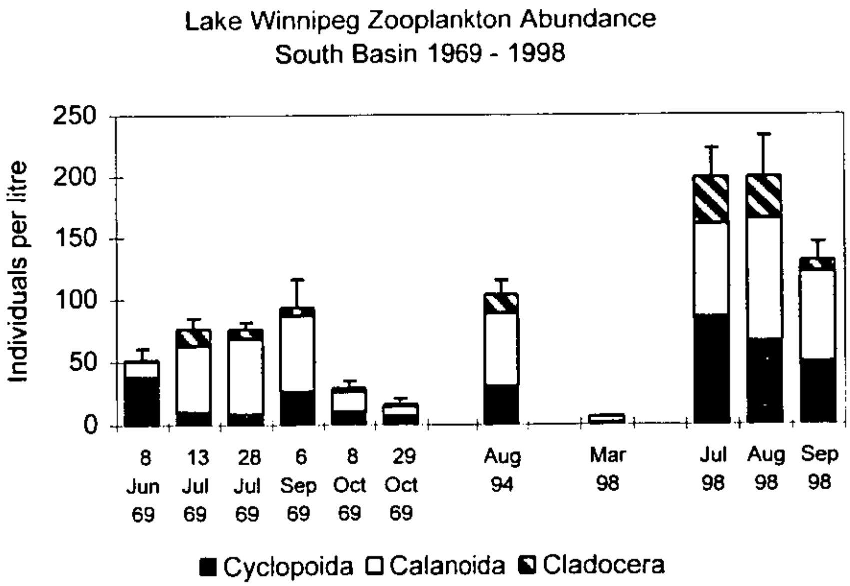


Figure 27. Mean total abundance of crustacean groups in particular months of 1998, 1994, and 1969 in the south basin of Lake Winnipeg. Values are means ± SE.

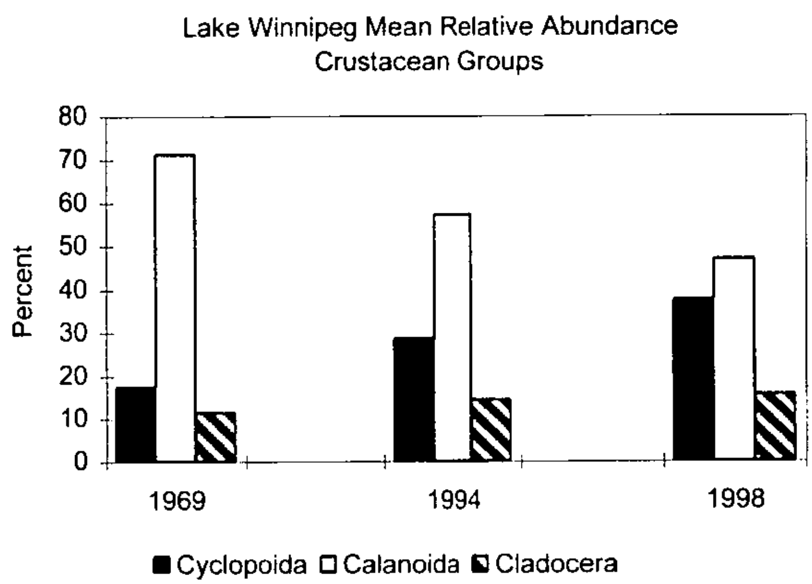


Figure 28. Mid summer mean relative abundance of cyclopoids, calanoids and cladocerans in the south basin of Lake Winnipeg in 1998, 1994, and 1969.

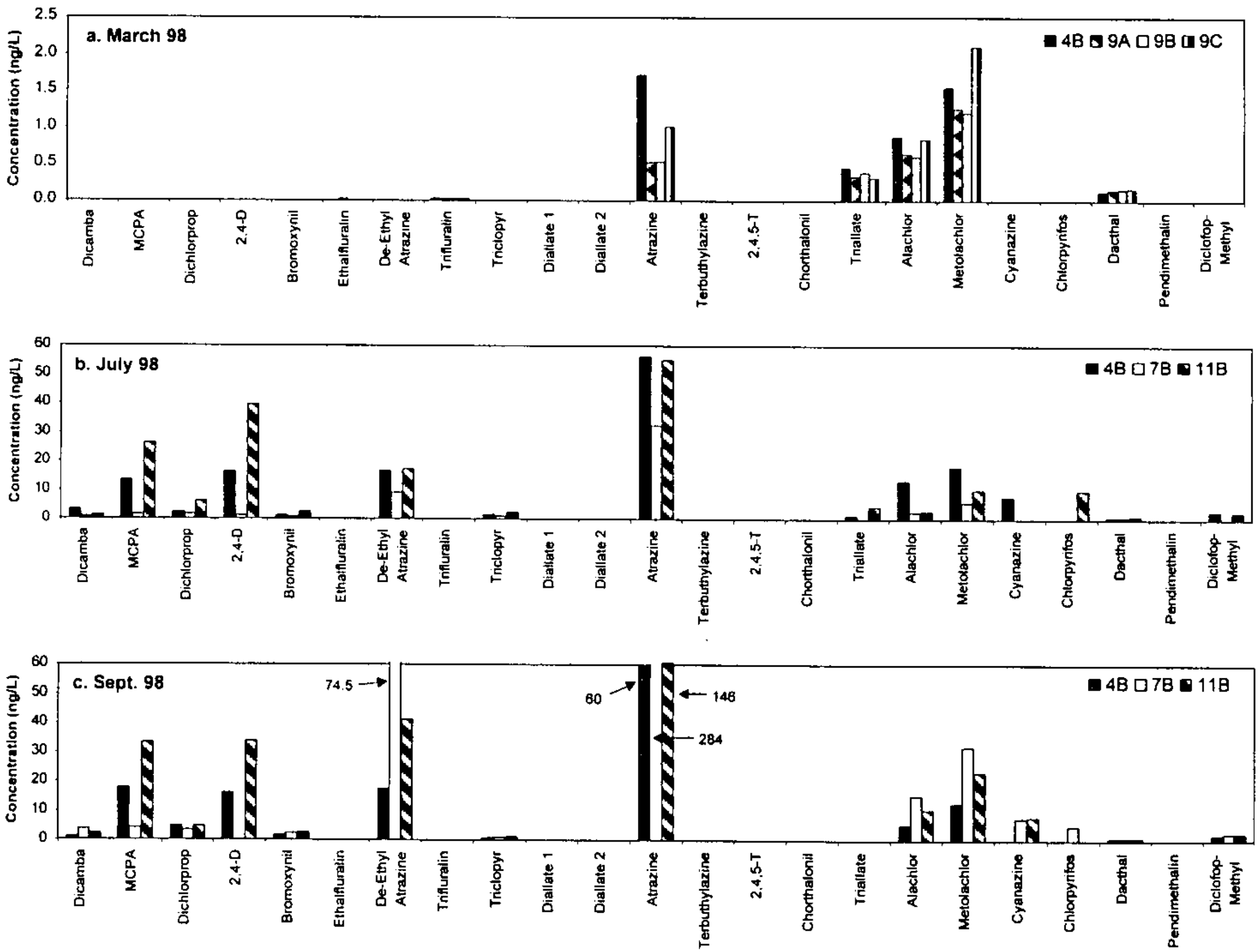


Figure 29. Herbicide concentrations in water samples collected from sites in the south basin of Lake Winnipeg in a. March, b. July and c.September 1998. Note that sites 9A, 9B and 9C are only sampled in March.

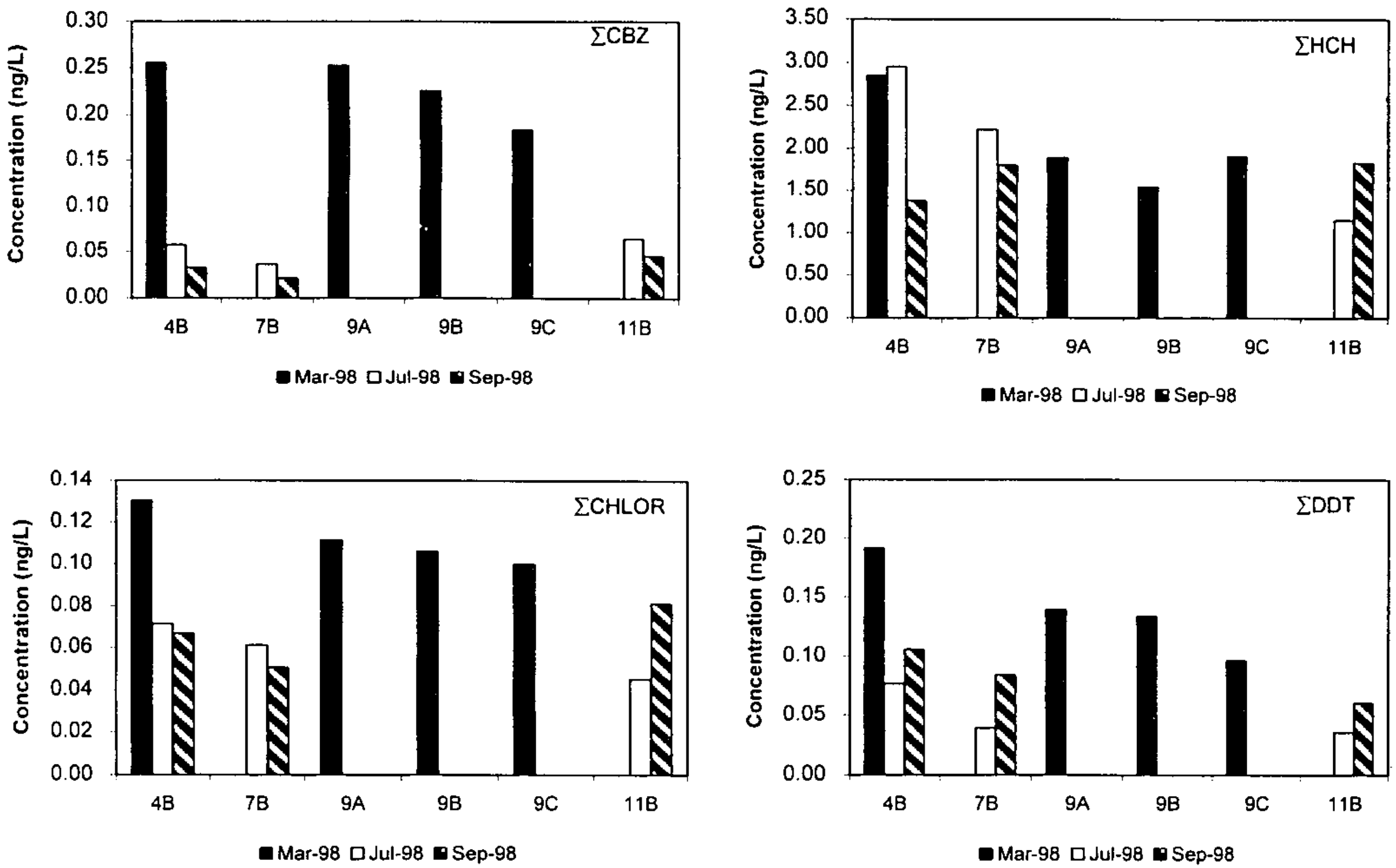


Figure 30. Organochlorine concentrations in water samples collected from sites in the south basin of Lake Winnipeg in 1997.

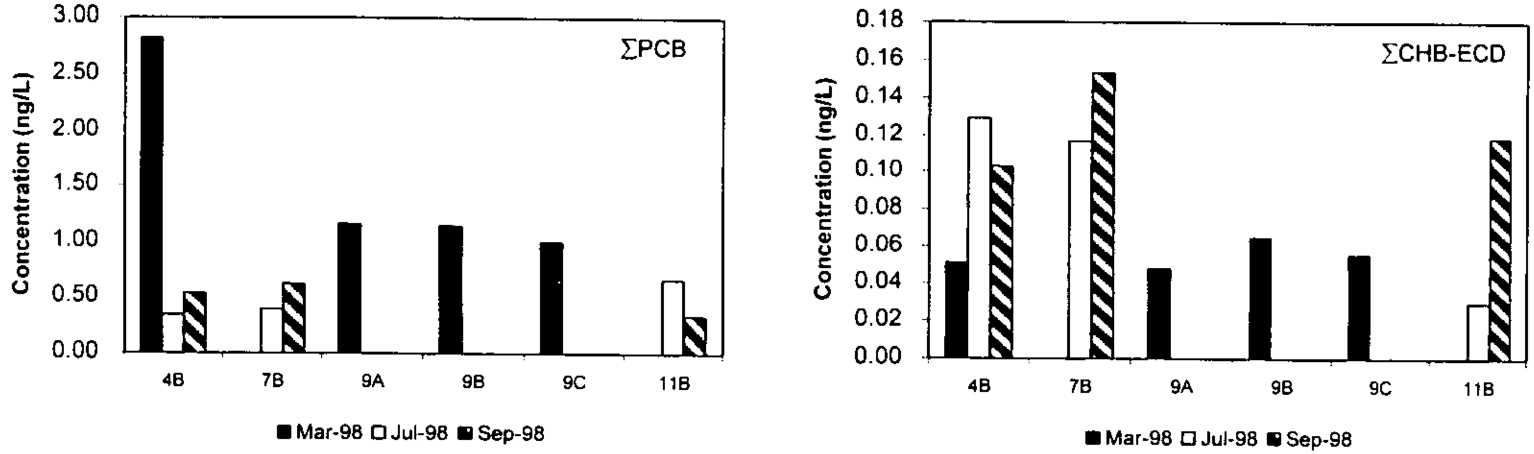


Figure 30. Organochlorine concentrations in water samples collected from sites in the south basin of Lake Winnipeg in 1997.

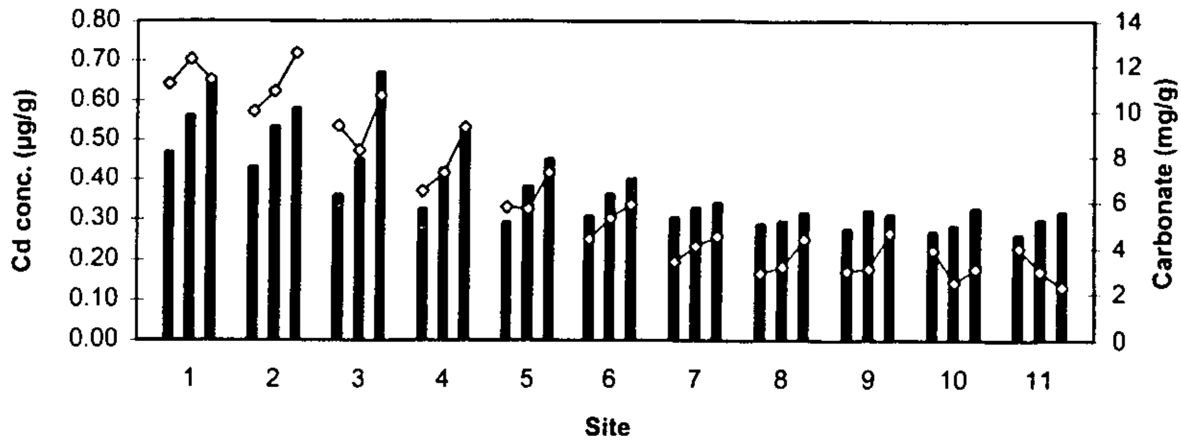


Figure 31. Cadmium concentrations (black bars) and carbonate concentrations (diamonds) in surface sediment grabs from the south basin of Lake Winnipeg. Bars are grouped by site. Transect A is the first bar, transect B is the second bar and transect C is the third bar of each category.

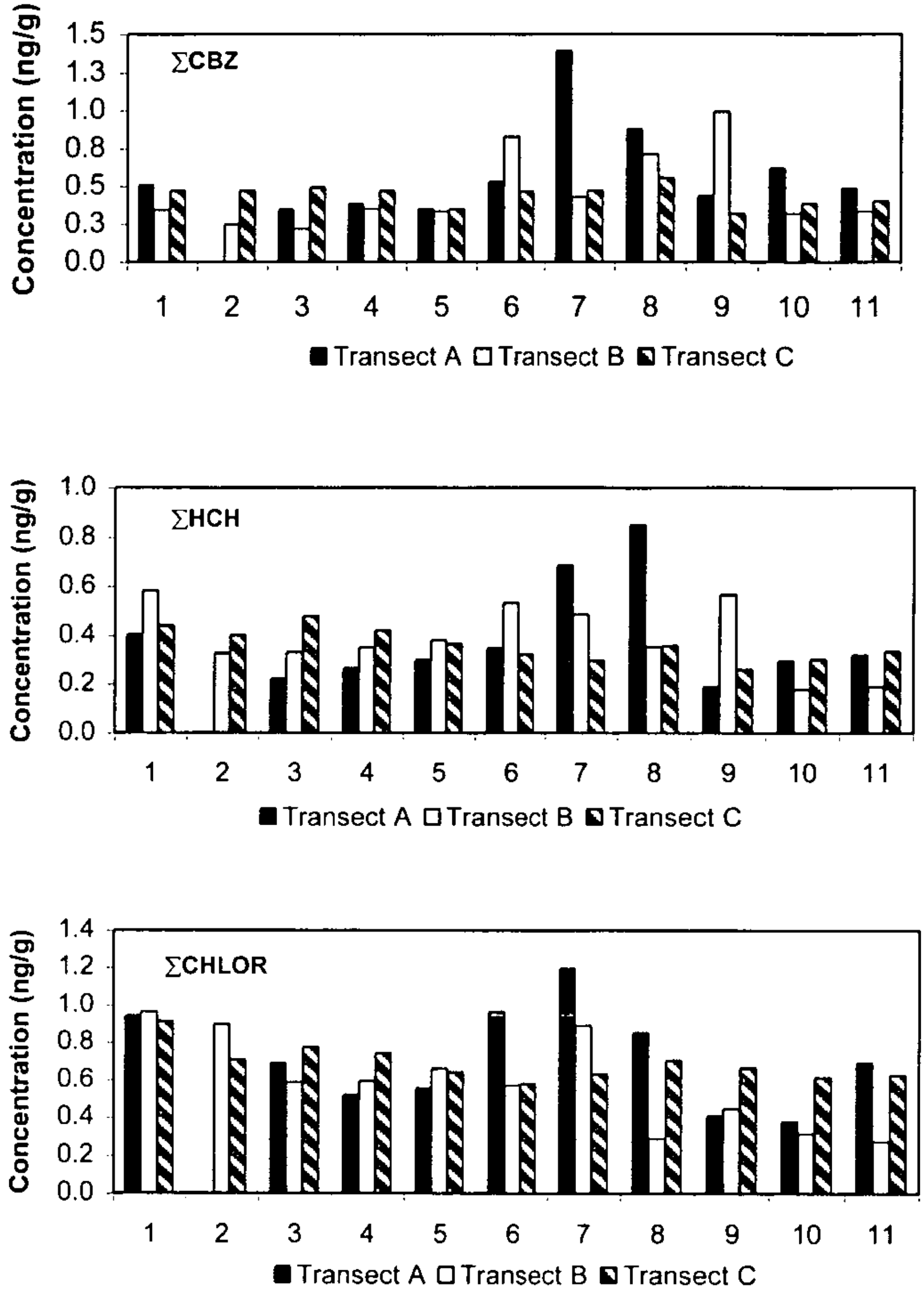


Figure 32. Organochlorine concentrations in surface sediments from sites in the south basin of Lake Winnipeg.

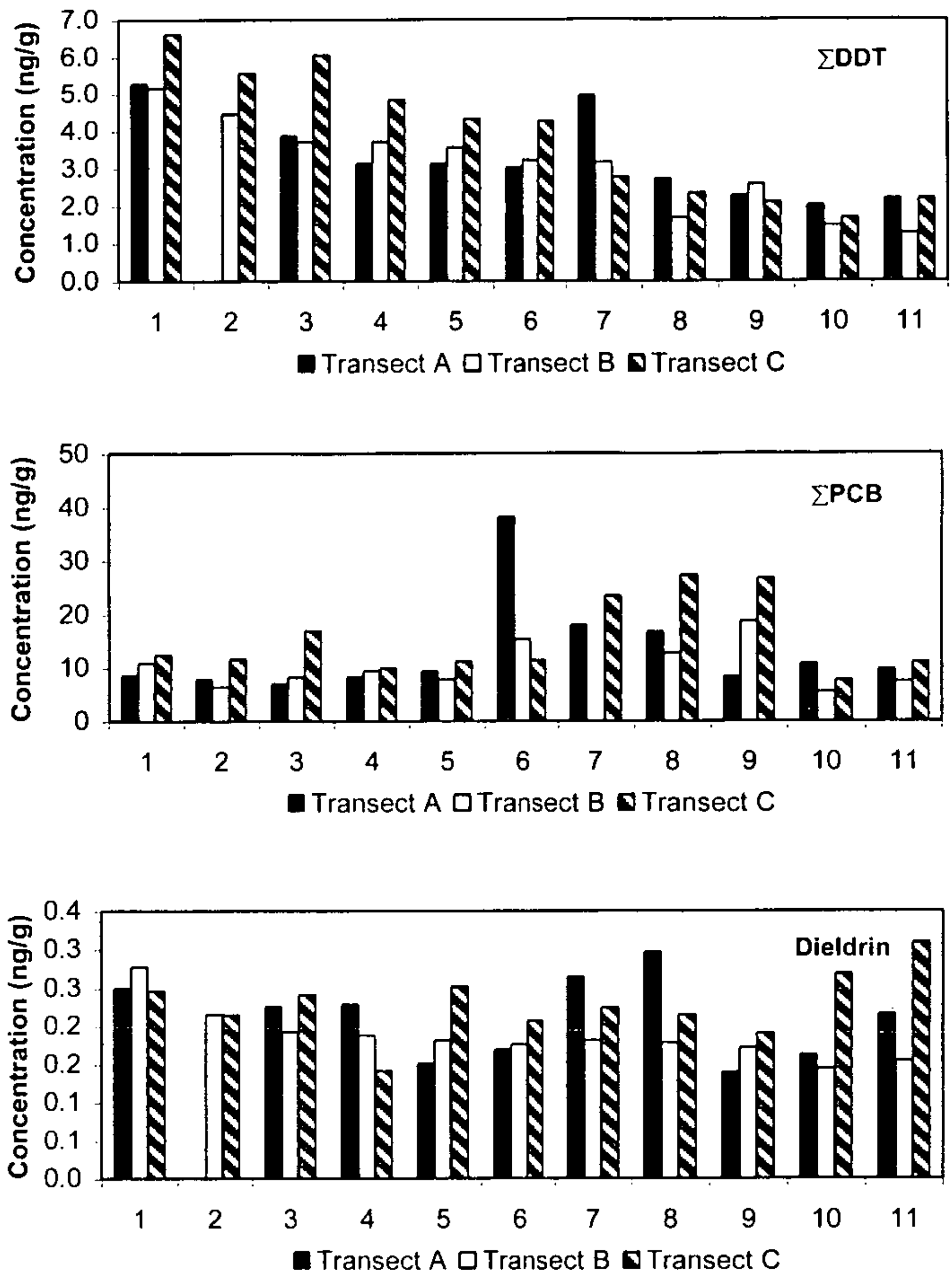


Figure 32. Organochlorine concentrations in surface sediments from sites in the south basin of Lake Winnipeg.

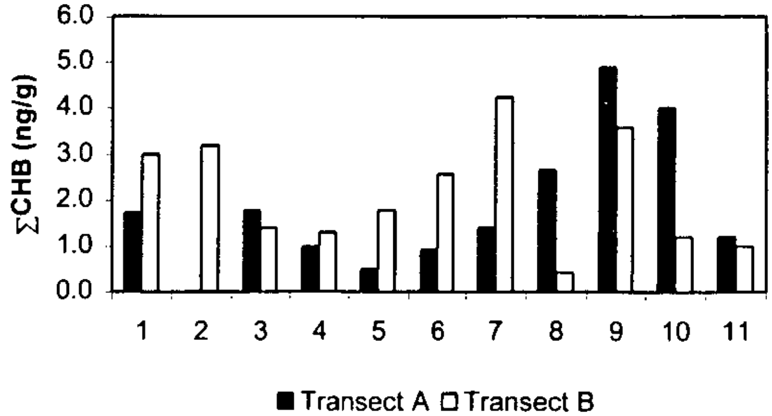


Figure 33. Concentrations of total toxaphene in surface sediment samples collected from the south basin of Lake Winnipeg in 1998.

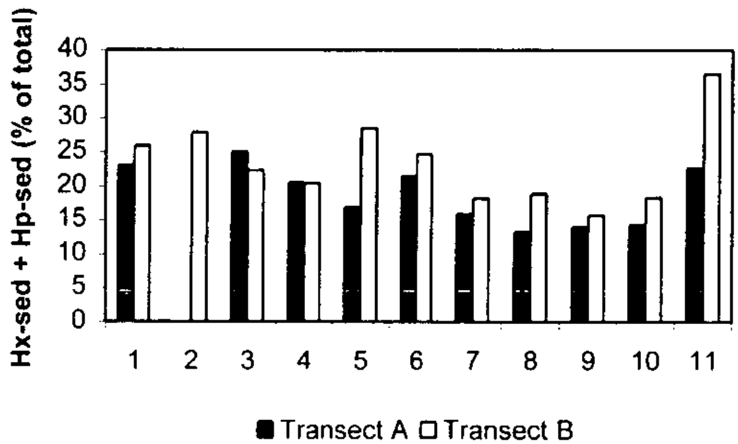


Figure 34. Concentrations of Hx-sed and Hp-sed toxaphene congeners as a ratio of total toxaphene in surface sediment samples collected from the south basin of Lake Winnipeg in 1998.

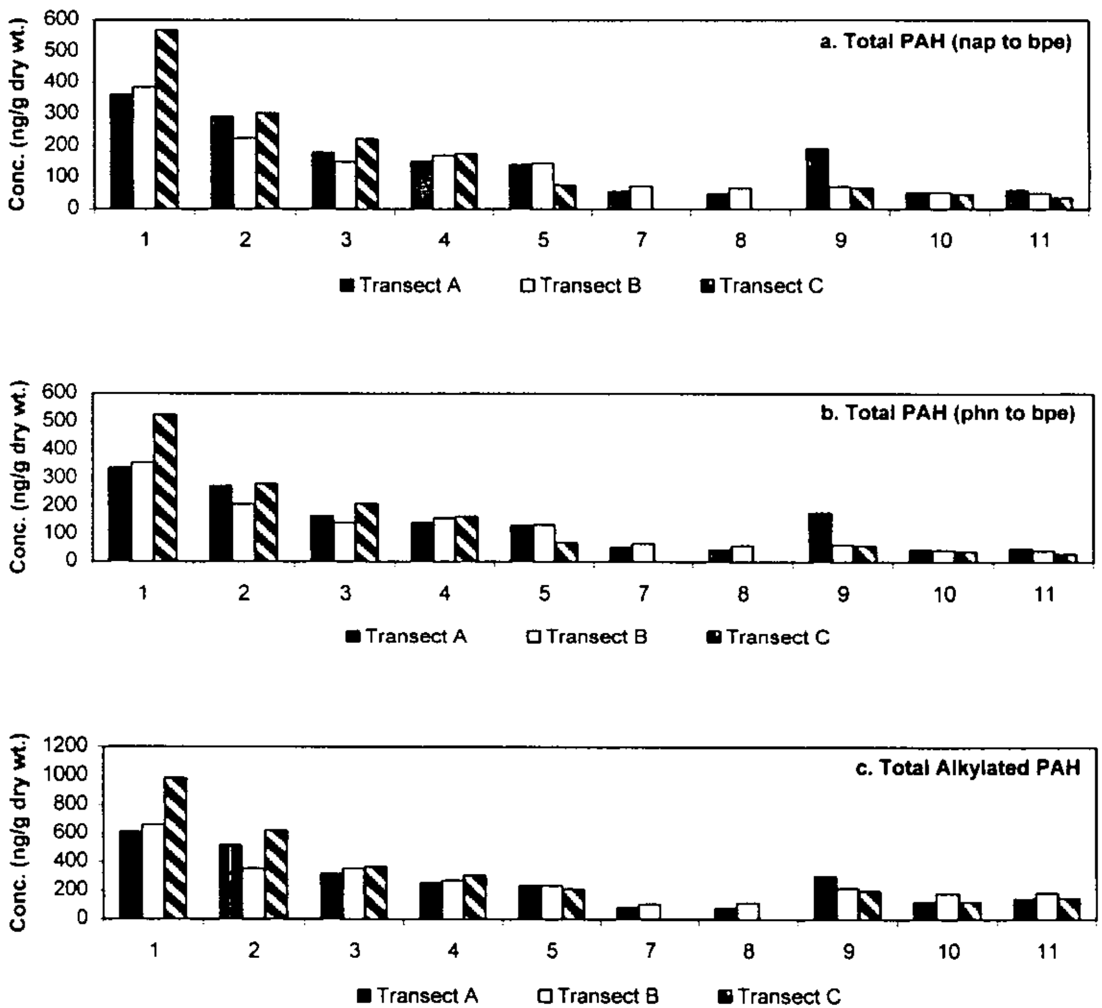


Figure 35. Concentration of Polyaromatic hydrocarbons in surface sediment samples from sites in the south basin of Lake Winnipeg. a. Total PAH (nap to bpe). b. Total PAH (phn to bpe). c. Total alkylated PAH.

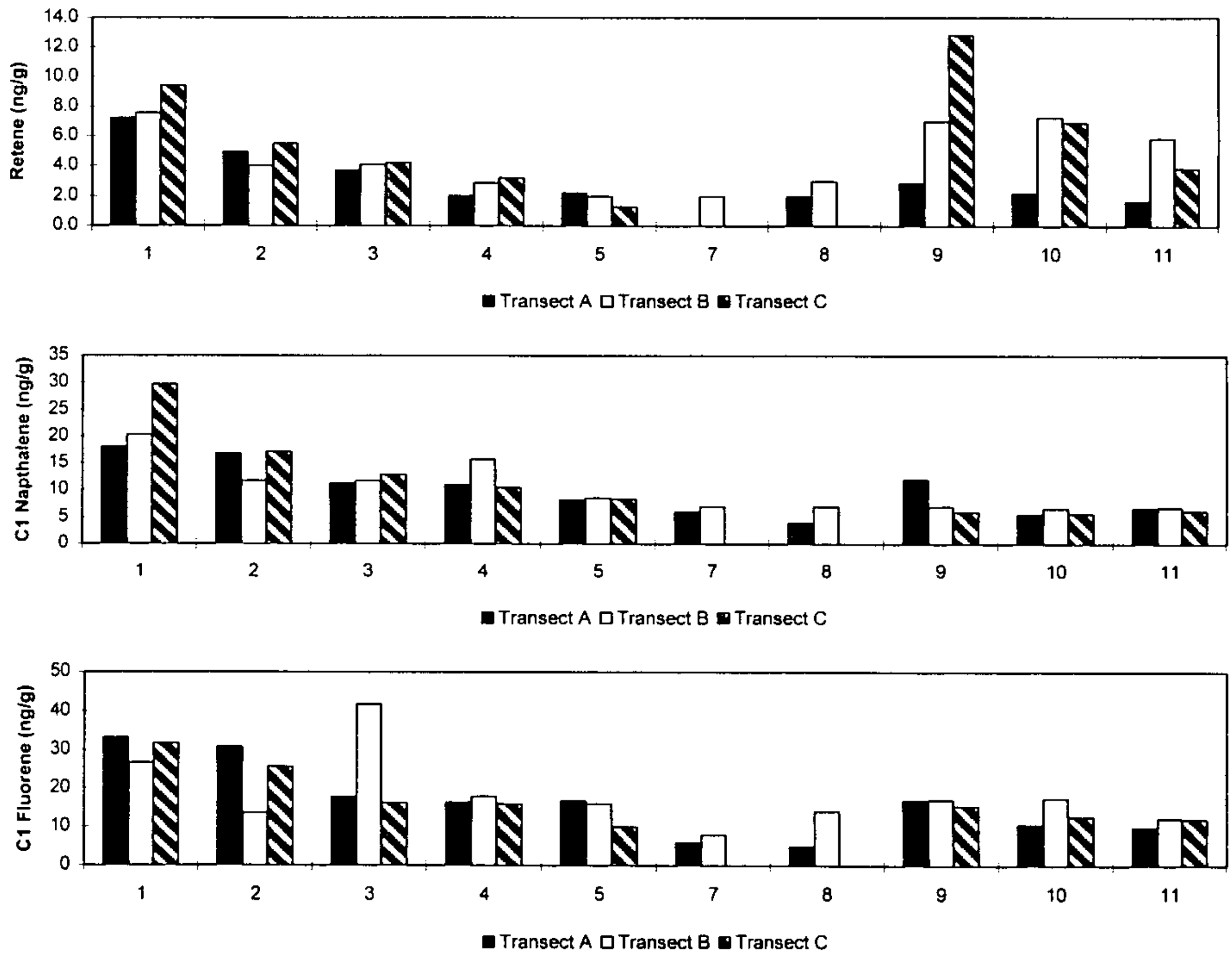


Figure 36. Concentrations of Polyaromatic hydrocarbons in surface sediments at sites in the south basin of Lake Winnipeg.

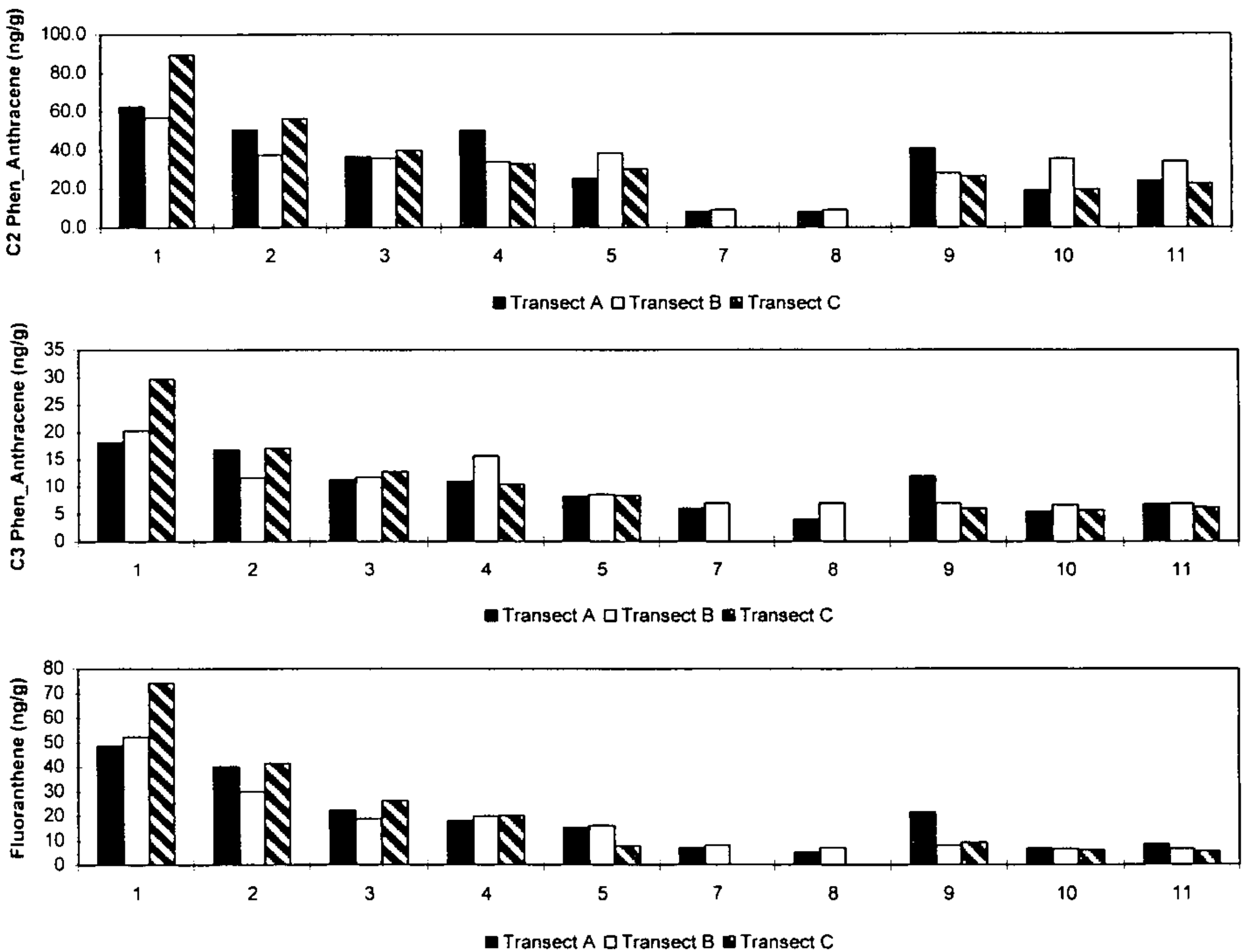


Figure 36. Concentrations of Polyaromatic hydrocarbons in surface sediments at sites in the south basin of Lake Winnipeg.

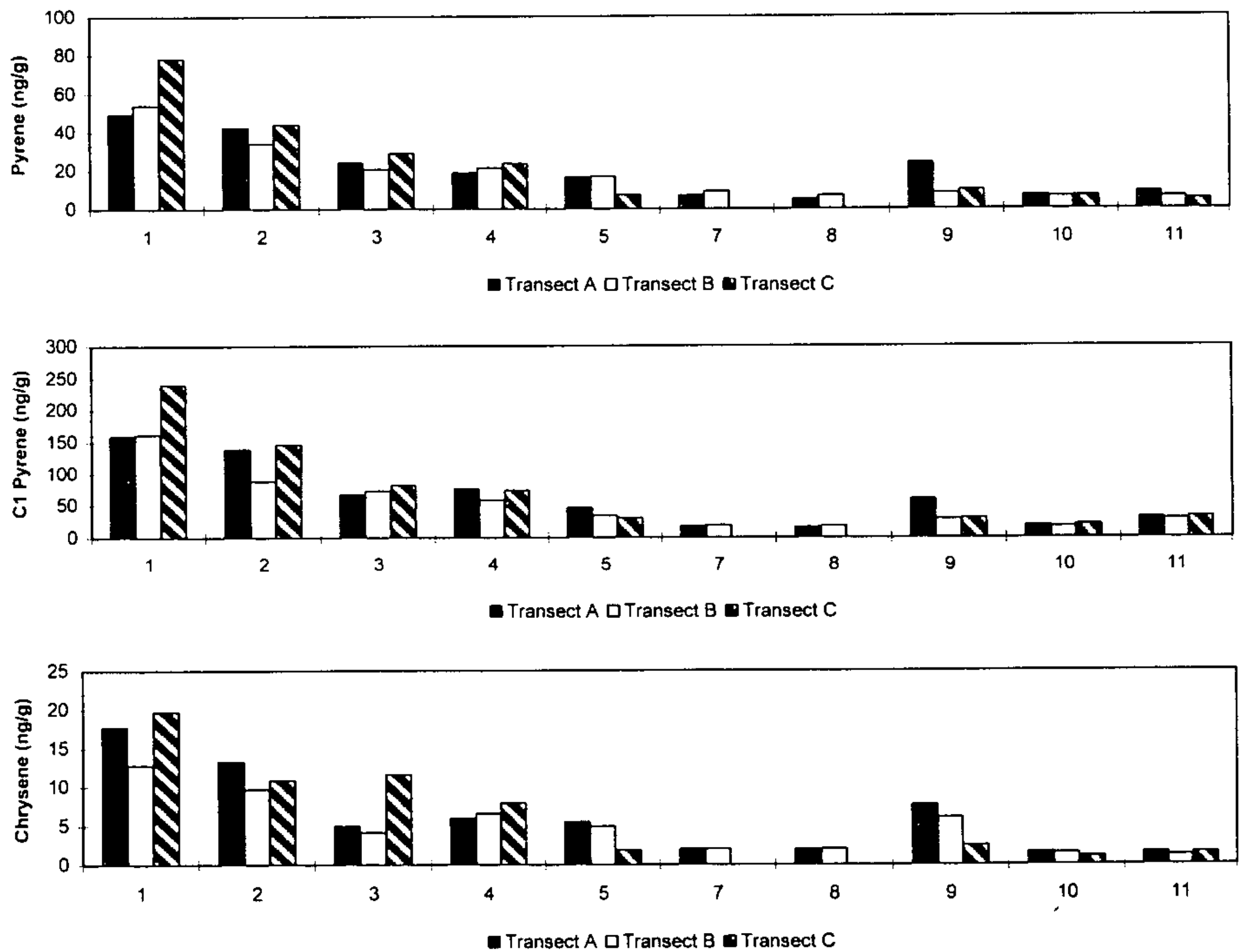


Figure 36. Concentrations of Polyaromatic hydrocarbons in surface sediments at sites in the south basin of Lake Winnipeg.

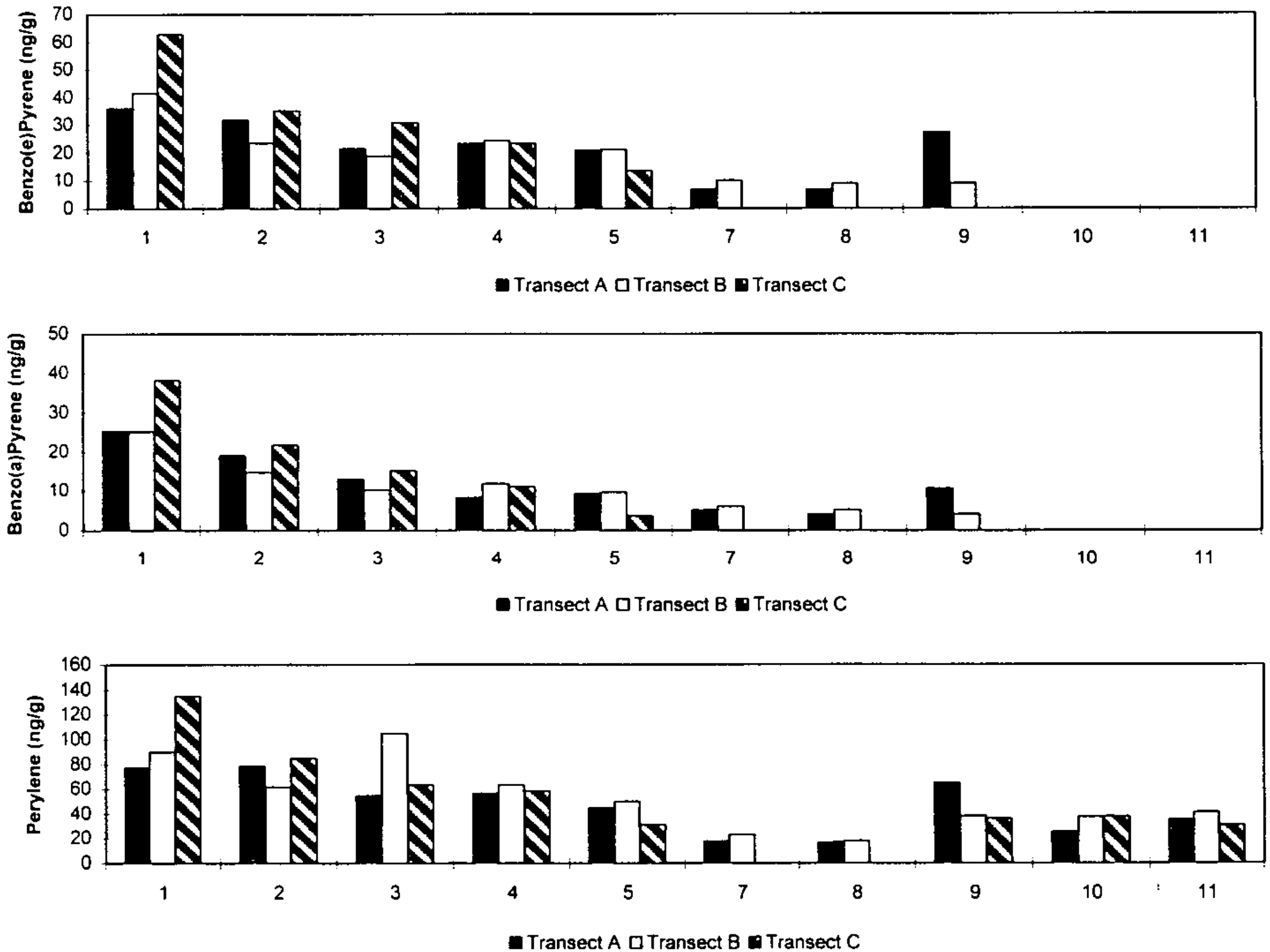


Figure 36. Concentrations of Polyaromatic hydrocarbons in surface sediments at sites in the south basin of Lake Winnipeg.

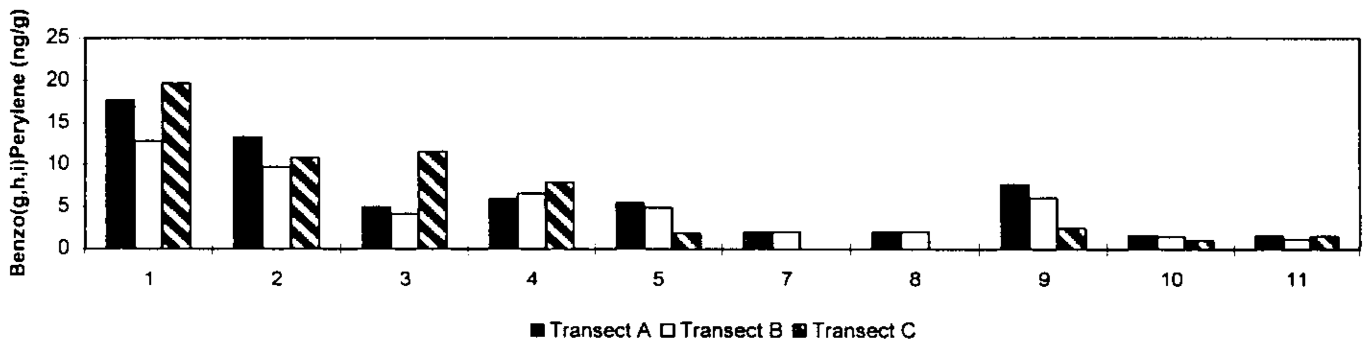


Figure 36. Concentrations of Polyaromatic hydrocarbons in surface sediments at sites in the south basin of Lake Winnipeg.

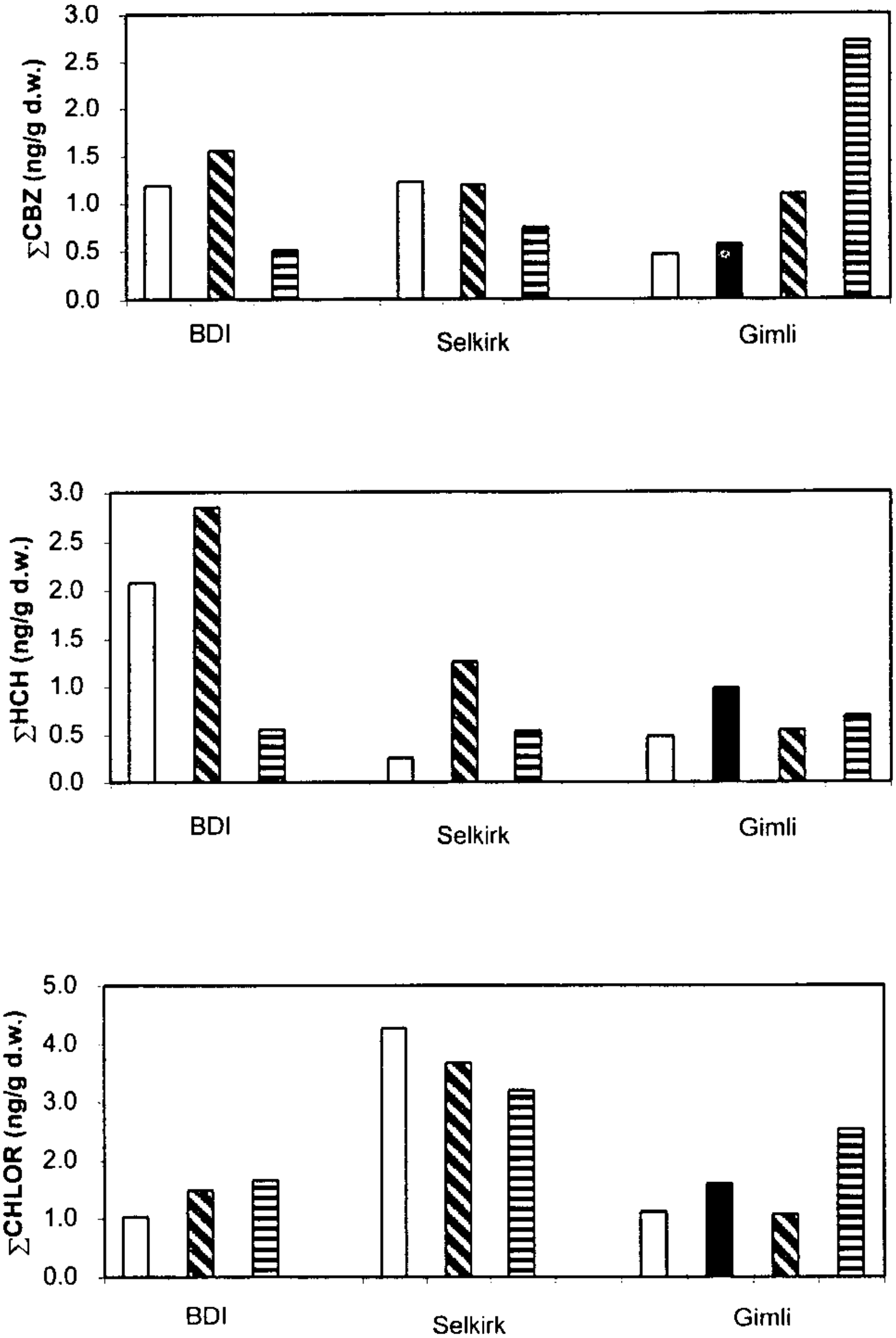


Figure 37. Organochlorine concentrations in mayflies collected at the Bridge Drive-In (BDI) in Winnipeg, at Selkirk, and at Gimli in 1997. Male sub-imago - white bar. Male imago -black bar. Female sub-imago - slanted bar. Female imago - hatched bar.

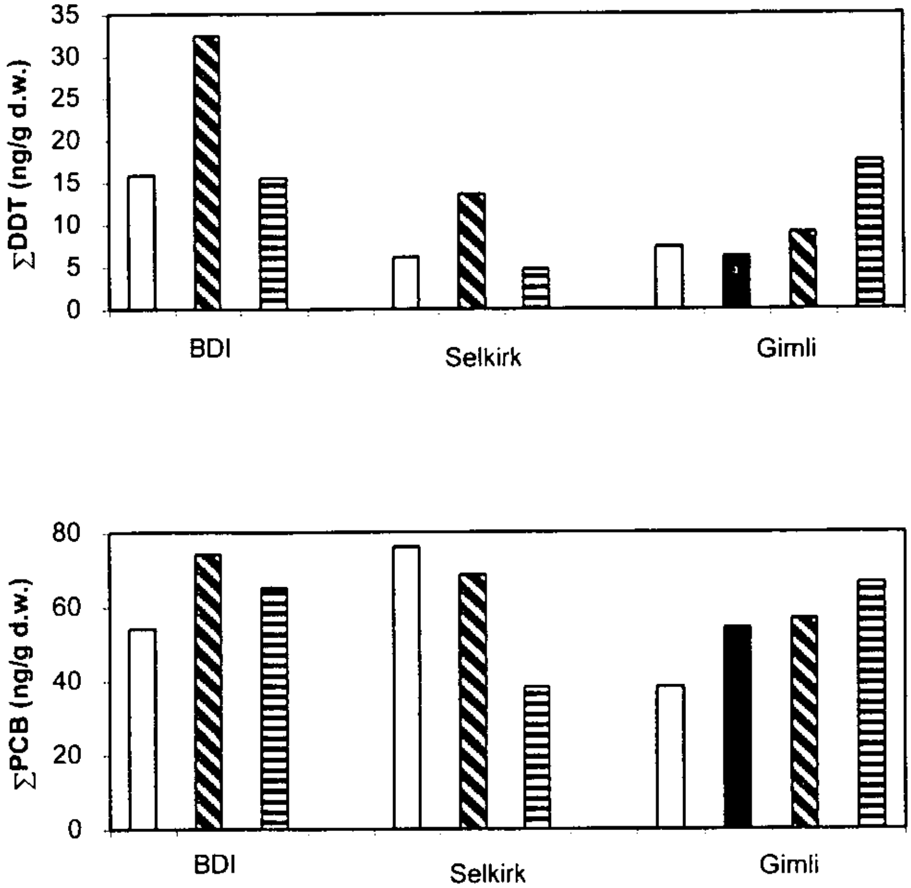


Figure 37. Organochlorine concentrations in mayflies collected at the Bridge Drive-In (BDI) in Winnipeg, at Selkirk, and at Gimli in 1997. Male sub-imago - white bar. Male imago -black bar. Female sub-imago - slanted bar. Female imago - hatched bar.

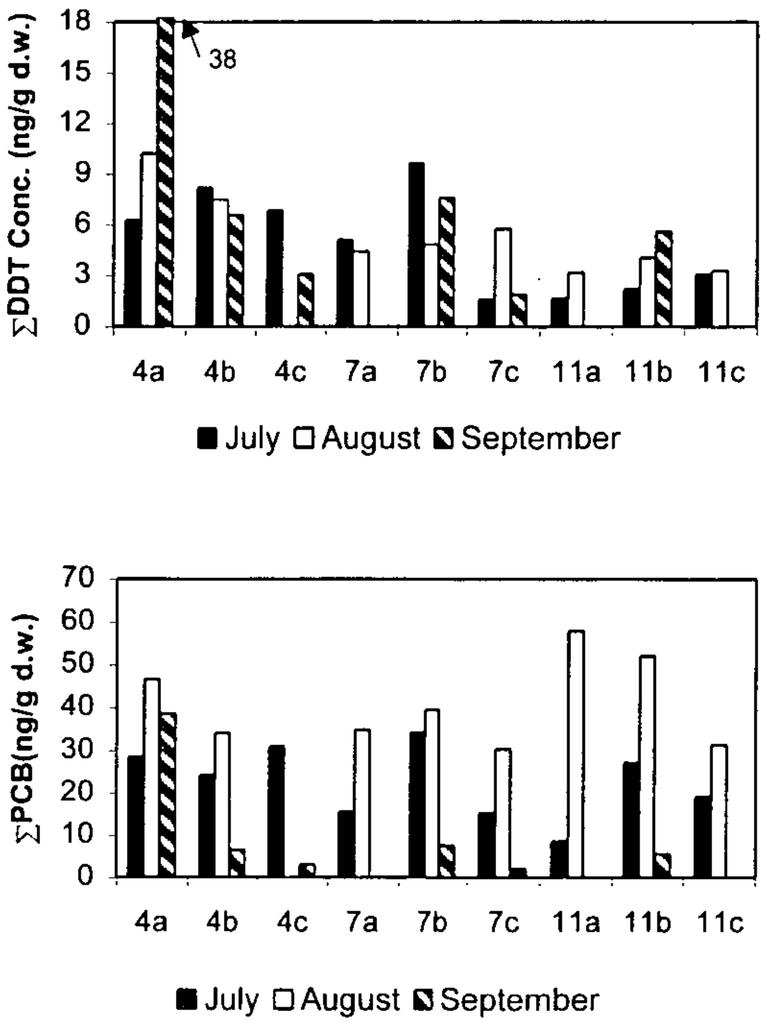


Figure 38. Organochlorine concentrations in zooplankton collected from sites in the south basin of Lake Winnipeg in 1998.

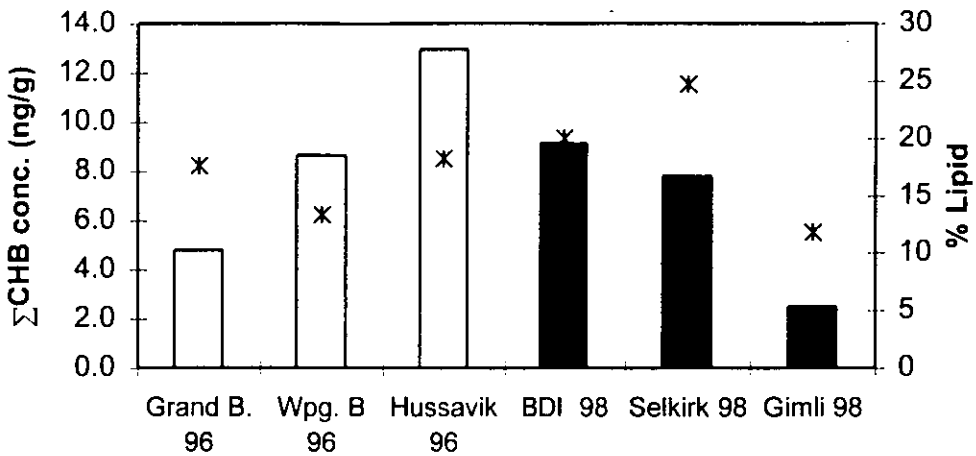
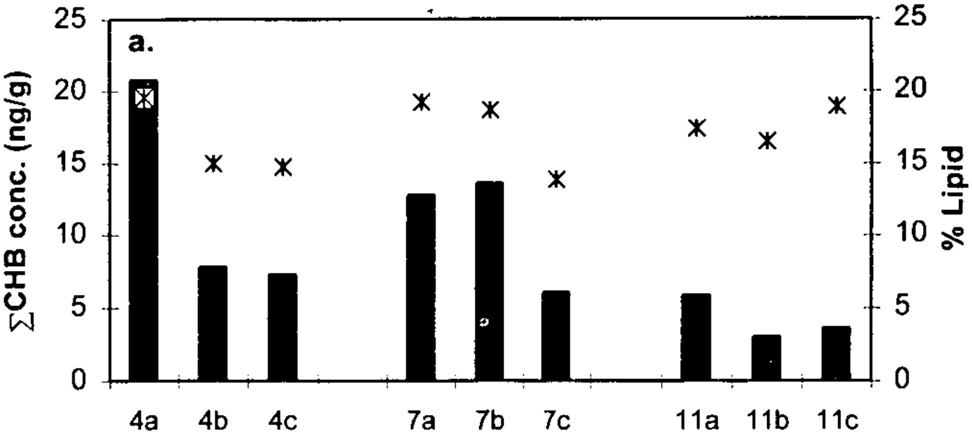


Figure 39. Toxaphene concentrations (ng/g) in mayflies collected from the south basin prior to the flood in 1996 (white bars) and after the flood at Winnipeg (BDI), Selkirk, and Gimli (black bars). Bars are toxaphene concentration and stars are % lipid in each sample.



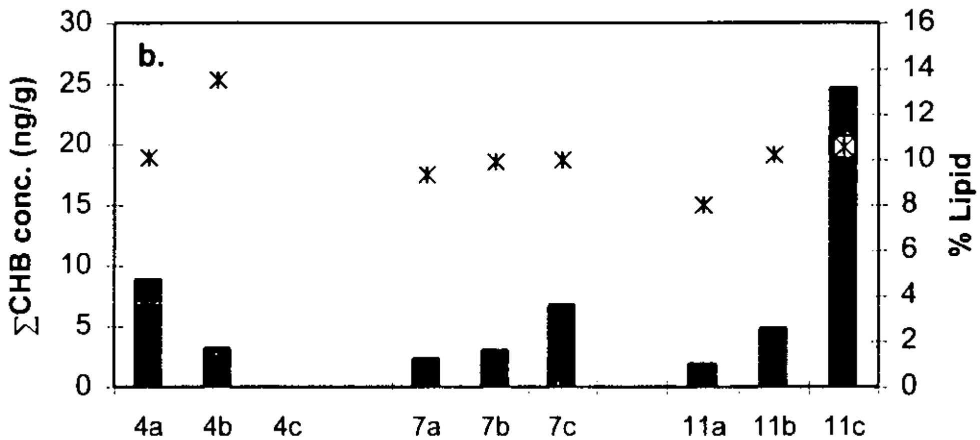
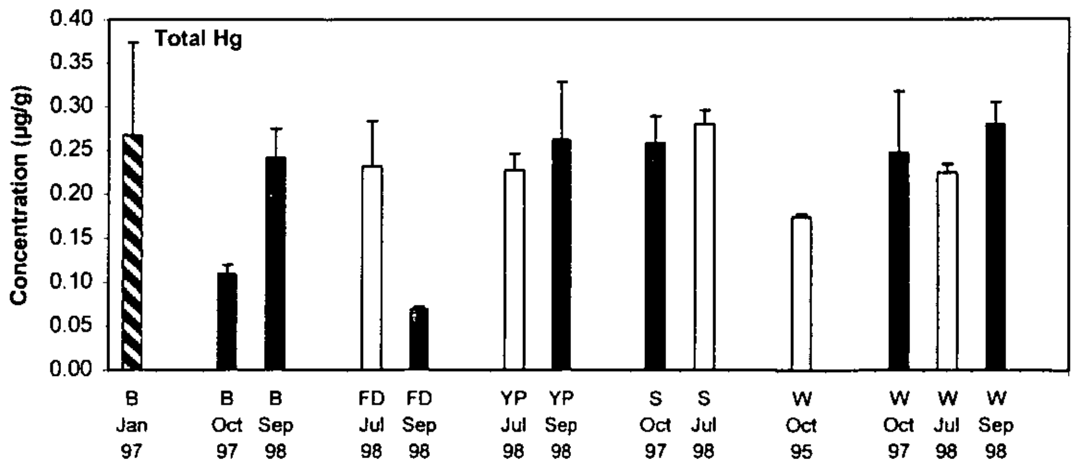


Figure 40. Toxaphene concentrations (ng/g) in zooplankton collected from the south basin in a. July 1998 and b. August 1998. Bars are toxaphene concentration and stars are % lipid in each sample.



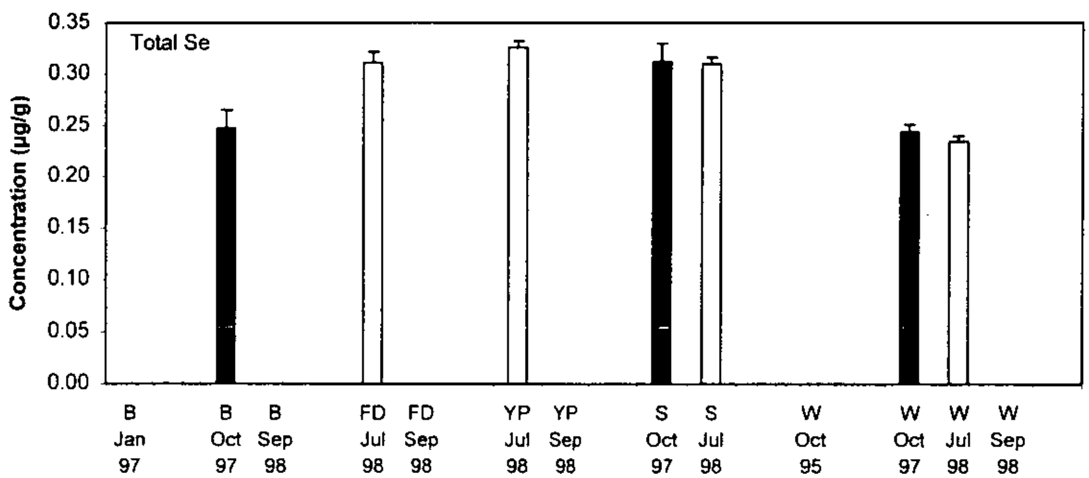


Figure 41. Mercury and selenium concentrations in fish collected near Winnipeg Beach (black bars), Riverton (white bars) and Traverse Bay (hatched bar) in the south basin of Lake Winnipeg before and after the 1997 flood. Values are means ± SE. B - burbot. FD - freshwater drum. YP - yellow perch. S - sauger. W - walleye.

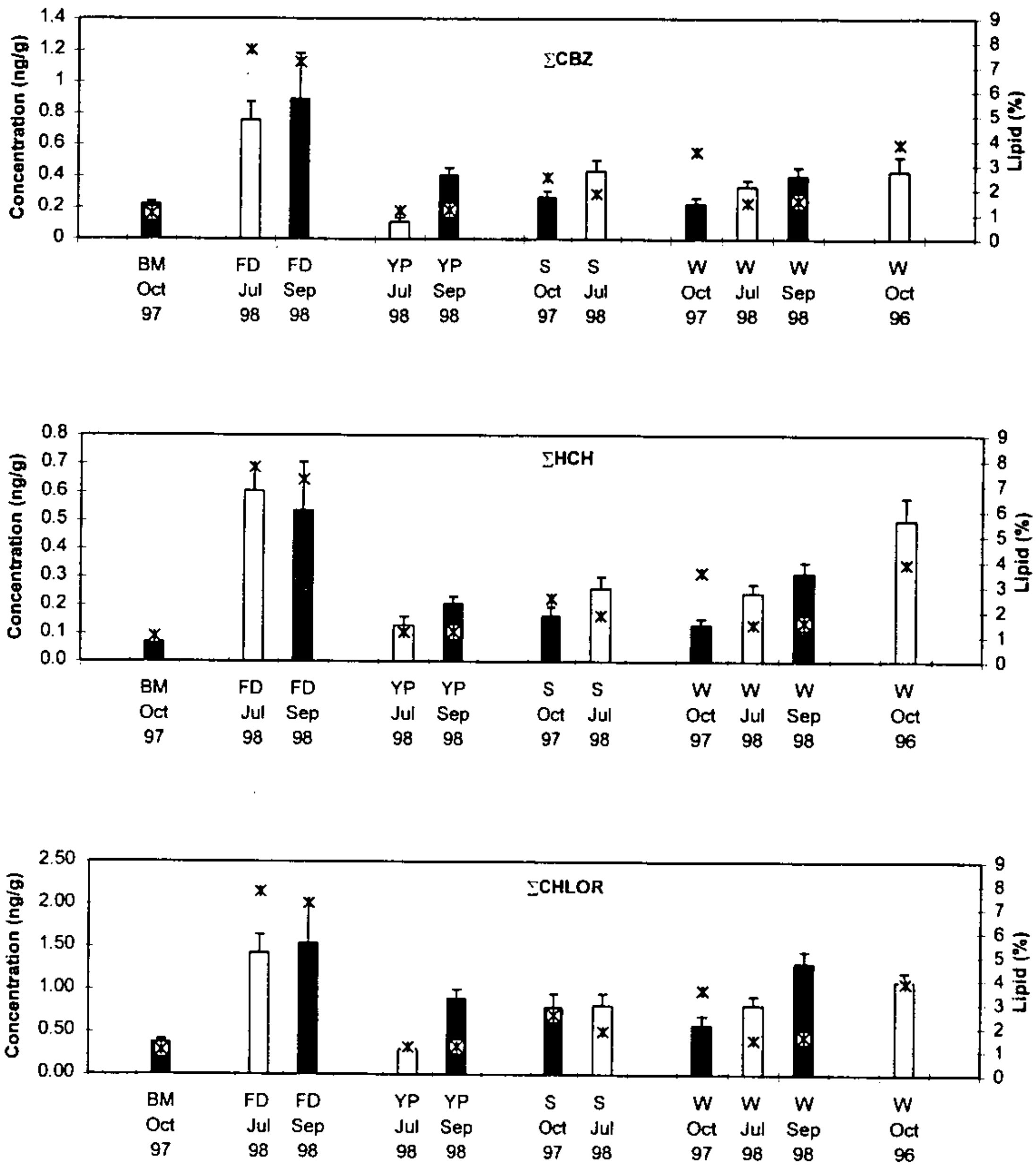


Figure 42. Organochlorine concentrations in fish collected near Winnipeg Beach (black bars) and Riverton (white bars) in the south basin of Lake Winnipeg.

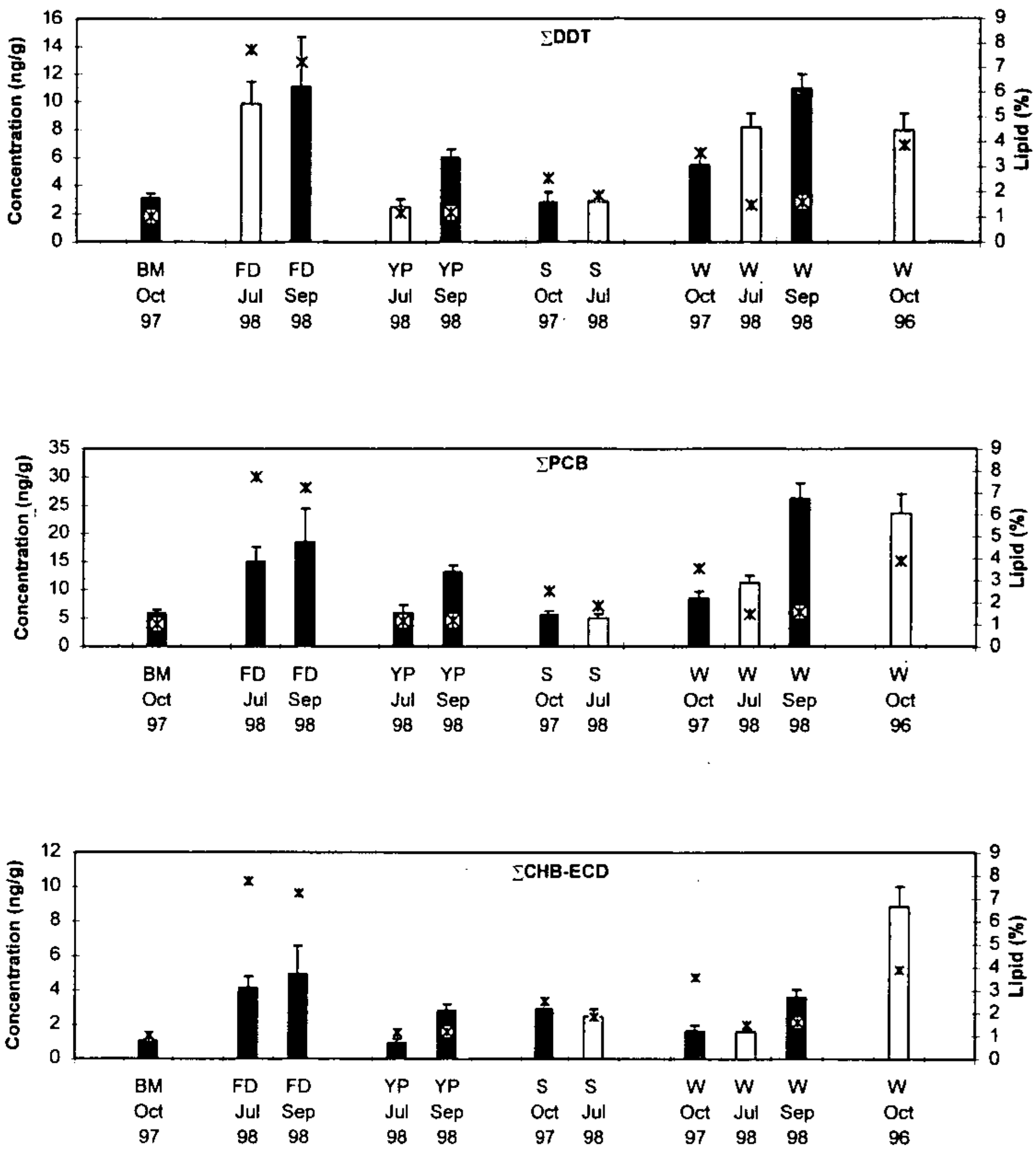


Figure 42. Organochlorine concentrations in fish collected near Winnipeg Beach (black bars) and Riverton (white bars) in the south basin of Lake Winnipeg.

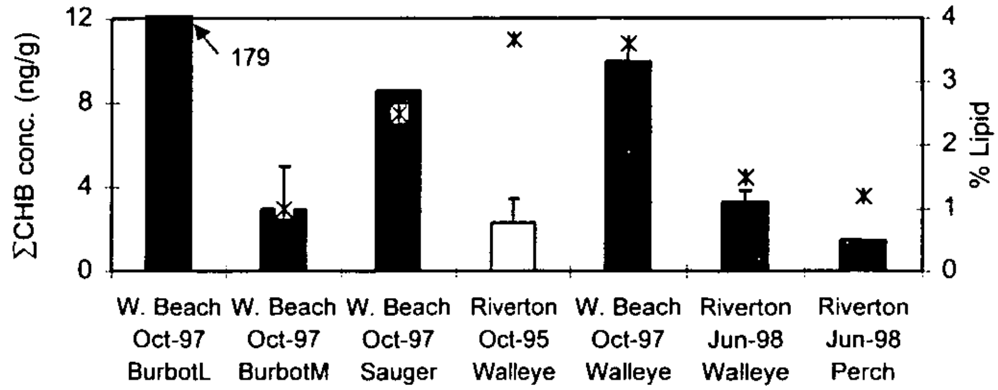


Figure 43. Toxaphene concentrations in fish collected from Winnipeg Beach in October 1997 and Riverton in July 1998 (Bars). Values for walleye collected prior to the flood in 1996 at Riverton are shown (white bar). Values are means ± SE. Stars indicate mean % lipid content for each group of fish.

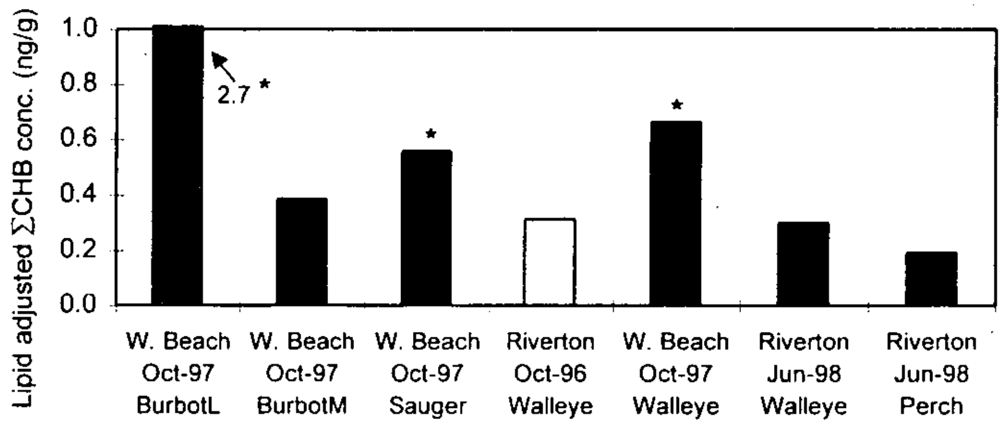


Figure 44. Lipid adjusted toxaphene concentrations in fish collected from Winnipeg Beach in October 1997 and Riverton in July 1998 (Bars). Values for walleye collected prior to the flood in 1996 at Riverton are shown (white bar). Values are means. Asterisks indicate a significant difference from walleye collected prior to the flood.

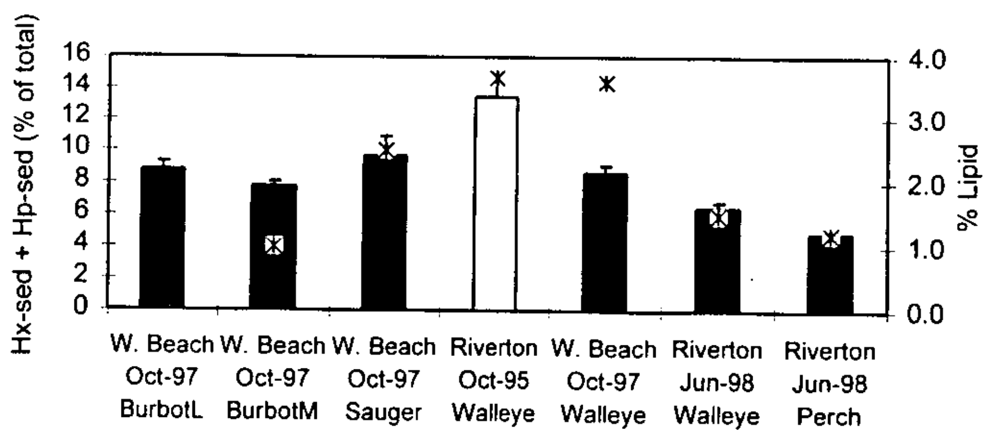


Figure 45. Concentrations of Hx-sed and Hp-sed toxaphene congeners as a ratio of total toxaphene in fish collected from Winnipeg Beach in October 1997 and Riverton in July 1998 (Bars). Values for walleye collected prior to the flood in 1996 at Riverton are shown (white bar). Values are means ± SE. Stars indicate mean % lipid content for each group of fish.

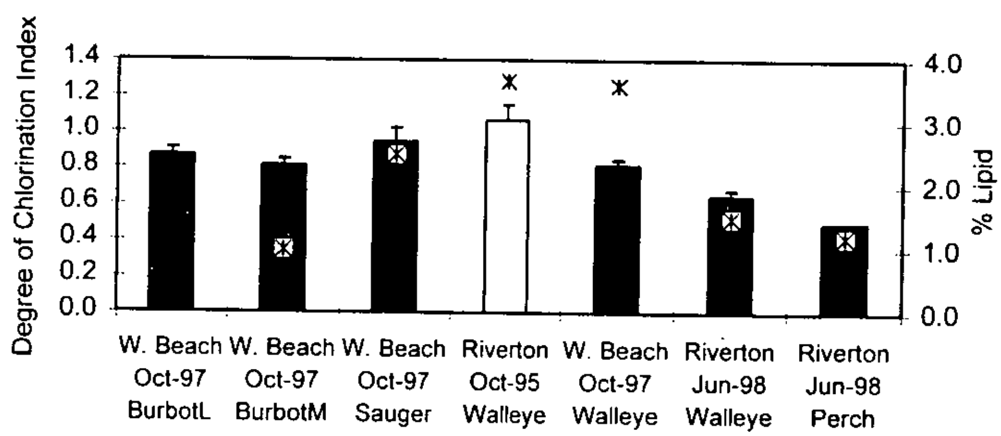


Figure 46. Degree of chlorination index (sum of hexa- plus heptachlorinated toxaphene homologues divided by the sum of the octa- plus nona-chlorinated homologues) for fish collected from Winnipeg Beach in October 1997 and Riverton in July 1998 (Bars). Values for walleye collected prior to the flood in 1996 at Riverton are shown (white bar). Values are means ± SE. Stars indicate mean % lipid content for each group of fish.

Appendix I Table 1. Frequency of sampling. X- major elements and nutrients. C - Contaminants

Date	Floodway	Selkirk	North Perimeter	Assiniboine River	South Perimeter
28 Apr 97	XC	XC	X	X	
29 Apr 97	X	X	X	X	X
30 Apr 97	XC	XC	X	X	X
1 May 97	X	X	X	X	
2 May 97	XC	XC	X	X	X
3 May 97	X	X	X	X	X
4 May 97	X	X	X	X	X
5 May 97	XC	XC	X	X	X
6 May 97	X	X	X	X	X
7 May 97	XC	XC	X	X	X
8 May 97	X	X	X	X	X
9 May 97	XC	XC	X	X	X
10 May 97	X	X	X	X	X
11 May 97	X	X	X		X
12 May 97	XC	XC	X	X	X
13 May 97	X	X	X	X	X
14 May 97	XC	XC	X	X	X
15 May 97	X	X	X	X	X
16 May 97	XC	XC	X	X	X
17 May 97	X	X	X		X
18 May 97	X	X	X		X
19 May 97	X	X	X		X
20 May 97	XC	XC	X	X	
21 May 97	X	X	X		X
23 May 97	XC	XC	X	X	X
26 May 97	XC	XC	X	X	X
28 May 97	X	X	X	X	X
29 May 97	C	C			
30 May 97	X	X	X	X	X
2 Jun 97	XC	XC	X	X	X
4 Jun 97	X	X	X	X	X
5 Jun 97		C			
6 Jun 97		X	X	X	
11 Jun 97		XC		X	X
18 Jun 97		XC		X	
26 Jun 97		XC			
15 Jul 97		XC			
15 Aug 97		XC			
15 Sep 97		XC			
15 Oct 97		XC			

Appendix I Table 2. Nutrient constituents analyzed for in water samples.

Analysis	Comments
Nitrate and Nitrite	Colourimetric Autoaalyzer
Ammonia	Colourimetric Autoanalyzer
Total Dissolved Nitrogen (TDN)	UV Digestion Colourimetric Analysis (TDN - NO3 = Kjeldahl Nitrogen)
Suspended Nitrogen	High temperature combustion - Analysis as N2
Total Nitrogen	Sum of Suspended N + TDN
Soluble Reactive Phosphorous	Colourimetric Autoanalyzer
Total Dissovled Phosphorous	UV Digestion - Colourimetric Analysis
Suspended Phosphorous	High temp. oxidation, acid hydrolis analysis as PO4
Dissolved Inorganic Carbon	CO2 specific Near Infrared detection
pCO2	GC Headspace analysis. PCO2 is indicative of relative dominance of Respiration or Photosynthesis.
Dissolved Organic Carbon	Persulphate Digestion - analysis as CO2 with Near Infrared
Suspended Carbon	High Temperture Combustion - Analysis as CO2
Chlorophyll Pigments	Solvent extraction and Fluorescent Detection
Chlorophyll-a	Solvent extraction and HPLC analysis of Chlorophyll-a
Soluble reactive Silicon	Colourimetric - Flow Injection Analysis
Chloride and Sulphate	Ion Chromatography -
Na, K, Mg, Ca, Fe, Mn	Atomic Absorption
Total Suspended Solids	Gravimetric on GF/C filters
Conductance	Platinum Electrode at 25C
PH	Conventional Electrode
Algal Toxins	Solvent extraciton and HPLC

Appendix I Table 3. Actual location of each sample site on Lake Winnipeg.

Site	Transect A		Transect B		Transect C	
#	North	West	North	West	North	West
1	50°25.882	96°53.055	50°25.566	96°48.368	50°25.457	96°44.367
2	50°27.942	96°53.205	50°27.775	96°48.124	50°27.584	96°43.828
3	50°30.050	96°53.153	50°29.922	96°47.969	50°29.810	96°43.359
4	50°32.183	96°53.296	50°32.081	96°47.584	50°31.821	96°42.862
5	50°34.344	96°53.540	50°34.292	96°47.525	50°33.972	96°42.653
6	50°36.694	96°53.141	50°36.435	96°47.180	50°35.684	96°42.544
7	50°38.858	96°53.190	50°38.736	96°47.038	50°38.328	96°41.387
8	50°41.015	96°53.118	50°40.880	96°46.705	50°40.464	96°40.877
9	50°43.129	96°53.095	50°42.991	96°46.492	50°42.555	96°40.392
10	50°48.552	96°51.793	50°48.299	96°44.919	50°47.938	96°38.922
11	50°53.836	96°50.836	50°53.623	96°43.301	50°53.330	96°37.525

Appendix I Table 4. Water depth (m) and ice thickness (cm) at sample sites on Lake Winnipeg.

Site	Transect A		Transect B		Transect C	
#	water	ice	water	ice	water	ice
1	4.6	70	4.9	62	4.9	75
2	6.1	62	6.4	69	5.8	66
3	6.7	50	7.0	61	6.7	50
4	7.3	55	7.9	61	8.8	59
5	7.6	61	8.2	60	7.9	65
6	8.5	51	8.8	64	8.8	64
7	8.8	69	9.1	51	9.1	55
8	9.8	65	9.8	64	9.1	65
9	9.8	60	10.4	65	10.4	66
10	9.8	55	10.7	62	10.1	61
11	8.5	66	9.9	74	10.1	67

APPENDIX I

Appendix I Table 5. Detection limits and instrumentation for elements and sample matrices.

Element	Instrumentation	Matrices			
		Sediment	Fish	*Hexagenia*	Zooplankton
Hg	CVAAS	4 ng/g	10 ng/g	10 ng/g	10 ng/g
As	SBRAAS	0.1 ug/g			
Se	SBRAAS	0.1 ug/g	0.05 ug/g		
Ni	FAAS	2.0 ug/g			
Cu	FAAS	1.0 ug/g		2.0 ug/g	
Cd	GFAAS	3 ng/g		10 ng/g	
Pb	DCP	2.0 ug/g			
Al	DCP	2.0 ug/g			
Fe	DCP	4.0 ug/g			
Mn	DCP	4.0 ug/g			
Zn	DCP	0.5 ug/g			
V	DCP	2.0 ug/g			
Cr	DCP	2.0 ug/g			
Ti	DCP	1.0 ug/g			

CVAAS: cold vapor atomic absorption spectrophotometry

SBRAAS: sodium borohydride reduction atomic absorption spectrophotometry

FAAS: flame atomic absorption spectrophotometry

GFAAS: graphite furnace atomic absorption spectrophotometry

DCP: direct current plasma atomic emission spectrometry

Appendix I Table 6. Method detection limits (MDL) and instrument detection limits (IDL) for herbicides measured in Red River Flood Study.

Compound	Method Detection limit[1] (ng/L)	Instrument Detection limit (ng)
2,4,5-T	0.31	0.0038
2,4-D	0.95	0.0094
Alachlor	0.50	0.0054
Atrazine	0.29	0.0036
De-Ethyl Atrazine	0.55	0.0034
Bromoxynil	0.17	0.0008
Chlorothalonil	1.62	0.0137
Chlorpyrifos	0.72	0.0069
Chlorthal-Methyl (Dacthal)	0.12	0.0015
Cyanazine	1.67	0.0221
Dicamba	0.11	0.0012
Dichlorprop	0.10	0.0011
Diclofop-Methyl	0.20	0.0029
Ethylfluralin	1.80	0.0122
MCPA-Methyl Ester	0.19	0.0027
Metolachlor	0.14	0.0018
Pendmethalin (Penoxaline)	1.07	0.0143
Terbuthylazine	0.73	0.0021
Triallate	0.59	0.0041
Diallate 1	0.19	0.0017
Diallate 2	0.31	0.0015
Triclopyr	0.17	0.0029
Trifluralin	0.35	0.0021

[1]Method Detection Limits are based on 2L sample volumes.

$$\text{MDL} = \frac{(IDL(pg/\mu l)\ x\ 100\mu l\ sample}{2L\ filtered\ volume} + 3 \text{ x SD of lowest conc. Std. (run in triplicate).}$$

Appendix I Table 7. List of organochlorine compounds analyzed in flood study.

Abbreviated Name	Chemical Name	Comments
1245TCB	1,2,4,5-Tetrachlorobenzene	
1234TCB	1,2,3,4-Tetrachlorobenzene	
P5CBZ	Pentachlorobenzene	
HCBZ	Hexachlorobenzene (HCB)	
a-HCH	HCH-alpha	
d-HCH	HCH-delta	
b-HCH	HCH-beta	
g-hch	HCH-gamma	
"C"	Chlordane related (unspecified)	
heptaclr	Heptachlor	
OCSTYR	Octachlorostyrene	
C1A	C1A heptachlor isomer (D&H #47)	Dearth & Hites (1991)
C1B/U6	C1B/U6 heptachlor isomer (D&H #48)	Dearth & Hites (1991)
C2/U-5	C2/U-5 heptachlor isomer (D&H #54)	Dearth & Hites (1991)
C3	C3 heptachlor isomer (D&H #55)	Dearth & Hites (1991)
C5	C5 octachlordane (D&H #59)	Dearth & Hites (1991)
U3	U3 nonachlor isomer (nonachlor III, D&H #64)	Dearth & Hites (1991)
U1	U1 photoheptachlor	
OXYCLR	Oxychlordane	
T-CHLOR	Chlordane, trans	
C-CHLOR	Chlordane, cis	
T-NONA	trans-nonachlor	
C-NONA	cis-nonachlor	
H. EPOX	Heptachlor epoxide	
DIELD	Dieldrin	
op-DDE	DDE,o,p'	
pp-DDE	DDE,p,p'	
op-DDD	DDD,o,p'	
pp-DDD	DDD,p,p'	
op-DDT	DDT,o,p'	
pp-DDT	DDT,p,p'	
MIREX	Mirex	
P.MIRX	Photomirex	
PCA	Pentachloroanisole	
END. 1	Endosulfan,alpha	
END. 2	Endosulfan,beta	
END. SULF.	Endosulfan sulphate	
MEOCL	Methoxychlor,p,p'	
TOX_1		toxaphene detected in first fraction
TOXSRF_1		toxaphene detected in first fraction
TOX_2		toxaphene detected in second fraction
TOXSRF_2		toxaphene detected in second fraction
1	PCB 1	

Appendix I Table 7. List of organochlorine compounds analyzed in flood study.

Abbreviated Name	Chemical Name	Comments
3	PCB 3	
4/10	PCB 4/10	
7	PCB 7	
6	PCB 6	
5	PCB 5	
8	PCB 8	
8/5	PCB 8/5	
19	PCB 19	
18	PCB 18	
17	PCB 17	
24/27	PCB 24/27	
16/32	PCB 16/32	
26	PCB 26	
25	PCB 25	
31	PCB 31	
28	PCB 28	
33	PCB 33	
22	PCB 22	
45	PCB 45	
46	PCB 46	
52	PCB 52	
49	PCB 49	
47	PCB 47	
48	PCB 48	
44	PCB 44	
42	PCB 42	
41/71	PCB 41/71	
64	PCB 64	
40	PCB 40	
74	PCB 74	
70/76	PCB 70/76	
66	PCB 66	
95	PCB 95	
66/95	PCB 66/95	
56/60	PCB 56/60	
91	PCB 91	
84/89	PCB 84/89	
101	PCB 101	
99	PCB 99	
83	PCB 83	
97	PCB 97	
87	PCB 87	
85	PCB 85	
136	PCB 136	
110	PCB 110	
82	PCB 82	

Appendix I Table 7. List of organochlorine compounds analyzed in flood study.

Abbreviated Name	Chemical Name	Comments
151	PCB 151	
144/135	PCB 144/135	
149	PCB 149	
118	PCB 118	
134	PCB 134	
114	PCB 114	
131	PCB 131	
146	PCB 146	
153	PCB 153	
132	PCB 132	
105	PCB 105	
141	PCB 141	
130	PCB 130	
176	PCB 176	
130/176	PCB 130/176	
179	PCB 179	
137	PCB 137	
138	PCB 138	
158	PCB 158	
178/129	PCB 178/129	
175	PCB 175	
187	PCB 187	
183	PCB 183	
128	PCB 128	
185	PCB 185	
174	PCB 174	
177	PCB 177	
171	PCB 171	
156	PCB 156	
201/157	PCB 201/157	
172/197	PCB 172/197	
180	PCB 180	
193	PCB 193	
191	PCB 191	
200	PCB 200	
170	PCB 170	
190	PCB 190	
198	PCB 198	
199	PCB 199	
196/203	PCB 196/203	
189	PCB 189	
208	PCB 208	
195	PCB 195	
207	PCB 207	
194	PCB 194	
205	PCB 205	

Appendix I Table 7. List of organochlorine compounds analyzed in flood study.

Abbreviated Name	Chemical Name	Comments
206	PCB 206	
209	PCB 209	
3CL-VER	3,4,5-Trichloroveratrole	
4CL-VER	Tetrachloroveratrole	
ENDRIN	Endrin	
END. KET.	Endrin ketone	
TRIFLU	Trifluralin	
TRIALL	Carbamothic acid (Triallate)	
OCN	Octachloronaphthalene	
ALD/OCN	Aldrin/Octachloronaphthalene	
ΣCBZ	Chlorinated benzenes (total)	sum of chlorinated benzenes
ΣHCH	HCHs (total)	sum of HCHs
ΣCHLOR	Chlordanes (total)	sum of chlordanes
ΣDDT	DDTs (all isomers of DDT and their metabolites)	sum of DDTs
ΣPCB	PCBs	sum of all PCBs
ΣTOX		sum of toxaphene
ΣTOXSRF		sum of toxaphene single response factor
DIELDRIN	Dieldrin	
ΣVERATROLS	Chlorinated veratroles (total)	sum of chlorinated veratroles
ΣMON/DI	Mono and di chloro PCBs	sum of mono and di chloro PCBs
ΣTRI	Trichlorinated PCBs	sum of trichlorinated PCBs
ΣTETRA	Tetrachlorinated PCBs	sum of tetrachlorinated PCBs
ΣPENTA	Pentachlorinated PCBs	sum of pentachlorinated PCBs
ΣHEXA	Hexachlorinated PCBs	sum of hexachlorinated PCBs
ΣHEPTA	Heptachlorinated PCBs	sum of heptachlorinated PCBs
ΣOCTA	Octachlorinated PCBs	sum of octachlorinated PCBs
ΣNONA	Nonachlorinated PCBs	sum of nonachlorinated PCBs
ΣDECA	Decachlorinated PCBs	sum of decachlorinated PCBs

Appendix I Table 8. Instrument detection limits (IDL) and method detection limits (MDL) for organochlorines in water, zooplankton and mayflies, and sediment.

Compound[a]	Instrument ng	Water[b] ng/L	Zoop/Mayflies[c] ng/g dw	Sediment[d] ng/g dw
1245TCB	0.000335	0.067	0.017	0.026
1234TCB	0.000142	0.028	0.007	0.299
P5CBZ	0.000040	0.008	0.002	0.103
HCBZ	0.000027	0.005	0.001	0.168
a-HCH	0.000029	0.006	0.001	0.085
b-HCH	0.000097	0.019	0.005	0.523
g-hch	0.000029	0.006	0.001	0.056
d-HCH	0.000033	0.007	0.002	0.003
"C"	0.000033	0.007	0.002	0.003
heptaclr	0.000033	0.007	0.002	0.012
OCSTYR	0.000022	0.004	0.001	0.002
C1A	0.000037	0.007	0.002	0.003
C1B/U6	0.000037	0.007	0.002	0.003
C2/U-5	0.000037	0.007	0.002	0.003
C3	0.000037	0.007	0.002	0.003
C5	0.000037	0.007	0.002	0.003
U3	0.000037	0.007	0.002	0.003
U1	0.000037	0.007	0.002	0.003
OXYCLR	0.000035	0.007	0.002	0.066
T-CHLOR	0.000037	0.007	0.002	0.003
C-CHLOR	0.000037	0.007	0.002	0.003
T-NONA	0.000035	0.007	0.002	0.003
C-NONA	0.000032	0.006	0.002	0.002
HEP EPOX	0.000035	0.007	0.002	0.003
DIELD	0.000034	0.007	0.002	0.335
op-DDE	0.000051	0.010	0.003	0.004
pp-DDE	0.000039	0.008	0.002	0.009
op-DDD	0.000063	0.013	0.003	0.055
pp-DDD	0.000058	0.012	0.003	0.004
op-DDT	0.000054	0.011	0.003	0.004
pp-DDT	0.000059	0.012	0.003	0.005
MIREX	0.000067	0.013	0.003	0.005
PH.MIREX	0.000054	0.011	0.003	0.004
PCA	0.000026	0.005	0.001	0.021
ENDOSUL	0.000037	0.007	0.002	0.067
MEOCL	0.000147	0.029	0.007	0.011
TOXSRF_1	0.005000	1.000	0.250	0.383
TOXSRF_2	0.005000	1.000	0.250	0.383
1	0.001541	0.308	0.077	0.118
3	0.000354	0.071	0.018	0.027
4/10	0.000305	0.061	0.015	0.023
7	0.000135	0.027	0.007	0.364

Appendix I Table 8. Instrument detection limits (IDL) and method detection limits (MDL) for organochlorines in water, zooplankton and mayflies, and sediment.

Compound[a]	Instrument ng	Water[b] ng/L	Zoop/Mayflies[c] ng/g dw	Sediment[d] ng/g dw
6	0.000290	0.058	0.015	0.022
8/5	0.000234	0.047	0.012	0.534
19	0.000336	0.067	0.017	0.026
18	0.000318	0.064	0.016	0.122
17	0.000318	0.064	0.016	0.640
24/27	0.000187	0.037	0.009	0.041
16/32	0.000191	0.038	0.010	0.064
26	0.000170	0.034	0.008	0.013
25	0.000116	0.023	0.006	0.264
31	0.000178	0.036	0.009	0.254
28	0.000119	0.024	0.006	0.362
33	0.000151	0.030	0.008	0.082
22	0.000099	0.020	0.005	0.054
45	0.000168	0.034	0.008	0.013
46	0.000203	0.041	0.010	0.016
52	0.000223	0.045	0.011	0.017
49	0.000173	0.035	0.009	0.663
47	0.000145	0.029	0.007	0.822
48	0.000198	0.040	0.010	0.015
44	0.000141	0.028	0.007	0.011
42	0.000120	0.024	0.006	0.009
41/71	0.000120	0.024	0.006	0.009
64	0.000095	0.019	0.005	0.319
40	0.000116	0.023	0.006	0.009
74	0.000123	0.025	0.006	0.142
70/76	0.000137	0.027	0.007	0.011
66	0.000179	0.036	0.009	0.112
95	0.000102	0.020	0.005	0.112
56/60	0.000125	0.025	0.006	0.081
91	0.000062	0.012	0.003	0.005
84/89	0.000121	0.024	0.006	0.009
101	0.000144	0.029	0.007	0.011
99	0.000120	0.024	0.006	0.009
83	0.000120	0.024	0.006	0.009
97	0.000118	0.024	0.006	0.009
87	0.000093	0.019	0.005	0.013
85	0.000093	0.019	0.005	0.007
136	0.000187	0.037	0.009	0.027
110	0.000110	0.022	0.005	0.098
82	0.000084	0.017	0.004	0.006
151	0.000106	0.021	0.005	0.008
144/135	0.000083	0.017	0.004	0.006
149	0.000132	0.026	0.007	0.155

Appendix I Table 8. Instrument detection limits (IDL) and method detection limits (MDL) for organochlorines in water, zooplankton and mayflies, and sediment.

Compound[a]	Instrument ng	Water[b] ng/L	Zoop/Mayflies[c] ng/g dw	Sediment[d] ng/g dw
118	0.000084	0.017	0.004	0.073
134	0.000109	0.022	0.005	0.008
114	0.000069	0.014	0.003	0.005
131	0.000087	0.017	0.004	0.007
146	0.000085	0.017	0.004	0.007
153	0.000085	0.017	0.004	0.109
132	0.000116	0.023	0.006	0.009
105	0.000066	0.013	0.003	0.005
141	0.000064	0.013	0.003	0.159
179	0.000064	0.013	0.003	0.005
137	0.000059	0.012	0.003	0.005
130/176	0.000075	0.015	0.004	0.006
138	0.000087	0.017	0.004	0.178
158	0.000050	0.010	0.002	0.004
178/129	0.000070	0.014	0.003	0.022
175	0.000070	0.014	0.003	0.005
187	0.000064	0.013	0.003	0.012
183	0.000065	0.013	0.003	0.022
128	0.000072	0.014	0.004	0.248
185	0.000043	0.009	0.002	0.013
174	0.000074	0.015	0.004	0.056
177	0.000074	0.015	0.004	0.006
171	0.000065	0.013	0.003	0.005
156	0.000051	0.010	0.003	0.004
201/157	0.000067	0.013	0.003	0.005
172/197	0.000038	0.008	0.002	0.003
180	0.000048	0.010	0.002	0.055
193	0.000051	0.010	0.003	0.004
191	0.000049	0.010	0.002	0.004
200	0.000050	0.010	0.002	0.004
170	0.000054	0.011	0.003	0.004
190	0.000052	0.010	0.003	0.004
198	0.000053	0.011	0.003	0.004
199	0.000050	0.010	0.003	0.004
196/203	0.000053	0.011	0.003	0.004
189	0.000051	0.010	0.003	0.004
208	0.000057	0.011	0.003	0.004
195	0.000063	0.013	0.003	0.005
207	0.000058	0.012	0.003	0.004
194	0.000053	0.011	0.003	0.004
205	0.000064	0.013	0.003	0.005
206	0.000058	0.012	0.003	0.004
209	0.000065	0.013	0.003	0.005

Appendix I Table 8. Instrument detection limits (IDL) and method detection limits (MDL) for organochlorines in water, zooplankton and mayflies, and sediment.

Compound[a]	Instrument ng	Water[b] ng/L	Zoop/Mayflies[c] ng/g dw	Sediment[d] ng/g dw
3CL-VER	0.000062	0.012	0.003	0.013
4CL-VER	0.000019	0.004	0.001	0.001
ENDRIN	0.000050	0.010	0.003	0.004
Endrin ketone	0.000047	0.009	0.002	0.004
ΣCBZ	0.000136	0.027	0.007	0.149
ΣHCH	0.000047	0.010	0.002	0.221
ΣCHLOR	0.000035	0.007	0.002	0.007
ΣDDT	0.000054	0.011	0.003	0.013
ΣPCB	0.000131	0.026	0.007	0.076
DIELD	0.000034	0.000	0.002	0.335
ΣMON/DI	0.000476	0.095	0.024	0.182
ΣTRI	0.000198	0.040	0.010	0.175
ΣTETRA	0.000151	0.030	0.008	0.153
ΣPENTA	0.000099	0.020	0.005	0.027
ΣHEXA	0.000094	0.019	0.005	0.066
ΣHEPTA	0.000053	0.011	0.003	0.013
ΣOCTA	0.000057	0.011	0.003	0.004
ΣNONA	0.000058	0.012	0.003	0.004
ΣDECA	0.000065	0.013	0.003	0.005

[a] Detection limits of totals (e.g. ΣCBZ) are based on the average MDL for the summed congeners.

[b] Water MDL = $\dfrac{(IDL(pg/\mu l)\ x\ 200\mu l\ sample)}{20L\ filtered\ volume}$

[c] Zooplankton/Mayfly MDL = $\dfrac{(IDL(pg/\mu l)\ x\ 50\mu l\ sample)}{1g\ tissue}$

[d] Sediment MDL = average conc. of field blank (replicated) + (3 x SD of field blanks).

If field blank = 0, then MDL = $\dfrac{(IDL(pg/\mu l)\ x\ 200\mu l\ sample)}{2.61\text{g sediment (dw)}}$

Sediments OC analysis

D.C.G. Muir, A. Omelchenko, N.P. Grift, D.A. Savoie, W.L. lockhart, P. Wilkinson and G.J. Brunskill. 1996. Spatial Trends and Historical Deposition of Polychlorinated Biphenyls in Canadian Midlatitude and Arctic Lake Sediments. Environ. Sci. Technol. 30: 3609-3619.

D.C.G. Muir, N.P. Grift, W.L. lockhart, P. Wilkinson, B. Billeck and G.J. Brunskill. 1995. Spatial Trends and Historical Profiles of Organochlorine Pesticides in Arctic Lake Sediments. Sci. Total Environ. 160/161:447-457.

Hx and Hp-Sed Ref. (Structural characterizations)

G.A. Stern, M.D. Loewen, B.M. Miskimmin D.C.G. Muir and J.D. Westmore. 1996. Characterization of Two Major Toxaphene Components in Treated Lake Sediment. Environ. Sci. Technology 30: 2251-2258.

T2 and T12 Ref's. (Structural characterizations)

G.A. Stern, D.C.G. Muir, J.B. Westmore and W.D. Buchannon. 1993. Mass Spectrometric Studies of the Toxaphene Components 2-*exo*,3-*endo*,5-*exo*,6-*endo*,8,8,10,10-Octachlorobornane (T2) and 2-*exo*,3-*endo*,5-*exo*,6-*endo*,8,8,9,10,10-Nonachlorobornane (T12)", Biological Mass Spectrometry 22:19-30.

G.A. Stern, D.C.G. Muir, C.A. Ford, N.P. Grift, E. Dewailly, T.F. Bidleman and M.D. 1992. Walla Isolation and Identification of Two Major Recalcitrant Toxaphene Congeners in Aquatic Biota. Environmental Science and Technology. 26:1838-1840.

APPENDIX I

Appendix I Table 9. Detection limits for hydrocarbon compounds.

Compound	Method Detection Limit[a] (ng/g)	Instrument Detection Limit (pg)
Naphthalene	14.0	0.72
2-Methylnaphthalene	9.2	0.72
1-Methylnaphthalene	3.5	0.72
C1 Naphthalenes	9.2	0.72
C2 Naphthalenes	9.2	0.72
C3 Naphthalenes	9.2	0.72
C4 Naphthelenes	9.2	0.72
Biphenyl	1.1	0.79
Acenaphthylene	0.8	0.79
Acenaphthene	0.6	0.79
Dibenzofuran	0.6	0.92
Fluorene	0.6	0.67
C1 Fluorenes	0.6	0.67
C2 Fluorenes	0.6	0.67
C3 Fluorenes	0.6	0.67
Dibenzothiophene	0.5	0.67
C1 Dibenzothiophenes	0.5	0.67
C2 Dibenzothiophenes	0.5	0.67
C3 Dibenzothiophenes	0.5	0.67
Phenanthrene	1.5	0.67
Anthracene	1.3	0.67
C1 Phen_Anthr	1.5	0.67
C2 Phen_Anthr	1.5	0.67
C3 Phen_Anthr	1.5	0.67
C4 Phen_Anthr	1.5	0.67
Fluoranthene	1.8	0.79
Pyrene	1.5	0.79
C1 Pyrene	1.5	0.79
C2 Pyrene	1.5	0.79
C3 Pyrene	1.5	0.79
Retene(Methyl-isopropylphen)	2.1	0.79

Appendix I Table 9. Detection limits for hydrocarbon compounds.

Compound	Method Detection Limit[a] (ng/g)	Instrument Detection Limit (pg)
Benzo(a)anthracene / Tetraphene	4.3	1.14
Triphenylene	4.0	1.14
Chrysene	3.6	1.14
C1 Chrysene	3.6	1.14
C2 Chrysene	3.6	1.14
C3 Chrysene	3.6	1.14
Benzo(b)fluoranthene	9.9	2.03
Benzo(k)fluoranthene	3.5	2.03
Benzo(e)Pyrene	4.4	2.34
Benzo(a)pyrene	6.2	2.34
Perylene	4.1	2.34
Indeno(1,2,3-c,d)pyrene	12.7	4.78
Dibenzo(a,h)anthracene	8.4	5.51
Benzo(g,h,i)perylene	12.9	4.53

[a] Method Detection Limit = average conc. of field blank (replicated) + (3 x SD of field blanks).

APPENDIX I

Analysis of polycyclic aromatic hydrocarbons (PAH), alkylated PAH, and alkanes in environmental samples by high-resolution gas chromatography and mass selective detection in sim mode.

Hydrocarbon analysis: Dried sediments, spiked with a standard solution containing 100 ng each of seven deuterated PAHs and 500 ng each of three deuterated Alkanes, are solvent extracted using a Dionex ASE200 accelerated solvent extractor using dichloromethane (Giger and Schaffner, 1978; McVeety and Hites, 1988). Cleanup of extracts involved the removal of sulfur using activated copper powder with subsequent fractionation on silica/alumina columns (Boehm, 1983). Chromatography and detection of the hydrocarbon fractions was by GC/MSD using a bonded phase, 30 m x 0.25 mm, J & W, DB-5 fuse silica capillary column. A multiple internal standard method (Fisk et al, 1986: McVeety and Hites, 1988), with the MSD in the single ion monitoring (SIM) mode was used for identification an quantitation of the hydrocarbons.

Equipment

- ASE200 accelerated solvent extractor
- HP5890 gas chromatograph with Electronic Pressure Programming
- HP5970 Mass Selective Detector
- HP7673 autosampler
- HP-UX Chemstation, Unix software version B.07.01

Reagents

- HPLC grade hexane
- HPLC grade dichloromethane
- HPLC grade toluene
- UHP grade helium

Supplies

- High-resolution capillary column (J & W fused silica DB5MS column, 30 m, 0.25 mm internal diameter and 0.25 micron film thickness)
- Ferrules (15% graphite, 85% vespel)
- Merlin Microseal septum
- Syringe - 10 µL, 701N 23 ga. Hamilton
- Standards and surrogates

Boehm, P. D. (1983b). Coupling of organic pollutants between the estuary and the continental shelf and the sediments and water column of the New York Bight region. Canadian Journal of Fisheries and Aquatic Sciences, Vol. 40 (Suppl. 2): 262-276.

Fisk, J. F., A. M. Haeberner and S. P. Kovell (1986). GC/MS methods for analysis of pollutants in hazardous wastes. *Spectra*, 10, 22-39.

Giger, W. and C. Schaffner (1978). Determination of PAH's in the environment by glass capillary chromatography. Analytical Chemistry Vol 50, no. 2: 243-249.

Lockhart, W. L., et al (1993). Polycyclic aromatic hydrocarbons and mercury in sediments from two isolated lakes in central and northern Canada. Water Science Technology, Vol. 28, No. 8-9: 43-52.

McVeety, B. D. and R. A. Hites (1988). Atmospheric deposition of polycyclic aromatic hydrocarbons to water surfaces: A mass balance approach. Atmospheric Environment, vol 22 no. 3: 511-536.

Appendix II Table 1. Metals and trace elements in suspended sediments collected at the Floodway and Selkirk during the flood and summer of 1997.

Site	Date	Aluminum mg/g	Chromium µg/g	Manganese µg/g	Iron mg/g	Nickel µg/g	Copper µg/g	Zinc µg/g	Mercury µg/g	Cadmium µg/g	Lead µg/g	Vanadium µg/g	Titanium mg/g
Floodway	28 Apr 97	78.0	94.1	618	35.1	34.4	101.2	140	0.119	0.514	13.0	164	2.73
Floodway	30 Apr 97	75.7	96.0	699	45.9	43.2	96.6	163	0.147	0.593	16.2	213	3.75
Floodway	2 May 97	72.2	90.4	677	44.4	40.8	75.3	143	0.097	0.541	15.0	207	3.47
Floodway	5 May 97	71.4	91.2	925	46.6	45.2	174.6	177	0.135	0.739	14.2	202	3.76
Floodway	7 May 97	69.2	92.0	668	45.9	40.4	52.7	152	0.077	0.481	16.2	198	3.81
Floodway	9 May 97	81.9	97.6	535	39.5	42.7	50.9	152	0.040	0.405	13.9	204	3.78
Floodway	12 May 97	92.7	99.1	554	41.3	41.7	60.7	148	0.036	0.438	13.8	192	3.86
Floodway	14 May 97	87.2	98.1	495	41.9	37.2	55.4	129	0.042	0.478	12.6	196	3.55
Floodway	16 May 97	86.2	95.9	619	41.6	39.7	88.7	143	0.040	0.491	14.7	204	3.97
Floodway	20 May 97	91.5	97.3	743	45.1	44.8	62.3	151	0.040	0.538	15.2	210	3.65
Floodway	23 May 97	65.4	103.4	764	38.6	43.9	46.3	136	0.044	0.559	15.5	206	3.54
Floodway	26 May 97	82.8	102.5	947	42.0	50.0	36.0	139	0.125	0.526	14.1	214	3.21
Floodway	29 May 97	87.3	107.2	1270	42.0	55.0	228.5	169	0.046	0.568	14.7	220	3.46
Floodway	2 Jun 97	78.7	106.6	1787	38.2	61.3	557.0	165	0.055	0.711	16.0	202	3.17
Selkirk	28 Apr 97	77.4	100.5	843	39.4	38.8	49.5	149	0.062	0.571	15.5	194	3.12
Selkirk	30 Apr 97	85.4	100.2	923	42.1	41.3	51.1	145	0.066	0.663	16.6	201	3.05
Selkirk	2 May 97	75.7	95.7	772	48.7	45.9	61.8	152	0.093	0.436	14.3	207	3.42
Selkirk	5 May 97	78.3	102.7	848	39.6	38.0	53.0	148	0.066	0.618	14.4	212	3.35
Selkirk	7 May 97	94.6	99.3	810	41.1	39.9	96.4	161	0.080	0.564	16.5	205	3.60
Selkirk	9 May 97	82.3	98.7	602	41.2	37.2	42.7	117	0.050	0.515	14.7	194	3.74
Selkirk	12 May 97	87.2	99.2	698	42.2	38.4	58.9	134	0.040	0.528	12.1	209	3.64
Selkirk	14 May 97	64.3	101.3	778	38.8	45.0	75.2	131	0.045	0.489	14.4	199	3.75
Selkirk	16 May 97	73.1	89.7	1796	34.6	46.5	83.8	125	0.053	0.601	14.1	177	3.36
Selkirk	20 May 97	77.6	98.9	1458	36.2	44.2	63.4	150	0.079	0.545	17.0	184	3.45
Selkirk	23 May 97	99.1	101.2	900	43.6	42.2	73.3	155	0.052	0.418	13.1	192	3.64
Selkirk	26 May 97	93.5	104.4	650	41.0	43.6	65.0	142	0.039	0.461	12.1	208	3.90
Selkirk	29 May 97	73.1	101.0	867	42.2	46.2	40.8	138	0.050	0.501	14.2	218	3.59
Selkirk	5 Jun 97	88.8	104.7	1181	40.3	53.5	317.9	164	0.088	0.594	16.1	200	3.64
Selkirk	11 Jun 97	92.4	95.8	728	39.2	40.7	68.0	165	0.049	0.460	15.8	203	3.58

Appendix II Table 1. Metals and trace elements in suspended sediments collected at the Floodway and Selkirk during the flood and summer of 1997.

Site	Date	Aluminum mg/g	Chromium µg/g	Manganese µg/g	Iron mg/g	Nickel µg/g	Copper µg/g	Zinc µg/g	Mercury µg/g	Cadmium µg/g	Lead µg/g	Vanadium µg/g	Titanium mg/g
Selkirk	26 Jun 97	94.0	98.6	666	43.2	41.8	68.5	142	0.045	0.948	13.6	218	3.72
Selkirk	16 Oct 97	85.6	92.6	1314	39.4	45.1	98.7	156	0.060	0.538	17.0	207	3.85

Appendix II Table 2. Herbicide concentrations (ng/L) in water samples collected on the Floodway and Red River at Selkirk and at sites in the south basin of Lake Winnipeg.

Extraction	Site	Date	Dicamba	MCPA-Methyl Ester	Dichlorprop	2,4-D	Bromoxynil	Ethalfluralin
XAD	Floodway	28-Apr-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Floodway	30-Apr-97	<0.11	<0.19	<0.10	<0.95	<0.17	4.69
XAD	Floodway	2-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Floodway	5-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Floodway	7-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Floodway	9-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Floodway	12-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	3.59
XAD	Floodway	14-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
SPE	Floodway	20-May-97	3.63	5.47	<0.10	3.73	2.65	<1.8
SPE	Floodway	23-May-97	0.91	4.63	<0.10	3.17	2.61	<1.8
SPE	Floodway	26-May-97	2.45	18.35	2.43	30.00	4.35	<1.8
SPE	Floodway	29-May-97	1.07	11.39	<0.10	19.76	2.72	<1.8
SPE	Floodway	2-Jun-97	2.14	3.99	<0.10	11.07	0.86	<1.8
XAD	Selkirk	28-Apr-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Selkirk	30-Apr-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Selkirk	2-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Selkirk	5-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Selkirk	7-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	Selkirk	9-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	2.07
XAD	Selkirk	12-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
SPE	Selkirk	16-May-97	1.21	18.29	3.02	33.01	4.54	2.13
XAD	Selkirk	20-May-97	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
SPE	Selkirk	23-May-97	2.71	3.97	<0.10	<0.95	1.42	<1.8
SPE	Selkirk	26-May-97	2.49	13.19	2.22	18.60	3.85	<1.8
SPE	Selkirk	29-May-97	1.73	1.74	<0.10	<0.95	2.07	<1.8
SPE	Selkirk	2-Jun-97	2.98	1.48	<0.10	<0.95	0.65	<1.8
SPE	Selkirk	5-Jun-97	2.76	2.61	<0.10	2.90	1.46	<1.8
SPE	Selkirk	11-Jun-97	0.86	11.55	3.20	37.77	2.24	<1.8
SPE	Selkirk	18-Jun-97	3.90	13.58	<0.10	50.01	4.74	<1.8
SPE	Selkirk	26-Jun-97	2.15	25.46	5.92	31.18	10.80	<1.8
SPE	Selkirk	15-Jul-97	10.67	4.51	<0.10	<0.95	81.68	<1.8
SPE	Selkirk	15-Aug-97	1.85	3.15	<0.10	<0.95	2.44	<1.8
SPE	Selkirk	15-Sep-97	0.94	2.19	<0.10	<0.95	0.71	<1.8
SPE	Selkirk	16-Oct-97	15.15	1.41	<0.10	<0.95	0.98	<1.8
XAD	4B	5-Mar-98	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	9A	5-Mar-98	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	9B	5-Mar-98	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
XAD	9C	6-Mar-98	<0.11	<0.19	<0.10	<0.95	<0.17	<1.8
SPE	4B	16-Jul-98	3.42	13.41	2.39	16.40	1.11	<1.8
SPE	7B	16-Jul-98	0.72	1.48	1.72	1.25	0.85	<1.8
SPE	11B	14-Jul-98	1.41	26.24	6.24	39.56	2.59	<1.8
SPE	4B	15-Sep-98	0.97	17.91	4.71	16.03	1.54	<1.8
SPE	7B	15-Sep-98	3.79	4.13	3.32	<0.95	2.35	<1.8
SPE	11B	15-Sep-98	2.13	33.25	4.77	33.94	2.67	<1.8

Appendix II Table 2. Herbicide concentrations (ng/L) in water samples collected on the Floodway and Red River at Selkirk and at sites in the south basin of Lake Winnipeg.

Extraction	Site	Date	De-Ethyl Atrazine	Trifluralin	Triclopyr	Diallate 1	Diallate 2	Atrazine
XAD	Floodway	28-Apr-97	<0.55	0.92	<0.17	<0.19	<0.31	3.57
XAD	Floodway	30-Apr-97	<0.55	3.60	<0.17	<0.19	<0.31	3.07
XAD	Floodway	2-May-97	<0.55	0.88	<0.17	<0.19	<0.31	8.93
XAD	Floodway	5-May-97	<0.55	2.26	<0.17	<0.19	<0.31	9.37
XAD	Floodway	7-May-97	<0.55	3.74	<0.17	<0.19	<0.31	4.13
XAD	Floodway	9-May-97	<0.55	0.66	<0.17	<0.19	<0.31	9.74
XAD	Floodway	12-May-97	<0.55	13.65	<0.17	<0.19	<0.31	8.02
XAD	Floodway	14-May-97	<0.55	<0.35	<0.17	<0.19	<0.31	13.03
SPE	Floodway	20-May-97	19.34	9.70	1.59	<0.19	<0.31	47.97
SPE	Floodway	23-May-97	13.80	3.54	1.25	<0.19	<0.31	42.36
SPE	Floodway	26-May-97	14.60	2.58	3.01	<0.19	<0.31	41.61
SPE	Floodway	29-May-97	18.22	2.19	2.35	<0.19	<0.31	41.55
SPE	Floodway	2-Jun-97	<0.55	<0.35	2.21	<0.19	<0.31	29.63
XAD	Selkirk	28-Apr-97	<0.55	0.38	<0.17	<0.19	<0.31	9.68
XAD	Selkirk	30-Apr-97	<0.55	<0.35	<0.17	<0.19	<0.31	1.92
XAD	Selkirk	2-May-97	<0.55	0.53	<0.17	<0.19	<0.31	10.61
XAD	Selkirk	5-May-97	<0.55	<0.35	<0.17	<0.19	<0.31	11.73
XAD	Selkirk	7-May-97	<0.55	1.52	<0.17	<0.19	<0.31	9.83
XAD	Selkirk	9-May-97	<0.55	9.04	<0.17	<0.19	<0.31	11.79
XAD	Selkirk	12-May-97	<0.55	<0.35	<0.17	<0.19	<0.31	16.36
SPE	Selkirk	16-May-97	9.27	10.94	2.66	<0.19	<0.31	41.66
XAD	Selkirk	20-May-97	<0.55	<0.35	<0.17	<0.19	<0.31	8.52
SPE	Selkirk	23-May-97	12.93	3.59	0.71	<0.19	<0.31	43.96
SPE	Selkirk	26-May-97	14.21	3.41	2.51	<0.19	<0.31	38.43
SPE	Selkirk	29-May-97	13.87	1.82	0.93	<0.19	<0.31	40.17
SPE	Selkirk	2-Jun-97	10.39	0.48	0.69	<0.19	<0.31	31.82
SPE	Selkirk	5-Jun-97	9.65	0.91	0.91	<0.19	<0.31	44.31
SPE	Selkirk	11-Jun-97	12.68	0.64	2.19	<0.19	<0.31	30.13
SPE	Selkirk	18-Jun-97	9.38	0.43	2.25	<0.19	<0.31	31.57
SPE	Selkirk	26-Jun-97	10.10	0.48	0.82	<0.19	<0.31	29.03
SPE	Selkirk	15-Jul-97	49.11	1.75	<0.17	<0.19	<0.31	305
SPE	Selkirk	15-Aug-97	12.04	<0.35	0.61	<0.19	<0.31	43.30
SPE	Selkirk	15-Sep-97	10.31	<0.35	<0.17	<0.19	<0.31	24.24
SPE	Selkirk	16-Oct-97	9.67	1.91	1.02	<0.19	<0.31	31.32
XAD	4B	5-Mar-98	<0.55	<0.35	<0.17	<0.19	<0.31	1.72
XAD	9A	5-Mar-98	<0.55	<0.35	<0.17	<0.19	<0.31	0.53
XAD	9B	5-Mar-98	<0.55	<0.35	<0.17	<0.19	<0.31	0.53
XAD	9C	6-Mar-98	<0.55	<0.35	<0.17	<0.19	<0.31	1.01
SPE	4B	16-Jul-98	16.58	<0.35	1.64	<0.19	<0.31	56.52
SPE	7B	16-Jul-98	9.14	<0.35	0.89	<0.19	<0.31	32.53
SPE	11B	14-Jul-98	17.27	<0.35	2.34	<0.19	<0.31	55.11
SPE	4B	15-Sep-98	17.47	<0.35	0.89	<0.19	<0.31	60.01
SPE	7B	15-Sep-98	74.57	<0.35	1.05	<0.19	<0.31	284.02
SPE	11B	15-Sep-98	41.16	<0.35	1.15	<0.19	<0.31	146.42

Appendix II Table 2. Herbicide concentrations (ng/L) in water samples collected on the Floodway and Red River at Selkirk and at sites in the south basin of Lake Winnipeg..

Extraction	Site	Date	Terbuthyl-azine	2,4,5-T	Choro-thalonil	Triallate	Alachlor	Metolachlor
XAD	Floodway	28-Apr-97	<0.73	<0.31	<1.62	17.28	1.50	8.08
XAD	Floodway	30-Apr-97	<0.73	<0.31	<1.62	9.63	0.98	8.54
XAD	Floodway	2-May-97	<0.73	<0.31	<1.62	33.47	2.79	18.59
XAD	Floodway	5-May-97	<0.73	<0.31	<1.62	33.73	1.65	20.88
XAD	Floodway	7-May-97	<0.73	<0.31	<1.62	24.72	1.86	12.59
XAD	Floodway	9-May-97	<0.73	<0.31	<1.62	18.80	1.45	14.79
XAD	Floodway	12-May-97	<0.73	<0.31	<1.62	15.19	1.14	10.40
XAD	Floodway	14-May-97	<0.73	<0.31	<1.62	10.05	0.74	7.58
SPE	Floodway	20-May-97	<0.73	<0.31	<1.62	5.39	1.02	24.78
SPE	Floodway	23-May-97	<0.73	<0.31	<1.62	5.25	3.15	19.88
SPE	Floodway	26-May-97	<0.73	<0.31	<1.62	4.31	2.11	17.26
SPE	Floodway	29-May-97	<0.73	<0.31	<1.62	6.70	2.48	16.83
SPE	Floodway	2-Jun-97	<0.73	<0.31	<1.62	7.37	3.82	19.26
XAD	Selkirk	28-Apr-97	<0.73	<0.31	<1.62	33.49	<0.50	9.67
XAD	Selkirk	30-Apr-97	<0.73	<0.31	<1.62	13.81	<0.50	7.84
XAD	Selkirk	2-May-97	<0.73	<0.31	<1.62	36.19	1.79	19.92
XAD	Selkirk	5-May-97	<0.73	<0.31	<1.62	34.20	1.53	20.10
XAD	Selkirk	7-May-97	<0.73	<0.31	<1.62	25.06	1.59	18.28
XAD	Selkirk	9-May-97	<0.73	<0.31	<1.62	20.55	1.73	17.71
XAD	Selkirk	12-May-97	<0.73	<0.31	<1.62	24.17	2.29	17.47
SPE	Selkirk	16-May-97	<0.73	<0.31	<1.62	13.06	2.32	26.28
XAD	Selkirk	20-May-97	<0.73	<0.31	<1.62	10.38	1.41	13.50
SPE	Selkirk	23-May-97	<0.73	<0.31	<1.62	4.98	2.02	20.64
SPE	Selkirk	26-May-97	<0.73	<0.31	<1.62	5.06	1.94	17.46
SPE	Selkirk	29-May-97	<0.73	<0.31	<1.62	8.14	2.52	16.12
SPE	Selkirk	2-Jun-97	<0.73	<0.31	<1.62	4.42	2.37	12.73
SPE	Selkirk	5-Jun-97	<0.73	<0.31	<1.62	4.70	21.27	14.37
SPE	Selkirk	11-Jun-97	<0.73	<0.31	<1.62	2.84	24.57	12.18
SPE	Selkirk	18-Jun-97	<0.73	<0.31	<1.62	2.37	5.66	9.48
SPE	Selkirk	26-Jun-97	<0.73	<0.31	<1.62	2.14	1.71	7.54
SPE	Selkirk	15-Jul-97	<0.73	<0.31	<1.62	7.52	12.39	46.37
SPE	Selkirk	15-Aug-97	<0.73	<0.31	<1.62	1.24	<0.50	3.77
SPE	Selkirk	15-Sep-97	<0.73	<0.31	<1.62	<0.59	<0.50	1.42
SPE	Selkirk	16-Oct-97	<0.73	<0.31	<1.62	2.25	<0.50	<0.14
XAD	4B	5-Mar-98	<0.73	<0.31	<1.62	<0.59	0.88	1.55
XAD	9A	5-Mar-98	<0.73	<0.31	<1.62	<0.59	0.64	1.25
XAD	9B	5-Mar-98	<0.73	<0.31	<1.62	<0.59	0.60	1.20
XAD	9C	6-Mar-98	<0.73	<0.31	<1.62	<0.59	0.85	2.10
SPE	4B	16-Jul-98	<0.73	<0.31	<1.62	1.23	13.26	17.90
SPE	7B	16-Jul-98	<0.73	<0.31	<1.62	<0.59	2.45	5.94
SPE	11B	14-Jul-98	<0.73	<0.31	<1.62	4.23	2.68	10.12
SPE	4B	15-Sep-98	<0.73	<0.31	<1.62	<0.59	5.31	12.67
SPE	7B	15-Sep-98	<0.73	<0.31	<1.62	<0.59	15.17	31.91
SPE	11B	15-Sep-98	<0.73	<0.31	<1.62	<0.59	10.47	23.19

Appendix II Table 2. Herbicide concentrations (ng/L) in water samples collected on the Floodway and Red River at Selkirk and at sites in the south basin of Lake Winnipeg.

Extraction	Site	Date	Cyanazine	Chlorpyrifos	Chlorthal-Methyl (Dacthal)	Pendimethalin (Penoxaline)	Diclofop-Methyl
XAD	Floodway	28-Apr-97	<1.67	<0.72	0.23	<1.07	<0.20
XAD	Floodway	30-Apr-97	<1.67	<0.72	0.12	<1.07	<0.20
XAD	Floodway	2-May-97	<1.67	<0.72	0.22	<1.07	<0.20
XAD	Floodway	5-May-97	<1.67	<0.72	0.18	<1.07	<0.20
XAD	Floodway	7-May-97	<1.67	<0.72	0.13	<1.07	<0.20
XAD	Floodway	9-May-97	<1.67	12.66	0.13	<1.07	<0.20
XAD	Floodway	12-May-97	<1.67	2.03	<0.12	<1.07	<0.20
XAD	Floodway	14-May-97	<1.67	<0.72	0.15	<1.07	<0.20
SPE	Floodway	20-May-97	3.91	<0.72	0.83	<1.07	1.49
SPE	Floodway	23-May-97	4.28	<0.72	0.66	<1.07	0.96
SPE	Floodway	26-May-97	3.44	<0.72	0.92	<1.07	0.77
SPE	Floodway	29-May-97	4.33	<0.72	0.66	<1.07	1.63
SPE	Floodway	2-Jun-97	2.85	2.18	0.37	<1.07	1.09
XAD	Selkirk	28-Apr-97	<1.67	1.17	0.24	<1.07	<0.20
XAD	Selkirk	30-Apr-97	<1.67	<0.72	0.12	<1.07	<0.20
XAD	Selkirk	2-May-97	<1.67	1.02	0.16	<1.07	<0.20
XAD	Selkirk	5-May-97	<1.67	11.04	0.22	<1.07	<0.20
XAD	Selkirk	7-May-97	<1.67	1.22	0.14	<1.07	<0.20
XAD	Selkirk	9-May-97	<1.67	6.64	0.15	<1.07	<0.20
XAD	Selkirk	12-May-97	<1.67	1.14	0.19	<1.07	<0.20
SPE	Selkirk	16-May-97	<1.67	<0.72	0.87	<1.07	3.65
XAD	Selkirk	20-May-97	<1.67	<0.72	0.18	<1.07	<0.20
SPE	Selkirk	23-May-97	3.55	<0.72	0.60	<1.07	0.77
SPE	Selkirk	26-May-97	3.96	<0.72	0.88	<1.07	1.61
SPE	Selkirk	29-May-97	4.59	<0.72	0.56	<1.07	1.03
SPE	Selkirk	2-Jun-97	2.90	7.41	0.37	<1.07	0.53
SPE	Selkirk	5-Jun-97	5.64	<0.72	0.61	<1.07	0.99
SPE	Selkirk	11-Jun-97	4.72	<0.72	0.90	<1.07	1.97
SPE	Selkirk	18-Jun-97	4.49	2.74	0.50	<1.07	2.33
SPE	Selkirk	26-Jun-97	4.99	<0.72	0.45	<1.07	3.47
SPE	Selkirk	15-Jul-97	9.27	<0.72	0.96	<1.07	13.52
SPE	Selkirk	15-Aug-97	7.36	<0.72	0.34	<1.07	2.37
SPE	Selkirk	15-Sep-97	4.75	<0.72	0.27	<1.07	2.59
SPE	Selkirk	16-Oct-97	3.83	<0.72	0.65	<1.07	<0.20
XAD	4B	5-Mar-98	<1.67	<0.72	0.13	<1.07	<0.20
XAD	9A	5-Mar-98	<1.67	<0.72	0.15	<1.07	<0.20
XAD	9B	5-Mar-98	<1.67	<0.72	0.16	<1.07	<0.20
XAD	9C	6-Mar-98	<1.67	<0.72	0.17	<1.07	<0.20
SPE	4B	16-Jul-98	7.90	<0.72	0.65	<1.07	2.78
SPE	7B	16-Jul-98	<1.67	<0.72	0.66	<1.07	<0.20
SPE	11B	14-Jul-98	<1.67	9.99	0.90	<1.07	2.34
SPE	4B	15-Sep-98	<1.67	<0.72	0.79	<1.07	2.04
SPE	7B	15-Sep-98	7.54	4.96	0.81	<1.07	2.32
SPE	11B	15-Sep-98	7.83	<0.72	0.78	<1.07	2.39

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	1245TCB	1234TCB	P5CBZ	HCBZ	a-HCH	b-HCH	g-HCH	"C"
Floodway	28-Apr-97	0.191	0.153	0.284	0.013	2.426	0.732	0.023	<0.007
Floodway	30-Apr-97	<0.067	<0.028	0.085	0.369	0.575	0.734	2.145	<0.007
Floodway	2-May-97	<0.067	<0.028	0.048	0.071	0.217	<0.019	0.687	<0.007
Floodway	5-May-97	0.083	0.062	0.199	0.040	0.722	0.025	3.364	<0.007
Floodway	7-May-97	<0.067	<0.028	0.081	0.013	0.267	<0.019	1.708	<0.007
Floodway	9-May-97	<0.067	<0.028	0.211	0.029	0.458	<0.019	3.017	<0.007
Floodway	12-May-97	<0.067	<0.028	0.058	0.015	0.242	<0.019	1.524	<0.007
Floodway	14-May-97	<0.067	<0.028	0.130	0.341	0.388	0.063	0.084	<0.007
Floodway	16-May-97	<0.067	<0.028	0.123	0.028	0.449	<0.019	4.224	<0.007
Floodway	20-May-97	<0.067	0.032	0.134	0.015	0.303	<0.019	3.282	<0.007
Floodway	23-May-97	<0.067	<0.028	0.157	0.014	0.420	<0.019	2.118	<0.007
Floodway	26-May-97	<0.067	<0.028	0.132	0.014	0.371	<0.019	2.309	<0.007
Floodway	29-May-97	<0.067	<0.028	0.071	<0.005	0.243	0.021	0.111	<0.007
Floodway	2-Jun-97	<0.067	<0.028	0.056	<0.005	0.162	<0.019	1.555	<0.007
Selkirk	28-Apr-97	<0.067	0.030	<0.008	0.590	0.420	<0.019	2.120	<0.007
Selkirk	30-Apr-97	0.250	0.210	5.100	0.380	0.600	0.060	1.920	<0.007
Selkirk	2-May-97	<0.067	<0.028	<0.008	0.053	0.274	<0.019	<0.006	<0.007
Selkirk	5-May-97	<0.067	0.700	0.150	0.560	0.580	0.040	2.670	<0.007
Selkirk	7-May-97	<0.067	<0.028	0.073	0.018	0.417	<0.019	1.942	<0.007
Selkirk	9-May-97	0.126	0.050	0.178	0.026	0.514	<0.019	2.822	<0.007
Selkirk	12-May-97	<0.067	<0.028	0.040	0.320	0.510	<0.019	2.870	<0.007
Selkirk	14-May-97	<0.067	0.033	0.013	0.009	<0.006	<0.019	<0.006	<0.007
Selkirk	16-May-97	<0.067	<0.028	0.129	0.023	0.500	<0.019	4.792	<0.007
Selkirk	20-May-97	<0.067	<0.028	0.060	0.010	0.300	<0.019	2.230	<0.007
Selkirk	23-May-97	<0.067	<0.028	0.137	0.017	0.316	<0.019	2.738	<0.007
Selkirk	26-May-97	<0.067	<0.028	0.108	0.022	0.320	<0.019	2.301	<0.007
Selkirk	29-May-97	<0.067	<0.028	0.042	0.006	0.255	<0.019	1.834	<0.007
Selkirk	26-Jun-97	<0.067	<0.028	0.024	<0.005	0.122	0.030	2.121	<0.007
Selkirk	15-Jul-97	<0.067	<0.028	0.025	<0.005	0.153	0.026	3.061	<0.007
Selkirk	15-Aug-97	<0.067	<0.028	0.012	0.009	0.061	0.021	0.838	<0.007
Selkirk	15-Sep-97	<0.067	<0.028	0.015	<0.005	0.073	0.022	1.839	<0.007
Selkirk	16-Oct-97	<0.067	<0.028	0.039	0.007	0.235	0.021	2.107	<0.007
4B	16-Jul-98	<0.067	<0.028	0.031	0.010	0.088	<0.019	2.854	<0.007
7B	16-Jul-98	<0.067	<0.028	0.023	0.010	0.199	<0.019	2.007	<0.007
11B	14-Jul-98	<0.067	<0.028	0.041	0.016	<0.006	<0.019	1.152	<0.007
4B	15-Sep-98	<0.067	<0.028	0.022	0.011	0.150	<0.019	1.229	<0.007
7B	15-Sep-98	<0.067	<0.028	0.012	0.010	0.152	<0.019	1.645	<0.007
11B	15-Sep-98	<0.067	<0.028	0.031	0.009	0.157	<0.019	1.668	<0.007
4B	5-Mar-98	<0.067	0.056	0.126	0.074	0.893	<0.019	1.962	<0.007
9A	5-Mar-98	<0.067	0.051	0.078	0.088	0.834	<0.019	1.057	<0.007
9B	5-Mar-98	<0.067	0.045	0.079	0.067	0.828	<0.019	0.709	<0.007
9C	6-Mar-98	<0.067	<0.028	0.071	0.085	0.867	<0.019	1.029	<0.007

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	Heptaclr	C1A	C1B/U6	C2/U-5	C3	C5	OXYCLR	T-CHLOR
Floodway	28-Apr-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.015
Floodway	30-Apr-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.139
Floodway	2-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.018
Floodway	5-May-97	0.015	<0.007	0.017	0.010	<0.007	0.012	0.013	0.070
Floodway	7-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.010	0.028
Floodway	9-May-97	0.013	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.022
Floodway	12-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.010
Floodway	14-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Floodway	16-May-97	<0.007	<0.007	<0.007	0.029	<0.007	0.021	0.009	0.032
Floodway	20-May-97	<0.007	<0.007	0.009	<0.007	<0.007	0.011	<0.007	0.017
Floodway	23-May-97	<0.007	<0.007	0.011	<0.007	<0.007	0.009	<0.007	0.013
Floodway	26-May-97	<0.007	<0.007	0.008	<0.007	<0.007	0.009	<0.007	0.010
Floodway	29-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Floodway	2-Jun-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Selkirk	28-Apr-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.020
Selkirk	30-Apr-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.040
Selkirk	2-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Selkirk	5-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.040
Selkirk	7-May-97	0.016	0.007	0.013	0.008	<0.007	0.013	0.018	0.032
Selkirk	9-May-97	0.012	0.010	0.010	<0.007	<0.007	<0.007	0.013	0.033
Selkirk	12-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.020
Selkirk	14-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Selkirk	16-May-97	0.007	<0.007	0.010	<0.007	<0.007	0.010	<0.007	0.021
Selkirk	20-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Selkirk	23-May-97	<0.007	<0.007	0.008	<0.007	<0.007	0.009	<0.007	0.017
Selkirk	26-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	0.008	<0.007	0.013
Selkirk	29-May-97	<0.007	<0.007	<0.007	<0.007	<0.007	0.008	<0.007	0.014
Selkirk	26-Jun-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.008
Selkirk	15-Jul-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Selkirk	15-Aug-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.008
Selkirk	15-Sep-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.009
Selkirk	16-Oct-97	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
4B	16-Jul-98	<0.007	0.010	<0.007	<0.007	<0.007	<0.007	<0.007	0.008
7B	16-Jul-98	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
11B	14-Jul-98	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.008
4B	15-Sep-98	<0.007	0.009	<0.007	<0.007	<0.007	<0.007	<0.007	0.009
7B	15-Sep-98	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
11B	15-Sep-98	<0.007	0.010	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
4B	5-Mar-98	0.008	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.012
9A	5-Mar-98	0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	0.008
9B	5-Mar-98	0.008	<0.007	<0.007	<0.007	<0.007	<0,007	<0.007	0.008
9C	6-Mar-98	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	C-CHLOR	T-NONA	HEP EPOX	DIELD	op-DDE	pp-DDE	op-DDD	pp-DDD
Floodway	28-Apr-97	<0.007	0.028	0.244	0.398	<0.01	0.054	<0.013	<0.012
Floodway	30-Apr-97	0.017	0.030	0.241	0.438	0.019	0.048	<0.013	<0.012
Floodway	2-May-97	0.008	0.016	0.126	0.262	<0.01	<0.008	<0.013	<0.012
Floodway	5-May-97	0.111	0.059	0.431	0.635	<0.01	0.140	0.036	0.107
Floodway	7-May-97	0.015	0.073	0.128	0.207	<0.01	0.067	<0.013	0.035
Floodway	9-May-97	0.017	0.041	0.203	0.369	<0.01	0.043	0.016	0.022
Floodway	12-May-97	0.009	0.026	0.123	0.179	<0.01	0.032	<0.013	<0.012
Floodway	14-May-97	<0.007	<0.007	0.099	0.127	<0.01	<0.008	<0.013	<0.012
Floodway	16-May-97	0.019	0.042	0.233	0.314	<0.01	0.036	<0.013	0.024
Floodway	20-May-97	0.011	0.035	0.213	0.364	<0.01	0.028	0.015	0.023
Floodway	23-May-97	0.012	0.038	0.162	0.289	<0.01	0.026	<0.013	0.028
Floodway	26-May-97	0.010	0.031	0.146	0.239	<0.01	0.027	<0.013	0.014
Floodway	29-May-97	<0.007	0.012	0.082	0.145	<0.01	0.011	<0.013	<0.012
Floodway	2-Jun-97	<0.007	0.008	0.061	0.109	<0.01	0.012	<0.013	0.014
Selkirk	28-Apr-97	<0.007	0.010	0.140	0.240	<0.01	0.030	0.030	0.040
Selkirk	30-Apr-97	<0.007	0.030	0.160	0.330	<0.01	0.050	0.070	0.090
Selkirk	2-May-97	<0.007	0.008	0.108	0.290	0.036	0.087	0.703	0.034
Selkirk	5-May-97	0.020	0.020	0.180	0.370	<0.01	0.090	0.030	0.090
Selkirk	7-May-97	0.024	0.069	0.336	0.479	<0.01	0.095	0.023	0.055
Selkirk	9-May-97	0.030	0.060	0.276	0.399	<0.01	0.063	<0.013	0.046
Selkirk	12-May-97	<0.007	0.020	0.150	0.300	<0.01	0.030	0.020	<0.012
Selkirk	14-May-97	<0.007	<0.007	<0.007	0.009	<0.01	0.015	<0.013	<0.012
Selkirk	16-May-97	0.017	0.042	0.280	0.392	<0.01	0.012	<0.013	0.028
Selkirk	20-May-97	<0.007	0.020	0.110	0.260	<0.01	0.020	<0.013	<0.012
Selkirk	23-May-97	0.011	0.031	0.163	0.273	<0.01	0.023	<0.013	0.015
Selkirk	26-May-97	0.010	0.027	0.126	0.212	<0.01	0.021	<0.013	0.016
Selkirk	29-May-97	0.008	0.022	0.090	0.165	<0.01	0.018	<0.013	0.018
Selkirk	26-Jun-97	<0.007	<0.007	0.037	0.055	<0.01	0.011	<0.013	0.021
Selkirk	15-Jul-97	<0.007	<0.007	0.059	0.096	<0.01	<0.008	<0.013	0.016
Selkirk	15-Aug-97	<0.007	<0.007	0.029	0.056	<0.01	0.012	<0.013	0.018
Selkirk	15-Sep-97	<0.007	<0.007	0.029	0.058	<0.01	0.011	<0.013	0.021
Selkirk	16-Oct-97	<0.007	<0.007	0.040	0.087	<0.01	0.010	<0.013	0.013
4B	16-Jul-98	<0.007	<0.007	0.037	0.064	<0.01	0.015	0.013	0.048
7B	16-Jul-98	<0.007	<0.007	0.035	0.056	<0.01	0.010	<0.013	0.020
11B	14-Jul-98	<0.007	<0.007	0.029	0.071	<0.01	0.011	<0.013	<0.012
4B	15-Sep-98	<0.007	<0.007	0.030	0.062	<0.01	0.020	0.020	0.064
7B	15-Sep-98	<0.007	<0.007	0.035	0.069	<0.01	0.021	0.014	0.045
11B	15-Sep-98	<0.007	<0.007	0.048	0.064	<0.01	0.010	<0.013	0.037
4B	5-Mar-98	0.015	0.021	0.062	0.115	<0.01	0.039	0.046	0.075
9A	5-Mar-98	0.010	0.009	0.072	0.131	<0.01	0.034	0.034	0.064
9B	5-Mar-98	0.009	0.013	0.063	0.123	<0.01	0.037	0.028	0.064
9C	6-Mar-98	<0.007	<0.007	0.071	0.130	<0.01	0.026	0.021	0.047

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	op-DDT	pp-DDT	PCA	ENDOSUL	MEOCL	3CL-VER	4CL-VER	ENDRIN
Floodway	28-Apr-97	0.011	<0.012	<0.005	<0.007	<0.029	0.063	<0.004	0.059
Floodway	30-Apr-97	0.015	<0.012	0.919	<0.007	<0.029	0.093	<0.004	0.093
Floodway	2-May-97	0.026	<0.012	0.032	<0.007	<0.029	0.025	<0.004	0.043
Floodway	5-May-97	0.131	0.113	0.748	0.049	0.137	0.151	0.017	0.145
Floodway	7-May-97	0.063	0.048	0.204	0.010	0.041	0.054	0.005	0.042
Floodway	9-May-97	0.046	0.027	0.273	0.088	0.094	0.063	<0.004	0.061
Floodway	12-May-97	0.025	0.014	0.272	0.012	<0.029	<0.012	<0.004	0.026
Floodway	14-May-97	<0.011	<0.012	0.043	<0.007	<0.029	<0.012	<0.004	<0.01
Floodway	16-May-97	0.111	0.135	0.562	0.017	<0.029	<0.012	<0.004	0.052
Floodway	20-May-97	0.049	0.016	0.398	0.010	0.030	<0.012	<0.004	0.046
Floodway	23-May-97	0.051	0.020	0.406	0.009	<0.029	<0.012	0.004	0.084
Floodway	26-May-97	0.041	0.013	0.095	0.009	<0.029	<0.012	<0.004	0.054
Floodway	29-May-97	0.014	<0.012	0.066	<0.007	<0.029	<0.012	<0.004	0.029
Floodway	2-Jun-97	0.015	<0.012	0.084	<0.007	<0.029	<0.012	<0.004	0.022
Selkirk	28-Apr-97	<0.011	0.030	<0.005	<0.007	0.220	0.080	<0.004	0.070
Selkirk	30-Apr-97	0.020	0.020	<0.005	<0.007	0.110	<0.012	<0.004	0.050
Selkirk	2-May-97	0.167	0.028	0.345	<0.007	<0.029	<0.012	<0.004	0.063
Selkirk	5-May-97	<0.011	0.060	<0.005	<0.007	<0.029	0.040	<0.004	0.080
Selkirk	7-May-97	0.076	0.046	0.328	0.024	0.042	0.115	0.006	0.105
Selkirk	9-May-97	0.066	0.032	0.525	0.023	<0.029	0.094	0.006	0.132
Selkirk	12-May-97	0.030	0.030	<0.005	<0.007	0.070	0.030	<0.004	0.040
Selkirk	14-May-97	<0.011	<0.012	<0.005	0.014	<0.029	<0.012	<0.004	<0.01
Selkirk	16-May-97	0.064	0.020	0.385	0.014	0.044	0.062	<0.004	0.057
Selkirk	20-May-97	<0.011	<0.012	<0.005	<0.007	0.060	0.020	<0.004	0.040
Selkirk	23-May-97	0.041	0.017	0.336	<0.007	<0.029	<0.012	<0.004	0.071
Selkirk	26-May-97	0.036	0.015	0.170	<0.007	<0.029	<0.012	<0.004	0.047
Selkirk	29-May-97	0.029	<0.012	0.134	<0.007	<0.029	<0.012	<0.004	0.033
Selkirk	26-Jun-97	<0.011	<0.012	0.093	<0.007	<0.029	<0.012	<0.004	0.011
Selkirk	15-Jul-97	<0.011	<0.012	0.164	<0.007	0.048	<0.012	<0.004	0.022
Selkirk	15-Aug-97	<0.011	<0.012	0.052	<0.007	<0.029	<0.012	<0.004	<0.01
Selkirk	15-Sep-97	<0.011	<0.012	0.113	<0.007	<0.029	<0.012	<0.004	<0.01
Selkirk	16-Oct-97	<0.011	<0.012	0.957	<0.007	0.030	<0.012	<0.004	0.013
4B	16-Jul-98	<0.011	<0.012	<0.005	0.011	<0.029	<0.012	0.008	<0.01
7B	16-Jul-98	<0.011	<0.012	0.006	0.076	<0.029	<0.012	0.010	<0.01
11B	14-Jul-98	0.015	<0.012	0.006	0.029	0.081	<0.012	0.008	<0.01
4B	15-Sep-98	<0.011	<0.012	<0.005	0.025	<0.029	<0.012	0.009	<0.01
7B	15-Sep-98	<0.011	<0.012	<0.005	0.026	<0.029	<0.012	0.007	<0.01
11B	15-Sep-98	<0.011	<0.012	<0.005	0.019	<0.029	<0.012	0.008	<0.01
4B	5-Mar-98	<0.011	0.022	0.173	0.029	0.240	<0.012	0.019	0.016
9A	5-Mar-98	<0.011	<0.012	0.075	0.031	0.125	<0.012	0.019	0.011
9B	5-Mar-98	<0.011	<0.012	0.096	0.014	0.098	<0.012	<0.004	<0.01
9C	6-Mar-98	<0.011	<0.012	0.069	0.022	0.125	<0.012	0.019	0.013

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	Endrin Ketone	ΣCBZ	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	DIELDRIN
Floodway	28-Apr-97	<0.009	0.640	3.181	0.287	0.076	1.668	0.398
Floodway	30-Apr-97	<0.009	0.533	3.454	0.427	0.082	0.218	0.438
Floodway	2-May-97	<0.009	0.119	0.904	0.169	0.026	0.174	0.262
Floodway	5-May-97	0.025	0.385	4.110	0.742	0.529	2.731	0.635
Floodway	7-May-97	<0.009	0.101	1.979	0.261	0.223	1.249	0.207
Floodway	9-May-97	<0.009	0.261	3.485	0.299	0.153	1.413	0.369
Floodway	12-May-97	<0.009	0.103	1.777	0.177	0.071	0.595	0.179
Floodway	14-May-97	<0.009	0.496	0.535	0.099	<0.011	0.283	0.127
Floodway	16-May-97	<0.009	0.221	4.691	0.392	0.306	1.006	0.314
Floodway	20-May-97	<0.009	0.230	3.592	0.309	0.130	1.153	0.364
Floodway	23-May-97	0.016	0.220	2.552	0.255	0.132	0.498	0.289
Floodway	26-May-97	0.010	0.190	2.693	0.226	0.106	0.531	0.239
Floodway	29-May-97	<0.009	0.096	0.376	0.124	0.036	0.330	0.145
Floodway	2-Jun-97	<0.009	0.107	1.735	0.097	0.050	0.294	0.109
Selkirk	28-Apr-97	<0.009	0.660	2.540	0.180	0.130	0.190	0.240
Selkirk	30-Apr-97	<0.009	5.940	2.580	0.230	0.250	0.190	0.330
Selkirk	2-May-97	<0.009	0.053	0.274	0.121	1.056	0.895	0.290
Selkirk	5-May-97	<0.009	1.410	3.290	0.270	0.270	0.860	0.370
Selkirk	7-May-97	0.021	0.105	2.372	0.537	0.294	1.982	0.479
Selkirk	9-May-97	0.016	0.379	3.352	0.472	0.212	1.612	0.399
Selkirk	12-May-97	<0.009	0.360	3.380	0.190	0.120	0.140	0.300
Selkirk	14-May-97	<0.009	0.072	<0.01	<0.007	0.015	0.526	0.009
Selkirk	16-May-97	<0.009	0.235	5.309	0.406	0.124	0.959	0.392
Selkirk	20-May-97	<0.009	0.070	2.530	0.130	0.030	0.210	0.260
Selkirk	23-May-97	0.013	0.216	3.065	0.255	0.107	0.523	0.273
Selkirk	26-May-97	0.009	0.181	2.630	0.205	0.095	0.449	0.212
Selkirk	29-May-97	<0.009	0.076	2.096	0.159	0.082	0.336	0.165
Selkirk	26-Jun-97	<0.009	0.061	2.274	0.080	0.047	0.220	0.055
Selkirk	15-Jul-97	<0.009	0.068	3.241	0.096	0.041	0.311	0.096
Selkirk	15-Aug-97	<0.009	0.047	0.920	0.067	0.045	0.256	0.056
Selkirk	15-Sep-97	<0.009	0.038	1.935	0.071	0.049	0.283	0.058
Selkirk	16-Oct-97	<0.009	0.084	2.362	0.075	0.036	0.280	0.087
4B	16-Jul-98	<0.009	0.058	2.949	0.071	0.077	0.338	0.064
7B	16-Jul-98	<0.009	0.037	2.224	0.061	0.039	0.391	0.056
11B	14-Jul-98	<0.009	0.065	1.154	0.045	0.036	0.659	0.071
4B	15-Sep-98	<0.009	0.033	1.384	0.067	0.106	0.533	0.062
7B	15-Sep-98	<0.009	<0.027	1.807	0.051	0.084	0.615	0.069
11B	15-Sep-98	<0.009	0.047	1.831	0.081	0.061	0.336	0.064
4B	5-Mar-98	<0.009	0.256	2.855	0.130	0.192	2.826	0.115
9A	5-Mar-98	<0.009	0.253	1.895	0.112	0.140	1.165	0.131
9B	5-Mar-98	<0.009	0.226	1.547	0.106	0.134	1.148	0.123
9C	6-Mar-98	<0.009	0.184	1.911	0.100	0.096	1.000	0.130

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	ΣMON/DI	ΣTRI	ΣTETRA	ΣPENTA	ΣHEXA	ΣHEPTA
Floodway	28-Apr-97	0.202	0.597	0.287	0.343	0.204	0.036
Floodway	30-Apr-97	<0.095	<0.04	0.070	0.054	0.071	0.023
Floodway	2-May-97	<0.095	<0.04	<0.03	0.044	0.056	0.070
Floodway	5-May-97	<0.095	0.313	0.498	0.647	0.735	0.441
Floodway	7-May-97	<0.095	0.116	0.200	0.259	0.316	0.273
Floodway	9-May-97	<0.095	0.300	0.153	0.287	0.425	0.175
Floodway	12-May-97	<0.095	0.084	0.114	0.160	0.118	0.066
Floodway	14-May-97	<0.095	<0.04	<0.03	0.103	0.117	0.064
Floodway	16-May-97	<0.095	0.161	0.257	0.268	0.184	0.093
Floodway	20-May-97	<0.095	0.094	0.145	0.277	0.350	0.254
Floodway	23-May-97	<0.095	0.101	0.090	0.138	0.106	0.046
Floodway	26-May-97	<0.095	0.083	0.109	0.124	0.137	0.053
Floodway	29-May-97	<0.095	0.075	0.055	0.088	0.072	0.022
Floodway	2-Jun-97	<0.095	0.063	0.055	0.078	0.065	0.021
Selkirk	28-Apr-97	<0.095	<0.04	0.100	<0.02	0.050	0.030
Selkirk	30-Apr-97	<0.095	<0.04	0.070	<0.02	0.080	0.040
Selkirk	2-May-97	<0.095	<0.04	0.039	0.416	0.323	0.074
Selkirk	5-May-97	<0.095	0.060	0.230	0.140	0.270	0.150
Selkirk	7-May-97	<0.095	0.363	0.482	0.493	0.377	0.175
Selkirk	9-May-97	<0.095	0.289	0.318	0.397	0.339	0.171
Selkirk	12-May-97	<0.095	<0.04	0.050	0.020	0.060	<0.011
Selkirk	14-May-97	<0.095	<0.04	0.116	0.195	0.149	0.035
Selkirk	16-May-97	<0.095	0.218	0.174	0.240	0.191	0.094
Selkirk	20-May-97	<0.095	<0.04	0.080	0.030	0.060	0.040
Selkirk	23-May-97	<0.095	0.089	0.100	0.133	0.128	0.064
Selkirk	26-May-97	<0.095	0.086	0.078	0.102	0.088	0.068
Selkirk	29-May-97	<0.095	0.061	0.058	0.086	0.074	0.038
Selkirk	26-Jun-97	<0.095	0.079	0.046	0.035	0.026	<0.011
Selkirk	15-Jul-97	<0.095	0.070	0.065	0.061	0.058	0.030
Selkirk	15-Aug-97	<0.095	0.064	0.043	0.058	0.043	0.013
Selkirk	15-Sep-97	<0.095	0.079	0.062	0.057	0.041	0.012
Selkirk	16-Oct-97	<0.095	0.085	0.066	0.040	0.029	<0.011
4B	16-Jul-98	<0.095	0.073	0.068	0.081	0.067	0.044
7B	16-Jul-98	<0.095	0.104	0.071	0.075	0.067	0.061
11B	14-Jul-98	<0.095	0.089	0.141	0.152	0.153	0.100
4B	15-Sep-98	<0.095	0.186	0.100	0.110	0.071	0.054
7B	15-Sep-98	<0.095	0.142	0.138	0.159	0.105	0.060
11B	15-Sep-98	<0.095	0.096	0.079	0.079	0.052	0.022
4B	5-Mar-98	0.143	0.694	0.698	0.609	0.478	0.187
9A	5-Mar-98	<0.095	0.205	0.260	0.319	0.290	0.089
9B	5-Mar-98	<0.095	0.241	0.285	0.276	0.240	0.082
9C	6-Mar-98	<0.095	0.179	0.171	0.287	0.275	0.089

Appendix II Table 3. Organochlorine concentrations in water samples collected from the Floodway and Red River at Selkirk in 1997 and at sites in the south basin of Lake Winnipeg in 1998.

Site	Date	ΣOCTA	ΣNONA	ΣDECA
Floodway	28-Apr-97	<0.011	<0.012	<0.013
Floodway	30-Apr-97	<0.011	<0.012	<0.013
Floodway	2-May-97	<0.011	<0.012	<0.013
Floodway	5-May-97	0.063	<0.012	<0.013
Floodway	7-May-97	0.041	<0.012	<0.013
Floodway	9-May-97	0.012	<0.012	<0.013
Floodway	12-May-97	<0.011	<0.012	<0.013
Floodway	14-May-97	<0.011	<0.012	<0.013
Floodway	16-May-97	<0.011	<0.012	<0.013
Floodway	20-May-97	0.030	<0.012	<0.013
Floodway	23-May-97	<0.011	<0.012	<0.013
Floodway	26-May-97	<0.011	<0.012	<0.013
Floodway	29-May-97	<0.011	<0.012	<0.013
Floodway	2-Jun-97	<0.011	<0.012	<0.013
Selkirk	28-Apr-97	<0.011	<0.012	<0.013
Selkirk	30-Apr-97	<0.011	<0.012	<0.013
Selkirk	2-May-97	0.044	<0.012	<0.013
Selkirk	5-May-97	<0.011	<0.012	<0.013
Selkirk	7-May-97	0.019	<0.012	<0.013
Selkirk	9-May-97	0.033	<0.012	<0.013
Selkirk	12-May-97	<0.011	<0.012	<0.013
Selkirk	14-May-97	<0.011	<0.012	<0.013
Selkirk	16-May-97	<0.011	<0.012	<0.013
Selkirk	20-May-97	<0.011	<0.012	<0.013
Selkirk	23-May-97	<0.011	<0.012	<0.013
Selkirk	26-May-97	0.014	<0.012	<0.013
Selkirk	29-May-97	<0.011	<0.012	<0.013
Selkirk	26-Jun-97	<0.011	<0.012	<0.013
Selkirk	15-Jul-97	<0.011	<0.012	<0.013
Selkirk	15-Aug-97	<0.011	<0.012	<0.013
Selkirk	15-Sep-97	<0.011	<0.012	<0.013
Selkirk	16-Oct-97	<0.011	<0.012	<0.013
4B	16-Jul-98	<0.011	<0.012	<0.013
7B	16-Jul-98	<0.011	<0.012	<0.013
11B	14-Jul-98	0.015	<0.012	<0.013
4B	15-Sep-98	<0.011	<0.012	<0.013
7B	15-Sep-98	<0.011	<0.012	<0.013
11B	15-Sep-98	<0.011	<0.012	<0.013
4B	5-Mar-98	0.017	<0.012	<0.013
9A	5-Mar-98	<0.011	<0.012	<0.013
9B	5-Mar-98	<0.011	<0.012	<0.013
9C	6-Mar-98	<0.011	<0.012	<0.013

Appendix II Table 4. Organochlorine concentrations on suspended sediments in the Red River at Selkirk and at the Floodway during 1997.

Site	Date	1234TCB	P5CBZ	HCBZ	a-HCH	b-HCH	g-HCH	d-HCH	heptaclr	OXYCLR	T-CHLOR
Floodway	28 Apr 97	1.140	1.019	0.646	0.204	<0.523	<0.056	0.058	<0.012	0.081	0.895
Floodway	30 Apr 97	0.558	0.235	0.340	<0.085	<0.523	0.725	0.037	<0.012	<0.066	0.434
Floodway	2 May 97	<0.299	0.117	<0.168	0.091	<0.523	0.626	0.012	<0.012	<0.066	0.352
Floodway	5 May 97	0.723	0.364	0.401	0.185	1.334	0.812	<0.003	<0.012	0.084	0.539
Floodway	7 May 97	0.378	0.373	0.291	<0.085	<0.523	0.747	0.053	<0.012	0.172	0.560
Floodway	9 May 97	0.656	0.609	<0.168	0.180	<0.523	0.977	<0.003	0.017	0.312	0.267
Floodway	12 May 97	0.772	0.418	<0.168	0.120	<0.523	0.975	<0.003	0.012	0.269	0.166
Floodway	14 May 97	<0.299	0.191	<0.168	0.092	<0.523	0.664	0.017	<0.012	0.093	0.105
Floodway	16 May 97	0.320	0.388	<0.168	0.121	<0.523	0.629	<0.003	0.012	0.276	0.195
Floodway	20 May 97	0.539	0.325	<0.168	0.133	<0.523	0.519	<0.003	0.014	0.254	0.178
Floodway	23 May 97	<0.299	0.169	<0.168	<0.085	<0.523	0.890	<0.003	<0.012	0.107	0.093
Floodway	26 May 97	<0.299	0.145	<0.168	<0.085	<0.523	1.168	<0.003	<0.012	0.182	0.089
Floodway	29 May 97	<0.299	0.382	0.210	0.115	<0.523	0.907	<0.003	<0.012	0.325	0.139
Selkirk	28 Apr 97	<0.299	0.382	0.407	0.136	<0.523	0.487	0.053	<0.012	0.101	0.445
Selkirk	30 Apr 97	0.466	0.620	0.455	0.215	<0.523	0.984	0.031	<0.012	0.163	0.542
Selkirk	2 May 97	<0.299	0.108	<0.168	<0.085	<0.523	0.531	<0.003	<0.012	<0.066	0.329
Selkirk	5 May 97	0.445	0.838	0.383	0.253	<0.523	0.438	0.054	<0.012	0.071	0.343
Selkirk	7 May 97	0.491	0.395	<0.168	0.209	<0.523	0.679	<0.003	0.066	0.346	0.495
Selkirk	9 May 97	0.938	0.516	0.181	0.238	<0.523	1.011	<0.003	0.067	0.379	0.538
Selkirk	12 May 97	<0.299	0.170	<0.168	0.196	<0.523	0.858	0.020	<0.012	0.095	0.125
Selkirk	14 May 97	0.501	0.377	<0.168	0.120	<0.523	0.623	<0.003	0.024	0.255	0.161
Selkirk	16 May 97	0.458	0.388	<0.168	0.121	<0.523	0.710	<0.003	<0.012	0.280	0.204
Selkirk	20 May 97	<0.299	0.360	0.269	0.156	<0.523	0.492	0.038	<0.012	0.095	0.147
Selkirk	23 May 97	<0.299	0.137	<0.168	<0.085	<0.523	0.691	<0.003	<0.012	<0.066	0.095
Selkirk	26 May 97	<0.299	0.147	<0.168	<0.085	<0.523	0.644	<0.003	<0.012	<0.066	0.082
Selkirk	29 May 97	<0.299	0.157	0.185	<0.085	<0.523	0.640	<0.003	<0.012	0.098	0.189
Selkirk	5 Jun 97	0.355	0.761	<0.168	0.214	<0.523	0.385	<0.003	0.015	0.559	0.298
Selkirk	18 Jun 97	0.347	0.342	0.208	0.321	<0.523	0.398	<0.003	<0.012	0.436	0.441
Selkirk	15 Jul 97	0.445	1.200	<0.168	0.185	<0.523	0.333	<0.003	<0.012	0.165	0.334
Selkirk	16 Oct 97	<0.299	0.115	<0.168	<0.085	<0.523	0.306	<0.003	<0.012	<0.066	0.069

Appendix II Table 4. Organochlorine concentrations on suspended sediments in the Red River at Selkirk and at the Floodway during 1997.

Site	Date	C-CHLOR	T-NONA	H. EPOX	DIELD	op-DDE	pp-DDE	op-DDD	pp-DDD	op-DDT	pp-DDT
Floodway	28 Apr 97	0.176	0.279	0.390	0.831	<0.004	3.755	<0.055	0.780	1.471	7.538
Floodway	30 Apr 97	0.107	0.268	0.332	0.784	0.174	3.467	0.075	0.448	1.500	5.739
Floodway	2 May 97	0.152	0.147	0.240	0.634	0.060	1.780	0.241	2.864	0.812	8.389
Floodway	5 May 97	0.149	0.220	0.326	0.820	0.092	3.400	0.240	0.644	1.414	8.647
Floodway	7 May 97	0.193	0.230	0.325	0.694	0.102	3.089	0.080	0.783	1.610	7.625
Floodway	9 May 97	0.161	0.188	0.347	0.588	0.109	2.024	0.062	0.311	0.720	4.614
Floodway	12 May 97	0.102	0.156	0.243	0.529	0.078	1.266	<0.055	0.181	0.584	2.422
Floodway	14 May 97	0.070	0.097	0.139	0.431	0.023	0.868	<0.055	0.143	0.565	1.935
Floodway	16 May 97	0.120	0.175	0.224	0.482	0.051	1.251	<0.055	0.246	0.589	3.098
Floodway	20 May 97	0.112	0.178	0.200	0.503	0.092	1.254	<0.055	0.252	0.595	2.527
Floodway	23 May 97	0.040	0.088	0.083	0.442	0.014	0.652	0.065	0.168	0.093	1.042
Floodway	26 May 97	0.043	0.101	0.119	0.524	0.027	0.787	0.087	0.202	0.343	1.023
Floodway	29 May 97	0.071	0.118	0.155	0.705	0.035	1.155	0.151	0.428	0.302	1.618
Selkirk	28 Apr 97	0.197	0.156	0.247	0.709	0.067	2.140	0.264	1.022	0.683	4.099
Selkirk	30 Apr 97	0.260	0.255	0.382	0.933	0.130	3.470	0.336	1.590	1.360	8.922
Selkirk	2 May 97	0.158	0.123	0.191	0.502	0.048	1.626	0.083	0.375	0.785	4.909
Selkirk	5 May 97	0.154	0.192	0.321	0.687	<0.004	3.017	<0.055	0.850	1.607	3.819
Selkirk	7 May 97	0.218	0.251	0.242	0.691	0.133	2.893	0.383	1.508	0.901	7.016
Selkirk	9 May 97	0.278	0.306	0.387	0.810	0.256	3.272	0.305	1.025	1.416	8.360
Selkirk	12 May 97	0.070	0.082	0.140	0.359	0.038	0.965	<0.055	0.278	0.653	2.588
Selkirk	14 May 97	0.101	0.149	0.180	0.435	0.085	1.220	0.057	0.287	0.530	2.055
Selkirk	16 May 97	0.107	0.156	0.202	0.477	0.089	1.199	0.063	0.312	0.554	2.156
Selkirk	20 May 97	0.077	0.152	0.154	0.526	<0.004	1.408	<0.055	0.223	0.741	1.392
Selkirk	23 May 97	0.040	0.094	0.092	<0.335	<0.004	0.658	0.078	0.247	0.261	0.923
Selkirk	26 May 97	0.035	0.094	0.097	<0.335	0.019	0.711	0.101	0.260	0.235	0.786
Selkirk	29 May 97	0.055	0.115	0.107	<0.335	0.033	0.793	0.147	0.493	0.372	1.046
Selkirk	5 Jun 97	0.137	0.172	0.071	<0.335	0.074	1.700	0.371	1.485	0.497	1.815
Selkirk	18 Jun 97	0.200	0.170	0.149	0.378	0.048	1.225	0.543	1.947	0.563	2.184
Selkirk	15 Jul 97	0.150	0.100	<0.003	<0.335	<0.004	1.692	0.426	1.725	0.395	1.355
Selkirk	16 Oct 97	0.027	0.048	0.033	<0.335	<0.004	0.412	0.096	0.279	0.078	0.254

Appendix II Table 4. Organochlorine concentrations on suspended sediments in the Red River at Selkirk and at the Floodway during 1997.

Site	Date	PCA	END. 1	3CL-VER	4CL-VER	ENDRIN	TRIFLU	MEOCL	ΣCBZ	ΣHCH	ΣCHLOR
Floodway	28 Apr 97	0.994	<0.067	<0.013	<0.001	<0.004	5.292	2.608	2.806	0.461	1.821
Floodway	30 Apr 97	1.005	<0.067	<0.013	<0.001	<0.004	5.596	1.003	1.133	1.295	1.202
Floodway	2 May 97	2.161	<0.067	<0.013	<0.001	<0.004	4.903	0.816	0.381	0.725	0.943
Floodway	5 May 97	0.517	<0.067	<0.013	<0.001	<0.004	7.057	3.162	1.488	2.331	1.318
Floodway	7 May 97	0.469	<0.067	<0.013	<0.001	<0.004	5.308	1.787	1.042	1.112	1.479
Floodway	9 May 97	0.466	0.084	<0.013	0.024	<0.004	9.800	0.366	1.399	1.157	1.292
Floodway	12 May 97	0.467	0.093	<0.013	0.007	<0.004	10.948	0.211	1.269	1.096	0.947
Floodway	14 May 97	0.378	<0.067	<0.013	<0.001	0.064	8.619	0.269	0.478	0.756	0.503
Floodway	16 May 97	0.493	0.086	<0.013	0.009	<0.004	9.117	0.160	0.799	0.750	1.002
Floodway	20 May 97	0.418	0.131	<0.013	0.011	<0.004	11.126	0.163	0.927	0.652	0.936
Floodway	23 May 97	0.348	<0.067	<0.013	<0.001	0.067	1.449	0.469	0.432	0.969	0.411
Floodway	26 May 97	0.188	<0.067	0.028	<0.001	0.061	1.857	0.476	0.346	1.253	0.534
Floodway	29 May 97	0.295	<0.067	<0.013	<0.001	0.089	1.880	0.418	0.732	1.022	0.808
Selkirk	28 Apr 97	2.149	<0.067	<0.013	<0.001	<0.004	3.416	0.796	1.063	0.693	1.146
Selkirk	30 Apr 97	1.667	<0.067	<0.013	<0.001	<0.004	5.913	0.911	1.541	1.319	1.601
Selkirk	2 May 97	0.599	<0.067	<0.013	<0.001	<0.004	4.553	1.015	0.440	0.828	0.810
Selkirk	5 May 97	2.275	<0.067	<0.013	0.014	0.080	3.584	0.848	1.666	0.690	1.081
Selkirk	7 May 97	1.024	0.183	<0.013	0.011	<0.004	8.510	0.602	1.048	0.887	1.619
Selkirk	9 May 97	0.675	0.242	<0.013	0.024	<0.004	14.556	0.354	1.635	1.249	1.955
Selkirk	12 May 97	0.491	<0.067	<0.013	<0.001	0.022	4.135	0.317	0.442	1.054	0.512
Selkirk	14 May 97	0.528	0.092	<0.013	0.007	<0.004	12.471	0.225	0.951	0.743	0.869
Selkirk	16 May 97	0.446	0.102	<0.013	0.009	<0.004	11.140	0.220	0.911	0.831	0.955
Selkirk	20 May 97	0.656	<0.067	<0.013	0.002	0.038	4.006	0.366	0.847	0.648	0.625
Selkirk	23 May 97	0.276	<0.067	<0.013	<0.001	0.047	1.228	0.261	0.294	0.761	0.383
Selkirk	26 May 97	0.231	<0.067	0.037	<0.001	0.068	1.370	0.402	0.332	0.716	0.368
Selkirk	29 May 97	0.212	<0.067	<0.013	<0.001	0.057	1.471	0.370	0.342	0.725	0.564
Selkirk	5 Jun 97	0.437	0.080	<0.013	0.009	<0.004	0.704	0.225	1.274	0.599	1.251
Selkirk	18 Jun 97	0.730	0.171	<0.013	0.021	<0.004	0.843	0.632	0.896	0.718	1.396
Selkirk	15 Jul 97	0.691	<0.067	<0.013	<0.001	<0.004	<0.433	<0.011	1.759	0.518	0.749
Selkirk	16 Oct 97	0.401	<0.067	0.038	<0.001	<0.004	0.537	0.209	0.193	0.338	0.216

Appendix II Table 4. Organochlorine concentrations on suspended sediments in the Red River at Selkirk and at the Floodway during 1997.

Site	Date	ΣDDT	ΣPCB	DIELDRIN	ΣMON/DI	ΣTRI	ΣTETRA	ΣPENTA	ΣHEXA	ΣHEPTA	ΣOCTA	ΣNONA	ΣDECA
Floodway	28 Apr 97	13.544	40.562	0.831	5.743	6.564	9.105	3.591	3.515	11.447	0.597	<0.004	<0.005
Floodway	30 Apr 97	11.403	10.535	0.784	1.125	2.042	1.707	2.311	2.160	1.140	0.051	<0.004	<0.005
Floodway	2 May 97	14.145	5.731	0.634	0.617	0.806	1.659	0.955	0.793	0.868	0.033	<0.004	<0.005
Floodway	5 May 97	14.436	30.339	0.820	1.910	4.617	4.178	4.146	8.210	6.825	0.454	<0.004	<0.005
Floodway	7 May 97	13.290	24.038	0.694	1.469	2.522	2.449	2.385	3.414	6.097	4.200	1.152	0.349
Floodway	9 May 97	7.839	3.889	0.588	0.661	0.924	0.996	0.730	0.401	0.178	<0.004	<0.004	<0.005
Floodway	12 May 97	4.562	3.767	0.529	0.393	0.677	0.862	0.805	0.746	0.254	0.021	0.009	<0.005
Floodway	14 May 97	3.534	6.023	0.431	0.639	1.138	1.230	1.002	0.837	0.893	0.034	<0.004	<0.005
Floodway	16 May 97	5.281	3.922	0.482	0.392	0.673	1.386	0.762	0.502	0.188	0.019	<0.004	<0.005
Floodway	20 May 97	4.767	9.631	0.503	0.573	0.904	1.141	1.094	2.666	2.779	0.276	0.056	<0.005
Floodway	23 May 97	2.032	2.914	0.442	0.511	0.347	0.198	0.642	0.558	0.466	0.108	0.028	<0.005
Floodway	26 May 97	2.468	6.922	0.524	0.450	0.241	0.713	1.684	2.381	1.203	0.125	<0.004	<0.005
Floodway	29 May 97	3.689	7.437	0.705	0.493	0.282	0.382	2.040	2.743	1.192	0.042	<0.004	<0.005
Selkirk	28 Apr 97	8.273	16.637	0.709	1.799	3.124	4.318	1.953	1.750	3.523	0.170	<0.004	<0.005
Selkirk	30 Apr 97	15.809	15.778	0.933	3.007	2.253	3.082	1.793	1.694	3.774	0.176	<0.004	<0.005
Selkirk	2 May 97	7.827	6.166	0.502	0.941	1.009	1.207	0.736	0.634	1.599	0.039	<0.004	<0.005
Selkirk	5 May 97	9.293	25.156	0.687	3.264	5.228	6.080	3.379	2.567	3.610	0.138	<0.004	<0.005
Selkirk	7 May 97	12.834	11.940	0.691	0.408	1.766	2.566	2.703	2.765	1.515	0.112	0.024	<0.005
Selkirk	9 May 97	14.635	17.293	0.810	1.045	1.922	3.105	4.313	4.187	2.289	0.268	0.025	<0.005
Selkirk	12 May 97	4.522	5.497	0.359	0.601	1.024	1.256	0.915	0.733	0.750	0.028	<0.004	<0.005
Selkirk	14 May 97	4.233	4.128	0.435	0.401	0.790	1.088	0.910	0.596	0.304	0.028	0.010	<0.005
Selkirk	16 May 97	4.372	4.180	0.477	0.369	0.798	1.140	0.929	0.603	0.296	0.033	0.011	<0.005
Selkirk	20 May 97	3.765	13.586	0.526	0.980	2.655	3.198	1.930	1.723	2.507	0.110	<0.004	<0.005
Selkirk	23 May 97	2.167	3.399	<0.335	0.340	0.205	0.499	2.171	4.064	1.224	0.196	0.023	0.014
Selkirk	26 May 97	2.113	8.812	<0.335	0.254	0.400	0.604	1.567	2.291	0.960	0.228	0.021	0.016
Selkirk	29 May 97	2.882	6.396	<0.335	0.197	0.400	0.604	1.567	2.291	0.960	0.228	0.021	0.016
Selkirk	5 Jun 97	5.942	8.752	<0.335	0.720	1.924	2.263	1.986	1.280	0.486	0.072	0.022	<0.005
Selkirk	18 Jun 97	6.509	9.468	0.378	0.589	1.184	2.311	2.096	2.384	0.868	0.036	<0.004	<0.005
Selkirk	15 Jul 97	5.593	11.325	<0.335	1.156	1.589	2.528	2.708	2.415	0.929	<0.004	<0.004	<0.005
Selkirk	16 Oct 97	1.118	2.749	<0.335	0.597	0.379	0.382	0.776	0.464	0.139	0.012	<0.004	<0.005

Appendix II Table 5. Toxaphene concentrations in water collected at the Floodway and Red River at Selkirk in 1997.

Location	Date	Hexa	Hepta	Octa	Nona	Hx-sed	Hp-sed	T2	T12	Total
Selkirk	28 Apr	0.060	0.319	0.130	0.026	0.038	0.029	0.001	0.004	0.534
Selkirk	2 May	0.074	0.497	0.327	0.076	0.040	0.044	0.004	0.015	0.973
Selkirk	5 May	0.014	0.088	0.028	0.004	0.009	0.009	0.000	0.001	0.133
Selkirk	7 May	0.082	0.645	0.503	0.065	0.056	0.054	0.005	0.026	1.296
Selkirk	9 May	0.060	0.496	0.387	0.059	0.039	0.036	0.005	0.019	1.002
Selkirk	16 May	0.189	1.454	1.162	0.194	0.122	0.097	0.013	0.062	2.998
Selkirk	23 May	0.304	2.397	1.549	0.249	0.207	0.175	0.022	0.070	4.500
Selkirk	26 May	0.019	0.183	0.200	0.038	0.009	0.015	0.003	0.007	0.440
Selkirk	26 Jun	0.117	0.361	0.158	0.013	0.092	0.042	0.001	0.003	0.649
Selkirk	15 Jul	0.148	0.646	0.245	0.035	0.094	0.072	0.004	0.002	1.073
Selkirk	15 Aug	0.132	0.411	0.128	0.018	0.082	0.055	0.002	0.002	0.689
Selkirk	15 Sep	0.139	0.369	0.130	0.017	0.083	0.047	0.002	0.002	0.656
Selkirk	16 Oct	0.080	0.282	0.094	0.014	0.055	0.048	0.002	0.001	0.470
Floodway	28 Apr	0.064	0.534	0.377	0.075	0.039	0.042	0.005	0.022	1.050
Floodway	30 Apr	0.114	0.694	0.506	0.092	0.055	0.057	0.007	0.022	1.406
Floodway	2 May	0.114	0.926	0.601	0.113	0.056	0.060	0.010	0.019	1.753
Floodway	5 May	0.007	0.111	0.181	0.053	0.003	0.008	0.002	0.010	0.352
Floodway	7 May	0.080	0.663	0.527	0.095	0.043	0.048	0.008	0.033	1.364
Floodway	9 May	0.056	0.875	1.119	0.224	0.023	0.071	0.014	0.033	2.275
Floodway	12 May	0.052	0.458	0.309	0.049	0.030	0.033	0.006	0.018	0.868
Floodway	14 May	0.070	0.142	0.014	0.004	0.049	0.047	0.000	0.000	0.230
Floodway	16 May	0.080	0.630	0.703	0.078	0.062	0.047	0.007	0.020	1.492
Floodway	20 May	0.148	1.482	1.204	0.147	0.116	0.108	0.016	0.047	2.981
Floodway	23 May	0.311	2.449	1.583	0.255	0.211	0.179	0.022	0.072	4.598
Floodway	23 May	0.175	1.380	0.951	0.141	0.104	0.118	0.015	0.055	2.647
Floodway	29 May	0.020	0.227	0.279	0.044	0.012	0.020	0.004	0.014	0.570
Floodway	29 May	0.126	0.856	0.578	0.083	0.077	0.058	0.008	0.026	1.644
Floodway	2 Jun	0.104	0.657	0.437	0.052	0.074	0.052	0.005	0.016	1.250

Appendix II Table 6. Toxaphene concentrations in suspended sediments collected at the Floodway and Red River at Selkirk in 1997.

Location	Date	Hexa	Hepta	Octa	Nona	Hx-sed	Hp-sed	T2	T12	Total
Selkirk	27 Apr	0.363	2.306	2.887	0.722	0.154	0.266	0.057	0.189	6.951
Selkirk	30 Apr	1.048	8.521	10.391	3.055	0.591	0.799	0.185	0.550	21.800
Selkirk	5 May	0.466	4.677	5.944	1.830	0.228	0.473	0.147	0.483	12.917
Selkirk	6 May	0.411	3.391	3.869	0.634	0.260	0.369	0.023	0.146	8.305
Selkirk	7 May	0.448	2.946	4.915	1.212	0.165	0.292	0.105	0.275	9.521
Selkirk	9 May	0.303	3.763	5.342	1.999	0.199	0.364	0.036	0.422	11.406
Selkirk	12 May	0.290	3.470	5.732	1.467	0.127	0.276	0.073	0.367	10.959
Selkirk	14 May	0.299	3.948	5.616	1.831	0.161	0.288	0.058	0.209	11.693
Selkirk	16 May	0.310	4.709	6.409	1.392	0.174	0.386	0.063	0.277	12.820
Selkirk	20 May	0.549	7.010	11.888	3.172	0.243	0.592	0.189	0.706	22.619
Selkirk	23 May	0.214	2.820	2.627	1.132	0.093	0.210	0.049	0.052	6.793
Selkirk	26 May	0.071	2.194	4.358	1.760	0.015	0.342	0.051	0.341	8.383
Selkirk	29 May	0.179	2.607	3.627	0.788	0.089	0.163	0.046	0.170	7.201
Selkirk	30 May	0.944	10.876	11.192	3.259	0.502	1.111	0.225	0.362	26.272
Selkirk	18 Jun	0.550	3.078	2.724	0.753	0.303	0.408	0.020	0.186	7.105
Selkirk	15 Jul	0.938	5.784	3.601	0.645	0.671	0.745	0.032	0.108	10.968
Floodway	28 Apr	0.171	3.445	5.157	1.084	0.107	0.352	0.085	0.333	11.454
Floodway	30 Apr	0.259	3.549	5.362	1.511	0.101	0.285	0.160	0.420	9.178
Floodway	2 May	0.369	3.994	4.632	1.165	0.183	0.380	0.061	0.282	9.931
Floodway	5 May	0.328	3.878	5.136	2.185	0.129	0.275	0.070	0.348	10.771
Floodway	7 May	0.185	4.192	6.398	1.546	0.108	0.341	0.089	0.360	13.839
Floodway	9 May	0.396	5.341	5.757	2.322	0.176	0.410	0.087	0.161	13.817
Floodway	12 May	0.274	4.658	7.790	1.951	0.181	0.361	0.083	0.557	14.672
Floodway	14 May	0.365	4.230	6.274	1.735	0.138	0.335	0.111	0.465	12.603
Floodway	16 May	0.360	6.571	9.916	2.709	0.213	0.500	0.095	0.631	19.555
Floodway	20 May	0.234	4.130	7.362	1.835	0.150	0.311	0.077	0.513	13.562
Floodway	23 May	0.289	3.347	4.736	0.909	0.204	0.285	0.053	0.314	9.281
Floodway	26 May	0.256	2.831	2.890	0.611	0.096	0.247	0.061	0.084	6.588
Floodway	29 May	0.345	4.370	5.489	1.645	0.142	0.213	0.060	0.128	11.849

Appendix II Table 7. Hydrocarbon concentrations (ng/g dry wt.) in suspended sediments collected from Selkirk during 1997.

COMPOUND	9 May	14 May	17 May	23 May	26 May	29 May	11 Jun	26 Jun	15 Oct
Naphthalene	21.4	11.5	9.3	9.4	12.2	13.9	10.3	12.4	<7
2-Methylnaphthalene	13.9	11.9	6.7	5.7	6.5	7	7.9	11.1	<4.6
1-Methylnaphthalene	4.8	3.4	2.3	2	2.8	2.7	3.4	4.3	<1.8
C1 Naphthalenes	18.7	15.2	9.1	7.7	9.3	9.7	11.3	15.3	6.1
C2 Naphthalenes	23.5	11.2	9.1	<4.6	<4.6	<4.6	18.2	25	<4.6
C3 Naphthalenes	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
C4 Naphthelenes	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Biphenyl	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Acenaphthylene	1.8	1.4	1.4	1.2	1.6	1.8	1.6	1.9	0.7
Acenaphthene	2.3	2.1	1.6	1.3	2.7	2.6	1.9	1.9	0.8
Dibenzofuran	8.9	6.4	4.7	3.7	5.2	5.8	5.9	5.1	2.6
Fluorene	3.3	2.6	2.3	1.5	2.4	2.4	2.4	2.3	0.9
C1 Fluorenes	25.8	13	7.2	11.7	11	11.7	11.5	21.4	7.7
C2 Fluorenes	14.9	<0.3	<0.3	5.3	<0.3	<0.3	<0.3	<0.3	<0.3
C3 Fluorenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Dibenzothiophene	5.8	3.5	2.4	3.8	4.8	4.7	5	8.7	2.9
C1 Dibenzothiophenes	8.1	4.3	2.4	<0.3	8.1	7.6	9	15	<0.3
C2 Dibenzothiophenes	9.1	<0.3	3.1	<0.3	6.3	<0.3	<0.3	12.3	<0.3
C3 Dibenzothiophenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Phenanthrene	23	19.6	18.7	14.4	24.8	24.8	19.1	14	9.7
Anthracene	4.3	4.9	3.9	4	7	9.7	4.1	2.1	1
C1 Phen_Anthr	52.4	26.9	22.1	31.1	39.8	36	45.6	67.4	22.9
C2 Phen_Anthr	53.7	17.1	14.3	26.2	33.2	32.9	37.7	68.9	20
C3 Phen_Anthr	41.2	17.4	18.9	12.5	18	41.3	<0.7	<0.7	<0.7
C4 Phen_Anthr	33.2	<0.7	<0.7	14.3	25.4	25.7	<0.7	<0.7	<0.7
Fluoranthene	30.8	22.5	22	20.4	37.3	36.3	28.2	20.8	17.8
Pyrene	38.5	27.3	23.2	22.6	39.9	41.5	40.4	32.6	18.7
C1 Pyrene	118	79.7	86.5	73.6	125.4	141.6	143.6	157.4	69.7
C2 Pyrene	40.4	15.9	13	10.2	19.7	30.2	45.3	61.8	15.7
C3 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
C4 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Retene	1.9	<1	<1	<1	<1	<1	2.3	3.4	<1
Benzo(a)anthracene	9.3	7.2	7.5	6.5	11.6	14.1	8.4	3.7	2.7
Triphenylene	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chrysene	19.1	11.7	9.4	10.2	24.3	22.4	13.8	7.2	13.9
C1 Chrysene	21	10.7	5.7	4.9	13.4	19.5	31.3	15.6	14.5
C2 Chrysene	24.2	<1.8	<1.8	<1.8	<1.8	24.9	43.5	83.3	<1.8
C3 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
C4 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Benzo(b)fluoranthene	23	13.8	13.9	15.2	25.4	25.7	25.6	26.1	13.7
Benzo(k)fluoranthene	7.6	4.8	6.3	5.7	10.4	11.1	10.3	5.4	4.9
Benzo(e)Pyrene	30.2	16	16.1	18.6	29.7	32	35.3	36	16.5
Benzo(a)pyrene	17	11.1	11.7	12.4	18.9	23.1	19.3	11	5.3
Perylene	31.7	11.5	9.8	15.4	20.4	31.2	77.7	113.9	17.4
Indeno(1,2,3-c,d)pyrene	10.2	7.8	8.8	6.9	11.7	15	12.7	9.8	<6.4
Dibenzo(a,h)anthracene	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Benzo(g,h,i)perylene	17.1	9.6	9.2	9.8	15.2	18.6	17.5	17.8	6.5
Total PAH (nap to bpe)	262	175	168	161	277	298	254	205	124
Total PAH (phn to bpe)	233	157	153	148	259	277	238	186	116
Total Alkylated PAH	467	207	186	197	295	373	388	516	157

Appendix II Table 7. Hydrocarbon concentrations (ng/g dry wt.) in suspended sediments collected from the Floodway during 1997.

COMPOUND	9 May	14 May	17 May	23 May	26 May	29 May	11 Jun	26 Jun
Naphthalene	10.8	9.2	<7	9.2	7.8	15.4	12.6	12.5
2-Methylnaphthalene	10.5	8.3	6.2	9.3	7	13.5	10.1	11
1-Methylnaphthalene	3.3	2.6	1.9	2.9	2.8	5.1	4.1	4.4
C1 Naphthalenes	13.8	10.9	8	12.2	9.8	18.6	14.2	15.4
C2 Naphthalenes	13.6	9.7	7.1	10.5	<4.6	<4.6	<4.6	23.5
C3 Naphthalenes	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
C4 Naphthelenes	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Biphenyl	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Acenaphthylene	1.3	0.9	0.8	1.1	1.2	1.4	1	1
Acenaphthene	0.5	0.4	0.3	0.4	0.3	0.4	0.6	0.9
Dibenzofuran	5.9	3.9	3.8	6	2.5	3.4	4.6	6.1
Fluorene	1.8	1	0.7	1.1	0.7	0.7	1	2
C1 Fluorenes	13.3	7.4	6.2	11	12.5	11.6	16.8	29.9
C2 Fluorenes	10.2	2.7	3.9	<0.3	<0.3	<0.3	<0.3	<0.3
C3 Fluorenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Dibenzothiophene	5.6	2.3	2.4	4	3.7	4.2	6.2	7.7
C1 Dibenzothiophenes	1.8	3.4	3.1	5.3	5.4	8.8	12.6	16.1
C2 Dibenzothiophenes	8.4	3.2	3.7	7.6	<0.3	<0.3	<0.3	<0.3
C3 Dibenzothiophenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Phenanthrene	13.1	8.1	6.1	8.2	4.4	5.7	6.6	10.6
Anthracene	1.3	0.6	<0.6	1	<0.6	<0.6	0.9	1.3
C1 Phen_Anthr	43.7	21.1	20.2	33.2	26.7	33.7	46.2	68.1
C2 Phen_Anthr	39.3	19.1	19.1	31.2	21.5	25.9	38.9	68.8
C3 Phen_Anthr	14.8	18	22.9	21.8	<0.7	<0.7	<0.7	<0.7
C4 Phen_Anthr	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Fluoranthene	15.6	9.3	8.3	9.4	4.7	6.3	8.4	10.1
Pyrene	21.7	15.1	29.2	13.1	7.4	11.7	18	20.1
C1 Pyrene	83.3	46.1	41.9	81.1	30.1	52.6	75.3	111.2
C2 Pyrene	26.1	10.9	12.1	25.5	<0.7	<0.7	<0.7	<0.7
C3 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
C4 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Retene	1.3	<1	<1	<1	<1	<1	<1	2.3
Benzo(a)anthracene	4.1	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	2.2
Triphenylene	<2	<2	<2	<2	<2	<2	<2	<2
Chrysene	9.7	5.1	4.1	4	<1.8	2.7	2.8	4.4
C1 Chrysene	21.8	8.2	3.9	12.5	<1.8	4.2	<1.8	22
C2 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
C3 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
C4 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Benzo(b)fluoranthene	15.7	6.6	5.8	8.2	<5	6	8.1	11.8
Benzo(k)fluoranthene	5.1	2.2	2.1	3	<1.8	<1.8	2.4	2.2
Benzo(e)Pyrene	20.3	9.7	7.7	13.8	5.9	8.1	14.3	22.9
Benzo(a)pyrene	9.3	4.1	<3.1	5.1	<3.1	<3.1	5.4	6.4
Perylene	15.5	6.3	7.5	17.1	10.7	15.5	37.6	61.5
Indeno(1,2,3-c,d)pyrene	8.5	<6.4	<6.4	<6.4	<6.4	<6.4	<6.4	7.1
Dibenzo(a,h)anthracene	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Benzo(g,h,i)perylene	12.5	<6.4	<6.4	7.5	<6.4	<6.4	8	14
Total PAH (nap to bpe)	153	83	84	90	45	66	96	129
Total PAH (phn to bpe)	139	72	76	78	36	48	81	113
Total Alkylated PAH	280	154	145	239	100	147	191	339

Appendix III Table 1. Abundance (individuals per litre) of crustacean plankton species instars at 7 pelagic stations in the South Basin of Lake Winnipeg, March 5, 1998.

STATION		4B	9A	9B	9C	11A	11B	11C	Basin
MONTH		March	March	March	March	March	March	March	Mean
DAY		5	5	5	5	5	5	5	
DEPTH		7.9	8.8	9.1	9.1	8.5	9.9	10.1	
SPECIES	LIFE STAGE								
Diacylops bicuspidatus thomasi Forbes	FEMALE					0.03	0.01	0.01	0.01
	FEMALE WITH EGG								
	MALE		0.05	0.10				0.01	0.02
	COPEPODID I-V		0.35	1.02	0.44	0.03	0.04	0.09	0.28
Acanthocyclops vernalis Fischer	FEMALE								
	FEMALE WITH EGG								
	MALE								
	COPEPODID I-V								
Mesocyclops edax (Forbes)	FEMALE								
	FEMALE WITH EGG								
	MALE								
	COPEPODID I-V								
Cyclopoid nauplii	NI-NVI	0.17	0.25	0.44	0.49		0.04	0.55	0.28
Diaptomus oregonensis Lilljeborg	FEMALE								
	FEMALE WITH EGG								
	MALE								
	COPEPODID I-V								
Diaptomus ashlandi Marsh	FEMALE	1.12	1.81	0.88	0.39	0.62	0.65	0.33	0.83
	FEMALE WITH EGG	0.16	0.25	0.88	0.19	0.18	0.63	0.11	0.34
	MALE	2.35	0.91	1.60	0.58	1.33	1.14	0.42	1.19
	COPEPODID I-V	0.39	0.10	0.10	0.05	0.18	0.20		0.15
Diaptomus siciloides Lilljeborg	FEMALE								
	FEMALE WITH EGG								
	MALE								
	COPEPODID I-V								
Limnocalanus macrurus Sars	TOTAL								
Epischura lacustris Forbes	ADULT								
Epischura copepodids	COPEPODID I-V								
Epischura nevadensis Lilljeborg	TOTAL								
Calanoid nauplii	NI-NVI	2.13	0.55	3.70	6.81	0.42	1.41	1.47	2.35
Daphnia retrocurva Forbes	FEMALE								
	FEMALE WITH EGG								
	MALE								
	JUVENILE								
Daphnia galeata mendotae Birge	FEMALE								
	FEMALE WITH EGG								
	MALE								
	JUVENILE								
Bosmina longirostris (Muller)	ADULT + JUVENILE						0.04	0.02	0.01
	FEMALE WITH EGG								
Diaphanosoma leuchtenbergianum Fischer	TOTAL								
Holopedium gibberum Zaddach	TOTAL								
Leptodora kindtii (Focke)	TOTAL								
Ceriodaphnia quadrangula (Muller)	TOTAL								
Total Cyclopoida		0.17	0.65	1.56	0.92	0.05	0.10	0.66	0.59
Total Calanoida		6.15	3.62	7.15	8.02	2.73	4.02	2.32	4.86
Total Cladocera		0.00	0.00	0.00	0.00	0.00	0.04	0.02	0.01
Total Crustaceans Individuals/Litre		6.32	4.27	8.70	8.95	2.79	4.17	3.00	5.46
Mysis relicta									

Appendix III Table 2. Abundance (individuals per litre) of crustacean plankton species instars at 9 pelagic stations in the South Basin of Lake Winnipeg. July 16. 1998.

STATION		4A	4B	4C	7A	7B	7C	11A	11B	11C	Basin Mean
MONTH		JULY	JULY	JULY	JULY	JULY	JULY	JULY	JULY	JULY	
DAY		16	16	16	16	16	16	16	16	16	
DEPTH		8	8	8	8.5	8.5	10	9	11	10	
SPECIES	LIFE STAGE										
Diaclops bicuspidatus thomasi Forbes	FEMALE										
	FEMALE WITH EGG				0.13			0.06			0.02
	MALE								0.40		0.04
	COPEPODID I-V							0.49			0.05
Acanthocyclops vernalis Fischer	FEMALE		4.98	1.11	3.64		2.21	0.49	0.40	0.44	1.48
	FEMALE WITH EGG	0.14	1.11	1.52	0.78	0.13	3.21	0.25	0.20	0.22	0.84
	MALE	3.87	44.80	10.51	5.73	0.52	21.24	1.97	1.21	1.33	10.13
	COPEPODID I-V	12.72	63.61	8.85	32.27	2.60	53.54	22.62	3.62	7.08	22.99
Mesocyclops edax (Forbes)	FEMALE										
	FEMALE WITH EGG				0.26			0.49			0.08
	MALE										
	COPEPODID I-V						0.88				0.10
Cyclopoid nauplii	N1-NVI	61.39	29.31	22.12	140.03	12.49	64.16	25.57	36.60	43.81	48.28
Diaptomus oregonensis Lilljeborg	FEMALE									0.44	0.05
	FEMALE WITH EGG			0.01	0.26			0.06	0.40		0.09
	MALE							0.49			0.05
	COPEPODID I-V								0.80		0.09
Diaptomus ashlandi Marsh	FEMALE	7.19	2.21		2.08	6.25	0.88	8.85	3.22	3.54	3.80
	FEMALE WITH EGG	8.99	0.55	0.41	1.43	2.21	1.33	1.97	0.25	1.33	2.05
	MALE	7.74		0.55	4.69	8.33	0.00	12.29	10.86	4.87	5.48
	COPEPODID I-V	29.87	13.83	26.00	35.92	21.34	14.16	54.08	36.60	25.22	28.56
Diaptomus siciloides Lilljeborg	FEMALE				0.13						0.01
	FEMALE WITH EGG			0.003							0.0003
	MALE			0.14							0.02
	COPEPODID I-V										
Limnocalanus macrurus Sars	TOTAL				0.003						0.0004
Epischura lacustris Forbes	ADULT	0.83	1.38			0.52		0.12	0.10	0.22	0.35
Epischura copepodids	COPEPODID I-V		1.11			2.60	0.44	0.98	6.44	2.65	1.58
Epischura nevadensis Lilljeborg	TOTAL			0.14	0.78	0.39	1.00	2.46	0.85	1.00	0.73
Calanoid nauplii	N1-NVI	62.50	19.36	18.81	48.41	20.30	19.47	47.69	31.38	29.20	33.01
Daphnia retrocurva Forbes	FEMALE	8.85	3.32	12.17	2.08	1.04	0.44	3.93	2.41	3.54	4.20
	FEMALE WITH EGG	6.64	2.21	3.60	3.51	0.65	2.77	4.92	1.21	2.10	3.07
	MALE	1.11		3.32	0.52	0.52	0.44	0.49	0.40		0.76
	JUVENILE	38.16	11.62	42.04	19.26	4.69	6.19	22.12	5.23	2.21	16.84
Daphnia galeata mendotae Birge	FEMALE	0.55	0.55		3.12				0.40		0.51
	FEMALE WITH EGG	0.28	4.15	1.24	1.56	1.30	0.55			0.66	1.08
	MALE										
	JUVENILE	13.27	9.96	19.91	6.25	2.08	1.33	14.75	0.80	4.42	8.09
Bosmina longirostris (Muller)	ADULT + JUVENILE				0.52			0.49			0.11
	FEMALE WITH EGG										
Diaphanosoma leuchtenbergianum Fischer	TOTAL	8.30	2.21	3.87	4.16		2.21	2.46	0.05	0.44	2.63
Holopedium gibberum Zaddach	TOTAL										
Leptodora kindtii (Focke)	TOTAL	1.24	1.24	0.14	0.14	0.02	0.09	0.07	0.55	0.002	0.39
Ceriodaphnia quadrangula (Muller)	TOTAL										
Total Cyclopoida		78.13	143.81	44.11	182.85	15.75	145.24	51.93	42.44	52.88	84.12
Total Calanoida		117.12	38.44	46.05	93.70	61.95	37.28	128.99	90.91	68.47	75.88
Total Cladocera		78.40	35.26	86.28	41.13	10.30	14.02	49.24	11.06	13.39	37.68
Total Crustaceans Individuals/Litre		273.64	217.51	176.45	317.69	88.00	196.55	230.16	144.41	134.74	197.68
Mysis relicta											

Appendix III Table 3. Abundance (individuals per litre) of crustacean plankton species instars at 9 pelagic stations in the South Basin of Lake Winnipeg, August 12, 1998.

STATION		4A	4B	4C	7A	7B	7C	11A	11B	11C	Basin
MONTH		AUG	AUG	AUG	AUG	AUG	AUG	AUG	AUG	AUG	Mean
DAY		12	12	12	12	12	12	12	12	12	
DEPTH		7.3	8	8	8.5	9.2	9.2	9	11	7.3	
SPECIES	LIFE STAGE										
Diaclops bicuspidatus thomasi Forbes	FEMALE										
	FEMALE WITH EGG										
	MALE										
	COPEPODID I-V						0.962			0.303	0.141
Acanthocyclops vernalis Fischer	FEMALE	3.632	0.553	1.106	2.082	0.481	0.481				0.926
	FEMALE WITH EGG	0.605	0.069	0.553	2.603	0.361	0.120		0.050	0.003	0.485
	MALE	25.423	1.659	7.743	7.288	3.367	1.924	0.492	0.402	0.303	5.400
	COPEPODID I-V	59.32	22.12	102.32	13.01	19.24	29.34		0.402	0.909	27.408
Mesocyclops edax (Forbes)	FEMALE		0.003			0.002					0.001
	FEMALE WITH EGG		0.003								0.0003
	MALE										
	COPEPODID I-V	1.816	0.553	2.765					0.805		0.660
Cyclopoid nauplii	NI-NV1	79.900	14.381	16.593	61.426	18.276	13.948	17.699	23.733	23.942	29.989
Diaptomus oregonensis Lilljeborg	FEMALE				0.521				0.050		0.063
	FEMALE WITH EGG		0.003			0.481	0.481			0.006	0.108
	MALE			0.553							0.061
	COPEPODID I-V			0.553	0.521						0.119
Diaptomus ashlandi Marsh	FEMALE	1.816	17.146	11.062	1.562	4.810	6.252	1.475	4.425	5.152	5.967
	FEMALE WITH EGG	1.211	1.314		0.390		3.487	0.061	0.101	0.909	0.830
	MALE	0.605	14.381	3.319	1.562	7.695	10.581	0.061	2.011	0.909	4.569
	COPEPODID I-V	21.791	39.823	42.589	21.343	20.681	43.767	27.532	23.331	20.609	29.052
Diaptomus siciloides Lilljeborg	FEMALE	2.421			2.603	0.481		1.967		0.303	0.864
	FEMALE WITH EGG	0.151	0.069		0.911		0.481	0.553			0.241
	MALE	9.080		0.553	3.123	1.443		1.967	1.609	2.121	2.211
	COPEPODID I-V	1.816			1.041	0.962	1.443	0.983		3.031	1.031
Limnocalanus macrurus Sars	TOTAL							0.002			0.0003
Epischura lacustris Forbes	ADULT		0.091				0.120				0.023
Epischura copepodids	COPEPODID I-V			2.765			0.481				0.361
Epischura nevadensis Lilljeborg	TOTAL		0.055	0.138		0.240			0.008	0.152	0.066
Calanoid nauplii	NI-NV1	39.345	89.049	87.389	30.193	53.867	63.967	43.756	49.477	23.639	53.409
Daphnia retrocurva Forbes	FEMALE	1.816		1.659	3.644		0.481		0.402		0.889
	FEMALE WITH EGG		0.553	0.277	3.123	0.120		0.492			0.507
	MALE	6.658		1.106	1.041						0.978
	JUVENILE	88.980	7.190	11.615	29.151	0.962	1.924	0.983	1.207	1.515	15.948
Daphnia galeata mendotae Birge	FEMALE		2.765	1.106	1.562	1.443	0.481		0.805	0.303	0.941
	FEMALE WITH EGG			0.553	0.521	0.721	1.924				0.413
	MALE										
	JUVENILE	16.949	3.319	5.531	8.329	3.367	8.657	0.983	2.011	0.606	5.528
Bosmina longirostris (Muller)	ADULT + JUVENILE	1.211	1.106			0.481	2.405	0.492	0.402	0.303	0.711
	FEMALE WITH EGG										
Diaphanosoma leuchtenbergianum Fischer	TOTAL	16.343	5.531	16.040	14.055	9.619	10.581	0.061	1.609	0.909	8.305
Holopedium gibberum Zaddach	TOTAL								0.050		0.006
Leptodora kindtii (Focke)	TOTAL	1.362	0.008	0.058	0.135	0.113	0.051	0.088	0.141	0.167	0.236
Ceriodaphnia quadrangula (Muller)	TOTAL						0.120				0.013
Total Cyclopoida		170.696	39.345	131.084	86.413	41.725	46.773	18.191	25.392	25.461	65.009
Total Calanoida		78.236	161.930	148.921	63.769	90.660	131.060	78.358	81.012	56.831	98.975
Total Cladocera		133.318	20.473	37.945	61.562	16.826	26.623	3.100	6.627	3.803	34.475
Total Crustaceans Individuals/Litre		382.250	221.748	317.951	211.744	149.211	204.456	99.648	113.031	86.095	198.459
Mysis relicta											

Appendix III Table 4. Abundance (individuals per litre) of crustacean plankton species instars at 7 pelagic stations in the South Basin of Lake Winnipeg, September 15, 1998.

STATION		4A	4B	4C	7A	7B	7C	11B	Basin Mean
MONTH		SEPT	SEPT	SEPT	SEPT	SEPT	SEPT	SEPT	
DAY		15	15	15	15	15	15	15	
DEPTH		8	8.5	8	8.5	8.5	8.2	11	
SPECIES	LIFE STAGE								
Diaclops bicuspidatus thomasi Forbes	FEMALE			0.28					0.04
	FEMALE WITH EGG			0.03			0.07	0.80	0.13
	MALE		0.26		0.52				0.11
	COPEPODID I-V	0.28	0.26	1.38			1.08		0.43
Acanthocyclops vernalis Fischer	FEMALE		0.26	0.28					0.08
	FEMALE WITH EGG			0.03		0.03	0.03	0.40	0.07
	MALE	0.83	2.86	7.47			4.86	2.01	2.58
	COPEPODID I-V	19.08	16.66	37.61	14.58	6.25	8.09	16.49	16.97
Mesocyclops edax (Forbes)	FEMALE	0.01	0.04		0.03				0.01
	FEMALE WITH EGG								
	MALE								
	COPEPODID I-V								
Cyclopoid nauplii	NI-NVI	32.08	9.11	40.93	39.04	23.95	10.79	42.64	28.36
Diaptomus oregonensis Lilljeborg	FEMALE	0.28				0.52		0.01	0.12
	FEMALE WITH EGG	0.00				0.03		0.004	0.01
	MALE		0.26						0.04
	COPEPODID I-V			0.55					0.08
Diaptomus ashlandi Marsh	FEMALE	2.21	2.86	4.15	5.21	3.12	1.08	0.80	2.78
	FEMALE WITH EGG	0.35	0.04	0.36	0.03	0.10		3.22	0.59
	MALE	1.11	2.86	7.19	2.60	2.08	2.70	1.61	2.88
	COPEPODID I-V	28.76	36.70	43.69	66.11	35.40	22.66	23.73	36.72
Diaptomus siciloides Lilljeborg	FEMALE	0.28				2.08		0.80	0.45
	FEMALE WITH EGG					0.29	0.03	2.01	0.33
	MALE			0.28		1.56	0.54	1.21	0.51
	COPEPODID I-V					0.52			0.07
Limnocalanus macrurus Sars	TOTAL								
Epischura lacustris Forbes	ADULT	0.02	0.01	0.11		0.07	0.10	0.40	0.10
Epischura copepodids	COPEPODID I-V		1.04				0.54		0.23
Epischura nevadensis Lilljeborg	TOTAL	0.02	0.01	0.50	0.10	0.13	0.27		0.15
Calanoid nauplii	NI-NVI	34.85	10.41	22.12	33.84	37.48	22.12	25.74	26.65
Daphnia retrocurva Forbes	FEMALE	1.11		0.28	1.56	0.52			0.49
	FEMALE WITH EGG			0.03			0.03		0.01
	MALE	0.28		0.28					0.08
	JUVENILE	0.55		0.83	0.52		1.08	0.40	0.48
Daphnia galeata mendotae Birge	FEMALE	0.55	0.52	1.66		1.56	0.54		0.69
	FEMALE WITH EGG	0.003		0.17	0.03	0.13	0.10	1.21	0.23
	MALE		0.26	1.38					0.23
	JUVENILE	0.83	0.26	3.87		2.08	2.16	0.80	1.43
Bosmina longirostris (Muller)	ADULT + JUVENILE		0.52	15.21		0.52	5.94	0.40	3.23
	FEMALE WITH EGG			1.38					0.20
Diaphanosoma leuchtenbergianum Fischer	TOTAL	1.11	2.86	4.42	1.04	3.12	2.16	2.01	2.39
Holopedium gibberum Zaddach	TOTAL								0.00
Leptodora kindtii (Focke)	TOTAL	0.01	0.003	0.01	0.01	0.003	0.44	0.002	0.07
Ceriodaphnia quadrangula (Muller)	TOTAL								
Total Cyclopoida		52.27	29.45	88.00	54.17	30.23	24.92	62.35	48.77
Total Calanoida		67.88	54.20	78.95	107.89	83.39	50.05	59.55	71.70
Total Cladocera		4.43	4.43	29.52	3.16	7.94	12.44	4.83	9.54
Total Crustaceans Individuals/Litre		124.59	88.08	196.47	165.22	121.56	87.42	126.73	130.01
Mysis relicta					0.003	0.003			0.001

Appendix III Table 5. Organochlorine concentrations in surface sediment grabs collected from sites in the south basin of Lake Winnipeg.

Site	1234TCB	P5CBZ	HCBZ	a-HCH	b-HCH	g-HCH	d-HCH	heptaclr
Transect A								
1	<0.299	<0.103	0.256	0.098	<0.523	0.225	0.084	<0.012
2	<0.299	<0.103	<0.168	<0.085	<0.523	<0.056	<0.003	<0.012
3	<0.299	<0.103	<0.168	<0.085	<0.523	0.153	0.048	<0.012
4	<0.299	0.132	0.196	0.087	<0.523	0.132	0.052	<0.012
5	<0.299	<0.103	0.177	0.089	<0.523	0.151	0.042	<0.012
6	<0.299	0.112	0.221	<0.085	<0.523	0.199	0.079	<0.012
7	0.699	<0.103	0.608	0.180	<0.523	0.413	0.096	<0.012
8	<0.299	0.151	0.453	0.239	<0.523	0.611	0.096	<0.012
9	<0.299	0.110	0.191	<0.085	<0.523	0.117	0.073	<0.012
10	<0.299	0.229	0.235	0.088	<0.523	0.206	0.074	<0.012
11	<0.299	<0.103	0.258	0.137	<0.523	0.183	0.090	<0.012
Transect B								
1	<0.299	<0.103	0.206	0.106	<0.523	0.264	0.009	0.056
2	<0.299	<0.103	0.174	<0.085	<0.523	0.116	0.037	0.209
3	<0.299	<0.103	<0.168	<0.085	<0.523	0.102	0.029	0.056
4	<0.299	<0.103	0.177	<0.085	<0.523	0.112	0.048	0.068
5	<0.299	<0.103	0.220	0.091	<0.523	0.149	0.071	0.129
6	0.475	0.126	0.224	<0.085	<0.523	0.147	0.049	0.120
7	<0.299	<0.103	0.267	0.122	<0.523	0.217	0.075	0.114
8	0.310	0.115	0.290	<0.085	<0.523	0.107	0.089	0.033
9	<0.299	0.454	0.430	0.157	<0.523	0.334	0.077	0.015
10	<0.299	0.125	<0.168	<0.085	<0.523	0.085	0.064	0.036
11	<0.299	0.118	<0.168	<0.085	<0.523	0.063	0.059	0.035
Transect C								
1	<0.299	0.131	<0.168	0.105	<0.523	0.263	0.067	<0.012
2	<0.299	0.128	0.175	0.097	<0.523	0.254	0.046	<0.012
3	<0.299	0.174	0.203	0.130	<0.523	0.284	0.066	<0.012
4	<0.299	<0.103	0.169	0.117	<0.523	0.247	0.061	<0.012
5	<0.299	<0.103	<0.168	0.115	<0.523	0.218	0.062	<0.012
6	<0.299	0.168	0.178	0.111	<0.523	0.191	0.125	<0.012
7	<0.299	<0.103	0.181	0.092	<0.523	0.182	0.071	<0.012
8	<0.299	0.166	0.186	0.114	<0.523	0.218	0.076	<0.012
9	<0.299	<0.103	<0.168	<0.085	<0.523	0.146	0.080	<0.012
10	<0.299	<0.103	<0.168	0.095	<0.523	0.177	0.096	<0.012
11	<0.299	<0.103	0.199	0.121	<0.523	0.184	0.101	<0.012

Appendix III Table 5. Organochlorine concentrations in surface sediment grabs collected from sites in the south basin of Lake Winnipeg.

Site	OXYCLR	T-CHLOR	C-CHLOR	T-NONA	C-NONM	H. EPOX	DIELD	op-DDE	pp-DDE
Transect A									
1	0.126	0.325	0.140	0.123	0.174	0.056	<0.335	0.283	1.320
2	<0.066	<0.003	<0.003	<0.003	<0.002	<0.003	<0.335	<0.004	<0.009
3	0.104	0.219	0.094	0.099	0.117	0.052	<0.335	0.184	0.925
4	0.106	0.162	0.073	0.078	0.052	0.041	<0.335	0.056	0.782
5	0.103	0.151	0.067	0.114	0.072	0.041	<0.335	0.171	0.749
6	0.118	0.521	0.064	0.086	0.110	0.047	<0.335	0.184	0.667
7	0.219	0.291	0.085	0.104	0.438	0.057	<0.335	0.950	1.068
8	0.111	0.215	0.119	0.055	0.261	0.092	<0.335	0.151	0.710
9	0.089	0.082	0.051	0.050	0.062	0.067	<0.335	0.102	0.638
10	0.085	0.086	0.037	0.048	0.051	0.057	<0.335	0.137	0.607
11	0.067	0.092	0.059	0.072	0.343	0.061	<0.335	0.090	0.729
Transect B									
1	0.111	0.359	0.131	0.143	0.112	0.054	<0.335	0.147	1.690
2	0.087	0.245	0.102	0.136	0.080	0.039	<0.335	0.136	1.353
3	0.078	0.174	0.071	0.087	0.072	0.049	<0.335	0.129	1.104
4	0.090	0.169	0.077	0.077	0.071	0.040	<0.335	0.163	1.085
5	0.105	0.160	0.073	0.078	0.072	0.044	<0.335	0.050	0.986
6	0.091	0.152	0.059	0.058	0.050	0.041	<0.335	0.047	0.903
7	0.209	0.289	0.049	0.125	0.059	0.046	<0.335	0.078	1.080
8	<0.066	0.079	0.016	0.032	0.019	0.048	<0.335	0.227	0.713
9	0.083	0.104	0.074	0.072	0.057	0.040	<0.335	0.069	0.747
10	<0.066	0.065	0.040	0.040	0.038	0.043	<0.335	0.047	0.480
11	<0.066	0.029	0.037	0.044	0.083	0.027	<0.335	0.040	0.449
Transect C									
1	0.138	0.370	0.155	0.057	0.106	0.076	<0.335	0.144	1.574
2	0.122	0.269	0.108	0.045	0.095	0.060	<0.335	0.150	1.472
3	0.139	0.286	0.113	0.038	0.094	0.088	<0.335	0.129	1.473
4	0.119	0.235	0.099	0.040	0.176	0.068	<0.335	0.166	1.120
5	0.108	0.201	0.083	0.023	0.162	0.059	<0.335	0.112	0.967
6	0.131	0.193	0.085	0.028	0.077	0.052	<0.335	0.109	1.109
7	0.092	0.168	0.070	0.026	0.197	0.066	<0.335	0.075	0.712
8	0.105	0.122	0.069	0.020	0.289	0.086	<0.335	0.094	0.598
9	0.086	0.097	0.056	0.016	0.337	0.060	<0.335	0.089	0.516
10	0.099	0.087	0.050	0.016	0.292	0.068	<0.335	0.093	0.410
11	0.099	0.085	0.066	0.020	0.291	0.064	<0.335	0.112	0.563

Appendix III Table 5. Organochlorine concentrations in surface sediment grabs collected from sites in the south basin of Lake Winnipeg.

Site	op-DDD	pp-DDD	pp-DDT	PCA	END. 1	MEOCL	3CL-VER	4CL-VER
Transect A								
1	0.568	2.662	0.448	6.863	0.145	0.263	<0.013	0.010
2	<0.055	<0.004	<0.005	<0.021	<0.067	<0.011	<0.013	<0.001
3	0.426	2.077	0.265	3.058	0.079	0.218	<0.013	0.011
4	0.357	1.694	0.236	0.654	<0.067	0.176	<0.013	<0.001
5	0.351	1.604	0.243	0.950	<0.067	0.121	<0.013	0.006
6	0.377	1.526	0.276	1.407	<0.067	0.167	<0.013	<0.001
7	0.532	1.887	0.528	1.131	0.180	0.176	<0.013	0.025
8	0.246	1.205	0.312	1.308	0.240	0.178	<0.013	0.017
9	0.201	1.018	0.304	0.481	<0.067	0.218	<0.013	0.006
10	0.156	0.883	0.226	0.249	0.145	0.147	<0.013	0.010
11	0.190	0.947	0.223	14.776	0.109	0.084	<0.013	0.012
Transect B								
1	0.620	2.338	0.368	0.529	0.077	0.211	0.020	0.005
2	0.531	2.120	0.320	0.479	0.112	0.219	0.190	0.002
3	0.404	1.749	0.328	0.370	0.127	0.255	0.019	<0.001
4	0.408	1.789	0.265	0.136	0.070	0.122	0.026	<0.001
5	0.414	1.799	0.301	0.187	<0.067	0.117	<0.013	0.004
6	0.406	1.566	0.300	0.217	<0.067	0.074	<0.013	0.004
7	0.275	1.440	0.289	0.240	0.140	0.127	<0.013	0.010
8	0.112	0.488	0.132	0.087	0.071	0.124	<0.013	0.007
9	0.263	1.064	0.430	0.321	0.200	0.141	<0.013	0.011
10	0.140	0.626	0.169	0.194	<0.067	0.071	<0.013	0.004
11	0.105	0.545	0.116	0.179	<0.067	0.045	<0.013	0.007
Transect C								
1	0.667	3.752	0.473	0.457	0.072	0.138	<0.013	0.016
2	0.523	2.872	0.550	0.486	0.140	0.146	<0.013	<0.001
3	0.675	3.458	0.308	0.270	0.102	0.146	<0.013	0.017
4	0.504	2.788	0.271	5.365	<0.067	0.123	<0.013	0.017
5	0.468	2.475	0.294	4.511	<0.067	0.099	<0.013	0.019
6	0.467	2.323	0.268	0.322	<0.067	0.098	<0.013	0.026
7	0.318	1.405	0.251	2.537	<0.067	0.091	<0.013	0.011
8	0.281	1.122	0.227	3.067	<0.067	0.076	<0.013	0.017
9	0.268	1.015	0.198	5.417	<0.067	0.067	<0.013	0.013
10	0.155	0.843	0.178	3.691	<0.067	0.077	<0.013	0.013
11	0.196	1.077	0.233	2.929	0.082	0.094	0.039	0.012

Appendix III Table 5. Organochlorine concentrations in surface sediment grabs collected from sites in the south basin of Lake Winnipeg.

Site	TRIFLU	ΣCBZ	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	DIELD	ΣMON/DI	ΣTRI
Transect A									
1	<0.433	0.509	0.403	0.943	5.281	8.591	<0.335	0.269	1.277
2	<0.433	<0.149	<0.221	<0.007	<0.013	7.872	<0.335	0.300	1.199
3	<0.433	0.345	<0.221	0.689	3.878	6.983	<0.335	0.311	1.440
4	<0.433	0.383	0.265	0.520	3.125	8.400	<0.335	0.414	1.683
5	<0.433	0.347	0.300	0.553	3.118	9.407	<0.335	0.563	2.677
6	<0.433	0.532	0.349	0.966	3.032	38.097	<0.335	1.599	18.198
7	<0.433	1.390	0.683	1.194	4.966	17.944	<0.335	1.656	5.214
8	<0.433	0.875	0.850	0.853	2.716	16.734	<0.335	1.399	5.206
9	<0.433	0.439	<0.221	0.405	2.263	8.384	<0.335	0.624	2.483
10	<0.433	0.619	0.294	0.377	2.009	10.728	<0.335	0.789	3.340
11	<0.433	0.489	0.320	0.693	2.179	9.690	<0.335	0.867	3.000
Transect B									
1	0.480	0.341	0.580	0.965	5.162	10.809	<0.335	0.419	1.369
2	<0.433	0.246	0.326	0.898	4.459	6.429	<0.335	<0.182	0.780
3	<0.433	0.217	0.332	0.587	3.715	8.250	<0.335	0.285	0.863
4	<0.433	0.350	0.351	0.591	3.710	9.440	<0.335	0.480	0.837
5	<0.433	0.332	0.380	0.661	3.550	7.782	<0.335	0.410	1.310
6	<0.433	0.826	0.532	0.570	3.223	15.331	<0.335	0.580	5.787
7	<0.433	0.431	0.486	0.892	3.162	<0.076	<0.335	<0.182	<0.175
8	<0.433	0.714	0.354	0.288	1.672	12.787	<0.335	0.791	2.225
9	<0.433	0.993	0.563	0.446	2.575	18.772	<0.335	1.366	4.730
10	<0.433	0.319	<0.221	0.314	1.463	5.484	<0.335	0.389	0.954
11	<0.433	0.333	<0.221	0.271	1.256	7.419	<0.335	0.534	1.670
Transect C									
1	<0.433	0.468	0.439	0.914	6.610	12.443	<0.335	0.585	2.136
2	0.557	0.467	0.400	0.709	5.568	11.624	<0.335	0.662	2.136
3	<0.433	0.492	0.479	0.775	6.043	16.900	<0.335	0.899	4.107
4	<0.433	0.467	0.419	0.742	4.850	9.884	<0.335	0.549	1.438
5	<0.433	0.347	0.366	0.640	4.317	11.186	<0.335	0.641	2.595
6	<0.433	0.464	0.320	0.579	4.275	11.426	<0.335	0.783	2.869
7	<0.433	0.472	0.297	0.633	2.760	23.353	<0.335	1.422	8.646
8	<0.433	0.556	0.359	0.704	2.321	27.266	<0.335	1.671	9.889
9	<0.433	0.320	0.259	0.662	2.085	26.731	<0.335	1.485	11.085
10	<0.433	0.385	0.301	0.611	1.679	7.725	<0.335	0.918	2.321
11	<0.433	0.404	0.333	0.624	2.181	11.020	<0.335	1.134	3.795

Appendix III Table 5. Organochlorine concentrations in surface sediment grabs collected from sites in the south basin of Lake Winnipeg.

Site	ΣTETRA	ΣPENTA	ΣHEXA	ΣHEPTA	ΣOCTA	ΣNONA	ΣDECA
Transect A							
1	0.901	2.411	2.097	1.217	0.292	0.058	0.014
2	1.478	1.916	1.784	0.894	0.228	0.051	0.020
3	1.109	1.671	1.374	0.820	0.157	0.043	0.010
4	1.789	1.832	1.467	0.899	0.222	0.031	0.014
5	1.813	1.761	1.473	0.771	0.167	0.054	0.027
6	11.699	4.200	1.401	0.706	0.155	0.049	0.012
7	3.165	3.621	2.643	1.045	0.122	<0.004	<0.005
8	2.696	3.856	2.300	1.063	0.193	0.021	<0.005
9	1.665	1.561	1.064	0.755	0.164	0.042	0.027
10	2.445	2.091	1.194	0.657	0.174	0.027	0.012
11	1.022	2.075	1.828	0.727	0.126	0.032	0.013
Transect B							
1	1.894	2.892	2.345	1.347	0.193	0.131	0.047
2	1.011	1.564	1.382	1.143	0.155	0.105	0.019
3	1.491	1.919	1.986	1.193	0.155	0.096	0.019
4	1.720	2.422	2.120	1.298	0.218	0.138	0.032
5	0.891	1.999	1.667	1.160	0.166	0.093	0.019
6	3.348	2.405	1.701	1.178	0.157	0.076	0.024
7	<0.153	<0.027	<0.066	<0.013	<0.004	<0.004	<0.005
8	1.731	4.403	2.043	1.110	0.316	0.032	0.026
9	3.635	4.116	3.070	1.469	0.247	0.022	0.022
10	0.715	1.099	1.125	0.926	0.172	0.021	0.020
11	1.279	1.486	1.380	0.830	0.168	0.011	0.022
Transect C							
1	2.892	2.880	2.252	1.315	0.303	0.061	0.021
2	2.523	2.687	1.905	1.309	0.316	0.064	0.023
3	4.178	3.414	2.467	1.372	0.368	0.074	0.020
4	1.829	2.632	1.971	1.123	0.278	0.052	0.012
5	2.404	2.702	1.500	1.019	0.258	0.054	0.014
6	2.494	2.294	1.559	1.050	0.304	0.053	0.023
7	7.184	3.787	1.288	0.746	0.229	0.040	0.011
8	9.144	4.503	1.235	0.610	0.176	0.039	<0.005
9	8.621	3.827	1.104	0.494	0.077	0.019	0.019
10	1.562	1.335	1.001	0.492	0.076	0.020	<0.005
11	1.775	2.215	1.402	0.636	0.040	0.023	<0.005

Appendix III Table 6. Hydrocarbon concentrations (ng/g dry wt.) in surface sediments collected from sample sites in the south basin of Lake Winnipeg in the spring of 1998. A – westerly site. B – middle site. C – easterly site.

COMPOUND	1A	2A	3A	4A	5A	7A	8A	9A	10A	11A
Naphthalene	14.8	12.5	10.1	7	<7	<7	<7	10.9	<7	<7
2-Methylnaphthalene	13	11.2	7.9	7.4	5.2	<4.6	<4.6	8	<4.6	4.8
1-Methylnaphthalene	5.1	5.7	3.4	3.5	3.1	2	<1.8	4	<1.8	2
C1 Naphthalenes	18.1	16.8	11.3	11	8.3	6	<4.6	12	5.5	6.8
C2 Naphthalenes	38.9	41	26	23	21.4	10	9	40.3	22.1	24.4
C3 Naphthalenes	24.8	18.6	14.7	14.9	12.3	6	5	19.9	<4.6	8.3
C4 Naphthelenes	<4.6	<4.6	<4.6	6.4	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Biphenyl	<0.6	<0.6	<0.6	<0.6	<0.6	1	1	<0.6	<0.6	<0.6
Acenaphthylene	1.7	1.5	1.3	0.9	0.8	<0.4	<0.4	1.1	<0.4	0.8
Acenaphthene	2.8	2.2	1.1	0.9	0.7	<0.3	<0.3	1	0.4	0.6
Dibenzofuran	8.6	7.5	4.2	3.9	3.2	1	1	4.4	2.2	2.7
Fluorene	5.6	4.2	2.2	1.5	1.4	<0.3	<0.3	1.6	0.9	1
C1 Fluorenes	33.2	30.8	17.9	16.4	17	6	5	16.9	10.7	9.8
C2 Fluorenes	8.7	<0.3	8.6	14.6	6.1	3	2	15.4	<0.3	9.9
C3 Fluorenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Dibenzothiophene	4.4	3.9	2.6	3.2	2.7	<0.3	<0.3	3.5	2.7	2.9
C1 Dibenzothiophenes	4.8	6.3	<0.3	<0.3	<0.3	1	<0.3	<0.3	1.2	<0.3
C2 Dibenzothiophenes	7.3	8.5	3.8	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
C3 Dibenzothiophenes	<0.3	18	10.2	<0.3	9	4	3	<0.3	<0.3	<0.3
Phenanthrene	28.9	23.7	12.6	9.8	8.3	4	4	11.6	5.2	6.8
Anthracene	12.1	8.1	3.4	1.8	1.6	<0.6	<0.6	2.2	0.8	0.8
C1 Phen_Anthr	78.6	50.2	38.5	41.9	27	11	9	37.9	22.2	29.7
C2 Phen_Anthr	62.7	50.8	36.7	50.5	25.4	8	8	41	18.8	24
C3 Phen_Anthr	107.2	104.1	44.8	<0.7	32.2	3	5	18.4	22.9	<0.7
C4 Phen_Anthr	20.9	14.6	17.5	<0.7	10.8	4	2	12.4	<0.7	<0.7
Fluoranthene	48.7	40.3	22.4	17.8	15.2	7	5	21.4	6.8	8.5
Pyrene	49.4	42.5	24.2	19	16.6	7	5	24.1	7	8.9
C1 Pyrene	159.8	139.3	67.2	76.3	46.9	18	16	60.6	19.2	31.5
C2 Pyrene	25	21.9	19.6	<0.7	<0.7	3	2	10.3	<0.7	<0.7
C3 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	1	1	<0.7	<0.7	<0.7
C4 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Retene	7.2	5	3.7	2	2.2	<1	2	2.9	2.2	1.7
Benzo(a)anthracene	13.8	9.4	4.8	4.6	4.7	<2.2	<2.2	6.2	<2.2	<2.2
Triphenylene	<2	<2	3.1	2.3	2.7	2	<2	3.3	<2	<2
Chrysene	17.7	13.3	5	6	5.5	2	2	7.7	<1.8	<1.8
C1 Chrysene	35	31.8	17.1	<1.8	5.3	2	2	21.2	<1.8	<1.8
C2 Chrysene	<1.8	<1.8	<1.8	<1.8	24.3	3	6	<1.8	<1.8	<1.8
C3 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
C4 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Benzo(b)fluoranthene	34.9	29.6	20.9	21	18.9	6	6	24.6	10.4	11.7
Benzo(k)fluoranthene	15.3	11.9	8.2	6.5	6	2	2	8.3	3	4.2
Benzo(e)Pyrene	36.1	31.9	21.6	23.3	21	7	7	27.4	<2.2	<2.2
Benzo(a)pyrene	25.4	19.1	12.9	8.2	9.2	5	4	10.6	<3.1	<3.1
Perylene	77.3	78.4	54.6	56.6	44.6	18	17	64.8	25.6	35.5
Indeno(1,2,3-c,d)pyrene	26	20.6	13.2	10.8	10.6	<6.4	<6.4	13.4	<6.4	<6.4
Dibenzo(a,h)anthracene	4.9	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Benzo(g,h,i)perylene	24.5	18.4	12.8	10.3	11	<6.4	<6.4	16.3	<6.4	<6.4
Total PAH (nap to bpe)	362.79	292.75	179.71	151.5	140.26	56	48	191.52	52.75	59.64
Total PAH (phn to bpe)	337.9	272.32	165.07	141.22	131.11	52	45	177	46.25	50.3
Total Alkylated PAH	613	519.88	319.57	254.92	236.8	84	78	306.2	121.41	144.24

Appendix III Table 6. Hydrocarbon concentrations (ng/g dry wt.) in surface sediments collected from sample sites in the south basin of Lake Winnipeg in the spring of 1998. A – westerly site. B – middle site. C – easterly site.

COMPOUND	1B	2B	3B	4B	5B	7B	8B	9B	10B	11B
Naphthalene	18.0	10.0	<7	8.3	7.4	<7	7.0	<7	<7	7.3
2-Methylnaphthalene	14.2	8.2	7.1	7.9	5.4	5.0	5.0	5.0	4.6	4.9
1-Methylnaphthalene	6.1	3.5	4.6	7.8	3.1	2.0	2.0	2.0	2.1	2.0
C1 Naphthalenes	20.3	11.7	11.7	15.7	8.5	7.0	7.0	7.0	6.7	6.9
C2 Naphthalenes	38.4	30.3	26.0	30.6	27.9	14.0	13.0	29.0	38.8	34.9
C3 Naphthalenes	27.7	19.7	18.0	17.4	14.8	6.0	6.0	16.0	9.9	<4.6
C4 Naphthelenes	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6	<4.6
Biphenyl	<0.6	<0.6	<0.6	<0.6	<0.6	1.0	1.0	3.0	<0.6	<0.6
Acenaphthylene	1.8	1.4	0.8	1.3	0.8	<0.4	<0.4	1.0	0.7	0.7
Acenaphthene	3.7	2.1	1.1	1.0	1.0	<0.3	<0.3	<0.3	0.3	0.5
Dibenzofuran	10.5	5.3	3.6	4.4	2.9	2.0	2.0	2.0	2.9	2.8
Fluorene	6.5	3.2	2.0	2.0	1.4	1.0	1.0	1.0	1.0	1.0
C1 Fluorenes	26.7	13.6	41.8	17.9	16.0	8.0	14.0	17.0	17.5	12.3
C2 Fluorenes	13.0	13.0	15.9	<0.3	7.9	3.0	3.0	6.0	11.0	12.2
C3 Fluorenes	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Dibenzothiophene	4.5	2.8	2.7	3.1	2.7	1.0	1.0	3.0	2.9	3.1
C1 Dibenzothiophenes	7.7	4.0	3.9	<0.3	<0.3	1.0	1.0	2.0	2.2	<0.3
C2 Dibenzothiophenes	8.9	4.1	6.8	<0.3	<0.3	<0.3	12.0	3.0	<0.3	<0.3
C3 Dibenzothiophenes	8.3	<0.3	<0.3	<0.3	11.7	3.0	<0.3	8.0	<0.3	<0.3
Phenanthrene	32.2	16.8	10.5	11.8	8.3	5.0	5.0	6.0	5.5	6.3
Anthracene	12.2	5.7	2.7	2.1	1.5	1.0	<0.6	1.0	0.7	0.8
C1 Phen_Anthr	77.6	42.1	40.2	33.2	28.6	11.0	11.0	31.0	27.8	35.8
C2 Phen_Anthr	57.2	37.6	35.6	34.0	38.3	9.0	9.0	28.0	35.3	34.0
C3 Phen_Anthr	100.7	53.0	37.9	40.7	34.0	9.0	13.0	25.0	15.3	20.6
C4 Phen_Anthr	19.4	11.7	19.2	7.9	7.9	4.0	2.0	6.0	<0.7	<0.7
Fluoranthene	52.2	29.9	18.8	19.8	15.8	8.0	7.0	8.0	6.6	6.5
Pyrene	54.0	34.1	20.7	21.4	16.9	9.0	7.0	8.0	6.3	6.3
C1 Pyrene	162.0	87.7	72.5	58.4	34.6	19.0	18.0	29.0	17.4	28.6
C2 Pyrene	24.1	15.5	16.6	<0.7	<0.7	3.0	1.0	5.0	<0.7	<0.7
C3 Pyrene	11.9	<0.7	<0.7	<0.7	<0.7	<0.7	3.0	2.0	<0.7	<0.7
C4 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Retene	7.6	4.0	4.1	2.9	2.0	2.0	3.0	7.0	7.3	5.9
Benzo(a)anthracene	11.9	6.8	3.6	5.0	4.2	<2.2	<2.2	<2.2	<2.2	<2.2
Triphenylene	5.1	<2	2.4	2.6	2.4	2.0	2.0	<2	<2	<2
Chrysene	12.8	9.7	4.2	6.6	4.9	2.0	2.0	6.0	<1.8	<1.8
C1 Chrysene	31.7	19.1	17.7	17.0	11.1	2.0	3.0	4.0	<1.8	<1.8
C2 Chrysene	53.4	<1.8	<1.8	<1.8	6.0	6.0	9.0	8.0	<1.8	<1.8
C3 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
C4 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
Benzo(b)fluoranthene	39.1	22.2	17.6	22.3	20.0	8.0	7.0	7.0	10.3	11.0
Benzo(k)fluoranthene	16.1	9.2	6.1	7.6	6.5	3.0	3.0	2.0	<1.8	2.9
Benzo(e)Pyrene	41.6	23.6	18.9	24.3	21.1	10.0	9.0	9.0	<2.2	<2.2
Benzo(a)pyrene	25.2	14.6	10.1	11.7	9.5	6.0	5.0	4.0	<3.1	<3.1
Perylene	89.8	61.4	104.9	63.7	49.8	23.0	18.0	38.0	37.3	41.3
Indeno(1,2,3-c,d)pyrene	24.6	16.6	11.8	10.3	10.0	<6.4	<6.4	<6.4	<6.4	<6.4
Dibenzo(a,h)anthracene	4.3	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2	<4.2
Benzo(g,h,i)perylene	24.1	14.6	12.4	11.6	12.5	<6.4	<6.4	<6.4	7.0	<6.4
Total PAH (nap to bpe)	385.3	222.6	149.9	169.7	144.0	73.0	67.0	70.0	51.4	50.1
Total PAH (phn to bpe)	355.3	205.9	139.9	157.1	133.5	66.0	59.0	62.0	43.1	40.7
Total Alkylated PAH	664.0	355.0	353.0	272.7	235.5	104.0	114.0	216.0	179.7	185.2

Appendix III Table 6. Hydrocarbon concentrations (ng/g dry wt.) in surface sediments collected from sample sites in the south basin of Lake Winnipeg in the spring of 1998. A – westerly site. B – middle site. C – easterly site.

COMPOUND	1C	2C	3C	4C	5C	7C	8C	9C	10C	11C
Naphthalene	25.9	13.0	8.3	8.1	<7			<7	<7	<7
2-Methylnaphthalene	21.9	12.0	8.7	6.7	5.2			<4.6	<4.6	<4.6
1-Methylnaphthalene	7.8	5.2	4.1	3.8	3.1			<1.8	<1.8	1.9
C1 Naphthalenes	29.8	17.2	12.8	10.5	8.4			6.1	5.7	6.2
C2 Naphthalenes	61.5	42.0	31.2	31.1	25.6			24.4	21.1	22.6
C3 Naphthalenes	35.7	22.3	14.0	18.7	12.1			8.0	<4.6	9.9
C4 Naphthelenes	<4.6	<4.6	4.9	<4.6	<4.6			<4.6	<4.6	<4.6
Biphenyl	<0.6	<0.6	<0.6	<0.6	<0.6			<0.6	<0.6	<0.6
Acenaphthylene	2.8	1.5	1.2	0.9	0.5			0.7	0.7	<0.4
Acenaphthene	5.5	3.2	1.5	1.3	0.6			0.5	0.5	0.3
Dibenzofuran	13.6	8.0	5.1	4.5	2.3			2.4	2.2	2.4
Fluorene	7.9	4.4	2.4	2.0	0.8			1.0	0.8	0.7
C1 Fluorenes	31.7	25.6	16.4	16.1	10.0			15.4	12.7	12.1
C2 Fluorenes	17.7	18.7	17.7	15.3	9.8			11.5	6.7	8.3
C3 Fluorenes	<0.3	<0.3	<0.3	<0.3	<0.3			<0.3	<0.3	<0.3
Dibenzothiophene	6.7	3.7	3.0	2.8	2.3			2.7	2.4	2.7
C1 Dibenzothiophenes	9.2	3.8	3.6	<0.3	<0.3			1.6	<0.3	<0.3
C2 Dibenzothiophenes	12.5	4.2	5.1	<0.3	<0.3			<0.3	<0.3	<0.3
C3 Dibenzothiophenes	18.0	9.1	11.2	<0.3	11.0			<0.3	<0.3	<0.3
Phenanthrene	49.3	24.5	14.6	11.6	4.9			6.3	5.1	4.5
Anthracene	18.4	8.6	3.8	2.4	<0.6			1.0	<0.6	<0.6
C1 Phen_Anthr	106.4	60.1	38.9	26.3	27.4			32.1	20.8	26.5
C2 Phen_Anthr	89.5	56.5	39.9	32.8	30.1			26.4	19.5	22.5
C3 Phen_Anthr	153.2	82.1	68.1	56.7	37.2			38.7	15.6	10.4
C4 Phen_Anthr	34.0	22.3	8.8	11.3	5.8			<0.7	<0.7	<0.7
Fluoranthene	74.3	41.4	26.3	20.0	7.7			9.2	6.1	5.5
Pyrene	78.1	44.1	29.0	23.5	7.3			9.6	6.5	5.1
C1 Pyrene	239.5	146.4	81.4	73.4	30.5			30.5	20.3	32.1
C2 Pyrene	45.4	30.3	18.6	<0.7	<0.7			3.7	<0.7	<0.7
C3 Pyrene	<0.7	13.7	<0.7	<0.7	<0.7			<0.7	<0.7	<0.7
C4 Pyrene	<0.7	<0.7	<0.7	<0.7	<0.7			<0.7	<0.7	<0.7
Retene	9.4	5.5	4.2	3.2	1.3			12.8	6.9	3.9
Benzo(a)anthracene	17.9	9.8	9.5	6.0	<2.2			<2.2	<2.2	<2.2
Triphenylene	6.2	3.9	3.5	3.3	<2			<2	<2	<2
Chrysene	19.7	10.9	11.6	7.9	1.9			2.5	<1.8	<1.8
C1 Chrysene	51.8	36.2	15.3	15.9	<1.8			<1.8	<1.8	<1.8
C2 Chrysene	89.1	49.2	<1.8	<1.8	18.1			<1.8	<1.8	<1.8
C3 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8			<1.8	<1.8	<1.8
C4 Chrysene	<1.8	<1.8	<1.8	<1.8	<1.8			<1.8	<1.8	<1.8
Benzo(b)fluoranthene	58.0	32.4	27.2	21.7	11.3			10.4	10.3	11.0
Benzo(k)fluoranthene	26.4	13.0	10.7	7.6	3.6			3.5	2.7	<1.8
Benzo(e)Pyrene	62.9	35.3	31.0	23.4	13.6			<2.2	<2.2	<2.2
Benzo(a)pyrene	38.3	21.8	15.1	11.0	3.6			<3.1	<3.1	<3.1
Perylene	135.1	84.6	63.2	58.4	31.4			36.0	38.0	30.9
Indeno(1,2,3-c,d)pyrene	33.4	17.7	10.6	10.0	<6.4			<6.4	<6.4	<6.4
Dibenzo(a,h)anthracene	7.8	<4.2	<4.2	<4.2	<4.2			<4.2	<4.2	<4.2
Benzo(g,h,i)perylene	33.9	15.8	14.5	14.2	7.7			8.5	<6.4	<6.4
Total PAH (nap to bpe)	566.9	301.2	220.8	175.0	77.3			65.57	45.45	35.75
Total PAH (phn to bpe)	524.8	279.1	207.4	162.7	70.6			58.23	38.1	28.75
Total Alkylated PAH	985.2	622.4	367.8	308.0	214.9			198.1	122.42	150.49

Appendix III Table 7. Organochlorine concentrations and percent lipid in mayflies collected at BDI, Selkirk and Gimli.

Site	Sex	Molt[a]	%LIPID	ΣCBZ	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	ΣTOXSRF	DIELDRIN
BDI	Male	SI	23.2	1.18	2.08	1.03	15.82	54.06	4.06	1.34
BDI	Female	SI	20.1	1.55	2.85	1.48	32.42	74.05	3.71	1.46
BDI	Female	IM	8.3	0.51	0.55	1.65	15.53	65.16	3.48	0.51
Selkirk	Male	SI	14.9	1.22	0.25	4.26	6.09	75.95	1.68	0.12
Selkirk	Female	IM	10.8	0.74	0.53	3.19	4.69	38.24	2.34	3.93
Selkirk	Female	SI	24.8	1.18	1.26	3.67	13.52	68.59	5.98	1.91
Gimli	Male	SI	12.4	0.46	0.48	1.11	7.29	38.34	1.41	0.82
Gimli	Male	IM	16.7	0.56	0.98	1.60	6.19	54.42	3.26	1.56
Gimli	Female	SI	11.9	1.09	0.54	1.07	9.00	56.68	1.88	1.11
Gimli	Female	IM	19.2	2.71	0.69	2.53	17.52	66.41	7.06	1.36

[a]SI – sub-imago. IM – imago.

Site	Sex	Molt	ΣMON/DI	ΣTRI	ΣTETRA	ΣPENTA	ΣHEXA	ΣHEPTA	ΣOCTA	ΣNONA	ΣDECA
BDI	Male	SI	0.55	8.26	8.93	8.94	13.74	10.74	2.75	0.15	<0.003
BDI	Female	SI	0.63	6.02	19.00	19.75	16.76	10.09	1.80	<0.003	<0.003
BDI	Female	IM	0.16	4.05	9.98	23.26	18.87	7.44	1.27	0.13	<0.003
Selkirk	Male	SI	1.22	15.21	14.97	15.00	16.79	9.92	2.71	0.13	<0.003
Selkirk	Female	IM	0.18	4.71	8.98	10.56	8.36	4.10	1.22	0.12	<0.003
Selkirk	Female	SI	0.74	10.55	14.73	17.75	14.29	8.49	1.90	0.15	<0.003
Gimli	Male	SI	0.28	4.19	6.64	9.24	10.38	5.74	1.65	0.18	0.05
Gimli	Male	IM	0.43	7.50	10.22	11.86	13.59	7.97	2.36	0.44	0.05
Gimli	Female	SI	0.33	5.84	9.93	13.45	15.37	8.92	2.45	0.34	0.06
Gimli	Female	IM	0.75	9.83	11.05	13.28	17.87	10.44	2.59	0.50	0.11

Appendix III Table 8. Organochlorine concentrations and percent lipid in zooplankton collected from sites in the south basin of Lake Winnipeg.

Date	Site	%LIPID	ΣCBZ	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	ΣTOXSRF	DIELDRIN
16 Jul 98	4A	19.4	0.654	0.446	0.645	6.234	28.434	4.661	1.901
16 Jul 98	4B	15.0	1.070	0.501	0.756	8.168	24.201	4.610	17.075
16 Jul 98	4C	14.7	0.467	0.391	0.871	6.807	30.892	4.586	1.109
16 Jul 98	7A	19.3	0.357	0.437	0.710	5.082	15.621	6.308	1.243
16 Jul 98	7B	18.7	1.404	1.336	1.480	9.636	34.122	9.884	30.251
16 Jul 98	7C	13.9	0.431	0.236	0.408	1.567	15.224	3.763	1.338
14 Jul 98	11A	17.4	0.357	2.995	0.779	1.643	8.397	4.024	25.518
14 Jul 98	11B	16.5	0.492	3.577	0.845	2.174	27.051	4.992	1.339
16 Jul 98	11C	18.9	0.571	0.222	0.659	3.074	19.082	2.906	7.657
12 Aug 98	4A	10.1	1.019	0.279	0.629	10.191	46.508	3.508	0.815
12 Aug 98	4B	13.5	2.333	0.129	0.546	7.439	34.037	3.194	0.796
12 Aug 98	4C	-	-	-	-	-	-	-	
21 Aug 98	7A	9.4	0.798	0.259	0.395	4.391	34.702	2.183	1.196
21 Aug 98	7B	9.9	4.933	0.100	1.475	4.814	39.512	2.385	0.461
21 Aug 98	7C	10.0	2.700	0.413	0.886	5.729	30.191	4.655	1.202
21 Aug 98	11A	8.0	1.679	0.266	0.438	3.174	57.904	1.793	0.199
21 Aug 98	11B	10.2	1.414	0.282	1.122	4.044	52.046	1.859	0.859
21 Aug 98	11C	10.560	1.248	0.920	1.919	3.270	31.261	2.010	0.668
15 Sep 98	4A	25.300	1.485	1.881	4.744	38.628	204.936	8.525	2.296
15 Sep 98	4B	13.100	0.692	1.333	0.776	6.544	81.377	2.088	1.285
15 Sep 98	4C	12.600	1.138	0.094	0.450	3.048	80.333	0.510	0.160
15 Sep 98	7A	-	-	-	-	-	-	-	-
15 Sep 98	7B	18.700	0.941	0.313	0.610	7.555	102.985	1.532	1.655
15 Sep 98	7C	14.200	1.072	0.112	0.306	1.900	119.650	0.504	0.065
15 Sep 98	11A	-	-	-	-	-	-	-	-
15 Sep 98	11B	11.800	0.708	0.742	0.808	5.587	51.373	3.564	1.059
15 Sep 98	11C	-	-	-	-	-	-	-	-

Appendix III Table 8. Organochlorine concentrations and percent lipid in zooplankton collected from sites in the south basin of Lake Winnipeg.

Date	Site	%LIPID	ΣMON/DI	ΣTRI	ΣTETRA	ΣPENTA	ΣHEXA	ΣHEPTA	ΣOCTA	ΣNONA	ΣDECA
16 Jul 98	4A	19.360	0.021	3.541	5.913	6.617	6.818	4.452	0.924	0.146	<0.003
16 Jul 98	4B	14.960	<0.024	0.872	4.298	7.636	6.364	4.063	0.824	0.102	0.029
16 Jul 98	4C	14.740	<0.024	1.259	6.041	8.532	8.094	5.585	1.202	0.145	0.034
16 Jul 98	7A	19.250	0.025	1.303	2.578	4.014	4.059	2.932	0.602	0.083	0.025
16 Jul 98	7B	18.700	0.105	2.533	7.103	7.739	8.471	6.444	1.488	0.203	0.037
16 Jul 98	7C	13.860	0.330	1.910	4.113	3.521	2.881	1.913	0.481	0.074	<0.003
14 Jul 98	11A	17.380	0.049	0.530	0.408	1.249	2.469	3.080	0.544	0.068	<0.003
14 Jul 98	11B	16.500	0.083	2.208	4.913	8.597	7.807	2.971	0.471	<0.003	<0.003
16 Jul 98	11C	18.920	0.166	1.614	2.171	3.747	5.738	4.586	0.972	0.087	<0.003
12 Aug 98	4A	10.120	0.129	0.972	4.757	14.586	16.079	8.460	1.374	0.115	0.036
12 Aug 98	4B	13.530	0.029	0.545	2.580	7.581	11.920	8.963	2.040	0.321	0.058
12 Aug 98	4C	-	-	-	-	-	-	-	-	-	-
21 Aug 98	7A	9.350	0.130	1.739	3.262	7.684	11.158	8.381	1.992	0.300	0.055
21 Aug 98	7B	9.900	0.275	2.654	2.509	5.477	13.053	11.785	3.199	0.560	<0.003
21 Aug 98	7C	9.990	0.570	2.607	1.214	5.820	10.106	7.690	1.890	0.270	0.025
21 Aug 98	11A	8.020	0.424	4.873	3.655	9.255	16.488	17.342	5.265	0.602	<0.003
21 Aug 98	11B	10.230	0.320	4.265	4.295	8.438	15.820	14.410	3.781	0.716	<0.003
21 Aug 98	11C	10.560	0.266	2.623	3.632	6.101	9.194	7.745	1.558	0.140	<0.003
15 Sep 98	4A	25.300	3.593	11.675	21.087	48.837	67.135	42.862	9.040	0.707	<0.003
15 Sep 98	4B	13.100	1.809	4.707	7.238	19.244	25.431	18.818	3.642	0.403	0.084
15 Sep 98	4C	12.600	2.600	6.240	6.355	15.010	21.560	22.718	4.750	1.100	<0.003
15 Sep 98	7A	-	-	-	-	-	-	-	-	-	-
15 Sep 98	7B	18.700	1.857	5.420	8.491	24.554	34.957	21.900	5.077	0.599	0.129
15 Sep 98	7C	14.200	1.670	6.030	10.792	38.970	39.700	18.948	3.250	0.290	<0.003
15 Sep 98	11A	-	-	-	-	-	-	-	-	-	-
15 Sep 98	11B	11.800	1.405	4.830	6.590	9.275	14.235	11.926	2.893	0.220	<0.003
15 Sep 98	11C	-	-	-	-	-	-	-	-	-	-

Appendix III Table 9. Toxaphene homologue (Hx, Hp, O, N), toxaphene congener (T2, T12, Hx-sed, Hp-sed) and total toxaphene concentrations, Degree of Chlorination Index (DCI) and percent lipid in mayflies collected from Winnipeg (BDI), Selkirk and the south basin of Lake Winnipeg (Grand Beach, Winnipeg Beach, Hussavik and Gimli).

Site	Sex/Molt[a]	Date	Hx	Hp	O	N	T2	T12	Hx-Sed	Hp-Sed	Total	Hx-sed + Hp-sed/Total (%)	DCI[b]	% Lipid
Grand Beach	FemaleSI	Jul-96	0.61	1.56	2.25	0.35	0.01	0.13	0.37	0.13	4.8	10.4	0.84	17.7
Wpg. Beach	FemaleSI	Jul-96	0.73	2.98	3.66	1.27	0.09	0.72	0.49	0.48	8.7	11.2	0.75	13.4
Hussavik	FemaleSI	Jul-96	1.04	4.25	5.77	1.90	0.11	0.95	0.69	0.63	12.9	10.2	0.69	18.3
BDI	MaleSI	Jul-98	0.433	1.811	2.439	0.631	0.013	0.123	0.205	0.430	5.3	11.9	0.73	23.2
BDI	FemaleSI	Jul-98	0.987	3.873	6.886	0.686	0.011	0.126	0.793	0.183	12.4	7.9	0.64	20.1
BDI	FemaleI	Jul-98	0.799	2.188	4.151	0.552	0.005	0.282	0.612	0.113	7.7	9.4	0.64	8.3
Selkirk	MaleSI	Jul-98	0.180	0.543	0.973	0.436	0.000	0.144	0.093	0.098	2.1	9.0	0.51	14.9
Selkirk	FemaleSI	Jul-98	0.806	2.032	3.221	0.585	0.066	0.175	0.349	0.215	6.6	8.5	0.75	24.8
Selkirk	FemaleI	Jul-98	0.267	0.924	1.700	0.316	0.006	0.111	0.147	0.033	3.2	5.6	0.59	10.8
Gimli	MaleSI	Jul-98	0.339	0.758	1.178	0.308	0.039	0.108	0.228	0.109	2.6	13.0	0.74	12.4
Gimli	MaleI	Jul-98	0.248	0.843	1.276	0.449	0.015	0.155	0.124	0.077	2.8	7.1	0.63	16.7
Gimli	FemaleSI	Jul-98	0.303	0.698	1.138	0.190	0.030	0.083	0.160	0.070	2.3	9.9	0.75	11.9
Gimli	FemaleI	Jul-98	0.317	1.388	2.419	0.887	0.031	0.449	0.134	0.031	5.0	3.3	0.52	19.2

[a]SI – sub-imago (pre-molt). I – imago (post-molt).

[b]DCI – Degree of chlorination index is the sum of hexa- plus heptachlorinated toxaphene homologues divided by the sum of the octa- plus nona-chlorinated homologues.

Appendix III Table 10. Toxaphene homologue (Hx, Hp, O, N), toxaphene congener (T2, T12, Hx-sed, Hp-sed) and total toxaphene concentrations, Degree of Chlorination Index (DCI) and percent lipid in zooplankton collected from the south basin of Lake Winnipeg.

Site	Date	Hx	Hp	O	N	T2	T12	Hx-Sed	Hp-Sed	Total	Hx-sed + Hp-sed/Total (%)	DCI[b]	% Lipid
4A	Jul-98	2.097	7.622	10.125	0.917	0.008	0.319	1.814	0.135	20.7	9	0.88	19.6
4B	Jul-98	1.113	3.060	3.289	0.350	0.013	0.107	0.746	0.064	7.8	10	1.15	15.0
4C	Jul-98	0.844	2.830	3.206	0.391	0.011	0.113	0.573	0.053	7.3	9	1.02	14.7
7A	Jul-98	1.518	5.093	5.578	0.584	0.022	0.269	1.095	0.091	12.8	9	1.07	19.3
7B	Jul-98	1.717	4.986	6.210	0.686	0.033	0.258	1.308	0.092	13.6	10	0.97	18.7
7C	Jul-98	0.871	1.898	2.930	0.336	0.005	0.121	0.549	0.032	6.0	10	0.85	13.9
11A	Jul-98	0.761	1.979	2.873	0.237	0.002	0.075	0.660	0.021	5.9	12	0.88	17.4
11B	Jul-98	0.214	0.908	1.761	0.178	0.001	0.050	0.160	0.009	3.1	6	0.58	16.5
11C	Jul-98	0.297	1.242	1.882	0.183	0.002	0.037	0.252	0.024	3.6	8	0.75	18.9
4A	Aug-98	1.386	3.595	3.473	0.432	0.004	0.087	0.858	0.072	8.9	10	1.28	10.1
4B	Aug-98	0.343	0.961	1.578	0.277	0.004	0.076	0.186	0.016	3.2	6	0.70	13.5
7A	Aug-98	0.373	0.810	0.999	0.155	0.024	0.040	0.247	0.084	2.3	14	1.03	9.4
7B	Aug-98	0.310	1.016	1.443	0.265	0.006	0.055	0.161	0.022	3.0	6	0.78	9.9
7C	Aug-98	0.839	2.328	3.084	0.517	0.011	0.089	0.485	0.052	6.8	8	0.88	10.0
11A	Aug-98	0.167	0.590	1.000	0.152	0.002	0.026	0.105	0.004	1.9	6	0.66	8.0
11B	Aug-98	0.544	1.640	2.287	0.337	0.002	0.062	0.404	0.000	4.8	8	0.83	10.2
11C	Aug-98	2.654	9.265	11.729	1.016	0.020	0.301	2.295	0.177	24.7	10	0.94	10.6

[a]DCI – Degree of chlorination index is the sum of hexa- plus heptachlorinated toxaphene homologues divided by the sum of the octa- plus nona-chlorinated homologues.

Appendix III Table 11. Mercury and selenium in fish muscle collected from the south basin of Lake Winnipeg. Values are means ± SE.

Species	Site	Date	n	Hg	Se
Burbot	Wpg. Beach	Oct-97	7	0.109 ± 0.010	0.247 ± 0.018
Burbot	Wpg. Beach	Sep-98	10	0.242 ± 0.033	-
F. Drum	Riverton	Jul-98	10	0.232 ± 0.051	0.311 ± 0.011
F. Drum	Wpg. Beach	Sep-98	10	0.069 ± 0.004	-
Y. Perch	Riverton	Jul-98	10	0.227 ± 0.019	0.326 ± 0.006
Y. Perch	Wpg. Beach	Sep-98	10	0.263 ± 0.065	-
Sauger	Wpg. Beach	Oct-97	5	0.259 ± 0.030	0.312 ± 0.018
Sauger	Riverton	Jul-98	10	0.280 ± 0.015	0.310 ± 0.006
Walleye	Wpg. Beach	Oct-97	9	0.248 ± 0.070	0.243 ± 0.007
Walleye	Riverton	Jul-98	10	0.225 ± 0.010	0.234 ± 0.005
Walleye	Wpg. Beach	Sep-98	10	0.280 ± 0.025	-

Appendix III Table 12. Organochlorine concentrations in fish muscle collected from the south basin of Lake Winnipeg. Values are means ± SE. Burbot liver concentrations are also provided (L – liver , M – muscle).

Species	Site	Date	n	ΣCBZ	ΣHCH	ΣCHLOR	ΣDDT	ΣPCB	ΣTOX-ECD
Burbot L	Wpg. Beach	Oct-97	7	2.86 ± 0.29	3.54 ± 0.38	25.9 ± 2.82	216 ± 18	547 ± 54.8	129 ± 11.1
Burbot M	Wpg. Beach	Oct-97	7	0.22 ± 0.02	0.07 ± 0.01	0.37 ± 0.04	3.10 ± 0.34	5.87 ± 0.65	1.05 ± 0.13
F. Drum	Riverton	Jul-98	10	0.75 ± 0.12	0.60 ± 0.10	1.42 ± 0.22	9.81 ± 1.61	15.1 ± 2.53	4.12 ± 0.66
F. Drum	Wpg. Beach	Sep-98	10	0.89 ± 0.29	0.54 ± 0.17	1.54 ± 0.51	11.1 ± 3.59	18.42 ± 6.0	4.93 ± 1.64
Y. Perch	Riverton	Jul-98	10	0.11 ± 0.03	0.13 ± 0.03	0.30 ± 0.07	2.50 ± 0.53	5.98 ± 1.35	0.93 ± 0.22
Y. Perch	Wpg. Beach	Sep-98	10	0.41 ± 0.04	0.21 ± 0.03	0.89 ± 0.11	6.02 ± 0.56	13.2± 1.16	2.81 ± 0.38
Sauger	Wpg. Beach	Oct-97	5	0.27 ± 0.04	0.16 ± 0.03	0.79 ± 0.16	2.82 ± 0.68	5.62 ± 0.69	2.91 ± 0.49
Sauger	Riverton	Jul-98	10	0.43 ± 0.07	0.26 ± 0.04	0.81 ± 0.14	2.84 ± 0.55	4.92 ± 0.82	2.48 ± 0.42
Walleye	Wpg. Beach	Oct-97	9	0.23 ± 0.03	0.13 ± 0.02	0.58 ± 0.11	5.45 ± 0.77	8.57 ± 1.18	1.64 ± 0.33
Walleye	Riverton	Jul-98	10	0.33 ± 0.04	0.24 ± 0.03	0.81 ± 0.11	8.15 ± 0.95	11.2 ± 1.33	1.61 ± 0.19
Walleye	Wpg. Beach	Sep-98	10	0.40 ± 0.05	0.31 ± 0.04	1.30 ± 0.14	11.0 ± 1.01	26.2 ± 2.79	3.58 ± 0.44

Appendix III Table 12. Continued

Species	Site	Date	n	DIEL	ΣMON/DI	ΣTRI	ΣTETRA	ΣPENTA
Burbot L	Wpg. Beach	Oct-97	7	2.26 ± 0.29	0.48 ± 0.06	2.20 ± 0.23	35.9 ± 3.33	110 ± 9.92
Burbot M	Wpg. Beach	Oct-97	7	0.16 ± 0.02	0.02 ± 0.00	0.08 ± 0.01	0.58 ± 0.05	1.34 ± 0.14
F. Drum	Riverton	Jul-98	10	0.27 ± 0.04	0.08 ± 0.01	0.24 ± 0.04	1.29 ± 0.19	3.66 ± 0.61
F. Drum	Wpg. Beach	Sep-98	10	0.27 ± 0.09	0.09 ± 0.03	0.45 ± 0.14	1.88 ± 0.57	4.45 ± 1.47
Y. Perch	Riverton	Jul-98	10	0.10 ± 0.02	0 ± 0	0.10 ± 0.02	0.44 ± 0.10	1.11 ± 0.22
Y. Perch	Wpg. Beach	Sep-98	10	0.19 ± 0.03	0.09 ± 0.01	0.56 ± 0.06	1.35 ± 0.15	2.99 ± 0.36
Sauger	Wpg. Beach	Oct-97	5	0.17 ± 0.03	0.04 ± 0.01	0.20 ± 0.03	0.65 ± 0.08	1.29 ± 0.12
Sauger	Riverton	Jul-98	10	0.15 ± 0.02	0.04 ± 0.01	0.14 ± 0.02	0.49 ± 0.09	1.04 ± 0.17
Walleye	Wpg. Beach	Oct-97	9	0.25 ± 0.04	0.03 ± 0.01	0.09 ± 0.01	0.67 ± 0.07	1.87 ± 0.19
Walleye	Riverton	Jul-98	10	0.23 ± 0.03	0.04 ± 0.01	0.13 ± 0.02	0.74 ± 0.08	2.22 ± 0.27
Walleye	Wpg. Beach	Sep-98	10	0.33 ± 0.03	0.06 ± 0.01	0.43 ± 0.06	2.41 ± 0.27	5.2 ± 0.52

Appendix III Table 12. Continued

Species	Site	Date	n	ΣHEXA	ΣHEPA	ΣOCTA	ΣNONA	ΣDECA
Burbot L	Wpg. Beach	Oct-97	7	242 ± 25.6	124 ± 12.8	27.8 ± 2.87	3.20 ± 0.26	1.12 ± 0.11
Burbot M	Wpg. Beach	Oct-97	7	2.16 ± 0.25	1.35 ± 0.16	0.27 ± 0.04	0.05 ± 0.01	0.01 ± 0.00
F. Drum	Riverton	Jul-98	10	5.84 ± 0.99	3.11 ± 0.56	0.59 ± 0.10	0.24 ± 0.05	0 ± 0
F. Drum	Wpg. Beach	Sep-98	10	7.18 ± 2.37	3.53 ± 1.15	0.63 ± 0.22	0.22 ± 0.09	0 ± 0
Y. Perch	Riverton	Jul-98	10	2.29 ± 0.50	1.72 ± 0.45	0.29 ± 0.06	0.03 ± 0.00	0 ± 0
Y. Perch	Wpg. Beach	Sep-98	10	4.37 ± 0.36	3.24 ± 0.25	0.55 ± 0.05	0.09 ± 0.01	0 ± 0
Sauger	Wpg. Beach	Oct-97	5	1.97 ± 0.18	1.11 ± 0.23	0.23 ± 0.05	0.09 ± 0.02	0.04 ± 0.01
Sauger	Riverton	Jul-98	10	1.93 ± 0.34	1.03 ± 0.17	0.20 ± 0.04	0.04 ± 0.01	0 ± 0
Walleye	Wpg. Beach	Oct-97	9	3.25 ± 0.52	2.24 ± 0.34	0.33 ± 0.05	0.08 ± 0.01	0.01 ± 0.01
Walleye	Riverton	Jul-98	10	4.30 ± 0.52	3.20 ± 0.37	0.41 ± 0.05	0.14 ± 0.02	0 ± 0
Walleye	Wpg. Beach	Sep-98	10	9.99 ± 1.05	6.94 ± 0.76	0.94 ± 0.11	0.23 ± 0.03	0 ± 0

Appendix III Table 13. Toxaphene homologue (Hx, Hp, O, N), toxaphene congener (T2, T12, Hx-sed, Hp-sed) and total toxaphene concentrations, and Degree of Chlorination Index (DCI) in fish collected from the south basin of Lake Winnipeg (Winnipeg Beach, Riverton).

Site	Species	Date	No.	Hexa	Hepta	Octa	Nona	Hx-sed	Hp-sed	T2	T12	Total (ng/g)	Hp-sed+ Hx-sed/Total (%)	DCI[a]
WpgBeach	Walleye	Oct-97	1	0.873	3.997	5.776	1.167	0.622	0.148	0.098	0.559	11.814	6.5	0.70
WpgBeach	Walleye	Oct-97	2	0.584	2.097	3.292	0.698	0.436	0.027	0.085	0.304	6.671	6.9	0.67
WpgBeach	Walleye	Oct-97	3	1.468	5.480	8.158	1.313	1.129	0.044	0.187	0.758	16.418	7.1	0.73
WpgBeach	Walleye	Oct-97	4	0.699	2.531	2.683	0.603	0.540	0.367	0.076	0.216	6.516	13.9	0.98
WpgBeach	Walleye	Oct-97	5	0.625	2.598	2.832	0.431	0.490	0.241	0.070	0.104	6.486	11.3	0.99
WpgBeach	Walleye	Oct-97	6	0.209	1.794	5.341	2.471	0.130	0.062	0.199	1.124	9.814	2.0	0.26
WpgBeach	Walleye	Oct-97	7	0.804	3.453	4.329	1.123	0.506	0.256	0.138	0.356	9.709	7.8	0.78
WpgBeach	Walleye	Oct-97	8	0.460	1.944	2.648	0.723	0.286	0.131	0.053	0.178	5.774	7.2	0.71
WpgBeach	Walleye	Oct-97	9	1.442	5.346	5.334	0.875	1.046	0.246	0.149	0.337	12.998	9.9	1.09
Riverton	Walleye	Jun-98	1	0.146	0.506	0.724	0.179	0.103	0.017	0.009	0.038	1.555	7.7	0.72
Riverton	Walleye	Jun-98	2	0.034	0.147	0.183	0.041	0.009	0.008	0.015	0.019	0.405	4.1	0.81
Riverton	Walleye	Jun-98	3	0.242	0.955	1.356	0.290	0.184	0.037	0.014	0.077	2.843	7.8	0.73
Riverton	Walleye	Jun-98	4	0.171	0.610	0.806	0.169	0.101	0.028	0.011	0.043	1.755	7.4	0.80
Riverton	Walleye	Jun-98	5	0.252	0.961	1.853	0.446	0.166	0.033	0.013	0.085	3.512	5.7	0.53
Riverton	Walleye	Jun-98	6	0.167	0.828	1.521	0.316	0.096	0.031	0.007	0.048	2.833	4.5	0.54
Riverton	Walleye	Jun-98	7	0.253	1.057	1.985	0.402	0.152	0.029	0.016	0.109	3.696	4.9	0.55
Riverton	Walleye	Jun-98	8	0.305	1.050	1.669	0.359	0.197	0.035	0.015	0.089	3.384	6.9	0.67
Riverton	Walleye	Jun-98	9	0.264	1.012	1.730	0.403	0.165	0.037	0.013	0.086	3.408	5.9	0.60
Riverton	Walleye	Jun-98	10	0.123	0.477	0.799	0.220	0.068	0.013	0.007	0.035	1.619	5.0	0.59
WpgBeach	Burbot (L)	Oct-97	1	43.493	113.484	65.673	10.232	32.479	11.807	5.209	3.469	232.882	19.0	2.07
WpgBeach	Burbot (L)	Oct-97	2	8.302	37.745	33.557	8.907	6.136	2.523	1.535	2.655	88.512	9.8	1.08
WpgBeach	Burbot (L)	Oct-97	3	4.760	27.582	37.914	10.193	3.164	1.275	2.159	4.685	80.449	5.5	0.67
WpgBeach	Burbot (L)	Oct-97	4	8.767	52.318	66.841	23.164	5.874	6.476	6.187	10.523	151.091	8.2	0.68
WpgBeach	Burbot (L)	Oct-97	5	10.996	50.708	65.095	17.976	7.763	3.925	4.332	8.615	144.773	8.1	0.74
WpgBeach	Burbot (L)	Oct-97	6	9.329	41.293	57.741	17.921	6.494	4.231	3.721	8.295	126.284	8.5	0.67
WpgBeach	Burbot (L)	Oct-97	7	7.937	45.918	76.812	24.227	5.088	3.226	4.283	13.275	154.895	5.4	0.53

Appendix III Table 13. Toxaphene homologue (Hx, Hp, O, N), toxaphene congener (T2, T12, Hx-sed, Hp-sed) and total toxaphene concentrations, and Degree of Chlorination Index (DCI) in fish collected from the south basin of Lake Winnipeg (Winnipeg Beach, Riverton).

Site	Species	Date	No.	Hexa	Hepta	Octa	Nona	Hx-sed	Hp-sed	T2	T12	Total (ng/g)	Hp-sed+ Hx-sed/Total (%)	DCI[a]
WpgBeach	Burbot (M)	Oct-97	1	0.169	0.824	0.823	0.183	0.104	0.082	0.025	0.044	2.000	9.3	0.99
WpgBeach	Burbot (M)	Oct-97	2	0.180	1.094	1.112	0.285	0.152	0.107	0.046	0.093	2.671	9.7	0.91
WpgBeach	Burbot (M)	Oct-97	3	0.139	0.783	0.877	0.255	0.105	0.069	0.045	0.103	2.054	8.4	0.81
WpgBeach	Burbot (M)	Oct-97	4	0.162	0.982	1.052	0.307	0.122	0.076	0.097	0.117	2.503	7.9	0.84
WpgBeach	Burbot (M)	Oct-97	5	0.177	1.152	1.067	0.477	0.109	0.113	0.063	0.094	2.874	7.7	0.86
WpgBeach	Burbot (M)	Oct-97	6	0.222	1.618	1.820	0.857	0.129	0.182	0.052	0.121	4.516	6.9	0.69
WpgBeach	Burbot (M)	Oct-97	7	0.163	1.154	1.369	0.499	0.100	0.096	0.089	0.173	3.185	6.1	0.70
WpgBeach	Sauger	Oct-97	1	0.604	2.148	2.441	0.624	0.391	0.178	0.042	0.163	5.817	9.8	0.90
WpgBeach	Sauger	Oct-97	2	0.455	2.241	2.387	0.454	0.294	0.189	0.052	0.156	5.536	8.7	0.95
WpgBeach	Sauger	Oct-97	3	0.466	1.880	2.164	0.426	0.286	0.185	0.044	0.126	4.937	9.5	0.91
WpgBeach	Sauger	Oct-97	4	0.717	2.892	3.330	0.656	0.440	0.285	0.067	0.194	7.595	9.5	0.91
WpgBeach	Sauger	Oct-97	5	0.796	3.080	3.539	0.584	0.496	0.258	0.057	0.170	7.999	9.4	0.94
Riverton	Perch	Jun-98	1	0.110	0.595	1.252	0.286	0.060	0.028	0.019	0.062	2.242	3.9	0.46
Riverton	Perch	Jun-98	2	0.054	0.321	0.782	0.162	0.034	0.008	0.007	0.042	1.320	3.2	0.40
Riverton	Perch	Jun-98	3	0.048	0.206	0.404	0.111	0.035	0.004	0.005	0.025	0.769	5.1	0.49
Riverton	Perch	Jun-98	4	0.051	0.191	0.295	0.086	0.034	0.009	0.003	0.014	0.623	6.9	0.64
Riverton	Perch	Jun-98	5	0.072	0.247	0.414	0.134	0.050	0.008	0.003	0.029	0.867	6.7	0.58
Riverton	Perch	Jun-98	6	0.081	0.358	0.655	0.128	0.053	0.008	0.006	0.037	1.222	5.0	0.56
Riverton	Perch	Jun-98	7	0.028	0.138	0.301	0.083	0.015	0.009	0.006	0.017	0.549	4.4	0.43
Riverton	Perch	Jun-98	8	0.054	0.260	0.524	0.132	0.034	0.004	0.006	0.033	0.969	4.0	0.48
Riverton	Perch	Jun-98	9	0.030	0.108	0.199	0.056	0.014	0.003	0.001	0.008	0.392	4.3	0.54
Riverton	Perch	Jun-98	10	0.088	0.303	0.446	0.138	0.045	0.006	0.004	0.020	0.975	5.2	0.67
Riverton	Walleye	Oct-95	1	0.428	0.805	0.955	0.129	0.324	0.016	0.011	0.047	2.317	14.7	1.14
Riverton	Walleye	Oct-95	2	0.359	0.794	1.032	0.136	0.254	0.029	0.011	0.036	2.321	12.2	0.99

[a]DCI – Degree of chlorination index is the sum of hexa- plus heptachlorinated toxaphene homologues divided by the sum of the octa- plus nona-chlorinated homologues.