AN ANALYSIS OF HOUSEHOLD WATER EXPENDITURES IN MAJOR METROPOLITAN AREAS IN CANADA 1969 - 1982

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Master's Thesis submitted to the
Department of Geography, University of Manitoba
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A thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

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ABSTRACT

The study compares household water expenditures among 12 major cities in Canada. Expenditure data were derived from the Statistics Canada series, *Urban Family Expenditure 1969-1982* (cat. nos. 62-534, 62-550). A nationwide telephone survey of the waterworks department in each study metropolitan centre was also conducted to determine related information concerning source of water supply, water billing frequency and water cost calculation in each of the cities.

The study revealed that major metropolitan areas in Canada have significantly different means of managing, charging and billing for water. This management inconguity has, in turn, caused variations in water charges among cities. Household water expenditures ranged over the study period between a high of over $60.00 (1971 dollars) in Regina in 1978, to a low of $3.40 in 1969 in Quebec City. These figures denote the cost for the procurement of water to an average household in each city, over a one year period. Generally, water expenditures were highest in metropolitan areas located in the Prairie region, while the majority of Eastern cities indicated costs below the national average.

Overall, water expenditures appeared to fit in a pattern of regional water availability, in that costs were high in water-short regions, while expenditures were low in areas of water abundance. Water expenditures were also generally related to billing frequency, type of water supply source, per capita water use, method of water cost calculation, and level of wastewater treatment among the study metropolitan centres.

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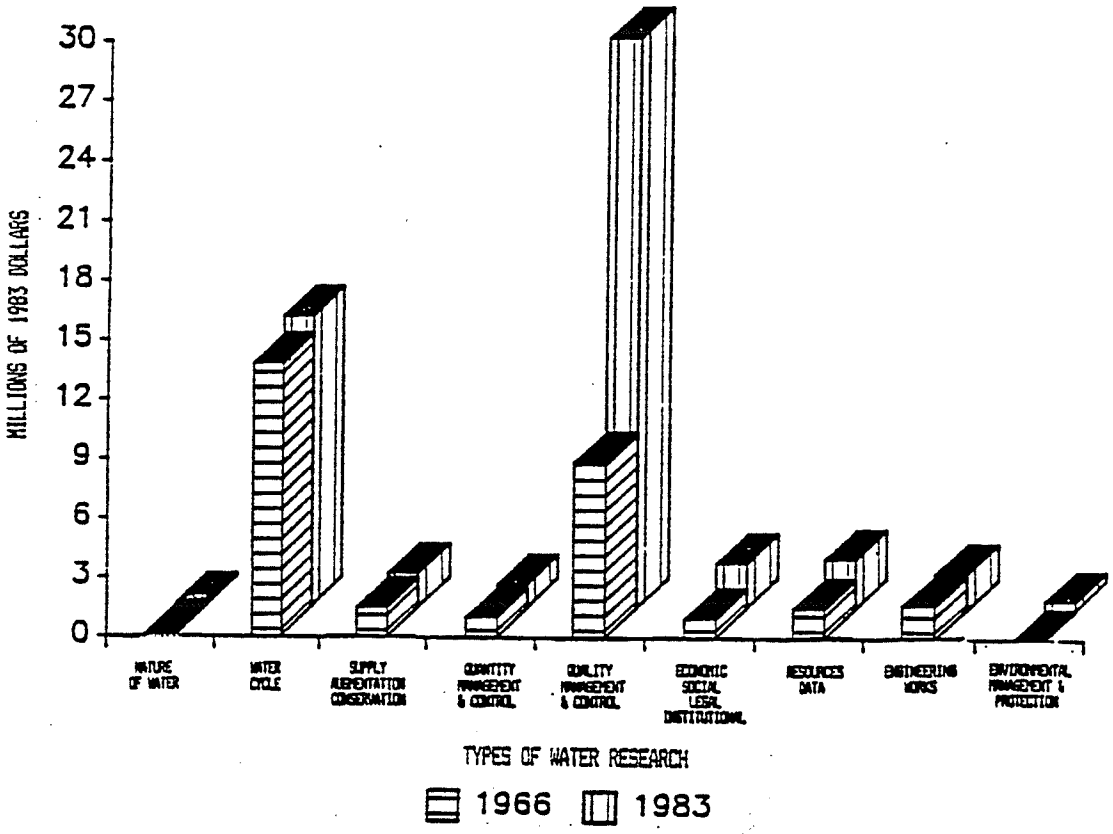
PREFACE

The task of examining household water expenditures is a difficult exercise, for a variety for reasons. First, the topic covers a large area and time period, with the study of 12 separate metropolitan areas and their urban water supply arrangements, over a 13 year period. Many aspects of hydrology, engineering, climatology, biology, political science, economics, and geography are involved, in varying degrees, in any discussion of urban-water supply, hence, the examination of each city in a one particular year alone could have warranted a separate study. The wide scope was necessary, however, to gain a broad perspective of the entire Canadian urban-water system, although the logistics of the topic entails analysis and interpretation that only scratchs the surface of these disciplines and their relationships with the subject.

Secondly, a more serious problem existed with respect to the lack of related literature. Biologists and hydrologists have long dominated water research, and they have concentrated on issues of water quality and water cycle study, at the expense of most all else. Consequently, a significant gap exists in the literature of urban-water management, particularly with respect to pricing issues. This trend was identified by Mitchell and McBean (1985) who examined changes in funding for various types of water research, by source since 1966, as shown in Figure A. Water quality and water cycle research was and remains the main focus of funding, while the category of *Economic, Social, Legal and Institutional* research amounted to only three percent of total funding in 1966, with a slight increase to four percent by 1983. The fact that water economics was grouped in a general category with the other three research areas would also suggest that specific economic study was only a portion of this small amount. This evidence explains why a significant portion of the works listed in the bibliography are not cited directly in the study.

Thirdly, the use of subjective interpretation was often necessary

FIGURE A: FUNDING FOR VARIOUS TYPES OF WATER RESEARCH, 1966,1983



Source: B. Mitchell and A. McBean. 1985. "Funding for Various Types of Water Research" in Inquiry on Federal Water Policy. *Currents of Change - Final Report*. 1985. Minister of Supply and Services, Ottawa. p. 115.

because information regarding basic aspects of urban-water management, the source of water supply for example, was not readily available. A general inventory of water management arrangements was conducted for all the study cities, but this information only described the framework of urban-water management bureaucracy. It did not explain how these factors related, if at all, to household water expenditures. Subjective interpretation, therefore, was needed to hypothesize links between the two.

Above all, the thesis will address various aspects of Canadian urban-water supply, however modestly, with a national perspective. Many people are becoming increasingly concerned with the scarcity of

water, the quality of its accompanying infrastructure, and the possibility of water export to the United States, all of which have important implications for Canada's urban-water supply. The advent of the Inquiry on Federal Water Policy (1985), an advisory committee appointed to the Federal Minister of Environment, has finally spurred this concern into more detailed discussion of these and other water resource problems, on a national scale.

In this context, the organization of the study is as follows. The first chapter examines the isolated nature of Canadian water management, and it is argued that metropolitan areas in Canada have become distinct 'city states', removed from other cities and other levels of government, in regard to water management arrangements. The second chapter examines past case studies of water-pricing in Canada and the United States. The review illustrates the many difficulties associated with comparing water prices and water management arrangements between cities. Chapter three discusses the study methodology, which involves a review of the Statistics Canada series *Urban Family Expenditure in Canada* (cat. nos. 62-534, 62-550), from which, the household expenditure data were derived. The chapter also details the nationwide survey which was conducted to collect specific information regarding each waterworks department. The fourth chapter presents the study results and discusses the trends comparing such variables as precipitation, population size, per capita water use, pricing and billing procedures, level of water treatment and source of supply among the study metropolitan centres. Lastly, chapter five presents the conclusions, and offers recommendations concerning urban-water research.

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CHAPTER ONE - INTRODUCTION

Issues of urban-water pricing have not been the centre of national survey, hence, it is the intent of this study to identify the basic residential water pricing and billing arrangements in the major metropolitan centres of Canada. Spatial variations in these water supply components will also be discussed in reference to geographic factors, across regions and among cities. The study will examine the household water expenditures[1] in 12 major cities, namely St. John's, Halifax, Quebec, Montreal, Ottawa, Toronto, Winnipeg, Regina, Saskatoon, Calgary, Edmonton and Vancouver, in selected years between 1969 and 1982. The analysis is designed with the following three objectives: the review of past literature; the identification of the water expenditures and basic water management arrangments in each study metropolitan centre during the specified time frame; and the analysis and explanation of the evident trends.

Why Study Household Water Expenditures?

There are several reasons why the study of this subject is important. First, metropolitan water supply facilities and their related economic components should be subject to continuous scrutiny because of the high concentrations of population and water use in these urban areas. The combined population of the 12 study cities represented nearly half of the total population of Canada during the study period, while the combined municipal water use in the 12 metropolitan areas amounted to nearly 2.3 trillion litres in 1976, nearly 55 percent of the total municipal water use in Canada in that year (Statistics Canada,1983; *Canada Water Yearbook,* 1983).

Secondly, past research by Lee (1969,1972), Quinn (1968,1973, 1976,1977,1981) Sewell (1961,1966,1974,1977,1978,1981,1983), Tate (1978,1983,1984) and White (1969) have utilized geographic methodologies and approaches in their analysis of North American water issues. It is recognized, then, that geographers have played a pivotal role in past water research, justifying their active

involvement in present and future water study.

Lastly, the use of household water expenditures provides a consistent, if not a simplier, quantitative index for comparing costs between metropolitan centres. Expenditures are measured over time, a one year period in this case, as opposed to measures which are generally given in terms of cost per unit volume. Past pricing studies have generally used municipal water rates, which correspond to specific blocks of water usage, as the sole criterion for comparison. However, the great degree to which municipal water rates and accounting procedures vary among cities makes it difficult to establish accurate comparisons. Some cities charge by the amount of water used, others by a flat-rate based on property value, while one city calculates charges based on the number of rooms and water fixtures in the household.

The Isolated Nature of Canadian Urban-Water Management

The remainder of the chapter will examine various aspects of the Canadian water management system to better illustrate the regulatory environment in which urban-water use and cost are determined. The overview reveals that the lack of a coordinated water policy among all government levels has developed a substantial diversity in municipal water management arrangements. Water procurement for metropolitan centres has evolved with little or no cooperation with either the federal or provincial governments. Consequently, each metropolitan area can be likened to a separate city state with respect to water management because all aspects of pricing, billing, source of water supply, and water treatment are mostly the choice of the city alone.

The three levels of government provide essentially four water services to the people of Canada. The local level supplies freshwater and sewer services to each household and business, while the provincial governments maintain hydro-facilities and water-related recreational sites. The federal government is generally responsible for transportation, navigation, agriculture, trade and Northern

concerns, while at the same time, all three levels are involved in protecting Canada's water from the pollution and natural destruction which often accompanies the provision of the services just described. The record of each level of government research and action within this management scheme has been one of isolation, evidenced by the frequent overlaps in water agency mandates and jurisdictions between and within levels of government. Bureaucratic confusion and conflict has been the result, with hundreds of water-related departments administering different types of programs, each with its unique priorities and objectives (Gibson,1969; Judy,1969; Foster and Sewell, 1981).

The reasons for this fragmented nature of management can be traced back to the *British North America Act (B.N.A.)* of 1867, which established the legal framework for all subsequent water management in Canada. This document drew a distinction between the proprietary and legislative rights of governments to water, that is, between who owns the resource and who can legislate regarding its use, although this distinction does not apply in the northern territories where the federal government retains complete jurisdiction. Elsewhere, the provinces own the resources and as owners, they authorize and license development, levy fees, and regulate flows. The only provinces that regulate inter-provincial flows are Manitoba, Saskatchewan and Alberta, all of which formed the Prairie Provinces Water Board in 1948 to better study water flow problems in the region. Water charges and user fees are also more common in the Prairie provinces because of the many water-short areas in the region (Sadler,1983).

The federal government can legislate exclusively with respect to navigation, fisheries, agriculture and, indirectly, in regulation of interprovincial and international undertakings, including trade. The federal government may also provide funding for system construction, particularly in areas of federal interest, such as interjurisdctional water, military bases and native lands. This government level also provided assistance for public water system construction through its Community Services Contribution Program, but this service expired in

1984 (Tate et al., 1984). The Prairie Farm Rehabilitation Administration continues to assist in the financing and construction of farm water water supplies and small community systems in Western Canada. In a few cases, private industrial operations may also provide financial support for water services. In one-industry towns, for example, large industrial plants may supply the municipal water and waste treatment facilities (Sadler,1983).

The provinces, as owners of the water, delegate large areas of responsibility over water supply and sewage treatment to municipal and/or regional governments. Most of the provinces also assign water recreation and administration of public lands and associated waters to separate ministries (Tinney and Van Loon,1972; Bellinger,1975; Mitchell,1975).

Yet, the theoretical division of propiertary and legislative rights is mostly inconsequential when viewing the evolution of water management following the B.N.A. Act. Water stewardship for the next hundred years would be mostly ad hoc, acting in response to identifiable water problems. The Water Survey of 1908 and the *International Boundary Water Treaty* of 1909 are two examples in this regard. The Water Survey remains in operation today and obtains basic hydraulic and hydrologic information on water levels, temperature, quality and sediment from over 3,000 stations across Canada. The *International Boundary Waters Treaty* was established between Canada and the United States to assign rights and duties to both countries regarding shared waters. The International Joint commission was formed as a direct result of this agreement with the aim of resolving common water problems through cooperative proceedings (I.J.C.,1980). Although these developments were important, a serious oversight was the lack of any unifying policy objectives regarding water use. The first sign of any water policy would not appear until 1970, with the establishment of the Department of the Environment and the *Canada Water Act*. The former was created with primary responsibility for administering water resources from the national point of view, while

the latter was enacted to provide for comprehensive water quality and quantity management in major river basins across Canada, in conjunction with the various provincial governments. These developments reflected a growing trend among the federal and provincial governments for greater research regarding water quantity and quality and other related environmental concerns during the 1970s.

These delays in formulating federal policy would have far-reaching effects, especially with respect to the provision of urban-water supplies, which went largely unnoticed by the federal and provincial governments. Metropolitian centres were almost always the sole financial contractors of their own water development, although grants and cost-sharing agreements may have been common between the provinces and selected rural municipalities. Canadian metropolitan centres can be classified as micro-regions in this regard, because they designed and constructed their own waterwork systems in sole relation to the perceived needs of the proximate urban area, on a scale proportional to the level of population and industrial concentration.

Another factor which further isolated municipal water management from the federal and provincial levels was, and remains, the differing objectives involved in each. Water managers at the local level are the most politically sensitive of all water resource professionals to public criticism because a majority of Canadians live in cities, and they have generally come to expect water in the purest state in unlimited quantity, a common perception of urban residents regarding their water supply (Ibsen and Ballweg,1969; McMeiken,1972; Wasny,1982). In this manner, the urban dwelling, or the home, is the locale where the majority of Canadians come into direct contact with water everyday. Meanwhile, provincial and federal officials are responsible for water removed from urban centres, the residents of which, usually express a decreasing lack of interest in natural resource development and protection, the further removed its activity is from the city. This situation is not always the case, as evidenced

by the protest of many environmental groups, native interests and concerned proximate inhabitants in opposing water projects, although this type of protest is confined to an almost insignificant proportion of the total population.

The urban bias of Canadian society places more intense political pressure on municipal managers to deliver a tangible water supply to each dwelling and business. In contrast, the federal and provincial governments usually offer a service of transportation, navigation and environmental protection in their water-related activity. Generally speaking, then, municipal governments are geared toward a 'water-good' orientation, while 'water-service' is the emphasis of the other levels of government. This observation may seem elementary, but it relates a key distinction between levels of government and how each possesses its own objectives and ethos in water management.

Summary

This chapter has demonstrated that cities are isolated areas of water management, both in a theoretical and spatial setting. The lack of a national or regional water policy in Canada has allowed cities to develop their own water priorities and develop cost structures mostly independent of any external guidelines that would usually be imposed by higher levels of government. The emphasis on water as an economic good in municipal concerns, as opposed to water as a service in other governments, is further cause for distinction. Above all, cities have developed water supply arrangements independent of one another, hence, much diversity in structure and cost can be expected in municipal water management economies across Canada.

Notes

[1] In this study, the terms 'water expenditure' and 'water cost' are considered synonymous and will be used interchangeably.

CHAPTER TWO - WATER-PRICING CASE STUDIES

The theoretical trends of urban-water management reviewed in the first chapter lead into an examination of past water-pricing case studies. This research has examined price schedules, water cost calculations, billing frequency and other related supply characteristics in a number of cities and municipalities. The review will be divided into two sections, namely unpublished and published studies. The former have emphasized a national approach at the expense of in-depth analyses, while the latter have documented water-pricing in specific cities and regions, but not on a national scale. The published studies will be reviewed first.

Published Studies

Seidel and Cleasby (1966) published a summary of statistical data on waterworks departments in the United States, and reported that the size of the utility, degree of treatment, and type of ownership affected the level of rates, although no coefficients of relationships were generated from their analysis. Afifie and Bassie (1969) reported that the most important determinants of water prices in Illinois were as follows: total population served; type of ownership; source of supply; quantity of water produced; balance of long-term debts; percent of metered accounts; type of treatment income per head; average cost of water; and number of years the water charge had been in effect. These two American studies indicated that urban-water prices were related, in part, to cost of supply, while debt service costs and system scale were also important explanatory variables.

Penman (1981) noted that there are five general principles underlying the setting of water rates, namely life-line, flat-rate, demand-modification, value of service, and cost of service. Water rates using the life-line principle would be very low for the minimum amount of water required for health standards, while in a flat-rate system, customers are charged a fixed amount regardless of the amount

of water used. Demand-modification refers to the development of artificial rates, as opposed to cost-based rates, to increase or decrease the amount of consumption, while in the value of service principle, rates are set at what the market will bear. The cost of service principle dictates that water charges to customer classes are based on the actual cost of serving the customers.

He also reported that the cost of service rate may be derived by two different water cost calculation methods, namely functional cost and base-extra capacity. Rates in the functional cost method are determined in consideration of the total costs associated with operating the utility, in addition to the total water sold within selected volume categories. Following this, the volume categories or blocks are associated with types of customers, usually residential, commerical or industrial. The base-extra capacity method also considers total costs but other costs are considered on the basis of the design of the system for certain peak requirements. In simplier terms, functional cost accounts for water utility cost plus the cost of the water itself, while base-extra capacity accounts for the same costs, although the extra cost of designing for peak flow is included. Engineering design parameters, therefore, are the basis of these rate methods.

A problem with the Penman study is that it fails to explain the exact relationship between water rates and total costs. Past work by Ciriacy-Wantrup (1961), Seidel and Cleasby (1966), Lee (1972), Grima (1984), and Tate et al. (1984) have agreed that many cities determine their water rates based, in part, on the total costs of their operations. Yet, the exact definition of 'total cost' for a metropolitan area water utility remains uncertain. The most visible cost is the yearly operating expenses but there may be other costs that are not so easily apparent. For example, a utility may have accumulated a deficit over a period of time, which may or may not be its responsibility to retire, while in other cases, the host city may consider the utility debt as merely a necessary civic expense, and

subsidize its operations through general tax revenues[1]. The utility may also be expected to pay a proportion or all of the debt interest, or even the principal itself, hence, the degree to which civic water rates reflect yearly cost of operations, past debts, or debt interest payments is not known.

The descriptive nature of Penman's study is an exception among the majority of published literature in this area, which is more critical in its assessment of urban-water pricing. Davar (1977) noted that water rates in all sectors of the Canadian economy were related to token charges, providing revenue to offset administrative expenses of the waterworks departments. Grima (1972) reported that the capital costs of water-based infrastructure in metropolitan centres were becoming increasingly expensive. He suggested that flat-rates and cost of service rates were inefficient as the basis of water charges because they promoted overuse of the resource, and the overbuilding of water supply systems. These methods do not recognize that the vast majority of water demands are fairly elastic, in that an increase in water prices would lead to a decrease in demand. This evidence suggests that a system of increasing block rates, which increases cost with greater water use, would promote water conservation and more rational water system construction, although at present, declining block rates are mostly in effect, which encourage significant water waste. The latter rate method, as its name implies, entails the overall unit cost of a large volume of water being less than the unit cost of a small volume of water. However, before a customer receives the benefit of the reduced rate for larger volume, the higher rate must be paid for the initial usage. The decreased unit cost of supplying the larger volume, it is argued, justifies the decreased unit cost.

Sewell and Roueche (1974) studied water pricing in Victoria, British Columbia, and noted that economically viable water pricing would lower peak water demands, leading to savings in both construction and operating costs. These general conclusions were

later shared by Gill and Leitch (1983), who conducted a review of the water and sewer rate design in the municipality of Durham, Ontario. Their study noted that it was common practice in the municipality to channel part of the water system revenues into general funds unrelated to the provision of water services. This practice was considered to be politically advantageous in that it kept taxes down, while maintaining the level of water services for only modest increases, although it resulted in improper price signals being sent to customers. Consequently, their conclusions concurred with earlier studies which strongly urged that water pricing should be better designed to promote more efficient water use.

A similar study to this household expenditure analysis was by Grima (1984), who performed a comparative analysis of the cost of supply and water rates in 43 Ontario municipalities for the period 1965-1969. He determined that the average cost of urban-water services in Ontario was 35 cents per 1,000 gallons in 1969, and the costs ranged from a low of 13 cents in St. Catherine's, to a high of 70 cents in Bertie township. The variance was explained by the two major components of debt service cost and operating costs, but it was suggested that there were important political inputs into the decisions to price urban-water services. Over 80 percent of the 42 municipalities charged less than average cost to large customers, who used over two million gallons per month, while 18 of the municipalities charged less than average cost to small industrial users, who used approximately 50,000 gallons per month. Smaller residential/commercial users were also charged less than average costs in six municipalities, and the required revenue was recovered by means of fixed service charges and/or higher rates for small users. Overall, Grima reported that the pricing of urban-water services was not cost-related, and there was considerable over-investment in municipal water supply systems because of underpricing.

The household water expenditure study is generally similar to Grima's analysis in that water costs are compared between Canadian

metropolitan divisions, although costs are strictly defined in terms of expenditure over a yearly period, not, as in Grima's case, a rate per 1,000 gallons. However, the limited scope of Grima's analysis, within southern Ontario during the years 1965-1969, enabled the study of such detailed data as the debt service cost and operating expenditure of each municipality. Unfortunately, these factors cannot be considered in this study because exact financial information regarding water supply systems of major Canadian cities is not readily available.

Unpublished Studies

At the outset, water cost calculation and billing frequency merit discussion because they will be referred to in this section. The former refers to the method by which the costs of water are calculated, which involves a flat-rate charge, a metered cost, or some combination of both. The flat-rate system bases costs on a fixed charge in relation to property value, or the number of rooms and water fixtures in a dwelling, thus, the amount of water used plays no role in the cost for its procurement. The metered system calculates costs based on consumption, which may or may not include a minimum service charge, and a meter must be first installed in each dwelling to calculate the amount of water use. Billing frequency refers to the number of times water bills are issued every year. In some cities, for example, a water bill is sent out only once a year while in other metropolitan centres, water bills are issued monthly.

Robinson (1984) studied aspects of municipal water conservation and pricing in the municipalities of Kitchener-Waterloo and Cambridge, Ontario. He reported that no incentives existed for water conservation and, as a result, water systems in general were overbuilt in these municipalities. Robinson suggested that more water conservation measures be implemented, namely rebates for installing water-saving devices, the encouragement of retrofits of water-using appliances, and rewriting plumbing codes and housing standards to

encourage conservation.

A comprehensive work in water pricing was undertaken by Tate et al. (1984), who distributed questionnaires to municipalities in all regions of Canada and gathered data on current water pricing practices, aspects of jurisdiction, tariffs and charges, financial aspects of water servicing and water quality. Comparisons of water prices between municipalities were undertaken using the cost of an 'average' household water pumpage, selected at an arbitrary 20,000 litres per month. The respondent municipalities were then grouped by region, namely Atlantic, Quebec, Ontario, Prairies and B.C.. Table 2.1 displays a sample of their results for the Atlantic region, although the 'population served' category in each municipal listing infers that the majority of municipalities were rural, or at least, not major metropolitan centres. These figures, therefore, are a greater reflection of rural water water prices than city water charges.

Most municipalities surveyed used either a flat-rate, declining block rate, or a combination of both. The correlation between total pumpage and the estimated cost of a typical amount of water was below .2 for all five regions, illustrating that water price played little apparent role in municipal water use at the regional level. It was argued that this result did not negate previous research which has suggested that price may be a significant variable in the water use of individual municipalities. Water use, for example, has proven to be highly elastic, in that increases in price will lead to a decrease in demand, hence, water pricing is an effective demand-modification tool (Ciriacy-Wantrup,1960). In addition, the correlation between total residential water pumpage and total population was high, over .8 for all regions, indicating that the greater the population, the more water use.

It was not specified how water costs compared among regions, so the average monthly cost for each region was calculated from their results, as shown in Figure 2.1. The averages are lower in the

TABLE 2.1: ATLANTIC REGION SURVEY RESULTS

Municipality	Residential Rate Structure	Per Capita Use By Population Served (cu. M/D)[1]	Population Served	Average Flow Pumpage (cu. M/D)	Cost[2] ($1984)
01	flat	1.06	30,000	31,779	10.40
02	flat	1.13	6,000	6,809	6.25
03	flat	0.23	12,000	2,721	9.00
04	flat	-[3]	-	-	5.75
05	flat	0.38	5,400	2,042	16.00
06	flat	0.45	10,000	4,538	12.00
07	flat	0.68	10,000	6,809	-
08	flat	0.45	9,439	-	2.34
09	decline block	0.60	21,000	12,471	2.72
10	flat	-	-	-	3.58
11	decline block	0.71	7,800	5,561	3.34
12	flat	0.61	42,400	-	9.33
13	flat	0.80	5,616	5,883	10.16
14	flat	-	-	-	5.06
15	flat	-	-	-	9.83
16	flat	3.18	80,000	254,692	4.44
17	decline block	.57	15,600	8,852	6.07
18	increase block	-	-	-	9.67
19	decline block	1.82	33,515	60,833	4.00
20	flat	0.99	10,849	10,755	4.56
21	decline block	0.46	8,319	3,813	3.74
22	flat	-	-	-	5.28
23	decline block	-	-	-	3.92
24	decline block	0.60	6,000	3,631	5.19
25	flat	1.15	13,047	15,000	3.20
26	decline block	0.58	272,000	156,688	3.40
27	flat	0.72	11,000	7,904	1.89

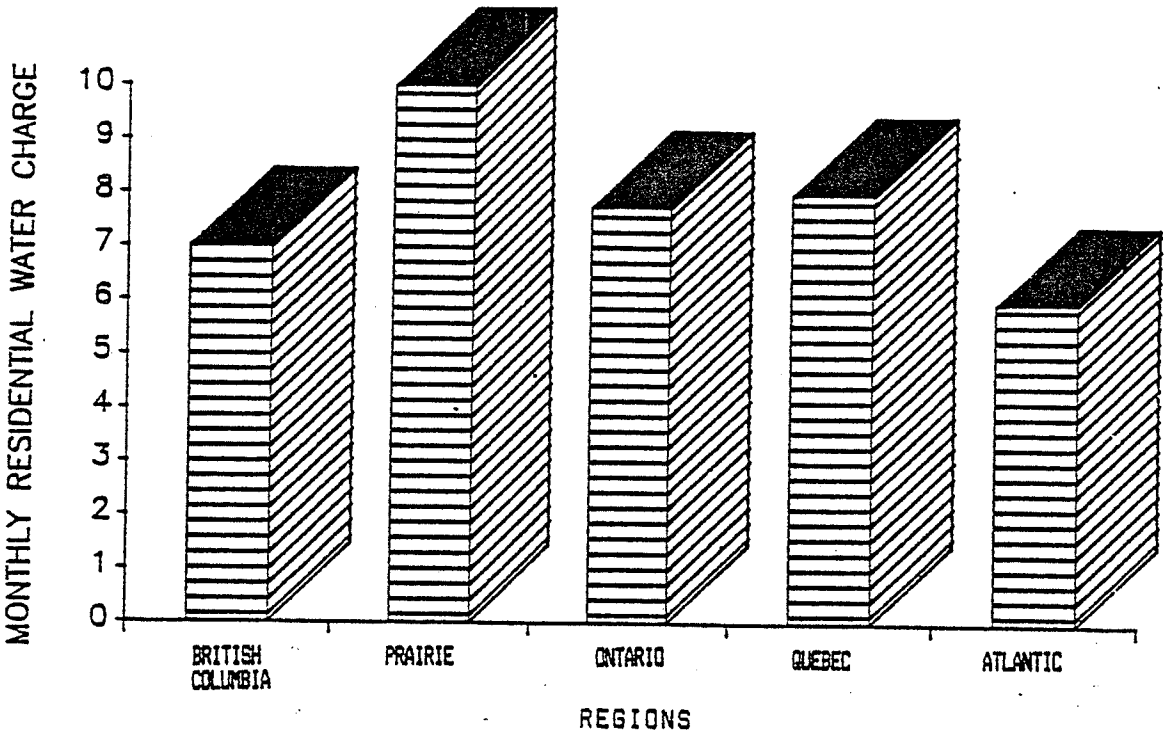
[1] Cubic meters per day.

[2] Denotes average monthly cost ($1984) for 20,000 litres of water use.

[3] Data not available.

Source: Tate, D.M., P.J. Reynolds and P.A. Dossett. 1984. *The Role of Water Pricing in Canadian Water Management.* Unpublished paper to OECD. Water Planning and Management. Inland Waters Directorate. Ottawa, Ontario.

FIGURE 2.1: AVERAGE RESIDENTIAL MONTHLY WATER CHARGE BY REGION



Figures denotes the average cost in $1984 for the procurement of 20,000 litres of water for residential use, of those municipalities surveyed. Source: Adapted from Tate et al. (1984) *The Role of Water Pricing in Canadian Water Management.* Unpublished report to O.E.C.D., Environment Canada, Ottawa.

Atlantic, Central and B.C. regions of Canada, reflecting that water prices were generally lower in areas of abundant supply, although the quality in some cases might be an issue. The Prairie region indicated a higher average, suggesting that the procurement of its water supply was more involved and expensive because of its semi-arid climate.

A difficulty with this study concerns the method by which the water cost for municipalities based on a flat-rate structure were calculated. Flat-rate water costs are usually based on the property value of the residence and the assumption is that the higher the value of the residence, the greater the ability to pay. Consequently, this rate method entails a higher water bill for residents of higher valued properties. The amount of water used, therefore, plays no role in the water charge, and in this case, the use of the standard 20,000

litres per month for residential water use is meaningless. Instead, the average property value of each municipality would have had to been calculated, and then measured against the rate at which properties were assessed in regard to water charges. The fact that no mention was made of this procedure suggests caution in the use of the results.

The Comptroller's Department, City of Regina, undertook cost comparison studies that were similar to the Tate et al. (1984) analysis, although on a smaller scale. In the Regina study, greater emphasis was placed on identifing water and sewer charges, as indicated on Tables 2.2 and 2.3. Water consumption was assumed to occur evenly throughout the year which is, in fact, a misrepresentation because water use greatly increases during the

TABLE 2.2: COMBINED WATER AND SEWER CHARGES OF EIGHT CITIES BY USAGE, 1982[1]

Usage[2]	Toronto	Thunder Bay	Winnipeg	Regina	Saskatoon	Calgary	Edmonton	Vancouver	AVERAGE
6,500	72	97	118	116	88	210	140	49	111
12,000	133	123	218	221	156	275	251	49	178
250,000	2,789	1,234	4,000	4,688	2,943	3,129	4,301	863	2,993
1,000,000	11,155	4,737	15,145	18,992	11,230	12,124	16,274	2,728	11,548

[1] Numbers are in rounded $1982 and denote how much each metropolitan area charged for the given block of water usage in 1982.

[2] Usage is in cubic feet.

Source: Regina Comptrollers Department. 1983. *Comparison of Water and Sewage Rates in Selected Canadian Cities - 1982.* Unpublished Report by the Comptrollers Department, City of Regina, Saskatchewan.

TABLE 2.3: COMBINED WATER AND SEWER CHARGES OF EIGHT CITIES BY USAGE, 1984[1]

Usage[2]	Toronto	Thunder Bay	Winnipeg	Regina	Saskatoon	Calgary	Edmonton	Vancouver	AVERAGE
6,500	89	109	138	129	103	281	167	65	135
12,000	163	138	255	245	186	368	300	64	215
250,000	3,398	1,393	4,708	5,219	3,555	4,600	5,272	927	3,634
1,000,000	13,591	5,345	17,645	20,894	13,680	14,071	20,038	2,933	13,525

[1] Numbers are in rounded $1984 and denote how much each metropolitan area charged for the given block of water usage in 1984.

[2] Usage is in cubic feet.

Source: Regina Comptrollers Department. 1985. *Comparison of Water and Sewage Rates in Selected Canadian Cities - 1984.* Unpublished Report by the Comptrollers Department, City of Regina, Saskatchewan.

summer months, while another problem concerned the lack of methodology in explaining how the water costs were calculated. For example, Toronto water charges are based on the number of rooms and water fixtures in each dwelling, plus a meter rental charge based on the size of the meter and a sewer charge, where applicable. Consequently, the authors of the Regina study had to convert this structure into specific blocks of usage, 6,500 cubic feet, and then calculate a yearly rate for Toronto. This procedure likely involved interpolation and subjective judgement which suggests caution in the use of the results.

The study revealed that Vancouver costs were, by far, the cheapest of the eight cities in all usage categories. This trend was attributable, in part, to the fact that Vancouver residents do not pay sewer charges, which are financed from general tax revenues, as was also the case in Thunder Bay. Calgary displayed the highest costs in the residential usage categories, while Winnipeg was the most costly in the industrial/commericial classification. Generally speaking, the Eastern cities of Toronto and Thunder Bay, the latter of which is arguably 'Eastern' per se, indicated lower costs than Western metropolitan centres, with the exception of Vancouver. Detailed explanations of these trends are given in later discussion of the household water expenditures where the Regina results will be compared with this analysis.

Table 2.4 indicates the structure of residential combined charges to determine the relative proportion of water and sewer costs in the total water charge. Thunder Bay and Vancouver indicated a structure of 100 percent in the water category because there were no sewage charges in those cities. Toronto indicated a sewage cost structure of approximately 13 percent while, in contrast, the remainder of the cities displayed sewage proportions between 30 and 50 percent of total cost. It can be inferred, therfore, that water costs in the West, with the exception of Vancouver, were mostly derived from water supply charges.

TABLE 2.4: STRUCTURE OF COMBINED WATER AND SEWER CHARGES, 1984[1]

Usage[2]	Toronto	Thunder[3] Bay	Winnipeg	Regina	Saskatoon	Calgary	Edmonton	Vancouver[4]
6,500								
Water	86.5	100.0	58.7	51.1	62.1	58.4	69.5	100.0
Sewer	13.5	0.0	41.3	48.8	37.8	41.6	30.5	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
12,000								
Water	87.1	100.0	58.4	50.6	60.8	58.4	68.7	100.0
Sewer	12.9	0.0	41.6	49.3	39.2	41.6	31.3	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
250,000								
Water	87.0	100.0	53.3	50.3	58.1	58.4	62.9	100.0
Sewer	13.0	0.0	46.7	49.7	41.9	41.6	37.1	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1,000,000								
Water	87.0	100.0	50.1	50.2	57.9	58.4	61.0	100.0
Sewer	13.0	0.0	49.9	49.8	42.1	41.6	39.0	0.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] Denotes the percentage proportion of the water and sewer charges within the combined charge. The important issue here is to identify which of these two charges dominate the total charge.

[2] Usage is in cubic feet.

[3+4] No sewage charges were assessed in the cities of Thunder Bay and Vancouver. Instead, sewage charges are financed from general tax revenues.

Source: Regina Comptrollers Department. 1985. *Comparison of Water and Sewage Rates in Selected Canadian Cities - 1984.* Unpublished Report by the Comptrollers Department, City of Regina, Saskatchewan. The structure analysis is the work of the author, not the City of Regina Comptroller's Department.

The City of Winnipeg Waterworks, Waste and Disposal Division performed similar water cost and water billing comparisons among Canadian cities in the years 1982 and 1984, as shown in Tables 2.5 and 2.6. The 1982 and 1984 studies are markedly different in a number of ways, namely the number of cites being compared, the categories of usage, and the time period over which the costs are measured, although the reason for these differences is not known. The 1984 study is identical to the Regina studies in two regards, namely the categories of consumption, and water costs being determined per volume of use. In fact, the costs quoted in the 1984 Winnipeg study are similar to those in the 1984 Regina work, except for the fact that Vancouver was

TABLE 2.5: COMPARISON OF THREE MONTH COMBINED WATER AND SEWER CHARGES BY USAGE, 1982[1]

Usage[2]	Winnipeg	Regina	Calgary	Edmonton
3,000 (Dwelling A)[3]	7.67	21.00	18.34	29.22
7,000 (Dwelling B)	14.48	21.00	21.98	29.22
19,000 (Dwelling C)	36.05	40.53	32.93	52.14
88,000 (Small Restaurant)	151.78	179.76	132.99	188.01
510,000 (Automatic Car Wash)	752.16	1,030.26	498.72	905.69
978,000 (Large Restaurant)	1,336.37	1,974.00	833.68	1,634.46
1,848,000 (Hotel)	2,393.33	3,727.92	1,423.10	2,988.88
14,043,000 (Foundry)	17,128.89	28,313.04	8,837.66	18,929.09

[1] Numbers are in $1982 and denote the three-month combined water and sewer charge by usage categories for various types of dwellings.

[2-3] Note the usage is in gallons not cubic feet as in the Regina studies. The usage rate quoted, however, refers to the average water consumption of the type of dwelling (indicated in brackets) during a three-month period. Additionally, 'Dwelling A-C' denotes three separate sizes of residential units in increasing order of square footage.

Source: City of Winnipeg Waterworks, Waste and Disposal Department. 1983. *Survey of Billing Procedures of Selected Canadian Cities - 1982.* Unpublished Report by the Waterworks, Waste and Disposal Department. City of Winnipeg, Manitoba.

TABLE 2.6: COMBINED WATER AND SEWER CHARGES OF SEVEN CITIES BY USAGE, 1984[1]

Usage[2]	Toronto	Thunder Bay	Winnipeg	Regina	Saskatoon	Calgary	Edmonton
6,500	77	109	138	129	103	281	167
12,000	142	138	255	245	186	368	300
250,000	2,955	1,393	4,708	5,219	3,555	4,600	5,272
1,000,000	11,818	5,345	17,953	20,894	13,680	14,071	20,038

[1] Numbers are in rounded $1984 and denote how much each metropolitan area charged for the given block of water usage in 1984.

[2] Usage is in cubic feet.

Source: City of Winnipeg Waterworks, Waste and Disposal Department. 1985. *Survey of Billing Procedures of Selected Canadian Cities - 1984.* Unpublished Report by the Waterworks, Waste and Disposal Department. City of Winnipeg, Manitoba.

not listed, and the rates cited for Toronto were somewhat lower in the Winnipeg study.

Another observation concerns the 1982 studies of both Winnipeg and Regina, and how each study indicated different results regarding the same cities. The 1982 Winnipeg study displayed that Edmonton had the highest cost in the residential category, and was followed in order by Regina, Calgary and Winnipeg. The 1982 Regina study, however, indicated that Calgary had the highest cost, followed in order by Edmonton, Winnipeg and Regina. In other words, both cities reported entirely different rankings and results even though the same water rates from each metropolitan centre, during the same year, were being compared. Furthermore, in each 1982 study, Regina and Winnipeg each listed themselves as having the cheapest costs of the four Prairie cities, suggesting significant point-of-origin bias in calculating water charges.

Summary

The chapter has reviewed a selection of published and unpublished water-pricing case studies. The published works of Davar (1977), Grima (1972,1984) and Gill and Leitch (1984) have suggested that water pricing, in general, is not cost-related and that many political variable influence water costs. Tate et al. (1984) have also reported that water systems in Canada are heavily subsidized in all sectors, and that few economic relationships exist between the user of water services and the amount paid. Meanwhile, studies undertaken by the City of Regina and City of Winnipeg Waterworks Departments have collected useful data regarding general rates structures and water billing procedures, but their cost comparisons are inconsistent and therefore must be used with caution.

Notes

[1] Personal Communication with Sharon Martissen, Water Rates Analyst, City of Winnipeg Waterworks, Waste and Disposal Division, October 17, 1985, Winnipeg, Manitoba.

CHAPTER THREE - METHODOLOGY OF STUDY

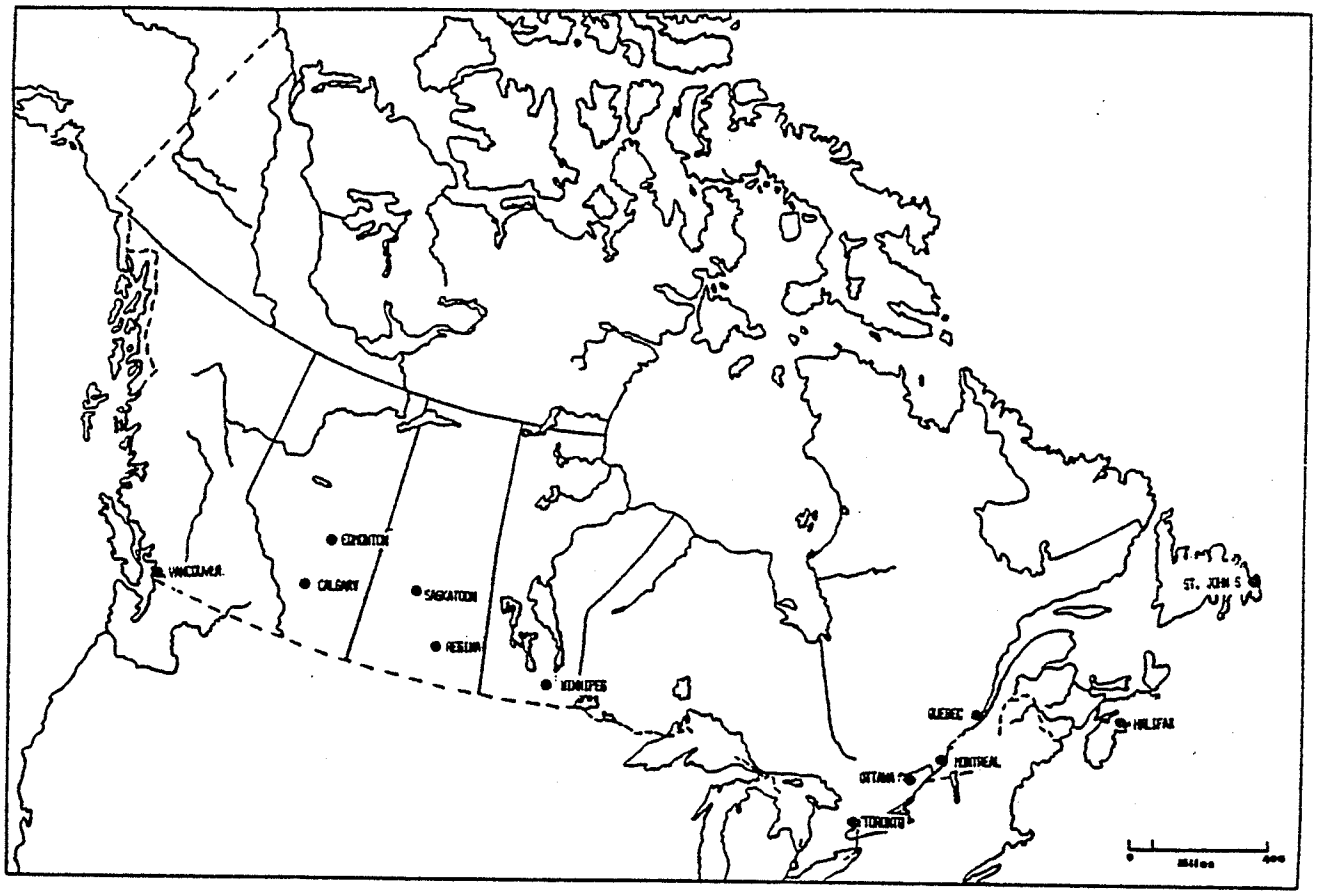
This chapter examines the study methodology and reviews the Statistics Canada series, *Urban Family Expenditure in Canada*, from which, the household water expenditure data were derived. The discussion will focus on the method in which the data were collected, and note the difficulties associated with gathering data of this type. The explanatory variables will be examined, namely source of water supply, water billing trends, precipitation levels, water use, population size, level of water treatment, and total household expenditure, and it will be explained why these variables was selected as significant determinants in this analysis. Information regarding several of these variables was derived by a nationwide telephone survey of the waterworks departments of each study city and this survey will also be reviewed. The chapter is divided into three sections: an explanation of the study metropolitan centres and time frame; the discussion of the household water expenditure data; and the examination of the comparison variables.

Study Metropolitan Centres and Time Frame

The 12 cities used in the study were specifically selected on the basis of data availability because the Family Expenditure surveys, which will be discussed shortly, were conducted mostly in these major metropolitan centres. The cities also provided an adequate representation of the Atlantic, Quebec, Ontario, Prairie and British Columbia regions of Canada, as shown in Figure 3.1. The year 1969 was chosen as a beginning point of study because it was the first year in which the Family Expenditure surveys had been conducted on a national scale with consistent sampling techniques in all study cities (Statistics Canada,1983). Prior to 1969, these surveys did not record such details as water expenditures and instead only tabulated general categories of household expenditures such as food, shelter and clothing. 1982 was chosen as the final year of study because it was the most recent year in which the household water expenditure data

were available.

FIGURE 3.1 - STUDY METROPOLITAN CENTRES



Household Water Expenditure

Household water expenditure is the amount of money spent in one year by an individual, or a group of individuals living in a residential unit, be it a duplex, apartment, or house, for the procurement of water services to their dwelling. This expenditure refers to both water supply and sewage charges, although Vancouver is an exception since no sewage charges are assessed to its water customers. The expenditures are the average of all the water costs indicated by each respondent, for their household in the given city during the specified year. The water expenditures of all surveyed

households, be it a one room apartment or a 20 room house, were added for a given metropolitan area and then divided by the total sample size in the same city, to calculate the 'average' water expenditure.

The data are wholly derived from the Statistics Canada series, *Urban Family Expenditure in Canada* (cat. nos. 62-534, 62-550) which is developed by the Family Expenditure Section, Consumer Income and Expenditure Division, of Statistics Canada. This agency has conducted ongoing personal interviews with selected families, in major metropolitan areas across Canada since 1937, although detailed records of expenditure did not begin until 1969 (Statistics Canada,1983). Statistics Canada officials collect information in the interviews regarding all expenditures made by the household for the survey year. The surveys are conducted in January, February and March, and respondents are asked to recall their expenditures for the previous calendar year. In 1982, for example, the expenditures indicated for that year are for 1982 alone, although the results were tabulated by personal interview in the first three months of 1983. The accuracy of these data depended on the ability of the respondent to remember individual purchases at a considerable level of detail (Statistics Canada,1983).

The recollection of water expenditures would have been somewhat difficult for most of the respondents because water bills usually accounted for less than half a percent of total family expenditure in a year. Another issue involved the manner in which the respondent was billed for water, considering that billing frequency varied among the cities. Calgary, for example, issued water bills every month to each household, while in Vancouver no water bills, in the strict sense of the word, were sent out and, instead, water charges were included in an itemized statement of general civic taxes which was issued only once a year. The pricing system used to calculate water expenditure in each city was another related variable because some metropolitan centres charged a flat-rate for water service, while other cities based water charges on metered use. The extent to which these

differing methods of billing and pricing affected a respondent's ability to recall their yearly water expenditures is not clear, although residents who faced a metered charge likely had a greater water cost awareness than did householders who paid a flat-rate. Respondents who lived in cities with a higher frequency of water billing, every month or two months, could also be expected to possess a greater awareness of water cost than those who were billed once a year, inferring that the higher the water bill frequency in a city, the more accurate of its response. Either way, the issue is that water billing procedures and cost arrangments likely had some effect on the respondents' view of their water expenditures.

The expenditures may have a downward bias because most apartment dwellers usually paid much less, in some cases even nothing, for water service than did homeowners. Although rental agreements vary from building to building, it is common practice of landlords to include water charges as part of the basic rental payment or lease agreement with their tenants. In most cases, a statement of the water charge to the apartment unit is not listed on the rental invoice, hence, respondents who lived in apartments had to estimate their water costs who, in turn, likely indicated water expenditures that were relatively low. However, the use of averages negated some of the extreme miscalculations to provide a relatively accurate index of the expenditures.

Comparison Variables

The data were then analyzed in consideration of relevant geographic factors, which were selected on the basis of two criterion: each had to be 'geographic' in nature, related to the provision and pricing of a water supply to a city; and each had to be information accessible, which refers to the amount of available data and information regarding the variable. Seven variables were selected within this criteria, namely water supply source, billing frequency, method of water cost calculation, level of precipitation, per capita

and general water use, population size and growth, extent of water sewage treatment, and level of total household expenditure. This list does not preclude the fact that a number of other variables may be signficant, either singly or jointly, in affecting household water expenditures, although the seven selected variables appear to be those most likely to have signifcant affects on the issue.

All the variables, with the exception of the water supply source, billing frequency, and method of water cost calculation were derived from a variety of government publications. Data on the latter were collected from a nationwide telephone survey undertaken during October, 1985, although the water supply source of Vancouver, Calgary, Edmonton, Saskatoon and Winnipeg were identified from annual civic budget reports for each city. Water supply source information concerning Regina was derived from Cullimore (1980), but direct contact was necessary with the waterworks departments of Eastern cities to determine their water supply source.

A telephone survey was considered to be the most logical method of data collection because of the large distances between the metropolitan centres, and the inherent difficulties associated with mail surveys to government agencies. The waterworks department, or similarly named agency, of each study city was contacted, and a brief interview, which ranged between 15 minutes and one hour, was conducted with a willing respondent. Prepared questions were then asked to determine the basic water management arrangements in each city, namely the water supply source, frequency of water billing, method of water cost calculation, and water rate structure (see Appendix 3.1 for the survey results). Information derived from this survey regarding these variables will be assumed to be the conditions which were in place over the 1969-1982 study period.

This survey also yielded some rather unexpected results because in several of the Eastern cities, waterworks personnel who answered the call could not identify the water supply source source of their own metropolitan area. A second or third person referral was often

necessary to find out its exact location(s), which suggests a deficiency of information concerning basic urban-water supply arrangements in several study cities.

Several of the survey results were also somewhat different than those reported by earlier surveys regarding the same variables. In this survey, two pricing and billing procedures were often in effect in the same city for different user types. Billing frequency was different for low-volume residential users and high-volume industrial/commerical users in several metropolitan centres, while in others, the frequency was identical, a water bill every month in Calgary, for example, for all residences and industry. Toronto and Vancouver, in particular, issued residential bills twice and once a year respectively, while billing for industrial/commerical users was more frequent, four times a year in Toronto and six times annually in Vancouver. Methods of water cost calculation was also different between user types several cities charged a flat-rate fee for residential use, while a metered charge was being assessed for industrial users. Earlier studies merely classified water cost calculations as either 'flat rate', 'metered', or 'flat rate and metered'. The question that arises from this situation is, does the indicated trend refer to residences or industry or both? Unfortunately, this was never made clear in the past literature, but this study has taken care to correctly associate the specific billing trend with its proper user type.

Summary

This chapter rationalized the study metropolitan centres and time frame and reviewed the method in which expenditure data were collected and tabulated. Household water expenditure denotes the average yearly expenditure for water service procurement, which includes both water supply and sewage, as reported by the respondents of the *Urban Family Expenditure in Canada* survey, in the given city during the specified year. The household water expenditures of all

respondents in a particular city were added up, and then divided by the total number of households in the survey, to calculate the 'average' expenditure. This chapter also identified seven comparison variables to be used in the study analysis, described in the next chapter.

CHAPTER FOUR - THE ANALYSIS OF HOUSEHOLD WATER EXPENDITURES

This chapter presents the water expenditure study results and offers explanations regarding the prevailing trends. The first section will identify the household water expenditures and the basic water management arrangements in each of the study cities, while the second section will analyze the results utilizing several comparison variables. The discussion will also examine the breakdown of expenditures by class of tenure, family income and family size of all cities combined.

Presentation of Results

Table 4.1 identifies household water expenditures, in constant 1971 dollars, for the seven occasions between 1969 and 1982 when the Family Expenditure surveys were undertaken[1]. Figure 4.1 indicates that water expenditures were generally higher in the Prairie metropolitan areas, particularly in Regina, Calgary and Edmonton, and lowest for the two coastal cities of St. John's, Newfoundland and Vancouver, British Columbia. Quebec City registered the lowest average household cost over the study period, while Montreal indicated an average water cost that was nearly five times that of its provincial counterpart, as shown in Figure 4.2. Montreal was also the only Eastern city to indicate water costs above the national average, particularly in 1971 and 1972 when the expenditures were nearly $50.00, while all Prairie cities were also above the national average.

Overall, water expenditures appeared to be generally related to variations in geography, particularly with respect to precipitation patterns, rather than being an issue in isolation. The higher costs in Prairie cities were related to the water-deficit nature of the region, while the low expenditures in B.C. Central and Atlantic metropolitan centres reflected the relative abundance of water supplies in those areas.

Table 4.2 displays that Edmonton and Calgary[2] indicated large net increases in water expenditure of over $18.00 and nearly $15.00

TABLE 4.1: HOUSEHOLD WATER EXPENDITURES BY CITY 1969-1982[1]

	1969	1971	1972	1974	1976	1978	1982	Average Water Expenditure By City, 1969-82[2]
St. John's	9.4	15.3	11.2	16.8	14.2	18.7	13.6	14.6
Halifax	17.4	23.9	21.3	25.6	21.8	25.3	20.6	22.2
Quebec	3.4	-[3]	-	10.2	-	9.2	7.0	7.5
Montreal	41.3	49.3	46.9	42.4	41.0	36.5	26.2	36.6
Ottawa	16.8	23.2	22.4	21.5	22.6	21.7	23.2	20.8
Toronto	24.0	22.6	24.9	25.1	26.3	29.1	31.5	27.4
Winnipeg	27.3	29.0	29.1	28.2	33.6	34.4	31.5	30.4
Regina	43.5	-	-	39.8	-	61.2	52.8	49.3
Saskatoon	37.6	-	-	38.6	-	40.1	34.5	37.7
Calgary	-	-	-	44.2	-	37.7	59.1	47.0[4]
Edmonton	32.6	33.5	34.4	35.5	40.0	45.1	50.8	41.0
Vancouver	18.4	21.6	21.2	19.4	14.6	11.0	10.4	14.8
Average By Year	24.7	25.4	26.4	28.9	26.8	30.8	30.1	29.1

[1] Numbers are in $1971 and denote average yearly water expenditure of households living in an urban residential dwelling, be it a single family home, duplex, or apartment, in a given city for the specified year. See Appendix 4.2 for a listing of the yearly dollar conversion index. The data were derived from Statistics Canada series, *Urban Family Expenditure in Canada*, 1969-1982 inclusive.

[2] The Average Expenditure By City, 1969-82 denotes the average of the years 1969, 1974, 1978 and 1982. The years 1971, 1972 and 1976 were omitted in this calculation because there were less metropolitan areas surveyed and significantly less samples returned during the Family Expenditure Surveys in those three years. Furthermore, the years 1969, 1974, 1978 and 1982 provided more consistent and logical time-intervals for the 14 year study period.

[3] Data were not available for these cities in the given years because the metropolitan areas were excluded from the Family Expenditure surveys in those years.

[4] The missing data for Calgary in 1969 necessitated this average to include only the years 1974, 1978 and 1982.

TABLE 4.2: NET AND PERCENTAGE CHANGE OF WATER EXPENDITURES 1969-1982[1]

	1969-1974	1974-1978	1978-1982	1969-1982
St. John's	7.4 (78.7)	1.9 (11.3)	-5.1 (27.3)	4.2 (44.7)
Halifax	8.2 (47.1)	-.3 (-1.2)	-4.7 (-18.6)	3.2 (18.4)
Quebec	6.8 (200.0)	-1.0 (-9.8)	-2.2 (-23.9)	3.6 (105.9)
Montreal	1.1 (2.7)	-5.9 (-13.9)	-10.3 (-28.2)	-15.1 (-36.6)
Ottawa	4.7 (28.0)	.2 (.9)	1.5 (6.9)	6.4 (38.1)
Toronto	1.1 (4.6)	4.0 (15.9)	2.4 (8.2)	7.5 (31.3)
Winnipeg	.9 (3.3)	6.2 (22.2)	-2.9 (-8.4)	4.2 (15.4)
Regina	-3.7 (-8.5)	21.4 (53.8)	-8.4 (-13.7)	9.3 (21.4)
Saskatoon	1.0 (2.7)	1.5 (3.9)	-5.6 (-14.0)	-3.1 (-8.2)
Calgary	- [2]	-6.5 (-14.7)	21.4 (56.8)	14.9 (33.7)[3]
Edmonton	2.9 (8.9)	9.6 (27.0)	5.7 (12.6)	18.2 (55.8)
Vancouver	1.0 (5.4)	-8.4 (-43.3)	-.6 (-5.5)	-8.0 (-43.5)
Average By Year	4.2 (17.0)	1.9 (6.6)	-.7 (-2.3)	5.4 (21.9)

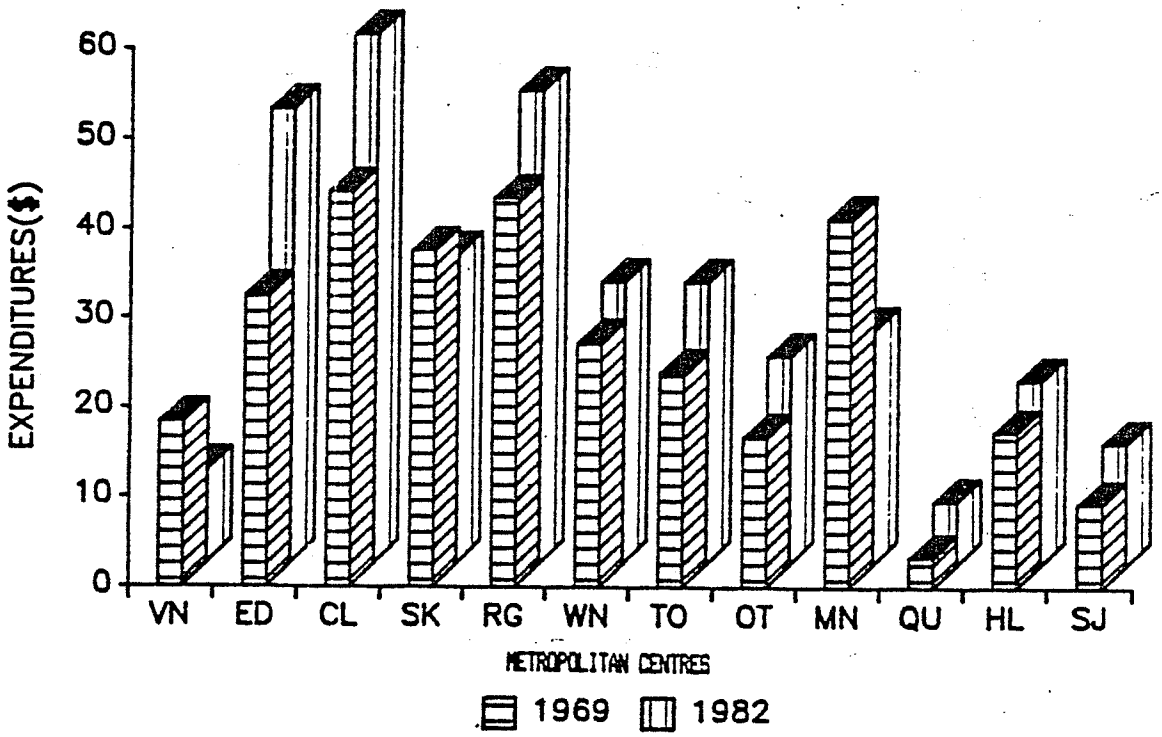
[1] Numbers not in brackets denote the net change of the water expenditures by city in $1971, while the percentage change is indicated in brackets.

[2] Data were not available in Calgary in that year because of that city's exclusion from the Family Expenditure surveys in 1969.

[3] Denotes net and percentage change for the period 1974-1982.

Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982.

FIGURE 4.1: HOUSEHOLD WATER EXPENDITURES BY CITY, 1969-1982[1]

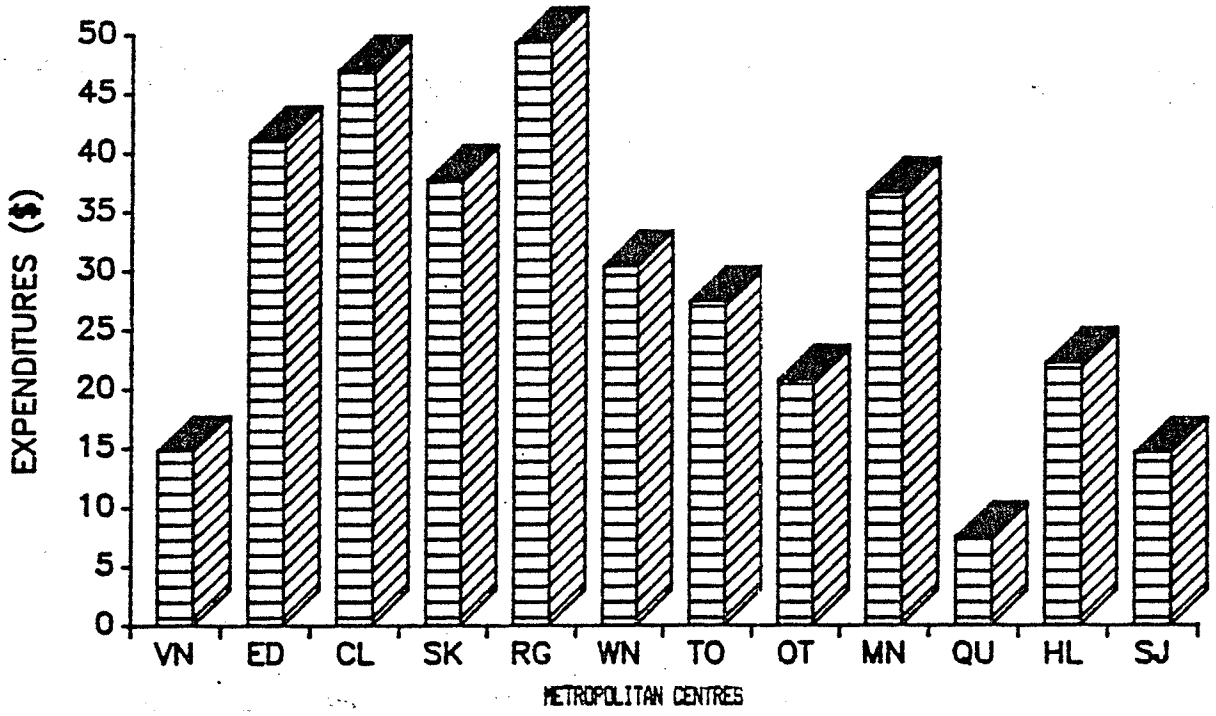


The expenditure indicated for Calgary in 1969 is, in fact, its cost in 1974 because data were not available for the city in 1969. The key for the metropolitan centre abbreviations is as follows: VN - Vancouver; ED - Edmonton; CL - Calgary; SK - Saskatoon; RG - Regina; WN - Winnipeg; TO - Toronto; OT - Ottawa; MN- Montreal; QU - Quebec City; HL - Halifax; SJ - St. John's. Source: Adapted from Statistics Canada. *Family Expenditure in Canada, 1969-1982.*

respectively over the study period, while Regina and Toronto household costs also showed significant net gains. The large percentage increase of Quebec is misleading, because its water cost was only $3.40 in 1969, which later more than doubled by 1982. The only cities to indicate a net decrease in expenditure over the study period were Montreal, Saskatoon and Vancouver. Montreal, in particular, had the largest net decrease of over $15.00, Vancouver displayed the highest percentage decrease, nearly 45 percent, while Saskatoon indicated a slight $3.00 reduction in water expenditure over the same period.

A trend of declining household water expenditures was evident in the majority of cities over the study period. Total expenditures in Vancouver, Halifax, Quebec, and Montreal steadily decreased after

FIGURE 4.2: AVERAGE WATER EXPENDITURE BY CITY, 1969-1982



The average expenditure by city denotes the average of the years 1969, 1974, 1978 and 1982.
Source: Adapted from Statistics Canada. *Family Expenditure in Canada, 1969-1982.*

1974, while costs in Winnipeg, Regina, Saskatoon and St. John's declined between 1978 and 1982. Four of the 12 cities illustrated steady increases over the study period, namely the two Ontarian cities of Ottawa and Toronto, and the Albertan metropolitan areas of Calgary and Edmonton. These trends of declining costs were significant because each city increased in population and thereby relatively increased its level of water use, both at a macro and micro scale (*Canada Water Yearbook,* 1983). Net increases in manufacturing and construction at a national level precipitated more water use, while the advent of such products as dishwashers and electric washing machines had significant repercussions for water use in the home (Tate, 1983; *Canada Yearbook,* 1981-1982). In 1971, for example, there were approximately half a million automatic dishwashers and nearly 2,300,000 automatic washing machines in Canada, but in 1981, there were over two million dishwashers and six million washing machines, a

fourfold and nearly threefold increase respectively (Statistics Canada,1971,1981).

The observation that water cost decreased in constant dollars, despite increased demand, is contrary to normal theories of market behaviour. An accepted economic maxim is that as the demand for an item increases, so does its price, in order to maximize the use of scarce resources. In this case, as the demand rose, the price decreased, hence, households were paying increasingly less money for substantially more water use in the majority of the study metropolitan centres.

Tables 4.3 and 4.4 display that several of the most easterly cities, namely St. John's, Halifax, and Quebec, enjoyed a relative comparative advantage concerning water procurement because water expenditures there were among the lowest, yet, the household sizes of these metropolitan areas were among the largest of all study areas. The largest increases in per capita expenditure were displayed by Calgary, Edmonton and Regina in the West, while Toronto and Ottawa showed the greatest gains of all Eastern cities (see Appendix 4.3 for a listing of the average household size of each city over the study period). The correlation between the average water expenditures and average per capita costs was .95, using Spearman's coefficient.

The examination of the water supply source, frequency of water billing and water cost calculation reveals a diversity of water procurement arrangements among the study cities. Table 4.5 lists the specific source(s) of supply, while Table 4.6 classifies the water source by lake, river and groundwater. The latter listings are simplifications of complex water management arrangements, but the intent is to establish the main type of water source for each city. For example, Quebec and Vancouver also draw part of their water from rivers, but the cities are classified as lake-fed because lakes are the main points of origin in their water supply. Regina is the only city to be classified into two sources of supply categories because that metropolitan area has unique water supply arrangements, namely a

TABLE 4.3: HOUSEHOLD WATER EXPENDITURES PER CAPITA[1]

	1969	1974	1978	1982	Average Per Capita Water Expenditure 1969-1982
St. John's	2.2	4.2	5.1	3.9	3.9
Halifax	4.8	7.8	8.2	7.1	7.0
Quebec	.9	3.1	3.0	2.4	2.4
Montreal	12.5	13.7	12.6	9.7	12.1
Ottawa	4.9	6.9	8.0	8.6	7.1
Toronto	7.1	8.1	10.0	11.3	9.1
Winnipeg	8.5	9.4	12.3	12.1	10.6
Regina	13.2	12.8	21.1	19.6	16.7
Saskatoon	11.4	12.9	14.3	13.3	13.0
Calgary	- [2]	14.3	13.0	21.1	16.1
Edmonton	9.6	11.5	15.6	18.1	13.7
Vancouver	7.4	9.3	10.6	10.9	9.6
Average By Year	7.5	9.5	11.2	11.5	10.1

[1] These per capita expenditures are in $1971 and were derived using the following formula:

$$\frac{\text{Household Water Expenditure for each corresponding city and year}}{\text{Average Household Size for each corresponding city and year.}}$$

[2] Data were not available in 1969 in Calgary because of its exclusion from the Family Expenditure surveys in that year. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982. and Statistics Canada. 1982. *Census Household By Size*. cat. no. 93-708. Minister of Supply and Services, Ottawa. See Appendix 5.3 for a listing of the average household size for each study city during the years 1969, 1974, 1978, and 1982.

TABLE 4.4: NET AND PERCENTAGE CHANGE OF WATER EXPENDITURE PER CAPITA[1]

	1969-1974	1974-1978	1978-1982	1969-1982
St. John's	2.0 (91.0)	.9 (21.4)	-1.2 (-23.5)	1.7 (77.3)
Halifax	3.0 (62.5)	.4 (5.1)	-1.1 (-13.4)	2.3 (47.9)
Quebec	2.2 (244.4)	-.1 (-3.2)	-.6 (-20.0)	1.5 (166.7)
Montreal	1.2 (9.6)	-1.1 (-8.0)	-2.9 (-23.0)	-2.8 (-22.4)
Ottawa	2.0 (40.8)	1.1 (15.9)	.6 (7.5)	3.7 (75.5)
Toronto	1.0 (14.1)	1.9 (23.5)	1.3 (13.0)	4.2 (59.2)
Winnipeg	.9 (10.6)	2.9 (30.9)	-.2 (-1.6)	3.6 (42.4)
Regina	-.4 (-3.0)	8.3 (64.8)	-1.5 (-7.1)	6.4 (48.5)
Saskatoon	1.5 (13.2)	1.4 (10.9)	-1.0 (-7.0)	1.9 (16.7)
Calgary	- [2]	-1.3 (-9.0)	8.1 (62.3)	6.8 (47.5)[3]
Edmonton	1.9 (19.8)	4.1 (35.7)	2.5 (16.0)	8.5 (88.5)
Vancouver	.6 (9.5)	-2.8 (-40.6)	-.1 (-2.4)	-2.3 (-36.5)
Average By Year	1.9 (25.7)	1.3 (14.0)	.3 (2.8)	3.5 (47.3)

[1] Numbers not in brackets denote the net change of the water expenditures per capita in $1971, while percentage change is indicated in brackets.

[2] Data were not available in Calgary in that year because of its exclusion from the Family Expenditure surveys in 1969.

[3] Denotes net and percentage change for the period 1974-1982.

Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982. and Statistics Canada. 1982. *Census Household By Size*. cat. no. 93-708. Minister of Supply and Services, Ottawa.

TABLE 4.5: WATER SUPPLY SOURCE OF STUDY METROPOLITAN CENTRES[1]

St. John's	Windsor Lake, Petty Harbour Lake with supplemental water purchased from a separate government water authority, and pumped from Bay Bull's Big Pond.
Halifax	A 17 square kilometer watershed area encompassing Long Lake, First Chain Lake, Second Chain Lake, Withrod Lake and Pockwock Lake.
Quebec City	A lake system comprised of approximately 30 small lakes ending at Lac St. Charles. The water flows in 12 kilometers from Lac St. Charles, via St. Charles River to Quebec City.
Montreal	St. Lawrence River
Ottawa	Ottawa River
Toronto	Lake Ontario
Winnipeg	Shoal Lake, located 160 kilometers south-east ofthe city in Ontario.
Regina	Approximately two thirds of Regina's supply is drawn from Buffalo Pound Lake. This water is treated at the Buffalo Pound Filtration Plant which is jointly owned and operated by Moose Jaw and Regina. Moose Jaw depends entirely on this supply whereas Regina obtains up to a third of its supply from 25 groundwater wells, the water of which is untreated (Cullimore,1980).
Saskatoon	Lake Diefenbaker
Calgary	Bow River, Elbow River
Edmonton	North Saskatchewan River
Vancouver	Water is drawn from mountain lakes and streams in the Coast Range north and west of Burrard Inlet. The Greater Vancouver Water District (G.V.W.D.) supplies water by gravity from three sources: Capilano River; Seymour River; and Coquitlam Lake. These sources comprise 585 square kilometers of watershed area.

[1] Eastern city listings were derived from the October, 1985 telephone survey of the water departments, or similarly-named agency, in each metropolitan centres. Western city listings were derived from the annual civic budgets reports, although in the case of Regina, additional information was derived from Cullimore (1980).

third of its supply is derived from groundwater, while the other portion is drawn from Buffalo Pound Lake (Cullimore, 1980). Overall, eight of the metropolitan areas draw water from a lake source, while four cities draw their supply from a river.

Table 4.6 also indicates that Prairie cities had a more frequent issue of water bills than did Eastern cities. Saskatoon, Calgary and Edmonton all distributed water bills once a month to their residential customers, while in contrast, Quebec, Montreal and Vancouver billed their customers once a year. Halifax, Ottawa and all the Prairie cities distributed a separate bill for water charges which was

TABLE 4.6: WATER BILLING FREQUENCY, WATER COST CALCULATION, AND TYPE OF WATER SUPPLY SOURCE BY CITY

	Water Billing Frequency[1]	Method of Water Cost Calculation[2]	Type of Water Supply Source[3]
St. John's	2	flat-rate	lake
Halifax	4	metered	lake
Quebec	1	flat-rate	lake
Montreal	1	flat-rate	river
Ottawa	3	metered	river
Toronto	2	flat-rate	lake
Winnipeg	4	metered	lake
Regina	6	metered	lake/groundwater
Saskatoon	12	metered	lake
Calgary	12	flat-rate	river
Edmonton	12	metered	river
Vancouver	1	flat-rate	lake

[1] Water billing frequency denotes the number of times water bills are issued annually to residential customers.

[2] Method of water cost calculation denotes the method by which water charges were calculated for residential dwellings in that city. Toronto and Calgary are exceptions in this regard because a minority of residential dwellings in those cities, under 30 percent of the total, were in some instances based on a metered rate, in conjunction with the existing flat-rate. The fact that the flat-rate system dominated residential water charges in the two metropolitan centres warranted their flat-rate classification.

[3] Type of Water Supply Source denotes the nature of the watercourse which provided the metropolitan centre with a majority of its water supply. These listings are simplications of complex water supply arrangements, espcially in the cases of Vancouver and Quebec City, which also draw part of their water from river and stream flows. Regina was classified as having two types of water supply sources because of it's unique supply arrangements, in that a third of the city's supply is derived from groundwater. However, the issue is to establish a general comparison of the water expenditures with the main type of water supply source for each of study cities.

separately assessed and mailed alone, and did not include a statement of other civic taxes. Water charges in Vancouver, Toronto, Montreal, Ottawa and St. John's were included as part of a general civic tax statement, in which, the water charge was a one or two line statement, among a list of many other charges for property tax, fire and police protection, civic services, and roads and transportation tax. There were also marked differences among cities regarding the method of

water cost calculation. Western cities, with the exception of Vancouver and Calgary, utilized the metered system of water-cost calculation, while Eastern metropolitan centres, with the exception of Ottawa and Halifax, used the flat-rate system.

There was conflicting information regarding the method of water cost calculation in Calgary because Thompson (1983) reported that approximately 80 percent of residential users there are metered. This information clearly differed with a report given by a Calgary waterworks official during the telephone survey who noted that the clear majority of residential customers were billed a flat-rate[3]. A survey undertaken by the City of Winnipeg Waterworks, Waste and Disposal Division (1984) also indicated that approximately three-quarters of residential dwellings in Calgary were assessed a flat-rate charge, hence, in this study, Calgary is classified as a flat-rate city.

Analysis of Results

Variations among cities regarding water cost and billing arrangements may be attributed to two factors, namely bureaucracy and geography. First, water prices, and their related arrangements, have been set by a bureaucratic process which has established relatively low prices for the 'public good', broadly defined as issues concerning public health, fire protection, and industrial development. The role of a water utility, therefore, has been to provide an essential service, the standards of which, Ciriacy-Wantrup (1961) suggests are best achieved when divorced from economics. The bureaucracy has had no particular interest in saving water in this objective, or establishing prices more in line with water's economic value, however that value is defined. The cost differences among cities, therefore, can be traced back to the first efforts at a centralized water supply in each city. Prices and arrangements have evolved as each successive civic administration saw fit, generally in a manner which was different than other Canadian urban centres. Different approaches to

recovering water supply costs have developed as a result, with each metropolitan centre possessing its unique objectives and priorities concerning civic taxation, a component of which involves charging for water. It is not presumed, then, that the household water expenditures are a direct reflection of the cost of its provision.

Secondly, geographical factors play a critical role in explaining the expenditure variance, hence, this issue will be the subject of the remaining discussion in the chapter.

The water expenditures and the basic water management arrangements fit into a pattern of regional water availability, as shown in Table 4.7. Prairie metropolitan centres had the highest total and per capita water expenditures, more frequent water billing,

TABLE 4.7: HOUSEHOLD WATER EXPENDITURES BY REGION[1]

Region	City	Average Expenditure	Average Expenditure By Region
British Columbia	Vancouver	14.8	14.8
Prairie	Winnipeg	30.4	41.1
	Regina	49.3	
	Saskatoon	37.7	
	Edmonton	41.0	
	Calgary	47.0	
Ontario	Toronto	27.4	24.1
	Ottawa	20.8	
Quebec	Montreal	36.6	22.1
	Quebec City	7.5	
Atlantic	Halifax	14.6	18.4
	St. John's	22.2	

[1] Figures are in $1971. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada. 1969-1982.*

and the metered system of cost calculation. The water-deficit nature of the region necessitated the use of pricing and billing instruments which priced water higher and more closely monitored its use. The water abundant B.C., Central and Atlantic regions also fit this pattern, although in a different manner, because metropolitan centres in those areas generally displayed low total and per capita expenditures, infrequent water billing, and the flat-rate system of cost calculation. The relative abundance of water in these regions reflected, in turn, urban-water arrangements which priced water lower, and were less stringent in monitoring its use.

Tables 4.8 and 4.9 indicate that water costs were significantly higher in metropolitan centres with frequent billing and the metered

TABLE 4.8: HOUSEHOLD WATER EXPENDITURES BY WATER BILLING FREQUENCY[1]

Water Billing Frequency	City	Average Expenditure	Average Expenditure By Water Billing Frequency
12	Saskatoon	37.7	41.9
	Calgary	47.0	
	Edmonton	41.0	
6	Regina	49.3	49.3
4	Halifax	22.2	24.8
	Winnipeg	27.4	
3	Ottawa	20.8	20.8
2	St. John's	14.6	21.0
	Toronto	27.4	
1	Quebec	7.5	19.6
	Montreal	36.6	
	Vancouver	14.8	

[1] Expenditures are in $1971. Water billing frequency denotes the number of times water bills were issued to each household in a year. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada. 1969-1982.*

TABLE 4.9: HOUSEHOLD WATER EXPENDITURES BY WATER COST CALCULATION

Flat Rate	Average Expenditure[1]	Metered	Average Expenditure
St. John's	14.6	Halifax	22.2
Quebec	7.5	Ottawa	20.8
Montreal	36.6	Winnipeg	30.4
Toronto	27.4	Regina	49.3
Vancouver	14.8	Saskatoon	37.7
Calgary	47.0	Edmonton	41.0
Average	24.7	Average	33.6

[1] Denotes the average expenditure in $1971 of each city for the years 1969, 1974, 1978 and 1982. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982.

system. Each of the water management arrangements, namely the water billing frequency, water cost calculation, and the source of supply are not so much the major causes of expenditure differences, as they are an indication of other underlying cost differences. Frequent billing necessitates greater expense for computer processing, postage, and sending and receiving mail, while with less frequent water billing, billing costs are substantially less. Metered water service is also more costly to operate than a flat-rate service because in the former, a water meter has to be first manufactured, and then installed in every residence. A substantial number of personnel and equipment is then needed for the installation of these devices, along with the ongoing maintenance and readings of the meters. In turn, the field personnel are supported by a clerical staff which must process the readings and tabulate the water bills.

Conversely, water charges are easier to derive in the flat-rate system because water costs are based on the property value of the home or the number of rooms and water fixtures in the residence. The necessary information is contained in the assessment rolls of each city, and as a result, little field personnel or equipment are needed. Furthermore, over many years, the cost savings in using the flat-rate

system may be appreciable, considering the large capital investment, substantial equipment depreciation, and greater workforce associated with the metered system of water cost. A management-level employee of the City of Winnipeg Waterworks, Waste and Disposal Division remarked in this regard that water metering was a highly costly endeavour, almost to the point of being unreasonable[4]. This person also suggested that if the decision to install water meters was to be made at the present time, it is likely that their use would have been rejected based upon past experience. The issue, then, is that frequent billing and the metered system, which are substantially more costly to operate, are related to higher water expenditures, while infrequent billing and the flat-rate method, which are less costly, are related to low water costs.

The water supply source of each city is another indicator of underlying cost differences among metropolitan centres. Table 4.10 illustrates that on average, river based source of supply cities had

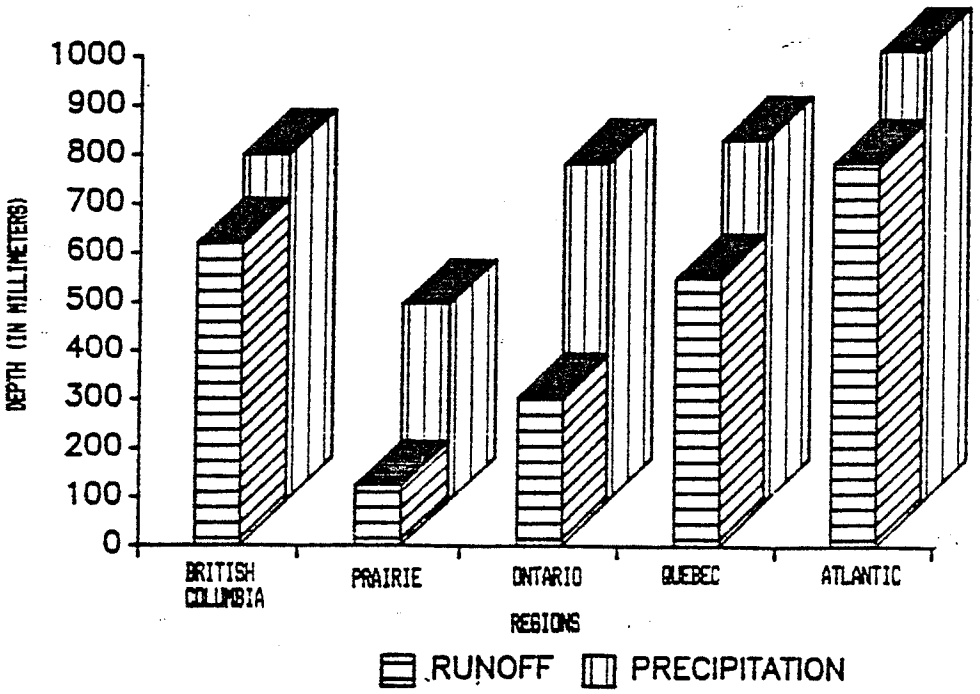
TABLE 4.10: HOUSEHOLD WATER EXPENDITURES BY SOURCE OF SUPPLY[1]

Source	City	Average Expenditure	Average Expenditure By Source of Supply
Lake	St. John's	14.6	25.5
	Halifax	22.2	
	Quebec	7.5	
	Toronto	27.4	
	Winnipeg	30.4	
	Regina	49.3	
	Saskatoon	37.7	
	Vancouver	14.8	
River	Montreal	36.6	36.4
	Ottawa	20.8	
	Calgary	47.0	
	Edmonton	41.0	
Groundwater	Regina	36.4	36.4

[1] Expenditures are in $1971. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada, 1969-1982.*

water expenditures substantially higher than lake-based metropolitan areas. There are many matters of technical feasibility surrounding individual sites of a water supply source, hence, the exact reason for the cost difference between lake and river source of supply is not readily apparent from an engineering perspective. However, other factors appear to be related, namely runoff and precipitation rates, and level of water treatment. Figure 4.3 displays that water supplies are more difficult to acquire in the Prairie region because of its semi-arid climate, and the fact that only a third of total precipitation in the region occurs as runoff, the lowest amount of runoff in any region. River levels are also highly variable throughout the year in the region and this may cause problems when the water demands are near or exceed the available river supply. More retention ponds and water storage facilies are needed as a result to ensure that water demands are met in times of short supply. These factors are related, to some extent, to the high water cost for the cities of Calgary and Edmonton, which draw their water from the Bow and North Saskatchewan Rivers respectively.

FIGURE 4.3: AVERAGE ANNUAL PRECIPITATION AND RUNOFF IN CANADA, BY REGION

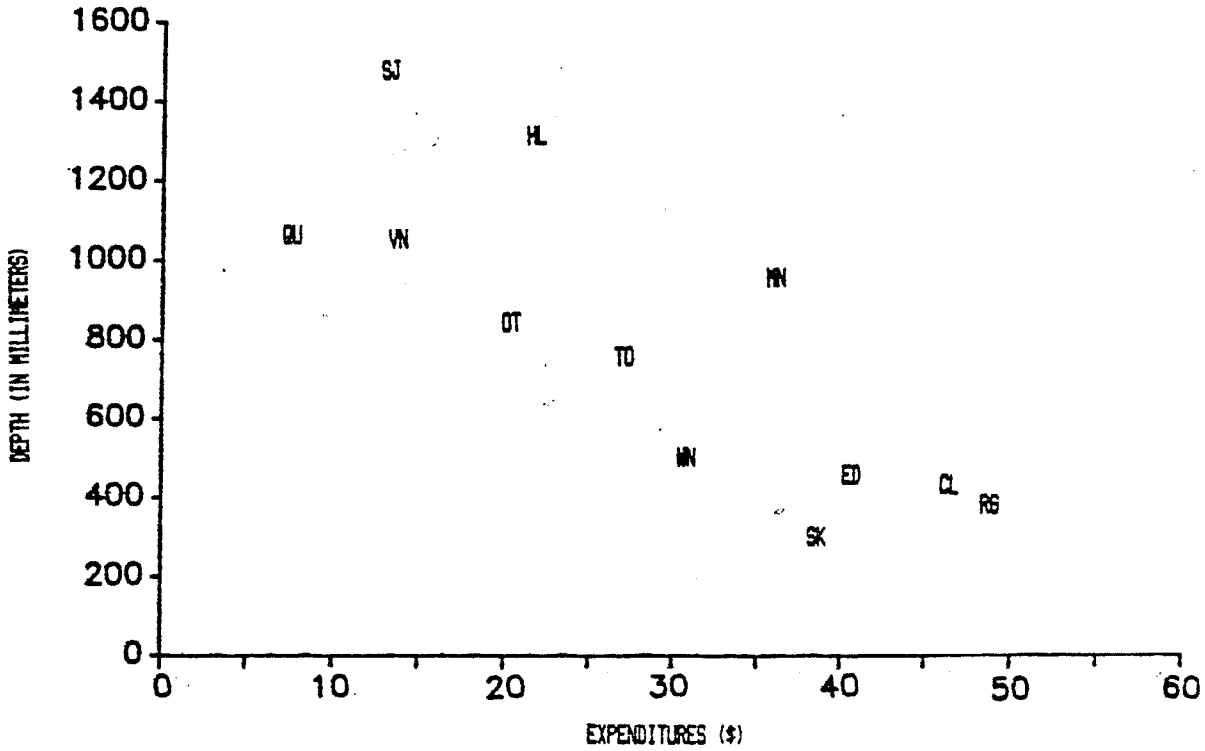


Source: Adapted from Environment Canada. 1983. *Canada Water Yearbook 1981-1982*. Minister of Supply and Services, Ottawa.

Secondly, the fact that Montreal draws its water from the St. Lawrence River, a watercourse filled with pollution and effluent from upstream sources in the Great Lakes, is another related factor. Montreal water is subject to extensive filtration, disinfection and taste and odor adjustment before delivery to its residential customers. Montreal had the highest number of water treatment processes of all the study cities, and these purification processes require considerable expense, especially at a scale necessary to supply water to the nearly three million residents of Montreal (*Canada Water Yearbook*, 1979).

Figure 4.4 displays that in metropolitan centres which experience high levels of precipitation, it was common to have lower levels of expenditure. The identified precipitation derived from Environment

FIGURE 4.4: AVERAGE ANNUAL PRECIPITATION LEVEL BY AVERAGE ANNUAL WATER EXPENDITURE



The letters on the plot denote the abbreviated city name, while their positions correspond with their precipitation level and average water expenditure. Source: Precipitation data are adapted from Environment Canada. 1983. *Canada Water Yearbook 1981-1982*. and the expenditure data are derived from Statistics Canada. *Urban Family Expenditure in Canada. 1969-1982.*

Canada (1982) is for the city proper because in the majority of metropolitan areas the water supply was relatively proximate to the civic boundaries. The issue is to identify a general level of precipitation for each metropolitan centre, although the figures do not represent precipitation levels in the larger water basins which feed the civic water supply. In this context, the correlation between average expenditure and average annual precipitation was -.85, using Spearman's coefficient. Greater water availability appears to be related to the low expenditures in this regard because the high annual rainfalls in and around St. John's, Halifax, Quebec and Vancouver enables each of these cities to draw water supplies from nearby freshwater sources, which considerably reduces pumpage and water treatment expenses. Quebec City draws water from a lake system comprised of 30 lakes, whereas Halifax draws from a watershed area of five separate lakes. St. John's has three lakes for a water supply source, while Vancouver draws water from three sources, all derived from mountain lakes and streams surrounding the Burrard Inlet.

Precipitation levels and water supplies in the Prairie metropolitan centres were also reflected in the expenditures, although in a different manner. Regina indicated on average, the highest expenditure over the study period because of several factors, namely its dependence on groundwater and its use of a dual water supply. First, approximately a third of Regina's supply was drawn from groundwater sources, which entail significant pumpage costs (Biere and Worman,1983). Secondly, Regina was the only study city to utilize a dual water supply structure and provide two types of water services, namely the provision of the usual potable supply to all residences and commercial dwellings, and the supply of relatively less-pure water for high volume commercial use (Tate et al.,1984). A dual service such as this is relatively expensive to operate, hence, the high water expenditures appear to be related to these greater industrial water services. Tate et al. (1984) noted that the cost of industrial water use is often absorbed, in varying degress, by residential customers

customers and Regina appears to fit this pattern.

Regina is also unique because it is the only major Canadian metropolitan area to share a water supply source with another separate city. Regina and Moose Jaw jointly draw their water from Buffalo Pound Lake, and both share in the costs of operating a filtration plant on the lake (Cullimore,1980).

Saskatoon and Winnipeg are other examples illustrating the problems with securing adequate water supplies in the Prairie region. Saskatoon draws its water from Lake Diefenbaker, an artificial lake which was created as part of the South Saskatchewan Dam project, while Winnipeg is the only metropolitan centre in Canada whose water supply is external to its own provincial boundaries. The distance between its civic boundaries and it source of supply, Shoal Lake, is 160 kilometers, the longest distance between a city and its water supply source of all study cities. Winnipeg's water system is similar to urban water supply arrangements in such American states as Arizona and California in this regard. Cities such as Phoenix and Los Angeles also pump in water from great distances using aqueducts, although the scale of the inter-basin diversions and the nature of the climates of these American cities receiving the water are significantly different than Winnipeg[5].

Overall, the high expenditures in the Prairie cities were related to low precipitation levels and the special nature of their water supply sources. Winnipeg relies on a distant water supply, Saskatoon depends on an artificial lake, Regina draws a significant portion from expensive groundwater sources, while Calgary and Edmonton rely on rivers which experience considerable seasonal fluctuations.

The differing levels of wastewater treatment are also related to the variations in water supply costs among cities. Tate and Lacelle (1978) noted that there was inadequate sewage treatment facilities in the provinces of Quebec, Nova Scotia and Newfoundland, while there was a greater emphasis on sewage treatment processes in the majority of Western cities. These patterns were later reiterated in the *National*

Inventory of Municipal Waterworks and Wastewater Systems in Canada[6], which was conducted in January, 1985, by the Environmental Protection Service, of Environment Canada, as indicated in Table 4.11. The study reported that coastal provinces, especially Atlantic provinces, treated a smaller percentage of their wastewater than did Ontario and the Prairie provinces, chiefly because they discharged their sewage directly into the ocean. Quebec and Newfoundland, in particular, served only 13 and six percent of their populations respectively with sewage treatment. These figures are in contrast with those of the Prairie provinces, all of which serve at least 95 percent of their populations with sewage treatment.

St. John's, Halifax and Quebec City have no water treatment while only over five percent of Montreal residents are serviced in this

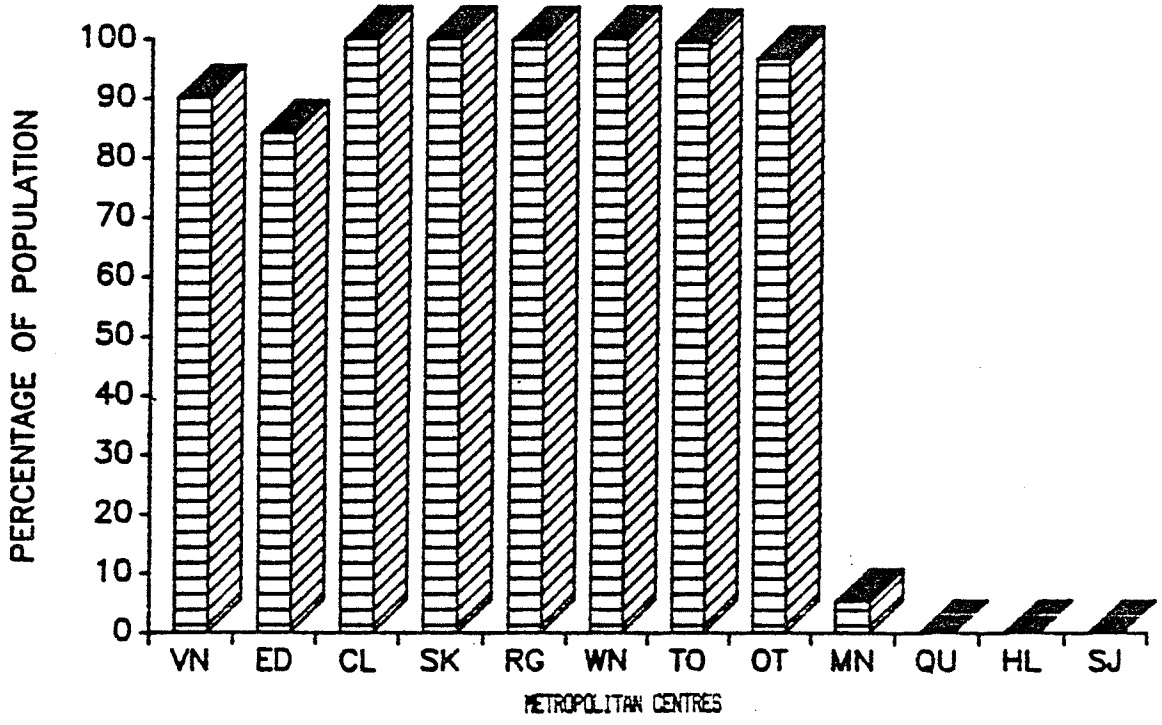
TABLE 4.11: WASTEWATER SYSTEMS, EXTENT OF SERVICE IN EACH PROVINCE OR TERRITORY[1]

Province or Territory	Total Population Surveyed	Percentage Served By Sewers	Percentage Served By Sewage Treatment
Newfoundland	497,018	60.0	12.8
Prince Edward Island	57,587	100.0	94.4
Nova Scotia	536,604	83.3	21.4
New Brunswick	409,900	91.8	60.7
Quebec	6,685,434	81.9	6.2
Ontario	7,641,607	86.1	83.5
Manitoba	839,158	94.9	94.7
Saskatchewan	611,072	99.0	99.0
Alberta	1,852,714	99.3	99.3
British Columbia	2,175,754	77.5	77.5
Yukon Territory	21,888	88.0	86.2
Northwest Territories	42,953	91.6	52.5
Total	21,372,690	85.3	57.3

[1] Data were provided by the provincial and territorial governments on an irregular basis. Source: Adapted from Environment Canada, Environmental Protection Service. 1982. *National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1981*. Supply and Services Canada, Ottawa. Data updated to January, 1985. as cited in Inquiry on Federal Water Policy. 1985. *Currents of Change - Final Report*. Minister of Supply and Services, Ottawa.

manner, as indicated on Figure 4.5. Conversely, Western cities had nearly all their residents serviced by sewage treatment, although Vancouver and Edmonton were slight exceptions. It appears, then, that the level of wastewater treatment was related to the water expenditures because water costs in the East, which had fewer sewage facilities, were lower, while in the West, where wastewater treatment was prevalent, expenditures were higher. Elements of scale also play an important role in this regard because the cost for treatment equipment would be more costly, relatively speaking, for a city the size of Saskatoon or Regina, than in the case of either Montreal or Toronto. Larger cities are able to finance and construct these facilities at a lesser relative expense because of their large economies of scale and a greater revenue base[7].

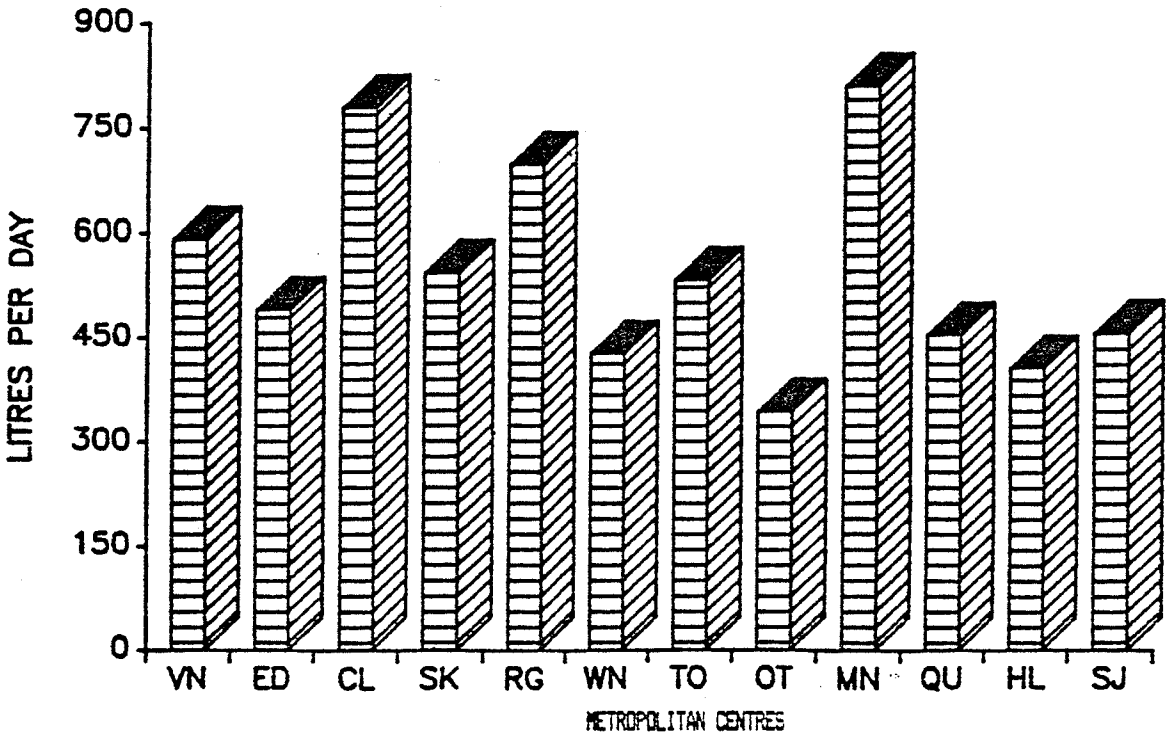
FIGURE 4.5: PERCENTAGE OF POPULATION SERVED BY SEWAGE TREATMENT BY CITY, 1966



Note that there was no sewage treatment in Quebec City, Halifax and St. John's. Source: Adapted from Environment Canada. 1979. *Canada Water Yearbook 1977-1978*. Minister of Supply and Services, Ottawa.

Figure 4.6 indicates that on average, daily per capita water use was nearly 20 percent greater in Western cities compared to Eastern metropolitan areas. There also existed a relationship, a correlation of .56 using Spearman's correlation, between levels of per capita water use and average water expenditure. Regina and Calgary showed significantly high per capita use because of a major chemical plant, Kalium Chemicals, in the former and a large petroleum industry in the latter city, both of which are high water use sectors (Tate,1983). Past research has also indicated that water procurement for large-scale uses of the type just described was usually subsidized by residential users (Grima,1972; Davar,1977; Tate et al.,1984). This factor is related, in part, to the fact that Regina and Calgary had the two highest expenditures of all cities over the study period. Calgary, in particular, contains both the flat-rate and metered system

FIGURE 4.6: DAILY PER CAPITA WATER USE BY CITY, 1976

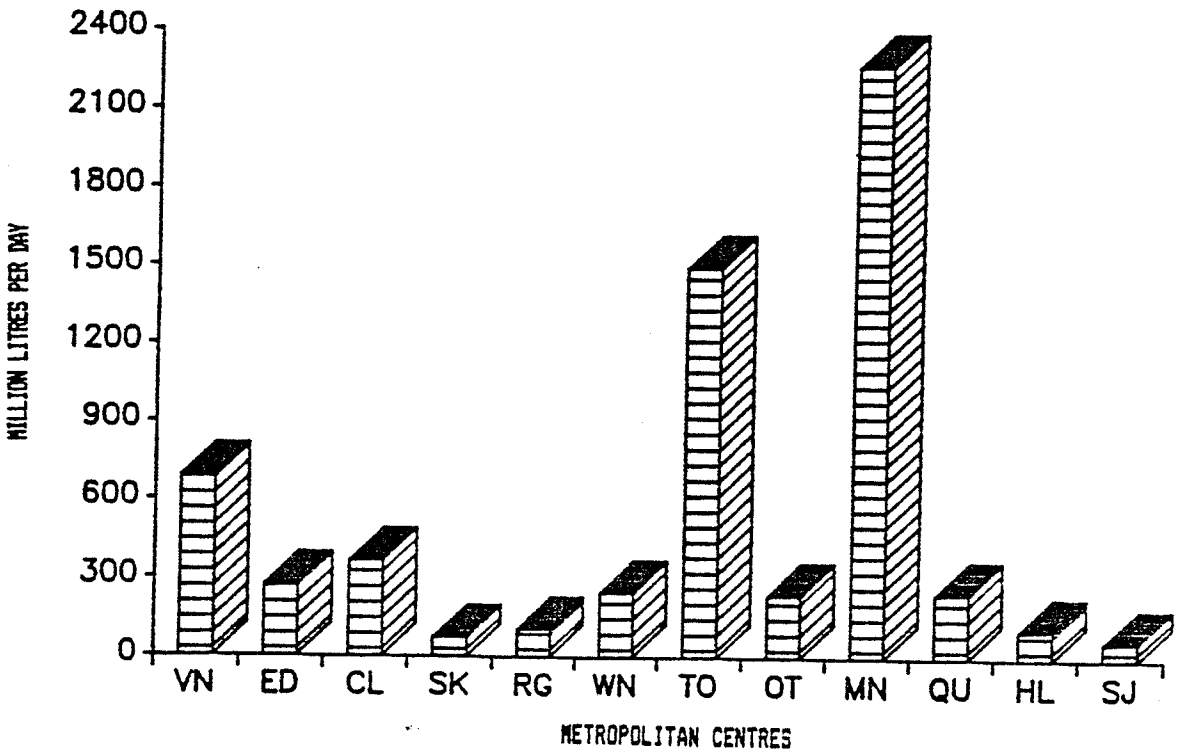


Figures denote the combined industrial, commercial and residential per capita water use. Source: Adapted from Environment Canada. 1983. *Canada Water Yearbook 1981-1982*. Minister of Supply and Services, Ottawa.

of residential water cost calculation, although the former system is used in the vast majority of households. Past studies by Kellow (1970) and Gysi (1981) have shown that on average, each flat rate customer used nearly 50 percent more water than each metered customer. The higher per capita water use in that city was attributable, in part, to this factor. Greater per capita water use in Prairie metropolitan centres, therefore, were related to higher water charges because all cities in the region, with the exception of Calgary, based water costs on a metered system.

In the East, Montreal displayed the highest per capita water use and total use, as shown in Figure 4.7. Most significant in this regard is that Toronto water use was a third less than Montreal, despite Toronto's population being larger in that year (Statistics Canada,1981). This incongruity is not easily explained, but several reasons likely account for this difference. First, evidence based on general estimates of water use and civic expenditure points to

FIGURE 4.7: DAILY TOTAL WATER USE BY CITY, 1976



Figures denote the combined industrial, commercial and residential water use in million litres per day. Source: Adapted from Environment Canada. 1979. *Canada Water Yearbook 1977-1978*. Minister of Supply and Services, Ottawa.

Montreal having a greater level of water leakage through its municipal water pipes and sewers than Toronto (*Canada Water Yearbook*,1979). Deteriorating water systems are a common problem in many North American cities because of the lack of routine maintenance, repairs and replacement of water-related equipment. Powledge (1983) reported that the tunnels, pipes and water mains that service a city are literally out of sight, and often out of mind, particularly when financially-troubled cities must confront other, more visible problems. For example, in 1982, Boston was found to be losing 78 million gallons a day, or about half of its water supply from broken and leaking pipes, while in New York City, water loss estimates range from 70 to 200 million gallons a day. Houston also loses 20 to 30 percent of its water supply in transit although it is a relatively young city, while in Winnipeg, nearly 20 percent of the total water supply is either used for firefighting or is lost through leakage (Penman,1981).

Secondly, the fact that the data were collected in 1976, the year of the Olympic Games in Montreal, is another factor. Water use in that year may be artifically high because water supplies were provided to the tens of thousands of athletes and spectators who visited Montreal in the summer of 1976.

Thirdly, Montreal contained more food and beverage, primary metal, and paper and allied industries, all of which are high water use industries, within its specific city limits than did Toronto (Tate,1983; Statistics Canada,1983). In southern Ontario, the manufacturing base is relatively diffuse over the area bounded by Lakes Huron and Ontario, although a significant portion is located in Toronto. A greater concentration of high water use industries in Montreal, therefore, partially explains the greater water use by that city.

Two patterns concerning Montreal merit further attention, namely its high expenditures and its significant decrease in water cost over the study period. First, Montreal expenditure was, by far, the

highest of all Eastern cities and this was somewhat surprising because of its low water bill frequency and the use of the flat-rate system. However, these billing arrangements do not automatically infer that Montreal's expenditure would be low because water expenditures differ, in varying degress, between cities using the same method of water cost calculation due to differing fiscal arrangments or assessment methods. Metropolitan centres which used the metered system also had relatively different methods of calculating charges, even though all charges are based on volume of water use. There exist inter and intra differences regarding water charging methods which must be recognized in this xregard, and in the case of Montreal, it appears that water taxes composed a greater proportion of total property value than other cities based on a flat-rate.

Secondly, the most puzzling trend displayed by Montreal was its $15.00 decrease in expenditure between 1976 and 1982, the largest net decrease of all cities. Study error might be a factor in this regard because the drop in cost was both sudden and substantial, especially considering that before 1976, Montreal expenditures were among the highest of all study cities. Statistics Canada interviewers may have accidentally reported inflated results when they surveyed Montreal respondents. Water procurement charges in Montreal are assessed in a general civic tax bill, in which, water charges are grouped in an 'essential service tax' which includes a charge for fire and police protection. It is not known whether each of these essential services are separately identified within the total, but assuming there is no breakdown, interviewees may have unintentionally included these costs for fire and police in the water expenditure category. Statistics Canada officials may have subsequently discovered this error by 1976, and ensuing water expenditure reporting after that year only considered the 'true' water expenditure and not the other essential service expenses.

General population trends of the study cities over the study period also appear to relate in some cases to the water expenditures.

Table 4.12 displays that Calgary and Edmonton both demonstrated an over 30 percent increase in population between 1971 and 1981, the highest percentage increases of all study cities. It appears that these increases related to the substantial gains in water cost in these Albertan cities, despite the fact that the correlation between net change in expenditures and net change in population was low, .26, for all study cities. The energy crisis of 1973 precipitated the oil boom in Alberta and many people migrated to that province in the wake of new investment and employment opportunities. The sudden growth in population and industry, particular in the petroleum sector, necessitated rapid installation of new water mains, sewer lines, hydrants, and other water supply infrastructure. Increased residential water charges appeared to be related because water costs increased

TABLE 4.12: COMPARISON OF POPULATION CHANGE AND WATER EXPENDITURE TRENDS

	Net and Percentage Change in Population 1971-1981[1]	Net and Percentage Change in Water Expenditures 1969-1982	Net and Percentage Change in Per Capita Expenditures 1969-1982
St. John's	23.0 (17.5)	4.2 (44.7)	1.7 (77.3)
Halifax	55.1 (24.7)	3.2 (18.4)	2.3 (47.9)
Quebec	95.6 (19.9)	3.6 (105.9)	1.5 (166.7)
Montreal	85.1 (3.1)	-15.1 (-36.6)	-2.8 (-22.4)
Ottawa	115.4 (19.2)	6.4 (38.1)	3.7 (75.5)
Toronto	370.9 (14.1)	7.5 (31.3)	4.2 (59.2)
Winnipeg	44.5 (8.2)	4.2 (15.4)	3.6 (42.4)
Regina	23.6 (16.8)	9.3 (21.4)	6.4 (48.5)
Saskatoon	27.8 (22.0)	-3.1 (-8.2)	1.9 (16.7)
Calgary	189.4 (32.0)	14.9 (33.7)	6.8 (47.5)
Edmonton	161.3 (32.5)	18.2 (55.8)	8.5 (88.5)
Vancouver	185.8 (17.2)	-8.0 (-43.5)	-2.3 (-36.5)

[1] The net change in population is expressed in 000's, while all net changes in expenditures and per capita expenditure are denoted in $1971. All figures in brackets denote percentage change. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada.* 1969-1982. and Statistics Canada. 1983. *Population For Canada and the Provinces.* cat. no. 91-201. Minister of Supply and Services, Ottawa.

nearly $15.00 and over $18.00 in Calgary and Edmonton respectively.

Significant increases in total and per capita costs in Regina appeared to be related to its increasing dependence on groundwater sources, caused by the significant 15 percent population growth between 1971 and 1981 (Statistics Canada,1981). In the East, Toronto and Ottawa showed significant gains in total and per capita water expenditure which were related, in part, to their population increases of over 350,000 and 115,000 respectively between 1971 and 1981. The construction of new water infrasturctures to accommodate the large population gains appeared to be related to the residential water charges, which increased nearly $10.00 and $8.00 in Regina and Toronto respectively.

Montreal, Vancouver and Saskatoon were the only metropolitan centres to display a net decrease in water expenditures between 1969 and 1982, despite the fact that population gains were experienced, in varying degrees over the study period. Vancouver, in particular, displayed a population gain of nearly 200,000 between 1971 and 1981, yet water expenditures dropped $8.00 over the study period, while in Saskatoon, water costs dropped nearly 10 percent even though that city increased in population by nearly 25 percent. Population increases, therefore, were not related to water costs in these cities, although it appears that expenditures declined because water charges to customers remained stable in current dollars, even though rising inflation rates decreased the cost in constant dollars.

Table 4.13 displays that water expenditures were, on average, one third of one percent of total household expenditure[a] in the majority of metropolitan centres over the study period. The fact that total expenditures never exceeded $62.00, and were as low as $3.40 for an entire year of water procurement, illustrates that many urban Canadians paid very little, both relatively and absolutely, for a crucial household service. The percentage figures also reflected the absolute value of the original expenditures because water expenditures in Quebec City, for example, were low, both in absolute

TABLE 4.13: A COMPARISON OF WATER EXPENDITURES AND TOTAL HOUSEHOLD EXPENDITURES[1]

	1969	1974	1978	1982
St. John's	.1	.1	.2	.1
Halifax	.2	.2	.2	.2
Quebec	.0	.1	.1	.1
Montreal	.5	.4	.3	.3
Ottawa	.2	.2	.2	.2
Toronto	.2	.2	.2	.3
Winnipeg	.3	.3	.3	.3
Regina	.5	.4	.5	.5
Saskatoon	.5	.4	.4	.4
Calgary	.3	.4	.3	.4
Edmonton	.2	.3	.4	.4
Vancouver	.2	.2	.1	.1
Average	.3	.3	.3	.3

[1] These figures denote the percentage of household water expenditure within total household expenditure, which accounts for all items, services, gifts and contributions purchased in a year. These numbers were derived using the following formula:

$$\frac{\text{Household Water Expenditure}}{\text{Total Household Water Expenditure}} \cdot 100\%$$

Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada.* 1969-1982.

terms (compared to other cities) and low in relative terms (compared to the total household expenditure). Montreal, Regina and Saskatoon also indicated water costs as a relatively 'high' percentage of total household expenditure in this regard. Consequently, differences in the level of total household expenditure were not a major factor in the water expenditure variance among cities.

The discussion will now shift focus and examine the water expenditures of all cities combined by selected family characteristics. Table 4.14 illustrates that tenant water costs were often less than a third of homeowner water expenditure. This trend occurred because tenant water charges are usually included in the general rental agreement of the rented dwelling. Tenants are the most

TABLE 4.14: HOUSEHOLD WATER EXPENDITURES BY CLASS OF TENURE[1]

	1969	1974	1978	1982	Net and Percentage Change 69-82
All Homeowners[2]	43.5	43.8	43.0	35.3	-8.2 (-18.9)
All Tenants[3]	15.0	17.1	15.8	10.7	-4.3 (-28.7)

[1] The expenditures are in $1971 and refer to all cities combined. For example, in 1974, a total of 12 cities were surveyed. Thus, all the water expenditures in all cities in this one year were combined, and then re-classified by class of tenure.

[2] All Homeowners denotes the average expenditure of all surveyed homeowners. These are people who lived for the full survey year in a dwelling owned, with or without a mortgage, by a family member.

[3] All tenants denotes the average water expenditure by all surveyed tenants. These are people who rented a dwelling for the full survey year, as a regular tenant, as a roomer, or rent free. Source: Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982.

isolated of all residential users from information which describes their water procurement costs and their level of water use, while self-owned households are directly responsible for their own water procurement and water charges are unavoidable, be it either a flat-rate or metered charge.

Table 4.15 indicates that in general, the greater the household income, the greater the water expenditure. This pattern occurred because a vast majority of the households paid for water as a function of household value, and in this way, as the property value of the residence rose, so too did the water expenditures. However, only in metered cities could increased water use, be it a function of higher family income, cause higher water charges because any water use incurred in a flat-rate city is inconsequential to the water cost. The $35,000+ income group was the only category to indicate a net increase in water expenditures over the study period, while the $10,000-$14,999 and $15,000-$19,999 categories illustrated percentage decreases in water expenditures of nearly 40 percent over the same period. Higher income groups, therefore, paid an increasing share of water procurement costs, albeit minimal, indicating that water costs in the higher income households increased over the study period, both

TABLE 4.15: HOUSEHOLD WATER EXPENDITURES BY FAMILY INCOME[1]

	1969	1974	1978	Net and Percentage Change 69-78
Under $10,000	26.1	21.0	18.6	-7.5 (-28.7)
$10,000-$14,999	35.2	28.7	22.0	-13.2 (-37.5)
$15,000-$19,999	42.7*[2]	33.6	27.1	-15.6 (-36.5)
$20,000-$24,999	42.7	38.4	31.2	-11.5 (-26.9)
$25,000-$25,999	42.7	*48.4**	36.7	-6.0 (-14.1)
$30,000-$34,999	42.7	48.4	37.4	-5.3 (-12.4)
$35,000+ over	42.7	48.4	*48.2**	+5.5 (+12.9)

[1] Expenditures refer to all cities combined and are in $1971. Different income classifications through the study period necessitated the use of estimates regarding several income classifications. In addition, expenditures were not available for 1982 because of the exclusion of a breakdown by family income in the survey results in that year.

[2] * Denotes the highest family income group, for which, Statistics Canada provided water expenditures in the specified year. For example, in 1969, the family income classification of $15,000-$19,999 was the highest level of family income, for which, Statistics Canada identified a water expenditure. In later years, however, Statistics Canada provided water expenditures for higher levels of family income, as was the case in 1974 ($25,000-$25,999) and 1978 ($35,000+). The comparison of water expenditures between the three years, therefore, necessitated the use of expenditure estimates, as indicated in italics. For comparison purposes, the water expenditure indicated in the highest family income group in that year, are extrapolated to represent all higher family income groups. Source: Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982.

in current and constant dollars.

Lower income classes indicated a marked decline in water expenditures even though the property values of these lower income households increased, in varying degrees, through the study period. The fact that middle and lower income groups paid increasingly less for water service suggests that water charges remained relatively static in current dollars, while these costs substantially decreased in constant dollars. Another possible reason for this condition is that the higher income groups probably owned their houses which increased in value during this period. Lower income households were probably renting or living in areas where house values did not rise

significantly, or as fast as in the 'higher income' areas.

Table 4.16 illustrates that the expenditures increased at a rate commensurate with the number of persons in the household. Expenditures also rose steeply in relation to increased family size, at a rate of approximately $10.00 for each additional person, until the expenditure corresponded to four persons. At this family size and larger, expenditures appeared to stabilize. St. John's, Halifax and Quebec enjoyed a higher level of water use with less cost in this regard because of the generally larger family size in each city.

TABLE 4.16: HOUSEHOLD WATER EXPENDITURES BY FAMILY SIZE[1]

	1969	1974	1976[2]	Net and Percentage Change 69-76
One Person	9.8	11.6	15.7	5.9 (60.2)
Two Persons	24.3	24.6	25.9	1.6 (6.6)
Three Persons	31.3	37.0	31.8	.5 (1.6)
Four Persons	39.6	43.0	41.6	2.0 (5.1)
Five or More	42.7	42.2	42.2	-.5 (-1.2)

[1] Expenditures refer to all cities combined, and are in $1971. The expenditure denoted for each family size classifications (i.e one person, two persons) is the average of the various adult-child combinations which inhabit the household, assuming that there is at least one adult in each household. For example, the 'three persons' category is the average of the expenditure for all of the following: three adults; one adult and two children; and two adults and one child.

[2] A breakdown of water expenditures by family size was not available in the 1978 and 1982 family expenditure surveys. For this reason, 1976 is used in this listing. Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada*. 1969-1982.

Summary

This chapter identified the significant range of household water expenditures and water procurement arrangements among major metropolitan centres in Canada. Issues of billing, source of supply, sewage treatment, population size and growth, water use, precipitation, family size and income, and class of tenure were related to the water expenditures.

Notes

[1] See Appendix 4.1 for the ranking of the highest to lowest water expenditures by city.

[2] Missing data in 1969 for Calgary necessitated the use of 1974 and 1982 figures for the net and percentage change data.

[3] Personal communication with an employee of the Calgary Waterworks Department, who wished to remain anonymous. October 17, 1985, Winnipeg, Manitoba.

[4] Personal communication with an employee of the City of Winnipeg Waterworks, Waste and Disposal Division, who wished to remain anonymous. November 5, 1983. Winnipeg, Manitoba.

[5] Personal Communication with Dr. I. Goulter, Professor of Engineering, University of Manitoba. April 2, 1986, Winnipeg, Manitoba.

[6] *The National Inventory of Municipal Waterworks and Wastewater Systems in Canada* (1976,1981,1985) was initiated in 1975 by Environment Canada in order to monitor various aspects of water management arrangements in municipalities across Canada, at five-year intervals. The title alone would suggest similar research goals as this study but it is significantly different. Research is oriented toward technical and engineering concerns, regarding inventories of such information as sewer line widths, water main layouts, and water treatment processes.

[7] Personal communication with Mr. E. Kuiper, Professor of Engineering, Department of Engineering, University of Manitoba. January, 1984, Winnipeg, Manitoba.

[8] Total household expenditure denotes the combined costs of all items, services, securities and gifts purchased by all working adults residing in the surveyed household for a full year (Statistics Canada,1983). See Appendix 4.4 for a listing of the total household expenditures by city over the study period.

CHAPTER FIVE - OBSERVATIONS AND CONCLUDING REMARKS

This chapter will summarize the study results across regional lines, note several general observations, discuss the future trends of household water expenditures in Canada, and pinpoint future areas of research in the urban-water management area.

Study Results

Cities in the Atlantic region displayed water expenditures below the national average and a number of factors appeared to be related in this regard, namely high levels of precipitation, no sewage treatment, and moderate levels of per capita water use. Differing methods of cost calculation and billing were in effect in the region, as Halifax used the metered system and billed its residential customers four times a year, while St. John's assessed a flat-rate charge and billed its customers twice a year. Both cities also draw water from a series of proximate, freshwater lakes, considerably reducing pumpage and water treatment costs. Both metropolitan centres indicated declining water costs over part of the study period, Halifax expenditure decreased steadily after 1974, while St. John's water cost dropped between 1978 and 1982. Halifax and St. John's also enjoyed a relative comparative advantage concerning water procurement because water costs there were among the lowest of all cities, even though the household sizes of these metropolitan areas were the largest of all study areas.

Quebec metropolitan centres indicated water costs that were in sharp contrast because Quebec City expenditures were the lowest of all cities, while Montreal costs were above the national average. Quebec City costs also declined steadily after 1974, while Montreal expenditures dropped dramatically between 1978 and 1982. Cost calculation, billing frequency, levels of precipitation, and sewage treatment did not appear to be factors in this regard because flat-rate charges, annual billing, high levels of precipitation, and little or no wastewater treatment were apparent in both cities.

However, differences in the source of supply, per capita water use, level of water treatment, and population size appeared to be related issues. First, Montreal draws its water from the St. Lawrence River, a polluted watercourse, while Quebec City draws its supply from a series of 30 unpolluted fresh-water lakes. A greater number of water treatment processes in Montreal, entailed more cost, relatively speaking, than in Quebec City which required little water treatment because of its pure water supply source. Secondly, the fact that Montreal was five times the population of Quebec over most of the study period appeared to have entailed greater cost, relatively speaking, for Montreal in servicing their larger water infrastructure. Thirdly, per capita water use in Montreal was nearly double that of Quebec City, indicating distinct differences in general patterns of residential, industrial and commercial water use between the two cities.

The Ontarian cities of Ottawa and Toronto indicated water expenditures below the national average and number of factors appear to be related to this pattern, namely level of precipitation and source of water supply. Both cities are located in a region with substantial precipitation and many sources of supply, although water quality is an issue in some cases. Ottawa draws water from the Ottawa River, while Toronto derives its supply from Lake Ontario, both of which are reliable, abundant sources of water supply. Water expenditures were somewhat higher in Toronto and it appears that cost calculation, billing frequency, and per capita water use were factors in this regard. Toronto utilized the flat-rate system and issued bills twice a year, while Ottawa used the metered method and distributed bills three times a year. The fact that Toronto costs were higher than Ottawa expenditures, despite the fact that the former utilized the flat-rate system, is noteworthy. Substantial differences in population size and per capita water use, both of which are significantly higher in Toronto, appear to related in this regard. Ottawa and Toronto also showed steady increases in water cost over the

entire study period, and substantial population gains in both cities appeared to be a related factor. The population of Toronto increased by nearly 400,000, the largest net increase of all study cities, while Ottawa increased by over 100,000 persons between 1971 and 1981. It appears that residential water charges were related, to some extent, to the increased water supply construction to accommodate this greater population, as evidenced by the gain of $7.50 and $6.40 in water costs in Toronto and Ottawa respectively.

Prairie metropolitan areas generally indicated the highest total and per capita water expenditures of all study cities, and a number of factors appear to be related, namely level of precipitation, cost calculation, billing frequency, source of supply, level of sewage treatment, per capita water use, and population change. First, precipitation levels on the Prairies were, by far, the lowest of all regions indicating that the procurement of water would be more involved and expensive because of the scarcity of supply. The use of the metered system, with the exception of Calgary, and frequent billing in all the Prairie cities appeared to be related to the lack of water availability. Consequently, water use was priced higher and more closely monitored in this region more than any other. Secondly, sewage treatment was ubiquitous in the Prairie metropolitan centres, as opposed to the Atlantic and Quebec regions where little or no wastewater treatment was undertaken. It appears, then, that water costs were related to the extent of wastewater service because Prairie expenditures were high while the expenditures in the Eastern regions were generally low.

Thirdly, per capita water use was high in Prairie metropolitan centres, particularly in Calgary and Regina. This trend indicates that the structure and concentration of residential, industrial and commercial operations in Prairie cities necessitated higher levels of water usage, relatively speaking, than other regions. The fact that this higher water use was, in turn, more closely monitored through metering in all Prairie cities, with the exception of Calgary,

indicates that increased water use was related to the higher expenditures in the region. Fourthly, Edmonton and Calgary showed the highest net increases of water expenditure over the study period. Population change appears to be an issue in this regard because both Albertan metropolitan centres experienced significant rises in population and industry during the 1970s. Edmonton and Calgary were also the only Prairie cities to indicate a steady increase in cost over the study period, since Saskatoon, Regina and Winnipeg showed declining expenditures between 1978 and 1982. Fifthly, Regina indicated on average, the highest cost of all cities over the study period, and this trend appeared to be related to several unique water management arrangements there, namely its use of groundwater for a third of its supply, and its use of a dual water supply.

In the B.C. region, Vancouver indicated expenditures below the national average, and precipitation, cost calculation, billing frequency, and source of supply appear to be related issues. First, abundant precipitation and runoff levels in the region enabled the procurement of water supplies to be less costly compared to the Prairie region because Vancouver draws it water from nearby mountain lakes and streams which flow by gravity to the city. Secondly, the use of the flat-rate system and infrequent billing in the city presupposes a low priority for identifying water use and cost to its residential customers. This low priority, in turn, can be related to the low water expenditures, which showed a steady decline after 1974. Lastly, Vancouver residents did not face a charge for sewer services because sewage charges for individual households were financed out of general tax revenues.

There are a number of observations regarding the study in general which also merit further discussion. First, water expenditures appear to be related to two major factors, namely regional water availability, and different bureaucratic approaches to recovering water supply costs. Water availability is a function of the hydrologic cycle, a recycling process in which freshwater is stored in

lakes, while the remainder circulates dynamically through evaporation, transpiration, and precipitation. The abundance or scarcity of water in a region, in turn, necessitates the development of corresponding pricing and monitoring arrangements by civic bureaucracies. However, each civic administration possesses different objectives regarding finance, cost distributions, and the role of water procurement charges within the tax system. These factors explain, to some extent, the diversity of water costs and management arrangements among the study cities.

Secondly, water expenditures decreased in eight of the 12 cities between 1978 and 1982, indicating that many urban residents in Canada paid less money, for appreciably more water use. The decreasing costs appeared to be the result of entrenched water pricing arrangements in the majority of study cities. Water procurement charges remained relatively constant in current dollars, but the rising inflation rates of the 1970s gradually lessened the cost of these charges in constant dollars.

Thirdly, water costs were generally higher in metropolitan centres which utilized the metered system of water cost calculation. The higher expenditures appeared to be related to increased costs for water meter installation, maintenance, and reading, while metropolitan areas utilizing the flat-rate system calculated water charges based on assessment data, the collection of which was less costly and involved. Higher total water expenditures were also evident in metropolitan areas with greater water bill frequency. Cities which issued water bills every month displayed total expenditures that were, on average, nearly double those of cities which issued water bills only once a year. The greater expense associated with more frequent water billing, including increased costs for computer processing, postage, envelopes, and paper appear to be related, to some extent, to the higher water costs.

Fourthly, a majority of the Canadian population residing in the study cities had little, or no association between water use and its

cost. The three largest cities in Canada, Montreal, Toronto, and Vancouver, based water charges on a flat-rate total, while apartment dwellers in metered cities also paid a flat-rate because water charges were usually included in the general rental charge of the dwelling. There is also little relationship between water use and cost in metered cities, even though water use is more strictly monitored. There exists a general understanding that water procurement charges should be relatively low to encourage public cleanliness, attract industry, create employment, and develop other activity for the 'public good'. Yet, this deliberate underpricing or unpricing of water has sent improper signals to residents about the real costs of water procurement, and extensive water waste and pollution has been the result in some locales.

Fifthly, the study exposed significant deficiencies in urban-water management research in Canada. A national telephone survey of waterworks departments, in particular, revealed that some waterworks personnel could not identify the water supply source of their own city. Several management-level employees of water departments also had no knowledge whatsoever concerning the Inquiry on Federal Water Policy (1985), while past studies in the general urban-water management area have presented vague, and often conflicting reports of water cost arrangments between cities. This evidence appears to indicate a significant level of institutionalized ignorance regarding urban-water supply concerns which, over time and at a sufficient scale, could limit the effectiveness of existing and future water management strategies.

Future Trends

The future is never certain, but water costs in Prairie cities will likely remain the highest of all metropolitan areas in Canada. The metered systems now in place and the frequent billing procedures currently practiced will probably remain because of the relative shortage of water in the region. B.C., Central and Atlantic

metropolitan centres based on a flat-rate will likely exhibit relatively low household costs in the future, considering the nature of the flat-rate system which indicates little regard for water use or the cost involved in its procurement. However, the extent to which these general water pricing and billing arrangements are entrenched is debatable. Would Montreal, for example, ever convert to a metered system, or would Winnipeg ever adopt a flat-rate system? Changing from a metered to a flat-rate system would likely be the result of cost pressures, because the latter system is easier to operate and less expensive in comparison to the elaborate, capital-intensive metered method. Conversely, the conversion from the use of flat-rates to a metered system would likely be related to a need for better identifying specific levels of use to both supplier and consumer. Water-short regions would not be the only areas to utilize a metered system in this regard, because in locales with extensive water pollution, higher pricing and strict monitoring of water use may be needed to deter further pollution, and to ensure a minimum potable supply.

There also appear to be several economic and social forces at work, all of which could potentially collide, in the field of Canadian urban-water management. First, water demands will increase to accomodate demographic and industrial growth or, at the very least, sustain the present quality of life for the current and upcoming generations. Up to the present, increases in demand have been met with equivalent increases in the water supply, a situation Tate (1983) refers to as the 'supply fix'.

Secondly, the diminishing fiscal power of municipal governments has forced decision-makers to be more reluctant in underwriting large expenditures for the expansion of water services. Reduced transfer payments between levels of government(s), large deficits, high interest rates, a declining dollar, and steady inflation have been the main factors in this issue. This trend is further compounded by the fact that Canada's present water infrastructure is in need of

large-scale restoration. The Federation of Canadian Municipalities (1985) noted that $12 billion (1985 dollars) will be needed to bring many of the watermains and sewers of Canadians cities up to standard (Hunter,1985). The repair of the existing water supply infrastructure, therefore, would appear to be of a greater priority than the construction of new or expanded waterworks systems in the future. New York City has reached a dilemma in this regard because water use there is bordering on the amount that can be supplied. Furthermore, the city has barely enough funds to repair leaky water mains, let alone finance massive new water supply systems[1] (Sewell,1966; Powledge,1983; Keating, 1985).

Thirdly, a perception exists among many Canadians that water should be supplied in virtually limitless quantities, at little or no cost. This pattern is further accentuated by the fact that water charges to many urban Canadian households have steadily decreased in constant dollars since 1978.

It appears, then, that Canadian urban-water managers may soon have to resolve conflicts concerning the economic expectation, fiscal reality, and public perception of its water supply. People will almost certainly want more water for their homes and businesses, at the same low costs, although the government's ability to continually deliver the high volumes, in pure quality, at low price appears to be diminishing. Similar to New York, Canadian cities may not have enough revenue at the municipal level to continually satisfy their ever-increasing water demands. As a result, there may be a greater appreciation of scarcity in the future, although this realization would be one of fiscal restraint, not one of a genuine concern for the efficient use of water. It is probable, then, that water costs may rise in the future, not for controlling demand, but in order to generate more revenue to build even bigger water delivery systems to meet the larger demands. This circular and cumulative causation is certainly possible if the present emphasis on supply orientation continues, and demand-modification options are not further explored.

Future Research

An urgent need exists for more detailed, integrated and comprehensive urban-water research studies if planners are to better understand the nature, variability, and effects of water pricing and water billing arrangements in the various cities and regions of Canada. Geographers such as Quinn (1977) and Sewell (1981) have had a prominent role in identifying these and other water resource problems in a broad Canadian context, but more work is needed at a micro-level which further emphasizes an inter-disciplinary perspective. Geographers have a strategic role to play in this regard, particularly in the coordination and synthesis of urban-water research to better reflect holistic approaches and methodologies.

A number of issues demand careful consideration in the urban-water research area, recognizing the need for ongoing concern and input by geographers. First, greater attention must be paid to inventory research, detailing all aspects of the history, billing, pricing, water use, number and type of employed, administrative structure, classification and number of water customers, department expenditure, and revenue of each waterworks deparment. This information would allow for more enlightened comparisons among cities and across regions regarding their water procurement arrangments. Secondly, the exact relationship between municipal financing and water pricing should be better explored. Comparisons of expenditure allocations and water revenues between types and classes of customers are also necessary to determine the structure of water-related financing in each metropolitan centre. Thirdly, greater efforts are needed in the detection of urban-water system leakage. The location, extent, and cause(s) of the leakage problem must be addressed if water waste is to be minimized.

Fourthly, more studies should be undertaken which compare use rates among persons regarding their class of tenure, family income, family size, stage of life-cycle and sex. Demand-modification

techniques should also be better researched to determine what effect(s) higher pricing, rebates, public education, water-saving devices, and other demand-modifiers have on water use in the home, and public attitudes in general. Fifthly, detailed forecasts of water use are needed from metropolitan centres to determine their future water requirements, especially in the wake of ongoing proposals for water export to the United States. Past research regarding this issue has been characterized by many sweeping assumptions of water use, along very broad regional lines, hence, more micro-level data should be examined before any formal negotiations begin concerning water export. Lastly, the water management practices of other nations warrant further investigation, to better understand how and why countries have succeeded, or failed, in urban-water management concerns. Water quality and quantity issues in the United States, in particular, should be constantly monitored because of the potential for export, and the possibility of pollution and contamination through shared waters.

Above all, the underlying theme of this research would be to establish a national perspective, and a number of options for action are recommended toward this end. First, the establishment of a annual metropolitan water conference would be invaluable in promoting discussion of urban-water concerns in Canada. Ideas and information could be exchanged concerning water pricing, demand-modification techniques, budgetary issues, and billing practices. A wide variety of experiences and suggestions considering the diversity of geography, climate, and population size among the major metropolitan centres of Canada could be aired. At present, the Conference on Drinking Water is conducted annually, sponsored by a variety of federal and provincial agencies, but its mandate is the specific discussion of water and sewage treatment issues. Consequently, a separate conference would have to be established to focus on pricing and billing concerns, and to develop concepts of direction at a national level in this research area.

Secondly, the federal government should expand its existing water research programs to include the study of urban-water concerns. *The National Inventory of Municipal Waterworks and Wastewater Systems in Canada* (1976,1981,1985) has collected valuable data on water and sewer processes, but more information and analysis is needed from a policy perspective to identify pricing, billing, and water use patterns in specific cities and municipalites. The federal government should also expand its *WATDOC* system, a computer-based environmental reference service, to include the complete citation of water-related documents from the public and private sectors of both domestic and foreign sources. This on-line library would allow for quick and convenient referral from one central source, with consistent indexing. The fact that present cataloguing of water information is less than adequate in many government publication libraries would provide further incentive to implement such a system.

The cost of such a program would probably be high, especially at its outset, but over several years, this information network would likely prove to be more cost-effective in developing and accessing research than would be if every city waterworks department had its own, autonomous research body. Furthermore, budgetary constraints of many departments may entail substantial cutbacks in research funding, if not the elimination of these programs altogether, hence, a computer-based national network would still provide crucial information links, at minimum cost. The computer service should be established in the offices of every waterworks department, not in a nearby municipal or university library, to encourage water management decision-makers to personally use the service, as often as possible, to maximize their information awareness. The federal government would, in turn, gain valuable contacts and develop new channels of communication with the major municipal governments. In this way, the implementation and enforcement of any future national water policy could be achieved with greater efficiency and effectiveness, aided by the information infrastructure already in place.

Lastly, university researchers, including professors, graduate students, and undergraduate students, should be encouraged to take a more active role in water research in Canada. Governments and industry should sponsor or cost-share more water research projects with universities or particular departments, and a greater number of water study scholarships should be offered to stimulate interest in the subject at both an under and post graduate level. Universities would gain increased funding and a more active voice in water management decision-making in this arrangement, while government and industry would benefit from the expertise of many academics, whose skills up to this point, have been largely untapped in the urban-water management area. At this time, several federal agencies such as the Canada Mortage and Housing Corporation and the Inland Waters Directorate award scholarships in this field of water study, as does the Canadian Water Resources Association, a private organization concerned with Canadian water issues, but the scale of support is minimal. Ultimately, the funding and scholarship programs of these organizations could be further expanded, either individually, or in cooperation with other government agencies and private interests to create a Canadian Water Research Foundation, the function of which would be to solicit and distribute funding for water research in Canada.

APPENDICES

APPENDIX 3.1

TELEPHONE SURVEY RESULTS (1985)

RESIDENTIAL WATER BILLING FACTORS BY CITY[1]

St. John's

Freq:[2] bi-annually (April, October)
Calc:[3] flat-rate
Rate:[4] $55.00 per half year. Water bills are assessed by the civic tax department as part of a general civic tax bill. No separate water bill is issued per se, only a one or two line statement of water cost is included in the general itemized civic tax charge.

Halifax

Freq: quarterly
Calc: metered (read every three months)
Rate: A minimum service rate is charged, depending on the size of the meter, plus an additional charge of $.165 per cubic meter of water use and $.115 per cubic meter for sewage use.

Quebec

Freq: annually
Calc: flat-rate
Rate: The water charge is included in a general civic tax bill. In this bill, water is included as part of a 'general civic service tax' category. In this case, a statement of water charges is not even listed, instead, it is grouped in this tax category which also includes the costs of fire and police protection.

Montreal

Freq: annually
Calc: flat-rate
Rate: The billing structure is nearly identical to Quebec City. A general service charge is assessed in proportion to the property value of the residence.

Ottawa

Freq: tri-annually
Calc: metered (accounts are read every four months)
Rate: A minimum charge of $2.00 per month is charged, which is assessed whether or not any water is used. This minimum cost includes up to six cubic meters of water use. Beyond this volume, an additional charge of $.335 per cubic meter is charged.

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[1] The general consensus is that a residence is any single family dwelling, duplex or other building which does not exceed four living units or apartments. Accoringly, these billing factors do not refer to large apartment blocks.

[2] Freq denotes Bill Frequency. This refers to the number of times water bills are issued each year.

[3] Calc denotes Water Cost Calculation. This denotes the main method by which water bills were calculated. This usually involved either a flat-rate charge (water consumption is not considered and only a pre-determined amount is assessed for the service) or a metered charge (water meters are installed, and water cost is based on consumption which may or may not be in addition to minimum service charges).

[4] The rates quoted are in reference to October, 1985. In most cases, the rates include both water supply and sewage.

Toronto

Freq: bi-annually
Calc: flat-rate
Rate: The water charge is based on the total number of rooms, water fixtures and toilets in each residence. Each room costs $3.10, every fixture is $5.79, and each toilet is $9.55 for every six month period. Also included is a sewage discharge cost which totals to 15 percent of the water bill. In other words, a flat rate is charged for water service and 15 percent of this cost is added on as a sewage charge.

Winnipeg

Freq: quarterly
Calc: metered (read every three months)
Rate: The charge is $2.24 per 100 cubic feet (c.f.) of water use up to 9,600 cubic feet of consumption during the billing period. This cost is further divided into $1.30 for water and $.94 for sewer per 100 c.f. of use. Above this volume, $1.01 for and $.94 for sewer is charged per 100 c.f. up to 96,000 c.f. of use. Over this volume, water is .$91 per 100 cubic feet, but the sewer rate remains the same. It is also important to note that charges are based solely on consumption, with no service or meter fee.

Regina

Freq: sec-annually
Calc: metered (read every two months)
Rate: A minimum charge of $20.40 is assessed each bill ($10.50 for water and $9.90 for sewer service). This charge includes up to 1,000 cubic feet of water use. Above this amount, $1.09 for water and $1.07 for sewer is charged per 100 cubic feet.

Saskatoon

Freq: monthly
Calc: metered (readings are made quarterly and then estimated)
Rate: Minimum charge is $2.50 and is assessed whether any water is used or not. In addition, the first 400 c.f. cost $1.01 per 100 c.f. The next 600 c.f. is $.90 per 100 c.f. The next 3,300 c.f. per month is 4.83 per 100 c.f. while the next 20,700 c.f. is $.78 per 100 c.f. The lawn and garden rate, meanwhile, is $.72 per 100 c.f. This lawn and garden rate is used when consumption is over the average consumption, which is based on the first three months of the year.

Calgary

Freq: monthly
Calc: flat-rate
Rate: The water charge is included as part of a general utility bill which includes sewer, electricity and water. In this case, the charge is based on the assessed value of the residence.

Edmonton

Freq: monthly
Calc: metered (actual reading occurs every three months while the other two months are estimated.
Rate: A minimum montly charge of $5.75 is charged for water while a separate sewage bill is $2.20 per month. Above this basic service charge are additional consumption charges. Sewage costs $.8451 for 100 c.f. while water charges are based on a declining block rate. The first 800 c.f. cost $1.95 per 100 c.f., the next 3,200 c.f. cost $1.60 per 100 c.f., the next 21,000 c.f. are priced at $1.40 per 100 c.f. The following 475,000 c.f. is $1.29 per 100 c.f., while any water over this volume is priced at $.94 per 100 c.f.

Vancouver

Freq: annually
Calc: flat-rate
Rate: A standard rate of $70.00 is charged for water use in each Vancouver residence. For every extra suite in a home, there is an additional $25.00 charge. Duplexes, meanwhile, are charged $47.50 per side. Again, no formal water bill is issued per se, rather, water charges are listed on a fee statement of general civic taxes, which is distributed once a year.

WATER BILLING FREQUENCY, WATER COST CALCULATION BY CITY

City	Residential Billing Frequency	Industrial Billing Frequency	Residential Cost Calculation	Industrial Cost Calculation
St. John's	2	2	flat-rate	flat-rate
Halifax	4	4	metered	metered
Quebec	1	1	flat-rate	flat-rate
Montreal	1	1	flat-rate	metered
Ottawa	3	3	metered	metered
Toronto	2	4	flat-rate	metered
Winnipeg	4	4	metered	metered
Regina	6	6	metered	metered
Saskatoon	12	12	metered	metered
Calgary	12	12	flat-rate	metered
Edmonton	12	12	metered	metered
Vancouver	1	6	flat-rate	metered

APPENDIX 4.1

RANKING OF HIGHEST WATER EXPENDITURES 1969-1982

Rank	1969		1974		1978		1982	
1.	Regina	43.5[1]	Calgary	44.2	Regina	61.2	Calgary	59.1
2.	Montreal	41.3	Montreal	42.4	Edmonton	45.1	Regina	52.8
3.	Sasktoon	37.6	Regina	39.8	Saskatoon	40.1	Edmonton	50.8
4.	Edmonton	32.6	Saskatoon	38.6	Calgary	37.7	Saskatoon	34.5
5.	Winnipeg	27.3	Edmonton	35.5	Montreal	36.5	Winnipeg	31.5
6.	Toronto	24.0	Winnipeg	28.2	Winnipeg	34.4	Toronto	31.5
7.	Vancouver	18.4	Halifax	25.6	Toronto	29.1	Montreal	26.2
8.	Halifax	17.4	Toronto	25.1	Halifax	25.3	Ottawa	23.2
9.	Ottawa	16.8	Ottawa	21.5	Ottawa	21.7	Halifax	20.6
10.	St. John's	9.4	Vancouver	19.4	St. John's	18.7	St. John's	13.6
11.	Quebec	3.4	St. John's	16.8	Vancouver	11.0	Vancouver	10.4
12.	- [2]		Quebec	10.2	Quebec	9.2	Quebec	7.0
	Average	24.7		28.9		30.8		30.1

[1] Number denotes the average household water expenditure in $1971 of each city over the 1969-1982 study period.

[2] Data were not available for Calgary in 1969 because of the city's exclusion in the Family Expenditure surveys in that year.

Source: Adapted from Statistics Canada. 1971- 1984. *Urban Family Expenditure in Canada 1969-1982.* Inclusive. cat. no. 62-534, 62-550. Minister of Supply and Services, Ottawa.

APPENDIX 4.2

DOLLAR INDEX (1971=100)

Year	Index
1969	.941
1970	.972
1971	1.000
1972	1.048
1973	1.127
1974	1.250
1975	1.385
1976	1.489
1977	1.608
1978	1.752
1979	1.912
1980	2.106
1981	2.369
1982	2.625

Source: Statistics Canada. 1983. *The Consumer Price Index*. cat. no. 62-001. Minister of Supply and Services, Ottawa.

APPENDIX 4.3

INTERCENSAL ESTIMATES OF AVERAGE HOUSEHOLD SIZE IN CANADA 1969-1982[1]

	1969	1974	1978	1982	Net/% Change 1969-82
St. John's	4.3	4.0	3.7	3.5	-.8 (-18.6)
Halifax	3.6	3.3	3.1	2.9	-.7 (-19.4)
Quebec	3.6	3.3	3.1	2.9	-.7 (-19.4)
Montreal	3.3	3.1	2.9	2.7	-.6 (-18.2)
Ottawa	3.4	3.1	2.9	2.7	-.7 (-20.6)
Toronto	3.4	3.1	2.9	2.8	-.6 (-17.6)
Winnipeg	3.2	3.0	2.8	2.6	-.6 (-18.8)
Regina	3.3	3.1	2.9	2.7	-.6 (-18.2)
Saskatoon	3.3	3.0	2.8	2.6	-.7 (-21.2)
Calgary	3.3	3.1	2.9	2.8	-.5 (-15.2)
Edmonton	3.4	3.1	2.9	2.8	-.6 (-17.6)
Vancouver	2.9	2.9	2.7	2.6	-.3 (-10.3)
Average	3.4	3.2	3.0	2.8	-.6 (-17.6)

[1] Figures denote average household size in each city and year.

Source: Adapted from Statistics Canada. 1982. *Census Households By Size*. cat. no. 93-708. Minister of Supply and Services, Ottawa.

APPENDIX 4.4

TOTAL HOUSEHOLD EXPENDITURE BY CITY[1]

	1969	1974	1978	1982
St. John's	7,220.7	11,567.0	10,181.2	11,145.4
Halifax	8,793.6	11,716.6	10,600.3	10,848.2
Quebec	8,522.6	10,675.5	12,576.7	10,308.4
Montreal	8,974.4	10,634.1	11,049.6	10,224.1
Ottawa	11,410.8	13,339.5	13,506.2	12,929.0
Toronto	11,191.8	11,869.9	11,876.6	11,861.1
Winnipeg	8,585.4	10,994.5	9,960.9	10,506.4
Regina	8,010.5	10,526.8	11,466.7	11,454.8
Saskatoon	8,018.2	9,509.8	10,836.2	9,831.5
Calgary	- [2]	11,144.7	13,383.0	13,539.3
Edmonton	9,947.1	11,207.8	12,496.9	12,010.9
Vancouver	8,865.8	11,120.6	11,336.2	11,485.8
Average	9,045.2	11,192.2	11,605.9	11,345.4

[1] All numbers are in $1971. The figures denote the combined costs of all items, services, securities and gifts purchased by all working adults residing in the surveyed household for a full year.

[2] Data for Calgary were not available in 1969 owing to the city's exclusion in the Family Expenditure surveys in that year.

Source: Adapted from Statistics Canada. *Urban Family Expenditure in Canada 1969-1982.* Inclusive.

BIBLIOGRAPHY

Books

Addison, Herbert. 1961. *Land, Water and Food.* Chapman and Hall, Ltd., London.

Amoss, Harold ed. 1961. *Western Resources Paper 1960 - Water: Measuring and Meeting Future Requirements.* Measuring and Meeting Future Future Requirements Ltd., Boulder.

Biere, Arlo and Frederick Worman. 1983. "Irrigation Management: Current and Prospective Issues". in Ted Napier ed. 1983. *Water Resources Research: Problems and Potentials for Agriculture and Rural Communities.* Soil Conservation Society of America, Ankeny.

Bliss, Micheal. 1982. *The State and Economic Life in Canada.* Harvest House, Toronto.

Bloomfield, L.M. and Gerald Fitzgerald. 1958. *Boundary Water Problems of Canada and the United States.* Carswell Co., Toronto.

Borchert, John. 1959. "The Surface Water Supply of American Municipalities" in Henry Ransom ed. *Readings in Urban Geography.* University of Chicago Press, Chicago.

Bocking, Richard C. 1972. *Canada's Water: For Sale.* James Lewis and Samuel, Toronto.

Camu, P. and E.P. Weeks, Z.W. Samitz. 1964. *Economic Geography of Canada.* Macmillan of Canada, Toronto.

Canada West Foundation. 1982. *Nature's Lifeline: Prairie and Northern Waters.* Canada West Foundation Publishers, Calgary.

Carson, John et al. 1973. *Community Growth and Water Resources Policy.* Praeger Publishers, New York.

Cass-Beggs, D. 1963. "Water as a Basic Resource". in Ralph Krueger ed. *Regional and Resource Planning in Canada.* Holt, Rinehart and Winston of Canada., Ltd. Toronto.

Ciriacy-Wantrup. 1961. "Projections of Water Requirements in the Economics of Water Policy". in Herald Amoss ed. *Western Resources Papers 1960 - Water: Measuring and Meeting Future Requirements.* Measuring and Meeting Future Requirements Ltd., Boulder.

Cram, J.S. 1968. *Water: Canadian Needs and Resources.* Harvest House, Montreal.

Cullimore, D.R. 1980. "Water Problems of a Growing City in a Semi-Arid Area". in *Regina: Regional Isolation and Innovative Development.* Department of Geography, University of Victoria.

Doerkson, Harvey and John Pierce. 1976. *Water Politics and Public Involvement.* Ann Arbor Publishers, Ann Arbor.

Firey, Walter. 1960. *Man, Mind and Land: A Theory of Resource Use.* The Free Press, Glencoe.

Foot, David K. 1982. *Canada's Population Outlook.* James Lorimer and Co., Toronto.

Garreau, Joel. 1981. *The Nine Nations of North America.* Avon Books, New York.

Goodwin, Harold Leland. 1964. *Space: Frontier Unlimited.* D. Van Nostrand Co. Inc., Princeton.

Grima, Angelo. 1972. *Residential Water Demand.* University of Toronto Press, Toronto.

Hirshleifer J. et al. 1973. *Water Supply: Economics, Technology and Policy.* University of Chicago Press, Chicago.

Hunt, Cynthia A. and Robert M. Garrels. 1972. *Water: The Web of Life.* W.W. Norton and Co., New York.

Hunter, h.D.G. 1971. "Whose Jurisdictions". in *Management of Canada's Water Resources.* Proceedings of a Conference Sponsored by the Association of Consulting Engineers of Canada, the Engineering Institute of Canada and the Canadian Water Resources Association, Toronto.

Ibsen, Charles and John Ballweg. 1969. *Public Perception of Water Resource Problems.* Water Resource Research Centre, Blacksburg, Virginia.

James Douglas and Robert Lee. 1971. *Economics of Water Resources Planning.* McGraw-Hill Book Co., London.

1974. "Recommendations from a Water Resources Planning Viewpoint". in *Man and Water.* University of Lexington, Lexington.

Johnson, Sue. 1974. "Recent Sociological Contributions to Water Resources Management and Development". in James Douglas ed. *Man and Water.* University of Lexington, Lexington.

Kahrl. W. 1979. *The California Water Atlas.* Prepared by the Governor's Office of Planning and Research in co-operation with the California Department of Water Resources, Los Angeles.

Kanter, Arnold. 1979. *Defence Politics: A Budgetary Perspective.* University of Chicago Press, Chicago.

Kneese, Allan. 1964. *The Economics of Regional Water Quality Management.* John Hopkins Press, Baltimore, Maryland.

Kristjanson, Kris and W.R.D. Sewell. 1961. "Water Management Problems and Issues in Canada". in *Resources For Tomorrow: Conference Background Papers Vol. 1.* Queen's Printer, Ottawa.

Krueger, R. and Bruce Mitchell eds. 1977. *Managing Canada's Renewable Resources.* Methuen Publications, Toronto.

Kuiper, Ed and J. Murray. 1969. "Water Supplies". in *A North American Common Market.* Iowa State University Press, Ames, Iowa.

1977. *Water Resources Project Economics.* Butterworths, London.

1978. *Water Resources Development: Planning, Engineering and Economics.* Butterworths, London.

Laskin, Bora. 1961. "Jurisdictional Framework for Water Management". in *Resources For Tomorrow: Conference Background Papers Vol. 1.* Queen's Printer, Ottawa.

Lee, Terence. 1969. *Residential Water Demand and Economic Development.* University of Toronto Press, Toronto.

Lypsey, R. 1979. *Economics.* Harper and Row, New York.

Maclennan, Hugh. 1974. *Rivers of Canada.* Macmillan Ltd., Toronto.

Mann, Dean. 1963. *The Politics of Water in Arizona.* University of Arizona Press, Tuscon.

Matthews, O.P. 1984. *Water Resources: Geography and Law.* Association of American Geographers, Pennsylvania.

Maughan, J.H. 1950. "Social and Administrative Aspects of Irrigation". in Brownlee J. Davidson. ed. *Irrigation, Principles and Practices.* John Wiley and Sons Inc., New York.

Mitchell, Bruce. 1975. *Institutional Arrangements for Water: Canadian Experiences.* Department of Geography Publication Series, No. 5, University of Waterloo, Waterloo.

Moss, Frank. 1971. "Toward a North American Water Policy". in ed. J.G. Nelson and M.J. Chamber. *Water: Process and Method in Canadian Geography.* Methuen Publishers, Toronto.

Napier, Ted et al. ed. 1983. *Water Resources Research: Problems and Potentials for Agriculture and Rural Communities.* Soil Conservation Society of America, Ankeny.

Olson, Ralph. 1970. *A Geography of Water.* William C. Brown Co. Publishers, Dubuque.

Overman, Michael. 1976. *Water: Solutions to a Problem of Supply and Demand.* Open University Press, London, England.

Powledge, Fred. 1983. *Water: The Nature, Uses and Future of Our Most Precious and Abused Resource.* McGraw-Hill Ryerson Ltd., New York.

Prairie Provinces Water Board. 1982. *Water Demand Study: Historical and Current Uses in the Saskatchewan Nelson Basin. Report No. 3.* Prairie Provinces Water Board, Regina.

Proceedings of the International Seminar on Soil and Water Utilization. 1961. South Dakota State College Press, Brookings.

Proceedings of the National Water Symposium: Changing Directions in Water Management. An Infrastructure Financing Policy Symposium. 1983. American Public Works Association, Washington.

Putnam, D.F. and Putnam, B.G. 1979. *Canada: A Regional Analysis.* J.M. Dent and Sons Ltd., Toronto.

Quinn, F.J. 1976. "Canada's Surface Water Resources: Inventory and Management". in G.R. McBoyle and E. Sommerville eds. *Canada's Natural Environment.* Methuen, London, Ontario.

1977. "Notes for a National Water Policy". in Ralph Krueger and Bruce Mitchell eds. *Managing Canada's Renewable Resources.* Methuen, Toronto.

1977. "The North Also Thirsts: Countering the Threat of Water Export". in Ralph Krueger and Bruce Mitchell eds. *Managing Canada's Renewable Resources.* Methuen, Toronto.

Sewell, W.R.D. 1977. "Broadening the Approach to Evaluation in Resources Management Decision Making". in Ralph Krueger and Bruce Mitchell eds. *Managing Canada's Renewable Resources.* Methuen, Toronto.

1978. "The Changing Content of Water Resources Planning: The

Next Twenty-Five Years". in A. Utton and L. Teclaff eds. *Water in a Developing World.* Westview Press, Boulder, Colorado.

1983. "Commentary". in Barry Sadler ed. *Water Policy for Western Canada: The Issues of the Eighties.* University of Calgary Press, Calgary.

and L. Roueche. 1974. "The Potential Impact of Peak Load Pricing on Urban Water Demands: Victoria, British Columbia, A Case Study". in Western Geographical Series, vol. 8. University of Victoria, Victoria.

and H. Foster. 1981. *Water: The Emerging Crisis in Canada.* University of Toronto Press, Toronto.

Smith, Stephen and Emery Castle. 1964. *Economics and Public Policy in Water Resource Development.* Iowa State University Press, Ames.

Steel, E.W. and T.J. McGhee. 1979. *Water Supply and Sewerage.* McGraw-Hill Book Co., New York.

Swainson, Neil. 1976. "Defining the Problem". in *Managing the Water Environment.* University of British Columbia Press, Vancouver.

Templeton, Carson. 1983. "The Practical Constraints on Water Management". in Barry Sadler ed. *Water Policy for Western Canada: The Issues of the Eighties.* University of Calgary Press, Calgary.

Thompson, D. 1983. "Water Allocation Systems and Their Implications for Management". in Barry Sadler. *Water Policy for Western Canada: the Issues of the Eighties.* University of Calgary Press, Calgary.

Thompson, J. 1960. *Public Adminstration of Water Resources in Texas.* Institue of Public Affairs, Austin.

Tinney, E. Roy and R.J. Van Loon. 1972. "Canadian Federal Water Resource Policy". in *Water Management: Basic Issues.* Organization for Economic Development, Paris, France.

Utton, Albert and Ludwik Teclaff. 1978. *Water in a Developing World: The Management of a Critical Resource.* Westview Press Inc., Boulder.

Van Dir Leeden, Frits. 1975. *Water Resources of the World.* Water Information Centre, New York.

Vesilind, P. Aarne. 1975. *Environmental Pollution and Control.* Ann Arbor Science Publishers, Ann Arbor.

Ward, Barbara. 1968. *The Lopsided World.* W.W. Norton and Co., New York.

1979. *Progress for a Small Planet.* W.W. Norton and Co., London, England.

Weber, Max. 1930. *The Protestant Ethic and the Spirit of Capitalism.* George Allen Ltd., London, England.

White, Gilbert F. 1969. *Strategies of American Water Management.* Longmans Canada Ltd., Don Mills, Ontario.

Wilson, J.M. 1973. *People in the Way: The Human Aspects of the Columbia River Project.* University of Toronto Press, Toronto.

Wollman, Nathaniel and Gilbert Bonem. 1971. *The Outlook for Water:*

Quality, Quantity and National Growth. Resources For the Future Inc., London, England.

Government Publications

Barker, Mary L. 1974. *Water Resources and Related Land Uses, Strait of Georgia: Puget Sound Basin.* Geographical Paper No. 56. Department of the Environment, Minister of Supply and Services, Ottawa.

Bellinger, D.F. 1975. *Canadian Water Management Policy Instruments.* Social Science Series No. 13. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Ottawa.

Canada Water Act. 1969. The House of Commons. Bill C-144. Ministry of Supply and Services, Ottawa.

Canada Yearbook 1970-1982. 1971-1983 Inclusive. Information Services, Minister of Supply and Services, Ottawa.

Cranmer, V. 1974. *Land Use Programs in Canada, Newfoundland and Labrador.* Environment Canada, Lands Directorate.

Davar, Z. 1977. *Licensing for Consumptive Use of Water: Current Practics and Implications for a Pricing Policy.* Department of Fisheries and Environment, Halifax.

Environment Canada. 1976. *Canada Water Yearbook 1975.* Minister of Supply and Services, Ottawa.

1979. *Canada Water Yearbook 1977-1978.* Minister of Supply and Services, Ottawa.

1983. *Canada Water Yearbook 1981-1982.* Minister of Supply and Services, Ottawa.

1978. *Hydrological Atlas of Canada.* Minister of Supply and Services, Ottawa.

1973. *Inventory of Canadian Freshwater Lakes.* Environment Canada, Inland Waters Directorate, Water Resources Branch, Minister of Supply and Services, Ottawa.

1982. *National Water Research Institute 1981-1982 Report.* Environment Canada, Inland Waters Directorate, Burlington.

Federation of Assocations on the Canadian Environment (FACE). 1981. *National Inventory of Municipal Waterworks and Wastewater Systems in Canada.* Environment Canada, Minister of Supply and Services, Ottawa.

Gill, G.W. and A.F. Leitch. 1983. *Municipal Water/Sewer Rate Design, Regional Municipality of Durham Case Study.* Municipality of Durham, Whitby, Ontario.

Ibsen, Charles and John Ballweg. 1969. *Public Perception of Water Resource Problems.* United States Department on the Interior, Office of Water Resources Research, Washington, D.C.

Inquiry on Federal Water Policy. 1984. *Water is a Mainstream Issue.* Minister of Supply and Services, Ottawa.

1985. *Hearing About Water: A Synthesis of Public Hearings of the Inquiry on Federal Water Policy.* Minister of Supply and Services,

Ottawa.

1985. *Currents of Change: Final Report.* Minister of Supply and Services, Ottawa.

Judy, Richard. 1969. "Economic Problems in Water Resources Management in Canada". in *Water Resources Research: Social Science Priorities.* Department of Energy, Mines and Resources, Policy and Planning Branch, Ottawa.

Kellow, R.L. 1970. *A Study of Water Use in Single-Dwelling Residences in the City of Calgary, Alberta.* Department of Agricultural Economics and Rural Sociology, University of Alberta, Edmonton.

Lee, T.R. 1972. *Approaches to Water Requirement Forecasting: A Canadian Perspective.* Social Science Series No. 9. Environment Canada, Canada Centre for Inland Waters, Burlington.

Manitoba Environmental Council. 1980. *Manitoba Environmental Council Annual Report.* Province of Manitoba, Winnipeg.

McMeiken, J. Elizabeth. 1972. *Public Health Professionals and the Environment: A Study of Perceptions and Attitudes.* Social Science Series No. 5. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Ottawa.

Mitchell, B. and G. McBean. 1985. *Water Resources Research in Canada, 1966-1983.* Research Paper No. 16, Commissioned by the Inquiry on Federal Water Policy, Ottawa.

Morley, C.G. 1975. *The Legal Framework for Public Participation in Canadian Water Management.* Social Science Series No. 14. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Burlington, Ontario.

Organization of the Government of Canada. 1975. Information Canada, Minister of Supply and Services, Ottawa.

Payment, Diane. 1979. *The Winnipeg Aqueduct: 1919.* The Canadian Engineering Heritage Record, City of Winnipeg.

Penman, A. ed. 1981. *City of Winnipeg Water Rate Study.* City of Winnipeg, Waterworks, Waste and Disposal Division, Winnipeg.

1979. *North End Water Pollution Control Centre.* Brochure by City of Winnipeg, Waterworks, Waste and Disposal Division, Winnipeg.

1979. *Pure Water.* Brochure by City of Winnipeg, Waterworks, Waste and Disposal Division, Winnipeg.

1983. *Winnipeg's Water Supply.* Brochure by City of Winnipeg, Waterworks, Waste and Disposal, Division, Winnipeg.

Province of Nova Scotia. 1980. *Minamkeak Lake Protected Water Area: A Guide for Residents and Property Owners.* Department of the Environment, Halifax.

1981. *Water Supply: A Resource in Need of Protection: Province of Nova Scotia.* A Summary Report of the Water Issue Group. Nova Scotia Deputy Minister's Committee on on Land Use Policy, Halifax.

Quellet, Lionel. 1969. "Legal and Administrative Problems of Water Management in Canada: A Suggested Framework for Analysis". in *Water Management Research: Social Science Priorities.* Department of Energy, Mines and Resources, Policy and Planning Branch,

Ottawa.

Quinn, Frank. 1973. *Area-of-Origin Protectionism in Western Waters.* Social Science Series No. 6. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Ottawa.

Rueggeberg, Harriet. 1985. *Northern Water Issues.* Research Paper No. 12, Commissioned by the Inquiry on Federal Water Policy, Ottawa.

Statistics Canada. 1982. *Census Households By Size.* cat. no. 93-708. Minister of Supply and Services, Ottawa.

1983. *Consumer Price Index.* cat. no. 62-001. Minister of Supply and Services, Ottawa.

1983. *Estimates of Population for Canada and the Provinces.* cat. no. 91-201. Minister of Supply and Services, Ottawa.

1971-1984. *Family Expenditure in Canada 1969-1982.* Inclusive. cat. nos. 62-534, 62-550. Minister of Supply and Services, Ottawa.

1983. *Federal Government Employment 1981.* cat. no. 72-004. Minister of Supply and Services, Ottawa

1973-1983. *Federal Government Finance 1971-1981.* Inclusive. cat. no. 68-211. Minister of Supply and Services, Ottawa.

1973-1983. *Local Government Finance 1971-1981.* Inclusive. cat. no. 62-537. Minister of Supply and Services, Ottawa.

1973-1983. *Provincial Government Finance.* Inclusive. cat. no. 68-205. Minister of Supply and Services, Ottawa.

1984. *System of Government Financial Management Statistics.* cat. no. 68-507 E. Minister of Supply and Services, Ottawa.

Tate, Donald. 1983. *Water Use in the Canadian Manufacturing Industry.* Social Science No. 18. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Ottawa.

Therrien, Jacques. 1972. "Financial Arragements, Flow of Money, Bookkeeping, Budgetary Constraints". in Harry Hill ed. *Proceedings of Planning Division Seminar, University of Waterloo, February 1971.* Social Science Series No. 7, Environment Canada, Inland Waters Directorate, Ottawa.

Vindasius, Dana. 1974. *Public Participation Techniques and Methodologies: A Resume.* Social Science Series No. 12. Environment Canada, Inland Waters Directorate, Water Planning and Management Branch, Ottawa.

Watson, William G. 1983. *A Primer on the Economics of Industrial Policy.* Policy Study Series, Ontario Economic Council, Toronto.

Interviews

Ball, Dr. Timothy. Professor of Geography, University of Winnipeg, March 17, 1985, Winnipeg, Manitoba.

Chambers, Glen. Civil Engineer with the City of Winnipeg Waterworks, Waste and Disposal Division. July 11, 1983, Winnipeg, Manitoba.

Henderson, I.B. Civil Engineer with the City of Winnipeg Waterworks,

Waste and Disposal Division, November 23, 1982, Winnipeg, Manitoba.

Kenny, B. Hyrologist with the National Water Research Institute. September 21, 1983. Winnipeg, Manitoba.

Kuiper, E. Professor of Civil Engineering, University of Manitoba. January 23, 1984. Winnipeg, Manitoba.

Martinssen, Sharon. Water Rates Analyst, City of Winnipeg Waterworks, Waste and Disposal Division. October 17, 1985. Winnipeg, Manitoba.

McLauren, Ian. Public Relations Officer with Environment Canada. August 27, 1984. Winnipeg, Manitoba.

Pearse, Peter. Chairman of Inquiry on Federal Water Policy. October 25, 1984. Winnipeg, Manitoba.

Smith, Dr. Neil. Professor of Geography, Columbia University. June 17, 1984. New York City, New York.

Tate, Donald. Policy Analyst, Inland Waters Directorate, Environment Canada, Ottawa. October 17, 1984. Winnipeg, Manitoba.

Warkentin, John. Technical Supervisor, City of Winnipeg Works and Operations, District 6. July 8, 1983, Winnipeg, Manitoba.

Newspapers

Bannister, Greg. 1983. "Funding shortage seen as roadblock to flooding solution". *Winnipeg Free Press.* December 10, 1983.

Braid, Don. 1985. "Western Canadians flock to Palm Springs". *Winnipeg Free Press.* January 14, 1985.

"B.C. parks at risk in reservoir plan". 1985. *Globe and Mail.* April 15, 1985.

"Change in water use urged". 1984. *Winnipeg Free Press.* November 6, 1984.

Curtin, J.A. 1985. "Georgian Bay water for metro". *Globe and Mail.* January 22, 1985.

Danylchuk, J. 1985. "Alberta water enjoyed in U.S. despite policy set in Ottawa". *Globe and Mail.* April 9, 1985.

"Davis denies backing water export to U.S.". 1985. *Globe and Mail.* April 20, 1985.

Davey, Tom. 1985. "Parasetic disease found in Alberta, U.S. water". *Globe and Mail.* December 24, 1984.

Edgar, Robert. 1982. "Water Priorities". *New York Times.* September 23, 1982.

Goldstein, Tom. 1983. "Mayor would fight water with water". *Winnipeg Free Press.* December 7, 1983.

Hannant, Larry. 1984. "Economic zone scheme could ignite B.C. labor war". *Globe and Mail.* December 3, 1984.

Hunter, Gary. 1985. "City works upgrade priced at $800 million".

Winnipeg Free Press. January 22, 1985.

Keating, Micheal. 1985. "Canada urged to use water as lever in U.S. trade deals". *Globe and Mail.* April 18, 1985.

Keating, Micheal. 1985. "Canadians see water problems leading to crisis, Inquiry finds". *Globe and Mail.* April 15, 1985.

1984. "Environment budget cutters underestimated public concern". *Globe and Mail.* December 24, 1984.

1984. "Government opinion polls show public against environment cuts". *Globe and Mail.* December 19, 1984.

1985. "National Inquiry reaps abundance of water worries". *Globe and Mail.* January 7, 1985.

1985. "Watchdog vital to prevent water crises". *Globe and Mail.* May 14, 1985.

1985. "Water pollution worsens". *Globe and Mail.* May 15, 1985.

1985. "The Dry West: A Four Part Series - 1. Water crisis growing as supplies run dry". *Globe and Mail.* August 19, 1985.

1985. "2. Drought exacerbates water crisis". *Globe and Mail.* August 20, 1985.

1985. "3. Water overuse haunts U.S. West". *Globe and Mail.* August 21, 1985.

1985. "4. Adopting Conservation a way out of hot water". *Globe and Mail.* August 22, 1985.

McGrath, Paul. 1984. "Thirsty to put water where it isn't". *Globe and Mail.* September 4, 1984.

"10,000 caribou drownings blamed on Quebec Hydro". 1984. *Winnipeg Free Press.* October 3, 1984.

"Water sales scheme called 'horrendous'". 1985. *Winnipeg Free Press.* June 12, 1985.

"Widespread water use crisis feared". 1984. *Winnipeg Free Press.* December 10, 1984.

Periodicals

Afifi, H. and V. Bassie. 1969. *Water Pricing: Theory and Practice in Illinois.* Bureau of Business and Economic Research, University of Illinois. Urbana, Illinois. pp. 64-78.

"America's Fractured Framework". 1983. *International Operating Engineer.* v. 126, n. 1, January. pp. 7-13.

"American the Dry". 1981. *Life.* v. 4, n. 7, July. pp. 34-47.

Armitage, A. 1983. "The Pricing of Water, The New Economics". *Journal of Freshwater.* Special Report, v. 7. pp. 18-20.

Berry, D. James. 1979. "Interprovincial Water Resource Concerns". *Canadian Water Resources Journal.* v. 4, n. 1. pp. 33-39.

Burke, C.D. 1980. "The Eighties: Implications for Water Management".

Canadian Water Resources Journal. v. 5, n. 2. pp. 1-12.

Canby, Thomas. 1980. "Our Most Precious Resource: Water". *National Geographic.* v. 128, n. 2, August. pp. 148-154.

Castle, Emery. 1983. "Water Availability: The Crisis of the Eighties". *Canadian Water Resources Journal.* v. 8, n. 4. pp. 57-66

Cooley, John K. 1984. "The War Over Water". *Foreign Policy.* v. 54, n. 2, Spring. pp. 134-139.

Dreiziger, N.F. 1983. "International Water Management in Canadian-American Relations, 1894-1907". *Canadian Water Resources Journal.* v. 8, n. 3. pp. 58-65.

Foster, Henry S. and Bruce R. Beattie. 1979. "Urban Residential Demand for Water in the United States". *Land Economics.* v. 55, n. 1, February. pp. 43-58.

Franklin, W. and G. Hardy. 1980. "Water Management in the Maritimes". *Canadian Water Resources Journal.* v. 5, n. 3. pp. 13-15.

Gibson, Dale. 1969. "The Constitutional Context of Canadian Water Planning". *Alberta Law Review.* v. 7, n. 1. pp. 45-53.

Gilchrist, Donald. 1983. "Property Rights and Water Scarcity". *Canadian Water Resources Journal.* v. 8, n. 4. pp. 88-94.

Gray, John. 1983. "Water: A Resource Like Any Other?" *Canadian Water Resources Journal.* v. 8, n. 4. pp. 35-41.

Grima, A.P. 1984. "Empirical Basis for Municipal Water Rates Modification". *Canadian Water Resources Journal.* v. 9, n. 3. pp. 22-39.

Gysi, M. 1981. "The Cost of Peak Capacity Water". *Water Resources Bulletin.* v. 17, n. 16. pp. 956-961.

Heatwole, Charles and Wendy Saten. 1983. "Marine Crimes in New York City". *Geographical Review.* v. 73, n. 3., July. pp. 67-75.

Hill, Harry. 1981. "Water and Public Policy in Western Development". *Canadian Water Resources Journal.* v. 6, n. 1. pp. 77-84.

Kuiper, Ed. 1966. "Canadian Water Export". *Journal of the Hydraulics Division.* v. 24, n. 6, July. pp. 66-74.

Lang, M. 1983. "Water Management in a Democracy: Understanding the Issue". *Journal of Freshwater.* Special Report, V. 7. S-6-S-7.

Luten, Dan. 1972. "Progress Against Growth". *Sierra Club Bulletin.* v. 57, n. 6. pp. 22-24.

Maclean, Susan. 1982. "Backflow prevention can keep you out of court". *Civic Public Works.* v. 34, n. 2, February. pp. 30-34.

Mann, P.C. and P.R. LeFrancois. 1983. "Trends in the Real Price of Water". *Journal of the American Water Works Association".* v. 75, n. 9. pp. 441-443.

Manning, E.W. 1983. "Developing Geographers for Public and Private Sector Research". *The Operational Geographer.* v. 6, n. 1. pp. 23-26.

Marchand, Len. 1978. "Federal Policy Statement on Inland Waters".

Canadian Water Resources Journal. v. 3, n. 2. pp. 7-12.

Marlin, L. and R.J. Bennet. 1984. "The Thirsty Algarve". *Geographical Magazine*. v. 55, n. 6. pp. 34-36.

Millerd, Frank W. 1984. "The Role of Pricing in Managing the Demand for Water". *Canadian Water Resources Journal*. v. 9, n. 3. pp. 7-16.

Mitchell, Bruce. 1984. "The Value of Water as a Commodity". *Canadian Water Resources Journal*. v. 9, n. 2. pp. 30-36.

Ohlendorf, Pat. 1982. "The World Water Crisis". *Maclean's*. v. 16, n. 12, December 17. pp. 40-45.

Pearse, Peter. 1984. "Of Home and River". *Canadian Water Resources Journal*. v. 9, n. 2. pp. 1-6.

Percy, David. 1981. "Legal, Moral and Political Aspects of Water Transfer from the Northwest Territories". *Canadian Water Resources Journal*. v. 6, n. 1. pp. 17-23.

Pillsbury, Arthur. 1981. "Salinity of Rivers". *Scientific American*. v. 245, n. 1, July. pp. 521-526,

Plain, Richard. 1981. "Policy Perspectives on Water Resource Development in Alberta". *Canadian Water Resources Journal*. v. 6, n. 1. pp. 23-25.

Powledge, Fred. 1982. "Water, Water, Running Out". *The Nation*. v. 234, n. 23, June 12. pp. 56-58.

Protti, Gerald J. 1979. "Water Use by Energy Producers: Some Economic Considerations". *Canadian Water Resources Journal*. v. 4, n. 1. pp. 23-32.

Quinn, Frank. 1981. "Water Transfers - Canadian Style". *Canadian Water Resources Journal*. v. 6, n. 1. pp. 108-132.

1968. "Water Transfers - Must the American West Be Won Again". *Geographical Review*. v. 58, n. 1, January. pp. 108-132.

Rogers, Peter. 1983. "The Future of Water". *The Atlantic Monthly*. v. 252, n. 1, July. pp. 80-95.

Romanowski, Jacek I. 1983. "Manitoba's Northern Rural Frontier". *Bulletin - Association of North Dakota Geographers*. v. 33, n. 2. pp. 5-6.

Seagel, G.C. and M.F. Dugh. 1981. "A Perspective on Water Transfer: McGregor Diversion Project". *Canadian Water Resources Journal*. v. 6, n. 1. pp. 23-25.

Seidel, H.F. and J.L. Cleasby. 1966. "A Statistical Analysis of Waterwork Data for 1960". *Journal American Waterworks Association*. v. 58, n. 12. pp. 1507-1527.

Sewell, W.R.D. 1966. "The New York Water Crisis: An Opportunity for More Effective Use of Water Supplies". *Journal of Geography*. v. 21, n. 11, November. pp. 384-389.

Tate, D.M. 1984. "Canadian Water Management: A One-Armed Giant". *Canadian Water Resources Journal*. v. 9, n. 3. pp. 1-6.

and Lacelle. 1978. "Municipal Water Use In Canada". *Canadian Water Resources Journal*. v.3, n.2. pp. 61-78.

and P.J. Reynolds. 1983. "Meeting the Demand for Industrial Water: Intermediate Water Transfers". *Canadian Water Resources Journal*. v. 8, n. 4. pp. 10-19.

White, T.A.E. 1976. "Government and Industry in Water Resource Management in Ontario". *Geoscope*. v. 7, n. 1, April. pp. 23-28.

Unpublished Works

Ball, Dr. Timothy. 1984. *Submission by the Manitoba Water Commission to the Inquiry on Federal Water Policy*. Presented October 25, 1984 to the Inquiry on Federal Water Policy, Winnipeg.

Bocking, Richard. 1985. *Canadian Water - A Commodity For Export?* A presentation for the National Symposium convened by The Rawson Academy of Aquatic Science. "Canadian Waters - The State of the Resource". May 26-29, 1985, Toronto, Ontario.

Clements, Spencer. 1977. *Aspects of Residential Water Use in Winnipeg*. B.A. Thesis submitted to the Department of Geography, University of Winnipeg.

Ogrodnik, Laurence. 1984. *A History and Policy Review of Water Management in the Lower Red River Basin*. A Practicum submitted in partial fulfillment of the requirements for the degree, Master of Natural Resources Management. Natural Resources Institute, The University of Mantioba, Winnipeg.

Reid, Crowther and Partners, Ltd. 1983. *City of Winnipeg District 6 Water Distribution Study*. Reid, Crowther and Partners, Ltd., Consulting Engineers, Winnipeg.

Regina Comptrollers Department. 1983. *Comparison of Water and Sewage Rates in Selected Canadian Cities, 1982*. Unpublished report prepared by the Comptrollers Department, City of Regina, Saskatchewan.

1985. *Comparison of Water and Sewage Rates in Selected Canadian Cities, 1984*. Unpublished report prepared by the Comptrollers Department, City of Regina, Saskatchewan.

Robinson, J.E. 1983. *Water Conservation Research and Evaluation Program*. Unpublished progress report submitted to Environment Canada, Waterloo, Ontario.

Romanowski, Dr. Jacek I. 1981. *Models of Land Resource Systems Management in Rural Communities*. Unpublished paper given at the I.G.U. Commission on Rural Development Symposium, Fresno, California, January, 1981.

1982. *The Need for Martial Law in Poland's Water Management*. Unpublished paper, Department of Geography, University of Manitoba.

Tate, D.M. and P.J. Reynolds, P.A. Dossett. 1984. *The Role of Water Pricing in Canadian Water Management*. Unpublished paper to O.E.C.D., Environment Canada, Ottawa.

Wasny, Garrett J. 1982. *A Case Study of Residents' Perception of Water Resources and Water Politics in Canada*. B.A. Thesis submitted to the Department of Geography, University of Winnipeg.

Water Resource Graduate Studies. 1984. *Large Scale Irrigation on the*

Canadian Prairies - A Reconnaissance Study. Unpublished paper, Department of Engineering, University of Manitoba. April.

Winnipeg Waterworks, Waste and Disposal Division. 1983. *Survey of Billing Procedures of Selected Canadian Cities, 1982*. Unpublished paper prepared by the Waterworks, Waste and Disposal Division, City of Winnipeg, Manitoba.

1985. *Survey of Billing Procedures of Selected Canadian Cities, 1984*. Unpublished paper prepared by the Waterworks, Waste and Disposal Division, City of Winnipeg, Manitoba.