METRO TORONTO
REMEDIAL ACTION PLAN

Stage 1:

Environmental Conditions and Problem Definition

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METRO TORONTO REMEDIAL ACTION PLAN
ENVIRONMENTAL CONDITIONS AND PROBLEMS

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METRO TORONTO REMEDIAL ACTION PLAN
ENVIRONMENTAL CONDITIONS AND PROBLEM DEFINITION

Report prepared by:

Environment Canada
Environment Ontario
Ministry of Natural Resources
Metropolitan Toronto and Region Conservation Authority

JULY 1993

FOREWORD

This document summarizes environmental conditions and identifies environmental problems in the Metro Toronto Area of Concern. The document was originally published in September 1988, in two parts: a stand-alone executive summary; and the detailed report. This format allowed greater use to be made of the document in public consultation activities. To date, most of the participants involved in the public advisory process have received the Executive Summary. Distribution of the main report has been limited primarily to members of the technical and public advisory committees, and to organizations or individuals desiring detailed information.

The document has been modified slightly in this release, by the addition of two summary tables located in the Foreword and the Executive Summary. Table I, provided at the end of this Foreword, gives a summary of the fourteen designated impairments cited in Annex 2 of the Great Lakes Water Quality Agreement, together with their relative significance to the Metro Toronto RAP. Table II, provided in the Executive Summary, gives a summary of the environmental problems and sources which are of greatest concern in the Metro Toronto RAP. The document contained herein constitutes the Stage I submission of the Metro Toronto Remedial Action Plan, in accordance with the Canada-Ontario commitment to the Great Lakes Water Quality Agreement.

The RAP development process has continued since the original writing of this report. A workshop was held in October of 1988 to discuss this report and the status of existing remedial programs. The workshop also began the process of consensus-building on goals for the RAP.

As a result of the workshop, a group of participants formed an interim committee to assist the RAP team and its public facilitator in the formation of a Public Advisory Committee. This group's efforts led to the formation of sector committees and a Public Advisory Committee. The sector committees have been meeting as required, typically monthly, since February 1989. These committees provide an opportunity for broad public input to the RAP, as any citizen with interest in the RAP can participate in their meetings. Each sector has selected members to represent them on the Public Advisory Committee (PAC). The PAC has been meeting since the end of March and is currently finalizing the goals of the Metro Toronto RAP. PAC meetings are currently scheduled on a monthly basis through to the end of the summer.

A technical advisory committee (TAC) was established in February. This committee is comprised of scientific and technical staff from government agencies, including the local and regional municipalities. Representatives from municipal works, health and planning departments are among the participants. Members of this committee have been co-ordinating the collection of information on pollution control programs for input to the RAP. Three reports dealing with municipal and and Conservation Authority programs are near completion. These reports will be used to formulate a prototype of a draft RAP which will be used as the basis for beginning the discussions leading to priority setting and selection of remedial options. The discussions will involve both the PAC and the TAC.

Technical studies continue as part of the long-term RAP development process. Several studies conducted through the RAP and through other programs such as the Municipal Industrial Strategy for Abatement (MISA) and the Toronto Area Watershed Management Strategy (TAWMS), will be completed in 1989. These will be used to supplement the information contained in this document at the time of the Stage II submission. Additional studies being undertaken this year include:

- fish community and habitat surveys to upgrade our knowledge of non-water quality fishery limitations and opportunities.

- a wet weather toxics survey to provide improved estimates of loadings of toxic organics from sewer outfalls and water pollution control plant discharges.

- biomonitoring and sediment sampling to prepare for future monitoring of the effects of remedial actions.

- socioeconomic studies dealing with benefit assessment and funding.

The current Metro Toronto RAP schedule is provided below. The RAP team has acknowledged that the need for meaningful input from the PAC and the TAC is of paramount importance. Target dates are therefore subject to change if either advisory committee feels that it is being given insufficient time to provide input.

Metro Toronto RAP - Timetable

Activity	Target Completion
Identification of Water Use Goals	2 Qtr 1989
Description of Technical Options	3 Qtr 1989
Selection of Preferred Options	4 Qtr 1989
Draft RAP (for PAC, TAC review)	1 Qtr 1990
Public Review of Draft RAP	3 Qtr 1990
Stage II Draft Report Submission (to RAP Steering Committee)	4 Qtr 1990

TABLE I

Summary of Potential Use Impairments as Cited in Annex 2 of the GLWQA and Their Significance to the Metro Toronto RAP

Potential Impaired Use	Significance to Metro Toronto RAP
i) Restrictions on fish or wildlife consumption.	Human consumption advisories exist for the larger sizes of several species because of mercury, PCB and Mirex levels. Evidence indicates that this is both a local and a lake-wide problem.
ii) Tainting of fish and wildlife flavour.	No reports of tainting.
iii) Degradation of fish and wildlife populations.	Historic degradation and loss of species dating back to the 1800's. Continued impact from urbanized area today.
iv) Fish tumors or other deformities.	Visual inspection of captured fish in recent studies has indicated no evidence of tumors. Tests of the Main STP effluent have shown it to be non-mutagenic.
v) Bird or animal deformities or reproductive problems.	Current reproductive rates of herring gulls and other species are normal. Incidence of deformities has declined. Organochlorine residues in gulls eggs have declined.
vi) Degradation of benthos.	Benthic communities in embayments and near river mouths are dominated by species indicative of organic enrichment. Densities are lower than in the past suggesting some improvement. Benthos bioaccumulate metals and trace organics.

TABLE I (cont'd)

Potential Impaired Use	Significance to Metro Toronto RAP
vii) Restrictions on dredging activities.	Sediments in most embayment areas exceed Ontario's open water disposal guidelines. Dredging has been subject to Environmental Assessment in the past and is likely to continue to be in the future.
viii) Eutrophication or undesirable algae.	Phosphorus often exceeds Provincial Water Quality Guideline of 20 µg/l across the waterfront. Algal and weed problems are restricted to the western shoreline because of lack of suitable substrate and wave action in other areas.
ix) Restrictions on drinking water consumption, or taste and odour problems.	No restrictions, based on current monthly sampling for 160 parameters. No reported taste or odour problems.
x) Beach closings.	Frequent beach postings as a result of stormwater and CSO contamination.
xi) Degradation of aesthetics.	Aesthetic concerns relate primarily to debris and litter. Turbidity is also a concern near river mouths and in the vicinity of lakefilling operations. Weed growth is a concern along the western shoreline.
xii) Added costs to agriculture or industry.	No evidence of impairment.
xiii) Degradation of phytoplankton and zooplankton populations.	Communities are influenced by lake-wide factors, physical factors and local pollution sources. Information is currently insufficient to determine relative significance of local sources.
xiv) Loss of fish and wildlife habitat.	Historic loss of habitat. Loss of riverine habitat continues. Contamination of existing or newly created habitats is of concern.

ACKNOWLEDGEMENTS

This document was prepared by the Metro Toronto Remedial Action Plan Team. The RAP Team membership currently includes:

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* Denotes writing team member
** Editor

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1.0 Introduction

The International Joint Commission (IJC) has identified 42 areas of concern in the Great Lakes basin. These are areas where Remedial Action Plans (RAPs) are to be developed to restore water uses and protect water supplies, recreation and aquatic life. The Toronto waterfront was identified as one of these areas of concern. The Metro Toronto Remedial Action Plan will include the waterfront from Etobicoke Creek to the Rouge River and all watersheds draining this area.

Environment Ontario and Environment Canada are jointly coordinating the preparation of the Metro Toronto RAP through a RAP team, with representatives from Environment Ontario, Environment Canada, the Metropolitan Toronto Region Conservation Authority, and the Ministry of Natural Resources. The RAP team membership will be expanded as the plan progresses, to reflect the needs of the development process.

The RAP team is responsible for the preparation of the RAP through consultation with all those with an interest in or responsibility for the area of concern. The RAP team is required to report to the IJC at 3 stages:

1. when the definition of environmental conditions and problems, including a statement of the goals, is complete;

2. when remedial and regulatory measures have been selected;

3. when monitoring indicates that identified beneficial uses have been restored.

To date, the RAP team has concentrated on defining the current environmental conditions; identifying impaired uses, describing the causes of impairment, identifying and quantifying the known sources of pollution and documenting the status of remedial programs. This report summarizes the current status of the Metro Toronto RAP area.

1.1 The RAP Process

Implementation of the remedial action plan will be the joint responsibility of all jurisdictions and interests with a direct responsibility for the area of concern. The RAP needs, therefore, to reflect the priorities and concerns of the community as well as established international, federal and provincial water quality objectives. It is essential that the local communities in the Toronto area see the RAP as a means of achieving their goals for the area of concern. In order for RAPs to reflect community views, the local public must be actively involved in and consulted during the development of the plan.

The RAP team has established an approach which reflects the need for strong public involvement. The approach includes a general public involvement program, a public advisory process and a technical advisory committee.

A prerequisite to effective public involvement is an informed public. A general public involvement program has therefore been established to inform the public about: the RAP process; the area of concern, including its geographic boundaries, current water quality conditions, problems, and sources and impaired uses; remedial measures currently planned or underway; and opportunities for public involvement as the RAP progresses.

Supplementing the general program, is the public advisory process, which allows direct involvement in the RAP. The public advisory process reflects the need for strong public input into all stages of the RAP. To date, public meetings have been held with different sectors of the public and informal discussions have been held with interest groups. A workshop will be held in the fall of 1988 to gain further public input. The public advisory process will continue throughout the RAP development, through regular workshops and/or the creation of a public advisory committee. A facilitator has been hired to assist in the public advisory process.

The technical advisory committee will function under the direction of the RAP team and will be responsible for taking the views of the public into account during the development of remedial options. The committee will have technical experts from agencies or departments having responsibilities for the protection of the environment.

An interactive planning process is being used to develop the RAP. The public will articulate the goals and objectives of the RAP, the technical committee will develop and cost remedial options; the public will evaluate the options and recommend choices; the RAP team will prepare a draft RAP on the basis of these recommendations and the input of the technical advisory committee; the public will review and respond to the draft(s); the RAP team will prepare a final RAP for implementation; the public will review and monitor the plan's implementation.

1.2 Future of the RAP

This document summarizes the current status of the Metro Toronto RAP area. It contains the most up to date information available. Studies continue within the study area, and new information will be incorporated as it becomes available.

Sections of the report describe:

i) the area and existing beneficial uses;
ii) the existing environmental conditions and indicators of impairment;
iii) the problems and concerns;
iv) the sources of the problems including their relative magnitude;
v) the remedial programs and actions which are in progress.

The reader is encouraged to review and comment on the report. Written comments received will, together with the results of public discussions, lead to the establishment of use goals and subsequent identification and costing of additional remedial options. The options selected for consideration will be presented for public discussion and review prior to development of a draft RAP.

2.0 DESCRIPTION OF THE AREA

Once cradled in the only natural harbour on Lake Ontario's northwestern shores, Metropolitan Toronto has expanded to become the commercial, industrial and administrative hub of the province of Ontario. Port activities and development have literally reshaped the face of Toronto's waterfront through dredging, land reclamation and lakefilling over the past 150 years (Central Waterfront Planning Committee 1974). A 5 km long headland to provide an outer harbour for port expansion is now one of Toronto's most prominent shoreline features. Lakefilling remains a major means of expanding public ownership and recreational use of the waterfront, and a number of lakefills dot the shoreline.

With a population of 2.1 million (according to 1985 Federal census estimates), over 3 million including the greater Metro area, and one third of Ontario's population, Metropolitan Toronto has become an international city with a conglomeration of diverse resources and services, meeting business, lifestyle and recreational needs. The waterfront and forested river valleys which link inland open spaces are sources of civic pride. The 45 km shoreline provides many regional public attractions such as Exhibition Park, Ontario Place, Centre Island and Harbourfront, as well as many swimming beaches and protected mooring for over 7,000 small craft. These amenities are focal points for a prosperous tourist industry. The 1987 attendance at Harbourfront alone was 3.3 million (Harbourfront Corporation personnel communication).

In the past decade, as a result of Canadian and American fish stocking programs, a world class salmon and trout fishery has developed in the nearshore area off Toronto and produced a multimillion dollar tourist and support industry. Derbies such as the Toronto Star Great Salmon Hunt and the Sun/Bud Fishing Derby log tens of thousands of participants annually.

Unfortunately the watercourses and nearshore waters of Lake Ontario on which Toronto residents depend for their recreation, sportfish, livelihood and drinking water, have also been increasingly affected by the effects of urbanization and the discharge of wastes. Beneficial uses of the waterfront and the nearshore waters have been impaired because of bacterial contamination, elevated nutrient levels, discharges of toxic metals and organics, and accumulations of contaminated sediments. The problems of the waterfront extend up the rivers which drain the highly urbanized watersheds.

2.1 LOCATION

As noted previously, the Metropolitan Toronto area of concern includes the waterfront and the adjacent drainage basins (Fig.2.1). From west to east these include Etobicoke Creek, Mimico Creek, the Humber and Don Rivers, Highland Creek and the Rouge River. These are separated into western and eastern sectors by the Port of Toronto which encompasses the Don River, Ontario Place, the inner and outer harbours, the Toronto Islands and the Eastern Headland. This 2,000 km^2 area includes the Regional municipalities of Metropolitan Toronto, Peel and York and the following local municipalities: Etobicoke, North York, York, Toronto, East York, Scarborough, Mississauga, Brampton, Caledon, King City, Richmond Hill, Vaughan, Whitchurch-Stouffville and Markham.

2.2 WATERCOURSE CHARACTERISTICS

Table 2.1 provides, in chart form, the significant characteristics of each watercourse. In general, the watercourses are relatively short and react quickly to rainfall events. In specific instances, the rapid response of the watercourses has been increased by the conversion of land from rural to urban use.

Figure 2.2 shows general physiographic features of the drainage basins.

The Oak Ridge Moraine Complex

Stretching across the northern boundary of the RAP area, this regionally significant landform is the divide for streams draining to Lake Ontario and those draining to the north. The Moraine is referred to as interlobate, having been formed between two ice lobes during the last glacial period, and has the characteristics typical of such features - knobby hills,

FIGURE 2.1: THE RAP STUDY AREA

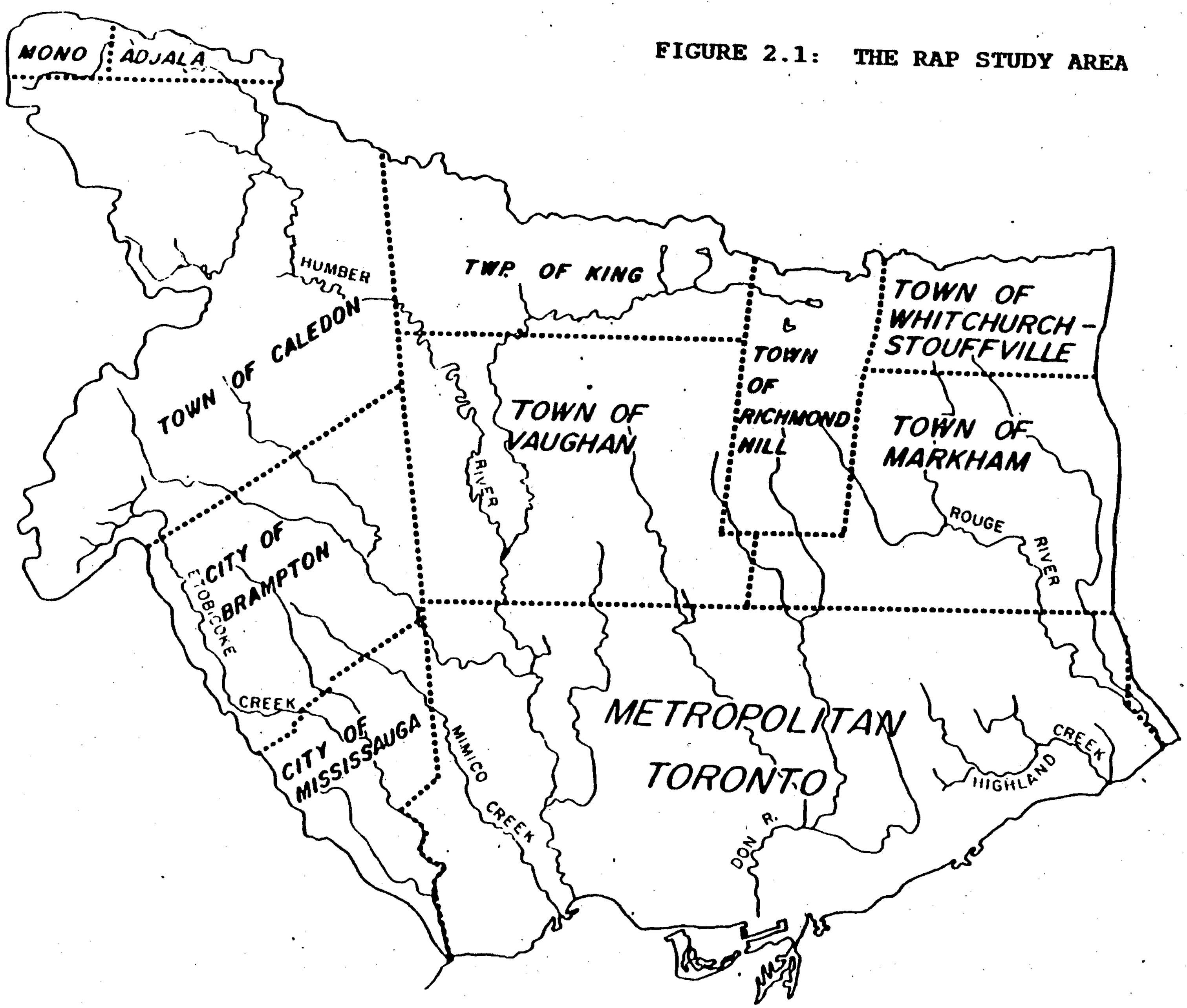
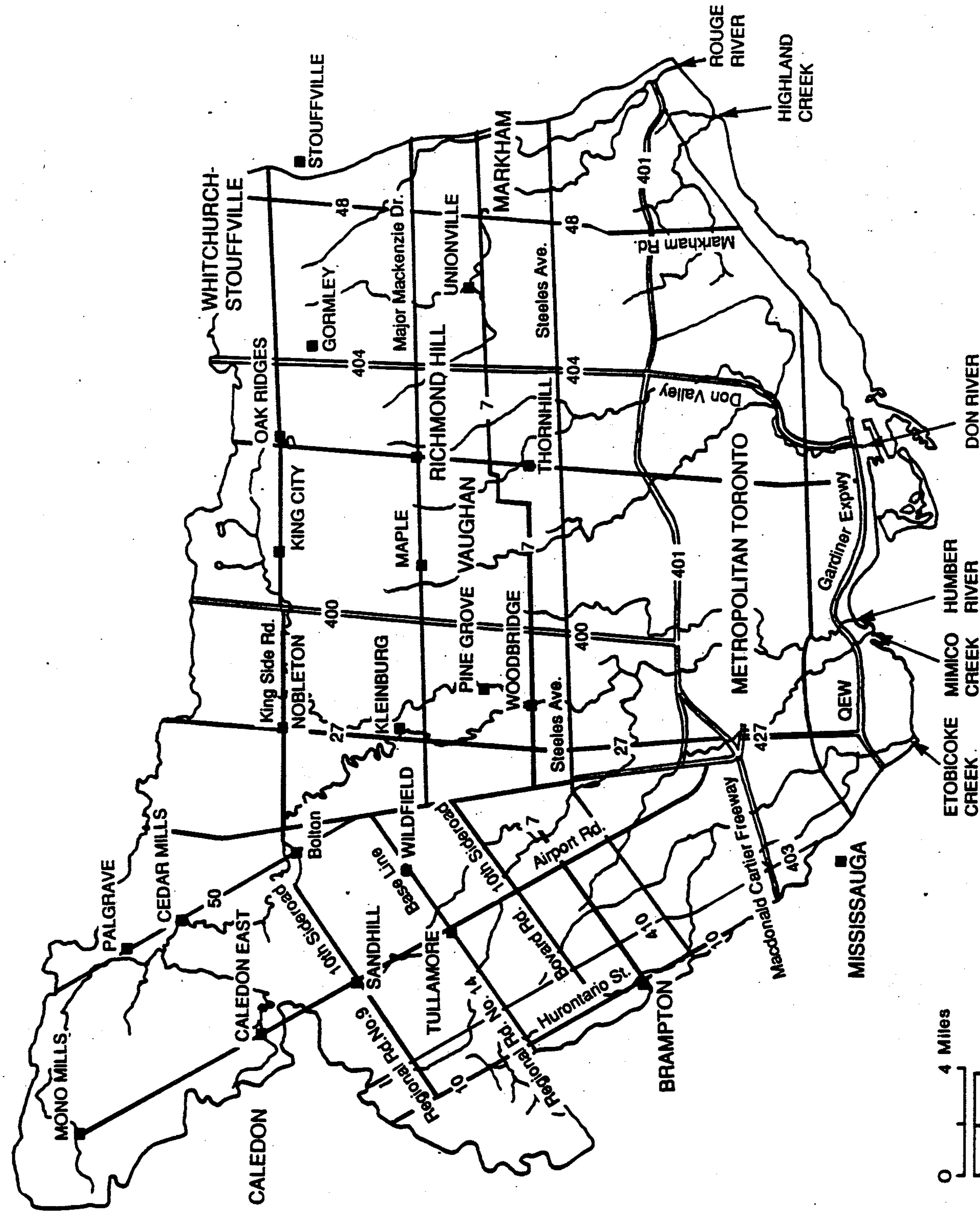


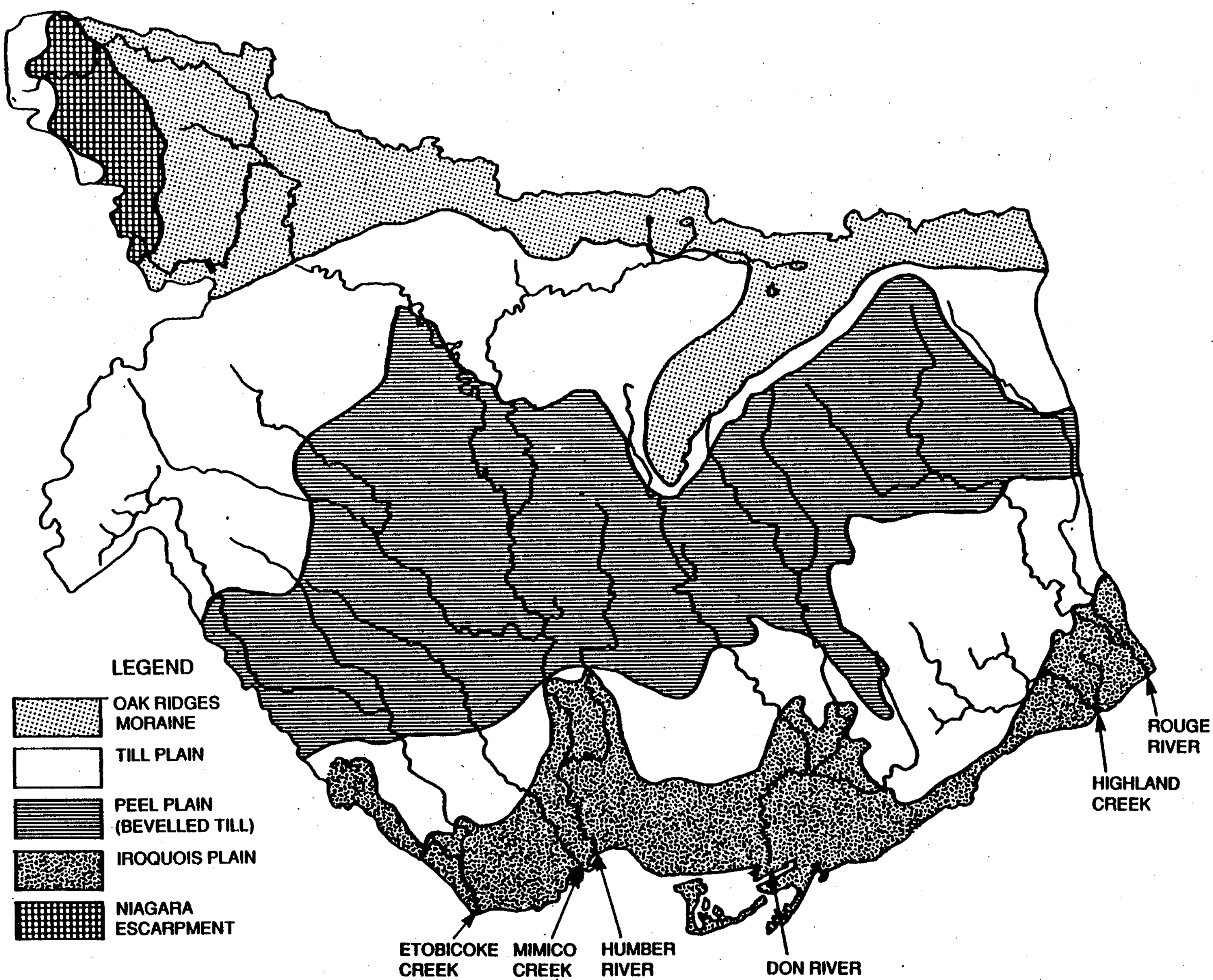
TABLE 2. 1: WATERSHED CHARACTERISTICS

WATERCOURSE	DRAINAGE AREA	SOURCE AREA	CONFLUENCE	GRADIENT	PHYSIOGRAPHIC INFLUENCE	ADJACENT LAND USE
Etobicoke	207 km2	**East Branch**—Heart lake **West Branch**—Till Plain **Little Etobicoke**—Till Plain	**East & West**—north of Bloor Street **Little Etobicoke**—at the Queensway	**Main & West**—3.0m/km **East**—4.5m/km **Little Etobicoke**—11.4m/km	Till Plain and Peel Plain predominate. Iroquois Plain in lower reaches	Rural reaches rural, central and lower reaches urban
Mimico	28 km2	Rises on Peel Plain	East & West at— Ferry Road	4.9m/km	Peel Plain in north, Till Plain in central sector; Iroquois Plain downstream	Predominately urban with development occurring in upper reaches
Humber	857 km2	**West**—Till Plain **Main**—Niagara Escarpment & Moraine **East**—Willow Lake **Black Creek**—Peel Plain	**Main & East**—at Woodbridge **Main & West**—at Thistletown **Main & Black Creek**—west of Scarlett Road	**West**—4.6m/km **East**—4m/km **Main**—above Cedar Mills 10m/km —Below Cedar Mills 2.5m/km	**West**—Till Plain and Peel Plain **Main**—Niagara Escarp. Moraine, Till Plain, Peel Plain and Iroquois Plain **East**—Till Plain and Peel Plain **Black Creek**—Peel Plain and Iroquois Plain	Predominately rural upstream of Metropolitain Toronto. Heavily urban in Metro
Don	360 km2	**West**—northwest of Maple East (Little Don)—Richmond Hill Area **German Mills Creek**—West of Richmond Hill **Massey Creek**—edge of Peel Plain	**German Mills Creek and East Branch**—at Steeles Avenue **West,East and Massey Creek**—near Don Mills Road and Don Valley Parkway	6m/km	**Upper**—Till Plain and Peel Plain **Lower**—Iroquois Plain	Heavily urbanized with some rural remnants in upper sections(except Massey Creek)
Highland	107 km2	**Rises in north Scarborough**—vicinity of Milliken—Till Plain	Morningside Park	**Upper reaches**—7.8m/km **Lower reaches**—3m/km	Predominately Till Plain. Iroquois Plain in lower reaches	Urban (Scarborough)
Rouge	327 km2	Along southern edge of Moraine	Main Confluence north of Highway 401	**Upper reaches** —25m/km **Lower reaches**—2.5m/km	Southern edge of Moraine, then south across across Peel Plain, Till Plain and Iroquis Plain	Predominately rural, urban in lower reaches


ROUGE RIVER
HIGHLAND CREEK
STOUFFVILLE
WHITCHURCH-STOUFFVILLE
MARKHAM
UNIONVILLE
GORMLEY
Major Mackenzie Dr.
Markham Rd.
Steeles Ave.
401
48
404
OAK RIDGES
RICHMOND HILL
THORNHILL
Don Valley
DON RIVER
KING CITY
MAPLE
VAUGHAN
7
METROPOLITAN TORONTO
Gardiner Expwy
HUMBER RIVER
MIMICO CREEK
ETOBICOKE CREEK
400
King Side Rd.
NOBLETON
KLEINBURG
PINE GROVE
WOODBRIDGE
QEW
427
27
Bolton
WILDFIELD
10th Sideroad
Airport Rd.
Macdonald Cartier Freeway
403
MISSISSAUGA
CEDAR MILLS
PALGRAVE
50
CALEDON EAST
SANDHILL
Base Line
TULLAMORE
Boyaird Rd.
410
BRAMPTON
Hurontario St.
Regional Rd. No. 14
Regional Rd. No. 9
10
MONO MILLS
CALEDON
0
4 Miles
6 Km

OVER ►

FIGURE 2. 2: METRO TORONTO RAP PHYSIOGRAPHIC FEATURES



kettle lakes, and a complex mix of glacially deposited sand, gravel and till with outcrops of boulders and clay.

On the crest of the Moraine itself, few streams are found, however, precipitation falling over the land percolates through the porous materials until impervious material is reached, then flows horizontally, and surfaces as numerous feeder streams along the slopes of the Moraine.

Niagara Escarpment

The Niagara Escarpment, in the northwest section of the study area is the headwaters of the main branch of the Humber River. This landform was created over 400 million years ago and is composed of layers of shale, limestone, sandstone and dolomite. Subsequent erosion and the deposition of a mantle of glacial drift have given the Escarpment its present characteristics.

Till Plain

The Till Plain is a glacial feature exhibiting the characteristics of a ground moraine - from relatively little relief to areas of irregular knolls and hollows. In the eastern parts of the watershed the till materials are sandy, while toward the west, clay predominates. Tributaries of the Etobicoke, Humber, Don, and Rouge, traverse the Plain, cutting sharp valleys where the flow is at right angles to the slope.

Peel Plain (Bevelled Till)

An undulating clay plain, underlain by till or boulder clay stretches through the western and central portions of the region. The heavy textured clays and isolated sandy areas may have been deposited by a temporary glacial lake. The Brampton Esker, a narrow gravel ridge, cuts across the Plain in the Region of Peel and is a source area for Etobicoke Creek. Tributaries and main branches of the Etobicoke and Mimico creeks and the Humber, Don, and Rouge Rivers cut valleys of varying depths in the Peel Plain.

Iroquois Plain and Shoreline

During glaciation, the lowlands of Lake Ontario were inundated by the waters of glacial Lake Iroquois covering previous clay and till deposits and adding, in some locations, a layer of sand. The shoreline of this glacial lake is evident across the central and eastern part of the region and, at the Scarborough Bluffs, becomes nearly coincident with the present shoreline of Lake Ontario.

The river mouths and bays of the rivers and creeks of the watershed are found on this plain. Post-glacial erosion and deposition have modified the valley features. The land between the valleys is characterized by clays and till.

2.3 LAKE ONTARIO SHORELINE

Along the western waterfront, the shoreline west of the Humber River is relatively inaccessible to the public , partly because of extensive private property ownership (motels, Palace Pier condominium, apartments, houses) and partly because of rapid drop to the water's edge. Two Lakefill projects in this area have increased public access to the western waterfront (Colonel Sam Smith Park and Humber Bay Park). A user satisfaction survey (MTRCA, 1985a) has indicated that swimming pools are a high priority request among user groups because poor water quality has curtailed use of nearshore swimming areas.

East of the Humber River, the gently sloping shoreline is readily accessible along the Western Beaches. The shoreline is a continuous sandy strip for approximately 2 km reaching as far as the Boulevard Club. The sandy beach is bordered to the north by parkland providing recreational facilities such as playgrounds and picnic areas. The Sunnyside pool and adjacent beach serve as focal points for swimming activities in the area.

East of the Western Beaches, the shoreline is generally more steeply sloping, and thus less suitable for swimming. Nevertheless, it does provide a base for other water-related recreational facilities such as the Toronto Sailing and Canoe Club, the Argonaut Rowing Club and a number of marinas.

The Central Waterfront is dominated by the port area of the City of Toronto, which is enclosed by natural and man-made features. The shoreline in the vicinity of Toronto harbour, is composed predominantly of recent sand and silt-sand deposits derived from the erodible Scarborough Bluffs. Extensive filling has taken place historically, resulting in the creation of the port area and much of the waterfront in this area.

Construction of the East Headland (Leslie Street Spit) has resulted in the creation of 130.28 ha of land during the period 1956 to 1987 (THC, 1987a and 1987b). The East Headland consists of three containment cells for the placement of contaminated dredgeate and an endikement for armouring against wave-action dispersal of the dredgeate material. Completion of the adjacent Tommy Thompson Park (Aquatic Park) will provide habitat for flora and fauna in a protected area, as well as providing parkland for public use. The construction of marina facilities here is expected to relieve some of the pressure for wet-berth space for boaters.

The principle shoreline features of the Eastern Waterfront, from west to east, are Ashbridge's Bay, the Eastern Beaches and the 100 m high Scarborough Bluffs. During 1972 to 1976, lakefilling operations at Ashbridges Bay created over 17 ha of parkland and 7.3 ha of protected water area (OMOE, 1988). Over the years, measures such as hard points, extending out from the beaches and an offshore rubble breakwater, have been constructed to protect beach areas from erosion.

Efforts have also been made to protect the toe of the Scarborough Bluffs, though much of the shoreline remains in a relatively unprotected state. Lakefilling at Bluffer's Park has created a 42 ha expanse of protected moorings, public lands and artificial beach with armoured headlands.

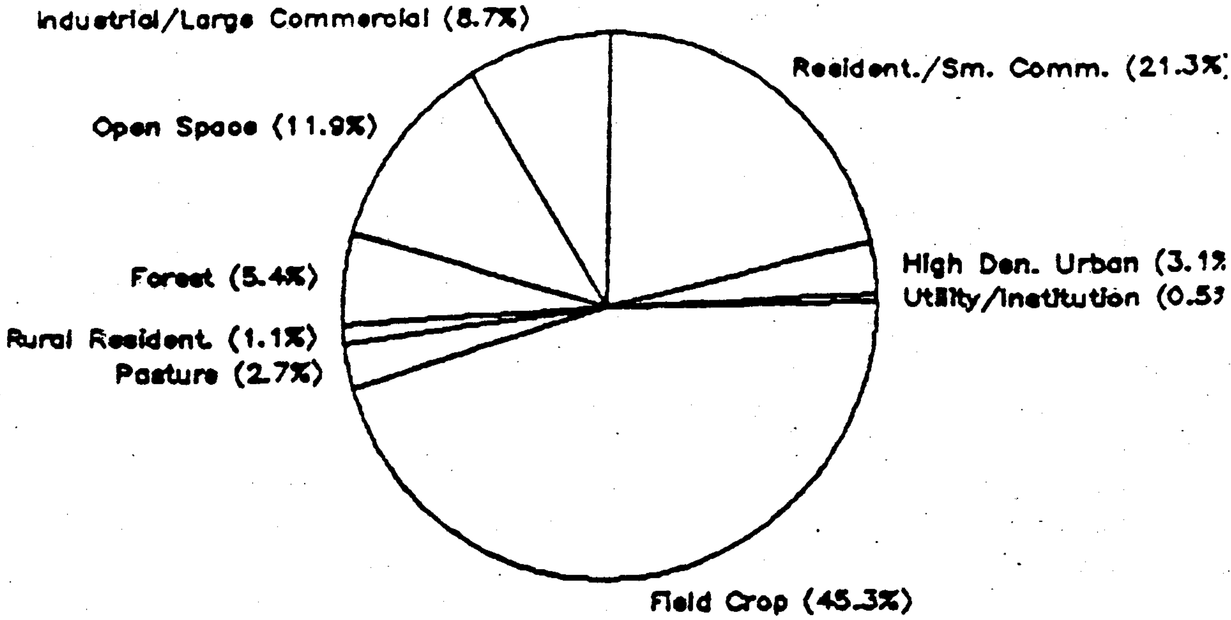
2.4 LAND USES

A listing of existing land use is provided in Table 2.2 for the six watersheds within the Metro Toronto RAP area, Figure 2.3 indicates the relative size and rural/urban breakdown of the watersheds.

BY WATERSHED (1983)

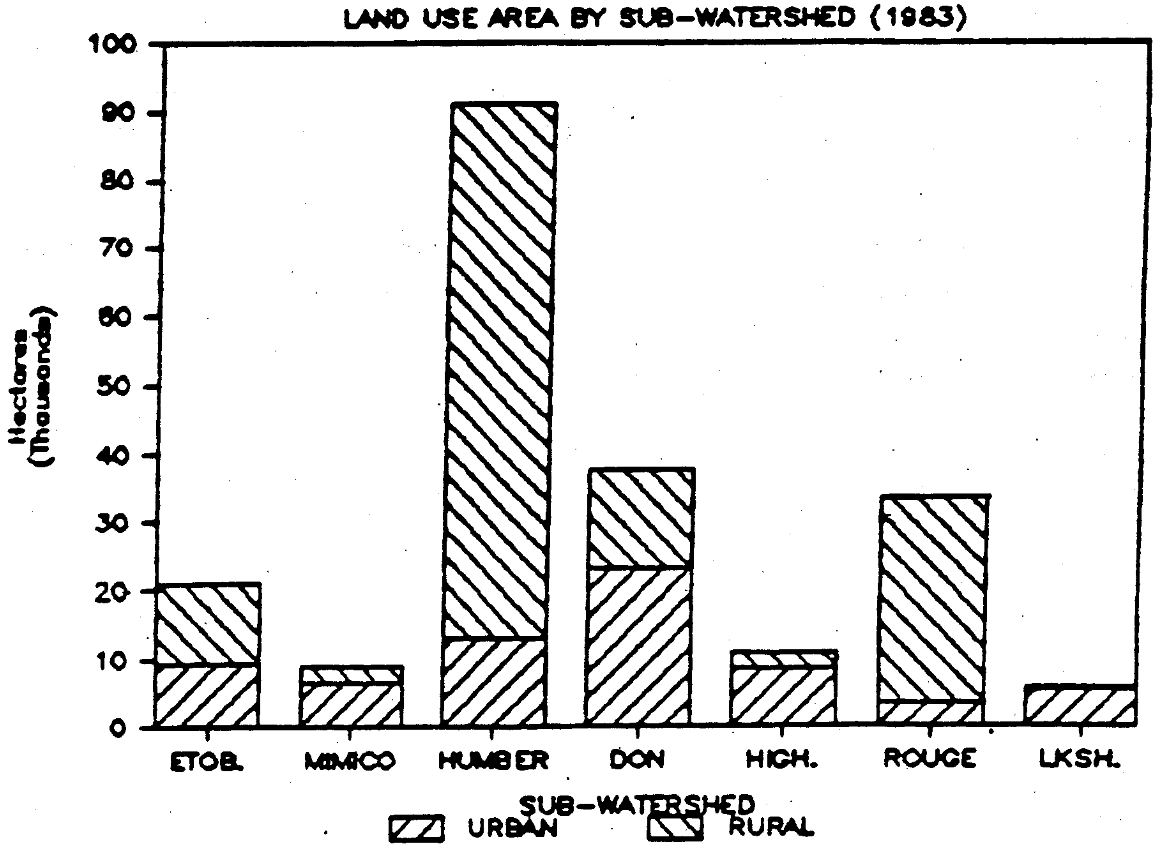
LAND USE	WATERSHED AREA (ha)							
	ETOBICOKE	%	MIMICO	%	HUMBER	%	DON	%
Residential/Small Commercial	5,755	27.5%	3,575	39.5%	8,951	9.8%	14,472	38.5%
Industrial/Large Commercial	3,393	16.2%	2,960	32.7%	4,003	4.4%	4,347	11.6%
Utility/Institional	218	1.0%	118	1.3%	252	0.3%	152	0.4%
High Density Urban	0	0.0%	0	0.0%	0	0.0%	4,012	10.7%
TOTAL URBAN	9,366	44.7%	6,653	73.5%	13,206	14.5%	22,983	61.2%
Field Crop	5,750	27.4%	172	1.9%	54,974	60.3%	9,888	26.3%
Pasture	0	0.0%	0	0.0%	5,096	5.6%	544	1.4%
Rural Residential	24	0.1%	0	0.0%	1,725	1.9%	0	0.0%
Forest	407	1.9%	34	0.4%	7,607	8.3%	1,203	3.2%
Open Space	5,406	25.8%	2,191	24.2%	8,542	9.4%	2,943	7.8%
TOTAL RURAL	11,587	55.3%	2,397	26.5%	77,944	85.5%	14,578	38.8%
TOTAL WATERSHED	20,953	100.0%	9,050	100.0%	91,150	100.0%	37,561	100.0%

LAND USE	WATERSHED AREA (ha)							
	HIGHLAND	%	ROUGE	%	LAKESHORE	%	TOTAL	%
Residential/Small Commercial	6,966	63.5%	2,576	7.7%	2,165	37.7%	44,462	21.3%
Industrial/Large Commercial	1,730	15.8%	850	2.5%	858	14.9%	18,142	8.7%
Utility/Institional	20	0.2%	121	0.4%	91	1.6%	972	0.5%
High Density Urban	0	0.0%	0	0.0%	2,383	41.4%	6,395	3.1%
TOTAL URBAN	8,716	79.5%	3,547	10.5%	5,497	95.6%	69,971	33.5%
Field Crop	204	1.9%	23,797	70.7%	0	0.0%	94,787	45.3%
Pasture	0	0.0%	20	0.1%	0	0.0%	5,660	2.7%
Rural Residential	0	0.0%	577	1.7%	0	0.0%	2,326	1.1%
Forest	293	2.7%	1,819	5.4%	10	0.2%	11,373	5.4%
Open Space	1,755	16.0%	3,876	11.5%	243	4.2%	24,957	11.9%
TOTAL RURAL	2,252	20.5%	30,089	89.5%	253	4.4%	139,103	100.0%
TOTAL WATERSHED	10,968	100.0%	33,636	100.0%	5,750	00.0%	209,074	100.0%



TORONTO WATERFRONT DRAINAGE BASIN

LAND USE AREA BY SUB-WATERSHED (1983)



Land use in the western waterfront drainage basin is primarily agricultural, with rural lands (including pasture, crop and forested land) making up about 97% of the catchment of the Humber watershed north of Steeles Avenue (TAWMS Technical Report #8, 1986). In the lower Humber (south of Steeles Avenue), land use is primarily residential and industrial. The developed area on the entire Humber watershed is expected to increase from the 18% of 1983 to 22% by the year 2000 (M.T.R.C.A., 1983). This projected increase is expected to result primarily from a shift in land use from pasture and field crops to rural industrial.

The Etobicoke and Mimico Creek watersheds are smaller and more highly developed than the Humber. Mimico Creek is the more highly developed with about 74% of its area devoted to urban uses. This figure is expected to rise to about 82% by the year 2000. Etobicoke Creek is approximately 45% urban at present and will likely increase to 58% by 2000.

Urban land uses predominate in the Toronto central waterfront (Don River) drainage basin, accounting for 60% of the total land area. High density urban lands and the Toronto central waterfront development area dominate the waterfront, although in recent years increasing commercial and residential uses have reduced industrial and storage uses.

While some agricultural activity occurs in the northwest corner of the basin, the main respite from urban influence comes from open space and forested areas in valley lands. These areas extend along the Don River into the heart of high density urban areas in the City of Toronto. Large open areas are also found on the Toronto Islands and the Eastern Headland. These open areas and the Toronto central waterfront shoreline support a variety of wildlife and wildlife habitat.

Land uses in the Toronto eastern waterfront drainage basin are characterized by the urbanization influence of Metropolitan Toronto (M.T.R.C.A., 1983a). This is evident in the extensive Metropolitan Toronto urban area, an extensive urbanizing fringe in the region of York, and an evolving rural hinterland. The rural hinterland contains many small towns that serve, in part, as bedroom communities for the larger urban area. Away from these, rural residential communities have arisen as a result of strip development or as estate residential developments.

In the Toronto eastern waterfront basin, total urban land uses account for approximately 30% of the basin area. Urban uses comprise almost 80% of the Highland Creek and the Lakeshore watersheds, while non-urban uses predominate in the larger Rouge River watershed. North of Metropolitan Toronto, Unionville, Markham, Richmond Hill and Stouffville are the major urbanizing areas. Non-urban land uses include extensive areas of cropland to the north, with river valleys forming systems of open space and forests that extend through the urban areas to the south.

2.5 WATER USES AND INFLUENCES

Sewage

Metro Toronto has an extensive sewer system consisting of combined sewer and storm sewer networks. Storm sewers serve to facilitate efficient overland drainage. Urban storm runoff is conveyed by storm sewers directly to the Metro waterfront and its tributaries. The volume and rate of flow varies with the duration, intensity and areal extent of storms, and the time interval between each successive event. The locations of major storm and combined sewer outfalls along the central waterfront are shown in Figure 2.4.

Older areas of development within Metropolitan Toronto were initially serviced with combined sewers which were designed to carry both sanitary sewage and stormwater runoff. During dry weather, sanitary sewage is conveyed to area Water Pollution Control Plants (WPCPs) for treatment. During wet weather, stormwater runoff enters the combined sewers and mixes with the sanitary sewage and is termed combined sewage. During small storms, which do not exceed the capacity of the system, the combined sewage is be conveyed to the WPCPs for treatment. Combined sewer overflows (CSO's) occur when the capacity of the system is exceeded. Excess combined sewage is then discharged directly to the receiving waters of the Humber and Don rivers and Lake Ontario. Although the City of Toronto, the City of Scarborough and the Borough of East York have undertaken major storm sewer separation programs, a large portion of the stormwater in older areas still enters combined sewers.

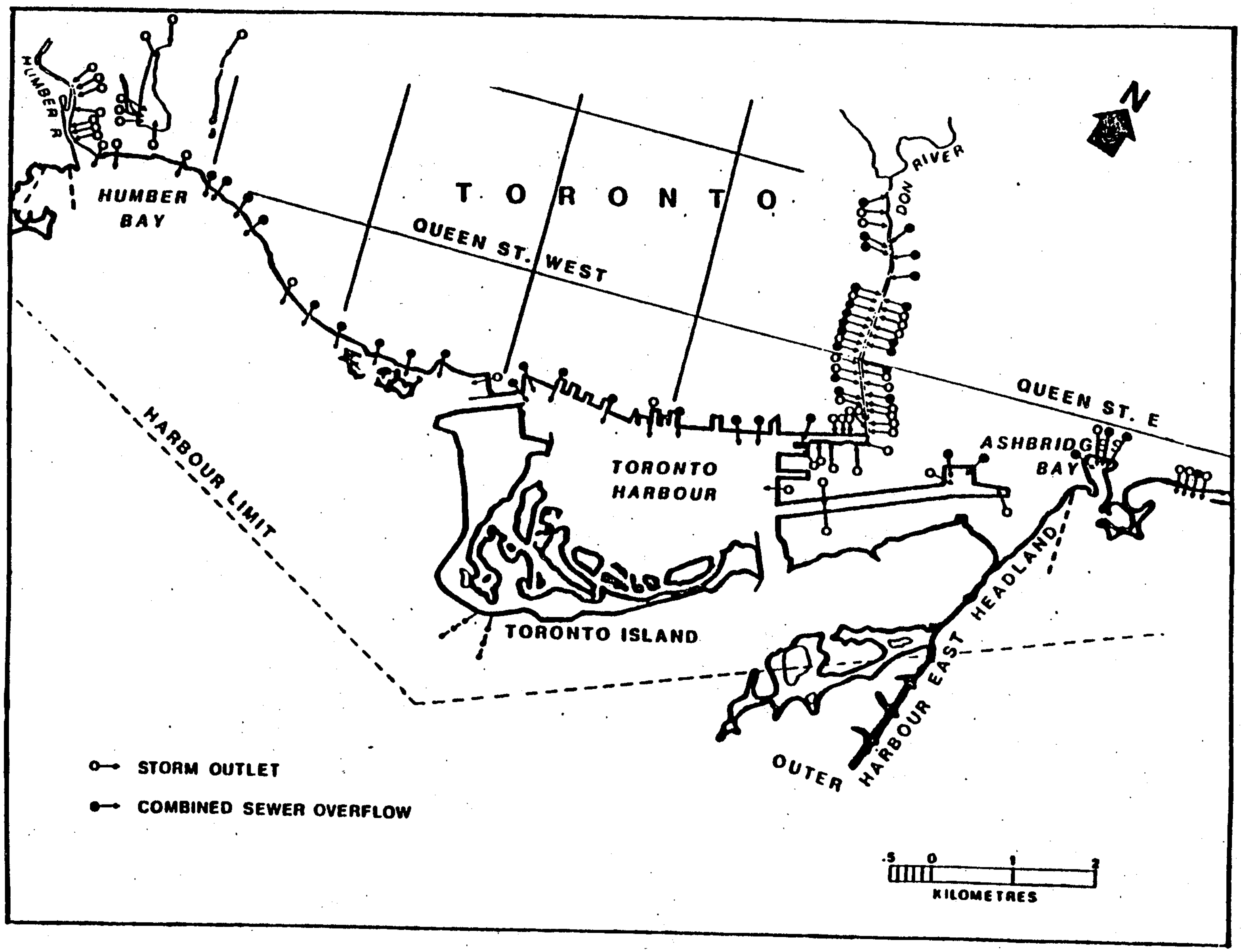


FIGURE 2.4: STORM AND COMBINED SEWER OUTFALLS

Storm and combined sewers may also carry flows during dry weather as a result of minor tributaries, groundwater infiltration, illegal sanitary connections or malfunctioning CSO regulators.

Domestic sewage from within the study area is conveyed by sanitary sewers to five water pollution control plants (WPCP's):

- Humber WPCP;
- Toronto Main WPCP;
- Highland Creek WPCP;
- North Toronto WPCP; and
- Kleinburg WPCP.

The Humber, Main and Highland Creek WPCPs discharge treated effluent directly to Lake Ontario. The North Toronto WPCP discharges to the Don River. These four WPCPs are operated by the Regional Municipality of Metropolitan Toronto. The Kleinburg WPCP is a very small plant which discharges its effluent to the Humber River north of Metropolitan Toronto. The Lakeview WPCP (63 MGD) lies outside the study area, west of Etobicoke Creek.

The four largest WPCP's serving the Toronto area are conventional activated sludge plants with continuous phosphorus removal. The Kleinburg WPCP is an extended aeration plant. Additional information on these plants is provided in Table 2.3.

There are no direct discharges of industrial process waters to the waterfront (only cooling water discharges are allowed), but there are periodic spills of oils and other materials into the Spadina and Simcoe Street Slips, probably from the waterfront railway lands and adjacent urban areas.

Table 2.3

Water Pollution Control Plants

Intakes and Outfalls in the Metro Toronto Watershed

Wastewater Treatment Plants	Area Served	Population Served	Treatment Type	Capacity MGD	Capacity $1000M^3$	Location
Humber Bay	North York, York Etobicoke, Vaughan	660,000	conventional activated sludge & continuous P removal	90	409.1	Lake Ont.
North Toronto	North York, Toronto East York	55,000	"	10	45.5	Don River
Highland Creek	Scarborough Markham	290,000	"	48	218.2	Lake Ont.
Ashbridge's Bay (Main)	North York, Tornto East York, Markham Scarborough	1,200,000	"	180	818.3	Lake Ont.
Kleinburg	Vaughan	900	extended aeration	0.05	0.23	Humber River
TOTAL		2,205,900		328	1491.3	

Source: Report on the 1986 Discharges from Municipal Wastewater Treatment Facilities in Ontario, October 1987, Ontario Ministry of the Environment.

Drinking Water

Since January 1, 1954, Metro Toronto has been responsible for the production, treatment, storage, pumping and trunk transmission of drinking water in the Metro area. As one of its functions under the Municipality of Metropolitan Toronto Act, the Metro Works Department oversees all the above mentioned tasks including the operation of all treatment plants, pumping stations, reservoirs, elevated tanks and large diameter trunk mains. The Metro water supply is regulated under the Water Resources Commission Act (recently incorporated in the Environmental Protection Act) so that the Ministry of the Environment has jurisdiction to the point of ensuring that the water supply in any municipality is to an acceptable standard.

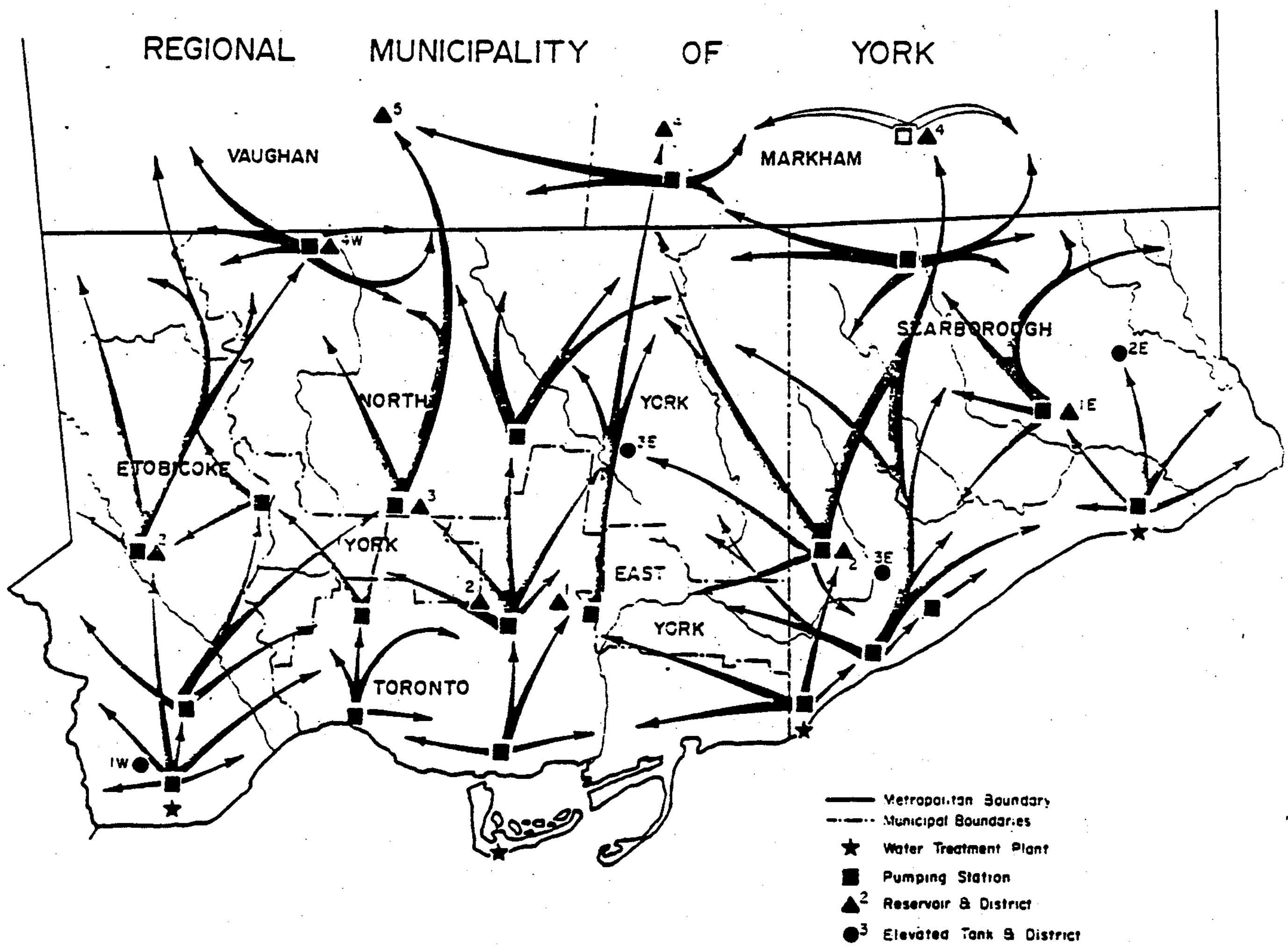
The Metro Water Works System has a rated production capacity of 2.5 million cubic metres per day (m^3/d) at its four filtration plants: the R.L. Clark, the Island, the Easterly, and the R.C. Harris (OMOE, 1987). Twenty-two pumping stations on various levels of the system account for 8.4 million m^3/d in pumping capacity. Other features of this system include 1.6 million m^3 of storage capacity in ten reservoirs and four elevated tanks, and 460 kilometers of 600 mm - 2300 mm diameter water mains.

All of the water filtration plants take raw water from Lake Ontario. Water treatment at each plant consists of coagulation, sedimentation, filtration, chlorine disinfection and fluoridation, and ammoniation. The plants feed a fully interconnected regional water distribution system servicing the watershed area (Fig. 2.5).

The R.L. Clark filtration plant is the most westerly plant, situated in the City of Etobicoke at 23rd Street just north of nearshore Lake Ontario. This plant has been fully operational since 1968. Its design capacity of 455,000 m^3/d and ultimate capacity of approximately 659 000 m^3/d can be increased when the intake flow quality is high. Raw water is drawn from an intake located approximately 1615 m from shore in 18 m of water.

The Island filtration plant, located on Centre Island, is a seasonally operated plant. It operates during high

FIGURE 2.5: METRO TORONTO DIAGRAMMATIC WATER DISTRIBUTION PATTERN



consumption periods, notably in the summer months (from roughly May 1 to October 1 each year). The Island plant has undergone numerous modifications since its initial construction. The existing plant was completed in 1977. The Island plant draws water through two intakes, at depths of 6.5 and 15 m, located approximately 762 m offshore.

Like the R.L. Clark plant, the R.C. Harris filtration plant operates year round. Situated at the foot of Nursewood Road in the City of Scarborough, it is Metro's largest water filtration facility. The original plant capacity has been enlarged throughout its 47-year history. The enlargements have included construction of a second intake, and doubling the filtration and settling areas. The R.C. Harris plant draws raw water through two intakes located in 15 m of water, approximately 2650 m offshore.

The Easterly plant is Metro's newest water filtration facility. Atop the Scarborough Bluffs on Manse Road, the Easterly plant came on-line in 1979. The design capacity is smallest of all the Metro filtration plants, and it is capable of 50% overload for extended periods when intake quality is high. The easterly plant draws its water from an intake located 2960 m from shore at a depth of 18 m.

Additional data on Toronto's water treatment plants is provided in Table 2.4.

Aquatic Uses

The Port of Toronto supports shipping traffic, and has extensive cargo storage and handling facilities, most of which are located at the eastern end of the harbour. Warehousing and other storage areas, including outside storage facilities, are scattered throughout the waterfront area. Spillage, leakage and pipeline failures in these locations have the potential to affect water quality in the harbour.

A notable trend in the Toronto area is the growing number of boaters and windsurfers, and the resulting need for the expansion of existing facilities. A general increase in the number of boats within the last decade has corresponded with

Table 2.4

Water Treatment Plants

Intakes and Outfalls in the Metro Toronto Watershed

Water Treatment Plants	Area Served	Design Population Served	Treatment Type	Capacity MGD	Capacity $1000M^3$	Location
Clark	North York, East York Etobicoke, Scarborough Markham, Vaughan	660,000	coagulation sedimentation filtration taste & odour control fluoridation chlorination	145	659.2	Lake Ont.
Toronto Island	North York, East York Etobicoke, Toronto Scarborough, York	140,000	"	90	409.1	Lake Ont.
Harris	North York, East York Scarborough, Toronto York, Richmond Hill Vaughan	1,110,000	"	220	1000.1	Lake Ont.
Easterly	North York, Toronto East York, Etobicoke Scarborough, York	450,000	"	100	454.6	Lake Ont.
TOTAL		2,360,000		555	2523.0	

Source: Municipal Water Treatment Works in Ontario, December 1986, Ontario Ministry of the Environment an increase in the number of boat owners residing within 20 km of the waterfront sectors (MTRCA, 1985b). The demand for marina wet-berth facilities has exceeded available supply. An MTRCA Boating Demand Study Update (1985b) estimates that 2555 wet-berths will be needed to satisfy the growing boat-user population by the years 1990 - 2000. The revival of sport fishing in Lake Ontario is expected to continue to increase the demand for docking space, across the waterfront.

The sport of wind surfing has experienced a major growth in popularity along Metro beaches in recent years. Being more mobile and portable than dinghy sailing, board sailing has less need for an exclusive shoreline space equipped with a full range of facilities and amenities such as clubhouses incorporating restaurants, etc. (MTRCA, 1985b). The relatively low cost of outfitting more than likely contributes to a broader range of participants. Data from the MTRCA boat study (1985b) indicates that board sailing has affected and, is in part, responsible for the decline in dinghy sailing.

Fisheries

The offshore boat fishery for coho and chinook salmon, rainbow, brown and lake trout is the most visible and economically valuable sports fishery in the Toronto area. Millions of dollars are spent annually on boats, tackle, specialized equipment, accommodations and food, as fishermen vie for trophy fish or prizes offered in derbies sponsored by newspapers and others. A charter boat industry has developed and depends on fishing rentals. In 1987 "charter boaters" accounted for up to one third of the total salmon fishing effort expended (P. Savoie, personal communication). This fishery is currently supported by government stocking programs as the nearshore of Lake Ontario in the Toronto area and the lower parts of the river systems here are incapable of meeting the physical and chemical habitat requirements to allow these fish to successfully reproduce.

Sport fishing is also an activity common to river mouths, and shorelines of waterfront parks along Lake Ontario. In a creel survey conducted by MTRCA (1986), waterfront fishing sites were found to have a diverse number of catchable species, although they were often present in only small numbers. Catch per unit effort by shore waterfront anglers at the parks was very low (0.095 fish per angler-hour). Conversely, fishing success was very good at inland sites (0.74 fish per angler-hour) for sunfish, bullheads and bass. While these latter species provide excellent fishery for children, they do not often encourage the mature angler. With the exception of migratory salmonids, urban anglers fish for warm water and coarse game species. Urban waters have much potential for a bass and pike fishery, but as water quality and physical habitats deteriorated throughout the years, hardier species have prevailed (MTRCA, 1986).

3.0 PHYSICAL PROCESSES

Overview

The physical processes affecting the Toronto shoreline, including currents, eddies, thermal stratification, winds and upwelling/downwelling episodes, all play a role in the dilution or accumulation of contaminants. These processes vary a great deal both spatially and temporally. The high degree of variability in the physical processes helps in the dilution of contaminants.

In general, circulation along the waterfront is towards the west in summer and towards the east in winter. On any particular day, however, the physical conditions may produce different circulation patterns. As a result, the most suitable use for available data and models is in predicting the impacts of sources on water uses and optimizing the design and locations of outfalls, for different combinations of physical conditions.

One general pattern relating to the physical processes does have a significant impact on water quality along the waterfront. Many areas along the shore, (i.e., embayments, slips, harbours, lagoons) are protected from the full energy of open lake currents and wind driven effects. These areas form relatively quiescent zones where contaminants can settle and accumulate. Scouring, resuspension and dilution of these accumulated deposits occur less frequently than in areas fully exposed to the open lake. As a result these areas tend to have degraded water and sediment quality. In some cases the quality problems are not associated with specific, nearby sources, but are the result of a more general degradation, coupled with the depositional environment.

Physical Characteristics

Nearshore currents are responsible for the transport and dispersion of contaminants discharged to the lake region. The processes involved can vary both temporally and spatially. Thermal stratification and wind are the two most important characteristics affecting currents in the nearshore regions during the summer.

For the Toronto waterfront area, current meter records are available over many years. The statistics apply only to the location where the measurements were taken. Moreover, these statistics may be different from one year to another due to changes in wind conditions and water temperature.

A single recording current meter data cannot be used to predict the impact of a discharge. However, these data illustrate periods of small, medium and high currents and their prevailing directions. This information may be useful in explaining water quality degradation for a discharge. Summarized current meter data for the Toronto waterfront are provided in The Toronto Waterfront Summary Reports (Beak et al., 1987).

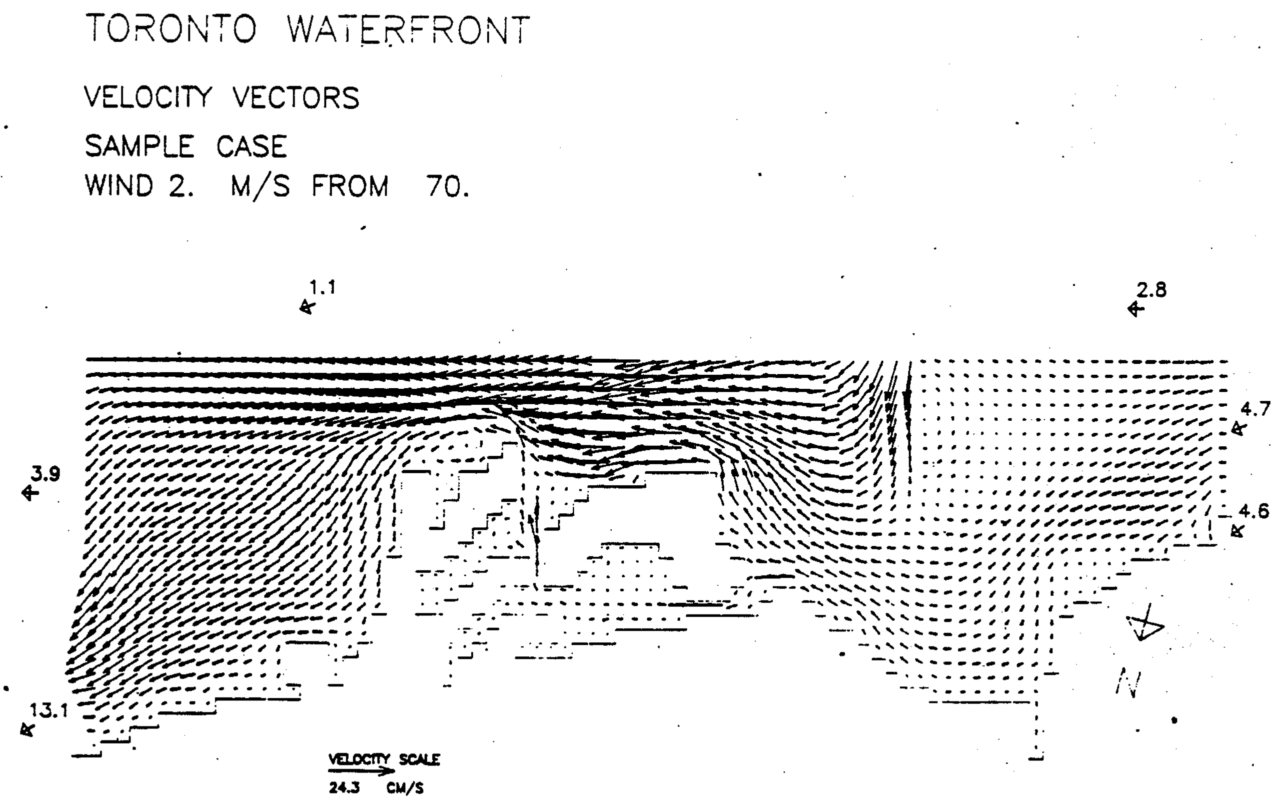
In order to predict the effect of a discharge, it is necessary to combine concurrent measurements at many locations and use a numerical model. The model predicts an area circulation pattern for the period of interest and the impact of a discharge for any episode. For example, prediction models for phosphorus concentrations, based on westerly and easterly flow conditions, are shown in Figures 3.1 and 3.2.

Physical characteristics can also be assessed by tracking drogues or dye plumes. This method simulates the behaviour of effluent plumes in the receiving water. The trackings must be repeated under different wind conditions to determine the statistical characteristics of effluent behaviour over a period of time. Drogue tracking data for the area around the Eastern Headland and Eastern Beaches are summarized in Figures 3.3 and 3.4, respectively.

If wastes are discharged in a stratified lake, the effluent plume may not be able to penetrate the thermocline. The plume will remain below the thermocline, resulting in lower dilution. Knowledge of thermocline depth is therefore essential to assess the effects of discharges to the nearshore area. The thermal stratification data in the Toronto waterfront are summarized in Figure 3.5.

Upwelling/downwelling episodes are sudden drops/rises of water temperature. These are periodic occurrences, caused by certain

FIGURE 3.1: PREDICTION MODEL FOR PHOSPHORUS CONCENTRATIONS BASED ON EASTERLY AND WESTERLY FLOW CONDITIONS



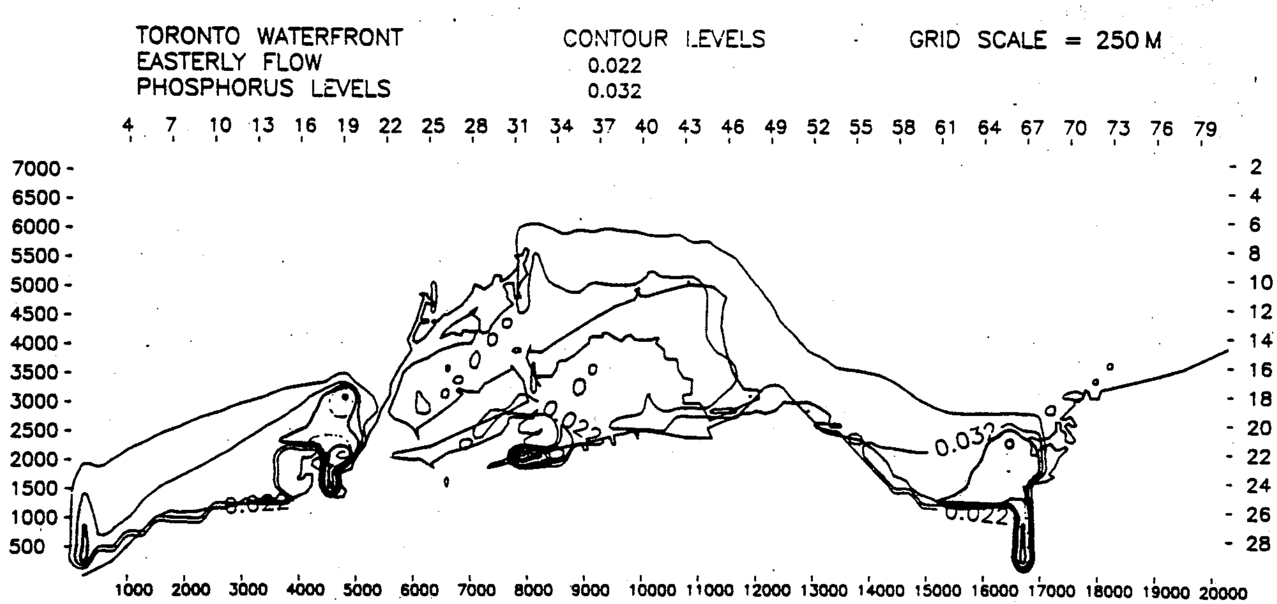
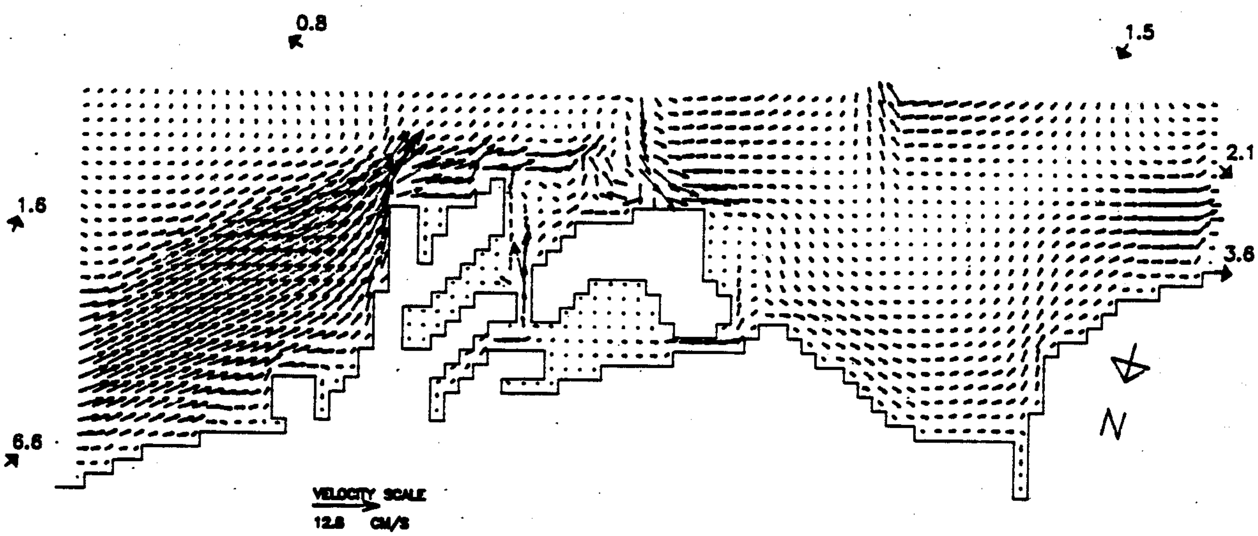


FIGURE 3.2: PREDICTION MODEL FOR PHOSPHORUS CONCENTRATIONS BASED ON EASTERLY AND WESTERLY FLOW CONDITIONS

TORONTO WATERFRONT

VELOCITY VECTORS

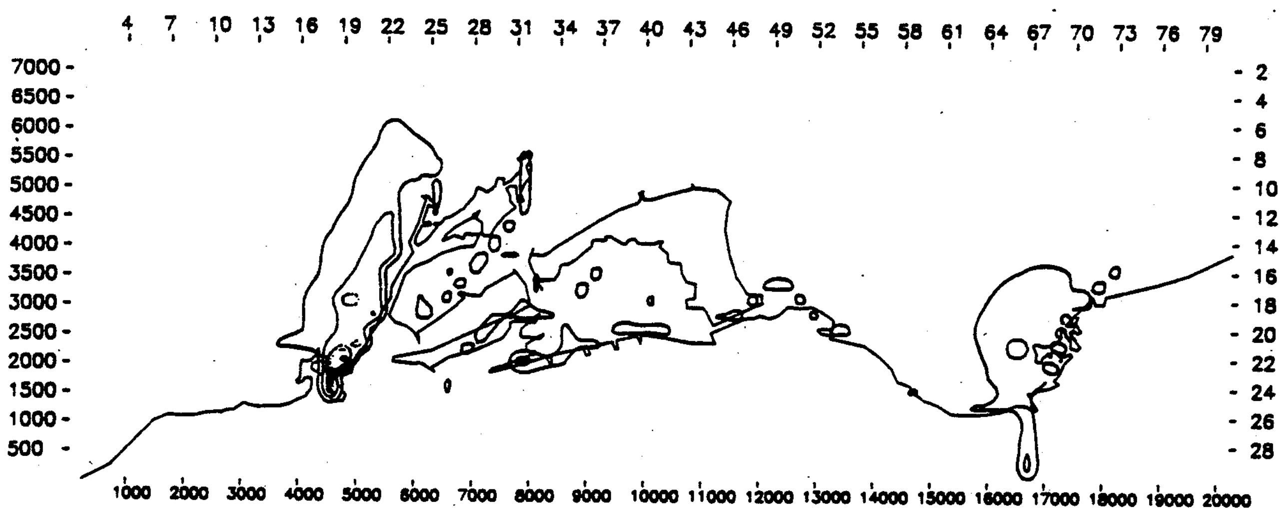
TIME STEP 480 HOUR 16.001
WESTERLY FLOW
WIND 1. M/S FROM 320.



TORONTO WATERFRONT
WESTERLY FLOW
PHOSPHORUS LEVELS

CONTOUR LEVELS
0.022
0.060 0.240

GRID SCALE = 250 M



OVER ➤

FIGURE 3.3: MAIN WPCP OUTFALL AREA DROUGUE TRACKING

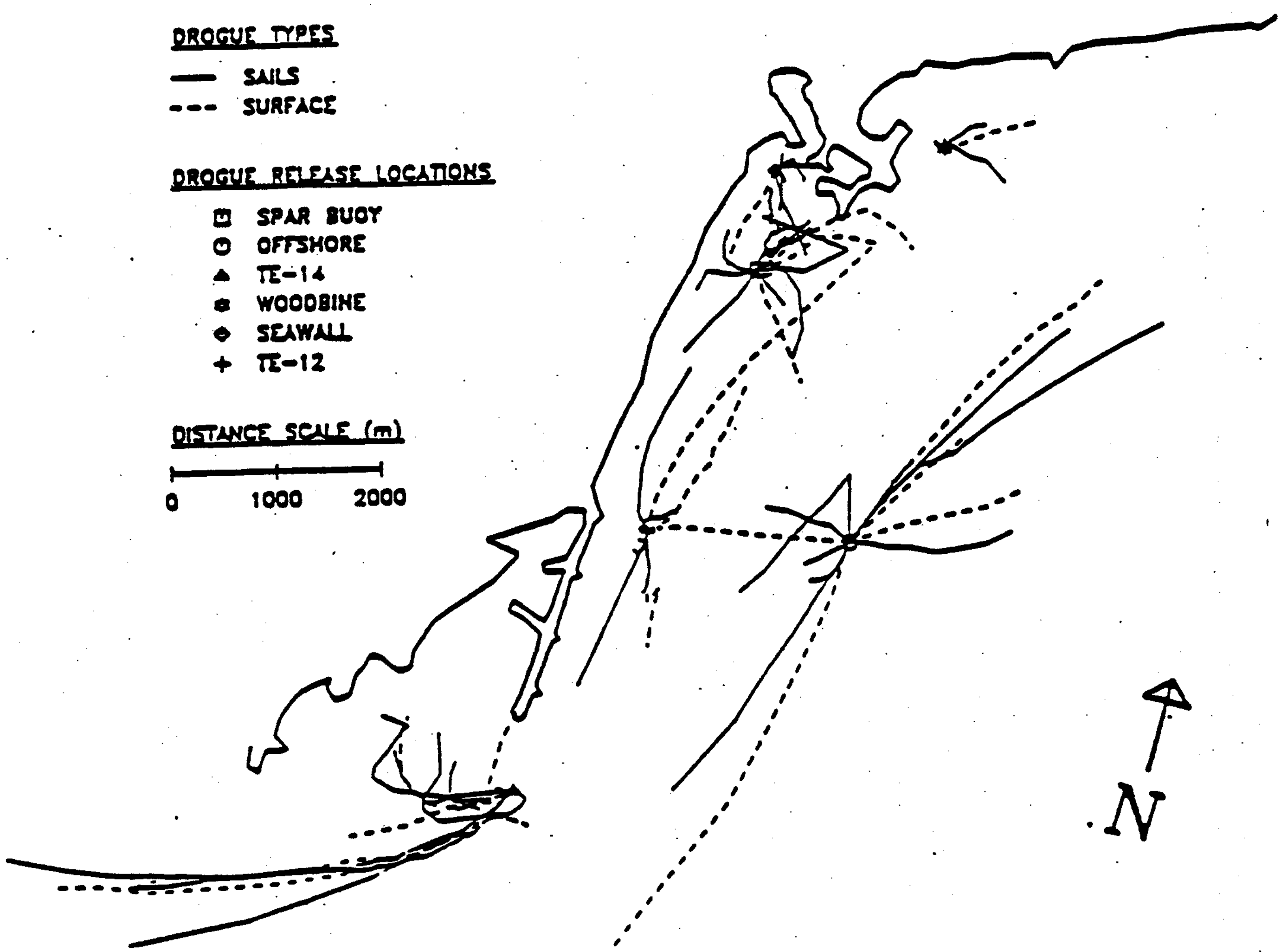


FIGURE 3.4: EASTERN BEACHES DROUGUE TRACKING 1985

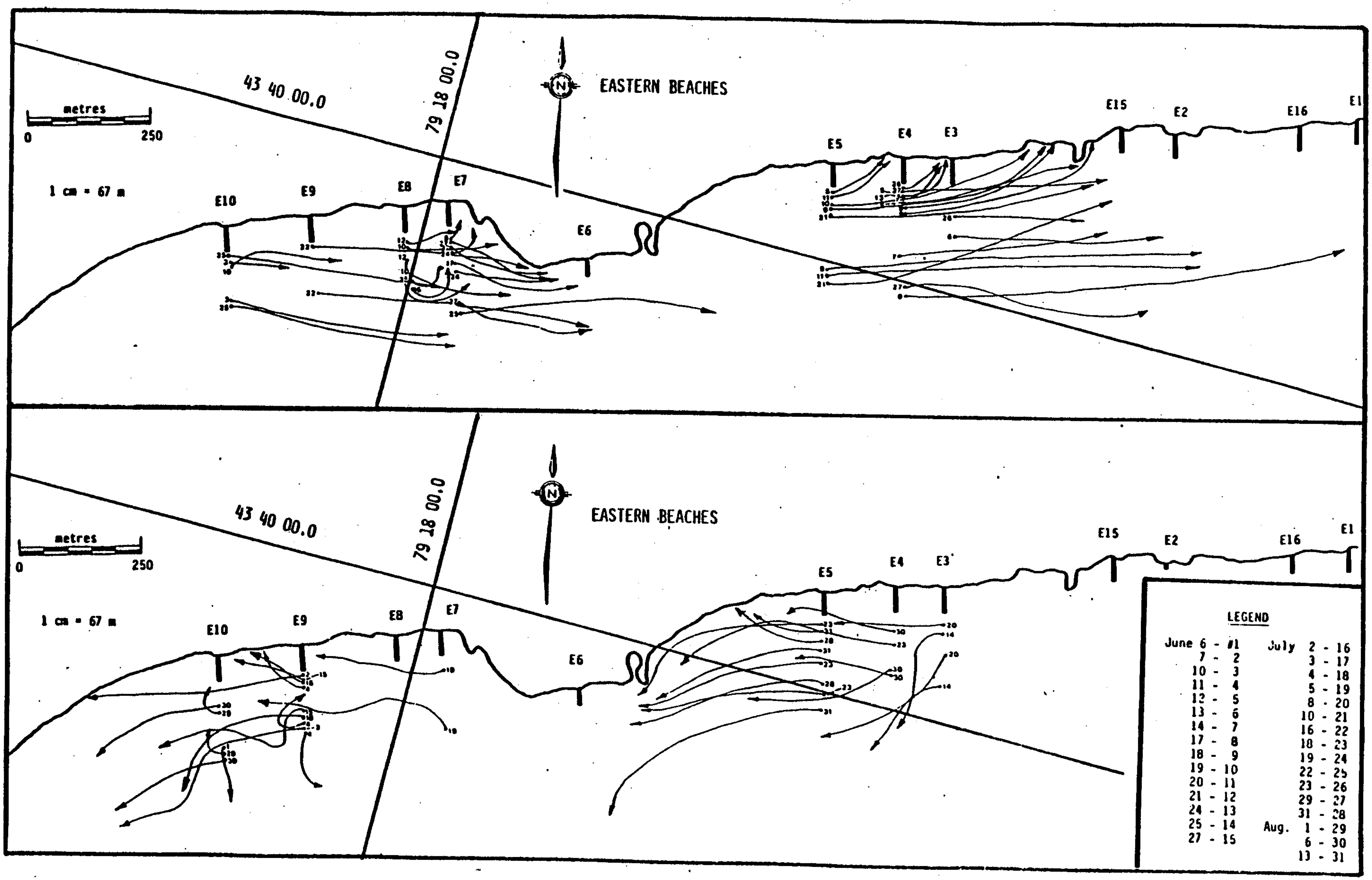
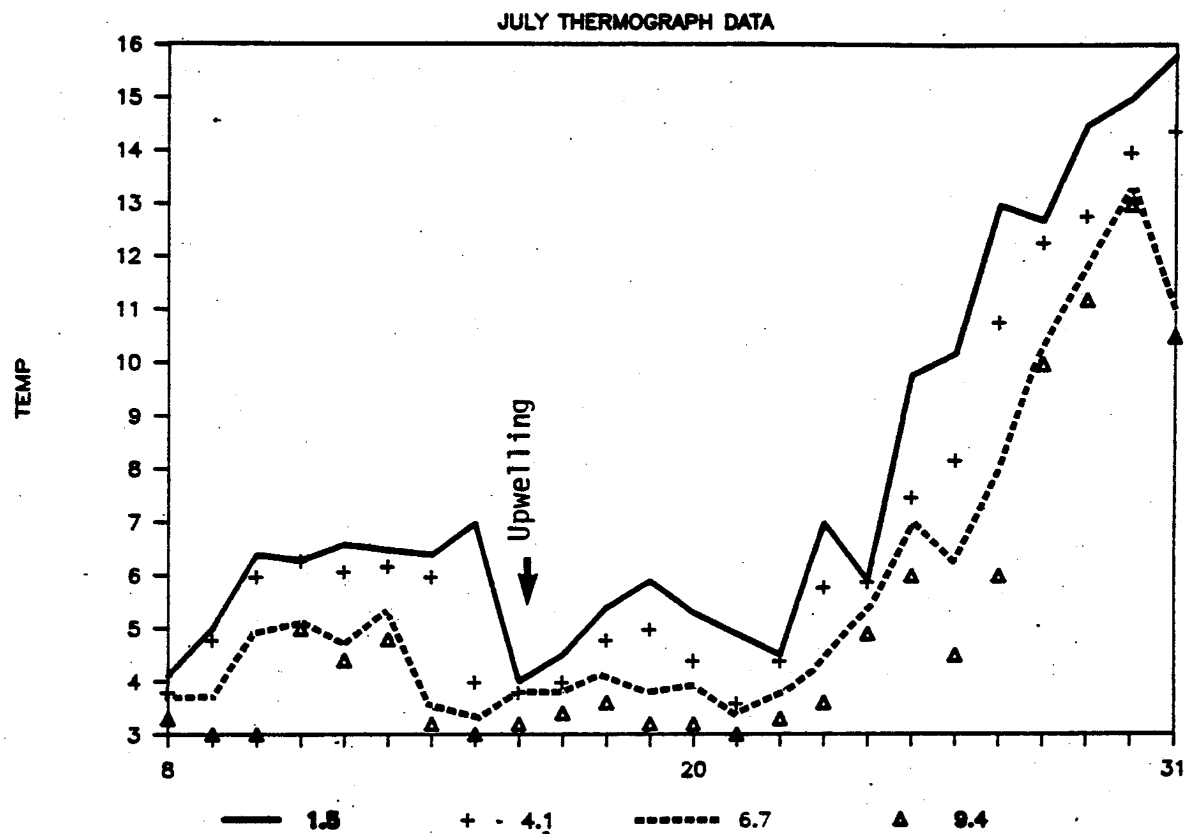
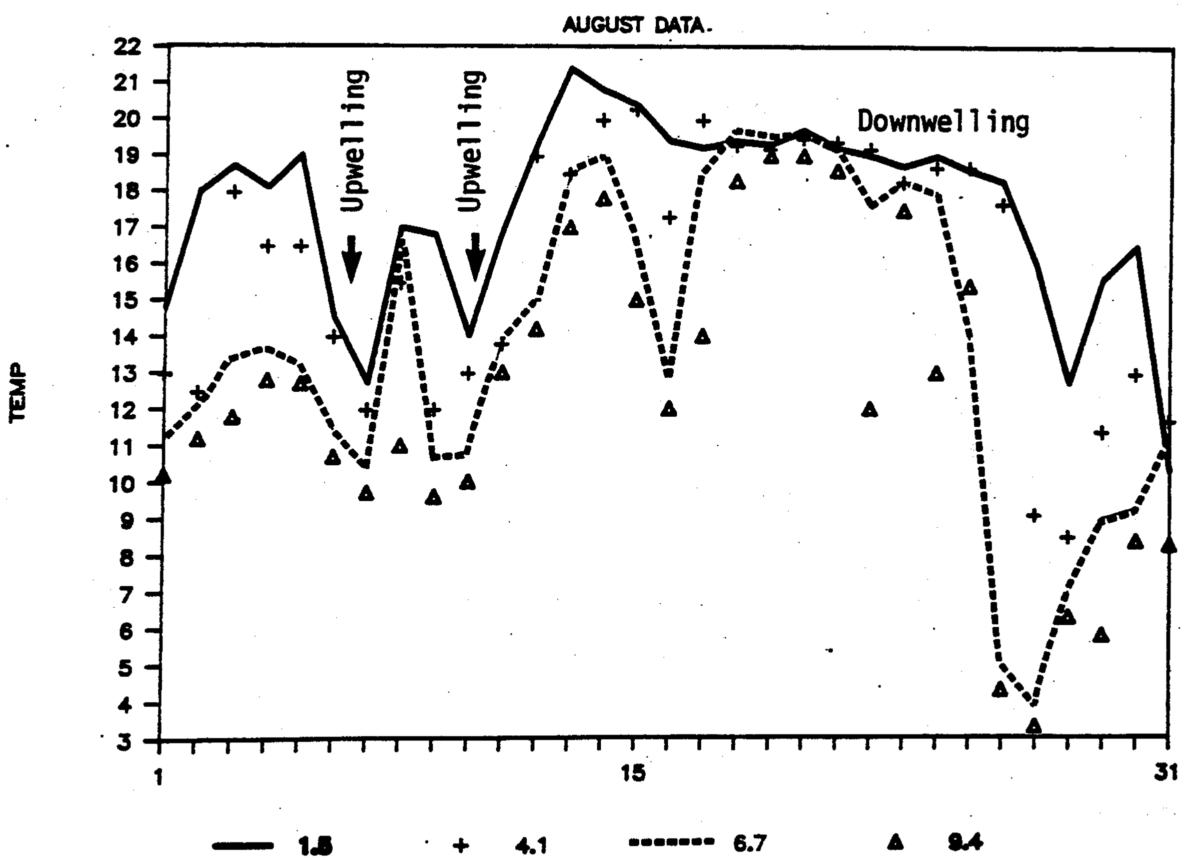


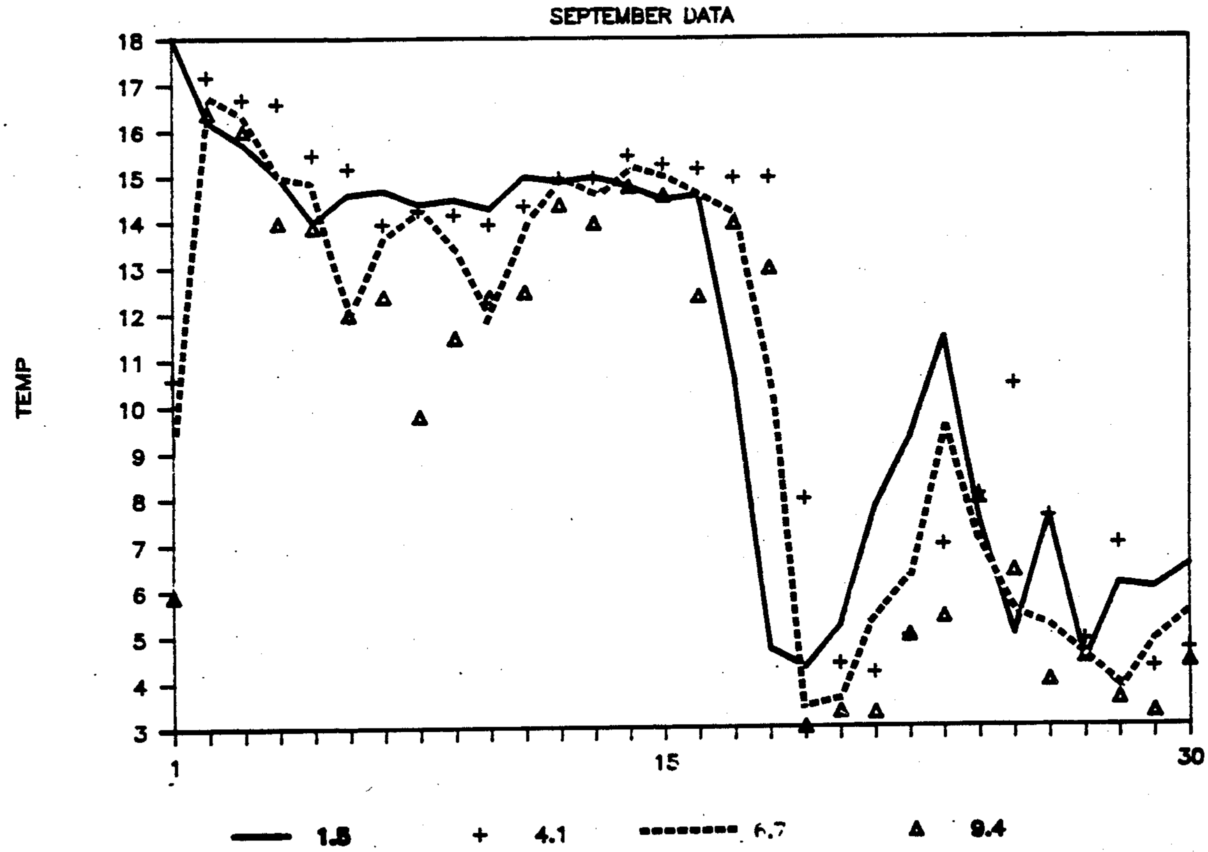
FIGURE 3.5: THERMAL STRATIFICATION IN THE TORONTO WATERFRONT NEARSHORE

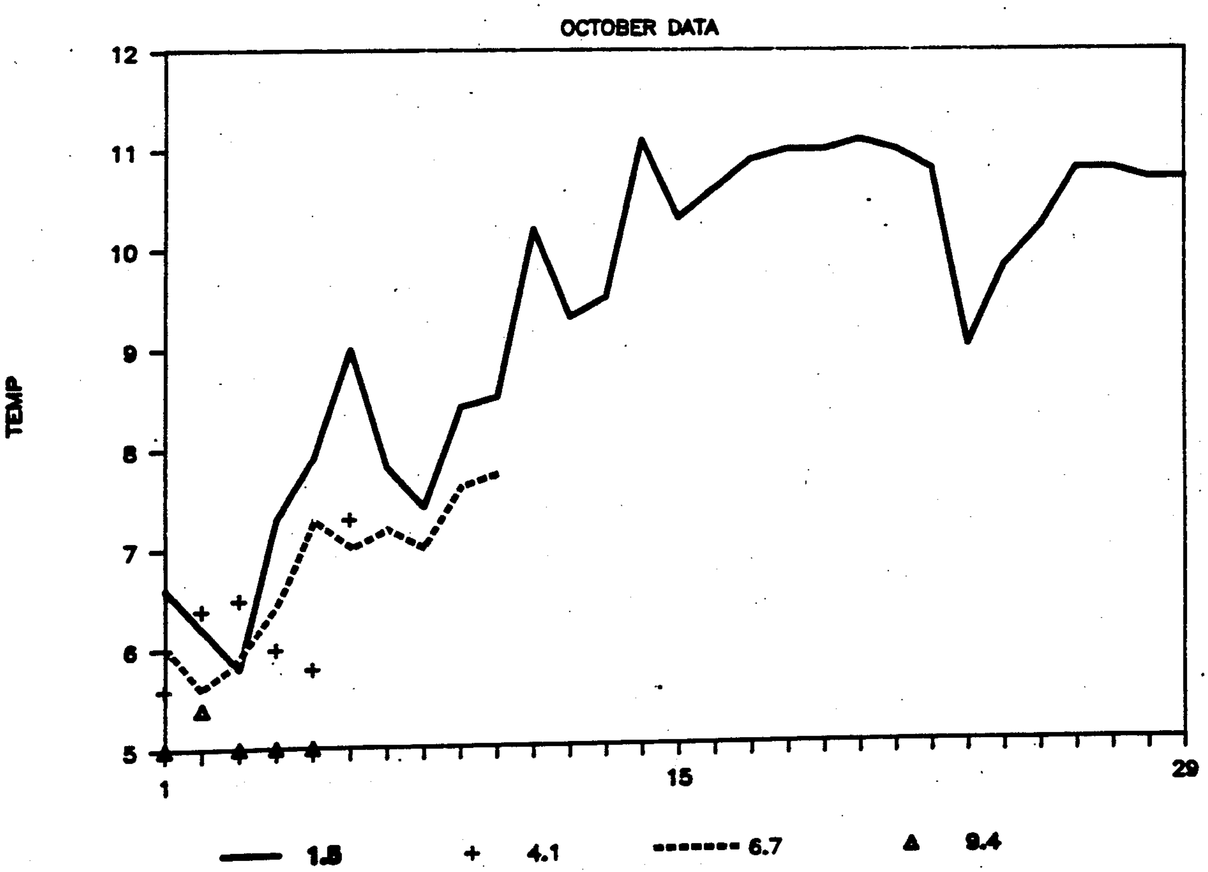




OVER ➤

WATERFRONT NEARSHORE





wind episodes. Upwelling episodes reduce the impacts of discharges, except at the shore. For water quality management of the nearshore zone, the number of days when upwelling/downwelling occurs is the only significant statistic. In 1984, there were six upwelling events lasting a total of 13 days, and one downwelling event lasting four days over a period of 91 days.

Eddies are closed circular motions. Any wastes discharged within eddies will be trapped until the eddies break up due to strong nearshore currents. Higher pollutant concentrations are observed within the eddies since these do not permit exchange or mixing with the nearshore water. Limited data are available on nearshore eddies on the Toronto waterfront. In the Woodbine Beach area, nearshore eddies occur about 60% of the time, while 800 m to the east at Scarborough Beach, they occur only 5% of the time. Areas of persistent eddies should be avoided for discharges.

Recent beach closings on the western beaches have resulted in several studies to examine the effects of the Humber River, Humber WPCP outfall and storm sewer plumes on the levels of fecal coliforms in the area, as well as mixing and transport behind the breakwater. The first evidence of the Humber River plume affecting the inner breakwater water quality came from aerial photographs. The surface river turbidity plume was observed to enter the breakwater at the river outlet and move eastward. A deflector jetty was constructed at the river mouth in late 1984. The jetty did not close off the breakwater gap entirely.

Subsequent aerial photographs have shown that the surface Humber River plume can still move through the gap and travel eastward. A time lapse video of the Humber River mouth (Hunter, 1985) found intrusions as far as the third gap. The intrusion to the first gap was 68% of the time and no intrusions were observed for 24% of the time. These intrusions are for the surface water of the Humber River. It is not known from these studies whether the intrusions are merely a surface phenomena. If so, there may be relatively little impact on the water quality at the Western Beaches.

A limited drogue tracking study (MOE, 1985), using clusters of drogues, illustrated that the river water can intrude through the gaps between the breakwater structures during southerly winds. The drogues, unlike the aerial photographs, measure the movement of the surface water (to 1.5 m). A dye experiment has shown that the breakwaters are permeable below the water line, and consequently transport can occur through the breakwater (Kleinfeldt, 1986). There are no measurements of magnitude for the flow through the breakwater, or its impact on the Western Beaches fecal coliform densities. Figure 3.6 shows the probable circulation patterns in the gaps as measured by dye and drogue tracking.

A model prediction study (McLaren, 1986), using a fine resolution grid (30 m) for the nearshore area of the Western Beaches, has been used to study the impact of the storm sewers and Humber River on the Western Beaches. The current patterns for easterly and westerly current conditions in the lake are shown in Figure 3.7.

3.1 WATER QUALITY

Overview

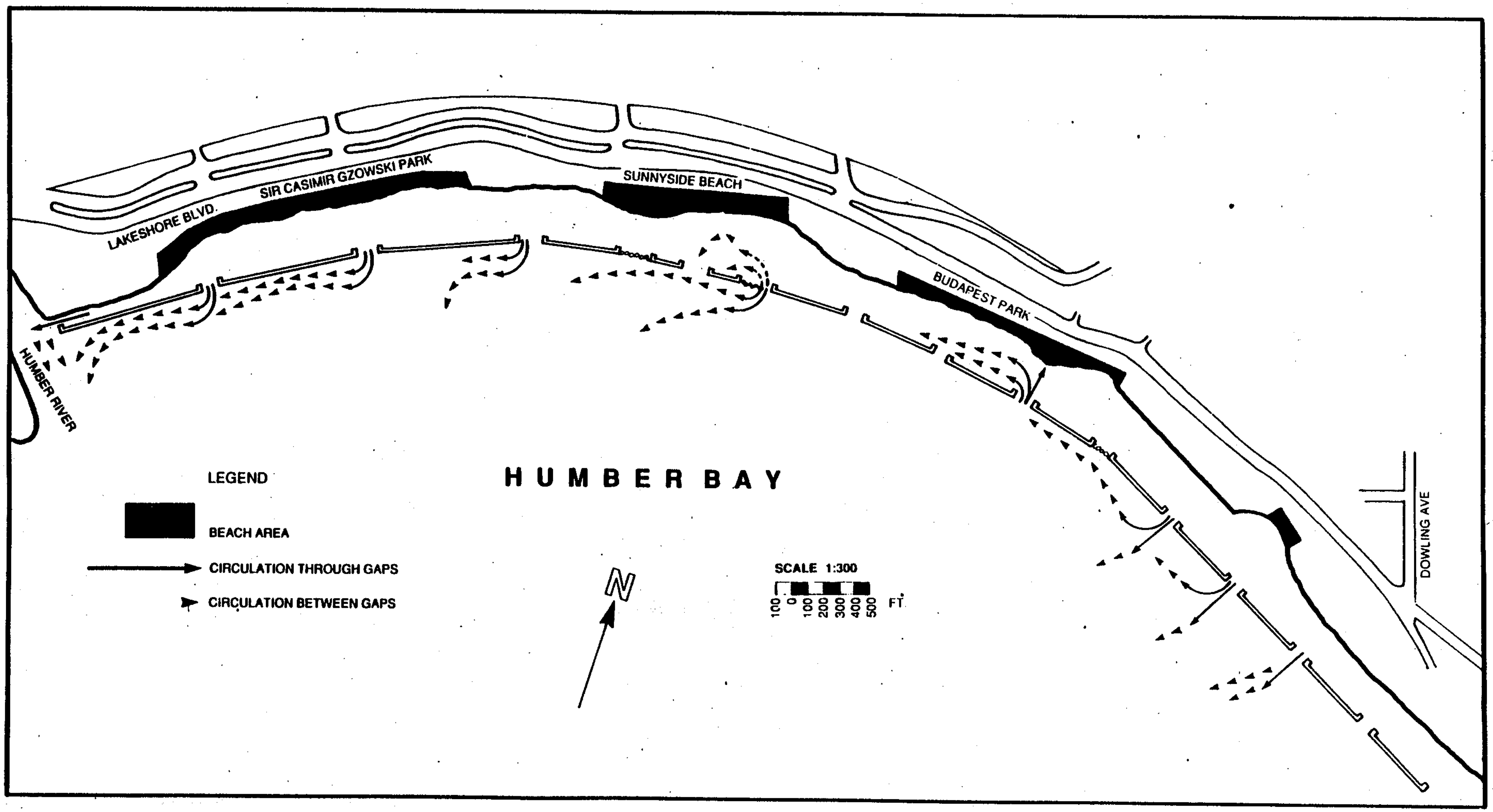
Water quality data indicate widespread and frequent exceedences of Provincial Water Quality Objectives (PWQO) for nutrients and fecal coliform bacteria across the entire Toronto Waterfront. The municipal Water Pollution Control Plants (WPCP) otherwise known as Sewage Treatment Plants (STP) are the principal loading source of nutrients. Sewer systems, discharging either directly or via the tributaries, are the greatest contributors of fecal coliform bacteria.

Degradation of water quality due to heavy metals and organics is more localized, with violations of PWQO being most prevalent near point sources, at the mouths of tributaries, and in areas with poor water circulation. Away from these sources, few data exceed the PWQO, indicating little adverse impact.

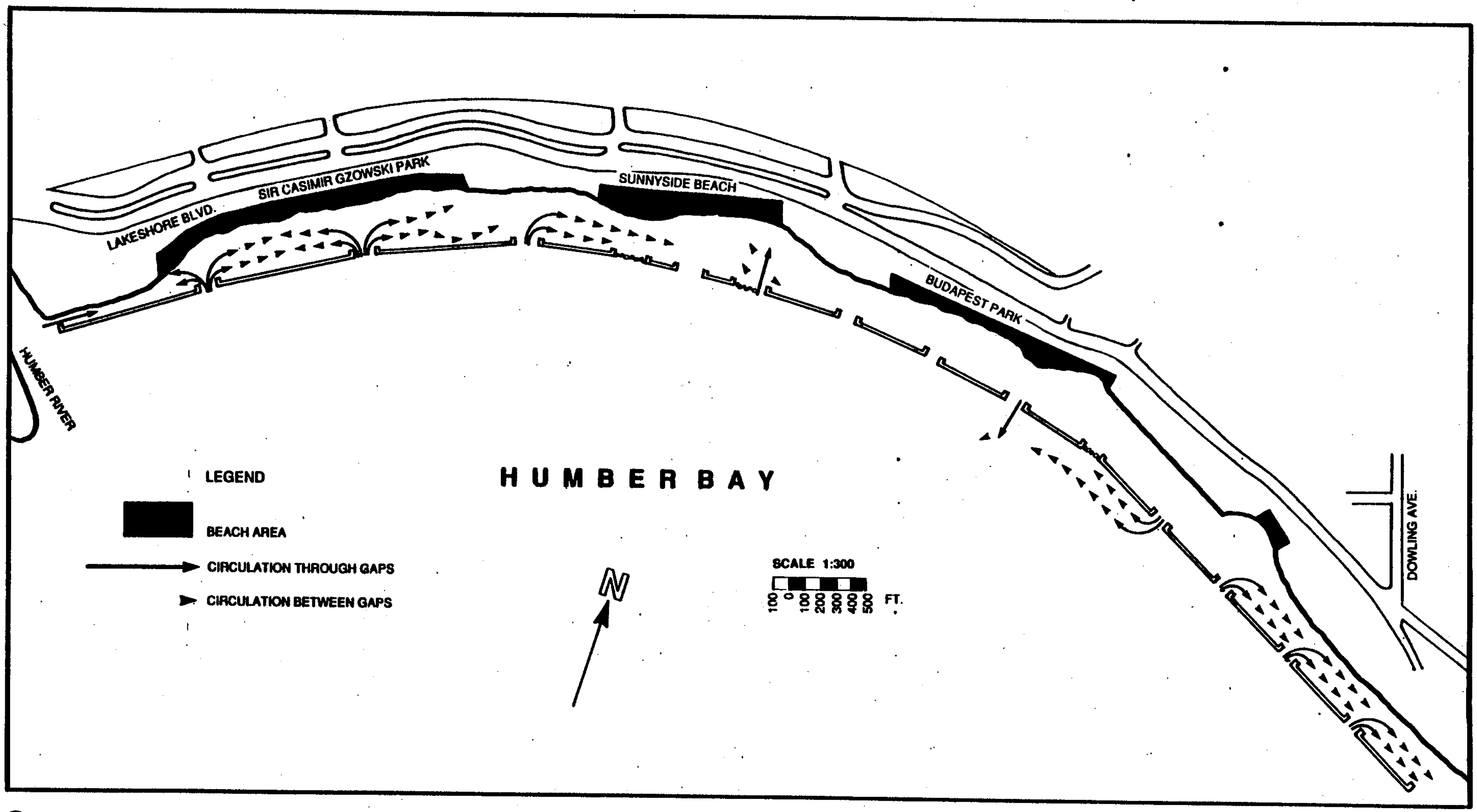
Humber Bay and Inner Toronto Harbour represent the most degraded areas of water quality along the Toronto waterfront. The poor dispersion characteristics of embayments and harbours are largely responsible for nutrient, metal, organic contaminants and bacterial accumulation in such areas. The

FIGURE 3.6: THE MOST PROBABLE CIRCULATION PATTERN

(A) NORTH WIND

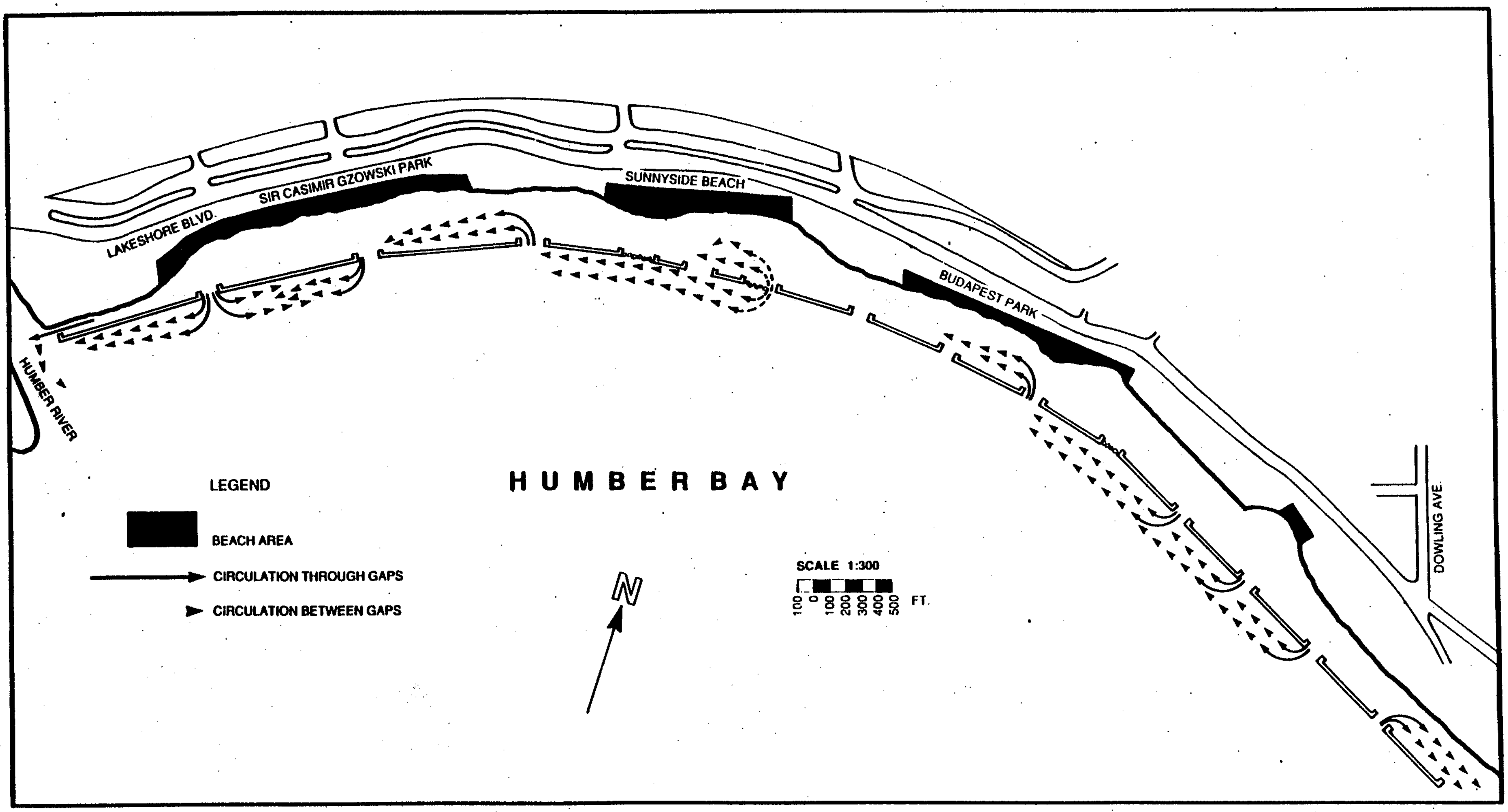


(B) SOUTH WIND



OVER ▸

(C) EAST WIND


LAKESHORE BLVD.
SIR CASIMIR GZOWSKI PARK
SUNNYSIDE BEACH
BUDAPEST PARK
DOWLING AVE.
HUMBER RIVER
HUMBER BAY
N
LEGEND
BEACH AREA
CIRCULATION THROUGH GAPS
CIRCULATION BETWEEN GAPS
SCALE 1:300
100 0 100 200 300 400 500 FT.

(D) WEST WIND

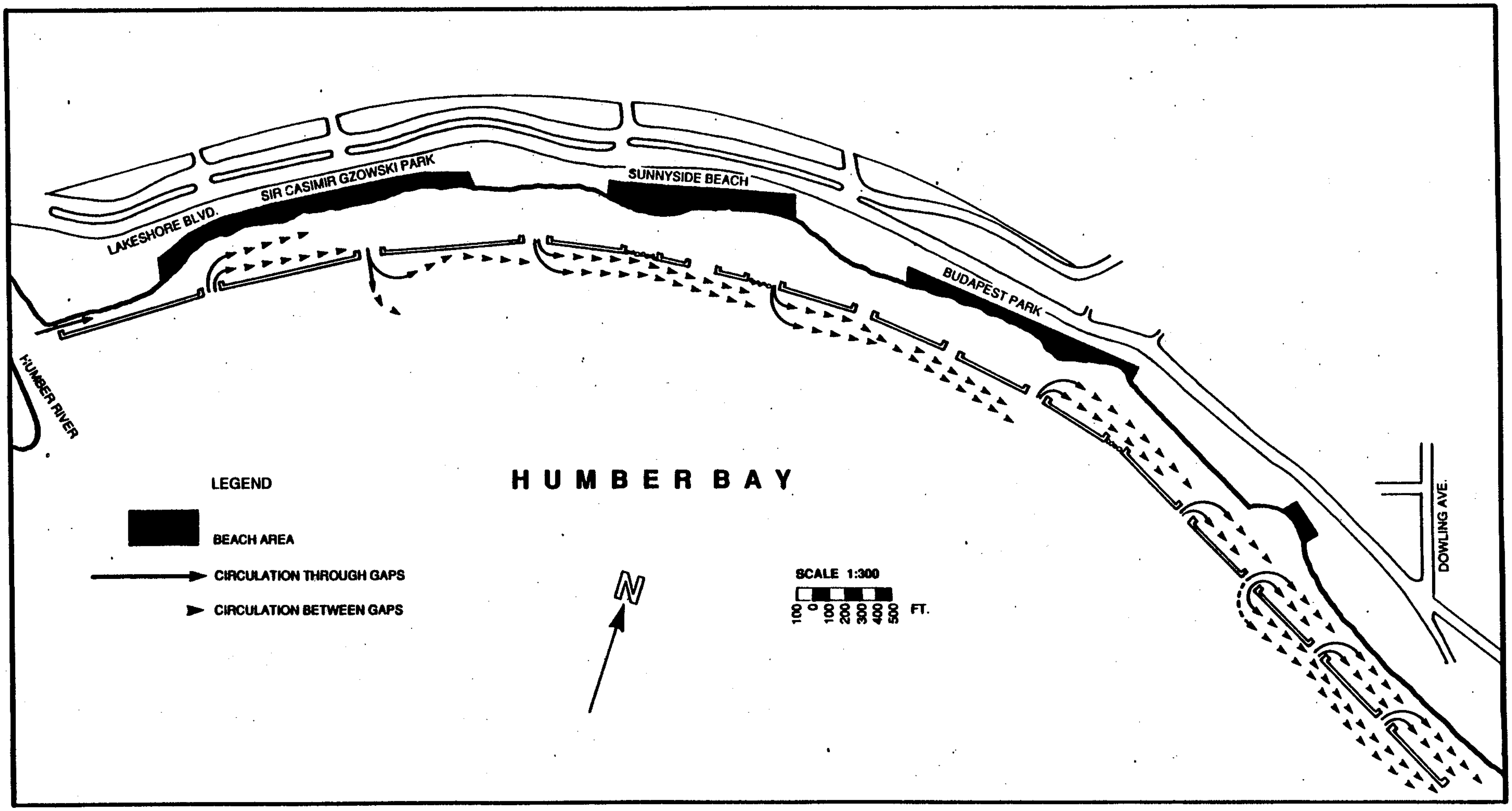
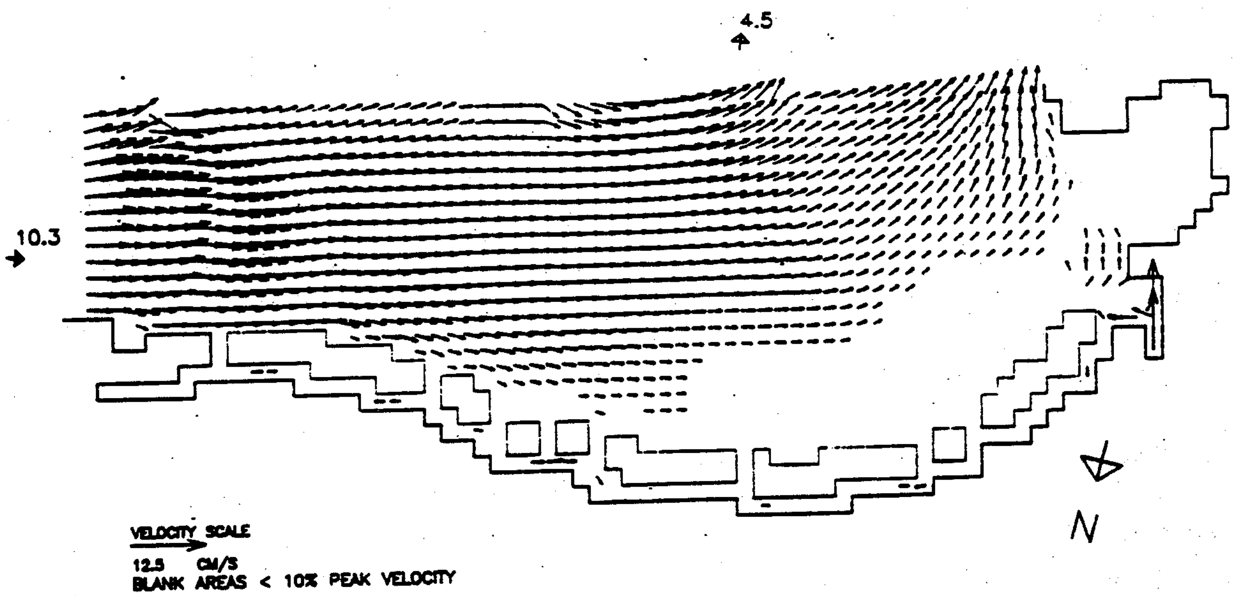
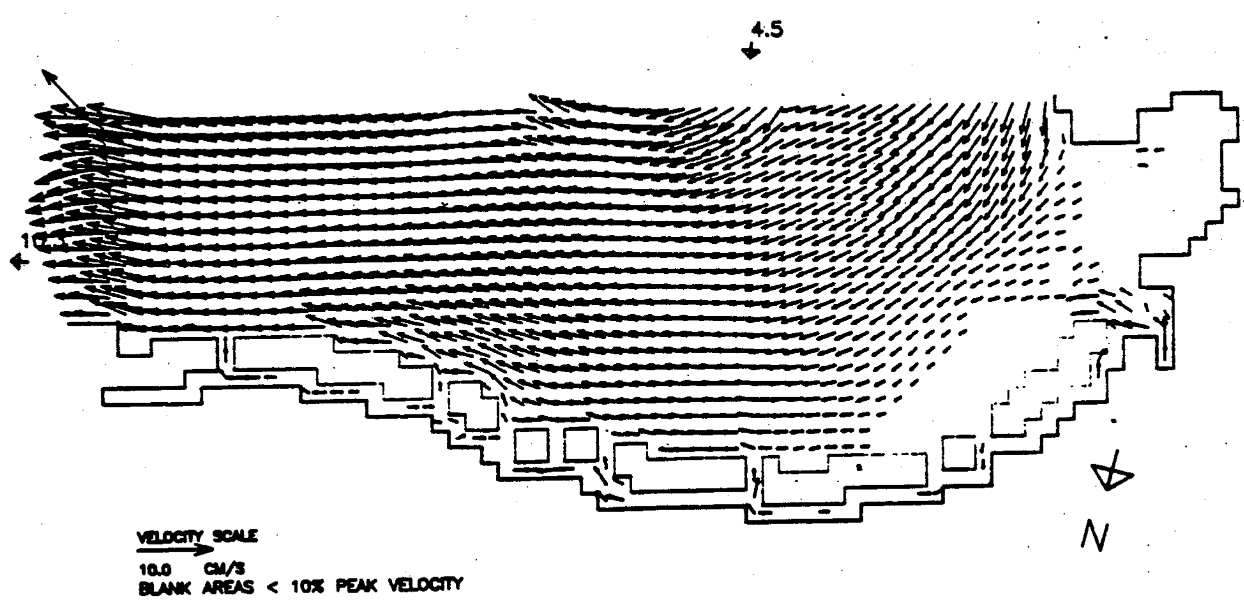

LAKESHORE BLVD.
SIR CASIMIR GZOWSKI PARK
SUNNYSIDE BEACH
BUDAPEST PARK
DOWLING AVE.
HUMBER RIVER
HUMBER BAY
LEGEND
BEACH AREA
CIRCULATION THROUGH GAPS
CIRCULATION BETWEEN GAPS
N
SCALE 1:300
100 0 100 200 300 400 500 FT.

FIGURE 3. 7: WESTERLY BEACHES STUDY— VELOCITY VECTORS

WESTERLY FLOW
WIND 1. M/S FROM 90.



EASTERLY FLOW
WIND 1. M/S FROM 270.



opposite effect is true of the Eastern Waterfront, where a relatively straight shoreline and open lake circulation contribute to reduced impacts on water quality.

Humber Bay is characterized by three general zones of water quality. High levels of nutrients, metals and bacteria concentrate west of the Humber River mouth, and decrease outwards from the embayment area. Fecal coliform densities and phosphorus concentrations increase after rainfall events, hugging the shoreline in a 0.5-1.0 km band.

Highly contaminated waters from the combined loadings of the Don River and the numerous storm and combined sewer overflows, distinguish the Inner Harbour from the Outer Harbour and open Lake Ontario. Although the Outer Harbour shows intermediate water quality, it is affected by fecal coliform densities from the Eastern Gap during wet weather flow.

Ashbridges Bay and the surrounding area have relatively high concentrations of nutrients, metals and bacteria, probably owing to the close proximity of the Main WPCP discharge, numerous sewers and the eroding materials from the Eastern Headland. Investigations to evaluate the impact of lakefilling activities have found that impairment of water quality was localized, temporary, and generally secondary to the effects of discharges from the Main WPCP.

Examination of treated and raw water at the water filtration plants revealed no adverse impacts on drinking water supplies throughout the Metropolitan region.

3.1.1 Nutrients

This nutrient status section is largely based on two recent reports: "Toronto Waterfront General Water Quality 1976-1983" by D.J. Poulton and M. Griffiths and "Aquatic Environment of Humber Bay", ed. M. Griffiths.

Western Waterfront

Humber Bay water quality can be divided into three general zones (Fig. 3.8) as derived from cluster analysis of several conventional parameters (nutrients, turbidity, conductivity) sampled during dry weather conditions in 1983.

Zone 1: a degraded area in the immediate vicinity of the Humber WPCP outfall, as well as Mimico Creek and Humber River outlets;

Zone 2: intermediate, localized area of impact less than 1 km wide, confined to the above major sources of input;

Zone 3: offshore area.

While during dry weather conditions, zones of impact are restricted to areas close to the source inputs, more extensive zones are evident after rainfall events. A September 1983 wet weather survey revealed a 0.5-1.0 km band of elevated phosphorus concentrations (greater than the MOE guideline of 0.020 mg/l) extending from Parkside Drive along the entire western Humber Bay shoreline (Fig. 3.9).

Local growths of the nuisance algae Cladophora are attributed to the high phosphorus concentrations in combination with a suitable substrate. An algae skimmer has been successfully employed by the City of Etobicoke to remove Cladophora within 3 feet of the shoreline. Phosphorus input sources include Mimico Creek, Humber River, storm and combined sewer overflows, and the Humber WPCP.

Central Waterfront

Water quality in the central waterfront area varies with proximity to sources. Five water quality zones have been defined using cluster analysis for conventional pollutants. In decreasing order of impairment they are:

i) the Keating Channel

ii) the northeast corner of the Inner Harbour (adjacent to the Keating Channel)

iii) the remainder of the Inner Harbour

iv) the Outer Harbour and East and West Gaps

v) offshore waters

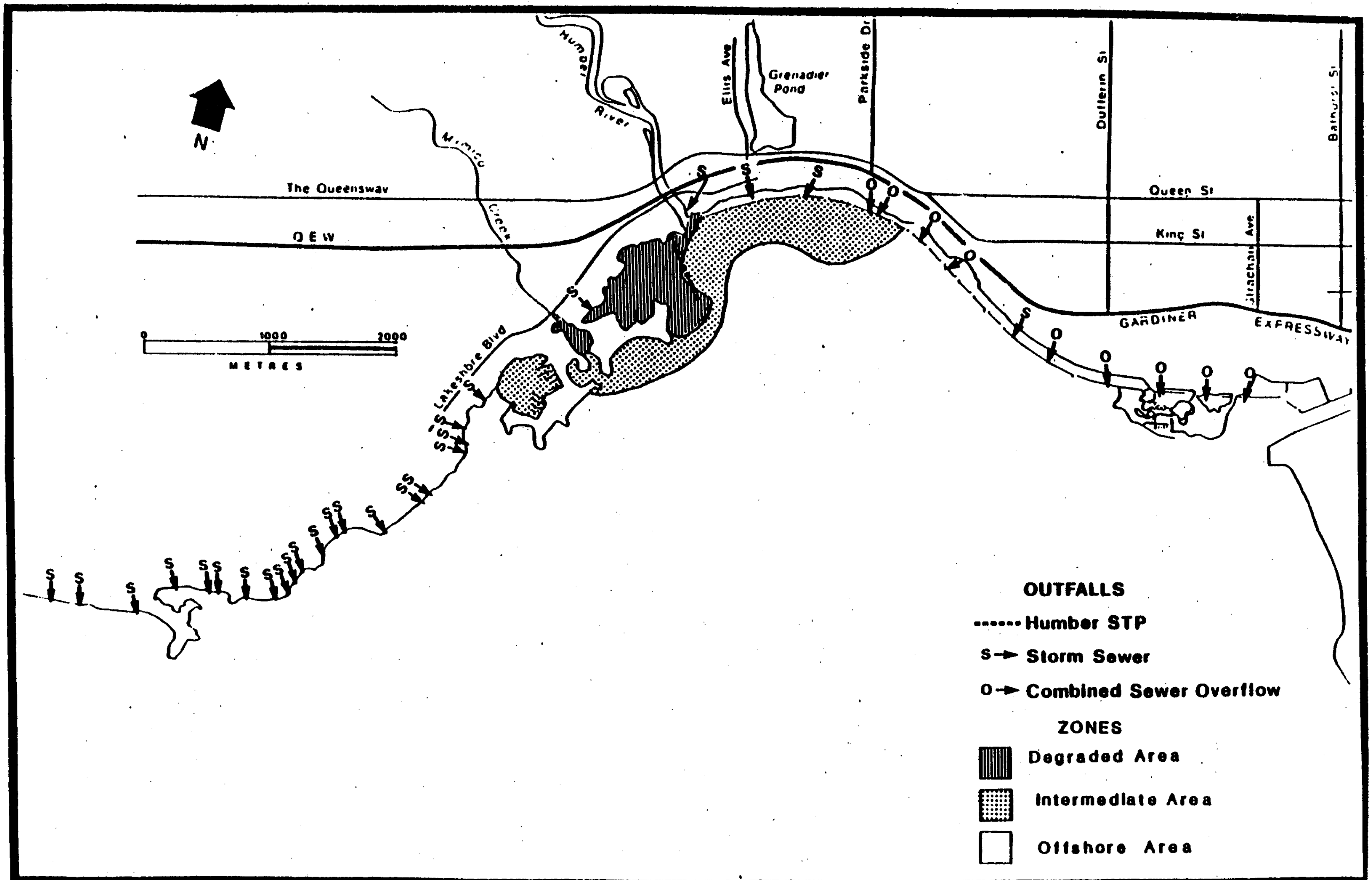


FIGURE 3.8: WATER QUALITY ZONES IN HUMBER BAY, DURING DRY WEATHER PERIODS, 1983

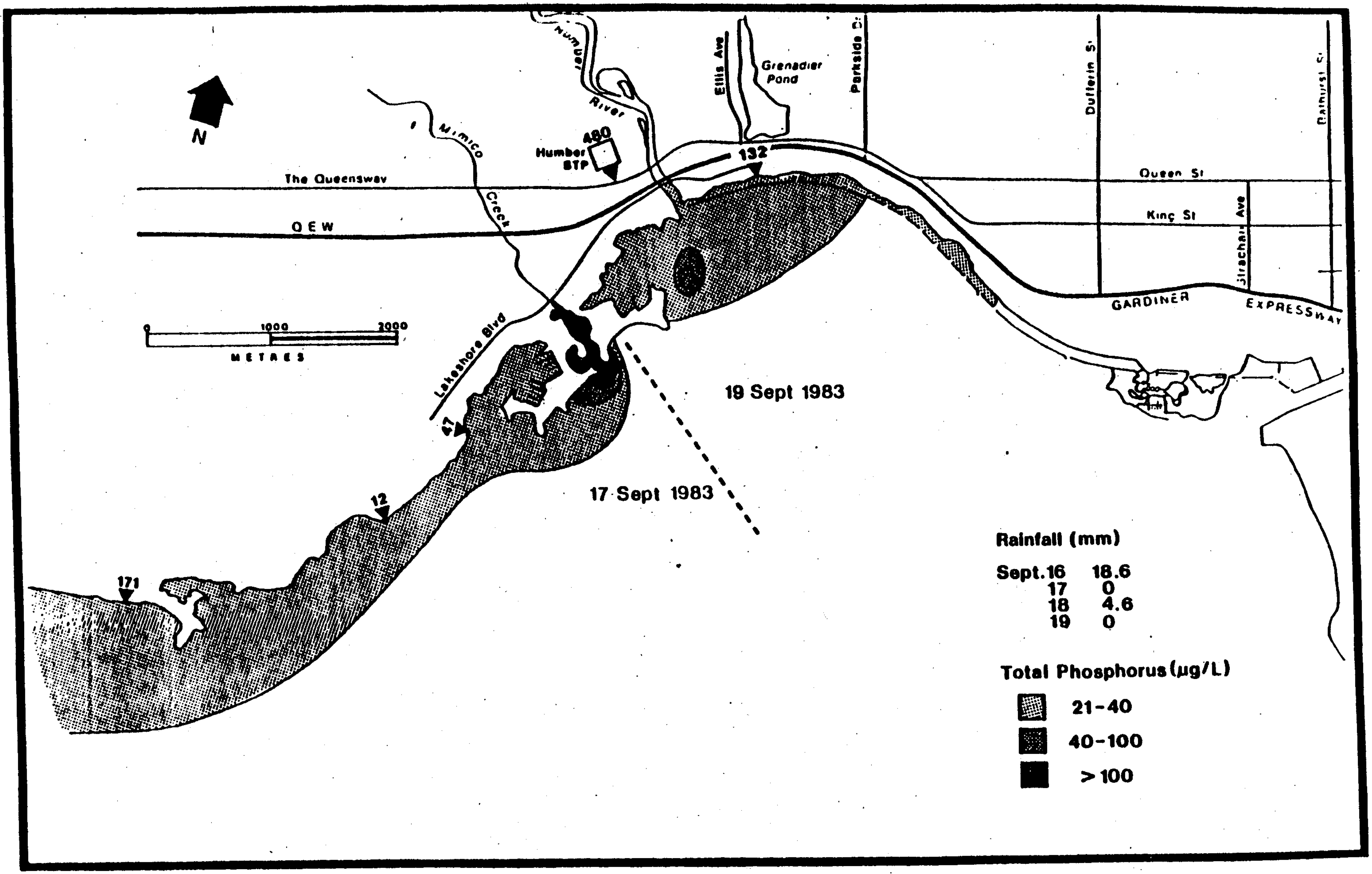


FIGURE 3.9: TOTAL PHOSPHORUS LEVELS FOLLOWING RAIN

Urban storm runoff via rivers and sewer outfalls has significant impact on waterfront water quality, especially in the Inner Harbour where influences from both the Don River and combined sewer overflows are present. The influence of runoff is reduced with increasing distance from shore. For example, a comparison of water quality at the Simcoe St. slip with the Inner Harbour reveals that during dry weather intervals, water quality in the slip is very similar to that in the harbour. This indicates that no significant dry weather flows are occurring, i.e. all sewage flows are being diverted by the interceptor sewers. Under runoff conditions, higher peak concentrations are observed at the slips. These peaks are highest for total phosphorus, compared to either nitrate-N or conductivity.

As expected, the Inner Harbour is by far the most severely affected area from runoff. The Outer Harbour is affected primarily by substances transported from the Inner Harbour through the East Gap or the Hearn G.S. via the Ship Channel. Direct influences on the lake are minor or non-existent, with the strongest effect of runoff being turbidity and suspended solids eroded from the Eastern Headland or other shoreline areas.

The parameter most highly influenced by runoff is turbidity (plus the associated clarity parameters suspended solids and secchi disk). High turbidity input from the Don River is frequently being transported along the east side of the Inner Harbour, and through the Eastern Gap and Ship Channel to the Outer Harbour. At other times, turbidity is observed to be concentrated along the north shore of the Inner Harbour, or transported along the Toronto Island shoreline.

The mean total phosphorus level in the Inner Harbour has decreased significantly from 0.130 mg/l in 1969 to levels around 0.027 mg/l by 1983, and has apparently now reached an equilibrium value in the waterfront area. This is expected since loadings to the waterfront area have remained relatively constant since phosphorus removal was begun at the Main WPCP in 1976. The significant decrease of 9% per year in the Inner Harbour between 1968-69 and 1977 reflects the effect of phosphorus removal and detergent phosphorus limitations introduced in the early 1970's. This decrease is in agreement with observations in the Lake Ontario nearshore area (MOE 1980). Although largely a whole-lake effect, decreased loadings at the Main WPCP and Don River also contributed to the decrease. Loadings from the Main WPCP show a maximum in 1970 just prior to the start of detergent reformulation, with effluent total phosphorus concentrations dropping to average values of 1.0 mg/L or lower since 1976 as a consequence of P removal.

A similar decrease in phosphorus loadings was observed in the Don River as a result from phosphorus removal at several sewage treatment plants. Three of the four WPCPs in the Don River watershed (Pugsley, North Don and John Street) were removed in the fall of 1981, and their sewage flow diverted to the York-Durham system. Resultant decreases in P loading in the Don have produced a small decrease in average Inner Harbour phosphorus concentration.

Annual mean concentrations of total Kjeldahl nitrogen (TKN) in the Inner Harbour and Outer Harbour range from 0.45 to 0.55 mg/L during the years 1976 to 1983. Mean open lake concentrations were usually less than 0.40 mg/L, declining to roughly 0.27 mg/L over the 1977-to-1983 period. However, higher annual mean values were observed for TKN in 1984, both in the Inner Harbour as well as Lake Ontario locations (Beak et al, 1987). Along the central waterfront ammonia levels exceed objectives of 0.02 mg/L as unionized NH_3 only in the Keating Channel (0.031 mg/L).

<u>Eastern Waterfront</u>

This area consists of relatively straight stretches of shoreline and, with the exception of Ashbridges Bay and Bluffers Park, lacks major harbours or embayments which can suffer from degraded water quality due to their limited water exchange rate characteristics. Nevertheless, even the straight areas of the eastern shoreline exhibit some degree of water quality degradation. Water high in NH_3 (ammonia), originating from the Main WPCP plume, is being carried westward along the Eastern Headland and even south of the Toronto Islands. Indeed, locations near the southern end of the Eastern Headland, nearly always shows ammonia values elevated above background, with an average of 0.36 mg/L and a maximum of 0.69 mg/L during the 1977-78 dry weather surveys. At a location south of the southern tip of the islands and near the Island Filtration Plant intakes, average total ammonia-N was 0.11 mg/L and maximum was 0.35 mg/L. By contrast, locations further offshore and less influenced by the Main WPCP plume, reveal consistent ammonia levels of 0.01-0.02 mg/L, similar to values generally observed along the Lake Ontario nearshore. Similar effects are noticeable in the total Kjeldahl N data for these stations. This east-to-west transport is in accordance with average circulation patterns for the area. As a result, the Provincial Water Quality Objective of 0.02 mg/L for unionized ammonia is exceeded near the Main WPCP outfall and is within compliance throughout the offshore waters of the eastern waterfront.

In addition to elevated ammonia levels, turbidity is the other factor contributing to somewhat degraded water quality of the eastern waterfront. Lakefilling activity and disposal of dredged material from the Keating Channel during 1980 and 1981 were shown to have a significant effect on turbidity and suspended solids near the dredge spoil disposal area along the Eastern Headland (Griffiths 1980, 1983; Griffiths and Winiecki 1981). Turbidity plumes can exceed 2 km in length under high winds (above 20 km/h).

Phosphorus levels are still occasionally exceeding the PWQG of 0.020 mg/L, especially in Ashbridges Bay and near point source inputs. Nevertheless, mean total phosphorus concentrations in Ashbridges Bay declined from 0.28 mg/L to 0.17 mg/L between the periods 1976-1978 and 1980-1985. Exceedences of the PWQG for total phosphorus also declined.

Offshore of Highland Creek phosphorus concentrations are much lower (mean: 0.019 mg/L), with fewer exceedences of the PWQG. In Highland Creek itself, concentrations are much higher than at the nearshore locations, dropping slightly from 0.258 mg/L in 1979 to 0.119 mg/L in 1981. Similarly, high total phosphorus levels have been observed in the Rouge River over the past 20 years, with a distinct downward trend since the mid 1970's (Beak et al, 1987).

3.1.2 Bacteria

Current provincial bacteriological guidelines for aquatic recreational use state that the geometric mean fecal coliform (FC) density at a location should not exceed 100 FC/100 ml for a minimum of 10 samples in a monthly period (MOE, 1984). Exceedences of this guideline may cause adverse reactions in humans, ranging from gastrointestinal illness to skin, ear, eye, nose and throat infections (Health and Welfare Canada, 1983).

At present, Provincial bacteriological guidelines for E. coli and Pseudomonas aeruginosa are not available. The proposed IJC objectives for E. coli are 23 organisms/100 ml, and for Pseudomonas aeruginosa as no greater than 10 organisms/100 ml in more than 25 percent of the seasonal samples. E. coli levels could provide medical authorities with a measure of the potential risk of gastroenteric disease for bathers, and Pseudomonas aeruginosa could provide a measure of protection for swimmers from otitis externa (swimmer's ear). For example, the risk of otitis externa associated with the IJC Pseudomonas aeruginosa objective is 12 per cent.

Beaches along the Toronto waterfront are posted when the running geometric mean of 10 samples exceeds the 100 FC/100 ml guideline. A Beach Hotline (392-0975) is available to inform the public of the status of Toronto's beaches. Fecal coliform densities have been observed to rise over the summer as the season progresses. The majority of open days occur early in the season.

A summary of beach posting durations and seasonal geometric means for all stations monitored by the local Health Departments is provided in Table 3.1. The locations of sampling stations are shown in Figures 3.10 and 3.11. Figures indicating the range of bacteria levels recorded at different locations are provided in Appendix A.

Some of the highest levels of fecal coliforms along the Metro Toronto shoreline are found associated with river inputs which have the potential to affect nearby beach locations. The most impacted beach on the Metropolitan shoreline is Marie Curtis Park (likely affected by Etobicoke Creek), followed by Amos Waites (possibly affected by nearby sewers and Mimico Creek). Close behind are two Etobicoke beaches: Rotary Park and Long Branch, as well as Windermere which is located in the most western portion of the Western Beaches and which is probably affected both by the outflow from the Humber River as well as by nearby sewers.

The least bacteriologically contaminated swimming areas are found at Hanlan's Point and Cherry Beach. Both of these locations are removed from the direct impact of source inputs.

Table 3.1: BACTERIOLOGICAL STATUS ALONG METRO TORONTO WATERFRONT SUMMER 1987

STATION NO.	LOCATION	FECAL COLIFORM GEO. MEAN**	NO. DAYS POSTED
9710*	Humber Bay Pk.W. North boat launch	4692	N/A
9702	Marie Curtis Park, West	1651	100
9401*	Humber R. Mouth, East	1372	N/A
9701	Marie Curtis Park, West	1341	100
9708	Amos Waites	1114	100
9709*	Humber Bay Pk.W. South boat launch	472	N/A
9707	Rotary Park	420	100
9705	Long Branch Park	372	100
9704	Marie Curtis Park, East	338	100
9402	Windermere	335	67
9703	Marie Curtis Park, East	334	100
9519	Balmy Beach	318	56
9516	Balmy Beach	296	56
9405	Ellis Ave.	291	67
9605	Lake Ontario Rouge, East	230	55
9517	Balmy Beach	223	56
9515	Balmy Beach	223	56
9711	Humber Bay Park, East	214	100
9509	Kew Beach	212	42
9406	Sunnyside	196	67
9508	Beaches Park	187	42
9518	Balmy Beach	170	56
9601	Bluffers Park West	168	55
9604	Lake Ontario Rouge, West	148	55
9514	Kew Beach	136	42
9501	Woodbine Beach	132	33

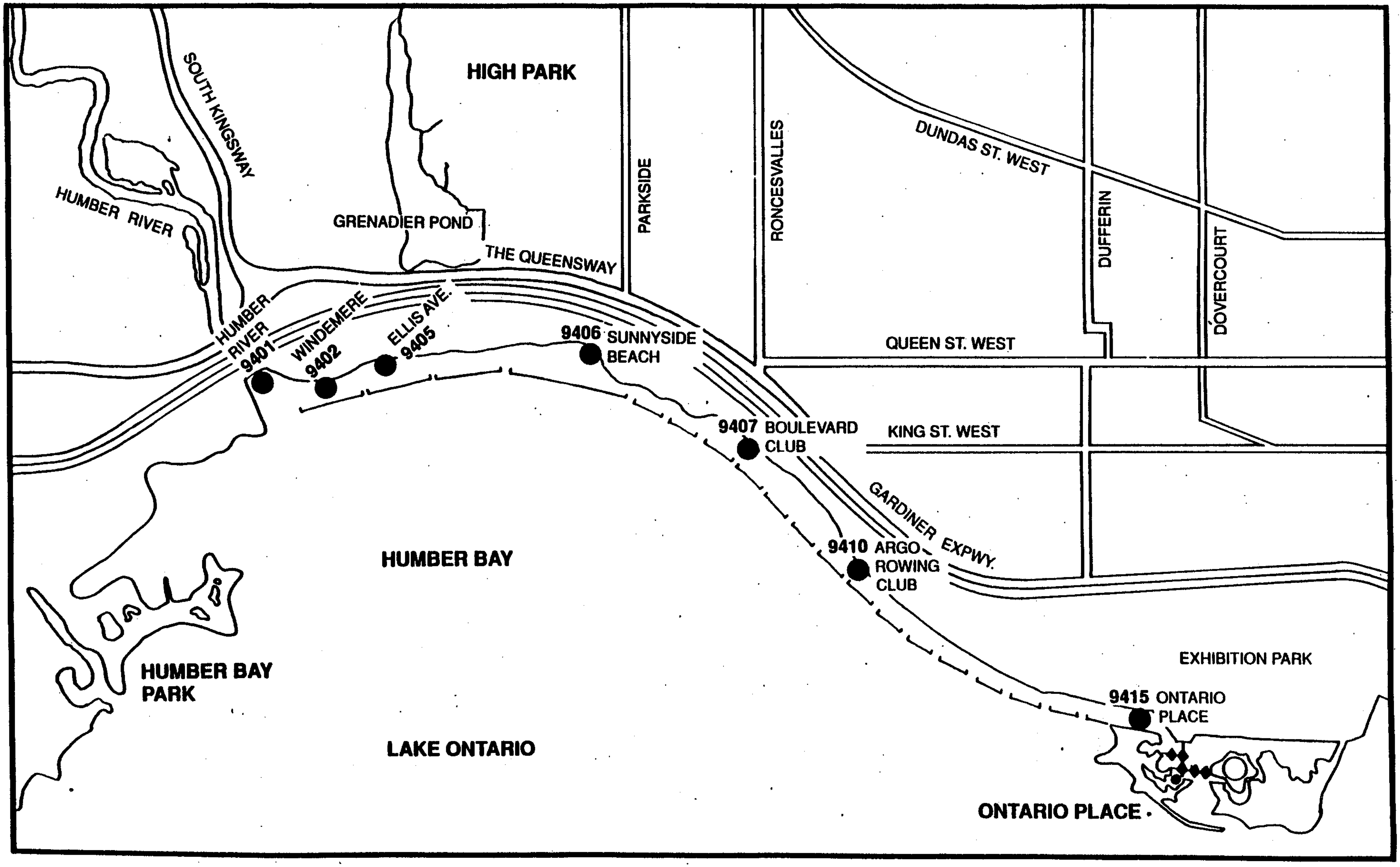
NA - Not applicable.
* indicates a location that is not a recognized beach.
**indicates fecal coliform geometric mean as number of organisms/ 100 ml.

Table 3.1 Continued

STATION NO.	LOCATION	FECAL COLIFORM GEO. MEAN**	NO. DAYS POSTED
9415*	Ontario Place	128	N/A
9502	Woodbine Beach	121	33
9507	Beaches Park	119	42
9602	Bluffers Park Centre	116	55
9520	Kew Beach	104	42
9513	Kew Beach	101	42
9410*	Argonaut Rowing Club	93	N/A
9512	Kew Beach	87	42
9506	Beaches Park	86	42
9407	Boulevard Club East	84	67
9521	Beaches Park	84	42
9503	Woodbine Beach	67	33
9504	Woodbine Beach	67	33
9603	Bluffers Park East	64	55
9500	Woodbine Beach	60	33
9505	Beaches Park	59	42
9435	Cherokee Beach	52	47
9430	Olympic Beach 1	44	55
9431	Olympic Beach 2	32	55
9440	Centre Island	23	55
9434	Snake Island	20	55
9441	Centre Island	12	55
9460	Wards Island	6	25
9445	Centre Island	5	55
9450	Hanlans Point	5	15
9471	Cherry Beach West	5	26
9470	Cherry Beach East	4	26
9480*	Leslie Street Spit	4	N/A

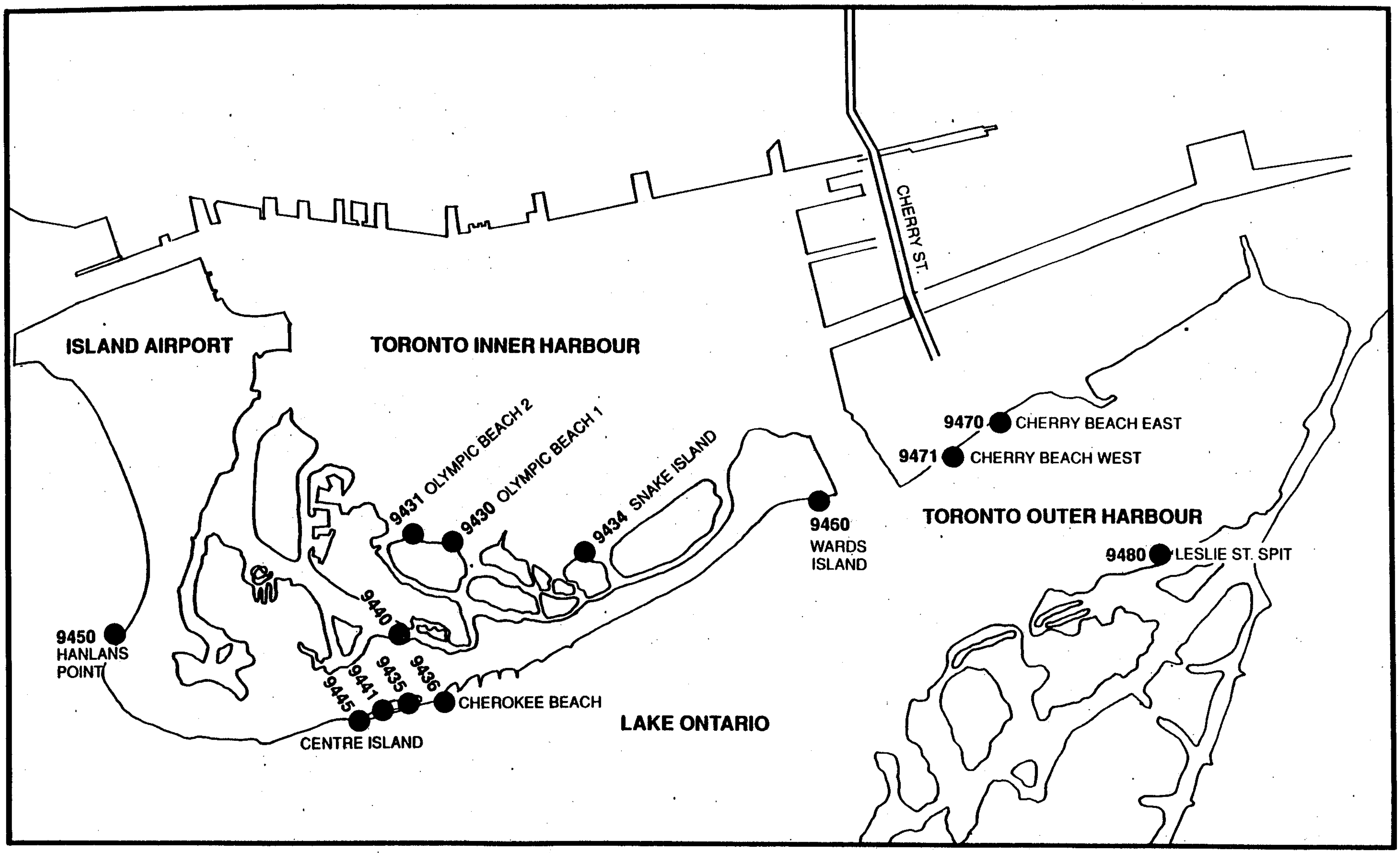
NA - Not applicable.
* indicates a location that is not a recognized beach.
**indicates fecal coliform geometric mean as number of organisms/100 ml.

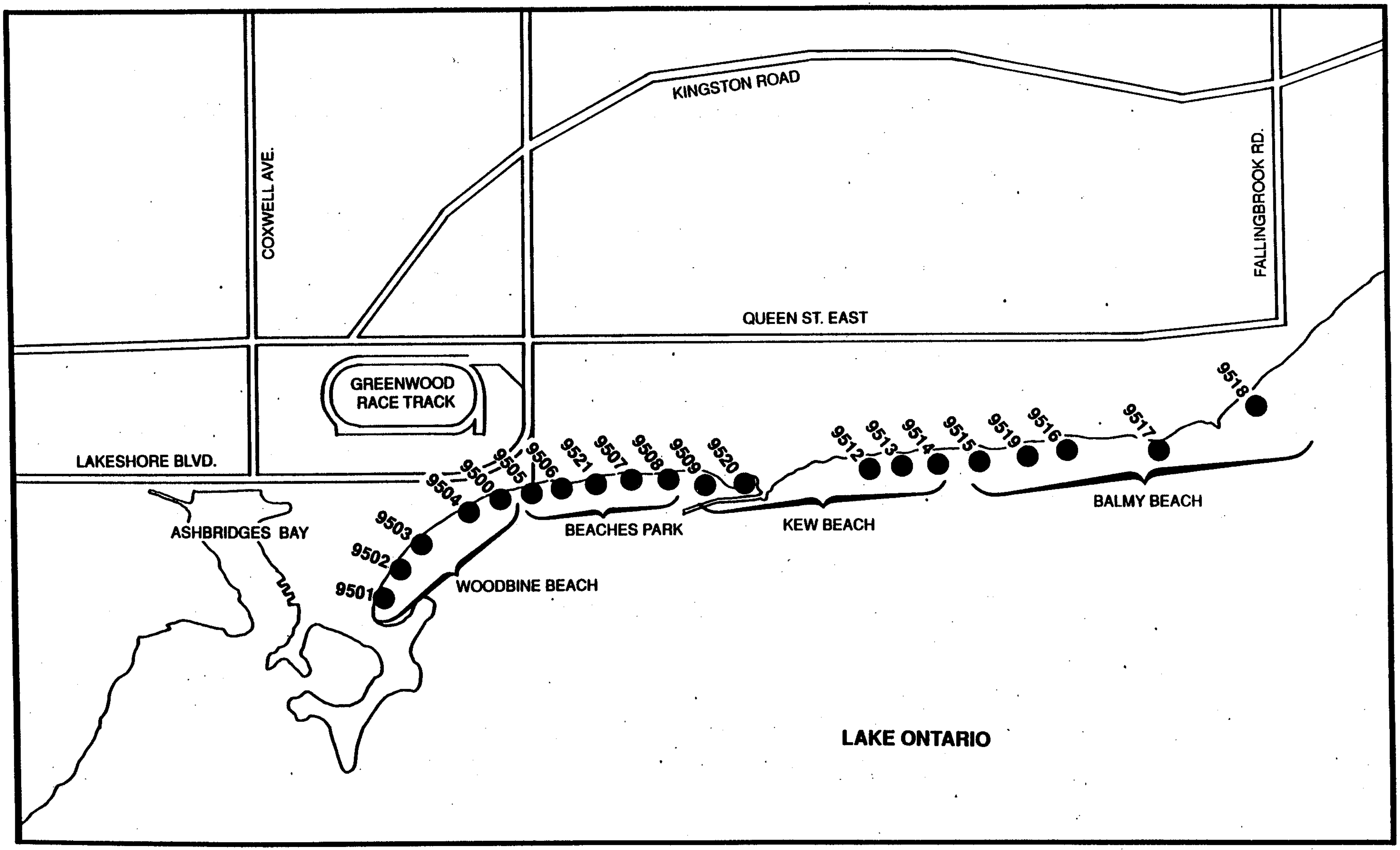
FIGURE 3.10: CITY OF TORONTO HEALTH UNIT SAMPLING LOCATIONS (1987)



OVER ►

FIGURE 3.10: CITY OF TORONTO HEALTH UNIT SAMPLING LOCATIONS (1987)





KINGSTON ROAD
COXWELL AVE.
FALLINGBROOK RD.
QUEEN ST. EAST
GREENWOOD RACE TRACK
LAKESHORE BLVD.
ASHBRIDGES BAY
9501
9502
9503
9504
9500
9505
9506
9521
9507
9508
9509
9520
9512
9513
9514
9515
9519
9516
9517
9518
WOODBINE BEACH
BEACHES PARK
KEW BEACH
BALMY BEACH
LAKE ONTARIO

FIGURE 3.11: ETOBICOKE HEALTH UNIT SAMPLING LOCATIONS (1987)

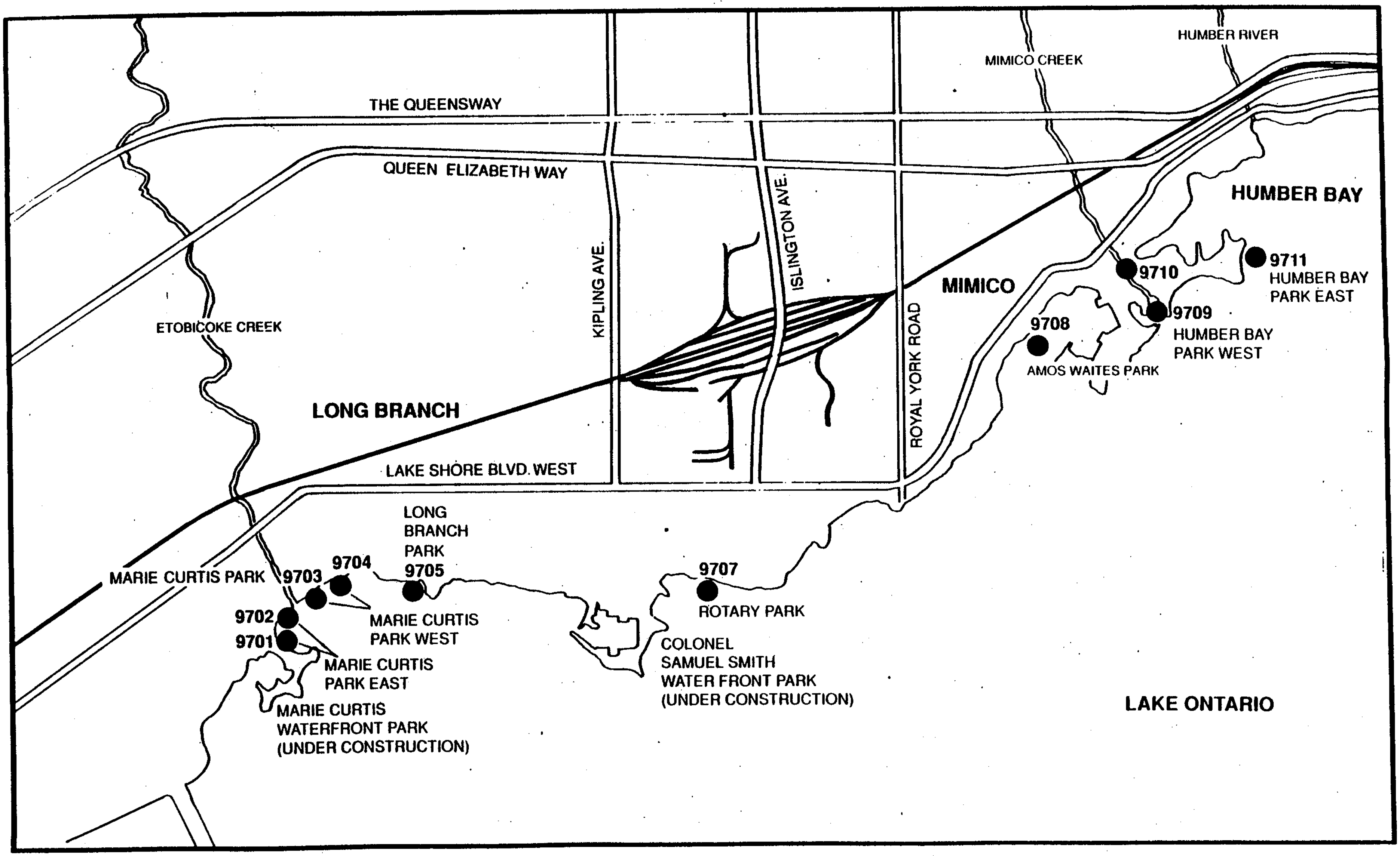


FIGURE 3.11(a): SCARBOROUGH HEALTH UNIT SAMPLING LOCATIONS (1987)

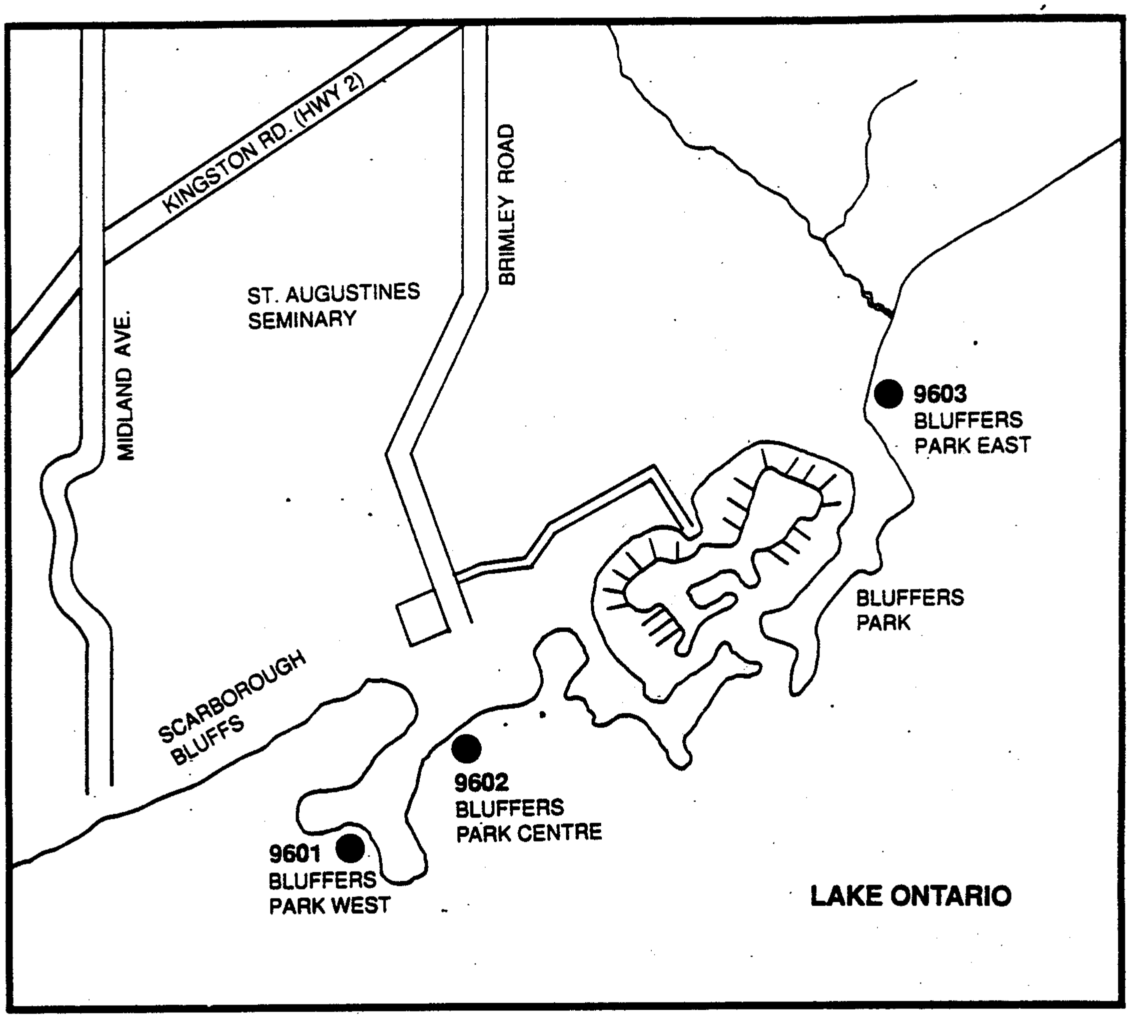
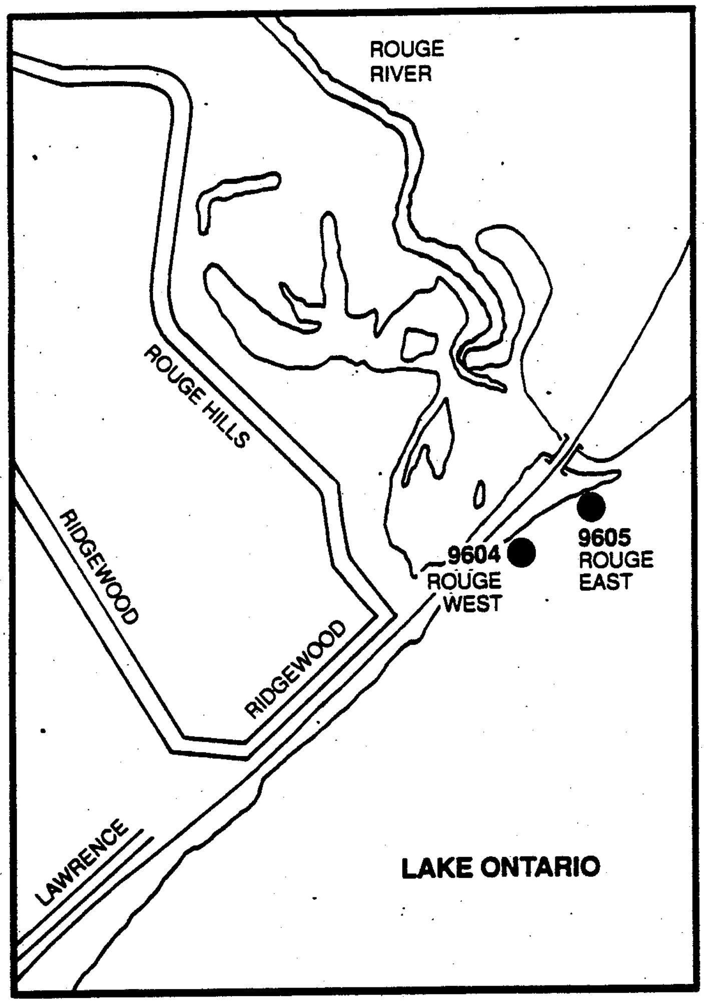


FIGURE 3.11(b)


ROUGE
RIVER
ROUGE HILLS
RIDGEWOOD
RIDGEWOOD
LAWRENCE
9604
ROUGE
WEST
9605
ROUGE
EAST
LAKE ONTARIO

Preliminary results of a study carried out by MOE indicate that, in addition to fecal coliforms, two other bacteria - E. coli and Pseudomonas aeruginosa - are found in high numbers in embayments within the Metro Toronto shoreline (Table 3.2). The embayments investigated are mainly used as marinas and, in selected locations, as swimming beaches.

Of the three beaches tested, the Olympic Beach site located in the Toronto Inner Harbour had the highest levels of Pseudomonas aeruginosa (25 percent of the samples were equal to or exceeded 24 organisms/100 ml), followed by Amos Waites and Scarborough Bluffs beaches. Overall, the highest Pseudomonas aeruginosa levels in the embayments themselves were found near inputs such as Mimico Creek (25% > 1740 organisms/100 ml), in Humber Bay W. embayment near a sewer adjacent to Amos Waites Beach (25% > 260 organisms/100 ml), and in the lagoons of Ontario Place near combined sewer overflows (25% > 100 organisms/100 ml). High Pseudomonas aeruginosa and E. coli levels in these embayments may limit their potential for primary and secondary body contact recreation.

Western Waterfront

Bacterial contamination of Humber Bay has received considerable attention since the summer 1983 placarding of the Western Beaches by the City of Toronto Department of Public Health. Several studies have been conducted to examine the problems during both wet and dry weather conditions.

During dry weather, a distinct gradient of fecal coliforms is apparent behind the breakwall with highest concentrations near the Humber River mouth decreasing toward the east and lowest levels found near the Argonaut Rowing Club. Fecal coliform levels inside the breakwall are significantly higher than those outside the breakwall with the exception of an area near the Parkside Drive and Howard Park combined sewer overflows. This observation may indicate possible dry weather inputs and/or non-point sources such as bird droppings or sediment resuspension caused by boating or wave action contributions at these locations. During wet weather, fecal coliform levels are elevated both inside and outside the breakwall.

Table 3.2: Levels of Bacteria (organisms/100 ml) in Metro Toronto Embayments During Summer 1987

LOCATION	E. coli (geometric mean)	Pseudomonas aeruginosa (upper quartile level)*
Humber Bay		
2914	138	260
2915**	53.7	12
2979	55.0	68
2916	25.7	4
1917	20.0	8
2041	53.7	20
2169	2089.3	1740
2918	100.0	16
2072	44.7	64
Ontario Place		
2919	104.7	44
2920	147.9	40
2921	239.9	32
2922	281.8	8
2923	354.8	92
2924	338.8	16
2925	316.2	100
2926	245.5	24
Toronto Islands		
2928	24.5	4
2929	45.7	4
1771	36.3	4
2930	85.1	4
2931	87.1	8
1773**	53.7	24
2932	74.1	8
2933	51.3	4
2934	52.5	8
Scarborough Bluffs		
2937	97.7	16.0
2938**	20.9	8.0
2939**	41.3	4.0
2940	102.3	10.0
2941	14.5	8.0
2943	55.0	48.0
2942	15.8	53.0

Station locations are provided on maps in Appendix A.

* Upper quartile level indicates that the reported level or higher was found in 25% of the samples.

**Indicates a swimming location.

A comparison of dry-weather versus all-weather running geometric means at locations west of the Humber River shows only small differences between them, indicating that local storm sewer runoff and wet-weather discharge from Mimico Creek may have only a minor effect on bacterial levels at these sites. The small size of the data set used may bias this conclusion, however. Limited data collected by MOE in Mimico Creek, has shown a distinct difference between dry weather and wet weather coliform levels.

In contrast, distinct differences between dry-weather and all-weather running geometric means at the Western Beaches suggest that storm related inputs from local combined sewer overflow and storm sewers and overland inputs elevate bacterial levels above those prevailing during dry-weather conditions.

The extent of bacterial contamination in Humber Bay during a rain event in September 1983 is illustrated in Figure 3.12. This scenario shows plumes containing elevated numbers of fecal coliforms hugging the shoreline west of the Humber River along a 0.5-1.0 km band and intruding behind the breakwall along the entire length of the Western Beaches. This observation was made before the construction of a deflecting jetty. Although intrusions of Humber River water still occur, they are now less frequent than before the jetty construction.

A numerical model of Humber Bay has shown that the Humber WPCP outfall has no effect on the FC levels at the Western Beaches (MacLarens 1986). Fecal coliform densities are so small by the time the Humber plume reaches the Western Beach area that the plume does not affect the beach fecal coliform densities.

At all sampling sites, the running geometric mean of fecal coliforms consistently increase toward the latter portion of the summer. Increased survival rates of bacteria in sediment related to warmer temperatures, in combination with constant dry-weather loads from the Humber River, and higher frequency of rainfall events, may be some of the factors contributing to this increase.

Central Waterfront

The Central Waterfront beaches are impacted by bacterial contamination in a manner similar to that noted for the Western

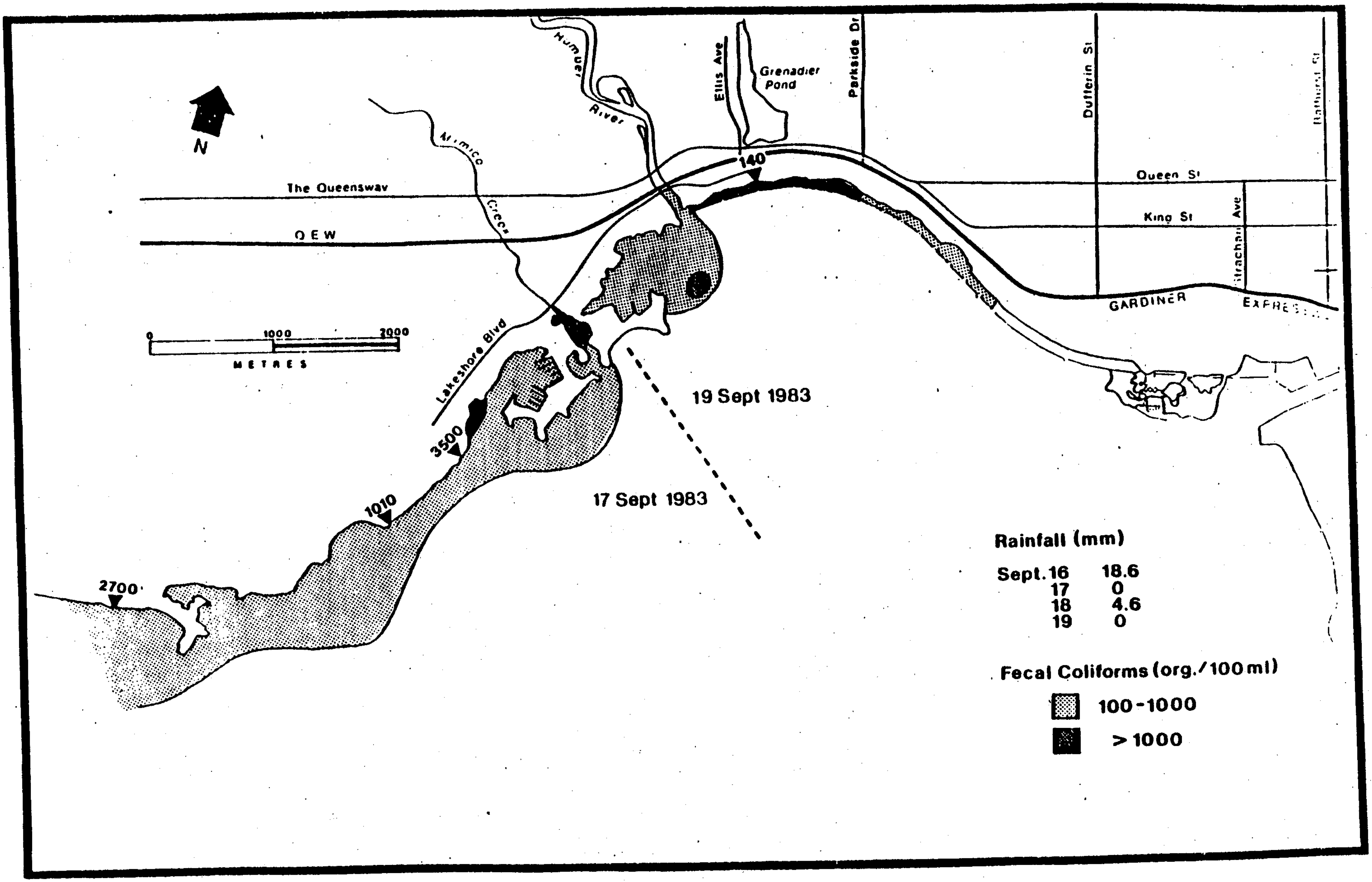


FIGURE 3.12: FECAL COLIFORM LEVELS FOLLOWING RAIN

Beaches. Increased fecal coliform densities have been noted during wet weather and as the season progresses. The location of the Central Waterfront beaches relative to sewer outfalls and tributary mouths renders them slightly less susceptible to contamination than the Western Beaches. Records of beach closures in 1987 show the harbour-side beach areas were closed for 55% of the season (Olympic and Snake Island), while the more remote beaches (relative to sewer inputs) were closed for shorter durations (Cherry 26%; Wards Island 25%; Hanlans Point 15%). The Centre Island beaches and Cherokee beach were closed 47-55% of the time. For comparison, the Western Beaches were closed for 67% of the time.

The Centre Island beaches may be impacted by water passing through the Eastern Gap. Studies conducted in 1986 (Gore and Storrie, 1986) have shown fecal coliform contaminated waters from the Eastern Gap to impact the area behind the Centre Island breakwall during rainfall events. During dry weather, towards the end of summer, resuspension of FC contaminated sediments are suspected of elevating bacterial densities.

<u>Eastern Waterfront</u>

Beaches along the Eastern Waterfront are impacted by the same conditions affecting the other waterfront areas. Based on 1987 closures (Balmy 56% closure; Kew 42%; Beaches Park 42%; Woodbine 33%) the level of contamination falls between that experienced on the Western Waterfront and the Central Waterfront.

Analysis of wet and dry weather data sets indicate that wet weather FC densities are significantly higher than during dry weather. Elevated FC densities coincident with rainfall events are attributed to the effects of combined sewer overflows and stormwater discharge. Fecal coliform densities have been observed to increase as the season progresses as noted at the other beach areas.

3.1.3 Contaminants

A summary of contaminant status along the Toronto waterfront based on a Ministry of the Environment survey conducted in 1985 (Boyd, 1988) is presented in Table 3.3. These findings

Table 3.3: **TORONTO WATER QUALITY 1985 —— MAXIMUM CONCENTRATIONS OF METALS, AND TRACE ORGANIC COMPOUNDS WITH PERCENTAGE OF SAMPLES DETECTED IN EXCESS OF PROVINCIAL WATER QUALITY OBJECTIVES**

PARAMETER	Cd ug/l		Cu ug/l		Fe ug/l		Ni ug/l		Pb ug/l		Zn ug/l		LINDANE ng/l		HEPTCHLR/ EPOX ng/l		ALD/DIEL ng/l		SUM OF DDT ng/l		PENTACHLR PHNL ng/l	
PWQO	0.2		5		300		25		25**		30		10		1		1		3		500	
LOCATION	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%	Max	%
2054 Mimico Creek	0.7	25	7	42	340	17	14	0	7	0	50	17	5	0	ND	0	ND	0	ND	0	ND	0
2072 Humber WPCP	0.8	58	20	75	970	83	30	33	4	0	80	50	6	0	ND	0	ND	0	ND	0	60	0
9053 Humber River	0.3	17	7	33	1400	25	6	0	6	0	16	0	2	0	1	0	ND	0	ND	0	ND	0
1536 Island FP	ND	0	5	0	44	0	3	0	8	0	3	0	ND	0	ND	0	ND	0	ND	0	343	0
1364 Inner Harbour	ND	0	35	30	260	0	2	0	4	0	16	0	10	0	2	10	ND	0	ND	0	ND	0
2017 Dredging	0.2	0	10	50	1070	100	3	0	13	0	18	0	5	0	1	0	ND	0	ND	0	ND	0
1379 Cherry Street	0.5	10	15	80	1200	100	7	0	18	0	28	0	89	30	6	10	11	50	ND	0	842	22
2020 Lower Don	0.2	0	41	100	1200	100	14	0	14	0	34	10	42	25	7	25	3	25	ND	0	144	0
1987 East Headland	ND	0	7	20	4300	80	4	0	93	20	22	20	ND	0	ND	0	1	0	5	10	ND	0
1419 Main WPCP	0.4	20	33	60	1400	20	13	0	15	0	100	20	2	0	2	10	ND	0	ND	0	285	0
2029 Harris FP	ND	0	4	0	28	0	2	0	7	0	4	0	ND	0	ND	0	ND	0	ND	0	117	0
1997 Control	0.3	10	6	10	22	0	2	0	6	0	5	0	1	0	ND	0	ND	0	ND	0	ND	0

PWQO - indicates Provincial Water Quality Objectives
MAX - indicates Maximum Concentration detected at that location in the 1985 survey
% - indicates Percentage of samples detected in excess of PWQO in the 1985 survey
Dredging - indicates a dredging location at the mouth of the Don River
Cherry St. - indicates a location in the Keating Channel at Cherry Street
E. Headland - indicates a lakefilling location near the Eastern Headland
* - indicates Guideline Only
** - indicates Variable Objective
ND - indicates Not Detected

indicate that localized areas within the Toronto waterfront (chiefly in the vicinity of rivers, WPCP outfalls, and lakefilling operations) exceed some Ministry water quality objectives for the protection of aquatic life, the magnitude and frequency of non-compliance varying according to parameter and location. Parameters of non-compliance include cadmium, copper, iron, nickel, lead, zinc, lindane, heptachlor/heptachlor epoxide, aldrin/dieldrin, pentachlorophenol, and DDT and metabolites.

Suspended sediment concentrations of metals and trace organics are generally higher at the sewage treatment plant outfalls than at river mouths or the lakefilling operation. However, comparison of whole water chemistry (water plus suspended sediment) with results for suspended sediments alone, shows that water quality is more dependent on the quantity of suspended material in the water column than the quality of the suspended material itself.

Prior to deposition, contaminants associated with suspended sediments contribute to violations of Ministry water quality objectives for metals and organics. They may also represent a direct source of contaminants for aquatic biota within the water column and, following deposition, to benthic and epibenthic biota.

Contaminant loadings are largely related to flows, particularly at rivers. The Main WPCP represents the single largest source of nutrients, metals and organics to the waterfront, followed by the Humber WPCP, the Humber River, the Don River and Mimico Creek. Estimates of contaminant loadings have not been attempted for the lakefilling operation or for sewers discharging to the waterfront.

Estimates of partitioning between particulate and aqueous forms of phosphorus and most metals show the potential for substantial reductions in loadings of these substances to the waterfront by reducing the discharge of suspended sediments from rivers, sewage treatment plant outfalls, and the lakefilling operation.

<u>Western Waterfront</u>

Provincial Water Quality Objectives (PWQOs) were exceeded for cadmium, copper, iron, lead, nickel and zinc in the vicinity of the three major input sources to Humber Bay (Humber River, Mimico Creek and Humber WPCP) (Griffiths, 1988). The greatest frequency of PWQO violations for metals was found near the Humber WPCP (which also had the highest maximum concentrations), followed by Mimico Creek and Humber River. Copper may be the most significant metal of concern since it was frequently found in concentrations above the PWQO.

Organochlorine compounds detected near the input sources include trichlorobenzene, tetrachlorobenzene, α, β and γ-BHC, pentachlorophenol and HCB (hexachlorobenzene). All of the above were found in trace amounts only, and were never found to exceed existing PWQOs. PCBs and DDT were not found in water column samples using conventional detection levels.

<u>Central Waterfront</u>

Data on heavy metals for the Central Waterfront area have been available since 1976, where the most commonly measured metals - lead, chromium, copper and mercury - have generally been reported at the detection limits. Most violations of PWQO occurred in the Inner Harbour. Storm sewer outfalls in the lower reaches of the Don River account for a significant proportion of heavy metal contamination. Although heavy metal contamination is not extremely high, it may present a chronic impact to aquatic life forms, notably in Keating Channel and localized spots of the Inner Harbour (Hart, 1985). The Outer Harbour displayed a trend of significant decrease for copper and mercury between 1981 and 1984 (Beak et al., 1987).

Available data for organic contaminants indicate that concentrations of PCBs and DDT, in the Inner Harbour, Outer Harbour and Lake Ontario, are at or below the detection limit. Additional organochlorine data for Toronto Harbour, Don River and Keating Channel indicate infrequent occurrences of dieldrin, endrin and endo-sulphan in excess of their respective PWQO. Lindane concentrations in the Don River were commonly above the PWQO of 10 ng/l, whereas aldrin concentrations infrequently exceeded the PWQO of 1 ng/l. Phenolic levels in the Inner Harbour, Outer Harbour and open Lake Ontario usually exceeded 5 ug/l.

<u>Eastern Waterfront</u>

In reference to organic contaminants, mean phenolic concentrations at Ashbridges Bay have declined from 2 ug/l to less than 1 ug/l between the periods 1976-78 and 1980-85. Moving offshore, concentrations were generally below the detection limit of 1 ug/l. Water samples near the Main WPCP discharge have occasionally exhibited detectable levels of 1,2,3,4-tetrachlorobenzene, dichlorvos, mevinphos and γ-BHC. In addition, lindane has been detected slightly above the PWQO of 10 ug/l (Beak et al., 1987).

Inorganic data for the past three to four years is highly variable and sparse, with most observations close to detection limits. Only iron exceeded the PWQO (of 0.30 mg/l) at Ashbridges Bay during the period of 1980-85.

3.1.4 Drinking Water

During 1986, the MOE introduced the Drinking Water Surveillance Program (DWSP) at three Toronto water filtration plants: R.C. Harris, R.L. Clark and Easterly. The R.C. Harris plant is the largest, and produces a mean annual water output of 660 x 1000 m^3/day. The R.L. Clark plant produces a mean annual water output of 400 x 1000 m^3/day and the Easterly plant has a mean annual output of 273 x 1000 m^3/day.

The DWSP analyzes for more than 160 parameters including bacteriological, inorganic and organic chemicals, on a monthly basis at each of these plants.

Raw water monitoring from this program at all three locations during 1987 showed that arsenic was always below detection limits while cadmium, chromium and lead were below detection limits in most samples. Mercury, barium, copper, zinc and nickel were detected in the raw water but at levels considerably below Ontario Drinking Water Objectives (ODWO). A single high level of 0.14 ug/L was recorded for mercury.

Traces of α BHC were found in most raw water samples; this pervasive contaminant, the predominant isomer of lindane, is found throughout the Great Lakes basin at mostly trace levels. Lindane was also found at trace levels, but in only a few samples. No other pesticides were found in raw water samples during 1987, although atrazine was found at a trace level in treated water at R.C. Harris on one occasion, as was pp-DDE at R.L. Clark.

A trace of toluene was found once in the raw water at R.C. Harris and of ethylbenzene at both Easterly and R.L. Clark on only one occasion; a trace of hexachloroethane was found once at R.L. Clark. Phenolic compounds were detected very occasionally. No polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) or other organic substances were detected in the raw water at any of the plants.

Overall, filtered drinking water for Metro Toronto is of excellent quality. Trihalomethanes, produced when the chlorine added for disinfection purposes reacts with naturally occurring organic substances in the water, were found in all treated water samples. The levels found were all well below the ODWO of 350 ug/L, with a high level of 37 ug/L being found on one occasion at the R.L. Clark plant. Traces of αBHC and lindane occurred in some treated waters. Traces of some chloroaromatic compounds such as hexachloroethane were found infrequently in treated water at all the plants as were traces of some volatile compounds like toluene and ethylbenzene. Since these compounds seem to occur in all treated waters from municipal water supplies, irrespective of the water source, they would appear to be products or contaminants from the treatment process itself.

The treated drinking water produced by all three Toronto water plants did not exceed any health-related guidelines for organic or inorganic substances. Such guideline values represent, in general, the level of a contaminant in drinking water that does not result in any significant risk to the consumer over a lifetime of consumption.

3.2 SEDIMENT QUALITY

Overview

Contaminant levels in sediments show considerable variation across the waterfront. High levels of nutrients, organics, and metals occur in areas with poor water circulation (embayments, slips) and near tributary mouths and municipal discharges. Contaminants/sediments in these areas are predominantly in geochemically available forms, which suggests anthropogenic origins. Organic pesticides were measured at only very low concentrations in sediments, often at detection limits.

Humber Bay and Inner Toronto Harbour possess the most highly contaminated sediments along the Toronto waterfront. The Eastern Waterfront has the cleanest sediments. Within Humber Bay, the relatively great depths, large volume and sheltering from direct main lake circulation, result in widespread contaminant distribution. The Toronto Island lagoons and the north shore slips of the Inner Harbour are heavily contaminated. Again, poor water circulation to disperse the influx of contaminated sediments encourages the deposition of suspended solids. The embayment of Ashbridges Bay is also contaminated, though not to the extent of Humber Bay.

The Outer Harbour exhibits intermediate sediment quality with the exception of a more contaminated zone in the middle of the approach channel. Although the Toronto East Headland appears to be a source of contaminants to local sediment within the vicinity, it is generally secondary to the flow of suspended solids discharged from the Don River and the Main sewage treatment plant.

Unrestrained wave action and currents in the open lake area along the Eastern Beaches (with relatively low inputs) produce the least contaminated sediment zones within the Toronto waterfront area.

A summary of average contaminant levels found in sediments across the waterfront is presented in Table 3.4. Whole lake mean values (Thomas and Murdoch, 1979) of sediment and MOE's Open Water Disposal Guidelines for Dredged Material are shown for comparative purposes.

3.2.1 Sediment Sources

Metro Toronto nearshore sediments are derived mainly from shoreline and bluff erosion, stream and river discharges, urban runoff, and lakefilling activities (Persaud et al., 1985). Shoreline and bluff erosion is a major source of the Toronto nearshore sediments (Rukavina, 1976). Erosion caused by wind generated waves and currents often facilitates the suspension and transport of sediment particles along the shoreline "littoral zone" (zone of nearshore material movement). The material transported, referred to as "littoral drift", is moved along the littoral zone by the shoreline currents and waves (Persaud et al., 1985). In the Toronto area, the net littoral

Table 3.4
Mean Concentrations of Chemical Parameters
In Sediment
[all values in ppm dry wt. except LOI(%)]

Parameter	Open Water Disposal Guideline	Humber Bay	Toronto Harbour	Toronto East Headland	Eastern Toronto Waterfront	Lake Ontario Surficial Sediment **
Lead (Pb)	50	104	271	83	17	107
Zinc (Zn)	100	280	339	129	35	214
Copper (Cu)	25	90	90	38	9	50
Iron (Fe)	10000	22169	26700	21520	13150	55700
Manganese (Mn)	-	417	493	358	296	3200
Chromium (Cr)	25	133	92	46	19	48
Total Kjeldahl Nitrogen (TKN)	2000	1780	2100	900	400	ND
Total Phosphorus (TP)	1000	2100	1810	900	1040	2200
Total Organic Carbon (TOC)	1000*	15100	29200	ND	4920	ND
Sol. Ext.	1500	3605	5689	1926	602	ND
Mercury (Hg)	.3	0.22	0.47	0.17	0.02	0.65
Cadmium (Cd)	1.0	5.00	3.93	1.54	0.36	2.50
Arsenic (As)	8.0	4.70	6.90	5.00	0.40	3.30
Loss on Ignition (LOI)	6%	4.98	7.26	3.22	1.59	1.96
PCBs	0.05	0.13	0.32	0.13	0.02	0.06

* = Internal Guideline

** = Whole lake mean values from R.L. Thomas and A. Murdoch (1979).

ND = No Data

Source: Persaud et al 1987

drift is from the east to west, which has resulted in the formation of the Toronto Islands from sediment derived from Scarborough Bluffs (Fricbergs, 1970).

Stream and river discharges from the six major watercourses within the Metropolitan region (namely, Etobicoke Creek, Mimico Creek, Humber River, Don River, Highland Creek and Rouge River) represent the second major source of sediment inputs to the Toronto shoreline. Sediment production in the drainage basins results mainly from urban activities (e.g. construction), and, to a lesser extent, erosion of agricultural lands and streambanks (Persaud et al., 1985). The degree of sediment bacterial and chemical contamination varies with the intensity and type of landuse.

The third major source of sediment, and a primary source of contamination to the waterfront, is the water pollution control plants (WPCP's) and the storm sewer discharges. Contaminants originate from both point and non-point sources, and include nutrients (e.g. nitrogen, phosphorus), trace metals (e.g. copper, lead, mercury), and organics (e.g. volatiles, oil and grease, and PCBs). Point source contaminants to the Toronto waterfront include WPCP discharges from the Humber WPCP, Toronto Main WPCP, North Toronto WPCP (via the Don River), and Highland Creek WPCP. Non-point sources include urban storm runoff, combined sewer overflow, and atmospheric deposition (Persaud et al., 1985).

Lakefilling activities, notably the Eastern Headland, produce localized impacts on sediment quality and the related water quality (Boyd and Griffiths, 1985).

3.2.2 Contaminant Uptake by Sediment

Hutchinson and Fitchko (1974) outlined numerous factors relating to contaminant concentrations in sediments. The first order factors refer to the amount of contaminant input, which is dependent upon the magnitude and proximity of urban-industrial and agricultural sources, the rates of erosion in the drainage basins, the geology of the area, the efficiency of transport and the geomorphological characteristics of the receiving water body (e.g. depositional versus non-depositional)..

Second order factors include the mechanisms of contaminant uptake and retention by sediment. It is known that bacteria and chemical contaminants adsorb to the surface of sediment particles, especially fine particles. 'Carrier particles', as they are termed, are the principal means of contaminant conveyance. Prevalent carrier particles include organic material (measured as loss on ignition (LOI), total organic carbon or total Kjeldahl nitrogen), the hydrous oxides of Fe and Mn (mainly for metals) and clay minerals. Binding and retention mechanisms are often contingent upon the quantity of hydrated ions (including Fe and Mn hydrous oxides), the amount of organic matter, and the percentage of fine sediment, e.g., clay minerals and silt (Persaud et al.,1987). These mechanisms are affected by physical disturbances, such as wave action, currents, dredging and shipping activities, in addition to geochemical and biological mobilization of contaminants (Beak et al., 1987).

Contaminant uptake depends, to a large extent, on the form in which the contaminant exists in the sediment. This is particularly true for heavy metals, where only a fraction of the total levels may be geochemically available in the sediment (Persaud et al., 1987). Most chemical contaminants within the study area are associated with fine grained sediment. The bulk chemical parameters in the sediment and the inherent organic content of the samples show strong correlation, thereby suggesting a distribution pattern of parameters governed mainly by their association with organic material (Persaud et al., 1987). Data from sequential extraction analysis of the sediment samples support the strong relationship between most metals (except Fe and Mn) and the organic content of sediments (Persaud et al., 1987).

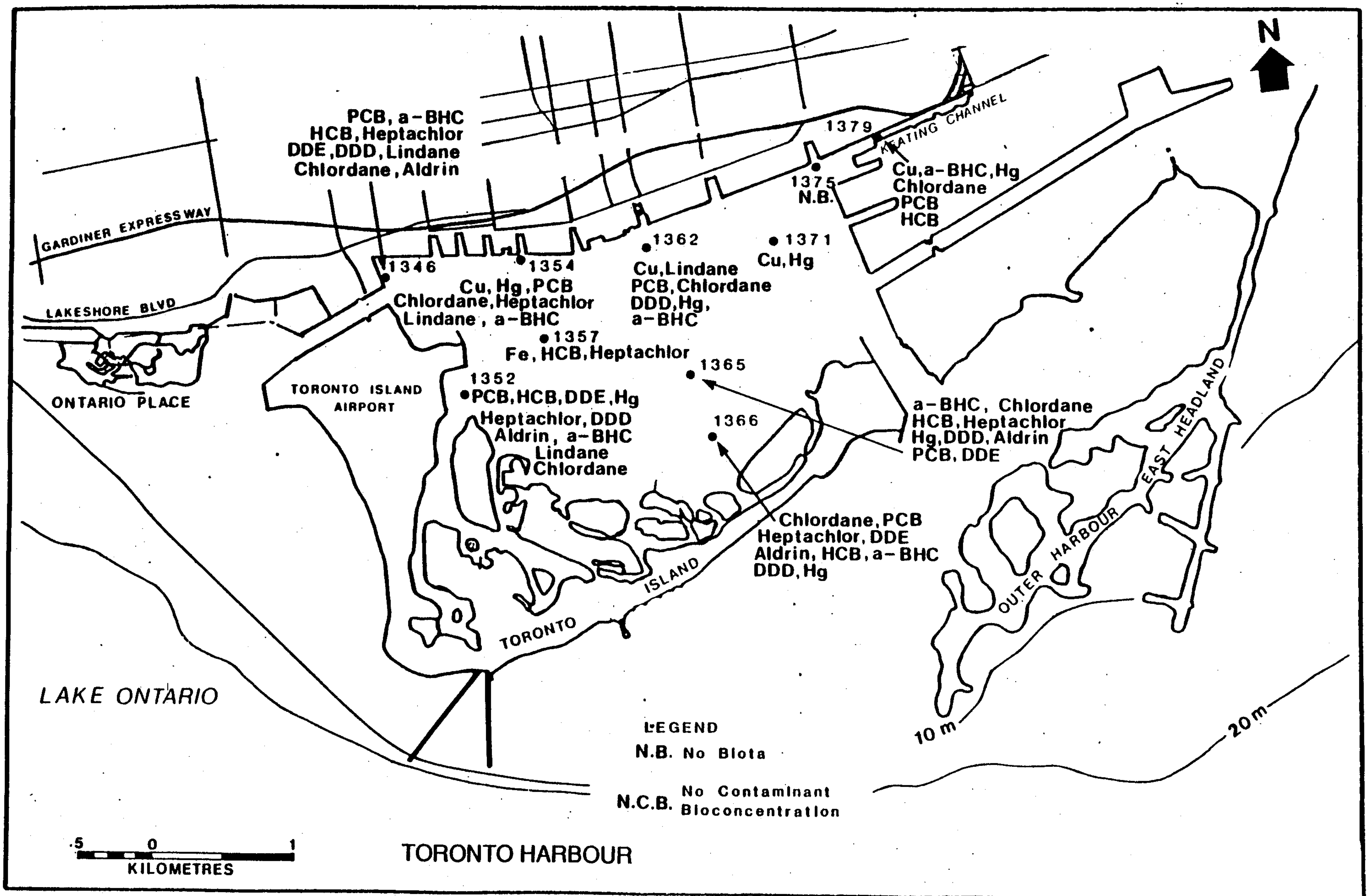
The mechanisms of contaminant uptake and transport play a significant role in influencing the extent and magnitude of "in-place pollutant" problems. Contaminated sediment is usually greatest in quiescent, depositional environments such as embayments and harbour areas, because the fine grained, organic materials (which hold the greatest amounts of contaminants) can settle out. In less sheltered areas these fine-grained sediments tend to be scoured and dispersed.

The impact of contaminated sediment is reflected in the body burden (tissue concentrations) in the benthic fauna. Measured as a ratio of benthic tissue concentration to sediment concentration (or other media from which uptake occurs, such as the water column) for given parameters, bioconcentration factors provide a qualitative measure of contaminant bioaccumulation in benthic tissue. Bioconcentration factors greater than or equal to 1.0 identify the parameters with the greatest influence on body burden levels. It should be stressed that bioconcentration factors are useful in identifying the contaminants which bioaccumulate, but not necessarily the level of sediment impairment. Bioconcentration factors are often highest in the areas with the lowest sediment organic content. In these areas the low sediment organic matter concentration and relative bioavailability of contaminants (due to the coarse nature of the sediment) produces high bioconcentration factors. Conversely, in more contaminated areas, the tendency of the fine and organic rich sediment to retain the contaminant and the overall high sediment concentrations tend to produce lower bioconcentration factors.

Parameters with bioconcentration factors greater than 1.0 are shown for various locations across the Toronto waterfront (Figures 3.13a to d). Humber Bay, the Inner Harbour, and the stations around the Main WPCP, show bioconcentration of a variety of parameters including pesticides and other organics, and metals such as copper, zinc, mercury and iron. Bioconcentration in the Outer Harbour and along the Eastern Waterfront is primarily restricted to the metals, although PCBs and lindane show bioconcentration factors greater than 1.0 near Bluffers Park. Lead, cadmium and manganese did not show bioconcentration factors greater than 1.0 anywhere along the waterfront. As noted previously, pesticides were not found at high levels in the sediments across the waterfront and bioaccumulation of these contaminants is likely through the water column rather than via sediment uptake.

The figures also note the absence of biota in numerous locations. Along the Eastern Waterfront this is likely due to a lack of suitable substrate. In the vicinity of point source discharges such as the Main and Humber WPCP's, the absence of biota is indicative of the local point source impact, probably related to chlorine or ammonia toxicity.

FIGURE 3.13: STATION LOCATION AND PARAMETERS SHOWING BIOCONCENTRATION FACTOR GREATER THAN ONE



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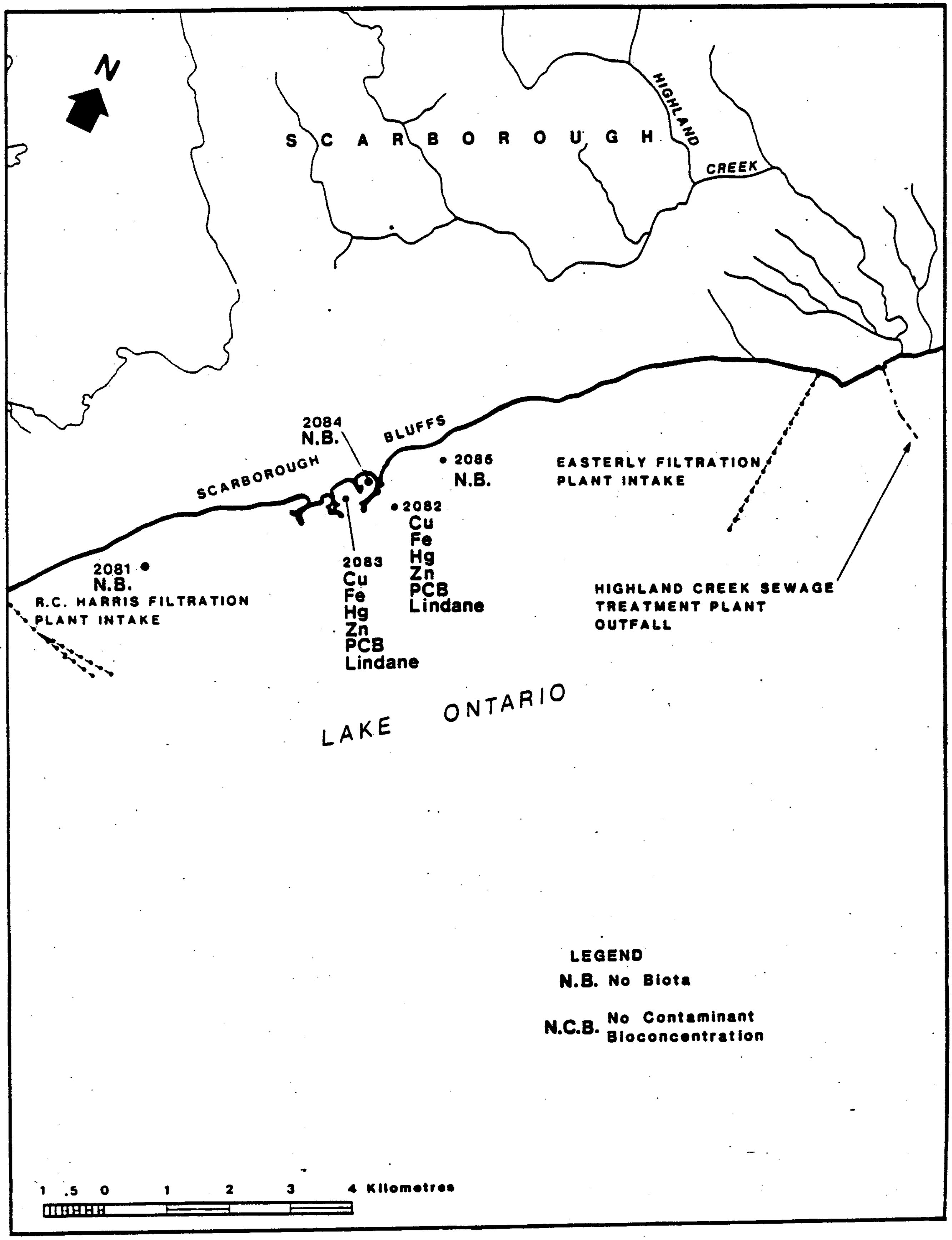
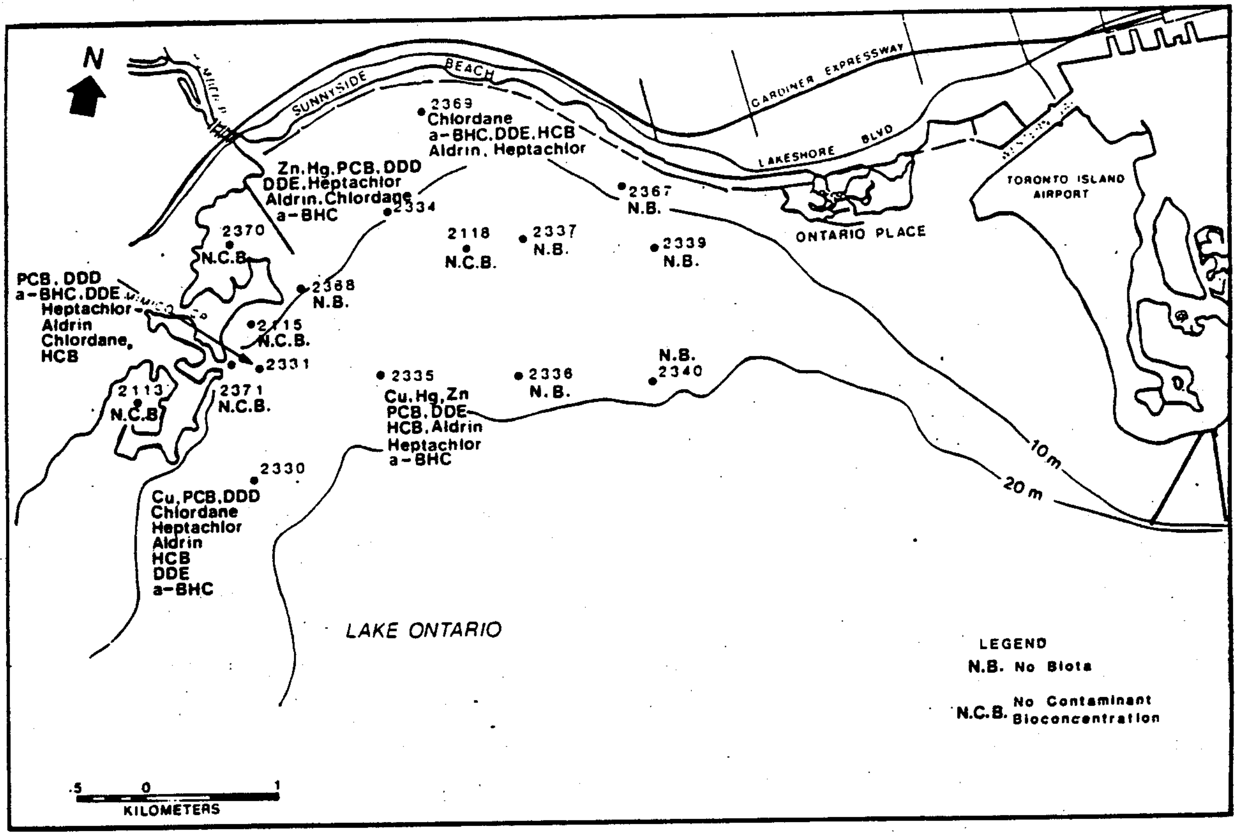
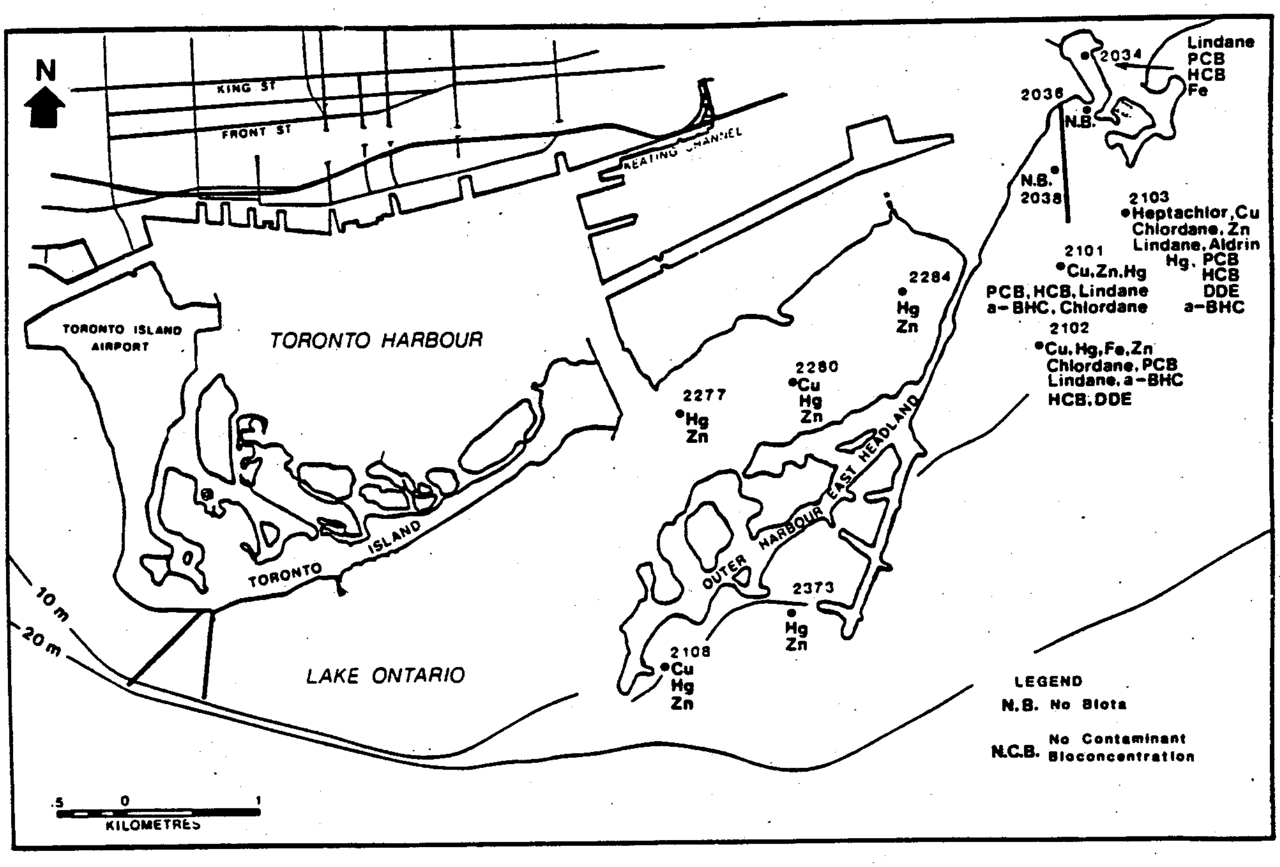


SCARBOROUGH BLUFFS



HUMBER BAY



EASTERN HEADLAND AND ASHBRIDGES BAY

3.2.3 Recent Studies

Aquatic organisms accumulate contaminants directly from the water column and indirectly via food and sediment uptake. By virtue of their often sedentary lifestyles, benthic organisms are frequently used as indicators of contamination of sediment. Contaminants are assimilated into benthic tissue through absorption from solution and by feeding (via the digestive process) (Persaud et al., 1987).

Persaud et al. (1987) identified several trends in contaminant uptake in studies conducted along the Metro Toronto waterfront. Firstly, pesticides, measured at low levels in the sediment, were elevated in benthic tissue predominantly in the vicinity of storm sewer outfalls and water pollution control plant discharges. Pesticides that were discharged at low concentrations from these outfalls, were taken up by benthos via respiration from the aqueous phase and obligatory feeding on/in the sediment. Boyd's investigation (1987) on contaminant levels in suspended solids further supported this observation. Usually under anaerobic conditions, organic contaminants, which include many organochlorine pesticides, are readily bound to organic matter, or are dissolved in the solvent extractable fraction (Meier and Rediske, 1984), thereby reducing their bioavailability. In-place sediments do not therefore appear to be a major source of biota contamination in terms of pesticides in areas where organic content is high.

Secondly, copper, zinc, mercury and PCBs exhibited evidence of bioaccumulation in benthic tissue. Contaminant uptake tends to be inversely related to the amount of organic matter in the sediment. In areas of high organic matter content, oligochaete body burdens of Cu, Zn, Hg and PCBs were low in comparison to their surrounding sediment and to other organisms from areas with sediment of low organic content (Persaud et al., 1987). The relatively 'cleaner' areas with low organic content and sediment contaminant levels had higher body burdens in relation to the sediment.

Finally, it is noteworthy that there is extreme variability in uptake of different metals by biota. Manganese, cadmium and lead were found at extremely low levels in benthic organisms compared to the sediment levels. Mercury, copper, iron and zinc showed high uptake by benthic organisms relative to the sediment content. Zinc uptake was the greatest.

Western Waterfront

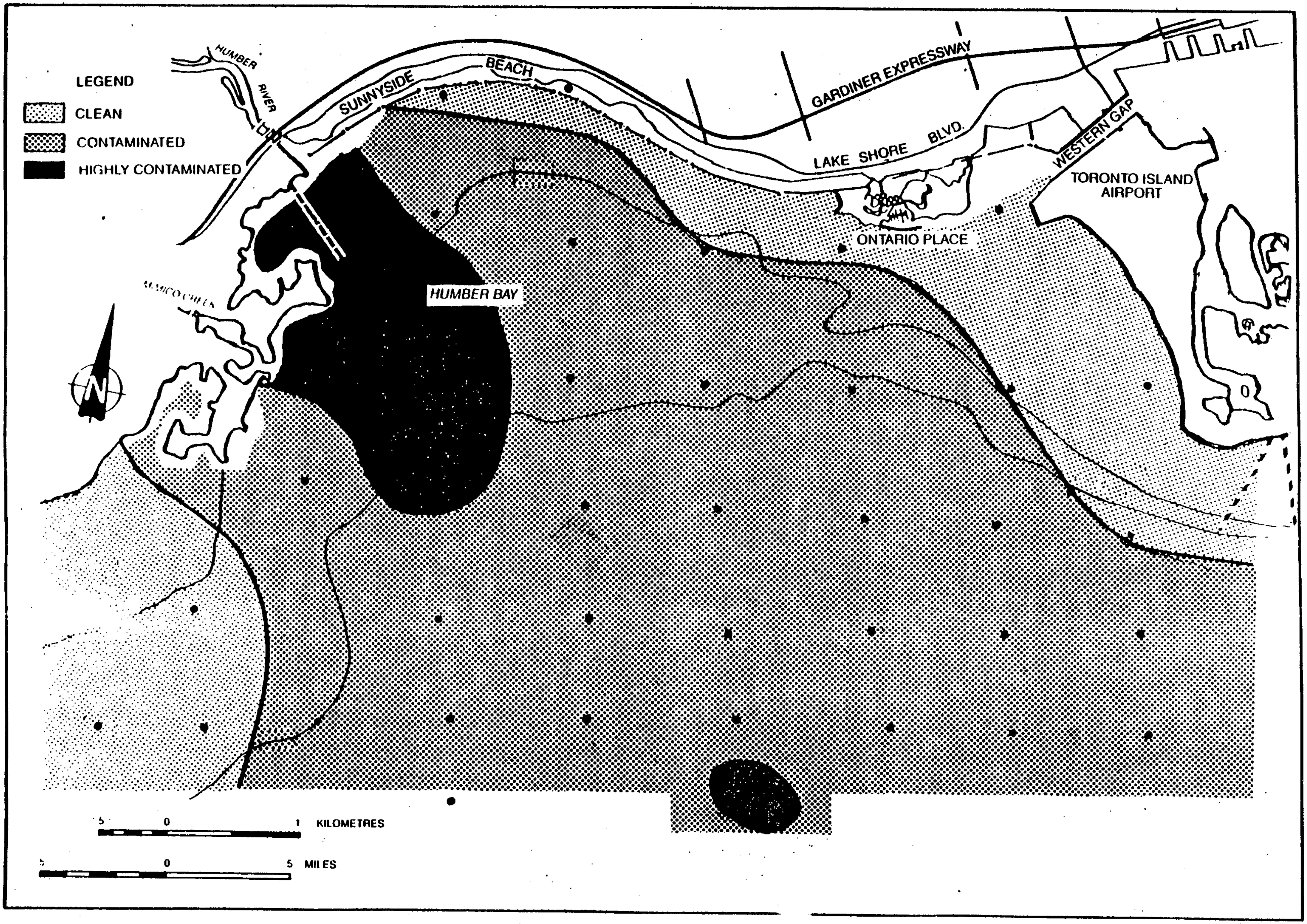
The data on sediment quality clearly indicate the effect of local discharges (e.g. the Humber WPCP, the Humber River, Mimico Creek) and nearshore hydrodynamic forces (waves and currents) on the sediment quality in the western waterfront area (Beak et al., 1987). Humber Bay has been described as a "bathymetric trap", in which most of the sediment material discharged into the bay, accumulates and remains relatively undisturbed (Lewis and Sly, 1971). The identifiable input sources are the Humber River, Mimico Creek, the Humber WPCP, and the storm sewer outfalls. The influence of southwesterly waves (flowing north), and the relatively great depths, provide ideal conditions for material deposition. The embayment contours of the shoreline precludes most of the littoral process west of the bay as evidenced by sparse deposits of littoral drift material. The physical characteristics and distribution of the Humber Bay sediments have changed little over the past 50 years (Persaud et al., 1985).

Sediment data from various studies have been compared to the MOE Open Water Disposal Guidelines for Dredged Material. These guidelines are used to determine the degree of contamination and indicate whether sediments could be disposed of in the open water. Parameters in excess of the guidelines are termed contaminated (highly contaminated when two times in excess of the guideline). Parameters below the guidelines are termed clean or uncontaminated.

Within Humber Bay, zones of contaminated sediments are discernable. A strip of coarse, clean material (sand), may be identified along the shoreline on the west side of the Toronto Islands continuing over to Sunnyside Beach. As well, pockets of coarse, clean, material are found to the west of the Bay. Fine (silts and clays), contaminated materials are found in the inner portion of the Bay extending lakeward. The sediment sampled in this area is contaminated with organic material, nutrients, metals, solvent extractables and PCBs. A highly contaminated zone is found in the area extending from the Humber River around the Humber Sewage Treatment Plant outfall over to Mimico Creek (Figure 3.14).

The sediment quality behind the Humber Bay breakwall is patchy, varying between clean and contaminated material. The sediment near the Humber River and close to the Boulevard Club consists

FIGURE 3.14: SEDIMENT QUALITY ZONES WIHTIN HUMBER BAY (1979)



of coarse, clean material. The sediment in the areas in between is fine, contaminated material. This material has elevated levels of phosphorus, cadmium, copper, chromium, lead, zinc, solvent extractables and PCBs.

MOE survey data between 1979 and 1982 illustrated a correlation between sediment type and sediment quality (Persaud et al.,1985). The contaminated central portion of Humber Bay consists primarily of fine material which have a high area to volume ratio essential to the adsorption of bacterial and chemical contaminants. In contrast, the material found closer inshore, extending from Sunnyside beach to Ontario Place, consists of uncontaminated, coarse-grained sand (Fig. 3.15). As suggested by Lewis and Sly (1971), these sands may be derived from littoral drift material originating at Scarborough Bluffs, whereafter their initial transport to Gibraltar Point on Toronto Island, they were subjected to the northwards flow of the southwestern currents.

Central Waterfront

Sediment surveys across the Central Waterfront generally show the Inner Harbour to be heavily contaminated, the Outer Harbour moderately contaminated and open Lake Ontario locations to be relatively clean. Total phosphorus and TKN concentrations were high in most sediments across the Central Waterfront, often exceeding the MOE Open Water Disposal Guidelines. Inner Harbour stations showed frequent exceedances of the MOE guidelines for total phosphorus, TKN, copper, lead, zinc, and PCBs. Exceedances were less frequent for mercury and nickel. Highly concentrated solvent extractables (oil and grease) were found near the boat slips and Keating Channel (Persaud et al., 1985). Contamination of the Outer Harbour is primarily in the form of elevated metals levels.

In the Inner Harbour, distinct zones, varying in degree of contamination can be identified. Generally, the harbour sediments consist of fine material, that are heavily contaminated with most of the parameters measured. The most highly contaminated areas of the Harbour are found in the slips along the north shore, followed by sediments within the Toronto Island waterways. The main harbour sediments are less contaminated than the slips. In the Keating Channel, the sediments vary from coarse material near the Don River mouth to fine material at the lower end (west) of the channel. The

FIGURE 3.15: SEDIMENT TYPE IN HUMBER BAY (1979)

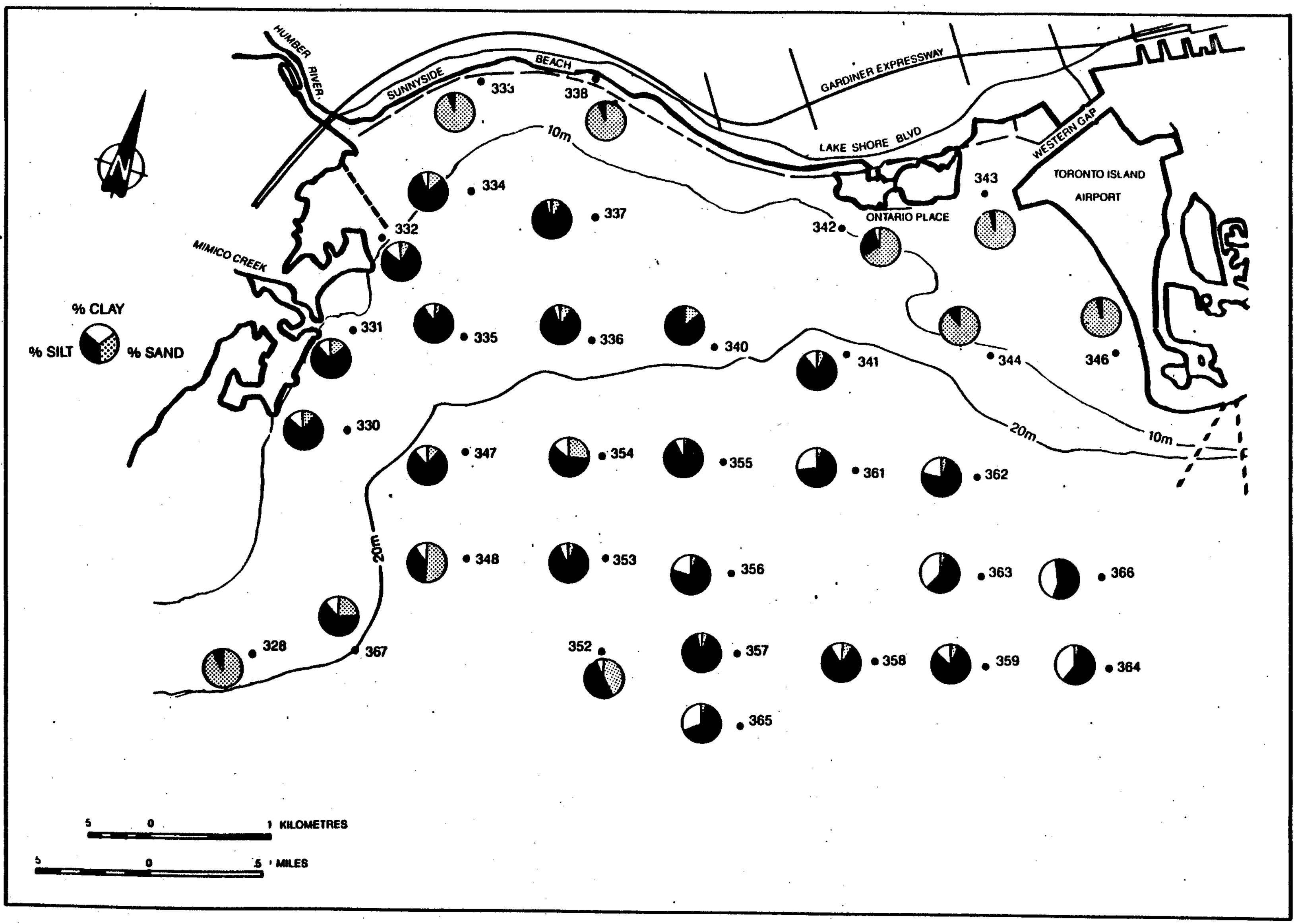


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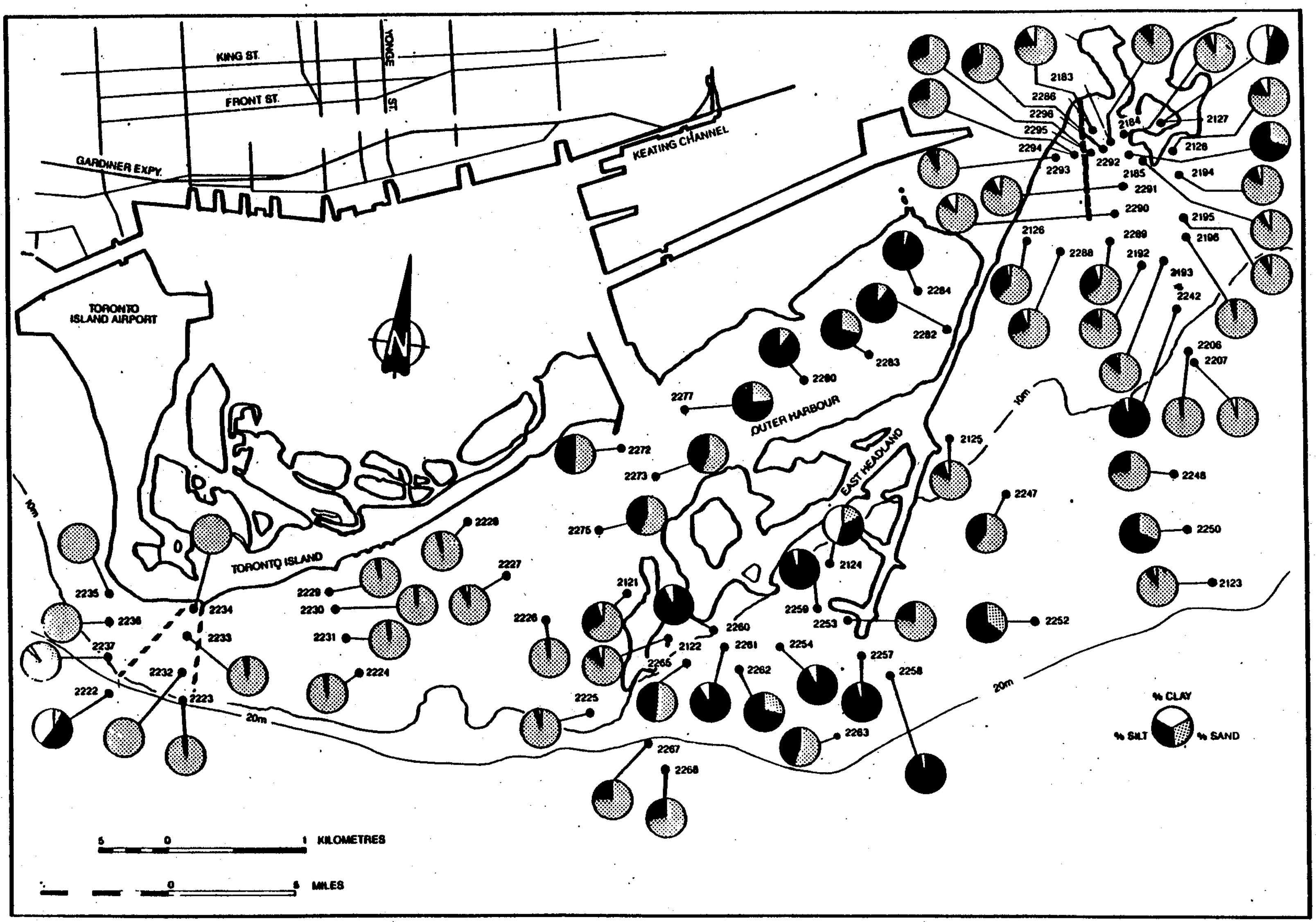
FIGURE 3.16: SEDIMENT TYPE IN OUTER HARBOUR & EASTERN HEADLAND AREA (1982)



chemical quality of the sediment also becomes progressively worse from east to west in Keating Channel, but in general is much better than the rest of the Inner Harbour.

The sediments in the deeper portions of the Outer Harbour (Shipping Channel) consist of fine contaminated material, possibly originating from the Inner Harbour and adjacent lakefilling activity. Outside of the Channel, the sediment is coarse and clean.

The sediment south of the Toronto Island is mainly coarse, clean material. Much of this material was derived from littoral drift originating from the Scarborough Bluffs.

The sediments around the Eastern Headland vary in physical type and chemical quality. The area south of the headland is moderately contaminated and in the area immediately east of the headland, the sediments at some stations are clean, while others show slight elevations in contaminant levels.

Although one small depositional zone was found close to one of the intake pipes for the Island drinking water filtration plant, much of the Outer Harbour and the open lake nearshore regions possess coarse-grained (sandy) sediments (Figure 3.16, page 68). These sediments are relatively uncontaminated by virtue of the considerably lower sorption capacity for contaminants in sand as compared to silt and clay loams (Beak et al., 1987). Conversely, the Inner Harbour has finer sediments with a higher loss on ignition (LOI) value (reflecting a higher organic content) than sediments elsewhere in the Central Waterfront area (Figure 3.17). The generally degraded quality of the sediment is attributed to the close proximity to major input sources, such as the combined sewer overflows, storm sewer discharge and the Don River, via Keating Channel.

Keating Channel provides partial deposition for large amounts of silt, debris and associated contaminants discharged from the Don River. The channel's sediments are relatively coarse at the upstream end, grading to finer silts and clays at the western downstream end. Consequently, the correlation between sediment type and sediment quality is indicative of the progressively improving sediment conditions of Keating Channel from west to east.

FIGURE 3.17: SEDIMENT TYPE IN THE TORONTO HARBOUR (1977)

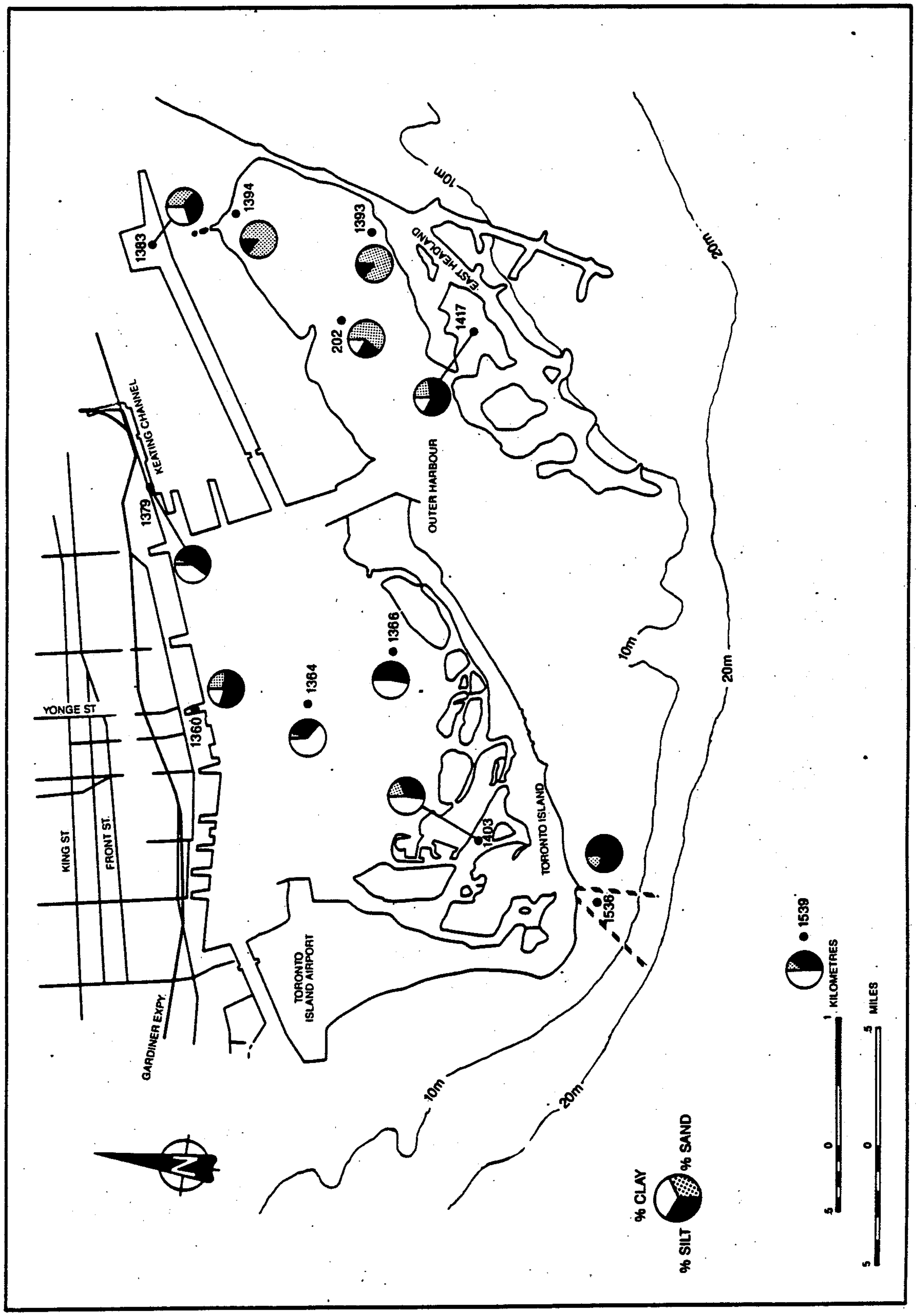


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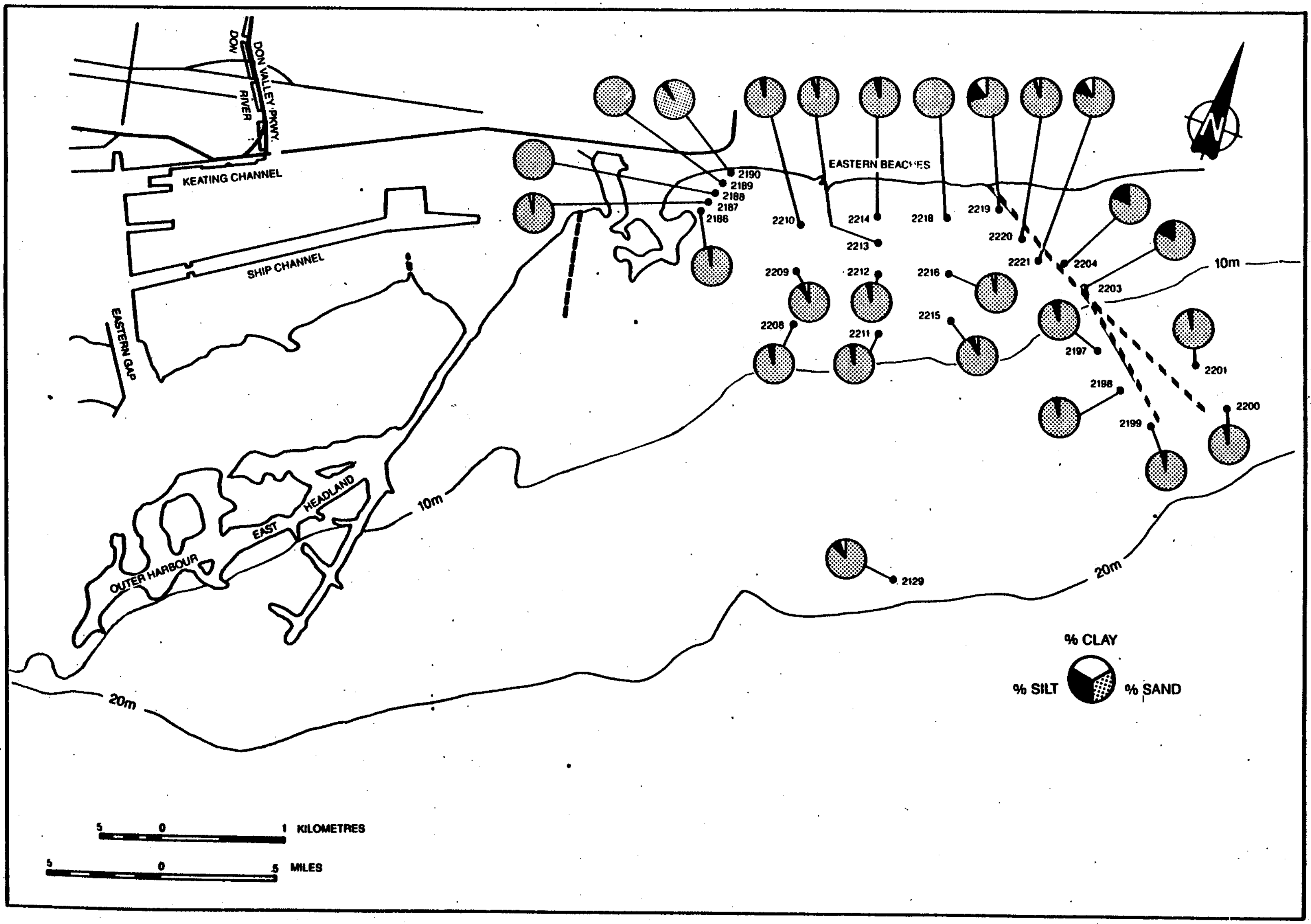
FIGURE 3.18: SEDIMENT TYPE IN THE EASTERN BEACHES (1982)



Eastern Waterfront

Sediment quality data for the Eastern Waterfront indicate that much of this area is comprised of clean, coarse material. Areas of contamination are discernible but are generally more localized than on the Western and Central Waterfront areas. The Ashbridges Bay area is the most contaminated portion of Eastern Waterfront with some sampling stations showing contamination by TKN, total organic carbon, oil and grease, chromium, copper and zinc. Elevated phosphorus levels are generally more common. Some small areas show PCB levels above the open water disposal guidelines. The station in the Ashbridges Bay lakefill embayment is notably more contaminated than adjacent stations with dredging guidelines for mercury and lead being exceeded as well as the parameters noted above.

The major source of contaminants in the vicinity of Ashbridges Bay is the Main WPCP. The material from the WPCP outfall may be carried in an easterly or westerly direction, depending on current direction. It appears that very little of this discharge is deposited in the vicinity of the outfall, as shown by the low parameter values in the sediment at the stations around the WPCP outfall.

The area encompassing the Eastern Beaches (Ashbridges Bay to Highland Creek) is comprised of coarse, clean material. Several stations show slight elevations in levels of total phosphorous which may be a reflection of the continuous influence of the Main WPCP discharges. Slight elevations in oil and grease at some stations and some arsenic at one station represent pockets of localized deposition in perhaps small depressions.

The station at the mouth of Highland Creek probably reflects the influence of the Highland Creek WPCP which, until recently, discharged into the Creek near its mouth. Elevations in the level of oil and grease above the dredging guidelines were noted at this station.

Most of the Eastern Waterfront sediment consists of coarse sandy material (Figure 3.18, page 70). Contaminant levels for metals in sediments for this area consistently show a higher percentage in the geochemically unavailable phase than is common on the rest of the waterfront. Relatively unrestrained wave and current action tends to prevent the accumulation of organic matter and fine-grained sediments which are generally associated with higher levels of contamination.

3.2.4 Lakefilling

Lakefilling activities are carried out at locations across the Toronto waterfront. These activities affect sediment quality directly through the introduction of contaminated materials and indirectly through the creation of depositional (embayments) areas. Surveys of embayments, created by lakefill projects indicate that many contain an abundance of fine sediments with contaminant concentrations for metals, PCBs and solvent extractables higher than the Open Water Disposal Guidelines.

With regard to the direct introduction of sediment, the most extensive studies into lakefilling have taken place at the East Headland (Leslie Street Spit). Water quality studies have indicated occasional exceedences of PWQO for trace metals (cadmium, copper, iron, lead, and zinc) and DDT near the lakefilling operation. Other organic parameters were generally observed at or near the detection limit. The exceedences observed were localized and were generally smaller than observed near other sources such as the Don River and the Main WPCP. There was no evidence of an impact on drinking water supplies as a result of lakefilling activities.

Sediment surveys indicate localized depositional areas with elevated concentrations of metals, PCBs and solvent extractables. Although the Main WPCP could also be affecting sediment quality in this area, diver observations have noted turbidity plumes moving out from the active face, producing an accumulation of silt over the sand bed. Accumulations of this fine sediment are likely removed by winter storms, but there is a potential for effects on benthos during the summer period. Studies have indicated that many metals in the sediments are in bioavailable forms.

Surveys of suspended sediment in the water column near the lakefill have shown contaminant levels in suspension near the bed as high as two orders of magnitude above the levels found in the open lake. The suspended sediment contaminant levels occasionally reach levels similar to those found near the Main WPCP discharge. In general, however, contaminants associated with suspended solids near the lakefill have lower concentrations than found near WPCP discharges or river mouths.

In terms of contamination levels in the fill, truckfill samples and cores of in-place material indicate that approximately 25% of incoming fill is unacceptable based on lakefilling guidelines. MOE has recently instituted a stricter sampling and waybill system in order to deal with this problem. Lakefilling policies are under development and review and should be available within the next year.

3.3 BENTHIC INVERTEBRATES

Overview

Studies of benthic invertebrates have been conducted for nearly a century along the Toronto waterfront, although the majority have been carried out over the last three decades. Areas of organic pollution and elevated contaminant levels continue to be evident near point source discharges, tributary mouths, and areas of restricted water circulation. Overall, however, the studies indicate an improving trend over time.

The most recent study of benthic fauna along the waterfront (Persaud et al 1988 In-Press) indicates distinct zones of environmental conditions as defined by the benthic fauna. Areas along the Toronto waterfront, inside Toronto Harbour (along the north shore), at Ashbridges Bay, and Mimico Creek appear to be organically polluted. The benthic communities were reduced in diversity and consisted primarily of oligochaetes and chironomids. Species present were typical of organically polluted areas. These areas are also the most chemically contaminated areas, though the benthic community, already a stressed fauna, shows no clear evidence of effects by these chemical pollutants. A general reduction in faunal density, as compared to earlier studies, was evident throughout. Though such a reduction is consistent with sub-acute effects of contaminants, it could also have been a result of lower organic content in the sediments.

Areas slightly further offshore, and the embayments of the Outer Harbour and East Headland bear evidence of organic enrichment, though the fauna appear less severely affected. Contaminant levels were generally lower as well.

Sandy, erosional areas such as found along the Eastern Beaches, east of the East Headland, and along the nearshore of the Western Beaches, have their own characteristic faunas. Sediments in these areas were characterized by very low organic content.

A more mesotrophic area exists offshore, in the deeper waters of Humber Bay and south of the Islands. These areas are characterized by low organic and contaminant levels and contain elements of the benthos more typical of the oligotrophic profundal regions of Lake Ontario.

Finally, a littoral, eutrophic though apparently not organically polluted zone exists near the Toronto Islands, (inside the harbour). This zone is characterized by a large diversity and density of littoral organisms, many commonly associated with coarse detritus and macrophytes. Organic content was variable and contaminant levels were generally low.

3.3.1 Historic Studies

The composition of the benthic fauna is a widely used indicator of water quality. Within the sediments, benthic invertebrates form relatively sedentary communities with respect to their surroundings. Benthic fauna respond to both gradual and rapid changes in their environment and therefore provide an indication of environmental quality over the long-term as well as in the present. The species composition of the benthic community represents an integration of a variety of physical and chemical factors including water depth, substrate type, organic matter, temperature, wave exposure, currents, nutrients and toxics. Thus, evaluating a "point in time" sample of the benthos can provide a more holistic view of environmental conditions at a location than a simple water or sediment sample.

Ecological studies of benthic fauna normally focus on three measures to relate benthic community health to ambient water and sediment quality:

i) densities of organisms;

ii) some measure of the diversity and heterogeneity of species in the community;

iii) densities or presence/absence of type species (species whose biology, habitat requirements and tolerances are well known), and when found (or not found) typify the range of environmental conditions that can be expected to occur.

Barton (1986) reported that chemical and biological studies suggest that the offshore regions of the Canadian waters of Lake Ontario are oligotrophic to slightly mesotrophic. However, the nearshore zone is more eutrophic, largely owing to the formation of a thermal bar in Spring and Autumn, which prevents complete mixing throughout the lake during periods of maximum runoff. Lake-wide benthic surveys support this assessment: the oligotrophic indicators, the scud (Pontoporeia hoyi) and the worm (Stylodrilus heringianus), dominate offshore communities, but are replaced by Tubificidae near various point sources of organic enrichment, so that the total abundance of invertebrates declines with depth and distance from shore (Hiltunen, 1969; Kinney, 1972; Nalepa and Thomas, 1976; and Golini, 1979).

Nalepa and Thomas (1976) reported that tubificid worms, mostly T. tubifex, comprised of 99 % of the benthic fauna (46161/m^2) at a depth of 54 m offshore of Toronto Islands. This location was considered "highly polluted", as indicated by the presence of Gammarus fasciatus, a pollution tolerant amphipod, and the absence of P. hoyi. Slightly deeper at 77 m, P. hoyi was present, while G. fasciatus was absent. Based on the distributions of amphipods and oligochaetes, Nalepa and Thomas (1976) suggested that the impacts of Toronto's "effluents" on Lake Ontario extend to these depths, some 3-5 km offshore.

In the nearshore (less than 20 m depths), benthic fauna abundance appears to be more related to differences in the substratum than water quality conditions (Integrated Exploration, 1984; Barton, 1986), except adjacent to point source discharges. Average densities were significantly lower on sand and rock. Exposure to wave action, longshore currents and turbulence due to boat traffic prevents the accumulation of organic material (food), and causes physical shifting of sediments and displacement of organisms. Thermal stress caused by frequent upwelling of cold hypolimnetic water in summer contributes to the low abundance of organisms.

Within the Toronto area, river mouths, treatment plant effluents, harbour activity, storm and combined sewer discharges, direct surface runoff, land creation activities, and domestic and wild animals represent the major "point sources" that influence benthic invertebrates.

In Humber Bay, the water pollution control plant, the Etobicoke, Mimico and Humber rivers, storm sewer discharges and lakefilling at Humber Bay, Colonel Samuel Smith, the Harbour and Outer Harbour, have been major influences on the distribution of benthic macroinvertebrates. All are significant sources of silt, nutrients and/or toxic substances. The WPCP, in particular, has been a major nutrient source. The toxic effects of chlorine in eliminating benthos from the immediate vicinity of the outfall are also evident.

A benthic invertebrate study of Humber Bay (Barton, 1980) concluded that the majority of the fauna is composed of large densities (50000 - 150000/m^2) of pollution tolerant tubificids (Limnodrilus hoffmeisteri and T. tubifex), with highest densities at the Mimico and Humber river mouths. Further west, in the vicinity of Colonel Samuel Smith waterfront area, densities were generally lower, about 250 - 3000/m^2. These densities tend to be at the low end of the range (574 - 61699/m^2) found in shallow waters throughout Lake Ontario (Nalepa and Thomas, 1976), probably reflecting the predominance of rock and bedrock. This benthic invertebrate fauna includes species such as the snails Valvata and Gyranlus, that inhabit rock or bedrock substrates; L. hoffmeistri and T. tubifex that inhabit soft substrates; Gammarus, Hyallela azteca and Asellus, which prefer extensive attached algal beds (e.g. Cladophora); and S. heringianus, which prefers sandy substrates. This mixture and diversity of organisms and relatively low densities in the vicinity of the Colonel Samuel Smith waterfront area reflects habitat diversity and improved water and sediment quality relative to Humber Bay.

In a 1980 study (Acres, 1983) tubificids comprised over 93% of the fauna (densities of 25000 - 75000/m^2) in the Toronto Harbour, Keating Channel and Lower Don River, thereby suggesting heavy organic pollution. Tubificid densities in two locations in the Inner Harbour were less than 1000/m^2, suggesting chronic or toxic effects. However, in comparison to previous studies (Hutchison et al., 1974), generally lower tubificid densities in the 1980 harbour data suggests some improvement in water quality in the open areas of the Inner Harbour.

Benthic communities at 13 transects between Ontario Place and Gibraltar Point of the Toronto Islands suggested better conditions than in the Harbour (Barton, 1980). At 30 locations around the Eastern Headland, tubificid densities also decreased in comparison to the Inner Harbour, representing only 64 % of total densities. P. hoyi also occurred at most stations and composed 25 % of the total fauna. S. heringianus also occurred here, and its presence along with P. hoyi suggested relatively good water quality conditions.

At Ashbridges Bay waterfront area, Proctor and Redfern (1979) concluded that the low abundance of benthos east of the park was the result of unstable substrates (primarily sand). In contrast, west of the park, tubificid densities indicative of organic pollution, occurred, particularly in the mouth of the Coatsworth Cut, in the park's mooring basin and near the WPCP outfall.

Along the Scarborough Bluffs the MOE (1976) reported that the benthic community around Bluffers waterfront area was characterized by low densities (2000 - $4000/m^2$) and diversity, presumably due to unstable substrates. Higher densities (22000 - $39000/m^2$) typical of poor water quality, occurred within the park embayments and along newly created beaches as a result of entrapment of fine materials or organic polluntants from storm sewers (Proctor and Redfern, 1979). Further east, near the Guild Inn, the benthic community showed striking variation in total densities due to substrate variablity and instability (Integrated Exploration, 1984). Overall densities tended to be less than $10000/m^2$ (Integrated Exploration, 1984). Tubificid numbers of only 12 - 15 % of total fauna and the presence of P. hoyi and Vejdovskeyella intermedia suggest good water quality conditions.

3.3.2 Recent Studies

The most recent study of benthic fauna and sediments (Persaud et al 1988) was based on data collected in 1985. The study provides a comprehensive picture of environmental conditions across the waterfront, as defined by benthic diversity, type and mass, sediment quality, and contaminants in benthos. The results suggest that many areas of the waterfront have improved since earlier surveys. The results of this study are presented by geographical area in the following sections. Station locations referred to are shown on Figure 3.19.

Western Waterfront

The stations located in Humber Bay define four broad zones. The first is a shallow-water zone characterized by the deposition of fine sediments and high organic content. The benthic community is typical of eutrophic littoral areas, comprised mainly of fine particle feeders, the chironomids and oligochaetes. Where contaminant levels were low, the fauna appeared quite diverse (Station 2113) and density was high. Where contaminant levels were high, the fauna appeared to be reduced (Station 2332). This zone appears to be restricted to the protected bays and shoreline areas.

The second zone is an erosional area along the open shoreline of the bay, which as a result of wave or current action, appears to retain little organic matter. As a consequence, these areas (Stations 2333 and 2339) are low in sediment organic content, and density and biomass of the benthos is lower. The sandy substrate, low in organic matter, bore little evidence of contaminants.

Further offshore lies an area of deeper water that seems to receive much of the fine sediments, carried as outwash from Humber River and Mimico Creek, and as washdown from shallower, shoreline areas. This area of silty sediments, high in organic content (Station 2335), is characterized by high densities of typically eutrophic species (oligochaetes). This area formed the eutrophic third zone.

The last zone is the deeper, mesotrophic area furthest out into Lake Ontario. These areas (Stations 2355, 2363 and 2367) are characterized by faunal elements typical of the deep, oligotrophic areas of Lake Ontario though it does contain some characteristically eutrophic elements as well. Contaminant levels are low and appear to have no effect on the fauna at this point.

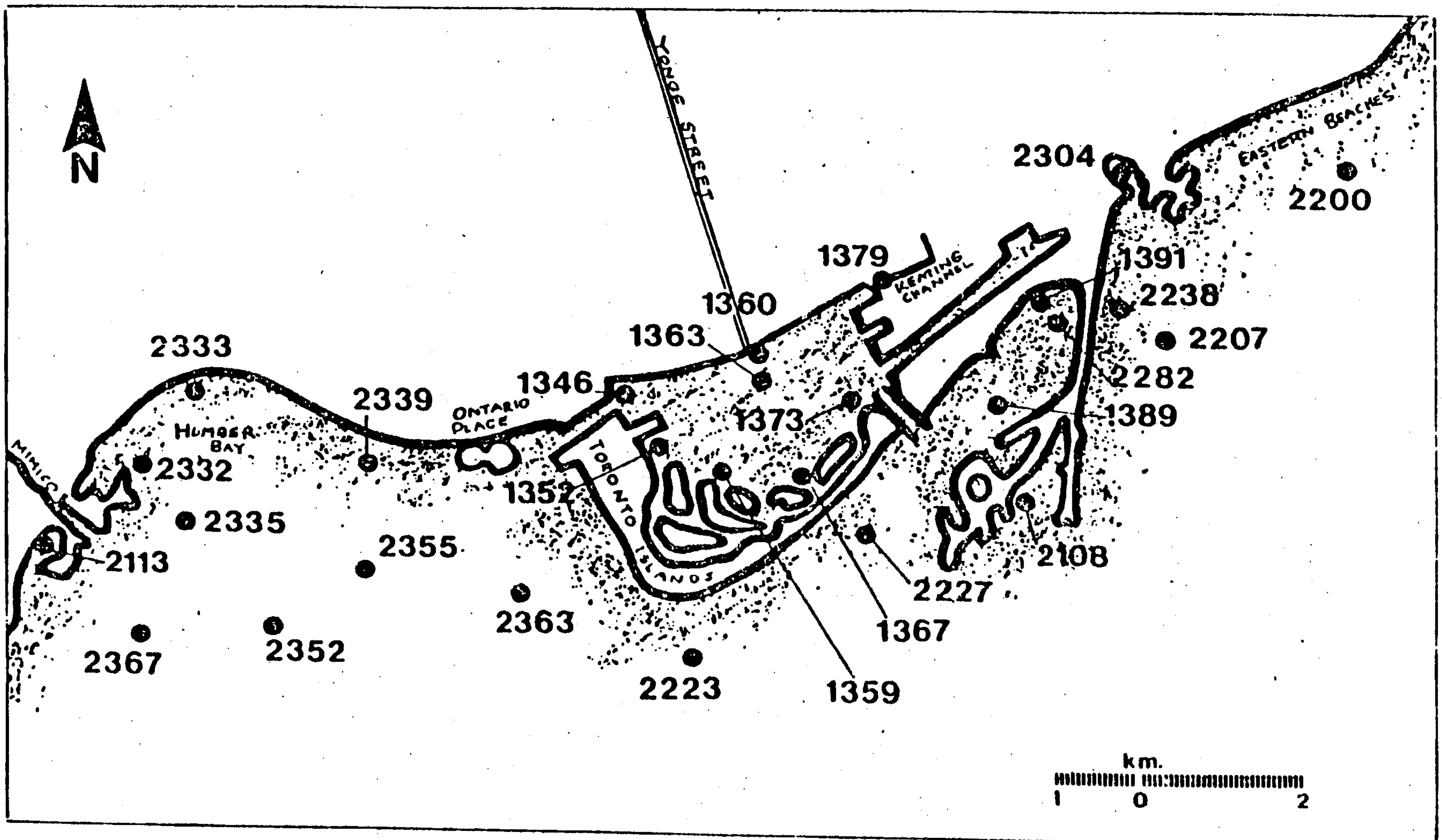


FIGURE 3.19: BENTHIC SAMPLING STATIONS

Central Waterfront

Three broadly defined areas are evident within the Toronto Harbour, based upon the benthic fauna. The first is a zone of organically enriched sediment along the waterfront, characterized by high densities of oligochaetes. Some improvement appears to have occurred in this area. Brinkhurst (1970) found densities of oligochaetes upwards of 250,000/m^2 while the maximum recorded during the 1985 survey was 31,631 at Station 1360. It was concluded that some decrease in organic content and therefore organic pollution has occurred since Brinkhurst's (1970) survey. While contaminant levels in these same areas were high, they have apparently had little effect on the oligochaete community, the major benthic group that existed in these areas. It should be pointed out, however, that these levels could limit future colonization of these areas by other organisms as sediment organic conditions continue to improve. It appeared, however, that many of the contaminants were not reaching the organisms and to this end it was possible that the high organic/clay content of the sediments was acting as a sink for many of the metals. A transitional area, represented by Station 1363, also revealed a trend toward improved sediment conditions. Specifically this is reflected by the increased diversity of feeding groups and a decreased dominance of the benthic fauna by high densities of oligochaetes. One of the most heavily polluted areas during the 1969 survey by Brinkhurst (1970), this area appears to have undergone a change in character since then.

The third zone, located around the Toronto Islands, is characterized by a diverse fauna, typical of shallow, eutrophic littoral areas of the Great Lakes. Sediment organic content is very low, as are contaminant levels and the major factors determining benthic composition appear to be depth, the occurrence of macrophytes, and the levels of detrital material.

Two broad regions may also be delineated by stations outside the Inner Harbour. The first is an area of organic deposition which occurs in the protected bays and shallows along the Outer Harbour and Eastern Headland (Stations 1389, 1391, 2282 and 2108). These areas are not heavily contaminated, and contaminant levels appear to play a minor role in limiting the faunal density. These depositional regions appear to be suffering only from varying degrees of organic enrichment.

The second region is represented by the deeper, offshore areas. Low in organic content, the fauna at these stations (2223 and 2227) have a more mesotrophic character, containing organisms commonly found in the profundal regions of Lake Ontario. Depth and substrate appear to be the major determining factors while contaminant levels were generally low with no apparent effect on the benthic community.

Eastern Waterfront

Two zones may be defined along the eastern waterfront. Protected bay areas are characterized by accumulations of fine, organic sediments as well as contaminants. Ashbridges Bay (station 2304) contains sediments with very high organic content and contaminant levels. A sizeable oligochaete community exists, although it is comprised primarily of the most pollution tolerant forms. The relatively low density of fauna despite the high organic content of the sediment may be the result of the elevated levels of contaminants. Ashbridges Bay shows signs of relatively severe organic contaminants in the benthic fauna.

The second region (Stations 2238, 2200, and 2207) is one of erosional environments, located offshore of the Eastern Waterfront and Eastern Headland and is characterized by sandy substrates supporting low densities of organisms. Contaminant levels and organic matter levels are low and the major factors effecting the benthos appear to be current and hence substrate type.

3.4 PHYTOPLANKTON

Studies of algae communities are generally undertaken to examine primary productivity or as a measure of nutrient relationships of a water body. Typical measurements include cell biomass, chlorophyl a, carbon assimilation, photosynthetic activity, taxonomic studies and cell counts or densities. The biology of many algal species is well known (Hutchison, 1967).

Algal communities are often divided into two major groups: periphyton (or attached algae), which includes filamentous algae such as Cladophora; and phytoplankton, algae that is unattached and distributed throughout the water column (diatoms, blue-green algae, green algae, etc.).

The distribution, standing stocks, abundance and species composition of algal communities is governed by physical processes (shoreline configuration, substrates, light penetration, lake thermodynamics and current) and water chemistry changes (nutrients, trace and toxic chemical substances). Seasonal, depth and shore proximity effects are also prominent in large lakes.

Despite nutrient enriched conditions in the Toronto nearshore waters, Cladophora growths reach nuisance proportions only west of the mouth of Mimico Creek. This is the only area where extensive, natural rock substrates exist for attachment. Man-made shoreline features (breakwalls, revetements, groynes, lakefills) provide limited substrates for Cladophora attachment in other areas along the Metro Toronto waterfront. Cladophora growths in Toronto are governed by physical habitat criteria rather than nutrient sources.

Phytoplankton collections were made weekly or monthly from raw water intake samples taken at the Toronto Island Water Filtration Plant between 1923 and 1963 (Schenk and Thompson, 1964). During this period, mean annual algal levels showed an increasing trend and nearly doubled over the period of record. Increasing trends in ammonia, chloride and turbidity also occurred during this period that may be reflected by the phytoplankton trend. Since only ammonia and turbidity were higher than corresponding mid lake levels, it was unclear if the observed changes represented a local or lakewide effect.

The Toronto Island Filtration Plant records indicated that diatoms (Bacillariophyta) dominated the Toronto phytoplankton community during the period of record with a dominance shift from Asterionella to Cyclotella, and a greater abundance of Melosira after 1938. Fragillaria and Turbellaria were other important diatoms. The blue-green algae (cyanobacteria) Anabaenae and Oscillatoria and representatives of the green algae (Chlorophyta), were occassionally contributed to the counts. Studies reported in 1967 (Nalewajko) and 1969 (Michalski) noted high numbers of the diatom Stephanodiscus tenuis, which is typical of more eutrophic conditions. Nalewajko (1967) suggested that eutrophic conditions in the Toronto area resulted from confinement of nutrients to the nearshore by thermal bar formations. Michalski (1969) also noted that green algae Chlamydomonas sp., the crytomonal Cryptomonas sp. and the blue-green algae Aphanizomenon flos-aqua, were major representatives of the algal community at the R.C. Harris Filtration Plant intake. Biomass was higher and diversity was lower in the Toronto Harbour than at the plant intake (Michalski, 1969). He also noted that S. hantzshi and S. tenius were dominant in Toronto Harbour. Haffner et al. (1984) reported that the predominant species in the eastern portion of the Toronto waterfront were the diatoms A. formosa, M. islandica, Synedra acus and the cryptomonads C. ovata and Rhodomonas minuta.

Bioavailability studies of in-place pollutants in Toronto Harbour were carried out in 1985-86 to assess the toxicity of contaminants originating from sediments, and to compare and assess the release and bioavailability of in-place pollutants from dredging, dredge disposal, and navigational activities in Toronto Harbour (Munawar et al., 1986). In situ techniques developed during a study of the Triangle Pond, Leslie Street Spit (Munawar et al., 1984) were directly applied to the monitoring of sediment resuspension in the shipping channels.

Sediment and water quality samples were collected for chemical analysis. Plankton samples were collected, and C-14 uptake experiments were performed to estimate primary production for background monitoring, before, during and after dredging and disposal operations and ship manoeuvering in 1985. In addition, C-14 Algal Fractionation Bioassays (Munawar et al., 1983) were conducted to assess the bioavailability/toxicity of sediment associated contaminants to phytoplankton of central Lake Ontario.

Overall findings indicated that carbon assimilation rates were inhibited by dredging and ship movement, and enhanced by dredge spoil operations as shown in the following table.

Chlorophyl a levels in the eastern end of the Toronto waterfront ranged from 1 - 8 ug/L in 1981 (Yallop et al., 1980). Available data on phytoplankton communities in the Metro Toronto Waterfront area are insufficient to identify zones or sources of nutrient enrichment or pollution.

ACTIVITY	TIME PERIOD	CARBON ASSIMILATION RATE CHANGE* > 20 um fraction	< 20 um fraction
Dredging	after a 2 hour dredging period	- 9.4%	- 22.2% (p<0.001)
Disposal	within 10 mins.	+ 18.4% (p<0.02)	
	after 75 mins.	+ 15.8%	+ 11.9% (p<0.05)
Ship Docking Movement	immediate	- 18.2%	- 51.2% (p<0.05)
	after 90 mins.	- 47.4%	

* a "+" indicates that the activity enhanced carbon assimilation, and a "-" indicates that the activity inhibited carbon assimilation, compared with the rates measured prior to the start of the activity.

3.5 ZOOPLANKTON

The important groups represented in the zooplankton of lakes belong to the Protista, Rotifera and Crustacea. Most studies in lakes focus on Crustacea because they are nektonic (free swimmming) and generally larger than other organisms, thus more susceptable to capture and identification. They are generally more important as phytoplankton grazers and fish prey. Crustacean zooplankton are primarily cyclopoid and calanoid copepods and cladocerans (branchiopods) and Malacostraca (*Mysis relicta*).

Aquatic ecosystems have characteristically been disturbed through the addition of nutrients stimulatory to phytoplankton, by substances toxic to such production, or by the addition of new exotic fishes. The crustacean zooplankters respond, as evidenced by changes in abundance and community structure, to changes in food resources and selective predation (McNaught and Buzzard, 1973). Thus whether ecosystems are stimulated from the top downward or the first trophic level upward, the crustaceans are sensitive integrators of such changes (McNaught and Buzzard, 1973).

Great Lakes zooplankton studies have occurred since the turn of the century, and in Lake Ontario they have largely focused on whole lake studies. Generally speaking, data relevent to the Metro Toronto Waterfront are limited to isolated samples from such studies.

Zooplankton communities exhibit seasonal and diurnal distributions that are thought to be strongly influenced by primary production, predator-prey interactions and lake thermaodynamics. Thus, apparent changes in community structure and abundance may result from the influences of these phenomena on sampling design. However, Roff and Wilson (1973) noted that by sampling in the western basin during daylight hours in early fall, the majority of the crustacean zooplankton could be found in the upper 20m of the water column except for M. relicta, Daphnia sicilis and Limnocalanus macrurus. At other times of the year, the near diurnal depth of most species was greater than 20m.

McNaught and Buzzard (1973) noted that there have been shifts in zooplankton community structure between 1939 and 1972 at the ordinal (calanoida to cyclopoida and cladocera) and generic (Daphnia and Diaptomics to Cyclops and Bosmina). They concluded that although Lake Ontario is morphometrically oligotrophic, these zooplankton changes suggest that it is more eutrophic than the upper Great Lakes. It was also noted that these changes in community structure resulted in increases in diversity, which were typified by an increase in species evenness rather than increases in densities and species richness.

Studies by Yallop et al. (1980) and Johannsson (1987) provide a general description of the current zooplankton community in the Toronto area. The community is dominated by copepods with seasonal peaks of cladocerans and rotifers (Yallop et al., 1980). Bosmina longirostris, Daphnia recurvata, Ceriodaphnia lacustris, Eubosmina coregoni, Diacyclops thomasi and Tropocyclops prasinus mexicanus were the major species (Johannsson, 1987). On a lakewide basis, there has apparently been no significant change in zooplankton abundance, and no change in cladoceran and copepod communities between 1969 and 1984 (Johannsson, 1987). Johannsson (1987) also noted that no changes had occurred despite two strong contrasting management strategies applied since the 1970's: phosphorus control and salmonid stocking. However the potential for change remains great.

Some Toronto vicinity studies were reported by Patalas (1969). These showed that the distribution and abundance of three zooplankers was strongly influenced by their proximity to the harbour. High densities of C. bicuspidatus thomasi and Leptodora kindtii and low densties of B. longifostris may be related to pollution sources from the harbour. A more recent study by Yallop et al. (1980) of three stations along the Scarborough Bluffs suggested that thermal instability and upwelling could account for much of the observed changes in abundance of zooplankton. Such changes may be the result of thermally or nutrient induced increases (or decreases) in production or lateral water movement (displacement).

Sufficient data on local zooplankton abundance and community structure are lacking to permit an evaluation of the current effects of pollutant loadings in the Toronto area. The limited data available suggest that a number of lakewide factors exert strong controls over zooplankton population dynamics, which must be recognized when attempting to fill Toronto area data gaps. An evaluation is required to determine whether it is possible to distinguish between microscale effects (i.e. Toronto pollution sources) and lakewide influences on zooplankton. Lakewide influences include:

1. nearshore lake thermodynamics (upwellings, thermal bar formation, seiches)
2. lakewide programs of phosphorus control and salmonid stocking
3. seasonal and diurnal zooplankton movements.

3.6 FISHERIES RESOURCE

Overview

Two centuries of development in the Toronto area has resulted in degraded aquatic habitats and significant changes in the fish community. Agricultural, industrial and urban impacts have impaired the ability of rivers and streams, wetlands, embayments and nearshore areas to produce fish. Recent management initiatives have recognized the need to protect water quality and rehabilitate degraded environments. Fisheries habitat protection and where practical, rehabilitation of fisheries, recently have been stated as management priorities by the Ontario Ministry of Natural Resources (OMNR, 1987).

Fish species assemblages, including consideration of changes in abundance and distribution over time, are considered to be good barometers of water and fish habitat quality. For example, point discharge of toxic waste results in localized absence of fish, whereas general degradation of water quality usually results in a change in fish species composition and abundance. The continuum of change usually results in the depreciation or loss of desirable fish species having high environmental quality requirements (e.g., trout, whitefish, walleye) to predominantly more tolerant, more prolific, and less valuable species such as carp, smelt, freshwater drum, catfish and suckers.

Whillans (1979) has provided a comprehensive record of historic transformation of fish communities in Toronto Bay (Appendix B). At least 50 species of fish were known to have been endemic residents of Toronto Bay. Another 11 species have been intentionally or inadvertently introduced over the past 150 years. At least 20 endemic species have been either extirpated or have not been recorded locally for decades. Biette et al. (1987) also described the historical and present fisheries resources in the Toronto area including the Credit, Humber, Don, Rouge Rivers and Duffins Creek, as well as the nearshore of Lake Ontario. Steedman et al. (1987) described the sequence of degradation associated with commercialization, industrialization and urbanization for the streams and nearshore areas of the Toronto area from the time of European settlement in the late 1700's until the present. The sequence of change in the fish community is clear and the causative factors evident.

In the mid to late 19th century major rivers in the Toronto area supported abundant populations of native brook trout and Atlantic salmon. The nearshore of Lake Ontario, river mouths and lower river reaches supported bass, walleye, perch and pike populations. Muskellunge, sturgeon, American eel and catfish inhabited the Toronto waterfront while Atlantic salmon, whitefish, lake trout and herring were abundant in Lake Ontario (Whillans 1979).

Fluctuations in abundance, changes in distribution, extirpation and new introductions, characterized the Toronto area fishery over the past century. Atlantic salmon were extirpated by 1898, while muskellunge, walleye and sturgeon became locally extinct or rare, and warmwater species were reduced in abundance. Lake trout and lake herring disappeared from Lake

Ontario, and whitefish populations were significantly reduced (Whillans 1979). Overfishing, clearing of land for agriculture, damming of rivers for power generation, waste discharges, and alteration of habitat through nearshore and marsh filling, channelization and substrate removal, have been identified as factors contributing to the decline or extirpation of fish species (Whillans 1979).

Within the past decade, recognition of the problems affecting the fish community, their documentation and propositions for rehabilitation and prevention of further degradation, have occurred (e.g., OMNR 1981, OMNR 1987, Biette et al. 1987, Steedman et al. 1987). Moreover, some gains have been made in mitigating the stresses impacting the fishery. Improvements in sewage treatment plants, control of fish harvest, fish stocking programs and fish habitat protection and rehabilitation initiatives have offset losses to some extent. Since the early 1960's ambitious stocking programs by the Province of Ontario, which have been complemented by stocking initiatives by New York State, have created tens of thousands of new angling opportunities for Pacific salmon, rainbow, lake and brown trout, in the offshore and nearshore waters of Lake Ontario. Toronto streams, with the exception of the Don River, have provided important sites of imprinting these migratory salmonids as well as providing staging areas during the fall and spring. Lake trout, which were eliminated in Lake Ontario in the 1950's are being re-established. The result has been the creation of a successful put-and-delayed- take recreational fishery for salmonids in Lake Ontario fronting Toronto, and to a lesser extent in the lower reaches of Toronto area streams. These new fishing opportunities, along with the recent resurgence of interest in developing other urban fishing for warmwater species, is serving to focus the attention of management agencies and the public on urban waters and issues.

3.6.1 Fish Distribution

Presently, three general categories of aquatic habitat can be recognized in the Toronto area: stream and river systems, river mouths, and the nearshore area of Lake Ontario. While these three habitats differ in their physical structure they must also be recognized as partially integrated and interrelated components within the Lake Ontario watershed. The inter-connection of the different aquatic habitats has been described as a land-river-bay-lake continuum (Steedman et al.

1987). This concept emphasizes the physical and biological linkages between the various habitat components, their ecological inter-dependency and the need to coordinate their use, protection and rehabilitation.

Fish species present in the Toronto area have been quite well documented in recent years (Table 3.5, and Appendix B).

Streams and River Systems

The three major rivers in the Toronto area are the Rouge, Don and Humber Rivers. The headwaters arise in the Oak Ridges Morraine and they drain watershed areas of 327, 360, and 857 km^2, respectively. Although agriculture is a significant land use in the upper areas of the Rouge and Humber Rivers, centres of urban development are a predominant feature in both watersheds. The Don River watershed is intensively urbanized.

Cold headwaters of the Humber and Rouge Rivers still support some brook trout (Steedman, 1987). Self-reproducing populations of brown trout are present in the upper Humber above Bolton. In the Rouge River, there is some evidence that rainbow trout are naturally reproducing downstream of the Milne Reservoir (Steedman, 1987). While some coldwater habitat remains in the headwaters of the Don River, trout are no longer found there (Martin-Downs, 1987).

The midwater reaches of these streams are characterized by such fish species as minnows, suckers, darters and sunfish (Biette et al. 1987). In addition, the mid-to-lower reaches of the Rouge River support a warmwater fish community of largemouth and smallmouth bass, rock bass, carp and bullhead. The rare redside dace is found in several small tributaries in the Humber, Don and Rouge Rivers.

Seasonal migrations of coho and chinook salmon, brown and rainbow trout occur in both the Humber and Rouge Rivers. These fisheries are dependent upon provincial stocking programs. In the Humber River, migratory salmonids are essentially limited to the area below the Old Mill weir just above Bloor Street although some salmonids, particularly rainbows are found above this location if flows are suitable. In the main Rouge River, lake run salmonids are blocked from further upstream access by the Milne Dam at Markham. These salmonid runs provide fishing opportunities for shore anglers on a seasonal basis.

Table 3.5: Fish Species Present in the Metro Toronto RAP Area

Total	Humber River	Don River	Rouge River	Humber Marsh	Rouge Marsh	Waterfront
brook lamprey	x		x			
sea lamprey			x		x	x
bowfin					x	
alewife				x	x	x
gizzard shad			x	x	x	x
coho						x
chinook				x		x
rainbow			x		x	x
brown	x		x			x
brook trout	x		x			
lake trout						x
splake						x
lake whitefish						x
lake herring						x
round whitefish						x
smelt					x	x
pike				x	x	x
mud minnow	x		x	x	x	x
longnose sucker						x
white sucker	x	x	x	x	x	x
hog sucker	x					
goldfish	x	x	x	x		x
northern redbelly dace	x	x	x			
redside dace	x	x	x			
lake chub			x		x	x
carp	x	x	x	x	x	x
brassy minnow	x		x			
hornyhead chub			x			
river chub	x					
golden shiner	x			x	x	x
emerald shiner		x		x	x	x
common shiner	x	x	x	x	x	x
spottail shiner		x	x	x	x	x
rosyface shiner	x		x			
spotfin shiner				x		x
sand shiner	x				x	x
mimic shiner						x
bluntnose minnow	x	x	x	x	x	x
fathead minnow	x	x	x		x	x
blacknose dace	x	x	x	x		
longnose dace	x	x	x	x	x	x
creek chub	x	x	x	x	x	x
stoneroller			x		x	
brown bullhead	x		x	x	x	x
stonecat	x		x			
tadpole madtom					x	
eel						x

Table 3.5: Continued

Total	Humber River	Don River	Rouge River	Humber Marsh	Rouge Marsh	Waterfront
killifish	x				x	
brook stickleback	x	x	x		x	x
3-spine stickleback						x
trout perch	x				x	x
white perch				x	x	x
white bass					x	x
rock bass	x	x	x	x	x	x
pumpkinseed	x	x	x	x	x	x
smallmouth bass			x		x	x
largemouth bass	x		x	x	x	x
black crappie			x	x	x	x
yellow perch	x	x		x	x	x
blackside darter	x					
rainbow darter	x	x	x			
Iowa darter	x		x			
fantail darter	x					
Johnny darter	x	x	x	x	x	x
log perch			x			
tesselated darter						?
brook silverside						x
freshwater drum				x		x
mottled sculpin	x	x	x			x
slimy sculpin						x
70 species	36	21	37	27	35	49

References:

1 - Steedman, 1986. Field collections 1984, 1985.
2 - Martin-Downs, 1987. Field collections 1984.
3 - Stephenson. Field collections 1985, 1986.
4 - Martin-Downs, 1986. MTRCA data 1979-1983.

Occasionally a salmonid strays up the Don River, but for the most part migratory runs are limited to carp and white suckers. White sucker migrations have also been observed in both the Humber and Rouge Rivers.

There are also several small streams in the Toronto-centred area which support limited warmwater fish communities. These streams, which are generally degraded by urban land use, include Etobicoke Creek, Mimico Creek, and Highland Creek. The drainage areas for these creeks range between 28 and 207 km^2.

River Mouths

River mouths and associated wetland areas provide elements of both riverine and lake environments. Characteristic species include those from the nearshore of Lake Ontario and the river upstream.

The Humber Marsh remains as an important spawning and rearing area for many cool and warmwater species. Steedman et al. (1987) noted young, spawning and sexually mature fish of many species including carp, brown bullhead, yellow perch, white sucker, white perch, largemouth bass, black crappie, pumpkinseed, rock bass, white bass, northern pike and several forage species. Pumpkinseed, sucker and carp were the most common species caught in recent sampling surveys with representation by large mouth bass and gizzard shad (Martin-Downs 1986; Stephenson 1985).

Steedman et al. (1987) also found the same species in the Rouge Marsh as the Humber Marsh with the addition of smallmouth bass and bowfin. Brown bullhead, yellow perch and pumpkinseed were the most abundant game species caught in sampling surveys with a smaller representation of largemouth bass, northern pike, carp, shad, white perch and black crappie (Martin-Downs 1986; Stephenson 1985). Shore angling in this marsh is a popular pastime (MTRCA 1986).

The mouth of the Don River once emptied into the Ashbridges Bay marsh. After filling of the marsh in the early 1900's, the lower river and mouth were channelized. White sucker, emerald shiner and spottail shiners were the only species located in the river mouth in a 1984 survey (Martin-Downs 1987).

The Nearshore Zone of Lake Ontario

The nearshore of Lake Ontario fronting Toronto provides a somewhat hostile environment for many fish species. Approximately 42% of the shoreline between Port Credit and Duffins Creek is fully exposed to wave action (Martin-Downs 1986). Also, strong offshore winds cause warmer surface waters to be pushed downwind resulting in the upwelling of colder sub-surface waters. In summer, the prevailing winds cause these upwellings to occur frequently along the northwest shore (Boyce and Robertson 1984). Temperature fluctuations of 10-12°C for up to two weeks are common and may reduce survival and production of fish using these areas for spawning and rearing. More protected waters in the nearshore are found in association with river mouths, lakefill parks and the Toronto Islands.

Four landfill parks are located along the waterfront - Ashbridges Bay, Tommy Thompson, Bluffers and Humber Bay. Evidence suggests that these parks are having a positive impact on the nearshore cool and warmwater fish species by providing a diversified habitat. Hindley and Martin (1985) found more species associated with the lakefill parks, with greater abundance and consistency than the adjacent exposed shoreline.

The most common fish species across the waterfront in all habitat types are alewife, rainbow smelt, gizzard shad, common white sucker, and yellow perch. Emerald and spottail shiners are also common in nearshore protected waters. Longnose dace and mottled sculpin are abundant along the exposed shoreline. Other species such as carp, pike, white perch, pumpkinseed, and white bass occur with some regularity, but they are not abundant (Martin-Downs 1986; Hamilton 1987; Acres 1983). Another group of fishes comprised of largemouth and smallmouth bass, longnose sucker, white trout, lake and round whitefish, American eel, freshwater drum, black crappie, brown bullhead, goldfish, lake chub and rock bass also are found along the waterfront, but in lower numbers and with less regularity (Martin-Downs 1986; Acres 1983). Significant numbers of coho and chinook salmon, rainbow trout, brown trout and lake trout occur along the Lake Ontario nearshore area on a seasonal basis. Two additional species, lake whitefish and round whitefish, appear only in the eastern portion of the waterfront during late fall.

Movements of coho and chinook salmon, rainbow trout, brown trout and lake trout occur along the Lake Ontario nearshore area, particularly in spring and late summer. Concentrations of fish may be found inshore in spring along the Etobicoke shoreline foraging for alewife and smelt, and further offshore in late summer. They then move toward major rivers including the Humber, Credit, Rouge and Duffins. Although the Credit River and Duffins Creek are east and west of the main area of interest for the RAP, they are large river systems which have fish communities which contribute significantly to the urban and near urban fishery.

Recent field assessment work by OMNR and MTRCA indicates that the numbers of anadromous coldwater species migrating up the Rouge River have increased in recent years. As a result, Anderson and Gamble (1985), in a report for the City of Scarborough, have recommended that a put-and-delayed-take salmon program be initiated for the Lower Rouge River based on the suitability of the river for stocking, and that the City of Scarborough actively promote and develop ancillary services for a salmonid sport fishery along the Lake Ontario nearshore, particularly at Bluffers Park and at the Rouge River. MNR presently stocks some brown and rainbow trout in the Rouge River.

Spawning activity along the waterfront is not well documented. Seine collections along the waterfront by the Metro Toronto and Region Conservation Authority found young-of-the-year at various nearshore sites (MTRCA data 1979-1983). For example, at Humber Bay Park, young-of-the-year (YOY) alewife, rainbow smelt, white sucker, creek chub, brown bullhead, pumpkinseed, largemouth bass, yellow perch, emerald and spottail shiners and bluntnose minnows were located. In contrast, no YOY of any species was found to the west along the open shoreline. At Tommy Thompson Park, YOY of alewife, smelt, pumpkinseed, carp, largemouth bass and spottail and emerald shiners were locted. In the Toronto Islands, adjacent to Aquatic Park YOY northern pike, alewife, smelt were found (Hamilton 1987).

At Ashbridges Bay Park YOY for alewife, pumpkinseed, shad, emerald shiner, largemouth bass and white bass were located, while along the eastern beaches YOY alewife, longnose dace, shad and largemouth bass occurred. At Bluffers Park YOY species included: alewife, white bass, pumpkinseed, yellow perch, rainbow smelt, white sucker, emerald and spottail shiners, creek chub, smallmouth bass, largemouth bass, gizzard shad, white perch, northern pike, bluntnose minnow, Johnny darter and mottled sculpin (MTRCA data 1979;-1983).

No part of the Toronto waterfront is currently so degraded as to exclude all fish at any time of the year. Some fish are present in the seriously degraded Keating Channel and Ship Channel, even during the late summer, a period of higher water temperatures and lower dissolved oxygen concentrations. However, Maguire et al. (1982) reported that the concentration (0.84 ug/L) of tributyltin, a constituent of boat or ship paint, in Toronto Harbour was 15% of the 12 day lethal does for 100% mortality of rainbow trout yolk sac fry. They hypothesized that the elevated concentration may be exerting a chronic stress on local fish residents. Furthermore, the U.S. EPA (1984) reported that Toronto sediment elutraites caused 100 percent mortaility of newly hatched fathead minnow larvae.

3.6.2 Fisheries Resource Yield and Use

Fish yields for the Toronto area waters have been estimated based upon data provided in the Maple District Fisheries Management Planning Documents (OMNR, 1987 a, b). The potential yield* of coldwater fishes including brook and brown trout, for the Humber, Rouge and Duffins and associated tributaries is just over 700 kgs per year. This compares to a yield of 511 kgs per year for the Upper Credit River. In contrast, fish yield from warmwater sections of the Humber, Rouge, Etobicoke and Duffins Rivers is about 8800 kgs per year (OMNR, 1987). In comparison, Lake Ontario waters fronting Toronto could produce over one half million kgs of fish per year. Lake Ontario, near Toronto, is thought to be providing about 63,000 angler days of recreation each year and a harvest (current yield**) of about 125,000 kgs of fish. In comparison, fishing along the shore, in streams and in urban ponds in recent years contributed about 7000 angler days per year and 3500 kgs of fish per year.

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* Potential Yield - The theoretical weight of fish that can be removed from a waterbody on a sustained basis when there are not other constraints reducing yield (e.g., contaminants, eutrophication, habitat loss).

** Current Yield (estimated harvest) - The estimated weight of fish harvested from a body of water (or defined area).

The differences between potential yield and estimated harvest can be attributed to problems associated with access, public perception, limited use because of contaminants, undesirable fishing experiences, and underproducing waters due to habitat loss or disruption. It is also clearly evident that species desired by recreational fishermen may only be available on a seasonal basis (i.e., these fish do not depend upon Toronto area waters for much of their life history and are usually supported by hatchery stocking programs). Hatchery supported fisheries offer important urban and near urban angling opportunities and fish stocking programs are the basis for much of the fishery in the Western basin of Lake Ontario. Fish stocking programs by OMNR for the Toronto area waters have been summarized for the past six years (Table 3.6). However, the protection and improvement of streams and rivers, wetlands, littoral areas within the Toronto area will be essential if these fish communities are to survive and continue to provide angling opportunities and associated benefits.

Some commercial fishing activities occur in the Toronto area. Most streams in the area support commercial baitfish harvests. In addition, one commercial fisherman fishes for coldwater and warmwater species in the Frenchmans Bay area. His activities are restricted by the imposition of a small quota; his annual harvest averages about 150 kgs per year.

Table 3.6
Summary of Fish Stocked by Ministry of Natural Resources in the Vicinity of The Toronto Waterfront - 1982-1987

YEAR	SITE	SPECIES	NUMBER STOCKED
1982	Rouge River	Brown Trout	19,000
1983	Humber River	Brown Trout	21,700
1984	Humber River	Brown Trout	12,000
	Rouge River	Brown Trout	20,000
1985	Humber River	Brown Trout	26,500
	Rouge River	Brown Trout	6,500
1986	Rouge River	Rainbow Trout	20,000
		Brown Trout	20,000
	Humber River	Brown Trout	20,000
	Bluffers Park	Brown Trout	20,000
	Asbridges Bay	Brown Trout	16,000
1987	Rouge River	Rainbow Trout	30,000
		Brown Trout	33,000
	Humber River	Brown Trout	15,000
	Bluffers Park	Brown Trout	20,000
	Ashbridges Bay	Brown Trout	15,000

NB: In addition, adjacent waters are stocked which contribute to the Lake Ontario fishery. For example, in 1987 other stocked waters included the Credit River (chinook 182,000; coho 132,000; rainbow trout 140,000); Duffins Creek (rainbow trout 45,000; brown trout 20,000 (1986) and lake trout in Lake Ontario (80,000 (1986)).

3.6.3 Present Fisheries Management Practices

Fisheries management includes population management, habitat management, public services and extension, enforcement and planning. Present management practices by OMNR in the Toronto area waters include:

(a) Stocking of salmonids (coho and chinook salmon, brown and rainbow trout) in Lake Ontario and tributary streams for a put-and-delayed-take recreational fishery; rehabilitation stocking for lake trout in Lake Ontario;

(b) Stream rehabilitation projects in headwater areas of streams to restore or improve their capacity for producing fish;

(c) Informing and involving the public about the resource and the issues affecting it;

(d) Enforcement of existing fisheries regulations;

(e) The protection of fish habitat through input to the plan review process and examination of development proposals;

(f) With Ontario Ministry of the Environment, monitoring of contaminants in fish for the GUIDE TO EATING ONTARIO SPORTFISH;

(g) Limited stocking of brook and brown trout in headwater streams to enhance or expand existing populations;

(h) Promotion of urban fishing opportunities for underutilized species, primarily warmwater and coarse fish species, and providing access to this fishery.

It is recognized that more extensive, ambitious and innovative management measures will have to be taken if protection and rehabilitation of fisheries is going to occur. Strategies are now being proposed by OMNR in the Maple District Fisheries Management Plan (OMNR, 1987). These strategies include:

- protecting habitat, fish communities and individual fish stocks;
- rehabilitation of fish habitat;

- developing comprehensive fisheries inventory and assessment programs;
- encouraging public participation in local resource management;
- controlling angler exploitation rates;
- developing put-and-take fisheries;
- supplementing existing fisheries through increased fish stocking or encouraging the use of alternate species such as pike, bass, bullheads and yellow perch.

Improved fisheries management will depend upon public consultation, integrated resource planning, scientific information and education of resource users. The Maple District Fisheries Management Plan is seen as the vehicle for integrating fisheries management approaches through clearly stated objectives. Given the nature of the problems and issues facing fisheries in the Toronto area, inter-agency cooperation will also be crucial.

The fish community is recognized as an integrator of the aquatic ecosystem, an indicator of its health, and a most sensitive use. Planning must incorporate recognized values of fisheries which need to be complemented by the goals and objectives of other agencies and levels of government. In an urbanized and urbanizing environment, fish communities will continue to be degraded unless other uses of the environment are sensitive to and compatible with the goal of "healthy fish communities". Value of the fish community must be measured against other uses and needs, but it should not be valued in terms of just recreational opportunities, but rather as a measure of overall ecological health and ecosystem integrity.

3.7 Avifauna

The EPS (1977) delineated the Toronto waterfront and neighbouring areas of the Lake Ontario shoreline (from Hamilton Beach to Second Marsh at Oshawa) as a critical (sensitive) area for waterfowl. Although much of the original marsh habitat has been eliminated (Whillans, 1982), substantial concentrations of dabbling and diving ducks and Canada geese utilize the area during spring and fall staging, as well as for over-wintering. It is an area along the lower Great Lakes being used by a significant number of waterfowl for breeding. The proximity of the city and artificial feedings contribute greatly to waterfowl survival and success (Fetterolf, 1983).

A total of 30 species of waterfowl and waterbirds have been recorded as utilizing Tommy Thompson Park and surrounding waters. This species composition likely also applies to the Toronto eastern waterfront. Species diversity is highest during the spring and fall migration periods as both diving ducks and dabbling ducks are well represented.

Tommy Thompson Park and surrounding waters are of particular importance to migratory and overwintering waterfowl. Breeding populations of waterfowl at the Park are small. As the winter progresses and shallow waters surrounding the Eastern Headland freeze over, wintering waterfowl seek out open water habitat in other regions of the Toronto waterfront, e.g., Ashbridge's Bay. Figures delineating waterfowl nesting, staging and wintering areas at Tommy Thompson Park and surrounding waters are provided in Appendix C.

The Toronto Island lagoons are extensively used by mallards, Canada geese and some black ducks as breeding areas, whereas the Ontario Place lagoons are used to a much lesser extent. The lagoons in both areas are mainly ice covered through the winter and are, therefore, inaccessible to waterfowl. The Inner Harbour, when ice free areas exist, supports low density use. Utilization of the Lower Don River/Keating Channel areas by waterfowl is extremely limited due principally to the unnatural character of the riverine and riparian habitat along this reach. Humber Bay is used extensively by diving ducks for overwintering and as a staging area during spring and fall migration.

Of the waterfowl species, Canada Geese have recently been recognized as posing a "nuisance problem" in many public areas of Toronto. In 1979, the population reached an estimated 3,400 individuals in the Toronto central waterfront. Most geese nest on the Toronto Islands and on Tommy Thompson Park (Eastern Headland) (Fetterolf, 1983). From 1982-1986 mid-December counts of non- migrating Canada geese ranged from 2000 to 5100 birds and averaged 3700 along the Toronto waterfront (T.C. Smith pers. comm.).

Due to nuisance problems created by birds' defecation and their aggressive behaviour towards the public, a management program was begun in 1978 by the Canadian Wildlife Service in cooperation with the OMNR. This program has entailed the capture of and shipment to the United States of 15,000 geese between 1978 and 1987, as well as the removal of eggs from nests since 1979. These measures have reduced the resident goose population by an estimated 50% since 1980 (Fetterolf, 1983). A goose removal program continues to be implemented on an annual basis. Approximately 1000 adults and 500 goslings are removed each year in this program. Beyond the aesthetic impacts (resulting in some complaints by the public) of large amounts of goose droppings in areas of public use, there have been no definitive studies relating goose defecation to water quality impacts.

The Toronto waterfront also provides important habitats for colonial waterbird species, particularly gulls and terns. Herring gulls (Larus argentatus) are year-round residents, whereas the ring-billed gulls (L. delawarensis) are migrating species. Black-crowned night herons are also evident.

Tommy Thompson Park is a significant breeding area for gulls and terns while Ashbridge's Bay Park and Bluffers Park are important loafing and feeding locations of gulls. Herring gull breeding areas occur on Mugg's Island, with about 67 pairs noted in 1986 (Table 3.7). Similarly, 84 pairs of herring gulls were counted at Tommy Thompson Park in 1986 (Table 3.8). Ring-billed gulls also utilize Mugg's Island and Aquatic Park as nesting areas. The nesting population on Mugg's Island has been 7,715, 12,087 and 10,782 pairs for 1984, 1985 and 1986 respectively. The number of pairs nesting on Tommy Thompson Park has increased explosively from about ten pairs in 1973 to about 80,000 pairs in 1983. Since 1983, ring-billed gulls have declined to 40,160 pairs in 1986. Gull control operations were begun by MTRCA in 1984. This species had taken advantage of the newly created landfill which provided ideal nesting habitat.

Table 3.7
Numbers of Nests of Colonial Waterbirds at Mugg's Island during the Peak of the Breeding Season.
Source: Blokpoel, Canadian Wildlife Service

Year	Black-crowned Night Heron	Herring Gull	Ring-billed Gull*
1984	200	40	7715
1985	no data	44	12087
1986	340	67	10782

* Gull control operations by Metro Parks Properties in 1985.

Table 3.8
Numbers of Nests of Colonial Waterbirds
at Tommy Thompson Park (Aquatic Park)
Source: Blokpoel, Canadian Wildlife Service.

Year	Black-crowned Night Heron	Herring Gull	Ring-billed Gull	Common Tern	Caspian Tern
1983	20b	75b	± 80000d	±1500d	112c
1984	45b	91b	74500d	± 950d	168c
1985	39b	101b	46986b	564b	197c
1986	63b	84b	40160b	993b	202c

a Gull control operations by MTRCA began in 1984
b Nest counts at peak of nesting season
c Whole-season nest count up to hatching of first chick
d Whole-season estimates

Currently, common terns nest only on Tommy Thompson Park with the number of nests fluctuating between 560 and 2,200 since 1976. In 1986, 993 pairs of common tern were counted. Prior to 1976, common terns also nested on Mugg's Island and Toronto Island Airport.

Caspian terns have not historically nested on the Canadian side of Lake Ontario (Blokpoel, 1977). Since 1976, however, a nesting colony on Tommy Thompson Park has steadily increased each year to an estimated 202 nests in 1986. This colony may be threatened by Ring-billed Gulls (Blokpoel, unpublished).

Black-crowned night herons are also evident and 63 pairs were counted on Tommy Thompson Park in 1986, up from 20 pairs in 1983. Over 300 nests of black-crowned night herons were counted on Mugg's Island in 1986 (Table 1). Important breeding areas of herons, gulls and terns on Tommy Thompson Park are shown in Appendix C.

A particular concern has been the potential impact on water quality due to defecation by several hundred thousand ring-billed gulls during their breeding period from mid-March to late July. However, fecal coliform counts for the past 11 years from sampling locations near Tommy Thompson Park, Cherry Beach, Ward's Island Beach and Ashbridge's Bay Park showed no significant relationship to the number of pairs of gulls nesting on Aquatic Park (Fetterolf, 1983). These data suggest that the large amount of fecal material produced by the nesting gulls on Tommy Thompson Park does not have a notable impact on water quality at nearby swimming beaches.

3.7.1 Contaminant Impact on Avifauna

Fish eating birds occupy the highest trophic level of the aquatic food web and, therefore, they are especially vulnerable to biomagnification of environmental contaminants. Research on avian populations, particularly fish-eating species, indicated that these substances were accumulating through food chains. Concomitant data on eggshell thinning and reproductive failure also indicated that this contamination had significant biological impact.

The effects of chlorinated organics on the reproductive success of herring gull, black-crowned night heron and other colonial waterbird species in the Great Lakes were noted, particularly in Lake Ontario herring gull colonies in 1972. Reproductive success was about one-tenth of that of herring gull colonies at the New England coast. A high rate of egg loss in the Lake Ontario colonies during the early 1970's was explained by thinner eggshells, contributing to eggshell breakage. Eggshell thinning was significantly correlated with the content of DDE in the eggs. High early embryonic mortality, characteristic of egg failure, was explained in part by the variation in nest incubation temperatures due to poor nest attentiveness of the adults (Gilman et al. 1979). This reproductive failure phenomenon continued to occur through 1977.

During the episodes of reproductive failure in the early 1970's, congenital anomalies such as crossed bills, malformed eyes and extra limbs were abnormally prevalent in chicks of some species of fish eating birds in Lake Ontario. Gilbertson et al. (1976) reported that, during a 1972 survey, the most common abnormality found in common tern chicks in the Mugg's Island colony was crossed bills, a deformity which could result in impaired feeding and possible starvation. The percentage of abnormal chicks was 1.2% based on examination of about 420 chicks. During a 1973 survey of a ring-billed gull colony on Mugg's Island, more than 20 chicks of about 2,500 (about 8 per 1,000 chicks) were found with severe leg deformities. In contrast, Ryder and Chamberlain (1972) observed a single abnormal chick with extra food elements (polydactyly) in 359 ring-billed chicks banded (about 2.8 per 1,000 chicks) on Granite Island in Black Bay, Lake Superior.

Similar episodes of reproductive decline and/or failure occurred for other colonial fish-eating bird species, including the double crested cormorant (Phalacrocorax auritus) and common tern. For example, Connors et al. (1975) reported that, in 1972, hatching success in a colony of common terns on the Toronto Islands was less than 40%. In contrast, hatching success in Massachusetts and Long Island coastal colonies was 90% or higher. In 1978, breeding success increased significantly. This increase in reproductive success was paralleled by a significant decline in major organochlorine residues. For example, Weselch et al. (1979) reported a statistically significant decline in the concentration of six organochlorine contaminants in herring gull eggs collected from Mugg's Island between 1974 and 1978 (Table 3.9).

Gilbertson (1983) reported that studies of the incidence of congenital abnormalities in fish-eating birds of Lake Ontario have shown a marked decrease from the period 1971 to 1973 to the period 1975 to 1980. Incidence rates of congenital anomalies for common tern, caspian tern and black-crowned night heron (Nycticora nycticorax) were 12.2, 10.0 and 13.9 per 1,000 chicks respectively in 1971 to 1973. In 1975 to 1980, the rates for each of the three species were less than two per 1,000 chicks. The higher incidence of congenital anomalies during the early 1970's suggests the occurrence of a mutagenic or teratogenic agent(s) in the Lake Ontario Environment.

Current reproductive rates of herring gulls and other species are normal (Mineau et al. 1984), indicating that the concentration of the agent(s) has declined.

Table 3.9
Concentrations of Organochlorine Contaminants in Herring Gull Eggs from Mugg's Island

Mean (+ Standard Deviation) Concentration (ng/g)

Year	% Fat	DDE	DDT	Dieldrin	HCB	Mirex	PCB
1974	7.8+1.2	23+5.5	1.2+0.79	0.46+0.13	0.60+0.36	7.4+4.7	160+48
1975	7.7+0.8	22+5.5	0.13+0.06	0.24+0.16	0.45+0.26	3.4+1.4	110+21
1977	8.8+1.0	13+2.5	0.12+0.05	0.27+0.08	0.34+0.06	2.1+0.4	87+19
1978	8.6+1.0	11+3.0	0.10+0.05	0.25+0.05	0.28+0.06	1.4+0.7	75+17

3.8 CONTAMINANTS IN THE BIOTA

Toxic contaminants may be acutely lethal or exhibit chronic effects on biota. These effects are characterized by fish kills or the absence of biota (acute toxicity) and behavioral or reproductive anomalies (chronic toxicity). Contaminant concentrations may be sufficiently low however, as to have no apparent ill effects while still accumulating in the organism. These organisms may represent a source of contamination to predator species. Contaminant levels in the tissue of higher trophic level organisms may greatly exceed levels found in lower trophic forms. Alternately, contaminant concentration may be much lower in the higher trophic levels. The bioconcentration of contaminants depends upon the physical and chemical nature of the contaminant, the relative rates at which organisms throughout the food web ingest and eliminate waste, and the relative efficiency with which the biota retains contaminants (Boyd et al., 1987). Contaminants which biomagnify (increase in concentration as trophic level increases) are of particular concern because of potential impacts on birds, wildlife and humans who consume them.

The factors which affect biomagnification are complex, variable, and in general, poorly understood. Research is ongoing in this area. In the Toronto area, studies have been conducted to measure tissue contaminant levels in benthic invertebrates, and young-of-the-year fish. In addition, data for sport fish is available through the ongoing Sport Fish Contaminants Monitoring Program. Recent studies using clams have been undertaken but the data are not yet available. The majority of data are useful in identifying the concentration ranges for contaminants found in the different trophic levels. Some data is available to indicate trends in contaminant body burdens over time.

Overview

The accumulation of contaminants in biota is a concern both because of the stresses that may occur at different trophic levels and as an indicator of the relative health of Toronto's aquatic environment. The biological significance of contaminant body burdens is poorly understood except for parameters such a PCBs, DDT, and mercury which have been extensively studied. Efforts are under way within the Ontario Ministry of the Environment to develop guidelines to assist in assessing the concentrations measured in biota. Guideline development is insufficiently advanced to provide assistance at this time.

Examination of the various data for the different biological compartments indicates that, as expected, contaminants are accumulating. Levels of PCBs are above IJC guidelines in most of the biota. Limited trend analysis indicates that PCBs and other organics such as DDT and Chlordane, are decreasing.

Data on water chemistry, sediments and suspended solids have all pointed to zones of high contamination in the vicinity of point source discharges and river mouths. While there is some evidence of this in the biota contaminant accumulations, there is surprising uniformity in tissue concentrations across the waterfront. Except for PCBs, which are highest in Humber Bay near the mouth of the Humber River, maximum concentrations of the different contaminants are scattered. Peak concentrations do sometimes occur near the major sources, but they also occur in the "cleaner" areas of the waterfront. This finding is supported by the data on benthic invertebrates, young-of-the-year-fish and sport fish. The data suggests that a significant portion of the contaminants in the more heavily polluted areas are biologically unavailable, or that the biota naturally limit uptake or eliminate the contaminants.

The data on biota accumulations also indicates that many of the heavy metals associated with sediment and in-place pollutant problems, show limited potential to biomagnify. With the exception of mercury and arsenic, heavy metals are typically found at similar or lower levels in sport fish than in benthos.

3.8.1 Benthos

Persaud et al (1987) conducted an extensive study of sediment and benthic contaminant accumulation along the Toronto waterfront. The results of these studies are discussed in more detail in Sections 3.2 and 3.3. The ranges of contaminant concentrations measured in benthos across the waterfront are shown in Tables 3.10 and 3.11 for metals and organics, respectively.

There is no basis to assess the effect of the contaminant levels observed on the biota. It is therefore impossible to

Table 3.10

CONCENTRATION RANGES FOR METALS IN BENTHIC TISSUE

Location / Metal	Humber Bay	Toronto Harbour	Eastern Headland	Ashbridges Bay	Eastern Waterfront
Copper	3.0 - 13.0	4.0 - 14.0	4.9 - 12.4	6.0	2.0 - 12.0
Zinc	14.0 - 87.0	28.0 - 47.0	2.3 - 6.0	38.0	7.0 - 41.0
Lead	* - 2.0	* - 9.0	4.0 - 6.0	*	*
Cadmium	*	*	* - 0.2	*	*
Iron	115.0- 760.0	140.0 - 900.0	171.0 - 758.0	990.0	120.0 - 710.0
Manganese	2.0 - 15.0	2.0 - 8.0	4.6 - 18.8	13.0	1.0 - 8.0
Mercury	.013 - .055	.032 - .084	.036 - .081	.030	.013 - .058
Arsenic	0.1 - 0.6	-	0.1 - 0.6	-	-

Notes:
1. All values are in µg/g, wet weight, not corrected for gut content
2. An asterisk (*) indicates a value less than detection limit

Source: "The In-Place Pollutants Program, Volume iii, Phase 1 Studies", Ontario Ministry of the Environment, October, 1987.

Table 3.11

CONCENTRATION RANGES FOR ORGANICS IN BENTHIC TISSUE

Location / Organic	Humber Bay	Toronto Harbour	Ashbridges Bay	Eastern Waterfront
PCB	.22 - .6	ND - .32	.11	ND - .24
PP, DDD	ND - .026	ND - .032	ND	ND
PP, DDE	.014 - .051	ND - .013	ND	ND
A - BHC	ND - .031	ND - .005	ND	ND - .008
G-BHC(Lindane)	ND	ND - .015	ND	ND
Hexachlo-robenzene(HCB)	.012 - .025	ND - .017	.044	ND - .070
Aldrin	.003 - .008	ND - .007	ND	ND - .032
Heptachlor	ND - .004	ND - .015	ND	ND - .026
Chlordane	ND - .033	ND - .025	ND	ND

Notes: 1. All values are in µg, wet weight, not corrected for gut content
2. 'ND' indicated not detected in benthic organisms

Source: "The In-Place Pollutants Program, Volume iii, Phase 1 Studies", Ontario Ministry of the Environment, October, 1987.

indicate whether the benthos are impaired at the contaminant levels observed. The data is useful however, in identifying spatial trends in contaminant levels.

For the metals, benthic accumulations are generally similar across the waterfront. Concentrations close to the maximum recorded values occur in both polluted and relatively 'clean' areas. Although proximity to point sources and heavily contaminated sediments seems to be a factor in some instances, the levels of contaminants observed in benthic tissue are not as variable as might be expected. The data suggest that the contaminants in the more polluted areas are not as available for benthic uptake, or that the benthos are able to limit the levels of accumulation.

Some weak spatial trends are observable. Benthic tissue concentrations of copper, lead and cadmium are consistent in the median to upper levels of the observed range, in the vicinity of the Eastern Headland. Higher levels of copper and lead are however, found at some locations in the Inner Harbour and Humber Bay. Zinc levels are all in the upper range around the Eastern Headland. Mercury levels are similar across the waterfront and do not exhibit any significant spatial trend.

Organic contaminants are also found in similar ranges across the waterfront, although the effect of point sources is more pronounced. Benthic tissue levels do not appear to be correlated with sediment contaminant content alone and it appears that the primary accumulation route is through uptake of very low concentrations from the water column. Benthic accumulation of PCBs is consistently greatest in Humber Bay. A number of pesticides are found at the upper end of the observed range at one of the stations near the Main WPCP. This observation is not consistent for all parameters, and other stations close to the WPCP outfall do not exhibit elevated levels.

3.8.2 Young-of-the-year Fish

Young-of-the-year spottail shiners have been collected by the Nearshore Juvenile Fish Contaminants Surveillance Program since 1977, to monitor the presence of organochlorine compounds and mercury. The limited range and lifespan of these fish make them useful biomonitors for assessing the spatial distribution and temporal trends of contaminants.

Shiner collections were made at eight locations along the Toronto waterfront in 1987. The spatial distribution of organochlorine and mercury residues in spottail shiners was relatively uniform except for PCBs. PCB residues were found to be significantly ($p < 0.01$) higher in the Humber Bay collections whereas Bluffers Park and the Rouge River had the lowest residues (Table 3.12). The higher PCB residue availability in Humber Bay appears to be linked to Humber River discharges since PCB enrichment exists throughout the lower part of the river. In contrast the two most easterly sites, distant from industrial and municipal discharges (Bluffers Park, Rouge River), had the lowest PCB accumulations. This distribution pattern suggests that land-based PCB inputs continue to dominate PCB availability in the nearshore of Lake Ontario.

PCB residue levels at six of the eight sites sampled in 1987 were in excess of the IJC Aquatic Life Guideline of 100 ng/g. None of the other compounds analyzed exceeded the available criteria in the 1987 collections. Total DDT, mirex, ΣBHC, Σchlordane, hexachlorobenzene (HCB), octachlorostyrene (OCS), heptachlor, aldrin and toxaphene accumulations were generally low or not detected in the Toronto waterfront spottail shiner collections.

PCB, ΣDDT, ΣBHC and Σchlordane residue concentrations in the 1987 collections from Mimico Creek, Humber River and Toronto Inner Harbour were significantly ($p < 0.01$) lower relative to earlier collections. These trends demonstrate decreased contaminant bioavailability and a marked improvement over conditions observed in the late 1970's.

3.8.3 Sport Fish

Contaminant levels in sport fish have been monitored since the 1960's. Since 1976, the Sport Fish Contaminant Monitoring Program has operated and published the 'Guide to Eating Ontario Sport Fish'. The data collected under this program is oriented primarily towards providing advice on consumption of different fish species to the public. Analysis for contaminants is therefore based on skinless, boneless dorsal fillet samples. Although contaminant levels may be expected to reach higher levels in other portions of a fish, the data base accumulated remains a useful indicator of contaminant concentrations in the higher trophic levels.

Table 3.12: Organochlorine and mercury residues in young-of-the-year spottail shiners from Toronto waterfront (values shown in ng/g, means with SD, wet weight).

Location	N	Year	Fish Size (mm)	% Lipid	PCB	ΣDDT	Mirex	ΣBHC	Σ Chlordane	HCB	OCS	Mercury
Mimico Creek	5	1981	68±4	6.4± .2	1051±105	135±19	ND	19±2	47±3	ND	NA	NA
	6	1982	66±7	5.0± .3	572± 45	52± 7	TR	5±2	17±3	4±1	NA	30± 0
	7	1983	70±4	5.4± .4	542± 80	41± 4	ND	6±2	24±3	13±1	NA	NA
	6	1984	69±4	4.5±1.1	378± 69	50±16	ND	TR	18±2	TR	NA	NA
	7	1987	67±6	4.9± .5	163± 17	35± 7	ND	ND	19±5	TR	2±1	NA
Humber River	8	1977	62±3	7.3± .4	2218±263	268±32	5±2	41±8	58±16	5±1	NA	44± 5
	8	1978	58±5	5.8± .5	2938±391	406±99	15±4	3±4	ND	3±1	NA	36± 7
	8	1979	60±6	4.0±1.3	1223±347	76±12	ND	4±1	47± 9	3±1	NA	30±19
	6	1980	62±5	4.0± .4	621± 66	41± 4	ND	15±5	36± 6	2±1	NA	22± 4
	6	1981	62±5	5.0± .8	954± 45	86±41	ND	9±3	26± 9	ND	NA	NA
	6	1982	58±2	3.7± .4	353± 70	28±20	ND	3±0	22± 1	3±1	NA	30± 0
	7	1983	68±3	5.2± .4	537±122	48± 7	ND	5±1	21± 2	13±3	ND	NA
	7	1985	64±3	5.9± .7	524±152	48±21	ND	ND	11± 4	10±7	TR	NA
	6	1987	66±3	5.2± .6	235± 33	31± 4	ND	TR	9± 2	2±0	TR	14± 5
Tor.Inner Harbour (Olympic Island)	8	1979	46±3	5.1±1.0	423±105	82±17	TR	15±3	16± 2	1±1	NA	26± 5
	5	1987	41±4	2.7± .4	132± 25	20± 2	ND	ND	4± 2	ND	ND	12± 4
Tor.Outer Harbour (Leslie Spit)	4	1987	45±3	3.4± .3	185± 18	20± 3	ND	ND	ND	ND	ND	40± 0
Tor.Main STP* (Shoreline)	5	1987	48±5	3.2±1.1	169± 67	25±10	ND	TR	3± 1	3±1	1±1	16±13
Ashbridges Bay H.*	5	1987	48±4	3.8± .2	180± 32	30± 7	ND	TR	18± 3	5±0	2±1	16± 5
Bluffers Park	5	1987	48±4	3.4± .3	ND	6± 2	ND	ND	3± 1	ND	ND	10± 0
Rouge River	5	1979	45±4	3.2± .2	82± 35	26±13	ND	6±2	TR	TR	NA	22± 8
	5	1987	57±4	2.7±1.0	78± 17	26± 5	ND	ND	1± 1	ND	ND	28± 4
DETECTION LIMITS:					20	1	5	1	2	1	1	10
IJC Objective:					100	1000	Absent	300	–	–	–	500

*Emerald Shiners: NA - Not Analyzed: ND - Not Detected: TR - Trace

The discussion of contaminant levels in sport fish is, of necessity, divided into two sections: Fish Consumption; and Contaminant Accumulation. The principle reasons for this are the different uses and levels of potential impact. In general, health related guidelines for fish consumption are higher than those adopted for the protection of aquatic life because of differences in size, diet and ability to eliminate contaminants. As a result, conclusions related to fish consumption by humans do not necessarily apply to consumption by larger fish and fish eating birds.

Fish Consumption

Advice to restrict consumption of the larger sizes of some fish species has been issued at various locations along the Toronto waterfront. The reasons for the restrictions relate to the levels of mercury, PCBs and mirex. Other contaminants such as dioxin, DDT, chlordane and other heavy metals are not found at levels that require health related restrictions.

Existing advisories for most of the nearshore warm-water species, including northern pike, white sucker, white bass and yellow perch are based on mercury levels which approach or exceed the health guidelines. The mercury levels noted in Toronto fish are not significantly different than those found in fish collected in less urbanized areas of the Lake Ontario basin. It is not known whether complete elimination of human-related sources of mercury would be sufficient to allow lifting of current advisories. Carp and Grizzard Shad taken along the Toronto waterfront contain levels of PCBs which are cause for restricting consumption.

The salmonid fishery in the Toronto area is restricted for several species as a result of PCB and mirex contamination. Both contaminants occur at sufficiently high levels in larger fish to cause restrictions, but analysis indicates that mirex is the more limiting of the two. No sources of mirex exist in the Toronto area and contaminant levels are therefore the result of lakewide contamination, mainly from Niagara River inputs.

The Nearshore Fishery

Contaminant data on nearshore sport fish populations is available for eleven locations along the Toronto waterfront. While many nearshore fish have been collected and tested over the years, the presentation of long-term trends for any single species at a given location area is difficult because of the varying frequency and location of collections. More can be said about the current contaminant advisory situation.

Table 3.13 gives the locations, the species and sizes found, and the consumption advice status for nearshore locations in the Toronto area. For all species and locations, except Brown Trout at the Humber River mouth and Lake Trout at Scarborough Bluffs, the smaller sizes of every species found are suitable for unrestricted consumption. At the two locations noted, only the larger sizes of the species were caught, and as a cautionary procedure, all sizes have therefore been restricted.

Northern pike is the only nearshore "top predator" species which has been studied for contaminants at several waterfront locations. Figure 3.20 shows the mean PCB concentration in the edible portion of northern pike collected from the Hearn GS, Toronto Islands (Inner Harbour) and Frenchman Bay locations in the period 1975-86. No particular upward or downward trend can be discerned, but it should be noted that all samples collected were low enough in PCB to be considered suitable for unrestricted consumption as far as that contaminant is concerned.

At the Toronto Islands (Inner Harbour) location, northern pike collected in 1980 and 1986 show that mercury, PCB, mirex, DDT, and chlordane concentrations were lower in the latter year on standardized 60 cm length pike (Figure 3.21). The 1986 sample did not contain any very large 75-90 cm (30-40 inch) pike. Such pike obtained in the 1980 collection were found to have over 0.5 ppm mercury. As a cautionary procedure, the advisory to restrict consumption of northern pike over 75 cm (30 inches) in length from this location has been retained.

Mean PCB concentrations in the edible portion of white sucker are available from five locations on the waterfront; Marie Curtis Park, Humber River, Toronto Islands (Inner harbour), Ashbridges Bay and Scarborough Bluffs (Figure 3.22). As with the northern pike samples, a general trend is not obvious. It should be noted that PCB levels have been generally higher than those of northern pike despite the predatory habit of the latter. While higher, the PCB concentrations in white sucker

Table 3.13 - Consumption Advisory Status Toronto Nearshore Waterfront Fishing Areas.

Location	Species	Sizes Caught	Advised Limits
Marie Curtis Park	W. Sucker	20-45 cm (8-18")	No limit
Humber River Mouth	Brown Trout	45-75 cm (18-30")	Restricted
Humber Bay	Smelt	<15-25 cm (<6-10")	No limit
	W. Sucker	15-55 cm (6-22")	No limit
	Rainbow Trout	20-55 cm (8-22")	No limit
	Lake Trout	20-45 cm (8-18")	No limit
	Lake Trout	45-75 cm (18-30")	Restricted
Queensway Marsh	Brown Trout	25-45 cm (10-18")	No limit
	Brown Trout	45-65 cm (18-26")	Restricted
Hearn GS-Outer Harbour	Carp	65->75 cm (26->30")	Restricted
	W. Bass	20-35 cm (8-14")	No limit
	W. Bass	35-45 cm (14-18")	Restricted
	W. Perch	15-25 cm (6-10")	No limit
	Y. Perch	<15-30 cm (<6-12")	No limit
	Y. Perch	30-35 cm (12-14")	Restricted
	Rainbow Trout	20-45 cm (8-18")	No limit
	Brown Trout	25-35 cm (10-14")	No limit
	Gizzard Shad	30-35 cm (12-14")	No limit
	Gizzard Shad	35-45 cm (14-18")	Restricted
	Northern Pike	30-75 cm (12-30")	No limit
	Northern Pike	>75 cm (>30")	Restricted
	Smelt	15-30 cm (6-12")	No limit
Toronto Island Inner Harbour	Smelt	<15-20 cm (<6-8")	No limit
	Y. Perch	<15-35 cm (<6-14")	No limit
	W. Sucker	25-45 cm (10-18")	No limit
	W. Sucker	45-55 cm (18-22")	Restricted
	Northern Pike	45-75 cm (18-30")	No limit
	Northern Pike	>75 cm (>30")	Restricted
	Carp	45-65 cm (18-26")	No limit
	Carp	65->75 cm (26->30")	Restricted
Ashbridges Bay	Smelt	<15-25 cm (<6-10")	No limit
	W. Sucker	20-55 cm (8-22")	No limit
Scarborough Bluffs	Lake Trout	35-65 cm (14-26")	Restricted
	W. Sucker	20-55 cm (8-22")	No limit
Rouge Marsh	B. Bullhead	20-35 cm (8-14")	No limit
Rouge River Mouth	B. Bullhead	20-35 cm (8-14")	No limit
Frenchman Bay	B. Bullhead	25-30 cm (10-12")	No limit
	B. Bullhead	30-45 cm (12-18")	Restricted
	Carp	35-65 cm (14-26")	No limit
	Carp	65->75 cm (26->30")	Restricted
	Northern Pike	20->75 cm (8->30")	No limit
	Y. Perch	<15-20 cm (<6-8")	No limit

FIGURE 3.20:
PCB IN NORTHERN PIKE 1975—1986

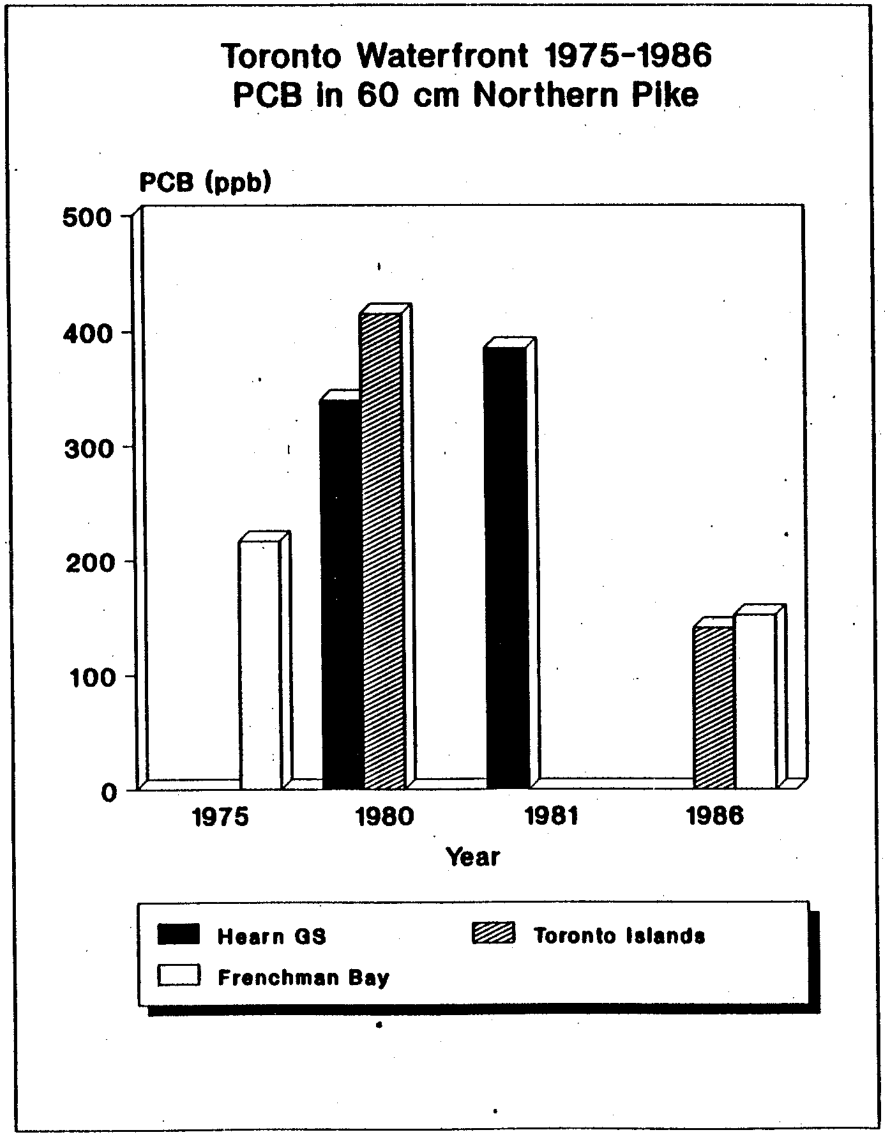


FIGURE 3.21:
HG,PCB,MIREX,DDT,CHLORDANE
IN NORTHERN PIKE

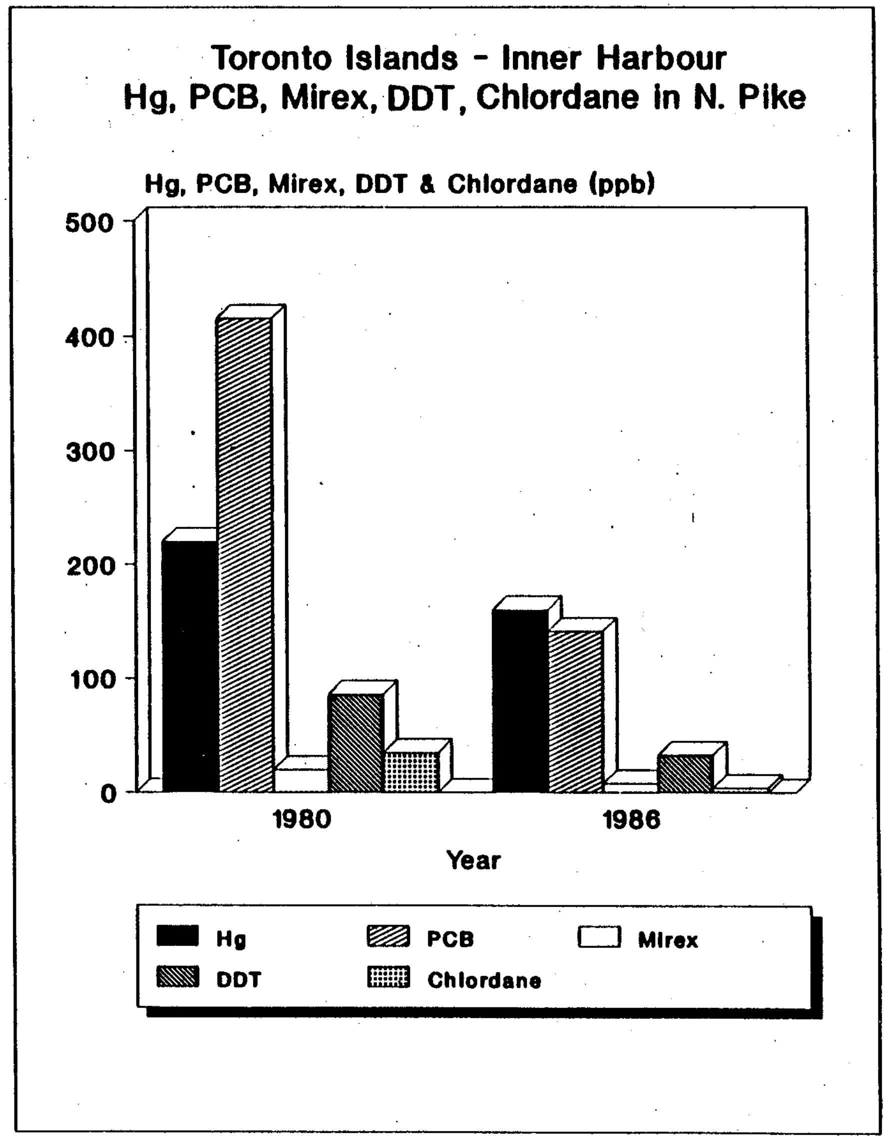


FIGURE 3.22:
PCB IN WHITE SUCKER
1975—1986

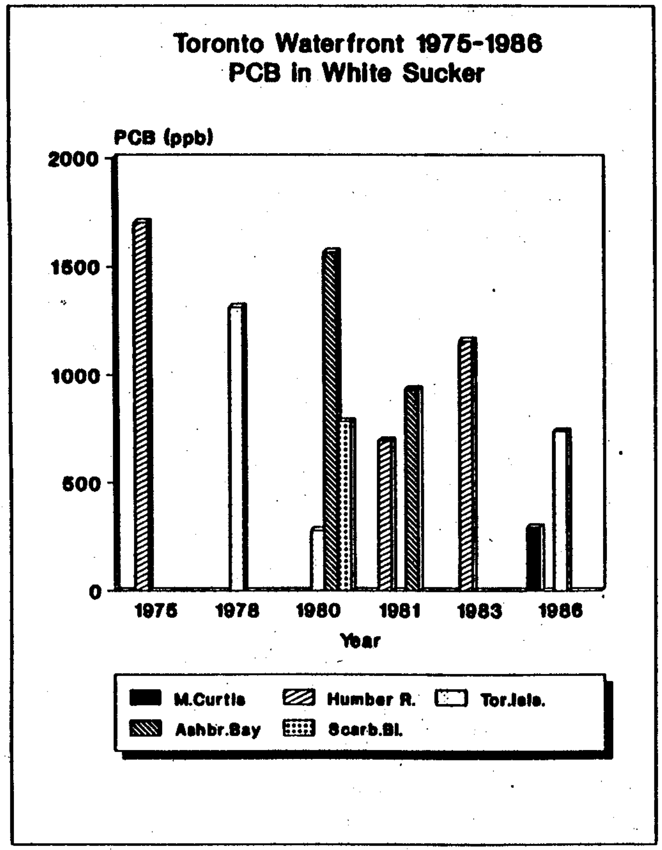


FIGURE 3.23:
PCB & DDT IN 40 CM
WHITE SUCKER—HUMBER RIVER

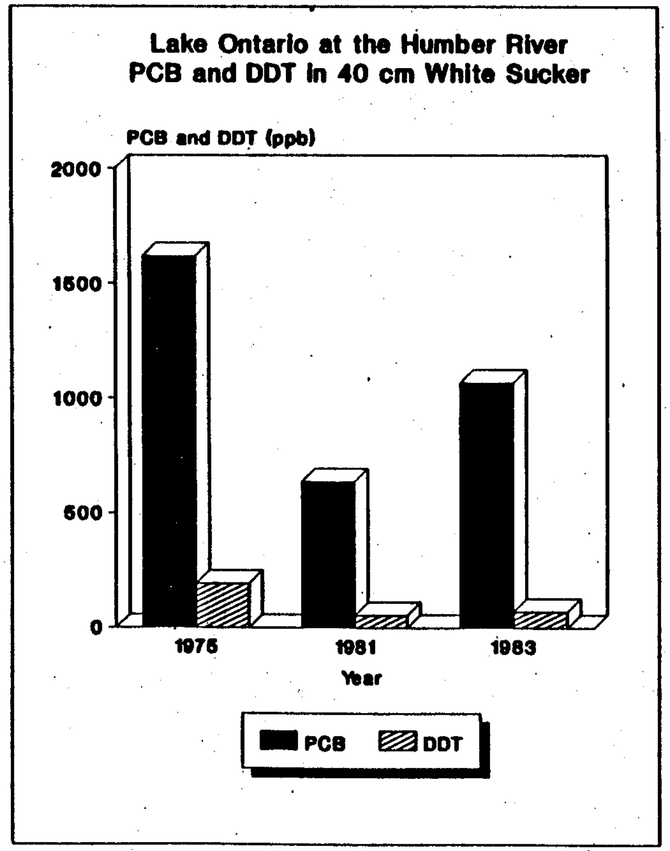
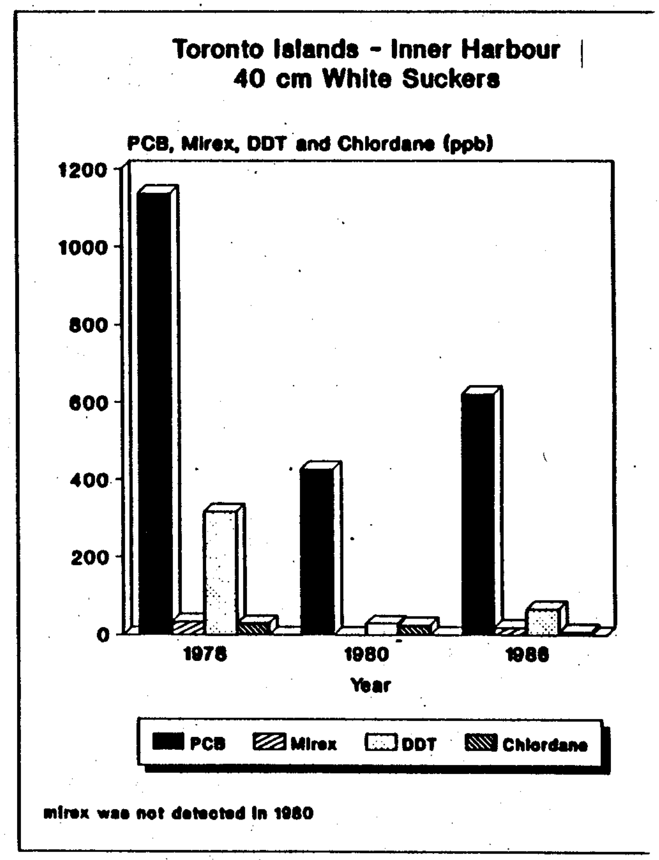


FIGURE 3.24:
PCB, MIREX, DDT, CHLORDANE
WHITE SUCKERS—INNER HARBOUR



values in all years being well below the 5000 ppb guideline. Chlordane levels were low in 1975 and declined further in 1981 and 1986.

The Open-Lake Fishery

The largest fishery, in terms of the visible presence of anglers, is that for the several species of salmon and trout stocked into Lake Ontario. Assessment during two major fishing derbies on Western Lake Ontario in 1986 estimated that 652,000 angler-hours of effort were expended to catch an estimated 168,000 salmon and trout. An estimated 85,000 of these fish were kept.

Insufficient data exists at locations within the Toronto study area to allow trend analysis for salmonids. The salmonids at the Credit River mouth location have therefore been chosen as a typical data set to represent the open-lake fishery in the Toronto area. Figure 3.27 shows the long-term trend in the mean levels of PCB found in the edible portion of coho salmon collected at the Credit River since 1972. In that year the average PCB concentration was 10.2 ppm; by 1986 it was 2.1 ppm. This long-term decline can be attributed to the elimination in the use of PCB in many commercial products in the 1970's.

The same run of coho salmon have been tested for mirex since 1976. Figure 3.28 gives the mean mirex concentrations in the edible portion. While there has been considerable fluctuation in the mean value of mirex from year to year, there has been little apparent real change in the 1976-1986 period.

Figure 3.29 shows the best fit curve of PCB versus length for four species of salmonid collected from Lake Ontario at the Credit River in 1986. Chinook salmon were found to have the lowest PCB levels of the four, at lengths up to 80 cm (32 inches). However, chinook salmon get much larger than this, so mature chinook do have higher PCB levels than the smaller coho salmon and rainbow trout. The curve for lake trout in this graph shows that while they are low in PCB while small, their slow rate of growth and long life span means that they will have spent more years in the lake than the other species, resulting in higher levels for the larger sizes.

Figure 3.30 shows the best fit curve of mirex versus length for four species of salmonid collected from Lake Ontario at the Credit River in 1986. While the relationships of mirex to

FIGURE 3.27:
PCB IN COHO SALMON
CREDIT RIVER

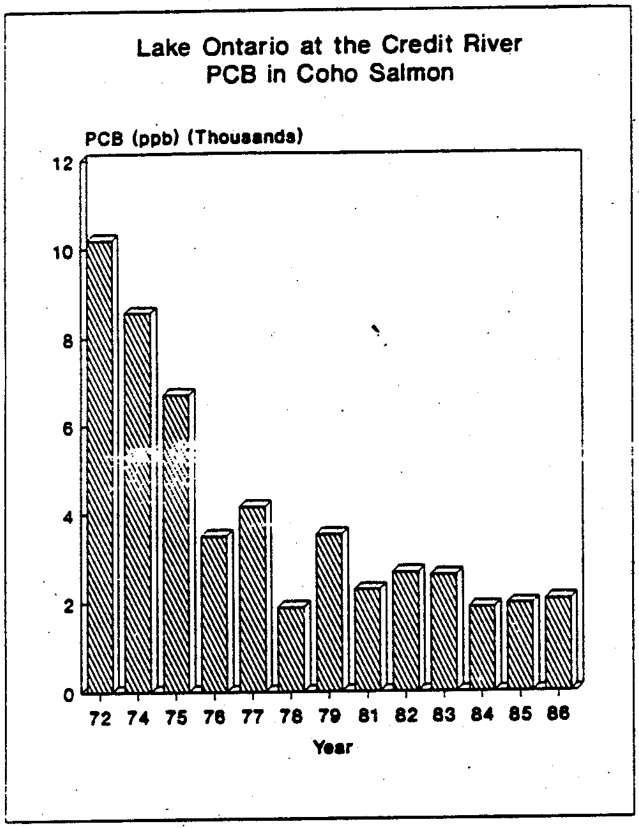


FIGURE 3.28:
MIREX IN COHO SALMON
CREDIT RIVER

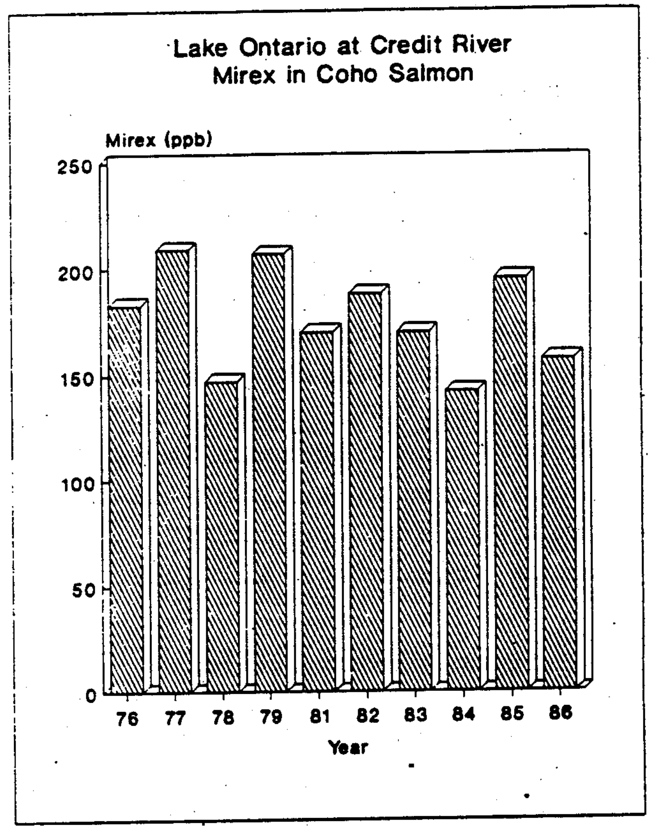


FIGURE 3.29:
LENGTH VS PCB
IN SALMONIDS

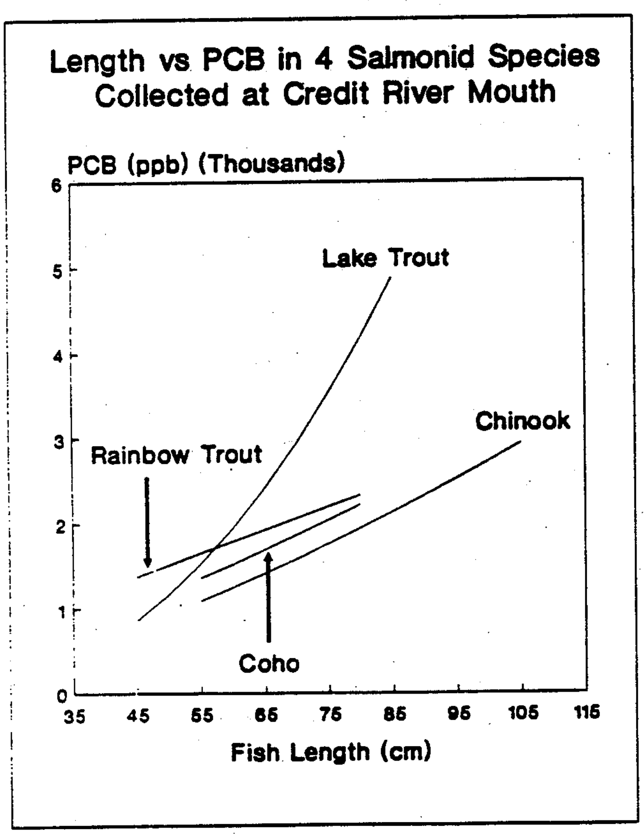
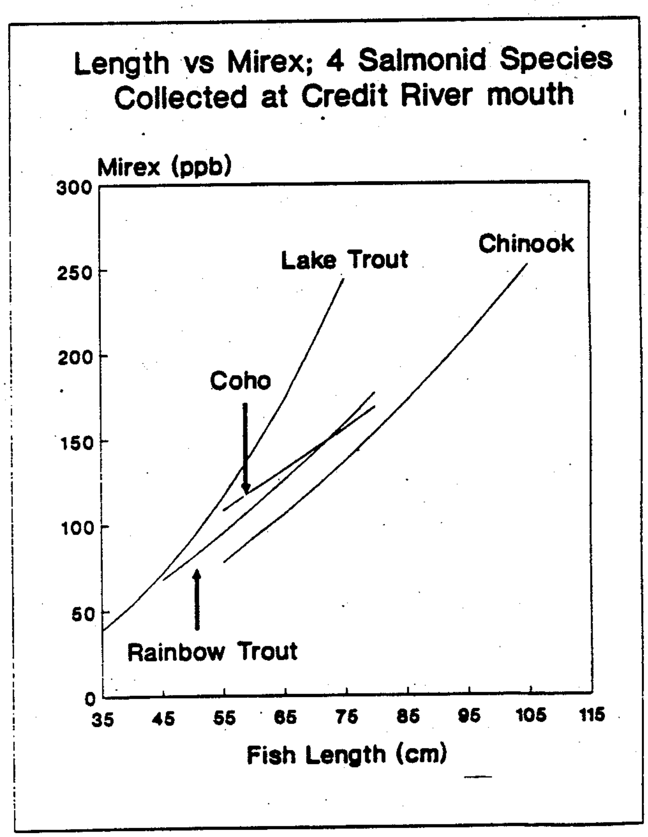


FIGURE 3.30:
LENGTH VS MIREX
IN SALMONIDS



length in these species is similar to the PCB-length relationship discussed above, the mirex-length curves for these species exceed the 100 ppb mirex Federal fish consumption guideline at a smaller size of fish than the PCB-length curves exceed the 2000 ppb PCB Federal fish consumption guideline. Therefore mirex can be considered the contaminant most limiting to the unrestricted consumption of these species in this part of Lake Ontario.

Table 3.14 gives the advised consumption status for the salmonids sampled from Lake Ontario at the mouth of the Credit River in 1986. Restrictions in consumption (no consumption by women of child-bearing age and children up to 15 years of age, occasional meals for other potential consumers) are still advised for the larger sizes of coho salmon, rainbow trout and lake trout and all sizes found of chinook salmon.

Inland Fishing Areas

As a result of the Doorstep Angling program of the 1970's, the Metropolitan Toronto and Region Conservation Authority has promoted angling in a number of smaller water bodies on the inland tributary streams in the Toronto area.

Currently, seven inland locations have had species of fish tested. Table 3.15 shows the summary of the consumption advisory status for these locations and the species found. With the exception of the rock bass in the Milne Reservoir, all samples were analysed for mercury, PCB, HCB, mirex, DDT, aldrin, heptaclor, lindane, chlordane and OCS. Milne Reservoir rock bass were analysed only for mercury.

With the exception of larger Rock Bass from Milne Reservoir, where mercury was found to exceed 0.5 parts per million, the fish species tested from the Toronto inland ponds are all suitable for unrestricted human consumption. In the case of Grenadier Pond, the 1986 collections confirm those made in 1979, which also indicated that all sizes tested were suitable for human consumption.

Contaminant Accumulation in Sport Fish

Beyond the use of the sport fish data for development of consumption advisories, the data provides some indication of contaminant accumulation in the upper trophic levels of the

Table 3.14 - Consumption Advisory Status of Lake Ontario Salmonids collected at the Credit River, 1986

Species	Size	Advised Consumption
Chinook Salmon	35->75 cm (14->30")	Restricted
Coho Salmon	30-45 cm (12-18")	No Limit
Coho Salmon	45->75 cm (18->30")	Restricted
Rainbow Trout	25-55 cm (10-22")	No Limit
Rainbow Trout	55->75 cm (22->30")	Restricted
Lake Trout	25-45 cm (10-18")	No Limit
Lake Trout	45-75 cm (18-30")	Restricted

Table 3.15 - Consumption Advisory Status, Toronto Inland Fishing Areas. 1988.

Location	Species	Sizes Caught	Advised Limits
Eglinton Flats Pond	B. Bullhead	20-35 cm (8-14")	No limit
	Goldfish	20-30 cm (8-12")	No limit
Grenadier Pond	Bl. Crappie	<15-30 cm (<6-12")	No limit
	W. Perch	15-25 cm (6-10")	No limit
	Pumpkinseed	<15-20 cm (<6-8")	No limit
Heart Lake	LM Bass	<15-45 cm (<6-8")	No limit
Milne Res.	Rock Bass	<15-20 cm (<6-8")	No limit
	Rock Bass	20-25 cm (8-10")	Restricted
G. Ross Lord Res.	Rock Bass	<15-20 cm (<6-8")	No limit
	B. Bullhead	20-30 cm (8-12")	No limit
Professor's Lake	Rock Bass	<15-25 cm (<6-10")	No limit
Clairville Res.	LM Bass	20-45 cm (8-18")	No limit
	B. Bullhead	15-30 cm (6-12")	No limit

food chain. The data are not suitable for defining a hazard or probable effect because higher levels of contaminants may occur in portions of the fish not used in the analysis. It should be noted, however, that bird and animal predators and scavengers tend to consume selected portions of larger fish and so the use of whole-fish data would also be inappropriate.

The data presented in the following tables have been combined for various species in order to show the range of contaminant concentrations observed in larger fish. It should be recognized that different species accumulate contaminants at different rates and to varying levels because their different metabolisms and feeding habits. The data provided is therefore not indicative of concentrations in a particular species.

The range of contaminant levels for different heavy metals are shown in Table 3.16. The heavy metal concentrations observed are similar at different locations across the waterfront. The highest levels of cadmium, copper, manganese and mercury were found in the vicinity of the Eastern Headland. The highest levels of arsenic, selenium and zinc were found along the Eastern Waterfront. Lead levels were highest in the Inner Harbour. With the exception of lead, concentrations comparable to the observed maximums were found at other locations scattered across the waterfront. The data therefore does not provide any indication that a specific location is worse than others in terms of metal accumulations in larger fish.

The biological significance of the contaminant levels observed for most of the metals cannot be assessed with the existing data base. It is notable, however, that with the exception of mercury and arsenic, the concentrations of metals in larger fish is typically two to five times lower than those found in benthic invertebrates. Most of the metals do not appear to be biomagnifying.

The observed concentrations of organic parameters are shown in Table 3.17 by year and location. The data indicate that PCBs in particular, are far in exceedance of the IJC guideline for the protection of birds and animals which consume fish (100 ppb). Although maximum values recorded are in many cases unusual (i.e. individual specimens), the prevalence of results 5 to 10 times the IJC guideline is a matter for concern.

Table 3.16

CONTAMINANT ACCUMULATIONS IN THE UPPER TROPHIC LEVELS CONCENTRATION RANGES FOR METALS IN LARGE FISH

Location / Metal	Humber Bay	Toronto Harbour	Eastern Headland	Ashbridges Bay	Eastern Waterfront
Copper	-	<.08 - 2.1	<.03 - 3.2	.03 - 1.95	<0.04 - 2.9
Zinc	-	3.1 - 10.0	3.6 - 35.0	.34 - 22.0	2.9 - 47.0
Cadmium	-	<.04 - .06	<.04 - 0.13	<.04 - .08	<0.04 - .07
Lead	-	<.6 - 11.0	<.06 - 2.1	<.06 - .85	<0.6
Manganese	-	.03 - .63	<.04 - 5.6	.03 - 2.2	<.04 - 2.8
Mercury	.01 - .53	.05 - .64	.03 - 1.4	.06 - .53	.01 - 1.1
Arsenic	-	.05 - .27	.03 - .37	.03 - .45	<.09 - 0.70
Selenium	-	.06 - .29	.13 - .74	.18 - .51	.03 - 0.79
Chromium	-	-	-	-	.07 - 0.38

Notes:
1. All values are in ppm, wet weight
2. Data based on analysis of lean dorsal tissue
3. Data for all species combined, 1980

Source: Contaminants in Fish Data Summary; unpublished MOE data

Table 3.17
Contaminant Accumulations in the Upper Trophic Levels
Concentration Ranges for Organics in Large Fish

Location	Year	PCB	Mirex	ΣDDT	Chlordane
Hearn GS.	1977	18-7550	ND-340	-	-
	1980	97-6646	ND-123	-	-
	1981	ND-5038	ND-276	-	-
Marie Curtis	1986	41-2160	ND	-	-
Ashbridges Bay	1980	415-3314	ND-52	-	-
	1981	154-3313	ND-41	-	-
Toronto Islands	1978	560-2980	11-62	155-501	ND-124
	1980	nd-1551	ND-82	ND-494	3-178
	1986	74-1280	ND-61	ND-224	ND-18
Humber River Mouth	1975	500-3500	-	80-465	2-20
	1981	80-10000	ND-370	14-278	6-45
	1983	529-2052	ND-12	43-157	2-30
	1985	111-2880	92-322	84-964	9-41
	1986	500-3110	41-247	64-1211	ND-22
Scarborough Bluffs	1980	ND-5161	ND-346	-	-
Rouge River Mouth	1975	1200-20000	-	125-1290	7-140
	1981	35-1844	ND-145	ND-327	ND-36
	1986	48-484	ND	6-97	ND-23

Notes 1. All values are in ppb, wet weight
2. Data is based on analysis of lean dorsal tissue
3. Data is for all species combined, by year indicated

Source: Contaminants in Fish Data Summary; unpublished MOE data

The limited trend information presented in the discussion related to fish consumption, also applies to concerns for the protection of aquatic life. The levels of PCBs, DDT and Chlordane appear to be going down, while no apparent trend exists for mirex. This observation agrees with young-of-the-year fish trends.

4.0 SPECIFIC ISSUES OF CONCERN

Based on the technical review by the Metro Toronto RAP Team, the following specific concerns have been identified.

4.1 BODY CONTACT RECREATION

All of Metro's waterfront beaches have been intermittently posted in recent years, advising against bathing, because of elevated levels of fecal coliform (FC) bacteria. FC do not cause disease or infection but are indicative of fecal contamination. When the geometric mean of a minimum of 10 samples exceeds 100 FC/100 ml, bathing is considered inadvisable because of the risk of gastrointestinal illness and skin, ear, eye, nose and throat infections. The beach posting history in recent years has remained relatively constant with no signs of improvement. The posting of beaches usually increases as the summer progresses, due to increased bacterial survival in sediment related to warmer temperatures, constant dry weather loadings and higher rainfall frequency.

Discharge from urban storm sewers and combined sewer overflows are the principal cause of FC contamination. The sewers impact the beach areas directly through discharge to the waterfront, and indirectly through discharge to the rivers which in turn discharge to the lake. The relative impact of direct sewer discharge and riverine discharge varies with beach location. Along the eastern waterfront the major beaches are influenced primarily by direct sewer discharge. Along the western waterfront studies have shown that the effect of either the direct discharges or the Humber River is sufficient to adversely affect the beaches. The central waterfront, including the Island beaches, are affected by both direct discharge and the Don River.

The water pollution control plant (WPCP) discharges do not appear to significantly affect FC levels at the major beaches during the summer because of their location relative to the beaches. Similarly, upstream agricultural inputs of bacteria play a relatively minor role at lakefront beaches, during dry weather, because of the time of travel down the river, combined with natural bacterial die-off. During wet weather; agricultural inputs to the rivers contribute to the lakeshore impacts because of higher densities and shorter travel times.

Sewer discharges affect the beaches in both dry and wet weather. In dry weather, illegal sanitary connections to storm sewers, combined with infiltration to the storm sewers and animal inputs, produce a constant discharge from some sewers. In wet weather, overflows from combined sewers introduce diluted sanitary sewage and storm sewers discharge accumulations of fecal material from the urban watersheds. The large volume of water discharged during wet weather produces extensive contamination of beaches which may persist for days following a rainfall.

The greatest concern related to bacterial contamination has historically been associated with bathing beaches and as a result most studies have focused on the shallow, near-shore waters adjacent to public beaches. Recent research has indicated the potential for an increased health risk for windsurfers in contaminated waters. Although local evidence of such health impacts is lacking, concerns must be extended to windsurfers and boaters (due to intentional capsizing). Since these uses occur in many areas removed from the public beaches, concerns over bacterial contamination cannot be restricted to the public beach areas alone.

4.2 NUTRIENTS

Phosphorus levels across the Toronto waterfront often exceed the Ministry of the Environment aquatic guideline of 20 µg/l, which is recommended to avoid nuisance concentrations of algae in lakes. Nutrient concentrations in the sediments of Humber Bay and the Inner Harbour exceed the Ministry's Open Water Disposal Guidelines for Dredged Material. In areas affected by nutrient-rich plumes, a benthic community dominated by species tolerant of organically enriched conditions has developed, although recent studies indicate a decline in organism density, suggesting some improvement in organic conditions.

High nutrient levels can result in increased algae growth which can degrade the waters' aesthetics through increased in turbidity and production of odours. Weed growth and production of filamentous algae (Cladophora) can impact on boating through the fouling of boat hulls and propellers. Detached algae can interfere with beach use.

Along most of the Toronto waterfront, weed production is limited by a lack of suitable substrate and the effects of wave action. Cladophora growth along the western shoreline has been a problem because of high nutrient levels and availability of rocky substrate. The City of Etobicoke has successfully employed an algae skimmer to remove Cladophora close to the shoreline.

Phosphorus concentrations in Toronto's nearshore waters have decreased significantly since the late 1960's due to controls on the use of phosphates in laundry detergents and the implementation of phosphorus removal at sewage treatment plants. In recent years the decline in phosphorus concentrations has levelled off. Despite current phosphorus removal requirements, the water pollution control plant discharges remain the largest source of phosphorus to the waterfront.

4.3 AQUATIC BIOTA

The aquatic community is stressed along the Toronto waterfront, especially in the vicinity of WPCP outfalls, tributary mouths and areas of poor water circulation, such as embayments.

The benthic community, although influenced by the type of habitat available, provides the most useful site-specific data because they are relatively stationary. Areas around the WPCP outfalls are devoid of benthic organisms as a result of chlorine and ammonia toxicity. Benthic diversity is low along the north shore of the Inner Harbour, near the river mouths in Humber Bay, and in Ashbridges Bay. Fauna in these areas are dominated by species indicative of organic pollution. Overall densities are lower than in the past suggesting some improvement. There is no clear evidence of toxic impacts on these relatively resistant organisms, but contaminant levels in sediment in these areas could limit future colonization by other species as organic conditions continue to improve.

Bioaccumulation of contaminants by benthos is also evident along the Toronto waterfront. Benthic organisms collected show bioconcentration of metals such as copper, iron, mercury and zinc, and organic contaminants such as PCBs, DDD, DDE, α-BHC, hexachlorobenzene, chlordane, heptachlor, aldrin and lindane. The significance of the contaminant levels in tissue are under investigation.

There is less evidence of the impact of contaminants on fish species along the Toronto waterfront. No part of the Toronto Waterfront is devoid of fish, and water samples generally indicate that toxic contaminants do not exceed Provincial Water Quality Objectives (PWQO) except in the immediate vicinity of point source discharges and near river mouths after rainstorms. The fishery is undoubtedly under stress, however, because of the frequent exceedence of the PWQO for many heavy metals in the rivers tributary to the lake. Ongoing studies under the MISA program at the Main WPCP indicate that the effluent is having both an acute and chronic impact on fish near the point of discharge.

Accumulations of persistent toxic contaminants in fish have been noted along the Toronto waterfront. PCB, ∑DDT, ∑BHC, and ∑Chlordane levels in spottail skinners have declined in recent years. PCB levels remain above the IJC Aquatic Life Guideline of 100 ppb which is based on the protection of fish eating birds and animals. DDT residues have dropped below the applicable IJC Aquatic Life Guideline. Contaminant data from the sport fish collection program confirm that PCB accumulation commonly exceeds the IJC Aquatic Life Guideline.

Fish eating birds represent the highest trophic level of the aquatic food web. During the late 1960's and early 1970's substantial impact, in the form of reduced reproductive success and deformities, occurred as a result of organochlorine pesticide residues. By the late 1970's decreases in organochlorine residues resulted in increased reproductive success and a significant reduction in deformities. Current reproductive rates for herring gulls and other species are considered normal.

4.4 AQUATIC HABITAT

The Toronto near-shore is a generally hostile environment for many fish species because of wave action, and temperature fluctuations caused by natural upwelling. The best warm water habitats along the Toronto waterfront are found in the river mouths, the Toronto Islands, and the embayments created by lakefilling projects.

There is clear evidence that the creation of lakefill parks has had a positive impact on the abundance of cool and warm water fish species. Lakefilling operations, however, can impact sediment and water quality and biota directly, through the introduction of sediment and contaminants. In addition, the creation of embayments, which have positive impacts on habitat, also produces suitable conditions for deposition of contaminated, fine-grained sediments from other sources. Biota have been shown to bioconcentrate contaminants in embayment areas.

Habitat considerations in Toronto cannot be limited to the lakeshore environment only. River mouths and upstream reaches are vital to the continued health of the fishery. The Humber and the Rouge marshes provide important spawning and rearing areas for many species. Seasonal migrations of stocked salmonids occur in both the Humber and the Rouge River.

Urbanization has impacted all of Toronto's rivers and marshes through increased runoff, erosion, temperature changes and storm water contamination. Accumulation of riverine contaminants in the marshes is of particular concern because of the sensitive life stages which utilize the marsh.

4.5 IN-PLACE POLLUTANTS

Many areas across the Toronto waterfront contain sediment deposits which exceed the Ministry's Open Water Disposal Guidelines for Dredged Material. Future dredging and dredge spoil disposal will have to continue to be conducted in an environmentally acceptable manner.

Contaminant release from the sediments through either physical or biological action is also of concern. Studies along the Toronto waterfront indicate that the uptake of contaminants by biota is extremely complex. Sediments are a significant source of bioaccumulation for copper, zinc, mercury and PCBs. They do not appear to be a significant source for pesticides, manganese, lead or cadmium in most cases. The organic content of the sediment has a great influence on contaminant uptake by biota because the fine-grained organic material binds contaminants and reduces bioavailability. Benthic body burdens in highly contaminated areas, with high organic content, were low, relative to sediment concentrations. In relatively 'cleaner' areas with low organic content, body burden levels were high in comparison to the sediment.

The Ontario Ministry of the Environment and Environment Canada are currently developing biologically-based sediment quality guidelines. These will be used to evaluate in-place pollutants along the Toronto waterfront and to assess the remedial measures required.

4.6 FISH CONSUMPTION

Concerns related to fish consumption along the Toronto waterfront occur because of advisories issued by the Ministry of the Environment through their "Guide to Eating Ontario Sport Fish". Different concerns exist for the nearshore (warmwater) and open lake (salmonid) fisheries because of the different sources of contamination.

With respect to the nearshore fishery, some restrictions on the consumption of the largest sizes of Carp, White Bass, Yellow Perch, Gizzard Shad, White Sucker and Northern Pike are advised. The Carp and Gizzard Shad are restricted because of concentrations of mirex and PCBs in the larger individuals. The remaining advisories are based on mercury levels. Mercury occurs both naturally and as a result of human activity, but it's use is highly restricted. The levels of mercury found in fish collected along the Toronto waterfront are comparable to those found in less urbanized areas of the Lake Ontario basin. It is not known therefore whether elimination of human-related sources of mercury would be sufficient to allow a lifting of current advisories.

The open-lake (salmonid) fishery is affected by PCBs and mirex. Within the Toronto study area, advisories have been issued for Brown Trout collected at the mouth of the Humber River, and the larger sizes of Lake Trout collected in Humber Bay and the Scarborough Bluffs. Although not within the study area, collections at the Credit River are considered representative of the open-lake fishery in the Toronto area. Advisories have been issued for the larger sizes of Coho Salmon, Rainbow and Lake Trout, and all sizes of Chinook Salmon, collected at the mouth of the Credit River. Analysis of the Credit River data indicates that average PCB levels in Coho Salmon have dropped from 10.2 ppm in 1972 to 2.1 ppm in 1986. Tests for mirex since 1976 on the same species have revealed little apparent change in contaminant levels. Mirex is the more restricting contaminant to consumption in the Toronto area. The only known active source of mirex to Lake Ontario is the Niagara River.

In addition to the lake collections, seven inland ponds in the Toronto area have been tested for contaminants. With the exception of larger Rock Bass at the Milne Reservoir, all sizes and species of fish collected at inland sites are suitable for unrestricted consumption. The advisory at the Milne Reservoir is based upon mercury levels.

4.7 WASTE ASSIMILATION

The Toronto waterfront and the rivers tributary to the waterfront are the receivers of sewage treatment plant discharge, storm sewer discharge and combined sewer overflows. Although improvements in effluent discharge quality may be expected as a result of ongoing and future initiatives, continued use of the receivers for waste assimilation is anticipated. These are therefore concerns about the location of some outfalls and the potential impacts on water pollution control plant efficiency, if combined sewer overflows and/or storm water runoff are to be retained for treatment.

The existing Humber WPCP outfall is located 250 m away from the Humber Bay Area Lakefill. The current location appears to affect the dispersion of effluent. Options for extending the outfall further offshore are presently being evaluated.

The proximity of storm and combined sewer outfalls along both the western and eastern waterfronts are affecting FC densities at public beaches because of poor nearshore dispersion. Extension of outfalls is being considered in some locations, in conjunction with the studies to examine use of detention tanks.

The North Toronto Water Pollution Control Plant discharges to the Don River. Metro is currently considering options which could entail abandonment, upgrading, or alternate use of the facility. Sewage flows would be transmitted to the Main WPCP if the plant was abandoned.

Various remedial measures which have been proposed in recent years would act to increase the flow of sewage and combined sewage to the Metro water pollution control plants. These are concerns for capacity and loss of treatment efficiency at the WPCP's if large scale implementation of such measures is undertaken. A study of the Humber Water Pollution Control Plant is near completion and a similar study of the Main WPCP is being undertaken. Thse studies will indicate the potential impacts on WPCP discharges.

4.8 INTERAGENCY COORDINATION

The study area for the Metro Toronto RAP is not linear; it includes the nearshore of Lake Ontario and six watersheds. Within this area are 14 local and 3 regional municipalities, half a dozen provincial agencies, several federal agencies, and numerous commissions, boards and crown corporations that have jurisdictional, resource management or legislative responsibilities here. These divisions of the area into political units, resources and regulatory powers causes sectoral, fragmented, often conflicting and ineffective ecosystem management efforts that focus on blocks of land as common units for management decision-making. This is a major obstacle in the Toronto area to overcome.

The need for a systematic and comprehensive ecosystem approach to restoring and protecting beneficial uses has been recognized within the context of the Metro Toronto RAP. The emphasis will be placed on the aquatic ecosystem, but the RAP process is sufficiently flexible to reflect broad discussions relating to land, air, and water. However, the RAP is a water quality plan and has no jurisdiction over local planning matters. The Metro Toronto RAP will be developed using an ecosystem approach and the RAP process should act as a catalyst for other responsible jurisdictions to adopt the principle of ecosystem planning for Toronto's waterfront and watersheds.

5.0 DESCRIPTION OF POTENTIAL POLLUTION SOURCES

Sources of water pollution within the area draining to the Metro Toronto waterfront include rural non-point sources, dry weather seepage, urban stormwater runoff, combined sewer overflows (CSOs), water pollution control plant (WPCP) discharges, sediments and atmospheric deposition.

Rural Sources

Rural non-point source pollution originates mainly in the upper areas of the Metro Toronto waterfront drainage basins. Rural land uses account for about two-thirds (or 139,100 ha) of the basins and are predominant in the upper reaches of Etobicoke Creek and the Humber, Don and Rouge Rivers. Significant processes impacting on pollutant loadings to streams include overland runoff, streambank erosion and direct access of livestock to streams. Studies by TAWMS found exceedences of PWQO/Gs for fecal coliform bacteria, total phosphorus, total suspended solids, lead, cadmium and copper in the Upper Humber River during wet and dry weather (MOE, 1983). The magnitude of exceedence was much greater during wet weather. The magnitude and frequency of exceedence also varied with the characteristics of storm events and with seasonal changes in landuse activities.

Urban Runoff and Combined Sewer Overflows

Urban stormwater runoff is a major cause of bacterial contamination of Metro Toronto's beaches and a significant source of heavy metals such as copper, lead and and zinc discharged to local tributaries and the waterfront. Information on organic contaminants in stormwater discharges in the Metro Toronto area is sparse. Stormwater runoff is also a cause of CSOs, sewage bypass at WPCPs and sewage backup in basements. Table 5.1 provides an indication of the number of storm sewer outfalls discharging to local tributaries and the waterfront. Over 80 storm sewer outfalls discharge directly to Lake Ontario or Toronto Harbour (see Figure 2.4). Over 2100 storm sewers discharge to the six area tributaries, within Metro Toronto's border. Table 5.2 presents observed concentrations of a number of pollutant parameters for some

TABLE 5.1
STORM & COMBINED SEWER OUTFALLS WITHIN METRO TORONTO

WATERSHED	STORMSEWERS	CSOs	TOTAL
	NUMBER OF OUTFALLS WITHIN METRO TORONTO		
Etobicoke Cr.[1]	NA	0	NA
Mimico Cr.[2]	191	0	191
Humber R.[3]	619	5	624
Don R.[4]	872	30	902
Highland Cr.[5]	473	0	473
Rouge R.[5]	13	0	13
Subtotal	2168[1]	35	2203[1]
Waterfront[6]	82	34	116
Total	2250	69	2319

1. Number of stormsewer outfalls on Etobicoke Creek not available: Totals include other five watersheds.
2. From Canviro (1986b)
3. From Gartner-Lee (1983)
4. From Canviro (1986a)
5. From Gartner-Lee (1987)
6. Estimated from available maps and waterfront dry-weather outfalls survey conducted in 1983.

TABLE 5.2
URBAN STORMWATER POLLUTANT CONCENTRATIONS

			POLLUTANT CONCENTRATIONS		
POLLUTANT	UNITS	EAST YORK[1]	EAST YORK[2]	E. BEACHES[3]	TYPICAL RANGE[4]
TSS	(mg/L)	281	131		$2 - 3.6 \times 10^4$
BOD_5	(mg/L)	14	70		0.5 – 700
TKN	(mg/L)	2.20	4.46		0.5 – 7.5
Total phosphorus	(mg/L)	0.48	0.97		0 – 9.4
Zinc	(μg/L)	330	535		10 – 100
Lead	(μg/L)	570	574		3 – 5000
Copper	(μg/L)	50	80		5 – 600
Chromium	(μg/L)	40	65		3 – 10,000
Iron	(μg/L)	5,460			
Manganese	(μg/L)		230		
Cadmium	(μg/L)		<10		0.6 – 9,000
Fecal Coliforms	(FC/100 ml)	1.1×10^4	$2,100 - 2.4 \times 10^6$	$1,000 - 1 \times 10^6$	$10 - 1.1 \times 10^7$
Phenols	(ug/L)		25		
DDT	(ppt)		30		
Atrazine			ND		
Lindane			ND		
Aldrin			ND		
Dieldrin			ND		

1 Kronis (1982); Barrington Catchment, mean of event means for 19 events in 1977.
2 Mills (1977); Barrington Catchment, mean of event means for 19 events in 1974 – 1976.
3 Gore & Storrie (1986a; 1987a); Glen Manor Drive, range of concentrations for 2 events in 1985 - 1986.
4 Environment Canada & MOE (1980), Ammon & Field (1980) for metals.

Metro Toronto sites and compares these to typical concentrations found in stormwater in other areas.

Areas of East York, Scarborough, Toronto and York are still served by combined sewers. During dry weather, sanitary sewage from these areas is conveyed via Metro's sanitary inteceptor sewers to the Water Pollution Control Plants (WPCPs) for treatment. During wet weather, up to five times the dry weather flow continues to be intercepted and treated. The excess combined sewage (storm and sanitary) overflows to the Humber and Don Rivers, the Toronto Harbour, the Eastern and Western Beaches and the Scarborough waterfront west of Bluffer's Park. There are 34 CSOs along the waterfront and another 35 which discharge to the Humber and Don Rivers (see Figure 2.4 and Table 5.1). Combined sewage carries high concentrations of bacteria and heavy metals. Information on organic contaminants in CSOs in the Metro Toronto area is sparse. Table 5.3 presents observed pollutant concentrations of a number of parameters for some Metro Toronto sites and compares these to typical concentrations found in CSO in other areas.

Some storm and combined sewer outfalls in the Metro Toronto area also discharge pollutants during dry weather. Of the nearly 2320 outfalls inventoried in the Metro area, over half were found to be active during dry weather (see Table 5.4). These dry weather discharges often exhibit high bacterial densities and high concentrations of nutrients and heavy metals. The number of outfalls where dry weather discharges were found to exceed "modified local sewer-use by-laws" is presented in Table 5.5 for a number of contaminants. The "modified sewer-use by-laws" used in the comparison were defined as part of the TAWMS Don River and Mimico Creek dry weather outfall surveys (Canviro, 1986a,b). Fecal coliform densities were the most frequently identified violation.

Approximately 12 per cent of the outfalls in the Metro Toronto area exceeded the TAWMS Abatement Committee guidelines for fecal coliforms during dry weather. Approximately 28 per cent of the outfalls which discharge directly to the waterfront were found to exceed these same guidelines. As a result of corrective works carried out by the local municipalities since

TABLE 5.3:
COMBINED SEWER POLLUTANT CONCENTRATIONS

		POLLUTANT CONCENTRATIONS				
POLLUTANT	UNITS	YORK[1]	COXWELL[2]	W. BEACHES[3]	E. BEACHES	TYPICAL RANGE[5]
TSS	(mg/L)	196	394			20 – 2000
BOD_5	(mg/L)	55				11 – 685
TKN	(mg/L)		6.0			
Total Phosphorus	(mg/L)	1.96	1.69			0.8 – 9.4
Zinc	(μg/L)	300	498			50 – 6,000
Lead	(μg/L)	182	342			30 – 60,000
Copper	(μg/L)	119	133			30 – 6,000
Chromium	(μg/L)		25			40 – 30,000
Iron	(μg/L)		11,232			
Manganese	(μg/L)		494			
Cadmium	(μg/L)					10 – 2,000
Fecal Coliforms	(FC/100 ml)	1.7×10^6	4.1×10^5	2×10^3–6.5×10^5	1.7×10^6–4.9×10^6	2×10^3–1.7×10^7
Phenol	(ng/L)		288			
Total PCBs	(ng/L)		175			
Atrazine	(ng/L)		700			
α BHC	(ng/L)		9.5			
HCB	(ng/L)		4.5			

1 Wong (1986); Hillary catchment, average flow weighted concentration for 14 events in 1983.
2 MOE (1983): Coxwell Twin CSO, mean concentration for one event in 1982.
3 Gore & Storrie (1987c); Wallace Ave. CSO, range of concentrations for four events in 1986.
4 Gore & Storrie (1987a): MacLean Ave. CSO, range of concentrations for one event in 1986.
5 Environment Canada & MOE (1980); Ammon and Field (1980) for metals.

TABLE 5.4
ACTIVE DRY-WEATHER SEWER OUTFALLS

WATERSHED	STORM SEWERS	CSOs	TOTAL
	OUTFALLS ACTIVE DURING DRY-WEATHER		
Etobicoke Cr.[1]	NA	0	NA
Mimico Cr.[2]	87	0	87
Humber R.[3]	366	NA	366
Don R.[4]	444	22	466
Highland Cr.[5]	323	0	323
Rouge R.[5]	11	0	11
Subtotal	1231	22	1253
Waterfront[6]	51	14	65
Total	1282	36	1318

1 Number of storm sewer outfalls on Etobicoke Creek not available: Totals include other five watersheds.
2 From Canviro (1986b)
3 From Gartner-Lee (1983)
4 From Canviro (1986a)
5 From Gartner-Lee (1987)
6 From waterfront dry-weather outfall survey conducted in 1983 (raw data).
7 An active outfall is an outfall that had a measureable discharge (approximtely 0.1 litres/second).

these outfall surveys were completed, a number of the outfalls identified in Table 5.5 no longer exceed the FC guidelines. Other commonly identified water quality problems at sampled outfalls were BOD_5, suspended solids, total phosphorus and iron.

Water Pollution Control Plants (WPCPs)

Four WPCPs operate within Metropolitan Toronto, serving a total population of over 2.2 million (MOE, 1987a). These are conventional activated sludge treatment plants with continuous phosphorus removal. The 3 largest plants, the Humber Bay WPCP, the Toronto Main WPCP and the Highland Creek WPCP, discharge their effluent directly to Lake Ontario in the vicinity of Humber Bay, Ashbridge's Bay and Highland Creek respectively. The North Toronto WPCP discharges to the Don River near Millwood Road. Another, much smaller plant is located in Vaughan and provides extended aeration treatment, before discharging to the Upper Humber River at Kleinburg. The Humber Bay and Main WPCPs were in non-compliance for total phosphorus during five and four months, respectively, in 1986. The Main WPCP also failed to comply with MOE's suspended solids effluent criteria in 1986 (MOE, 1987a). All four plants in Metro Toronto chlorinate their effluent during the summer months, and are not considered to have a significant effect on bacterial levels at Metro Toronto Beaches. Recently a decision has been made to require continuous chlorination, year-round.

Table 5.6 presents observed pollutant concentrations of a number of parameters for the Metro Toronto WPCPs. Table 5.7 illustrates the differences in wet and dry weather pollutant concentrations and loads for a number of parameters at the Main WPCP.

Atmospheric Deposition

Limited information is currently available to allow quantification of the deposition of contaminants from the atmosphere. The data available is useful only for preliminary estimates which suggest that direct deposition of contaminants to Lake Ontario is small in comparison to other sources such as the WPCPs. Deposition on land is likely to be more significant.

TABLE 5.5:
NUMBER OF STORM & COMBINED SEWER OUTFALLS WITHIN METRO TORONTO EXCEEDING LOCAL SEWER-USE BYLAWS[1]

		WATERSHED							
PARAMETER	MODIFIED SEWER-USE BYLAW	ETOBICOKE CREEK[2]	MIMICO CREEK[3]	HUMBER RIVER[4]	DON RIVER[5]	HIGHLAND CREEK[6]	ROUGE RIVER[6]	WATERFRONT[7]	TOTAL
Fecal Coliform[8]	10^4 org/sec	NA	24	25	125	74	3	32	283
BOD_5	15 mg/l	NA	16	33	65	22	0	11	147
Susp. Solids	15 mg/l	NA	15	67	140	NA	NA	40	262
Total Phosphorus	1.0 mg/l	NA	7	24	66	4	0	11	112
TKN	20 mg/l	NA	4	6	14	0	0	1	25
Zinc	1.0 mg/l	NA	1	5	10	6	0	0	22
Lead	1.0 mg/l	NA	0	0	8	2	0	0	10
Copper	1.0 mg/l	NA	0	0	6	1	0	1	8
Chromium	1.0 mg/l	NA	1	5	7	2	0	1	16
Iron	1.0 mg/l	NA	18	62	114	NA	NA	NA	194
Phenols	20 mg/l	NA	4	12	13	NA	NA	1	30
pH	6-9.5	NA	NA	NA	2	28	1	NA	31

1 Modifed sewer-use bylaws were defined as part of the TAWMS Don River and Mimico Creek Dry Weather Outfall Surveys (Canviro, 1986a,b)
2 No information was available for Etobicoke Creek; totals include other five watersheds.
3 From Canviro (1986b)
4 From Gartner-Lee (1983)
5 From Canviro (1986a)
6 From Gartner-Lee (1987)
7 From waterfront dry-weather outfall survey conducted in 1983 (raw data)
8 TAWMS Abatement Committee Criteria requires at least 4 samples; outfalls sampled less than four times but exceeding 10^4 org/sec are included here.

TABLE 5.6

METRO WPCP EFFLUENT POLLUTANT CONCENTRATIONS

POLLUTANT	UNITS	POLLUTANT CONCENTRATION		
		HUMBER WPCP	MAIN WPCP	HIGHLAND CREEK WPCP
TSS	(mg/L)	22.1	15.0	17.2
BOD_5	(mg/L)	13.9	14.5	22.6
TKN	(mg/L)	18.6	24.8	22.8
Total phosphorus	(mg/L)	1.26	0.93	0.95
Zinc	(µg/L)	115.5	71.6	79.4
Lead	(µg/L)	11.9	11.1	9.2
Copper	(µg/L)	20.8	35.1	43.5
Mercury	(µg/L)	0.23	0.45	0.55
Cadmium	(µg/L)	2.8	2.3	2.6
Fecal Coliforms*	(FC/100 ml)	-	220 (1800)	54 (1297)
Phenol	(µg/L)	5.4	0.83	4.1
α BHC	(µg/L)	0.002	0.00	0.004
γ BHC	(µg/L)	0.014	0.029	0.040
Isophorone	(µg/L)	2.8	0.42	0.43
Dichloromethane	(µg/L)	20.1	60.0	20.8
Trichloromethane	(µg/L)	2.6	3.8	3.3
1,2-dichlorobenzene	(µg/L)	4.2	0.9	1.2
1,3-dichlorobenzene	(µg/L)	0.75	0.25	0.50
1,4-dichlorobenzene	(µg/L)	2.4	2.8	2.2
Toluene	(µg/L)	2.4	0.41	0.57
Anthracene	(µg/L)	0.42	0.33	0.33

Source: Beak et al., (1987); Average flow-weighted concentrations 1981-85

* Numbers in brackets indicate concentrations for non-chlorinated effluent.

TABLE 5.7:
MAIN WPCP EFFLUENT CHARACTERISTICS DURING WET[1] & DRY[2] WEATHER

POLLUTANT	MAIN WPCP EFFLUENT CONCENTRATION			MAIN WPCP EFFLUENT LOAD		
	UNITS	DRY WEATHER	WET WEATHER	UNITS	DRY WEATHER	WET WEATHER
TSS	(mg/L)	9.1	21.0	(kg/hr)	310	997
Total Phosphorus	(mg/L)	0.63	1.64	(kg/hr)	21.2	77.8
TKN	(mg/L)	20.5	22.3	(kg/hr)	695	1,058
Zinc	(mg/L)	65	40	(kg/hr)	2.20	1.90
Copper	(μg/L)	24	80	(kg/hr)	0.81	3.80
Lead	(μg/L)	8	ND	(kg/hr)	0.27	–
FC	(FC/100 ml)	10	1,800	(FC/sec)	9.4×10^5	2.4×10^8
Total PCBs	(ng/L)	ND	57.5	(kg/hr)	–	0.0027
Flow	–	–		(m^3/sec)	9.4	13.2

Source: MOE (1983)

1 Wet weather event of June 15, 1982 sampled at Main WPCP diffuser (14 mm of rainfall)
ND not detected.

2 Dry weather data was collected on June 15, 1982 prior to the rain event.

Table 5.8 shows estimates of emission rates from a major local source, the Ashbridges Bay Incinerator, together with estimated total deposition rates on water and land within the Metro Toronto RAP. Since the wind disperses the atmospheric emissions in all directions, and atmospheric scavenging by wet and dry deposition processes is rather inefficient, only a small fraction of the air emissions would be expected to be deposited into the Toronto waterfront area. Deposition rates were taken largely from the APIOS monitoring network results (Ozvacic, 1986). Values were interpolated to the Toronto area.

The atmospheric inputs to the Toronto waterfront were estimated assuming that the main receptors were the Toronto Inner Harbour and Humber Bay, having a total surface area of about 30 km. The atmospheric inputs to land were estimated using a total land area of 1886 km^2, the combined area of the six watersheds within the Metro Toronto RAP area.

In addition to the estimates on emissions from the incinerator and deposition to the water and land, estimates of loads from the WPCPs are provided for comparison. It should be recognized that the atmospheric deposition to the land will to some extent be washed off during rainfall and will in fact contribute to the tributary stream loadings. Atmospheric loadings to land and tributary loadings to the waterfront are not independent.

It is clear that for all contaminants where simultaneous measurements are available, direct WPCP discharges exceed total atmospheric inputs directly to water by typically several orders of magnitude. The estimates of atmospheric deposition into the Toronto waterfront area may be low, since they are values interpolated from rural monitoring stations, and do not reflect the impact of the Toronto area itself on local atmospheric deposition. There is no reason to expect, however, a hundredfold elevation in deposition at the waterfront, over and above surrounding rural areas. Wet deposition measurements taken at a site in downtown Toronto (880 Bay Street), for example, indicate that rates of wet deposition there are typically about five times those at surrounding rural sites, for the trace metals of interest.

Table 5.8

COMPARISON OF ATMOSPHERIC DEPOSITION TO OTHER SOURCES

PARAMETER	EMISSION[1] RATE (Kg/yr)	ATMOSPHERIC LOADS TO WATER[2] (Kg/yr)	ATMOSPHERIC LOADS TO LAND[3] (Kg/yr)	WPCP LOADS (Kg/yr)
Lead	1700	300	18,860	5,000*
Zinc	930	230	14,460	38,500*
Cadmium	83	7	440	1,122*
Copper	77	56	3520	14,300*
Nickel	26	23	1450	18,000**
PCDDs & PCDFs	2-3	.001	.060	-
PCBs	0.08	0.1	.6	-
Chlorobenzenes	4.2	.002	.130	1,300**

1. Emissions from Asbridges Bay Incinerator only.
2. Based on an area of 30 km^2 and APIOS loading rates
3. Based on an area of 1886 km^2 and APIOS loading rates

* Includes Humber, Main and Highland Creek WPCPs.
** Main WPCP only

The impact of deposition on land may be more significant. Table 5.8 indicates that loads to the watersheds from atmospheric deposition are of a similar order of magnitude to those associated with the WPCPs. In the case of lead, the depositional load is higher. While the deposition of contaminants on land cannot be translated directly into loads to the waterfront, the data indicate that further efforts to quantify impacts of atmospheric loadings are warranted.

The Environment Ontario Air Resources Branch has recently established a toxics deposition and monitoring site on the Toronto Islands. This station will provide information on the deposition of persistent organics such as PCBs and DDT, and heavy metals such as cadmium and lead. This information will be used in estimating loads from the atmosphere. At present, the impacts of atmospheric loadings can only be interpreted through the loadings from storm sewers, as accumulated pollutants are washed off the urban lands.

Other Sources

Various organic and inorganic substances enter local streams in association with sediments. Major contaminants commonly linked with sediments are phosphorus, heavy metals and organochlorines. Contaminant levels in sediments along the Toronto waterfront often exceed MOE guidelines for open water disposal of dredged materials. There is also evidence that bacteria may bind to sediments (Beak, 1985). The resuspension of contaminated sediments likely contributes to the increasingly higher FC densities encountered along the Toronto waterfront as the summer progresses (Beak et al., 1987).

Gulls, Terns and Geese inhabit areas of the Metro Toronto Waterfront in large numbers. Defecation by these birds is considered to be a significant, albeit unmeasured, bacterial pollution source along the waterfront, particularly in the Western Beaches nearshore area (Metro Toronto Water Pollution Committee, 1985).

The Niagara River is the main source of water to Lake Ontario accounting for over 80 per cent of the incoming flow. While it is evident that industrial discharges of toxic chemicals has severely degraded the Niagara River, it is difficult to determine to what extent it affects the Metro Toronto waterfront. (WRAP, 1986).

5.1 SUMMARY OF WATERFRONT POLLUTANT LOADINGS AND IMPACTS

This section discusses pollutant loadings to the Metro Toronto waterfront and the resulting impacts on the beneficial uses. Section 5.1 first considers the relative significance of sources across the entire waterfront, then considers more localized impacts, in areas such as the Western Beaches, Centre Island Beaches, the Inner and Outer Harbours, and the Eastern Beaches.

Tables 5.9 and 5.10 (and Figure 5.1) present a comparison of selected annual pollutant loadings to the Metro Toronto waterfront by source. Pollutant loadings for other parameters were generally not available for all sources within the study area, and thus a waterfront-wide comparison can not be presented for these parameters. However, where information does exist for specific sources or areas of the waterfront, a discussion is included in Section 5.2. Sources considered in Table 5.9 include:

- Etobicoke Creek;
- Mimico Creek;
- Humber River;
- Don River;
- Highland Creek;
- Rouge River;
- Lake Ontario Shoreline;
- Humber WPCP;
- Toronto Main WPCP; and
- Highland Creek WPCP

In-stream pollutant loadings were estimated upstream of the mouths of the tributaries using MOE tributary monitoring data and average daily flow rates obtained from Water Survey of Canada (WSC). The Beale Ratio Estimator was used to calculate unbiased tributary loadings. WPCP pollutant loadings were

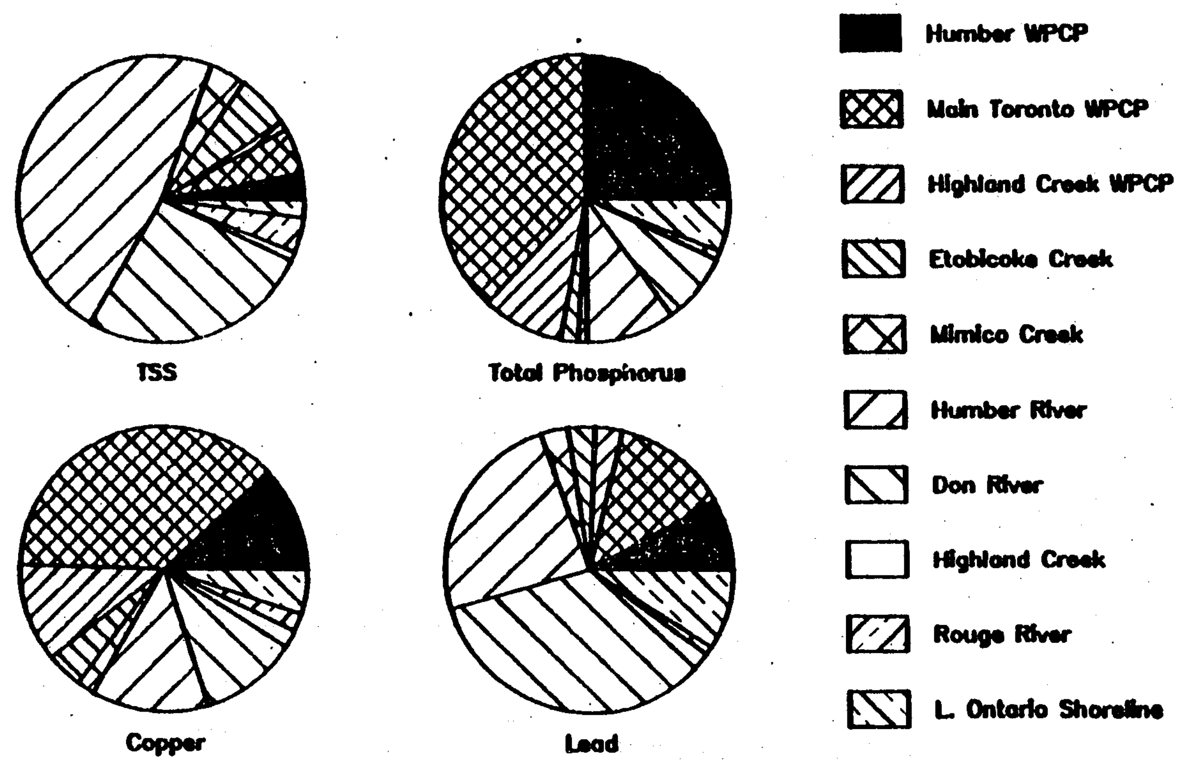
TABLE 5.9:
A COMPARISON OF POLLUTANT LOADS FROM METRO TORONTO WATERSHEDS AND WPCPs

SOURCE	FLOW (10^6 m^3/yr)	POLLUTANT LOAD			
		TSS (10^6 kg/yr)	TOTAL P. (10^3 kg/yr)	COPPER (10^3 kg/yr)	LEAD (10^3 kg/yr)
Humber WPCP	135.6	3.0	170.9	2.9	1.6
Toronto Main WPCP	259.9	3.9	240.8	8.8	2.8
Highland Creek WPCP	58.3	1.0	55.3	2.6	0.6
*Total WPCP Load	453.8	7.9	467.0	14.3	5.0
Etobicoke Creek	72.8	4.8	13.1	0.9	0.7
Mimico Creek	24.0	3.7	6.2	0.4	0.7
Humber River	218.5	40.9	60.9	3.2	5.1
Don River	138.8	22.7	53.8	2.6	7.1
Highland Creek	45.4	0.9	1.9	0.5	0.4
Rouge River	59.6	3.6	5.3	0.4	0.3
Total Tributary load	559.1	76.6	141.2	8.0	14.3
Lake Ontario Shoreline	17.6	1.7	39.2	1.1	1.4
Total Load	1,030.5	86.2	647.4	23.4	20.7

TABLE 5.10
A COMPARISON OF RELATIVE CONTRIBUTIONS FROM METRO TORONTO WATERSHEDS AND WPCPs

SOURCE	PERCENTAGE OF TOTAL INPUT				
	FLOW	TSS	TOTAL P.	COPPER	LEAD
Humber WPCP	13	3	26	12	8
Toronto Main WPCP	25	5	37	38	13
Highland Creek WPCP	6	1	9	11	3
*Total WPCP Load	44	9	72	61	24
Etobicoke Creek	7	6	2	4	3
Mimico Creek	2	4	1	2	3
Humber River	21	48	9	14	25
Don River	14	26	8	11	34
Highland Creek	4	1	1	2	2
Rouge River	6	4	1	1	2
Total Tributary load	54	89	22	34	69
Lake Ontario Shoreline	2	2	6	5	7
Total Load	100	100	100	100	100

FIGURE 5.1: TORONTO AREA WATERSHED AND WPCP POLLUTION LOADS



estimated from recorded flow rates and observed effluent concentrations from 1981-85. Pollutant loadings from storm and combined sewer outfalls discharging directly to the Metro Toronto waterfront were estimated from available information. In areas where no information existed, loadings were estimated by applying typical unit area loads(Beak et al., 1987).

Table 5.11 presents a further breakdown of pollutant loads contributed by the Humber, Main, and Highland Creek WPCPs for an extended group of contaminants. The relative proportions contributed by each of the WPCPs are shown in Figure 5.2, for selected parameters.

5.1.1 Suspended Solids

Sedimentation of the suspended solids fraction of a waste discharge may result in the accumulation of bottom deposits which exert a benthic oxygen demand. In addition, sediment from storm and combined sewer discharges, WPCP discharges, and from soil erosion and construction sites can cause turbidity problems, fill reservoirs and block navigational channels. In some cases, deposited sediments can have direct and adverse effects on fish populations by spoiling spawning areas, fouling gills and smothering bottom organisms upon which the fish feed (MOE, 1987d).

The Humber River is by far the largest single source of total suspended solids (TSS) to the Toronto waterfront, accounting for 47 per cent of the total load. The Don River is the next largest contributor of TSS (26 per cent). The three WPCPs which discharge directly to Lake Ontario account for only 10 per cent of the total waterfront TSS load. While annual flows from the Humber and Don Rivers and the Humber and Main WPCPs are of a similar magnitude, TSS concentrations in the tributaries are much higher.

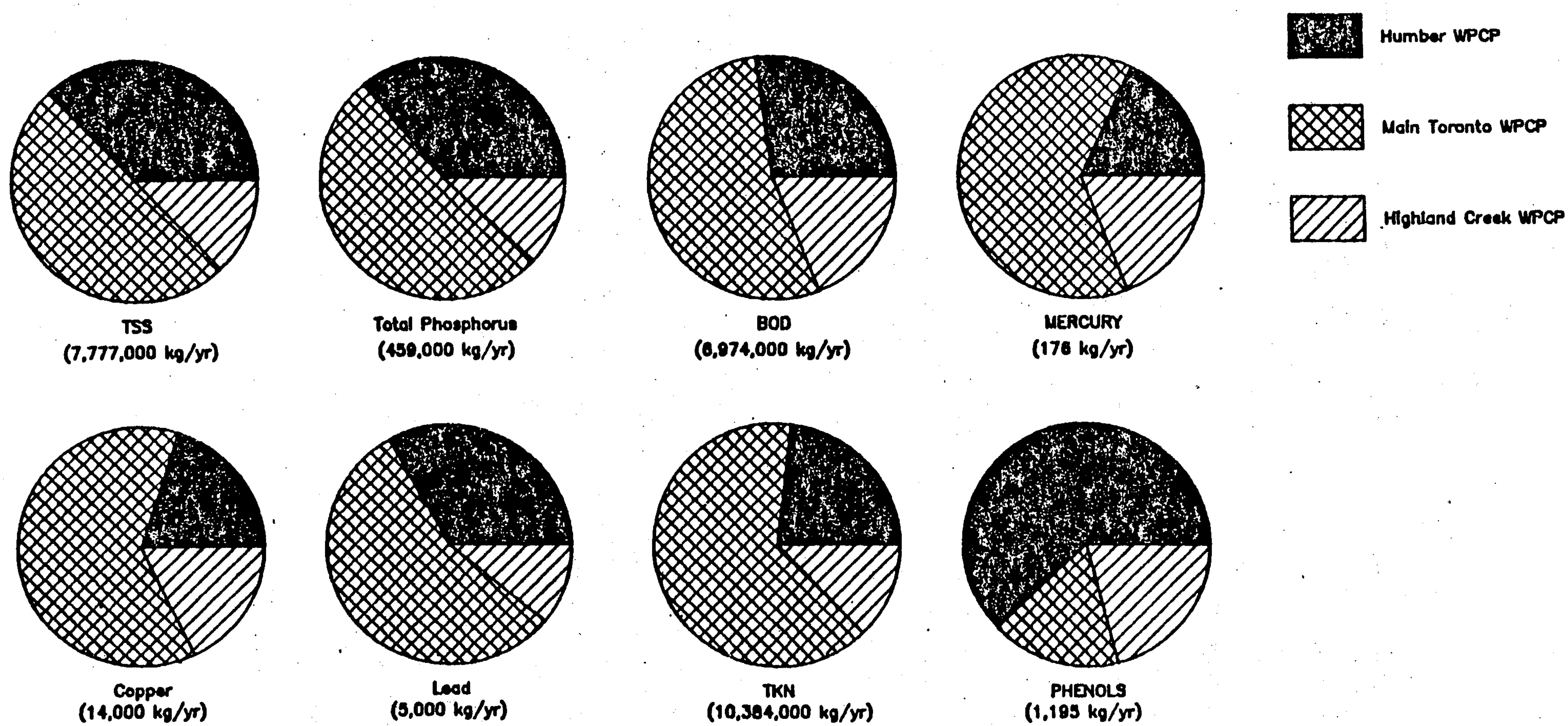
Toxic contaminants, especially heavy metals are often bound to the suspended solids discharged from the different sources. Metal concentrations in suspended solids discharged from the WPCPs are greater than those associated with suspended solids in riverine discharges. However, the impacts on water and sediment quality are more dependent upon the quantity of suspended sediment than on its quality. (Boyd, 1988).

TABLE 5.11:
METRO WPCP EFFLUENT POLLUTANT LOADS

POLLUTANT	UNITS	POLLUTANT LOADS (kg/yr)			
		HUMBER WPCP	MAIN WPCP	HIGHLAND CREEK WPCP	TOTAL
TSS	$x10^6$	3.0	3.9	1.0	7.9
BOD_5	$x10^6$	1.9	3.8	1.3	7.0
TKN	$x10^6$	2.4	6.6	1.3	10.3
Total Phosphorus	$x10^3$	170.9	240.8	55.3	467.0
Zinc	$x10^3$	15.9	17.9	4.7	38.5
Lead	$x10^3$	1.6	2.8	0.6	5.0
Copper	$x10^3$	2.9	8.8	2.6	14.3
Mercury		31.7	111.3	32.8	175.8
Cadmium		-	582.6	155.7	1,122.4
FC*	$x10^6$	384.1	17(140)	1.0(24)	-
Phenol		741.1	207.9	246.0	1,195.0
αBHC		0.3	0.0	0.2	0.5
γBHC		1.9	7.2	2.4	11.5
Isophorane		392.2	104.8	25.9	522.9
Dichloromethane	$x10^3$	2.8	15.0	1.2	19.0
Trichloromethane		365.3	936.0	194.8	1,496.1
1,2-dichlorobenzene		583.8	228.9	73.0	885.7
1,3-dichlorobenzene		103.9	62.4	29.8	196.1
1,4-dichlorobenzene		327.1	698.9	132.3	1,158.3
Toluene		329.8	101.8	33.9	465.5
Anthracene		57.5	82.4	19.9	159.8

Source:. Beak et al. 1987)
* FC/sec - numbers in brackets indicate loadings for non-chlorinated effluent

FIGURE 5.2: TORONTO AREA WPCP LOADS



Western Waterfront

The Humber River is the largest single contributor of TSS to the western waterfront, specifically Humber Bay. The remaining sources account for less that 23 per cent of the total western waterfront load.

Central Waterfront

The Don River is the predominant source of TSS in the Central Waterfront area. Storm and combined sewer outfalls within the Inner Harbour contribute very small annual loads of TSS.

Eastern Waterfront

The largest contributors of TSS to the Eastern Waterfront are the Toronto Main WPCP and the Rouge River. However, the contribution from each is less than 10 per cent of that which is discharged to Humber Bay by the Humber River.

5.1.2 **Nutrients**

Water quality data indicate frequent exceedences of Provincial Water Quality Objectives/Guidelines (PWQO/G) for nutrients across the entire Metro Toronto waterfront. The highest nutrient levels along the waterfront occur in Humber Bay in the vicinity of the Humber WPCP outfall and Mimico Creek and Humber River mouths, the Inner Harbour, and Ashbridges Bay in the vicinity of the Main WPCP outfall.

The municipal WPCPs are the principal source of nutrients. The Humber, Main and Highland Creek WPCPs account for 72 per cent of the estimated annual total phosphorus load. The Main WPCP contributes 37 percent of the total load. The largest tributary loads come from the Humber River (9 per cent) and the Don River (8 per cent). Direct discharges from storm and combined sewer outfalls contribute 6 per cent of the annual total phosphorus load.

Western Waterfront

In Humber Bay and along the Etobicoke waterfront, elevated phosphorus levels (in combination with the existence of a suitable substrate) are believed to be responsible for local growths of the nuisance algae Cladophora. The main source of phosphorus on the western waterfront is the Humber WPCP. It contributes 67 per cent of the annual western waterfront load. The Humber River accounts for a further 24 per cent of this load.

During dry weather conditions, zones of impact are restricted to the immediate vicinity of these inputs. More extensive zones are evident following rain events, most notably at the mouth of Mimico Creek (Griffiths, 1987). Stormwater runoff appears to be a significant contributor of phosphorus to Mimico Creek during wet weather.

Central Waterfront

Mean total phosphorus levels in the Inner Harbour remain consistently above the PWQO/G. The major contribution of total phosphorus comes from the Don River (73 per cent). The remainder is provided by direct storm and combined sewer discharge, mostly during dry weather.

Eastern Waterfront

While mean total phosphorus concentrations along the eastern waterfront have declined over the last 10 years, exceedences of the PWQO (guideline) still occur. The Main and Highland Creek WPCPs contribute the bulk of the total phosphorus loads to the eastern waterfront (76 and 17 per cent respectively). About 50 per cent of the annual total phosphorus loads to entire Metro Toronto waterfront are discharged along the eastern waterfront. However, this area is generally less prone to water quality problems as it lacks major harbours and embayments (except for Ashbridges Bay) and has a relatively straight shoreline (good) water circulation (Griffiths, 1987).

5.1.3 **Toxic Contaminants**

Degradation of Metro Toronto waterfront water quality due to toxic metals and organics tends to be localized, with violations of the PWQO being most prevalent near point sources, at the mouths of tributaries, and in areas of poor water circulation.

The Main WPCP is the largest source of copper along the waterfront, contributing about 38 per cent of the total load. The three WPCPs together account for 61 per cent of the waterfront load. The Humber and Don Rivers are the major tributary sources of copper, contributing 14 and 11 per cent of the total waterfront load respectively.

For lead, the Don and Humber Rivers are the two largest sources to the Metro Toronto waterfront, contributing 34 and 25 per cent of the total load respectively. The Humber, Main and Highland Creek WPCPs, together account for 24 per cent of the total lead load. Storm and combined sewer outfalls along the Metro Toronto Waterfront contribute more lead annually than each of the Humber and Highland Creek WPCPs.

Data for other heavy metals were not available for Mimico Creek, Highland Creek, the Rouge River and direct storm and combined sewer discharges along some areas of the waterfront. However, data does exist for mercury and cadmium for Etobicoke Creek and the Humber and Don Rivers. Assuming that the predominant tributary loads for these two heavy metals come from the Humber and Don Rivers, as is generally the case for copper and lead, then it would appear that the three WPCPs contribute the greatest amounts of mercury and cadmium to the waterfront. The three plants combined contribute about 16 times more mercury and 20 times more cadmium than the Humber River, which is the largest tributary source of these two heavy metals. The Main WPCP appears to be the largest single contributor of mercury and cadmium to the Metro Toronto waterfront.

PCB loads in Etobicoke Creek and the Humber and Don Rivers were estimated to be less than 1 kg/yr. PCBs were not detected in the effluents from the three WPCPs (Beak et al., 1987).

Loading estimates for pesticides and other toxic contaminants are not available for the tributaries or the waterfront storm and combined sewer discharges. Estimates are however available for the Humber, Main and Highland Creek WPCPs (see Table 5.10).

Loadings of the pesticide α BHC are approximately equally contributed by the Humber and Highland Creek WPCPs. The Main WPCP was found to contribute essentially no α BHC. This pesticide was also detected less frequently at the Main Plant. The Main WPCP, however, contributes the bulk of the pesticide γ BHC from the 3 plants. The Humber WPCP is largest source of Isophorone.

Of the three plants, the Main WPCP is the largest contributor of halogenated aliphatics such as Dichloromethane and Trichloromethane, monocyclic aromatics such as 1,4-dichlorobenzene and toluene, and the PAH anthracene. The Humber WPCP is the largest contributor of 1,2 and 1,3-dichlorobenzene and phenol. The Highland Creek WPCP is generally the smallest contributor of these toxic parameters.

In general, concentrations of these parameters in the effluent from the three plants are similar, and thus the loadings are generally driven by the discharge volume. However, some exceptions include high concentrations of Isophorone, 1,2-dichlorobenzene and toluene at the Humber WPCP, and low concentrations of phenol at the Main WPCP.

Western Waterfront

PWQOs for heavy metals such as cadmium, copper, iron, lead, nickel and zinc, have been exceeded in Humber Bay in the vicinity of the three major input sources; the Humber WPCP, the Humber River and Mimico Creek. Exceedences were most frequently found near the Humber WPCP (Beak et al., 1987).

The Humber River is the main source of lead to the western waterfront, contributing about 61 per cent of the total load. The Humber River and the Humber WPCP are comparable sources of copper, with each contributing about 40% of the total western waterfront load. While no load estimates are available for

Mimico Creek, the Humber WPCP appears to be the major contributor of mercury and cadmium to the western waterfront.

Other toxic substances detected near the input sources were found in trace amounts only, and never exceeded PWQOs.

Central Waterfront

Most PWQO violations for heavy metals have occurred in the Inner Harbour. The Don River is the largest source of heavy metals to this area, contributing about 81 and 90 per cent of the total copper and lead loads respectively. The remaining portions are provided by storm and combined sewer outfalls which discharge directly to the Harbour during wet and dry weather.

Eastern Waterfront

The Main WPCP is the major source of copper and lead along the Eastern Waterfront. It contributes approximately 70 and 64 per cent of the total copper and lead loads respectively. While no mercury or cadmium load estimates exist for Highland Creek and the Rouge River, the Main WPCP would also appear to be the most significant source of these heavy metals. The Highland Creek WPCP is the next largest source of heavy metals on the Eastern Waterfront.

Load estimates for other toxic parameters are not available for the two tributaries or any direct storm or combined sewer discharges. Of the two plants, the Main WPCP is the larger contributor of most of these parameters. The Toronto Main WPCP effluent was found to be non-mutagenic but rapidly lethal to fish, with a potential of producing an extensive mixing zone (MOE, 1987b).

5.1.4 Bacteria

Water quality data indicate frequent exceedences of the PWQO for fecal coliform (FC) bacteria across the Metro Toronto waterfront. The majority of these occurrences are coincident with rainfall. As a result, beaches right across the waterfront are regularly placarded to warn the public against swimming during the summer months. Although fecal coliforms are not pathogenic, their presence in water indicates the potential presence of pathogenic organisms. Exceedences of the PWQO may cause adverse reactions in humans, ranging from gastrointestinal illness to skin, ear, eye, nose and throat infections (Health and Welfare Canada, 1983).

Sewer systems, discharging either directly or via the six tributaries, are the greatest contributors of FC bacteria to the waterfront. Metro's WPCPs chlorinate their effluent over the summer period. As a result, bacterial loads from the WPCPs are minimal during this period. Fecal coliform densities have been observed to increase at beach locations as the summer season progresses. This is probably caused by the resuspension of contaminated sediments (Gore & Storrie, 1987a).

Western Waterfront

The highest wet weather bacterial densities on the Western Beaches occur near the Humber River and decrease toward the east. Some high fecal coliform (FC) densities also occur at the eastern end of the Western Beaches, but dissipate more rapidly than the peaks occurring near the Humber River. Direct stormwater runoff and the Humber River are the major causes of high FC densities at the Western Beaches. Plumes from storm and combined sewer outfalls discharging outside the breakwater have been observed to move through the breakwater gaps directly onto the beaches during runoff events. In general, mean FC densities in these sewer systems are approximately twice those found in the Humber River. However, Humber River loads are greater and occur over longer periods. The relative impact of the Humber River and sewer discharges on Sunnyside Beach FC levels is a function of the distribution of rainfall over the basin, the direction and magnitude of lake currents and the time after the storm (Gore & Storrie, 1987c).

Diffuse source dry weather inputs (birds) can elevate FC levels above the PWQO for several days after a rainfall (Kleinfeldt, 1986). Sediment resuspension does not appear to be a significant source of FC on the Western Beaches (Gore & Storrie, 1987c; Kleinfeldt, 1986).

Central Waterfront

High FC densities at Centre Island Beach are coincident with rainfall events even though there are no direct storm sewer discharges to the beach area. Contaminated discharge through the Eastern Gap during runoff events is affecting Centre Island Beach FC densities and causing placarding of the beach (Gore and Storrie, 1987b; 1986b).

Large bird populations do not directly affect water FC densities in the beach area (Gore & Storrie, 1986b). Resuspension of contaminated bottom sediments inside the breakwater can cause water FC densities inside the breakwater to increase. Resultant loadings are large enough to explain high dry weather FC densities measured in the beach area. The main source of sediment contamination is thought to be Eastern Gap water (Gore & Storrie, 1987b, 1986b).

The major source of FC loadings to the Inner Harbour are the Garrison Creek CSOs, which represent over 80 per cent of the predicted wet event loadings (Beak et al., 1987). These CSOs represent a significantly higher load than the Don River dry weather FC load.

Eastern Waterfront

Bacterial loadings to the Eastern Beaches are storm event related. Direct stormwater discharges were found to be the direct cause of increased FC densities at the beaches. Other contributing factors include lake currents and dispersion and FC die-off rates in the receiving water. Shore entrapment eddies reduce the dispersion of shore discharges, resulting in higher FC densities in the beaches area. Water quality degradation due to runoff events generally disappears within 24 hours after rainfall (Beak et al., 1987; Gore & Storrie, 1987a; 1986a, 1985a). Contaminated sediments can increase dry weather FC levels by 35-176 FC/100 ml (Gore & Storrie, 1987a; 1986a).

The Eastern Beaches do not appear to be affected by the Main WPCP effluent bacterial load during the summer. However, the effluent bacterial load from the plant at the sea wall does impact the coastal waters offshore of Coatsworth Cut. Occasionally, plant bypass flows are discharged to the Toronto Eastern Waterfront area. Analysis of data on plant bypass flows and Eastern Beaches bacterial densities indicated that these flows had no obvious effects on beach FC densities (Gore & Storrie, 1986e).

CSOs appear to be the predominant source of FC along the western portion of the Scarborough waterfront (Proctor & Redfern, 1987). No information is available on the impact of bacterial loadings from the Highland Creek WPCP on the waterfront.

5.2 SUMMARY OF WATERSHED POLLUTANT LOADINGS

Table 5.12 and 5.13 present estimates of the pollutant loads generated within each of the six major watersheds which discharge along the Toronto waterfront. Annual loads of four selected pollutants were estimated for the following sources (Beak _et_ _al_., 1987):

- Rural non-point sources;
- Dry weather seepage;
- Urban stormwater runoff;
- Combined sewer overflow; and
- Water pollution control plant discharges;

The estimates do not account for subsequent in-stream processes affecting pollutant transport to the waterfront.

Rural non-point source loads were estimated using a unit area loading approach (Beak _et_ _al_., 1987). Loading rates were estimated based on aggregate loading rates for small agricultural watersheds that resemble the study area in terms of soil content, topography and land use. Assumed loading rates and ranges are presented in Beak et al (1987).

Dry-weather seepage loads for the lower Humber River, Mimico Creek, Don River, Highland Creek and Rouge River basins were obtained from previous field assessments (Gartner-Lee, 1983, 1987; Canviro, 1986a,b). One outfall within the Don River

TABLE 5.12
ANNUAL LOADINGS BY SOURCE WITHIN EACH WATERSHED

		POLLUTANT LOADINGS (kg/yr)						
		Rural Non-Point	Dry Weather Seepage	Urban Runoff	CSO	WPCP	Total Input	Total Instream
Etobicoke Creek	TSS	4,564,119	99,713	1,206,506	-	-	5,870,338	4,790,023
	Total P	8,922	4,748	2,547	-	-	16,217	13,108
	Copper	336	119	45	-	-	500	859
	Lead	93	421	27	-	-	541	680
	Flow		7,611,136	116,186	-	-		72,800,000
Mimico Creek	TSS	944,178	71,232	698,308	-	-	1,713,718	3,622,185
	Total P	1,846	3,392	2,456	-	-	7,694	6,222
	Copper	70	85	42	-	-	197	408
	Lead	19	301	32	-	-	352	666
	Flow		5,437,120	89,699	-	-		24,000,000
Humber River	TSS	30,702,142	999,393	1,129,797	63,000	1,080	32,895,412	40,863,224
	Total P	60,017	8,503	3,254	690	376	72,840	60,854
	Copper	2,260	231	56	41	3	2,591	3,155
	Lead	624	745	41	65	3	1,478	5,123
	Flow		10,987,392	137,188	334,000	76,358		218,500,000
Don River	TSS	5,742,274	1,737,227	1,953,032	295,371	196,392	9,924,296	22,687,183
	Total P	11,225	29,207	5,578	2,147	12,542	60,699	53,789
	Copper	423	2,306	340	150	431	3,650	2,588
	Lead	117	2,143	3,352	229	496	6,337	7,066
	Flow		37,877,890			13,024,660		138,800,000
Highland Creek	TSS	887,063	95,004	802,321	-	-	1,784,388	857,941
	Total P	1,734	4,524	1,945	-	-	8,203	1,878
	Copper	65	113	34	-	-	212	525
	Lead	18	401	22	-	-	441	378
	Flow		7,251,712	91,020	-	-		45,400,000
Rouge River	TSS	11,852,057	38,662	328,429	-	-	12,219,148	3,608,145
	Total P	23,169	1,841	819	-	-	25,829	5,280
	Copper	873	46	14	-	-	933	384
	Lead	241	163	10	-	-	414	281
	Flow		2,951,104	37,136	-	-		59,600,000
Total	TSS	54,691,833	3,041,231	6,118,393	358,371	197,472	64,407,300	76,428,701
	Total P	106,913	52,215	16,599	2,837	12,918	191,482	141,131
	Copper	4,027	2,900	531	191	434	8,083	7,919
	Lead	1,112	4,174	3,484	294	499	9,563	14,194
	Flow		72,116,354			13,101,018		559,100,000

TABLE 5.13
ANNUAL PERCENTAGE CONTRIBUTION BY SOURCE WITHIN EACH WATERSHED

		PERCENTAGE OF TOTAL POLLUTANT INPUT					
		Rural Non-Point	Dry Weather Seepage	Urban Runoff	CSO	WPCP	Total Input
Etobicoke Creek	TSS	78	2	20	–	–	100
	Total P	55	29	16	–	–	100
	Copper	67	24	9	–	–	100
	Lead	17	78	5	–	–	100
Mimico Creek	TSS	55	4	41	–	–	100
	Total P	24	44	32	–	–	100
	Copper	36	43	21	–	–	100
	Lead	5	86	9	–	–	100
Humber River	TSS	93	3	4	0	0	100
	Total P	82	12	4	1	1	100
	Copper	87	9	2	2	0	100
	Lead	42	51	3	4	0	100
Don River	TSS	58	18	20	3	1	100
	Total P	18	48	9	4	21	100
	Copper	12	63	9	4	12	100
	Lead	2	34	53	3	8	100
Highland Creek	TSS	50	5	45	–	–	100
	Total P	21	55	24	–	–	100
	Copper	31	53	16	–	–	100
	Lead	4	91	5	–	–	100
Rouge River	TSS	97	0	3	–	–	100
	Total P	90	7	3	–	–	100
	Copper	94	5	1	–	–	100
	Lead	58	39	3	–	–	100
Total	TSS	85	5	9	1	0	100
	Total P	56	27	9	1	7	100
	Copper	50	36	7	2	5	100
	Lead	12	44	36	3	5	100

watershed, which contributed an unusually high total P load, was excluded from the Don River total P estimate. For the remaining watersheds and the Toronto waterfront, unit area loads, calculated from the existing data, were used (Beak et al., 1987).

Annual runoff volumes for the City of Toronto were obtained from recent QQS (Quantity/Quality Simulation model) simulations carried out by the city. Two other studies recently investigated the quantity and quality of stormwater runoff in the City of Scarborough (Proctor and Redfern, 1987) and the Borough of East York (Gore and Storrie, 1986e) using the STORM model. Urban runoff pollutant loadings were abstracted from these studies. The East York study did not present loadings for copper and lead. Average concentrations for these two parameters were applied to the annual volume produced by STORM; the concentrations were taken from a study by Kronis (1982). For all other urban areas, urban stormwater runoff volumes and loadings were estimated using derived probability models (Beak et al., 1987).

CSO volumes and pollutant loadings were abstracted, where available, from existing sources. For the City of York (tributary to Black Creek/Humber River), data were abstracted from the report "Humber River Sewershed Combined Sewer Overflow Study" (Wong, 1986). The U.S. EPA Stormwater Management Model (SWMM) was used to simulate the combined sewerage system using rainfall from April to October, 1979.

Annual CSO volumes and pollutant loads for the City of Toronto were obtained from recent QQS model (DORSCH, 1979) runs using precipitation records for 1982. Average pollutant concentrations were applied to the annual volumes for 1982; the concentrations were taken from the City of York CSO Study (Wong, 1986).

Annual CSO volumes and pollutant loads for the Borough of East York were obtained from recent STORM simulations, using rainfall from April to October, 1979 (Gore and Storrie, 1986e). Loadings were not presented for copper and lead. Average concentrations for these two parameters were applied to the annual volume produced by STORM; the concentrations were taken from the York CSO study (Wong, 1986).

A study of CSOs in the southwestern part of the City of Scarborough was recently completed, which included an assessment of the quantity and quality of CSO discharging into Massey Creek and Lake Ontario. Annual pollutant loads were calculated as the product of average annual CSO volume, determined using STORM, and average concentrations of pollutants observed in CSO, taken from Wong (1986). Twenty-three years of rainfall records (1960-1983) were used for the continuous STORM analysis.

In addition to the three WPCPs which discharge directly to Lake Ontario, two other plants operate within the study area. The Kleinburg WPCP services an area of Town of Vaughan and discharges its effluent to the Upper Humber River. The North Toronto WPCP discharges to the Don River within Metropolitan Toronto. Loadings were estimated from recorded flow rates and observed effluent concentrations (Beak et al., 1987). Copper and lead concentrations were not available for the Kleinburg WPCP. Loadings for these contaminants wEre estimated using concentrations observed at the North Toronto WPCP.

Table 5.12 also shows the tributary loads for each contaminant, calculated using observed in-stream concentrations and flows, for comparison with the estimated total loads contributed by the aforementioned sources. Differences between estimated inputs and in-stream loadings can be partially explained by the following:

- Dry-weather seepage pollution estimates are based on concentrations and flows, observed at each outfall, on between 1 and 4-6 occasions only, and as such may not accurately represent average conditions. In addition, the field assessments from which the loads were abstracted were, in some cases, conducted in different years. For areas where field assessments have not been conducted, unit loads calculated from existing data were used to estimate dry-weather seepage pollutants loads.

- Urban runoff pollution estimates were abstracted from a number of sources. Where possible, annual loads were obtained from previous studies. These studies used different techniques, and in some cases estimated pollutant loads for different years. However, the years were chosen so as to represent average conditions for the area in question. For all other urban areas, loadings were estimated using derived probability models. The level of detail of these various estimation techniques differs, and hence so do the level of accuracy of the estimates.

- CSO estimates were abstracted from previous studies. Again, different techniques were utilized in these studies. As such, the accuracy of the estimates may vary.

- Estimates of pollutant inputs within the six watersheds do not account for subsequent in-stream processes affecting pollutant transport to the Metro Toronto waterfront. These processes may be especially significant for pollutant loads contributed by sources in the upstream portions of these watersheds (e.g. rural non-point sources).

5.2.1 Suspended Solids

The six area tributaries are the major contributors of TSS along the Metro Toronto waterfront. Within the watersheds, the largest contribution of TSS on an annual basis comes from rural non-point sources. Rural non-point sources account for about 85 percent of the TSS discharged to the six tributaries. Urban stormwater runoff and dry-weather seepage account for approximately 8 and 5 percent of this TSS load, respectively. CSO and WPCP discharges occur only in the Humber and Don River watersheds and are relatively small sources of TSS on an annual basis.

Western Waterfront Tributaries

Rural non-point sources are the major contributors of TSS in the Etobicoke Creek, Mimico Creek and Humber River Watersheds. Only within the Mimico Creek Basin is urban stormwater runoff nearly as significant as rural non-point source TSS loads.

This can be explained by the greater percentage of urbanization within this watershed. CSOs account for less than 1 percent of the Humber River's annual TSS input, as does the Kleinburg WPCP.

Central Waterfront Tributaries

Rural non-point sources are the major contributors of TSS in the Don River Watershed, accounting for 58 percent of the annual TSS input. Urban stormwater runoff and dry-weather seepage account equally for the bulk of the remaining TSS load (20 and 18 percent respectively). CSOs and the North Toronto WPCP are relatively small sources of TSS within the watershed.

Eastern Waterfront Tributaries

Rural non-point pollution is the major contributor of TSS in the Rouge River Basin (97 percent). While rural non-point sources are also the largest contributor of TSS in the Highland Creek Basin (50 percent), urban stormwater runoff is nearly as great a contributor (45 percent). This can be explained by the greater percentage of urbanization within this watershed.

5.2.2 **Nutrients**

In the watersheds which are most highly urbanized, dry-weather seepage is the largest contributor of total phosphorus on an annual basis (i.e. Mimico Creek, Don River and Highland Creek). In the more rural watersheds, rural non-point sources contribute the bulk of the total phosphorus (i.e. Etobicoke Creek, Humber River and Rouge River). Overall, rural non-point sources are the largest source of total phosphorus within the six watersheds (56 percent). Dry-weather seepage accounts for 27 percent of the annual load. Urban stormwater runoff and the two upstream WPCPs contribute 9 and 7 percent, respectively. The WPCP contribution comes almost entirely from the North Toronto WPCP. Contributions from CSOs on the Don and Humber Rivers are relatively small (1 percent).

Western Waterfront Tributaries

As stated above, dry-weather seepage is the largest source of total phosphorus in the Mimico Creek watershed (44 percent).

Urban stormwater runoff and rural non-point sources account for 32 and 24 percent respectively.

Rural non-point sources are the major contributor of total P in the Etobicoke Creek watershed (55 percent). Dry-weather seepage and urban stormwater runoff account for 29 and 16 percent of the annual phosphorus load respectively.

In the Humber River Basin, rural non-point sources are by far the greatest contributor of total phosphorus (82 percent).

Central Waterfront Tributaries

Dry-weather seepage is the largest source of total phosphorus in the Don River Basin, accounting for approximately 48 percent of the annual load. The North Toronto WPCP is the next largest contributor of total phosphorus in this watershed (21 percent). Rural non-point sources, urban stormwater runoff and CSOs along the river account for 18, 9 and 4 percent of the annual total phosphorus load respectively.

Eastern Waterfront Tributaries

Dry-weather seepage is the greatest source of total phosphorus in the Highland Creek watershed (55 percent). Urban stormwater runoff and rural non-point sources account for 24 and 21 percent of the total annual load.

In the Rouge River watershed, the bulk of the annual total phosphorus load comes from rural non-point sources (90 percent).

5.2.3 Bacteria

The Humber River and Don River are major sources of bacterial contamination at the Western Beaches and Centre Island Beaches respectively. Storm and combined sewer outfalls discharging along these two rivers are major contributors of bacteria. There are no CSOs on the other four tributaries.

Annual wet weather loadings of bacteria within the six watersheds have not been estimated, and in any case, would not be very meaningful. However, FC loads have been estimated for chosen design (or observed) events and are used as the basis for further discussion.

Western Waterfront Tributaries

Estimated Humber River FC loadings for a storm with a one-year return period were several magnitudes higher than FC loadings during dry weather (Beak et al., 1987), indicating the significance of storm and combined sewer discharges along the river. Although unmeasured, sources outside Metro likely also contribute significantly to wet weather bacteria loads.

There are significant discharges of bacteria to the Humber River during dry weather. Three hundred and sixty-six storm sewer outfalls have been found to be active during dry weather. Of these, 25 exhibited poor bacterial quality (Gartner Lee, 1983). Eighty-seven outfalls were found to be active on Mimico Creek, of which 24 showed high bacterial levels (Canviro, 1986b). Similar information is not available for Etobicoke Creek.

Wet weather FC load estimates are not available for Etobicoke Creek or Mimico Creek.

Central Waterfront Tributaries

A study carried out in East York indicated that FC concentrations and loads from the CSOs were considerably greater than those from the storm sewer outlets. (Gore and Storrie, 1986). Little assessment has been made of the total Don River wet weather FC loadings and their impact on the Inner Harbour (Beak et al., 1987).

There are significant discharges of bacteria to the Don River during dry weather. Four hundred and forty-four storm sewers and 22 combined sewers have been found to be active during dry weather. One hundred and twenty-five of these exhibited unacceptable bacterial quality (Canviro, 1986a).

Bacterial loading from the North Toronto WPCP is not significant, representing less than 0.1 percent of the total dry weather FC load to the Don River.

Eastern Waterfront Tributaries

Wet weather bacteria loadings to Highland Creek and the Rouge River have not been estimated to date. They are not expected to be as significant as direct storm and combined sewer discharges to the Eastern beaches and Scarborough waterfront.

Dry weather loadings of FC have been assessed for Highland Creek and the Rouge River. A total of 323 and 11 storm sewers have been found to be active during dry weather on the Highland Creek and Rouge River respectively. Of these, 77 outfalls exhibit unacceptable FC levels (Gartner-Lee, 1987).

5.2.4 Toxic Contaminants

The six area tributaries are the major contributors of the heavy metals copper and lead along the Metro Toronto waterfront. Within the watersheds, the largest contributor of copper on an annual basis is rural non-point sources (50 percent), followed by dry-weather seepage (36 percent). The largest contributors of lead annually are dry-weather seepage (44 percent) and urban stormwater runoff (36 percent). CSOs contribute only 2-3 percent of the copper and lead within the watersheds.

Loading estimates for other metals, pesticides and organics are not available for sources within the watersheds.

Western Waterfront Tributaries

Rural non-point sources are the major contributors of copper in the Etobicoke Creek and Humber River watersheds (67 and 87 percent respectively). Dry-weather seepage is the largest source of copper in the Mimico Creek watershed (43 percent), closely followed by rural non-point sources (36 percent).

Dry-weather seepage is the largest source of lead in the Etobicoke Creek, Mimico Creek and Humber River basins, accounting for 78, 86 and 51 percent of the annual lead loads respectively. Only within the Humber River basin is rural non-point pollution nearly as significant as dry-weather seepage (42 percent).

Urban stormwater runoff, CSO and the Kleinburg WPCP are relatively small sources of both copper and lead.

Central Waterfront Tributaries

Dry-weather seepage is by far the largest source of copper within the Don River watershed (63 percent).

Urban stormwater runoff is the largest contributor of lead in the Don River watershed (53 percent), followed by dry-weather seepage (34 percent).

CSOs and the North Toronto WPCP are relatively small sources of both copper and lead in the Don River watershed.

Eastern Waterfront Tributaries

Within the Highland Creek basin, dry-weather seepage is the largest contributor of copper annually (53 percent). Rural non-point sources and urban stormwater runoff account for 31 and 16 percent of the annual copper load in this basin. Dry-weather seepage is by far the most significant source of lead in the Highland Creek watershed (91 percent).

6.0 REMEDIAL PROGRAMS

Numerous studies and programs have been initiated with the aim of developing remediation strategies for the entire Toronto waterfront. These programs and studies are briefly described below. More detailed information may be obtained from the published documents which are referenced in these sections.

6.1 Municipal Industrial Strategy for Abatement (MISA)

Environment Ontario has embarked on a Municipal Industrial Strategy for Abatement (MISA) which is aimed at controlling municipal and industrial discharges into surface waters. The MISA goals and objectives are outlined in a recently published document (MOE, 1986c). MISA's ultimate goal is the virtual elimination of persistent toxic contaminants from these discharges. The program will reduce the risk of damage to the ecosystem and protect public health by minimizing the presence of these contaminants in drinking water, fish and wildlife.

MISA will set strict pollution control standards for municipal WPCP effluents, including the Humber, Kleinburg, North Toronto, Main and Highland Creek WPCPs. For the first time, the total amount of each toxic contaminant from a polluter will be limited. This will be accomplished by requiring each plant to meet standards attainable by the best available pollution abatement technology, economically achievable.

Sensitive aquatic areas may require more stringent reduction programs. These areas will receive individual aquatic monitoring and discharge standards will be set accordingly. Toronto is one of six areas where pilot studies are being undertaken. The purpose of these pilot studies is to develop water quality impact effluent limits for these sites and to develop standardized water quality assessment procedures for application in other areas. The Toronto Main WPCP evaluations are unique among the MISA pilot sites in that they focus on whole lake impacts, in addition to the immediate zone of effect (MOE, 1987b). Early results on the Toronto Main WPCP effluent have found it to be non-mutagenic but rapidly lethal to fish with a potential of producing an extensive mixing zone. Dechlorination and possibly nitrification of the effluent may serve as interim abatement measures prior to the implementation of MISA Municipal sector regulations.

Also under the MISA program, a provincial Sewer Use Control Strategy will be developed, which will apply to all dischargers into sanitary sewer systems and will be enforceable. The Sewer Use Control Program will also control stormwater and cooling water discharge entering storm sewers from industrial sites. Significantly high levels of contaminants in industrial runoff will trigger remedial action, including implementation of Best Management Practices or end-of-pipe treatment. As an interim measure, prior to the implementation of regulations, a revised Model Sewer Use By-law has been released. The by-law provides stricter concentration limits and more outright prohibitions of contaminants to both sanitary and storm sewer systems, and lays out the requirements for the development of Best Management Practices (BMP) plans governing run-off from industrial sites. It provides guidance for the completion of waste survey reports which will provide municipalities with an inventory of the industrial wastes generated.

Ministries, municipalities, industry, the public and public interest groups will all participate in the development of the MISA program.

6.2 Toronto Area Watershed Management Strategy

In 1981, the MOE initiated a study of water quality in the Don River, Humber River and Mimico Creek. The Toronto Area Watershed Management Strategy (TAWMS) Study has dealt with water quality problems in the Humber River watershed during the 1982-1985 period, in Mimico Creek during 1983 and 1984, and is currently looking at the Don River watershed. This study was aimed at:

- better defining water quality conditions within the study area;
- analyzing the cause and effect relationships for problem constituents and areas; and
- developing cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and uses.

This study has produced a number of technical documents and has culminated in the "Humber River Water Quality Management Plan, 1986" (TAWMS, 1986a). A summary of the proposed management plan is provided in Tables 6.1 and 6.2.

The current status of the Humber River Management Plan is as follows:

- It was favourably received by the public, MTRCA and municipal respondents;
- Recommendations from the Plan were used in the 1987 report of the City of Toronto Waterfront Remedial Action Plan (WRAP) Committee;
- An Implementation Committee has been formed to facilitate the implementation of the Phase 1 recommendations.

Implementation of the recommendations from TAWMS will likely prove beneficial to the waterfront, and will include water quality monitoring to evaluate the effectiveness of recommended remedial actions in the field, thereby providing valuable input to the Toronto RAP.

A number of technical documents relating to Don River water quality have been produced. The Don River Water Quality Management Plan is being prepared by consultants. A draft plan is to be completed in 1989.

The MOE has provided over $3 million in funding for TAWMS investigations to date.

6.3 Metro Toronto Waterfront Water Quality Improvement Program (WWQIP)

Concurrently with TAWMS, the Ministry has provided funds to local municipalities through the Short-Term Program for Waterfront Water Quality Improvement (WWQIP) since 1984. Projects included in this program can generally be classed as one of:

- physical work on the watercourse, waterfront or sewer systems yielding immediate short-term benefits;

Table 6.1: Humber River Management Plan - Phase I

Option	Cost*	Scale	Effects	Benefits
1. CSO Control	$5.0	Black Creek	o reduces a potentially major source of human pathogens. o reduces input of industrial wastes and heavy metals and other hazardous contaminants. o reduces input of sanitary wastes.	o lessens public health risk. o reduces stress on fishery in the lower reaches. o reduces source of contamination for Humber Marsh and the lake (drinking water supply). o improves aesthetics, enhances recreational enjoyment.
2. Flood Reduction (local detention tanks)	$17.3	City of York	o upgrades level of protection to approximately 10 year design level.	o reduces frequency of basement flooding.
3. Catchbasin Cleaning	$3.7	Basin-wide	o reduces metal input to river at all points. o reduces input of litter and debris.	o reduces stress on the fishery throughout basin. o provides impetus for investigation of fisheries improvement programs. o reduces metal load to Humber Marsh and the lake. o improves aesthetics, enhances recreational enjoyment.
4. Dry Weather Sources (sanitary connections)	$6.6	Priority outfalls	o reduces potentially major source of human pathogens. o reduces FC loads in dry weather.	o lessens public health risk. o PWQO achieved in the lower reaches during dry weather.
5. Dry Weather Sources (permitted discharge)	NC	Industrial areas, Priority outfalls	o reduces dry weather input of metals and other toxic parameters. o reduces dry weather loads to lake.	o provides localized improvement in fishery habitat (spawning). o reduces pollutant accumulation in the marsh and lake.
6. Dry Weather Sources (dumping and poor handling of wastes)	NC	Industrial areas	o reduces frequency of discharge of industrial wastes and toxic contaminants.	o reduces potential for acute stress to the fishery. o reduces pollutant accumulation in the marsh and lake.

* Present value in millions of 1985 dollars, NC - Not Costed

Source: Humber River Water Quality Management Plan (MOE, 1986c)

Table 6.1 (Continued)

Option	Cost*	Scale	Effects	Benefits
7. Household Hazardous Contaminants	NC	Basin-wide	o reduces intermittent discharge of acute toxic substances. o reduces toxic loads to the lake.	o reduces the potential for intermittent fish kills. o reduces source of contamination for Humber Marsh and the lake (drinking water). o improves public awareness.
8. Dog and Litter Control	NC	Basin-wide	o reduces FC loads in wet weather. o improves aesthetics.	o lessens public health risk. o enhances recreational enjoyment. o improves public awareness.
9. Sediment Control Programs	NC	Basin-wide	o reduces in-stream sediment concentrations. o reduces sediment load to lake.	o reduces stress on fishery. o provides impetus for fishery habitat improvement. o reduces accumulation of sediment, nutrients and toxic substances in Humber Marsh and lake.
10. Rural Controls	NC	Upper Watershed	o reduces FC counts in upper Humber River. o reduces loads of sediment, nutrients and toxic substances to lake.	o lessens public health risk. o reduces accumulation of sediment, nutrients and toxic substances in Humber Marsh and the lake.
11. Disinfection	$0.2 mill	Pilot Project (Emery Creek)	o reduces major FC source in upper urban basin during dry weather. o provides test facility for optimizing dry weather disinfection technology. o provides test facility for treatment of retained stormwater.	o decreases dry weather FC counts between Emery Cr. and Black Cr. o lessens public health risk. o allows detailed evaluation of the capabilities and flexibility of dry weather disinfection. o allows evaluation of the feasibility of disinfecting wet weather flow.

* Present value in millions of 1985 dollars, NC - Not Costed

Table 6.1 (Continued)

	Cost*	Scale	Effects	Benefits
12. Stormwater Ponds (existing areas)	$1.3 mill	Pilot Project (Emery Creek)	o reduces metal loads from a major industrial catchment. o provides protection against spills. o provides test facility for evaluating pond effectiveness in terms of fishery enhancement. o provides test facility for optimization of pond design for load reduction.	o reduces PWQO violations locally. o reduces potential for acute toxic impacts on fishery. o provides impetus for parallel fishery habitat project. o allows improved quantification of the fisheries benefits of stormwater control. o allows evaluation of watershed specific load reductions for metals, nutrients and sediment.
13. Stormwater Ponds	NC	Pilot Projects (test sites to be determined)	o controls pollutant loads from new developments. o provides test facilities for evaluating pond effectiveness in developing areas.	o reduce future degradation of the watercourse. o reduce future contaminant loads to the lake. o allows evaluation of fisheries impacts in less stressed environments. o allows evaluation of load reductions in developing areas.
14. Enhanced Water Quality Monitoring	NC		o provides system data for watershed. o provides specific data on the impacts of combined water quality and habitat improvement.	o allows evaluation of overall Phase 1 effectiveness. o allows evaluation of specific fishery improvements possible.

*Present Value

Table 6.2: Humber River Management Plan - Phase 2

Option	Basis for Decision to Proceed	Scale	Cost *	Benefits
Disinfection (low flow)	o lack of success in tracing and eliminating bacterial sources o demonstrated effectiveness at Emery Creek facility	Black Cr. and other tributaries and priority outfall clusters	$0.2 million per facility	o reduction of dry weather FC counts o lessen public health risk
Disinfection (retained stormwater)	o demonstrated effectiveness of stormwater disinfection at Emery Creek o decision to proceed with stormwater pond controls throughout urban Humber	all feasible pond sites	$0.2 million per facility	o reduction of wet weather FC counts o lessen public health risk
Industrial Ponds (existing areas)	o demonstrated effectiveness of Emery Creek facility o demonstrated impacts on in-stream fishery in vicinity of Emery Creek site	all feasible pond sites serving primarily industrial areas	$1500/ha served + land cost (estimated cost: $3.8 mill + land)	o improved fishery o major reduction in loads to lake o major reduction in PWQO violations o spill control o aesthetic improvements
Residential Ponds (existing areas)	o as above o completion of industrial pond implementation program	all feasible pond sites serving primarily residential areas	$1500/ha served + land cost (estimated cost: $16.2 mill + land)	o as above
Ponds (new developments)	o demonstrated effectiveness of proposed test facilities	all new developments	NC	o as above o prevent future degradation of fishery

* Present value in 1985 dollars, NC - Not Costed

Source: Humber River Water Quality Management Plan (MOE, 1986c)

- studies and/or monitoring and investigations to provide information on which effective subsequent actions can be based;
- sewer separation, CSO and storm relief works yielding cumulative benefits over both short and long-terms.

Since 1984, the MOE has provided about $15.7 million through this program. Including the contributions from Metro, the six area municipalities, MTRCA and other government agencies, approximately $39.3 million has been spent over this same period.

The 1988 WWQIP will inject another $9.4 million into improving waterfront water quality. The MOE has agreed to provide about $4.7 million to local municipalities under the 1988 WWQIP.

6.3.1 Studies and Investigations

Table 6.3 presents a list of studies and investigations initiated by local municipalities through the MOE/Metro Toronto WWQIP since 1984. A summary of some of the larger studies is provided in the following paragraphs.

Dry-weather outfall surveys, funded by TAWMS, identified 196 priority outfalls within the Humber River, Don River and Mimico Creek drainage basins, which were consistent contributors of bacteria during dry weather (Gartner-Lee, 1983; Canviro, 1986 a,b; Stirrup, 1988). Thirty-two outfalls on Highland Creek were identified as priorities by a study initiated by the City of Scarborough (Gartner-Lee, 1987). Local municipalities have received funding through the WWQIP since 1985 to monitor and investigate these outfalls, in order to identify the sources of contamination. Techniques utilized include:

- Sewer outfall monitoring;
- Dye testing;
- Placement of wire screens in manholes, to trap toilet paper, etc;
- Television inspection

Table 6.3: MOE/Metro Toronto WWQIP Studies and Investigations (1984-1988)

Projects	Initiated by	Completed
Beach Monitoring and Modelling		
Local Influences on the Water Quality of the Western Beaches, Toronto, Ontario (Kleinfeldt)	Toronto, 1984 WWQIP	1986
Contaminants and Sediment Study (I.E.C. Beak)	Metro, 1984 WWQIP	1985
Eastern Beaches Study, 1984 (Gore and Storrie)	Toronto, 1984 WWQIP	1985
Eastern Beaches Study, 1985 (Gore and Storrie)	Toronto, 1985 WWQIP	1986
Eastern Beaches Study, 1986 (Gore and Storrie)	Toronto, 1986 WWQIP	1986
Centre Island Beach Study, 1985 (Gore and Storrie)	Toronto, 1985 WWQIP	1986
Centre Island Beach Study, 1986 (Gore and Storrie)	Toronto, 1986 WWQIP	1986
Centre Island Beach Study, 1987 (Gore and Storrie)	Toronto, 1987 WWQIP	ongoing work
Western Beaches Study, 1985 (Gore and Storrie)	Toronto, 1985 WWQIP	1986
Western Beaches Study, 1986 (Gore and Storrie)	Toronto, 1986 WWQIP	1987
Western Beaches Study, 1987 (Gore and Storrie)	Toronto, 1987 WWQIP	1988
Western Beaches Long-Term Simulation	Toronto, 1988 WWQIP	ongoing work
Impact of the Breakwall on the Western Beaches Nearshore Circulation and Water Quality (Kleinfeldt)	Toronto, 1985 WWQIP	1985
Pilot Study on Chlorination and Ultra-Violet Treatment	MOE/Toronto 1985, 86 WWQIP	1986

Table 6.3: (Continued)

Projects	Initiated by	Completed
Storm and Combined Sewer Outfall Monitoring		
Storm and Combined Sewer Outfall Monitoring and Investigations/Cross-Connection Identification	East York, 1985, 86, 88 WWQIP Etobicoke, 1985-88, WWQIP North York, 1985-88, WWQIP Scarborough, 1985-88 WWQIP Toronto, 1985-88 WWQIP York, 1985, 88 WWQIP	ongoing work
Highland Creek Pollution Survey (Gartner-Lee)	Scarborough, 1986 WWQIP	1987
Combined Sewer Modelling and Overflow Controls		
City of Scarborough Pollution Control Strategy (Proctor and Redfern)	Scarborough, 1985 WWQIP	1987
Review of Sewer Separation Impact and Evaluation of Alternative Strategies (Gore and Storrie)	East York, 1985 WWQIP	1986
Trunk Sewer System Review and Water Quality Management Plan (Gore and Storrie/MacLaren)	Metro/Toronto, 1985 WWQIP	1987
Inlet Control Study (Paul Theil Associates)	York, 1985 WWQIP	1987
Treatment Plant Studies		
Humber Treatment Plant Study (U.M.A.)	Metro, 1987 WWQIP	1988
Toronto Main Treatment Plant and Don Trunk Sewer System Study (U.M.A.)	Metro, 1988 WWQIP	ongoing work

Priority lists were also compiled for a number of other chemical parameters. To date, investigative efforts have concentrated on bacterial pollution problems. Because of the mainly intermittent nature of these sources, the municipalities have experienced difficulty in locating cross-connections. Local municipalities have requested funds from MOE through the proposed 1988 WWQIP to continue this work.

Sewer Discharge

Studies were initiated by East York, Scarborough, Toronto and York through the 1985 WWQIP to investigate methods of controlling CSO and basement flooding.

The Borough of East York conducted a review of the impacts of sewer separation and evaluated alternative control strategies (Gore and Storrie, 1986a). The report concluded that the provision of trunk storm sewers within the Borough has greatly increased its options for controlling urban runoff. On some local streets, local stormwater detention and inlet controls are the most economical method of providing basement flooding relief. On others, sewer separation or relief sewers are preferable. The report recommends that each street be reviewed in a detailed manner to arrive at the most applicable method of flood protection. The estimated cost of new sewer construction to relieve basement flooding in the Central, North and Southeast areas of the Borough is about $6 million. Stormwater detention facilities and inlet controls, recommended for the South Leaside and Leaside areas respectively, were not costed. The report also recommends that sewer outfall monitoring and investigations, aimed at eliminating sources of dry-weather pollution, continue.

The City of Scarborough initiated a study to assess the hydraulic performance of their combined sewer system and identify a program of remedial measures to reduce basement flooding and CSO (Proctor and Redfern, 1987). The report recommends hydraulic improvements aimed at reducing flows at source, including inlet controls, isolated sewer separation, roof-leader disconnection and underground storage, at a cost of approximately $7 million. The report also recommends that detention facilities be constructed to limit CSO to 10 percent ascertain the significance of the Humber River during both wet and dry conditions in causing beach FC densities to exceed 100/100 ml, and to determine the expected reductions in such occurrences for the following scenarios:

- Existing conditions
- Humber River dry-weather FC densities reduced to 100/100 ml. at the mouth
- Construction of detention tanks to eliminate discharges from Sunnyside and Roncesvalles outlets for up to a 1-year storm.
- Diversion of the Humber River further into Lake Ontario.

This study is included in the 1988 WWQIP.

The 1986 Centre Island Beaches Study (Gore and Storrie, 1987b) recommended a staged diffuser be constructed east of the breakwater to deflect contaminated Eastern Gap water away from the Centre Island Beach area during wet weather. The estimated cost of this device is $900,000.

The 1986 Eastern Beaches Study (Gore and Storrie, 1987a) recommended the control of discharges from 8 major sewer outlets to the beaches by building 2 detention tanks. These tanks would limit discharges to once per year on average at a cost of approximately $13 million. Public hearings are currently under way.

The City of Toronto and MOE undertook a joint project to determine the effectiveness of ultra-violet irradiation and chlorination on CSO and stormwater discharges, through the 1985 WWQIP. A field test facility was constructed and monitored at the Eastern Beaches to establish design and operating requirements for actual installations. The study found ultra-violet irradiation and chlorination to be effective methods of disinfecting CSO discharges. Work was continued in 1986 to develop capital operating and maintenance costs for such installations.

6.3.2 Capital Works and Remedial Measures

Table 6.4 presents a list of remedial measures undertaken through the MOE/METRO Toronto WWQIP since 1984.

Table 6.4: Remedial Measures Inititated through the MOE/Metro Toronto WWQIP (1984-1988)

Projects	Initiated by	Completed
Miscellaneous Improvements		
Shoreline Cleanups on Western and Eastern Beaches	Toronto, 1984, 85 WWQIP	1985
Improvements to Ashbridge's Bay Beach	MTRCA, 1984, 87 WWQIP	1987
Physical Improvements to Rotary and Amos Waites Parks	Etobicoke, 1985, 86 WWQIP	1986
Physical Improvements to Lee-Leuty Beach	Toronto, 1985, 86 WWQIP	1986
Algae Removal on Etobicoke Beaches	Etobicoke, 1984-86 WWQIP	1986
Grenadier Pond Diversion	Toronto, 1984, WWQIP	1984
Humber River Diversion Jetty	Toronto, 1984, 85 WWQIP	1985
Modifications to Chambers to Reduce Sewage Overflows	Toronto, 1986 WWQIP	1986
Diversion of Parking Lot Drains at Sunnyside Beach	Toronto, 1986, 87 WWQIP	1986
Connection of Ellis Ave. Storm Outlet to Road Storm Sewer on Lake Shore Blvd.	Toronto, 1987 WWQIP	1987
Roncesvalles Sewer Outlet Repair	Toronto, 1988 WWQIP	ongoing work
Repair of Drain Culvert East of the Boulevard Club	Metro, 1988 WWQIP	ongoing work
Installation of Roof Restrictions or Disconnection of Downspouts	York, 1987, 88 WWQIP	ongoing work

of the total runoff volume entering the combined system, at a cost of approximately $7 million. For the study area, this level of control actually reduces current CSO volumes by only 75 percent. Facilities to reduce CSOs to once per year would cost approximately $12 million, but would reduce current CSO volumes by 90 percent.

The Municipality of Metropolitan Toronto and the City of Toronto have completed a study which investigated the trunk sanitary servicing requirements for the Harbour West area and the potential optimization of presently available storage capacity within the sanitary interceptor system to store and convey CSO for treatment (Gore and Storrie and MacLaren, 1987). The report found that until the year 2015, the Mid-Toronto Interceptor (MTI) has some capacity to contain combined sewage flow, enough to reduce the frequency and volume of overflows during the summer months to 20 and 30 percent of current values respectively. Using real-time control would even further improve on these reductions, at a cost of $ 1 million. However, increased volumes of dilute sewage, resulting from detained CSO, could reduce treatment plant efficiency and increase sludge volumes. Provision for these increased flows in the MTI, plus the creation of additional storage to contain all remaining CSO at the Western Beaches resulting from a 1-year storm could cost in excess of $23 million. Storage and treatment of separate stormwater discharges at the Western Beaches for the same 1-year storm would cost about $38 million. The report concludes that while these provisions would substantially eliminate summer overflows along the Western Beaches, no significant reduction in beach placarding could be assured because of the continuing high bacterial loadings from the Humber River during storm events.

The report also estimates that it would cost in excess of $2.5 billion to limit storm and combined sewer overflows from the entire City of Toronto to once per year on average and to provide secondary treatment of these contained overflows. Again, despite this massive expenditure, there would be no assurance that the Humber River would not continue to pollute the Western Beaches, causing placarding.

Three levels of cost-effectiveness for control measures were thus identified by this report:

- Real time control of MTI ($1 million) and best management practices.
- Site-specific control measures such as protection of Western Beaches or improvement of Harbour ($5 to 20 million)
- Major structural measures such as storage of all storm and combined sewer overflow to improve overall waterfront water quality (billions of dollars)

Several options were identified as immediately feasible, including reactive real time control of the MTI and additional storage at the Western Beaches. The report suggests that there is little benefit in spending large budgets for CSO storage or any reasonable expansion of the Main Treatment Plant by reason of trunk sewer optimization, without comprehending the costs of similarly controlling the Humber River or stormwater discharges to the Western Beaches. Tradeoffs between objectives such as CSO elimination/reduction, resulting impacts on treatment plant operations, and basement flooding must all be considered. The report also recommends that further in-place studies should be conducted to determine the impact of accepting CSO on the plant's performance during wet weather. A study of the Main Treatment Plant and Don Trunk Sewer System, for this purpose, is included in the proposed 1988 WWQIP. A study of the Humber Treatment Plant, initiated under the 1987 WWQIP was recently completed.

Beaches

The City of Toronto has carried out studies since 1984 to determine the impact of discharges from combined and storm sewer outlets and diffuse sources on the water quality of the Eastern, Western and Centre Island Beaches (Gore and Storrie, 1985; 1986 a-c; 1987 a-c; 1988). The studies included the development of models to predict fecal coliform (FC) concentrations at the beaches during wet weather and evaluate management options.

The 1987 Western Beaches Study (Gore and Storrie, 1988) recommended that a long-term model simulation be conducted to

Table 6.4 (Continued)

Projects	Initiated by	Completed
Accelerated Sewer Separation		
East York	East York, 1984-87 WWQIP	ongoing work
York	York, 1984-87 WWQIP	
Toronto	Toronto, 1984-86 WWQIP	1986
Inlet Control Works		
York	York, 1986 - 88 WWQIP	ongoing work
Cross-Connection Removal		
Scarborough	Scarborough, 1986-88 WWQIP	ongoing work
East York	East York, 1985 WWQIP	1985
York	York, 1985-88 WWQIP	ongoing work
Design of Remedial Works		
Pollution Abatement Tanks at Eastern Beaches Preliminary Design	Toronto, 1987 WWQIP	1987
Pollution Abatement Tank at Eastern Beaches Structural Design (Phase 1)	Toronto, 1988 WWQIP	ongoing work
Design and Construction of Staged Diffuser at Centre Island Beach	Toronto, 1988 WWQIP	ongoing work

Sewer Separation and Inlet Control

Approximately $29 million has been spent on accelerated sewer separation projects carried out by East York, Toronto and York under the WWQIP since 1984. These municipalities practice "partial separation", which involves the construction of new "road storm sewers" which accept storm flow from street drainage only, for a 2-year storm (East York now provides protection for a 5-year storm). Private drains, including roof leaders, remain connected to the combined sewer system.

In East York the new trunk storm sewer system has helped to reduce surcharging of the combined sewers and has greatly reduced the frequency of flooding in these areas (Gore and Storrie, 1986a). In addition, it has provided a great deal of flexibility in dealing with basement flooding and CSO pollution.

Since 1984, Toronto has constructed new road storm sewers providing separation for a total area of 180 ha. Toronto estimates that these works have removed a total of 720,000 m^3 of storm runoff from the combined sewer system on an annual basis. During the period from 1966 to 1983, approximately $182 million was spent on new road storm sewer works, removing surface storm runoff from approximately 8100 ha of the City (City of Toronto, 1984).

York has carried out considerable storm trunk sewer construction in various areas of the City. However, local storm sewers, which will make up the greatest portion of the system, have only been installed to a limited extent. The number of basement flooding complaints received by York has been significantly reduced in areas where sewer separation works have been completed. York plans to carry out another $1 million worth of sewer separation works under the 1988 WWQIP.

In 1987, York began a small-scale trial program under the WWQIP, aimed at reducing storm inflow to the sanitary/combined sewer system from roofs. This is achieved by either installing roof restrictors or disconnecting roof downspouts from the sanitary/combined system. The area addressed comprises about 300 houses. The City completed a door to door survey and obtained consents from 56 homeowners to disconnect their roof downspouts. Work was to begin in January 1988. These houses, plus 58 already disconnected represent 38 per cent of the downspouts on the two streets being considered. York is continuing this program under the 1988 WWQIP.

In some areas of the City, York prefers to install inlet controls for controlling basement flooding and CSO. The basic principle of the inlet control method is to restrict the rate of inflow to the existing sewer system so that its capacity is not exceeded. Restrictors are placed in catchbasins to limit inflow. Other catchbasins are sealed wherever positive drainage can be maintained. Runoff exceeding the capacity of the sewer is then detained, either on the streets or below ground. York generally installs underground detention tanks in conjunction with the inlet control method, mainly for basement flooding relief. Since 1986, the WWQIP has included $ 1.6 million for these works. The 1988 WWQIP provides a further $1.5 million.

A study conducted by the City of Scarborough under the 1985 WWQIP recommended a number of sewer separation projects for the southwest portion of the City (Proctor and Redfern, 1987). This area is presently served by combined sewers. Three of these projects have been included in the 1988 WWQIP, at a cost of $590,000.

Dry Weather Contamination

As a result of the storm and combined sewer outfall monitoring and investigations carried out by the local area municipalities under the WWQIP and TAWMS, corrective works have been initiated to eliminate identified sources of dry-weather contamination. To date, efforts have concentrated on bacterial pollution. Thirty-eight outfalls have been removed from the priority list for Fecal Coliforms. In order to remove an outfall from this list, the municipalities are required to resample the outfall after corrections have been made to verify that the source of bacterial contamination has been eliminated. In some cases, the municipalities have corrected identified problems, but have not done the follow-up sampling to have the outfall taken off the priority list.

Shoreline and Beach Improvements

The City of Toronto has, since 1984, undertaken work to improve the shoreline, involving the clean-up of the nearshore area by the removal of debris and sediment and the construction of armoured stone walls to control shoreline erosion. On the Eastern Beaches, an existing breakwall was removed and a shallow area at Lee-Leuty Beach which exhibited high bacterial densities was filled with sand. The City of Etobicoke made physical improvements to Rotary and Amos Waites Parks and purchased equipment to remove algae from its lakefront areas.

In 1984 the City of Toronto put pumping facilities into place to divert flow from Grenadier Pond to the Humber River. The pond discharges to the Western Beaches via the Ellis Avenue storm sewer outfall. The City later concluded that this runoff was a relatively insignificant source of bacterial contamination, and subsequently discontinued this diversion in the summer of 1986. Instead, the City has constructed a diversion structure to connect the Ellis Avenue storm sewer to Lakeshore Boulevard West to divert this discharge to the Humber River. This eliminated the last remaining outfall discharging within the breakwater at the Western Beaches.

In 1984, MTRCA completed construction of the Humber River Diversion Wall. The wall was designed to direct flow from the Humber River farther into the lake, preventing the flow from intruding behind the Western Beaches breakwater. Subsequent beach water quality monitoring indicated that a limited amount of Humber River flow still enters the area behind the breakwater, affecting Western beaches water quality.

The 1985 and 1986 Western Beaches studies identified 3 parking lot drains as point sources of pollution at Sunnyside Beach (Gore & Storrie 1986c, 1987c). Toronto has since connected these drains to an existing storm sewer outlet which extends beyond the breakwater, via the road storm sewer on Lake Shore Boulevard West.

In 1986, an overflow chamber and a hydrobrake chamber were modified by Toronto to reduce the frequency of CSOs to the Eastern Beaches at Kenilworth Avenue to once per year on average.

Investigations carried out by the City of Toronto revealed open joints along the Roncesvalles sewer outlet, which affect water quality behind the breakwater. The City plans to repair the joints as part of the 1988 WWQIP.

Metro Toronto's Roads and Traffic Department have identified a rupture in their Wilson Avenue storm sewer outfall which results in direct discharges within the breakwater near the beach east of the Boulevard Club. The repair of this sewer is included in the 1988 WWQIP.

To remedy the placarding of the Centre Island Beach, the City of Toronto plans to construct a staged diffuser east of the breakwater (Gore & Storrie, 1987d). This device will generate a high velocity jet of water which acts as a curtain, deflecting contaminated Eastern Gap water away from the Centre Island Beach area during runoff events. During dry weather periods, the staged diffuser could be operated in reverse to provide circulation water inside the breakwater as required. Construction is included under the 1988 WWQIP. The City plans to construct the device in two stages. The first phase includes the staged diffuser only, with a water intake east of the beach area. The second phase will add the inlet/outlet manifold behind the breakwater for providing circulation during dry weather, if deemed necessary.

Based on the results of a study which investigated a number of pollution abatement alternatives for the Eastern Beaches, the City of Toronto has proposed construction of two detention tanks, one at Woodbine Beach (2,250 m^3) and the other at Scarboro Beach (16,000m^3). The tanks are expected to reduce discharges from six storm sewers and two CSOs to two or three times per year, thereby substantially reducing the number of days the Eastern Beaches are placarded during the summer. Construction of the smaller tank at Woodbine Beach is included in the 1988 WWQIP at a cost of $4 million. The tank system will include an outfall at least 130-400 m in length, and a control device that will allow direction of all or part of the flow, either to the Lakefront Interceptor Sewer (for treatment at the Main WPCP) or alternatively to the extended tank outfall. This first tank will intercept 4 storm sewers and 1 CSO, and is expected to reduce the number of days of beach posting at Woodbine Beach and Beaches Park to about one third of current levels. Public hearings regarding the construction of this tank, are currently under way.

Funding

The Ontario Legislature has approved legislation to allow Metro Toronto to spend surplus funds on pollution control projects. Over the past seven years, a surplus of more than $40 million has built up in Metro's Water Supply Surplus Account. Approximately $34 million have been transferred by Metro from this account to its Water Pollution Control Measures Fund since its establishment in early 1987. A further $10 million is kept in the Water Rate Stabilization Reserve Fund (Metro Toronto Works Dept.)

MOE is currently developing a policy for funding urban stormwater related pollution remedial works. The policy will provide grant funding for certain capital works that have been ineligible for MOE direct grant funding to date. The Ministry of Transport and Communications has recently amended its funding policy for sewer separation to include the use of storage tanks in certain situations.

6.4 Infrastructure Rehabilitation Program

In 1986, the MOE announced its Infrastructure Rehabilitation Program. The objectives of this program are to:

- appraise municipal needs in rehabilitating decaying and inefficient sanitary sewers and watermains.
- propose cost-effective alternative remedial measures.
- recommend a multi-year implementation program.

The "Needs Study" is the cornerstone of this program. Needs studies usually include the following components (MOE, 1988b):

- full inventory of the existing system for entry on a micro-computer.
- physical inspection of structures.
- monitoring to determine infiltration/inflow, losses, leakage, etc.
- review of existing maintenance programs and alternative improvements.
- review of existing by-laws.
- development of priorities and a multi-year implementation program to correct deficiencies within the system along with estimated costs.

Failure to correct problems will have serious economic implications, and in addition may disrupt services, inconvenience users and cause environmental and health problems.

The cities of North York, Etobicoke, Scarborough and York are currently conducting needs studies of their sanitary sewer systems. Estimated study costs are $1.75 million, $3.6 million, $2.1 million and $800 thousand respectively. Scarborough and York are also conducting studies of their water distribution systems, at a cost of $1.5 million and $800 thousand respectively.

On completion of a needs study, the MOE will provide one-third of the net cost of recommended projects related to the rehabilitation, renovation, repair or replacement of existing systems, under the recently announced Lifelines Program.

6.5 Water Pollution Control Plant Improvements

Metropolitan Toronto is considering the construction of a new outfall for the Humber WPCP. The proposed outfall will be located and designed so that the plant effluent discharges farther into the lake. Improved treatment is also proposed for the Humber WPCP (Beak et al., 1987).

A new outfall has been planned for the Main WPCP. It is to be designed for a maximum discharge of 679 MGD and will discharge 1700 m from shore in 15 to 20 m of water. The estimated cost of construction is $45 million. The new outfall, planned for 1993, should improve effluent dispersion and reduce shoreline discharge. Other planned remedial measures include improvements to solids handling and addition of new aeration capacity (Beak et al., 1987).

For the Highland Creek WPCP, planned remedial measures include improved solids handling, upgraded aeration capacity and implementation of new decant liquor treatment facilities. These improvements are planned for 1988-1989 (Beak et al., 1987). An increase in plant capacity to 64 MGD is planned for the year 2000 to maintain adequate capacity to handle new development.

A study of the future of the North Toronto WPCP was recently completed for Metro Toronto (Gore & Storrie, 1987e). The study evaluated capital and operating costs for various options, including abandoning the plant and conveying sewage to the Main WPCP or retaining and upgrading the plant. The recommended option involves abandoning the plant, constructing a new Don Valley Sanitary Trunk Sewer to carry existing flows to the MTI and using the abandoned site for.holding tanks to contain CSO from the North Toronto and Leaside Trunk Sewers. The estimated capital cost of this option is $59 million, with annual capital and operating costs of $8.6 million. This report is still under consideration by Metro Toronto.

In 1985, Metro Council authorized an increase for their WPCPs in phosphorus removal, lowering their target from 1.0 to 0.9 ppm.

6.6 Lake Ontario Toxics Management Plan

Under the provisions of the 1978 Great Lakes Water Quality Agreement, the Canadian and U.S. governments are required to control and prevent the input of persistent toxic substances into the Great Lakes, and to rehabilitate areas of the Great Lakes already degraded by toxic substances. The Lake Ontario Toxics Committee was formed to develop the Lake Ontario Toxics Management Plan. A draft plan and summary has been developed and made available for public discussions. Five public meetings have been held, including one in Toronto.

Concurrently, the Committee is beginning preparation of the final plan.

The draft plan outlines the following goals:

- reduction of chemical inputs in the short term.
- virtual elimination of persistent toxics in the Lake in the long term.
- achievement of protective ambient levels in the interim.

The draft plan recommends focusing corrective activities on the Niagara River and the seven IJC areas of concern (RAP sites), one of which is Metro Toronto.

6.7 Other Remedial Programs

In addition to the WWQIP, local municipalities continue to carry out regular works and maintenance programs. These programs include, among other things:

- sewer inspection
- sewer maintenance and repair
- sewer cleaning
- catchbasin cleaning and maintenance
- street cleaning
- dog litter control
- enforcement of numerous bylaws, including plumbing and sewer use bylaws.

The Cities of North York and Toronto have both run successful Household Hazardous Waste Collection Programs. Etobicoke, Scarborough and Metro Toronto planned similar programs for 1987-1988. The City of Mississauga is setting up a year-round collection depot.

Under an MOE program called SCOUR (Students Cleaning Our Urban Rivers), a cleanup of the streams and banks of Metro river valleys is conducted each summer by student work crews.

Proposals made in 1984 to control birds on the Western Beaches were not implemented as it was not practical to do so while the Humber River Diversion Jetty was being constructed. In 1985, the Western Beaches, Centre Island Beaches and Marie Curtis Park were included in the Canada Goose Control Program. Approximately 1400 adult geese were captured and shipped to a bird sanctuary in the United States. This program continues each year under the jurisdiction of the Canadian Wildlife Service.

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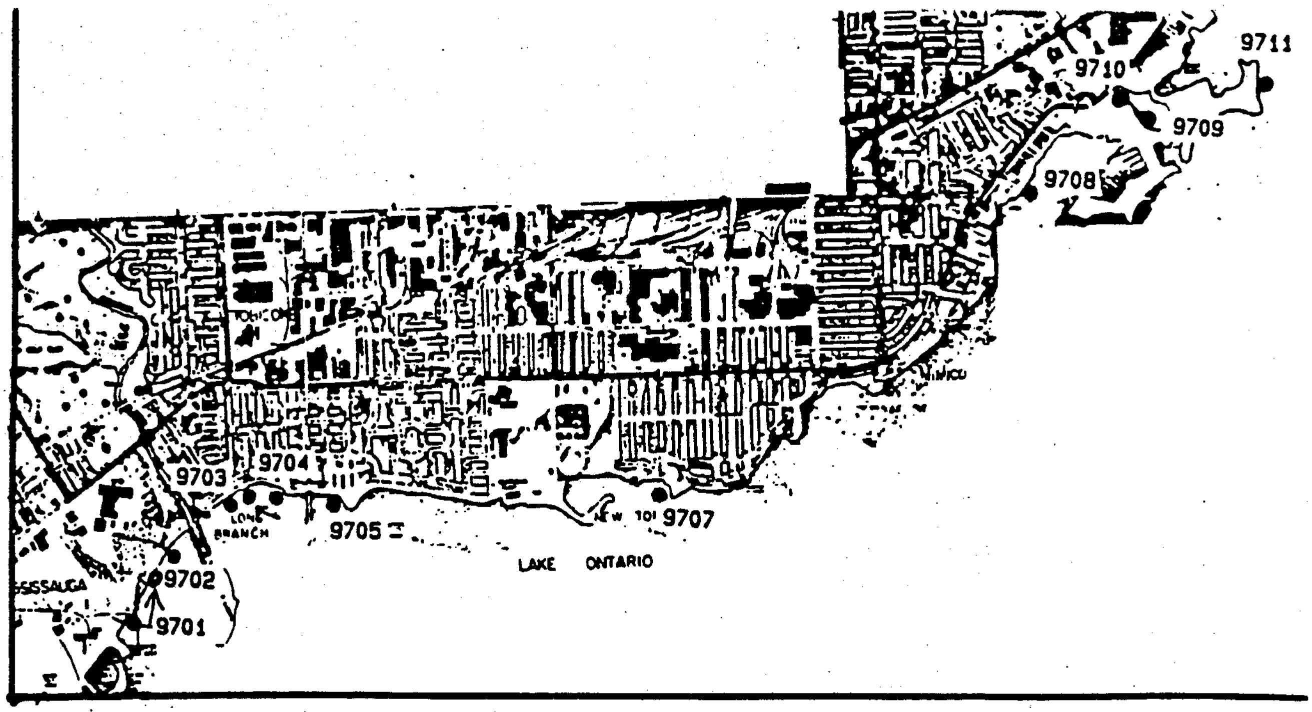
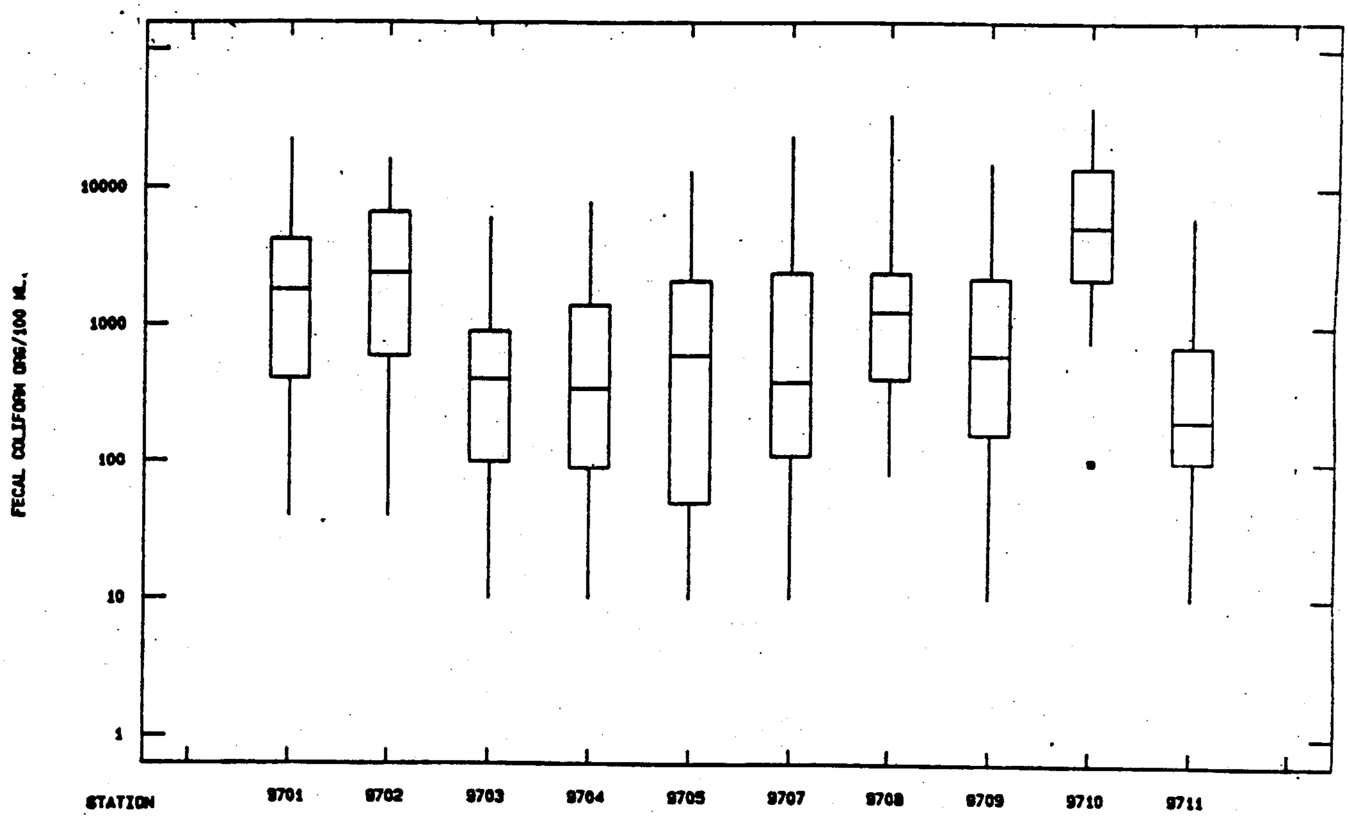
APPENDIX A

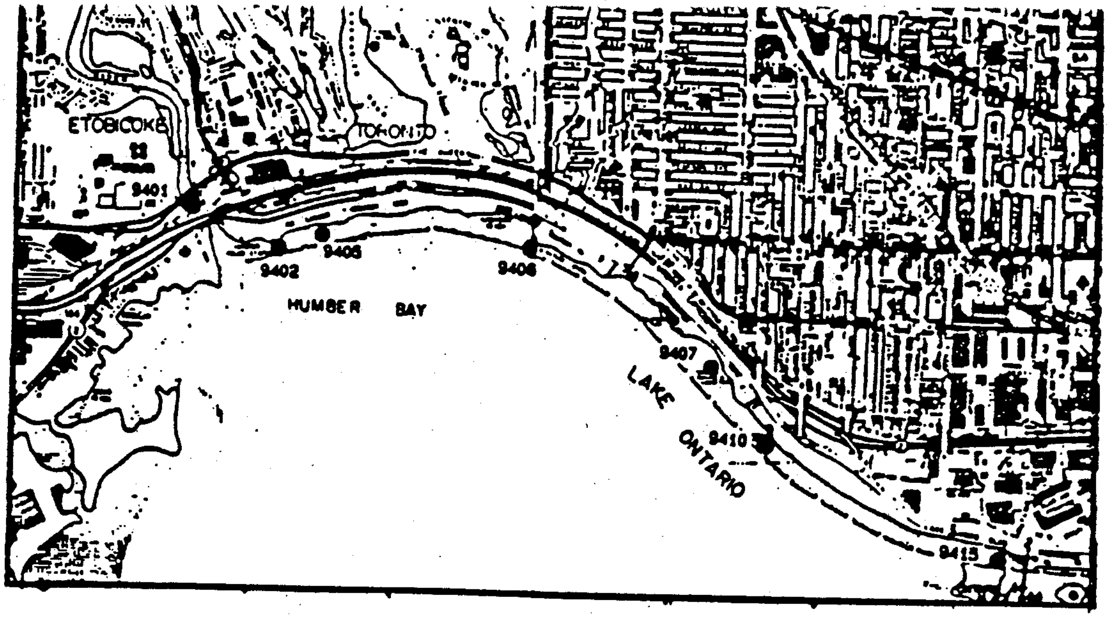
Fecal Coliform Ranges - Summer 1987

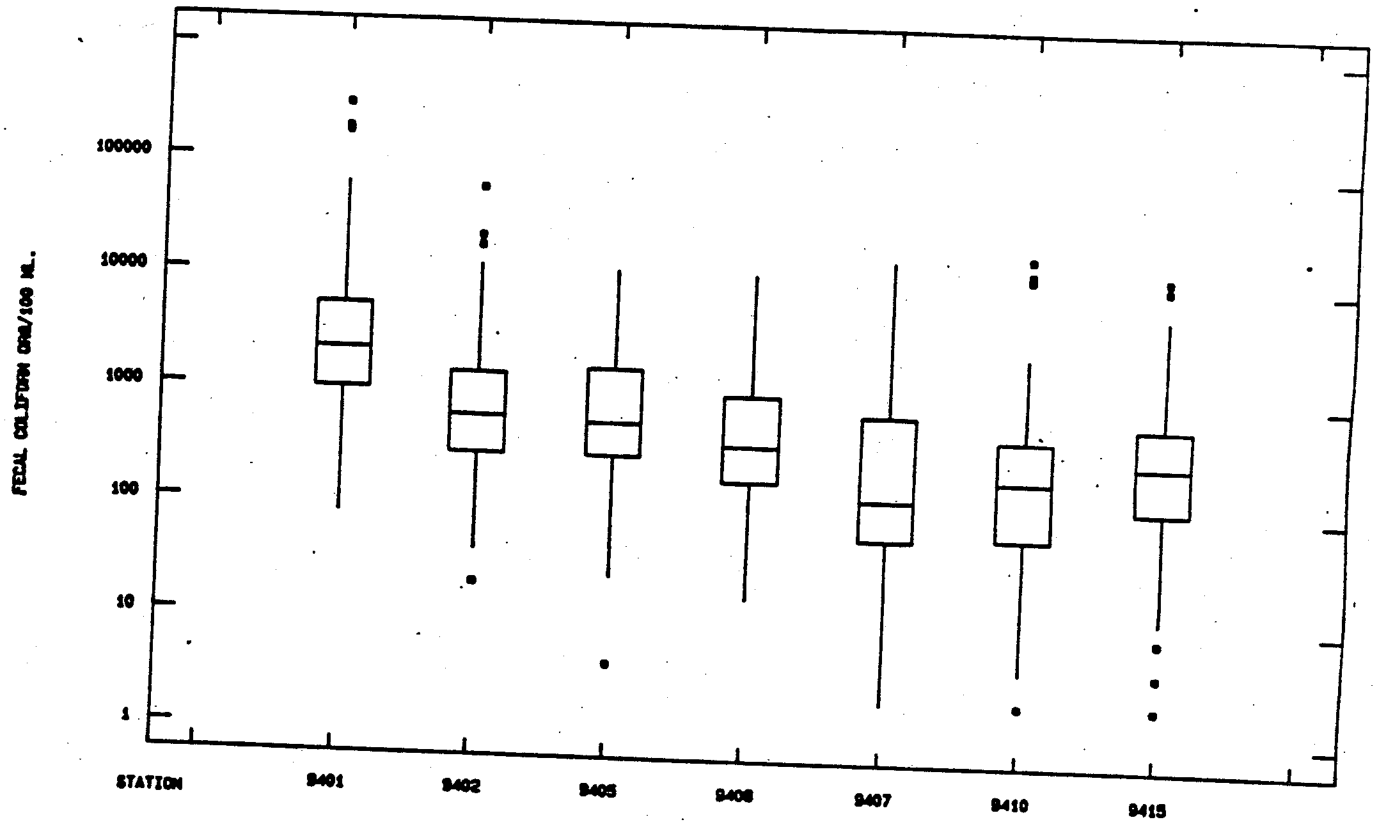




N	35	35	35	35	35	35	34	35	34	35
MAXIMUM	22000	16000	6000	7800	13000	23000	33000	15000	38000	6200
MINIMUM	40	40	10	10	10	10	80	10	100	10
MEDIAN	1800	2400	400	340	600	380	1250	600	5250	200
UPPER QUARTILE	4200	6600	900	1400	2100	2400	2400	2200	14000	700
LOWER QUARTILE	400	590	100	90	50	110	400	160	2200	100
GEOMETRIC MEAN	1341	1651	334	338	372	420	1114	472	4692	214
SD UPPER LIMIT	5248	6457	1380	1413	2042	2291	4074	2344	14454	794
SD LOWER LIMIT	240	295	48	48	30	35	224	45	1259	35

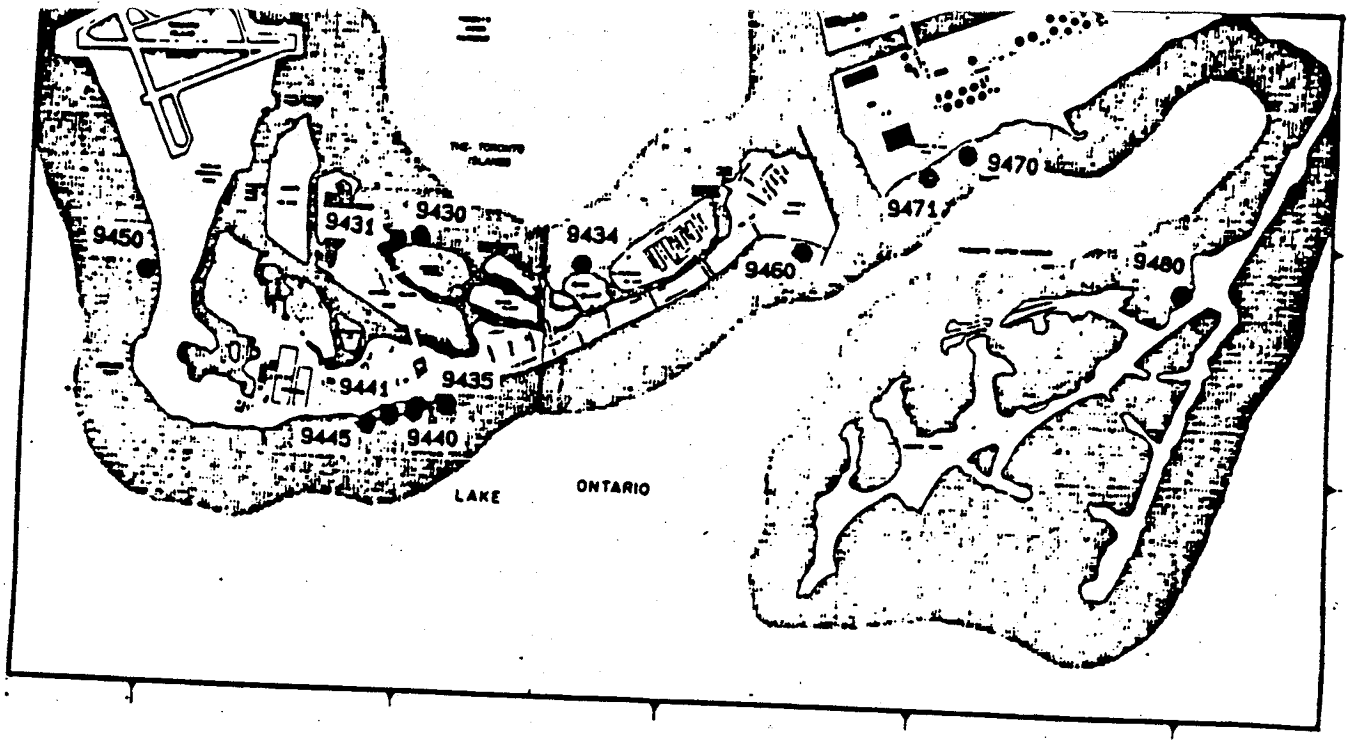
Fecal Coliform Levels along the Etobicoke Beaches During the Summer of 1987.

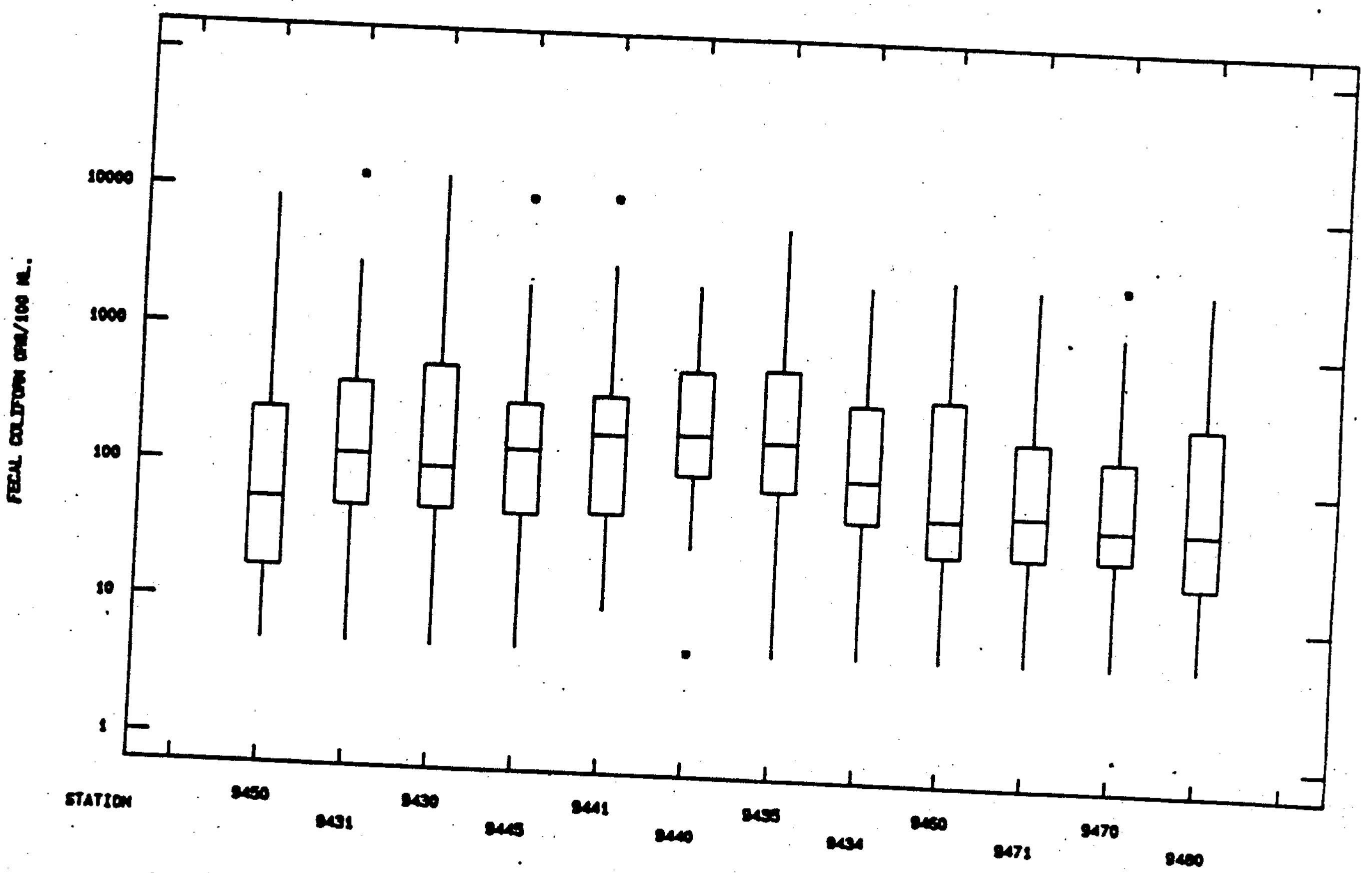




N	93	95	95	95	95	89	94
MAXIMUM	150000	29000	5733	5600	7800	8900	6300
MINIMUM	40	10	2	8	1	1	1
MEDIAN	1100	300	272	180	62	96	140
UPPER QUARTILE	2700	710	800	493	350	224	310
LOWER QUARTILE	500	140	139	86	28	30	56
GEOMETRIC MEAN	1372	335	291	196	84	93	128
SD UPPER LIMIT	5370	1230	955	631	282	251	407
SD LOWER LIMIT	257	62	58	42	9	9	16

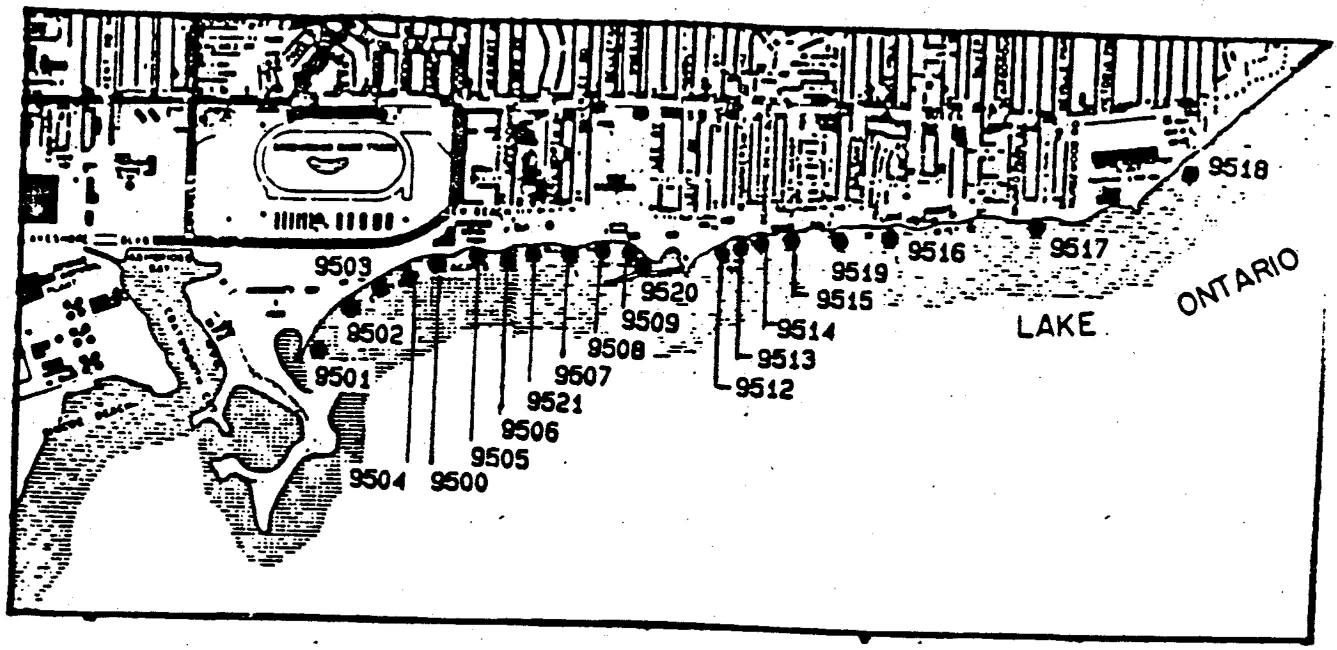
Fecal Coliform Levels along the Western Beaches During the Summer of 1987.

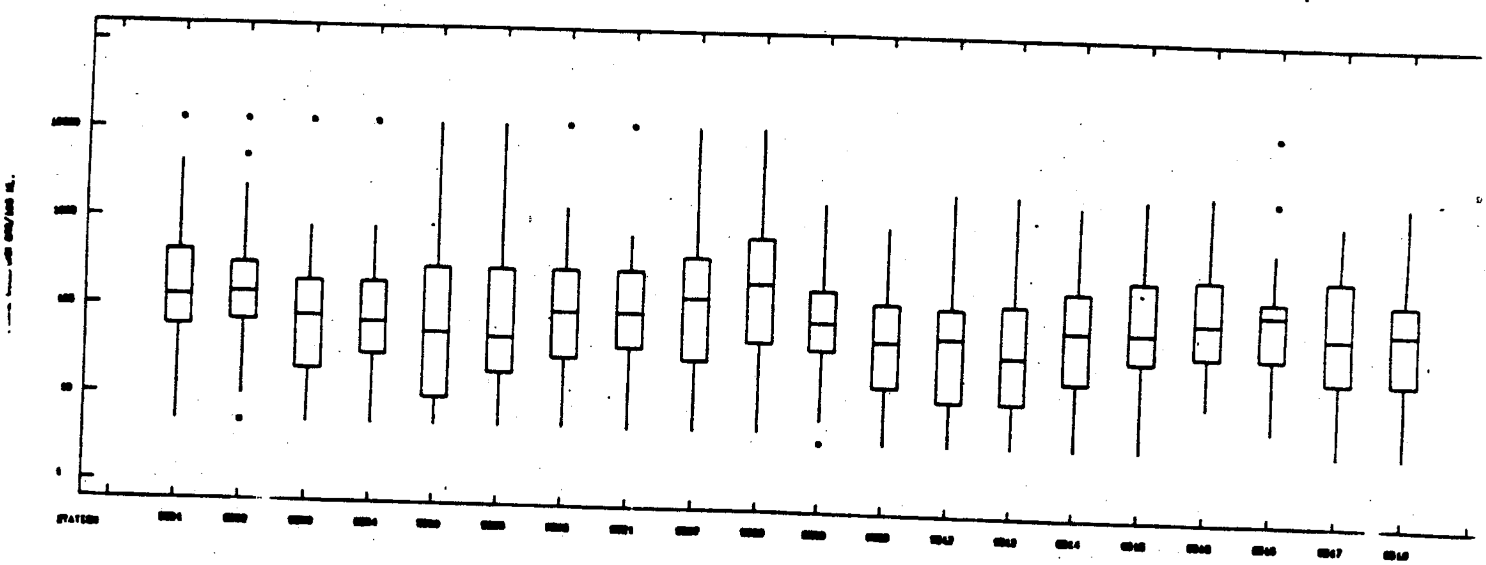




STATION	9450	9431	9430	9445	9441	9440	9435	9434	9460	9471	9470	9480
N	96	44	44	96	68	43	42	44	96	96	96	96
MAXIMUM	8600	13000	13000	9600	10000	2400	6800	2600	3000	2700	2900	2800
MINIMUM	1	1	1	1	1	1	1	1	1	1	1	1
MEDIAN	1	80	50	1	1	40	80	80	1	1	1	1
UPPER QUARTILE	30	288	508	43	200	230	380	140	80	40	30	20
LOWER QUARTILE	1	1	1	1	1	1	1	1	1	1	1	1
GEOMETRIC MEAN	5	32	44	5	12	23	82	20	6	5	4	4
SD UPPER LIMIT	15	63	95	17	31	47	93	40	17	13	10	13
SD LOWER LIMIT	1	1	1	1	1	1	1	1	1	1	1	1

Fecal Coliform Levels at Toronto Island Beaches, Cherry Street Beaches and Eastern Headland During the Summer of 1987.

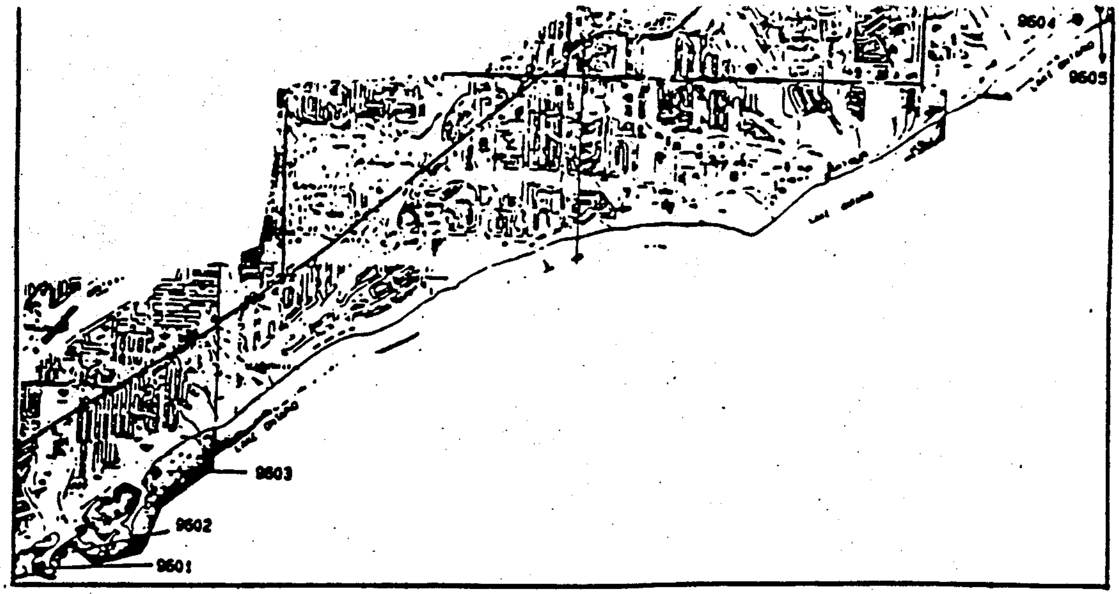


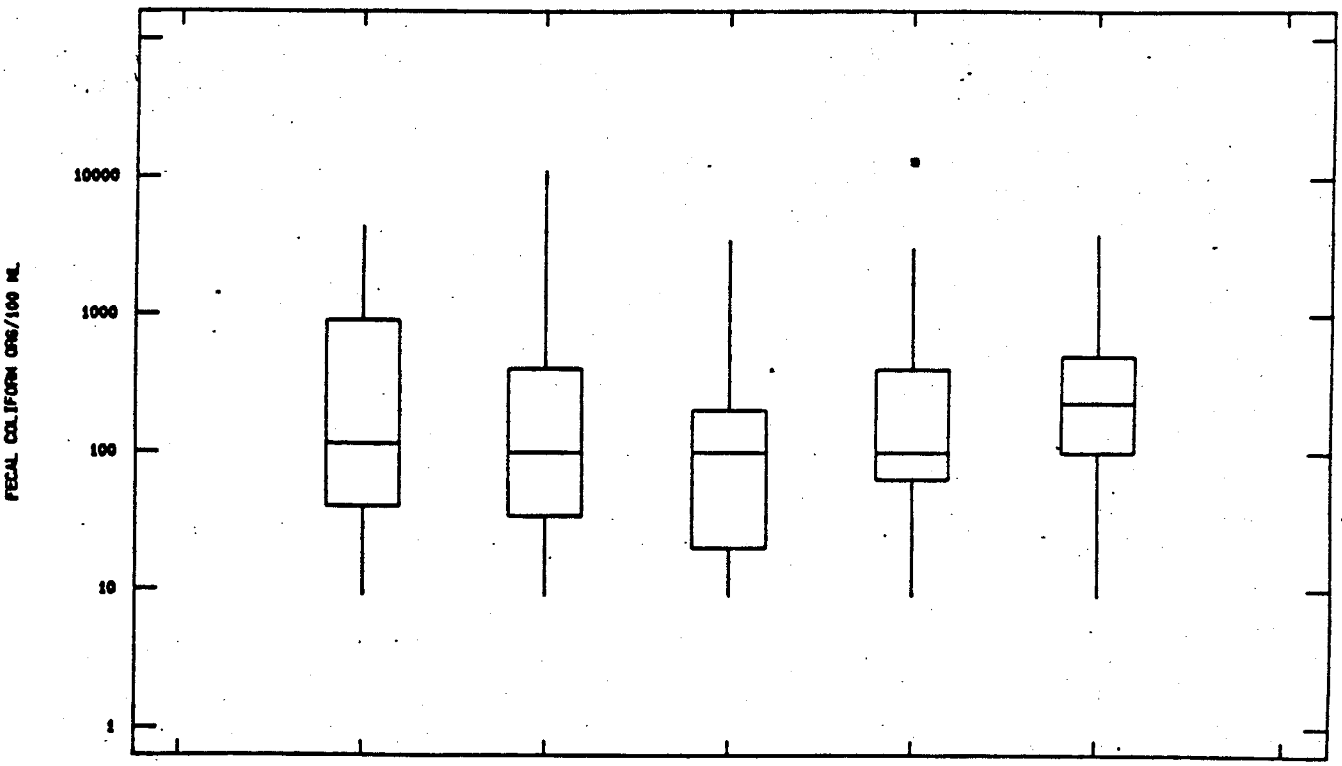


	42	42	42	42	42	42	41	41	42	42
JM	13000	13000	13000	13000	13000.	13000	13000	13000	13000	13000
M	5	5	5	5	5	5	5	5	5	5
I	130	145	80	70	55	50	100	100	155	235
QUARTILE	420	310	200	200	300	300	300	300	440	780
QUARTILE	60	70	20	30	10	20	30	40	30	50
TRIC MEAN	132	121	67	67	60	59	86	84	119	187
PER LIMIT	550	468	257	251	631	234	331	331	513	741
ER LIMIT	14	15	9	8	6	7	10	10	11	22

	42	40	42	42	41	42	40	41	42	42
JM	9000	4500	13000	13000	10000	13000	16000	100000	6800	13000
M	5	5	5	5	5	5	20	10	5	5
I	220	125	145	85	200	200	290	400	200	250
QUARTILE	590	425	370	430	680	1000	1150	600	1200	600
QUARTILE	90	30	20	20	40	80	100	100	50	50
TRIC MEAN	212	104	67	101	136	223	318	296	223	170
PER LIMIT	794	447	363	468	603	977	1230	1349	1023	724
ER LIMIT	32	10	8	9	13	23	54	35	22	18

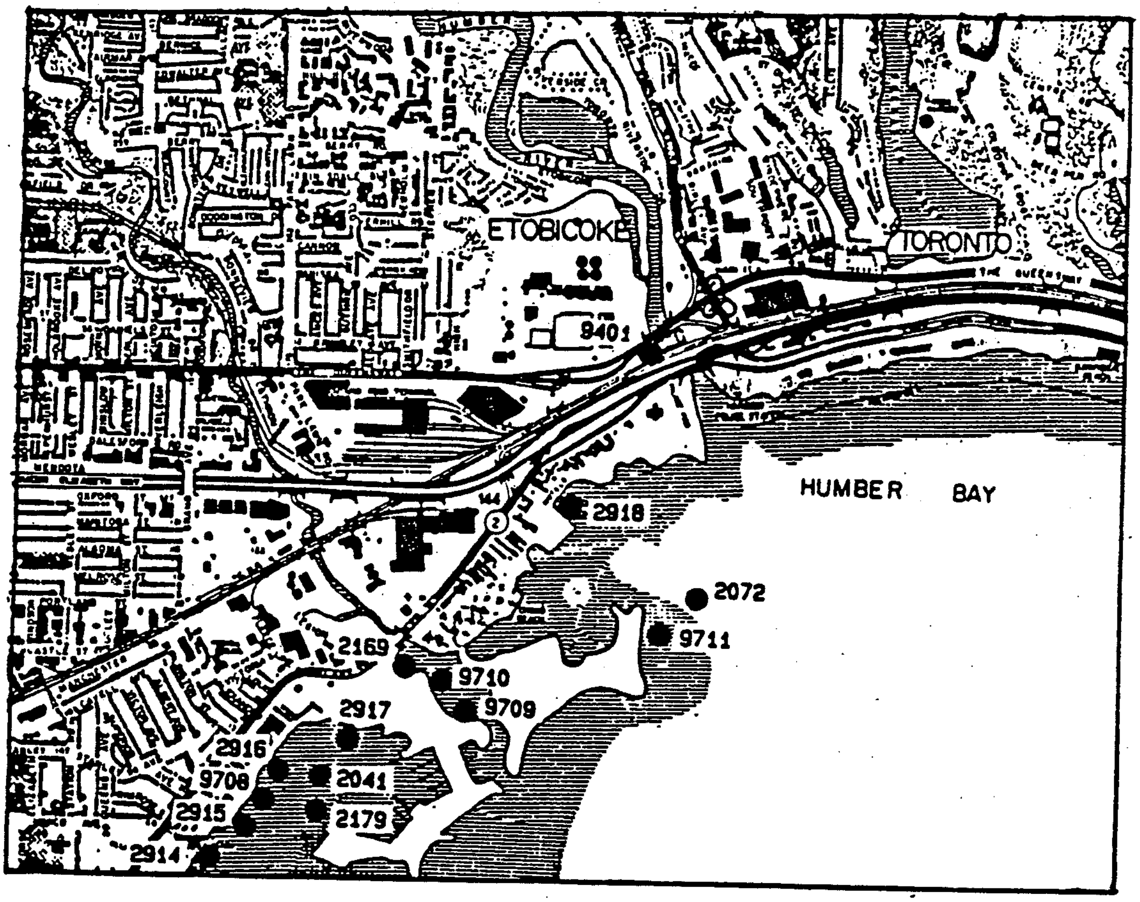
Fecal Coliform Levels along the Eastern Beaches During the Summer of 1987.

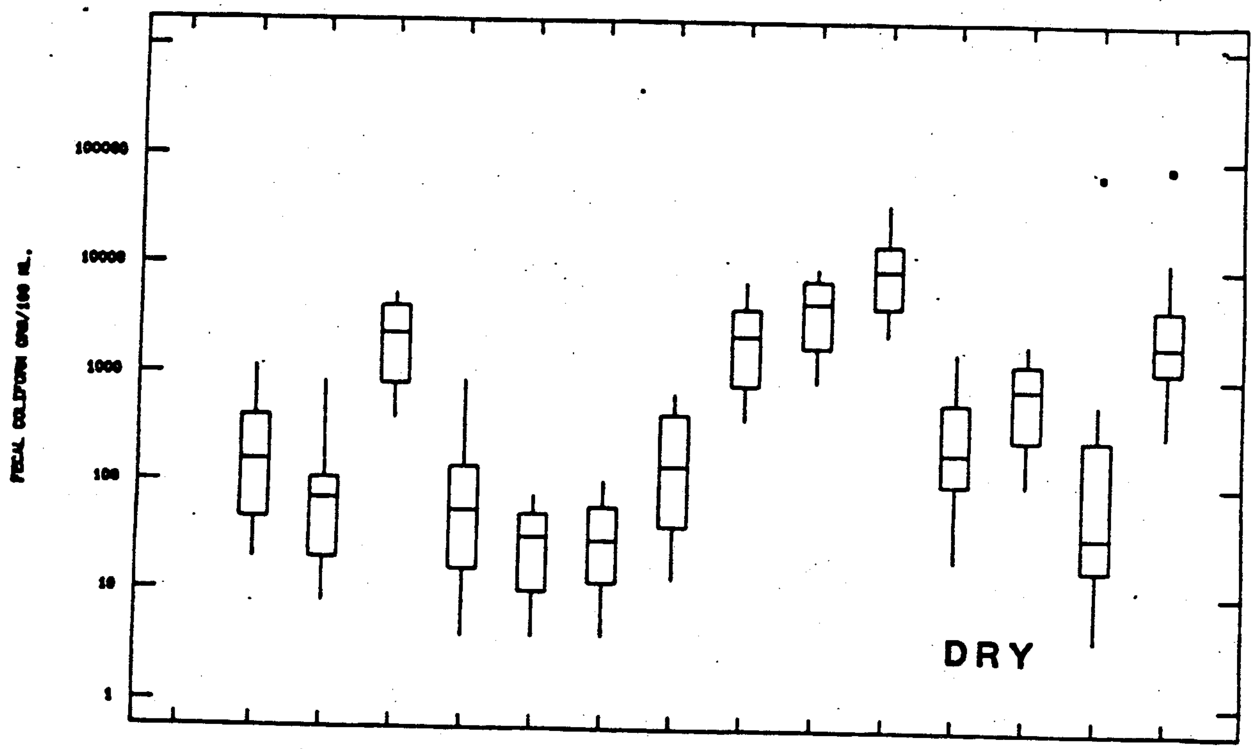




STATION	9601	9602	9603	9604	9605
N	140	140	132	136	126
MAXIMUM	4300	11000	3400	13000	3800
MINIMUM	9	9	9	9	9
MEDIAN	115	99	99	100	230
UPPER QUARTILE	900	400	200	400	500
LOWER QUARTILE	40	35	20	65	100
GEOMETRIC MEAN	168	116	64	148	230
SD UPPER LIMIT	692	468	195	513	708
SD LOWER LIMIT	21	15	13	27	54

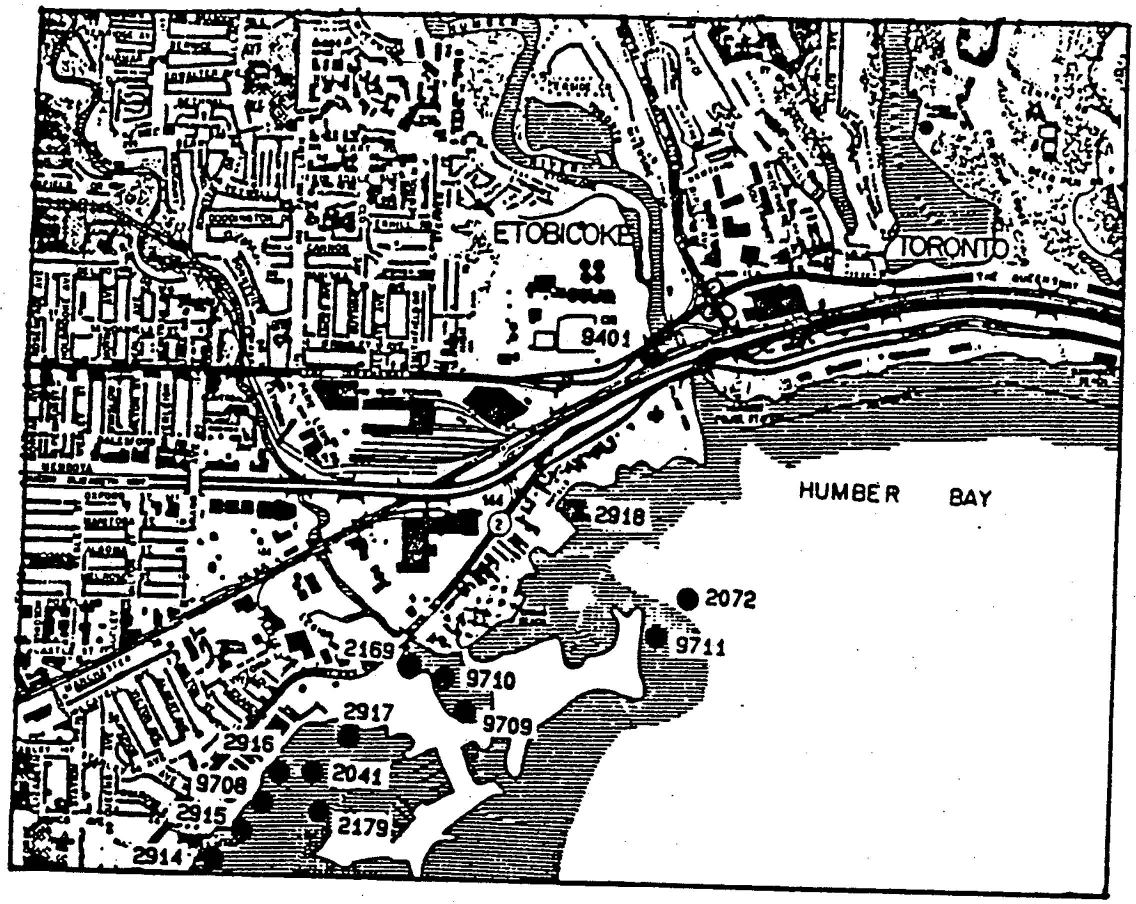
Fecal Coliform Levels along Scarborough Beaches During the Summer of 1987.

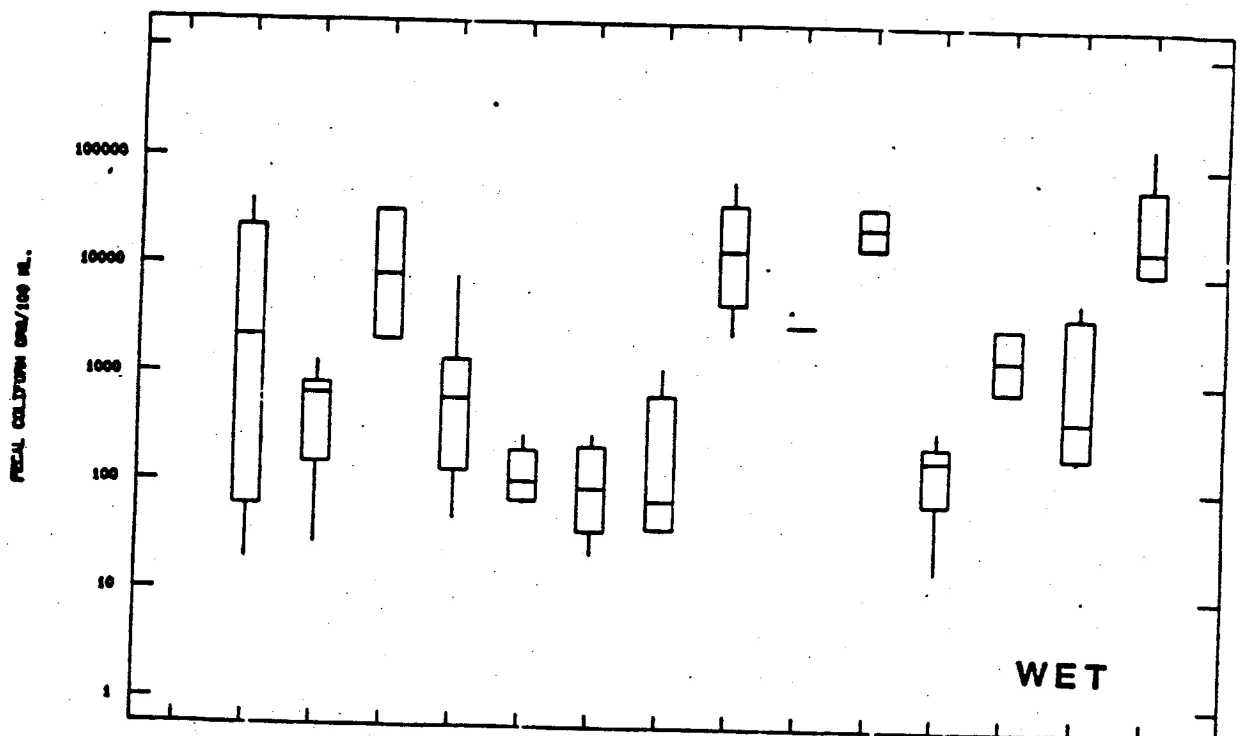




STATION	2914	2915	9708	2179	2916	2917	2041	2169	9709	9710	2918	9711	2072	9401
#	16	14	4	14	14	14	14	14	4	4	14	4	14	12
MAXIMUM	1160	840	8400	880	76	104	880	7300	9800	38000	1880	2000	71000	86000
MINIMUM	20	8	400	4	4	4	13	400	900	2400	20	100	4	300
MEDIAN	162	72	2480	88	32	30	144	3380	4800	9800	204	800	34	2000
UPPER QUARTILE	410	100	4300	140	82	60	440	4100	7800	16000	876	1480	268	8180
LOWER QUARTILE	87	20	1080	16	10	12	40	830	2380	4300	100	400	17	1300
GEOMETRIC MEAN	148	50	1081	88	32	27	128	1858	3734	9093	197	896	78	2802
SD UPPER LIMIT	460	190	8370	186	82	62	398	4870	10000	22909	617	1908	828	10000
SD LOWER LIMIT	31	11	862	9	6	9	28	661	1289	3311	47	181	3	801

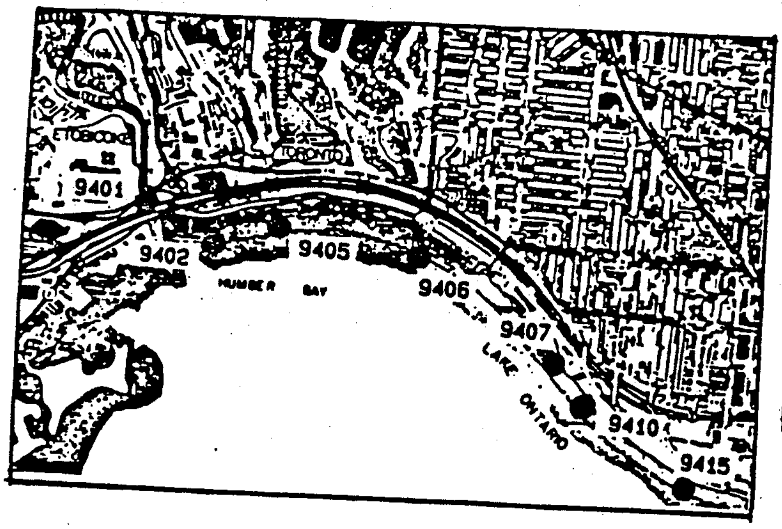
Fecal Coliform Levels in Humber Bay Waterfront Embayments During Dry Summer Days in 1987.

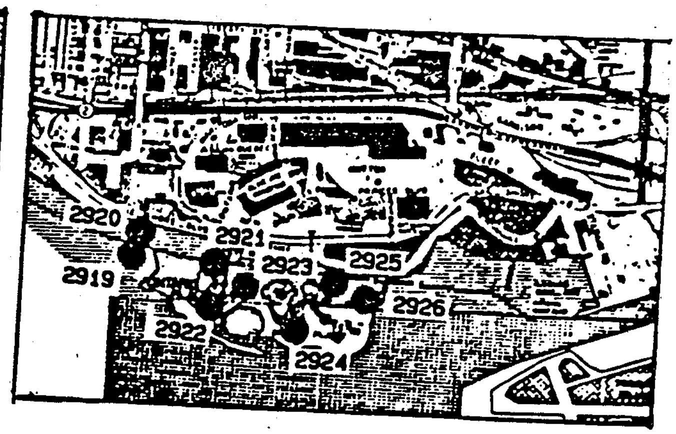


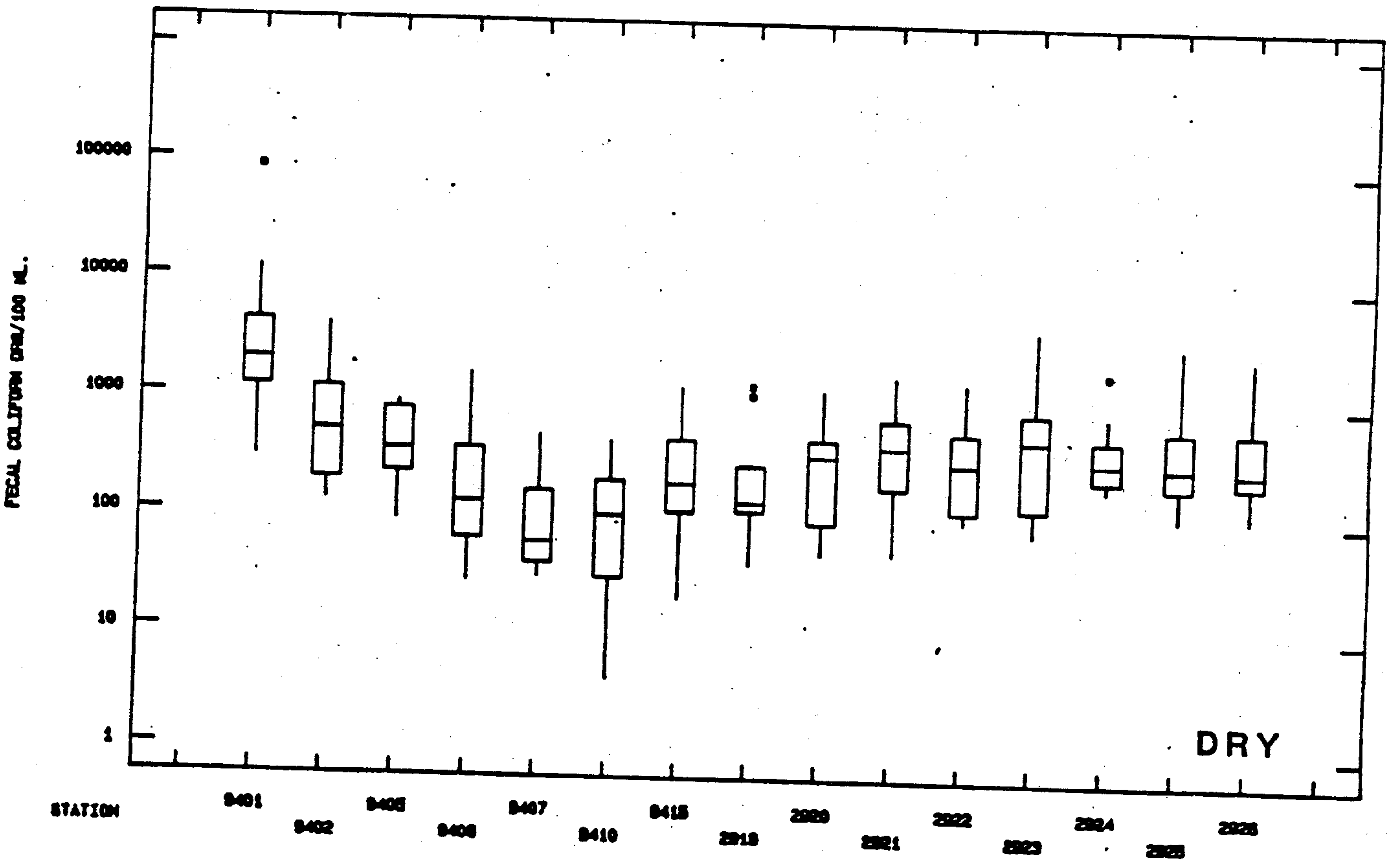


STATION	2914	2915	9708	2179	2916	2917	2041	2169	9709	9710	2918	9711	2072	9401
N	8	8	2	10	8	8	6	8	2	2	8	2	8	4
MAXIMUM	40000	1300	33000	8100	284	280	1200	68000	3000	38000	340	3000	8400	180000
MINIMUM	20	28	2100	48	66	23	40	2800	3000	16000	17	800	184	10000
MEDIAN	8134	660	17680	688	106	100	80	18900	3000	27000	180	1900	446	18500
UPPER QUARTILE	23800	838	33000	1400	207	227	680	41800	3000	38000	239	3000	3900	88000
LOWER QUARTILE	90	310	2100	132	70	38	40	8280	3000	16000	82	800	196	10800
GEOMETRIC MEAN	1291	388	8328	821	120	89	137	13730	3000	24668	123	123	732	20893
SD UPPER LIMIT	10849	1289	82480	2344	209	219	838	44668	-	48709	309	3890	2818	63176
SD LOWER LIMIT	33	66	1047	74	66	30	28	3718	-	13162	39	880	141	6919

Fecal Coliform Levels in Humber Bay Waterfront Embayments During Wet Summer Days in 1987.

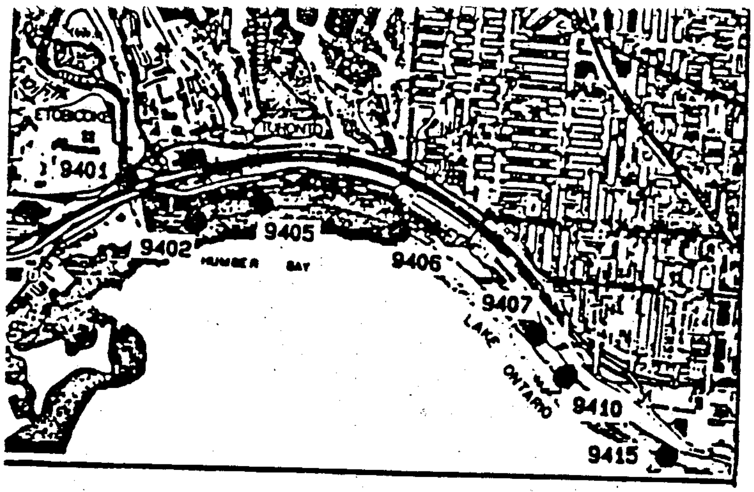


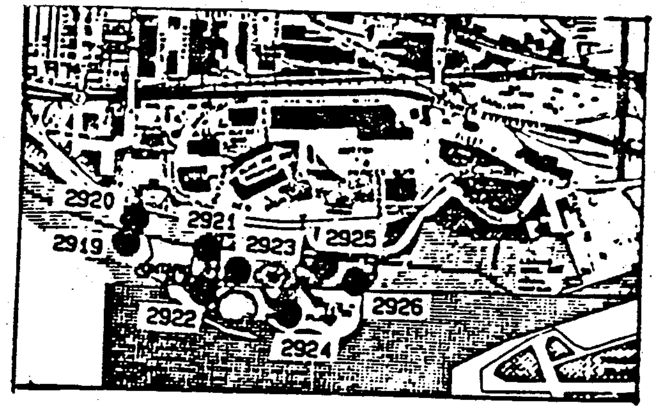


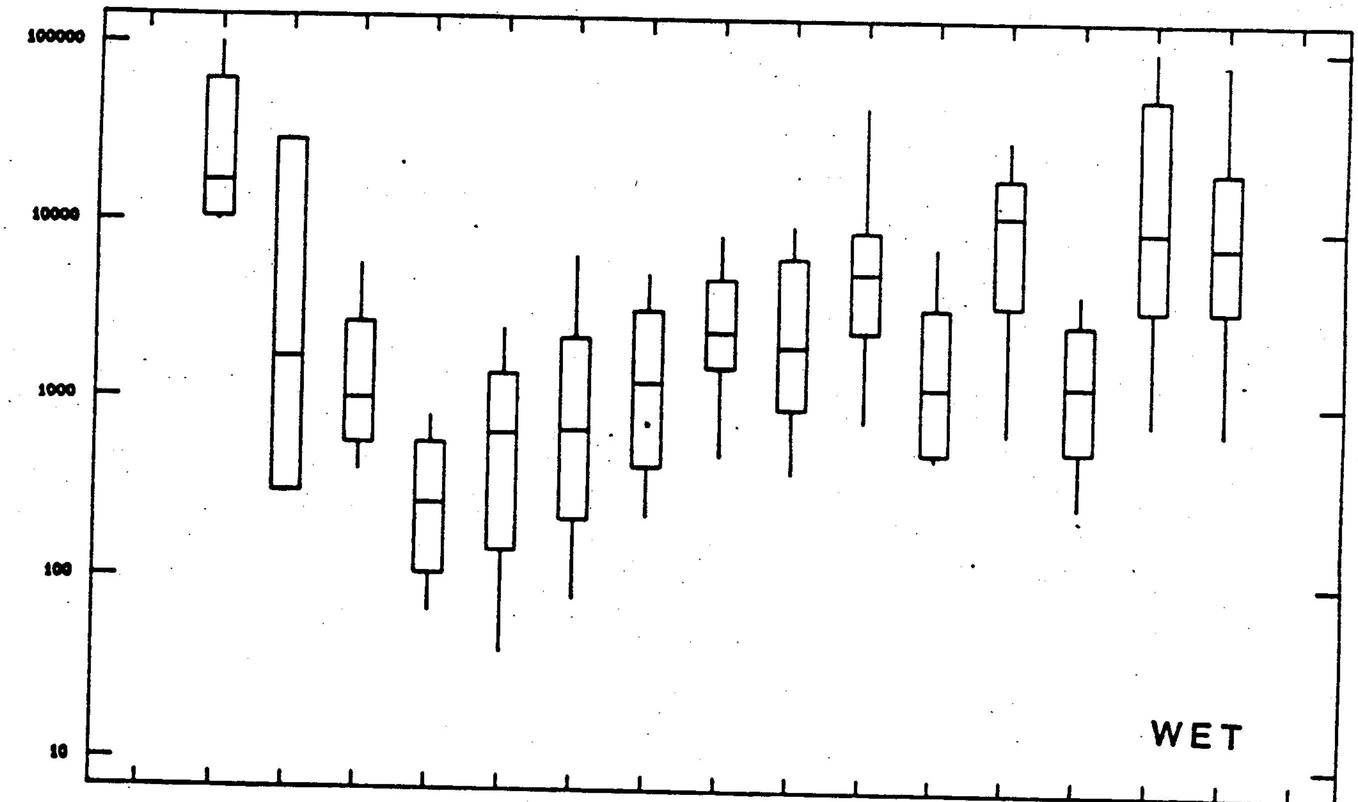


STATION	9401	9402	9405	9406	9407	9410	9415	2919	2920	2921	2922	2923	2924	2925	2926
N	12	12	12	12	12	12	12	13	14	14	14	14	13	14	14
MAXIMUM	86000	4000	693	1600	460	430	1250	1300	1200	1600	1440	4100	1800	3100	2800
MINIMUM	300	130	90	27	30	4	20	40	50	80	96	77	104	110	110
MEDIAN	2000	610	368	128	89	107	188	132	330	408	282	800	310	290	272
UPPER QUARTILE	5180	1170	790	377	160	197	488	272	460	690	840	810	490	600	600
LOWER QUARTILE	1200	196	229	63	40	31	110	112	90	180	116	124	220	196	210
GEOMETRIC MEAN	2502	836	370	142	83	71	189	177	240	362	284	488	362	374	384
SD UPPER LIMIT	10000	1448	741	417	188	218	680	437	603	671	676	1614	678	968	933
SD LOWER LIMIT	601	166	170	36	30	13	66	60	79	132	108	166	178	126	136

Fecal Coliform Levels along Western Beaches and in Ontario Place Lagoons During Dry Summer Days in 1987.

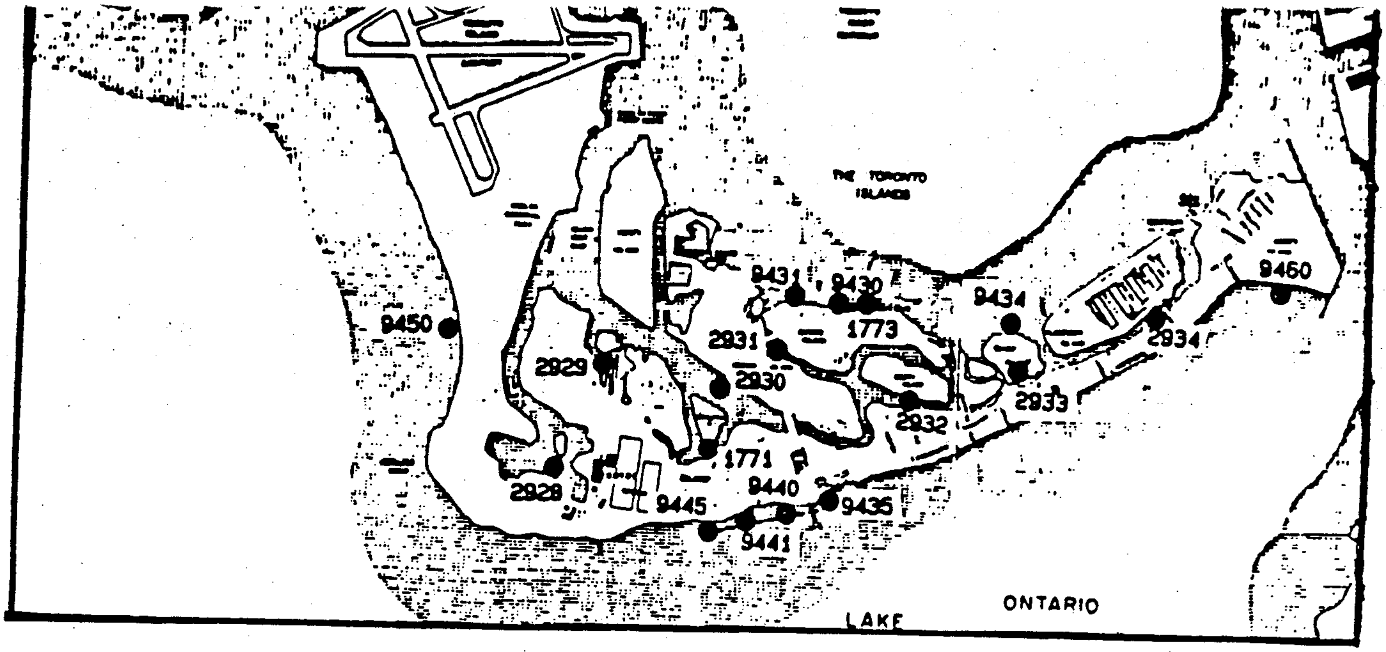


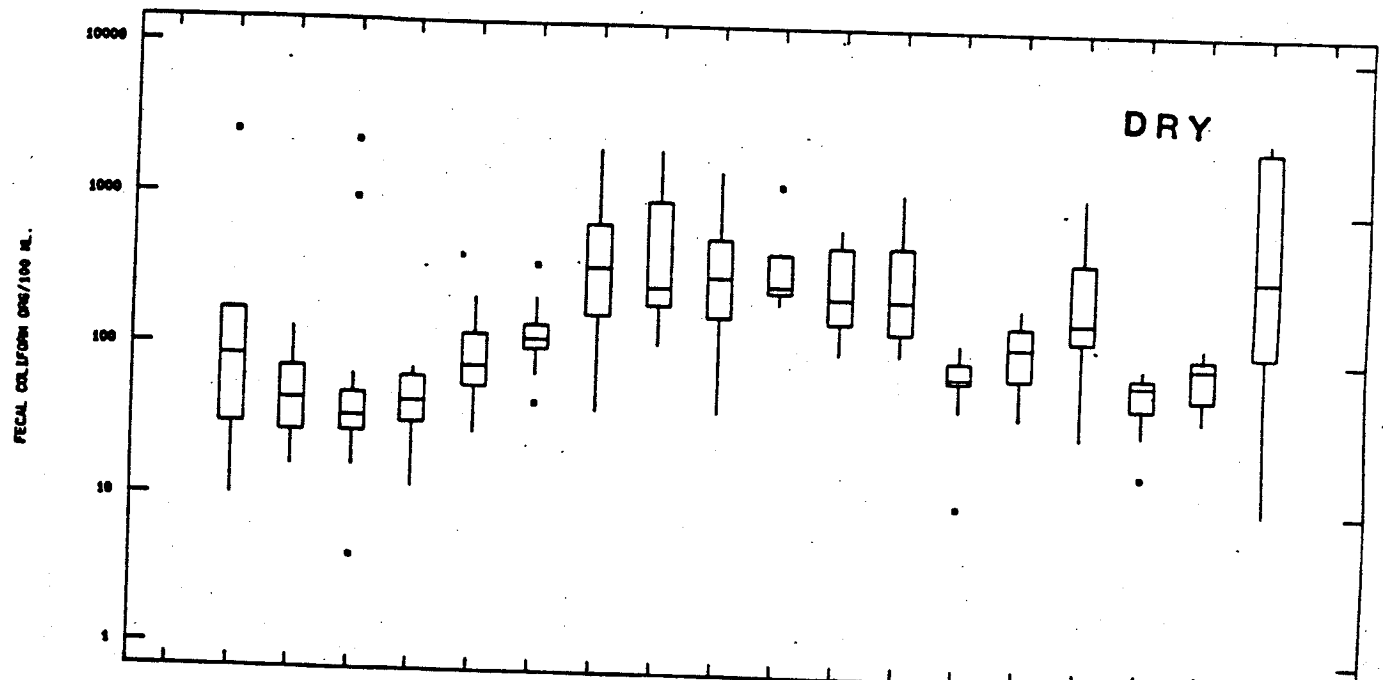




STATION	9401	9402	9405	9406	9407	9410	9415	2919	2920	2921	2922	2923	2924	2925	2926
N	4	3	4	4	4	4	4	8	8	8	8	8	8	8	8
MAXIMUM	180000	29000	8733	800	2800	6600	8200	8700	10000	47000	7600	31000	4200	146000	88000
MINIMUM	10000	300	400	67	40	80	230	496	400	780	484	680	288	780	700
MEDIAN	18800	1700	1034	290	668	608	1400	2430	2410	8860	1290	11780	1270	10880	8080
UPPER QUARTILE	68000	29000	3800	608	1680	3688	3600	8680	7080	9380	3400	19880	2900	61800	22700
LOWER QUARTILE	10800	300	600	119	288	340	818	1600	910	2880	824	4880	884	3740	4430
GEOMETRIC MEAN	35893	2488	1238	247	484	703	1176	2489	2218	8232	1427	7700	1200	11763	8208
SD UPPER LIMIT	83176	19498	3848	678	2089	3467	4074	6026	6761	16888	3890	30818	3981	60286	33113
SD LOWER LIMIT	6918	198	372	78	63	98	282	912	817	1448	468	1868	427	1860	1888

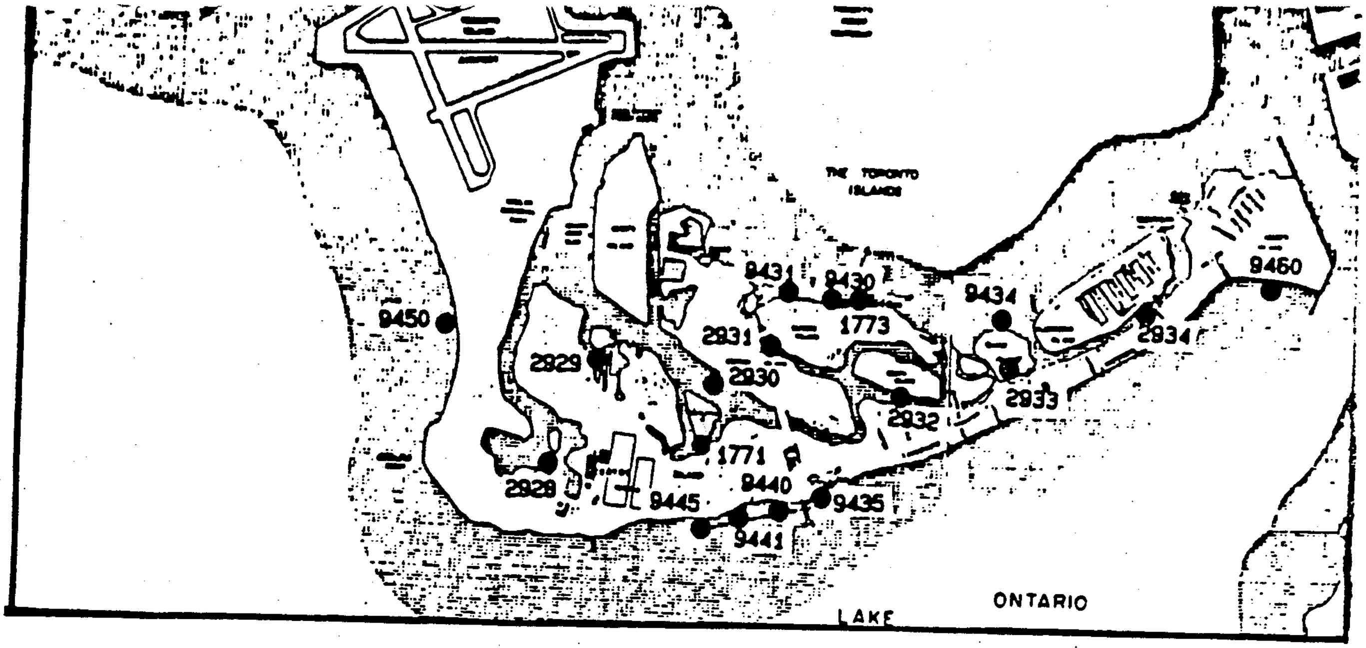
Fecal Coliform Levels along Western Beaches and in Ontario Place Lagoons During Wet Summer Days in 1987.

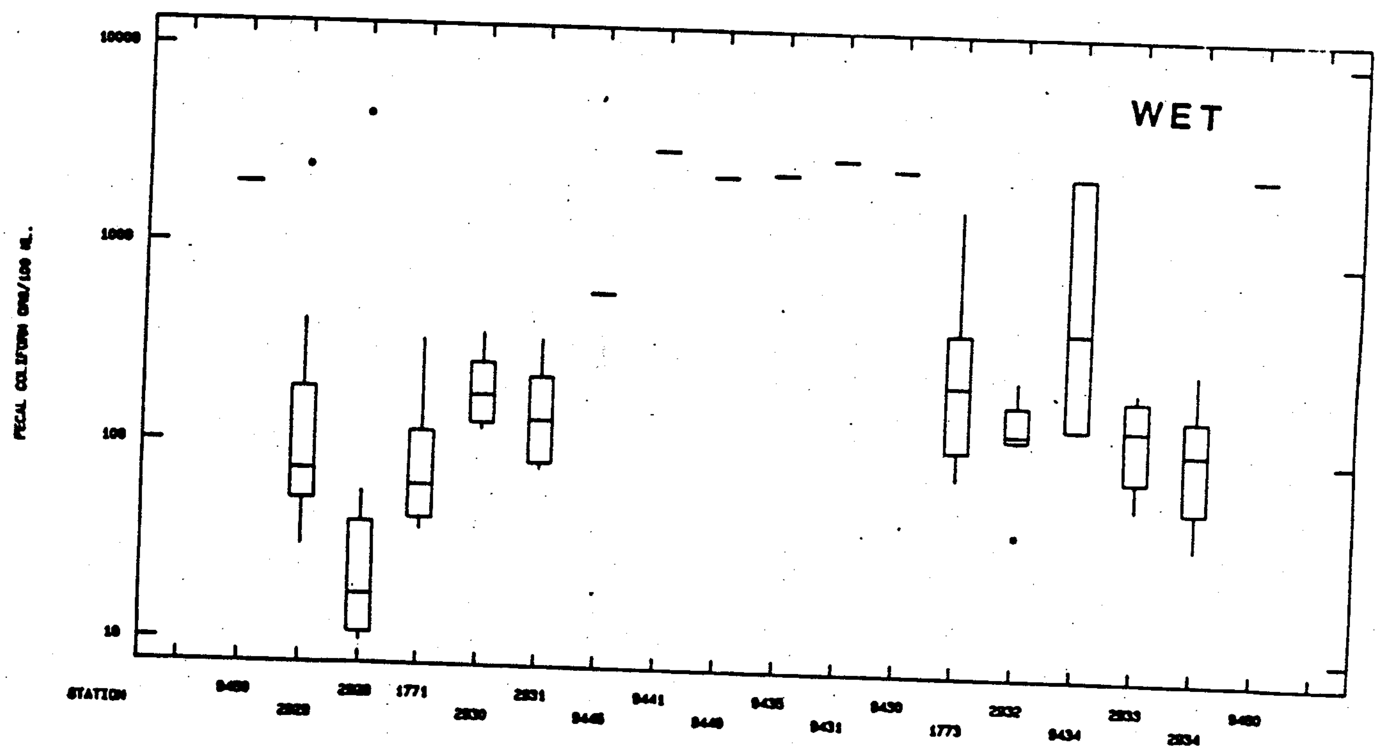




STATION	9450	2929	2928	1771	2930	2931	9445	9441	9440	9435	9431	9430	1773	2932	9434	2933	2934	9460
N	6	10	14	14	14	14	6	6	6	6	6	6	14	14	6	14	14	6
MAXIMUM	2600	132	2320	73	216	360	2200	2200	16	1300	680	1200	120	212	1200	88	124	3000
MINIMUM	10	16	4	12	28	44	40	110	40	210	100	100	10	40	30	17	40	10
MEDIAN	88	44	34	44	78	116	378	266	380	278	238	280	72	116	178	68	90	350
UPPER QUARTILE	170	72	48	64	124	144	690	1000	860	480	610	820	92	180	430	76	104	2600
LOWER QUARTILE	30	27	27	32	86	100	170	200	170	280	160	140	68	72	130	48	88	110
GEOMETRIC MEAN	99	47	48	40	82	120	329	387	290	364	269	278	67	111	197	38	80	318
SD UPPER LIMIT	479	87	186	68	141	191	1096	1096	912	692	613	676	117	174	603	89	115	1738
SD LOWER LIMIT	11	23	7	22	48	72	72	118	72	182	123	102	34	66	80	38	68	26

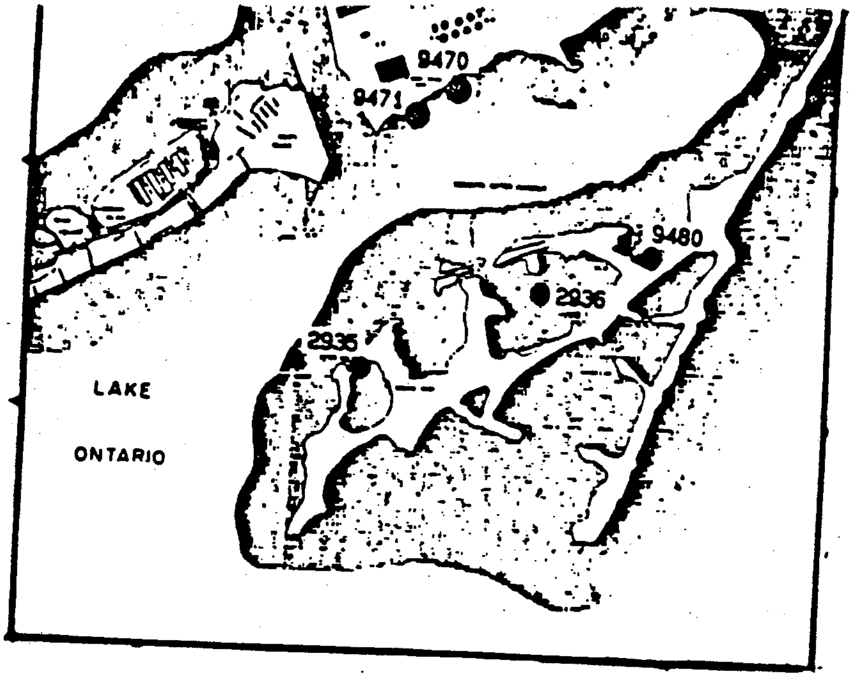
Fecal Coliform Levels along Toronto Island Shoreline (including Lagoons) During Dry Summer Days in 1987.

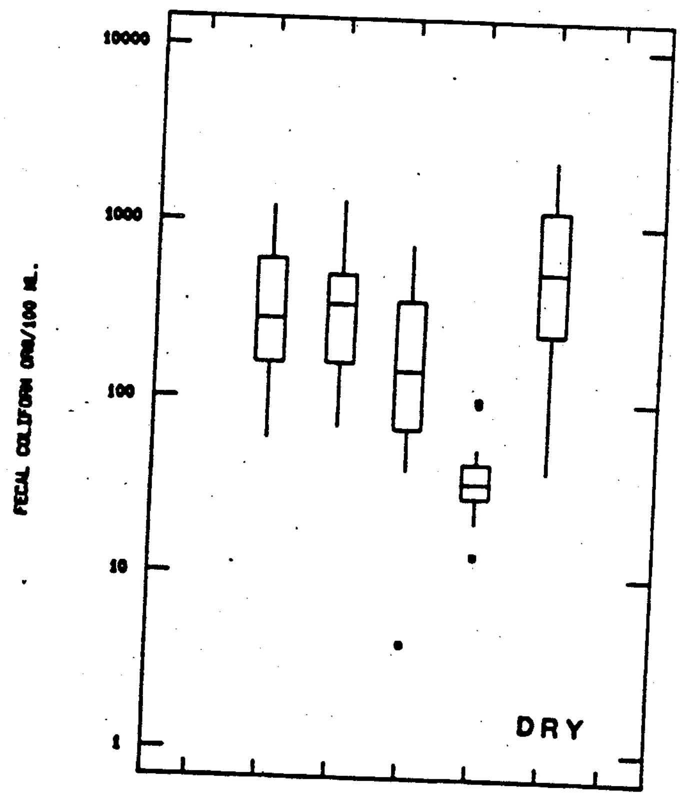




N	1	8	8	8	8	8	1	1	1	1	1	1	8	8	3	8	8	1
MAXIMUM	2003	2480	4600	340	372	380	600	3200	2400	2800	3000	2700	1720	244	2600	220	280	2700
MINIMUM	2003	30	10	37	120	76	600	3200	2400	2800	3000	2700	76	40	140	66	36	2700
MEDIAN	2003	73	18	63	182	140	600	3200	2400	2800	3000	2700	226	130	430	146	110	2700
UPPER QUARTILE	2003	282	42	124	268	227	600	3200	2400	2800	3000	2700	432	183	2600	200	165	2700
LOWER QUARTILE	2003	82	11	42	130	82	600	3200	2400	2800	3000	2700	106	122	140	78	58	2700
GEOMETRIC MEAN	2003	119	36	76	190	142	600	3200	2400	2800	3000	2700	244	130	839	126	99	2700
SD UPPER LIMIT	-	427	196	188	282	281	-	-	-	-	-	-	631	214	2089	209	191	-
SD LOWER LIMIT	-	23	3	33	123	76	-	-	-	-	-	-	79	74	110	68	46	-

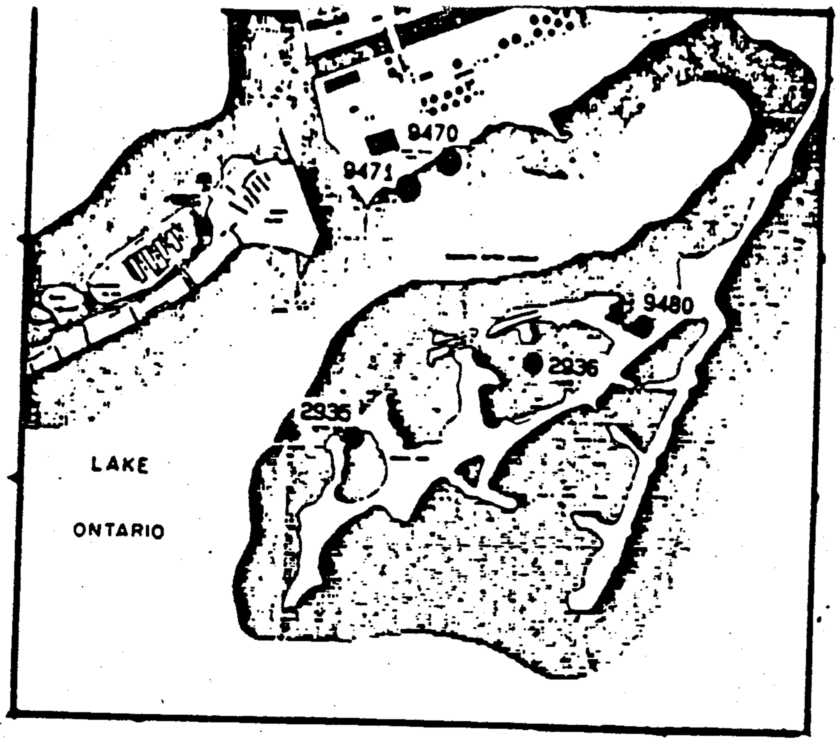
Fecal Coliform Levels along Toronto Island Shoreline (Including Lagoons) During Wet Summer Days in 1987.

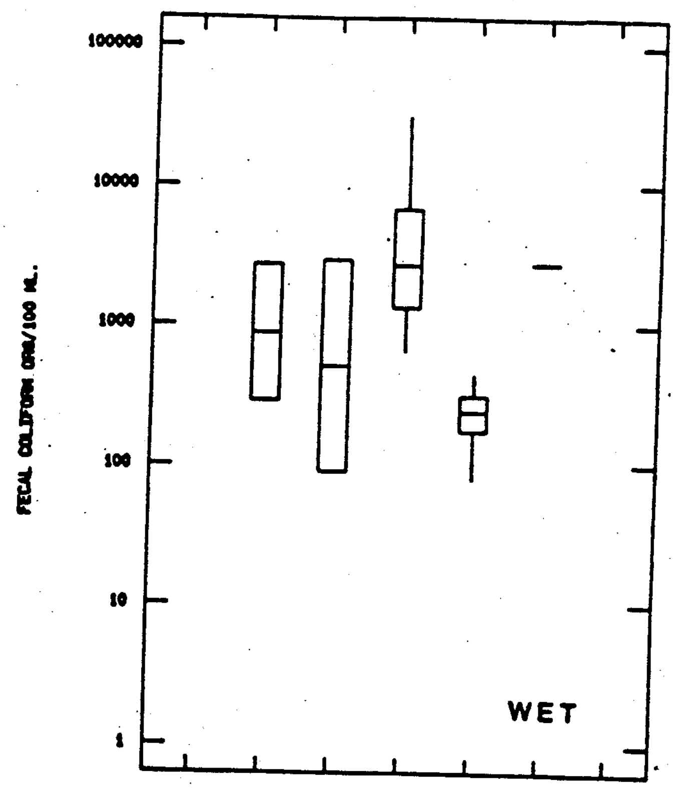




STATION	9471	9470	2935	2936	9480
N	6	6	14	14	6
MAXIMUM	1200	1300	740	100	2300
MINIMUM	60	70	4	13	40
MEDIAN	298	348	188	36	870
UPPER QUARTILE	610	600	360	44	1200
LOWER QUARTILE	160	160	66	28	240
GEOMETRIC MEAN	287	308	138	36	443
SD UPPER LIMIT	780	778	427	60	1888
SD LOWER LIMIT	91	107	26	20	91

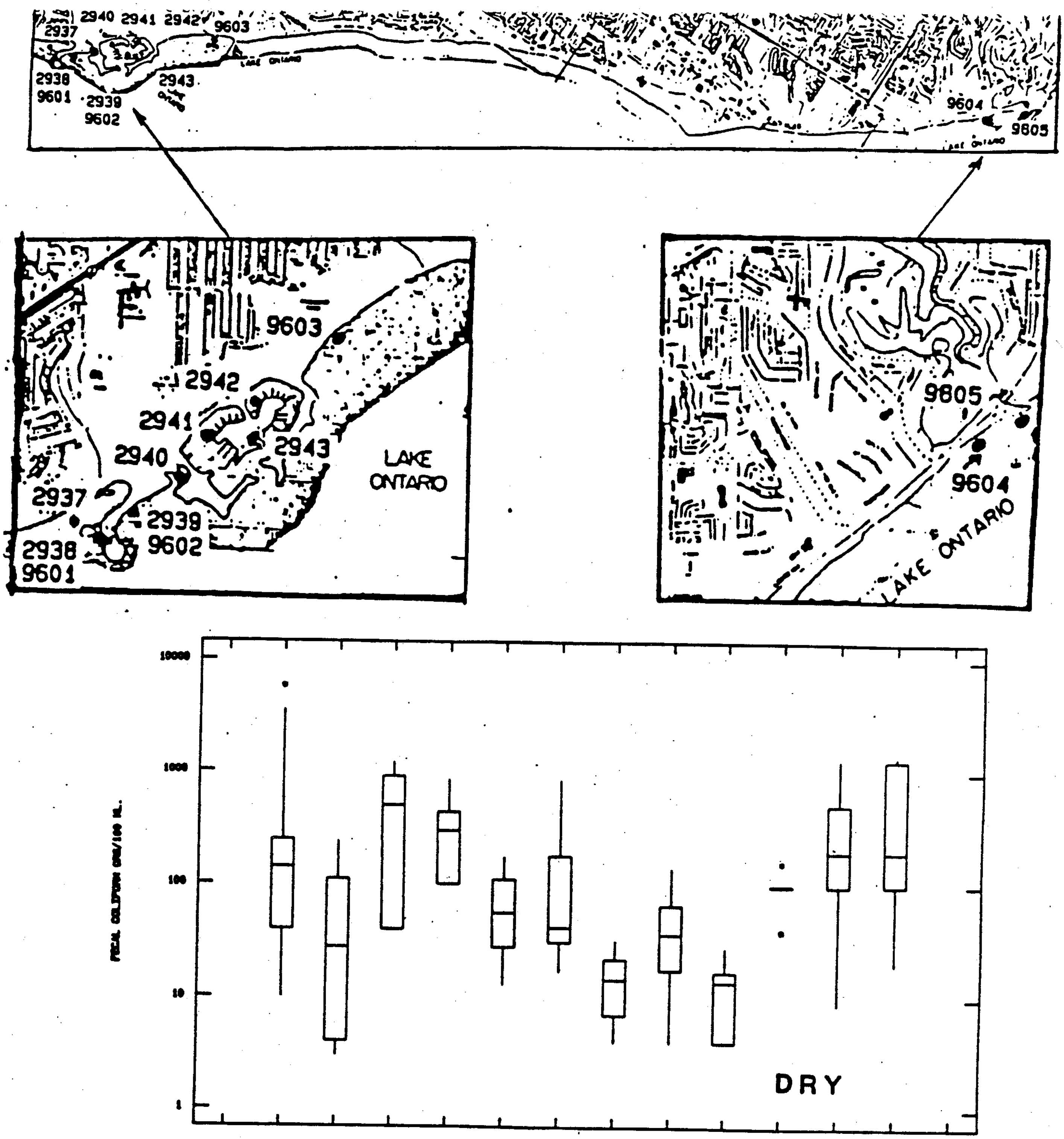
Fecal Coliform Levels along Cherry Beach and Eastern Headland Embayments During Dry Summer Days in 1987.





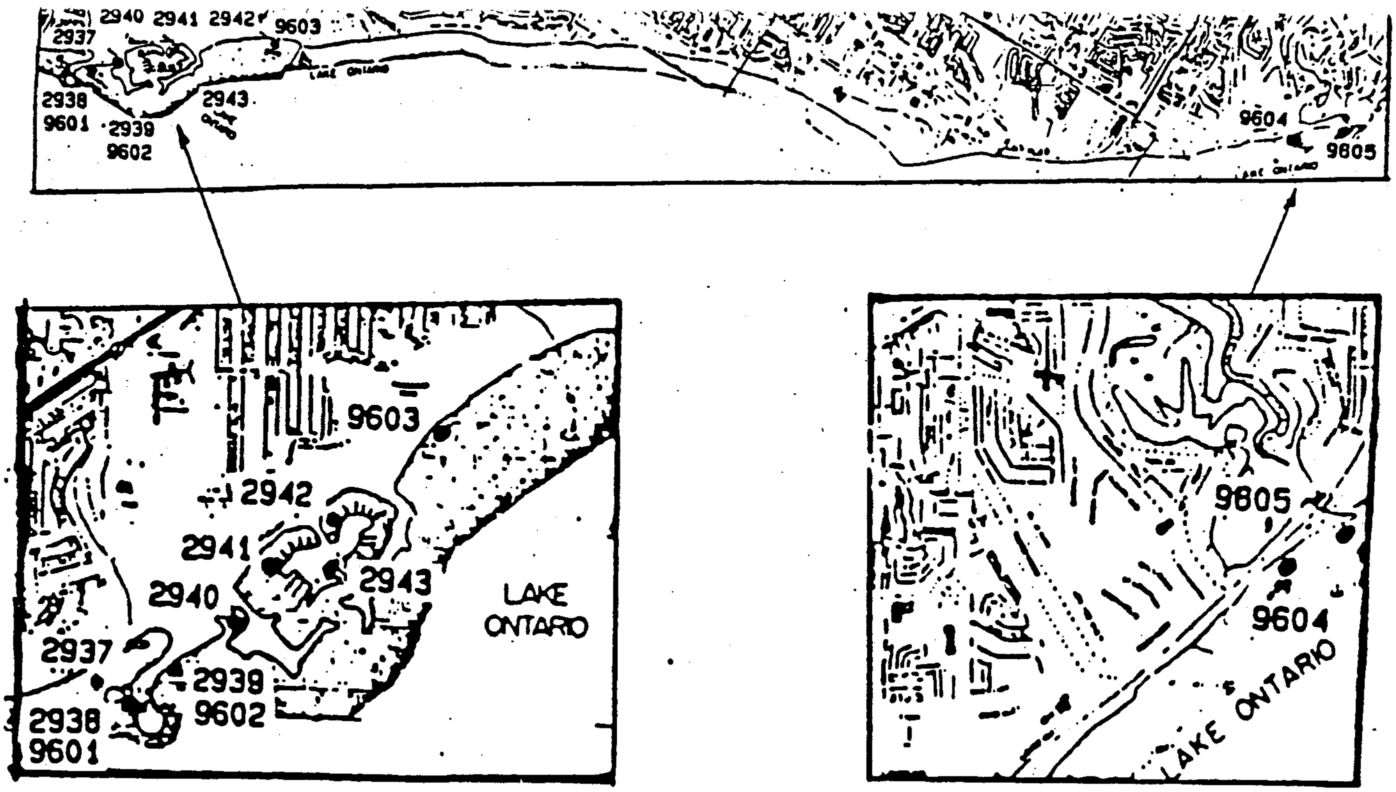
STATION	9471	9470	2935	2936	9480
N	2	2	8	8	1
MAXIMUM	2700	2900	31000	440	2800
MINIMUM	290	90	660	80	2800
MEDIAN	1495	1495	2780	248	2800
UPPER QUARTILE	2700	2900	6950	316	2800
LOWER QUARTILE	290	90	1400	170	2800
GEOMETRIC MEAN	885	511	3284	228	2800
SD UPPER LIMIT	3981	4677	10471	372	-
SD LOWER LIMIT	186	36	871	128	-

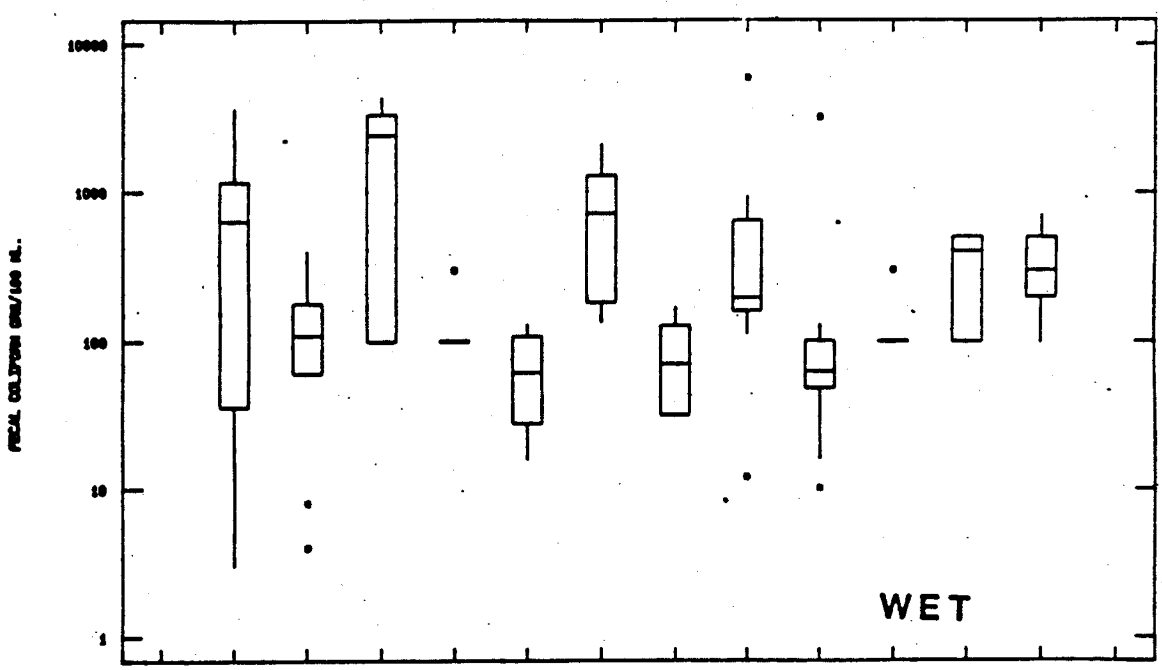
Fecal Coliform Levels along Cherry Beach and Eastern Headland Embayments During Wet Summer Days in 1987.



STATION	2937	2938	9601	9602	2939	2940	2941	2943	2942	9603	9604	9805
N	12	12	14	14	11	12	12	12	12	11	16	13
MAXIMUM	8700	240	1200	840	176	840	32	140	28	160	1300	1400
MINIMUM	10	3	40	99	13	17	4	4	4	40	9	20
MEDIAN	141	26	800	300	86	42	16	38	14	99	200	200
UPPER QUARTILE	280	110	900	440	110	168	42	66	17	100	820	1300
LOWER QUARTILE	43	4	40	100	28	32	7	19	4	99	99	100
GEOMETRIC MEAN	144	26	326	283	81	76	12	33	10	92	218	229
SD UPPER LIMIT	708	63	1096	801	108	240	23	78	19	141	708	813
SD LOWER LIMIT	14	3	66	118	21	68	6	10	4	86	48	46

Fecal Coliform Levels along Scarborough Shorline (Including Bluffers Park Embayments) During Dry Summer Days in 1987.





STATION	2937	2938	9601	9602	2939	2940	2941	2943	2942	9603	9604	9605
N	10	10	10	10	10	10	10	10	10	13	10	13
MAXIMUM	3600	400	4300	300	130	2100	170	5800	3140	300	500	700
MINIMUM	3	4	99	99	16	136	32	12	10	99	99	99
MEDIAN	640	111	2400	99	62	720	72	196	62	100	400	300
UPPER QUARTILE	1160	180	3300	100	108	1300	128	640	100	100	500	500
LOWER QUARTILE	36	60	99	99	28	184	32	160	48	99	99	200
GEOMETRIC MEAN	271	74	803	124	61	643	67	283	72	118	250	314
SD UPPER LIMIT	1479	234	3890	191	102	1413	123	977	278	174	528	662
SD LOWER LIMIT	10	12	102	76	22	178	32	41	13	76	108	162

Fecal Coliform Levels along Scarborough Shoreline (Including Bluffers Park Embayments) During Wet Summer Days in 1987.

APPENDIX B

Historical and Current Biological Status of Fish Species on the Toronto Waterfront

APPENDIX B

HISTORICAL AND CURRENT BIOLOGICAL STATUS OF FISH SPECIES IN TORONTO WATERFRONT

Common Name	Scientific Name	Historical and Present Status
lake chub	Couesius plumbeus	waterfront resident
northern redbelly dace	Phoxinus eos	recorded in Don, Humber, Rouge Rivers
redside dace	Clinostomus elongatus	Occurs in Rouge, Humber and Don Rivers. Distribution has declined since 1950.
carp	Cyprinus carpio	In 1902-1915, spawning was recorded in Toronto Bay and Toronto Islands; in 1973, spawning was observed in flooded lowland areas, especially around Lighthouse Pond in late May and early June; large concentrations of newly hatched fry were found there in early July; spawning has been recorded in the Don River. Carp spawn in shallow areas and bays of the Toronto Eastern Waterfront and probably in lower Humber and Rouge Rivers.
golden shiner	Notemigonus crysoleucas	long-standing resident (first record: 1913); present along waterfront and in lower Humber and Rouge Rivers.
emerald shiner	Notropis atherinoides	long-standing resident (first record: 1913); common forage species along waterfront and in river mouths.
common shiner	Notropis cornutus	commonly found in rivers, mouths and across waterfront.
spottail shiner	Notropis hudsonius	long-standing resident (first record: 1927); commonly found along waterfront and in lower portions of rivers.

Common Name	Scientific Name	Historical and Present Status
sand shiner	Notropis stramineus	recorded in eastern headland lagoons, the Rouge River and Humber River.
rosyface shiner	Notropis rubellus	recorded at Rouge River and Humber River.
spotfin shiner	Notropis spilopterus	resident; recorded Humber River.
mimic shiner	Notropis volucellus	likely resident; no site-specific records available, recorded at Rouge River Waterfront.
bluntnose minnow	Pimephales notatus	commonly found along waterfront in rivers and river mouths.
fathead minnow	Pimephales promelas	commonly found along waterfront in rivers and river mouths.
blacknose dace	Rhinichthys atratulus	most common species in rivers and river mouths.
longnose dace	Rhinichthys cataractae	most common species in rivers and river mouths. Also found along waterfront in exposed habitats.
creek chub	Semotilus atromaculatus	most common species found in all environments.
quillback	Carpiodes cyrpinus	extirpated (last record: 1913).
longnose sucker	Castostomus catostomus	long-standing resident (first record: 1858); still common across the waterfront.

Common Name	Scientific Name	Historical and Present Status
white sucker	Castostomus commersoni	historically, spawning occurred in Toronto Bay soon after ice-out; large numbers of white suckers entered bay tributaries; after 1923, runs became irregular; a recent (1981) spawning run in the Don River has been recorded. Historically, spawning runs of white sucker occurred in Highland Creek and the Rouge River also present in Humber River. Most common species across waterfront and in tributaries. Spawning runs in all tributaries.
shorthead redhorse	Moxostoma macrolepidotem	long standing resident (first record: 1858; last record: 1973); historically spawning runs of shorthead redhorse occurred in the Don River in the spring.
black bullhead	Ictalurus melas	extirpated (last record: 1927).
brown bullhead	Ictalurus nebulosus	brown bullhead still spawn in the Toronto Islands; nest building was seen at the edges of flooded areas in June; in 1906, large schools of young were observed near shore in lagoons in Toronto Islands in July, more abundant in Rouge River estuary than any other shoreline area; Humber and Rouge River along waterfront and particularly abundant in river mouths and bays.
channel catfish	Ictalurus punctuatus	extirpated (last record: 1853); in the early 1870's, the Toronto Islands were recognized as a nursery area.

Common Name	Scientific Name	Historical and Present Status
tadpole madtom	Noturus gyrinus	recorded at Rouge River estuary.
American eel	Anguilla rostrata	recorded at Toronto Island lagoons, East Point Park and Rouge River estuary.
Burbot	Lota lota	extirpated between 1920 and 1960.
brook stickleback	Culaea inconstans	common in Don, Humber, Rouge River, Rouge Marsh and along the waterfront.
threespine stickleback	Gasterosteus aculeatus	long-standing resident (first record: 1891); in 1974, spawning adults and adults in spawning condition were seen in the Toronto Islands; still found along waterfront.
ninespine stickleback	Pungitius pungitius	extirpated (last record: 1929).
trout-perch	Percopsis omiscomaycus	recorded at Rouge River estuary, Humber River and waterfront.
white perch	Morone americana	spawning likely occurs throughout the Toronto Waterfront in shallow water areas and embayments. Found in Humber, Rouge Marshes and common along waterfront.
white bass	Morone chrysops	gravid females were collected from Toronto Bay just off the outfall of the Hearn Generating Station; common resident. Found in Humber and Rouge Marsh and common along waterfront.
rock bass	Ambloplites rupestris	common in all environments.

Common Name	Scientific Name	Historical and Present Status
pumpkinseed	Leopomis gibbosus	spawning occurs in Toronto Bay and at Toronto Islands; nest building has been recorded at the margins of flooded areas in June; very common resident across waterfront and in tributaries.
bluegill	Leopmis macrochirus	long-standing resident (first record: 1858; last record: 1973). Not common along waterfront or in tributaries. Some in local ponds.
smallmouth bass	Micropterus dolomieui	in 1866, 'bass' spawned in the Don River and Rouge River. Still present in Rouge River Marsh and along waterfront.
largemouth bass	Micropterus salmoides	in 1866, 'bass' spawned in the Don River and Rouge River; young-of-the-year recorded as abundant in the shallows of Toronto Bay in 1928; young-of-the-year recorded abundant in Ashbridge's Bay in 1982. Present in Humber and Rouge River Marshes, Humber, Rouge and Don Rivers and waterfront.
silver lamprey	Ichthyomyzon unicuspis	extirpated (last record: 1858).
sea lamprey	Petromyzon marinus	spawning runs occur in the Don River, Rouge River, Humber River.
large sturgeon	Acipenser fulvescens	extirpated likely by 1900; until the population declined between 1841 and 1884, lake sturgeon migrated through Toronto Bay to spawn in the Don River; commercial and subsistence fishing pressure, the effects of deforestation and milling on the Don River habitat and the construction of dams impacted severely on lake sturgeon.

Common Name	Scientific Name	Historical and Present Status
longnose gar	*Lepisosteus osseus*	extirpated (last record: 1858).
bowfin	*Amia calva*	bowfins spawned in Toronto Bay in 1913; spawning recorded at the Hearn Generating Station Outfall Bay; bowfins spawned in Ashbridges Bay, present Rouge Marsh.
alewife	*Alosa pseudoharengus*	introduced; in mid-June 1973, large schools of adults in spawning condition were seen along the open lake side of the Toronto Islands; alewife extensively utilize the Toronto Waterfront shallow areas with gravel and sand substratum for spawning. Most common species across waterfront.
gizzard shad	*Dorosoma cepedianum*	common resident throughout the waterfront.
lake herring	*Coregonus artedii*	historically, runs of gravid lake herring moved to the shore of Toronto Island and into Toronto Bay; during 1880-1893; the runs were heavily fished; these runs ceased in about 1900; lake herring likely spawned over sand or gravel in inshore areas of the Toronto Waterfront; one record off Humber Bay recently.
lake whitefish	*Coregonus clupeaformis*	until the early 1880's, runs of gravid fish were recorded along Toronto Island and adjacent shores; currently, uncommon in the Toronto Waterfront, mainly found in the eastern sector.
coho salmon	*Onchorhynchus kisutch*	introduced; spawning runs occur in the Rouge and Humber Rivers.

Common Name	Scientific Name	Historical and Present Status
round whitefish	Prosopium cylindraceum	long-standing resident (first record; 1858) spawning likely occurs on gravel and rubble in 3 to 10 m of water. Mainly found in the eastern waterfront.
rainbow trout	Salmo gairdneri	introduced; spawning runs occur in the Rouge and Humber Rivers.
Atlantic salmon	Salmo salar	extirpated likely by 1900; historically, Atlantic salmon migrated through Toronto Bay to spawn in the Don River; the runs declined by 1829, although fish were still being speared on the spawning beds in early November 1873; Atlantic salmon runs in Highland Creek declined in 1881 (stocking did not re-establish the run; in the Rouge River spawning occurred on the rapids until 1882. Commercial and subsistence fishing pressure, the effects of deforestation and milling on the Don River habitat, and the construction of dams impacted severely on Atlantic salmon. U.S. stocking and soon to be stocked by Ontario.
brown trout	Salmo trutta	introduced; spawning runs occur in the Rouge and Humber Rivers.
splake	Salvelinus namaycush fontinalis	introduced; effectively new resident (first record; 1975); limited if any reproductive success; rare.
brook trout	Salvelinus fontinalis	resident of tributary headwaters of Rouge and Humber Rivers.

Common Name	Scientific Name	Historical and Present Status
lake trout	<u>Salvelinus namaycush</u>	extirpated/introduced; historically, spawning occured south of the eastern gap of the Toronto Islands; spawning occurred off the foot of Church Street, southeast of Ashbridge's Bay and off the Scarborough Bluffs; spawning declined in the 1870's; "stone-hooking" or removal of rock from the bottom for use as building material occurred during 1830 to 1930 and probably severely altered spawning grounds along the Toronto Waterfront; "trout" grounds were also almost destroyed by oil and tar material dredged out of Toronto Bay and dumped into the lake; currently, uncommon in the Toronto Waterfront; presence maintained by stocking programs.
rainbow smelt	<u>Osmerus mordax</u>	introduced; a spawning run was recorded in Toronto Bay in 1954; spawning occurs at the Hearn Generating Station Outfall Bay; spawning may also have occurred in the Outer Harbour; spawning occurs at the mouth of the Rouge River and Ashbridge's Bay; smelt have occupied the niche vacated by lake herring. Very common along waterfront.
mooneye	<u>Hiodon tergisus</u>	extirpated (last record; 1913).
central mudminnow	<u>Umbra limi</u>	long-standing resident (first run; 1913). Found in tributaries as well as river mouths and along waterfront.

Common Name	Scientific Name	Historical and Present Status
northern pike	Esox lucius	historically, large spawning runs entered Toronto Bay; in the 1860's to 1915, Toronto Islands were a spawning and nursery area; northern pike are now found only occasionally in Toronto Bay; spawning still occurs in a lagoon in the wildlife sanctuary on Toronto Islands; during the 1880's northern pike migrated by the thousands into Asbridge's Bay to spawn in the extensive Ashbridge's Marsh at the west end of the bay; this stock declined in 1898-1919 due to the destruction of the marsh; historically, northern pike entered Highland Creek every spring; fairly abundant across waterfront and Humber and Rouge mouths.
muskellunge	Esox masquinongy	extirpated likely by 1900; reported to be declining by the 1840's; commercial and subsistence fishing pressure, the effects of deforestation and milling on the Don River habitat, and the construction of dams impacted severely on muskellunge.
goldfish	Carassius auratus	introduced; in 1973; goldfish were observed spawning in late May and early June in flooded lowland areas of the Toronto Islands, including the Lighthouse Pond area, the large concentrations of newly hatched larvae were found there in early July; goldfish spawn in the marshes and bays of the Toronto Waterfront.

Common Name	Scientific Name	Historical and Present Status
black crappie	Pomoxis nigromaculatus	in about 1895, spawning occurred at Toronto Islands; since 1913, black crappies have not been abundant here; common resident along eastern waterfront and in river mouths.
rainbow darter	Etheosotoma caeruleum	common in Rouge, Don and Humber Rivers.
fantail darter	Etheostoma flabellare	tributary resident; Humber River.
Johnny (Tesselated) darter	Etheostoma nigrum	long-standing resident (first record; 1913); in 1973, spawning adults and adults in spawning condition were found in the Toronto Islands. Common in all environments.
yellow perch	Perca flavescens	in 1901, ripe males were collected in May and June at Centre Island; in 1891, spawning was completed in Ashbridge's Bay by 23 April; in 1912, spawning reported at mouth of Rouge River; more abundant in the Rouge River estuary than any other Metro shoreline area but considered common across the waterfront. Most common species across waterfront; also found in Humber and Don Rivers.
logperch	Pecina caprodes	recorded at Rouge River estuary.
sauger	Stizostedion canadense	extirpated (last record; 1913); spawning occurred in rivers entering Toronto Bay; the stock decreased in the mid-1870's and never recovered.

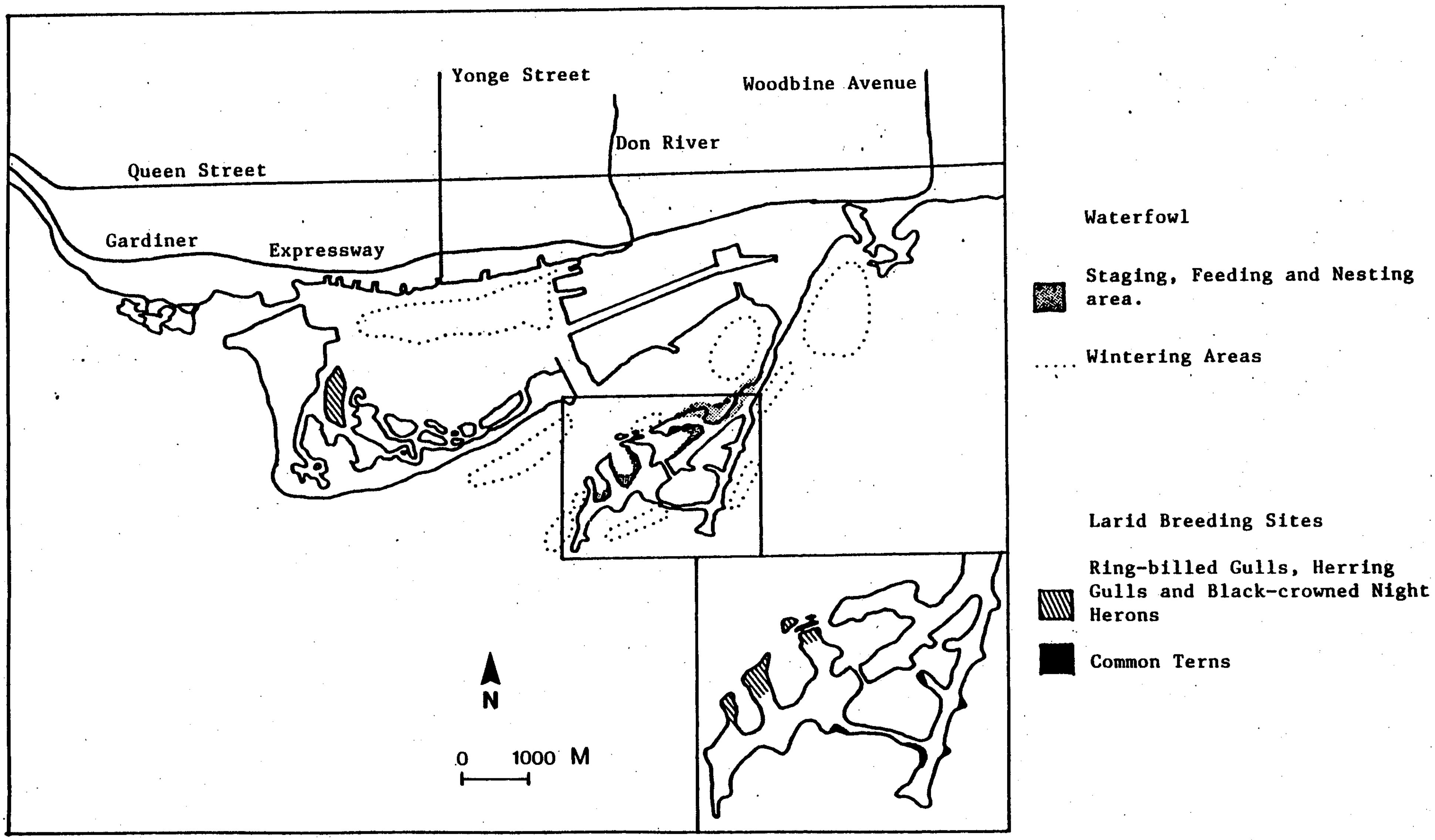
Common Name	Scientific Name	Historical and Present Status
yellow walleye	Stizostedion vitreum	extirpated; during the late 1860's, spawning still occurred in the Don River, but after 1874, the population essentially disappeared due to exploitation as well as habitat fluctuation and deterioration, e.g., destruction and siltation of spawning beds; historically spawning runs occurred in the Rouge River. Few walleye now in far eastern part of waterfront (Duffins, Pickering).
freshwater drum	Aplodinotus grunniens	common resident.
mottled sculpin	Cottus bairdi	common resident.
slimy sculpin	Cottus cognatus	effectively new resident (first record; 1970).

[1] Based on Whillans (1979); Goodyear et al. (1982); Acres (1983); Steedman (1986); Martin-Downs (1987); MTRCA data (1979-1982); Hamilton (1987); Stephenson (1985-1986 field collections)

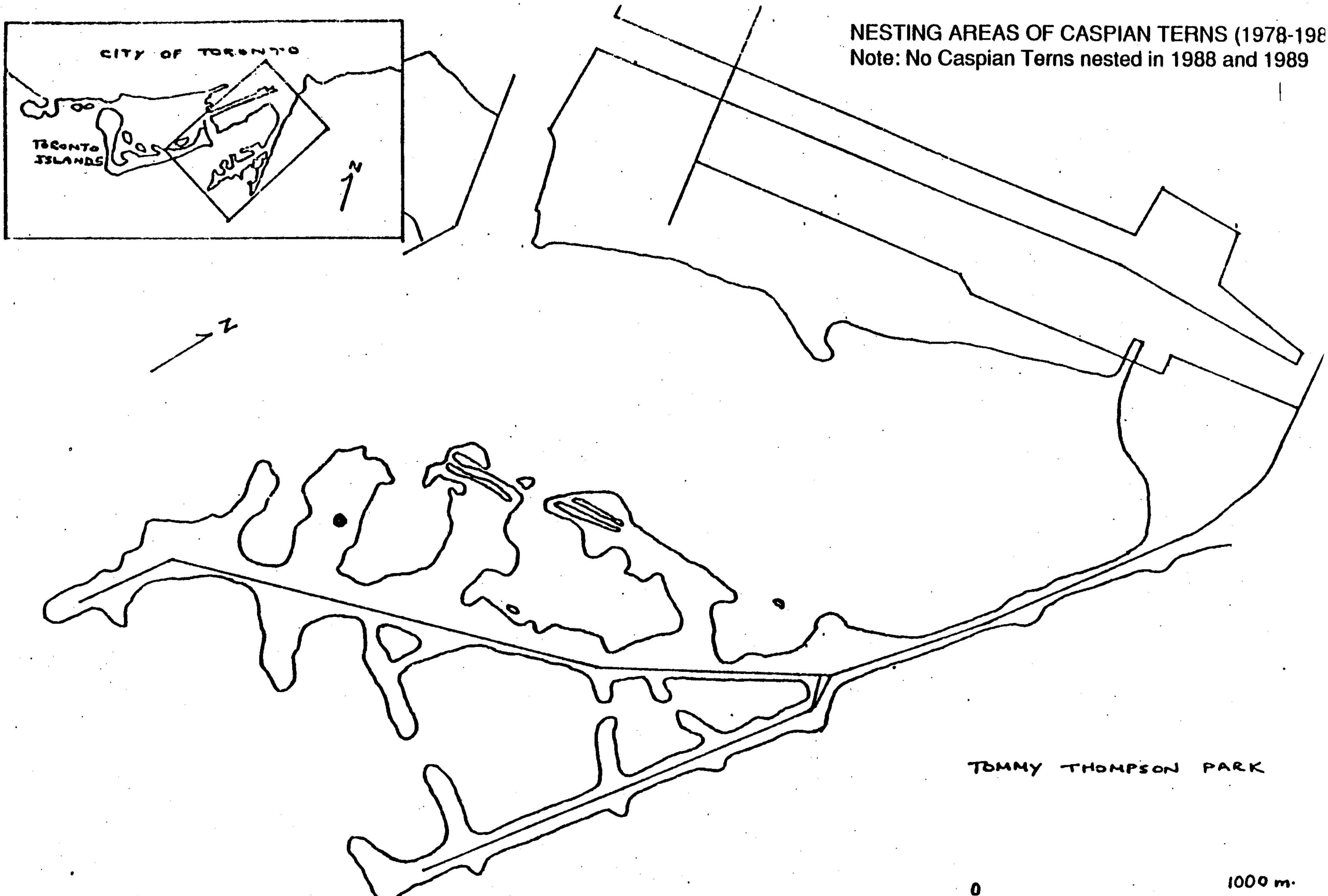
APPENDIX C

Waterfowl Nesting and Staging Areas Along the Central Waterfront

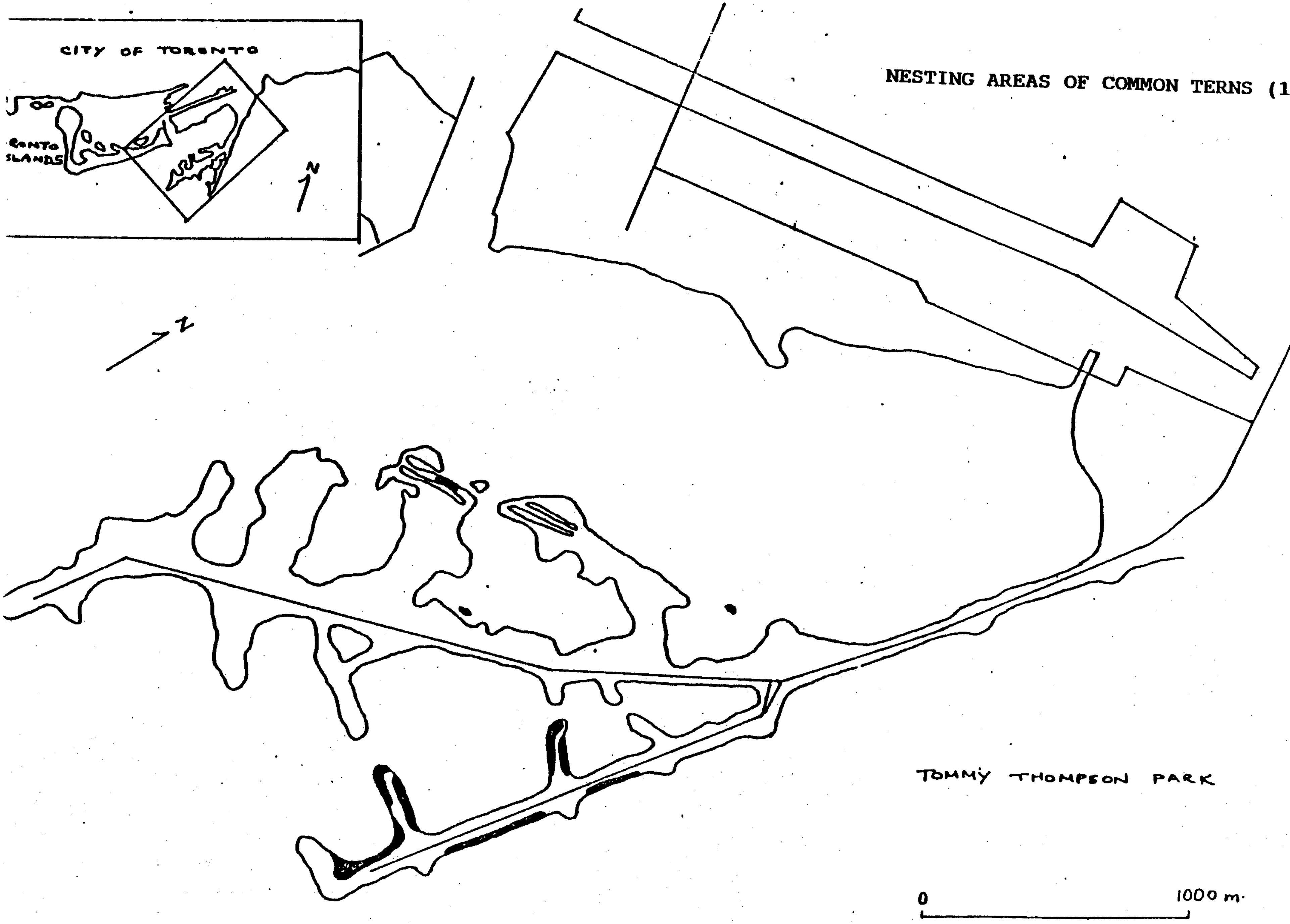
AVIAN UTILIZATION OF LESLIE ST. HEADLAND AND SURROUNDING WATERS

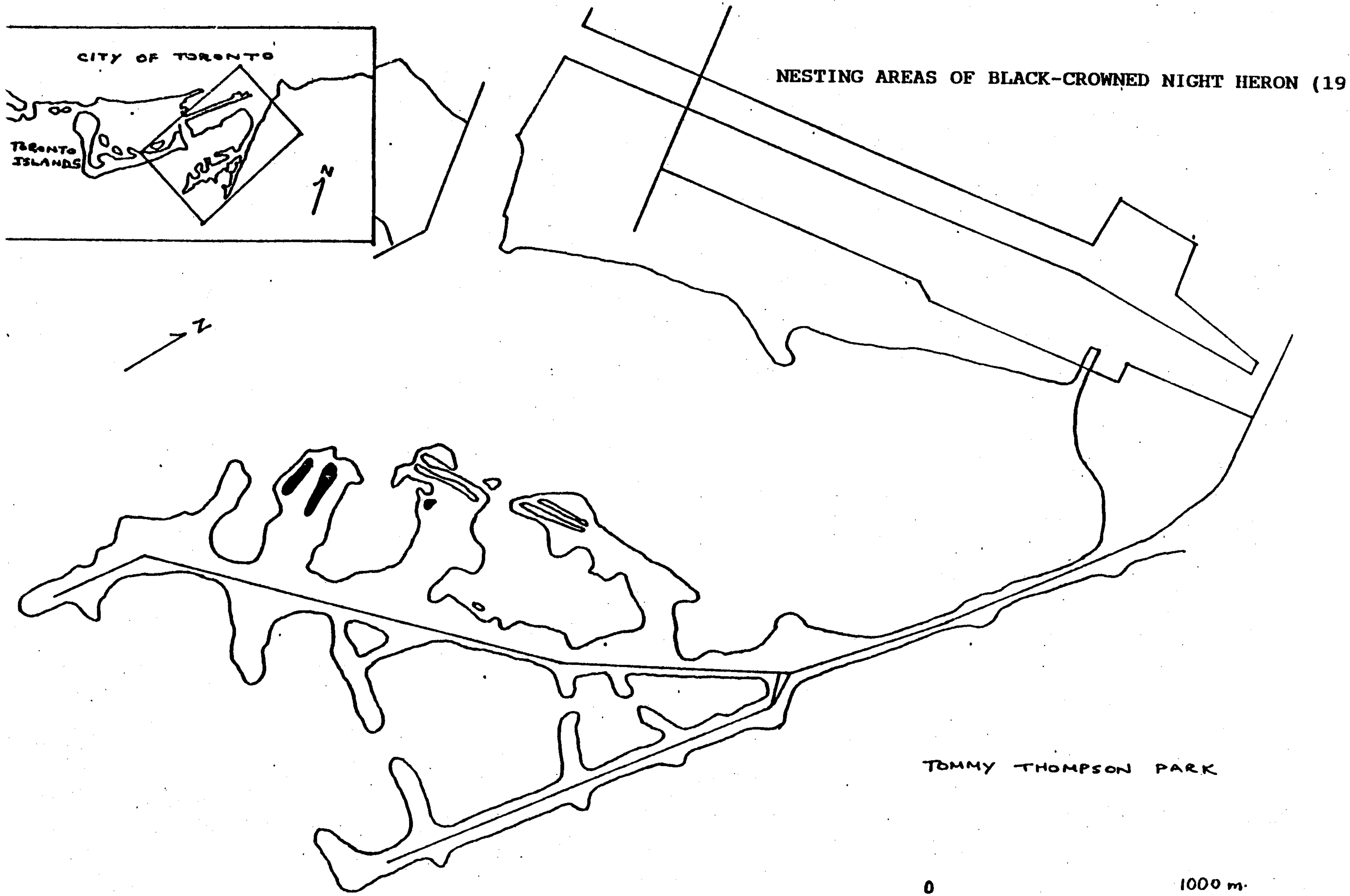


NESTING AREAS OF CASPIAN TERNS (1978-198
Note: No Caspian Terns nested in 1988 and 1989



NESTING AREAS OF COMMON TERNS (1986)




NESTING AREAS OF BLACK-CROWNED NIGHT HERON (19
CITY OF TORONTO
TORONTO ISLANDS
N
N
TOMMY THOMPSON PARK
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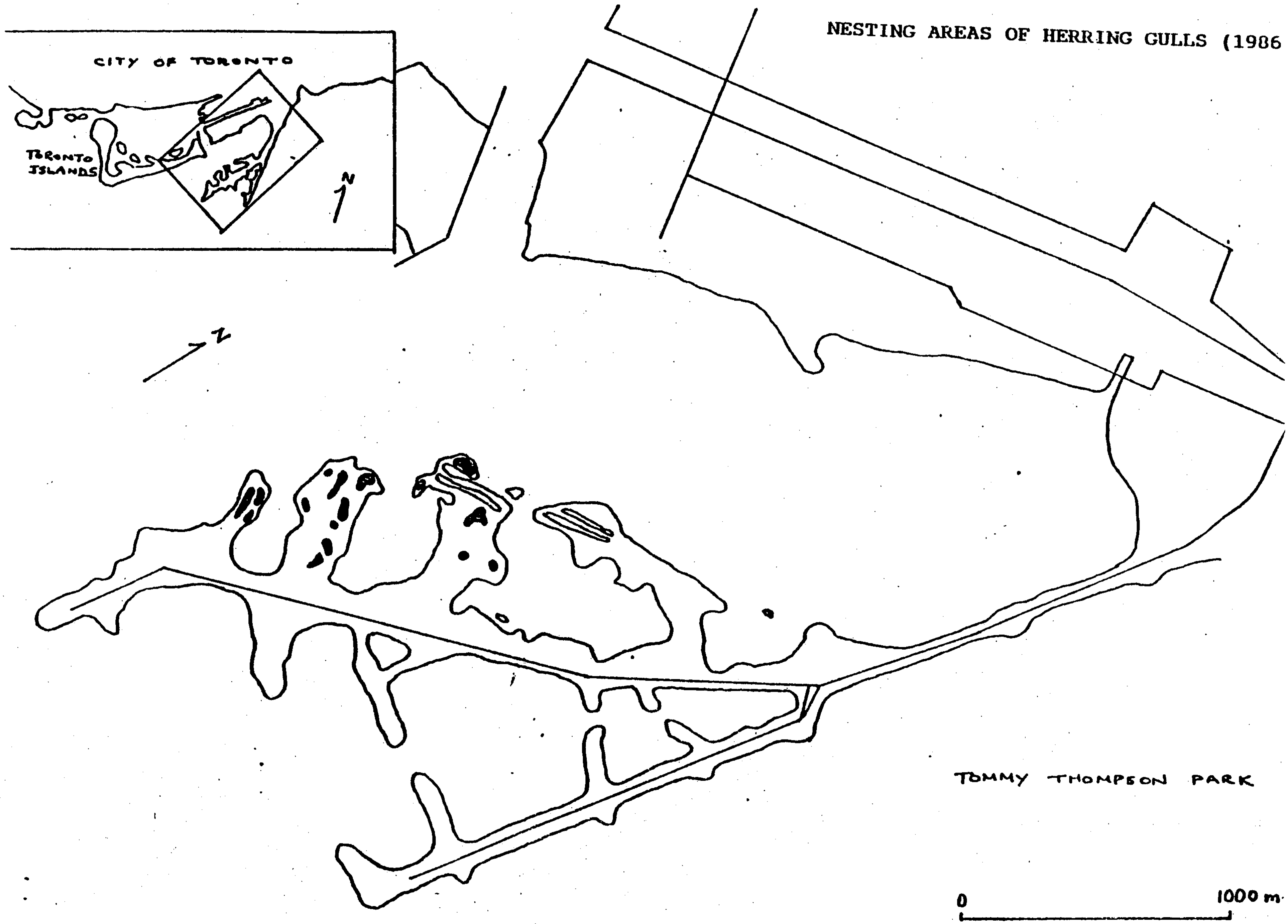
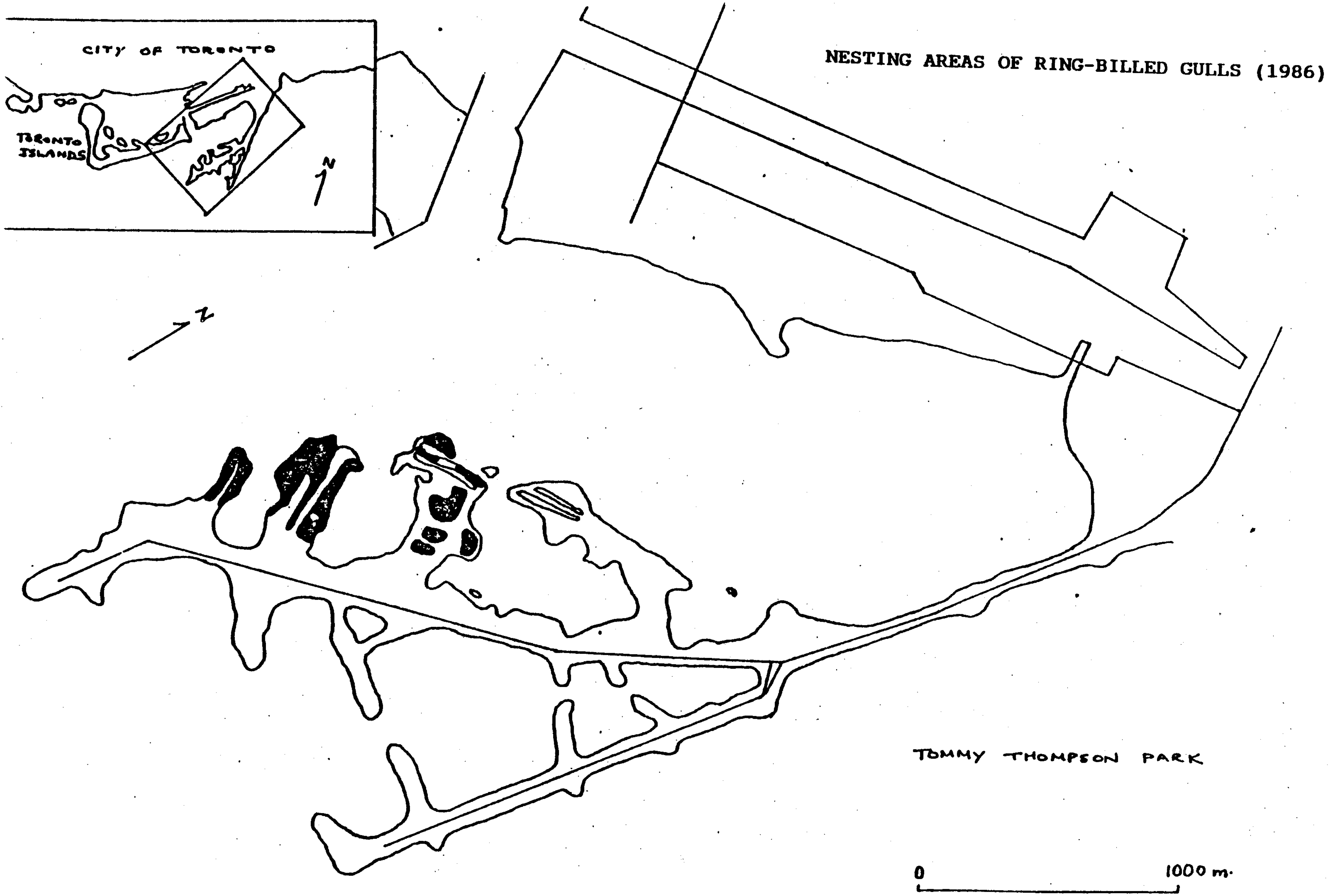
1000 m.

NESTING AREAS OF HERRING GULLS (1986




NESTING AREAS OF RING-BILLED GULLS (1986)
CITY OF TORONTO
TORONTO ISLANDS
N
N
TOMMY THOMPSON PARK
0
1000 m.

Remedial Action Plan
Plan d'Assainissement

Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs