# TOXIC CONTAMINANT LOADINGS FROM MUNICIPAL SOURCES IN ONTARIO RAP SITES

Final Report

Submitted to the Wastewater Technology Centre

Canada Centre for Inland Waters

Burlington, Ontario

Contract No. KA168-2-2215

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March 31, 1993
(Revised October 15, 1993)

Ref. 92-5

## ABSTRACT

The report provides planning level estimates of the annual loadings of 26 toxic contaminants for urban sources including: combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents from Ontario communities.

For this purpose, annual flow volumes and contaminant mass discharges from the various sources (runoff, CSOs, and STP effluents) were computed 47 urban centres located in the 17 Canadian Remedial Action Plan (RAP) areas of concern. Urban centres were defined as areas having sewage treatment plant serviced populations greater than 1,000.

The annual distribution of flow volumes among the different sources varies significantly in the RAP areas: surface runoff contributes 17 to 65%, overflows from combined sewers contribute 1 to 6%, and STP effluents contribute 35 to 80%. During wet weather, this distribution changes significantly, where surface runoff contributes 80%, CSOs supply 7%, and STP effluents contribute 13%.

The annual distribution of solids loads among each source in the RAP areas differs somewhat, where surface runoff generate 49 to 96%, CSOs contribute 2 to 20%, and STP effluents contributing 4 to 39%. During wet weather, the solids loads are almost entirely surface runoff and CSO sources.

The contaminant concentration data were collected in large urban and industrial catchments, and a few smaller communities with mostly residential land. These data were pooled together to compute loadings for other areas, specifically smaller communities with little industrial land, and other areas with different land uses. Therefore, the computed loads are considered order of magnitude estimates, which are sufficient for planning level analysis. A more accurate estimate requires site contaminant concentration data.

The highest annual loadings of toxic contaminants for each source were computed for the trace metals, followed by total PCBs, and the pesticide/herbicide group. In general, surface runoff contributed the greatest loads of all the sources. No general statements could be made for the base neutral/acid extractable organics, volatile and dioxin/furan compounds, because few of these compounds had sufficient concentration data to compute loads for all three urban sources.

**PREFACE**

The Cleanup Fund is one of three programs (the other two being Preservation and Health Effects) of the Federal Government's Great Lakes Action Plan. The Cleanup Fund provides resources to develop and demonstrate technologies and remedial programs to meet federal responsibilities in the Canadian Areas of Concern.

The report that follows was sponsored by the Great Lakes Action Plan Cleanup Fund and addresses water quality issues in all the Canadian Areas of Concern. Although the report was subject to technical review, it does not necessarily reflect the views of the Cleanup Fund or Environment Canada.

## ACKNOWLEDGMENTS

The principle writer of this report was Dr. Harold Schroeter. This contract has been initiated and sponsored under the Federal Government Great Lakes Action Plan, Cleanup Fund. Mr. Jiri Marsalek of the National Water Research Institute, Environment Canada, Burlington, Ontario, was the Contract Liaison Officer.

Additional guidance and advice were provided by the following individuals:

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|---|---|
| Mr. Don Weatherbe | Donald G. Weatherbe Associates Inc. |

From the Ontario Ministry of the Environment and Energy

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|---|---|
| Mr. Dale Henry, | MISA Office, |
| Mr. Mike D'Andrea, | Great Lakes Section, |
| Mr. Weng Yau Lian, | MISA Office, |
| Dr. James Li, | MISA Office, |

During the development and application of the load calculation procedures in this study, input data were furnished by a number of individuals and agencies, particularly from:

| | |
|---|---|
| Mr. Scott Amos | City of Waterloo, Planning Dept. |
| Mrs. Jean Best | City of East York, Planning Dept. |
| Mr. Carlo Bonanni | City of Etobicoke, Planning Dept. |
| Mr. Duncan Boyd | Ontario Ministry of the Environment and Energy |
| Mr. Philip Cheung | $CH_2M$-Hill Engineering Ltd. |
| Mr. Brian Greck | Aquafour Engineering Ltd. |
| Mr. Rob Horne | City of Cambridge, Planning Dept. |
| Mr. Bill Kirw | City of Scarborough, Planning Dept. |
| Miss. Karen Lude | RAP, Ministry of the Environment |
| Miss Darylann Perry | UMA Engineering Ltd. |
| Dr. Bill Pisano | Environmental Design & Planning, Boston |
| Mr. Mark Robinson | Region of Hamilton Wentworth |
| Mr. Peter Skoretz | City of Guelph, Planning Dept. |
| Mr. Bryan Smith | Ontario Climate Centre, AES |
| Mr. Glen Switzer | Halton Region Conservation Authority |
| Mr. Brian Turcott | City of London, Planning Dept. |
| Mrs. Barbara Veal | Grand River Conservation Authority |
| Mr. N. Villanveva | Metropolitan Toronto, Planning Dept. |
| Mr. George Zukovs | $CH_2M$-Hill Engineering Ltd. |

All of which is gratefully acknowledged.

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## LIST OF SYMBOLS

| Symbol | Units | Definition |
|---|---|---|
| $C_{SXi}$ | mg/kg | Concentration of contaminant i for source X in the solids discharge stream. |
| $C_{TSSX}$ | mg/L | Concentration of total suspended solids from source X. |
| $C_{WXi}$ | mg/L | Concentration of contaminant i for source X dissolved in water. |
| $L_{Xi}$ | kg or t | Load of contaminant i from source X for a given urban centre for specified time interval (e.g. one year). |
| $S_X$ | kg or t | Mass of solids discharge from source X for a given urban centre for specified time interval (e.g. one year). |
| $V_X$ | $m^3$ | Flow volume from source X for a given urban centre for specified time interval (e.g. one year). |
| URBLOAD | | Acronym for load calculation program used in this study, and means URBan LOADings. |

Subscripted Variables

| | |
|---|---|
| i | Denotes a particular contaminant. |
| SR | Surface (stormwater) runoff. |
| CSO | Combined sewer overflows |
| STP | Sewage treatment plant. |
| SWF | Sewage flowrate |
| DWF | Dry weather flow. |
| DWD | Dry weather deposits. |
| WWF | Wet-Weather flow. |

# 1. INTRODUCTION

In 1991, a study to establish planning level estimates of the annual contaminant mass loads of selected toxic contaminants from urban nonpoint sources in the 17 Areas of Concern in the Canadian Great Lakes Basin was sponsored by the Federal Government's Great Lakes Action Plan Cleanup Fund (Schroeter and Associates, 1992). This report presents a summary of results specific to the 47 urban centres located within the 17 Canadian Areas of concern. The sources considered in this investigation were combined sewer overflows, stormwater discharges, and sewage treatment plant effluents. The estimates are considered useful for preliminary comparisons between point and nonpoint source loadings, their potential impact on receiving water quality, and in the development of remedial action plans.

This summary report includes an overview of the methodology and the database used in computing planning-level loading estimates for urban nonpoint sources from Ontario communities within Remedial Action Plan (RAP) areas, and presents results for a selected number of contaminants. For this purpose, urban centres were defined as areas having a sewage treatment plant serviced populations greater than or equal to 1,000 persons.

Contaminant concentration data used in the loading estimates were obtained from an existing database collected in large urban and industrial catchments, and a few smaller communities with primarily residential land use. These data were pooled together to compute loads for other areas, which in some cases included smaller communities with little industrial land, or communities with different land use distributions. The computed loads are considered order of magnitude estimates, which are considered appropriate for planning-level analyses. A more detailed analysis requires site specific concentration data.

# 2. METHODOLOGY FOR CONTAMINANT LOADING ESTIMATES

## 2.1 OVERVIEW OF CALCULATION PROCEDURE

The objectives of the loading calculation procedure were threefold:

a) retain the simplicity of general mass budget accounting methods (e.g. Sullivan et al., 1978; Waller and Novak, 1981),

b) reflect local conditions (e.g. land use, topography and climate variables) in the computed loads, and

c) make best use of available data sources.

Consequently, the procedure outlined here is adapted from Marsalek and Schroeter (1989) for surface runoff loads and Waller and Novak (1981) for CSO and STP loads. Waller and Novak's method of accounting for the wet weather scouring of solids material deposited in the combined sewers during dry weather was refined using an empirical approach devised by Pisano and Queiroz (1977). Fig. 2.1 (adapted from Waller and Novak, 1981) gives a schematic representation of the linkage between the various loading sources for a typical urban centre that were considered in the computational procedures outlined below. It is noted, that Fig. 2.1 is missing some links/sources that are difficult to quantify, i.e. sewage treatment plant by-passes and cross-connections between sanitary and storm sewers.

With reference to Fig. 2.1 , the total load of contaminant "i" over a specified time interval (say one year) for a given urban centre is computed using

$$[2.1] \qquad L_{Ti} = L_{SRi} + L_{CSOi} + L_{STPi}$$

where L denotes contaminant load in units of mass (i.e. kg or tonnes), and the subscripts SR, CSO and STP represent the individual sources: surface (stormwater) runoff, combined sewer overflow and sewage treatment plant effluent.

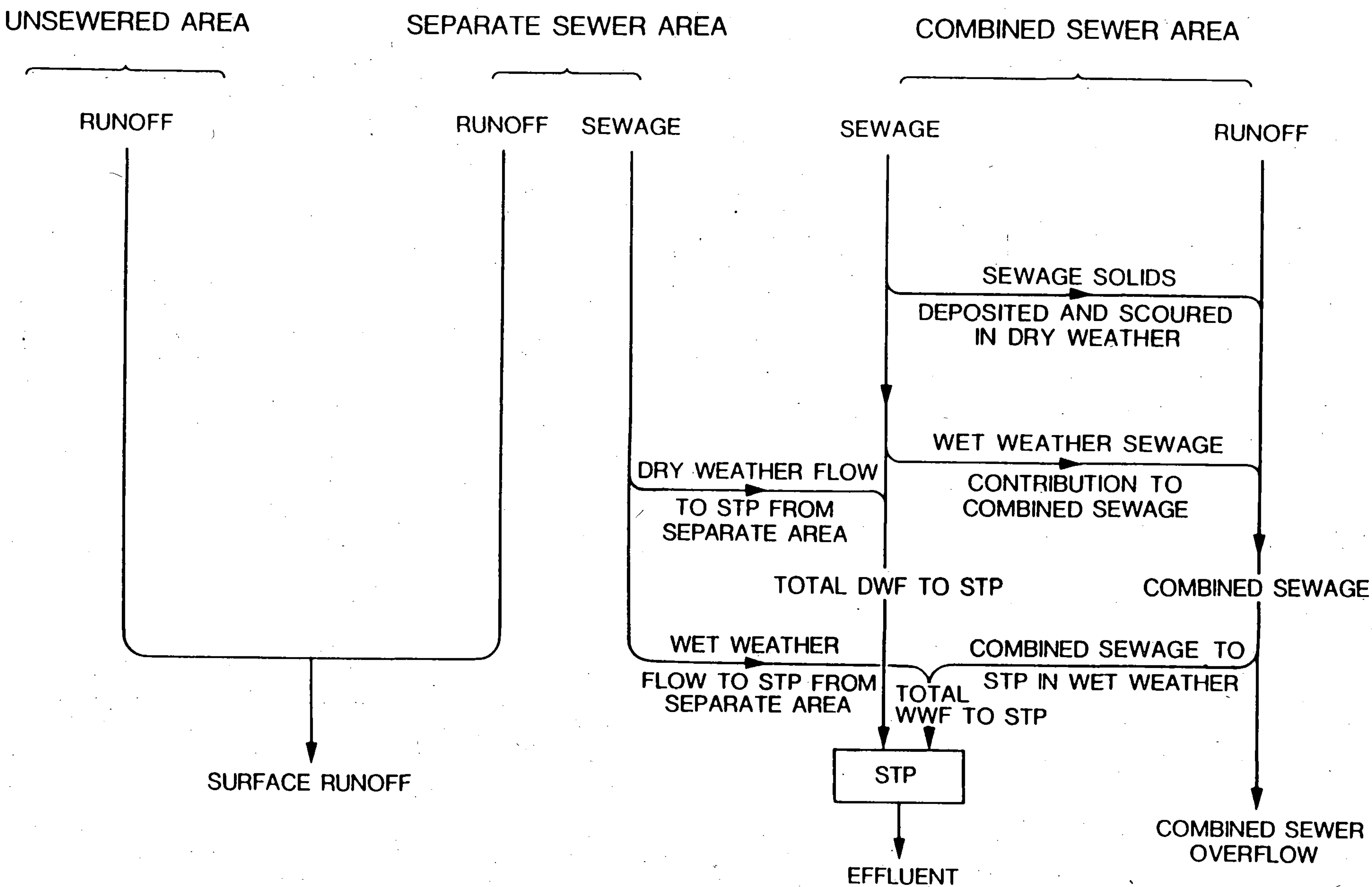



**Fig. 2.1** BASIS OF ALGORITHM FOR LOADING CALCULATIONS

Additional sources, such as backwash water from filtration plants, thermal generating station cooling water discharges, or effluents from specific industries, can be incorporated in [2.1], but were not included in this analysis.

It is generally recognized that many contaminants, especially organics and toxics, are associated with the sediment or solids transported by stormwater runoff (Marsalek and Schroeter, 1989). Consequently, the load for each individual source X in [2.1] is computed as the sum of water (dissolved) and solids (sediment) components as follows (Marsalek and Schroeter, 1989)

$$[2.2] \qquad L_{Xi} = C_{WXi} V_X + C_{SXi} S_X$$

where $C_{WXi}$ and $C_{SXi}$ denote the mean concentrations of contaminant i in the aqueous and solids phases, respectively, $V_X$ is the volume of water from source X, and $S_X$ is the discharge of solids, which is estimated as the mean suspended solids concentration, $C_{TSSX}$ and the flow volume as

$$[2.3] \qquad S_X = C_{TSSX} V_X$$

In general, the total loads for surface runoff, CSOs and STPs were determined by applying [2.2] and [2.3]. However, the method of determining the individual terms in [2.2] differ by source type, and are discussed fully in Schroeter and Associates (1992).

In general terms, estimates for the mean concentrations, $C_{WXi}$, $C_{SXi}$ and $C_{TSSX}$ were obtained from previous studies, where typically all the available field data were pooled together for a particular source, and the nondetected data were assigned half detection limit values (see Schroeter and Marsalek, 1989).

## 2.2 SEWAGE TREATMENT PLANT (STP) LOADS

The total STP effluent load is computed using [2.2] (with X=STP), where the sewage flow volume is taken as the sum of the observed total annual flows for all plants in a given urban centre, as reported in MOE's discharge summary (MOE, 1989). When observed sewage flows were not available, they were estimated as the product of the per capita sewage flows and the 'sewered' population served by the STPs in the area. In Ontario, the per capita sewage flow is about 670 L/d (MOE, 1989).

The mean concentrations, $C_{Wi}$, $C_{Si}$, and $C_{TSS}$ used in [2.2] and [2.3] would be representative of the level of sewage treatment (e.g. primary, secondary) provided in a given centre. Variations in effluent concentrations during wet weather, approximated here by mean estimates of wet and dry weather data, are a significant source of uncertainty. Contaminant concentrations of ($C_{Si}$) effluent solids were not available, but were estimated using weighted averages of measured concentrations in raw sludge from primary clarifiers and the treated sludge. For primary effluent, the contaminant concentrations in effluent solids were taken as 75% of the primary clarifier raw sludge concentration and 25% treated sludge concentration, whereas concentrations in secondary effluents were estimated using reversed proportions.

The mean concentrations used in the loading calculations for individual STPs were taken directly from a data set collected from 37 representative STPs (Canviro, 1988). However, in cases where site specific plant data were not available for a given urban centre, the mean concentrations computed by pooling together the entire 37 STP data set were used in the loading calculations. In some instances where several STPs were in a given RAP area, the individual communities were subdivided for computational purposes according to the population served by a particular STP. For example, in the Detroit River

RAP, Windsor was divided into Windsor-West, the area contributing to the Westerly STP, and Windsor-East, the area served by the Little River STP.

Estimates of $C_{Wi}$ obtained from the Canviro (1988) 37 STP data set measurements of whole water samples, where the aqueous and solids phases are not separated. This would tend to yield an over-estimate of mass loading for some parameters.

## 2.3 STORMWATER RUNOFF LOADS

Stormwater runoff volumes for sewered and unsewered areas were computed using [2.2]. Here, the total runoff volume was computed as the sum of runoff volume estimates calculated for the four principle land uses: residential, industrial, commercial, and open space. Runoff volumes for each land use were taken as the product of a volumetric runoff coefficient, the contributing area, and the mean annual precipitation for the urban centre. Marsalek and Schroeter (1989) selected the following runoff coefficients to reflect annual runoff volumes rather than single event conditions: 0.35 for residential land, 0.90 for commercial areas; 0.70 for industrial land and 0.10 for open land. The contributing area of each land use was estimated from empirical relationships between population and land use developed by the Community Planning Branch (1968), while the mean annual precipitation data were obtained from the Canadian Climate Normals, 1951-80 (AES, 1982).

Similarily, the contaminant mass loadings were also computed as the sum of the individual loads computed for each land use. These were calculated from [2.3], which requires estimates of mean suspended solids concentration for each land use (e.g., Section 3.4 and Table 3.4).

## 2.4 COMBINED SEWER OVERFLOWS

The total CSO load was computed from [2.2], with X=CSO. The required quantities in [2.2] depend on the time distribution of stormwater discharged to combined sewers, which varies according to the magnitude and duration of rain or snowmelt events causing runoff, as well as the interceptor sewer capacity or treatment rate. These quantities can be established by continuous simulation using an appropriate computer model (e.g. STORM, SWMM) and several years of data. However, in this analysis the simple approach of Waller and Novak (1981) was adopted whereby the CSO quantities were taken as a fraction of the total surface runoff (SR) and the sewage flow during wet weather (assumed to be equal to the dry weather flow, DWF) for the area serviced by the combined sewers (see Fig. 2.1). The SR and DWF were calculated as outlined above.

The actual fraction of annual surface runoff to sewage flow in the combined sewer overflows will depend on the capacity of the interceptor sewer that transports the combined sewage to the treatment plant and the duration of all runoff events in the year. Waller and Novak (1981) established these fractions (termed here, 'mixing factors'), based on STORM simulations for a hypothetical city having the mean characteristics (e.g. population, area, runoff coefficient) of the 56 cities they considered. For a typical interceptor sewer (e.g. capacity 2.5 times DWF), they found mixing factors of 0.65 for runoff and 0.023 for DWF. Some calibration of these factors was possible with results of previous STORM simulations for a few cities (e.g. Windsor, Sarnia, North York, Scarborough, Etobicoke, Hamilton, Kingston).

The corresponding CSO solids discharge were estimated in a similar manner, and included an allowance for the scouring of solids deposited during dry weather. The amount of solids deposited annually is calculated as a function of pipe network length, mean pipe slope, and the per capita sewage flow using an expression devised by Pisano and Queiroz (1977). Waller and Novak found that typically 6% of the solids deposited in dry weather will be scoured in wet weather. This fraction varies between 3 to 15%, depending on the topography of an urban area (e.g. lower values for flat terrain).

In summary, the total CSO load contains contaminant loads from the surface runoff, dry weather sewage, and the scoured solids.

Observed CSO mean contaminant concentrations ($C_{Wi}$ and $C_{Si}$) for direct use in [2.2] were not available, and were approximated by 'mixing' (flow-weighted average) the SR and DWF values. Here, the DWF aqueous phase concentrations were set at the raw sewage values, and the contaminant concentration in the solids phase were set equal to the primary clarifier raw sludge values. The ($C_{Wi}$ and $C_{Si}$) for SR were selected from Tables 3.3 and 3.4.

## 2.5 FRAMEWORK FOR LOADING CALCULATIONS

All the loading calculations outlined here were handled by a computer program called, URBLOAD (for Urban Loadings). A complete description of this program is provided in Schroeter and Associates (1992). Table 2.1 summarizes the input data requirements for URBLOAD. It is designed to use default values for various inputs when no site specific data are available.

Table 2.1 Summary of input data requirements for URBLOAD

General Inputs and default computation parameter values:

- land use estimation equation constants
- Runoff coefficients for each land use and sewer type (separate/combined)
- Solids concentrations for each land use for combined and separate sewers, as well as raw sewage, primary and secondary treated effluent.
- sludge adjustment factors for estimating solids amounts in raw sewage, primary and secondary treated effluent

Urban centre characteristics

- name of centre, population, mean precipitation (mm, annual or monthly),
- areas (ha) for each land use (residential, commercial, industrial, open)
- total land area (ha) and separate sewered area (ha) for centre
- percentage of total sewered area that is combined sewers
- pipe data: total pipe length (km) and mean pipe slope (in %)
- total daily sewage flow for the urban centre (in 1000's $m^3$/d)
- Sewage treatment code: 0=no treatment, 1=primary, 2=secondary, 3=lagoons
- CSO mixing (weighting) factors: FSR, FDWF and FDUR.
- mean minimum self-cleaning slope (%) for CSO pipes.

Mean Concentration Data

- parameter name and MOEE identification code
- water and solids concentration data for surface runoff, CSO, raw sewage, primary and secondary (or final) treatment.

# 3. DATASET FOR LOADING CALCULATIONS

## 3.1 STUDY AREA: THE CANADIAN GREAT LAKES BASIN

The study area represents the urban lands within the Canadian Great Lakes Basin. The basin was divided into six sub-basins corresponding to Lakes Erie, Huron, Ontario, St. Clair and Superior, as well as the St. Lawrence River. Areas contributing to the Ottawa River were included for comparison purposes. The 17 RAP (Remedial Action Plan) area locations are noted in Fig. 3.1.

## 3.2 MUNICIPAL INFORMATION

### 3.2.1 Identification of urban drainage areas

Information on actual urban drainage areas is difficult to collect and not readily available. Yet, it is possible to establish these areas from urban population estimates (Marsalek and Schroeter, 1989). Here, the population figures given in the Ontario STP discharge report (MOE, 1989) were used to define urban centres as areas where the STP serviced population was greater than 1,000. Where there were several STPs with the same level of treatment (e.g. primary or secondary), the serviced (sewered) populations were pooled (e.g. Metropolitan Toronto). Some centres have more than one STP providing different levels of treatment. In this case, the area was divided corresponding to the serviced area of each respective STP (e.g. Windsor East and Windsor West).

Using the above definition, 239 urban centres with a total population of 7,240,000 were identified in the study area. Forty-seven of these, comprising 3,900,000 people or 54% of the total, are located in the 17 RAP areas. The sub-basin and RAP area populations are summarized in Table 3.1, respectively.

# Fig. 3.1 Great Lakes Areas of Concern

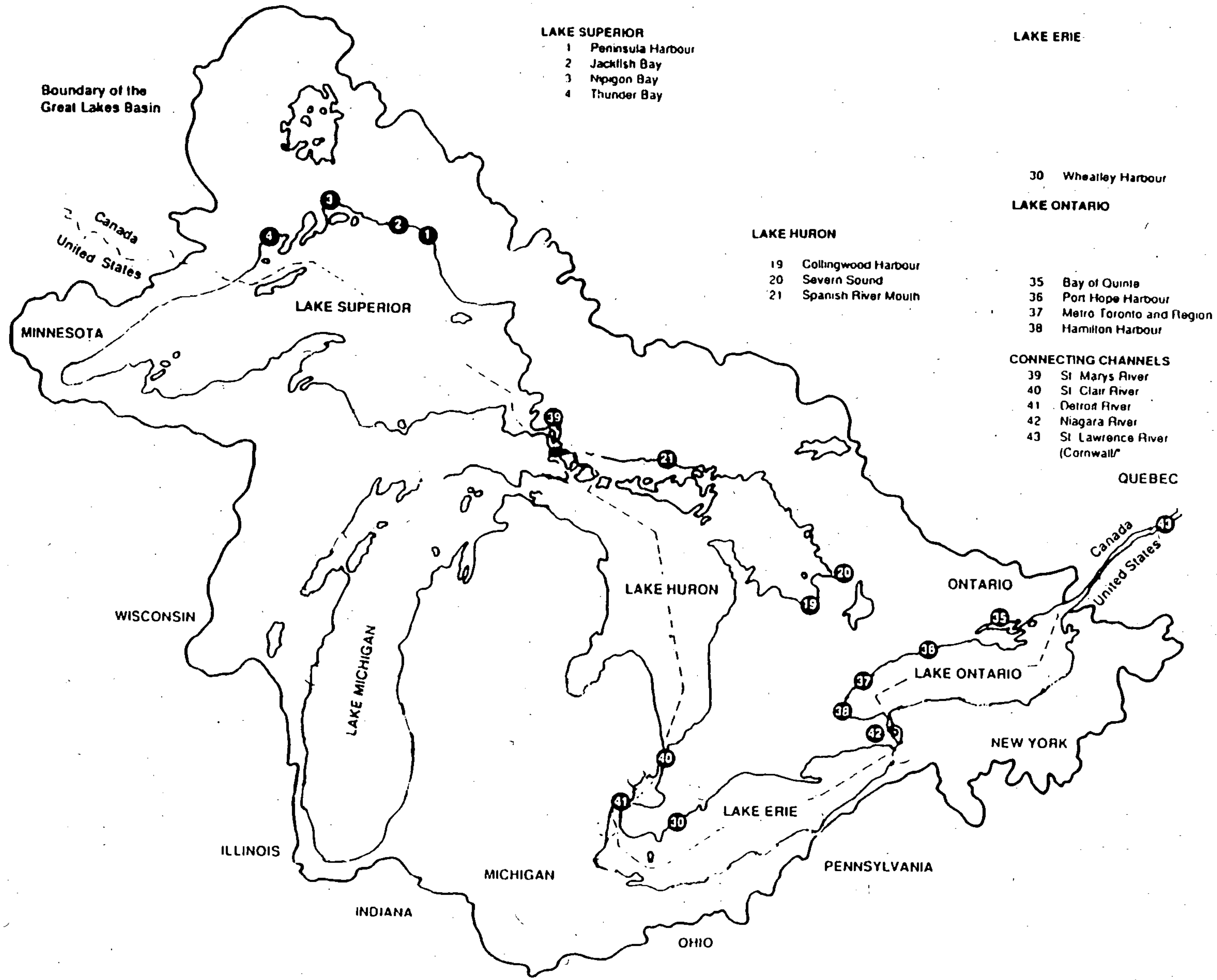


Table 3.1 Breakdown of urban population and land use for each sub-basin and RAP Site

a) Major Sub-basins in Ontario

| Sub-Basin | Population | Land Use Areas (ha) Resid. | Comm. | Indust. | Open | Total Area | Sewered Area (%) Sep. | Comb. |
|---|---|---|---|---|---|---|---|---|
| Lake Erie | 827925 | 20800 | 1830 | 6620 | 5320 | 34600 | 77.5 | 8.2 |
| Lake Huron | 632139 | 16700 | 1750 | 5500 | 5670 | 29600 | 82.4 | 1.5 |
| Lake Ontario | 4414526 | 78300 | 6940 | 28300 | 36600 | 150000 | 72.0 | 14.3 |
| Lake St. Clair | 514685 | 15400 | 1550 | 4930 | 6510 | 28400 | 69.0 | 9.1 |
| Lake Superior | 127869 | 2630 | 241 | 921 | 957 | 4750 | 62.3 | 17.5 |
| St. Lawrence River | 85390 | 2380 | 351 | 674 | 929 | 4330 | 78.1 | 14.0 |
| Ottawa River | 637800 | 12300 | 1120 | 4320 | 4460 | 22200 | 71.1 | 8.8 |
| Overall Totals | 7240334 | 148000 | 13800 | 51200 | 60400 | 274000 | 73.4 | 11.3 |

b) RAP Areas of Concern

| Area of Concern | Population | Land Use Areas (ha) Resid. | Comm. | Indust. | Open | Total Area | Sewered Area (%) Sep. | Comb. |
|---|---|---|---|---|---|---|---|---|
| Thunder Bay | 108802 | 2030 | 177 | 711 | 772 | 3690 | 56.6 | 22.5 |
| Nipigon Bay | 3330 | 117 | 13 | 41 | 34 | 205 | 83.4 | Nil |
| Peninsula Harbour | 5000 | 149 | 16 | 52 | 47 | 264 | 82.2 | Nil |
| St.Mary's River | 72861 | 2610 | 360 | 580 | 950 | 4500* | 99.9 | Nil |
| Spanish River | 4974 | 149 | 16 | 52 | 46 | 263 | 82.5 | Nil |
| Severn Sound | 21933 | 633 | 66 | 222 | 199 | 1120 | 61.5 | 20.6 |
| Collingwood Harbour | 12172 | 317 | 32 | 111 | 106 | 565 | 81.4 | Nil |
| St.Clair River | 70200 | 2110 | 209 | 1270 | 525 | 4180* | 81.1 | 12.9 |
| Detroit River | 193111 | 7060 | 540 | 1800 | 404 | 9810* | 75.8 | 24.1 |
| Wheatley Harbour | 2328 | 78 | 9 | 27 | 23 | 137 | 83.2 | Nil |
| Niagara River | 138267 | 3040 | 469 | 920 | 6770 | 11200* | 21.2 | 18.4 |
| Hamilton Harbour | 377640 | 7350 | 818 | 1440 | 5510 | 15300 | 52.0 | 29.0 |
| Toronto Water Front | 2761286 | 44900 | 3560 | 17800 | 15900 | 82300* | 80.0 | 14.2 |
| Port Hope | 10281 | 275 | 28 | 96 | 90 | 489 | 81.6 | Nil |
| Bay of Quinte | 66584 | 1640 | 160 | 576 | 581 | 2960 | 69.3 | 11.1 |
| St.Lawrence River | 46425 | 1300 | 241 | 298 | 582 | 2420* | 75.0 | 25.0 |
| RAP Site Totals | 3895194 | 73700 | 6710 | 26000 | 32500 | 139000 | 71.7 | 16.6 |

Note: * denotes RAPs where land use areas were measured

### 3.2.2 Land use distribution

It is well recognized that the quantity and quality of urban runoff may depend on population and land use activities (Sullivan et al., 1978). Therefore, the total urban land was divided into representative land use categories, such as residential, commercial, industrial and open land (Marsalek and Schroeter, 1989). However, the land use data were available for only a few cities (e.g. Cornwall, Niagara Falls, Welland, Fort Erie, Sarnia, Windsor, Sault Ste. Marie, Toronto and Hamilton). Consequently, the land use areas were established from existing empirical relationships between population and land use developed by the Community Planning Branch (1968), as suggested by Marsalek and Schroeter (1989).

The total land use areas for each RAP area and sub-basin are summarized in Table 3.1. For example, a typical urban centre in Ontario comprises 54% residential, 5% commercial, 19% industrial and 22% open space land.

### 3.2.3 Sewage flows, sewered area, pipe length and slope

The total sewage flows for each urban centre were taken directly from the STP discharge report (MOE, 1989). In 1988, the total sewage flow for Ontario (415 plants) was 4,975 (1000's) $m^3$/d, of which 97% contributed to the seven major sub-basins, and 53% was supplied by the 47 centres in RAP areas (Figure 3.1). Less than 20% of the total sewage flow receives primary treatment. The per capita sewage flow for Ontario is about 670 L/d, and 680 L/d for RAP areas.

Estimates of total sewered area requires a detailed review of sewer drainage maps. In the absence of actual data, the total sewered area was taken as the sum of the residential, commercial and industrial components. Estimates of the combined sewered area were taken from Waller and Novak (1981), and any site specific data available from other studies.

The total length of sewer pipe and the mean sewer slope were required in the dry weather solids deposition computations for combined sewered areas. These data were not available, and hence, were estimated from population density information using equations suggested by Pisano and Queiroz (1977). The mean sewer slope was set equal to the ground slope measured from topographic maps.

A complete listing of all the above data for each urban centre considered is summarized in Schroeter and Associates (1992).

### 3.3 PRECIPITATION DATA

The annual precipitation data were obtained from the Canadian Climate Normals, 1951-80 (AES, 1982). These data represent the total mean precipitation from rain and snowfall (equivalent water content when melted) for a 30 year period. For most urban centres, precipitation data were available, but in some cases, the annual precipitation was estimated from data for neighbouring areas using Thiesson polygon techniques described in hydrology texts. For centres with precipitation records from more than one station, the mean value was adopted.

### 3.4 OBSERVED TOXIC CONTAMINANT LEVELS IN NONPOINT SOURCES

A suitable data base of observed toxic contaminant levels for use in loading calculations was assembled from two existing studies; the surface runoff data for 12 cities from Marsalek and Schroeter (1989), and the sewage treatment information for 37 plants from Canviro (1988). Neither of these studies included toxic data for CSOs explicitly, and so they were computed as a combination (mixture) of surface runoff and raw sewage as described above.

Data for contaminants where significant number of samples (X %) contained data below the analytical detection limit for each loading source (runoff, raw sewage and STP effluent) were excluded from the analysis. From a list of 131 contaminants (all EPA priority pollutants), only 26 had concurrent data for all three loading sources in both water and sediment phases. A list of these 26 substances (arranged by contaminant groupings, e.g. metals), together with their MOEE Lab codes, number of samples collected, and detection frequency (in percent) is presented in Table 3.2.

Mean concentrations estimated for the 26 contaminants incorporate appreciable uncertainties because of the 'censored data' (e.g. concentration values at or below the analytical detection limits) contained in the data sets. These uncertainties and the relatively small number of samples with concentration data above the detection limits (Table 3.2) did not justify the division of concentration data by land use categories. The metals grouping had the highest detection frequencies of 46% to 68% for water samples, and 82% to 86% for sediment. Lower detection frequencies were observed for the organic compounds (ranging from not detected to 25%, with a higher detection frequency of 48% for the volatile organic compounds in runoff water).

Mean concentrations were estimated in Marsalek and Schroeter (1989) and Canviro (1988) by assigning half the detection limit to the undefined values. This approach was adopted in this study. Table 3.3 provides a complete summary of the mean concentration data used in the loading calculations. Mean suspended solids concentrations for surface runoff and the various sewage components are summarized in Table 3.4. Stormwater runoff and CSO values were taken directly from Marsalek (1978), whereas the sewage components (raw sewage, primary and secondary effluent) were calculated (flow-weighted mean) from information available in the STP discharge summary (MOE, 1989) and Canviro (1988).

Table 3.2 Detection frequencies for toxics data used in the loading calculations

| Parameter Name | MOEE CODE | Water Phase Samples: Runoff n | Runoff Freq. (%) | Raw Sewage n | Raw Sewage Freq. (%) | Treated Sewage: Primary n | Primary Freq. (%) | Secondary n | Secondary Freq. (%) | Sediment Phase Samples: Runoff n | Runoff Freq. (%) | Primary Sludge n | Primary Sludge Freq. (%) | Treated Sludge n | Treated Sludge Freq. (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Metals and Cynanide** | | | | | | | | | | | | | | | |
| Arsenic | ASUT | 83 | 87 | 308 | 1 | | N/A | 252 | 1 | 43 | 100 | 51 | 98 | 50 | 98 |
| Chromium | CRUT | 61 | 44 | 322 | 74 | 48 | 60 | 267 | 51 | 112 | 91 | 51 | 98 | 50 | 100 |
| Cobalt | COUT | 90 | 27 | 322 | 26 | 48 | 23 | 266 | 24 | 43 | 58 | 41 | 73 | 39 | 82 |
| Copper | CUUT | 105 | 93 | 49 | 98 | 8 | 88 | 47 | 64 | 112 | 94 | 46 | 100 | 45 | 100 |
| Mercury | HGUT | 34 | 66 | 283 | 97 | 39 | 97 | 233 | 94 | 100 | 80 | 50 | 100 | 50 | 98 |
| Nickel | NIUT | 104 | 87 | 322 | 32 | 48 | 21 | 267 | 64 | 111 | 88 | 46 | 96 | 45 | 93 |
| Lead | PBUT | 105 | 78 | 322 | 18 | 48 | 19 | 267 | 9 | 112 | 94 | 49 | 98 | 50 | 98 |
| Selenium | SEUT | 83 | 86 | 308 | 2 | 48 | 2 | 252 | 1 | 32 | 84 | 50 | 96 | 50 | 96 |
| Zinc | ZNUT | 105 | 98 | 322 | 98 | 48 | 100 | 267 | 98 | 112 | 100 | 51 | 100 | 50 | 100 |
| **Pesticides and Herbicides** | | | | | | | | | | | | | | | |
| 1-2-4 Trichlorobenzene | X2124 | 122 | 21 | 276 | 13 | 40 | 3 | 227 | 16 | 99 | 31 | 51 | 33 | 50 | 44 |
| Alpha-BHC | P1BHCA | 124 | 98 | 276 | 6 | 40 | 5 | 227 | 2 | 110 | 28 | 51 | 24 | 50 | 22 |
| Alpha-Endosulfan (I) | P1END1 | 124 | 26 | 276 | 2 | | ND | 227 | 1 | 110 | 18 | 51 | 18 | 50 | 12 |
| Beta-Endosulfan (II) | P1END2 | 124 | 26 | 276 | 4 | 40 | 3 | 227 | 1 | 110 | 10 | 51 | 12 | 50 | 14 |
| Dieldrin | P1DIEL | 124 | 26 | 276 | 3 | | ND | 227 | 1 | 110 | 16 | 51 | 39 | 50 | 30 |
| Endrin | P1ENDR | 124 | 23 | 276 | 2 | | ND | 227 | 1 | 110 | 26 | 51 | 16 | 50 | 10 |
| Gamma-BHC (Lindane) | P1BHCG | 124 | 86 | 276 | 52 | 40 | 73 | 227 | 69 | 110 | 18 | 51 | 55 | 50 | 24 |
| Gamma Chlordane | P1CHLG | 124 | 20 | 276 | 3 | | ND | 227 | 2 | 110 | 35 | 51 | 37 | 50 | 42 |
| Heptachlor Epoxide | P1HEPE | 124 | 27 | 276 | 1 | | ND | | ND | 110 | 35 | 51 | 24 | 50 | 20 |
| Hexachlorobenzene | X2HCB | 125 | 19 | 276 | 4 | | ND | | ND | 112 | 50 | 51 | 33 | 50 | 42 |
| Methoxychlor (DMDT) | P1DMDT | 124 | 21 | 276 | 17 | 48 | ND | 267 | ND | 110 | 12 | 51 | 37 | 50 | 30 |
| pp DDE | P1PPDE | 125 | 19 | 276 | 5 | | ND | 227 | 3 | 129 | 21 | 51 | 43 | 50 | 68 |
| pp DDT | P1PPDT | 125 | 22 | 276 | 3 | 40 | 3 | 227 | 1 | 129 | ND | 51 | 12 | 50 | 10 |
| Total PCB | P1PCBT | 121 | 46 | 276 | 15 | 40 | 18 | 227 | 4 | 123 | 86 | 51 | 78 | 50 | 64 |
| **Volatile Organic Compounds** | | | | | | | | | | | | | | | |
| 1-2 Dichlorobenzene | X212CB | 100 | 48 | 274 | 1 | | ND | | ND | 99 | 26 | | ND | | ND |
| 1-3 Dichlorobenzene | X213CB | 100 | 18 | | ND | | ND | | ND | 99 | 11 | 51 | 2 | 50 | ND |
| 1-4 Dichlorobenzene | X214CB | 100 | 25 | | ND | | ND | | ND | 99 | 13 | 51 | 2 | 50 | 4 |

NOTES: ND = not detected, mean value set equal to half the detection limit.
* = estimated from adjacent values.

Table 3.3 Concentration data used as input to URBLOAD

| Parameter Name | MOEE CODE | Unit | Mean Water Concentrations Runoff | Raw Sewage | Treated Sewage Primary | Treated Sewage Secondary | Unit | Mean Solids Concentrations Runoff | Primary Sludge | Treated Sludge |
|---|---|---|---|---|---|---|---|---|---|---|
| Metals and Cynanide | | | | | | | | | | |
| Arsenic | ASUT | ug/L | 1.70 | 16.80 | 16.7* | 16.7 | mg/kg | 8.2 | 6.13 | 5.40 |
| Chromium | CRUT | ug/L | 6.40 | 51.10 | 10.80 | 9.00 | mg/kg | 110.0 | 301.43 | 333.06 |
| Cobalt | COUT | ug/L | 2.70 | 9.30 | 6.50 | 6.40 | mg/kg | 11.0 | 9.29 | 9.14 |
| Copper | CUUT | ug/L | 19.00 | 110.60 | 18.20 | 13.10 | mg/kg | 67.0 | 606.31 | 732.24 |
| Mercury | HGUT | ug/L | 0.026 | 0.23 | 0.05 | 0.03 | mg/kg | 0.24 | 0.00223 | 0.00324 |
| Nickel | NIUT | ug/L | 16.00 | 38.80 | 8.70 | 22.10 | mg/kg | 50 | 59.17 | 72.95 |
| Lead | PBUT | ug/L | 90.00 | 59.50 | 20.80 | 16.50 | mg/kg | 470 | 173.99 | 196.92 |
| Selenium | SEUT | ug/L | 1.60 | 17.30 | 16.50 | 17.1 | mg/kg | 0.33 | 3.04 | 2.67 |
| Zinc | ZNUT | ug/L | 440 | 211.00 | 69.80 | 53.30 | mg/kg | 400 | 905.39 | 988.90 |
| Pesticides and Herbicides | | | | | | | | | | |
| 1-2-4 Trichlorobenzene | X2124 | ug/L | 0.0015 | 0.01 | 0.01 | 0.01 | ug/kg | 8.5 | 9.3 | 14.80 |
| Alpha-BHC | P1BHCA | ug/L | 0.019 | 0.01 | 0.01 | 0.01 | ug/kg | 4.9 | 5.50 | 5.60 |
| Alpha-Endosulfan (I) | P1END1 | ug/L | 0.00041 | 0.01 | ND=0.01 | 0.01 | ug/kg | 5.0 | 4.60 | 4.90 |
| Beta-Endosulfan (II) | P1END2 | ug/L | 0.00060 | 0.01 | 0.01 | 0.01 | ug/kg | 1.0 | 4.20 | 4.70 |
| Dieldrin | P1DIEL | ug/L | 0.00051 | ND=0.01 | ND=0.01 | 0.01 | ug/kg | 4.4 | 7.20 | 6.50 |
| Endrin | P1ENDR | ug/L | 0.00077 | 0.01 | ND=0.01 | 0.01 | ug/kg | 3.8 | 4.20 | 4.20 |
| Gamma-BHC (Lindane) | P1BHCG | ug/L | 0.0065 | 0.02 | 0.02 | 0.02 | ug/kg | 3.5 | 8.90 | 5.70 |
| Gamma Chlordane | P1CHLG | ug/L | 0.00079 | 0.01 | ND=0.01 | 0.01 | ug/kg | 21.0 | 6.00 | 6.80 |
| Heptachlor Epoxide | P1HEPE | ug/L | 0.00110 | 0.01 | ND=0.005 | ND=0.005 | ug/kg | 2.7 | 5.00 | 5.20 |
| Methoxychlor (DMDT) | P1DMDT | ug/L | 0.00150 | 0.08 | ND=0.04 | 0.04 | ug/kg | 5.9 | 45.80 | 34.10 |
| pp DDE | P1PPDE | ug/L | 0.00038 | 0.01 | ND=0.01 | 0.01 | ug/kg | 9.1 | 7.30 | 11.10 |
| pp DDT | P1PPDT | ug/L | 0.00036 | 0.04 | 0.02 | 0.02 | ug/kg | ND=3.0 | 16.40 | 16.70 |
| Total PCB | P1PCBT | ug/L | 0.01400 | 0.06 | 0.03 | 0.02 | ug/kg | NA | 88.70 | 114.10 |
| Volatile Organic Compounds | | | | | | | | | | |
| 1-2 Dichlorobenzene | X212CB | ug/L | 0.03900 | 20.05 | ND=1.0 | ND=1.0 | ug/kg | 120 | ND=20 | ND=20 |
| 1-3 Dichlorobenzene | X213CB | ug/L | 0.00740 | ND=20 | ND=1.0 | ND=1.0 | ug/kg | 27.0 | 635.5 | ND=20 |
| 1-4 Dichlorobenzene | X214CB | ug/L | 0.00890 | ND=20 | ND=1.0 | ND=1.0 | ug/kg | 40.0 | 643.7 | 272.7 |

NOTES: ND = not detected, mean value set equal to half the detection limit.
* = estimated from adjacent values.

Table 3.4 Suspended solids concentrations used for estimating solids discharges

| | SS (mg/L) |
|---|---|
| STP Characteristics | |
| Raw sewage | 245 |
| Primary Effluent | 40.0 |
| Secondary Effluent | 16.0 |

| | SS (mg/L) |
|---|---|
| Runoff Characteristics by land use | |
| Residential | 170 |
| Commercial | 173 |
| Industrial | 244 |
| Open space | 170 |

# 4. ANNUAL LOADINGS OF THE TOXIC CONTAMINANTS STUDIED

In this chapter, the annual loadings of 26 toxic contaminants from urban nonpoint sources are summarized in separate sections for each RAP area. The results are reported and discussed in two parts. Summaries of flow volumes and suspended solids discharges for each urban centre in a given RAP are followed by summaries of contaminant mass loadings from each source for the 26 toxic substances.

The contaminant mass loadings presented here are the best estimates made from a common database. Hence, they do not replace any loading estimates based on site specific information collected through local initiatives. Therefore, specific conclusions about the impact of the contaminant mass loadings in individual RAP areas are not made in this report.

## 4.1 OVERVIEW OF LOADINGS FROM ALL RAP AREAS

This section provides an overview of the loadings for all 17 RAP areas combined, so as to establish their relative contributions to the entire Great Lakes Basin. For presentation purposes, the results by RAP area are ordered by the geographic positioning of the RAP area from north (Lake Superior) to south (Lake Ontario). Complete results for all 131 contaminants and 239 communities within the Great Lakes Basin are provided in Schroeter and Associates (1992).

### 4.1.1 Flow volumes and solids discharges

The computed annual flow volumes and suspended solids discharges from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.1 and 4.2 for each RAP area and sub-basin. Fig. 4.1 gives a comparison of the relative contributions to the total annual flow volume and solids discharge totals from each loading source by RAP area.

Table 4.01 Annual Flow Volumes (1000s m^3) for all RAP Areas

| Basin/RAP | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Thunder Bay | 8040 | 1720 | 31200 | 41000 |
| Nipigon Bay | 642 | 0 | 902 | 1540 |
| Peninsula Harbour | 900 | 0 | 478 | 1380 |
| St.Mary's River | 15600 | 0 | 15300 | 30900 |
| Spanish River | 924 | 0 | 1060 | 1990 |
| Severn Sound | 3740 | 675 | 6180 | 10600 |
| Collingwood Hbr. | 1950 | 0 | 6460 | 8420 |
| St.Clair River | 14400 | 1490 | 19600 | 35400 |
| Detroit River | 27400 | 5960 | 54100 | 87500 |
| Wheatley Harbour | 465 | 0 | 307 | 772 |
| Niagara River | 21700 | 3500 | 37700 | 62900 |
| Hamilton Harbour | 29200 | 5340 | 139000 | 174000 |
| Toronto Waterfront | 211000 | 9520 | 618000 | 839000 |
| Port Hope | 1580 | 0 | 1630 | 3210 |
| Bay of Quinte | 12800 | 59 | 18800 | 31700 |
| St.Lawrence River | 6530 | 1520 | 18100 | 26100 |
| RAP Totals | 356000 | 29800 | 969000 | 1360000 |

Table 4.02 Annual Solids Discharge (Tonnes) for all RAP Areas

| Basin/RAP | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Thunder Bay | 1570 | 401 | 1250 | 3220 |
| Nipigon Bay | 125 | 0 | 36 | 161 |
| Peninsula Harbour | 176 | 0 | 8 | 184 |
| St.Mary's River | 2930 | 0 | 612 | 3540 |
| Spanish River | 181 | 0 | 43 | 223 |
| Severn Sound | 731 | 157 | 99 | 987 |
| Collingwood Hbr. | 382 | 0 | 103 | 485 |
| St.Clair River | 2950 | 330 | 783 | 4060 |
| Detroit River | 5270 | 1210 | 1870 | 8360 |
| Wheatley Harbour | 91 | 0 | 5 | 96 |
| Niagara River | 4060 | 1010 | 726 | 5800 |
| Hamilton Harbour | 5460 | 1210 | 2220 | 8890 |
| Toronto Waterfront | 41200 | 2470 | 9890 | 53500 |
| Port Hope | 310 | 0 | 26 | 336 |
| Bay of Quinte | 2540 | 14 | 301 | 2850 |
| St.Lawrence River | 1220 | 339 | 723 | 2290 |
| RAP Totals | 69200 | 7140 | 18700 | 95000 |

Fig. 4.2 presents similar information for wet weather conditions.

For RAP areas, the total flow is apportioned to each source as follows:

- o surface runoff accounts for 17 to 65%
- o STPs contribute 35 to 80%
- o CSOs (when present) supply 1 to 7%

The distribution of solids discharged from each source is:

- o surface runoff contributes 49 to 96%
- o STP effluents supply 4 to 40%
- o CSOs contribute 4 to 20%.

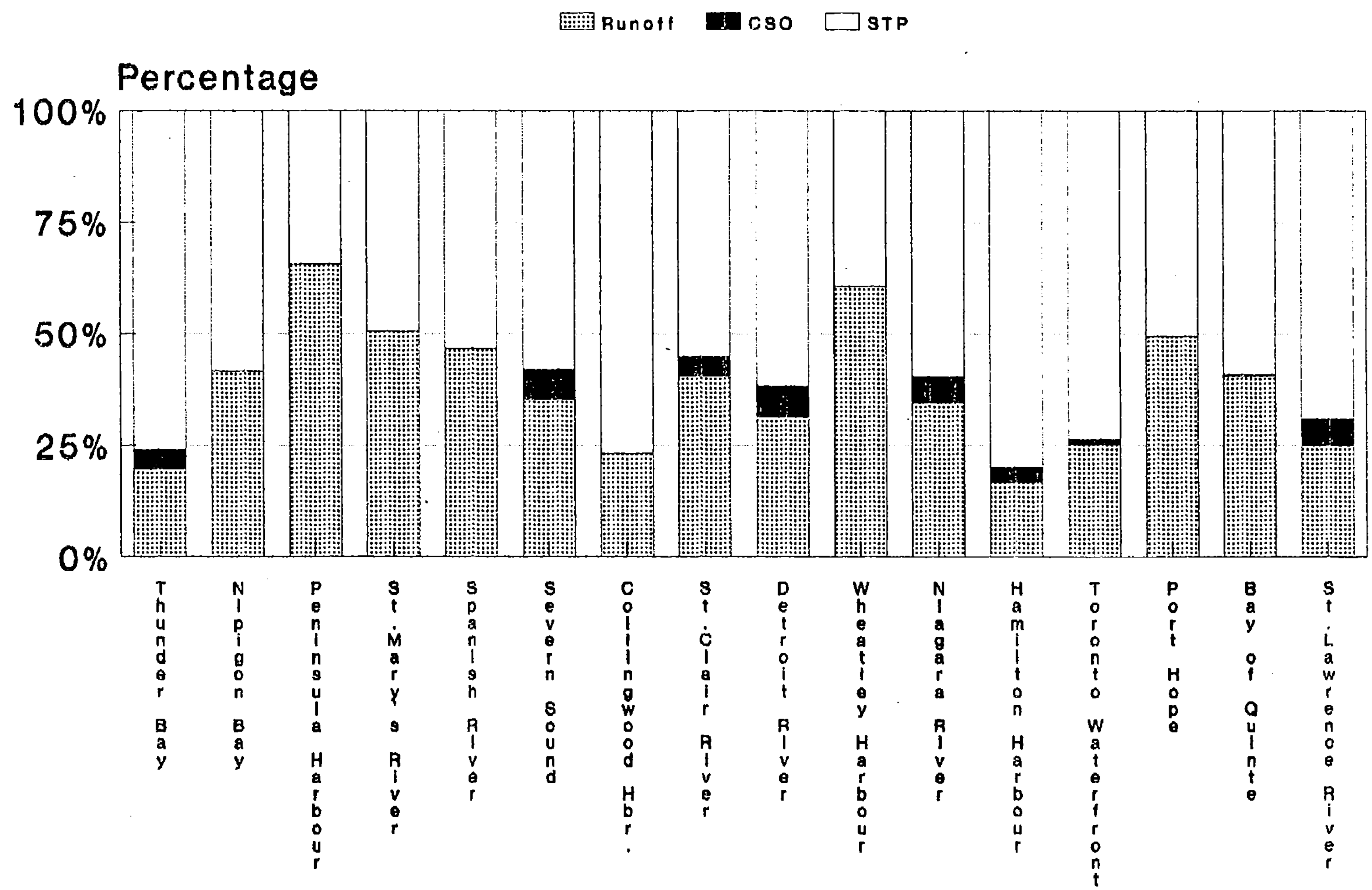
The relative contributions from each source to the total flow changes significantly during wet weather conditions, where

- o surface runoff accounts for 68 to 97%
- o STPs contribute 4 to 20%
- o CSOs contribute 4 to 17%

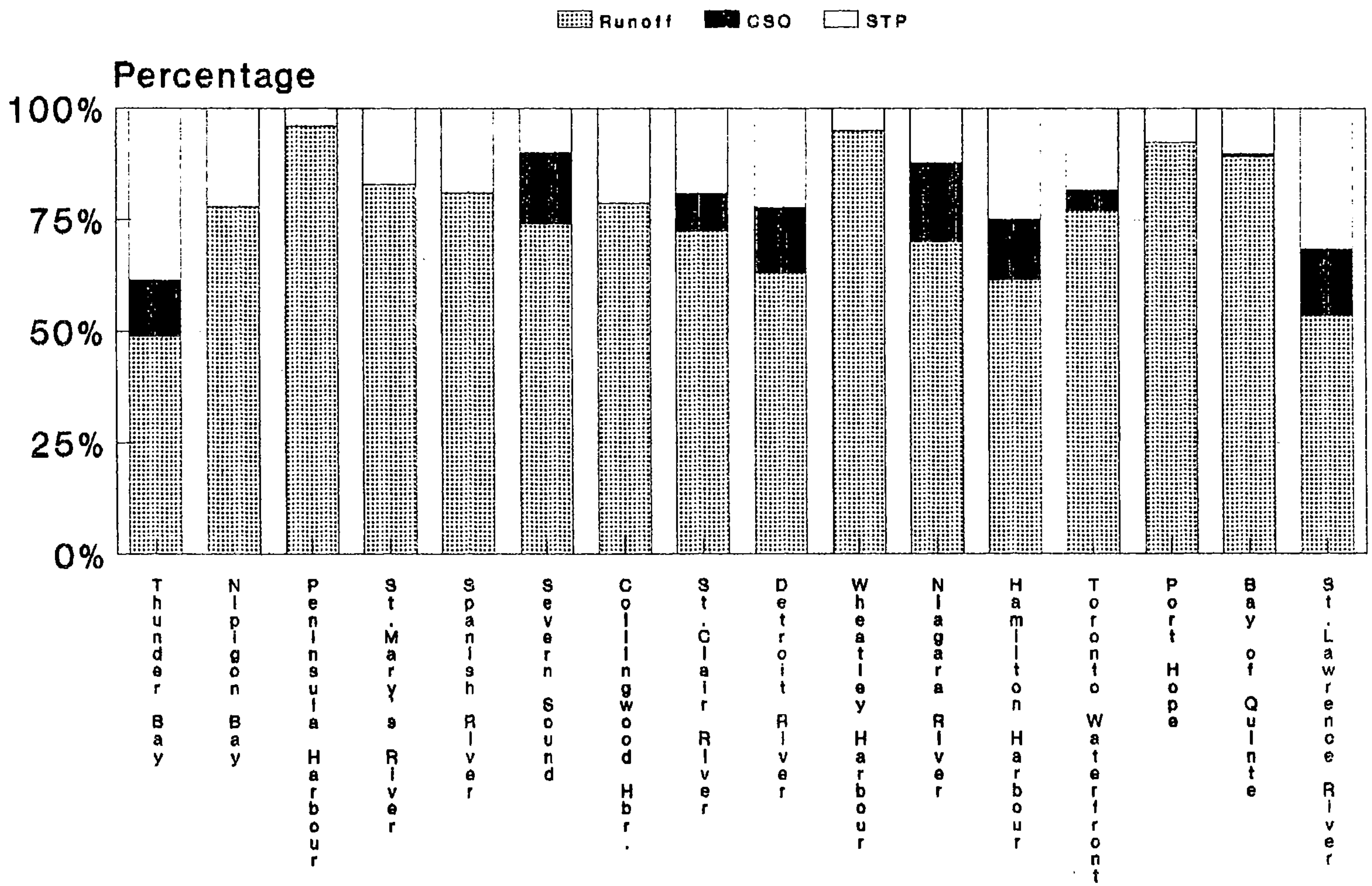
Similarily, the distribution of solids discharged during wet weather conditions from each source is

- o surface runoff accounts for 77 to 100%
- o STPs contribute 1.4%
- o CSOs contribute 5 to 23%.

# Fig. 4.01A Distribution of annual flow volumes



# Fig. 4.01B Distribution of annual suspended solids loadings



# Fig. 4.02A Distribution of annual flow volumes during wet weather

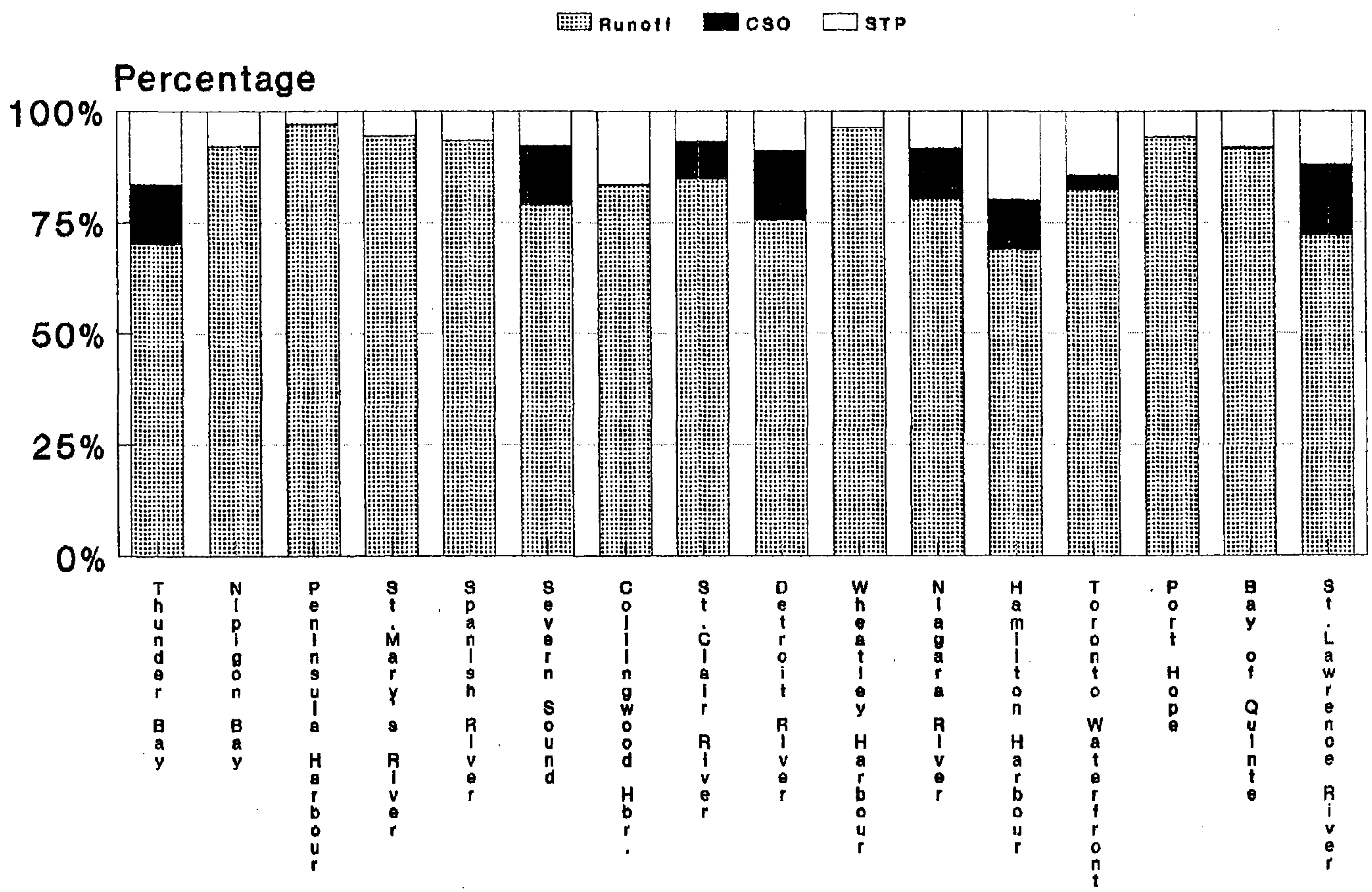
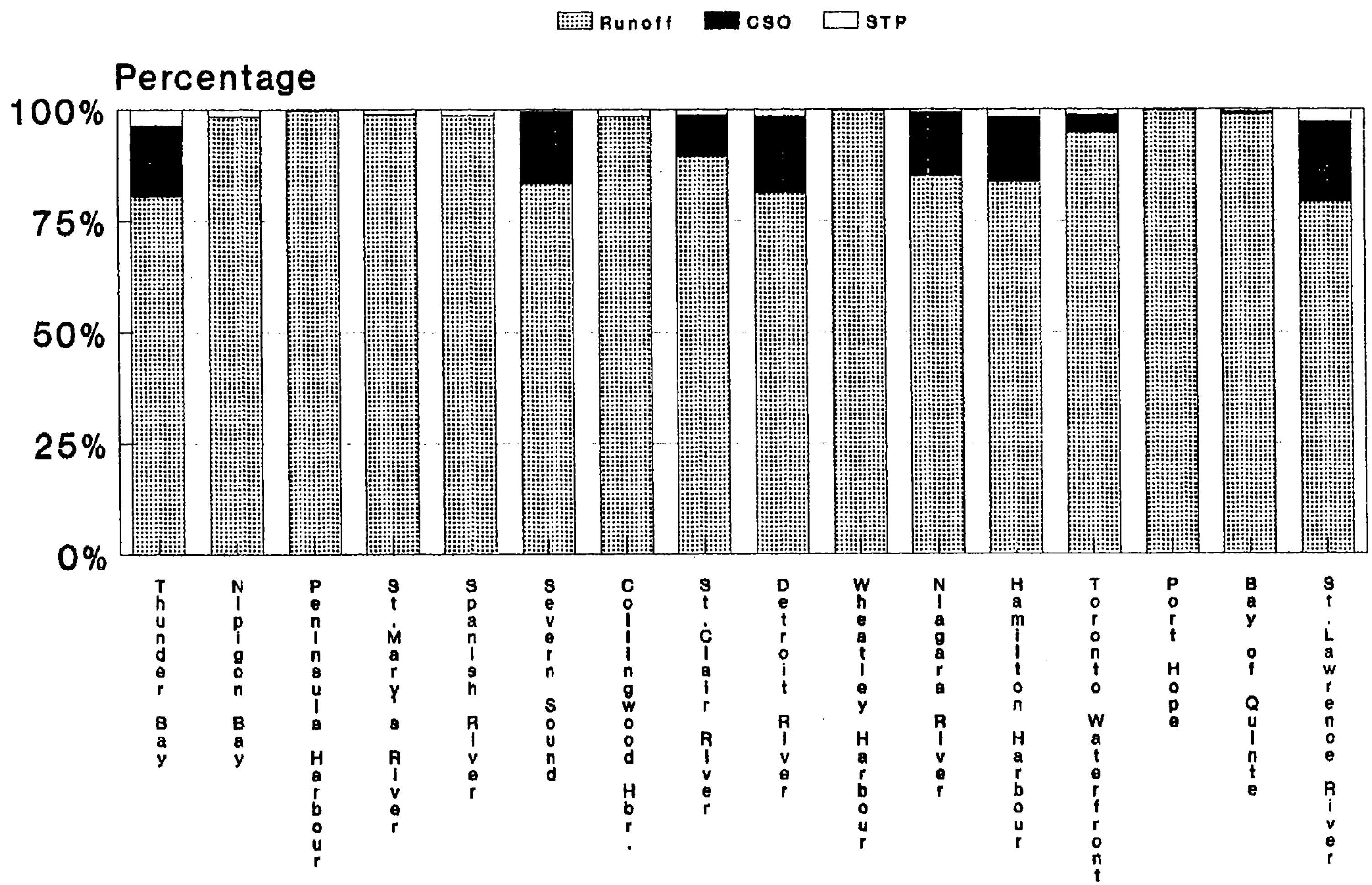


Fig. 4.02B Distribution of annual solids loadings during wet weather



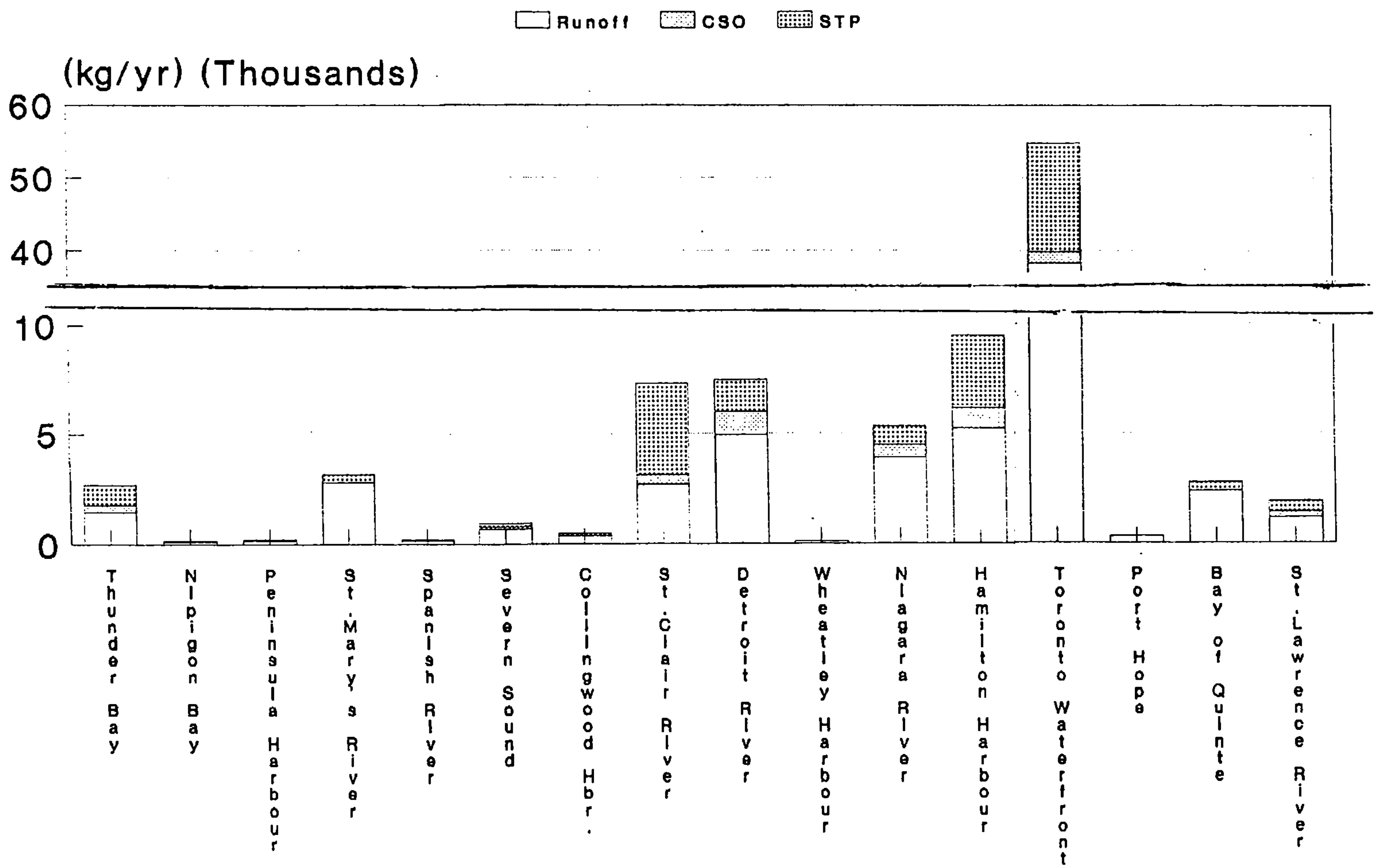
### 4.1.2 Toxic contaminant loadings

A comparison of the relative magnitudes of loadings from each RAP area for selected contaminants is presented in Figs. 4.03A to 4.03D. These four contaminants represent the highest two mass loadings among the metals and pesticides groups, respectively (zinc, lead, alpha-BHC and total PCBs). The loadings for the other 22 contaminants are presented in Schroeter and Associates (1992).

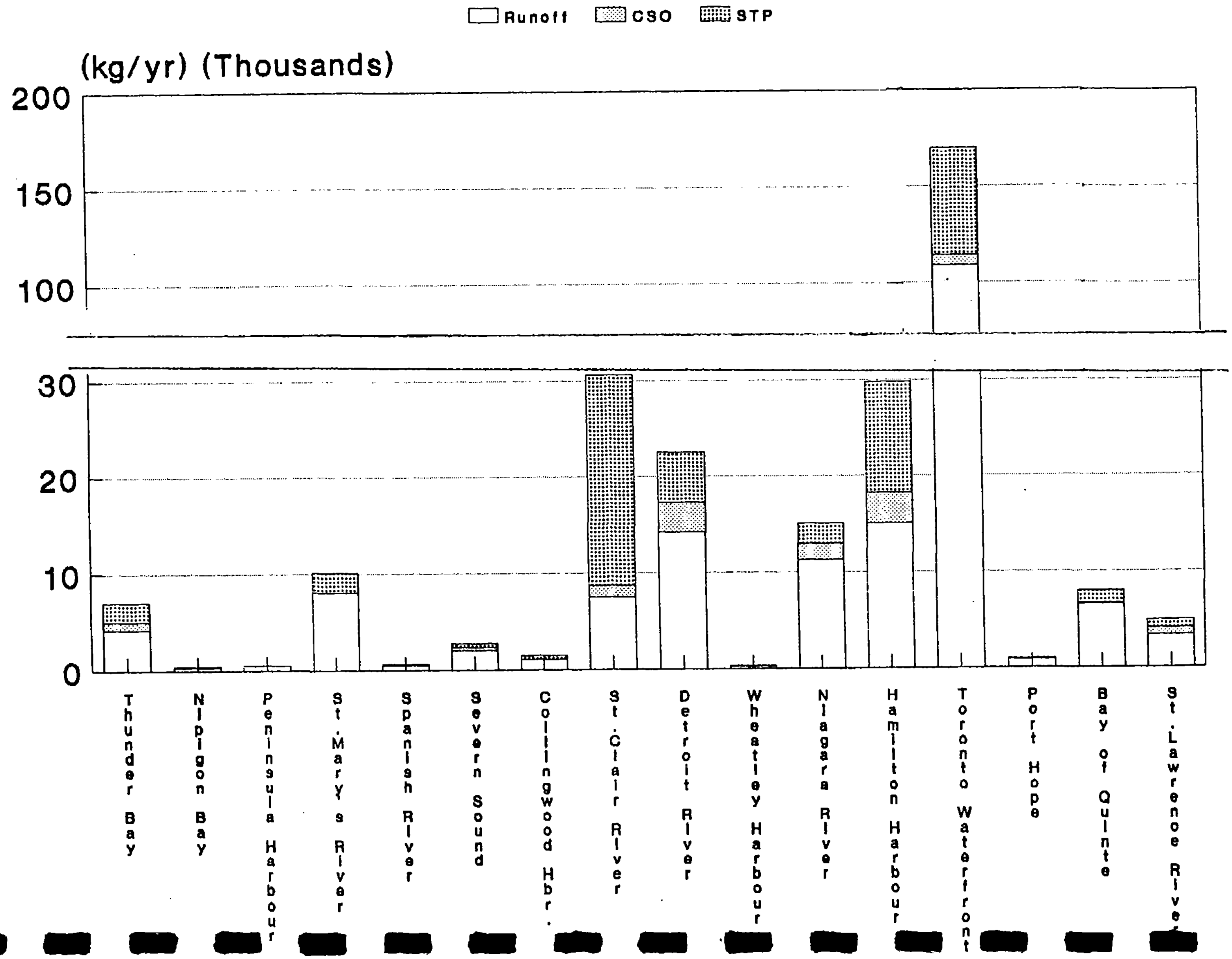
In terms of annual total loads, the computed values for the Toronto RAP were the highest for all loading sources, followed by Hamilton Harbour (usually about a third of the Toronto loads), and the four connecting channel RAPs, Detroit, Niagara, St. Clair and St. Mary's rivers. This pattern of relative loading magnitudes among RAPs was consistent for most contaminants. Generally, the highest loadings of any one source for all toxic contaminants considered were usually the sewage treatment plant effluents, whereas the lowest values were for the CSOs. This distribution of contaminant loadings follows closely the pattern set by the flow volumes (Table 4.01) and solids discharges (Table 4.02), i.e. contaminant mass loadings directly related to these two factors.

The estimates are considered planning level, suitable for comparing relative loading contributions from the various sources. The main sources of uncertainty in the loading estimates were previously identified and discussed include: precision and accuracy of analysis of water and sediment of samples, representativeness of samples collected, annual precipitation, annual runoff coefficients, land use area estimates, mean solids concentrations, average sewage flow, combined sewer contributing area estimates, the CSO mixing or weighting factors, and the combined sewer pipe length and slope.

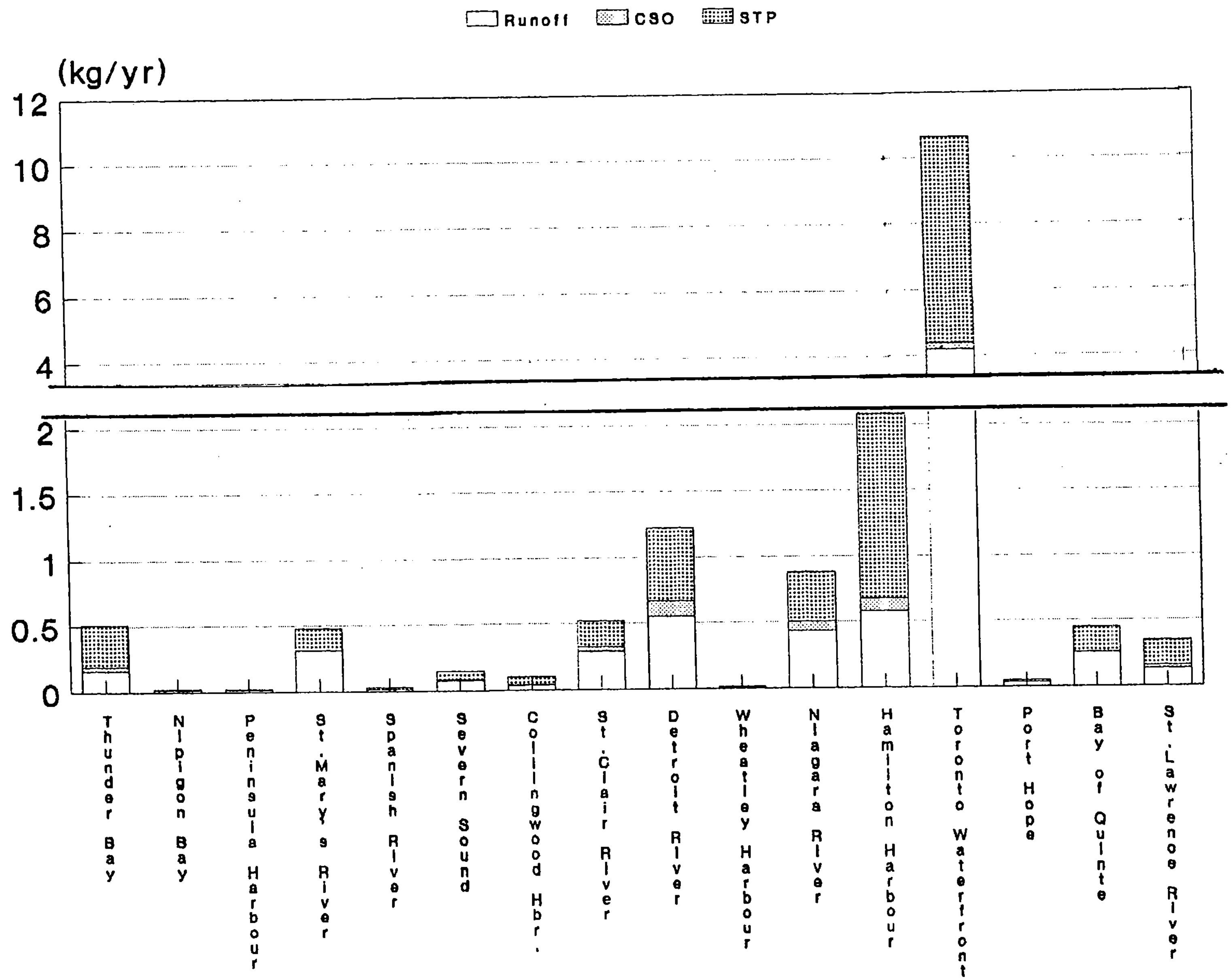
# Fig. 4.03A Comparison of loads for Lead from each RAP area



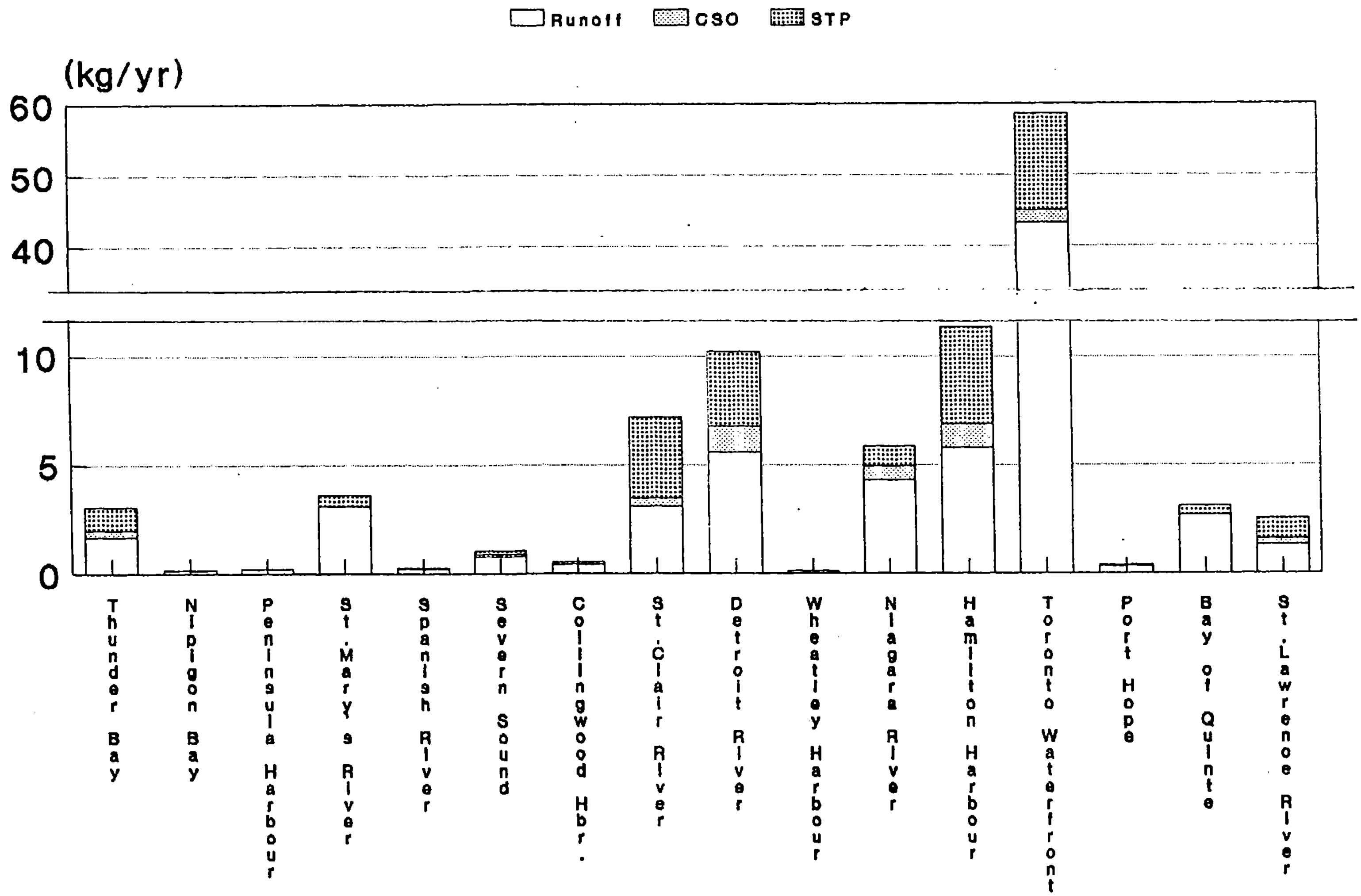
# Fig. 4.03B Comparison of loads for Zinc from each RAP area



# Fig. 4.03C Comparison of loads for alpha-BHC from each RAP area



# Fig. 4.03D Comparison of loads for Total PCBs from each RAP area



An analysis was conducted to determine the sensitivity of the computed loads in response to changes in input variables, coefficients or calculation procedure parameters. The degree of variability in the estimated loads as a result of varying the magnitude of input variables demonstrates the sensitivity of the estimate to that particular variable. With this knowledge, the data collection effort can focus on the most sensitive items. The sensitivity analysis revealed that the loading estimates are sensitive to: annual precipitation (for runoff and CSO), sewage flows (for STP effluents), contaminant concentrations, CSO serviced area and weighting factors (for CSOs only). The remaining data items (e.g. land use area, runoff coefficients, suspended solids concentrations, CSO pipe length and slope) presented secondary influences on the loading estimates.

## 4.2 THUNDER BAY

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.3 for Thunder Bay, the only urban centre considered in the area. Fig. 4.4 illustrates how these flow volumes and solids discharges are distributed among each loading source.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are given in Table 4.4. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.5, and in Fig. 4.6 for the organic compounds.

Table 4.03A Annual Flow Volumes (1000s m^3), Thunder Bay

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| THUNDER BAY | 8040 | 1720 | 31200 | 41000 |
| Totals | 8040 | 1720 | 31200 | 41000 |

Table 4.03B Annual Solids Discharge (Tonnes), Thunder Bay

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| THUNDER BAY | 1570 | 401 | 1250 | 3220 |
| Totals | 1570 | 401 | 1250 | 3220 |

Table 4.04 Annual Contaminant Loads (kg ), Thunder Bay

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 26.6 | 9.07 | 536 | 571 |
| Chromium | 225 | 55.1 | 543 | 823 |
| Cobalt | 39.0 | 11.0 | 353 | 403 |
| Copper | 258 | 86.7 | 1400 | 1740 |
| Mercury | .590 | .300 | 5.70 | 6.59 |
| Nickel | 207 | 48.1 | 298 | 553 |
| Lead | 1460 | 299 | 888 | 2650 |
| Selenium | 13.4 | 6.71 | 627 | 647 |
| Zinc | 4170 | 818 | 2010 | 7000 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0250 | .0074 | .330 | .360 |
| Alpha-BHC | .160 | .0320 | .320 | .510 |
| Alpha-Endosulfan (I) | .0110 | .0044 | .320 | .330 |
| Beta-Endosulfan (II) | .0064 | .0035 | .320 | .330 |
| Dieldrin | .0110 | .0044 | .320 | .340 |
| Endrin | .0120 | .0045 | .320 | .330 |
| Gamma-BHC (Lindane) | .0580 | .0150 | .630 | .700 |
| Gamma Chlordane | .0390 | .0098 | .320 | .370 |
| Heptachlor Epoxide | .0130 | .0047 | .160 | .180 |
| Hexachlorobenzene | .120 | .0260 | .160 | .310 |
| Methoxychlor (DMDT) | .0210 | .0220 | 1.30 | 1.34 |
| pp DDE | .0170 | .0056 | .320 | .340 |
| pp DDT | .0076 | .0100 | .650 | .660 |
| Total PCB | 1.66 | .330 | 1.06 | 3.04 |
| 1-2 Dichlorobenzene | .500 | 4.19 | 31.3 | 35.9 |
| 1-3 Dichlorobenzene | .1000 | 4.13 | 31.7 | 36.0 |
| 1-4 Dichlorobenzene | .130 | 4.14 | 31.9 | 36.1 |

# Fig. 4.04 Distribution of flow & solids from each source, Thunder Bay

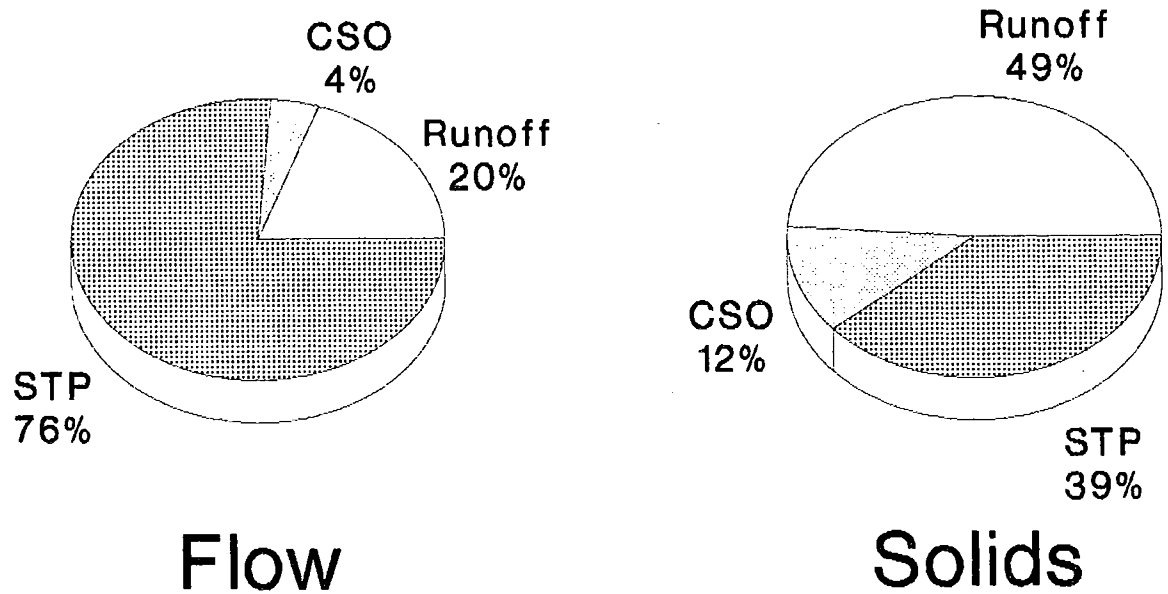
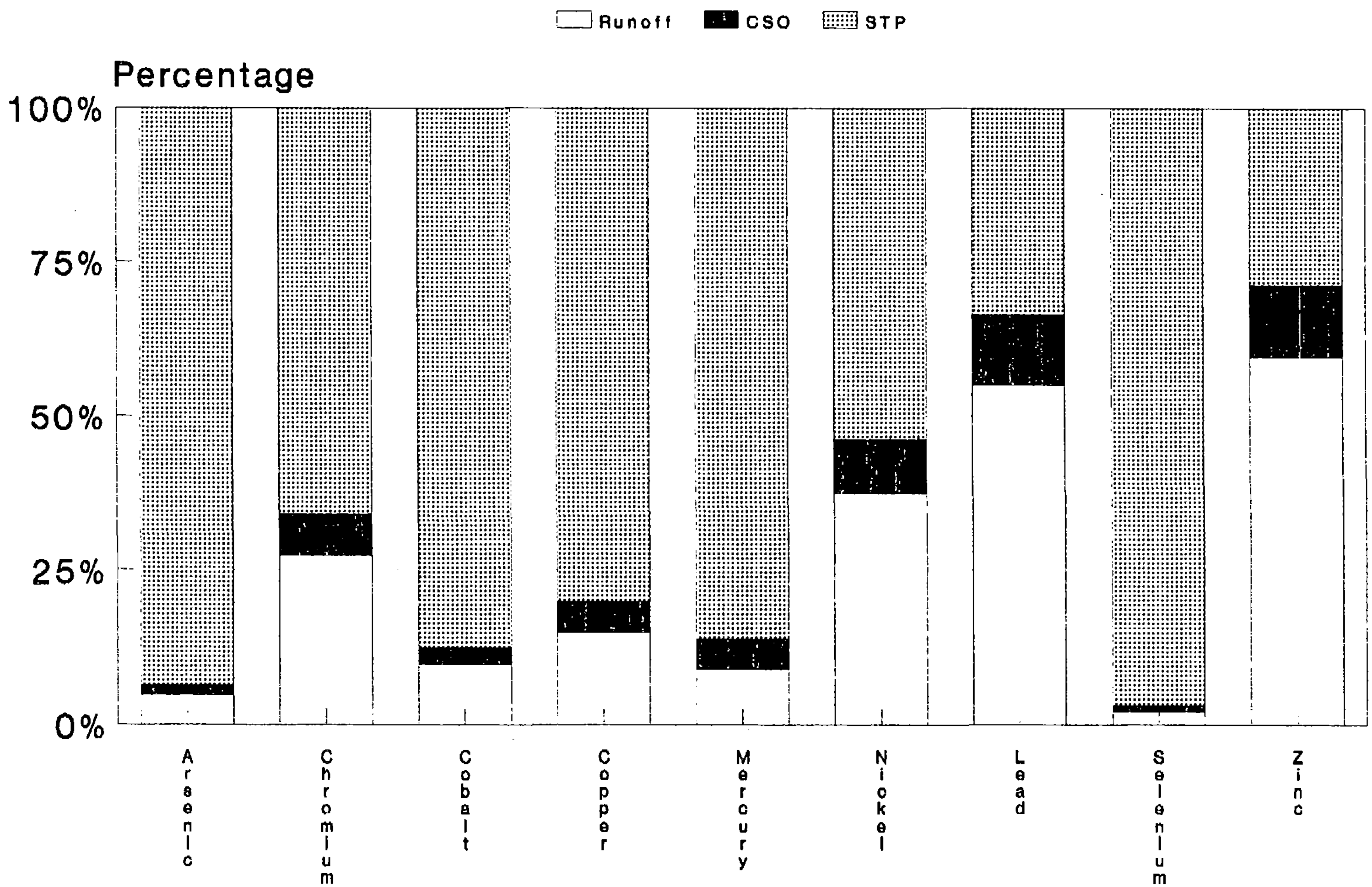
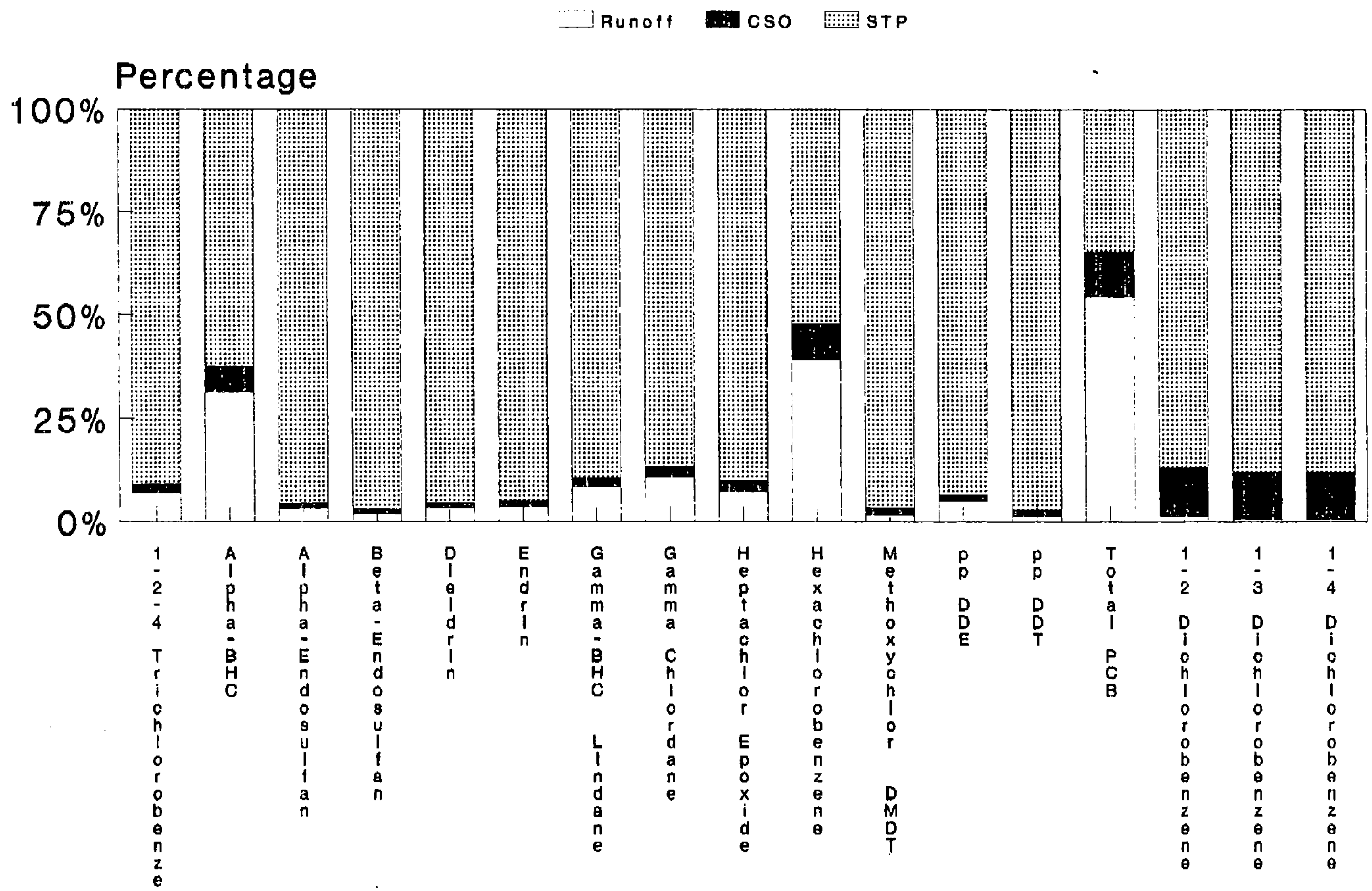


Fig. 4.05 Distribution of loads for
Thunder Bay Heavy Metals



# Fig. 4.06 Distribution of loads for Thunder Bay Organics



## 4.3 NIPIGON BAY

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.5 for each urban centre considered in the area (there are two, Nipigon and Red Rock). Fig. 4.7 illustrates how these flow volumes and solids discharges are distributed among each loading source.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are given in Table 4.6. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.8, and in Fig. 4.9 for the organic compounds.

Table 4.05A Annual Flow Volumes (1000s m^3), Nipigon Bay

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| NIPIGON | 404 | 0 | 599 | 1000 |
| RED ROCK | 237 | 0 | 303 | 541 |
| Totals | 642 | 0 | 902 | 1540 |

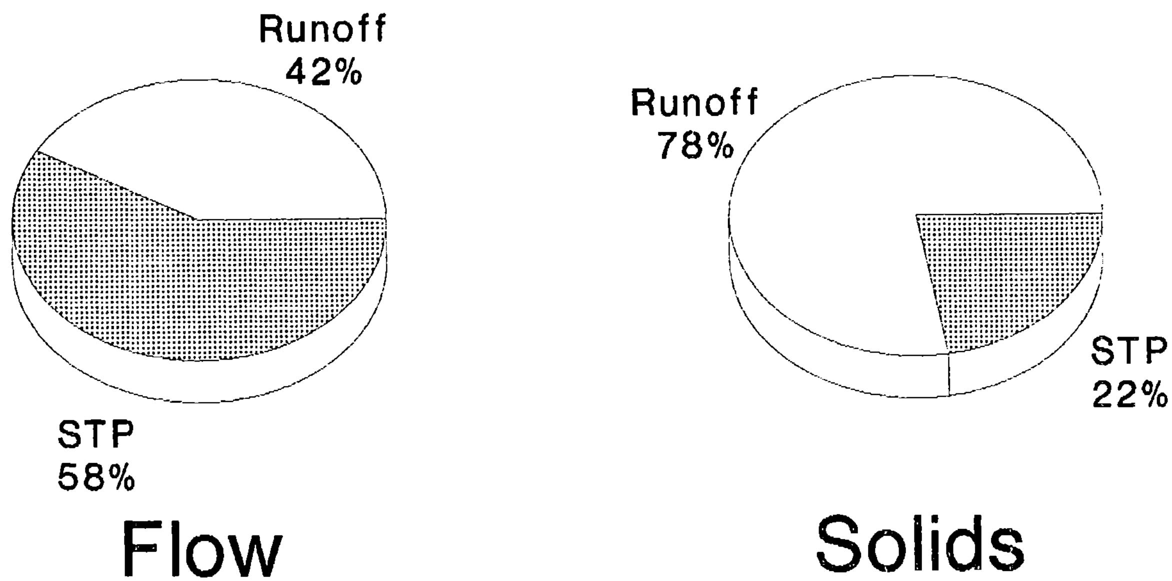
Table 4.05B Annual Solids Discharge (Tonnes), Nipigon Bay

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| NIPIGON | 79 | 0 | 24 | 103 |
| RED ROCK | 46 | 0 | 12 | 59 |
| Totals | 125 | 0 | 36 | 161 |

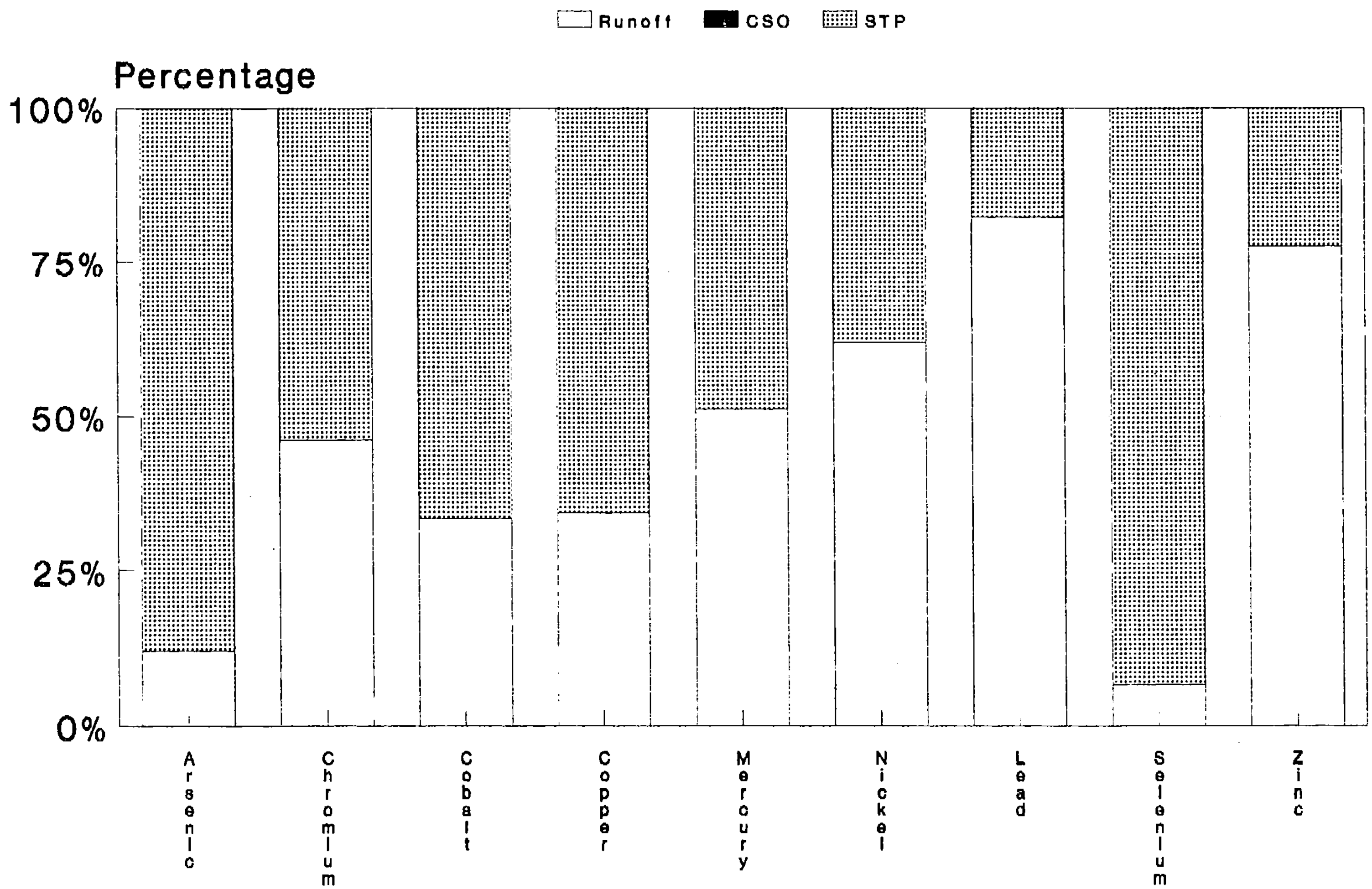
Table 4.06 Annual Contaminant Loads (kg ), Nipigon Bay

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 2.12 | 0 | 15.3 | 17.4 |
| Chromium | 17.9 | 0 | 20.9 | 38.8 |
| Cobalt | 3.11 | 0 | 6.20 | 9.31 |
| Copper | 20.6 | 0 | 39.4 | 60.0 |
| Mercury | .0470 | 0 | .0450 | .0920 |
| Nickel | 16.5 | 0 | 10.1 | 26.6 |
| Lead | 117 | 0 | 25.3 | 142 |
| Selenium | 1.07 | 0 | 15.0 | 16.1 |
| Zinc | 332 | 0 | 96.4 | 429 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0020 | 0 | .0094 | .0110 |
| Alpha-BHC | .0130 | 0 | .0092 | .0220 |
| Alpha-Endosulfan (I) | .0009 | 0 | .0092 | .0100 |
| Beta-Endosulfan (II) | .0005 | 0 | .0092 | .0097 |
| Dieldrin | .0009 | 0 | .0093 | .0100 |
| Endrin | .0010 | 0 | .0092 | .0100 |
| Gamma-BHC (Lindane) | .0046 | 0 | .0180 | .0230 |
| Gamma Chlordane | .0031 | 0 | .0092 | .0120 |
| Heptachlor Epoxide | .0010 | 0 | .0047 | .0057 |
| Hexachlorobenzene | .0099 | 0 | .0047 | .0150 |
| Methoxychlor (DMDT) | .0017 | 0 | .0380 | .0390 |
| pp DDE | .0014 | 0 | .0093 | .0110 |
| pp DDT | .0006 | 0 | .0190 | .0190 |
| Total PCB | .130 | 0 | .0300 | .160 |
| 1-2 Dichlorobenzene | .0400 | 0 | .900 | .940 |
| 1-3 Dichlorobenzene | .0081 | 0 | .920 | .930 |
| 1-4 Dichlorobenzene | .0110 | 0 | .920 | .930 |

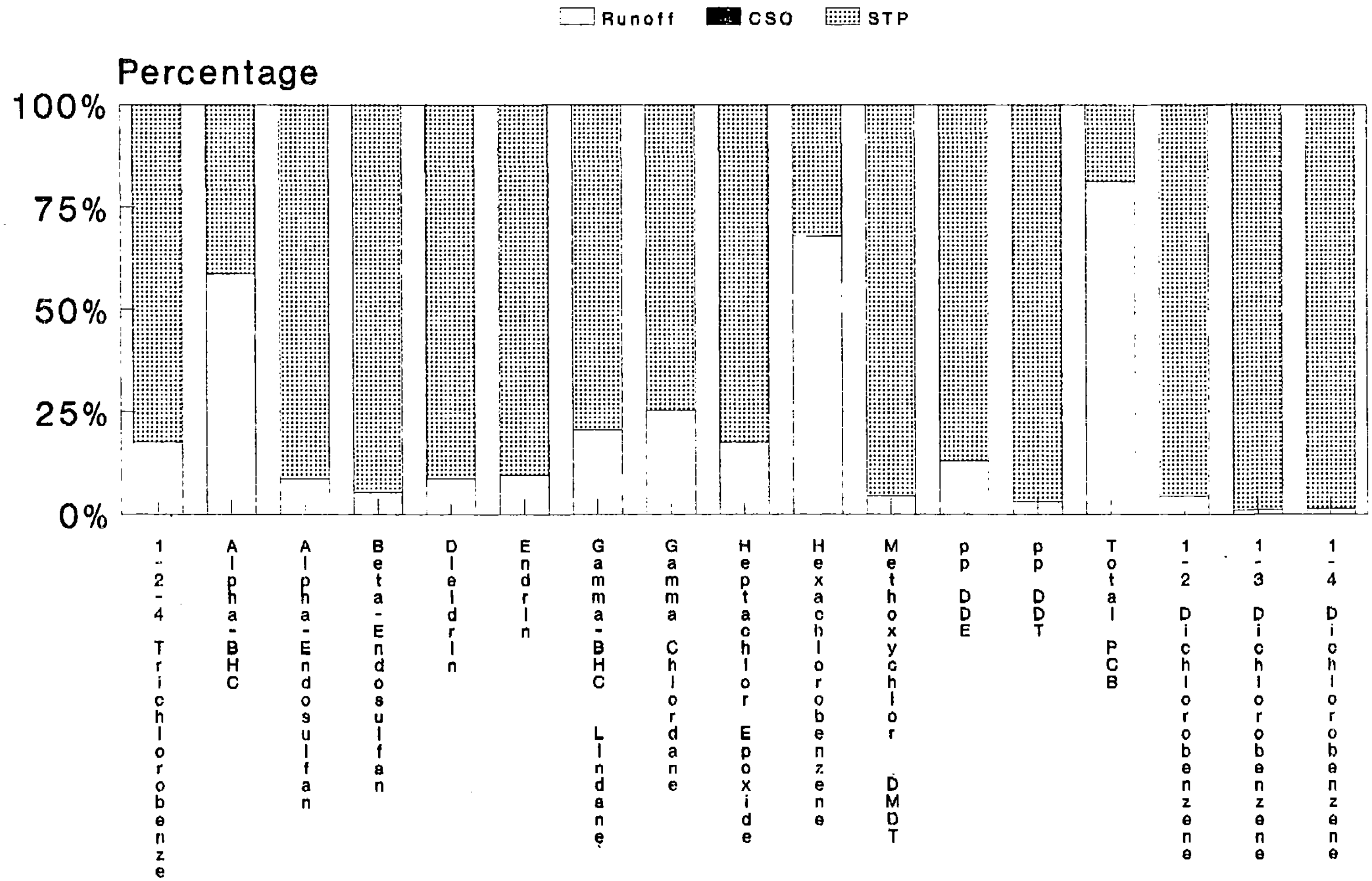
# Fig. 4.07 Distribution of flow & solids from each source, Nipigon Bay



# Fig. 4.08 Distribution of loads for Nipigon Bay Heavy Metals



# Fig. 4.09 Distribution of loads for Nipigon Bay Organics



## 4.4 PENINSULA HARBOUR

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.7 for Marathon, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.10.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.8. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.11, and in Fig. 4.12 for the organic compounds.

Table 4.07A Annual Flow Volumes (1000s m^3), Peninsula Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| MARATHON | 900 | 0 | 478 | 1380 |
| Totals | 900 | 0 | 478 | 1380 |

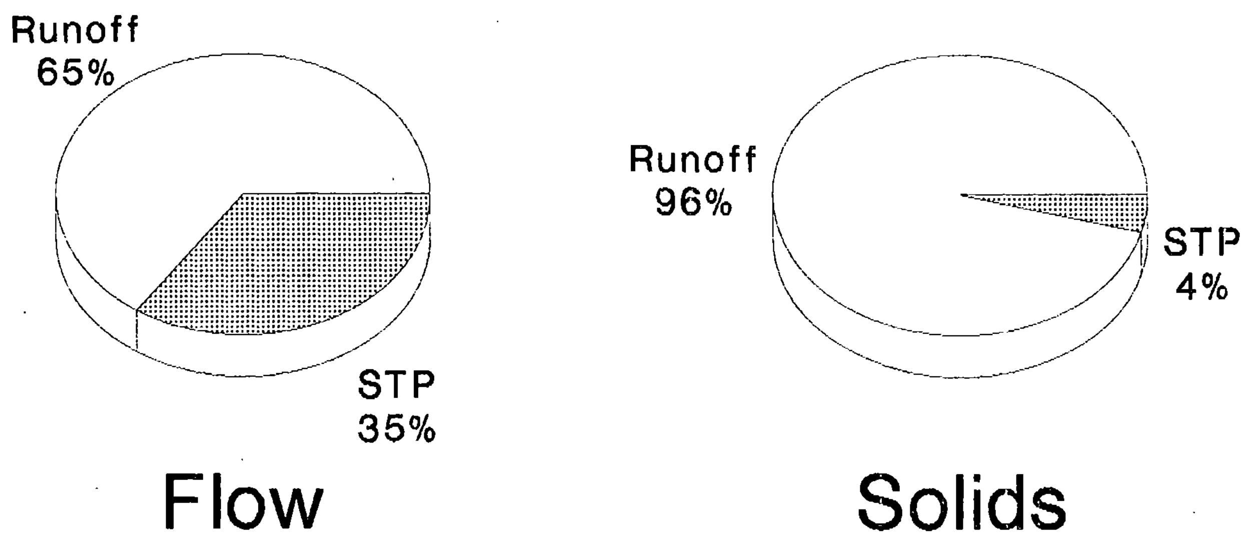
Table 4.07B Annual Solids Discharge (Tonnes), Peninsula Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| MARATHON | 176 | 0 | 8 | 184 |
| Totals | 176 | 0 | 8 | 184 |

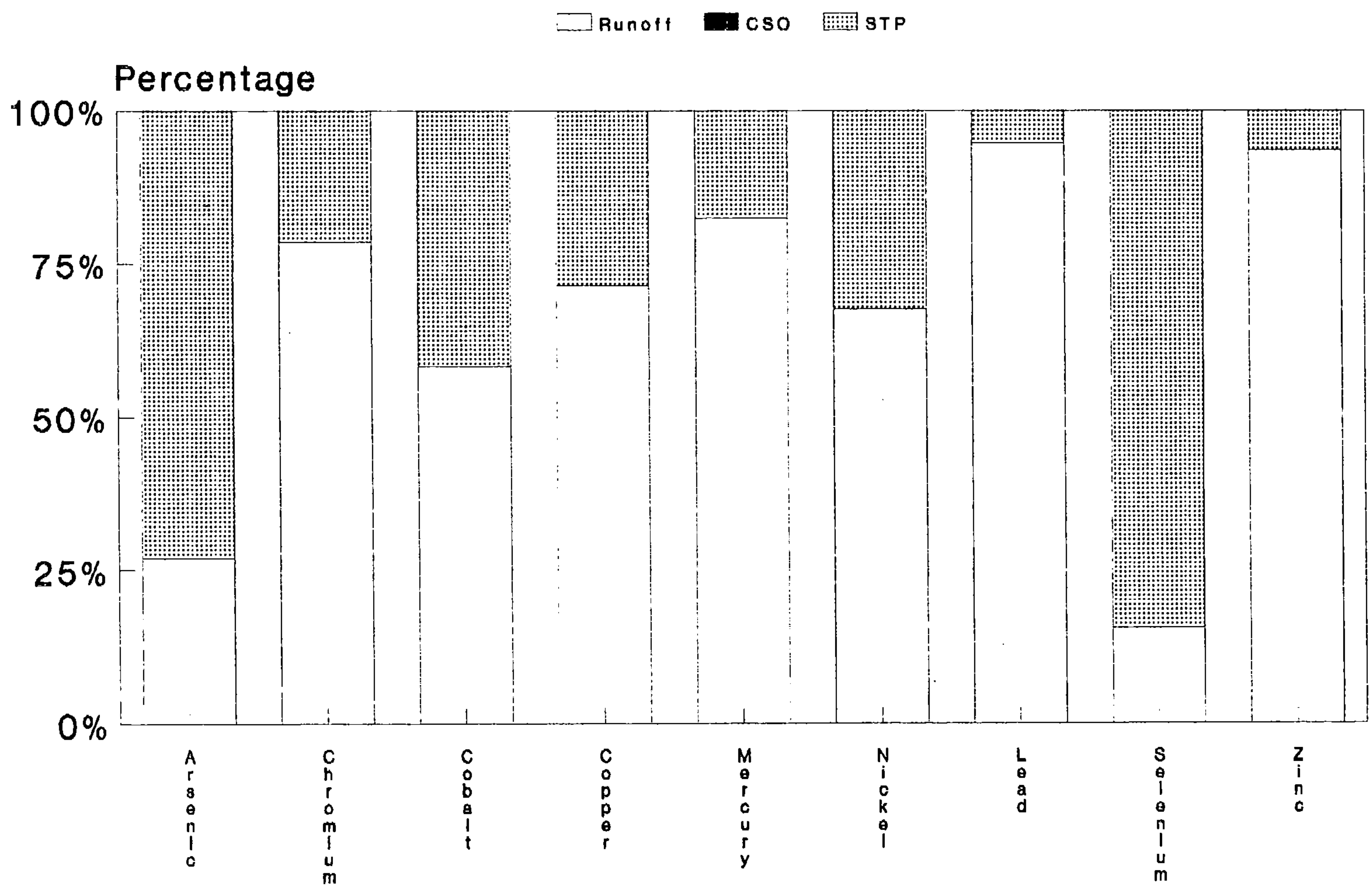
Table 4.08 Annual Contaminant Loads (kg ), Peninsula Harbour

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 2.97 | 0 | 8.03 | 11.0 |
| Chromium | 25.1 | 0 | 6.79 | 31.9 |
| Cobalt | 4.37 | 0 | 3.13 | 7.50 |
| Copper | 28.9 | 0 | 11.6 | 40.5 |
| Mercury | .0660 | 0 | .0140 | .0800 |
| Nickel | 23.2 | 0 | 11.1 | 34.3 |
| Lead | 164 | 0 | 9.36 | 173 |
| Selenium | 1.50 | 0 | 8.20 | 9.70 |
| Zinc | 467 | 0 | 32.9 | 500 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0028 | 0 | .0049 | .0077 |
| Alpha-BHC | .0180 | 0 | .0048 | .0230 |
| Alpha-Endosulfan (I) | .0012 | 0 | .0048 | .0061 |
| Beta-Endosulfan (II) | .0007 | 0 | .0048 | .0055 |
| Dieldrin | .0012 | 0 | .0048 | .0061 |
| Endrin | .0014 | 0 | .0048 | .0062 |
| Gamma-BHC (Lindane) | .0065 | 0 | .0096 | .0160 |
| Gamma Chlordane | .0044 | 0 | .0048 | .0092 |
| Heptachlor Epoxide | .0015 | 0 | .0024 | .0039 |
| Hexachlorobenzene | .0140 | 0 | .0024 | .0160 |
| Methoxychlor (DMDT) | .0024 | 0 | .0190 | .0220 |
| pp DDE | .0019 | 0 | .0049 | .0068 |
| pp DDT | .0008 | 0 | .0097 | .0110 |
| Total PCB | .190 | 0 | .0100 | .200 |
| 1-2 Dichlorobenzene | .0560 | 0 | .480 | .530 |
| 1-3 Dichlorobenzene | .0110 | 0 | .480 | .490 |
| 1-4 Dichlorobenzene | .0150 | 0 | .480 | .500 |

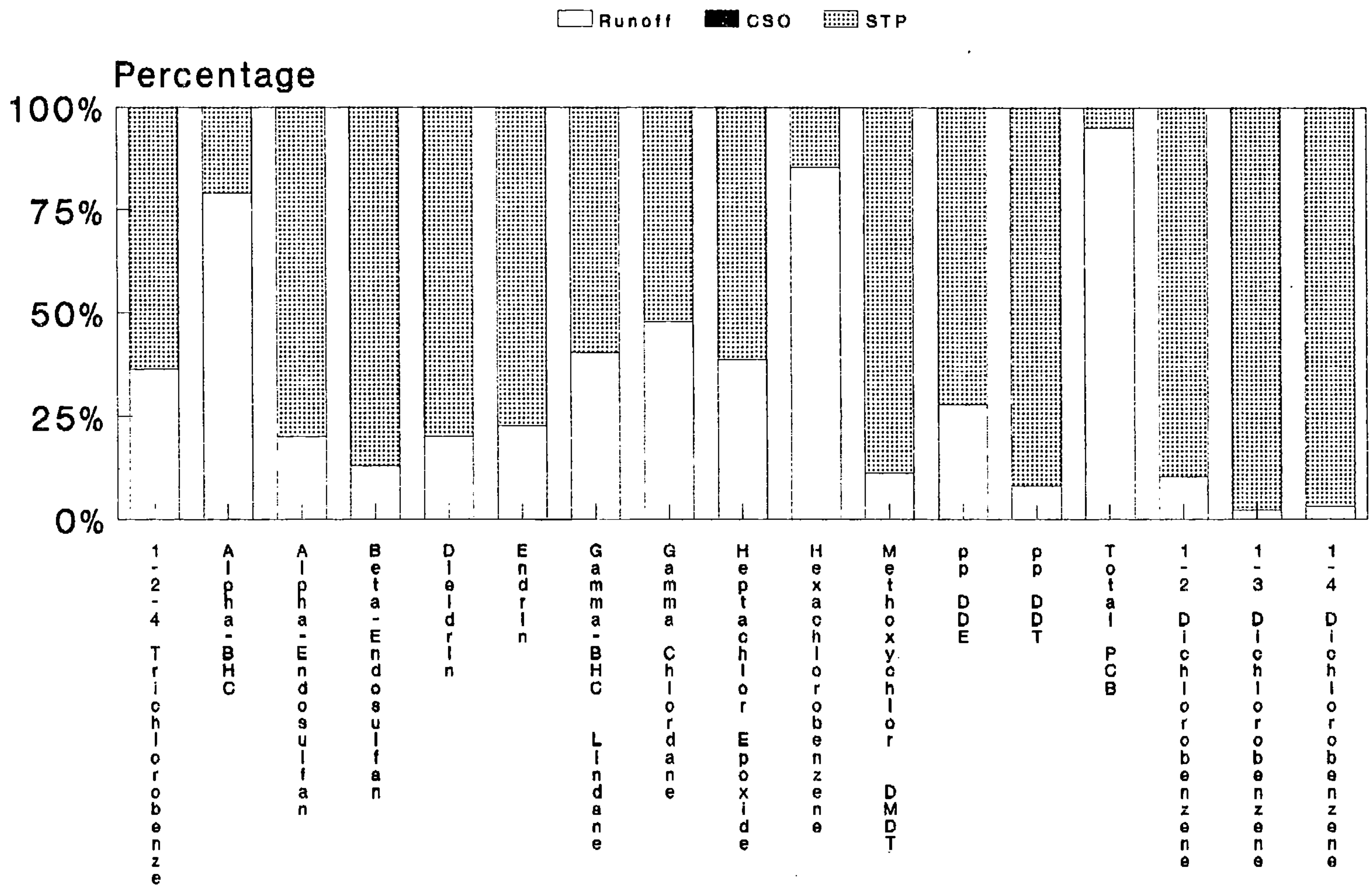
Fig. 4.10 Distribution of flow & solids from each source, Peninsula Harbour



## Fig. 4.11 Distribution of loads for Peninsula Harbour Heavy Metals



# Fig. 4.12 Distribution of loads for Peninsula Harbour Organics



## 4.5 ST. MARY'S RIVER

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.9 for Sault Ste. Marie, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.13.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.10. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.14, and in Fig. 4.15 for the organic compounds.

Table 4.09A Annual Flow Volumes (1000s m^3), St.Mary's River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| SAULT ST. MARIE | 15600 | 0 | 15300 | 30900 |
| Totals | 15600 | 0 | 15300 | 30900 |

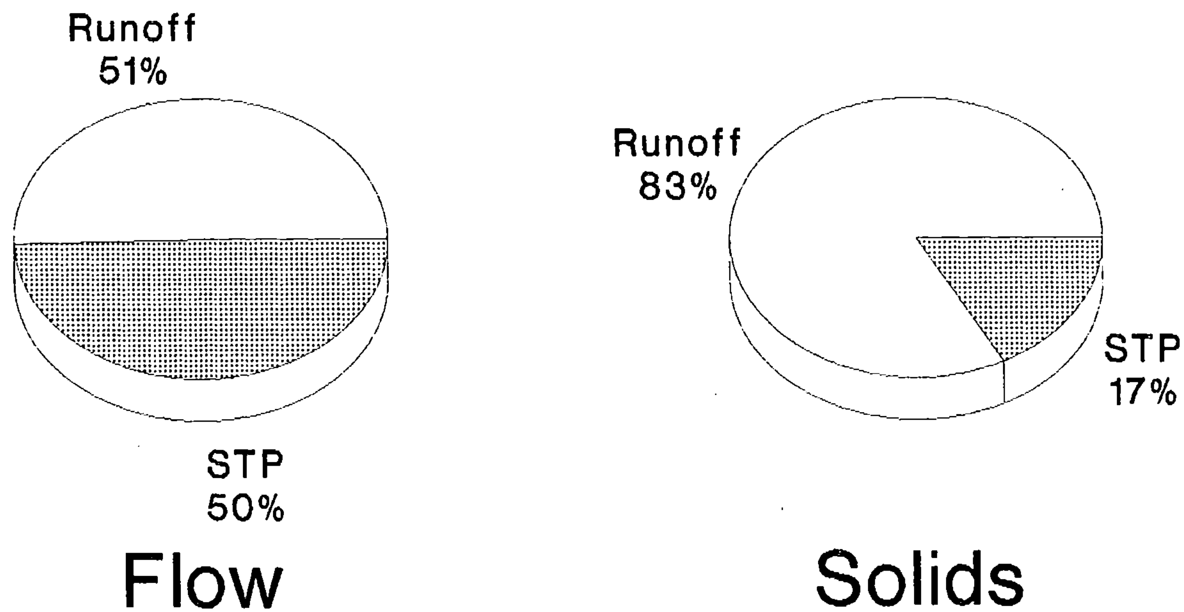
Table 4.09B Annual Solids Discharge (Tonnes), St.Mary's River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| SAULT ST. MARIE | 2930 | 0 | 612 | 3540 |
| Totals | 2930 | 0 | 612 | 3540 |

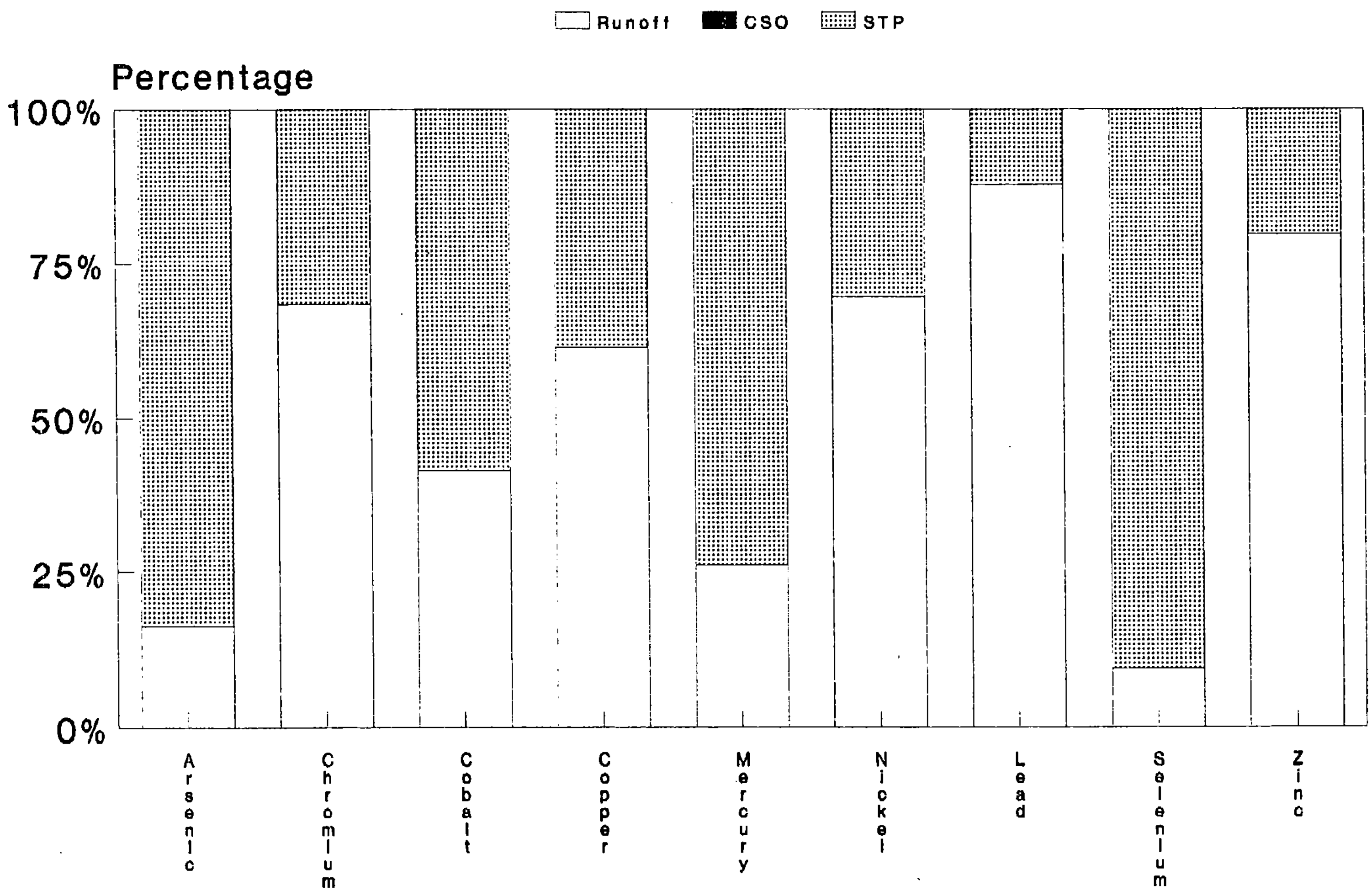
Table 4.10 Annual Contaminant Loads (kg ), St.Mary's River

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 50.6 | 0 | 258 | 308 |
| Chromium | 422 | 0 | 195 | 618 |
| Cobalt | 74.4 | 0 | 105 | 180 |
| Copper | 493 | 0 | 310 | 803 |
| Mercury | 1.11 | 0 | 3.15 | 4.26 |
| Nickel | 396 | 0 | 173 | 569 |
| Lead | 2780 | 0 | 386 | 3170 |
| Selenium | 25.9 | 0 | 254 | 280 |
| Zinc | 8040 | 0 | 2070 | 10100 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0480 | 0 | .170 | .220 |
| Alpha-BHC | .310 | 0 | .170 | .480 |
| Alpha-Endosulfan (I) | .0210 | 0 | .160 | .180 |
| Beta-Endosulfan (II) | .0120 | 0 | .160 | .170 |
| Dieldrin | .0210 | 0 | .160 | .180 |
| Endrin | .0230 | 0 | .160 | .180 |
| Gamma-BHC (Lindane) | .110 | 0 | .630 | .740 |
| Gamma Chlordane | .0740 | 0 | .160 | .230 |
| Heptachlor Epoxide | .0250 | 0 | .0800 | .1000 |
| Hexachlorobenzene | .230 | 0 | .0800 | .310 |
| Methoxychlor (DMDT) | .0410 | 0 | 3.85 | 3.89 |
| pp DDE | .0330 | 0 | .160 | .190 |
| pp DDT | .0140 | 0 | .360 | .370 |
| Total PCB | 3.09 | 0 | .540 | 3.63 |
| 1-2 Dichlorobenzene | .960 | 0 | 15.3 | 16.3 |
| 1-3 Dichlorobenzene | .190 | 0 | 15.6 | 15.7 |
| 1-4 Dichlorobenzene | .260 | 0 | 15.6 | 15.9 |

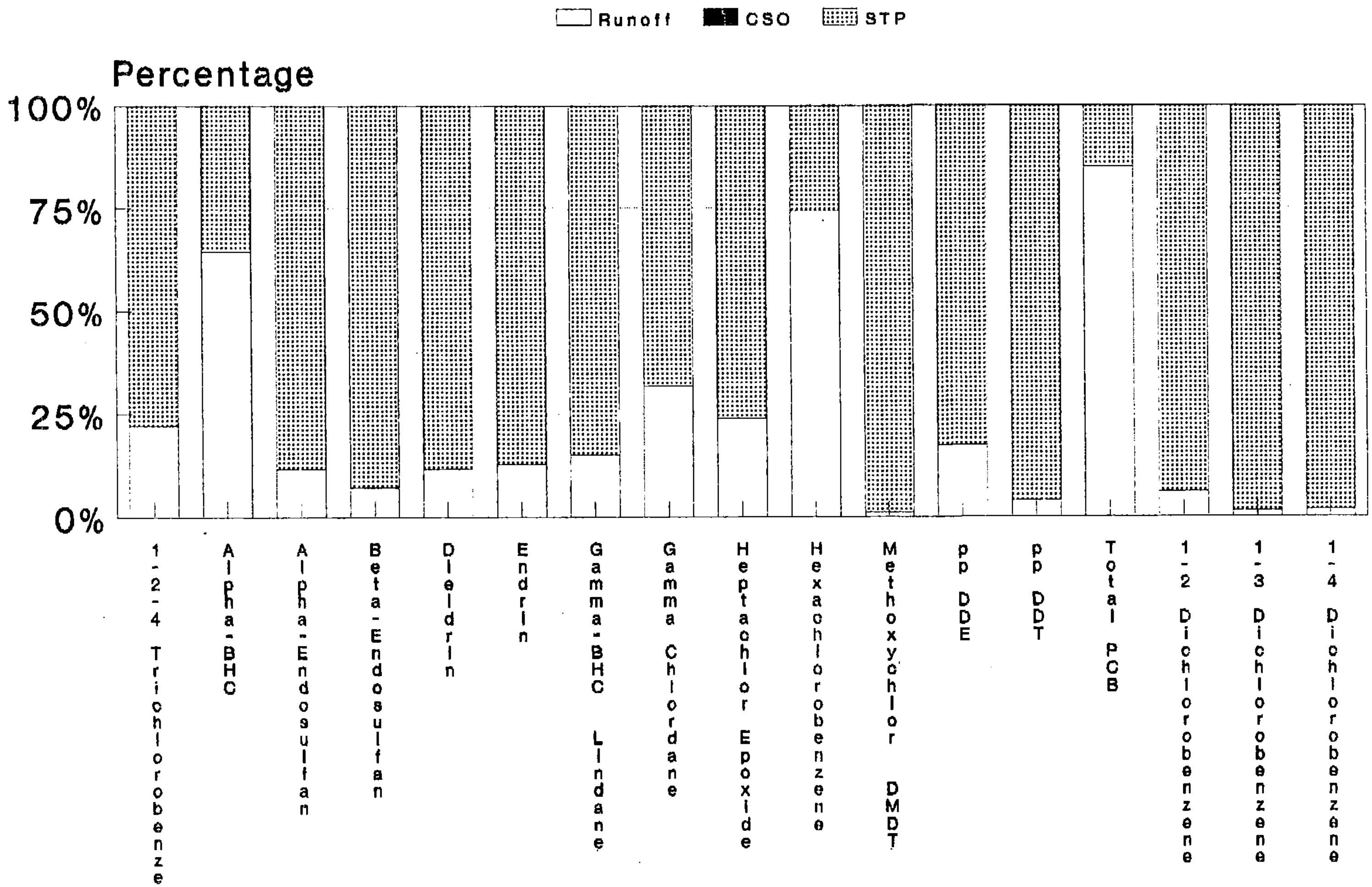
# Fig. 4.13 Distribution of flow & solids from each source, St.Mary's River



## Fig. 4.14 Distribution of loads for St.Mary's River Heavy Metals



# Fig. 4.15 Distribution of loads for St.Mary's River Organics



### 4.6 SPANISH RIVER

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.11 for Espanola, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.16.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.12. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.17, and in Fig. 4.18 for the organic compounds.

Table 4.11A Annual Flow Volumes (1000s m^3), Spanish River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| ESPANOLA | 924 | 0 | 1060 | 1990 |
| Totals | 924 | 0 | 1060 | 1990 |

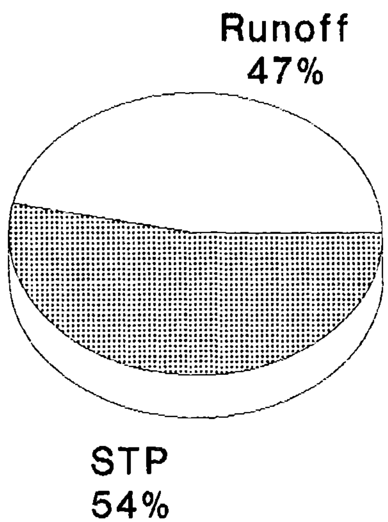
Table 4.11B Annual Solids Discharge (Tonnes), Spanish River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| ESPANOLA | 181 | 0 | 43 | 223 |
| Totals | 181 | 0 | 43 | 223 |

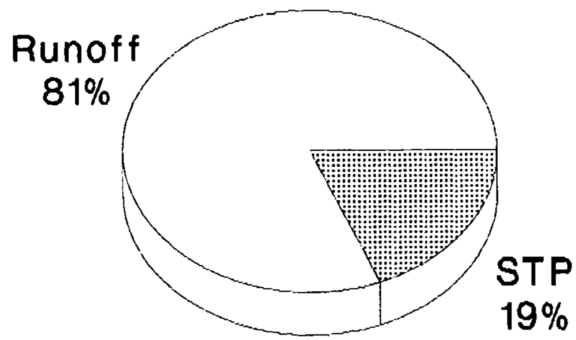
Table 4.12 Annual Contaminant Loads (kg ), Spanish River

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 3.05 | 0 | 18.0 | 21.1 |
| Chromium | 25.8 | 0 | 24.6 | 50.4 |
| Cobalt | 4.48 | 0 | 7.30 | 11.8 |
| Copper | 29.7 | 0 | 46.5 | 76.1 |
| Mercury | .0670 | 0 | .0530 | .120 |
| Nickel | 23.8 | 0 | 11.9 | 35.7 |
| Lead | 168 | 0 | 29.8 | 198 |
| Selenium | 1.54 | 0 | 17.7 | 19.2 |
| Zinc | 479 | 0 | 114 | 593 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0029 | 0 | .0110 | .0140 |
| Alpha-BHC | .0180 | 0 | .0110 | .0290 |
| Alpha-Endosulfan (I) | .0013 | 0 | .0110 | .0120 |
| Beta-Endosulfan (II) | .0007 | 0 | .0110 | .0120 |
| Dieldrin | .0013 | 0 | .0110 | .0120 |
| Endrin | .0014 | 0 | .0110 | .0120 |
| Gamma-BHC (Lindane) | .0066 | 0 | .0220 | .0280 |
| Gamma Chlordane | .0045 | 0 | .0110 | .0150 |
| Heptachlor Epoxide | .0015 | 0 | .0055 | .0070 |
| Hexachlorobenzene | .0140 | 0 | .0056 | .0200 |
| Methoxychlor (DMDT) | .0025 | 0 | .0440 | .0470 |
| pp DDE | .0020 | 0 | .0110 | .0130 |
| pp DDT | .0009 | 0 | .0220 | .0230 |
| Total PCB | .190 | 0 | .0360 | .230 |
| 1-2 Dichlorobenzene | .0580 | 0 | 1.06 | 1.12 |
| 1-3 Dichlorobenzene | .0120 | 0 | 1.08 | 1.10 |
| 1-4 Dichlorobenzene | .0150 | 0 | 1.09 | 1.10 |

## Fig. 4.16 Distribution of flow & solids from each source, Spanish River

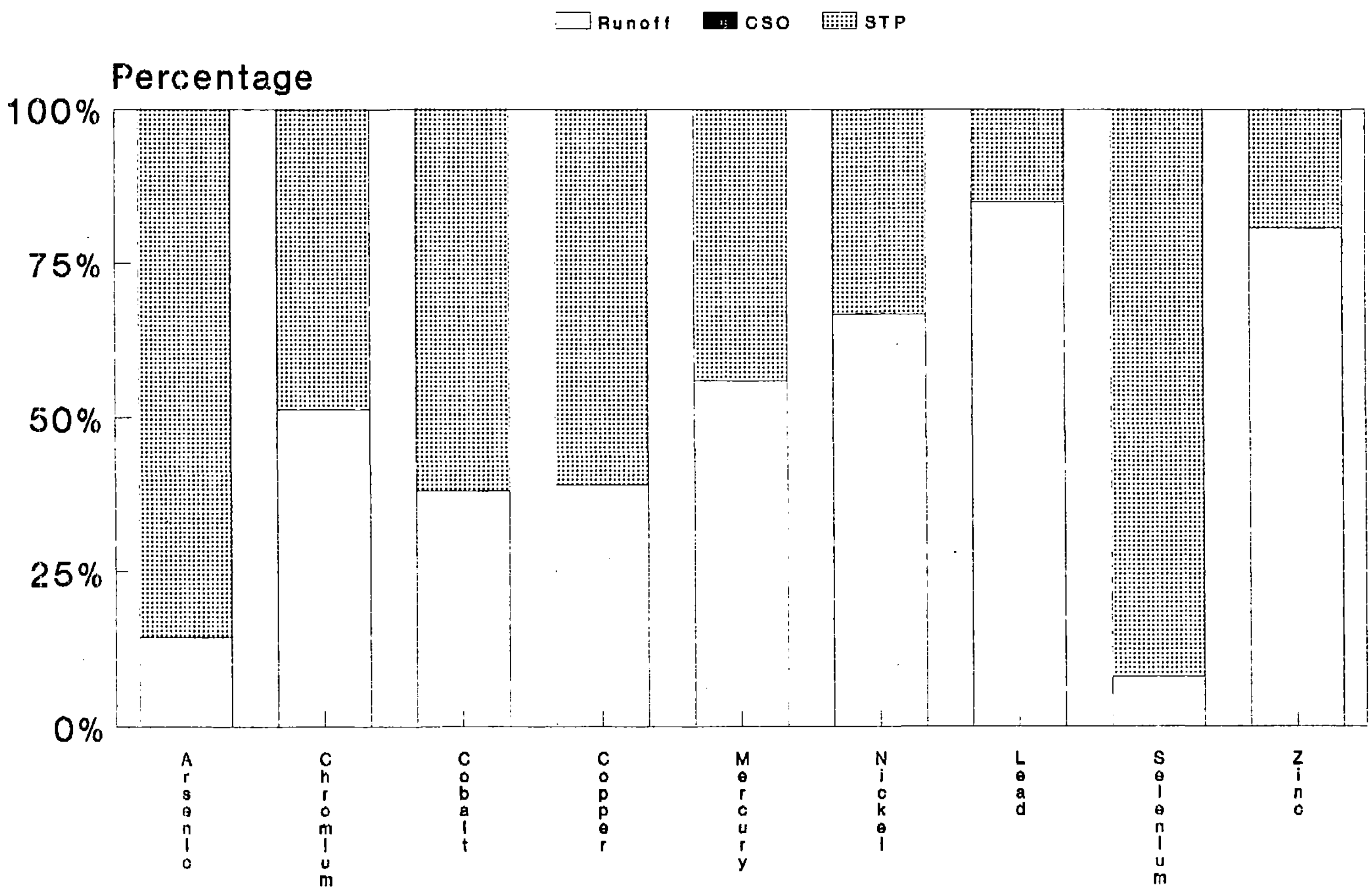



Flow

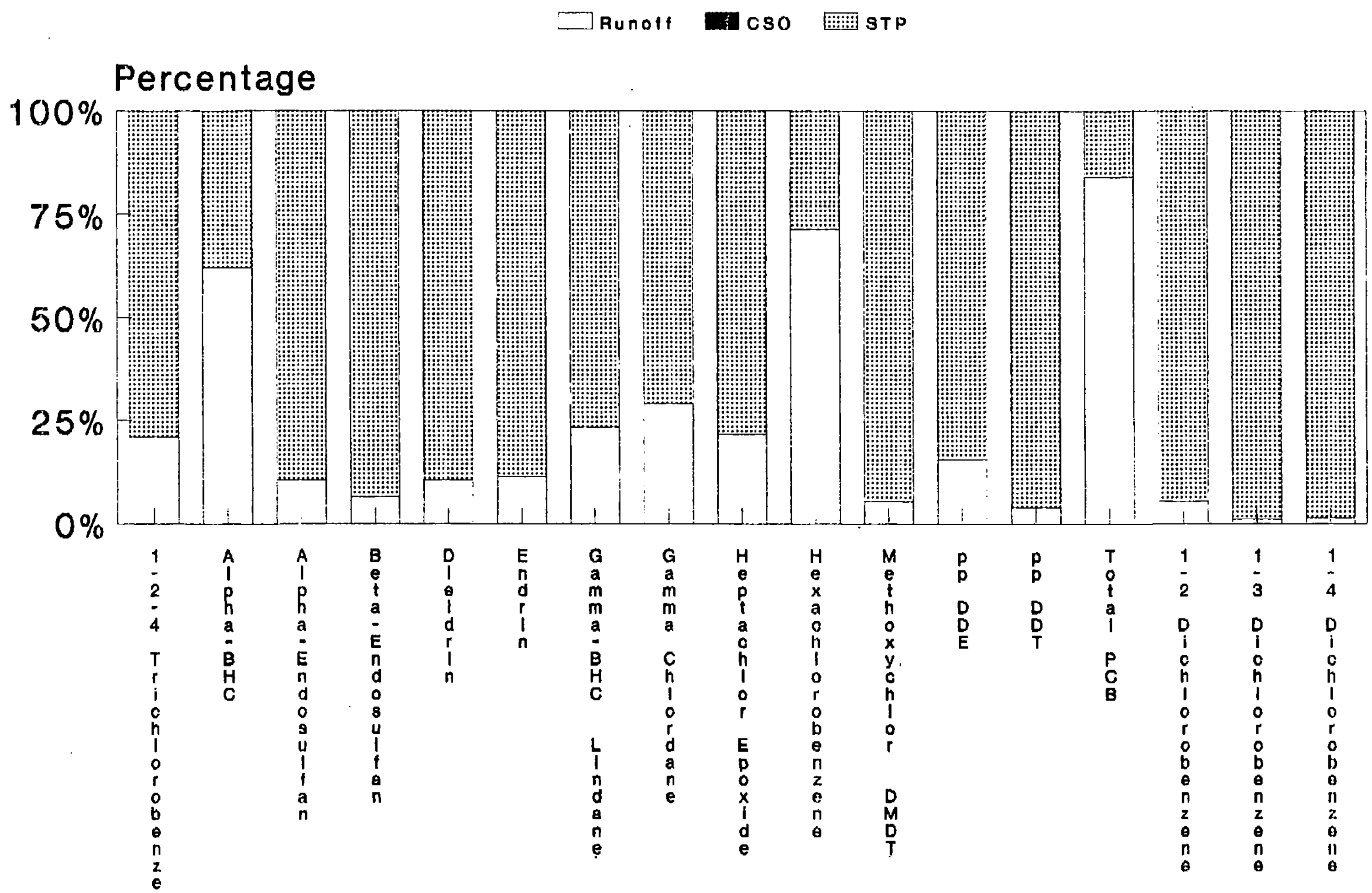



Solids

# Fig. 4.17 Distribution of loads for Spanish River Heavy Metals



# Fig. 4.18 Distribution of loads for Spanish River Organics



## 4.7 SEVERN SOUND

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.13 for each urban centre in the area. Five urban centres are considered in the Severn Sound RAP: Coldwater, Midland, Penetanquishene, Port McNicoll, and Victoria Harbour. Fig. 4.19 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.14. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.20, and in Fig. 4.21 for the organic compounds.

Table 4.13A Annual Flow Volumes (1000s m^3), Severn Sound

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| COLDWATER | 233 | 0 | 161 | 393 |
| MIDLAND | 1380 | 675 | 4130 | 6190 |
| PENETANQUISHENE | 1220 | 0 | 1390 | 2610 |
| PORT MCNICOLL | 466 | 0 | 267 | 732 |
| VICTORIA HARBOUR | 434 | 0 | 237 | 672 |
| Totals | 3740 | 675 | 6180 | 10600 |

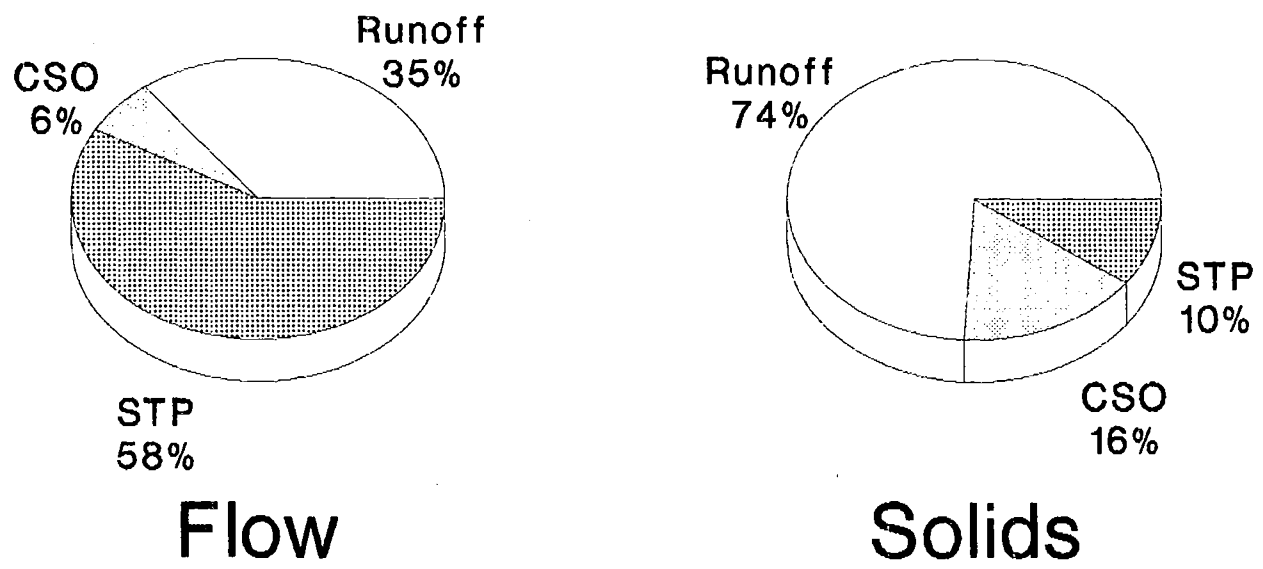
Table 4.13B Annual Solids Discharge (Tonnes), Severn Sound

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| COLDWATER | 45 | 0 | 3 | 48 |
| MIDLAND | 271 | 157 | 66 | 494 |
| PENETANQUISHENE | 239 | 0 | 22 | 261 |
| PORT MCNICOLL | 91 | 0 | 4 | 95 |
| VICTORIA HARBOUR | 85 | 0 | 4 | 89 |
| Totals | 731 | 157 | 99 | 987 |

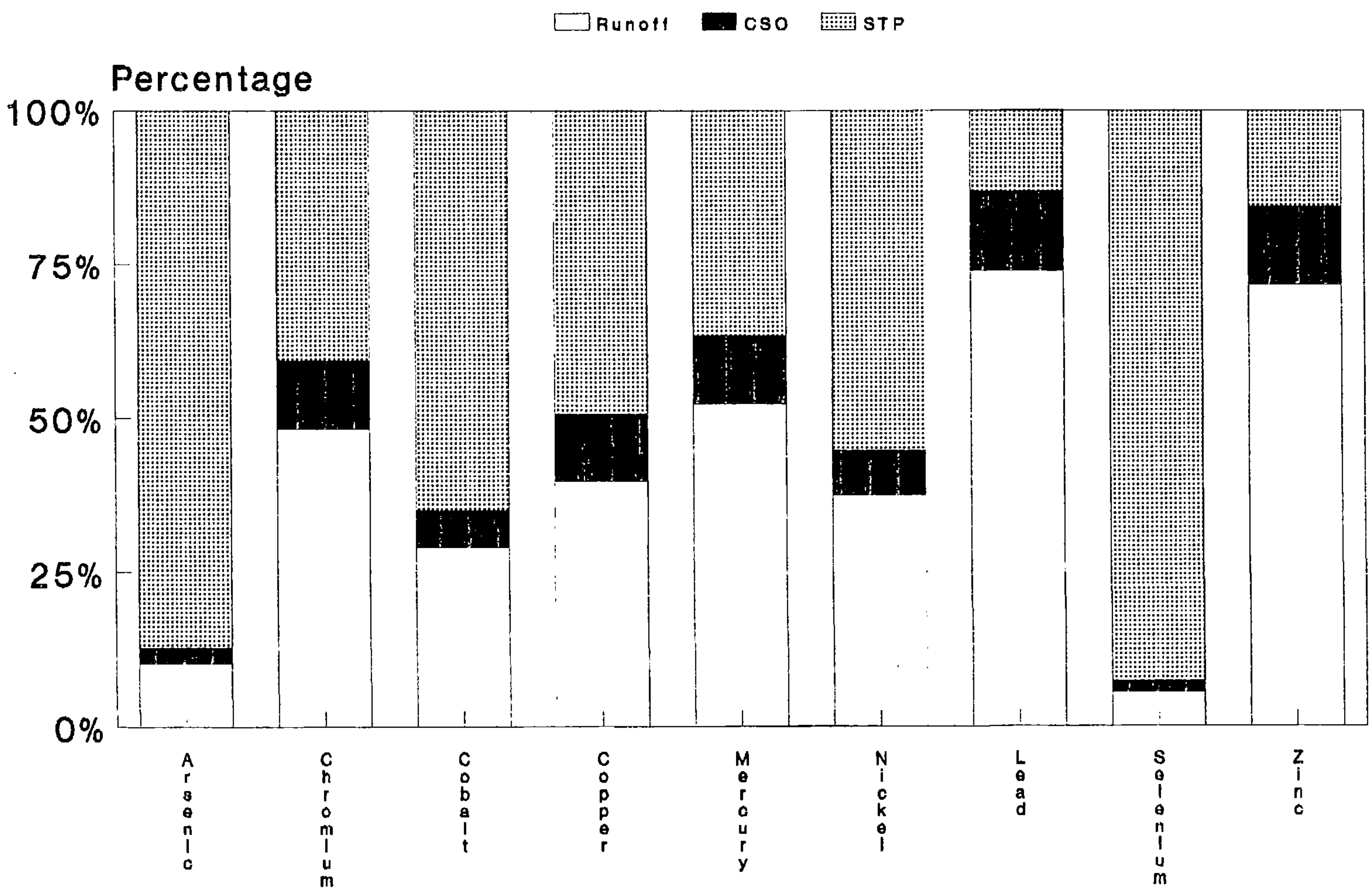
Table 4.14 Annual Contaminant Loads (kg ), Severn Sound

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 12.3 | 2.95 | 104 | 119 |
| Chromium | 104 | 23.5 | 87.8 | 216 |
| Cobalt | 18.1 | 3.60 | 40.5 | 62.2 |
| Copper | 120 | 32.7 | 150 | 303 |
| Mercury | .270 | .0570 | .190 | .520 |
| Nickel | 96.3 | 18.7 | 143 | 259 |
| Lead | 680 | 119 | 121 | 920 |
| Selenium | 6.22 | 1.91 | 106 | 114 |
| Zinc | 1940 | 346 | 425 | 2710 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0120 | .0026 | .0630 | .0780 |
| Alpha-BHC | .0750 | .0130 | .0620 | .150 |
| Alpha-Endosulfan (I) | .0052 | .0014 | .0620 | .0690 |
| Beta-Endosulfan (II) | .0030 | .0010 | .0620 | .0660 |
| Dieldrin | .0051 | .0014 | .0620 | .0690 |
| Endrin | .0057 | .0015 | .0620 | .0690 |
| Gamma-BHC (Lindane) | .0270 | .0056 | .120 | .160 |
| Gamma Chlordane | .0180 | .0036 | .0620 | .0840 |
| Heptachlor Epoxide | .0061 | .0016 | .0310 | .0390 |
| Hexachlorobenzene | .0580 | .0100 | .0320 | .0990 |
| Methoxychlor (DMDT) | .0099 | .0060 | .250 | .270 |
| pp DDE | .0081 | .0019 | .0630 | .0730 |
| pp DDT | .0035 | .0027 | .130 | .130 |
| Total PCB | .770 | .130 | .130 | 1.04 |
| 1-2 Dichlorobenzene | .230 | 1.00 | 6.18 | 7.41 |
| 1-3 Dichlorobenzene | .0470 | .970 | 6.20 | 7.22 |
| 1-4 Dichlorobenzene | .0620 | .980 | 6.22 | 7.25 |

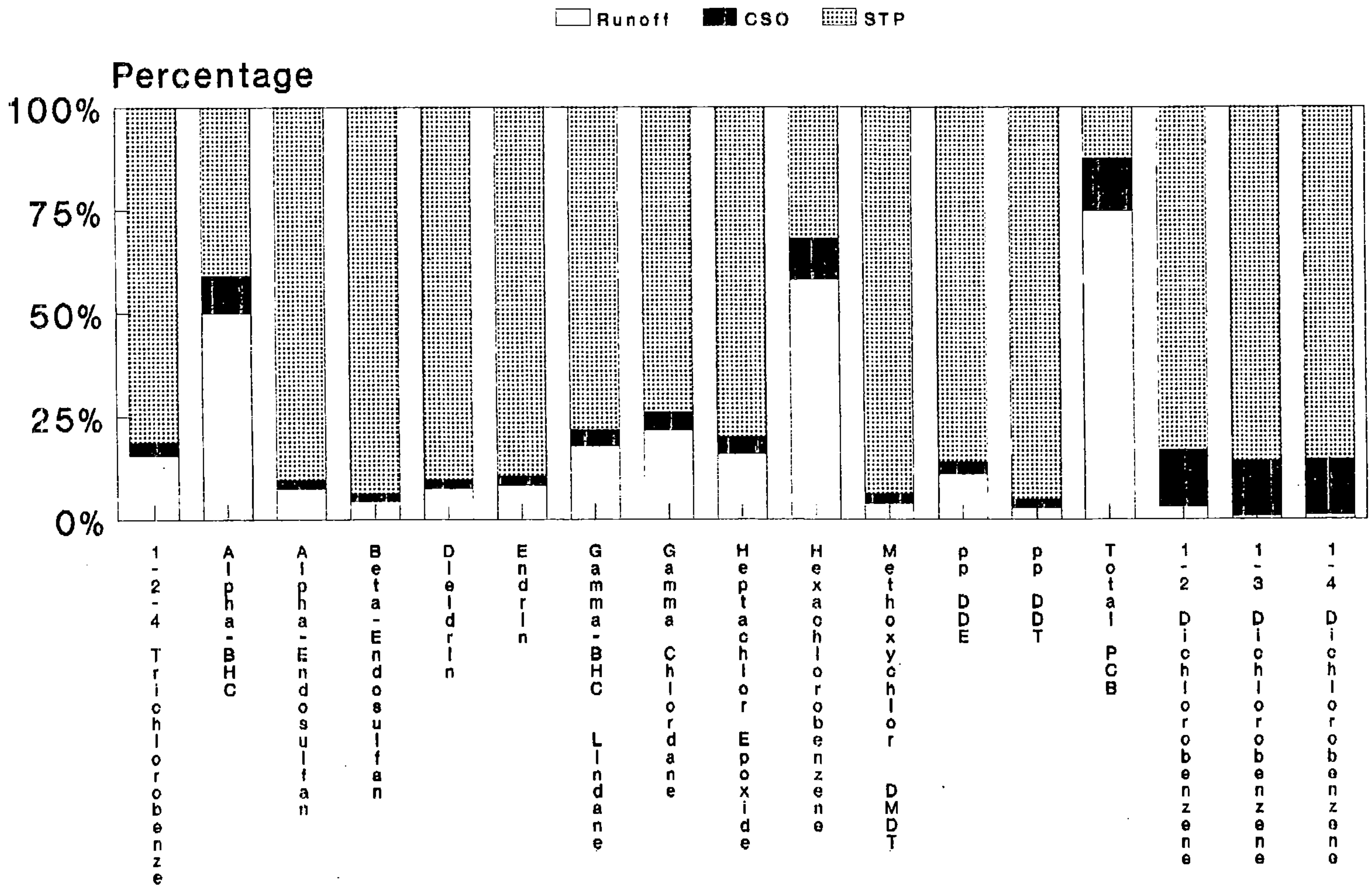
Fig. 4.19 Distribution of flow & solids from each source, Severn Sound



# Fig. 4.20 Distribution of loads for Severn Sound Heavy Metals



# Fig. 4.21 Distribution of loads for Severn Sound Organics



## 4.8 COLLINGWOOD HARBOUR

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.15 for Collingwood, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.22.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.16. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.23, and in Fig. 4.24 for the organic compounds.

Table 4.15A Annual Flow Volumes (1000s m^3), Collingwood Hbr.

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| COLLINGWOOD | 1950 | 0 | 6460 | 8420 |
| Totals | 1950 | 0 | 6460 | 8420 |

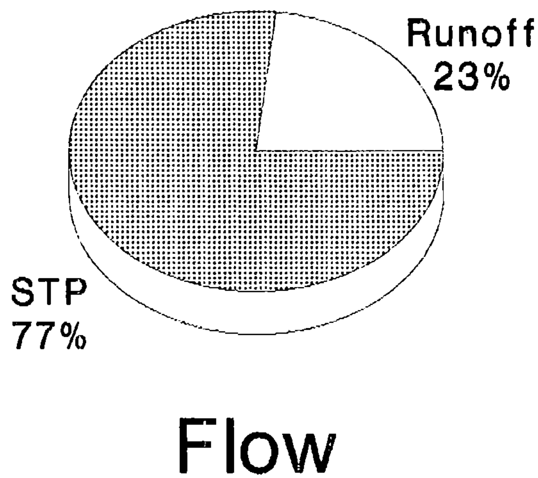
Table 4.15B Annual Solids Discharge (Tonnes), Collingwood Hbr.

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| COLLINGWOOD | 382 | 0 | 103 | 485 |
| Totals | 382 | 0 | 103 | 485 |

Table 4.16 Annual Contaminant Loads (kg ), Collingwood Hbr.

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 6.45 | 0 | 109 | 115 |
| Chromium | 54.5 | 0 | 91.8 | 146 |
| Cobalt | 9.48 | 0 | 42.3 | 51.8 |
| Copper | 62.7 | 0 | 157 | 220 |
| Mercury | .140 | 0 | .190 | .340 |
| Nickel | 50.3 | 0 | 150 | 200 |
| Lead | 355 | 0 | 126 | 482 |
| Selenium | 3.25 | 0 | 111 | 114 |
| Zinc | 1010 | 0 | 445 | 1460 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0062 | 0 | .0660 | .0720 |
| Alpha-BHC | .0390 | 0 | .0650 | .1000 |
| Alpha-Endosulfan (I) | .0027 | 0 | .0650 | .0680 |
| Beta-Endosulfan (II) | .0016 | 0 | .0650 | .0670 |
| Dieldrin | .0027 | 0 | .0650 | .0680 |
| Endrin | .0030 | 0 | .0650 | .0680 |
| Gamma-BHC (Lindane) | .0140 | 0 | .130 | .140 |
| Gamma Chlordane | .0096 | 0 | .0650 | .0750 |
| Heptachlor Epoxide | .0032 | 0 | .0330 | .0360 |
| Hexachlorobenzene | .0300 | 0 | .0330 | .0630 |
| Methoxychlor (DMDT) | .0052 | 0 | .260 | .270 |
| pp DDE | .0042 | 0 | .0660 | .0700 |
| pp DDT | .0018 | 0 | .130 | .130 |
| Total PCB | .400 | 0 | .140 | .540 |
| 1-2 Dichlorobenzene | .120 | 0 | 6.47 | 6.59 |
| 1-3 Dichlorobenzene | .0250 | 0 | 6.48 | 6.51 |
| 1-4 Dichlorobenzene | .0330 | 0 | 6.50 | 6.54 |

Fig. 4.22 Distribution of flow & solids from each source, Collingwood Hbr.



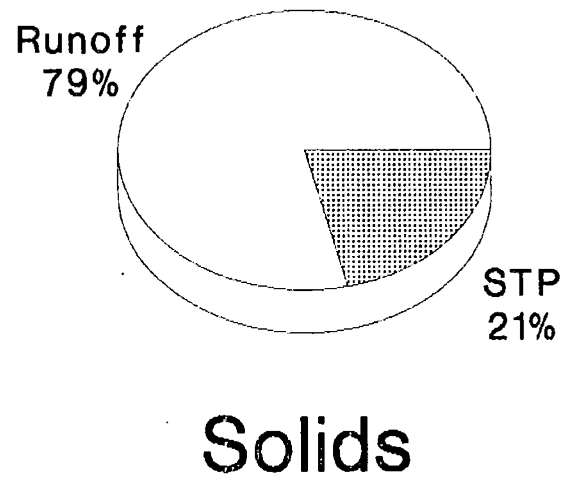
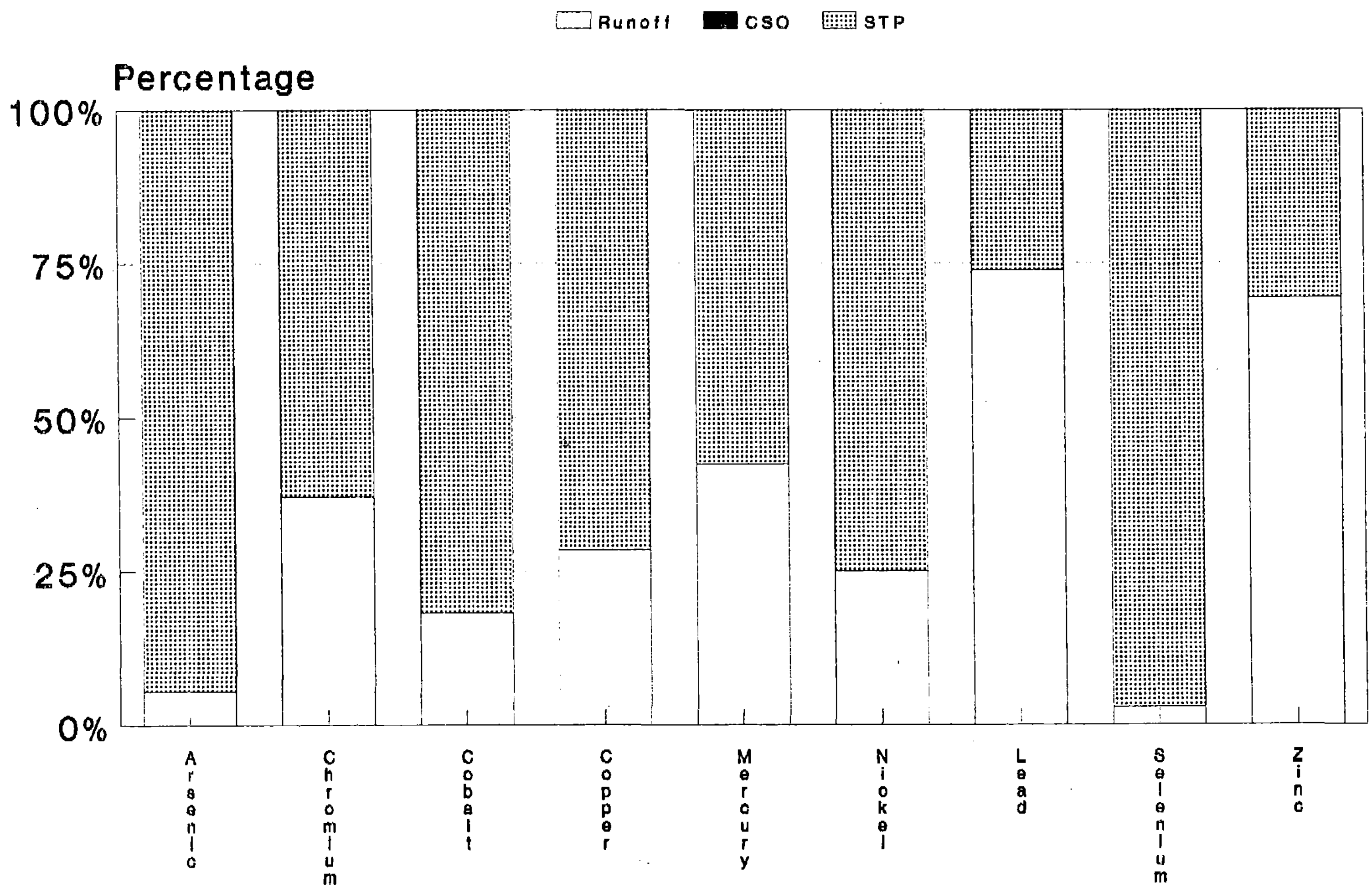
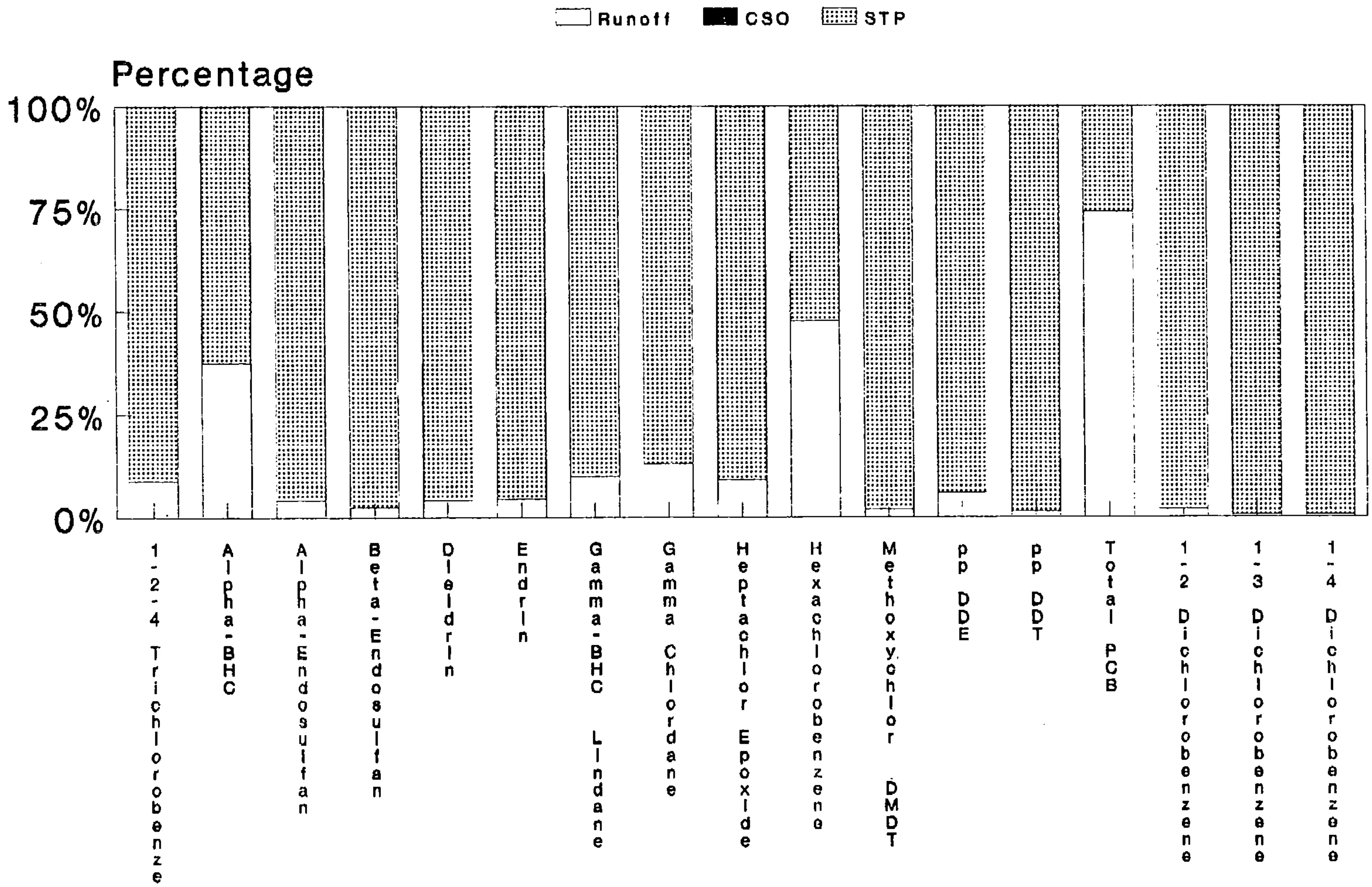



Fig. 4.23 Distribution of loads for Collingwood Hbr. Heavy Metals



# Fig. 4.24 Distribution of loads for Collingwood Hbr. Organics



## 4.9 ST. CLAIR RIVER

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.17 for Sarnia and Sarnia Township, the only urban centres in the area. Fig. 4.25 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.18. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.26, and in Fig. 4.27 for the organic compounds.

Table 4.17A Annual Flow Volumes (1000s m^3), St.Clair River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| SARNIA | 11200 | 1490 | 14000 | 26600 |
| SARNIA-TOWNSHIP | 3200 | 0 | 5590 | 8790 |
| Totals | 14400 | 1490 | 19600 | 35400 |

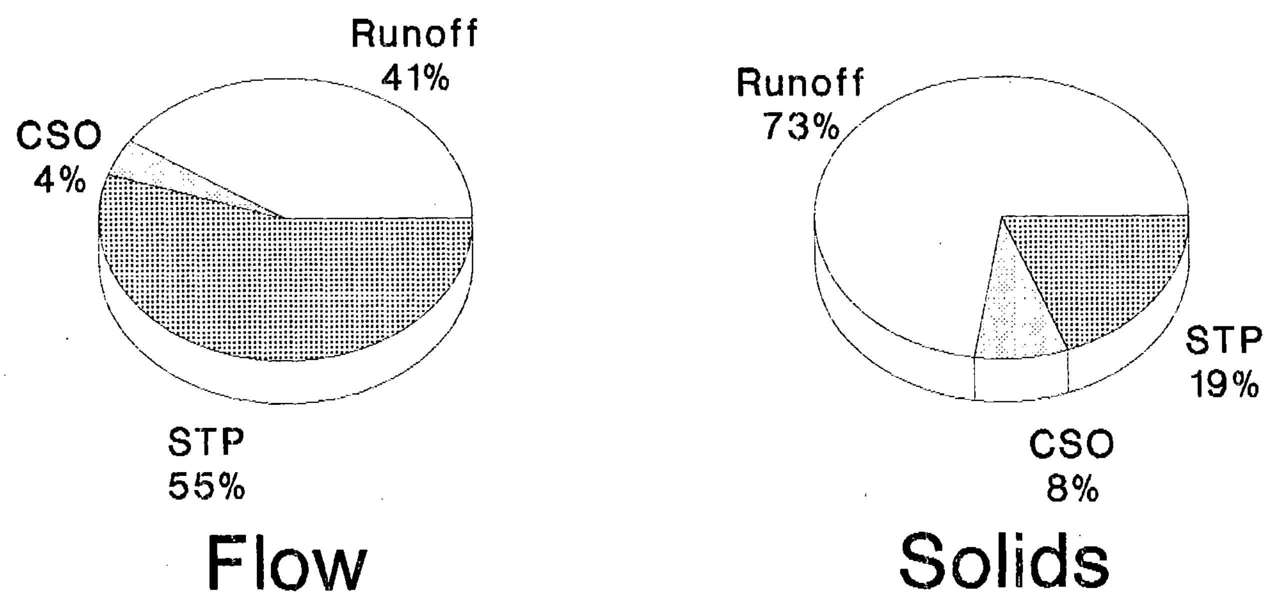
Table 4.17B Annual Solids Discharge (Tonnes), St.Clair River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| SARNIA | 2320 | 330 | 560 | 3210 |
| SARNIA-TOWNSHIP | 626 | 0 | 224 | 849 |
| Totals | 2950 | 330 | 783 | 4060 |

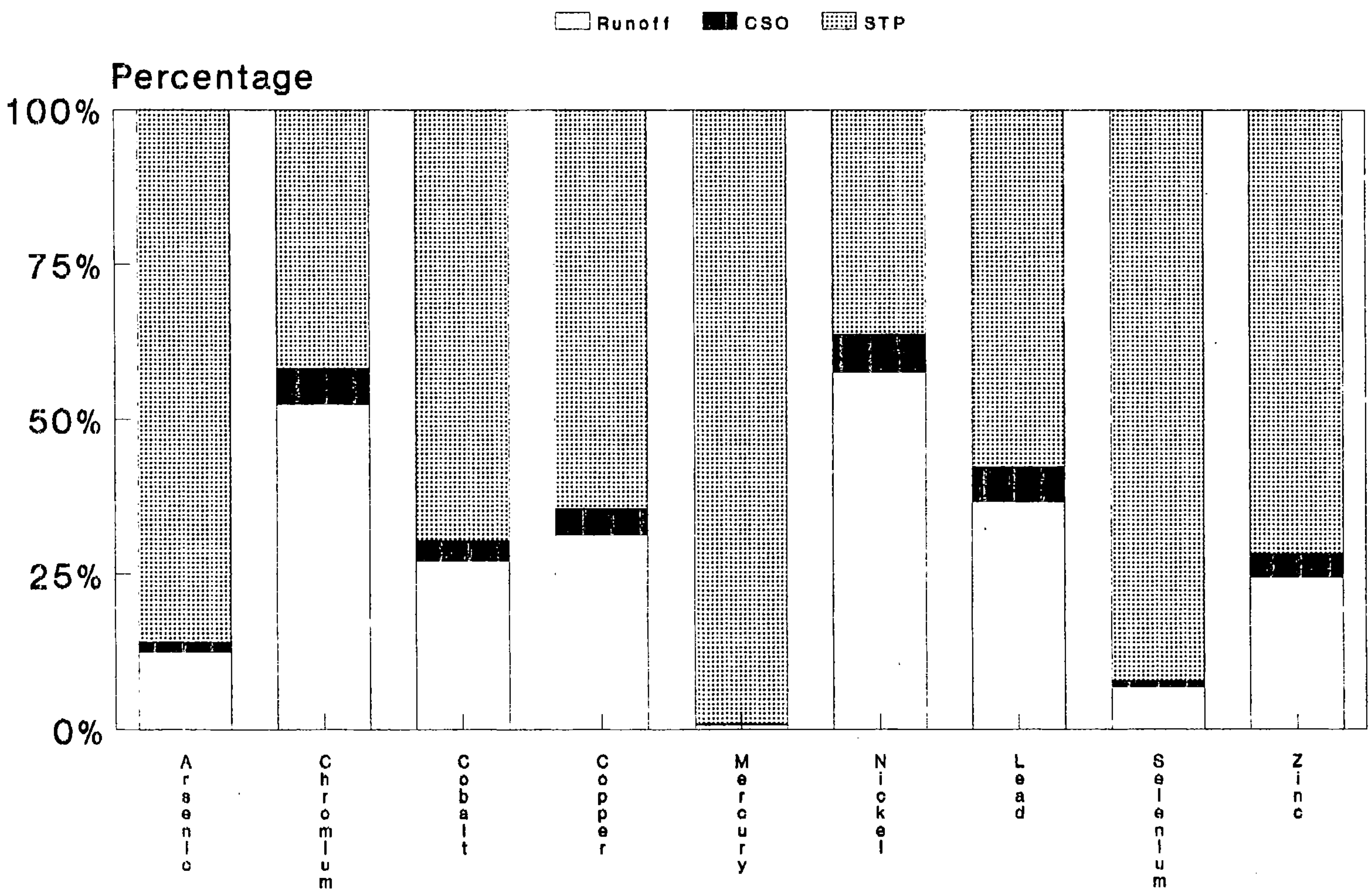
Table 4.18 Annual Contaminant Loads (kg ), St.Clair River

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 48.6 | 5.92 | 334 | 389 |
| Chromium | 416 | 45.0 | 333 | 794 |
| Cobalt | 71.2 | 8.35 | 183 | 263 |
| Copper | 470 | 63.2 | 964 | 1500 |
| Mercury | 1.08 | .190 | 142 | 143 |
| Nickel | 377 | 40.8 | 238 | 656 |
| Lead | 2680 | 397 | 4220 | 7300 |
| Selenium | 24.0 | 3.38 | 326 | 353 |
| Zinc | 7500 | 1170 | 21900 | 30500 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0470 | .0057 | .220 | .270 |
| Alpha-BHC | .290 | .0290 | .200 | .520 |
| Alpha-Endosulfan (I) | .0210 | .0027 | .200 | .220 |
| Beta-Endosulfan (II) | .0120 | .0018 | .200 | .210 |
| Dieldrin | .0200 | .0030 | .210 | .230 |
| Endrin | .0220 | .0029 | .200 | .230 |
| Gamma-BHC (Lindane) | .1000 | .0120 | .260 | .370 |
| Gamma Chlordane | .0730 | .0080 | .200 | .280 |
| Heptachlor Epoxide | .0240 | .0030 | .1000 | .130 |
| Hexachlorobenzene | .230 | .0260 | .170 | .430 |
| Methoxychlor (DMDT) | .0390 | .0088 | .820 | .860 |
| pp DDE | .0320 | .0046 | .230 | .270 |
| pp DDT | .0140 | .0038 | .400 | .420 |
| Total PCB | 3.09 | .360 | 3.77 | 7.22 |
| 1-2 Dichlorobenzene | .910 | 1.18 | 19.6 | 21.7 |
| 1-3 Dichlorobenzene | .190 | 1.11 | 19.9 | 21.2 |
| 1-4 Dichlorobenzene | .250 | 1.12 | 20.0 | 21.3 |

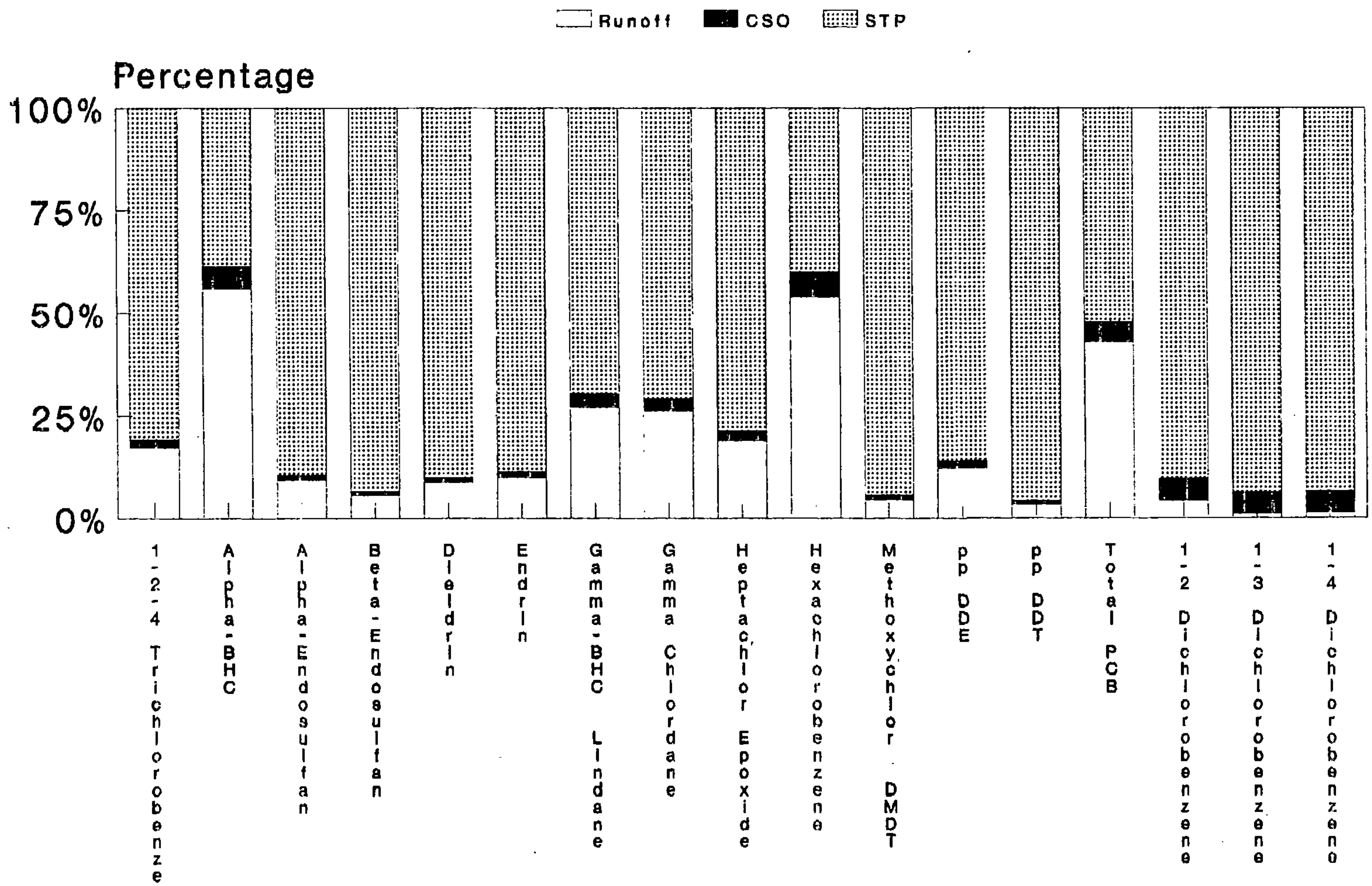
# Fig. 4.25 Distribution of flow & solids from each source, St.Clair River



# Fig. 4.26 Distribution of loads for St.Clair River Heavy Metals



# Fig. 4.27 Distribution of loads for St.Clair River Organics



## 4.10 DETROIT RIVER

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.19 for Windsor, the only urban centre in the area. Notice that Windsor has been divided into East and West portion, each contributing sewage to separate STPs with different levels of treatment (West is primary, and East is secondary). Fig. 4.28 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.20. A comparison of the relative magnitudes of the heavy metal loadings from each source is presented in Fig. 4.29, and in Fig. 4.30 for the organic compounds.

Table 4.19A Annual Flow Volumes (1000s m^3), Detroit River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| WINDSOR-EAST | 9020 | 649 | 12100 | 21800 |
| WINDSOR-WEST | 18400 | 5310 | 42000 | 65700 |
| Totals | 27400 | 5960 | 54100 | 87500 |

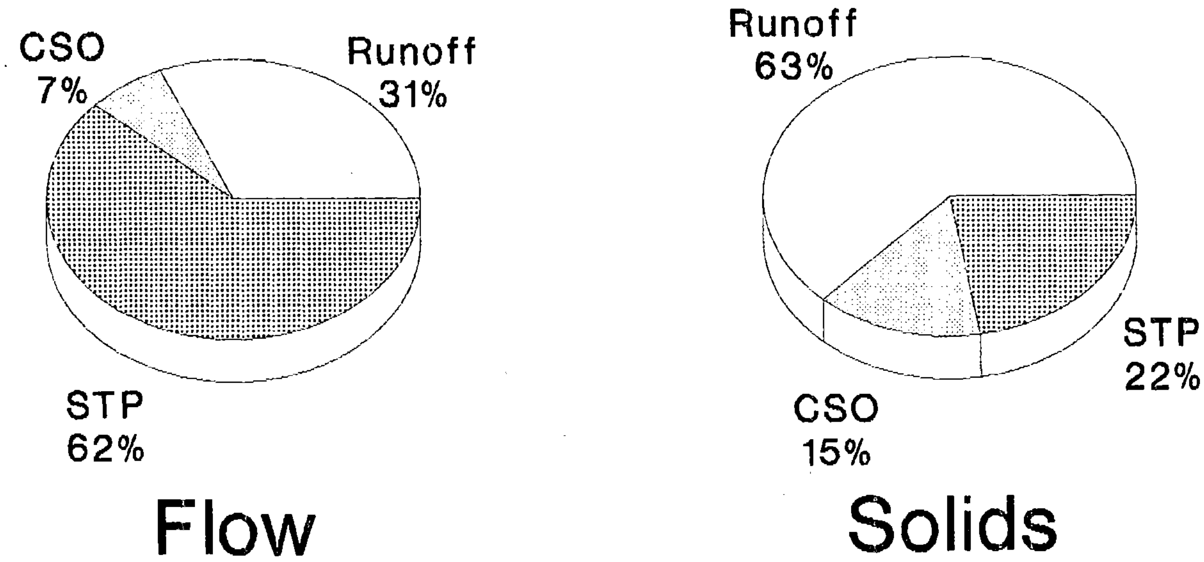
Table 4.19B Annual Solids Discharge (Tonnes), Detroit River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| WINDSOR-EAST | 1730 | 131 | 194 | 2060 |
| WINDSOR-WEST | 3540 | 1080 | 1680 | 6300 |
| Totals | 5270 | 1210 | 1870 | 8360 |

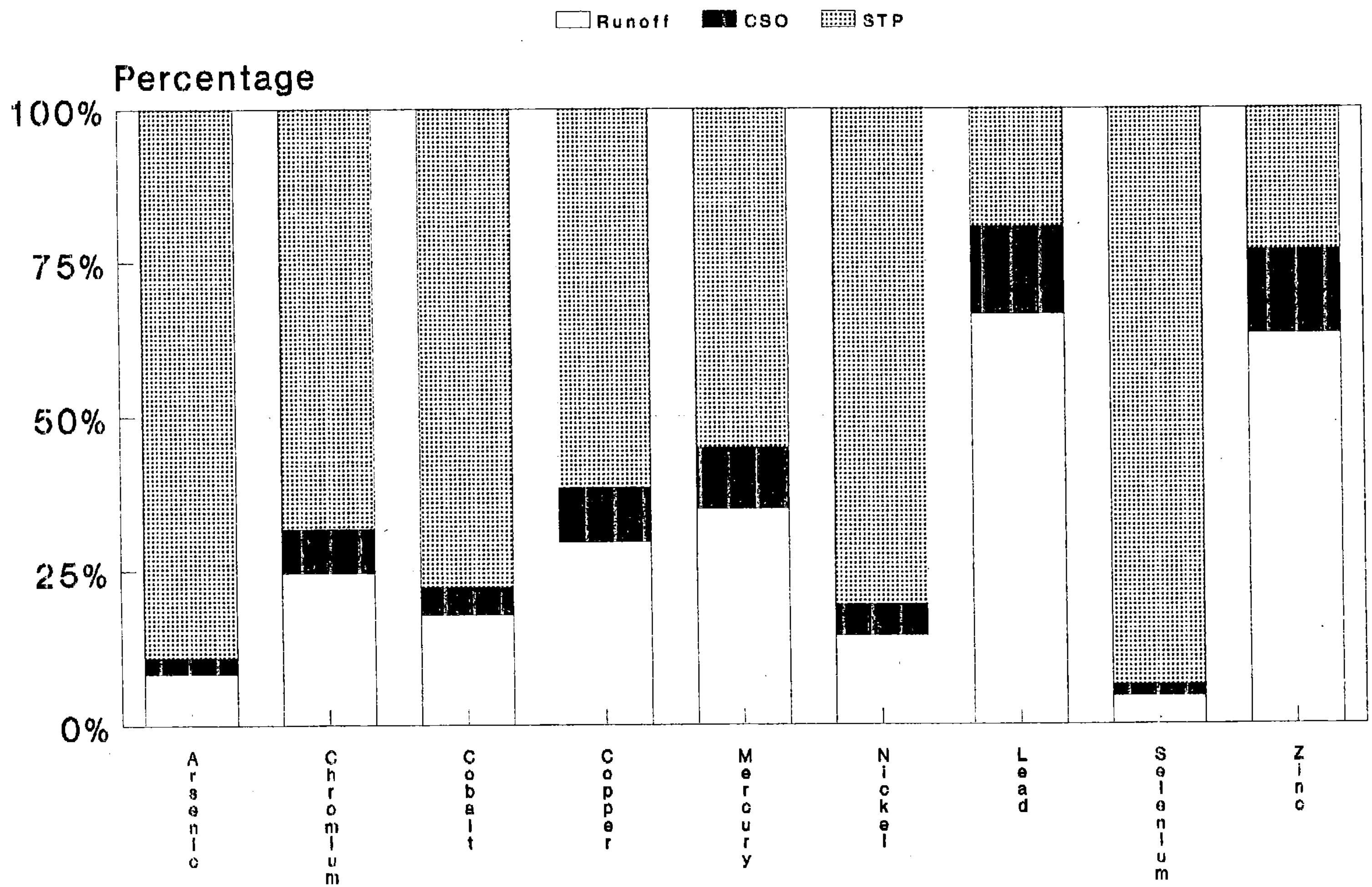
Table 4.20 Annual Contaminant Loads (kg ), Detroit River

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 89.9 | 26.4 | 957 | 1070 |
| Chromium | 756 | 215 | 2090 | 3060 |
| Cobalt | 132 | 32.0 | 575 | 739 |
| Copper | 874 | 260 | 1820 | 2960 |
| Mercury | 1.98 | .560 | 3.14 | 5.68 |
| Nickel | 703 | 237 | 3940 | 4880 |
| Lead | 4950 | 1050 | 1450 | 7450 |
| Selenium | 45.6 | 15.9 | 923 | 985 |
| Zinc | 14200 | 3030 | 5230 | 22400 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0860 | .0220 | .570 | .680 |
| Alpha-BHC | .550 | .120 | .550 | 1.22 |
| Alpha-Endosulfan (I) | .0380 | .0110 | .550 | .600 |
| Beta-Endosulfan (II) | .0220 | .0081 | .560 | .590 |
| Dieldrin | .0370 | .0120 | .580 | .630 |
| Endrin | .0410 | .0120 | .560 | .610 |
| Gamma-BHC (Lindane) | .200 | .0540 | 1.59 | 1.84 |
| Gamma Chlordane | .130 | .0310 | .570 | .730 |
| Heptachlor Epoxide | .0440 | .0130 | .280 | .340 |
| Hexachlorobenzene | .420 | .0920 | .280 | .790 |
| Methoxychlor (DMDT) | .0720 | .0380 | 2.69 | 2.80 |
| pp DDE | .0580 | .0160 | .560 | .640 |
| pp DDT | .0260 | .0190 | 1.11 | 1.16 |
| Total PCB | 5.55 | 1.20 | 3.44 | 10.2 |
| 1-2 Dichlorobenzene | 1.70 | 6.62 | 54.2 | 62.5 |
| 1-3 Dichlorobenzene | .350 | 6.36 | 54.9 | 61.6 |
| 1-4 Dichlorobenzene | .460 | 6.39 | 55.1 | 61.9 |

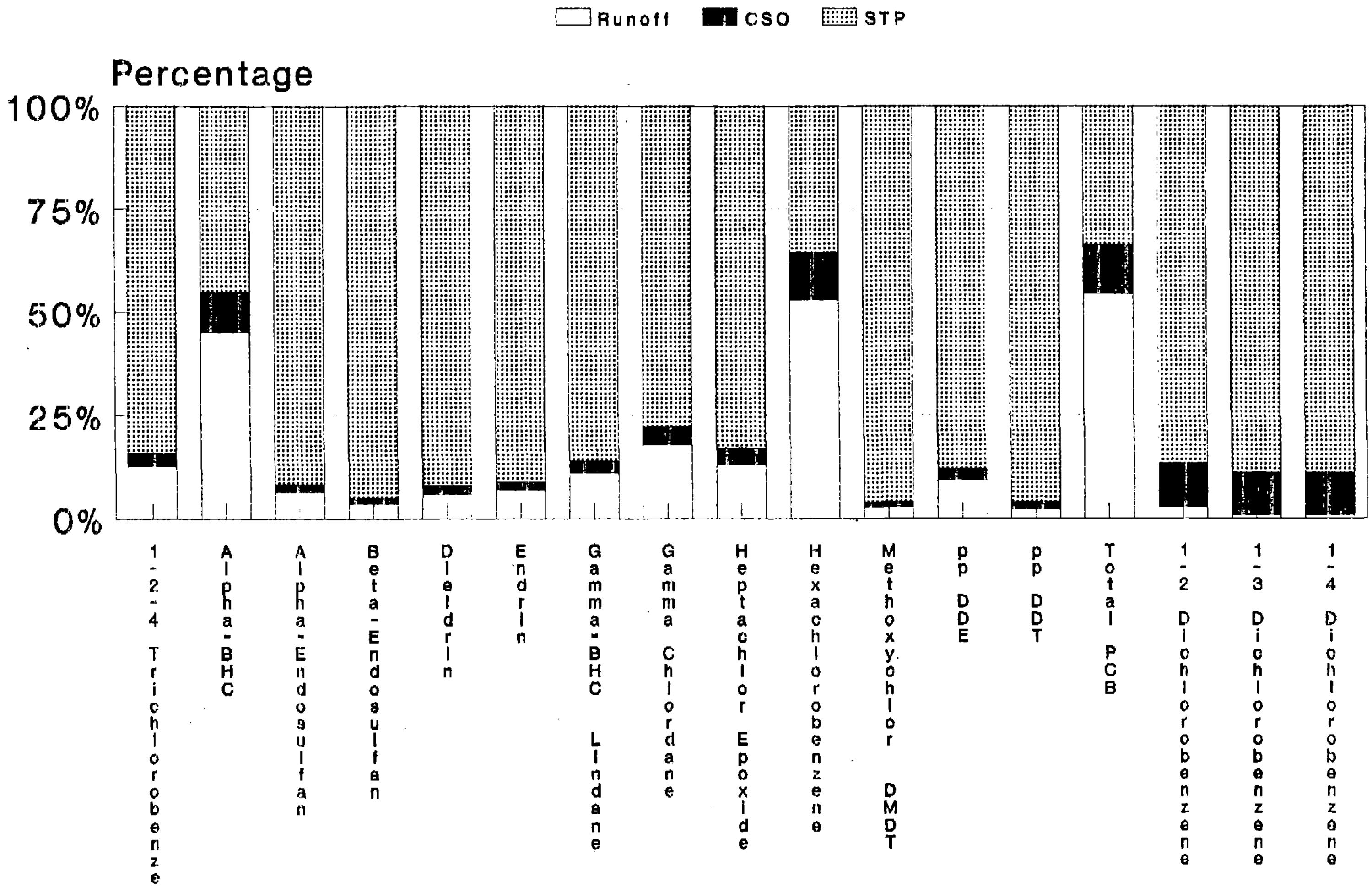
# Fig. 4.28 Distribution of flow & solids from each source, Detroit River



# Fig. 4.29 Distribution of loads for Detroit River Heavy Metals



## Fig. 4.30 Distribution of loads for Detroit River Organics



## 4.11 WHEATLEY HARBOUR

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.21 for Wheatley, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.31.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.22. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.32, and in Fig. 4.33 for the organic compounds.

Table 4.21A Annual Flow Volumes (1000s m^3), Wheatley Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| WHEATLEY | 465 | 0 | 307 | 772 |
| Totals | 465 | 0 | 307 | 772 |

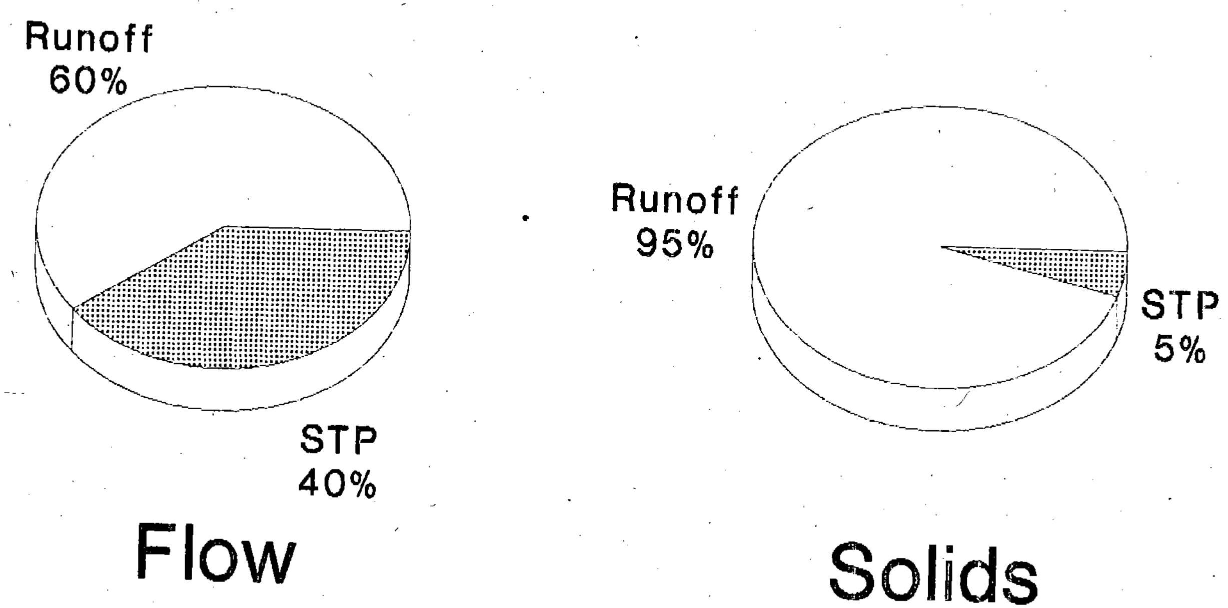
Table 4.21B Annual Solids Discharge (Tonnes), Wheatley Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| WHEATLEY | 91 | 0 | 5 | 96 |
| Totals | 91 | 0 | 5 | 96 |

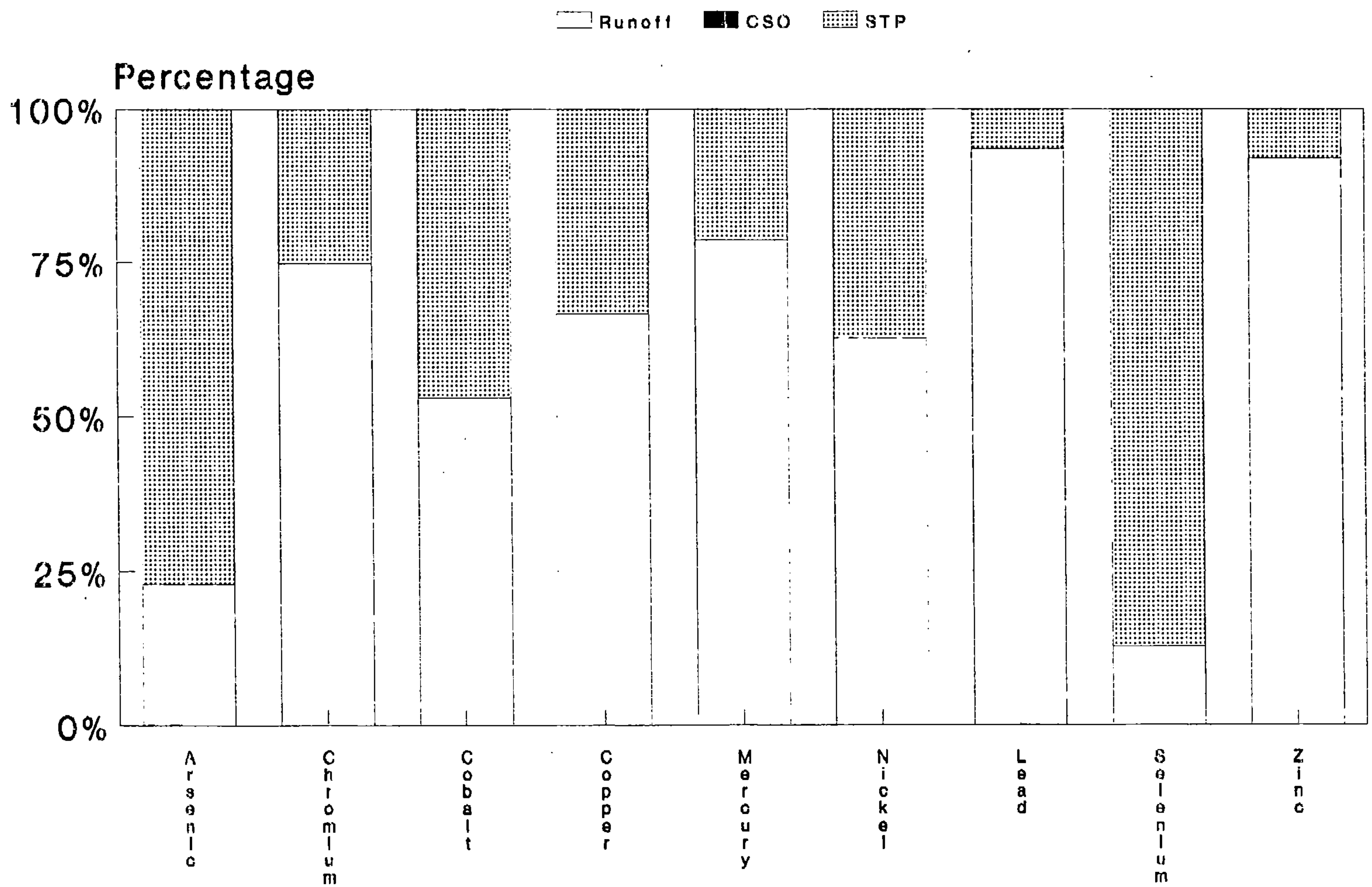
Table 4.22 Annual Contaminant Loads (kg ), Wheatley Harbour

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 1.54 | 0 | 5.15 | 6.69 |
| Chromium | 13.0 | 0 | 4.36 | 17.3 |
| Cobalt | 2.26 | 0 | 2.01 | 4.27 |
| Copper | 14.9 | 0 | 7.46 | 22.4 |
| Mercury | .0340 | 0 | .0092 | .0430 |
| Nickel | 12.0 | 0 | 7.12 | 19.1 |
| Lead | 84.6 | 0 | 6.00 | 90.6 |
| Selenium | .770 | 0 | 5.26 | 6.03 |
| Zinc | 241 | 0 | 21.1 | 262 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0015 | 0 | .0031 | .0046 |
| Alpha-BHC | .0093 | 0 | .0031 | .0120 |
| Alpha-Endosulfan (I) | .0007 | 0 | .0031 | .0037 |
| Beta-Endosulfan (II) | .0004 | 0 | .0031 | .0035 |
| Dieldrin | .0006 | 0 | .0031 | .0037 |
| Endrin | .0007 | 0 | .0031 | .0038 |
| Gamma-BHC (Lindane) | .0033 | 0 | .0062 | .0095 |
| Gamma Chlordane | .0023 | 0 | .0031 | .0054 |
| Heptachlor Epoxide | .0008 | 0 | .0016 | .0023 |
| Hexachlorobenzene | .0072 | 0 | .0016 | .0087 |
| Methoxychlor (DMDT) | .0012 | 0 | .0120 | .0140 |
| pp DDE | .0010 | 0 | .0031 | .0041 |
| pp DDT | .0004 | 0 | .0062 | .0067 |
| Total PCB | .0960 | 0 | .0067 | .1000 |
| 1-2 Dichlorobenzene | .0290 | 0 | .310 | .340 |
| 1-3 Dichlorobenzene | .0059 | 0 | .310 | .310 |
| 1-4 Dichlorobenzene | .0078 | 0 | .310 | .320 |

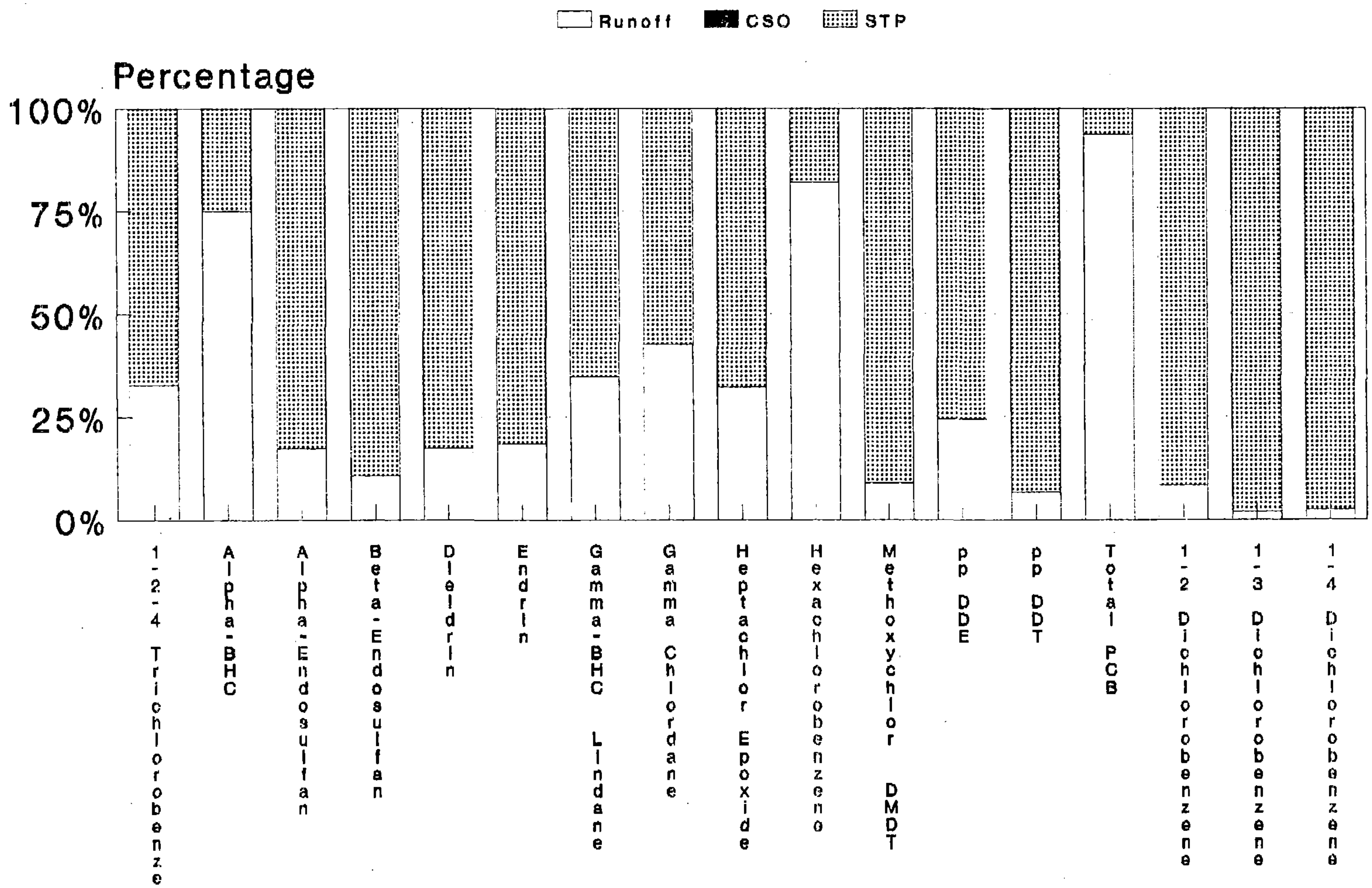
Fig. 4.31 Distribution of flow & solids from each source, Wheatley Harbour



# Fig. 4.32 Distribution of loads for Wheatley Harbour Heavy Metals



## Fig. 4.33 Distribution of loads for Wheatley Harbour Organics



## 4.12 NIAGARA RIVER

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.23 for each urban centre in the area. Four urban centres are considered in the Niagara River RAP: Fort Erie, Niagara Falls, Niagara-on-the-lake, and Welland. Fig. 4.34 illustrates how these flow volumes and solids discharges are distributed (in percent) among the loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.24. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.35, and in Fig. 4.36 for the organic compounds.

Table 4.23A Annual Flow Volumes (1000s m^3), Niagara River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| FORT ERIE | 3880 | 102 | 5120 | 9110 |
| NIAGARA FALLS | 10900 | 2680 | 21400 | 35000 |
| NIAGARA-ON-THE-LAKE | 959 | 0 | 1090 | 2050 |
| WELLAND | 5930 | 721 | 10100 | 16800 |
| Totals | 21700 | 3500 | 37700 | 62900 |

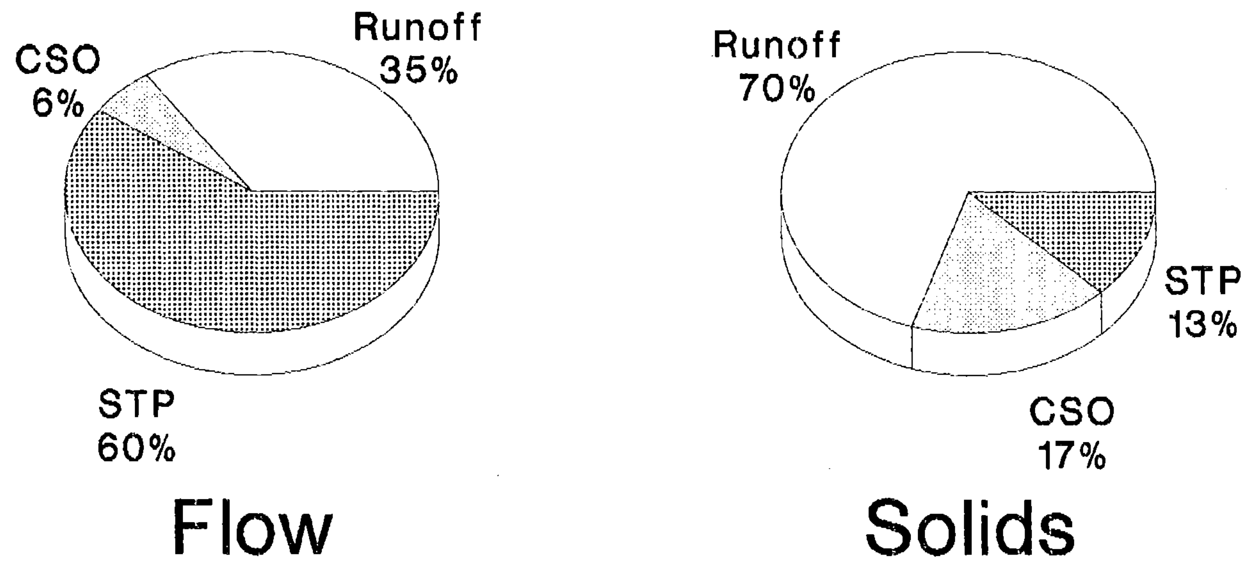
Table 4.23B Annual Solids Discharge (Tonnes), Niagara River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| FORT ERIE | 710 | 40 | 205 | 954 |
| NIAGARA FALLS | 2060 | 751 | 342 | 3150 |
| NIAGARA-ON-THE-LAKE | 188 | 0 | 18 | 205 |
| WELLAND | 1110 | 220 | 162 | 1490 |
| Totals | 4060 | 1010 | 726 | 5800 |

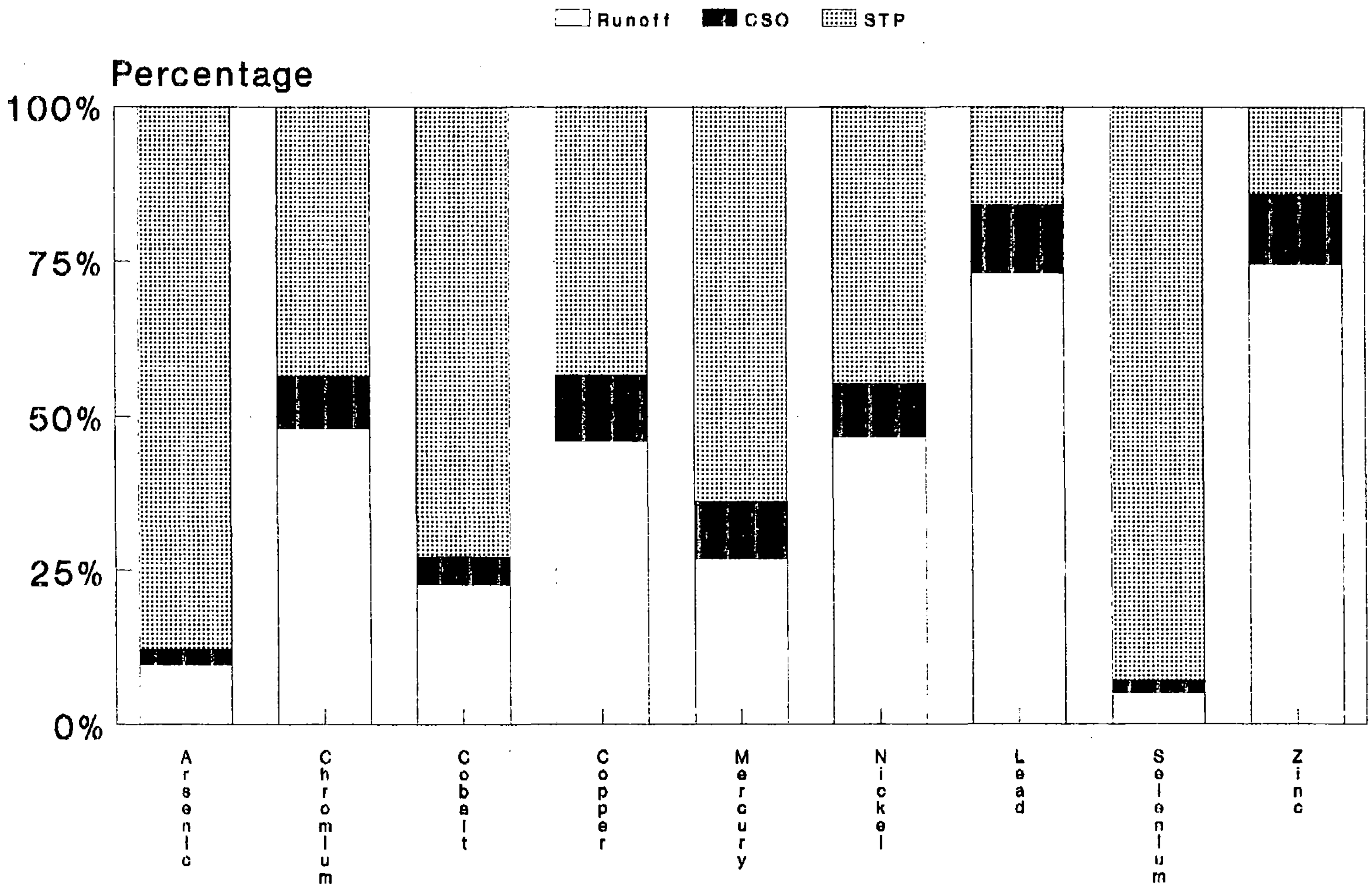
Table 4.24 Annual Contaminant Loads (kg ), Niagara River

| Parameter | Runoff | CSO | STP | Total |
| --- | --- | --- | --- | --- |
| Heavy Metals | | | | |
| Arsenic | 70.2 | 17.9 | 634 | 722 |
| Chromium | 586 | 103 | 532 | 1220 |
| Cobalt | 103 | 20.1 | 330 | 454 |
| Copper | 684 | 158 | 645 | 1490 |
| Mercury | 1.54 | .520 | 3.64 | 5.70 |
| Nickel | 550 | 97.8 | 527 | 1170 |
| Lead | 3860 | 582 | 842 | 5280 |
| Selenium | 36.0 | 12.9 | 644 | 693 |
| Zinc | 11200 | 1680 | 2110 | 15000 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0670 | .0150 | .390 | .470 |
| Alpha-BHC | .430 | .0700 | .380 | .880 |
| Alpha-Endosulfan (I) | .0290 | .0090 | .380 | .420 |
| Beta-Endosulfan (II) | .0170 | .0072 | .380 | .400 |
| Dieldrin | .0290 | .0091 | .380 | .420 |
| Endrin | .0320 | .0093 | .380 | .420 |
| Gamma-BHC (Lindane) | .160 | .0350 | .970 | 1.16 |
| Gamma Chlordane | .1000 | .0190 | .380 | .500 |
| Heptachlor Epoxide | .0350 | .0098 | .190 | .240 |
| Hexachlorobenzene | .320 | .0500 | .190 | .560 |
| Methoxychlor (DMDT) | .0560 | .0400 | 1.54 | 1.63 |
| pp DDE | .0450 | .0120 | .380 | .440 |
| pp DDT | .0200 | .0230 | .770 | .810 |
| Total PCB | 4.28 | .640 | .880 | 5.81 |
| 1-2 Dichlorobenzene | 1.33 | 8.88 | 37.7 | 47.9 |
| 1-3 Dichlorobenzene | .270 | 8.76 | 37.9 | 46.9 |
| 1-4 Dichlorobenzene | .360 | 8.78 | 38.0 | 47.2 |

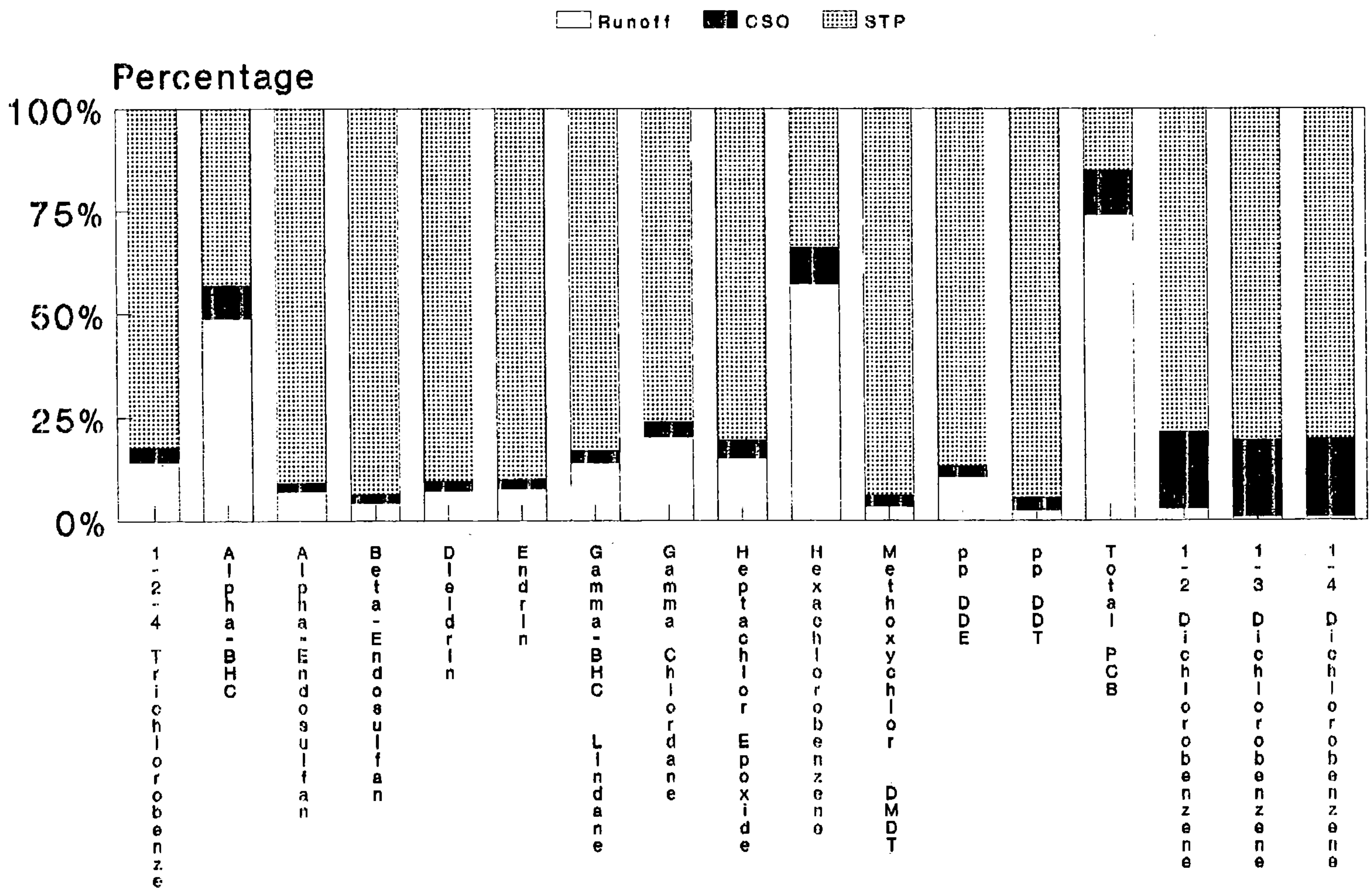
# Fig. 4.34 Distribution of flow & solids from each source, Niagara River



# Fig. 4.35 Distribution of loads for Niagara River Heavy Metals



# Fig. 4.36 Distribution of loads for Niagara River Organics



### 4.13 HAMILTON HARBOUR

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.25 for each urban centre in the area. Five urban centres are considered in the Hamilton Harbour RAP: Ancaster, Burlington (the western portion to Skyway STP), Dundas, Flamborough, and Hamilton. Fig. 4.37 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.26. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.38, and in Fig. 4.39 for the organic compounds.

Table 4.25A Annual Flow Volumes (1000s m^3), Hamilton Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| ANCASTER | 1940 | 0 | 1650 | 3590 |
| BURLINGTON West | 4300 | 0 | 23300 | 27600 |
| DUNDAS | 2870 | 0 | 2620 | 5480 |
| FLAMBOROUGH | 767 | 0 | 833 | 1600 |
| HAMILTON | 19300 | 5340 | 111000 | 135000 |
| Totals | 29200 | 5340 | 139000 | 174000 |

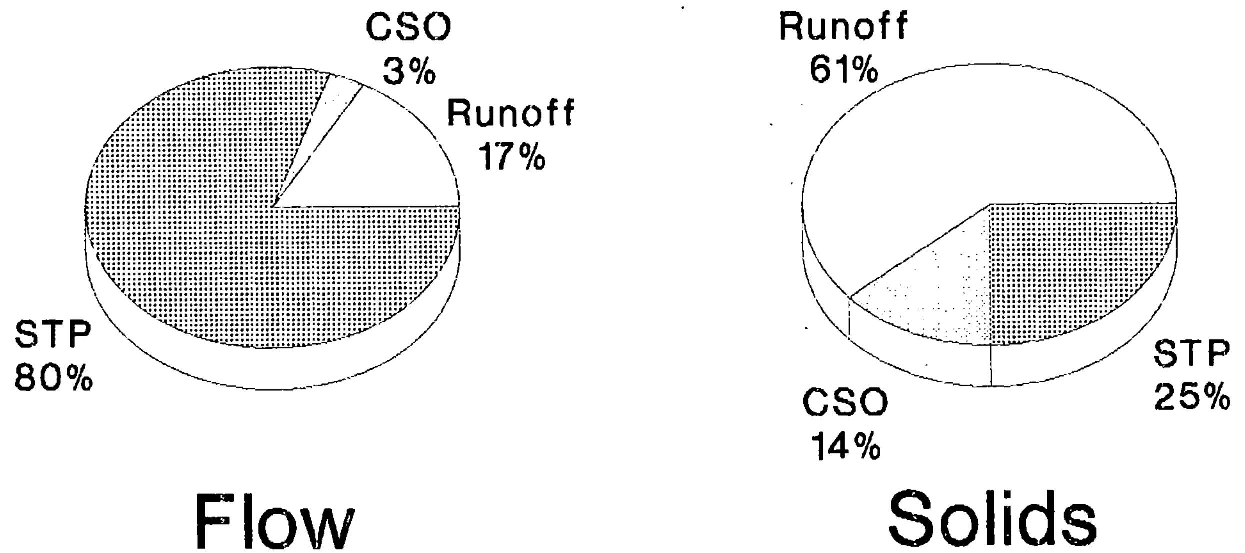
Table 4.25B Annual Solids Discharge (Tonnes), Hamilton Harbour

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| ANCASTER | 380 | 0 | 26 | 407 |
| BURLINGTON West | 841 | 0 | 372 | 1210 |
| DUNDAS | 561 | 0 | 42 | 603 |
| FLAMBOROUGH | 150 | 0 | 13 | 163 |
| HAMILTON | 3530 | 1210 | 1770 | 6510 |
| Totals | 5460 | 1210 | 2220 | 8890 |

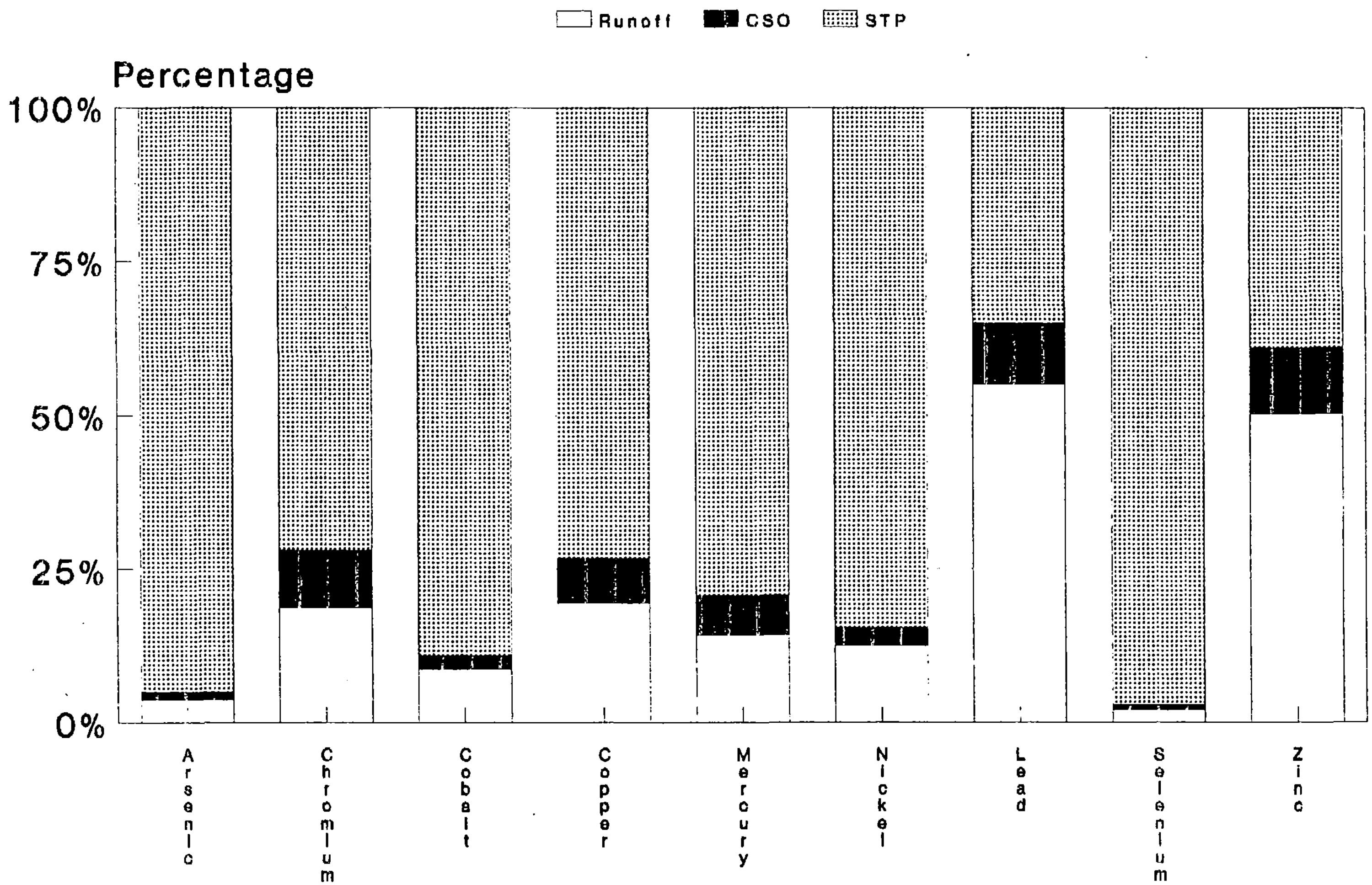
Table 4.26 Annual Contaminant Loads (kg ), Hamilton Harbour

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 94.4 | 29.0 | 2360 | 2480 |
| Chromium | 787 | 382 | 3000 | 4170 |
| Cobalt | 139 | 33.0 | 1410 | 1580 |
| Copper | 920 | 345 | 3460 | 4730 |
| Mercury | 2.07 | .920 | 11.5 | 14.5 |
| Nickel | 740 | 163 | 4970 | 5870 |
| Lead | 5190 | 934 | 3310 | 9440 |
| Selenium | 48.5 | 20.5 | 2400 | 2470 |
| Zinc | 15000 | 3150 | 11600 | 29700 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0900 | .0480 | 1.69 | 1.83 |
| Alpha-BHC | .580 | .1000 | 1.40 | 2.08 |
| Alpha-Endosulfan (I) | .0390 | .0140 | 1.40 | 1.46 |
| Beta-Endosulfan (II) | .0230 | .0110 | 1.40 | 1.43 |
| Dieldrin | .0390 | .0140 | 1.41 | 1.46 |
| Endrin | .0430 | .0140 | 1.40 | 1.46 |
| Gamma-BHC (Lindane) | .210 | .0560 | 2.57 | 2.83 |
| Gamma Chlordane | .140 | .0290 | 1.41 | 1.57 |
| Heptachlor Epoxide | .0470 | .0150 | .710 | .770 |
| Hexachlorobenzene | .430 | .0750 | .710 | 1.22 |
| Methoxychlor (DMDT) | .0760 | .0590 | 4.55 | 4.68 |
| pp DDE | .0610 | .0170 | 1.42 | 1.50 |
| pp DDT | .0270 | .0330 | 2.82 | 2.88 |
| Total PCB | 5.76 | 1.13 | 4.46 | 11.3 |
| 1-2 Dichlorobenzene | 1.79 | 13.2 | 139 | 154 |
| 1-3 Dichlorobenzene | .360 | 13.0 | 140 | 153 |
| 1-4 Dichlorobenzene | .480 | 13.0 | 140 | 153 |

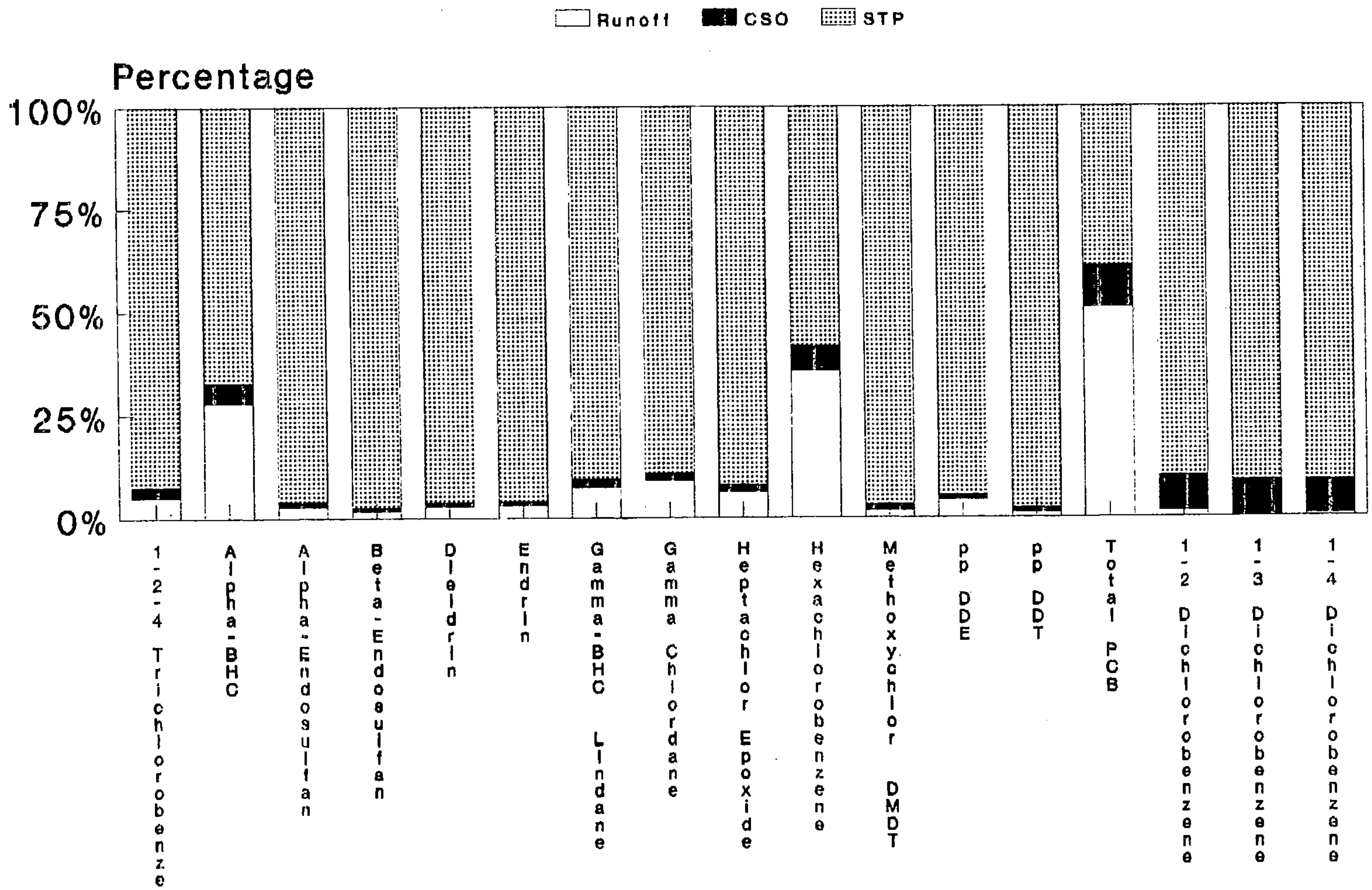
# Fig. 4.37 Distribution of flow & solids from each source, Hamilton Harbour



## Fig. 4.38 Distribution of loads for Hamilton Harbour Heavy Metals



# Fig. 4.39 Distribution of loads for Hamilton Harbour Organics



## 4.14 TORONTO WATERFRONT

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.27 for each urban centre in the area. Fourteen urban centres contribute flow to the Toronto Waterfront RAP: Brampton (East part serviced by the Humber STP), Caledon, East York, Etobicoke, King Township, Markham, Mississauga (Lakeview STP serviced portion), North York, Richmond Hill, Scarborough, Stouffville, Toronto, Vaughan and York. Fig. 4.40 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.28. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.41, and in Fig. 4.42 for the organic compounds.

Table 4.27A Annual Flow Volumes (1000s m^3), Toronto Waterfront

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| BRAMPTON East | 15300 | 72 | 31800 | 47200 |
| CALEDON | 1150 | 0 | 5840 | 6990 |
| EAST YORK | 1420 | 2910 | 23400 | 27700 |
| ETOBICOKE | 39900 | 232 | 68700 | 109000 |
| KING-TOWNSHIP | 1090 | 0 | 1310 | 2410 |
| MARKHAM | 11400 | 0 | 21700 | 33200 |
| MISSISSAUGA Lakevw | 19300 | 0 | 44900 | 64300 |
| NORTH YORK | 43300 | 0 | 128000 | 171000 |
| RICHMOND HILL | 5610 | 0 | 9200 | 14800 |
| SCARBOROUGH | 50100 | 1330 | 102000 | 153000 |
| STOUFFVILLE | 1180 | 0 | 1270 | 2450 |
| TORONTO | 9060 | 3750 | 137000 | 150000 |
| VAUGHAN | 6900 | 0 | 12300 | 19200 |
| YORK | 4780 | 1220 | 30900 | 36900 |
| Totals | 211000 | 9520 | 618000 | 839000 |

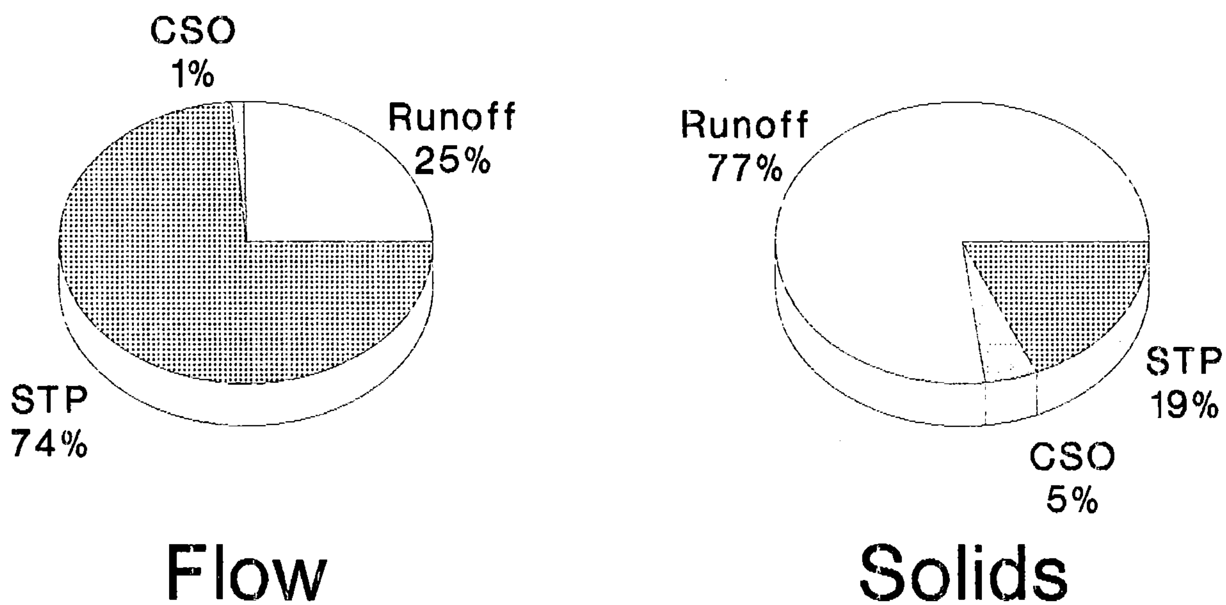
Table 4.27B Annual Solids Discharge (Tonnes), Toronto Waterfront

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| BRAMPTON East | 3000 | 37 | 508 | 3550 |
| CALEDON | 225 | 0 | 94 | 319 |
| EAST YORK | 263 | 592 | 374 | 1230 |
| ETOBICOKE | 8220 | 68 | 1100 | 9390 |
| KING-TOWNSHIP | 214 | 0 | 21 | 235 |
| MARKHAM | 2240 | 0 | 348 | 2580 |
| MISSISSAUGA Lakevw | 3790 | 0 | 719 | 4510 |
| NORTH YORK | 7990 | 0 | 2050 | 10000 |
| RICHMOND HILL | 1100 | 0 | 147 | 1250 |
| SCARBOROUGH | 9820 | 567 | 1620 | 12000 |
| STOUFFVILLE | 230 | 0 | 20 | 251 |
| TORONTO | 1790 | 926 | 2200 | 4910 |
| VAUGHAN | 1350 | 0 | 198 | 1550 |
| YORK | 943 | 279 | 494 | 1720 |
| Totals | 41200 | 2470 | 9890 | 53500 |

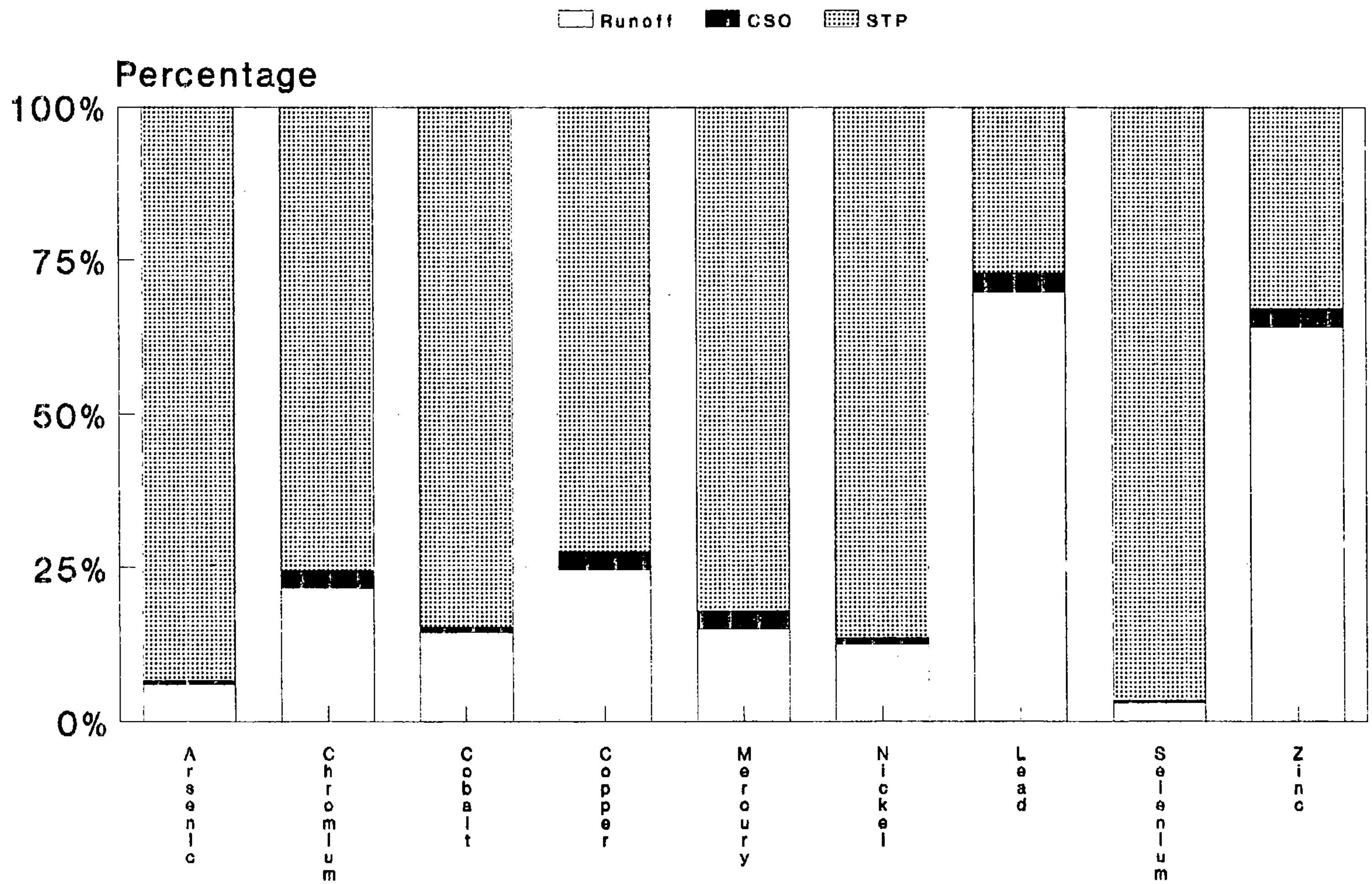
Table 4.28 Annual Contaminant Loads (kg ), Toronto Waterfront

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 696 | 55.3 | 10600 | 11400 |
| Chromium | 5880 | 749 | 20500 | 27100 |
| Cobalt | 1020 | 59.3 | 6010 | 7090 |
| Copper | 6760 | 757 | 19900 | 27400 |
| Mercury | 15.4 | 2.82 | 84.2 | 102 |
| Nickel | 5430 | 329 | 37400 | 43200 |
| Lead | 38300 | 1620 | 14800 | 54700 |
| Selenium | 350 | 41.8 | 10800 | 11200 |
| Zinc | 109000 | 5110 | 55500 | 170000 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .670 | .410 | 32.8 | 33.8 |
| Alpha-BHC | 4.20 | .180 | 6.26 | 10.6 |
| Alpha-Endosulfan (I) | .290 | .0300 | 6.38 | 6.70 |
| Beta-Endosulfan (II) | .170 | .0240 | 6.24 | 6.43 |
| Dieldrin | .290 | .0310 | 6.32 | 6.64 |
| Endrin | .320 | .0290 | 6.23 | 6.57 |
| Gamma-BHC (Lindane) | 1.51 | .1000 | 7.77 | 9.38 |
| Gamma Chlordane | 1.03 | .0570 | 6.29 | 7.38 |
| Heptachlor Epoxide | .340 | .0310 | 3.23 | 3.60 |
| Hexachlorobenzene | 3.24 | .140 | 3.28 | 6.67 |
| Methoxychlor (DMDT) | .560 | .170 | 25.2 | 25.9 |
| pp DDE | .450 | .0360 | 6.36 | 6.85 |
| pp DDT | .200 | .0770 | 12.5 | 12.8 |
| Total PCB | 43.3 | 1.74 | 13.4 | 58.4 |
| 1-2 Dichlorobenzene | 13.2 | 32.1 | 619 | 664 |
| 1-3 Dichlorobenzene | 2.67 | 31.8 | 621 | 655 |
| 1-4 Dichlorobenzene | 3.52 | 31.9 | 623 | 658 |

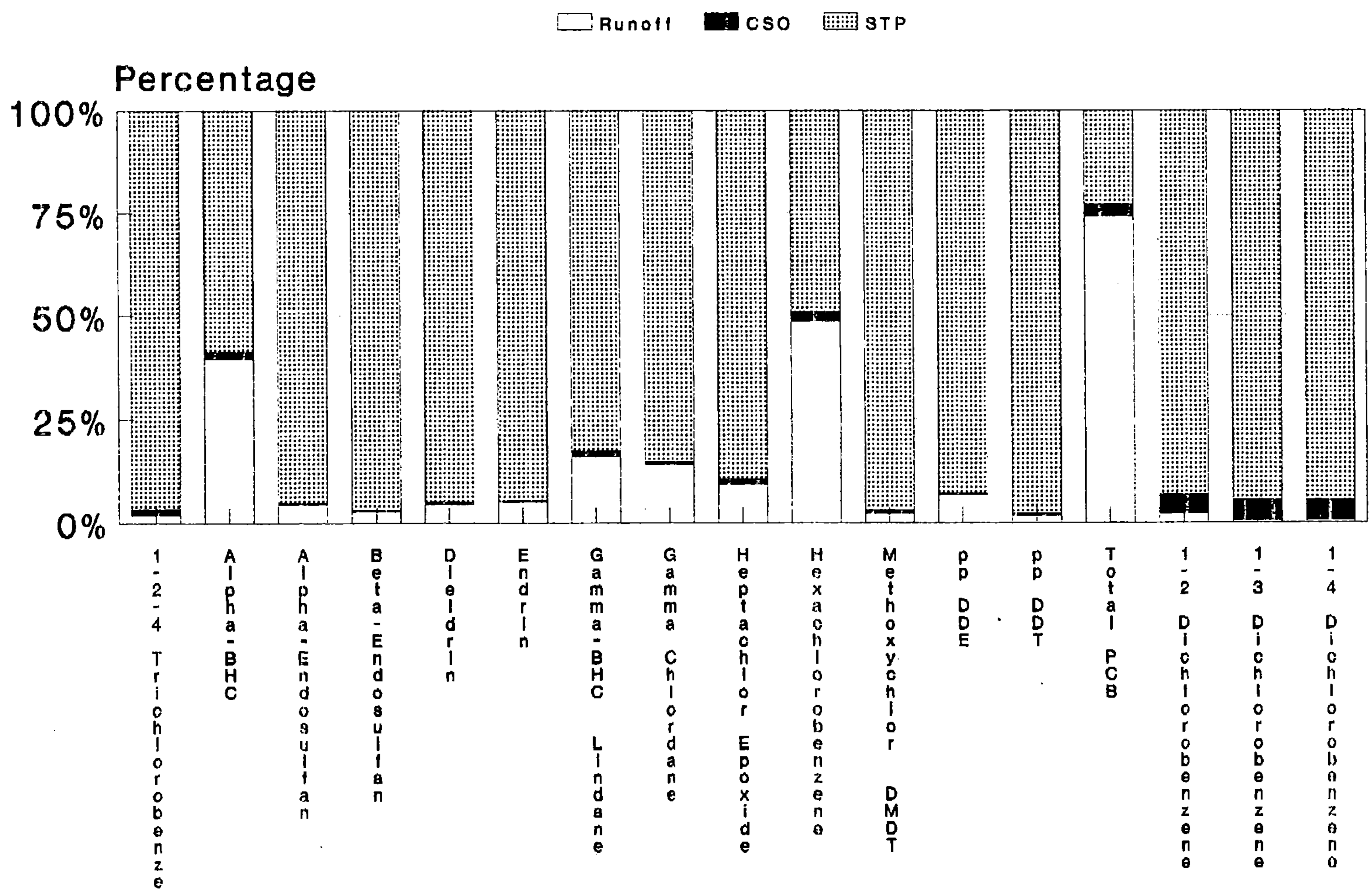
# Fig. 4.40 Distribution of flow & solids from each source, Toronto Waterfront



# Fig. 4.41 Distribution of loads for Toronto Waterfront Heavy Metals



# Fig. 4.42 Distribution of loads for Toronto Waterfront Organics



## 4.15 PORT HOPE

The computed annual flow volumes and solids discharged from surface runoff, and sewage treatment plant (STP) effluents are summarized in Table 4.29 for Port Hope, the only urban centre considered in the area. The relative distribution of these flow volumes and solids discharges among each loading source are displayed in Fig. 4.43.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.30. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.44, and in Fig. 4.45 for the organic compounds.

Table 4.29A Annual Flow Volumes (1000s m^3), Port Hope

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| PORT HOPE | 1580 | 0 | 1630 | 3210 |
| Totals | 1580 | 0 | 1630 | 3210 |

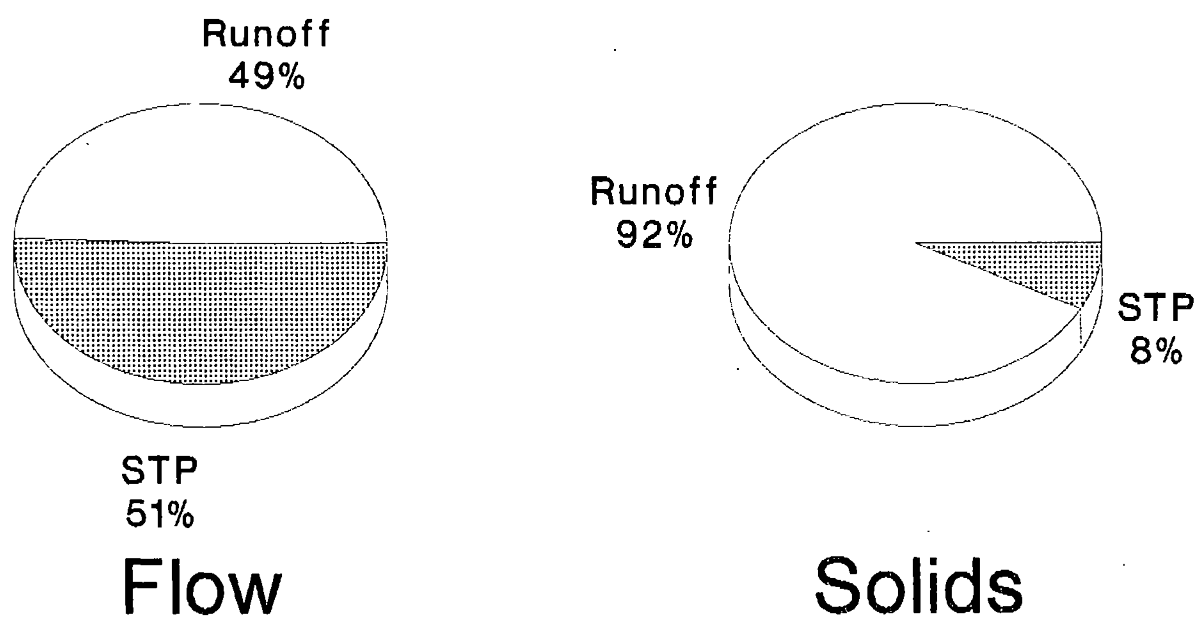
Table 4.29B Annual Solids Discharge (Tonnes), Port Hope

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| PORT HOPE | 310 | 0 | 26 | 336 |
| Totals | 310 | 0 | 26 | 336 |

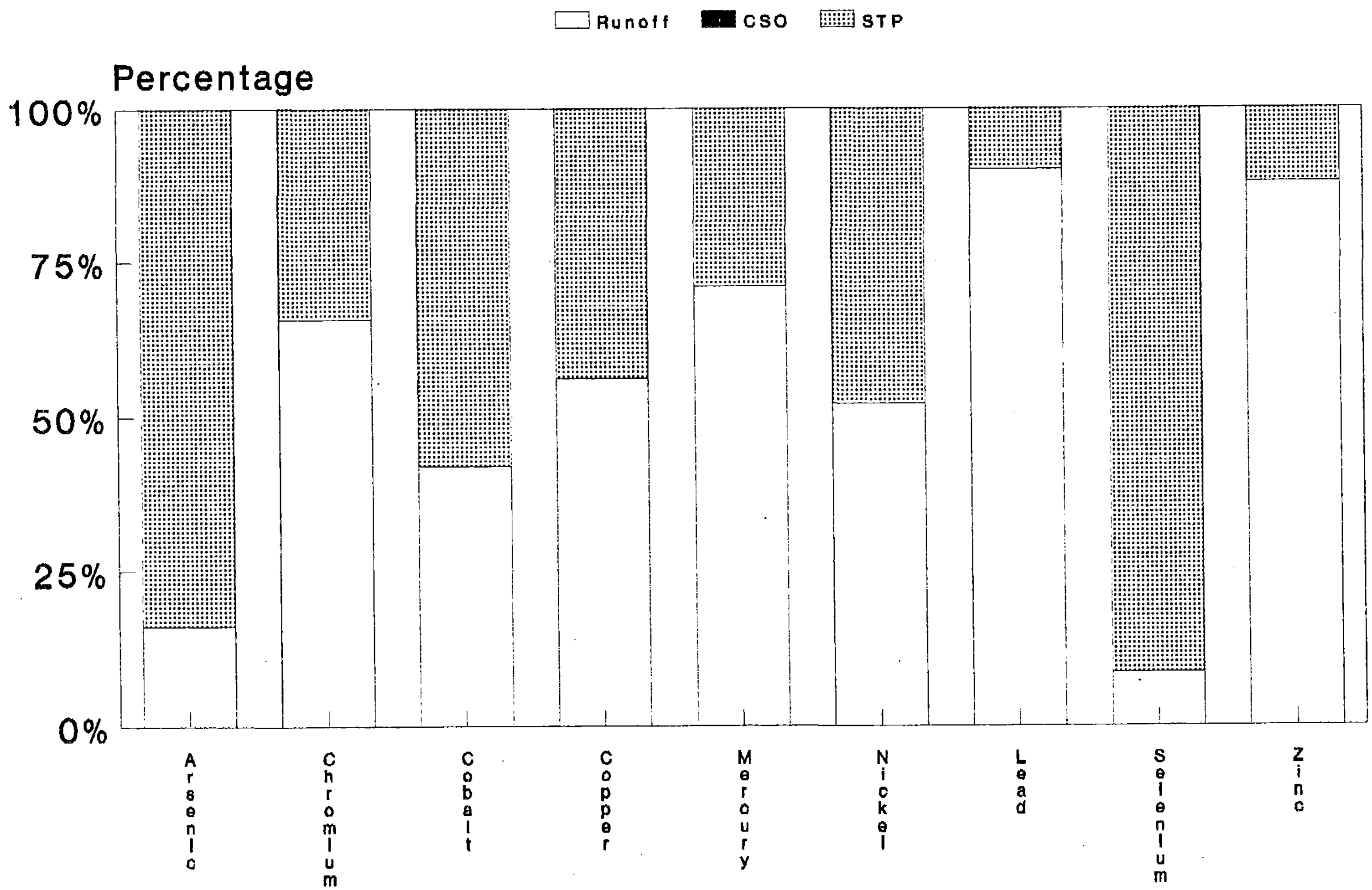
Table 4.30 Annual Contaminant Loads (kg ), Port Hope

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 5.23 | 0 | 27.3 | 32.5 |
| Chromium | 44.2 | 0 | 23.1 | 67.3 |
| Cobalt | 7.68 | 0 | 10.6 | 18.3 |
| Copper | 50.8 | 0 | 39.5 | 90.3 |
| Mercury | .120 | 0 | .0490 | .160 |
| Nickel | 40.8 | 0 | 37.7 | 78.5 |
| Lead | 288 | 0 | 31.8 | 320 |
| Selenium | 2.63 | 0 | 27.9 | 30.5 |
| Zinc | 820 | 0 | 112 | 932 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0050 | 0 | .0170 | .0220 |
| Alpha-BHC | .0320 | 0 | .0160 | .0480 |
| Alpha-Endosulfan (I) | .0022 | 0 | .0160 | .0190 |
| Beta-Endosulfan (II) | .0013 | 0 | .0160 | .0180 |
| Dieldrin | .0022 | 0 | .0160 | .0190 |
| Endrin | .0024 | 0 | .0160 | .0190 |
| Gamma-BHC (Lindane) | .0110 | 0 | .0330 | .0440 |
| Gamma Chlordane | .0077 | 0 | .0160 | .0240 |
| Heptachlor Epoxide | .0026 | 0 | .0083 | .0110 |
| Hexachlorobenzene | .0240 | 0 | .0083 | .0330 |
| Methoxychlor (DMDT) | .0042 | 0 | .0660 | .0700 |
| pp DDE | .0034 | 0 | .0170 | .0200 |
| pp DDT | .0015 | 0 | .0330 | .0340 |
| Total PCB | .330 | 0 | .0350 | .360 |
| 1-2 Dichlorobenzene | .0990 | 0 | 1.63 | 1.72 |
| 1-3 Dichlorobenzene | .0200 | 0 | 1.63 | 1.65 |
| 1-4 Dichlorobenzene | .0260 | 0 | 1.63 | 1.66 |

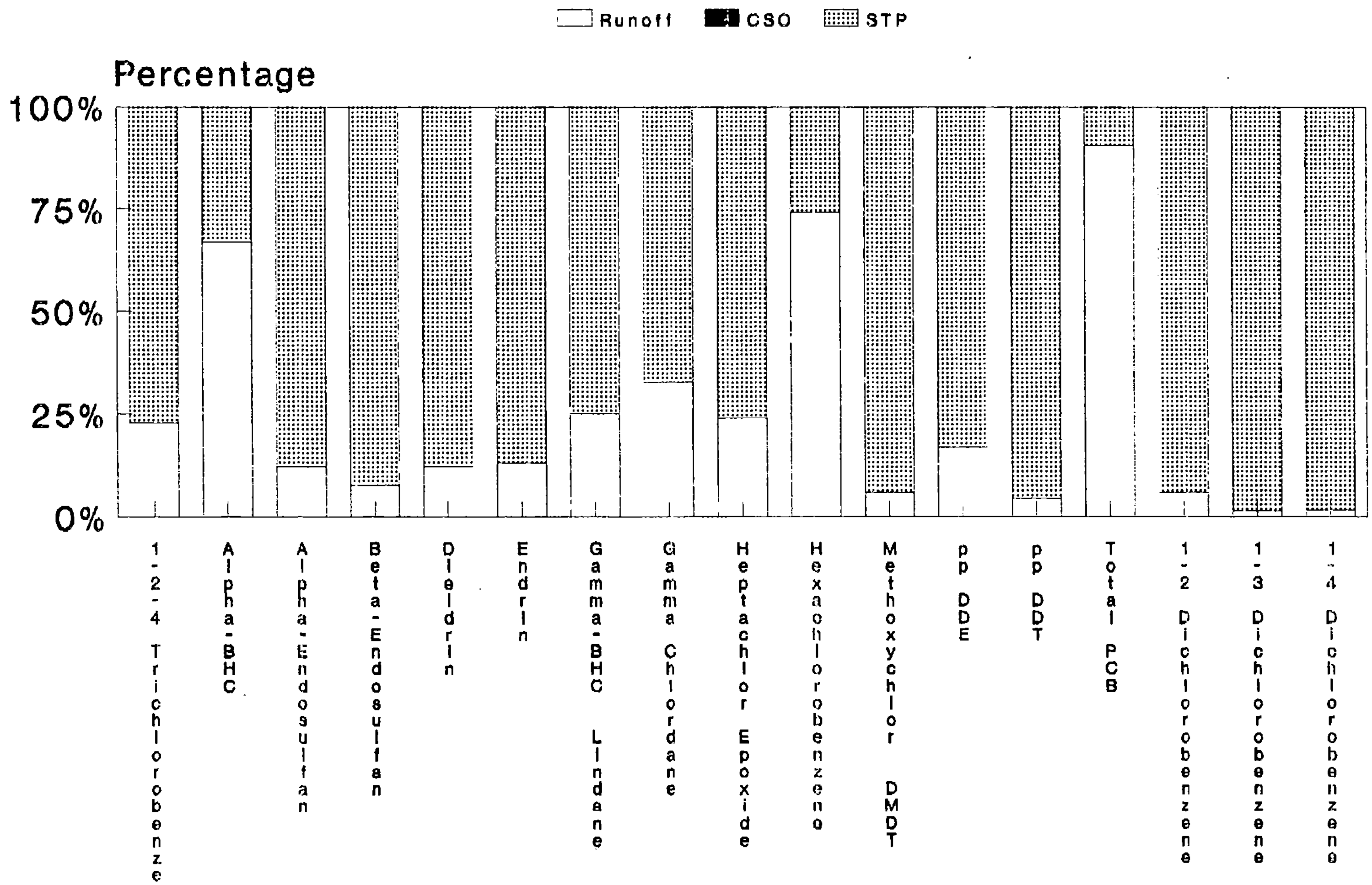
# Fig. 4.43 Distribution of flow & solids from each source, Port Hope



# Fig. 4.44 Distribution of loads for Port Hope Heavy Metals



# Fig. 4.45 Distribution of loads for Port Hope, Organics



## 4.16 BAY OF QUINTE

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.31 for each urban centre in the area. Six urban centres are considered in the Bay of Qunite RAP: Bath, Belleville, Deseranto, Napanee, Picton and Trenton. Fig. 4.46 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.32. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.47, and in Fig. 4.48 for the organic compounds.

Table 4.31A Annual Flow Volumes (1000s m^3), Bay of Quinte

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| BATH | 347 | 0 | 413 | 760 |
| BELLEVILLE | 7480 | 0 | 10800 | 18300 |
| DESERANTO | 385 | 0 | 457 | 842 |
| NAPANEE | 1660 | 59 | 1860 | 3580 |
| PICTON | 934 | 0 | 1020 | 1950 |
| TRENTON | 1990 | 0 | 4270 | 6270 |
| Totals | 12800 | 59 | 18800 | 31700 |

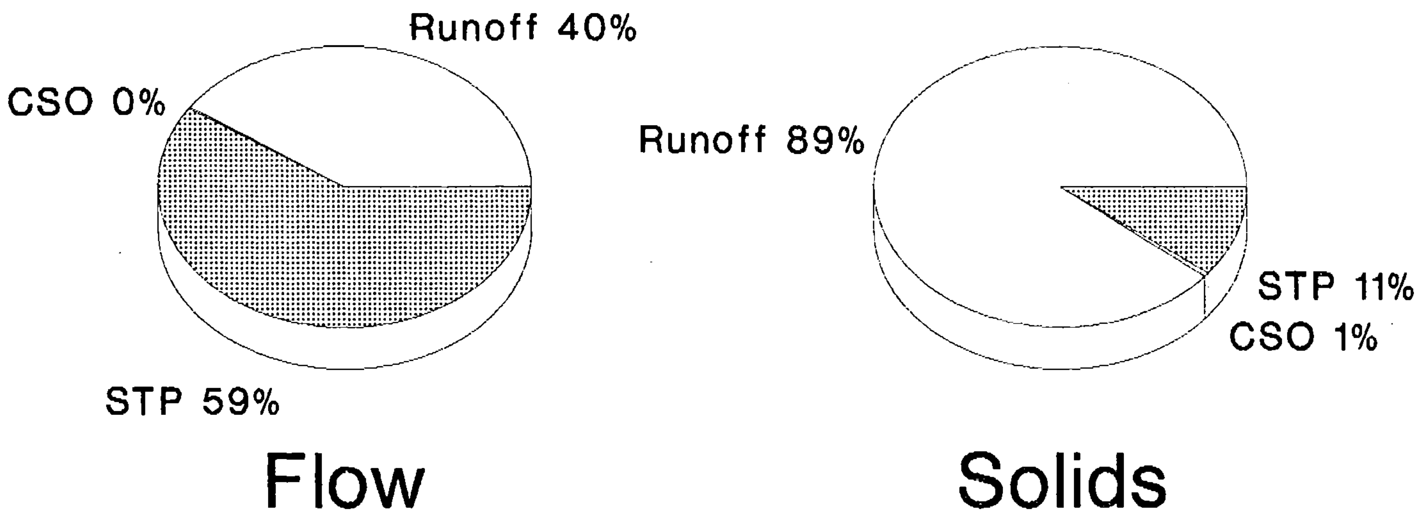
Table 4.31B Annual Solids Discharge (Tonnes), Bay of Quinte

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| BATH | 68 | 0 | 7 | 74 |
| BELLEVILLE | 1510 | 0 | 172 | 1680 |
| DESERANTO | 75 | 0 | 7 | 83 |
| NAPANEE | 326 | 14 | 30 | 370 |
| PICTON | 183 | 0 | 16 | 199 |
| TRENTON | 375 | 0 | 68 | 443 |
| Totals | 2540 | 14 | 301 | 2850 |

Table 4.32 Annual Contaminant Loads (kg ), Bay of Quinte

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| | Heavy Metals | | | |
| Arsenic | 42.6 | .230 | 316 | 358 |
| Chromium | 361 | 1.85 | 267 | 630 |
| Cobalt | 62.5 | .300 | 123 | 186 |
| Copper | 413 | 2.38 | 457 | 873 |
| Mercury | .940 | .0046 | .560 | 1.51 |
| Nickel | 332 | 1.57 | 436 | 770 |
| Lead | 2350 | 10.5 | 368 | 2720 |
| Selenium | 21.3 | .130 | 322 | 344 |
| Zinc | 6650 | 30.2 | 1290 | 7970 |
| | Organics | | | |
| 1-2-4 Trichlorobenzene | .0410 | .0002 | .190 | .230 |
| Alpha-BHC | .260 | .0012 | .190 | .450 |
| Alpha-Endosulfan (I) | .0180 | .0001 | .190 | .210 |
| Beta-Endosulfan (II) | .0100 | .0001 | .190 | .200 |
| Dieldrin | .0180 | .0001 | .190 | .210 |
| Endrin | .0200 | .0001 | .190 | .210 |
| Gamma-BHC (Lindane) | .0920 | .0004 | .380 | .470 |
| Gamma Chlordane | .0630 | .0003 | .190 | .250 |
| Heptachlor Epoxide | .0210 | .0001 | .0960 | .120 |
| Hexachlorobenzene | .200 | .0009 | .0960 | .300 |
| Methoxychlor (DMDT) | .0340 | .0003 | .760 | .800 |
| pp DDE | .0280 | .0001 | .190 | .220 |
| pp DDT | .0120 | .0001 | .380 | .390 |
| Total PCB | 2.67 | .0120 | .410 | 3.09 |
| 1-2 Dichlorobenzene | .800 | .0460 | 18.8 | 19.7 |
| 1-3 Dichlorobenzene | .160 | .0440 | 18.9 | 19.1 |
| 1-4 Dichlorobenzene | .220 | .0440 | 18.9 | 19.2 |

Fig. 4.46 Distribution of flow & solids from each source, Bay of Quinte



## Fig. 4.47 Distribution of loads for Bay of Quinte Heavy Metals

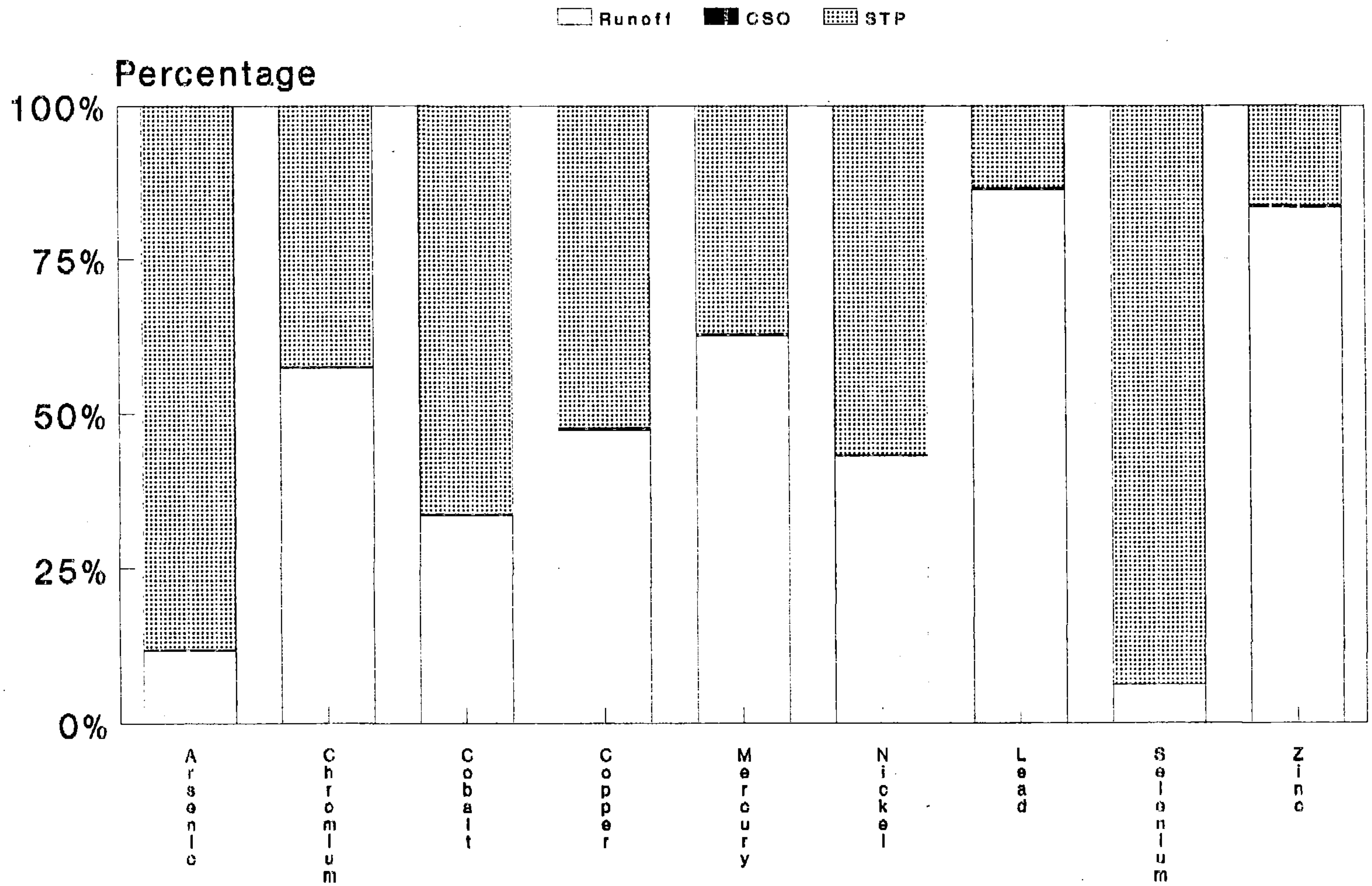
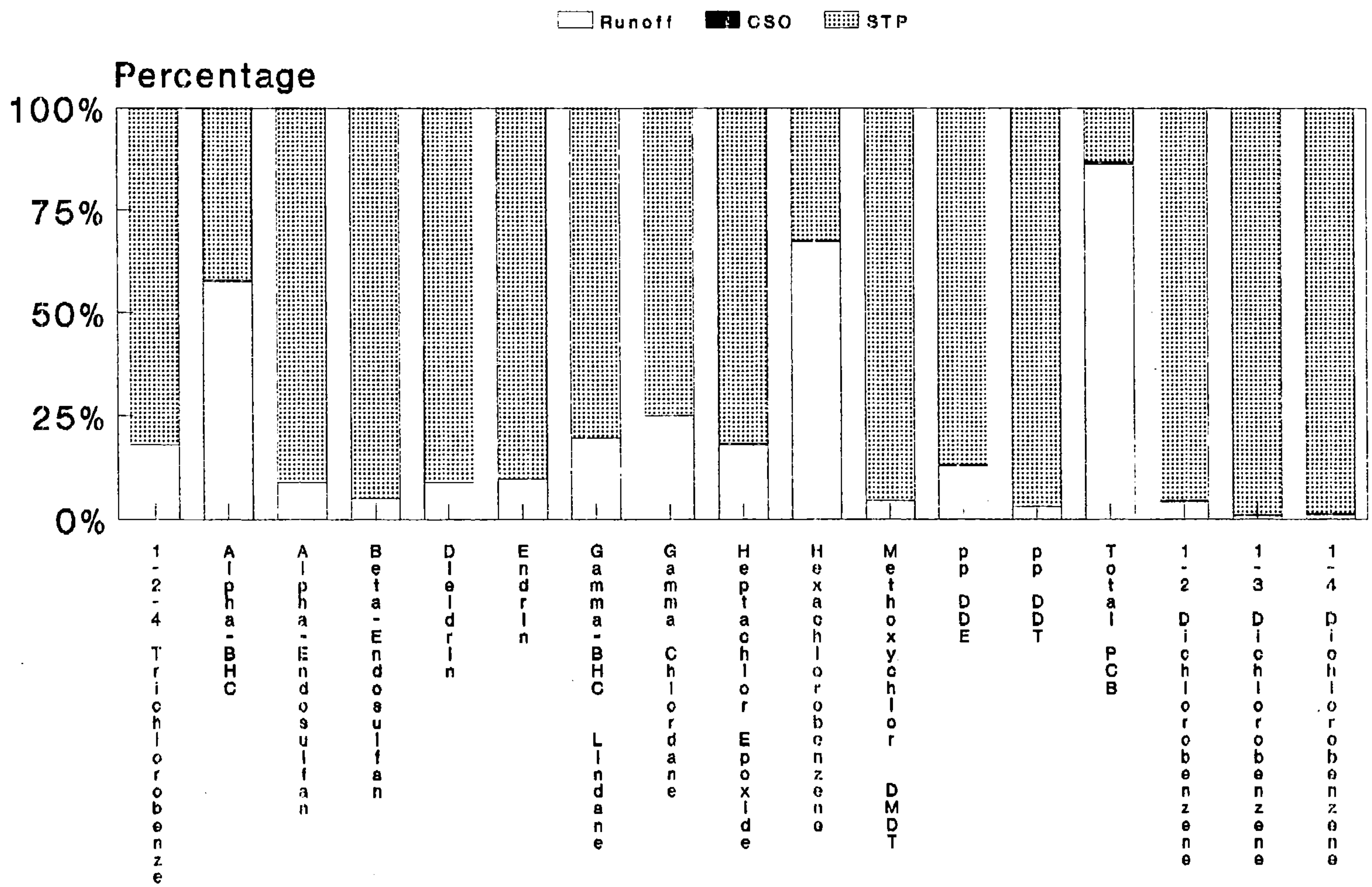


Fig. 4.48 Distribution of loads for
Bay of Quinte Organics



## 4.17 ST. LAWRENCE RIVER

The computed annual flow volumes and solids discharged from surface runoff, combined sewer overflows (CSOs), and sewage treatment plant (STP) effluents are summarized in Table 4.33 for Cornwall, the only urban centre considered in the area. Fig. 4.49 illustrates how these flow volumes and solids discharges are distributed among the various loading sources.

The annual loadings of 26 toxic contaminants (nine heavy metals, 13 pesticide/herbicides and three volatile organics) from each urban source are listed in Table 4.34. A comparison of the relative magnitudes of the heavy metals loadings from each source is presented in Fig. 4.50, and in Fig. 4.51 for the organic compounds.

Table 4.33A Annual Flow Volumes (1000s m^3), St.Lawrence River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| CORNWALL | 6530 | 1520 | 18100 | 26100 |
| Totals | 6530 | 1520 | 18100 | 26100 |

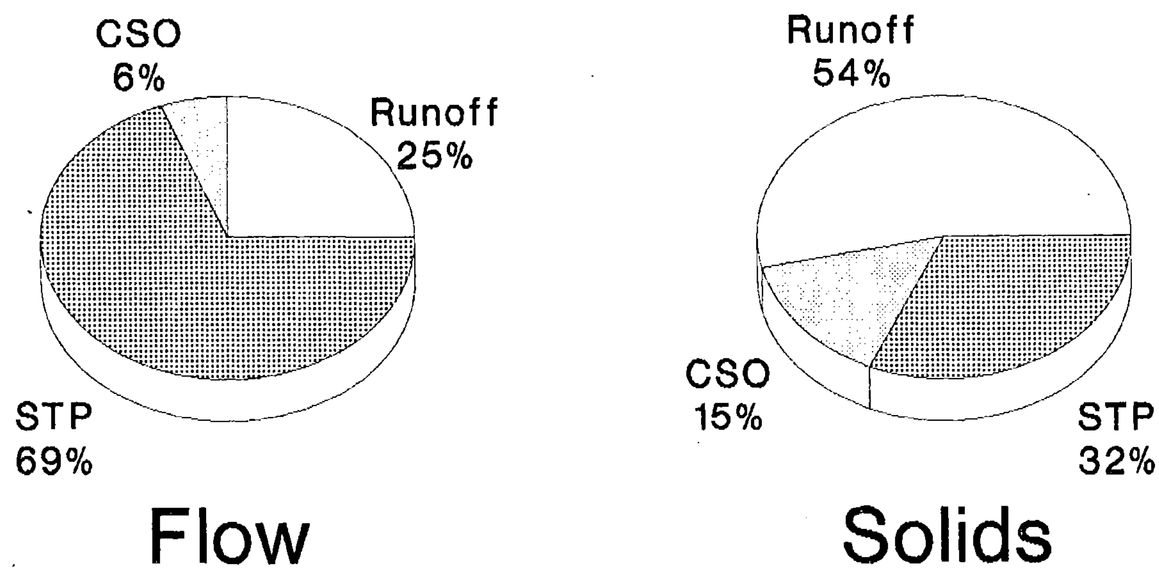
Table 4.33B Annual Solids Discharge (Tonnes), St.Lawrence River

| City | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| CORNWALL | 1220 | 339 | 723 | 2290 |
| Totals | 1220 | 339 | 723 | 2290 |

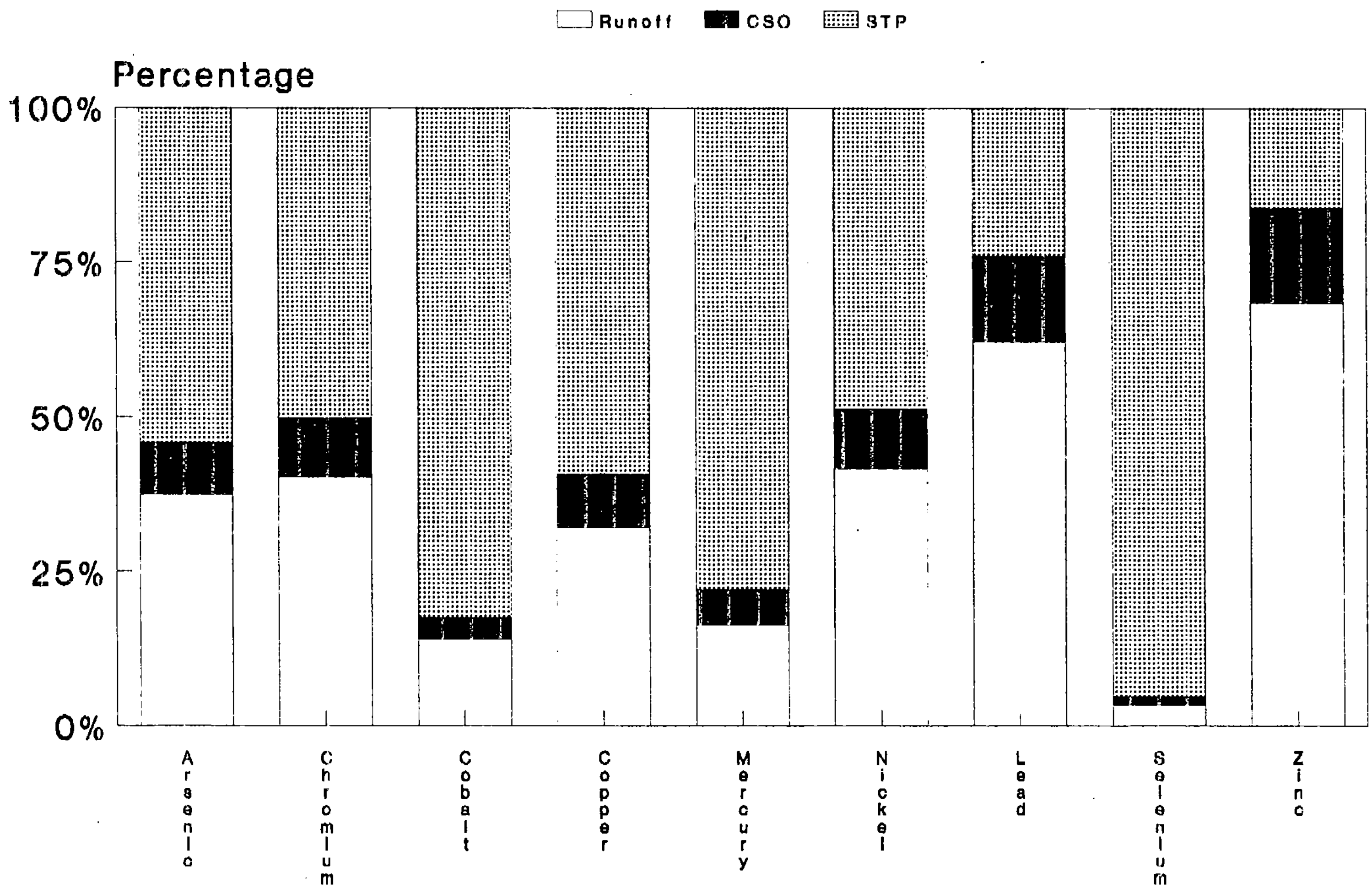
Table 4.34 Annual Contaminant Loads (kg ), St.Lawrence River

| Parameter | Runoff | CSO | STP | Total |
|---|---|---|---|---|
| Heavy Metals | | | | |
| Arsenic | 211 | 47.7 | 307 | 566 |
| Chromium | 176 | 41.6 | 220 | 438 |
| Cobalt | 31.1 | 7.83 | 183 | 222 |
| Copper | 206 | 54.6 | 380 | 641 |
| Mercury | .460 | .160 | 2.18 | 2.80 |
| Nickel | 166 | 38.9 | 195 | 399 |
| Lead | 1160 | 260 | 449 | 1870 |
| Selenium | 10.9 | 4.20 | 300 | 315 |
| Zinc | 3360 | 744 | 795 | 4900 |
| Organics | | | | |
| 1-2-4 Trichlorobenzene | .0200 | .0058 | .200 | .220 |
| Alpha-BHC | .130 | .0290 | .190 | .340 |
| Alpha-Endosulfan (I) | .0088 | .0031 | .180 | .200 |
| Beta-Endosulfan (II) | .0051 | .0023 | .180 | .190 |
| Dieldrin | .0087 | .0031 | .190 | .200 |
| Endrin | .0097 | .0032 | .180 | .200 |
| Gamma-BHC (Lindane) | .0470 | .0130 | .370 | .430 |
| Gamma Chlordane | .0310 | .0079 | .190 | .220 |
| Heptachlor Epoxide | .0100 | .0034 | .0940 | .110 |
| Hexachlorobenzene | .0960 | .0220 | .0950 | .210 |
| Methoxychlor (DMDT) | .0170 | .0140 | .760 | .790 |
| pp DDE | .0140 | .0051 | .180 | .200 |
| pp DDT | .0060 | .0059 | .370 | .390 |
| Total PCB | 1.29 | .290 | .950 | 2.53 |
| 1-2 Dichlorobenzene | .400 | 2.17 | 18.1 | 20.7 |
| 1-3 Dichlorobenzene | .0810 | 2.11 | 18.4 | 20.6 |
| 1-4 Dichlorobenzene | .110 | 2.12 | 18.4 | 20.7 |

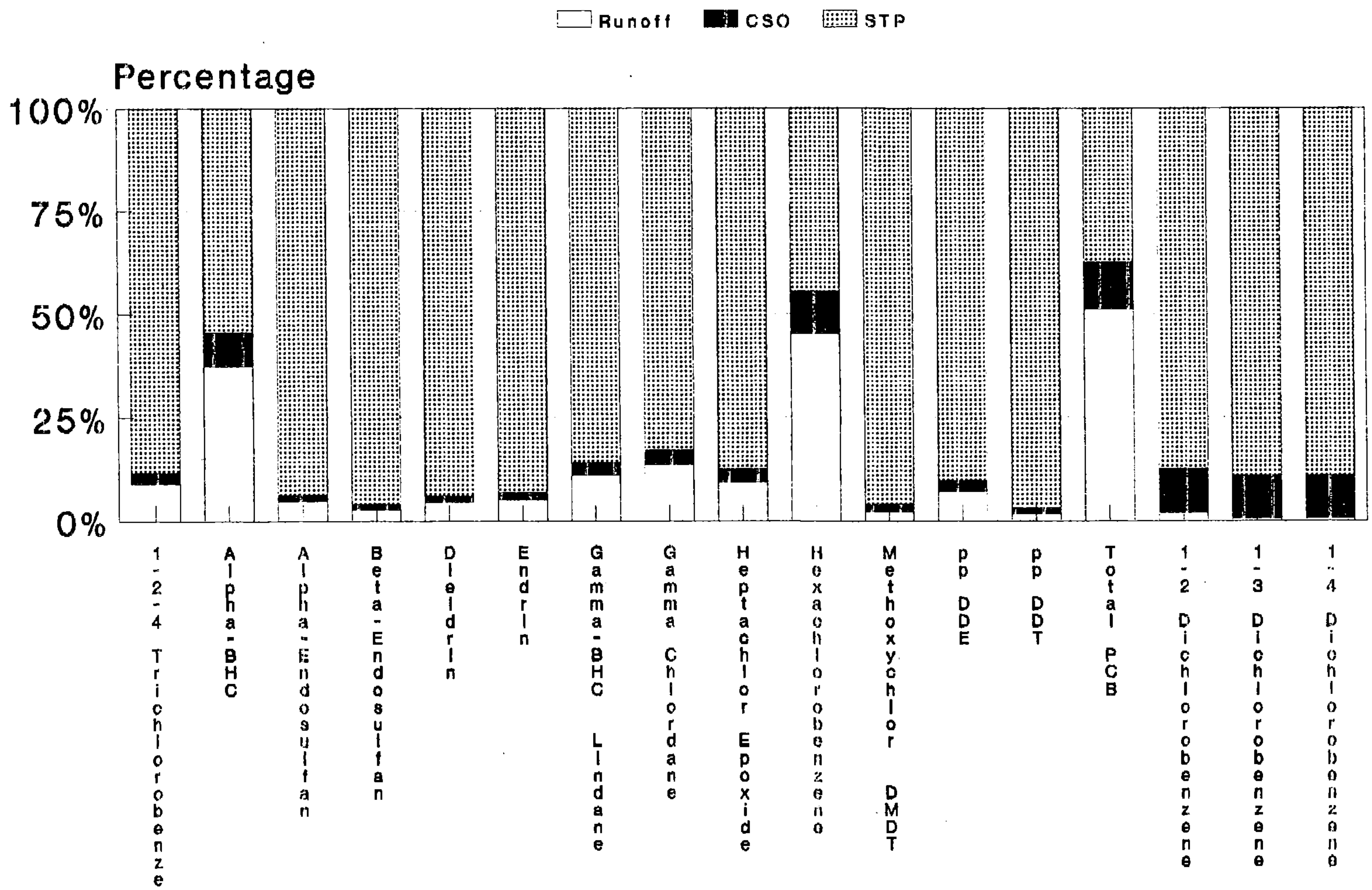
Fig. 4.49 Distribution of flow & solids from each source, St.Lawrence River



# Fig. 4.50 Distribution of loads for St.Lawrence River Heavy Metals



# Fig. 4.51 Distribution of loads for St.Lawrence River Organics



# 5. SUMMARY

The annual loadings of 26 toxic substances in urban stormwater runoff, combined sewer overflows (CSOs) and sewage treatment plant (STP) effluents have been estimated from existing data on toxic concentrations, and estimated annual flow volumes and solids loads for the various urban sources. The contaminant concentration data were collected in large urban and industrial catchments, and a few smaller communities with mostly residential land. These data were pooled together to compute loadings for other areas, specifically smaller communities with little industrial land, and other areas with different land uses. Therefore, the computed loads are considered order of magnitude estimates, which are sufficient for planning level analyses. A more accurate estimate requires site specific contaminant concentration data.

Flow volume and contaminant loadings were determined for 47 urban centres located in the 17 RAP areas. In this study, urban centres were defined as areas having sewage treatment plant (STP) serviced populations greater than or equal to 1,000 persons.

The annual distribution of flow volumes among the different sources varies significantly. Comparing flow volume estimates for Remedial Action Plan (RAP) areas:

- o surface runoff contributes 17 to 65%
- o CSOs contribute 1 to 6%
- o STP effluents contribute 35 to 80%

During wet weather, this distribution changes significantly,

- o surface runoff contributes 80%
- o CSOs contribute 7%
- o STP effluents contribute 13%

The annual distribution of solids loads among each source in the RAP areas differs somewhat, where

- o surface runoff contributes 49 to 96%
- o CSOs contribute 2 to 20%
- o STP effluents contribute 4 to 39%

During wet weather, the solids loads are almost entirely surface runoff and CSO sources.

The frequencies of detection for toxic substances in the existing surface runoff and STP database varied widely depending on the source, media sampled and the contaminants considered. In general, the frequencies of detection for sediment samples were about 50% higher than for water samples. Among the various contaminant groups, the highest frequencies were observed for the trace metals, followed by PCBs, pesticides/herbicides, volatile organic compounds, the base neutral/acid extractable organics, and the dioxin/furans.

In comparing the relative contributions from each source, the sewage treatment plant effluents contributed the highest loadings for all toxic contaminants considered, and the CSOs contributed the lowest loadings.

The trace metals generated the highest annual mass loadings. Among individual elements, the highest loads were estimated for zinc, lead, copper and then nickel. Among the PCB and pesticides/herbicides group, the highest loads were estimated for total PCBs, gamma-BHC, alpha-BHC, alpha-chlordane, and hexachlorobenzene.

No general statements can be made about the base neutral/acid extractable (BN/AE) organics, volatile organics and the dioxin/furan compounds, because concentration data was not always available for all three sources and the low detection frequencies preclude the computation of reasonable mean concentration estimates.

The annual contaminant loadings provide planning level estimates of municipal discharges, which can guide the development of remedial action plans, but it should be recognized that the relative magnitude of each loading source changes dramatically during wet weather periods (e.g. STP contributions decrease, and surface runoff and CSO contributions increase). The local impact of runoff and CSO discharges during wet weather can be significant. Improved estimates, using site specific contaminant data will be required for a detailed evaluation of their impact and the development of remedial options for these discharges.

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