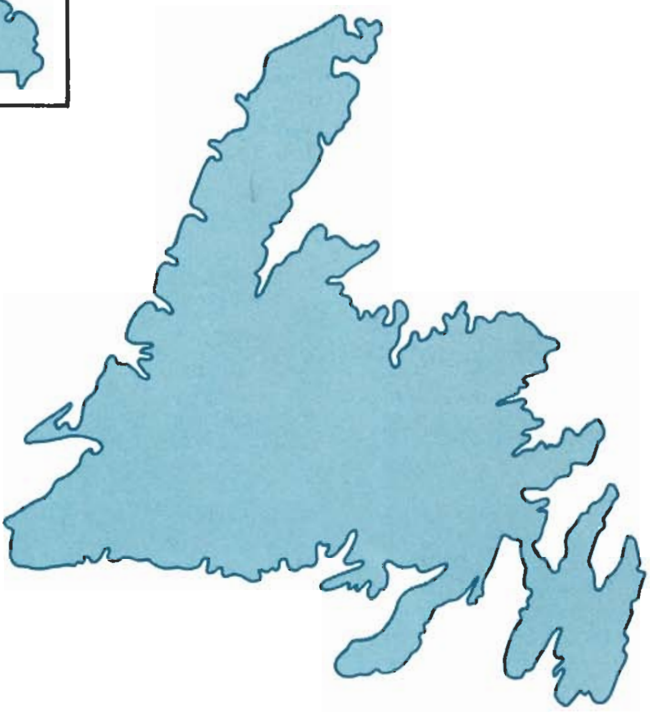
# CANADA-NEWFOUNDLAND
## WATER QUALITY MONITORING AGREEMENT

# ORGANIC AND INORGANIC CONTAMINANTS IN SEDIMENTS OF SELECTED RIVER BASINS, 1987-89



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CANADA-NEWFOUNDLAND WATER QUALITY

MONITORING AGREEMENT

# ORGANIC AND INORGANIC CONTAMINANTS IN BOTTOM SEDIMENTS OF SELECTED NEWFOUNDLAND RIVER BASINS: 1987-1989

by

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JUNE 1991

## LETTER OF TRANSMITTAL

File #5352

May 30, 1991

Coordinating Committee
Canada-Newfoundland Water Quality Monitoring Agreement

Dear Member:

During the summers of 1987, 1988 and 1989, the Bottom Sediment Survey was conducted under the Canada-Newfoundland Water Quality Monitoring Agreement. In the name of the Technical Subcommittee members, it is my pleasure to submit to you the final report for this survey.

Yours truly,

Sylvie Roussel

Sylvie C. Roussel
District Water Quality Officer (Nfld. and N.S.)

Attach.

Technical Subcommittee Members

Tony Blouin, Newfoundland Dept. of Environment and Lands
Sylvie C. Roussel, Environment Canada
Evan Watt, Environment Canada

## EXECUTIVE SUMMARY

The Bottom Sediment Survey was conducted during the summers of 1987, 1988 and 1989, as part of the Canada-Newfoundland Water Quality Monitoring Agreement. Its purpose was to measure the levels of contaminants in bottom sediments of selected sites, as bottom sediments are known to accumulate many toxic substances whose concentrations may be below detection limits in water samples.

Toxic metals and organics were analyzed in bottom sediments from selected sites in twelve river basins within the province. Particle size and organic matter content were also measured to facilitate the interpretation of the data. Heavy metal contamination appears to have occured in the relatively populated Exploits River, Waterford River and Humber River-Corner Brook Basins. Also, polynuclear aromatic hydrocarbons were detected at significant levels in the Waterford River Basin, while polychlorinated biphenyls were very high in St. John's Harbour and not as high in the Exploits River Estuary.

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## ACKNOWLEDGEMENTS

The authors wish to thank Ken MacKeigan (Water Quality Branch), Colin Howes (Water Resources Branch) and Gerry Collins (Nfld. Dept. of Environment and Lands) for the collection of samples. Special thanks are also extended to the National Water Quality Laboratory staff and the Atlantic Water Quality Laboratory staff for their meticulous analyses of the various samples. Completion of this report was made possible with the support and helpful suggestions from Dr. Wasi Ullah, Dr. Paul Belliveau and Roy John, members of the Coordinating Committee, and from Evan Watt.

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## ABSTRACT

A study on metal and organic contaminants in bottom sediments from selected sites in twelve basins within Newfoundland was conducted between 1987 and 1989. A method consisting of studying the relationship between aluminum, a reference element, and toxic metals was used to interpret the data. Heavy metal contamination occured mostly in the Exploits River, Waterford River and Humber River-Corner Brook Basins. Also, polychlorinated biphenyls were detected at some Waterford River sites, including St. John's Harbour, and in the Exploits River estuary. Levels of polynuclear aromatic hydrocarbons were also detected in the Waterford River Basin and the estuarine portion of the Garnish River.

This study shows that bottom sediments are good indicators of the anthropogenic influence existing in a water basin.

## RESUME

Une étude consacrée à la détermination de métaux toxiques et de composés organiques dans les sédiments de fond de sites choisis dans douze bassins de Terre-Neuve eut lieu entre 1987 et 1989. Afin de déterminer si les niveaux de métaux mesurés étaient dûs à une contribution anthropogène, une méthode qui consiste à normaliser les rapports entre l'aluminium, l'élément de référence, et les métaux toxiques fut utilisée. Les résultats démontrent qu'il existe une contribution anthropogène de métaux lourds dans les rivières Exploits, Waterford et Humber. Aussi, les biphényles polychlorés ont été détectés à des sites de la rivière Waterford, incluant le havre de St. John's, et de l'estuaire de la rivière des Exploits. Les hydrocarbures aromatiques polynucléaires étaient aussi présents à des niveaux détectables dans les sédiments de fonds de la rivière Waterford (St. John's) et de l'estuaire de la rivière Garnish sur la péninsule Burin.

Cette étude a démontré que l'analyse des sédiments de fonds est un moyen utile de déterminer la présence de contamination dans un bassin aquatique.

## 1. INTRODUCTION

As part of the Canada-Newfoundland Water Quality Monitoring Agreement, a bottom sediment survey was conducted between 1987 and 1989 in selected river basins of Newfoundland. Twelve watersheds of the Index Station Network were chosen for bottom sediment sampling. These basins belonged to one of three defined regions of the province (Western, Central and Eastern), and sampling was concentrated in a different region each year. Samples were analyzed for heavy metals, some toxic organic substances, particle size and organic content.

The objectives of the study were:

1) to examine occurances of organic and metal contaminants, and to identify if these were linked to anthropogenic sources;

2) to detect anthropogenic metal enrichment by calculating ratios between metal contaminants and a reference element, and by complementing the data with particle size and organic content information; and

3) to hypothesize on potential risks of these contaminants to aquatic biota.

This study applies methods used in previous studies to determine if levels of metals are indicative of a true anthropogenic metal enrichment, or just naturally occuring levels in a geological area. In addition, the presence of toxic organic contaminants will be discussed in light of the existing information on sediment quality guidelines.

## 2. METHODS

### 2.1 Sampling Program

Thirty-one stations in 12 different watersheds of Newfoundland were sampled for bottom sediments over the three year period of 1987 to 1989. The network was divided into three regions, Western, Central and Eastern, and sampling was concentrated in a different region each year. Sites were located either in ponds, river beds or estuaries. These sites are listed in Table 1, and plotted in Figure 1. Numbers from one to 31 will be used in all figures to identify the 31 sampling stations, as they are listed in Table 1.

The watersheds for this study were selected from the existing Index Station Network. Sampling sites had been preselected, but their location could vary depending on the availability of suitable bottom sediments. One to three sites were sampled in each basin, except in the Waterford River Basin, where seven sites were sampled because an intensive Recurrent Network study of that basin was concurrently taking place. Indian Brook, Northeast River and Rocky River were initially selected for bottom sediment sampling, but were eliminated during the study, due either to lack of time or to a failure to find sufficient quantities of fine bottom sediments. Consequently, the program as designed for bottom sediment sampling was only slightly reduced. A total of 86 samples, including duplicate and triplicate samples, were collected.

The selection of sites for sediment sampling depended on the nature of the sediment itself. Field officers were asked to sample sediments with high organic matter content and low particle size, since contaminants have a greater affinity for these types of sediments (Förstner, 1982). As a result of this, an intentional sampling bias for sediments with these particular

## TABLE 1: LIST OF STATIONS SAMPLED DURING THE BOTTOM SEDIMENT SURVEY

| SITE # | NAQUADAT # | DESCRIPTION |
|---|---|---|
| a) 1987 Survey | | |
| 1. | 50NF02YL0014 | Latitude 48° 57' 12" Longitude 57° 57' 02"<br>Corner Brook, 50 m downstream of West Valley Road |
| 2. | 51NF02YC0002 | Latitude 50° 36' 41" Longitude 57° 10' 08"<br>Pond on Torrent River, 1 m from northeast shore |
| 3. | 51NF02YC0003 | Latitude 50° 36' 44" Longitude 57° 10' 02"<br>Pond on Torrent River, at centre of pond |
| 4. | 51NF02YC0005 | Latitude 50° 36' 41" Longitude 57° 10' 04"<br>Pond on Torrent River, above Route 430 bridge |
| 5. | 53NF02YH0001 | Latitude 49° 27' 26" Longitude 57° 45' 32"<br>Lomond River Estuary, 1 m from left bank |
| 6. | 53NF02YH0002 | Latitude 49° 27' 17" Longitude 57° 45' 27"<br>Lomond River Estuary, 1 m north of northwest tip of island |
| 7. | 53NF02YJ0002 | Latitude 48° 25' 43" Longitude 58° 30' 21"<br>Harry's River Estuary, 150 m east of railroad bridge |
| 8. | 53NF02YL0001 | Latitude 48° 57' 30" Longitude 57° 56' 38"<br>Humber River Arm, 1 m southwest corner of pier above pulpmill |
| b) 1988 Survey | | |
| 9. | 51NF02YM0009 | Latitude 49° 27' 19" Longitude 56° 26' 38"<br>Indian Pond, 400m south of Indian Brook inflow |

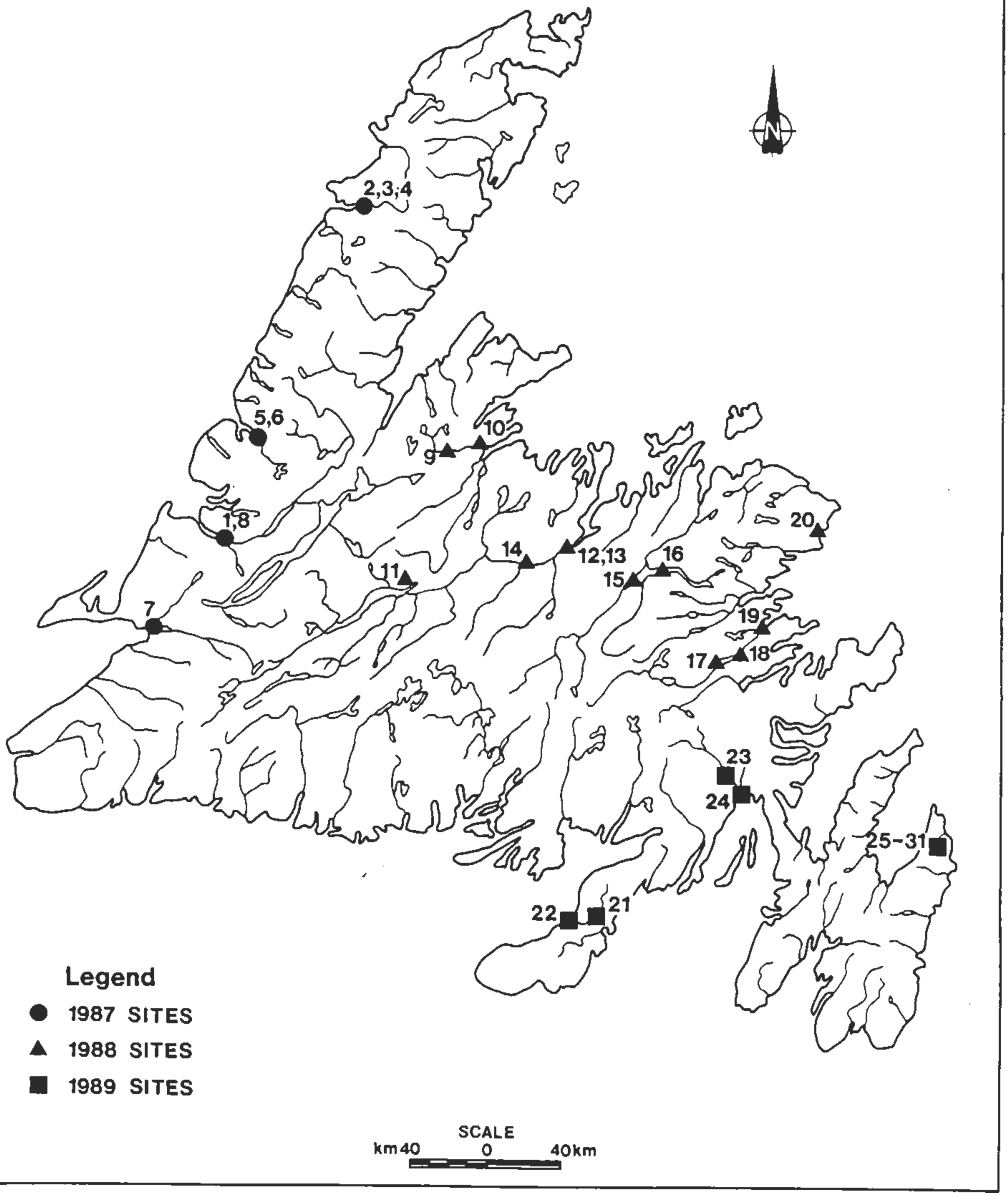
**TABLE 1 (Continued)**

| SITE # | NAQUADAT # | DESCRIPTION |
|---|---|---|
| 10. | 50NF02YM0001 | Latitude 49° 29' 44" Longitude 56° 05' 21"<br>Indian Brook, 200m upstream of WSC station |
| 11. | 50NF02YN0007 | Latitude 48° 50' 10" Longitude 56° 51' 19"<br>Buchans Brook, 200m downstream of Buchans Lake Dam |
| 12. | 52NF02YO0002 | Latitude 49° 01' 53" Longitude 55° 25' 30"<br>Exploits River, 2.0 km downstream of TCH bridge, left bank |
| 13. | 52NF02YO0004 | Latitude 49° 01' 49" Longitude 55° 25' 28"<br>Exploits River, 2.0 km downstream of TCH bridge, right bank |
| 14. | 50NF02YO0052 | Latitude 48° 56' 12" Longitude 55° 37' 04"<br>Exploits River, 3.5 km downstream of Grand Falls, left bank below municipal outfall |
| 15. | 51NF01YQ0015 | Latitude 48° 57' 55" Longitude 54° 52' 54"<br>Gander Lake, western shore 3.5 km from TCH bridge at Glenwood |
| 16. | 51NF02YQ0014 | Latitude 48° 50' 28" Longitude 54° 43' 32"<br>Gander Lake, 100m from entrance to Little Harbour Marina |
| 17. | 51NF02YS0060 | Latitude 48° 30' 47" Longitude 54° 14' 47"<br>Terra Nova Lake, mid-lake at hydro line crossing |
| 18. | 50NF02YS0011 | Latitude 48° 38' 36" Longitude 54° 03' 00"<br>Terra Nova River, above TCH bridge, left bank |
| 19. | 50NF02YS0013 | Latitude 48° 39' 20" Longitude 54° 01' 19"<br>Terra Nova River, 2.2 km upstream of South Glovertown Bridge, left bank |
| 20. | 50NF02YR0001 | Latitude 49° 10' 41" Longitude 53° 33' 47"<br>Pound Cove Brook, at the outlet of Pound Cove Brook Pond |
| c) 1989 Survey | | |
| 21. | 51NF02ZG0006 | Latitude 47° 12' 40" Longitude 55° 13' 15"<br>Garnish Pond, 0.3 km southwest from Black River outlet, at the centre of the pond |

**TABLE 1 (Continued)**

| SITE # | NAQUADAT # | DESCRIPTION |
|---|---|---|
| 22. | 52NF02ZG0007 | Latitude 47° 13' 45" Longitude 55° 20' 50"<br>Garnish River Estuary, at bend before entering Little Garnish Barasway |
| 23. | 50NF02ZH0011 | Latitude 47° 55' 50" Longitude 54° 16' 30"<br>Piper's Hole River, 200 m downstream of old bridge off Highway 210 in Piper's Hole River Park, 1 m from right bank |
| 24. | 52NF02ZH0012 | Latitude 47° 54' 10" Longitude 54° 15' 20"<br>Mooring Rock Cove - Piper's Hole River, 0.8 km below mouth of river between two small islands |
| 25. | 50NF02ZM0009 | Latitude 47° 31' 45" Longitude 52° 44' 34"<br>Waterford River at Kilbride at gauge, St. John's |
| 26. | 50NF02ZM0084 | Latitude 47° 31' 10" Longitude 52° 46' 26"<br>Flings Brook, experimental farm branch, 100m upstream of confluence with Waterford River |
| 27. | 51NF02ZM0100 | Latitude 47° 31' 22" Longitude 52° 51' 06"<br>Unnamed pond, Waterford River Basin, 0.5 km downstream of Bremigan's Pond dam, right bank |
| 28. | 51NF02ZM0101 | Latitude 47° 32' 02" Longitude 52° 51' 02"<br>Brazil Pond, northern tip of the pond, 2 m from bank, accessed from Topsail Road |
| 29. | 51NF02ZM0102 | Latitude 47° 33' 08" Longitude 52° 44' 27"<br>Mundy Pond, halfway between right shore of pond and small island |
| 30. | 51NF02ZM0103 | Latitude 47° 32' 10" Longitude 52° 42' 55"<br>Beaver Pond at the northeastern tip of the pond, midway between the two banks |
| 31. | 53NF02ZM0104 | Latitude 47° 33' 18" Longitude 52° 42' 40"<br>St. John's Harbour, 100m downstream of Pitts Memorial Drive, from the right side dock |

FIG.1: BOTTOM SEDIMENT SAMPLING SITES IN NEWFOUNDLAND



properties exists; however, it will facilitate the detection of anthropogenic pollution input to these aquatic systems.

The geological properties of the sites sampled are summarized in Table 2. Many of these sites were not easily sampled because organic and/or fine sediments were not readily available in certain watersheds. This is due to the sandy and rocky nature of many river beds in Newfoundland.

### 2.2 Field Methodology

The bottom sediment samples were collected with a 15cm x 15cm Ekman grab sampler. This device ensured the collection of relatively undisturbed samples of the top layer of sediment, and allowed for the study of the most recently deposited sediment layers (de Groot et al., 1982).

After the sample was collected, it was transferred to a pyrex tray. At the centre of the grab sample, the upper two centimeters of sediment were taken with an aluminum or plastic scoop, depending on the type of analysis to be performed, and placed in a large plastic or stainless steel bowl. Triplicate splits were prepared by repeating this procedure at least three times, homogenizing the three samples together to form a larger sample, dividing it into three different portions, and placing each portion in a separate container. This was done twice, once for the samples used for metal analyses (using plastic instruments), and once for the samples for toxic organics analyses (using metal instruments). These samples were sent to the laboratories, unidentified as triplicate samples, so that laboratory personnel were not aware that they were related to one another.

## TABLE 2: CHARACTERIZATION OF GEOLOGICAL PROPERTIES AT THE BOTTOM SEDIMENT SURVEY SITES (GSC, 1967)

| STATION(S) | GEOLOGICAL CONDITIONS |
|---|---|
| 50NF02YL0014,<br>53NF02YL0001 | Shale, sandstone, slate, greywacke, limestone, conglomerate, basic volcanic rocks |
| 50NF02YR0001,<br>50NF02YS0011 | Granite, granodiorite, syenite, monzonite, quartz diorite and related rocks |
| 50NF02YS0013 | Acidic to mafic volcanic rocks, slate, greywacke, conglomerate and metamorphic equivalents |
| 51NF02YC0005 | Limestone, quartzite, shale, dolomite, slate with arkose, conglomerate and basalt locally at base |
| 51NF02YM0009,50NF02YM0001,<br>50NF02YN0007,52NF02YO0002,<br>52NF02YO0004,50NF02YO0052 | Sandstone, conglomerate, acidic to mafic volcanic rocks, greywacke, shale, limestone |
| 51NF02YQ0015,<br>51NF02YQ0014 | Intermediate to mafic volcanic rocks, slate, greywacke, siltstone, chert, conglomerate, minor limestone |
| 51NF02YS0060 | Siltstone, quatzite, slate, greywacke and metamorphic equivalents |
| 53NF02YH0001,<br>53NF02YH0002 | Limestone, quartzite, dolomite, shale |
| 53NF02YJ0002 | Conglomerate, sandstone, siltstone, shale, limestone, gypsum,some coal |
| 51NF02ZG0006,52NF02ZG0007,<br>50NF02ZH0011 | Acidic to mafic volcanic rocks, slate, siltstone, greywacke, conglomerate |
| 50NF02ZH0012 | Granite, granodiorite, syenite, monzonite, quartz diorite and related rocks |
| 50NF02ZM0009,50NF02ZM0084,<br>51NF02ZM0102,51NF02ZM0103,<br>53NF02ZM0104 | Siltstone, arkose, conglomerate, slate, acidic to intermediate volcanic rocks |
| 51NF02ZM0100,<br>51NF02ZM0101 | Slate, siltstone, greywacke, conglomerate minor volcanic rocks |

A full description of the sampling procedures used for bottom sediments are described in "Sampling for Water Quality" (WQB, 1983). The quality assurance/quality control protocol employed is outlined in a report by Arseneault and Howell (1987).

Samples were kept frozen until they were sent to the National Water Quality Laboratory (NWQL) or the Atlantic Region Water Quality Laboratory (ARWQL), via air carrier in cold storage. This was essential for the prevention of biological activity and/or chemical transformations in the sediments (de Groot et al., 1982).

## 2.3 Laboratory Methodology

The laboratory analyses were divided between the ARWQL and the NWQL. In 1987, heavy metals, organic carbon and particle size were analyzed at the ARWQL, while OC-PCBs and particulate organic carbon and nitrogen were analyzed at the NWQL. In 1988 and 1989, all analyses were done at the NWQL, except for particle size which was done at the ARWQL.

The variables measured in the sediment samples are listed in Tables 3 and 4, and include extractable non-residual metals, total mercury, organochlorinated pesticides (OCs), polychlorinated biphenyls (PCBs), particulate organic carbon and nitrogen and particle size. In addition to these variables, the samples taken in 1989 were also analyzed for polynuclear aromatic hydrocarbons (PAHs), chlorinated phenols (CPs) and chlorinated benzenes (CBs).

Extractable non-residual metals were analyzed by atomic absorption with direct aspiration. For these analyses, the sample was sieved and weighed accurately in a propylene wide mouth bottle. A quantity of 0.5N HCl was added to the sample, and then tightly capped

**TABLE 3: LISTING AND DETECTION LIMITS OF VARIABLES STUDIED IN IN 1987 IN BOTTOM SEDIMENTS**

| VARIABLE | NAQUADAT CODE | DETECTION LIMIT |
|---|---|---|
| Mercury, Total | 80050L | 0.01 mg/kg |
| Aluminum, Ext. non-r. | 13054L | 0.1 mg/kg |
| Cadmium,Ext.non-r. | 48054L | 0.5 mg/kg |
| Copper, Ext. non-r. | 29054L | 0.1 mg/kg |
| Iron, Ext. non-r. | 26054L | 0.5 mg/kg |
| Lead, Ext. non-r. | 82054L | 0.1 mg/kg |
| Zinc, Ext. non-r. | 30054L | 0.1 mg/kg |
| Hexachlorobenzene | 17816L | 0.004 mg/kg |
| ρ,ρ-DDT | 18009L | " |
| o,ρ-DDT | 18008L | " |
| ρ,ρ-DDE | 18026L | " |
| ρ,ρ-Methoxychlor | 18034L | " |
| Heptachlor | 18043L | " |
| Heptachlor epoxide | 18048L | " |
| Alpha-endosulfan | 18054L | " |
| Beta-endosulfan | 18058L | " |
| Alpha-chlordane | 18063L | " |
| Gamma-chlordane | 18068L | " |
| Gamma-BHC (Lindane) | 18079L | " |
| Alpha-BHC | 18074L | " |
| Mirex | 18128L | " |
| Aldrin | 18133L | " |
| Endrin | 18143L | " |
| Dieldrin (HEOD) | 18153L | " |
| PCB, Total | 18177L | 0.09 mg/kg |
| Organic carbon | 06912L | 0.005 % |
| Organic nitrogen | 07912L | 0.005 % |
| Particle size - Sand | 97281L | - % |
| Silt | 97282L | - % |
| Clay | 97283L | - % |

## TABLE 4: LISTING AND DETECTION LIMITS OF VARIABLES STUDIED IN 1988 AND 1989 IN BOTTOM SEDIMENTS

| VARIABLE | NAQUADAT CODE | DETECTION LIMIT |
|---|---|---|
| Mercury, Total | 80500L | 0.01mg/kg |
| Aluminum, Ext. non-r. | 13054L | 0.2 mg/kg |
| Cadmium, Ext. non-r. | 48054L | 0.2 mg/kg |
| Copper, Ext. non-r. | 29054L | 0.2 mg/kg |
| Iron, Ext. non-r. | 26054L | 1.0 mg/kg |
| Lead, Ext. non-r. | 82054L | 1.0 mg/kg |
| Zinc, Ext. non-r. | 30054L | 0.2 mg/kg |
| Cobalt, Ext. non-r. | 27054L | 0.4 mg/kg |
| Chromium, Ext. non-r. | 24054L | 0.2 mg/kg |
| Nickel, Ext. non-r. | 28054L | 0.6 mg/kg |
| Hexachlorobenzene | 96810L | 6.3 ng/g |
| ρ,ρ-DDT | 96824L | 7.5 ng/g |
| o,ρ-DDT | 96822L | 7.0 ng/g |
| ρ,ρ-TDE | 96823L | 6.0 ng/g |
| ρ,ρ-DDE | 96819L | 5.6 ng/g |
| ρ,ρ-Methoxychlor | 96827L | 18.0 ng/g |
| Heptachlor | 96813L | 1.4 ng/g |
| Heptachlor epoxide | 96815L | 1.9 ng/g |
| Alpha-endosulfan | 96818L | 1.4 ng/g |
| Beta-endosulfan | 96825L | 2.9 ng/g |
| Alpha-chlordane | 96817L | 2.3 ng/g |
| Gamma-chlordane | 96816L | 1.5 ng/g |
| Gamma-BHC (Lindane) | 96812L | 2.9 ng/g |
| Alpha-BHC | 96811L | 2.3 ng/g |
| Mirex | 96826L | 4.3 ng/g |
| Aldrin | 96814L | 1.6 ng/g |
| Endrin | 96821L | 2.9 ng/g |
| Dieldrin (HEOD) | 96820L | 3.2 ng/g |
| PCB, Total | 96828L | 77.0 ng/g |
| Organic carbon | 06912L | 0.005% |
| Organic nitrogen | 07912L | 0.005% |
| Particle size - Sand | 97281L | -% |
| Silt | 97282L | -% |
| Clay | 97283L | -% |
| Oil and Grease | 06526L | 0.1% |

## TABLE 5: ADDITIONAL VARIABLES MEASURED IN BOTTOM SEDIMENTS DURING THE 1989 SAMPLING PERIOD

| VARIABLE | NAQUADAT CODE | DETECTION LIMIT |
|---|---|---|
| Polynuclear Aromatic Hydrocarbons | | |
| Indene | 96550L | 10 ng/g |
| 1,2,3,4-Tetrahydronaphthalene | 96551L | " |
| 2-Methylnaphthalene | 96552L | " |
| 1-Methylnaphthalene | 96553L | " |
| β-Chloronaphthalene | 96554L | " |
| Acenaphthylene | 96555L | " |
| Acenaphthene | 96556L | " |
| Fluorene | 96557L | 15 ng/g |
| Phenanthrene | 96558L | " |
| Pyrene | 96559L | " |
| Fluoranthene | 96560L | " |
| Benzo[b]fluoranthene | 96561L | 30 ng/g |
| Benzo[k]fluoranthene | 96562L | " |
| Benzo[a]pyrene | 96563L | " |
| Indenopyrene | 96564L | " |
| Benzoperylene | 96565L | " |
| Chlorophenols | | |
| O-Chlorophenol | 96580L | 10 ng/g |
| M-Chlorophenol | 96581L | " |
| P-Chlorophenol | 96582L | " |
| 2-Cl,5-Methylphenol | 96583L | " |
| 2,6-Dichlorophenol | 96584L | " |
| 4-Cl,3-Methylphenol | 96585L | " |
| 2,4-Dichlorophenol | 96586L | " |
| 3,5-Dichlorophenol | 96587L | " |
| 2,3-Dichlorophenol | 96588L | " |
| 3,4-Dichlorophenol | 96589L | " |
| 2,4,6-Trichlorophenol | 96590L | " |
| 2,3,6-Trichlorophenol | 96591L | " |
| 2,3,5-Trichlorophenol | 96592L | " |
| 2,4,5-Trichlorophenol | 96593L | " |
| 2,3,4-Trichlorophenol | 96595L | " |

**TABLE 5 (Continued)**

| VARIABLE | NAQUADAT CODE | DETECTION LIMIT |
|---|---|---|
| 3,4,5-Trichlorophenol | 96596L | " |
| 2,3,5,6-Tetrachlorophenol | 96597L | " |
| 2,3,4,6-Tetrachlorophenol | 96598L | " |
| 2,4,5,6-Tetrachlorophenol | 96599L | 10 ng/g |
| Pentachlorophenol | 96600L | 10 ng/g |
| Chlorobenzenes | | |
| 1,3-Dichlorobenzene | 96829L | 11.1 ng/g |
| 1,4-Dichlorobenzene | 96830L | 11.7 ng/g |
| 1,2-Dichlorobenzene | 96831L | 14.7 ng/g |
| 1,3,5-Trichlorobenzene | 96832L | 1.8 ng/g |
| 1,2,4-Trichlorobenzene | 96833L | 3.6 ng/g |
| 1,2,3-Trichlorobenzene | 96834L | 1.9 ng/g |
| 1,2,3,4-Tetrachlorobenzene | 96835L | 2.7 ng/g |
| Pentachlorobenzene | 96836L | 3.7 ng/g |

and shaken for 16 hours. The solution was then filtered, and the absorbance was measured at different levels with an acetylene-nitrous oxide reducing flame (WQB, 1988). This method of using strong acids for digestion represents a "strong attack" leaching procedure that can dissolve metals in sometimes unequal amounts (de Groot et al., 1982).

Total mercury was determined using a semi-automated flameless atomic absorption method. A representative aliquot of the homogenized wet sediment was digested with $H_2SO_4$, $HNO_3$ and HCl for two hours at 60°C. It was subsequently oxidized with $KMnO_4$ and $K_2S_2O_8$, and the solution was cleared with hydroxylammonium sulphate-sodium chloride. The sample was centrifuged, and an aliquot of the supernatant was used to measure the absorbance at 253.7 nm in an automated stannous reduction-cold vapour A.A.S. system (WQB, 1988).

Gas chromatographic/mass selective detector (GC-MSD) ultrasonic extraction method was used to determine levels of OCs, PCBs, PAHs and CBs in sediment. The sediment sample was extracted with a 1:1 hexane/acetone mixture. The extract was partitioned with water and re-extracted with dichloromethane. The combined organic extracts were dried, concentrated, and subjected to gel permeation chromatography. It was further cleaned on a silica gel column on which the OCs, PCBs, CBs and PAHs were separated into two fractions. Each fraction was then examined by GC and GC-MSD (WQB, in prep.). The method for analyzing OC-PCBs had been modified in 1988, so the detection limits of these variables for the 1987 samples were slightly different (either higher or lower).

The GC-MSD method was also used to analyze sediment samples for chlorophenols. The sediment sample was acidified to a pH of 2, and extracted with a 2:3 acetone-hexane mixture. The sample was then re-extracted with 2 percent potassium carbonate and derivatized. The extract was concentrated and cleaned on a semi-micro silica gel column. The desired fraction was then collected, and analyzed by a GC-MSD system.

Particle size analysis was conducted to determine percentages of sand, silt and clay in the sediment. The sand fraction is between 0.0625 and 2.00 mm in diameter, silt between 0.0039 and 0.0625 mm, and clay is less than 0.0039 mm in diameter (WQB, 1988).

## 2.4 Statistical Analysis

Statistical tests were only applied to metal results, since most of the organic contaminants were rarely detected, and permitted only interpretation by observation.

For calculation purposes, metal values lower than the detection limit were given a value equal to half the detection limit. As reported by Travis and Land (1990), this method causes a bias in the data, but for this study it involves only a few heavy metal values, as can be observed from the raw data (Appendix 1).

The computer statistical program RS/1 (BBN Software Products Corporation, 1987) was used to analyze the data. The results for aluminum, the reference element, and four toxic metals (copper, lead, nickel and zinc) were tested for normality, using the Wilk-Shapiro test (if $n<50$) or the Kolmogorov-Smirnov test (if $n>50$). Since none of the data sets were normally distributed, a log transformation of the data was done. A second test proved that the log values of these variables were normally distributed ($p<0.05$).

The rest of the procedure is similar to the one used by Schropp et al. (1990). For each toxic metal (copper, lead, nickel and zinc), ratios of toxic metal:aluminum were calculated from the results (not log transformed). The ratios obtained for each toxic metal were again tested for normality. If not satisfied, the data points which gave higher toxic metal: aluminum ratios were removed gradually until a normal distribution of the ratios was obtained. Higher toxic metal:aluminum ratios usually indicate the occurence of anthropogenic metal enrichment (White and Tittlebaum, 1984; Windom et al., 1989; Schropp et al., 1990). The resulting data set, without the higher metal:aluminum ratios, was used to prepare simple linear regressions between aluminum and the other four metals, and 95% confidence curves were added to the regression line. Data points of the higher ratios that had been removed were then compared to the linear regression.

Simple correlation coefficients were calculated between log values of aluminum and the other metals studied (Table 6), showing a significant positive correlation for all the pairs ($p<0.05$).

**TABLE 6: SIMPLE CORRELATION COEFFICIENTS BETWEEN LOG(Al) AND LOG(METAL), AND RESULTS OF THE NULL HYPOTHESIS THAT NO LINEAR RELATIONSHIP EXISTS ($H_0$: $\rho=0$)**

| Metal | N | r | $r^2$ | T cal | Linear rel. |
|---|---|---|---|---|---|
| Cadmium | 86 | 0.28 | 0.08 | 2.67 | yes[1] |
| Copper | 84 | 0.54 | 0.30 | 5.84 | yes |
| Lead | 85 | 0.38 | 0.14 | 3.73 | yes |
| Mercury | 62 | 0.58 | 0.34 | 5.53 | yes |
| Nickel | 62 | 0.37 | 0.14 | 3.09 | yes |
| Iron | 85 | 0.79 | 0.36 | 11.68 | yes |
| Cobalt | 62 | 0.69 | 0.62 | 7.79 | yes |
| Zinc | 86 | 0.60 | 0.47 | 6.87 | yes |

[1] $p<0.05$

# 3. RESULTS AND DISCUSSION

## 3.1 METAL CONTAMINANTS

Both toxic and non-toxic metals tend to accumulate in bottom sediments. They can be remobilized by various processes, but they can not be eliminated from the aquatic ecosystem because of their non-biodegradability (White and Tittlebaum, 1984). Therefore, bottom sediments are used as key elements for the detection of metal contamination in aquatic systems (White and Tittlebaum, 1984). They provide a temporally integrated indication of aquatic pollution (Schropp et al., 1990).

### 3.1.1 Metal Enrichment Measurements

The measurement of total metal concentrations do not give enough information to conclude that an anthropogenic contamination has occured in the system. It is difficult to determine whether the metal concentrations measured are at natural background levels or are anthropogenically enriched (Schropp et al., 1990). One method frequently used consists of using core samples to find existing differences between natural background metal levels and recently deposited anthropogenic levels (Johnson and Nicholls, 1988; Quevauviller et al., 1989).

It is frequently observed that natural metal concentrations can vary by orders of magnitude in sediments, depending on geological conditions, particle size composition and organic matter content (de Groot et al., 1982; White and Tittlebaum, 1984). For instance, metal concentrations in sediments will decrease as the particle size increases (Förstner, 1982; de Groot et al., 1982). Therefore, to make comparisons between metal levels of different areas, and to determine if metal pollution has occured over time, corrections of the data have to be made to compensate for these differences. de Groot et al. (1982) have suggested three methods for doing so, using only surficial sediment data:

a) Separation of grain size fractions: this method involves a physical separation of sediments into different particle sizes, and measuring metal concentrations in each particle size fraction individually for comparison. This method was not employed since it is a very time-consuming procedure, and the laboratory was not asked to provide this information.

b) Extrapolation from regression curves: this method requires the determination of the linear relationship between metal concentrations and grain size fractions. It was not used because only 28% of the samples had particle size data. Even for the samples that did have particle size data, the determination of particle size was not done in the same sub-sample as the one used for metal analysis. Also, de Groot et al. (1982) suggested that the use of this method would require 10-15 samples for each location, while this study consisted of triplicate samples only.

c) Comparison with "conservative" or reference element: this method consists of calculating toxic metal:reference element ratios and normalizing these by removing all higher ratios until normal distribution is attained. A linear regression and 95% confidence curves are then calculated with the remaining data, and all other data points exceeding the upper 95% prediction limit are considered influenced by anthropogenic metal sources (Schropp et al., 1990). However, there is always a possibility that these higher ratios could be attributed to procedural errors, such as sample contamination, or that occasional bottom sediment samples taken in natural areas could have toxic metal levels high enough to exceed the natural proportion with the reference element (Schropp et al., 1990). These factors were taken into consideration during the interpretation of the results.

The latter method was used for this study, since the use of ratios is necessary to reduce the effects of grain size composition, organic content and geological conditions (Förstner, 1976). Aluminum and iron are frequently used as reference elements (White and Tittlebaum, 1984; Windom et al., 1989; Schropp et al., 1990). Aluminum was chosen as the reference element because it is abundant in the earth's crust, has relatively constant proportions with other metals in the earth's crust, and is not likely to be significantly affected by anthropogenic sources (Schropp et al., 1990). This method is preferable to the method using particle size because aluminum content was determined in the same extracts used for heavy metal determination.

Extractable non-residual metal concentrations were analyzed in all sediment samples, and are shown by sampling year in Appendix 1. The data available on particle size fractions and percentages of particulate organic carbon and nitrogen are also presented in these tables.

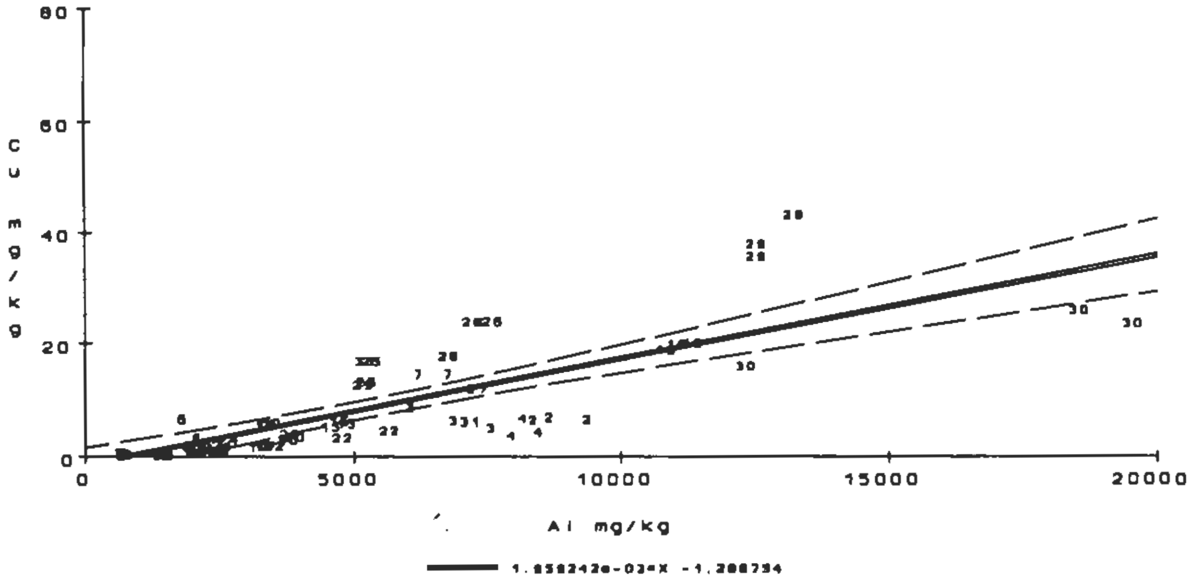
The comparison of toxic metals with aluminum was done only for copper, lead, nickel and zinc. Other toxic metals, such as cadmium and mercury, were not used either because normality of metal:aluminum ratios could not be achieved, even by removing the higher ratios, or because the number of detected values was insufficient for further data analysis.

In the following sections, the results obtained with the reference element method (described above and in section 2.4) are presented. First, a plot was prepared with the data whose toxic metal:aluminum ratios were normally distributed. This illustrates the linear regression between these two variables. Secondly, a comparison was made between the linear regression and the data points which had higher toxic metal:aluminum ratios. In these cases, toxic metal levels are unnaturally high in proportion to aluminum, and suggests an anthropogenic metal enrichment at these sampling sites.

### i) Extractable Copper

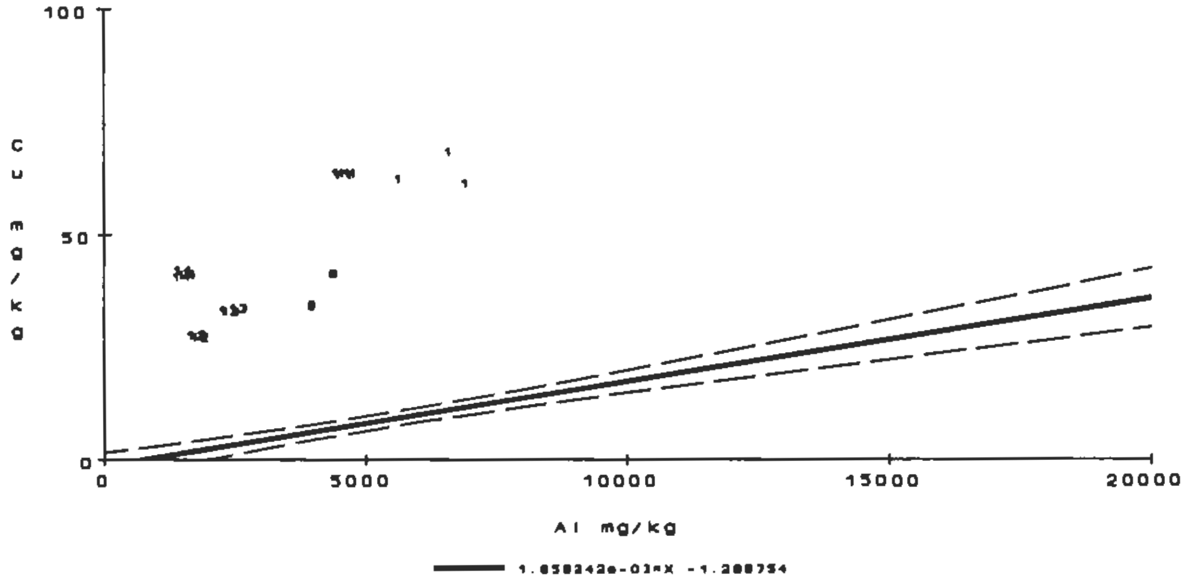
Figure 2a displays the linear relationship between extractable copper and aluminum. A total of 67 values (a statistically acceptable number) were used to obtain the regression. Aluminum concentrations in bottom sediments ranged from 670 to 19,600 mg/kg, and copper ranged between 0.696 and 69.0 mg/kg (Appendix 1). The two metals varied by almost two orders of magnitude for the whole data set collected throughout Newfoundland.

FIGURE 2a:
Linear regression between extractable copper and aluminum concentrations at natural proportions in bottom sediments of Newfoundland sites (with 95% confidence curves)



Stations in the Exploits River and Humber River-Corner Brook Basins had copper levels in sediment exceeding the natural proportion with aluminum (Figure 2b). These include stations #11, #12, #13, #14, #1 and #8. The Exploits River has received base metal input from tailing ponds of the abandoned mine at Buchans (Roussel et al., 1990), indicating a true anthropogenic metal enrichment at the sites located in this basin. Also, the Humber River-Corner Brook and Exploits River Basins are influenced by urbanization. Sewage treatment effluents are known sources of copper contamination (Demayo and Taylor, 1981), so sites in these basins were likely influenced by this source of copper.

FIGURE 2b:
Extractable copper vs aluminum in bottom sediments of Newfoundland sites showing unnatural proportions between them (compared to linear regression of FIG. 2a)



ii) Extractable Lead

The linear relationship between extractable aluminum and extractable lead concentrations is shown in Figure 3a, with data points representing a natural proportion between these two elements in bottom sediments. The regression was obtained from the analysis of 64 samples. As previously mentioned, the aluminum values ranged from 670 to 19,600 mg/kg, while extractable lead varied between 1.77 and 415 mg/kg (Appendix 1). Like copper, lead showed very high variability between sampling sites.

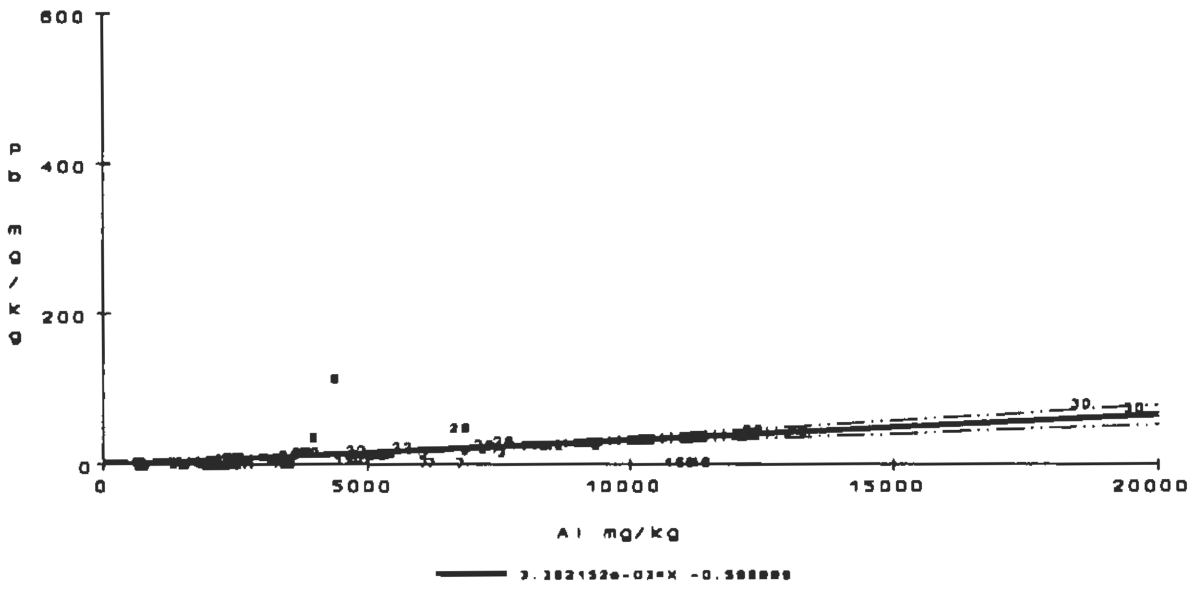


FIGURE 3a:
Linear regression between extractable lead and aluminum concentrations at natural proportions in bottom sediments of Newfoundland sites (with 95% confidence curves)

Figure 3b shows the data whose lead:aluminum ratios did not correspond to the natural proportions usually encountered in unimpacted bottom sediments, but rather the significantly higher ratios indicative of anthropogenic influence. These data came from sites in the Exploits River (#11, #12, #13 and #14), Humber River-Corner Brook (#1) and Waterford River Basins (#29 and #31). The anthropogenic sources of lead in these basins are likely the same as those for copper. Other potential causes at these urbanized sites are street runoff and the combustion of fossil fuels (CCREM, 1987).

### iii) Extractable Nickel

Figure 4a shows the linear relationship between extractable nickel and aluminum values

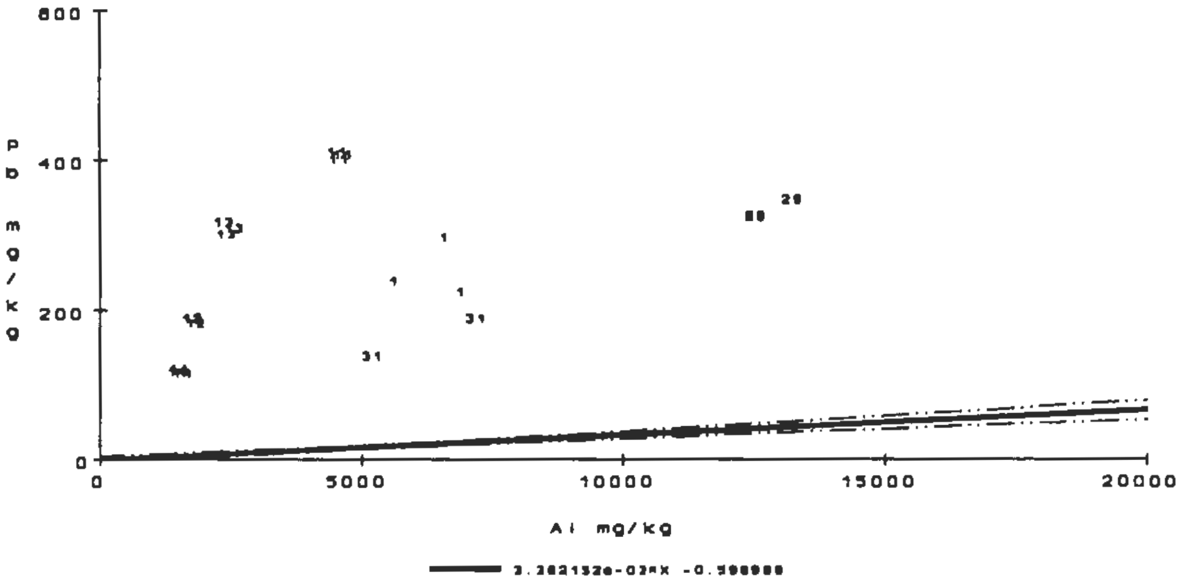


FIGURE 3b:
Extractable lead vs aluminum in bottom sediments of Newfoundland sites showing unnatural proportions between them (compared to linear regression of FIG. 3a)

(n=56) that were in constant proportion to one another. This means that the nickel:aluminum ratios were normally distributed. Nickel concentrations were not measured in samples collected in 1987, thus excluding samples from Humber River-Corner Brook, Torrent River, Lomond River and Harry's River. Nickel concentrations ranged from below the detection limit of 0.600 mg/kg to 75.1 mg/kg (Appendix 1).

Figure 4b shows only two stations whose nickel:aluminum ratios exceeded the natural proportions usually present in the earth's crust, these are located at Indian Pond (#9) and Gander Lake (#16). However, the highest concentrations (70.1 to 75.1 mg/kg) obtained at Gander Lake were at the same level documented (75 mg/kg) for the earth's crust (Taylor et al., 1979). In addition, there are volcanic rocks in the bedrock of the area, possibly contributing nickel to the bottom sediments (NAS, 1975). Therefore, bottom sediments at

FIGURE 4a:
Linear regression between extractable nickel and aluminum concentrations at natural proportions in bottom sediments of Newfoundland sites (with 95% confidence curves)

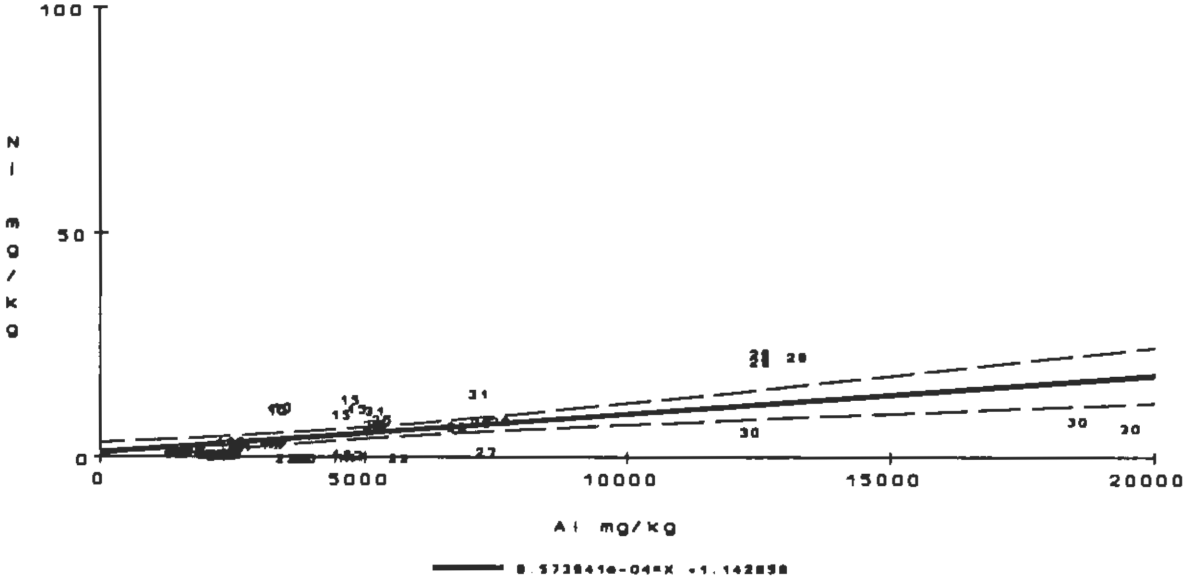
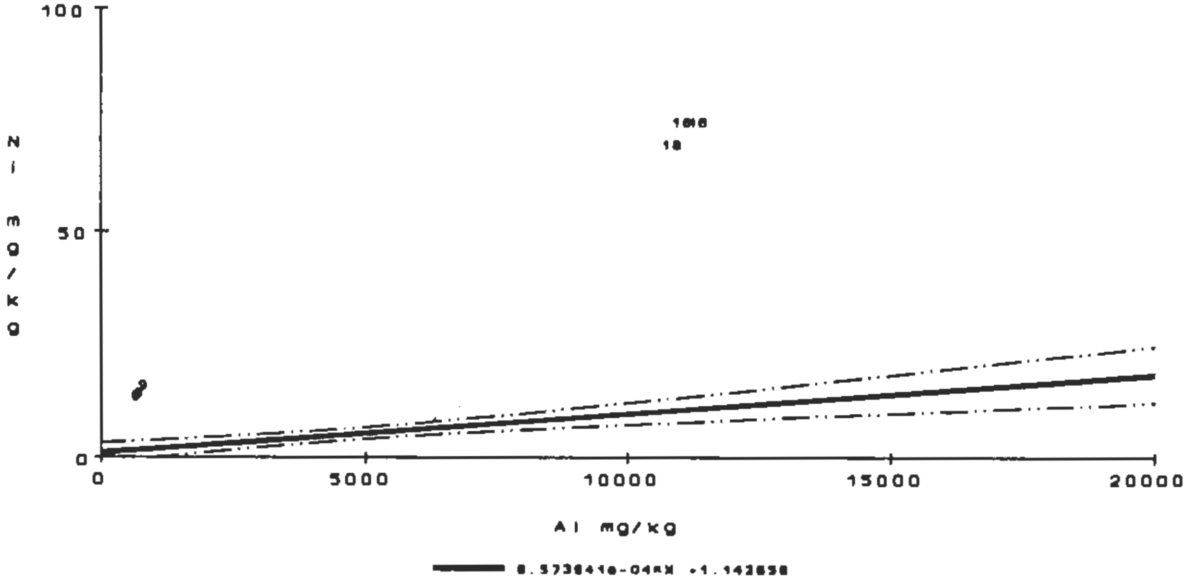


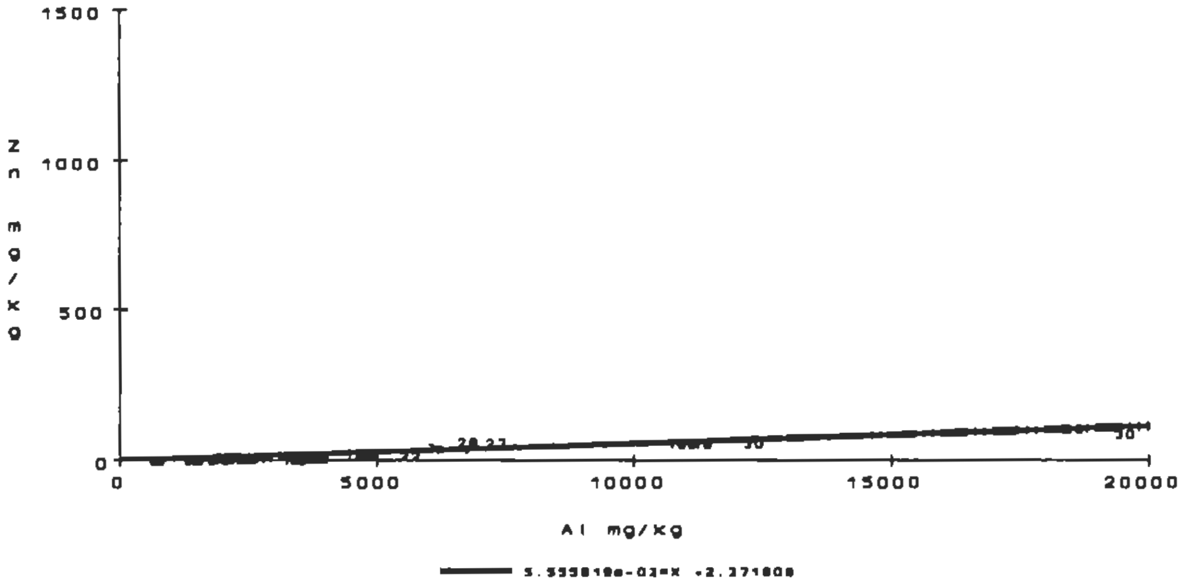
FIGURE 4b:
Extractable nickel vs aluminum in bottom sediments of Newfoundland sites showing unnatural proportions between them (compared to linear regression of FIG. 4a)



these sites are not likely contaminated by anthropogenic sources of nickel because the area is relatively pristine. As Schropp et al. (1990) have suggested, toxic metal:aluminum ratios can occasionally be higher than usual in natural areas.

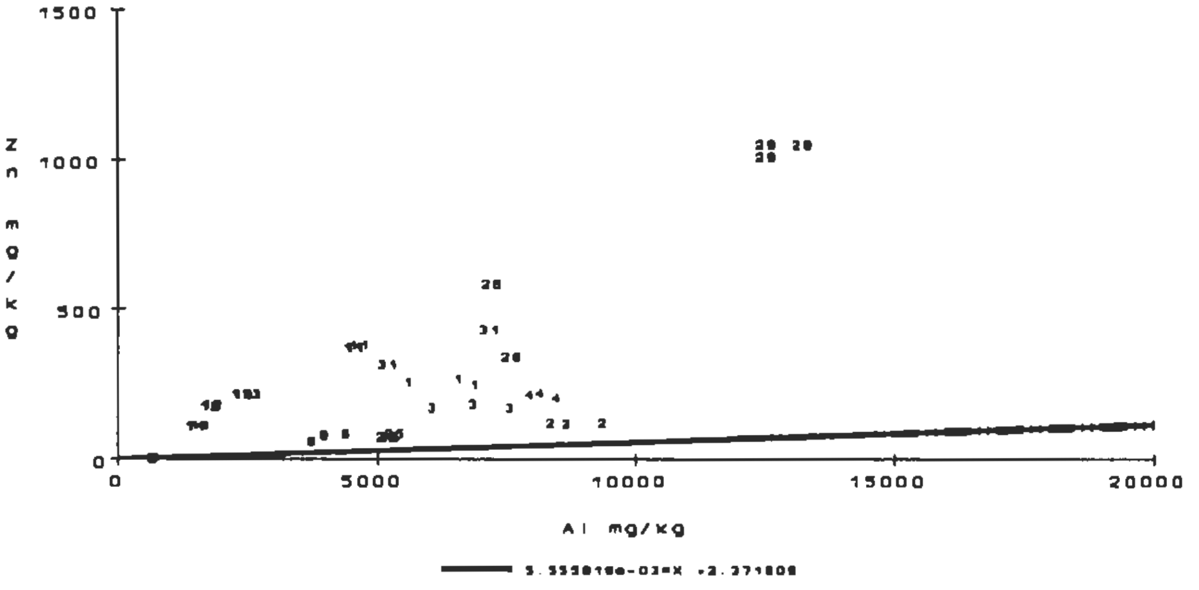
### iv) Extractable Zinc

FIGURE 5a:
Linear regression between extractable zinc and aluminum concentrations at natural proportions in bottom sediments of Newfoundland sites (with 95% confidence curves)



The linear relationship between extractable zinc and aluminum values present in natural proportions in the sediments is illustrated in Figure 5a. This relationship was derived from the analysis of 46 samples. The zinc concentrations in bottom sediments taken from stations in Newfoundland were highly variable and ranged from 8.06 to 1060 mg/kg (Appendix 1). Taylor and Demayo (1980) estimated that natural zinc concentrations in the top few centimeters of bottom sediments of lakes and rivers range from 10 to 700 mg/kg, averaging approximately 120 mg/kg.

FIGURE 5b:
Extractable zinc vs aluminum in bottom sediments of
Newfoundland sites showing unnatural proportions between
them (compared to linear regression of FIG. 5a)



The next figure (Figure 5b) compares the data that did not have natural proportions between aluminum and zinc to the regression curve obtained with the rest of the data. It shows that bottom sediments of sites in the following basins are possibly anthropogenically metal-enriched: Exploits River (#11, #12, #13 and #14), Humber River-Corner Brook (#1 and #8), Waterford River (#25, #26, #29 and #31), Torrent River (#2, #3 and #4) and Lomond River (#5). The site located at Mundy Pond in St. John's (#29) had the highest zinc concentrations measured in this study, ranging between 1020 and 1060 mg/kg. The sediment consisted mostly of silt and clay (85.8%), the fraction of sediment which has the greatest affinity for metals (Förstner, 1982).

The metal-enriched sediments located close to urban areas (Waterford River - St. John's, Humber River - Corner Brook and Exploits River - Grand Falls, Windsor and Bishop's

Falls) can be traced to anthropogenic inputs, including municipal wastewater, traffic (motor oils and motor vehicle tires), wood combustion and waste incineration (Taylor and Demayo, 1980). In particular, bottom sediments of the Exploits River Basin would be heavily impacted by base metal inputs from tailing ponds of an abandoned mine in Buchans (Roussel et al., 1990).

Figure 5b also shows that the Lomond and Torrent Rivers have sediment zinc levels high enough to be considered zinc-enriched. However, levels at Lomond River only reached 13.0 mg/kg, and the data analysis showed zinc enrichment only because the aluminum levels were relatively low compared to the rest of the data (Appendix 1). At the pond on Torrent River, where three sites were sampled, zinc concentrations in bottom sediments ranged between 127 and 228 mg/kg. Although the sites were located close to the highway, it is unlikely that these were anthropogenically enriched. Other base metals at these sites were present at natural levels.

### v) Cadmium and Mercury

Cadmium varied from below the detection limit of 0.2 mg/kg to 3.51 mg/kg. The maximum value was obtained in a sample from Mundy Pond, St. John's (#29) (Appendix 1). Baker and Matheson (1980) reported background levels of 1 to 2 mg/kg of cadmium in freshwater sediments of the Atlantic Region, while in marine sediments, the background levels were lower at 0.5 mg/kg (Swiss et al., 1980).

As for mercury, levels in bottom sediments ranged from below the detection limit (0.02 mg/kg) to 1.41 mg/kg. The highest mercury levels occured in St. John's Harbour sediments (#31) (Appendix 1). Wilson and Travers (1977) also reported higher levels in sediments of

St. John's Harbour, and in the Atlantic Region in general, they reported mercury levels in sediments below 0.1 mg/kg.

Cadmium and mercury were two toxic metals of importance that could not be interpreted with the method of comparison with a reference element. It was impossible to obtain a normal distribution with cadmium:aluminum and mercury:aluminum ratios, even by removing the higher ratios. The correlation coefficients of the log values were low (Cd-Al: $r^2$=0.08; Hg-Al: $r^2$=0.32). Windom et al. (1990) have suggested that the organic phase contributes a large part of these metals. Accordingly, their correlation with log values of particulate organic carbon (POC) were slightly better (Cd-POC: $r^2$=0.24; Hg-POC: $r^2$=0.47), but cadmium was not closely related to POC either. This could be due to the fact that cadmium is a labile element, as demonstrated by Collier and Edmond (1984) who reported a rapid release of cadmium from phytoplankton detritus into seawater.

### 3.1.2 Sediment Quality Guidelines

There are presently no sediment quality guidelines existing in Canada, although they are being developed for marine sediments (MacDonald and Smith, 1990). There have been some numerical limits established under the Ocean Dumping Regulations of the Canadian Environmental Protection Act (CEPA), Part VI. These "not to exceed" limits are 0.6 mg/kg for cadmium and 0.75 mg/kg for mercury in solid waste being dumped into harbours.

Sediment quality guidelines have been developed by other countries such as the United States, Europe and Japan, but the numbers often range over two or more orders of magnitude (MacDonald and Smith, 1990). Therefore, it is difficult to determine how our values compare to suggested guidelines. MacDonald and Smith (1990) have suggested that these guideline differences are most likely due to problems associated with the lack of quality data and the application of various approaches.

### 3.1.3 Adverse Effects on Biota

The measurement of total concentrations of metals in bottom sediments does not give a good indication of the bioavailability of the contaminants nor the stress that it causes on the biota (de Groot et al., 1982; Tessier and Campbell, 1987; Reynoldson and Zarull, 1989; Samant et al., 1990). Trace metals become associated with various sediment phases, and various extractions are required to measure the partitioning of the heavy metals among geochemical zones (Tessier and Campbell, 1987; Samant et al., 1990). Only a fraction of the heavy metal present is involved in short-term geochemical processes and may be bioavailable (de Groot et al., 1982).

Samples collected during this study were only treated with HCl, to determine the extractable non-residual portion of the metals in sediment. Consequently, it is impossible to determine how these levels would affect biota. Samant et al. (1990) demonstrated that a major proportion of metals was associated with the hydrous oxides of iron and manganese, and that they are easily released in the water column. Once released, the metals can cause adverse effects to aquatic organisms.

Such conclusions from our data are impossible, since trace metal levels that are available to the benthic organisms were not determined. Bioassessment techniques would be required to identify the types of stress and their severity to different aquatic organisms

(Reynoldson and Zarull, 1989).

## 3.2 TOXIC ORGANIC CONTAMINANTS

Bottom sediments were analyzed for organochlorinated pesticides (OCs) and polychlorinated biphenyls (PCBs). In addition, samples collected in 1989 were analyzed for polynuclear aromatic hydrocarbons (PAHs), chlorobenzenes (CBs) and chlorophenols (CPs). Measurements of total concentrations were usually done on triplicate samples.

Some organic compounds have a great affinity for bottom sediments. Very hydrophobic and persistent molecules, such as PCBs, PAHs, OCs and phthalates, are known to accumulate in sediments (Provini et al., 1989).

### 3.2.1 Organochlorinated Pesticides (OCs) and Polychlorinated Biphenyls (PCBs)

OC-PCBs have a tendency to adsorb onto particulate matter, and subsequent sedimentation causes this matter to accumulate in bottom sediments (McCrea et al., 1985). This process removes the OC-PCBs from the water column, however they can be remobilized later by physical, chemical or biological processes (Salomons, 1985). OC-PCBs are very persistent in the aquatic ecosystem (Gummer, 1979).

The use of OC-PCBs has not been extensive in Newfoundland, but Brun (1985) reported that BHC isomers and PCBs are transported by precipitation to the Atlantic Region. From data collected between 1980 and 1987, O'Neill (1988) also reported the presence of OCs and PCBs in water and bottom sediment samples of some Newfoundland basins. The results of OC-PCBs in bottom sediment samples collected in the present study are shown by sampling year in Appendix 2. Some detection limits changed from one year to the next. OCs that were detected include δ- and α-chlordane at Mundy Pond in St. John's (#29), and ρρ-DDE and ρρ-TDE, primary metabolites of DDT, in St. John's Harbour sediments (#31). These two sites are exposed to considerable human activity, but quantities of chlordane and DDT metabolites that were measured probably resulted from past use, since they are now regulated compounds in Canada (CCREM, 1987).

Total PCBs were detected (detection limits = 90 and 77.0 ng/g) at Mundy Pond (#29) (290-1140 ng/g), Brazil Pond (#28) (106 ng/g) and St. John's Harbour (#31) (537-903 ng/g), all in the Waterford River Basin, and in the estuarine section of the Exploits River (#12) (130-350 ng/g). Similarly, Bailey (1984) reported some PCB detections of bottom sediments in Bay of Exploits at 820 ng/g and in St. John's Harbour (1400-1600 ng/g) in 1982. Background levels for marine sediments generally range between 5 and 20 ng/g (Addison, 1984). These levels were exceeded at some sites in this study. Travers and Wilson (1977) observed that the highest levels of PCBs in St. John's Harbour were usually associated with raw sewage outfalls and large ship unloading docks, often oil tanker docks. Mundy Pond, where one sample had a PCB concentration as high as 1140 ng/g, was the location of an asphalt plant from 1965 to 1981. Considerable infilling of the pond has also occured; the fill came from various construction sites or demolition projects. At Exploits River, although PCBs were detected prior to 1983, one major source is suspected to be a PCB spill associated with a dam failure which occured in the lower basin in 1983 (Pierce and Power, 1985).

### 3.2.2 Polynuclear Aromatic Hydrocarbons (PAHs)

Concentrations of PAHs in the aquatic ecosystem are generally highest in sediments, as compared to water and biota, since they tend to associate primarily with inorganic and organic material in suspended and bottom sediments. It is mostly high-molecular weight PAHs that are susceptible to strong adsorption by particulate matter (NRCC, 1983).

PAHs are produced by incomplete combustion of organic material. Natural sources exist, such as forest fires and volcanic activity, but anthropogenic sources are a significant contributor. Some of these sources include the burning of fossil fuels, thermal power stations, internal combustion engines, and atmospheric deposition from these sources (CCREM, 1987). Gravens et al. (1982) have reported significant correlations between the hydrocarbon levels and the extent of urbanisation.

PAHs were only analyzed in bottom sediments collected at nine stations in 1989 (Appendix 3). Triplicate splits were prepared for most stations. A total of 16 PAHs were analyzed in each sample. Total PAHs in Appendix 3 represent the sum of all PAHs that were detected.

Background levels of total PAHs in bottom sediments of the Atlantic Region range between 10 and 20 ng/g (Eaton et al., 1986). PAHs were detected at the five stations located in the Waterford River Basin, and at the estuarine portion of Garnish River (#22). They were found to exceed the natural background levels. Samples taken at Piper's Hole River and Garnish Pond, sites located in pristine areas, did not have detectable levels of PAHs.

Such generalized presence in the Waterford River Basin is probably a result of wood combustion in this populated basin. PAH levels were exceedingly high in St. John's Harbour. A maximum value of 10,100 ng/g for fluoranthene was measured in the harbour's sediments, while Bailey (1984) had reported levels of 4,600 and 5,500 ng/g of fluoranthene at two sites in St. John's Harbour. There is an indication that just the levels of fluoranthene alone could affect the benthic community, since Dewitt et al. (1989) showed that 10.6 mg/kg was the $LC_{50}$ level that could affect the estuarine burrowing amphipod Eohaustorius estuarius Bosworth. Benzo[α]pyrene, a highly active carcinogen (Futona et al., 1981), reached high levels in St. John's Harbour (1,400-2,630 ng/g) and in Mundy Pond (145-1,260 ng/g), although results between replicate samples varied considerably. Among other activities in the area such as infilling and snow dumping, an asphalt plant had been located in proximity to Mundy Pond from 1965 to 1981, and asphalt plants are a known source of PAHs (CCREM, 1987). At both sites (#29 and #31), benzo[α]pyrene exceeded the guideline recommended by the IJC (1983) of 1,000 ng/g for the protection of freshwater fish. This guideline is applicable to the site at Mundy Pond because it is freshwater, but does not necessarily apply to a harbour site. However, it is the best indication of adverse effects on biota at the present time, as there are no marine sediment quality guidelines in existence in Canada (MacDonald and Smith, 1990).

### 3.2.3 Chlorobenzenes (CBs)

Chlorobenzenes are used as industrial solvents, pesticides, dielectric fluids, deodorants and chemical intermediates, and enter the aquatic environment from solid and liquid industrial effluents (CCREM, 1987). They are relatively persistent in the aquatic environment, and are removed from the water column mostly by sorption, volatization and bioaccumulation (CCREM, 1987).

CBs were only measured in bottom sediment samples collected during the 1989 study (Appendix 4). It was mostly dichlorobenzenes that were detected, and they occured in the Waterford River Basin in St. John's. A maximum value of 102 ng/g of 1,3-dichlorobenzene was obtained at station 50NF02ZM0084 (#26), a branch of the Waterford River where an Agriculture Canada experimental farm is located. All other detections were close to the respective detection limits.

Sediment quality guidelines for chlorobenzenes have not yet been developed in Canada, but a compilation by MacDonald and Smith (1990) of guidelines in other countries shows that the levels in this study were acceptable.

### 3.2.4 Chlorophenols (CPs)

Chlorophenols have various industrial and commercial uses, such as disinfectants, biocides, preservatives, dyes, pesticides and industrial and medical organic chemicals (CCREM, 1987). They often reach the aquatic environment in industrial effluents from pulp and paper and wood treatment plants, in effluents of sewage treatment plants that use chlorination, and in leachates of agricultural products.

Pentachlorophenol is an important wood preservative. It can be very persistent in natural sediments, and is considered ubiquitous in Canadian aquatic systems (CCREM, 1987). Also, pentachlorophenol has a high affinity for the organic matter content in sediments, since the affinity increases as the degree of chlorine substitution increases (CCREM, 1987). Thus, the sorption to the sediments removes mostly penta-, tetra- and trichlorophenols from the water column.

Chlorophenols were only mesured in bottom sediments collected in 1989, which includes the sites located at the Waterford, Piper's Hole and Garnish Rivers (Appendix 5). There were slight detections of chlorophenols at the Waterford River stations. Tetrachlorophenols and pentachlorophenol were detected at the site on Bremigan's Pond branch (#27), with a relatively high value of 215.3 ng/g for pentachlorophenol. This site is in a boggy area in close proximity to power lines, and a hydro pole was located close to where the sediment sample was taken. Thus, the use of pentachlorophenol as a wood preservative on telephone/electricity poles is the possible cause of this detection. Pentachlorophenol was also detected at four other stations in the Waterford River Basin, but levels were one order of magnitude lower than the level at site #27.

## 4. CONCLUSIONS AND RECOMMENDATIONS

From the results of the Newfoundland Bottom Sediment Survey, a number of conclusions can be reached:

1) Bottom sediments collected at Exploits and Humber River sites had extractable copper, lead and zinc levels exceeding the natural proportions with aluminum, thus indicating anthropogenic metal enrichment from sources in these basins. Lead and zinc also appeared to be enriched anthropogenically in bottom sediments of the Waterford River Basin. Torrent River and Lomond River showed proportionately higher zinc levels only. For nickel, data analysis indicated possible nickel pollution at Indian Pond and Gander Lake; however, other factors, such as their conformity to nickel levels documented for the earth's crust, suggest that nickel does not significantly enter the system from human sources;

2) Although it was impossible to use the method developed to detect anthropogenic metal enrichment for cadmium and mercury, the data did indicate a possible accumulation of cadmium at Mundy Pond, St. John's and in the Exploits River Basin, and mercury in the St. John's Harbour. These levels exceeded the CEPA Ocean Dumping Regulations, the only numerical levels available for use as sediment quality guidelines in Canada;

3) OCs were rarely detected, and appeared to be residues from past use. However, PCBs were detected at Mundy Pond, Brazil Pond, St. John's Harbour and the estuarine portion of the Exploits River. Since the background levels (up to 20 ng/g) were lower than the existing detection limits, any detection would suggest an anthropogenic influence;

4) PAHs, tested for only in the 1989 samples, were detected at all five sites in the Waterford River Basin, and in the estuarine portion of the Garnish River. Wood combustion in these basins is a likely cause. PAHs were particularly high at St. John's Harbour and Mundy Pond,

sites of existing or past anthropogenic sources. The levels at these two sites exceeded the recommended guideline of 1,000 ng/g for the protection of freshwater fish.

5) Chlorinated benzenes, often used as pesticides, were detected in the bottom sediments of the Waterford River Basin. Chlorinated phenols were also detected in the Waterford River Basin. A station on Bremigan's Pond branch, situated in proximity to power lines, had levels of the wood preservative pentachlorophenol one order of magnitude higher than was detected at the rest of the sites.

The study provided valuable information on the presence of organic and metal contaminants in bottom sediments of selected Newfoundland rivers. However, it was not one of the objectives of the study to verify their toxicity to biota, but could form the subject of a subsequent study. In order to be able to determine the effect of their presence on benthic communities and bottom-dwelling fish, the development of sediment quality guidelines and more elaborate chemical analyses are required.

Recommendations on the outcome of this study are as follows:

1) The results of this study indicate that the Exploits River, Waterford River and Humber River-Corner Brook Basins are impacted by human presence. The results justify a more intensive investigation of these systems. Since such studies have already taken place on the Exploits and Waterford Rivers, it is thus recommended that the next intensive recurrent survey be conducted in the Humber River-Corner Brook Basin;

2) Bottom sediment studies in Newfoundland should now be aimed at more intensive basin-specific sampling. This completed survey has proven to be valuable, since it has identified

the basins where further work should be undertaken; and

3) A future study should be conducted on the effects of contaminants present in bottom sediments on benthic communities and bottom-dwelling fish living in selected basins.

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# APPENDIX 1:

# RAW DATA (1987-1989) -

# HEAVY METALS, PARTICLE SIZE AND ORGANIC CONTENT IN BOTTOM SEDIMENTS

### 1987 RAW DATA -
### HEAVY METAL CONCENTRATIONS, ORGANIC CONTENT AND PARTICLE SIZE IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPLING DATE | PARTIC. CARBON | PARTIC. NITRO. | MERCURY TOTAL | ALUMINUM EXTRACT. | CADMIUM EXTRACT. | COPPER EXTRACT. | IRON EXTRACT. | LEAD EXTRACT. |
|---|---|---|---|---|---|---|---|---|---|
| 50NF02YL0014 | 28-AUG-87 | 2.77 | 0.205 | 0.33 | 6930 | 1.6 | 62 | 14530 | 228 |
| 50NF02YL0014 | 28-AUG-87 | 4.17 | 0.213 | 0.29 | 5650 | 1.7 | 63 | 12080 | 242 |
| 50NF02YL0014 | 28-AUG-87 | 6.43 | 0.133 | 0.31 | 6620 | 1.8 | 69 | 13730 | 300 |
| 51NF02YC0002 | 27-AUG-87 | 5.90 | 0.370 | 0.07 | 9400 | 1.4 | 7.0 | 19120 | 30 |
| 51NF02YC0002 | 27-AUG-87 | 5.71 | 0.361 | 0.07 | 8700 | 1.4 | 7.4 | 17090 | 30 |
| 51NF02YC0002 | 27-AUG-87 | 6.14 | 0.379 | 0.06 | 8400 | 1.4 | 6.9 | 17450 | 29 |
| 51NF02YC0003 | 27-AUG-87 | 1.16 | L.002 | 0.04 | 6100 | 1.3 | 9.2 | 19450 | 20 |
| 51NF02YC0003 | 27-AUG-87 | 1.23 | 0.099 | 0.06 | 7600 | 1.2 | 5.5 | 15680 | 20 |
| 51NF02YC0003 | 27-AUG-87 | 1.21 | 0.097 | 0.06 | 6900 | 1.3 | 6.8 | 18950 | 23 |
| 51NF02YC0005 | 27-AUG-87 | 1.74 | 0.155 | 0.04 | 8000 | 1.7 | 4.3 | 18040 | 28 |
| 51NF02YC0005 | 27-AUG-87 | 1.90 | 0.163 | 0.10 | 8200 | 1.7 | 7.2 | 20170 | 30 |
| 51NF02YC0005 | 27-AUG-87 | 1.65 | 0.158 | 0.11 | 8500 | 1.6 | 4.8 | 17560 | 28 |
| 53NF02YH0001 | 28-AUG-87 | 4.01 | L.002 | L.02 | 690 | 0.93 | 1.1 | 2730 | 7.0 |
| 53NF02YH0001 | 28-AUG-87 | 2.89 | L.002 | L.02 | 740 | 0.92 | 1.2 | 2120 | 7.0 |
| 53NF02YH0001 | 28-AUG-87 | 3.32 | L.002 | L.02 | 670 | 0.93 | 1.3 | 2330 | 7.0 |
| 53NF02YH0002 | 28-AUG-87 | 1.75 | L.002 | L.02 | 2480 | 0.74 | - | 15290 | 8.0 |
| 53NF02YH0002 | 28-AUG-87 | 1.71 | L.002 | L.02 | 2110 | 0.65 | 3.8 | 3690 | 7.0 |
| 53NF02YH0002 | 28-AUG-87 | 1.43 | L.002 | L.02 | 1840 | 0.57 | 7.1 | 5110 | 7.0 |
| 53NF02YJ0002 | 26-AUG-87 | 0.23 | L.002 | 0.02 | 6800 | 0.2 | 15 | 12400 | 6.0 |
| 53NF02YJ0002 | 26-AUG-87 | 0.308 | L.002 | L.02 | 6100 | 0.2 | 10 | 10120 | 6.0 |
| 53NF02YJ0002 | 26-AUG-87 | 0.233 | L.002 | 0.02 | 6250 | 0.2 | 15 | 12720 | 6.0 |
| 53NF02YL0001 | 28-AUG-87 | - | - | 0.26 | 3770 | 1.5 | - | - | - |
| 53NF02YL0001 | 28-AUG-87 | - | - | 0.22 | 4020 | 1.2 | 35 | 11230 | 40.0 |
| 53NF02YL0001 | 28-AUG-87 | 21.3 | L.002 | 0.17 | 4430 | 1.4 | 42 | 14630 | 118 |

1987 RAW DATA -
HEAVY METAL CONCENTRATIONS, ORGANIC CONTENT AND PARTICLE SIZE IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPLING DATE | ZINC EXTRACT. | SAND (%) | SILT (%) | CLAY (%) |
|---|---|---|---|---|---|
| 50NF02YL0014 | 28-AUG-87 | 256 | 40.0 | 50.0 | 10.0 |
| 50NF02YL0014 | 28-AUG-87 | 266 | - | - | - |
| 50NF02YL0014 | 28-AUG-87 | 277 | - | - | - |
| 51NF02YC0002 | 27-AUG-87 | 129 | 20.2 | 53.8 | 26.0 |
| 51NF02YC0002 | 27-AUG-87 | 127 | 26.6 | 48.0 | 25.4 |
| 51NF02YC0002 | 27-AUG-87 | 130 | 24.2 | 47.7 | 28.1 |
| 51NF02YC0003 | 27-AUG-87 | 180 | 58.0 | 29.6 | 12.4 |
| 51NF02YC0003 | 27-AUG-87 | 180 | 55.0 | 27.8 | 17.2 |
| 51NF02YC0003 | 27-AUG-87 | 193 | 52.0 | 30.0 | 18.0 |
| 51NF02YC0005 | 27-AUG-87 | 223 | 45.9 | 34.1 | 20.0 |
| 51NF02YC0005 | 27-AUG-87 | 228 | 51.0 | 32.6 | 16.4 |
| 51NF02YC0005 | 27-AUG-87 | 213 | 50.0 | 31.2 | 18.8 |
| 53NF02YH0001 | 28-AUG-87 | 12.0 | - | - | - |
| 53NF02YH0001 | 28-AUG-87 | 12.0 | 55.5 | 36.9 | 7.60 |
| 53NF02YH0001 | 28-AUG-87 | 13.0 | - | - | - |
| 53NF02YH0002 | 28-AUG-87 | 13.0 | 67.6 | 22.4 | 10.0 |
| 53NF02YH0002 | 28-AUG-87 | 11.0 | 68.0 | 23.2 | 8.80 |
| 53NF02YH0002 | 28-AUG-87 | 10.0 | 69.0 | 21.6 | - |
| 53NF02YJ0002 | 26-AUG-87 | 46.4 | 58.0 | 22.8 | 19.2 |
| 53NF02YJ0002 | 26-AUG-87 | 49.8 | 60.0 | 20.0 | 20.0 |
| 53NF02YJ0002 | 26-AUG-87 | 46.5 | 61.0 | 19.0 | 20.0 |
| 53NF02YL0001 | 28-AUG-87 | 70.0 | - | - | - |
| 53NF02YL0001 | 28-AUG-87 | 90.0 | - | - | - |
| 53NF02YL0001 | 28-AUG-87 | 94.0 | - | - | - |

### 1988 RAW DATA -
### HEAVY METAL CONCENTRATIONS AND ORGANIC CONTENT IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPLING DATE | PARTIC. CARBON | PARTIC. NITRO. | MERCURY TOTAL | ALUMINUM EXTRACT. | CADMIUM EXTRACT. | COBALT EXTRACT. | CHROMIUM EXTRACT. |
|---|---|---|---|---|---|---|---|---|
| 50NF02YM0001 | 22-AUG-88 | 0.94 | 0.02 | 0.02 | 3390 | L.200 | 2.05 | 4.18 |
| 50NF02YM0001 | 22-AUG-88 | 1.11 | 0.05 | 0.02 | 3500 | L.200 | 2.09 | 4.56 |
| 50NF02YM0001 | 22-AUG-88 | 1.77 | 0.05 | 0.02 | 3410 | L.200 | 2.14 | 4.47 |
| 50NF02YN0007 | 23-AUG-88 | 10.3 | 0.50 | 0.15 | 4630 | 2.70 | 4.31 | 3.30 |
| 50NF02YN0007 | 23-AUG-88 | 6.72 | 0.29 | 0.13 | 4590 | 2.73 | 4.01 | 1.23 |
| 50NF02YN0007 | 23-AUG-88 | 9.46 | 0.49 | 0.13 | 4710 | 3.07 | 3.68 | 2.11 |
| 52NF02YD0002 | 23-AUG-88 | 5.57 | 0.28 | 0.17 | 1820 | 1.87 | 1.27 | 1.41 |
| 52NF02YD0002 | 23-AUG-88 | 17.6 | 0.75 | 0.12 | 1830 | 1.86 | 1.49 | 1.12 |
| 52NF02YD0002 | 23-AUG-88 | 8.72 | 0.29 | 0.12 | 1880 | 1.99 | 1.52 | 1.22 |
| 52NF02YD0004 | 23-AUG-88 | 10.2 | 0.51 | 0.14 | 2470 | 2.29 | 4.65 | 1.85 |
| 52NF02YD0004 | 23-AUG-88 | 14.1 | 0.60 | 0.15 | 2420 | 2.35 | 4.65 | 2.02 |
| 52NF02YD0004 | 23-AUG-88 | 12.5 | 0.50 | 0.16 | 2620 | 2.38 | 5.16 | 1.71 |
| 50NF02YD0052 | 23-AUG-88 | 4.80 | 0.50 | 0.11 | 1560 | 1.17 | 2.19 | 1.89 |
| 50NF02YD0052 | 23-AUG-88 | 6.10 | 0.33 | 0.09 | 1540 | 1.14 | 2.07 | 1.72 |
| 50NF02YD0052 | 23-AUG-88 | 1.42 | 0.13 | 0.12 | 1630 | 1.18 | 1.86 | 2.82 |
| 50NF02YR0001 | 25-AUG-88 | 35.4 | 1.71 | 0.17 | 3820 | 0.302 | 0.552 | L.200 |
| 50NF02YR0001 | 25-AUG-88 | 32.5 | 1.23 | 0.17 | 3950 | 0.331 | 1.40 | L.200 |
| 50NF02YR0001 | 25-AUG-88 | 35.5 | 1.81 | 0.16 | 3860 | L.200 | 0.652 | L.200 |
| 50NF02YS0011 | 25-AUG-88 | 1.37 | L.01 | 0.04 | 2540 | 0.316 | 7.26 | 0.508 |
| 50NF02YS0011 | 25-AUG-88 | 1.25 | L.01 | 0.04 | 2330 | 0.324 | 7.22 | 0.297 |
| 50NF02YS0011 | 25-AUG-88 | 4.36 | 0.32 | 0.04 | 2450 | 0.272 | 7.13 | 0.390 |
| 50NF02YS0013 | 25-AUG-88 | 0.46 | L.01 | 0.02 | 1430 | L.200 | 3.29 | 0.433 |
| 50NF02YS0013 | 25-AUG-88 | 0.61 | L.01 | 0.02 | 1480 | L.200 | 3.17 | 0.467 |
| 50NF02YS0013 | 25-AUG-88 | 0.59 | L.01 | 0.02 | 1510 | 0.213 | 3.65 | 0.489 |
| 51NF02YM0009 | 22-AUG-88 | 0.44 | L.01 | 0.01 | 753 | L.200 | 1.80 | 4.27 |
| 51NF02YM0009 | 22-AUG-88 | 0.69 | 0.01 | 0.01 | 837 | L.200 | 2.12 | 4.88 |
| 51NF02YM0009 | 22-AUG-88 | 0.63 | 0.02 | 0.01 | 697 | L.200 | 1.70 | 2.84 |
| 51NF02YQ0014 | 25-AUG-88 | 5.66 | 0.85 | 0.17 | 11400 | 1.20 | 31.0 | 40.3 |
| 51NF02YQ0014 | 25-AUG-88 | 4.34 | 0.40 | 0.17 | 10900 | 1.09 | 29.0 | 33.3 |
| 51NF02YQ0014 | 25-AUG-88 | 4.31 | 0.19 | 0.16 | 11100 | 1.30 | 28.8 | 33.0 |
| 51NF02YQ0015 | 24-AUG-88 | 5.07 | 0.30 | 0.09 | 4790 | 0.511 | 13.1 | 2.70 |
| 51NF02YQ0015 | 24-AUG-88 | 4.64 | 0.43 | 0.07 | 4910 | 0.573 | 13.2 | 2.70 |
| 51NF02YQ0015 | 24-AUG-88 | 4.29 | 0.59 | 0.08 | 4610 | 0.471 | 13.2 | 2.25 |

### 1988 RAW DATA -
### HEAVY METAL CONCENTRATIONS AND ORGANIC CONTENT IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPLING DATE | PARTIC. CARBON | PARTIC. NITRO. | MERCURY TOTAL | ALUMINUM EXTRACT. | CADMIUM EXTRACT. | COBALT EXTRACT. | CHROMIUM EXTRACT. |
|---|---|---|---|---|---|---|---|---|
| 51NF02YS0060 | 25-AUG-88 | 2.42 | 0.12 | 0.06 | 3370 | 0.419 | 6.80 | 1.08 |
| 51NF02YS0060 | 25-AUG-88 | 1.80 | 0.04 | 0.06 | 3270 | 0.401 | 6.16 | 0.565 |
| 51NF02YS0060 | 25-AUG-88 | 1.85 | 0.07 | 0.07 | 3420 | 0.451 | 6.86 | 0.551 |

## 1988 RAW DATA -
## HEAVY METAL CONCENTRATIONS AND ORGANIC CONTENT IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPL1NG DATE | COPPER EXTRACT. | 1RON EXTRACT. | N1CKEL EXTRACT. | LEAD EXTRACT. | Z1NC EXTRACT. |
|---|---|---|---|---|---|---|
| 50NF02YM0001 | 22-AUG-88 | 5.99 | 3930 | 11.4 | 4.83 | 10.8 |
| 50NF02YM0001 | 22-AUG-88 | 6.34 | 3950 | 11.7 | 4.99 | 10.9 |
| 50NF02YM0001 | 22-AUG-88 | 6.19 | 4300 | 10.9 | 4.79 | 10.7 |
| 50NF02YN0007 | 23-AUG-88 | 63.8 | 10800 | 1.24 | 405 | 379 |
| 50NF02YN0007 | 23-AUG-88 | 64.4 | 10900 | L.600 | 415 | 382 |
| 50NF02YN0007 | 23-AUG-88 | 64.3 | 10600 | L.600 | 411 | 390 |
| 52NF02YD0002 | 23-AUG-88 | 28.2 | 3090 | 2.37 | 193 | 184 |
| 52NF02YD0002 | 23-AUG-88 | 28.4 | 3110 | 1.82 | 194 | 188 |
| 52NF02YD0002 | 23-AUG-88 | 27.9 | 3030 | 2.62 | 187 | 190 |
| 52NF02YD0004 | 23-AUG-88 | 33.7 | 6400 | 3.08 | 305 | 224 |
| 52NF02YD0004 | 23-AUG-88 | 33.9 | 6360 | 3.87 | 321 | 227 |
| 52NF02YD0004 | 23-AUG-88 | 34.3 | 6590 | 3.98 | 313 | 227 |
| 50NF02YD0052 | 23-AUG-88 | 42.8 | 3650 | 2.54 | 125 | 120 |
| 50NF02YD0052 | 23-AUG-88 | 41.4 | 3480 | 2.29 | 121 | 119 |
| 50NF02YD0052 | 23-AUG-88 | 41.7 | 3640 | 1.96 | 119 | 123 |
| 50NF02YR0001 | 25-AUG-88 | 3.52 | 4810 | L.600 | 20.2 | 13.1 |
| 50NF02YR0001 | 25-AUG-88 | 3.98 | 4510 | L.600 | 21.0 | 14.8 |
| 50NF02YR0001 | 25-AUG-88 | 4.41 | 4480 | L.600 | 18.6 | 13.9 |
| 50NF02YS0011 | 25-AUG-88 | 1.42 | 7190 | 1.27 | 13.3 | 13.2 |
| 50NF02YS0011 | 25-AUG-88 | 1.56 | 6630 | 0.892 | 12.6 | 11.9 |
| 50NF02YS0011 | 25-AUG-88 | 1.50 | 6910 | 1.02 | 13.6 | 12.4 |
| 50NF02YS0013 | 25-AUG-88 | 0.703 | 4890 | 1.20 | 4.38 | 9.21 |
| 50NF02YS0013 | 25-AUG-88 | 0.696 | 4780 | 1.41 | 4.03 | 8.94 |
| 50NF02YS0013 | 25-AUG-88 | 0.786 | 5240 | 1.70 | 4.40 | 9.59 |
| 51NF02YM0009 | 22-AUG-88 | 0.873 | 3390 | 14.8 | 2.01 | 8.18 |
| 51NF02YM0009 | 22-AUG-88 | 0.925 | 3980 | 16.6 | 2.08 | 8.91 |
| 51NF02YM0009 | 22-AUG-88 | 0.753 | 3390 | 14.3 | 1.98 | 8.06 |
| 51NF02YQ0014 | 25-AUG-88 | 20.6 | 35700 | 75.1 | 6.72 | 62.5 |
| 51NF02YQ0014 | 25-AUG-88 | 19.3 | 34400 | 70.1 | 6.53 | 65.0 |
| 51NF02YQ0014 | 25-AUG-88 | 20.4 | 31500 | 75.1 | 6.55 | 62.8 |
| 51NF02YQ0015 | 24-AUG-88 | 6.69 | 10900 | 13.4 | 12.3 | 33.5 |
| 51NF02YQ0015 | 24-AUG-88 | 6.28 | 11900 | 11.3 | 10.9 | 33.8 |
| 51NF02YQ0015 | 24-AUG-88 | 5.67 | 10900 | 10.1 | 9.51 | 32.4 |

1988 RAW DATA -
HEAVY METAL CONCENTRATIONS AND ORGANIC CONTENT IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE NOTED)

| STATION NUMBER | SAMPLING DATE | COPPER EXTRACT. | IRON EXTRACT. | NICKEL EXTRACT. | LEAD EXTRACT. | ZINC EXTRACT. |
|---|---|---|---|---|---|---|
| 51NF02YS0060 | 25-AUG-88 | 2.35 | 5230 | 3.44 | 8.9 | 25.7 |
| 51NF02YS0060 | 25-AUG-88 | 2.23 | 4740 | 3.16 | 8.85 | 24.1 |
| 51NF02YS0060 | 25-AUG-88 | 2.44 | 4640 | 4.00 | 9.78 | 26.0 |

1989 RAW DATA –
HEAVY METAL CONCENTRATIONS, ORGANIC CONTENT AND PARTICLE SIZE OF BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE REPORTED)

| STATION NUMBER | SAMPLING DATE | PARTIC. CARBON | PARTIC. NITRO. | MERCURY TOTAL | ALUMINUM EXTRACT. | CADMIUM EXTRACT. | COBALT EXTRACT. | CHROMIUM EXTRACT. | COPPER EXTRACT. |
|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | 18.4 | 1.53 | 0.10 | 7380 | L.200 | 40.2 | 2.34 | 12.4 |
| 51NF02ZM0101 | 08-AUG-89 | 18.1 | 1.84 | 0.09 | 6830 | 0.364 | 7.33 | 2.15 | 18.2 |
| 50NF02ZM0084 | 10-AUG-89 | 17.3 | 1.50 | 0.12 | 7660 | 0.619 | 25.9 | 7.40 | 24.5 |
| 50NF02ZM0084 | 10-AUG-89 | 18.9 | 1.60 | 0.07 | 7290 | 0.914 | 20.2 | 4.81 | 24.4 |
| 51NF02ZM0102 | 11-AUG-89 | 7.62 | 0.73 | 0.36 | 13300 | 3.51 | 27.1 | 59.9 | 43.6 |
| 51NF02ZM0102 | 11-AUG-89 | 7.51 | 0.73 | 0.35 | 12600 | 3.45 | 26.9 | 48.9 | 36.2 |
| 51NF02ZM0102 | 11-AUG-89 | 7.81 | 0.78 | 0.36 | 12600 | 3.09 | 26.5 | 52.9 | 38.4 |
| 53NF02ZM0104 | 11-AUG-89 | 5.83 | 0.51 | 1.35 | 7240 | 1.94 | 10.1 | 18.3 | 6.65 |
| 53NF02ZM0104 | 11-AUG-89 | 6.27 | 0.54 | 1.41 | 5260 | 1.57 | 7.39 | 13.6 | 17.3 |
| 50NF02ZM0009 | 14-AUG-89 | 0.17 | 0.04 | 0.03 | 5400 | L.200 | 7.39 | 6.57 | 17.3 |
| 50NF02ZM0009 | 14-AUG-89 | 0.15 | 0.03 | 0.03 | 5230 | L.200 | 7.90 | 5.79 | 13.1 |
| 50NF02ZM0009 | 14-AUG-89 | 0.14 | 0.03 | 0.03 | 5300 | 0.221 | 7.14 | 5.84 | 13.6 |
| 51NF02ZM0103 | 15-AUG-89 | 9.72 | 1.00 | 0.16 | 19600 | 0.438 | 10.8 | 5.93 | 24.1 |
| 51NF02ZM0103 | 15-AUG-89 | 9.59 | 0.98 | 0.11 | 12400 | L.200 | 5.92 | 3.05 | 16.4 |
| 51NF02ZM0103 | 15-AUG-89 | 3.56 | 0.38 | 0.18 | 18600 | 0.373 | 8.58 | 5.04 | 26.5 |
| 50NF02ZH0011 | 16-AUG-89 | 0.45 | 0.05 | L.01 | 2080 | L.200 | 3.73 | 3.03 | 2.28 |
| 50NF02ZH0011 | 16-AUG-89 | 0.42 | 0.04 | L.01 | 2040 | L.200 | 3.69 | 2.33 | 2.33 |
| 52NF02ZH0012 | 16-AUG-89 | 1.72 | 0.17 | 0.01 | 2600 | L.200 | 2.23 | 2.58 | 2.54 |
| 52NF02ZH0012 | 16-AUG-89 | 1.42 | 0.14 | 0.02 | 2720 | L.200 | 2.76 | 2.61 | 3.45 |
| 52NF02ZH0012 | 16-AUG-89 | 1.66 | 0.16 | 0.01 | 2150 | L.200 | 1.00 | 2.01 | 1.74 |
| 52NF02ZG0007 | 16-AUG-89 | 10.2 | 0.86 | 0.09 | 4840 | L.200 | 2.55 | 2.95 | 3.84 |
| 52NF02ZG0007 | 16-AUG-89 | 11.5 | 0.99 | 0.05 | 5720 | L.200 | 3.71 | 1.95 | 5.08 |
| 52NF02ZG0007 | 16-AUG-89 | 9.00 | 0.78 | 0.03 | 3560 | L.200 | 1.65 | 1.46 | 2.44 |
| 51NF02ZG0006 | 17-AUG-89 | 0.28 | 0.04 | L.01 | 2260 | L.200 | 3.21 | 1.79 | 2.01 |
| 51NF02ZG0006 | 17-AUG-89 | 0.19 | 0.02 | L.01 | 2440 | L.200 | 3.81 | 1.89 | 2.14 |
| 51NF02ZG0006 | 17-AUG-89 | 0.26 | 0.03 | L.01 | 2110 | L.200 | 2.09 | 1.52 | 1.75 |

## 1989 RAW DATA -
## HEAVY METAL CONCENTRATIONS, ORGANIC CONTENT AND PARTICLE SIZE OF BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG, UNLESS OTHERWISE REPORTED)

| STATION NUMBER | SAMPLING DATE | IRON EXTRACT. | MANGANESE EXTRACT. | NICKEL EXTRACT. | LEAD EXTRACT. | ZINC EXTRACT. | SAND (%) | SILT (%) | CLAY (%) |
|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | 23800 | 3580 | 1.72 | 24.3 | 66.2 | - | - | - |
| 51NF02ZM0101 | 08-AUG-89 | 6670 | 305 | 7.37 | 52.6 | 70.5 | - | - | - |
| 50NF02ZM0084 | 10-AUG-89 | 13800 | 655 | 8.62 | 34.4 | 351 | - | - | - |
| 50NF02ZM0084 | 10-AUG-89 | 14600 | 3270 | 8.22 | 31.4 | 592 | - | - | - |
| 51NF02ZM0102 | 11-AUG-89 | 33200 | 1780 | 23.0 | 351 | 1060 | 14.2 | 59.4 | 26.4 |
| 51NF02ZM0102 | 11-AUG-89 | 31200 | 1550 | 22.0 | 330 | 1060 | - | - | - |
| 51NF02ZM0102 | 11-AUG-89 | 32700 | 1780 | 23.7 | 328 | 1020 | - | - | - |
| 53NF02ZM0104 | 11-AUG-89 | 17800 | 207 | 14.7 | 193 | 441 | 42.2 | 43.0 | 14.8 |
| 53NF02ZM0104 | 11-AUG-89 | 12400 | 153 | 10.9 | 142 | 324 | - | - | - |
| 50NF02ZM0009 | 14-AUG-89 | 12600 | 930 | 8.95 | 18.5 | 92.7 | 82.0 | 11.3 | 6.7 |
| 50NF02ZM0009 | 14-AUG-89 | 13400 | 849 | 7.71 | 16.6 | 83.8 | - | - | - |
| 50NF02ZM0009 | 14-AUG-89 | 12800 | 916 | 8.00 | 16.8 | 84.0 | - | - | - |
| 51NF02ZM0103 | 15-AUG-89 | 7560 | 231 | 7.02 | 78.9 | 94.4 | - | - | - |
| 51NF02ZM0103 | 15-AUG-89 | 5040 | 137 | 6.24 | 50.2 | 66.2 | - | - | - |
| 51NF02ZM0103 | 15-AUG-89 | 7860 | 190 | 8.62 | 84.4 | 112 | - | - | - |
| 50NF02ZH0011 | 16-AUG-89 | 7040 | 808 | 1.24 | 4.88 | 16.5 | 85.4 | 10.3 | 4.3 |
| 50NF02ZH0011 | 16-AUG-89 | 5900 | 648 | 1.34 | 4.70 | 16.0 | - | - | - |
| 52NF02ZH0012 | 16-AUG-89 | 3460 | 83.5 | 2.59 | 3.96 | 14.3 | 85.8 | 10.7 | 3.5 |
| 52NF02ZH0012 | 16-AUG-89 | 4090 | 83.1 | 2.80 | 4.28 | 15.4 | - | - | - |
| 52NF02ZH0012 | 16-AUG-89 | 2580 | 57.3 | 1.16 | 4.16 | 12.8 | - | - | - |
| 52NF02ZG0007 | 16-AUG-89 | 4220 | 64.6 | 0.986 | 23.4 | 23.7 | 63.0 | 28.7 | 8.3 |
| 52NF02ZG0007 | 16-AUG-89 | 5550 | 95.2 | L.600 | 26.9 | 22.2 | - | - | - |
| 52NF02ZG0007 | 16-AUG-89 | 4460 | 70.0 | L.600 | 17.0 | 17.6 | - | - | - |
| 51NF02ZG0006 | 17-AUG-89 | 3430 | 697 | 0.657 | 3.01 | 18.3 | 90.0 | 7.3 | 2.7 |
| 51NF02ZG0006 | 17-AUG-89 | 3930 | 970 | 1.16 | 1.77 | 19.6 | - | - | - |
| 51NF02ZG0006 | 17-AUG-89 | 3170 | 703 | 1.12 | 1.85 | 19.9 | - | - | - |

# APPENDIX 2:

# RAW DATA (1987-1989) -

# OC-PCBs IN BOTTOM SEDIMENTS

1987 RAW DATA -
CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM
SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG)

| STATION NUMBER | SAMPLING DATE | HEXA CHLORO | ALPHA BHC | GAMMA BHC | HEPTA-CHLOR | ALDRIN | HEPTA CHLORO | GAMMA CHLORDANE | ALPHA CHLORDANE | A-ENDO SULFAN |
|---|---|---|---|---|---|---|---|---|---|---|
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 |

### 1987 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN MG/KG)

| STATION NUMBER | SAMPLING DATE | P,P- DDE | HEOD (DIELDRIN) | ENDRIN | O,P- DDT | P,P- TDE | P,P- DDT | BETA ENDO | MIREX | P,P- METHOXY- | TOTAL P.C.B. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 50NF02YL0014 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0002 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0003 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 51NF02YC0005 | 27-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YH0002 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YJ0002 | 26-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |
| 53NF02YL0001 | 28-AUG-87 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.004 | L.09 |

### 1988 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION # | DATE | HBC | a-BHC | g-BHC | HEPTA CHLOR | ALDRIN | HEPTA CHLOR | g-CHLOR DANE | a-CHLOR DANE | a-ENDO SULFAN |
|---|---|---|---|---|---|---|---|---|---|---|
| 50NF02YM0001 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YM0001 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YM0001 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YN0007 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YN0007 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YN0007 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0002 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0002 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0002 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0004 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0004 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02YD0004 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YD0052 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YD0052 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YD0052 | 23-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YR0001 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YR0001 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YR0001 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0011 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0011 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0011 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0013 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0013 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02YS0013 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YM0009 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YM0009 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YM0009 | 22-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0014 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0014 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0014 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0015 | 24-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0015 | 24-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YQ0015 | 24-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |

1988 RAW DATA -
CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION # | DATE | HBC | a-BHC | g-BHC | HEPTA CHLOR | ALDRIN | HEPTA CHLOR | g-CHLOR DANE | a-CHLOR DANE | a-ENDO SULFAN |
|---|---|---|---|---|---|---|---|---|---|---|
| 51NF02YS0060 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YS0060 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02YS0060 | 25-AUG-88 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |

### 1988 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION # | DATE | P,P DDE | HEOD | ENDRIN | O,P-DDT | P,P-TDE | P,P-DDT | b-ENDO SULFAN | MIREX | P,P-METHOXY | TOTAL PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 50NF02YM0001 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YM0001 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YM0001 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YN0007 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YN0007 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YN0007 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 52NF02YO0002 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | 220 |
| 52NF02YO0002 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | 350 |
| 52NF02YO0002 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | 130 |
| 52NF02YO0004 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 52NF02YO0004 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 52NF02YO0004 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YO0052 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YO0052 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YO0052 | 23-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YR0001 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YR0001 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YR0001 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0011 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0011 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0011 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0013 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0013 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 50NF02YS0013 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YM0009 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YM0009 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YM0009 | 22-AUG-88 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0014 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0014 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0014 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0015 | 24-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0015 | 24-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YQ0015 | 24-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |

### 1988 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION # | DATE | P,P DDE | HEOD | ENDRIN | O,P-DDT | P,P-TDE | P,P-DDT | b-ENDO SULFAN | MIREX | P,P-METHOXY | TOTAL PCB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 51NF02YS0060 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YS0060 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |
| 51NF02YS0060 | 25-AUG-88 | L5.6 | L3.2 | L2.9 | L7 | L6 | L7.5 | L2.9 | L4.3 | L18 | L77 |

### 1989 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | HEXA- CHLORO- | ALPHA BHC | GAMMA BHC | HEPTA CHLOR | ALDRIN | HEPTA CHLORO | GAMMA CHLORDANE | ALPHA CHLORDANE | A-ENDO SULFAN |
|---|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | 1.81 |
| 51NF02ZM0101 | 08-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZM0084 | 10-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZM0084 | 10-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZM0102 | 11-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | 6.45 | 5.44 | L1.4 |
| 51NF02ZM0102 | 11-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | 4.34 | 3.76 | L1.4 |
| 51NF02ZM0102 | 11-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | 2.79 | 2.45 | L1.4 |
| 53NF02ZM0104 | 11-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 53NF02ZM0104 | 11-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZM0009 | 14-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZM0009 | 14-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZM0009 | 14-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZM0103 | 15-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZM0103 | 15-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZM0103 | 15-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZH0011 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 50NF02ZH0011 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZH0012 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZH0012 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZH0012 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZG0007 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZG0007 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 52NF02ZG0007 | 16-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZG0006 | 17-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZG0006 | 17-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |
| 51NF02ZG0006 | 17-AUG-89 | L6.3 | L2.3 | L2.9 | L1.4 | L1.6 | L1.9 | L1.5 | L2.3 | L1.4 |

### 1989 RAW DATA -
### CONCENTRATIONS OF ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | P,P - DDE | HEOD (DIELDRIN) | ENDRIN | O,P- DDT | P,P- TDE | P,P- DDT | BETA- ENDO- | MIREX | P,P- METHOXY- | TOTAL P.C.B. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZM0101 | 08-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | 106 |
| 50NF02ZM0084 | 10-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 50NF02ZM0084 | 10-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZM0102 | 11-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | 1140 |
| 51NF02ZM0102 | 11-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | 788 |
| 51NF02ZM0102 | 11-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | 290 |
| 53NF02ZM0104 | 11-AUG-89 | 13.9 | L3.2 | L2.9 | L7.0 | 118 | L7.5 | L2.9 | L4.3 | L18.0 | 903 |
| 53NF02ZM0104 | 11-AUG-89 | 10.3 | L3.2 | L2.9 | L7.0 | 79.7 | L7.5 | L2.9 | L4.3 | L18.0 | 537 |
| 50NF02ZM0009 | 14-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 50NF02ZM0009 | 14-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 50NF02ZM0009 | 14-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZM0103 | 15-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZM0103 | 15-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZM0103 | 15-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 50NF02ZH0011 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 50NF02ZH0011 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZH0012 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZH0012 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZH0012 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZG0007 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZG0007 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 52NF02ZG0007 | 16-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZG0006 | 17-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZG0006 | 17-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |
| 51NF02ZG0006 | 17-AUG-89 | L5.6 | L3.2 | L2.9 | L7.0 | L6.0 | L7.5 | L2.9 | L4.3 | L18.0 | L77.0 |

# APPENDIX 3:

# RAW DATA (1989) -

# PAHs IN BOTTOM SEDIMENTS

## 1989 RAW DATA -
## CONCENTRATIONS OF POLYNUCLEAR AROMATIC HYDROCARBONS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| | STATION NUMBER | SAMPLING DATE | INDENE | 1,2,3,4 TET. HYDRO | 2-METHYL NAPHTALENE | 1-METHYL NAPHTALENE | B-CHLORO NAPHTALENE | ACENAPH TYLENE | ACENAPH THENE | FLUORENE |
|---|---|---|---|---|---|---|---|---|---|---|
| Kings Bk | 50NF02ZM0084 | 10-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L10 |
| [illegible] | 50NF02ZM0084 | 10-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| Mundy Pd | 51NF02ZM0102 | 11-AUG-89 | L10 | 13.5 | 63.1 | 49.2 | L10 | 24.6 | 49.2 | 172 |
| | 51NF02ZM0102 | 11-AUG-89 | L10 | L10 | 46.2 | 33.8 | L10 | L10 | 21.4 | 31.4 |
| | 51NF02ZM0102 | 11-AUG-89 | L10 | L10 | 23.0 | 18.2 | L10 | L10 | L10 | L15 |
| St John's [illegible] | 53NF02ZM0104 | 11-AUG-89 | L10 | L10 | 295 | 429 | 11.6 | 31.3 | 850 | 1330 |
| | 53NF02ZM0104 | 11-AUG-89 | L10 | L10 | 101 | 109 | L10 | 16.7 | 356 | 504 |
| Waterford | 50NF02ZM0009 | 14-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 50NF02ZM0009 | 14-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 50NF02ZM0009 | 14-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| Beaver Pd | 51NF02ZM0103 | 15-AUG-89 | L10 | L10 | 10.7 | L10 | L10 | L10 | L10 | L15 |
| | 51NF02ZM0103 | 15-AUG-89 | L10 | L10 | L10 | 21.0 | L10 | L10 | L10 | L15 |
| | 51NF02ZM0103 | 15-AUG-89 | L10 | L10 | 32.4 | 10.6 | L10 | L10 | L10 | L15 |
| [illegible] | 50NF02ZH0011 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 50NF02ZH0011 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 52NF02ZH0012 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 52NF02ZH0012 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 52NF02ZH0012 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| [illegible] | 52NF02ZG0007 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | 27.6 | 50.3 |
| | 52NF02ZG0007 | 16-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | 33.1 | 70.3 |
| | 52NF02ZG0007 | 16-AUG-89 | L10 | L10 | 14.1 | L10 | 16.0 | L10 | L10 | L15 |
| | 51NF02ZG0006 | 17-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 51NF02ZG0006 | 17-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |
| | 51NF02ZG0006 | 17-AUG-89 | L10 | L10 | L10 | L10 | L10 | L10 | L10 | L15 |

1989 RAW DATA -
CONCENTRATIONS OF POLYNUCLEAR AROMATIC HYDROCARBONS IN BOTTOM SEDIMENTS
OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | PHENAN THRENE | PYRENE | FLUORAN THENE | BENZO B FLUORAN | BENZO K FLUORAN | BENZO A PYRENE | INDENO PYRENE | BENZO PERYLENE | TOTAL PAHS |
|---|---|---|---|---|---|---|---|---|---|---|
| 50NF02ZM0084 | 10-AUG-89 | 160 | 286 | 424 | - | - | 109 | 52.8 | 62.6 | 1094.4 |
| 50NF02ZM0084 | 10-AUG-89 | 114 | 146 | 230 | - | - | 84.9 | 46.6 | 57.8 | 679.3 |
| 51NF02ZM0102 | 11-AUG-89 | 1620 | 2120 | 2780 | - | - | 145 | 638 | 885 | 8559.6 |
| 51NF02ZM0102 | 11-AUG-89 | 312 | 514 | 614 | - | - | 308 | 252 | 359 | 2491.8 |
| 51NF02ZM0102 | 11-AUG-89 | 105 | 211 | 227 | - | - | 1260 | 96.7 | 134 | 2074.9 |
| 53NF02ZM0104 | 11-AUG-89 | 7330 | 3890 | 10100 | 2410 | 1690 | 2630 | 1380 | 1750 | 34126.9 |
| 53NF02ZM0104 | 11-AUG-89 | 3170 | 4140 | 7270 | 1500 | 1050 | 1400 | 617 | 725 | 21000.0 |
| 50NF02ZM0009 | 14-AUG-89 | 30.3 | 45.8 | 62.5 | - | - | L30 | L30 | L30 | 138.6 |
| 50NF02ZM0009 | 14-AUG-89 | 18.5 | L15 | 20.7 | - | - | L30 | L30 | L30 | 39.2 |
| 50NF02ZM0009 | 14-AUG-89 | L15 | L15 | L15 | - | - | L30 | L30 | L30 | - |
| 51NF02ZM0103 | 15-AUG-89 | 88.2 | 136 | 208 | - | - | 151 | 97.2 | 116 | 867.1 |
| 51NF02ZM0103 | 15-AUG-89 | 127 | 164 | 230 | - | - | 142 | 129 | 150 | 963.0 |
| 51NF02ZM0103 | 15-AUG-89 | 87.8 | 131 | 175 | - | - | 94.1 | 66.7 | 87.2 | 684.8 |
| 50NF02ZH0011 | 16-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 50NF02ZH0011 | 16-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 52NF02ZH0012 | 16-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 52NF02ZH0012 | 16-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 52NF02ZH0012 | 16-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 52NF02ZG0007 | 16-AUG-89 | 499 | 825 | 1110 | 393 | 509 | 550 | 275 | 316 | 4554.9 |
| 52NF02ZG0007 | 16-AUG-89 | 841 | 1010 | 1420 | 441 | 465 | 662 | 329 | 384 | 5655.4 |
| 52NF02ZG0007 | 16-AUG-89 | 205 | 285 | 404 | 96.7 | 126 | 107 | 54.9 | 65.2 | 1373.9 |
| 51NF02ZG0006 | 17-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 51NF02ZG0006 | 17-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |
| 51NF02ZG0006 | 17-AUG-89 | L15 | L15 | L15 | L30 | L30 | L30 | L30 | L30 | - |

# APPENDIX 4:

# RAW DATA (1989) - CHLOROBENZENES IN BOTTOM SEDIMENTS

### 1989 RAW DATA -
### CONCENTRATIONS OF CHLOROBENZENES IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | 1,3-DI CHLORO- | 1,4-DI CHLORO | 1,2-DI CHLORO | 1,3,5-TRI CHLORO | 1,2,4-TRI CHLORO | 1,2,3-TRI CHLORO | 1,2,3,4 TET.CHL | PENTA CHLORO |
|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | L11.1 | 13 | L14.7<br>20.8 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0101 | 08-AUG-89 | 14.2 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZM0084 | 10-AUG-89 | 102 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZM0084 | 10-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0102 | 11-AUG-89 | 19.5 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0102 | 11-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | 4.25 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0102 | 11-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 53NF02ZM0104 | 11-AUG-89 | 26.8 | L11.7 | L14.7 | L1.8 | 4.86 | L1.9 | L2.7 | L3.7 |
| 53NF02ZM0104 | 11-AUG-89 | 36.8 | 23.4 | L14.7 | L1.8 | 5.43 | L1.9 | L2.7 | L3.7 |
| 50NF02ZM0009 | 14-AUG-89 | L11.1 | 15.1 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZM0009 | 14-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZM0009 | 14-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0103 | 15-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0103 | 15-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZM0103 | 15-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZH0011 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 50NF02ZH0011 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZH0012 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZH0012 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZH0012 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZG0007 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZG0007 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 52NF02ZG0007 | 16-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZG0006 | 17-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZG0006 | 17-AUG-89 | L11.1 | L11.7 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |
| 51NF02ZG0006 | 17-AUG-89 | 12.5 | 12.9 | L14.7 | L1.8 | L3.6 | L1.9 | L2.7 | L3.7 |

# APPENDIX 5:

# RAW DATA (1989) -

# CHLOROPHENOLS IN BOTTOM SEDIMENTS

1989 RAW DATA -
CONCENTRATIONS OF CHLOROPHENOLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS
IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | O-CHLORO PHENOL | M-CHLORO PHENOL | P-CHLORO PHENOL | 2-CHLORO 5-METHYL | 2,6-DI CHLORO | 4-CHLORO 3-METHYL | 2,4-DI CHLORO | 3,5-DI CHLORO |
|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | 50 | L10.0 | L10.0 | L10.0 | 22.7 | L10.0 | 10.9 | L10.0 |
| 51NF02ZM0101 | 08-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | 24 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | 19.2 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |

## 1989 RAW DATA -
## CONCENTRATIONS OF CHLOROPHENOLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | 2,3-DI CHLORO | 3,4-DI CHLORO | 2,4,6-TRI CHLORO | 2,3,6-TRI CHLORO | 2,3,5-TRI CHLORO | 2,4,5-TRI CHLORO | 2,3,4-TRI CHLORO | 3,4,5-TRI CHLORO |
|---|---|---|---|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | L10.0 | L10.0 | 11 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0101 | 08-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | 10.6 | L10.0 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 | L10.0 |

### 1989 RAW DATA -
### CONCENTRATIONS OF CHLOROPHENOLS IN BOTTOM SEDIMENTS OF SELECTED RIVERS IN NEWFOUNDLAND (VALUES REPORTED IN NG/G)

| STATION NUMBER | SAMPLING DATE | 2,3,5,6 TET. CHLOR. | 2,3,4,6 TET. CHLOR. | 2,4,5,6 TET. CHLOR. | PENTA CHLORO |
|---|---|---|---|---|---|
| 51NF02ZM0100 | 08-AUG-89 | 16.7 | 24.8 | 15.2 | 215.3 |
| 51NF02ZM0101 | 08-AUG-89 | L10.0 | L10.0 | L10.0 | 10.8 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0084 | 10-AUG-89 | L10.0 | L10.0 | L10.0 | 19.8 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | 20.6 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | 19.5 |
| 51NF02ZM0102 | 11-AUG-89 | L10.0 | L10.0 | L10.0 | 14.9 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | 11.7 | 37.2 |
| 53NF02ZM0104 | 11-AUG-89 | L10.0 | L10.0 | 11.6 | 44.6 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZM0009 | 14-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZM0103 | 15-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 50NF02ZH0011 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZH0012 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 52NF02ZG0007 | 16-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |
| 51NF02ZG0006 | 17-AUG-89 | L10.0 | L10.0 | L10.0 | L10.0 |