Direction du suivi de l'état de l'environnement
(Environment monitoring division)

METAL, PCB, DIOXIN AND FURAN CONCENTRATIONS IN FISH AND SEDIMENTS FROM FOUR LAKES IN NORTHERN QUÉBEC IN 2001

by

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and
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Ministère de l'Environnement
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SUMMARY

This environmental study pertains to lakes Chibougamau, Aux Dorés, Obatogamau, and Waconichi. These lakes are used in particular by the Cree communities for sustenance fishing and by the residents of the James Bay Region and other Québec regions for sport fishing.

The lacustrine sediments of Lac Chibougamau and Lac aux Dorés were analysed for their heavy metal and PCB levels. Samples from two mining effluents and from four waste sites located on the periphery of these lakes were also analysed for their metal levels. In addition, three fish species from these two lakes were sampled with the aim of assessing the influence of mining on mercury levels in fish. These levels were also compared to those of fish coming from the Obatogamau lakes and Lac Waconichi. Finally, five fish species from these four lakes were measured for heavy metals, PCBs, and dioxins and furans.

The results from analyses of the mining effluents show that the concentrations of six metals included in directive 019 for the mining industry fall within the authorized limits. However, a bioassay carried out in 2002 showed that the effluent of the mining water basin of the Copper Rand mine had toxic level that did not meet the directive for this parameter.

The sediments had low concentrations of mercury, with the highest level (0.34 mg/kg) coming from a site near the Henderson I Mine. None of the probable effect levels (0.49 mg/kg) and no harmful effects are expected on benthic organisms. Because of the low mercury levels, the mine tailings are not considered a probable source of contamination.

Sediments contained high levels of some metals, namely arsenic, cadmium, copper, nickel, and zinc. Sites near the Copper Rand mine, located south of the Principale mine and at the foot of Principale tailings site, show the highest concentrations for these metals. However, given the different types of mineralization that occur at these sites, it was not possible to precisely distinguish the proportion of metals natural in origin from the proportion of metals anthropic in origin.. Metals measured at the two reference control sites were generally below the respective medians.

No PCB was detected in sediments of Lac Chibougamau and Lac Aux Dorés.

The elevated arsenic, cadmium, copper, nickel, and zinc levels in sediments near tailings sites had no noticeable effect on the levels measured in fish flesh, which were similar to those measured at the control site (Lac Waconichi)

Levels for toxic metals such as arsenic, cadmium, chromium, and lead were weak or below the detection limit.

Currently available data does not prove that mining activity has caused an increase in mercury levels in fish. It is likely that these observed levels stem from natural characteristics of the lake. Moreover, fish from the Obatogamau lakes had the highest mercury levels, while fish from the reference control lake (Lac Waconichi) had the lowest.

For the four studied lakes, the average mercury levels for small, medium, and large walleye, northern pike and lake trout were generally lower or equal to the Québec average.

At Lac Chibougamau, mercury levels for lake trout caught in 2001 were lower than those of specimens caught in 1999.

Mercury concentrations for medium-sized and large lake trout from Lac Chibougamau and Lac aux Dorés, and large northern pike from Lac Chibougamau, along with medium and large northern pike and walleye from the Obatogamau lakes, exceeded the 0.5 mg/kg standard established by Health Canada for the sale of fishery products. The same can be said for large burbot found near and far from the mines at Lac Chibougamau and near the mines at Lac aux Dorés, as well as small, medium, and large burbot from the Obatogamau lakes. Mercury levels in all fish analysed exceeded the 0.033 mg/kg guideline for the protection of fish-eating terrestrial wildlife. However, this phenomena is not unusual in Québec.

Among the organic substances analyzed in fish, only PCB was higher at Lac Chibougamau and Lac aux Dorés than at the control lake (Lac Waconichi).

All PCBs and dioxin and furan levels remained below the Health Canada standards of 2000 µg/kg and 15 ng/kg respectively. Lake trout were the only fish species exceeding the guideline of 160 µg/kg for PCBs and 0.66 ng/kg for dioxins and furans in 2,3,7,8-TCDD toxic equivalents for the protection of fish-eating terrestrial wildlife.

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INTRODUCTION

This environmental study pertains to lakes Chibougamau, Aux Dorés, Obatogamau, and Waconichi. These lakes are used in particular by the Cree communities for sustenance fishing and by residents of the James Bay Region and other Québec regions for sport fishing.

The shores of Lac Chibougamau and Lac aux Dorés are home to many mine sites. Significant lake trout holes are located along the retaining walls of mine tailings sites. Lac Obatogamau is affected by a mine located in the Nemenjiche river basin, while Lac Waconichi, not having any mining activity in its vicinity, is taken as a control lake.

Lac Chibougamau, the jewel of the region, and Lac aux Dorés, with five Cree families, two outfitters and numerous cottages at their perimeters, are known for their fishing infrastructure. Recreational activities and tourism at these lakes are significant economic pillars for the town of Chibougamau and for northern Québec as a whole.

Taking this into account, *Les ressources intégrées de Chibougamau inc*. presented a multi-resource plan to the *Ministère des Ressources naturelles* and to the *Société de la faune et des parcs du Québec* with the aim of creating a community wildlife area on Lac Chibougamau. The proposed wildlife area aims to protect animal habitats and to ensure the quality of fish resources and fishing.

In 1998, 1999, and 2000, the *Ministère de l'Environnement du Québec* and the *Société de la faune et des parcs du Québec* carried out fish resource studies to evaluate the contamination of fish in Lac Chibougamau, Lac aux Dorés, and Lac Waconichi. The studies showed that mercury levels in large lake trout from Lac Chibougamau were well above the 0.5 mg/kg standard recommended by Health Canada for the sale of fishery products. The average mercury levels of lake trout caught in 2000 were twice as high as those measured at Lac Waconichi, the lake used as a reference control site.

Following these results, the public health commission of the *Centre régional de santé et des services sociaux de la Baie James* (James Bay regional health and social services centre) issued a public health alert on July 18, 2001, warning against the consumption of fish from Lac Chibougamau and Lac aux Dorés. The alert advised:

- the general public to consume no more than twice per month: lake trout longer than 50 cm or weighing over 1 kg, walleye longer than 50 cm, or northern pike longer than 70 cm.

- women who are pregnant, who seek to become pregnant, or who are breast-feeding, as well as children under 6 years of age: to avoid consuming lake trout over 50 cm or 1 kg, walleye over 50 cm long, or northern pikes over 70 cm long.

It was resolved to gather additional data in the Chibougamau region to respond to concerns raised over mining activity situated close to the Chibougamau, Aux Dorés, and Obatogamau lakes in regard to fish contamination.

At the same time, in September 2001, results of a study done in March 2001 in the Chibougamau region for the Grand Council of the Crees were published. This study, carried out by Covel and Masters (2001), indicated above guideline heavy metal concentrations in sediment and water samples taken in lakes Chibougamau, Aux Dorés, and Obatogamau.

The objectives of this study, conducted in the summer of 2001 by the *Ministère de l'Environnement du Québec* in collaboration with the *Société de la Faune et des parcs du Québec*, were:

- to determine if mining activity near Lac Chibougamau and Lac aux Dorés caused abnormally high levels of metal contamination in sediments and if these can have toxic effects on aquatic organisms;

- to determine if these activities have caused an increase in the mercury levels in walleye, northern pike, and lake trout in these lakes;

- to measure the contamination levels of fish in the Obotagamau lakes downstream from the mining activity;

- to determine if the levels of certain toxic metals in fish flesh exceed Health Canada standards for the commercial sale of fishery products.

DESCRIPTION OF THE AREA STUDIED

Human activity in the Chibougamau region belongs to either the industrial (mining and forestry) or recreational (tourism) sector. The lake region targeted by this study has a concentrated mining industry.

Mining extraction in the Chibougamau region began in the 1950s (Merrill Island Mine in 1955, Copper Rand Mine in 1959) with the exploitation of copper and gold. All mining activity has centred around two mine sites, the Copper Rand mine and the Principale mine, which are the only mine sites that have both treatment plants and tailings sites.

The Copper Rand mine is located on the Gouin peninsula that separates Lac Chibougamau and Lac aux Dorés. The Principale mine is located on Merrill Island in Lac aux Dorés. The two sites and their mined ores can be described as follows:

Copper Rand mine site

- The entire mine site is situated on the Gouin peninsula.

- Two mine tailing sites, Eaton Bay and Copper Rand, are located on this peninsula. Eaton Bay, currently inactive, contains some 6.3 million tonnes of mine tailings and is built in part on the shore of Lac Chibougamau. Copper Rand, currently active, holds

approximately 7.7. million tonnes of mine tailings and is located directly on the shore of Lac aux Dorés;

- All dikes containing these mining tailings were built with waste minerals and are permeable.

- The entire Eaton Bay tailings site is used as a basin for the sedimentation of drainage waters from the Copper Rand mine. The final mineral effluent of this sedimentation basin flows into Lac Chibougamau.

- The final mineral effluent from the Copper Rand waste site flows into Lac aux Dorés. The Copper Rand plant treats ores coming from the Bateman Bay, Copper Cliff, Copper Rand, Jaculet, and Québec Chibougamau mines (situated on the shore of Lac aux Dorés), as well as from the Bouzan and Portage mines (situated on the shore of Lac Chibougamau).

- With the exception of the Copper Rand mine, none of the above mines has ore treatment facilities.

- Flotation is the procedure used to extract copper.

- A cyanidation circuit (though already installed in 1985) began operations one year ago.

- The treatment plant has been inactive since December 1997 but will resume operations in 2003.

- Uncertainty remains over the generation of acid mineral drainage, which has a neutralizing effect, within mine tailings.

Principale mine site

- The entire mine site is located on Merrill Island in Lac aux Dorés.

- All dikes encompassing the waste sites, containing up to 19.3 million tonnes of mine tailings, were built in Lac aux Dorés at the start of the mine's operations in 1955.

- The dikes are made of waste minerals and are permeable.

- The final mineral effluent from the tailings flows into Lac aux Dorés.

- Ores mined at the Canadian Merrill, Cedar Bay, Chib-Kayrand, Kokko Creek, Merrill Island, Obalski, and Principale mines (on the shore of Lac aux Dorés), as well as the Grand Roy, Henderson I, and Henderson II mines (on the shore of Lac Chibougamau), along with the Icon (Lac Mistassini), Gwillim (Lac Gwillim), and Bruneau (Lac Bourbeau) mines, are treated at the plant on the Principale mine site.

- With the exception of the Principale mine, none of the above mines has treatment facilities.

- Copper is extracted using a flotation process followed by a cyanidation circuit.

- Operations at the plant were suspended from November 2000 up to January 2002 inclusively.

- Ores from the Joe Mann mine are currently treated with flotation to extract copper and with cyanidation to extract gold.

- Existing data are insufficient to determine the potential of acid generation from the mine tailings stored at the waste sites.

Almost all mine tailings generated by processes at the two treatment plants were stored in the various waste sites. An undetermined quantity has been used as backfill in underground worksites for mineral extraction.

Gold recovery through amalgamation (a process using mercury) has never been conducted at the Copper Rand or Principale mine sites. However, this recovery process was used at the Joe Mann mining site during its early operations between 1956 and 1958, where the treatment was carried out on the site followed by a cyanidation circuit.

In a geological terms, ores extracted in the Chibougamau region consist largely, in order of importance, of pyrite, pyrrhotite, chalcopyrite, sphalerite, and galena.

Electrical equipment used to distribute and transform electricity on the various mine sites contained PCBs in different concentrations. All equipment inventoried by Environment Canada in 1990, and subsequently removed from use, has been disposed of in compliance with the regulations in effect. Only the treatment plant at the Principale mine site had equipment containing PCB levels above 50 mg/L. This equipment is currently under tension and still in use.

The majority of mining sites are restored or in the process of being restored and have, often directly on the lake shores, accumulated waste mineral heaps.

MATERIALS AND METHODS

Sampling of effluents, sediments, and mine tailings

Lacustrine sediment samples have been taken in June and September of 2001 from the Lac Chibougamau and Lac aux Dorés. The samples were largely taken from the northwestern part of Lac Chibougamau and from the eastern part of Lac aux Dorés (figure 1). In total, 18 sites were sampled for sediments, four for mineral tailings, and two for mineral effluents (table 1).

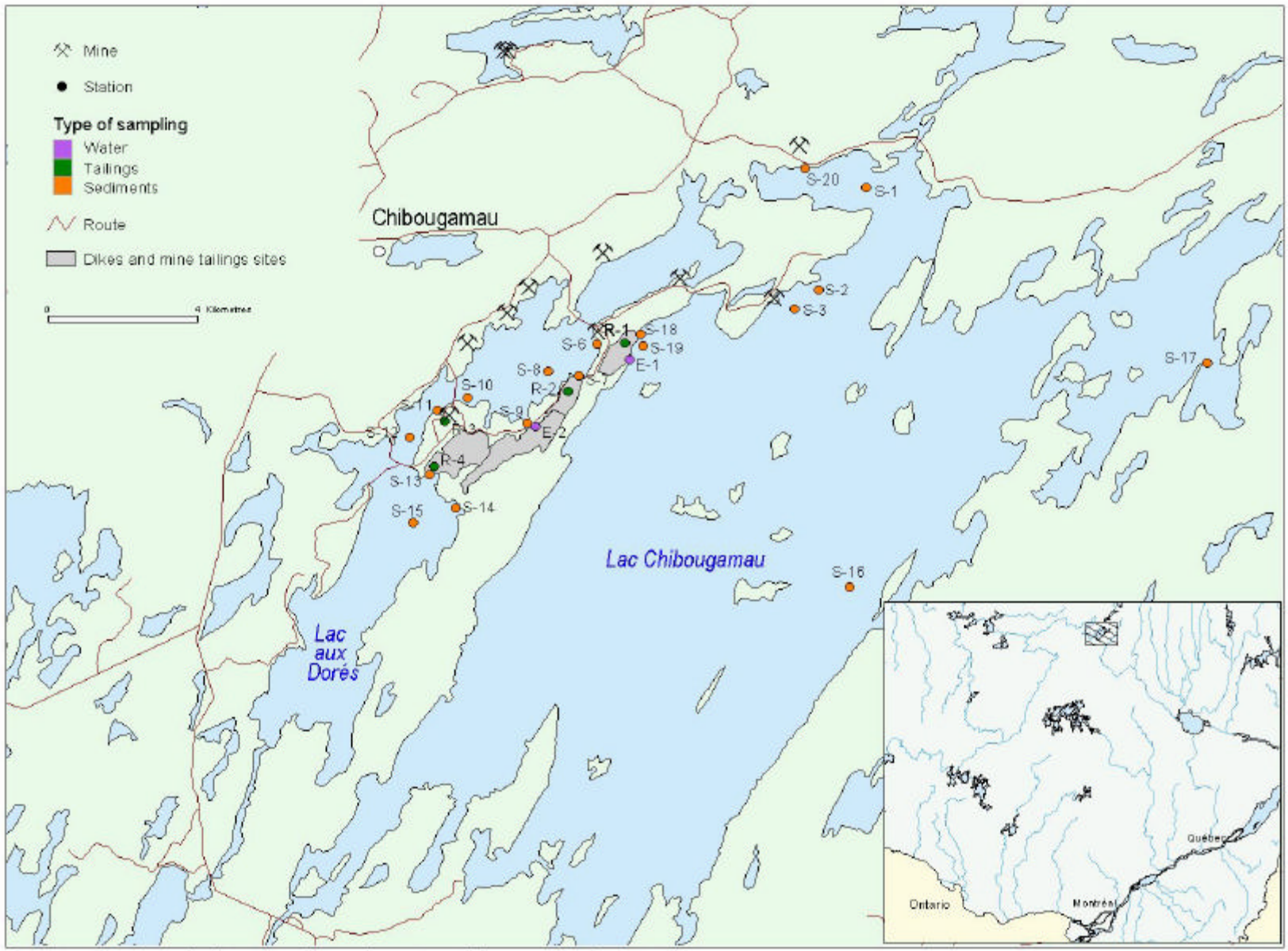

Figure 1 Locations of sediment sampling stations at Lac Chibougamau and Lac aux Dorés

Table 1: Description of mine sites and locations of sediment sampling stations in the circumference of Lac Chibougamau and Lac aux Dorés.

Sampling stations	Coordinates (UTM NAD27)			Locations
	Gore	North m	East m	
S-01	18U	5 530 401	559 082	Grand Roy
S-02	18U	5 527 634	557 811	Henderson II
S-03	18U	5 527 096	557 154	Henderson I
S-04	18U	-	-	Sampling not possible
S-05	18U	-	-	Replaced by S-17
S-06	18U	5 526 153	551 793	Copper Rand; Pointe Machin
S-07	18U	5 525 292	551 302	Copper Rand
S-08	18U	5 525 408	550 479	East of Copper Rand site
S-09	18U	5 524 015	549 917	At foot of Copper Rand site
S-10	18U	5 524 702	548 298	Principale; Pointe Campbell
S-11	18U	5 524 346	547 483	Principale; Pointe Campbell
S-12	18U	5 524 697	548 295	Principale; Pointe Campbell
S-13	18U	5 522 610	547 267	At foot of Principale site
S-14	18U	5 521 700	547 961	South of Copper Rand
S-15	18U	5 521 325	546 817	South of Principale site
S-16	18U	5 519 579	558 642	Île des Commissaires
S-17	18U	5 525 637	568 336	Pointe Needle
S-18	18U	5 526 400	553 000	East of Eaton Bay site
S-19	18U	5 526 150	552 950	East of Eaton Bay site
S-20	18U	5 530 930	557 350	Grand Roy
E-01	18U	5 525 750	552 650	Eaton Bay
E-02	18U	5 523 880	549 920	Copper Rand
R-1	18U	5 526 225	552 725	Eaton Bay
R-2	18U	5 525 100	551 000	Copper Rand
R-3	18U	5 524 150	547 650	Principale
R-4	18U	5 522 825	547 425	Principale

Samples for metal measurements in the effluents were taken against the current with decontaminated 250 mL bottles containing HNO_3. Additional samples were taken for mercury measurements with a 250 mL bottle containing a preservation agent. Immediately after the sampling, the bottles were placed in an icebox. To determine the contamination levels at the time of sampling, control samples were taken by transferring pure water into two 250 mL bottles, one containing HNO_3 (8N) for the metal control, the other containing $K_2Cr_2O_7$ (5 %) in HNO_3 (8N) for the mercury control. The bottles were both placed in the icebox. A double sample was also taken from the E-01 effluent.

The sediments were sampled with the aid of an Ekman grab sampler attached to a winch (figures 2 and 3). This grab sampler was systematically washed and rinsed with HNO_3 (10 %), hexane, demineralized water, as well as acetone (for PCBs) before each usage. One portion of the sediments was transferred into glass jars and then placed in an icebox. Gloves were used for all jars. To ensure reliability of the results, a double sample was prepared at the S-13 site. The sample was homogenized with the aid of a glass rod and placed in two separate jars. At the sampling locations, dissolved oxygen in the water as well as the temperature were measured at the bottom of the lake with the aid of an oximeter (table 2). Total organic carbon (TOC) was measured from the first 15 sediment samples using the modified Walkley-Black method.

Figure 2: Ekman grab sampler attached to a winch for sediment sampling

Figure 3: Winch used for sediment sampling

Tableau 2 : Description of sampling locations at Lac Chibougamau and Lac aux Dorés

Name of the station	Depth of the sample (m)	Description of the sediments	Temperature of the water (°C)	Dissolved oxygen mg/L	Diverse
S-01	39.6	Sandy clay	5.0	8.4	Fish à 80 feet.
S-02	8.2	Sand and gravel + hard crust	13.0	8.5 à 8.8	In front of the Henderson 2 effluent
S-03	39.6	Grey clay	13.0	8.8	
S-06	1.5	Fine sand	12.8	9.4	
S-07	4.3	Grey clay + deposit rust on the surface	13.0	8.1	
S-08	36.6	Grey clay + deposit rust on the surface	6.0	8.0	
S-09	2.7	Organic matter + clay	13.2	9.2	
S-10	33.5	Black clay+ deposist rust on the surface	6.2	8.9	
S-11	4.3	Black clay+ deposist rust on the surface	12.8	9.9	
S-12	16.5	Grey-yellowfish clay + deposit rust on the surface	12.9	9.5	
S-13	1.8	Grey grey	13.0	10.1	
S-14	2.4	Organic matter	12.9	10.2	
S-15	15.2	Black clay+ deposist rust on the surface	12.8	9.8	
S-16	27.4	Grey grey	13.0	9.3	Anchored at buoy CH-26
S-17	5.5	Brown grey	10.0	9.1	
S-18	3.0	Grey grey (tailing?)			In front of the pipe of the former sedimentation tower
S-19	123.7	Grey grey (tailing?)			In front of the east corner of the Eaton bay site
S-20	0.9	Claylike sand			Taken from the pier of the left bank
E-01		Waste water			Final effluent. Water basin of the Copper-Rand mine
E-02		Waste water			Final effluent of the Copper-Rand waste site
R-01	0 - 0.9	Mine tailing			Tailings from Eaton bay site
R-02	0 - 0.9	Mine tailing			Tailings from Copper Rand site
R-03	0 - 0.6	Mine tailing			Tailings from the old Principale site
R-04	0 - 0.9	Mine tailing			Tailings from the current Principale site

Samples of mine tailings were taken with the aid of an aluminium scoop rinsed with HNO_3 (10 %), hexane, demineralized water, and acetone (for PCBs). Disposable polyethylene gloves were used for all sampling. A hole approximately 60 to 90 cm deep was dug directly into the tailings with the scoop (figure 4). A polyethylene trowel rinsed with HNO_3 (10 %), hexane, demineralized water, and acetone (for PCBs) was used to take samples of all strata of tailings on the excavation wall. The jars were filled using the trowel and placed in an icebox. The samples were sent to the *Centre d'expertise en analyse environnementale du Québec* for analysis.

Figure 4: Sampling at the mine tailings site

Sampling of fish

The fish were caught according to the protocol described in the Guide de normalisation des méthodes utilisées en faune aquatique au ministère de l'Environnement et de la Faune du Québec (Ministère de l'Environnement et de la Faune, 1994). Experimental mono-filament netting with 8 panels 7.6 metres long and 1.8 metres high with stretched meshes measuring 25, 38, 51, 64, 76, 102, 127 and 152 mm were used. The netting was cast in the habitats and preferred depths of the species being studied. In lakes Chibougamau, Aux Dorés, Waconichi, and Obatogamau, five fish species were sought and caught: lake trout (*Salvelinus namaycush*), northern pike (*Esox lucius*), walleye (*Stizostedion vitreum*), lake whitefish (*Coregonus clupeaformis*), and burbot (Lota lota) (figures 5, 6 and 7).

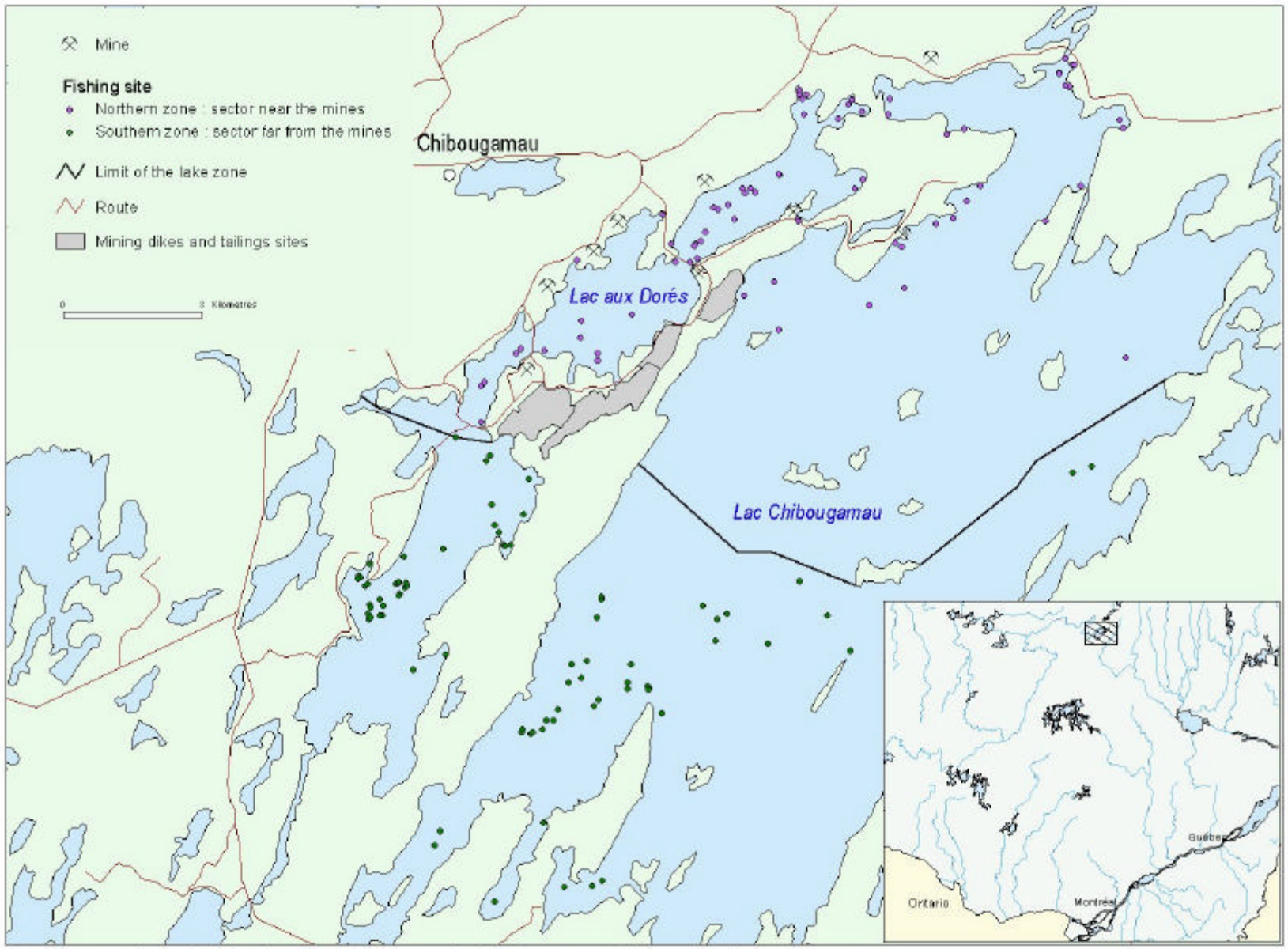

Figure 5 Locations of fishing sites with regard to contamination flow– Lac Chibougamau and Lac aux Dorés - 2001

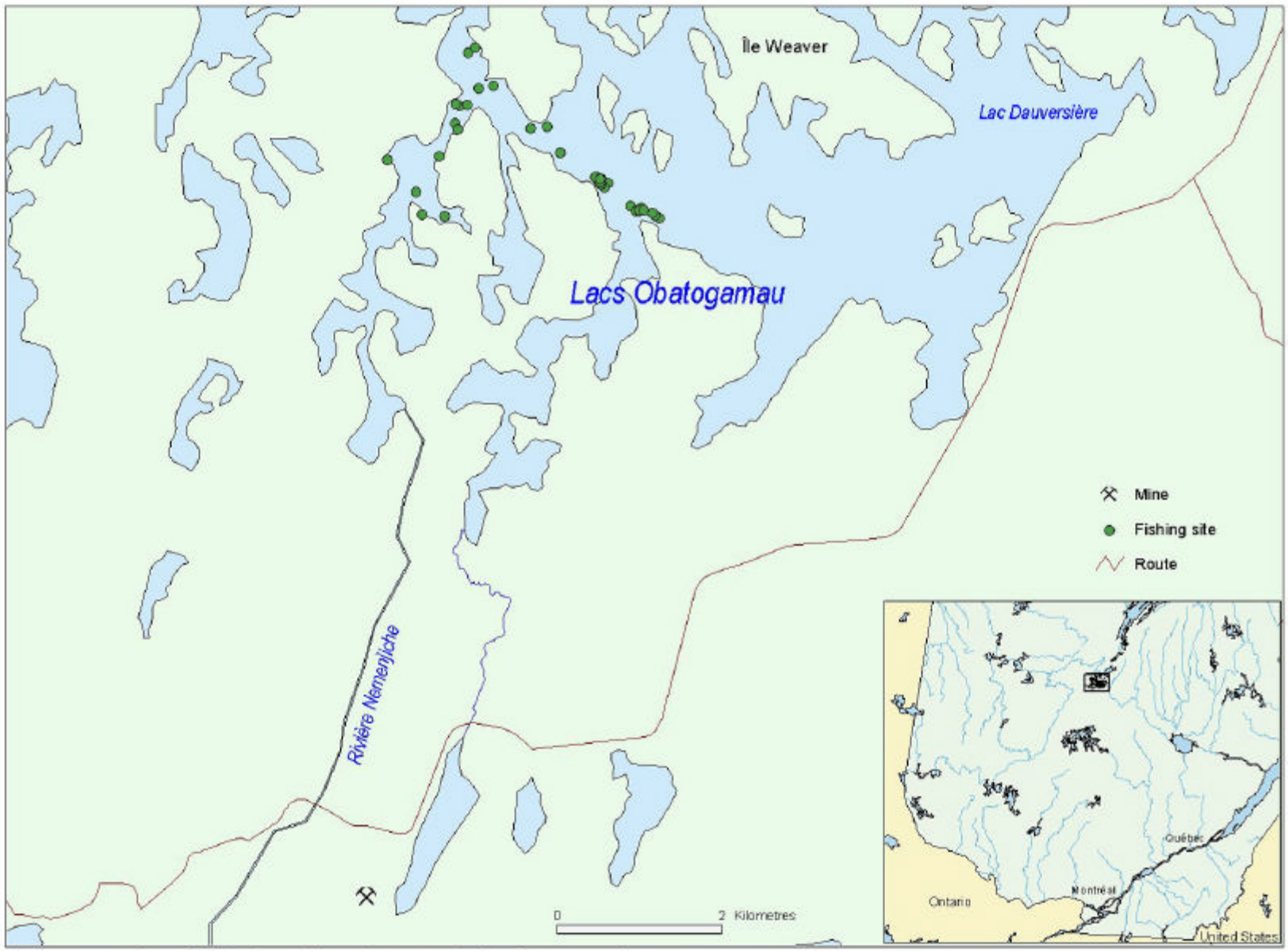

Figure 6 Locations of fishing sites with regard to contamination flow – Lacs Obatogamau - 2001

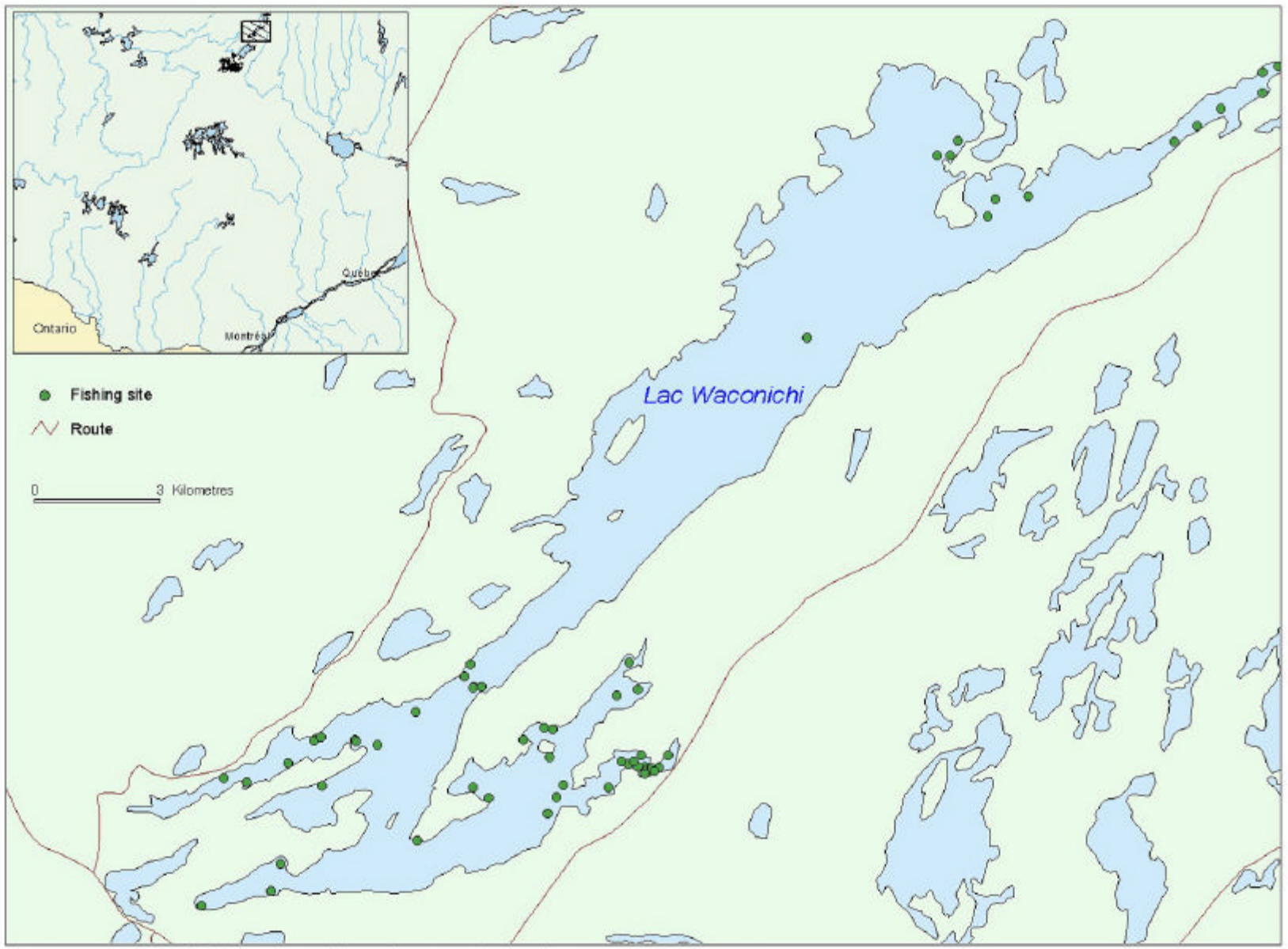

Figure 7 Locations of fishing stations with regard to contamination flow – Lac Waconichi - 2001

At Lac Chibougamau and Lac aux Dorés, links between mercury levels and the proximity of mine sites was evaluated by categorizing the first three of the above species as either close to or far from the mines. At Lac Chibougamau, the dividing line was set at Granite Island. Waters to the north were considered close and waters to the south were considered to be far from the mines (figure 5). At Lac aux Dorés, the southern edge of the Principale waste site was set as the dividing line (figure 1). Waters to the south of this limit were considered as being far from the mines, and waters to the north were considered close to the mines (figure 5).

Laboratory analysis

Arsenic, cadmium, copper, nickel, lead, and zinc levels were measured in the effluents, sediments, and mine tailings. The effluents and sediments were also analysed for aluminium, beryllium, chromium, selenium, and strontium. Iron was measured in sediments and mine tailings. PCBs were analysed only in sediments. Concentrations for sediments and mine tailings are expressed as dry weights (mg/kg) for metals and in µg/kg for PCBs.

For fish, the flesh was analysed for arsenic, cadmium, chromium, copper, manganese, lead, selenium, strontium, zinc, PCBs, and dioxins and furans. Individual mercury analyses were made for walleye, northern pike, and lake trout, while other substance measurements were made only from the homogenates of the flesh classified by size according to the species. Concentrations were measured in wet weights (mg/kg for metals, µg/kg for PCBs, and ng/kg for dioxins and furans). Mercury was measured with ultraviolet photometry (LDC Milton Roy) and vapour formation. Arsenic and selenium were measured by atomic absorption using a spectrophotometer (Perkin-Elmer, model 603). The other metals were measured with spectrophotometrics using argon plasma emission and measured with a Jarrell-Ash spectrophotometer (model ICAP-9000). PCBs and dioxins and furans were measured with a high-resolution mass spectrophotometer.

Choice of reference sites for sediments and fish

Given that natural metal levels in sediments were not known, the study determined reference points that were not likely to be influenced by mining activity. Sites S-16 and S-17 (Îles des Commissaires and Pointe Needle) on Lac Chibougamau were chosen as reference points, being located more than eight km from the nearest active mine. Their samples served to compare the metal levels in sediments from Lac Chibougamau and Lac aux Dorés. Lac Waconichi, with no mining activity currently taking place on its shores, was taken as a reference site for fish.

Standards and guidelines for comparing effluents, sediments, mine tailings, and fish

Metal concentrations in effluents were compared according to directive 019 of the *Ministère de l'Environnement du Québec* (table 3; *Ministère de l'Environnement*, 1989), while sediment concentrations were compared using guidelines established by the Canadian Council of Ministers of the Environment (table 5) (CCME, 2001). Two sets of guidelines used in this study were the interim sediment quality guideline (ISQG) for freshwater sediments and the probable effect

levels (PEL). For iron, criteria established by Croteau et al. (1984) and Paul and Laliberté (1985) (table 5) were applied. Concentrations of aluminium, beryllium, selenium, and strontium in sediments were compared only to the reference sites, given the absence of guidelines. Metal concentrations in mine tailings were compared with those of sediments.

Table 3: Maximum authorized concentrations of toxic levels in a sample taken from a non-diluted final effluent.

Metals	Concentration
	mg/L
Arsenic	0.50
Copper	0.30
Iron	3.00
Nickel	0.50
Lead	0.20
Zinc	0.50

For fish, levels of metals and organic compounds were compared using Health Canada standards for the sale of fishery products (table 4). These standards exist only for mercury (0.5 mg/kg), arsenic (3.5 mg/kg), lead (0.5 mg/kg), PCBs (2000 µg/kg), and dioxins and furans in toxic equivalent to 2,3,7,8 tetrachlorodibenzo-p-dioxin (2,3,7,8 –TCDD) (15 ng/kg). Concentrations of mercury, PCBs, and dioxins and furans were also compared with guidelines for the protection of terrestrial fish-eating wildlife (CCME, 2001 and U.S. EPA, 1995). These limits are respectively 0.033 mg/kg, 160 µg/kg, and 0.66 ng/kg.

Table 4: Standards and guidelines in effect for mercury, PCBs,and dioxins and furans in fish flesh.

Toxic component	Consumption	Terrestrial wildlife	Source
Arsenic	3.5 mg/kg		HC
Mercury	0.5 mg/kg	0.033 mg/kg	HC, EPA 1995
Lead	0.5 mg/kg		HC
PCBs	2 000 µg/kg	160 µg/kg	HC, EPA 1995
Dioxins and furans	15 ng/kg	0.66 ng/kg	HC, EPA 1995

HC= Health Canada

Statistical analysis

Covariant analyses, using mercury and total length as variables, were carried out to compare mercury levels for lake trout, northern pike, and walleye in each fishing area. Prior to the analyses, the normality of residues was verified. To ensure the reliability of statistical tests,

covariant non-parametric analyses were done. The results of these were similar to parametric test results, with the exception of two results that differed slightly. However, as the samples of residues for these two parametric analyses had not been normal, it was considered safe to conclude the study with the results from the non-parametric analysis. For each statistical analysis, the average levels were regarded as different when their probability was equal to or below 0.05.

Each fish species was classified in three sizes according to the guide for freshwater sport fish consumption (*Gouvernement du Québec, Ministère de l'Environnement et de la Faune*, 1995). The average levels of mercury for each of these classes was compared to the Health Canada standard of 0.5 mg/kg for the sale of fishery products and to the guideline of 0.033 mg/kg from the CCME (1999) for the protection of terrestrial fish-eating wildlife.

RESULTS AND DISCUSSION

Concentration of metals in effluents

The analyses of mining effluents detected a number of metals. Among these, the six metals included in directive 019 for the mining industry had concentrations below the authorized limits (tables 3 and 5). Beryllium, cadmium, chromium, lead, and selenium were not detected. Copper found in effluent E-01 was the only metal approximating the directive 019 limit (0.30 mg/L), with a concentration of 0.27 mg/L. Strontium, for which there is no standard, also showed a non-negligible concentration (0.43 mg/L). The E-01 effluent comes from the sedimentation basin at the Eaton Bay site, which receives drainage water from the Copper Rand mine. Concentrations of aluminium, copper, and strontium are much higher in this effluent than in the E-02 effluent (Copper Rand mine tailings site).

Contamination from mine sediments and tailings

Mercury

Despite the sharp variation in mercury concontrations, which range from <0.035 to 0.34 mg/kg (sites S-18 and S-03 respectively), the median (0.08 mg/kg) and most other levels fell below the ISQG interim guideline. Only site S-03 (0.34 mg/kg), near the Henderson I mine site, together with reference site S-17 (0.21 mg/kg), near Pointe Needle, showed levels above the interim guideline. Site S-17 is located downstream from the mouth of the Armitage River, which drains the Lemoine mine site. The other reference site, S-16, showed a much lower level (0.05 mg/kg). In comparison, the average mercury level in lacustrine sediments is 0.074 mg/kg, according to data from the Geological Survey of Canada (CCME, 2001). Levels at site S-15 (0.16 mg/kg) south of the Principale site were just below the limit set by the ISQG interim guideline. All levels remain below the probable effect level (0.486 mg/kg) and thus seem unlikely to present harmful effects to benthic organisms.

Sasseville *et al*. (1976) found mercury concentrations of 0.007 and 0.035 mg/kg and of 0.025 and 0.035 mg/kg in the sediments of Lac Chibougamau and Lac aux Dorés respectively in the 1970s.

Table 5: Concentrations of metals and PCBs in the sediments of Lac Chibougamau and Lac aux Dorés

Site		Al mg/kg	As mg/kg	Be mg/kg	Cd mg/kg	Cr mg/kg	Cu mg/kg	Fe mg/kg	Hg mg/kg	Ni mg/kg	Pb mg/kg	Se mg/kg	Sr mg/kg	Zn mg/kg	BPC µg/kg	COT %
	Min	6 700	2	<0.5	1	<0.05	18	10 000	<0.035	17	1	<0.2	6	25	<0.4	0.5
	Max	35 000	260	<0.5	8	68	7 800	190 000	0.34	345	67	4.2	45	410	<0.4	17.0
	Median	17 000	26.5	<0.5	2	23.0	560	46 500	0.08	66	22	1.1	26	130	<0.4	4.7
	ISQG	nd	5.9	nd	0.6	37.3	35.7	17 000	0.17	35	35.0	nd	nd	123	34.1	
	PEL	nd	17.0	nd	3.5	90.0	197	25 000	0.486	61	91.3	nd	nd	315	277	
	Lake															
S-01 (Grand Roy):	Lac Chibougamau	16 000	3.7	<0.5	2	53	31	**26 000**	0.09	53	9	0.9	27	110	<0.4	8.8
S-02 (Henderson I)	Lac Chibougamau	15 000	8.8	<0.5	2	68	59	**39 000**	0.06	**85**	13	<0.2	45	85	<0.4	0.5
S-03 (Henderson II)	Lac Chibougamau	19 000	7.2	<0.5	2	46	120	**28 000**	0.34	49	20	1.0	26	130	<0.4	10.0
S-06 (Pointe Machin)	Lac aux Dorés	29 000	**260**	<0.5	**7**	<0.5	**7 800**	**160 000**	0.09	**140**	37	2.3	6	**410**	<0.4	1.9
S-07 (Copper Rand)	Lac aux Dorés	15 000	**66**	<0.5	3	9	**680**	**59 000**	0.06	52	16	0.7	14	130	<0.4	1.2
S-08 (Parc Copper Rand)	Lac aux Dorés	17 000	16	<0.5	2	39	**480**	**37 000**	0.09	49	32	1.1	27	140	<0.4	6.3
S-09 (Parc Copper Rand)	Lac aux Dorés	6 700	7.2	<0.5	1	14	**220**	12 000	0.08	27	21	0.9	24	67	<0.4	6.9
S-10 (Pointe Campbell)	Lac aux Dorés	25 000	**44**	<0.5	**4**	18	**1 400**	**71 000**	0.07	**66**	42	2.1	18	280	<0.4	3.2
S-11 (Pointe Campbell)	Lac aux Dorés	19 000	**76**	<0.5	**8**	<0.5	**990**	**190 000**	0.08	**65**	46	4.2	9	**380**	<0.4	4.9
S-12 (Pointe Campbell)	Lac aux Dorés	18 000	**27**	<0.5	3	25	**990**	**57 000**	0.08	**67**	35	1.5	27	230	<0.4	4.4
S-13 (Principale site)	Lac aux Dorés	35 000	**120**	<0.5	**5**	4.5	**745**	**87 000**	0.10	**345**	38	4.0	21.5	295	<0.4	1.9
S-14 (Copper Rand site)	Lac aux Dorés	9 600	**26**	<0.5	1	22	**560**	16 000	0.11	58	22	1.3	27	120	<0.4	9.3
S-15 (Principale site)	Lac aux Dorés	25 000	**29**	<0.5	3	26	**970**	**54 000**	0.16	**86**	67	3.2	23	250	<0.4	4.9
S-16 (Île des Commissaires)	Lac Chibougamau	14 000	2	<0.5	1	42	39	19 000	0.05	44	10	0.4	41	66	<0.4	1.4
S-17 (Pointe Needle)	Lac Chibougamau	17 000	4.1	<0.5	2	23	18	19 000	0.21	17	26	1.0	26	130	<0.4	17.0
S-18 (Eaton Bay site)	Lac Chibougamau	na	**170**	na	na	na	**560**	**140 000**	<0.035	**157**	6	na	na	127	na	na
S-19 (Eaton Bay site)	Lac Chibougamau	na	**110**	na	na	na	**840**	**140 000**	0.07	**171**	13	na	na	128	na	na
S-20 (Grand Roy)	Lac Chibougamau	na	2	na	na	na	109	10 000	0.05	**137**	1	na	na	25	na	na
E-01 (Eaton Bay) **mg/l**	Lac Chibougamau	0.17	0.002	<0.01	<0.01	<0.01	0.27	na	<0.0001	0.04	<0.02	<0.001	0.43	0.07	na	na
E-02 (Copper Rand) **mg/l**	Lac aux Dorés	0.06	0.007	<0.01	<0.01	<0.01	0.01	na	0.0001	<0.01	<0.02	<0.001	0.08	0.06	na	na
R-1 (Eaton Bay)	Lac aux Dorés	na	**63**	na	na	na	**283**	**97 000**	0.04	**100**	2	na	na	85	na	na
R-2 (Copper Rand)	Lac aux Dorés	na	**203**	na	na	na	**340**	**120 000**	<0.035	**83**	3	na	na	99	na	na
R-3 (Principale)	Lac aux Dorés	na	**137**	na	na	na	**282**	**52 000**	<0.035	32	32	na	na	**520**	na	na
R-4 (Principale)	Lac aux Dorés	na	**333**	na	na	na	167	**39 000**	<0.035	26	3	na	na	135	na	na

NA = not analysed, n/a = not available, ISQG = interim sediment quality guideline, PEL = probable effect levels (CCME, 2001).
S = sediments, E = effluent, R = residues (tailings)
* Minimum, maximum and median levels relate solely to sediment levels.
TOC = total organic carbon

The median of 0.08 mg/kg in this study tends to confirm an increase of mercury levels in Lac Chibougamau sediments. If this was in fact the case, the increase may well be attributable to atmospheric fallout. Between 1977 and 1990, atmospheric concentrations of mercury in the northern hemisphere increased by an estimated 1.46 % per year over the Atlantic Ocean (Slemr and Langer, 1992).

However, an adequate comparison of mercury levels in sediments needs to take the percentage of total organic carbon (TOC) into account, as there is a positive correlation between a sediment's mercury level and its TOC percentage (figure 8). Four sites, for example, show levels that deviate from this correlation between mercury level and TOC percentages. The highest of these sites is S-03 (0.34 mg/kg) near the Henderson I site, followed by S-15 (0.16 mg/kg) south of the Principale site, S-13 (0.10 mg/kg) at the foot of the Principale site, and S-06 (0.09 mg/kg) at Pointe Machin. These sites thus seem to present abnormal environmental contamination when considering their TOC percentages. At reference site S-17, on the other hand, the mercury level is high (0.21 mg/kg), yet occurs in conjunction with a high percentage of total organic carbon (17%). The mercury here may be of natural origin since it increases in the same degree as carbon. In mine tailings, mercury was detected at only one (R-1) of the four sites, and only at a very low level (0.04 mg/kg). The samples thus appear to indicate that mine tailings do not constitute a significant source of mercury contamination in Lac Chibougamau and Lac aux Dorés. It must be stated, however, that our sampling was limited to tailings near the surface (0 to 90 cm), and that tailings at some sites can be up to ten or eleven meters deep. Moreover, since the tailings come from many different mines, the mineralogy of the tailings layer can change enormously with depth. Nevertheless, mercury levels are not likely to be higher in deeper layers, since processing through amalgamation did not take place nearby.

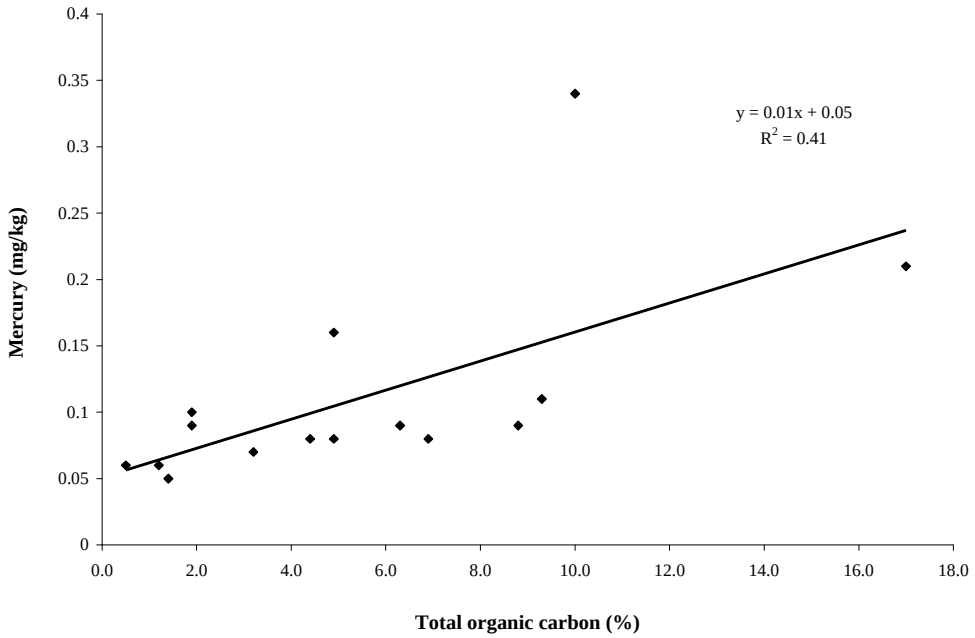

Figure 8 Concentration of mercury in relation to total organic carbon at 17 sediment sites in Lac Chibougamau and Lac aux Dorés

Aluminium

Aluminium concentrations in sediments varied between 6,700 and 35,000 mg/kg (S-09 near the Copper Rand mine site and S-13 near the Principale mine site), with a median level of 17,000 mg/kg (table 5). Most of the observed levels ranged near the median. There is no guideline for aluminium in sediments. Sites at Lac aux Dorés showed the highest aluminium concentrations: S-06 (29,000 mg/kg) at Pointe Machin, S-10 (25,000 mg/kg) north of Campbell Point, S-13 (35,000 mg/kg) at the foot of the Principale tailings site, and S-15 (25,000 mg/kg) south of the Principale tailings site.

The highest levels measured in this study appear to be above those observed at reference sites S-16 (14,000 mg/kg) and S-17 (17,000 mg/kg) in Lac Chibougamau.

Site S-06 (Pointe Machin) stands out when interpreting results because it is the former site for untreated drainage water from the Copper Rand mine site. We should also note that mine tailings are found beneath a waste rock pile in this area and that these tailings have been partly washed out toward Lac aux Dorés.

Arsenic

Arsenic concentrations run from 2 to 260 mg/kg (S-20 at the Grand Roy site and S-06 at Pointe Machin), with a median level of 26.5 mg/kg. Fourteen sites show arsenic levels higher than the ISQG interim guideline (5.9 mg/kg), and 10 sites have levels higher than the probable effect level (17.0 mg/kg) (table 5). Only four sites (S-01 and S-20 at the Grand Roy mine site plus S-16 at Île des Commissaires and S-17 at Pointe Needle) in Lac Chibougamau, have arsenic levels below the interim guideline (figure 1). It is to be noted that sampling site S-01 lies furthest from the mines (1.5 km). Apart from site S-20 (2 mg/kg), all the sites show arsenic concentrations higher than reference sites S-16 (2 mg/kg) and S-17 (4.1 mg/kg). Levels at the reference sites are comparable to the average arsenic level of 2.5 mg/kg in lacustrine sediments, according to the data from the Geological Survey of Canada. These levels are also similar to arsenic levels measured by the *Ministère des Richesses naturelles* (Ministry for Natural Resources) in 1987 for soil samples taken in sections of Lac Chibougamau and Lac aux Dorés (4 mg/kg)[1]. These data confirm that many arsenic levels in sediments from sections of Lac Chibougamau and Lac aux Dorés close to tailings sites to be abnormally high. However, given the different types of mineralization that occur on site, it was not possible to exactly distinguish the proportion of arsenic natural in origin from the proportion of arsenic anthropic in origin for sediments close to tailings sites.

It was observed that arsenic levels in mine tailings are higher than those in sediments. These tailings can thus be a potential source of contamination for the aquatic environment. It is thus of interest that arsenic levels are high at sites near the mine tailings: S-07 (66 mg/kg) at Copper Rand, S-11 (76 mg/kg) at Campbell Point, S-13 (120 mg/kg) at the foot of the Principale waste site, and S-18 and S-19 (170 and 110 mg/kg) east of the Eaton Bay site.

[1]Average arsenic level utilized on map 32 G 16 in the *Système d'information géominière du Québec*, SIGÉOM (Québec Geomining Information System).

Beryllium

Beryllium was not found above the detection limit of 0.5 mg/kg in sediments at any of the sampled sites.

Cadmium

Cadmium levels in sediments varied from 1 to 8 mg/kg (S-09 at the foot of the Copper Rand site and S-11 at Campbell Point), with a median level of 2 mg/kg. At all sites, cadmium levels in sediments exceeded the ISQG interim guideline (0.6 mg/kg), a result indicating a relatively high natural geochemical level in this area. Four sites at Lac aux Dorés show levels higher than the probable effect level (3.5 mg/kg): sites S-06 at Pointe Machin, S-10 and S-11 at Campbell Point, and S-13 at the foot of the Principale site (7, 4, 8 and 5 mg/kg respectively). Levels such as these are likely to have harmful effects on benthic organisms. Moreover, they are higher than levels measured at reference sites S-16 (1 mg/kg) and S-17 (2 mg/kg). These cadmium levels are also similar to those measured by the *Ministère des Richesses naturelles* (Ministry for Natural Resources) in 1987 for soil samples taken in sections of Lac Chibougamau and Lac aux Dorés (0.9 mg/kg)[2]. This data confirms cadmium levels in sediments from some sections of Lac Chibougamau and Lac aux Dorés close to tailings sites to be abnormally high. However, given the different types of mineralization that occur on site, it was not possible to exactly distinguish the proportion of cadmium natural in origin from the proportion of cadmium anthropic in origin for sediments close to tailings sites.

In comparison, the average cadmium level in lacustrine sediments is 0.32 mg/kg according to data from the Geological Survey of Canada (CCME, 2001).

Chromium

Chromium levels vary from <0.05 to 68 mg/kg (S-06 at Pointe Machin and S-02 at the Henderson II mine site), with a median level of 23 mg/kg. Five sites have chromium levels higher than the ISQG interim guideline (37,3 mg/kg): sites S-01 (53 mg/kg), S-02 (68 mg/kg), S-03 (46 mg/kg), S-08 (39 mg/kg), and S-16 (42 mg/kg), located respectively near the Grand Roy, Henderson II and Henderson I mine sites, near the Copper Rand site, and near the Île des Commissaires reference site. No site had levels above the probable effect level (90 mg/kg). The highest levels were not very different from those measured at the two site reference sites, S-16 and S-17 (42 and 23 mg/kg), and did not show major contamination of sediments. In comparison, the average chromium level in lacustrine sediments is 47 mg/kg according to data from the Geological Survey of Canada (CCME, 2001). This level is thus comparable to those measured at the reference sites and indicates no particular anomaly caused by geochemistry.

[2]Average cadmium level utilized on map 32 G 16 in the *système d'information géominière du Québec*, SIGÉOM (Québec Geomining Information System).

Copper

Copper levels vary sharply from one sampling site to another, ranging from 18 mg/kg (S-17 at Pointe Needle) to 7,800 mg/kg (S-06 at Pointe Machin), with a median level of 560 mg/kg. The majority of sites at both lakes show copper levels that greatly exceed the ISQG interim guideline (35.7 mg/kg) as well as the probable effect level (197 mg/kg). Copper concentrations this high in sediments are likely to have harmful effects on benthic organisms.

At the S-16 and S-17 reference sites, levels are among the lowest (39 and 18 mg/kg). These levels are also very similar to copper levels measured by the *Ministère des Richesses naturelles* (Ministry for Natural Resources) in 1987 for soil samples taken in sections of Lac Chibougamau and Lac aux Dorés (29.2 mg/kg)[3]. This data confirms many copper levels in sediments from sections of Lac Chibougamau and Lac aux Dorés close to tailings sites to be abnormally high. However, given the different types of mineralization that occur on site, it was not possible to exactly distinguish the proportion of copper natural in origin from the proportion of copper anthropic in origin for sediments close to tailings sites.

At the reference sites, the average copper levels of 31 mg/kg are also maintained in lacustrine sediments, according to data provided by the Geological Survey of Canada (CCME, 2001).

In addition to the reference sites which are a good distance from tailings sites, sites S-01 (31 mg/kg), S-02 (59 mg/kg), and S-03 (120 mg/kg), near the Grand Roy, Henderson II and Henderson I mines respectively, also have lower copper levels than sites located near tailings sites. These three sites were, in fact, the only ones with levels near the interim guideline. Site S-20 (109 mg/kg) near the Grand Roy mine site also had a copper level below the probable effect level.

Mine tailings showed relatively high copper levels (167 to 340 mg/kg). These concentrations are much higher than those of the reference sites S-16 and S-17 and may well constitute a source of copper contamination. It was also observed that most sediments sampled close to the mine tailings contained very high copper levels. On the contrary, all sediments from sites further away indicated copper levels lower than those of tailings sites.

Iron

Iron levels varied significantly among the different sampling sites, ranging from 10,000 mg/kg (S-20 near the Grand Roy site) to 190 000 mg/kg (S-11 at Campbell Point), with a median level of 46,500 mg/kg. There is no guideline for evaluating sediment quality for iron. The highest iron levels were measured at sites S-11 (190,000 mg/kg) at Campbell Point, S-06 (160,000 mg/kg) at Pointe Machin, and S-18 and S-19 (140,000 mg/kg for both) east of the Eaton Bay site. These levels seem much higher than those measured at reference sites S-16 and S-17 (19,000 mg/kg), indicating abnormal contamination of sediments.

[3] Average copper level utilized on map 32 G 16 in the *système d'information géominière du Québec*, SIGÉOM (Québec Geomining Information System).

It was observed that iron levels in sediments increase with proximity to mine tailings. As mine tailings sites showed high iron levels (39,000 to 120,000 mg/kg), they are like to contaminate the aquatic environment.

Nickel

The analysed sediments contained nickel levels varying between 17 mg/kg (S-17 at Pointe Needle) and 345 mg/kg (S-13 at the foot of the Principale site), with a median level of 66 mg/kg. All nickel levels, with one exception, exceeded the minor effect guideline (35 mg/kg) and many exceeded the harmful effect guideline (61 mg/kg).

The sites showing the highest nickel levels are S-13 (345 mg/kg) at the foot of the Principale waste site, S-18 and S-19 (157 and 171 mg/kg) east of the Eaton Bay site, S-06 (140 mg/kg) at Pointe Machin, and S-20 (137 mg/kg) near the Grand Roy mine site. With the exceptions of S-06 and S-20, the sites exceeding the harmful effect guideline are all located near mine tailings sites. Nickel concentrations at these levels in sediments are likely to cause harmful effects to benthic organisms.

Reference sites S-16 (44 mg/kg) and S-17 (17 mg/kg) have nickel levels that are below or near the minor effect guideline (35 mg/kg) and that are much lower than those measured at the most contaminated sites. These levels are also similar to nickel levels measured by the *Ministère des Richesses naturelles* (Ministry for Natural Resources) in 1987 for soil samples taken in sections of Lac Chibougamau and Lac aux Dorés (13.9 mg/kg)[4]. This data confirms many nickel levels in sediments from sections of Lac Chibougamau and Lac aux Dorés close to tailings sites to be abnormally high. However, given the different types of mineralization that occur on site, it was not possible to exactly distinguish the proportion of nickel natural in origin from the proportion of nickel anthropic in origin from sediments near tailings sites.

At reference sites, nickel levels are similar to the median nickel level in lacustrine sediments of 15 mg/kg (Environment Canada, 1994).

Nickel levels above the harmful effect guideline (66 mg/kg) for sediments were observed in mine tailings at sites R-1 (100 mg/kg) and R-2 (83 mg/kg). These levels show that mine tailings can be a source of nickel contamination in the aquatic environment.

[4] Average nickel level utilized on map 32 G 16 in the *système d'information géominière du Québec*, SIGÉOM (Québec Geomining Information System)..

Lead

Lead concentrations range from 1 to 67 mg/kg (S-20 at the Grand Roy mine site and S-15 south of the Principale site), with a median level at 22 mg/kg. Five measurements exceed the ISQG interim guideline (35 mg/kg), but all remain below the probable effect level (91 mg/kg). Lead concentrations exceeding the interim guideline were found at sites S-15 (67 mg/kg) south of the Principale waste site, S-10 and S-11 (42 and 46 mg/kg) at Campbell Point, S-13 (38 mg/kg) at the foot of the Principale site, and S-06 (37 mg/kg) at Pointe Machin.

Lead concentrations at reference sites S-16 and S-17 (10 and 26 mg/kg) fall below the guidelines, but seem to indicate that Lac Chibougamau has substantial natural lead concentrations. In comparison, the average lead concentration in lacustrine sediments is 6 mg/kg, according to data from the Geological Survey of Canada (CCME, 2001). This attests to relatively high lead concentrations in the area. These concentrations above the ISQG interim guideline (35 mg/kg) are also above those of the two reference sites, indicating abnormal lead contamination in the sediments.

With the exception of site R-3 (32 mg/kg) located in the Principale Nord mine tailings site, mine tailings contain much lower lead concentrations than sediments.

Selenium

Selenium concentrations in sediments vary from <0.2 (S-02 at the Henderson II mine site) to 4.2 mg/kg (S-11 at Campbell Point), with a median level at 1.1 mg/kg. There is no guideline for selenium in sediments. Selenium concentrations measured at the S-16 and S-17 reference sites (0.4 and 1.0 mg/kg) are similar to those measured at the majority of sites. Only three sites had levels differing slightly from those observed at the reference sites: S-11 (4.2 mg/kg) Campbell Point, S-13 (4.0 mg/kg) at the foot of the Principale waste site, and S-15 (3.2 mg/kg) south of the Principale site.

Strontium

Strontium concentrations in sediments vary from 6 mg/kg (S-06 at Pointe Machin) to 45 mg/kg (S-02 near the Henderson II mine site), with a median level of 26 mg/kg. There is no guideline for strontium in sediments. Strontium concentrations at reference sites S-16 and S-17 (41 and 26 mg/kg) are in the same range as those measured at the other sites, with the exception of sites S-06 (6 mg/kg) at Pointe Machin and S-11 (9 mg/kg) at Campbell Point that appear to be lower. With the available data, no abnormal strontium contamination could be detected.

Zinc

Zinc concentrations in sediments vary from 25 mg/kg (S-20 at the Grand Roy site) to 410 mg/kg (S-06 at Pointe Machin), with a median level of 130 g/kg. Zinc concentrations are generally above the ISQG interim guideline (123 mg/kg), and two levels exceed the probable effect level (315 mg/kg). The highest levels are observed at sites S-06 (410 mg/kg) at Pointe Machin, S-11 (380 mg/kg) at Campbell Point, S-13 (295 mg/kg) at the foot of the Principale waste site, S-10 (280 mg/kg) north of Campbell Point, S-15 (250 mg/kg) south of the Principale site, and S-12 (230 mg/kg) at Campbell Point. The sites with the highest zinc contamination are all west of Campbell Point. At the first two sites (S-06 and S-11), concentrations are high enough to produce effects harmful to benthic organisms.

The preceding levels are much higher than those measured at reference sites S-16 and S-17 (66 and 130 mg/kg). These levels are also similar to zinc levels measured by the *Ministère des Richesses naturelles* (Ministry for Natural Resources) in 1987 for soil samples taken in sections of Lac Chibougamau and Lac aux Dorés (57.7 mg/kg)[5]. This data confirms many zinc levels in sediments from sections of Lac Chibougamau and Lac aux Dorés close to tailings sites to be abnormally high. However, given the different types of mineralization that occur on site, it was not possible to exactly distinguish the proportion of zinc natural in origin from the proportion of zinc anthropic in origin for sediments near tailings sites.

In comparison, the average zinc concentration in lacustrine sediments is 104 mg/kg (Geological Survey of Canada, CCME, 2001), indicating that natural geochemical zinc concentrations in Lac Chibougamau and Lac aux Dorés are close to the average Canadian level.

In regard to samples of mine tailings, only site R-3 (520 mg/kg), at the Principale mine site, had a zinc concentration higher than those of the sediments. The sediments taken near these tailings have very high zinc concentrations. The other mine tailings sites show levels comparable to those of reference sites S-16 and S-17.

PCBs

For all sediments, PCB concentrations were below the detection limit of 0.4 µg/kg.

Contamination of fish flesh

Mercury concentrations in fish

Lake trout

In Lac Chibougamau, lake trout caught in 2001 either near or far from the mines had similar adjusted average mercury concentrations (0.75 and 0.79 mg/kg; p=0.86) (figure 9.1). These

[5] Average zinc level utilized on map 32 G 16 in the *système d'information géominière du Québec*, SIGÉOM (Québec Geomining Information System)..

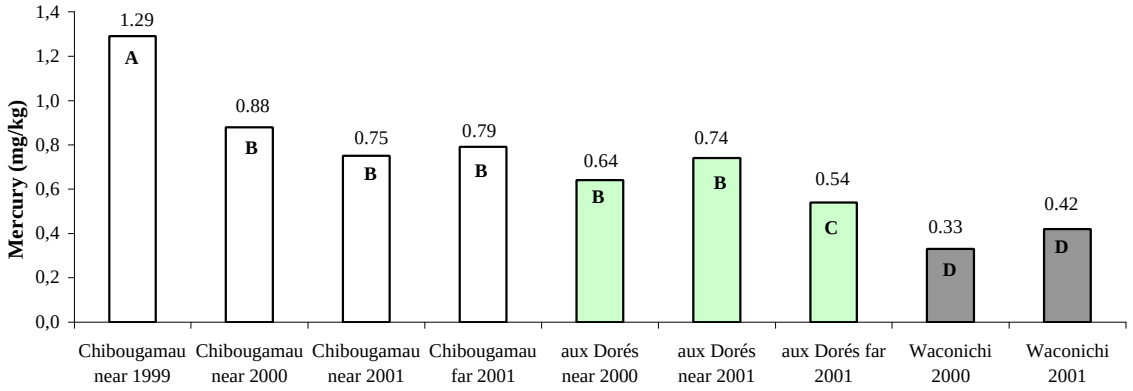

Figure 9.1 Adjusted average mercury levels in lake trout (*Salvelinus namaycush*) from lakes Chibougamau, aux Dorés, and Waconichi from 1999 to 2001

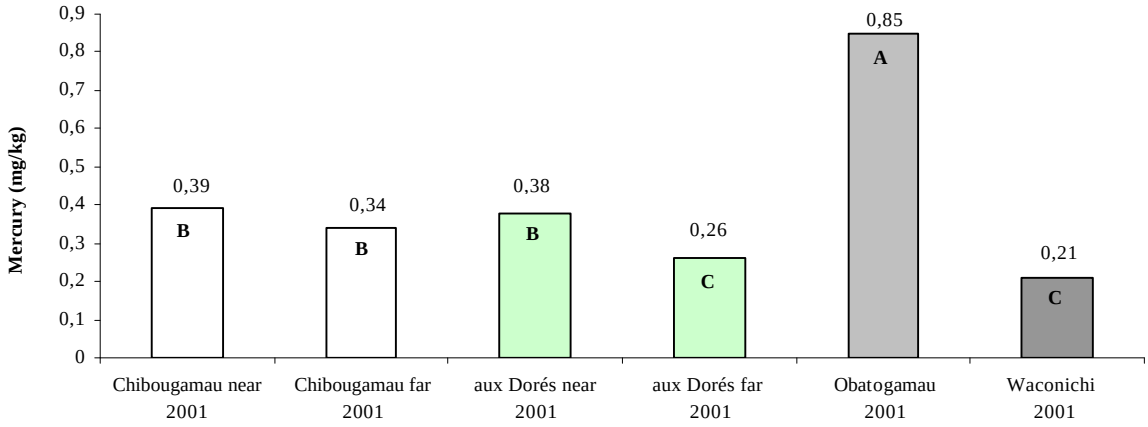

Figure 9.2 Adjusted average mercury levels in northern pike (*Esox lucius*) from lakes Chibougamau, aux Dorés, Obatogamau, and Waconichi in 2001

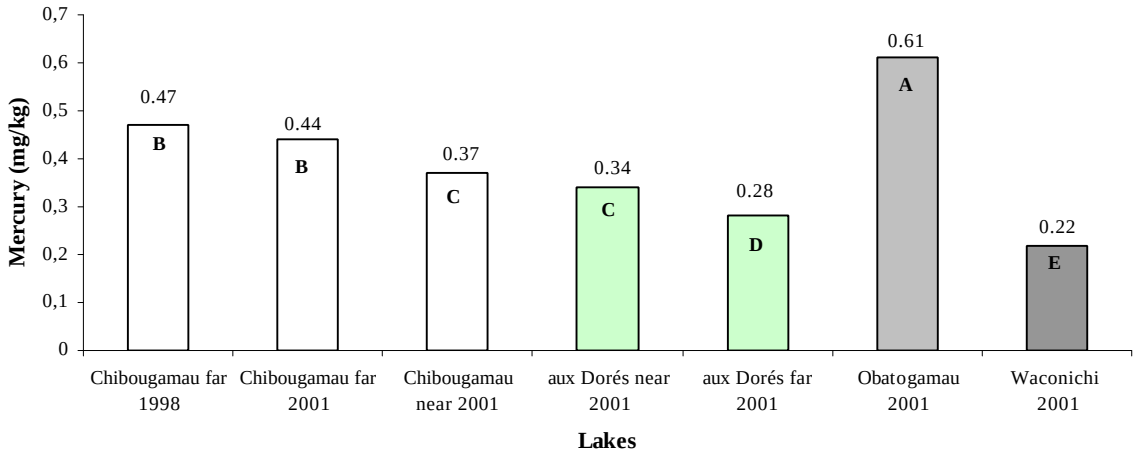

Figure 9.3 Adjusted average mercury levels in walleye (*Stizostedion vitreum*) from lakes Chibougamau, aux Dorés, Obatogamau, and Waconichi from 1998 to 2001

For figures 9.1, 9.2, and 9.3, identical letters represent similarity while different letters represent differences between average mercury levels.

concentrations are also comparable to those measured in 2000 near the mines (0.88 mg/kg; p=0.83). They are significantly different, however, from 1999 measurements of very elderly specimens caught near the mines (1.29 mg/kg; p <0.0003). It should be noted that the trout caught near the mines in Lac Chibougamau in 1999, 2000, and 2001 were not captured at the same sites.

In Lac aux Dorés, statistical analyses show that the adjusted average mercury concentration of lake trout caught in 2001 was higher for fish caught closer than for those caught further from the mines (0.74 and 0.54 mg/kg; p=0,008) (figure 9.1). The adjusted average concentrations in lake trout were similar in 2000 and 2001 (0.64 and 0.74 mg/kg; p=0.45).

In Lac Waconichi, lake trout caught in 2000 (0.33 mg/kg) had mercury concentrations similar to those caught in 2001 (0.42 mg/kg, p=0.25).

A comparison in mercury levels of lake trout from Lac Chibougamau, Lac aux Dorés, and Lac Waconichi (the control lake) in 2001 shows the highest mercury levels (0.79, 0.75, and 0.74 mg/kg; p< 0,0001) (figure 9.1) for trout caught in Lac Chibougamau (both sectors) and in the portion of Lac aux Dorés near the mines. The sector is a good distance from the mines in Lac aux Dorés and Lac Waconichi had the least contaminated lake trout (0.54 and 0.42 mg/kg; p<0,0001).

The average mercury concentrations increase with the size of the fish (figure 10 and table 6). For example, while none of the mercury levels in small trout exceeded Health Canada's 0.5 mg/kg standard for the commercial sale of fishery products, medium-sized and large trout from Lac Chibougamau and Lac aux Dorés surpassed the authorized limit. This is also the case when sizes were grouped according to proximity to a mine (table 7). In Lac Waconichi, levels remained below the authorized limit. However, no large specimens were caught in 2001.

Only the medium-sized lake trout from Lac Chibougamau have mercury levels that seem somewhat higher than the provincial median (table 6).

Northern pike

The northern pike caught in 2001 in Lac Chibougamau in areas near and far from the mines show similar adjusted average mercury levels (0.39 et 0.34 mg/kg; p=0.68) (figure 9.2). Yet at Lac aux Dorés, like the lake trout, northern pike caught closer to the mines had higher mercury levels than trout from areas further away (0.38 and 0.26 mg/kg; p=0.009) (figure 9.2). The area of Lac aux Dorés close to the mine does, however, show northern pike whose adjusted average mercury level is similar to those of both sectors of Lac Chibougamau. This same observation was made with respect to lake trout.

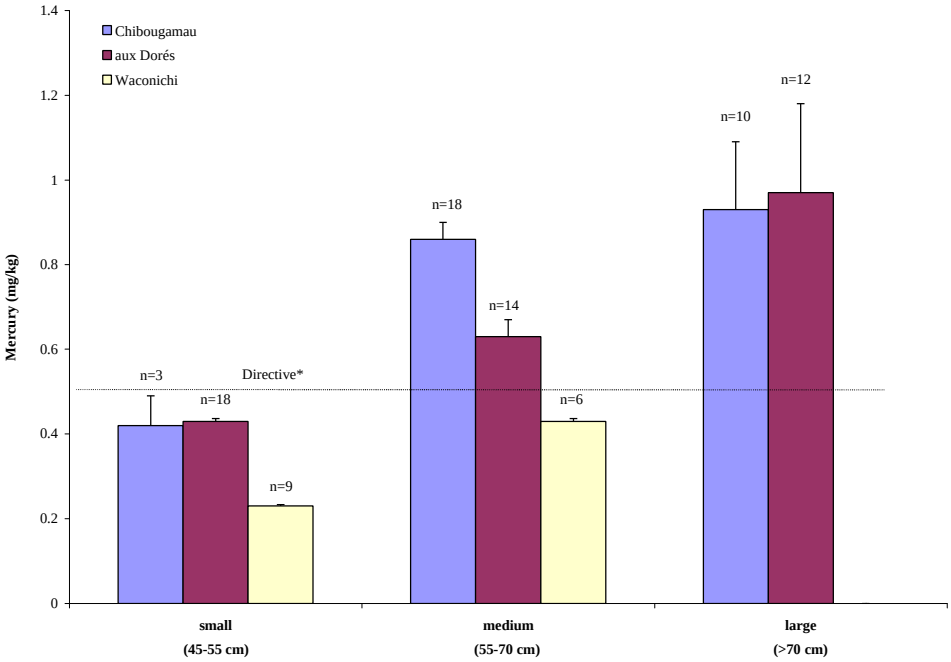

Figure 10 Comparison of mercury levels in relation to the size of lake trout (*Salvelinus namaycush*) caught in three lakes in northern Québec in 2001

*The dotted line represents the 0.5 mg/kg standard for the commercial sale of fishery products (HWC, 1986).

Table 6: Average mercury levels of three fish species caught in 2001 in four lakes in northern Québec in comparison with the provincial median

Lake	Species	Average mercury level			Provincial mercury median		
		Small mg/kg	**Medium** mg/kg	**Large** mg/kg	**Small** mg/kg	**Medium** mg/kg	**Large** mg/kg
Chibougamau	Lake trout	0.42 (3)	**0.86 (18)**	**0.93 (10)**	0.48 (111)	**0.75 (102)**	**1.24 (84)**
	Northern pike	0.27 (2)	0.35 (17)	**0.58 (17)**	0.40 (253)	**0.64 (235)**	**1.08 (179)**
	Walleye	0.27 (18)	0.42 (18)	0.48 (14)	0.50 (247)	**0.75 (228)**	**1.21 (174)**
aux Dorés	Lake trout	0.43 (18)	**0.63 (14)**	**0.97 (12)**			
	Northern pike	0.07 (2)	0.30 (16)	0.39 (7)			
	Walleye	0.26 (18)	0.32 (18)	0.37 (27)			
Obatogamau	Lake trout	-	-	-			
	Northern pike	0.41 (9)	**0.65 (9)**	**1.23 (4)**			
	Walleye	0.38 (8)	**0.56 (7)**	**0.98 (9)**			
Waconichi	Lake trout	0.23 (9)	0.43 (6)	-			
	Northern pike	0.09 (5)	0.17 (9)	0.30 (11)			
	Walleye	0.14 (9)	0.24 (9)	0.30 (3)			

The figures in parentheses represent the number of fish sampled for this study and the number of lakes included in the provincial median.

The highest adjusted average mercury levels for northern pikes were measured in the Obatogamau lakes (0.85 mg/kg), followed by Lac Chibougamau near and far from the mines (0.39 and 0.34 mg/kg), Lac aux Dorés near the mines (0.38 mg/kg), Lac aux Dorés far from the mines (0.26 mg/kg), and Lac Waconichi (0.21 mg/kg). Significant differences were noted for these four groups at a level of significance of $p<0.001$ (figure 9.2).

A comparison of size shows that only medium (0.65 mg/kg) and large (1.23 mg/kg) specimens caught in the Obatogamau lakes and large specimens (0.58 mg/kg) from Lac Chibougamau have average mercury levels higher than Health Canada's 0.5 mg/kg standard (figure 11 and table 6). When considering proximity to mines, the same trend is observed, with the exception that at Lac aux Dorés near the mines the average mercury level of large northern pike (0.55 mg/kg) also exceeds the standard (table 7).

Furthermore, the average mercury levels in large northern pike caught in the Obatogamau lakes slightly exceed the provincial median mercury levels for this species (table 6).

For the four lakes studied, average mercury levels in all size categories of northern pike exceeded the guideline of 0.033 mg/kg for the protection of fish-eating terrestrial wildlife.

Walleye

In Lac Chibougamau, walleye, unlike lake trout and northern pike, differ in adjusted average mercury levels depending on whether caught near or far from the mines (0.37 and 0.44 mg/kg; $p=0.02$) (figure 9.3). The sampling, carried out in 2001, showed a slightly lower average for walleye near the mines. Walleye samplings had also been carried out in 1998 in the northeast part of Lac Chibougamau (Baie des Îles), where there is little or no effect from the mining industry. These showed an adjusted average mercury level similar to the 2001 study (0.47 versus 0.44 mg/kg; $p=0.62$) based on an area that, although located in the southern part of the lake, was also far from the mines. This similarity for two sectors far apart from each other indicates homogeneity in mercury levels among walleye in areas far from the mine. At Lac aux Dorés, adjusted average mercury levels in walleye caught in 2001 are slightly higher near the mines than far from them (0.34 and 0.28 mg/kg; $p=0.001$) (figure 9.3).

For the four lakes studied, the results obtained in 2001 attest to, significant differences ($p<0.001$) between adjusted average mercury levels in walleye (figure 9.3). The highest average levels were measured in the Obatogamau lakes (0.61 mg/kg), followed by Lac Chibougamau far from mines (0.44 mg/kg), Lac Chibougamau and Lac aux Dorés near the mines (0.37 and 0.34 mg/kg), Lac aux Dorés far from the mines (0.28 mg/kg), and Lac Waconichi (0.22 mg/kg).

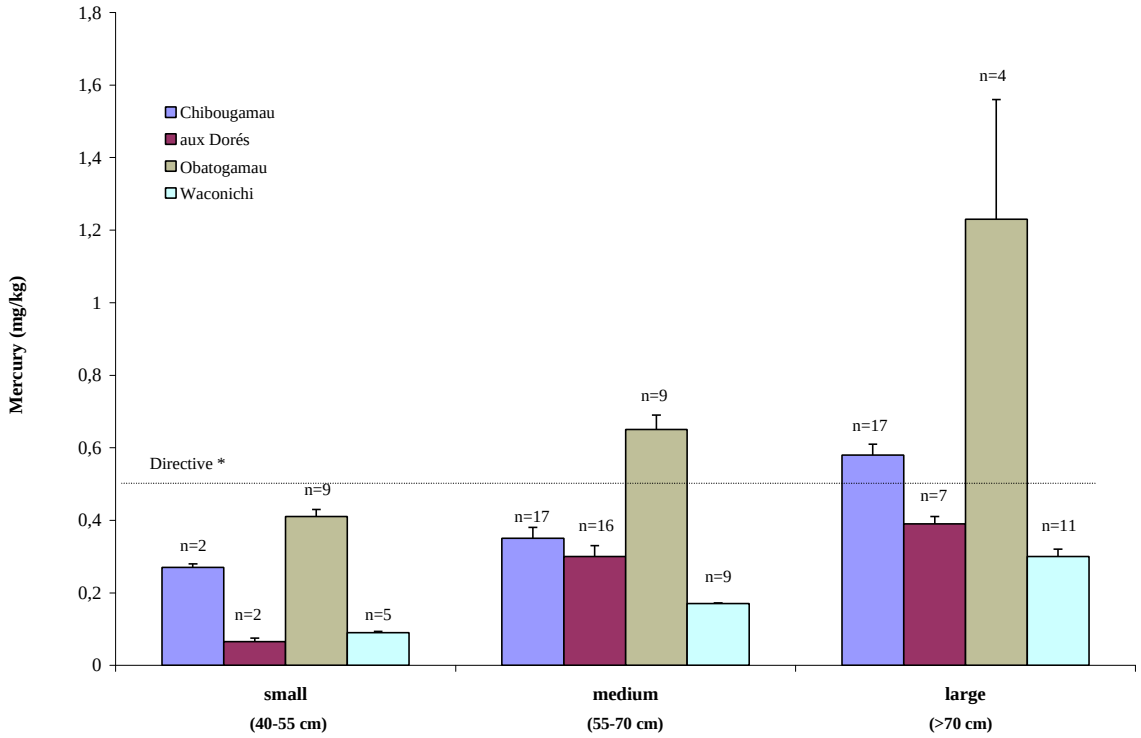

Figure 11 Comparison of mercury levels in relation to the size of northern pike (*Esox lucius*) caught in four lakes in northern Québec in 2001

* The dotted line represents the 0.5 mg/kg standard for the commercial sale of fishery products (HWC, 1986).

Table 7: Average mercury levels of three fish species caught in 2001 in two lakes in northern Québec in relation to their proximity to mining infrastructure.

Lake	Species	Average mercury level					
		Small		Medium		Large	
		Near	Far	Near	Far	Near	Far
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Chibougamau	Lake trout	0.49 (2)	0.28 (1)	**0.85 (9)**	**0.87 (9)**	**0.70 (4)**	**1.08 (6)**
	Northern pike	0.27 (2)	-	0.38 (9)	0.31 (8)	**0.57 (10)**	**0.59 (7)**
	Walleye	0.27 (10)	0.27 (8)	0.41 (9)	0.42 (9)	0.42 (8)	**0.57 (6)**
Aux Dorés	Lake trout	0.45 (9)	0.41 (9)	**0.76 (6)**	**0.53 (8)**	**1.19 (6)**	**0.75 (6)**
	Northern pike	0.08 (1)	0.05 (1)	0.35 (9)	0.24 (7)	**0.55 (2)**	0.33 (5)
	Walleye	0.29 (9)	0.23 (9)	0.37 (9)	0.26 (9)	0.37 (16)	0.37 (11)

The figures in parentheses show the number of fish sampled.

A comparison in results based on fish size shows that only the medium (0.56 mg/kg) and large (0.98 mg/kg) walleye caught in the Obatogamau lakes exceeds Health Canada's 0.5 mg/kg standard (figure 12 and table 6) for mercury levels. Moreover, groupings based on distance from the mines indicate that large walleye (0.57 mg/kg) caught in Lac Chibougamau far from the mines have an average mercury level above the standard (table 7). Average mercury levels in walleye from all four lakes, for the same size categories, are below the provincial median for this species Nevertheless, overall results for all four lakes and all size categories show average mercury levels exceeding the guideline of 0.033 mg/kg for the protection of fish-eating terrestrial wildlife.

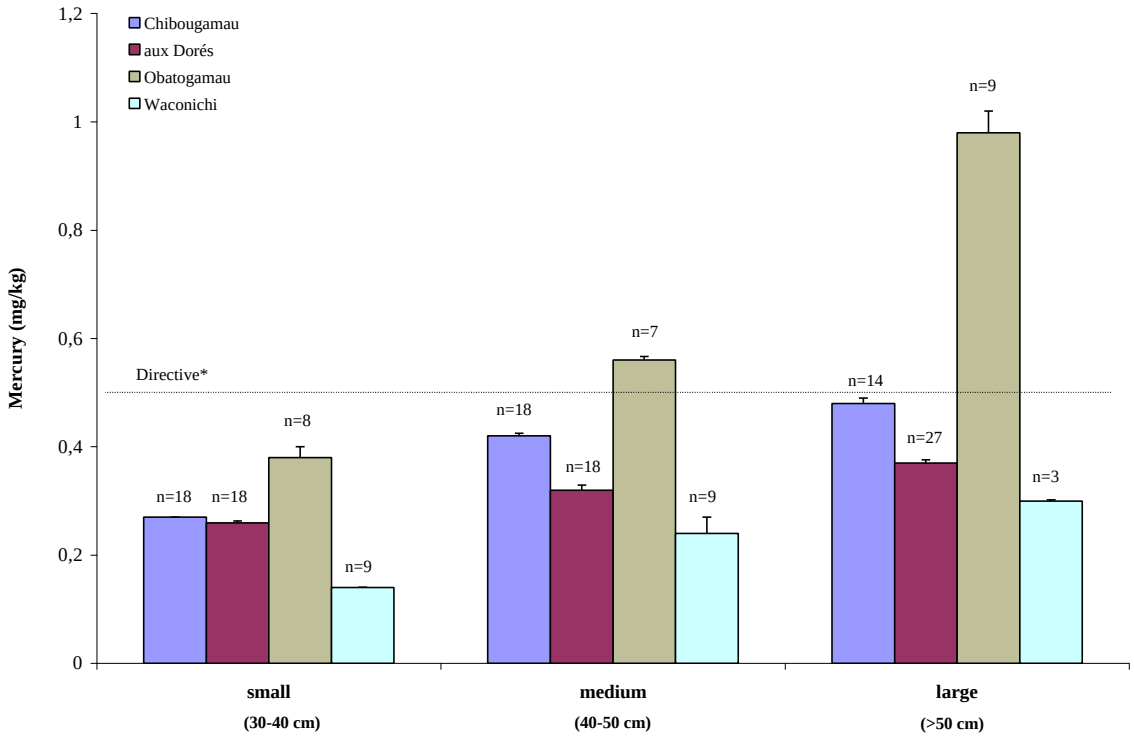

Figure 12 Comparison of mercury levels in relation to the size of walleye (*Stizostedion vitreum*) caught in four lakes in northern Québec in 2001

*The pointed line represents the 0.5 mg/kg standard for the commercial sale of fishery products (HWC 1986).

Lake whitefish and burbot

Mercury concentrations in lake whitefish homogenate range from 0.05 to 0.35 mg/kg, while those in burbot run from 0.22 to 0.65 mg/kg. Burbot show higher mercury levels than lake whitefish (table 8). Meanwhile, burbot from Lac Waconichi seem to have less mercury contamination than burbot from the other three lakes. No lake whitefish homogenate exceeds the Health Canada 0.5 mg/kg standard for the commercial sale of fishery products. In contrast, this level is exceeded in homogenates from large burbot near and far from the Lac Chibougamau mines and near the Lac aux Dorés mines, as well as in homogenates from small, medium, and large burbot from the Obatogamau lakes. For both species, all homogenates exceed the guideline of 0.033 mg/kg for the protection of fish-eating terrestrial wildlife.

Table 8: Average mercury levels of lake whitefish and burbot caught in four lakes in northern Québec; listed according to the size and compared to the provincial median.

Lake	Lake whitefish			Burbot		
	Small (35-40 cm) mg/kg	**Medium** (40-45 cm) mg/kg	**Large** (>45 cm) mg/kg	**Small** (30-45 cm) mg/kg	**Medium** (45-60 cm) mg/kg	**Large** (>60 cm) mg/kg
Chibougamau far	0.12	0.18	0.23	0.44	0.45	**0.61**
Chibougamau near	0.11	0.16	0.35	0.36	0.44	**0.60**
aux Dorés far	0.05	0.07	0.08	-	0.31	0.44
aux Dorés near	0.15	0.12	0.14	0.34	0.39	**0.54**
Obatogamau	0.07	0.11	0.22	**0.57**	**0.57**	**0.65**
Waconichi	0.09	0.10	0.17	0.25	0.22	0.29
Provincial mercury median	0.14	0.17	0.25	0.31	0.46	0.68

Metal concentrations in fish

Arsenic

Arsenic concentrations in fish vary from <0.05 to 0.1 mg/kg, with a median level of 0.05 mg/kg. The levels are all very low and well below Health Canada's 3.5 mg/kg standard concerning fish protein (table 9).

Cadmium

Cadmium concentrations in fish flesh range from 0.012 to 0.033 mg/kg, with a median level of 0.018 mg/kg. Levels remain low and vary little from the median level. There is no standard for cadmium concerning the commercial sale of fishery products.

Table 9: Concentrations of metals, PCB, and dioxins and furans in five species of fish from four lakes in northern Québec

Species	Size		As	Cd	Cu	Cr	Mn	Pb	Se	Sr	Zn	PCB	Fat	Dioxins and furans
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	%	ng/kg
		Min	<0.05	0.012	0.06	<0.05	<0.05	<0.10	0.25	<0.05	3.0	1.0	0.20	0.000
		Max	0.10	0.033	0.52	0.18	0.29	0.14	0.58	0.80	6.5	740	4.70	2.129
		Median	0.05	0.018	0.24	0.07	0.08	<0.10	0.37	0.07	3.8	15.0	0.80	0.043
		Lakes												
Lake trout	large	Chibougamau far	0.07	0.019	0.52	<0.05	<0.05	<0.10	0.37	<0.05	3.5	290.0	2.76	1.355
	large	Chibougamau near	0.06	0.018	0.39	0.06	<0.05	<0.10	0.48	<0.05	3.2	110.0	2.19	0.806
	large	aux Dorés far	<0.05	0.017	0.26	0.07	<0.05	0.10	0.53	0.07	3.3	350.0	2.71	1.332
	medium	aux Dorés near	<0.05	0.017	0.43	0.10	0.05	<0.10	0.39	<0.05	3.1	160.0	2.96	0.691
	large	aux Dorés near	0.08	0.012	0.47	0.09	<0.05	0.11	0.58	<0.05	3.3	740.0	4.70	2.129
	medium	Waconichi	0.06	0.019	0.28	0.08	0.11	<0.10	0.34	0.07	3.1	37.0	2.36	0.656
Northern pike	large	Chibougamau far	0.07	0.016	0.24	0.06	<0.05	<0.10	0.40	0.05	3.4	12.0	0.58	0.018
	large	Chibougamau near	0.07						0.35			10.0	0.26	0.008
	large	aux Dorés far	<0.05	0.030	0.29	0.09	0.21	<0.10	0.36	0.15	4.0	6.4	0.44	0.010
	large	aux Dorés near	<0.05	0.017	0.26	0.10	0.08	0.11	0.36	0.07	3.7	7.0	0.27	0.000
	large	Obatogamau	<0.05	0.016	0.27	0.06	0.12	0.12	0.41	0.10	4.6	1.3	0.38	0.040
	large	Waconichi	<0.05	0.022	0.20	0.07	0.14	<0.10	0.37	0.07	3.8	1.4	0.66	0.025
Walleye	large	Chibougamau far	0.05	0.016	0.32	0.05	0.06	<0.10	0.39	0.07	4.5	21.0	0.86	0.017
	large	Chibougamau near	0.05	0.020	0.25	0.06	0.08	<0.10	0.37	<0.05	4.3	39.0	1.33	0.110
	large	aux Dorés far	<0.05	0.023	0.23	0.07	0.06	<0.10	0.42	<0.05	4.7	40.0	2.29	0.118
	large	aux Dorés near	<0.05	0.020	0.22	0.18	0.05	<0.10	0.37	0.08	5.2	19.0	0.74	0.018
	large	Obatogamau	0.05	0.019	0.20	0.09	0.08	0.12	0.42	0.12	3.8	2.9	1.24	0.050
	petit	Waconichi	<0.05	0.018	0.18	0.12	0.08	<0.10	0.32	0.12	4.6	na	na	0.007
	medium	Waconichi	<0.05	0.032	0.15	0.07	0.09	<0.10	0.34	0.14	6.5	na	na	0.048
	large	Waconichi	<0.05	0.014	0.22	0.07	<0.05	<0.10	0.35	<0.05	4.5	2.5	0.92	0.007
Lake whitefish	large	Chibougamau far	0.05	0.023	0.14	0.08	0.08	<0.10	0.53	0.28	3.0	6.0	0.33	0.029
	large	Chibougamau near	0.05	0.031	0.23	0.06	<0.05	<0.10	0.46	0.10	3.1	48.0	0.57	0.063
	large	aux Dorés far	<0.05	0.023	0.22	0.07	0.20	<0.10	0.44	0.29	3.2	17.0	0.88	0.062
	large	aux Dorés near	<0.05	0.020	0.22	0.09	0.09	0.10	0.45	0.13	3.4	40.0	1.21	0.177
	large	Obatogamau	<0.05	0.023	0.19	0.07	0.16	<0.10	0.54	0.20	3.7	5.6	2.05	0.156
	large	Waconichi	0.10	0.015	0.06	0.06	0.07	0.10	0.54	<0.05	3.6	14.0	1.65	0.268
Burbot	large	Chibougamau far	0.07	0.017	0.31	0.06	<0.05	<0.10	0.30	0.09	5.3	33.0	0.45	0.012
	large	Chibougamau near	0.08	0.016	0.21	0.07	0.06	<0.10	0.28	0.05	4.5	16.0	0.58	0.017
	large	aux Dorés far	<0.05	0.012	0.27	0.07	0.14	<0.10	0.31	0.05	5.8	4.9	0.45	0.011
	large	aux Dorés near	0.05	0.015	0.27	0.10	0.12	0.10	0.25	0.10	5.8	25.0	0.52	0.045
	large	Obatogamau	0.05	0.033	0.22	0.10	0.29	0.14	0.29	0.80	3.2	1.0	0.46	0.004
	large	Waconichi	0.05	0.020	0.24	0.09	0.15	<0.10	0.28	0.28	5.9	3.5	0.20	0.011

Lake trout : medium (55-70 cm), large (>70 cm)
Northern pike :large (>70 cm)
Yellow walleye : small (30-40 cm), medium (40-50 cm), large (>50 cm)
Lake whitefish : large (>45 cm)
Burbot : large (>60 cm)

Chromium

Chromium concentrations in fish flesh run from <0.05 to 0.18 mg/kg, with a median level of 0.07 mg/kg. Levels remain low and vary little from the median level. Only the highest concentration, measured in large walleye from Lac aux Dorés caught near the mines, stands out from the group, while the other species present no notable chromium levels in this same area. There is no standard for chromium concerning the commercial sale of fishery products (table 9).

Copper

Copper concentrations vary from 0.06 to 0.52 mg/kg, with a median level of 0.24 mg/kg. Differences between measurements are only minor and do not allow for distinctions between particular sectors. Lake trout is the species with the high copper concentrations, especially in Lac Chibougamau far from the mines (0.52 mg/kg) and in Lac aux Dorés near the mines (0.47 mg/kg). There is no standard for copper concerning the commercial sales of fishery products (table 9).

Manganese

Manganese concentrations in fish varied from <0.05 à 0.29 mg/kg, with a median value of 0.08 mg/kg. Minor differences were observed between most measurements. Only the highest level measured in burbot from the Obatogamau lakes (0.29 mg/kg) stands out somewhat from the others, though it approximates the level measured in Lac Waconichi (the control lake) for the same species (0.15 mg/kg). There is no standard for manganese concerning the commercial sale of fishery products (table 9).

Lead

Lead concentrations range from <0.10 to 0.14 mg/kg, with a median level of <0.10 mg/kg and very little variation. Only a few samples exceeded the detection limit. Most of these came from different species caught in the Obatogamau lakes or Lac aux Dorés in areas near the mines. All levels are well below Health Canada's 0.5 mg/kg standard concerning fish protein.

Selenium

Selenium concentrations ranged from 0.25 to 0.58 mg/kg, with a median level of 0.37 mg/kg. Variations between measurements remained relatively low, meaning it is not possible to distinguish any particular sector. Levels for each species were very similar regardless of where they were caught, including Lac Waconichi (the control lake). Lake whitefish (0.44 to 0.54 mg/kg) and large lake trout (0.37 to 0.58 mg/kg) seemed to show the highest levels. There is no standard from selenium concerning the commercial sale of fishery products (table 9).

Strontium

Strontium concentrations varied from <0.05 to 0.80 mg/kg, with a median level at 0.07 mg/kg. The levels remained relatively low and only five of them exceeded 0.15 mg/kg. The highest levels were measured in burbot (0.80 mg/kg) and lake whitefish (0.20 mg/kg) from the Obatogamau lakes, in lake whitefish (0.29 and 0.28 mg/kg) caught far from the mines in Lac Chibougamau and Lac aux Dorés, and in burbot (0.28 mg/kg) in Lac Waconichi. Differences in strontium levels do not seem linked to any particular site and are similar to those measured in Lac Waconichi for the same species. Lake trout show the lowest strontium concentrations (<0.05 à 0.07 mg/kg). There is no standard for strontium concerning the commercial sale of fishery products (table 9).

Zinc

Zinc concentrations range from 3.0 to 6.5 mg/kg, with a median level at 3.8 mg/kg. For each species, zinc levels vary little according to site and are comparable to those of Lac Waconichi (the control lake). The highest levels are observed in walleye (3.8 to 6.5 mg/kg) and burbot (3.2 to 5.9 mg/kg). There is no standard for zinc concerning the commercial sale of fishery products (table 9).

PCBs

PCB concentrations vary widely, ranging from 1.0 to 740 µg/kg, with a median level at 15 µg/kg. The highest levels were found in lake trout from Lac aux Dorés near the mines 740 and 160 µg/kg, and far from the mines 350 µg/kg), and from Lac Chibougamau (far from mines 290 µg/kg, near mines 110 µg/kg). After having taken the percentage of fat into account[6], measurements showed only a small difference between the northern and southern sectors of Lac Chibougamau and Lac aux Dorés. Compared to previous PCB levels, those from Lac Waconichi are much lower (37 µg/kg). The other species had levels lower (1 to 48 µg/kg) than lake trout. Among these, levels measured in Lac Waconichi (1.4 to 14 µg/kg) and the Obatogamau lakes (1.0 to 5.6 µg/kg) are the lowest. No PCB level in fish exceeded Health Canada's 2,000 µg/kg standard for the commercial sale of fishery products. Only three lake trout homogenates showed PCB levels above the guideline of 160 µg/kg for the protection of fish-eating terrestrial wildlife.

Dioxins and furans

Dioxin and furan levels expressed as toxic equivalents to 2,3,7,8-TCDD range from undetected to 2.129 ng/kg, with a median level at 0.043 ng/kg. Of the five fish species analysed, lake trout had the highest 2,3,7,8-TCDD toxic equivalent levels. For this species, the highest levels were measured in large fish caught in Lac aux Dorés near (2.129 ng/kg) and far (1.332 ng/kg) from the mines, and in Lac Chibougamau far from the mines (1.355 ng/kg). As with PCB, these measurements show no notable difference between the northern and southern sectors of Lac

[6] PCB levels in fish generally increase with the percentage of fat in the tissue analysed.

Chibougamau and Lac aux Dorés once the fat percentage is taken into account. Lac Waconichi shows the lowest levels (0.656 ng/kg), equalling those at Lac aux Dorés near the mines (0.691 ng/kg) in medium-sized specimens. These levels in lake trout are also linked to the high percentage of fat in lake trout compared to other species. The latter have much lower levels than lake trout and show no particular differences between sites, including Lac Waconichi (the control lake). All these measurements are far below the Health Canada 15 ng/kg standard for the commercial sale of fishery products.

Of the five fish species analysed, only lake trout from Lac Chibougamau and Lac aux Dorés show 2,3,7,8-TCDD toxic equivalent levels above the guideline (0.66 ng/kg; U.S. EPA, 1995) for the protection of fish-eating terrestrial wildlife.

INTERPRETATION OF THE RESULTS

Mining effluents

In the two effluents analysed, a number of metals were detected, but all levels remain below directive 019 for mine effluents. Among the metals measured, copper and strontium show the highest concentrations. The E-01 effluent from the Eaton Bay tailings site, which receives the mine drainage water from Copper Rand, show concentrations higher than those of the E-02 effluent from the Copper Rand mine tailings site. Moreover, result of a bioassay with daphnia carried out in 2002 by the Ministère de l'Environnement showed that the effluent of the mining water basin of the Copper Rand mine was toxic and did not meet the directive 019.

Sediments and mine tailings

Mercury concentrations in sediments are mostly at an average level (0.08 mg/kg). Abnormally high levels are found at site S-03 (0.34 mg/kg) near Henderson I, S-15 (0.16 mg/kg) south of the Principale waste site, S-13 (0.10 mg/kg) at the foot of the Principale site, and S-06 (0.09 mg/kg) near the Copper Rand mine at Pointe Machin. All levels remain below the probable effect limit (0.49 mg/kg) and appear unlikely to produce harmful effects on benthic organisms. However, site S-06 (Pointe Machin), being the former waste site for untreated drainage water from the Copper Rand mine site, requires a specialized interpretation of results. At present, this water is sent to the basin of the Eaton Bay tailings site. It should also be noted that mine tailings are found nearby, beneath waste rock heaps, and that these tailings have been partly washed out toward Lac aux Dorés.

The mine tailings do not appear to be a source of mercury contamination because mercury was detected in only one of four sites and only at a very low level, slightly above the detection limit.

Among the metals measured in sediments from Lac Chibougamau and Lac aux Dorés, five near mining installations had abnormally high levels compared to the natural environment and are likely to cause harmful effects to benthic organisms. The five are arsenic, copper, nickel, zinc, and cadmium. The highest levels are observed at site S-06 near the Copper Rand mine and at sites S-10, S-11, S-12, S-13, and S-15 near the Principale mine. These sites are all located at Lac

aux Dorés. The first three of these metals were sampled at sites S-18 et S-19 near the Eaton Bay site in Lac Chibougamau in addition to the sites already mentioned (table 5). However, given the different types of mineralization that occur at these sites, it was not possible to precisely distinguish the proportion of metals natural in origin from the proportion of metals anthropic in origin. For sediments, the arsenic, copper, and zinc levels measured by Covel and Masters (2001) were similar to those measured in this study.

The analyses of mine tailings taken from the Eaton Bay, Copper Rand, and Principale waste sites show that concentrations of the above metals (with the exception of cadmium which was not measured) were all present at levels likely to be a source of contamination for the aquatic environment.

In general, the concentrations of various metals measured at reference sites S-16 and S-17 (Îles de Commissaires and Pointe Needle) were above the respective median levels (table 6). Site S-16 shows very low metal concentrations compared to the other sampling sites, with the exception of chromium and strontium (table 6) for which levels exceed median levels. At site S-17, only mercury and lead concentrations exceed median levels.

Fish

Statistical analyses show that in 2001 mercury levels in walleye, northern pike, and lake trout from Lac Chibougamau tend not to be higher near the mines (0.37, 0.39, and 0.75 mg/kg) than far from the mines (0.44, 0.34, and 0.79 mg/kg). Walleye from this lake actually shows lower levels near the mines. These data thus provide no link between mining activity and the presence of mercury in fish from Lac Chibougamou. When comparing levels from different dates, mercury levels of lake trout caught in 2001 (0.75 mg/kg) close to mines, were significantly below those measured in 1999 (1.29 mg/kg). This difference came about as specimens caught in 1999 were larger and much older than those caught in 2001 (appendix 1, figure 17). For walleye caught far from the mines, levels were similar in 1998 and 2001 (0.47 and 0.44 mg/kg).

At Lac aux Dorés, the three species studied (walleye, northern pike, and lake trout) have higher mercury levels near the mines (0.34, 0.38, and 0.74 mg/kg) than far from the mines (0.28, 0.26, and 0.54 mg/kg). However, mercury levels in the three species at Lac aux Dorés near the mines are comparable to or lower than (in the case of walleye) those at Lac Chibougamau far from the mines. This suggests that mining activity does not contribute to an increase in mercury levels in fish from Lac aux Dorés. The only sample from mine tailings that had mercury, showed a level close to the detection limit. The levels observed in fish may be due to the lake's natural characteristics.

The lower levels observed at Lac aux Dorés, far from the mines, may be due to different physiographic conditions or to the presence of high toxicity in the sediments, which would reduce the microbial activity that causes the methylation of mercury. The area far from the mines is located downstream from sites with sediments containing several metals that are potentially toxic for benthic organisms. Since the flow of water from Lac aux Dorés goes toward this sector, it is possible that the sediments are contaminated by these metals. However, no sediments were

analysed in this sector. Another hypothesis was that growth rates of fish are different in the two sectors. However, this hypothesis did not hold, as growth rates proved to be similar for both sectors of Lac aux Dorés (appendix 1, figure 18). Moreover, results of the statistical analysis show mercury levels of trout lake caught in 2000 and 2001 close to mines in Lac aux Dorés to be similar.

Mercury concentrations of fish in the Obatogamau lakes are higher than in Lac Chibougamau, Lac aux Dorés, and Lac Waconichi (the control lake). Nevertheless, current data does not allow for correlations between mining activity and mercury levels in fish from the Obatogamau lakes. Sampling of sediments and fish at a site far from mining activity is needed to test this hypothesis. The differences between the lakes could be of natural origin and attributable to physiographic conditions and still remains to be explained.

For the four lakes studied, average mercury levels for small, medium, and large walleye, northern pike, and lake trout were generally lower or similar to the median levels of all of Québec (table 6). Only the levels of large northern pikes caught in Lac Obatogamau and medium sized lake trout from Lac Chibougamau averaged on mercury levels that appear to be slightly more elevated.

Among the substances analysed, only mercury exceeded the Health Canada standard for the commercial sale of fishery products. The standard for mercury is 0.5 mg/kg. This limit is exceeded, however, only by medium-sized or large lake trout caught in Lac Chibougamau and Lac aux Dorés, by large northern pike from Lac Chibougamau, and by medium-sized and large northern pike and walleye from the Obatogamau lakes. While burbot of all sizes exceeded this limit in the Obatogamau lakes, large burbot exceeded the limit in Lac Chibougamau, both far from and near the mines, and in Lac aux Dorés near the mines. Nearly all mercury levels exceeded the guideline of 0.033 mg/kg for the protection of fish-eating terrestrial wildlife.

Levels above the Health Canada standard and above the Guideline for the protection of fish-eating terrestrial wildlife are common in Québec's natural environment, occuring in particular with fish-eating species such as walleye, northern pike, and lake trout. More than 50% of the medium and large sized specimen of these fish have mercury levels above 0.5 mg/kg (table 6). The principal cause of this is the atmospheric deposition of mercury and its biomagnification in the food chain, subsequent to its transformation into methyl mercury by aquatic bacteria.

The elevated arsenic, cadmium, copper, nickel, and zinc levels in sediments close to tailings sites had no noticeable effect on the levels measured in fish flesh (table 9), which were similar to those observed at the control lake (Lac Waconichi).

For the more toxic metals such as arsenic (<0.05 – 0.10 mg/kg), cadmium (0.012 – 0.033 mg/kg), chromium (<0.05 – 0.18 mg/kg), and lead (<0.10 – 0.14 mg/kg), levels were weak and often below the detection limit (arsenic and lead) (table 9). Covel et Masters (2001) measured levels below the detection limit for arsenic and chromium (<0.5 mg/kg), cadmium (<0.08 mg/kg), and lead (<0.18 mg/kg) for fish caught in lakes Chibougamau, Aux dorés, and Obatogamau in 2001.

On the other hand, with respect to PCBs as well as to dioxins and furans only 2,3,7,8-TCDD toxic equivalents in lake trout exceed the guidelines of 160 µg/kg et 0.66 ng/kg respectively for the protection of fish-eating terrestrial wildlife.

Lac Chibougamau and Lac aux Dorés have fish with PCB levels that seem higher than in Lac Waconichi and the Obatogamau lakes. As for other substances, it is not possible to distinguish any particular anomalies that may be due to mining activity.

CONCLUSION

In both effluents that were analysed, many metals were detected yet all levels remain below the directive 019 for mining effluents. However, a bioassay carried out in 2002 showed that the effluent of the mining water basin of the Copper Rand mine had toxic level that did not meet the directive 019.

Mercury concentrations in sediments are generally close to the average level (0.08 mg/kg), and mine tailings do not seem to be a source of mercury contamination. Abnormally high levels are perceptible in sediments at sites S-03 (0.34 mg/kg) near Henderson I, S-15 (0.16 mg/kg) south of the Principale waste site, S-13 (0.10 mg/kg) at the foot of the Principal waste site, and S-06 (0.09 mg/kg) near Copper Rand.

Of the metals measured in sediments from Lac Chibougamau and Lac aux Dorés, arsenic, copper, nickel, zinc and cadmium show abnormally high levels near mining installations compared to the natural environment and are likely to cause harmful effects to benthic organisms. However, given the different types of mineralization that occur at these sites, it was not possible to precisely distinguish the proportion of metals natural in origin from the proportion of metals anthropic in origin. These metals (apart from cadmium, which was not measured) are also present in mine tailings at levels likely to be a source of contamination for the aquatic environment.

Statistical analyses show that mercury levels in walleye, northern pike, and lake trout from Lac Chibougamau are no higher near mines than far from them and that these levels are similar to what is found at Lac aux Dorés near the mines. These results do not show that mining activity has caused mercury contamination of fish. When comparing levels of different dates, mercury levels of lake trout caught in 2001 close to mines were significantly lower than those measured in 1999.

At Lac aux Dorés, the three species studied (walleye, northern pike, and lake trout) have higher mercury levels near the mines than far from them. The lower concentrations observed at Lac aux Dorés away from the mines may be due to different physiographic conditions or to toxicity in the sediments.

Mercury levels in fish from the Obatogamau lakes are higher than in lakes Chibougamau, aux Dorés, and Waconichi (the control lake). Current data, however, are insufficient to allow for a correlation between mining activity and mercury levels in fish from the Obatogamau lakes.

Among the metals analysed, only mercury shows levels above the standard set by Health Canada for the commercial sale of fishery products. This 0.5 mg/kg limit for mercury is exceeded only by medium-sized and large lake trout caught in Lac Chibougamau and Lac aux Dorés, by large northern pike from Lac Chibougamau, and by medium-sized and large northern pike and walleye from the Obatogamau lakes. The limit was also found to be exceeded by large burbot from Lac Chibougamau near and far from the mines and from Lac aux Dorés near the mines, as well as by small, medium, and large burbot from the Obatogamau lakes. Mercury levels in all fish analysed exceed the guideline of 0.033 mg/kg for the protection of fish-eating terrestrial wildlife. However, this situation is not uncommon in Québec.

With respect to PCBs and to dioxins and furans, the highest concentrations were found in lake trout from Lac Chibougamau and Lac aux Dorés. However, all levels remained below the Health Canada standard of 2000 µg/kg and 15 ng/kg respectively for the commercial sale of fishery products. Only the levels in lake trout exceeded the guidelines of 160 µg/kg and 0.66 ng/kg for the protection of fish-eating terrestrial wildlife.

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Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area

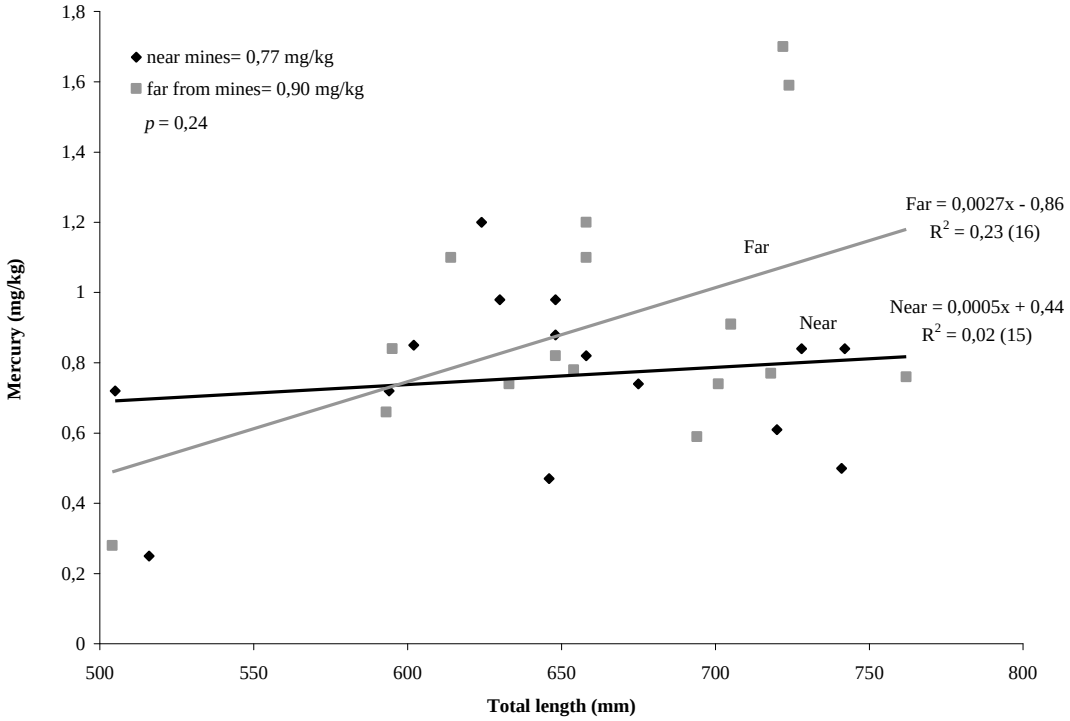

Figure 1 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in Lac Chibougamau in 2001

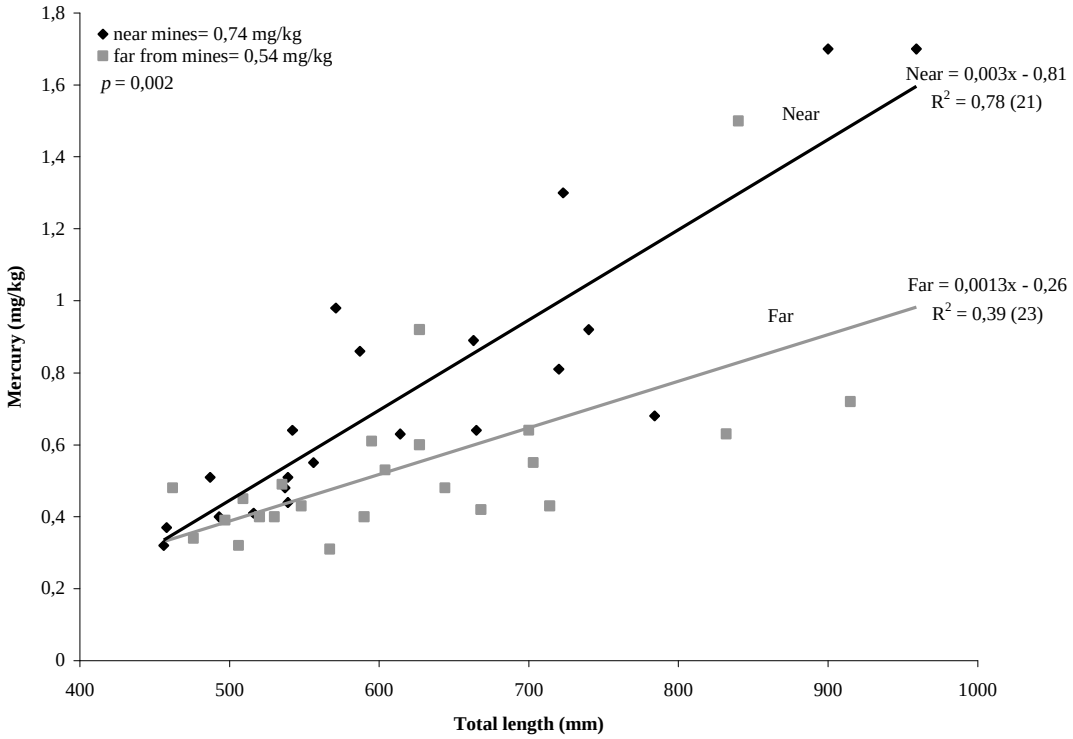

Figure 2 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in Lac aux Dorés in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

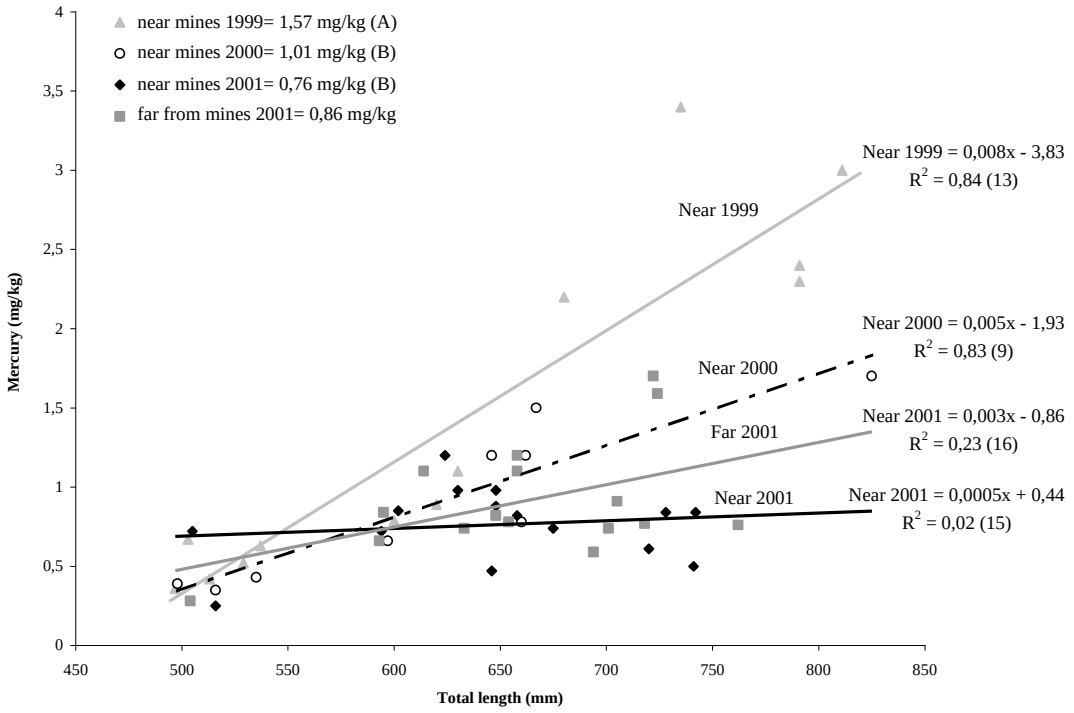

Figure 3 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in Lac Chibougamau from 1999 to 2001

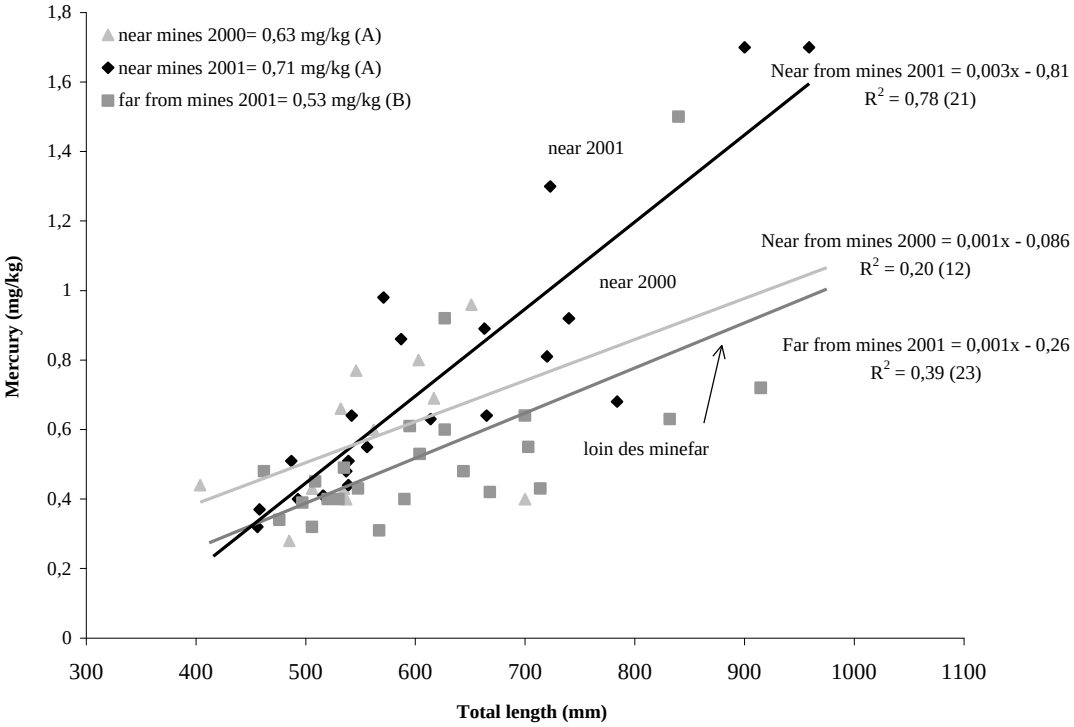

Figure 4 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in Lac aux Dorés in 2000 and 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

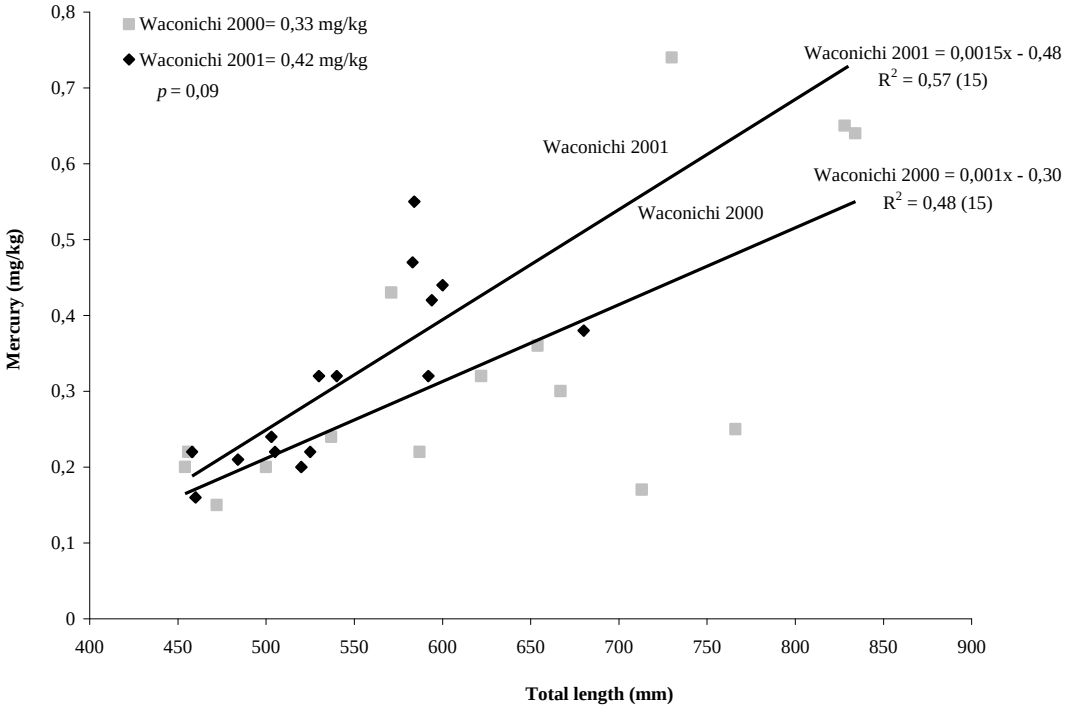

Figure 5 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in Lac Waconichi in 2000 and 2001

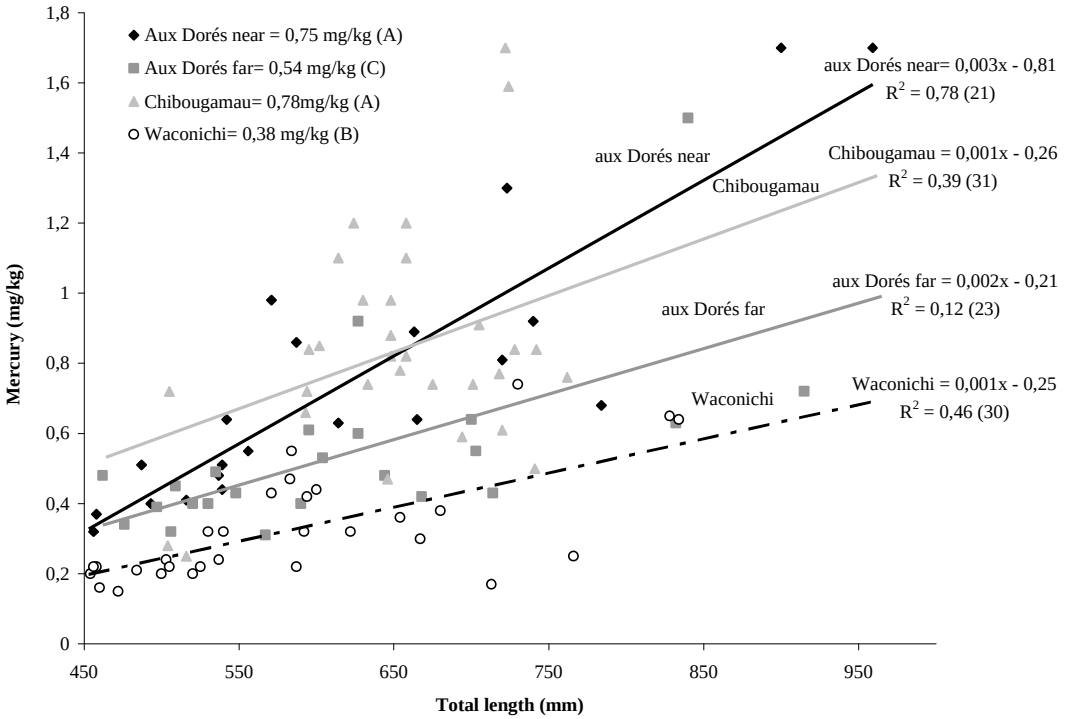

Figure 6 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to length, caught in all three lakes in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

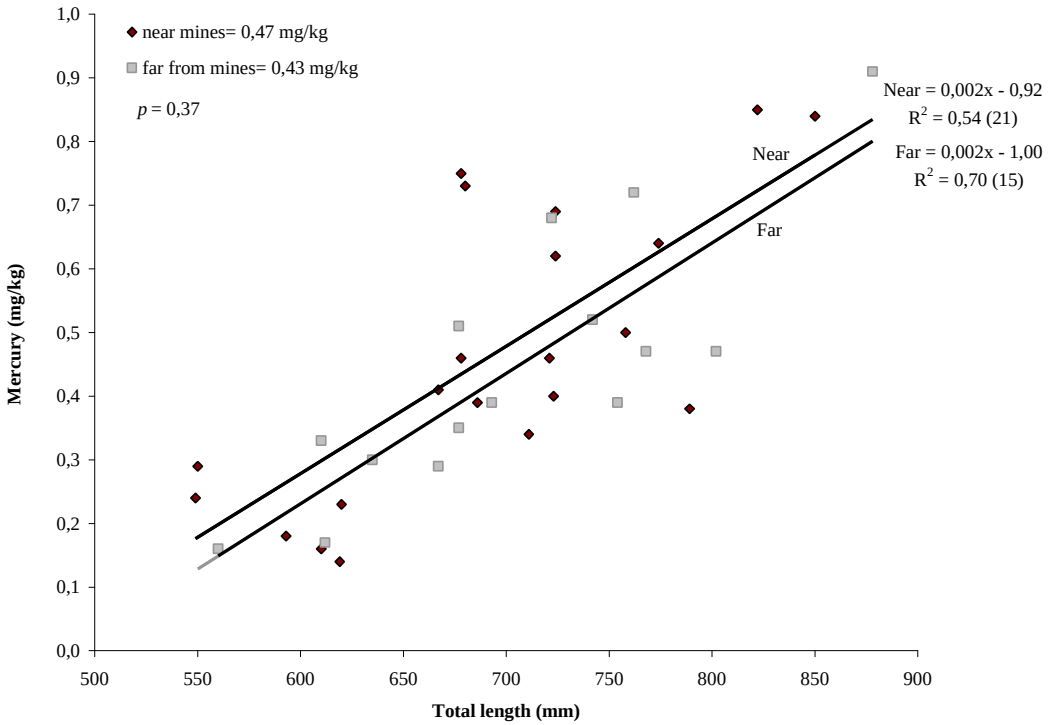

Figure 7 Mercury concentrations in northern pike (*Esox lucius*), according to length, caught in lac Chibougamau in 2001

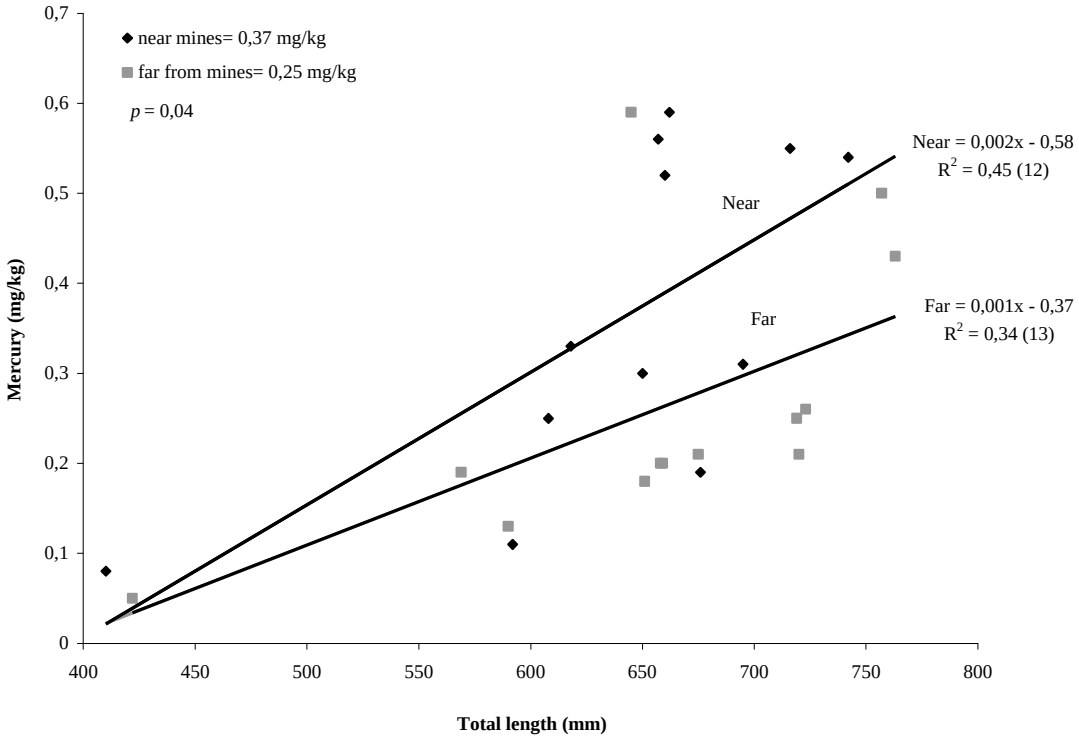

Figure 8 Mercury concentrations in northern pike (*Esox lucius*), according to length, caught in lac aux Dorés in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

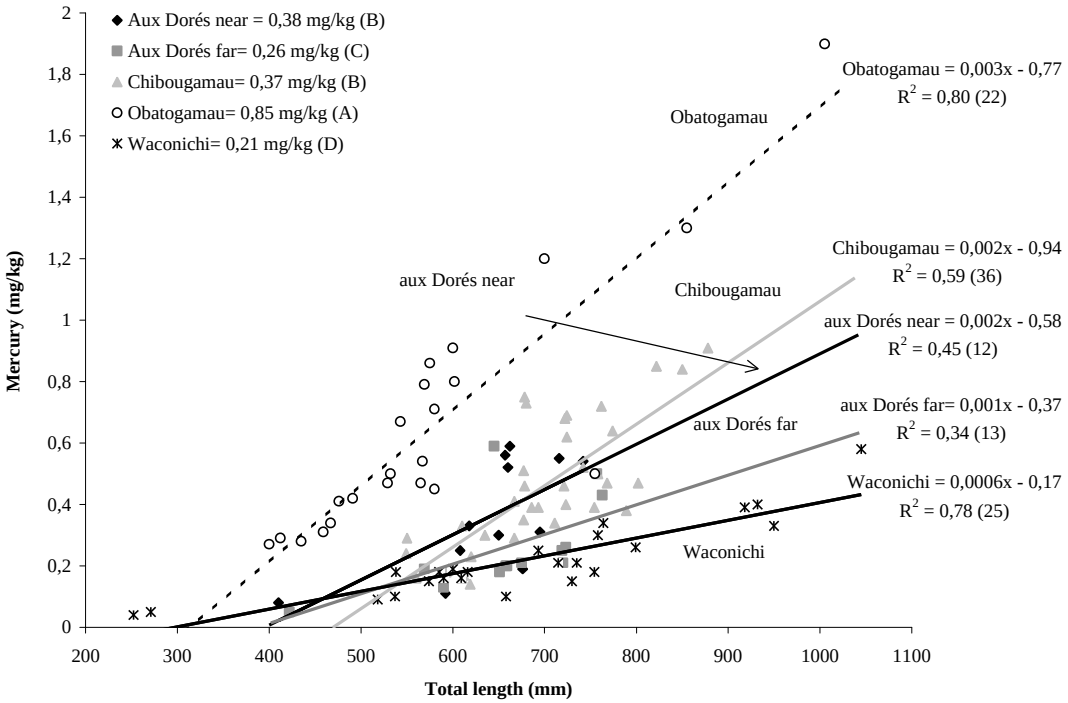

Figure 9 Mercury concentrations in northern pike (*Esox lucius*), according to length, caught in all four lakes in 2001

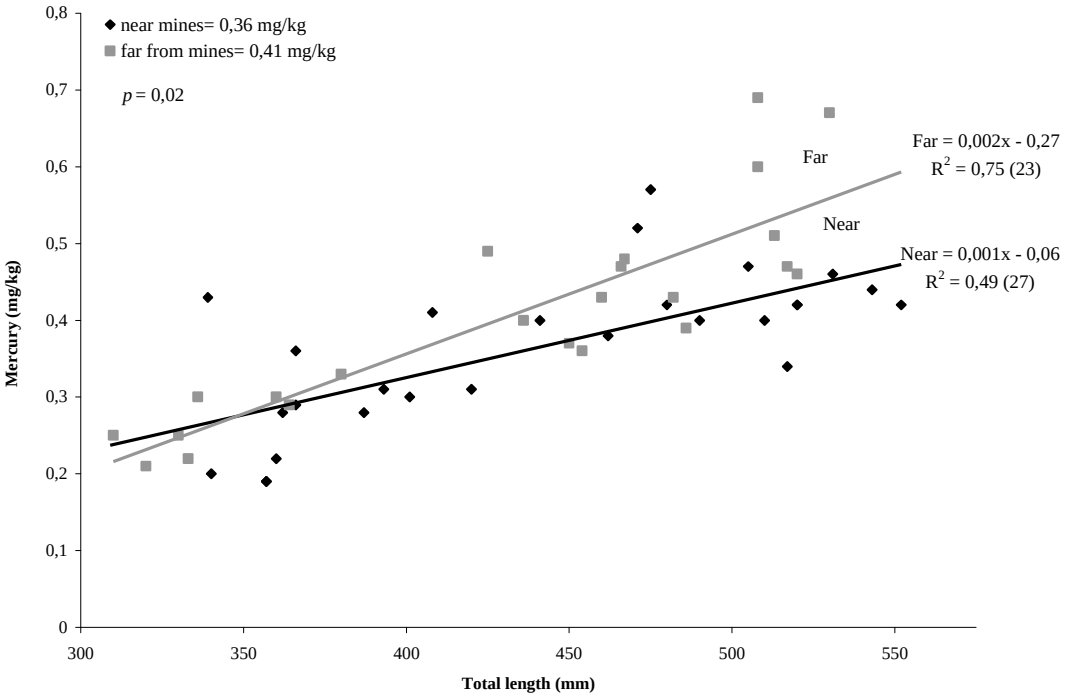

Figure 10 Mercury concentrations in walleye (*Stizostedion vitreum*) according to length, caught in Lac Chibougamau in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

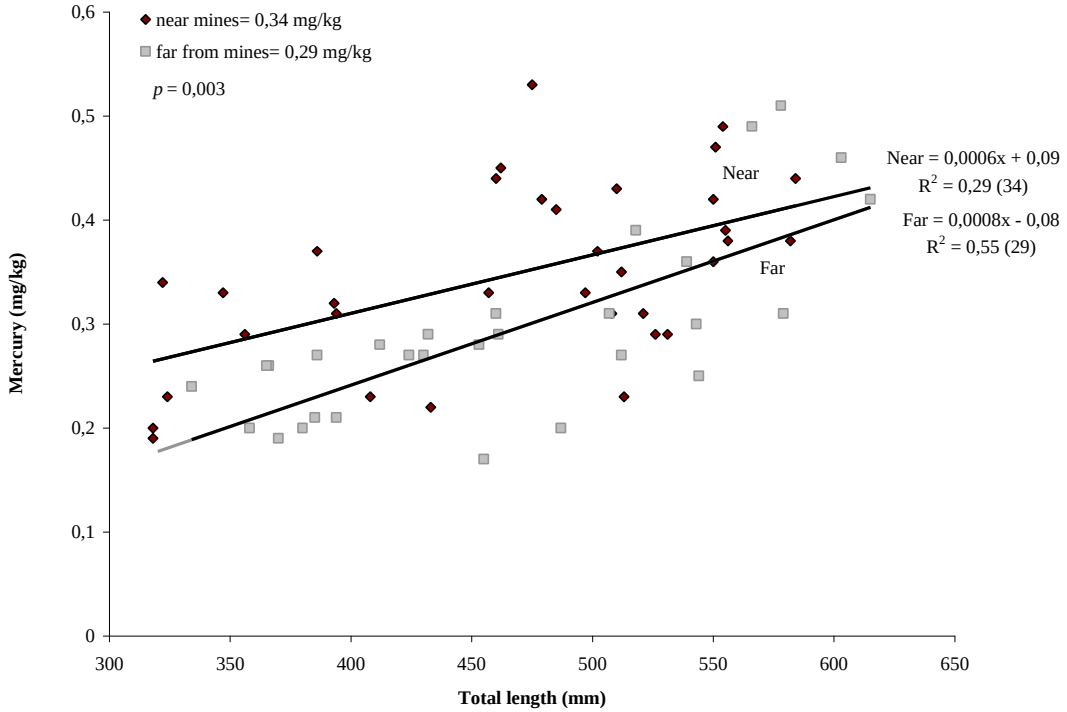

Figure 11 Mercury concentrations in walleye (*Stizostedion vitreum*) according to length, caught in Lac aux Dorés in 2001

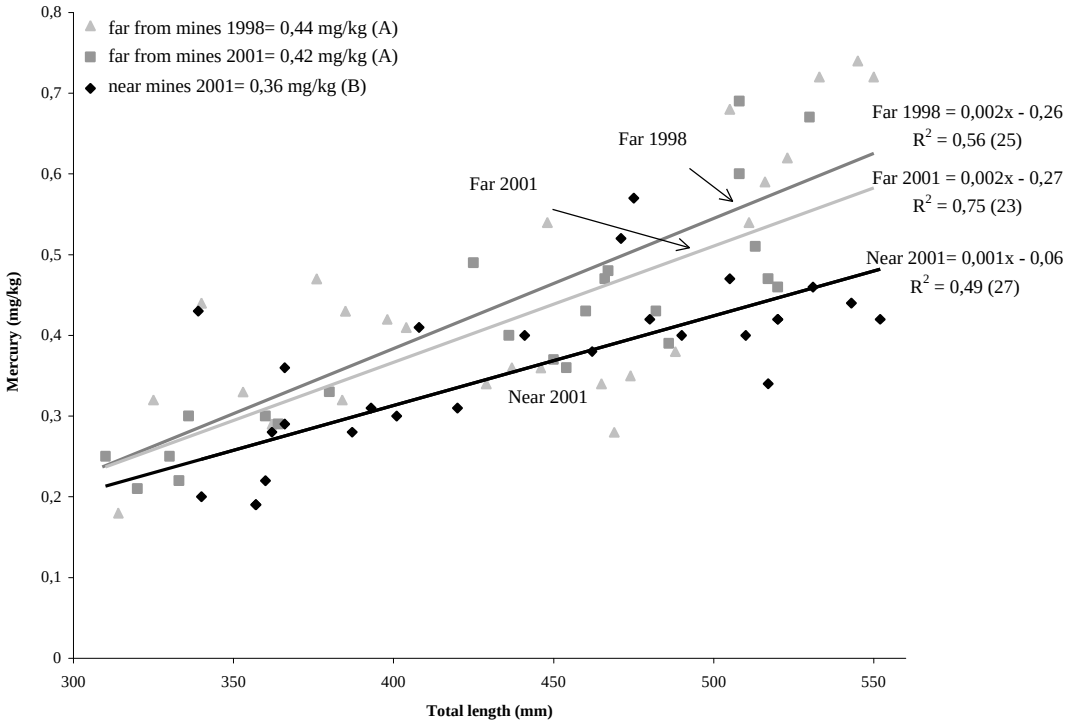

Figure 12 Mercury concentrations in walleye (*Stizostedion vitreum*) according to length, caught in Lac Chibougamau in 1998 and 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

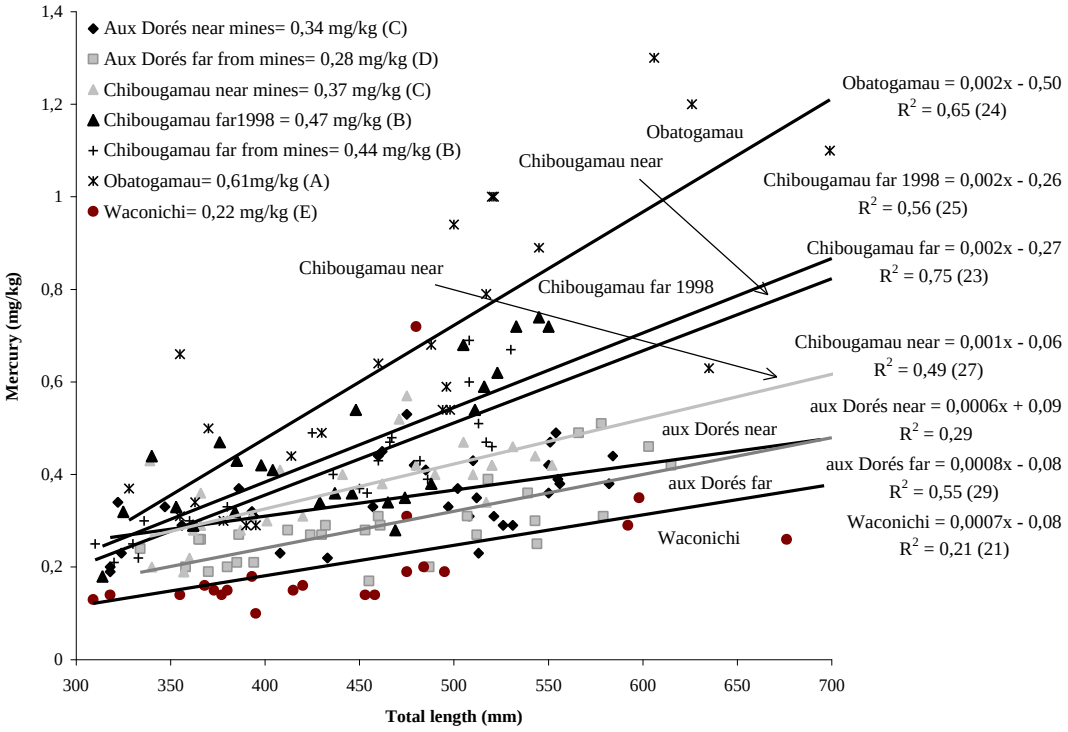

Figure 13 Mercury concentrations in walleye (*Stizostedion vitreum*) according to length, caught in all four lakes in 2001

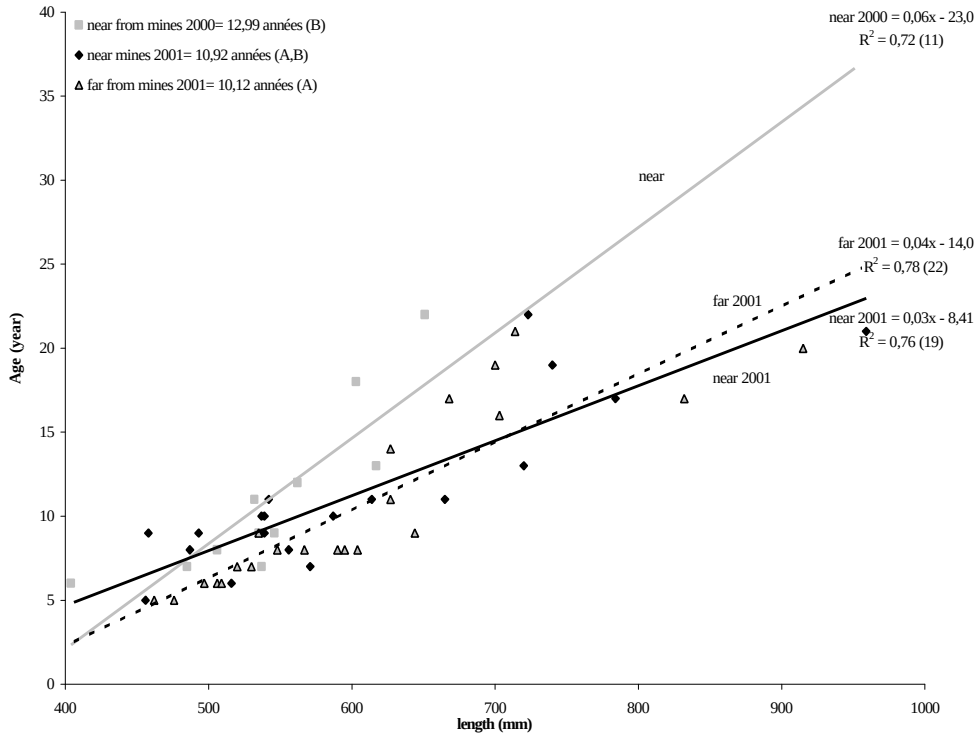

Figure 14 Growth rates of lake trout (*Salvelinus namaycush*) caught in Lac aux Dorés in 2000 and 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

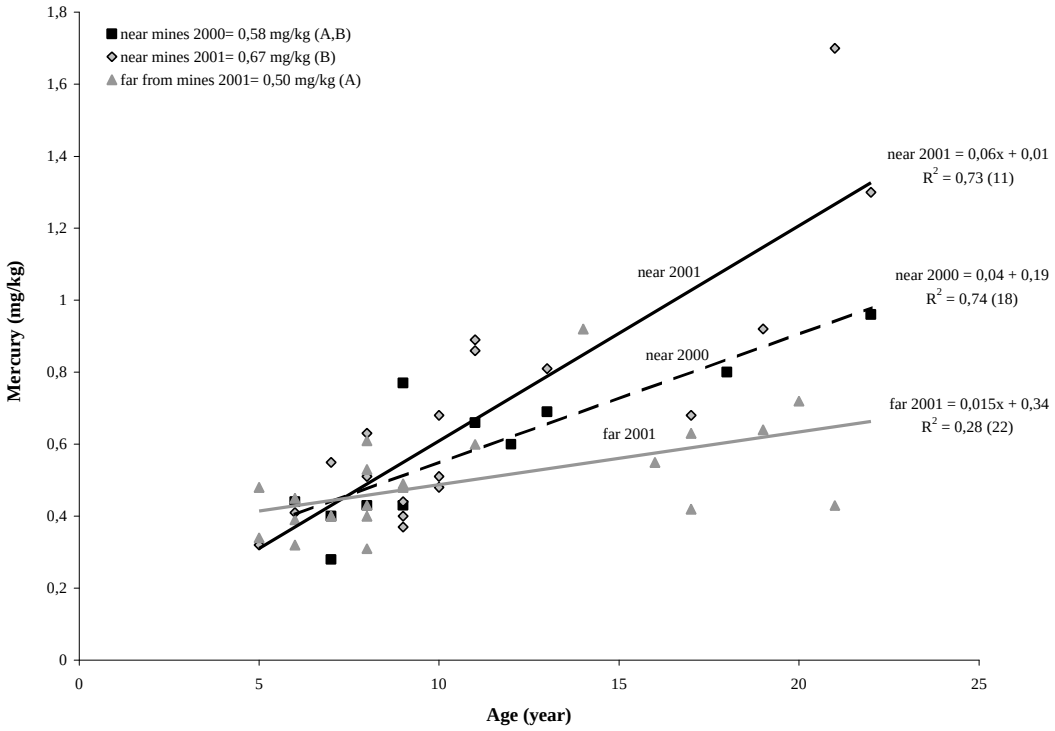

Figure 15 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to age, caught in Lac aux Dorés in 2000 and 2001

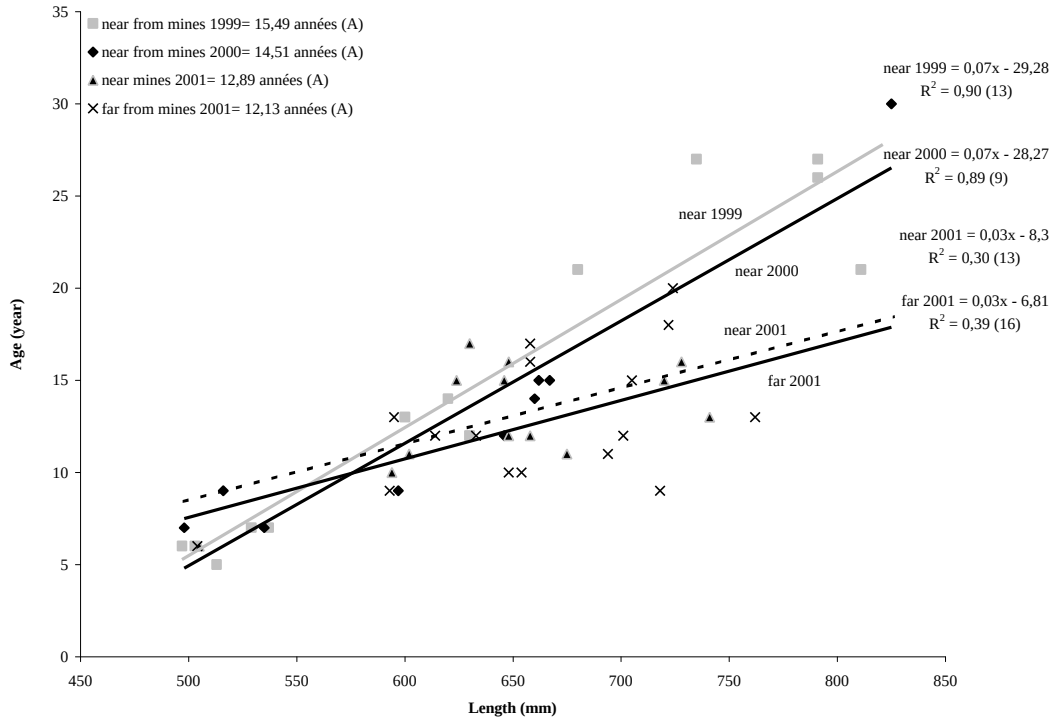

Figure 16 Growth rates of lake trout (*Salvelinus namaycush*) caught in Lac Chibougamau in 1999, 2000 and 2001

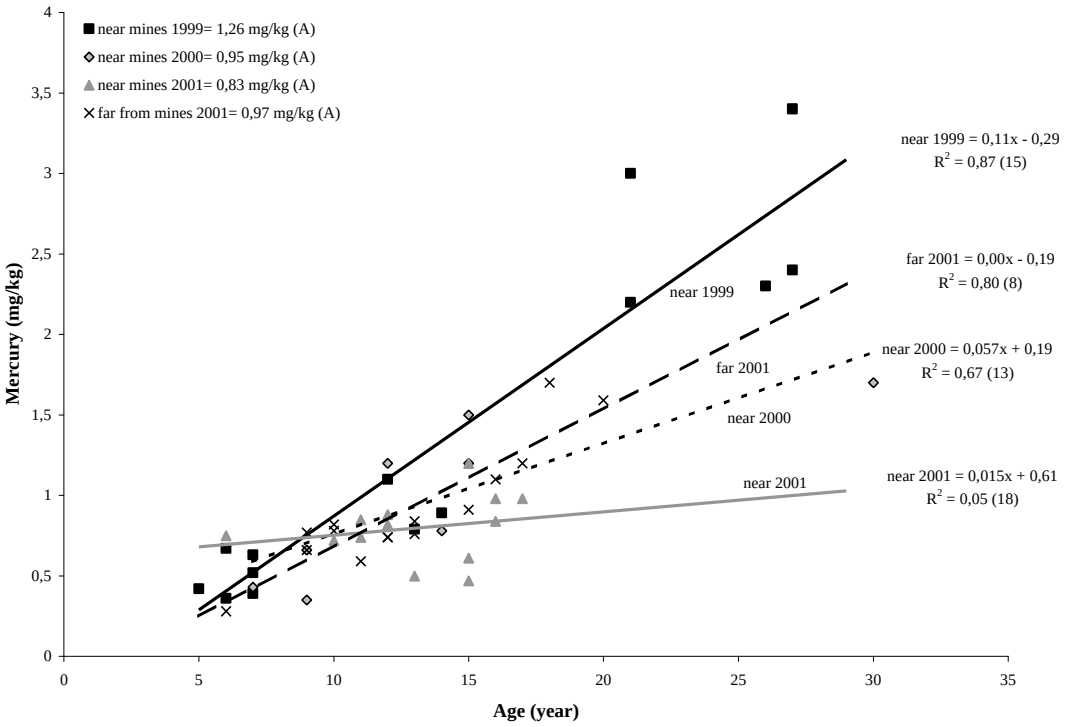

Figure 17 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to age, caught in Lac Chibougamau in 1999, 2000 and 2001

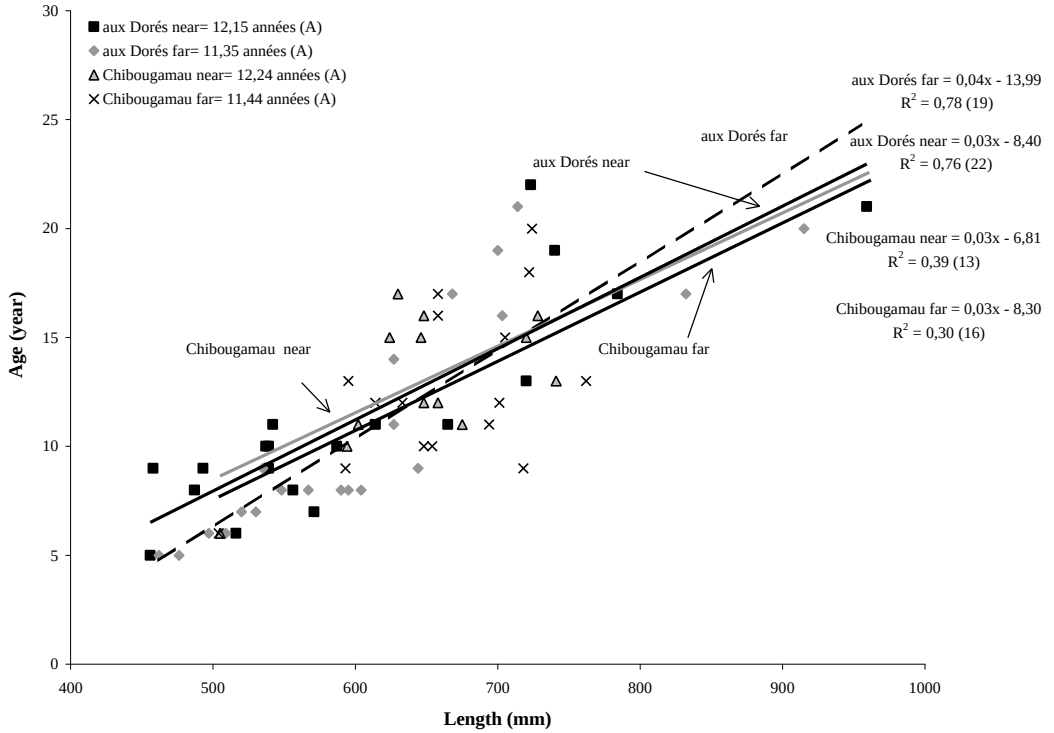

Figure 18 Growth rates of lake trout (*Salvelinus namaycush*) caught in Lac Chibougamau and Lac aux Dorés in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

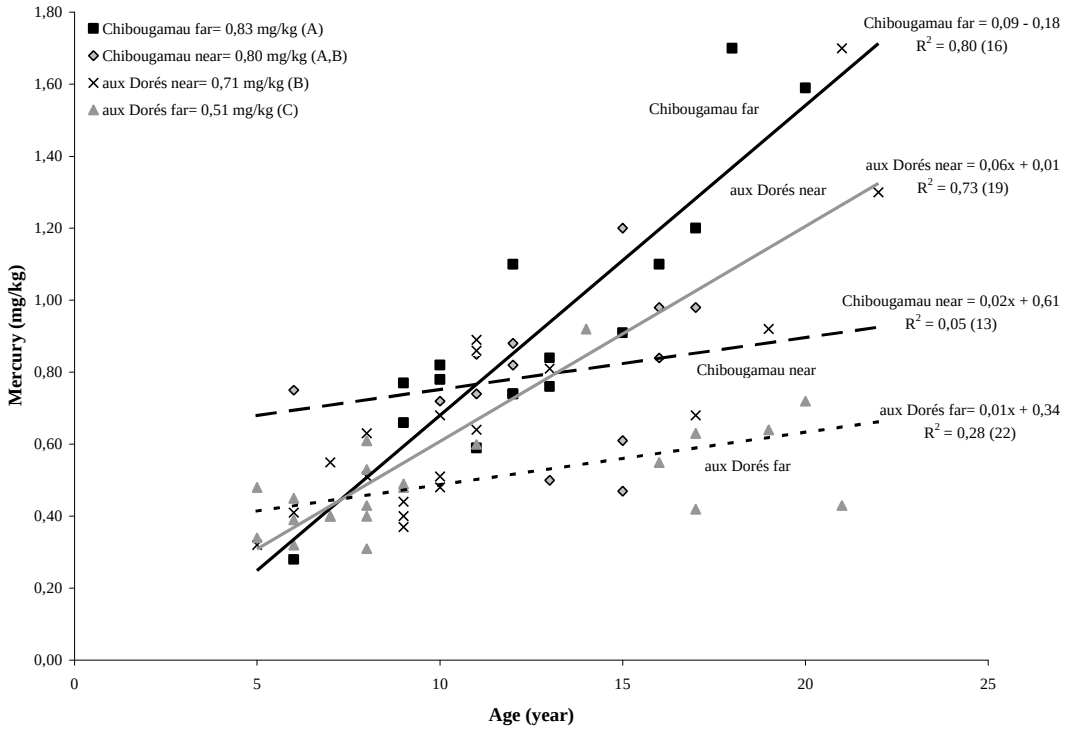

Figure 19 Mercury concentrations in lake trout (*Salvelinus namaycush*) according to age, caught in Lac Chibougamau and Lac aux Dorés in 2001

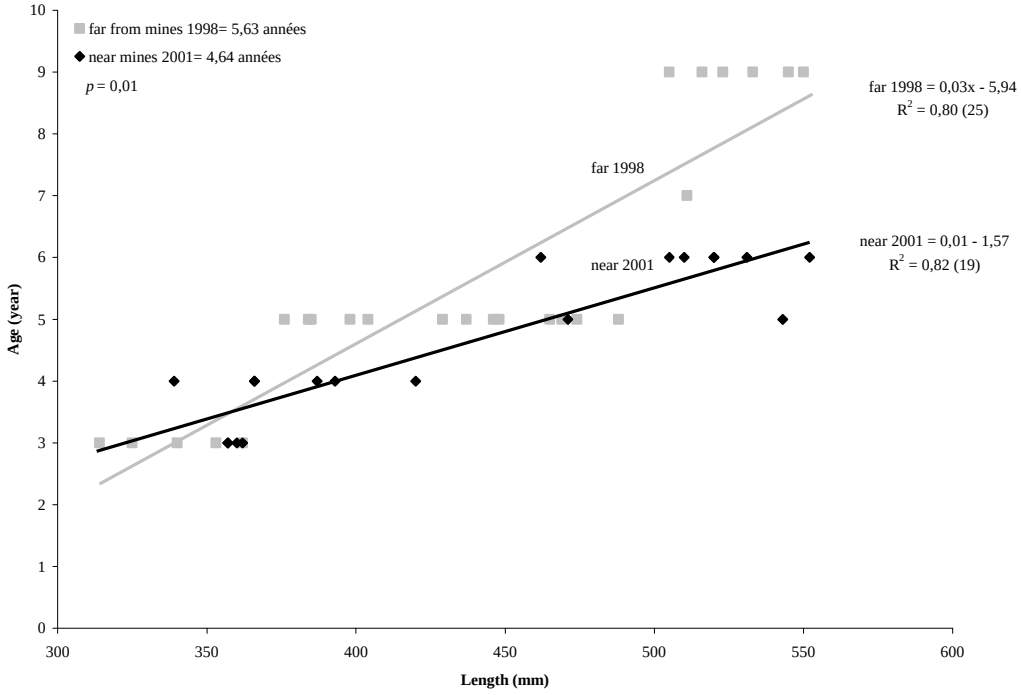

Figure 20 Growth rates of walleye (*Stizostedion vitreum*) caught in lac Chibougamau in 1998 and 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

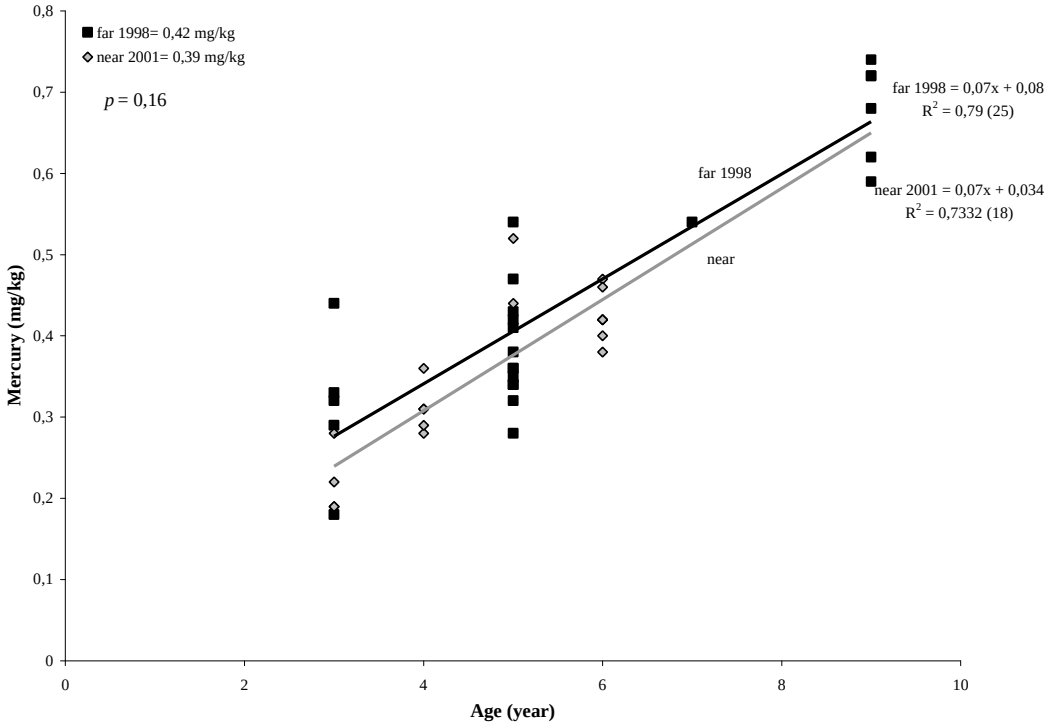

Figure 21 Mercury concentrations in walleye (*Stizostedion vitreum*) according to age, caught in Lac Chibougamau in 1998 and 2001

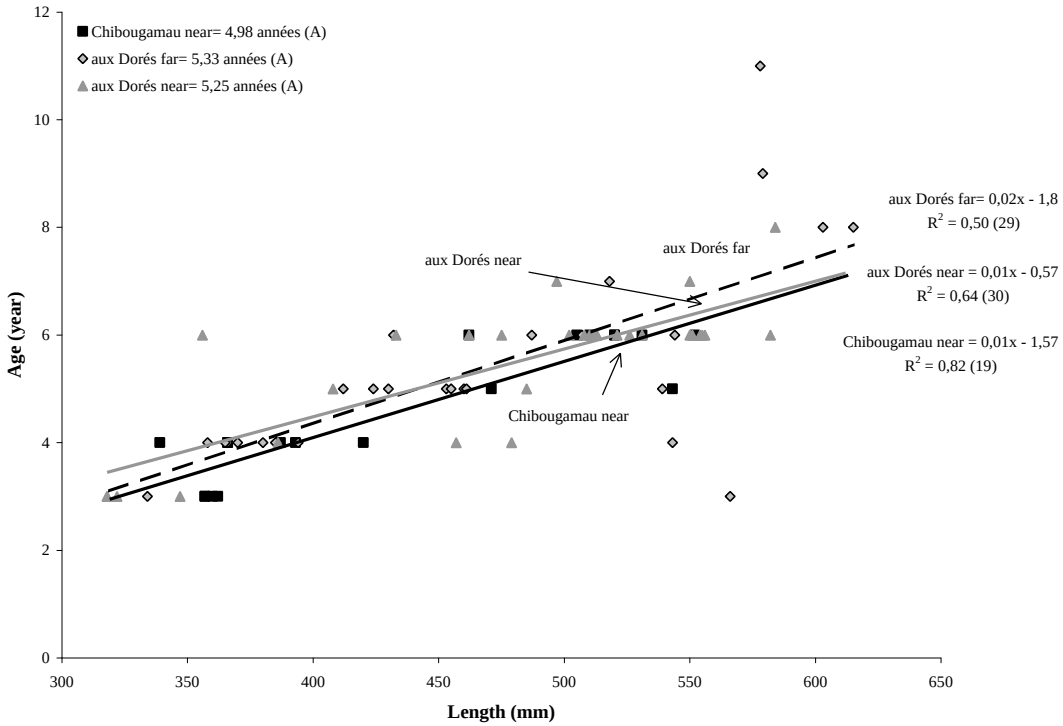

Figure 22 Growth rates of walleye (*Stizostedion vitreum*) caught in lac Chibougamau and Lac aux Dorés in 2001

Appendix 1 Mercury concentrations in relation to the length and the age of fish and the growth rate in four lakes in the Chibougamau area (next)

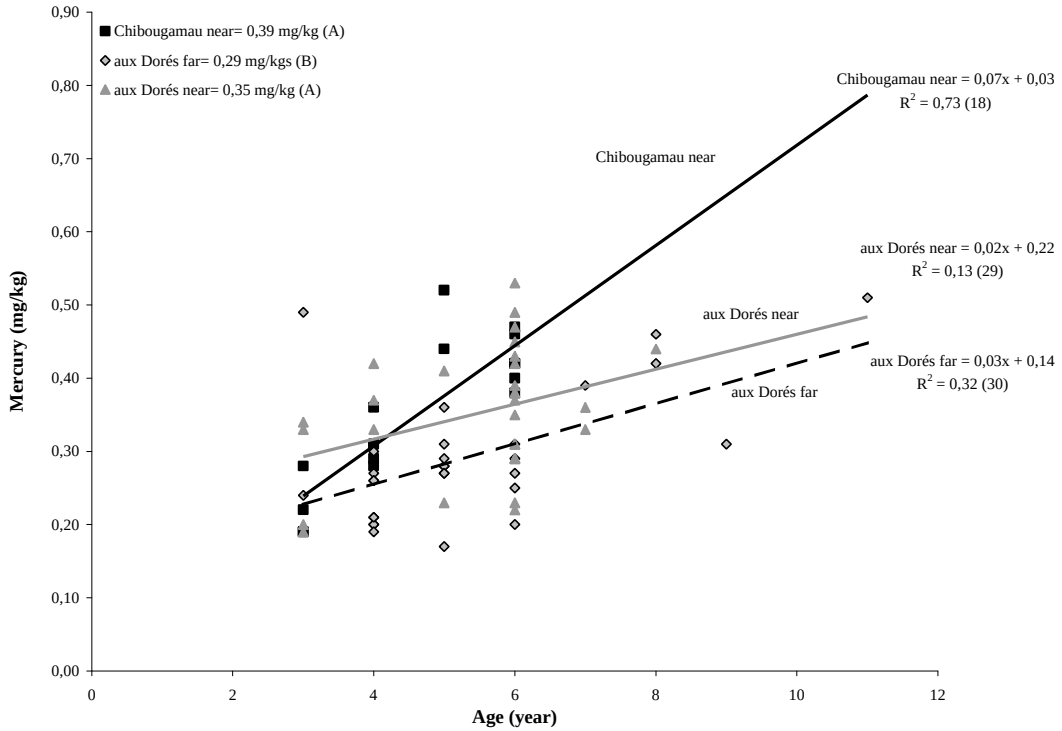

Figure 23 Mercury concentrations in walleye (*Stizostedion vitreum*) according to age, caught in Lac Chibougamau and Lac aux Dorés in 2001

Appendix 2 Raw data on fish in statistical test

observation	year	number	lake	species	size	âge year	size mm	length g	weight	Hg mg/kg
1	2001	54140	Aux dorés near mines	walleye	S		324	297	M	0.23
2	2001	54141	Aux dorés near mines	walleye	S	3	318	250	F	0.19
3	2001	54142	Aux dorés near mines	walleye	S	3	347	341	M	0.33
4	2001	54143	Aux dorés near mines	walleye	S	3	322	326		0.34
5	2001	54144	Aux dorés near mines	walleye	S	6	356	417	F	0.29
6	2001	54145	Aux dorés near mines	walleye	S	3	318	298	F	0.2
7	2001	54146	Aux dorés near mines	walleye	S	4	386	568	F	0.37
8	2001	54147	Aux dorés near mines	walleye	S		394	594	M	0.31
9	2001	54148	Aux dorés near mines	walleye	S		393	619	F	0.32
10	2001	54149	Aux dorés near mines	walleye	M		460	855	F	0.44
11	2001	54150	Aux dorés near mines	walleye	M	4	479	1092	F	0.42
12	2001	54151	Aux dorés near mines	walleye	M	6	462	984	M	0.45
13	2001	54152	Aux dorés near mines	walleye	M	5	485	1117	F	0.41
14	2001	54153	Aux dorés near mines	walleye	M	6	475	1007	M	0.53
15	2001	54154	Aux dorés near mines	walleye	M	4	457	797	F	0.33
16	2001	54155	Aux dorés near mines	walleye	M	5	408	599	F	0.23
17	2001	54156	Aux dorés near mines	walleye	M	6	433	742	F	0.22
18	2001	54157	Aux dorés near mines	walleye	M	7	497	1458	M	0.33
19	2001	54158	Aux dorés near mines	walleye	L	8	584	1963	F	0.44
20	2001	54159	Aux dorés near mines	walleye	L	6	582	2035	F	0.38
21	2001	54160	Aux dorés near mines	walleye	L	6	555	1788	F	0.39
22	2001	54161	Aux dorés near mines	walleye	L	6	550	1595	F	0.42
23	2001	54162	Aux dorés near mines	walleye	L	7	550	1694	F	0.36
24	2001	54163	Aux dorés near mines	walleye	L	6	502	1240	F	0.37
25	2001	54165	Aux dorés near mines	walleye	L	6	512	1450	M	0.35
26	2001	54166	Aux dorés near mines	walleye	L	6	526	1500	F	0.29
27	2001	54168	Aux dorés near mines	walleye	L	6	551	1847	F	0.47
28	2001	54169	Aux dorés near mines	walleye	L	6	508	1323	F	0.31
29	2001	54170	Aux dorés near mines	walleye	L	6	521	1491	F	0.31
30	2001	54171	Aux dorés near mines	walleye	L	6	513	1362	F	0.23
31	2001	54172	Aux dorés near mines	walleye	L	6	531	1516	F	0.29
32	2001	54173	Aux dorés near mines	walleye	L	6	556	2069	F	0.38
33	2001	54174	Aux dorés near mines	walleye	L	6	554	1880	F	0.49
34	2001	54175	Aux dorés near mines	walleye	L	6	510	1650	F	0.43
35	2001	54177	Aux dorés near mines	northern pike	S		410	414	M	0.08
36	2001	54178	Aux dorés near mines	northern pike	M		676	1806	F	0.19
37	2001	54179	Aux dorés near mines	northern pike	M		608	1488	F	0.25
38	2001	54180	Aux dorés near mines	northern pike	M		660	1542	F	0.52
39	2001	54181	Aux dorés near mines	northern pike	M		592	1440	F	0.11
40	2001	54182	Aux dorés near mines	northern pike	M		618	1495	F	0.33
41	2001	54183	Aux dorés near mines	northern pike	M		657	2000	M	0.56
42	2001	54184	Aux dorés near mines	northern pike	M		695	2000	M	0.31
43	2001	54185	Aux dorés near mines	northern pike	M		662	1399	M	0.66
44	2001	54186	Aux dorés near mines	northern pike	M		650	1719	M	0.3
45	2001	54187	Aux dorés near mines	northern pike	L		716	2234	F	0.55
46	2001	54188	Aux dorés near mines	northern pike	L		742	2893	F	0.54
47	2001	54402	Aux dorés near mines	lake trout	S	11	542	1317	M	0.64
48	2001	54403	Aux dorés near mines	lake trout	S	9	458	731	F	0.37
49	2001	54404	Aux dorés near mines	lake trout	S	6	516	1427	F	0.41
50	2001	54405	Aux dorés near mines	lake trout	S	10	537	1258	M	0.48

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
51	2001	54406	Aux dorés near mines	lake trout	S	10	539	1284	F	0.51
52	2001	54407	Aux dorés near mines	lake trout	S	9	539	1359	F	0.44
53	2001	54408	Aux dorés near mines	lake trout	S	5	456	815	F	0.32
54	2001	54409	Aux dorés near mines	lake trout	S	9	493	1019	F	0.4
55	2001	54410	Aux dorés near mines	lake trout	S	8	487	806	M	0.51
56	2001	54411	Aux dorés near mines	lake trout	M		663	2540	M	0.89
57	2001	54413	Aux dorés near mines	lake trout	M		570	1740	F	0.64
58	2001	54414	Aux dorés near mines	lake trout	M	11	665	3424	F	0.98
59	2001	54415	Aux dorés near mines	lake trout	M	7	571	1551	M	0.55
60	2001	54416	Aux dorés near mines	lake trout	M	8	556	1530	M	0.63
61	2001	54417	Aux dorés near mines	lake trout	M	11	614	2209	M	0.86
62	2001	54418	Aux dorés near mines	lake trout	M	10	587	1972	F	0.68
63	2001	54419	Aux dorés near mines	lake trout	L		900	10682	M	1.7
64	2001	54421	Aux dorés near mines	lake trout	L	22	723	4235	M	1.3
65	2001	54422	Aux dorés near mines	lake trout	L	21	959	9300	M	1.7
66	2001	54423	Aux dorés near mines	lake trout	L	13	720	3214	F	0.81
67	2001	54424	Aux dorés near mines	lake trout	L	17	784	4719	M	0.68
68	2001	54425	Aux dorés near mines	lake trout	L	19	740	4377	F	0.92
69	2001	54491	Aux dorés far from mines	walleye	S	4	386	511	M	0.27
70	2001	54492	Aux dorés far from mines	walleye	S	4	366	456	F	0.26
71	2001	54493	Aux dorés far from mines	walleye	S	4	394	592	F	0.21
72	2001	54494	Aux dorés far from mines	walleye	S	4	365	431	F	0.26
73	2001	54495	Aux dorés far from mines	walleye	S	4	358	433	F	0.2
74	2001	54496	Aux dorés far from mines	walleye	S	4	380	505	M	0.2
75	2001	54497	Aux dorés far from mines	walleye	S	4	385	517	F	0.21
76	2001	54498	Aux dorés far from mines	walleye	S	4	370	518	F	0.19
77	2001	54499	Aux dorés far from mines	walleye	S	3	334	327	M	0.24
78	2001	54500	Aux dorés far from mines	walleye	M	5	460	1000	M	0.31
79	2001	54501	Aux dorés far from mines	walleye	M	5	453	999	M	0.28
80	2001	54502	Aux dorés far from mines	walleye	M	6	487	2012	F	0.2
81	2001	54503	Aux dorés far from mines	walleye	M	5	455	1023	F	0.17
82	2001	54504	Aux dorés far from mines	walleye	M	5	424	772	M	0.27
83	2001	54505	Aux dorés far from mines	walleye	M	5	412	607	F	0.28
84	2001	54506	Aux dorés far from mines	walleye	M	5	461	1038	M	0.29
85	2001	54507	Aux dorés far from mines	walleye	M	5	430	746	M	0.27
86	2001	54508	Aux dorés far from mines	walleye	M	6	432	771	M	0.29
87	2001	54509	Aux dorés far from mines	walleye	L	5	539		F	0.36
88	2001	54511	Aux dorés far from mines	walleye	L	7	518	1674	F	0.39
89	2001	54512	Aux dorés far from mines	walleye	L	3	566	1976	F	0.49
90	2001	54513	Aux dorés far from mines	walleye	L	6	544	1605	F	0.25
91	2001	54514	Aux dorés far from mines	walleye	L	4	543	1829	F	0.3
92	2001	54515	Aux dorés far from mines	walleye	L	9	579	2233	F	0.31
93	2001	54516	Aux dorés far from mines	walleye	L	8	615	2696	F	0.42
94	2001	54517	Aux dorés far from mines	walleye	L	8	603	2482	F	0.46
95	2001	54520	Aux dorés far from mines	walleye	L	11	578	2278	M	0.51
96	2001	54522	Aux dorés far from mines	walleye	L	6	507	1255	M	0.31
97	2001	54523	Aux dorés far from mines	walleye	L	6	512	1356	M	0.27
98	1999	70086	Chibougamau near mines	lake trout	S	5	513	1146	F	0.42
99	1999	70087	Chibougamau near mines	lake trout	S	7	529	1224	M	0.52
100	1999	70088	Chibougamau near mines	lake trout	S	6	503	1064	M	0.67
101	1999	70089	Chibougamau near mines	lake trout	S	6	497	946	F	0.36

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
102	1999	70090	Chibougamau near mines	lake trout	M	21	680	3130	M	2.2
103	1999	70091	Chibougamau near mines	lake trout	M	13	600	1916	M	0.79
104	1999	70092	Chibougamau near mines	lake trout	M	7	537	1266	M	0.63
105	1999	70093	Chibougamau near mines	lake trout	M	14	620	1936	M	0.89
106	1999	70094	Chibougamau near mines	lake trout	M	12	630	2294	M	1.1
107	1999	70096	Chibougamau near mines	lake trout	L	21	811	6100	M	3,00
108	1999	70098	Chibougamau near mines	lake trout	L	27	735	4272	F	3.4
109	1999	70099	Chibougamau near mines	lake trout	L	27	791	4726	M	2.4
110	1999	70100	Chibougamau near mines	lake trout	L	26	791	5350	M	2.3
111	2000	90380	Chibougamau near mines	lake trout	S	7	498	834	M	0.39
112	2000	90382	Chibougamau near mines	lake trout	S	5	516	976	F	0.35
113	2000	90383	Chibougamau near mines	lake trout	S	1	535	1352	F	0.43
114	2000	90384	Chibougamau near mines	lake trout	M	9	597	1578	F	0.66
115	2000	90385	Chibougamau near mines	lake trout	M	14	660	2514	M	0.78
116	2000	90386	Chibougamau near mines	lake trout	M	15	667	2530	F	1.5
117	2000	90387	Chibougamau near mines	lake trout	M	15	662	2690	F	1.2
118	2000	90388	Chibougamau near mines	lake trout	M	12	646	2515	F	1.2
119	2000	90389	Chibougamau near mines	lake trout	L	30	825	4662	M	1.7
120	2001	54582	Aux dorés far from mines	lake trout	S	5	462	780	F	0.48
121	2001	54583	Aux dorés far from mines	lake trout	S	7	530	1251	M	0.4
122	2001	54584	Aux dorés far from mines	lake trout	S	7	520	1100	F	0.4
123	2001	54585	Aux dorés far from mines	lake trout	S	8	548	1417	F	0.43
124	2001	54586	Aux dorés far from mines	lake trout	S	5	476	872	F	0.34
125	2001	54587	Aux dorés far from mines	lake trout	S	6	497	956	M	0.39
126	2001	54588	Aux dorés far from mines	lake trout	S	9	535	1196	F	0.49
127	2001	54589	Aux dorés far from mines	lake trout	S	6	506	1137	F	0.32
128	2001	54590	Aux dorés far from mines	lake trout	S	6	509	1180	F	0.45
129	2001	54591	Aux dorés far from mines	lake trout	M	17	668	2362	M	0.42
130	2001	54592	Aux dorés far from mines	lake trout	M	9	644	2269	M	0.48
131	2001	54593	Aux dorés far from mines	lake trout	M	8	595	1691	M	0.61
132	2001	54594	Aux dorés far from mines	lake trout	M	8	567	1482	M	0.31
133	2001	54595	Aux dorés far from mines	lake trout	M	11	627	2375	M	0.6
134	2001	54596	Aux dorés far from mines	lake trout	M	14	627	2282	M	0.92
135	2001	54597	Aux dorés far from mines	lake trout	M	8	604	1993	F	0.53
136	2001	54598	Aux dorés far from mines	lake trout	M	8	590	1833	F	0.4
137	2001	54599	Aux dorés far from mines	lake trout	L	17	832	5500	F	0.63
138	2001	54600	Aux dorés far from mines	lake trout	L		840	4060	M	1.5
139	2001	54601	Aux dorés far from mines	lake trout	L	16	703	3249	M	0.55
140	2001	54602	Aux dorés far from mines	lake trout	L	20	915	8000	M	0.72
141	2001	54603	Aux dorés far from mines	lake trout	L	21	714	2725	M	0.43
142	2001	54604	Aux dorés far from mines	lake trout	L	19	700	3072	M	0.64
143	2001	54606	Aux dorés far from mines	northern pike	S		422	422	M	0.05
144	2001	54607	Aux dorés far from mines	northern pike	M		645	1595	M	0.59
145	2001	54608	Aux dorés far from mines	northern pike	M		659	1790	M	0.2
146	2001	54609	Aux dorés far from mines	northern pike	M		675	1998	F	0.21
147	2001	54610	Aux dorés far from mines	northern pike	M		651	1827	M	0.18
148	2001	54611	Aux dorés far from mines	northern pike	M		590	1384	F	0.13
149	2001	54612	Aux dorés far from mines	northern pike	M		658	1733	F	0.2
150	2001	54613	Aux dorés far from mines	northern pike	M		569	1065	F	0.19
151	2001	54616	Aux dorés far from mines	northern pike	L		720	2209	F	0.21

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
152	2001	54617	Aux dorés far from mines	northern pike	L		723	2453	F	0.26
153	2001	54619	Aux dorés far from mines	northern pike	L		719	2287	M	0.25
154	2001	54620	Aux dorés far from mines	northern pike	L		757	2286	M	0.5
155	2001	54622	Aux dorés far from mines	northern pike	L		763	2923	M	0.43
156	2001	54627	Chibougamau near mines	northern pike	S		549	967		0.24
157	2001	54628	Chibougamau near mines	northern pike	S		550	908	F	0.29
158	2001	54629	Chibougamau near mines	northern pike	M		678	2055	M	0.46
159	2001	54630	Chibougamau near mines	northern pike	M		680	2056	M	0.73
160	2001	54631	Chibougamau near mines	northern pike	M		593	1093	F	0.18
161	2001	54632	Chibougamau near mines	northern pike	M		667	1837	M	0.41
162	2001	54633	Chibougamau near mines	northern pike	M		620	1447	M	0.23
163	2001	54634	Chibougamau near mines	northern pike	M		610	1320	F	0.16
164	2001	54635	Chibougamau near mines	northern pike	M		619	1486	F	0.14
165	2001	54636	Chibougamau near mines	northern pike	M		678	2152	M	0.75
166	2001	54637	Chibougamau near mines	northern pike	M		686	1975	F	0.39
167	2001	54638	Chibougamau near mines	northern pike	L		721	2660	M	0.46
168	2001	54639	Chibougamau near mines	northern pike	L		723	2192	F	0.4
169	2001	54640	Chibougamau near mines	northern pike	L		758	3262	F	0.5
170	2001	54641	Chibougamau near mines	northern pike	L		789	3069	F	0.38
171	2001	54642	Chibougamau near mines	northern pike	L		724	2451	F	0.62
172	2001	54643	Chibougamau near mines	northern pike	L		822	4136	M	0.85
173	2001	54644	Chibougamau near mines	northern pike	L		724	2371	F	0.69
174	2001	54645	Chibougamau near mines	northern pike	L		711	2482	F	0.34
175	2001	54646	Chibougamau near mines	northern pike	L		774	3120	M	0.64
176	2001	54647	Chibougamau near mines	northern pike	L		850	4670	F	0.84
177	2001	54652	Chibougamau near mines	walleye	S	4	387	566	F	0.28
178	2001	54653	Chibougamau near mines	walleye	S		340	345	F	0.2
179	2001	54654	Chibougamau near mines	walleye	S	3	357	390	M	0.19
180	2001	54655	Chibougamau near mines	walleye	S	4	366	452	M	0.36
181	2001	54656	Chibougamau near mines	walleye	S	4	393	548	M	0.31
182	2001	54657	Chibougamau near mines	walleye	S	3	362	408	M	0.28
183	2001	54658	Chibougamau near mines	walleye	S	3	357	369	F	0.19
184	2001	54659	Chibougamau near mines	walleye	S	4	366	390	M	0.29
185	2001	54660	Chibougamau near mines	walleye	S	3	360	390	F	0.22
186	2001	55078	Chibougamau near mines	walleye	S	4	339	289	F	0.43
187	2001	54661	Chibougamau near mines	walleye	M	6	480	981	F	0.42
188	2001	54662	Chibougamau near mines	walleye	M	5	471	779	F	0.52
189	2001	54663	Chibougamau near mines	walleye	M	6	475	816		0.57
190	2001	54664	Chibougamau near mines	walleye	M		408	768	M	0.41
191	2001	54665	Chibougamau near mines	walleye	M	6	401	807	F	0.3
192	2001	54666	Chibougamau near mines	walleye	M		441	680	F	0.4
193	2001	54667	Chibougamau near mines	walleye	M	6	462	991	M	0.38
194	2001	54668	Chibougamau near mines	walleye	M	4	420	610	F	0.31
195	2001	54669	Chibougamau near mines	walleye	M	6	490	992	F	0.4
196	2001	54671	Chibougamau near mines	walleye	L	6	505	1058	M	0.47
197	2001	54672	Chibougamau near mines	walleye	L	6	520	1279	F	0.42
198	2001	54673	Chibougamau near mines	walleye	L	6	543	1603	F	0.44
199	2001	54674	Chibougamau near mines	walleye	L	6	531	1599	M	0.46
200	2001	54675	Chibougamau near mines	walleye	L	6	552	1497	F	0.42
201	2001	54676	Chibougamau near mines	walleye	L		517	1356	F	0.34
202	2001	54677	Chibougamau near mines	walleye	L	6	520	1366	F	0.42

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
203	2001	54678	Chibougamau near mines	walleye	L	6	510	1292	F	0.4
204	2001	54679	Chibougamau near mines	walleye	L	13	667	3103	F	1,00
205	2001	55062	Chibougamau near mines	lake trout	S		516	912		0.25
206	2001	55063	Chibougamau near mines	lake trout	S	6	505	1110	F	0.75
207	2001	55064	Chibougamau near mines	lake trout	M	12	658	2521	F	0.82
208	2001	55065	Chibougamau near mines	lake trout	M	15	646	2521	M	0.47
209	2001	55066	Chibougamau near mines	lake trout	M	10	594	1903	F	0.72
210	2001	55067	Chibougamau near mines	lake trout	M	12	648	2643	M	0.88
211	2001	55068	Chibougamau near mines	lake trout	M	15	624	2385	F	1.2
212	2001	55069	Chibougamau near mines	lake trout	M	11	675	2990	M	0.74
213	2001	55070	Chibougamau near mines	lake trout	M	16	648	2456	M	0.98
214	2001	55071	Chibougamau near mines	lake trout	M	11	602	2015	F	0.85
215	2001	55072	Chibougamau near mines	lake trout	M	17	630	2364	F	0.98
216	2001	55073	Chibougamau near mines	lake trout	L	16	728	2897	M	0.84
217	2001	55074	Chibougamau near mines	lake trout	L		742	3972		0.84
218	2001	55075	Chibougamau near mines	lake trout	L	13	741	3200	F	0.5
219	2001	55076	Chibougamau near mines	lake trout	L	15	720	3100	M	0.61
220	1998	44504	Chibougamau far from mines	walleye	S	5	385	485	M	0.43
221	1998	44505	Chibougamau far from mines	walleye	S	5	398	504	F	0.42
222	1998	44506	Chibougamau far from mines	walleye	S	5	384	477	M	0.32
223	1998	44507	Chibougamau far from mines	walleye	S	3	340	306	F	0.44
224	1998	44508	Chibougamau far from mines	walleye	S	5	376	476	F	0.47
225	1998	44509	Chibougamau far from mines	walleye	S	3	314	250	M	0.18
226	1998	44510	Chibougamau far from mines	walleye	S	3	353	388	F	0.33
227	1998	44511	Chibougamau far from mines	walleye	S	3	362	381	F	0.29
228	1998	44512	Chibougamau far from mines	walleye	S	3	325	304	M	0.32
229	1998	44513	Chibougamau far from mines	walleye	M	5	429	736	M	0.34
230	1998	44514	Chibougamau far from mines	walleye	M	5	437	694	M	0.36
231	1998	44515	Chibougamau far from mines	walleye	M	5	488	1068	F	0.38
232	1998	44516	Chibougamau far from mines	walleye	M	5	448	767	F	0.54
233	1998	44517	Chibougamau far from mines	walleye	M	5	446	753	F	0.36
234	1998	44518	Chibougamau far from mines	walleye	M	5	404	546	M	0.41
235	1998	44519	Chibougamau far from mines	walleye	M	5	465	999	M	0.34
236	1998	44520	Chibougamau far from mines	walleye	M	5	474	867	F	0.35
237	1998	44521	Chibougamau far from mines	walleye	M	5	469	936	M	0.28
238	1998	44522	Chibougamau far from mines	walleye	L	9	505	1085	M	0.68
239	1998	44523	Chibougamau far from mines	walleye	L	7	511	1292	M	0.54
240	1998	44524	Chibougamau far from mines	walleye	L	9	516	1372	M	0.59
241	1998	44525	Chibougamau far from mines	walleye	L	9	545	1625	M	0.74
242	1998	44526	Chibougamau far from mines	walleye	L	11	523	1306	M	0.62
243	1998	44528	Chibougamau far from mines	walleye	L	9	550	1485	M	0.72
244	1998	44530	Chibougamau far from mines	walleye	L	9	533	1220	M	0.72
245	2001	55079	Chibougamau far from mines	walleye	S		364	364	F	0.29
246	2001	55080	Chibougamau far from mines	walleye	S		310	227	F	0.25
247	2001	55081	Chibougamau far from mines	walleye	S		330	261	M	0.25
248	2001	55082	Chibougamau far from mines	walleye	S		380	460	M	0.33
249	2001	55083	Chibougamau far from mines	walleye	S		336	304	F	0.3
250	2001	55084	Chibougamau far from mines	walleye	S		320	306	M	0.21
251	2001	55085	Chibougamau far from mines	walleye	S		360	476	F	0.3

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
252	2001	55086	Chibougamau far from mines	walleye	S		333	330	F	0.22
253	2001	55087	Chibougamau far from mines	walleye	M		466	754	F	0.47
254	2001	55088	Chibougamau far from mines	walleye	M		425	599	F	0.49
255	2001	55089	Chibougamau far from mines	walleye	M		467	858	F	0.48
256	2001	55090	Chibougamau far from mines	walleye	M		436	632	F	0.4
257	2001	55091	Chibougamau far from mines	walleye	M		450	817	F	0.37
258	2001	55092	Chibougamau far from mines	walleye	M		454	796	F	0.36
259	2001	55093	Chibougamau far from mines	walleye	M		460	920	M	0.43
260	2001	55094	Chibougamau far from mines	walleye	M		486	1118	F	0.39
261	2001	55095	Chibougamau far from mines	walleye	M		482	1072	F	0.43
262	2001	55096	Chibougamau far from mines	walleye	L		667	1569	M	0.65
263	2001	55097	Chibougamau far from mines	walleye	L		560	1574	F	0.86
264	2001	55098	Chibougamau far from mines	walleye	L		665	2684	M	1.2
265	2001	55099	Chibougamau far from mines	walleye	L		530	1245	M	0.67
266	2001	55100	Chibougamau far from mines	walleye	L		508	1173	M	0.69
267	2001	55101	Chibougamau far from mines	walleye	L		520	1324	F	0.46
268	2001	55102	Chibougamau far from mines	walleye	L		517	1608	F	0.47
269	2001	55103	Chibougamau far from mines	walleye	L		513	1390	F	0.51
270	2001	55104	Chibougamau far from mines	walleye	L		508	1528	M	0.6
271	2001	55191	Chibougamau far from mines	lake trout	S	6	504	1036	F	0.28
272	2001	55192	Chibougamau far from mines	lake trout	M	11	694	3208	F	0.59
273	2001	55193	Chibougamau far from mines	lake trout	M	9	593	1636	M	0.66
274	2001	55194	Chibougamau far from mines	lake trout	M	10	654	2018	F	0.78
275	2001	55195	Chibougamau far from mines	lake trout	M	12	633	2344	M	0.74
276	2001	55196	Chibougamau far from mines	lake trout	M	10	648	2446	F	0.82
277	2001	55197	Chibougamau far from mines	lake trout	M	12	614	1756	F	1.1
278	2001	55198	Chibougamau far from mines	lake trout	M	13	595	1680	F	0.84
279	2001	55199	Chibougamau far from mines	lake trout	M	17	658	2514	M	1.2
280	2001	55200	Chibougamau far from mines	lake trout	M	16	658	2344	F	1.1
281	2001	55201	Chibougamau far from mines	lake trout	L	18	722	3020	F	1.7
282	2001	55203	Chibougamau far from mines	lake trout	L	9	718	3000	F	0.77
283	2001	55204	Chibougamau far from mines	lake trout	L	12	701	3338	F	0.74
284	2001	55205	Chibougamau far from mines	lake trout	L	20	724	4878	M	1.59
285	2001	55206	Chibougamau far from mines	lake trout	L	13	762	4450	F	0.76
286	2001	55207	Chibougamau far from mines	lake trout	L	15	705	3448	M	0.91
287	2001	55214	Chibougamau far from mines	northern pike	M		677	2117	F	0.35
288	2001	55215	Chibougamau far from mines	northern pike	M		560	1000	F	0.16
289	2001	55216	Chibougamau far from mines	northern pike	M		612	1636	F	0.17
290	2001	55217	Chibougamau far from mines	northern pike	M		667	2046	F	0.29
291	2001	55218	Chibougamau far from mines	northern pike	M		635	1866	M	0.3
292	2001	55219	Chibougamau far from mines	northern pike	M		693	2042	F	0.39
293	2001	55220	Chibougamau far from mines	northern pike	M		610	1372	F	0.33
294	2001	55221	Chibougamau far from mines	northern pike	M		677	2420	M	0.51
295	2001	55222	Chibougamau far from mines	northern pike	L		762	3496	M	0.72
296	2001	55223	Chibougamau far from mines	northern pike	L		742	2598	M	0.52
297	2001	55224	Chibougamau far from mines	northern pike	L		802	3900	F	0.47
298	2001	55225	Chibougamau far from mines	northern pike	L		722	3014	F	0.68
299	2001	55226	Chibougamau far from mines	northern pike	L		768	3266	F	0.47
300	2001	55227	Chibougamau far from mines	northern pike	L		754	3400	F	0.39
301	2001	55228	Chibougamau far from mines	northern pike	L		878	4664	F	0.91

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
302	2001	53664	Obatogamau	northern pike	S		400	335	F	0.27
303	2001	53665	Obatogamau	northern pike	S		476	628	F	0.41
304	2001	53666	Obatogamau	northern pike	S		412	370	F	0.29
305	2001	53667	Obatogamau	northern pike	S		491	675	F	0.42
306	2001	53668	Obatogamau	northern pike	S		467	550	F	0.34
307	2001	53669	Obatogamau	northern pike	S		532	879	M	0.5
308	2001	53670	Obatogamau	northern pike	S		529	756	M	0.47
309	2001	53671	Obatogamau	northern pike	S		435	430	M	0.28
310	2001	53672	Obatogamau	northern pike	S		543	935	M	0.67
311	2001	53673	Obatogamau	northern pike	M		565	1131	M	0.47
312	2001	53674	Obatogamau	northern pike	M		575	1112	M	0.86
313	2001	53675	Obatogamau	northern pike	M		569	1021	M	0.79
314	2001	53676	Obatogamau	northern pike	M		600	1091	F	0.91
315	2001	53677	Obatogamau	northern pike	M		580	1067	M	0.71
316	2001	53678	Obatogamau	northern pike	M		580	1201	M	0.45
317	2001	53679	Obatogamau	northern pike	M		567	921	M	0.54
318	2001	53680	Obatogamau	northern pike	M		459	517	F	0.31
319	2001	53681	Obatogamau	northern pike	M		602	1118	F	0.8
320	2001	53682	Obatogamau	northern pike	L		700	2200		1.2
321	2001	53683	Obatogamau	northern pike	L		755	2200		0.5
322	2001	53684	Obatogamau	northern pike	L		1005	8040	F	1.9
323	2001	53685	Obatogamau	northern pike	L		855	4049	F	1.3
324	2001	53823	Obatogamau	walleye	S		395	495	M	0.29
325	2001	53824	Obatogamau	walleye	S		390	505	F	0.29
326	2001	53825	Obatogamau	walleye	S		355	344	M	0.31
327	2001	53826	Obatogamau	walleye	S		355	408	F	0.66
328	2001	53827	Obatogamau	walleye	S		363	395	M	0.34
329	2001	53828	Obatogamau	walleye	S	6	378	449	M	0.3
330	2001	53829	Obatogamau	walleye	S	6	370	436	M	0.5
331	2001	53830	Obatogamau	walleye	S	4	328	362	F	0.37
332	2001	53831	Obatogamau	walleye	M	17	496	1155	F	0.59
333	2001	53832	Obatogamau	walleye	M		488	1020	M	0.68
334	2001	53833	Obatogamau	walleye	M		430	692	F	0.49
335	2001	53834	Obatogamau	walleye	M		460	838	M	0.64
336	2001	53835	Obatogamau	walleye	M	6	414	634	M	0.44
337	2001	53836	Obatogamau	walleye	M	7	498	1100	F	0.54
338	2001	53837	Obatogamau	walleye	M	7	494	1167	F	0.54
339	2001	53838	Obatogamau	walleye	L	17	606	2284	F	1.3
340	2001	53839	Obatogamau	walleye	L	16	520	1389	M	1,00
341	2001	53840	Obatogamau	walleye	L	12	500	1154	M	0.94
342	2001	53841	Obatogamau	walleye	L	17	521	1370	M	1,00
343	2001	53842	Obatogamau	walleye	L	12	545	1524	F	0.89
344	2001	53843	Obatogamau	walleye	L	10	517	1303	M	0.79
345	2001	53844	Obatogamau	walleye	L	19	699	2986	F	1.1
346	2001	53845	Obatogamau	walleye	L	18	626	2524	F	1.2
347	2001	53846	Obatogamau	walleye	L	13	635	2392	F	0.63
348	2001	53525	Waconichi	walleye	S	2	393	621	M	0.18
349	2001	53526	Waconichi	walleye	S	2	373	535	M	0.15
350	2001	53527	Waconichi	walleye	S	2	355	498	M	0.14
351	2001	53528	Waconichi	walleye	S		395	395	M	0.1

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
352	2001	53529	Waconichi	walleye	S		380	380	M	0.15
353	2001	53530	Waconichi	walleye	S	2	368	472	F	0.16
354	2001	53531	Waconichi	walleye	S	2	309	262	F	0.13
355	2001	53532	Waconichi	walleye	S	2	377	531	M	0.14
356	2001	53533	Waconichi	walleye	S	2	318	337	M	0.14
357	2001	53535	Waconichi	walleye	M		475	1162	M	0.19
358	2001	53536	Waconichi	walleye	M	3	495	1362	F	0.19
359	2001	53537	Waconichi	walleye	M	3	458	1039	M	0.14
360	2001	53538	Waconichi	walleye	M	2	415	749	F	0.15
361	2001	53539	Waconichi	walleye	M		475	1143	M	0.31
362	2001	53540	Waconichi	walleye	M		480	1228	M	0.72
363	2001	53541	Waconichi	walleye	M	3	453	974	M	0.14
364	2001	53542	Waconichi	walleye	M	3	420	739	M	0.16
365	2001	53543	Waconichi	walleye	M	4	484	1219	M	0.2
366	2001	53545	Waconichi	walleye	L	8	676	3549	F	0.26
367	2001	53546	Waconichi	walleye	L	5	592	2434	M	0.29
368	2001	53547	Waconichi	walleye	L	8	598	2596	M	0.35
369	2001	53555	Waconichi	lake trout	S	9	520	1144	M	0.2
370	2001	53556	Waconichi	lake trout	S	9	503	1034	F	0.24
371	2001	53557	Waconichi	lake trout	S	7	484	894	F	0.21
372	2001	53558	Waconichi	lake trout	S	9	530	1335	F	0.32
373	2001	53559	Waconichi	lake trout	S	9	458	756	M	0.22
374	2001	53560	Waconichi	lake trout	S	10	540	1332	M	0.32
375	2001	53561	Waconichi	lake trout	S	8	525	1160	M	0.22
376	2001	53562	Waconichi	lake trout	S	5	460	745		0.16
377	2001	53563	Waconichi	lake trout	S	8	505	1083	M	0.22
378	2001	53564	Waconichi	lake trout	M	11	594	1637	M	0.42
379	2001	53565	Waconichi	lake trout	M	10	592	1937	M	0.32
380	2001	53566	Waconichi	lake trout	M	12	680	3017	F	0.38
381	2001	53567	Waconichi	lake trout	M	10	584	1794	F	0.55
382	2001	53568	Waconichi	lake trout	M	11	600	1889	M	0.44
383	2001	53569	Waconichi	lake trout	M	12	583	1557	M	0.47
384	2001	53635	Waconichi	northern pike	S		518	586	F	0.09
385	2001	53636	Waconichi	northern pike	S		537	924	M	0.1
386	2001	53637	Waconichi	northern pike	VS		271	110	M	0.05
387	2001	53638	Waconichi	northern pike	VS		252	92	M	0.04
388	2001	53639	Waconichi	northern pike	S		538	1209	M	0.18
389	2001	53640	Waconichi	northern pike	M		658	743	F	0.1
390	2001	53641	Waconichi	northern pike	M		600	1353	M	0.19
391	2001	53642	Waconichi	northern pike	M		600	1259	F	0.19
392	2001	53643	Waconichi	northern pike	M		590	1265	M	0.16
393	2001	53644	Waconichi	northern pike	M		585	1216	M	0.18
394	2001	53645	Waconichi	northern pike	M		616	1608	M	0.18
395	2001	53646	Waconichi	northern pike	M		609	1459	F	0.16
396	2001	53647	Waconichi	northern pike	M		574	1345	M	0.15
397	2001	53648	Waconichi	northern pike	M		693	2120	M	0.25
398	2001	53649	Waconichi	northern pike	L		735	2674	M	0.21
399	2001	53650	Waconichi	northern pike	L		950	7700	F	0.33
400	2001	53651	Waconichi	northern pike	L		715	2014	M	0.21
401	2001	53652	Waconichi	northern pike	L		754	2730	M	0.18

Appendix 2 Raw data on fish in statistical test (next)

observation	year	number	lakes	species	size	âge year	size mm	length g	weight	Hg mg/kg
402	2001	53653	Waconichi	northern pike	L		932	5060	F	0.4
403	2001	53654	Waconichi	northern pike	L		764	2915	M	0.34
404	2001	53655	Waconichi	northern pike	L		730	2600	M	0.15
405	2001	53656	Waconichi	northern pike	L		799	3575	M	0.26
406	2001	53657	Waconichi	northern pike	L		758	2767	F	0.3
407	2001	53659	Waconichi	northern pike	L		918	4500	M	0.39
408	2001	53660	Waconichi	northern pike	L		1045	7500	F	0.58

Size S= Small. M= Medium. L= Large

Appendix 3 Raw data on fish homogenates used for comparison of metals, PCB, and dioxin and furan concentrations

observation	year	number	lake	species	size	length	weight	As	Cd	Cr	Cu	Hg	Mn	Pb	Se	Sr	Zn	PCB	fat	DF
						mm	g	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µg/kg	%	ng/kg
1	2001	54624	Lac Chibougamau, near from mines	burbot	S	390	362					0.36								
2	2001	56625	Lac Chibougamau, near from mines	burbot	M	475	643					0.44								
3	2001	54626	Lac Chibougamau, near from mines	burbot	L	665	2203	0.08	0.016	0.07	0.21	0.60	0.06	<0.10	0.28	0.05	4.5	16.0	0.58	0.017
4	2001	54648	Lac Chibougamau, near from mines	northern pike	L	760	3041											10.0	0.26	0.008
5	2001	54649	Lac Chibougamau, near from mines	lake whitefish	S	368	392					0.11								
6	2001	54650	Lac Chibougamau, near from mines	lake whitefish	M	430	644					0.16								
7	2001	54651	Lac Chibougamau, near from mines	lake whitefish	L	481	883	0.05	0.031	0.06	0.23	0.35	<0.05	<0.10	0.46	0.10	3.1	48.0	0.57	0.063
8	2001	54680	Lac Chibougamau, near from mines	walleye	L	544	1596	0.05	0.016	0.06	0.25		0.08	<0.10	0.37	<0.05	4.3	39.0	1.33	0.110
9	2001	55077	Lac Chibougamau, near from mines	lake trout	L	733	3292	0.06	0.018	0.06	0.39		<0.05	<0.10	0.39	<0.05	3.2	110.0	2.19	0.806
10	2001	55105	Lac Chibougamau, far from mines	walleye	L	554	1566	0.05	0.016	0.05	0.32		0.06	<0.10	0.39	0.07	4.5	21.0	0.86	0.017
11	2001	55106	Lac Chibougamau, far from mines	lake whitefish	S	374	407					0.12								
12	2001	55107	Lac Chibougamau, far from mines	lake whitefish	M	424	631					0.18								
13	2001	55108	Lac Chibougamau, far from mines	lake whitefish	L	473	875	0.05	0.023	0.08	0.14	0.23	0.08	<0.10	0.53	0.28	3.0	6.0	0.33	0.029
14	2001	55208	Lac Chibougamau, far from mines	lake trout	L	742	4305	0.07	0.019	<0.05	0.52		<0.05	<0.10	0.48	<0.05	3.5	290.0	2.76	1.355
15	2001	55209	Lac Chibougamau, far from mines	burbot	S	407	508					0.44								
16	2001	55210	Lac Chibougamau, far from mines	burbot	M	529	992					0.45								
17	2001	55211	Lac Chibougamau, far from mines	burbot	L	641	1838	0.07	0.017	0.06	0.31	0.61	<0.05	<0.10	0.30	0.09	5.3	33.0	0.45	0.012
18	2001	55230	Lac Chibougamau, far from mines	northern pike	L	800	3855	0.07	0.016	0.06	0.24		<0.05	<0.10	0.40	0.05	3.4	12.0	0.58	0.018
19	2001	54134	Lac aux Dorés, near from mines	burbot	S	408	589					0.34								
20	2001	54135	Lac aux Dorés, near from mines	burbot	M	530	1171					0.39								
21	2001	54136	Lac aux Dorés, near from mines	burbot	L	641	1832	0.05	0.015	0.10	0.27	0.54	0.12	0.10	0.25	0.10	5.8	25.0	0.52	0.045
22	2001	54137	Lac aux Dorés, near from mines	lake whitefish	S	374	396					0.15								
23	2001	54138	Lac aux Dorés, near from mines	lake whitefish	M	433	728					0.12								
24	2001	54139	Lac aux Dorés, near from mines	lake whitefish	L	496	1112	<0.05	0.020	0.09	0.22	0.14	0.09	0.10	0.45	0.13	3.4	40.0	1.21	0.177
25	2001	54167	Lac aux Dorés, near from mines	walleye	L	547	1818	<0.05	0.020	0.18	0.22		0.05	<0.10	0.37	0.08	5.2	19.0	0.74	0.018
26	2001	54189	Lac aux Dorés, near from mines	northern pike	L	729	2564	<0.05	0.017	0.10	0.26		0.08	0.11	0.36	0.07	3.7	7.0	0.27	0.000
27	2001	54419	Lac aux Dorés, near from mines	lake trout	M	604	2138	<0.05	0.017	0.10	0.43		0.05	<0.10	0.37	<0.05	3.1	160.0	2.96	0.691
28	2001	54426	Lac aux Dorés, near from mines	lake trout	L	804	6088	0.08	0.012	0.09	0.47		0.05	0.11	0.58	<0.05	3.3	740.0	4.70	2.129
30	2001	54489	Lac aux Dorés, far from mines	burbot	M	542	1337					0.31								
31	2001	54490	Lac aux Dorés, far from mines	burbot	L	689	2403	<0.05	0.012	0.07	0.27	0.44	0.14	<0.10	0.31	0.05	5.8	4.9	0.45	0.011
32	2001	54518	Lac aux Dorés, far from mines	walleye	L	593	2526	<0.05	0.023	0.07	0.23		0.06	<0.10	0.42	<0.05	4.7	40.0	2.29	0.118
33	2001	54579	Lac aux Dorés, far from mines	lake whitefish	S	376	436					0.05								
34	2001	54580	Lac aux Dorés, far from mines	lake whitefish	M	429	657					0.07								
35	2001	54581	Lac aux Dorés, far from mines	lake whitefish	L	476	974	<0.05	0.023	0.07	0.22	0.08	0.20	<0.10	0.44	0.29	3.2	17.0	0.88	0.062
36	2001	54605	Lac aux Dorés, far from mines	lake trout	L	784	4434	<0.05	0.017	0.07	0.26		<0.05	0.10	0.53	0.07	3.3	350.0	2.71	1.332
37	2001	54623	Lac aux Dorés, far from mines	northern pike	L	793	3197	<0.05	0.030	0.09	0.29		0.21	<0.10	0.36	0.15	4.0	6.4	0.44	0.010
38	2001	53661	Lac Obatogamau	burbot	S	405	462					0.57								
39	2001	53662	Lac Obatogamau	burbot	M	555	1046					0.57								
40	2001	53663	Lac Obatogamau	burbot	L	611	1244	0.05	0.033	0.10	0.22	0.65	0.29	0.14	0.29	0.80	3.2	1.0	0.46	0.004
41	2001	53686	Lac Obatogamau	northern pike	L	829	4122	<0.05	0.016	0.06	0.27		0.12	0.12	0.41	0.10	4.6	1.3	0.38	0.040
42	2001	53847	Lac Obatogamau	walleye	L	574	1881	0.05	0.019	0.09	0.20		0.08	0.12	0.42	0.12	3.8	2.9	1.24	0.050
43	2001	53848	Lac Obatogamau	lake whitefish	S	378	482					0.07								
44	2001	53849	Lac Obatogamau	lake whitefish	M	429	774					0.11								
45	2001	53850	Lac Obatogamau	lake whitefish	L	482	1115	<0.05	0.023	0.07	0.19	0.22	0.16	<0.10	0.54	0.20	3.7	5.6	2.05	0.156
46	2001	53534	Lac Waconichi	walleye	S	363	448	<0.05	0.018	0.12	0.18		0.08	<0.10	0.32	0.12	4.6			0.007
47	2001	53544	Lac Waconichi	walleye	M	462	1068	<0.05	0.032	0.07	0.15		0.09	<0.10	0.34	0.14	6.5			0.048
48	2001	53548	Lac Waconichi	walleye	L	622	2860	<0.05	0.014	0.07	0.22		<0.05	<0.10	0.35	0.05	4.5	2.5	0.92	0.007
49	2001	53549	Lac Waconichi	burbot	S	426	450					0.25								
50	2001	53550	Lac Waconichi	burbot	M	508	645					0.22								
51	2001	53551	Lac Waconichi	burbot	L	646	1311	0.05	0.020	0.09	0.24	0.29	0.15	<0.10	0.28	0.28	5.9	3.5	0.20	0.011
52	2001	53552	Lac Waconichi	lake whitefish	S	369	383					0.09								
53	2001	53553	Lac Waconichi	lake whitefish	M	432	643					0.10								
54	2001	53554	Lac Waconichi	lake whitefish	L	515	1224	0.10	0.015	0.06	0.06	0.17	0.07	0.10	0.54	0.05	3.6	14.0	1.65	0.268
55	2001	53570	Lac Waconichi	lake trout	M	606	1972	0.06	0.019	0.08	0.28		0.11	<0.10	0.34	0.07	3.1	37.0	2.36	0.656
56	2001	53658	Lac Waconichi	northern pike	L	793	3559	<0.05	0.022	0.07	0.20		0.14	<0.10	0.37	0.07	3.8	1.4	0.66	0.025

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 199	Lac Chibougamau	E-01	2001-09-27	Al	0.16	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Al	0.18	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	As	0.002	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	As	0.002	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Be	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Be	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Cd	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Cd	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Cr	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Cr	<0.01	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Cu	0.25	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Cu	0.28	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	HARD**	410	mg CaCO3/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	HARD**	440	mg CaCO3/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Hg	<0.0001	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Hg	<0.0001	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Ni	0.04	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Ni	0.04	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Pb	<0.02	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Pb	<0.02	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Se	<0.001	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Se	<0.001	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Sr	0.43	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Sr	0.43	mg/L	Copper Rand	Drainage water - Eaton Bay
49 199	Lac Chibougamau	E-01	2001-09-27	Zn	0.06	mg/L	Copper Rand	Drainage water - Eaton Bay
49 200	Lac Chibougamau (duplic.)	E-01	2001-09-27	Zn	0.06	mg/L	Copper Rand	Drainage water - Eaton Bay
49 192	Lac aux Dorés	E-02	2001-09-26	Al	0.06	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	As	0.007	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Be	<0.01	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Cd	<0.01	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Cr	<0.01	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Cu	0.01	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	HARD**	150	mg CaCO3/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Hg	0.0001	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Ni	<0.01	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Pb	<0.02	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Se	<0.001	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Sr	0.08	mg/L	Copper Rand	Final mine effluent water
49 192	Lac aux Dorés	E-02	2001-09-26	Zn	0.07	mg/L	Copper Rand	Final mine effluent water
49 182	Lac Chibougamau	S-01	2001-09-24	Al	16 000	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	As	3.7	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Be	<0.5	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Cd	2	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Cr	53	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Cu	31	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Hg	0.09	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Ni	53	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Pb	9	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Se	0.9	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Sr	27	mg/kg	Grand Roy	Pit (130 pieds)
49 182	Lac Chibougamau	S-01	2001-09-24	Zn	110	mg/kg	Grand Roy	Pit (130 pieds)

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 182	Lac Chibougamau	S-01	2001-09-24	BPC	<0.4	mg/kg	Grand Roy	Pit (130 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Al	15 000	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	As	8.8	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Be	<0.5	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Cd	2	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Cr	68	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Cu	59	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Hg	0.06	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Ni	85	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Pb	13	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Se	<0.2	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Sr	45	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Zn	85	mg/kg	Henderson	II (27 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	BPC	<0.4	mg/kg	Henderson	II (27 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Al	19 000	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	As	7.2	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Be	<0.5	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Cd	2	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Cr	46	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Cu	120	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Hg	0.34	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Ni	49	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Pb	20	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Se	1,0	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Sr	26	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Zn	130	mg/kg	Henderson	I (130 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	BPC	<0.4	mg/kg	Henderson	I (130 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Al	29 000	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	As	260	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Be	<0.5	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Cd	7	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Cr	<0.5	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Cu	7 800	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Hg	0.09	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Ni	140	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Pb	37	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Se	2.3	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Sr	6	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Zn	410	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	BPC	<0.4	mg/kg	Copper Rand	Pointe Machin (5 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Al	15 000	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	As	>60	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Be	<0.5	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Cd	3	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Cr	9	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Cu	680	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Hg	0.06	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Ni	52	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Pb	16	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Se	0.7	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Sr	14	mg/kg	Copper Rand	Near tailings site (14 pieds)

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 186	Lac aux Dorés	S-07	2001-09-26	Zn	130	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	BPC	<0.4	mg/kg	Copper Rand	Near tailings site (14 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Al	17 000	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	As	16	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Be	<0.5	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Cd	2	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Cr	39	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Cu	480	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Hg	0.09	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Ni	49	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Pb	32	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Se	1.1	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Sr	27	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Zn	140	mg/kg	Copper Rand	Pit (120 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	BPC	<0.4	mg/kg	Copper Rand	Pit (120 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Al	6 700	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	As	7.2	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Be	<0.5	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Cd	1	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Cr	14	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Cu	220	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Hg	0.08	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Ni	27	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Pb	21	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Se	0.9	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Sr	24	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Zn	67	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	BPC	<0.4	mg/kg	Copper Rand	Sediments - EMF (9 pieds)
49 189	Lac aux Dorés	S-10	2001-09-26	Al	25 000	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	As	44	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Be	<0.5	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Cd	4	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Cr	18	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Cu	1 400	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Hg	0.07	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Ni	66	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Pb	42	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Se	2.1	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Sr	18	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	Zn	280	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 189	Lac aux Dorés	S-10	2001-09-26	BPC	<0.4	mg/kg	Principale	N-E Pointe Campbell (110 pi)
49 193	Lac aux Dorés	S-11	2001-09-27	Al	19 000	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	As	76	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Be	<0.5	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Cd	8	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Cr	<0.5	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Cu	990	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Hg	0.08	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Ni	65	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Pb	46	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Se	4.2	mg/kg	Principale	Pointe Campbell (14 pieds)

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 193	Lac aux Dorés	S-11	2001-09-27	Sr	9	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	Zn	380	mg/kg	Principale	Pointe Campbell (14 pieds)
49 193	Lac aux Dorés	S-11	2001-09-27	BPC	<0.4	mg/kg	Principale	Pointe Campbell (14 pieds)
49 194	Lac aux Dorés	S-12	2001-09-27	Al	18 000	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	As	27	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Be	<0.5	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Cd	3	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Cr	25	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Cu	990	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Hg	0.08	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Ni	67	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Pb	35	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Se	1.5	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Sr	27	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	Zn	230	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 194	Lac aux Dorés	S-12	2001-09-27	BPC	<0.4	mg/kg	Principale	SW Pointe Campbell (54 pi)
49 195	Lac aux Dorés	S-13	2001-09-27	Al	44 000	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Al	26 000	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	As	120	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	As	120	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Be	<0.5	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Be	<0.5	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Cd	5	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Cd	5	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Cr	4	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Cr	5	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Cu	740	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Cu	750	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Hg	0.06	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Hg	0.52	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Ni	340	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Ni	350	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Pb	38	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Pb	38	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Se	4,0	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Se	4,0	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Sr	22	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Sr	21	mg/kg	Principale	Sediments - EMF (6 pieds)
49 195	Lac aux Dorés	S-13	2001-09-27	Zn	290	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Zn	300	mg/kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	BPC	<0.4	mg/kg	Principale	Sediments - EMF (6 pieds)
49 197	Lac aux Dorés	S-14	2001-09-27	Al	9 600	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	As	26	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Be	<0.5	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Cd	1	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Cr	22	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Cu	560	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Hg	0.65	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Ni	58	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Pb	22	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Se	1.3	mg/kg	Principale	Sediments SE EMF (8 pi)

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 197	Lac aux Dorés	S-14	2001-09-27	Sr	27	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	Zn	120	mg/kg	Principale	Sediments SE EMF (8 pi)
49 197	Lac aux Dorés	S-14	2001-09-27	BPC	<0.4	mg/kg	Principale	Sediments SE EMF (8 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Al	25 000	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	As	29	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Be	<0.5	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Cd	3	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Cr	26	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Cu	970	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Hg	0.16	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Ni	86	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Pb	67	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Se	3.2	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Sr	23	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Zn	250	mg/kg	Principale	Sediments South EMF (50 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	BPC	<0.4	mg/kg	Principale	Sediments South EMF (50 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Al	14 000	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	As	2	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Be	<0.5	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Cd	1	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Cr	42	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Cu	39	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Hg	0.05	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Ni	44	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Pb	10	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Se	0.4	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Sr	41	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Zn	66	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	BPC	<0.4	mg/kg	Île des Commissaires	Point opposite mine (90 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Al	17 000	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	As	4.1	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Be	<0.5	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Cd	2	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Cr	23	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Cu	18	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Hg	0.21	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Ni	17	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Pb	26	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Se	1,0	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Sr	26	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Zn	130	mg/kg	Lemoine ?	Forest cut ? (18 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	BPC	<0.4	mg/kg	Lemoine ?	Forest cut ? (18 pi)
8 412	Lac Chibougamau	S-18	2001-06-05	As	170	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Cu	560	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Hg	<0.035	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Ni	157	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Pb	6	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Zn	127	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	Fe	140 000	mg/kg	Eaton Bay	Sediment pipe
8 412	Lac Chibougamau	S-18	2001-06-05	W 105**	20.1	%(P/P)	Eaton Bay	Sediment pipe
8 413	Lac Chibougamau	S-19	2001-06-05	As	110	mg/kg	Eaton Bay	Corner of Sediments

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
8 413	Lac Chibougamau	S-19	2001-06-05	Cu	840	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	Hg	0.07	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	Ni	171	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	Pb	13	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	Zn	128	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	Fe	140 000	mg/kg	Eaton Bay	Corner of Sediments
8 413	Lac Chibougamau	S-19	2001-06-05	W 105**	47.4	%(P/P)	Eaton Bay	Corner of Sediments
8 418	Lac Chibougamau	S-20	2001-06-05	As	2	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Cu	109	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Hg	0.045	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Ni	137	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Pb	1	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Zn	25.1	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	Fe	10 000	mg/kg	Grand Roy	Sediments and tailings ?
8 418	Lac Chibougamau	S-20	2001-06-05	W 105**	37.1	%(P/P)	Grand Roy	Sediments and tailings ?
8 414	Lac aux Dorés	R-1	2001-06-05	As	63	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Cu	283	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Hg	0.043	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Ni	100	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Pb	2.4	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Zn	85	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	Fe	97 000	mg/kg	Eaton Bay	Mine tailings
8 414	Lac aux Dorés	R-1	2001-06-05	W 105**	30.5	%(P/P)	Eaton Bay	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	As	203	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Cu	340	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Hg	<0.035	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Ni	83	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Pb	3.3	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Zn	99	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Fe	120 000	mg/kg	Copper Rand	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	W 105**	25,0	%(P/P)	Copper Rand	Mine tailings
8 416	Lac aux Dorés	R-3	2001-06-05	As	137	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Cu	282	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Hg	<0.035	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Ni	32	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Pb	32	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Zn	520	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	Fe	52 000	mg/kg	Principale	Tailings (former site)
8 416	Lac aux Dorés	R-3	2001-06-05	W 105**	18.6	%(P/P)	Principale	Tailings (former site)
8 417	Lac aux Dorés	R-4	2001-06-05	As	333	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Cu	167	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Hg	<0.035	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Ni	26	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Pb	2.9	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Zn	135	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	Fe	39 000	mg/kg	Principale	Tailings (new site)
8 417	Lac aux Dorés	R-4	2001-06-05	W 105**	32.1	%(P/P)	Principale	Tailings (new site)
8 414	Lac Chibougamau	R-1	2001-06-05	Fe	97 000	mg/Kg	Eaton Bay	Mine tailings
8 415	Lac aux Dorés	R-2	2001-06-05	Fe	120 000	mg/Kg	Copper Rand	Mine tailings
8 416	Lac aux Dorés	R-3	2001-06-05	Fe	52 000	mg/Kg	Principale	Tailings (former site)
8 417	Lac aux Dorés	R-4	2001-06-05	Fe	39 000	mg/Kg	Principale	Tailings (new site)

Appendix 4 Raw data on concentrations of metals in water, sediments, and mine tailings (next)

Laboratoire	LAKE	SITE	DATE	PAR*	RESULTS	UNITS	MINE SITE	COMMENTS
49 182	Lac Chibougamau	S-01	2001-09-24	Fe	26 000	mg/Kg	Grand Roy	Pit (130 pieds)
49 183	Lac Chibougamau	S-02	2001-09-24	Fe	39 000	mg/Kg	Henderson	II (27 pieds)
49 184	Lac Chibougamau	S-03	2001-09-26	Fe	28 000	mg/Kg	Henderson	I (130 pieds)
49 185	Lac aux Dorés	S-06	2001-09-26	Fe	160 000	mg/Kg	Copper Rand	Pointe Machin (5 pieds)
49 186	Lac aux Dorés	S-07	2001-09-26	Fe	59 000	mg/Kg	Copper Rand	Near tailings site (14 pieds)
49 187	Lac aux Dorés	S-08	2001-09-24	Fe	37 000	mg/Kg	Copper Rand	Pit (120 pieds)
49 188	Lac aux Dorés	S-09	2001-09-24	Fe	12 000	mg/Kg	Copper Rand	Sediments - EMF (9 pieds)
49 189	Lac aux Dorés	S-10	2001-09-26	Fe	71 000	mg/Kg	Principale	NE Pointe Campbell (110 pi)
49 193	Lac aux Dorés	S-11	2001-09-27	Fe	190 000	mg/Kg	Principale	Pointe Campbell (14 pieds)
49 194	Lac aux Dorés	S-12	2001-09-27	Fe	57 000	mg/Kg	Principale	SW Pointe Campbell (54 pi)
49 195	Lac aux Dorés	S-13	2001-09-27	Fe	110 000	mg/Kg	Principale	Sediments - EMF (6 pieds)
49 196	Lac aux Dorés (duplic.)	S-13	2001-09-27	Fe	65 000	mg/Kg	Principale	Sediments - EMF (6 pieds)
49 197	Lac aux Dorés	S-14	2001-09-27	Fe	16 000	mg/Kg	Principale	Sediments SE EMF (8 pi)
49 198	Lac aux Dorés	S-15	2001-09-27	Fe	54 000	mg/Kg	Principale	Sediments South EMF (50 pi)
49 190	Lac Chibougamau	S-16	2001-09-26	Fe	19 000	mg/Kg	Île des Commissaires	Point opposite mine (90 pi)
49 191	Lac Chibougamau	S-17	2001-09-26	Fe	19 000	mg/Kg	Lemoine ?	Forest cut ? (18 pi)
8 412	Lac Chibougamau	S-18	2001-06-05	Fe	140 000	mg/Kg	Eaton Bay	Sediment pipe
8 413	Lac Chibougamau	S-19	2001-06-05	Fe	140 000	mg/Kg	Eaton Bay	Corner of Sediments
8 418	Lac Chibougamau	S-20	2001-06-05	Fe	10 000	mg/Kg	Grand Roy	Sediments and tailings ?

*PAR= PARAMETER
**HARD= hardness
***= W 105: weight loss at 105°C