Chapter I

INTRODUCTION

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1.1 Pollution in the Niagara River

On its route from Lake Erie to Lake Ontario, the Niagara River passes through a complex of steel, petrochemical, and chemical manufacturing industries. The Niagara Frontier's proximity to a source of cheap electrical power and water for use in industrial processing has caused it to become a highly industrialized area, particularly on the U.S. side.

Historically, decisions about the development of the Niagara Frontier have been based solely on economic factors, such as the creation of jobs and the production of cheaper materials. These decisions have proven to be the cause of environmental problems both in the Niagara River and the surrounding area.

More recently, environmental degradation and its impact on human health has become a pervailing consideration in decisions regarding use and management of the Niagara River. Over the last decade, high levels of bacteria, phenols, oil, iron, phosphorus, chloride, mercury, and color have been reduced significantly.

Currently, toxic substances and their effects on human health and the ecosystem are being focussed on. Major toxic waste disposal sites have been identified along the Niagara River corridor, and toxic substances have been measured in the effluents of industrial and municipal facilities discharging into the river.

With increased research, the link between the discharge of toxic substances into the Niagara River and the subsequent effects on the ecosystem has become more clear. In some cases, conditions in Lake Ontario can be attributed directly to substances from the Niagara River; the occurrence of mirex and dioxin in Lake Ontario fish is an example of such a direct relationship. Certain species of fish from specific areas of the lake are banned for commercial fishing as a result of mirex and PCB levels, attributable, in part, to Niagara River contaminants. In other cases, the linkage is less direct but nonetheless real; chemicals originating in the Niagara River combine with other sources to Lake Ontario to contaminate the water, sediment, and biota in the lake.

The presence of toxic chemicals in the Niagara River is not new; these substances have probably been in the river for years. The development of more sophisticated analytical equipment and methodology has led to greater detection capability, enabling scientists to find chemicals at very low concentrations. Unfortunately, the ability to detect these compounds has outstripped our ability to correlate their concentrations with direct adverse effects on human health and the environment.

Existing long term data show a decline in many contaminants, and, for the chemicals for which drinking water standards exist, monitoring shows that they are within current Canadian and United States limits. The development of drinking water standards is an on-going process, however, and there are chemical compounds presently being identified in the Niagara River for which no standards have as yet been established.

Many members of the public feel that there has been a lack of government concern and action in assessing and solving the problems in the Niagara River. In fact, pollution in the Niagara River has been a major concern of federal, state and provincial governments since the early 1950's.

Millions of dollars have been, and are continuing to be spent by government and industry in implementing clean-up programs, determining the effectiveness of river clean-up programs, and identifying additional contamination sources requiring action. Significant progress has already been made in alleviating the sources of many of the earlier problems, largely through the control of municipal and industrial waste discharges.

A continuing effort is now being directed at solving the more complex problems of toxic substance contamination in the Niagara River. In many cases, the scientific basis for understanding the environmental and human health significance of these chemical compounds, either individually or in combination, does not exist and will have to be developed. This is by no means an easy or inexpensive task, nor can it be accomplished in a short time frame. In the mean time, responsible Canadian and U.S. agencies have accepted the premise that they will have to make decisions regarding the control of toxic substances in the absence of all the evidence that might be scientifically desirable.

In summary, the occurrence of toxic chemicals in the Niagara River is a major public concern in both countries. While much has been accomplished, toxic substances remain a problem. The task is to assess what is there, identify the sources, implement additional appropriate abatement strategies, and monitor the effectiveness of these strategies.

1.2 The Niagara River Toxics Committee

The mutual concern of both Canadian and United States environmental agencies regarding the water quality of the Niagara River resulted in a decision to cooperate in a joint investigation of toxic chemicals entering the Niagara River. There had been previous investigations and reports on water quality in the river; however, no investigation had attempted a coordinated study on toxic substances pollution. In February, 1981, the Niagara River Toxics Committee (NRTC) was established to oversee and coordinate such a program. The committee consisted of representatives from:

- Environment Canada
- Ontario Ministry of the Environment
- United States Environmental Protection Agency
- New York State Department of Environmental Conservation

The Committee was co-chaired by representatives of Environment Canada and the New York State Department of Environmental Conservation. Funding for the investigation was provided by the four cooperating agencies.

The Niagara River Toxics Committee had three objectives:

1. Identify sources of toxic pollutants entering the Niagara River.
2. Recommend control programs where necessary.
3. Recommend long term water monitoring programs for the Niagara River that would allow evaluation of the effectiveness of control programs.

1.2.1. Project Activities

One of the primary functions of the NRTC was to integrate ongoing investigative programs along the river. At the program's inception, agencies on both sides of the border were to a large extent "locked in" to planned activities. As a result, the Niagara River Toxics Project consolidated a series of sub-projects that had been individually designed to fulfill certain specific agency objectives. A review of these ongoing activities identified specific areas with deficiencies or gaps in data. To address these concerns, various sub-project activities were augmented and others developed specifically for this study within the limits of available funding.

As a result of these projects, over 3000 water samples and 135 bottom sediment samples were collected for analysis. Biotic life sampled and analyzed included Spottail Shiners, Cladophora, caged freshwater clams, and sports fish.

Both water and suspended sediment samples were collected at the Lake Erie input to the river and at the outflow to Lake Ontario. This allowed an assessment to be made on the contribution of 52 substances to the Niagara River and the river's contribution to Lake Ontario. The discharges to the river and its tributaries from the major industries and municipal treatment plants were sampled to estimate the relative loading of toxic chemicals to the river from these sources. Fifty-five industries and fourteen municipal plants on both sides of the river were sampled and the samples analyzed for a wide range of chemicals.

An attempt was made to estimate the impact of landfills on the river. All landfills within three miles of the river on the U.S. side (164 sites) and all landfills within the Niagara River drainage basin on the Canadian side (17 sites) were investigated. Wells were sunk to bedrock at eleven locations on the U.S. side to intercept and sample area-wide groundwater.

Over 40 storm sewers were sampled to assess chemical transport to the river by this route.

The information on toxic substances from these studies is described in considerable detail in the report that follows. This information, combined with data from previous studies on the river, was the basis for the conclusions and recommendations in this report.

In addition, a number of Canadian research projects were carried out at the outlet of the Niagara River and adjacent parts of Lake Ontario to develop a historical picture of toxic chemical entry into Lake Ontario. Information from these studies has been published separately in the Journal of Great Lakes Research (Volume 9(2), 1983).

1.2.2 Data Quality Review

After the project was underway the Niagara River Toxics Committee became concerned with the comparability of data generated by different laboratories. To assist in assessing the numerous data sets, the Committee formed the Data Quality Sub-committee made up of participating agency laboratory and quality assurance staff who had not been involved in planning or carrying out the Project. This group was charged with evaluating the sampling and analytical procedures used in each of the sub-projects and advising the Committee on the results of their evaluation. The sub-committee was also requested to make recommendations to assure that quality data would be collected in any long-term monitoring program recommended by the Niagara

River Toxics Committee. The Sub-committee findings and recommendations are contained in a report which has been published separately[1]. Data quality discussions are included in all appropriate chapters of this report.

1.3 The Niagara River - Background and Overview

1.3.1 General Description

The 58 kilometre (37 mile) Niagara River, with an average flow of 5,700 cubic metres per second (cms) or 200,000 cubic feet per second (cfs), connects Lake Erie to Lake Ontario. Divided into the upper and lower reaches by Niagara Falls, it provides 83 percent of the total tributary flow to Lake Ontario. The river drains an area of about 227,000 square kilometres (88,000 square miles). Between Lake Erie and Lake Ontario, the river drops about 100 metres (328 feet) with about one-half of the drop occurring at Niagara Falls.

For both Canada and the United States, the Niagara River provides municipal and industrial water supplies and a source of power generation, commerce, recreation, and tourism.

As a source of municipal drinking water, it serves a combined Canadian/United States population of more than 400,000 people. The City of Buffalo municipal water plant, which obtains water at the junction of Lake Erie and the Niagara River, services an additional 530,000 people. The river, in return, receives the treated waste from these same populations.

From Lake Erie to Strawberry Island (off the southern tip of Grand Island), a distance of about eight kilometres (5 miles), the Niagara River drops about two metres (6 feet). At Strawberry and Grand Islands, the river divides into two channels, the Chippawa Channel and the Tonawanda Channel, located west and east of Grand Island, respectively.

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1 Niagara River Toxics Committee, Data Quality Sub-committee, Final Report to the Niagara River Toxics Committee, March, 1984.

The Chippawa Channel is approximately 18 kilometres (11 miles) long and carries about 57 percent of the total river flow, while the Tonawanda Channel is about 24 kilometres (15 miles) long and carries the remaining portion of the river flow. During the navigation season (April/May through November/December), the New York State Barge Canal withdraws water from the Tonawanda Channel at Tonawanda, New York and discharges it into Lake Ontario at several points in the State of New York. Average diversions by the Barge Canal in recent years during the navigation period have been about 30 cms (1100 cfs).

At the north end of Grand Island, the Chippawa and the Tonawanda Channels unite to form the Chippawa-Grass Island Pool. The fall between Strawberry Island and the Pool is about one metre (3 feet).

In 1950, Canada and the United States signed the Niagara River Treaty to preserve the scenic spectacle of Niagara Falls, and to make more efficient use of the Niagara River for power generation purposes. To fulfill the objectives of the Niagara River Treaty, Ontario Hydro and the New York Power Authority constructed a control structure at the lower end of the Chippawa-Grass Island Pool. The structure consists of eighteen gates and extends from the Canadian shore part way across the river. It is operated by the two power entities under the direction of the International Joint Commission's International Niagara Board of Control.

The Niagara River Treaty requires that a minimum flow of 2830 cms (100,000 cfs) be maintained over the Falls during the daylight hours of the tourist season (April through October). At all other times, the minimum required flow over the Falls is 1410 cms (50,000 cfs). The control structure permits a relatively quick change over from daylight to night-time flow (and vice versa) during the tourist season. It also regulates the water level in the Chippawa-Grass Island Pool to facilitate power diversions within limits established by the Niagara Board. The present procedure requires that the water level in the Pool be maintained as nearly as may be practicable to its long-term average elevation of 170.99 metres (561 feet) . The operation of the control structure has a negligible effect on the outflows of Lake Erie.

The Canadian plants include the Canadian Niagara, Ontario Power, and Sir Adam Beck I and II Power Plants. Total Canadian diversion capability is about 2350 cms (84,000 cfs). The Robert Moses Niagara Plant is the only plant on the Niagara River in the United States and has a diversion capacity of about 3115 cms (110,000 cfs). Each of these power plants withdraws water from the upper Niagara River and discharges it downstream of Niagara Falls. During the tourist season, the additional water made available for power purposes during night-time hours is diverted and stored in the pump-storage reservoirs and released during the daylight hours when the power demand is high. This is also the case during the non-tourist season, when the additional water is available on a continuous basis. The excess water is stored during periods of lower energy demand, such as nights and week-ends, and released during periods of high energy demand. Thus, there is a persistent within-the-day variation in flow in the lower Niagara River between the Falls and Queenston, Ontario, due to discharge from these plants.

At Niagara Falls, water drops about 56 metres (182 feet) over the Falls into the Maid-of-the-Mist Pool. In the next five kilometres (3 miles), the river drops about 23 metres (75 feet) through the Whirlpool Rapids. The fall in the 11 kilometre (6 mile) reach from the foot of the Whirlpool Rapids to Lake Ontario is about 0.2 metres (0.6 feet).

1.3.2 Local Inflows and Outflows

1.3.2.1 Surface Water

The flow of the Niagara River between Buffalo and Queenston is increased by the local inflow from streams tributary to the upper river and by the water diverted into the Welland River from the Welland Canal. It is reduced by the diversion of the New York Barge Canal, which has an average flow of about 30 cms (1100 cfs) during the navigation season. Local tributaries generally have a very mild slope and small drainage areas and, as a result, their flows are not large except during times of heavy runoff. The flow of water diverted to the Welland River from the Welland Canal is about 20 cms (700 cfs). The flow at the mouth of the Welland River (located in the Chippawa-Grass Island Pool) has been reversed as a result of the diversion by the Beck Power Plant and is discharged by the Beck Plant into the lower river. Figure 1.1 in schematic form shows the complete flow regime between Lake Erie and Lake Ontario.

1.3.2.2 Groundwater

The geologic zones of the Niagara Frontier are the result of a succession of sedimentary deposits. The relatively flat formations dip to the south-southeast at a rate of about 6 metres per kilometre or 30 feet per mile. The formations cut across the Niagara River at almost 90° and are essentially the same latitude on the Canadian and U.S. sides of the river.

The oldest deposit in the region is the Queenston Shale. This Shale is overlain by a series of sandstone, shale, and calcareous deposits, including the Lockport and Guelph formations. The transition between the Queenston Shale and overlying deposits is marked by the Niagara Escarpment. The overlying deposits farther to the south are limestone.

Throughout the region, the bedrock is overlain by clay, silt, sand, or mixtures thereof. On the Canadian side, the thickness of the overburden generally decreases from north to south, varying from 30 metres (98 feet) thick at Niagara-on-the-Lake to as little as two metres (6 feet) at Fort Erie. On the U.S. side, the overburden thickness increases from approximately 3.5 metres (10 feet) in the Niagara Falls area to about 20-25 metres (65-80 feet) in the Buffalo area.

In most cases the zone between the overburden and the bedrock is not distinct. Rather it is a transition zone consisting of unconsolidated overburden and highly fractured or weathered bedrock. In general terms, the

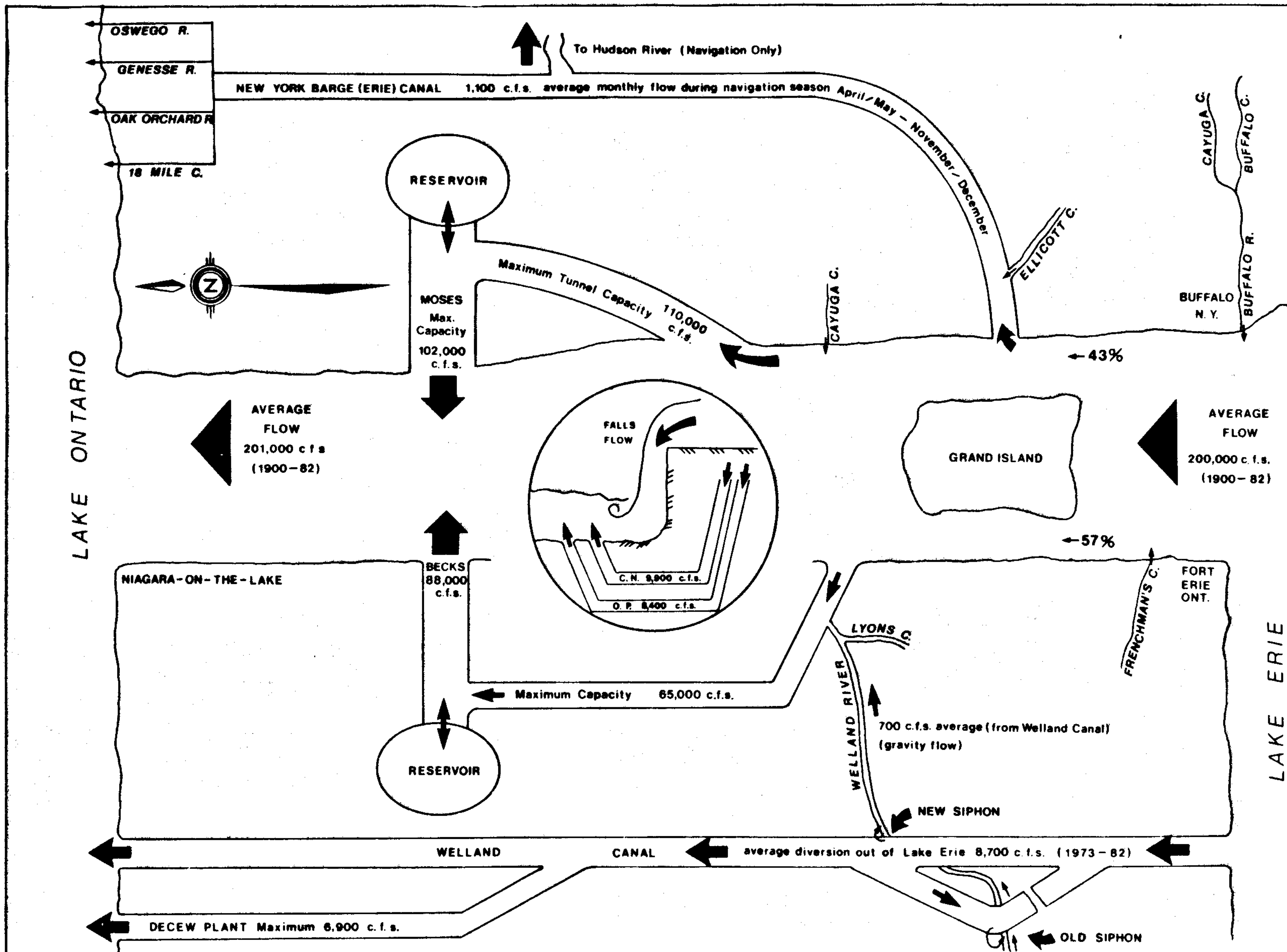

FIGURE 1.1 SCHEMATIC DIAGRAM SHOWING FLOWS AND HYDRO-ELECTRIC CAPACITIES OF THE NIAGARA RIVER, WELLAND CANAL, AND NEW YORK BARGE CANAL

upper aquifers of the region will be found in the unconsolidated overburden and upper fractured portion of the bedrock. On a macro scale, the groundwater or aquifer flow patterns tend to follow those of surface water courses.

The hydrologic properties of the bedrock aquifers vary considerably. The rate at which the water moves through an aquifer can vary up to three orders of magnitude within the region. Generally, the limestones and dolomites tend to be the most permeable, especially in their highly weathered and solutioned zones. The shales are inherently much less permeable, but in some areas, especially near the Niagara River, horizontal bedding plain fractures and vertical pressure fractures allow for some groundwater movement in this zone.

1.3.3 River Inlet Conditions

A rock ledge at the head of the Niagara River acts as a natural weir which controls the flow of Lake Erie into the Niagara River. Water entering the Niagara River from Lake Erie is influenced by circulation patterns in the lake.

In the central and eastern basins of Lake Erie, circulation patterns during the open water period are largely created by the wind, which blows parallel to the lake axis (Figure 1.2). In the shallow areas close to the shore, the water moves in the same direction as the wind, creating a predominant shoreline current. The larger water mass in the deep interior basin is less affected by the wind than water in the shallow zones. As a result, currents are many times weaker than shoreline currents, and move against the wind.

In the eastern basin, the strong eastward transport along the shore is followed by a compensating westerly return flow. Since only about one-tenth of the eastward transport leaves Lake Erie through the Niagara

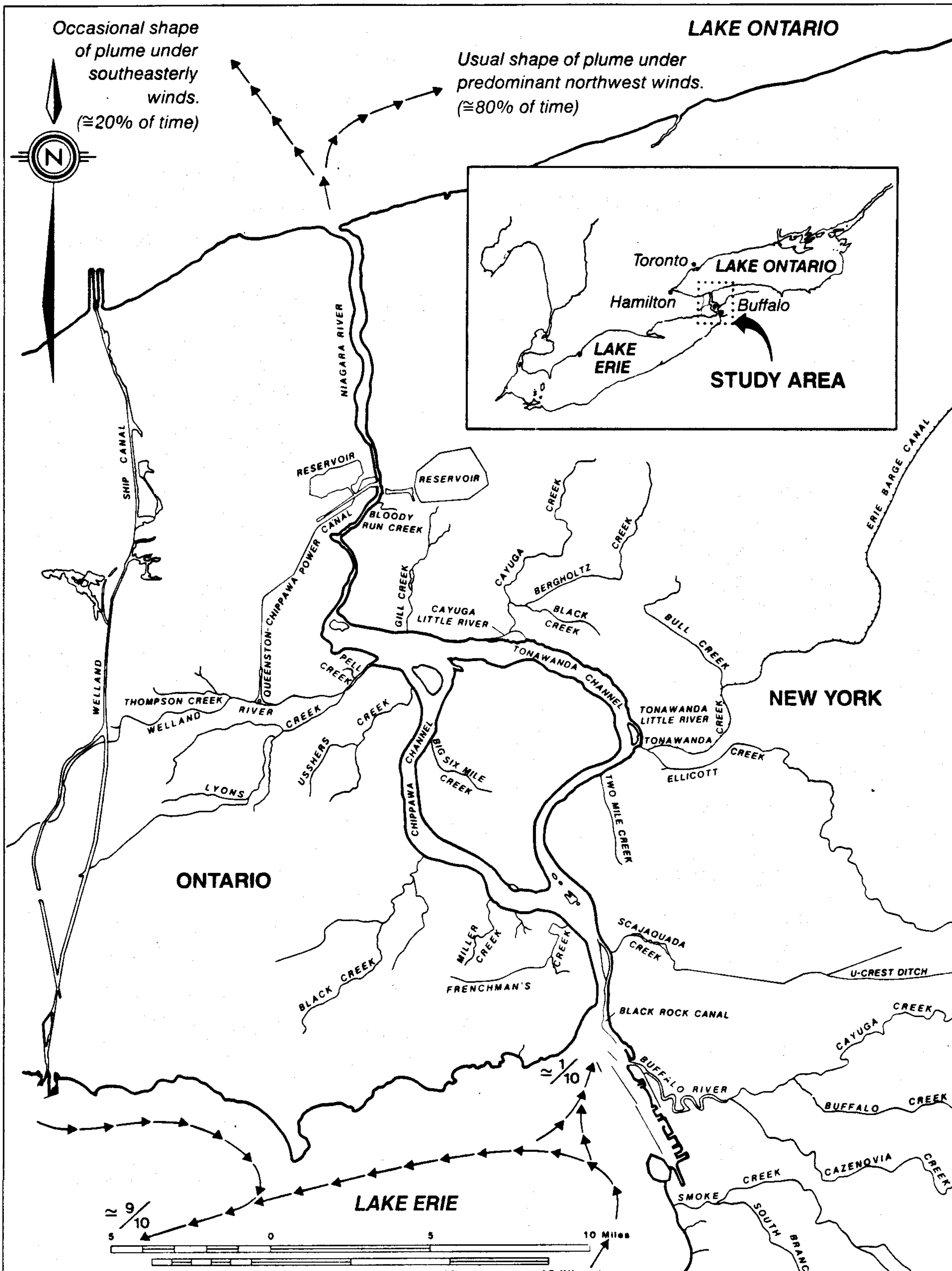

FIGURE 1.2 INLET/OUTLET CONDITIONS OF THE NIAGARA RIVER

River, most of the eastward flowing water returns in the deep westerly current.[2]

1.3.4 River Outlet Conditions

Vertical profiles taken at locations along the outlet plume edge in a band that extended from river water through the interface to lake water showed that within the first 2 - 3 km (1 - 2 miles) from the mouth of the Niagara River, the flow is hydraulically controlled, and the dynamics of the plume are jet-like (Figure 1.2). After this stage, the plume is directed eastward by lake circulation and prevailing winds, and is eventually caught up in the strong easterly coastal current. Horizontal velocity fields computed from a hydrodynamic model confirm this general picture of Niagara River plume behavior.[3]

1.3.5 Sub-Area Definition

For the purposes of illustrating and discussing the results of the source and ambient data in a consistent fashion, both the Canadian and the United States sides of the Niagara River have been divided into sub-areas. The American sub-areas have been further subdivided into segments. Subsequent discussions in this report will be under these general sub-area and segment headings.

The sub-areas and segments are listed in Table 1.1 and illustrated in Figure 1.3

The Buffalo-Lackawanna sub-area consists of four segments: Lake Erie (Bethlehem Steel to Buffalo River mouth), Buffalo River (Buffalo River watershed), Black Rock Canal (parallels Niagara River from Buffalo River mouth to a ship lock at the north end of Squaw Island), and Bird Island-Riverside

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[2] Dr. R. Murthy, NWRI, Personal Communication, 1983.

[3] Dr. J. Carey, NWRI, Personal Communication, 1983.

TABLE 1.1

PROJECT SUB-AREA DIVISIONS

SUB-AREA	LOCATION	SEGMENTS
UNITED STATES		
Buffalo-Lackawanna	S. end of Buffalo Harbor to northern Buffalo city limit, including Bethlehem Steel	1. Lake Erie* 2. Buffalo River 3. Black Rock Canal 4. Bird Island-Riverside
Tonawanda-North Tonawanda	Northern Buffalo city limit to North Tonawanda northern city limit	none
Niagara Falls, N.Y.	Northern city limit of North Tonawanda to Lake Ontario	1. Wheatfield-Upper River 2. Lower River
CANADA		
Fort Erie	Beginning of Niagara River to (and including) Frenchman's Creek	none
Chippawa	Frenchman's Creek to northern tip of Navy Island	none
Niagara Falls, Ontario	Niagara River north of Navy Island, including input of Welland River	none

* This is the small portion of Lake Erie that has been included in the project area. Although it is technically not part of the Niagara River, current flows are such that contaminants from this segment are carried into the river independently of the flow from the main portion of Lake Erie.

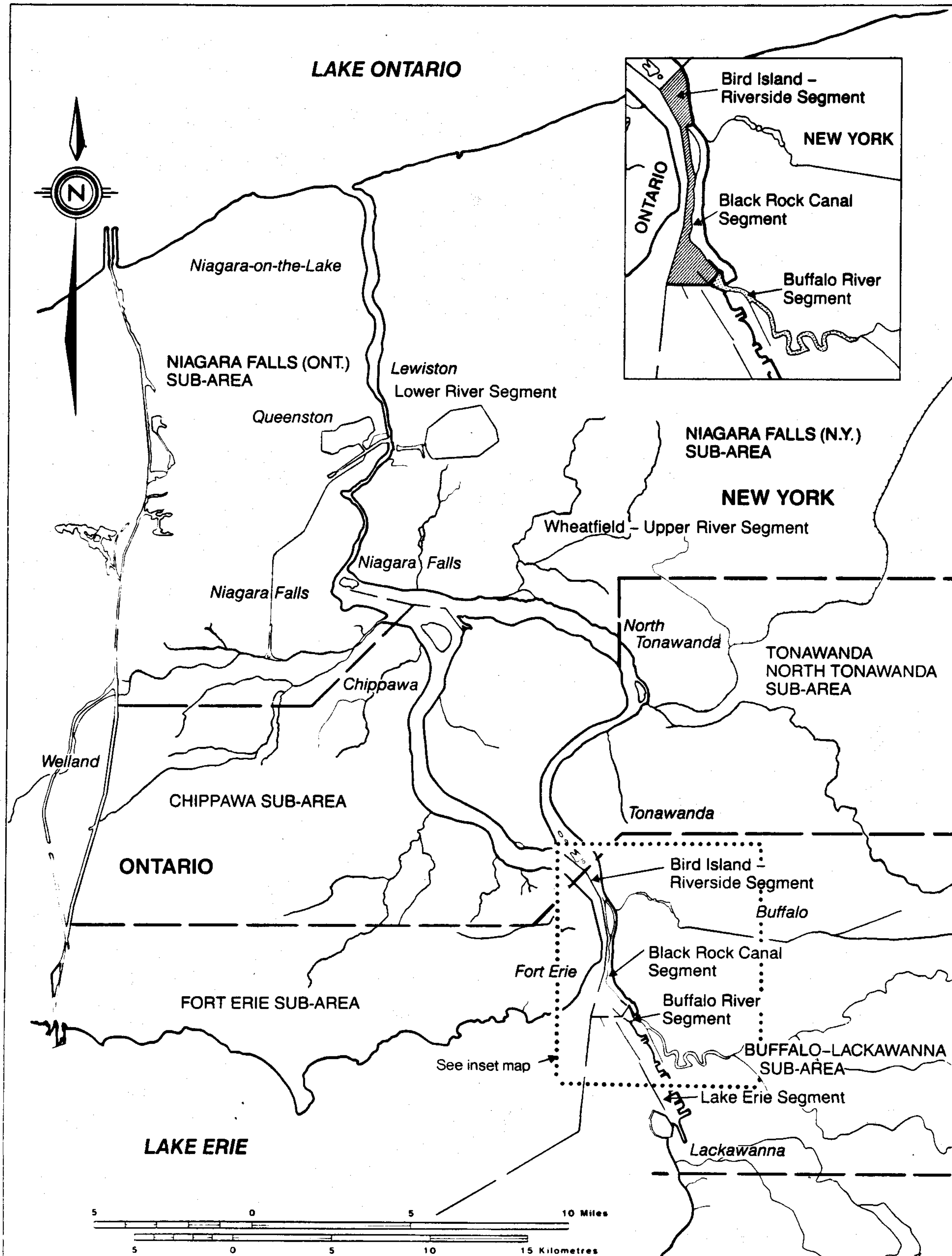

FIGURE 1.3 SUB-AREAS AND SEGMENTS ALONG THE NIAGARA RIVER

(Buffalo River to northern city limit). The Fort Erie sub-area comprises a short section of the river from its source to and including Frenchman's Creek.

The Tonawanda-North Tonawanda sub-area extends from the northern Buffalo City limit to the northern city limit of North Tonawanda and is not further sub-divided. The Chippawa Channel sub-area extends from Frenchman's Creek to the northern tip of Navy Island.

The Niagara Falls, N.Y. sub-area is divided into two segments: Wheatfield-Upper River (City of North Tonanwanda northern boundary to Niagara Falls) and lower River (Niagara Falls to Lake Ontario. The Niagara Falls, Ontario sub-area encompasses the Niagara River north of Navy Island and includes the input of the Welland River.