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P.O. Box 527
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K1P 5V6

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K1P 5V6


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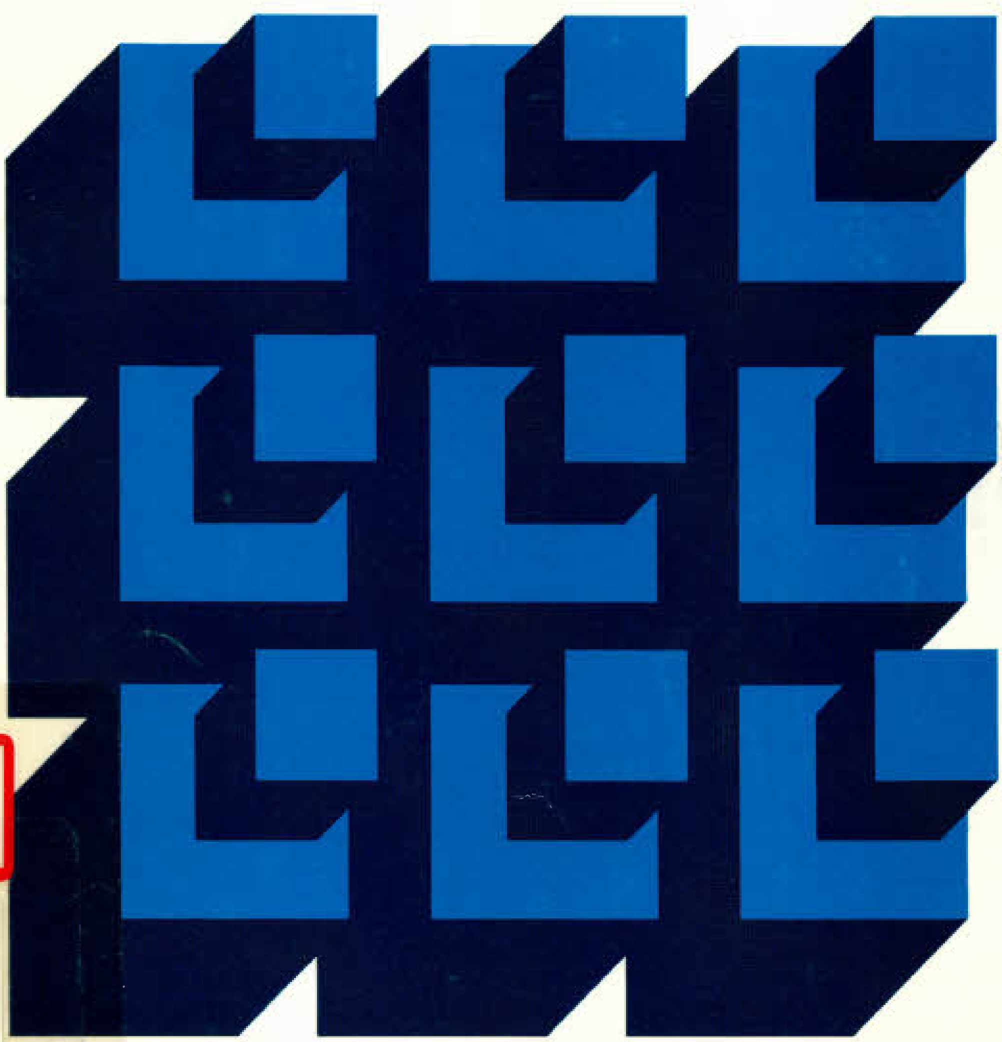

DISCUSSION PAPER NO. 279

# Water and Economic Growth in Western Canada

by Terrence S. Veeman



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## RÉSUMÉ

Les revenus de l'Ouest canadien pourraient être accrus grâce à une gestion plus rationnelle et à une meilleure répartition des ressources en eau. L'application de critères économiques à la gestion de l'eau permettrait une exploitation plus efficace et plus équitable de cette ressource et le recours à des instruments de politique économique et autres aiderait, dans le processus de répartition de l'eau, à privilégier les fins les plus utiles.

Il faudra pousser davantage les recherches afin de mieux connaître les utilisations actuelles et futures de l'eau dans trois secteurs importants : la culture irriguée, les utilisations à des fins énergétiques, et les usages de l'eau *in situ* (fins récréatives, pêche, navigation, usines de traitement, génération d'électricité et protection de l'habitat aquatique). L'agriculture est de loin la plus grande consommatrice d'eau dans l'Ouest canadien, même si la culture irriguée ne constitue pas une composante importante du secteur agricole. Pour ce genre de culture, les priorités consisteraient dans une meilleure utilisation des systèmes d'irrigation existants, plutôt que dans l'expansion de l'infrastructure en place. Il faudrait aussi accorder plus d'attention aux politiques et à la recherche concernant la

gestion de l'eau et de la neige dans la culture des terres agricoles sèches des Prairies.

L'approvisionnement actuel en eau ne constitue ni un frein, ni un stimulant pour la croissance économique régionale, du moins pour ce qui est du secteur non agricole. L'eau ne pose pas d'obstacles insurmontables au développement industriel, car le progrès technologique permet de la réutiliser. La mise en valeur des sables bitumineux près de la rivière Athabasca soulève des questions plus sérieuses au sujet de la pollution et de la qualité de l'eau; par ailleurs, l'exploitation future du pétrole lourd dans les régions de Cold Lake et de Battle River ne créera vraisemblablement aucune menace à l'environnement si l'eau est tirée de la North Saskatchewan River.

Les projets de transferts massifs d'eau d'un bassin à l'autre dans l'Ouest semblent se buter à des coûts prohibitifs et soulèvent de très sérieuses préoccupations au sujet de l'environnement. Par ailleurs, l'exportation d'eau à grande échelle vers les États-Unis en provenance de l'Ouest canadien semble improbable dans un avenir prévisible. Le Canada doit cependant élaborer dès maintenant une ligne de conduite et une politique au sujet de l'exportation d'eau.

Les ressources en eau de l'Ouest canadien seraient gérées de façon plus efficace si de nouvelles initiatives étaient prises ou si les politiques actuelles dans cinq secteurs importants étaient modifiées : 1) l'élaboration d'une stratégie nationale (et non uniquement fédérale) touchant la gestion de l'eau, en particulier dans l'Ouest canadien; 2) l'utilisation croissante de prix, de prélèvements et d'autres stimulants économiques imposés comme instruments de gestion de la demande aux consommateurs d'eau, soit les entreprises, les ménages et les exploitants agricoles qui pratiquent l'irrigation; 3) une réforme des régimes provinciaux de droits sur les ressources en eau, afin de promouvoir une plus grande flexibilité dans la réaffectation de l'eau à des fins plus souhaitables dans l'avenir; 4) l'application de mesures politiques et la création de structures institutionnelles visant à protéger les utilisations de l'eau *in situ* et à améliorer la qualité de l'eau; et 5) la mise sur pied ou la modification d'institutions et d'organismes de gestion de l'eau.

L'Ouest canadien n'est pas menacé par une crise d'eau, ni à l'heure actuelle, ni dans un proche avenir, mais plusieurs défis restent à relever afin d'assurer un approvisionnement en eau de bonne qualité. L'amélioration de la politique pertinente aiderait considérablement à relever ces défis.

## Summary

The regional income of Western Canada could be increased through sounder development and allocation of water resources. The use of economic criteria in water management would aid in developing water more efficiently and equitably; the use of economic and other policy instruments would assist in allocating water to higher valued purposes.

Further study is needed to clarify the current and future uses of water in three important areas: irrigated agriculture, energy-related uses, and instream uses. Agriculture is by far the largest consumptive user of water in Western Canada, although irrigated agriculture is not that large a component of the agricultural sector. The priorities for irrigated agriculture should involve making better use of the existing irrigation systems that are in place rather than expanding the irrigation base. More policy and research attention must be given to water and snow management in dryland agriculture on the prairies.

Regional economic growth, particularly non-agricultural growth, is neither greatly facilitated nor hindered by the availability of existing supplies of water. Water does not pose a significant constraint to industrial development chiefly because of technical change and the considerable possibilities for reusing water. Tar sands development near the Athabasca River raises more serious questions about water quality and pollution, whereas future heavy oil development in the Cold Lake and Battle River regions need not be constrained if water is piped from the North Saskatchewan River.

Massive interbasin transfers of water within Western Canada appear to have prohibitive economic costs and raise very serious environmental concerns. The export of water on any major scale to the United States from Western Canada seems unlikely in the foreseeable future. Nevertheless, Canada must begin to develop an explicit perspective and policy on water export.

The water resources of Western Canada could be managed more effectively if policy initiatives or changes were implemented in five important areas: (1) the formulation of a national (not merely a federal) strategy, and thence a western strategy, for water; (2) the increased use of prices, charges, and other economic incentives as demand management tools for many private uses of water by irrigators, firms, and households; (3) the reform of provincial systems of water rights to facilitate greater flexibility in the reallocation of water to higher valued uses in the future; (4) the implementation of policy measures and institutional structures to protect the instream uses of water and to enhance water quality; and (5) the development or modification of water institutions and organizations.

Although a water crisis is not present or imminent in Western Canada, there are many challenges to be faced with respect to water availability and quality. Improvements in water policy would greatly assist in meeting and overcoming these challenges in Western Canada.

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My biggest debt of gratitude is to Ellen Moreau who served as an extremely able research associate during this project. Ellen was responsible for much work on the tables and graphs in this paper, drafted the section relating to the industrial uses of water under my guidance, and supervised completion of the physical production of the first draft of the manuscript.

Most of the work on this discussion paper was completed at the University of Alberta. Judy Warren capably typed and produced the manuscript. The final three chapters of the manuscript were written at the University of New England, Armidale, Australia. I wish to thank the Department of Agricultural Economics and Business Management for providing congenial working facilities. I am especially grateful to Professor Warren Musgrave who introduced me to the Australian literature on water issues. Finally, I wish to thank Western Canadian colleagues, particularly John Gray, Arleigh Laycock, and Dixon Thompson, who provided very useful comments on the preliminary draft.

# Preface

Water is far from a simple commodity,
Water's a sociological oddity,
Water's a pasture for science to forage in,
Water's a mark of our dubious origin,
Water's a link with a distant futurity,
Water's a symbol of ritual purity,
Water is politics, water's religion,
Water is just about anyone's pigeon,
Water is frightening, water's endearing,
Water's a lot more than mere engineering,
Water is tragical, water is comical,
Water is far from the pure economical,
So studies of water, though free from aridity
Are apt to produce a good deal of turbidity.

Stanza III of Kenneth E. Boulding's "The Feather River Anthology," *Industrial Water Engineering* 3, 12 (December 1966): 32-33.

# WATER AND ECONOMIC GROWTH IN WESTERN CANADA

## Introduction

The role of water in current and future economic development in Western Canada is a topic needing economic examination. There are many issues concerning water development and use in this region which require clearer analytical perspectives and improved policy making. While it is not appropriate to consider either water quantity or quality issues in Western Canada as being of crisis proportions, there are clearly many challenges to be met and resolved in the water policy arena.

Policy making for water is complicated by a host of factors: long-standing and popularly held myths about the role of water in the development process; complex and, at times, conflicting inter-jurisdictional claims over water; the particular economic attributes of water in its many uses, some private and some collective in nature; the continuing inadequate attention to economic and legal institutions in water management--that is, to the possibilities of water pricing or the reform of water rights; and the historical lack of clear goals and an appropriate strategy for water, especially at the federal level but also at provincial levels. Kenneth Boulding's satirical stanza, quoted in the preface to this study, illustrates all too clearly the difficulties and complexities in water analysis and policy faced in a "maturing water economy" (Randall 1981).

Water issues in Western Canada range from the alleged current or potential physical shortages of water in several river basins--notably, the South Saskatchewan, North Saskatchewan, Okanagan, Milk, and Red-Assiniboine--to increasing concerns about water quality. Water shortages, however, are as much or even more the result of society's economic and legal regimes for water than a question of the inadequacy of the physical resource endowment. While most economists generally see conservation policies and demand management measures as the most efficient and sensible direction to take in alleviating water shortages in the short and medium run, proponents of water supply augmentation tend to see the solution in terms of more dams and diversions, first with respect to internal basin supplies but thereafter with respect to inter-basin water transfers. The relative merits of alternative strategies of water management are clearly at issue.

It is popularly believed that water is not only unique but also essential--to agricultural and industrial development, to the sustenance of economic and population growth (particularly in semi-arid environments), and indeed to life itself (Erlenkotter *et al* 1979). Whether in Alberta or Arizona, the "water problem" is popularly conceived as one of limited water supplies, which might prove to be the primary constraint on continued growth of the economy (Kelso *et al* 1973). The degree to which fact or, alternatively, mythology and misconception underlies such beliefs deserves close examination.

In large measure, questions of water scarcity in both Western Canada and the western United States revolve around the current and prospective roles of irrigated agriculture. Irrigation is by far the largest consumptive use of water in either Western Canada or in the western United States (over 83 percent of total consumptive use, for example, in California, the state with the largest irrigated acreage). Many water issues in the western half of North America must be assessed, therefore, in terms of whether the agricultural sector is using water efficiently and for sufficiently high-valued purposes and whether irrigated agriculture should be further expanded or sustained. Certainly the controversial issues surrounding inter-basin water transfer within Western Canada and the possibility of water exports from Canada to the United States must be scrutinized from this perspective.

The water resources of Western Canada have been undergoing considerable study in recent years. Most work to date has been concentrated on physical description, surveys of current water uses, and general outlines of water issues, eschewing the thornier questions related to future uses and policy prescription. The most significant studies include: the Canada West Foundation study on water resources, entitled *Nature's Lifeline: Prairie and Northern Waters* (Canada West Foundation 1982); the Prairie Provinces Water Board study on current uses of water in the Saskatchewan-Nelson basin (Prairie Provinces Water Board 1982a); and the recently released planning study on the South Saskatchewan River Basin by Alberta Environment (1984). Environment Canada (1983) has suggested that while the foregoing studies offer some promise, they do not include a comprehensive study of the region as a whole. Nor do they include any serious research effort on water demand forecasting or a well thought out water strategy for the prairie region.

The major objectives of the present study are to provide an overview, primarily from an economic perspective, of the main issues of water development and use facing Western Canada and to assess the role which water might play, either as a catalyst or constraint, to growth opportunities in Western Canada. The main focus is on the prairie region, particularly the province of Alberta where some 40 percent of Canada's consumptive use of water occurs. Brief attention will also be paid to water issues in the Okanagan and Peace basins within British Columbia, but not in the basins of the Pacific-flowing rivers such as the Fraser. Northern rivers will be considered in the context of potential inter-basin water transfers and water export.

The study is de-limited by focusing more on water quantity than water quality issues, by concentrating on surface water rather than ground water issues, and by paying only limited attention to the role of water in hydroelectric energy generation and exports. No consideration is given either to questions relating to drainage in irrigated and dryland agriculture. The desired end product is to make policy recommendations which might lead to the more efficient and equitable development and use of the water resources of Western Canada.

## Water Availability and Use in Western Canada

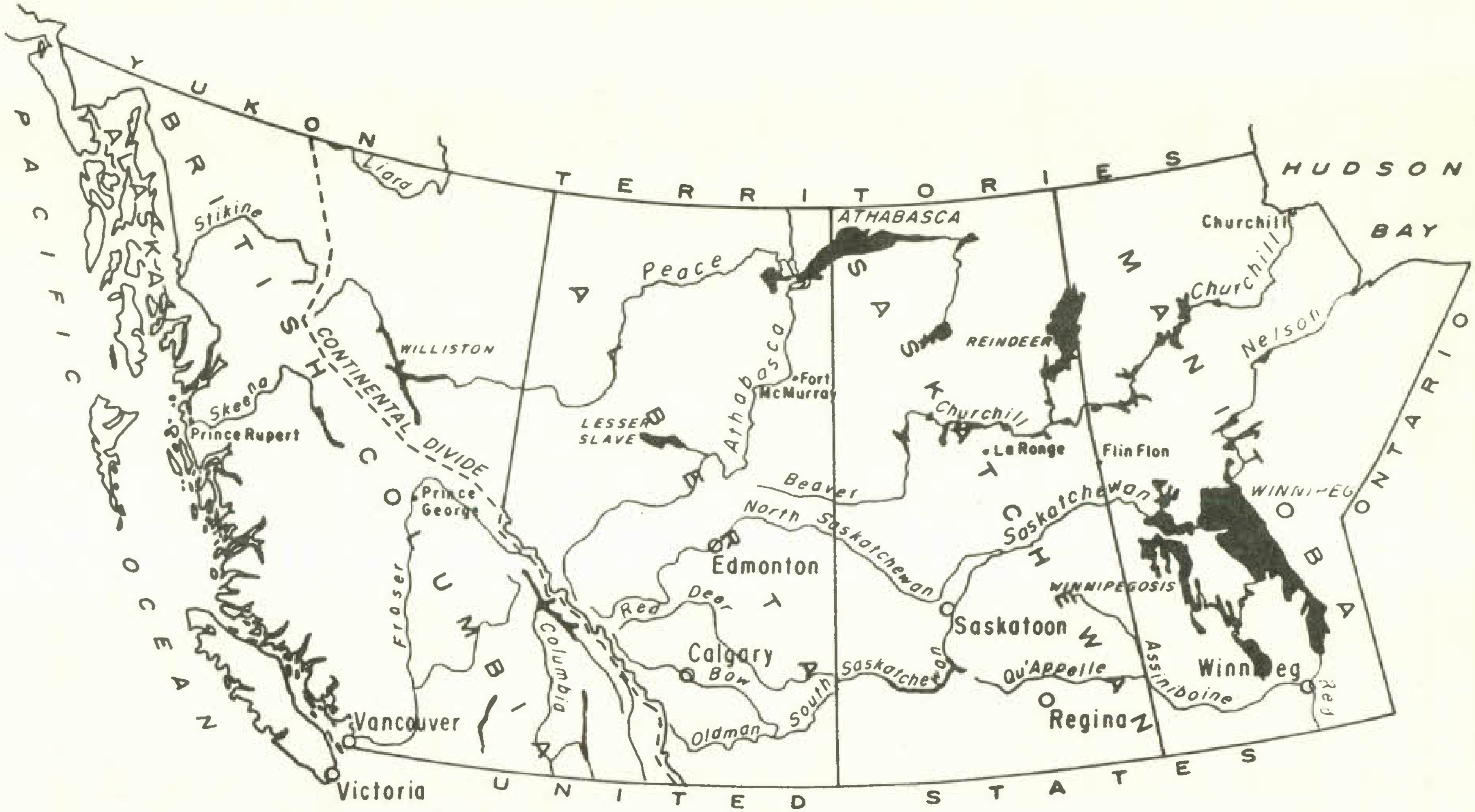
There is increasing controversy over the degree to which water resources in Western Canada are scarce and whether water shortage crises are imminent in certain basins. A sensible balance must be struck in the debate between those who view Canada's water resources as being unlimited and those who fear that we are "running out" of water.

The major rivers and lakes of Western Canada are portrayed in Figure 1. The dominant river basin in the settled portion of the prairies is the Saskatchewan-Nelson basin where four million Canadians reside. The relative sizes of the various rivers in Western Canada are portrayed graphically in Figure 2, using material provided by the Canada West Foundation study (1982). The rivers originating on the plains (Battle, Qu'Appelle, Assiniboine) are very small, those originating in the mountains of south-western Alberta (Bow, Red Deer, Oldman, and North Saskatchewan) are larger, and the northern rivers (Peace, Liard, and Mackenzie) are very large.

Overall, Western Canada might be regarded as having relatively abundant water resources, although concerns are certainly expressed about both spatial and temporal imbalances. The major concern regarding spatial imbalance results from the concentration of both population and economic activity in the southern portions of the western provinces. However, the bulk of streamflow, at least in the prairie provinces, is in the northern area of these provinces, the main system--the Peace-Athabasca--discharging via the Mackenzie River to the

FIGURE 1

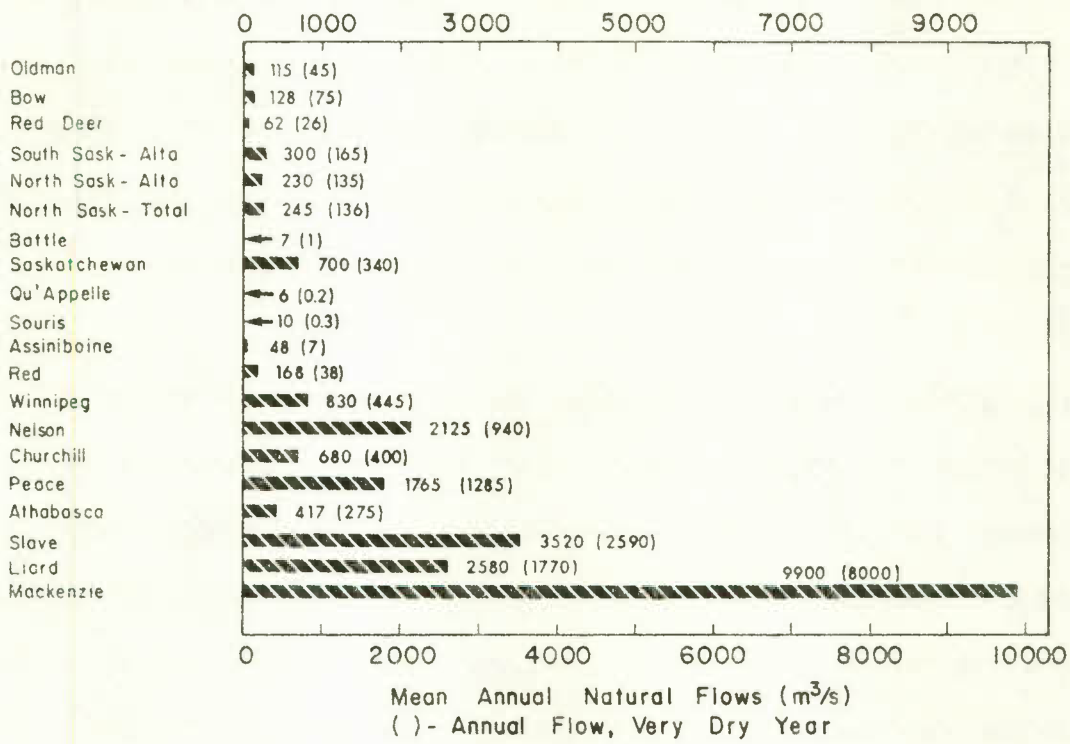
The Water Resources of Western Canada




Source: Prairie Farm Rehabilitation Administration, <u>History of Irrigation in Western Canada</u>, 1982, p. 7.

Figure 2

Relative Sizes of Rivers in Western Canada




Source: Canada West Foundation, Nature's Lifeline: Prairie and Northern Waters, 1982, p. xxii.

Arctic Ocean. The main temporal concern arises from the fact that 60 percent of the total annual flow of prairie rivers passes through the prairies on its way to Hudson Bay during the period from early May to mid-July (Canada West Foundation 1982, xxiv). While both these spatial and temporal considerations constrain and influence western water policy, they are not sufficient bases for water management in and of themselves without reference to the relative social benefits and costs (as well as the incidence of those benefits and costs) of either water transfer or water storage.

In Tables 1 and 2, the major uses of water in Western Canada are outlined in two separate sets of estimates prepared by Environment Canada. In assessing water use, a distinction should be made between withdrawal and consumptive use. Although water may be withdrawn from a river or lake, only a portion of it may be physically "used up" or consumed in the production (or consumption) process. The difference between withdrawal use and consumptive use is essentially the return flow to the waterbody (although, clearly, the qualitative characteristics of the return may be altered). One should also note that these use tables do not include any formal recognition of "in situ" or instream uses of water. That is, they do not recognize such (non-withdrawal) uses as water-based recreation, fishing, navigation, water quality improvement, hydroelectric power generation, and the provision or maintenance of ecological and habitat regimes.

**Table 1. Withdrawal and Consumptive Use of Water, Canada, Western Canada, Prairies, and British Columbia, 1980**

(million litres per day)

| **Withdrawal** | Canada | Share of Total Use (%) | Western Canada | Share of Total Use (%) | Prairies | Share of Total Use (%) | B.C. | Share of Total Use (%) |
|---|---|---|---|---|---|---|---|---|
| Municipal & rural domestic | 12,410 | 11.1 | 2,815 | 10.9 | 1,739 | 10.6 | 1,076 | 11.5 |
| Manufacturing | 38,156 | 34.2 | 6,502 | 25.3 | 860 | 5.3 | 5,642 | 60.3 |
| Mining | 4,443 | 4.0 | 2,616 | 10.2 | 2,339 | 14.3 | 277 | 3.0 |
| Agriculture | 8,296 | 7.4 | 7,446 | 28.9 | 5,878 | 35.9 | 1,568 | 16.8 |
| Thermal | 48,400 | 43.3 | 6,344 | 24.7 | 5,557 | 33.9 | 787 | 8.4 |
| TOTAL | 111,705[1] | 100.0 | 25,723 | 100.0 | 16,373 | 100.0 | 9,350 | 100.0 |
| **Consumption** | | | | | | | | |
| Municipal & rural domestic | 2,075 | 22.5 | 752 | 13.8 | 470 | 11.5 | 282 | 20.7 |
| Manufacturing | 1,567 | 17.0 | 381 | 7.0 | 154 | 3.8 | 227 | 16.7 |
| Mining | 792 | 8.6 | 574 | 10.6 | 465 | 11.4 | 109 | 8.0 |
| Agriculture | 4,409 | 47.9 | 3,678 | 67.7 | 2,941 | 72.2 | 737 | 54.2 |
| Thermal | 364 | 4.0 | 48 | 0.9 | 42 | 1.0 | 6 | 0.4 |
| TOTAL | 9,207 | 100.0 | 5,433 | 100.0 | 4,072 | 100.0 | 1,361 | 100.0 |

[1] Recirculation of water in the manufacturing and mining sectors has stretched total water withdrawals in Canada to meet a requirement of 173,000 million litres per day.

Source: Environment Canada, *Canada Water Year Book 1981-1982*.

**Table 2. Withdrawal and Consumptive Use of Water, Canada, Western Canada, Prairies, and British Columbia, 1980: Environment Canada's Estimates Compiled by Drainage Basins**

(million litres per day)

| **Withdrawal** | Canada | Share of Total Use (%) | Western Canada[1] | Share of Total Use (%) | Prairies | Share of Total Use (%) | B.C. | Share of Total Use (%) |
|---|---|---|---|---|---|---|---|---|
| Municipal & rural domestic | 11,310 | 9.4 | 3,036 | 8.6 | 1,568 | 6.1 | 1,468 | 15.0 |
| Manufacturing | 38,927 | 32.4 | 7,738 | 21.9 | 2,096 | 8.2 | 5,642 | 57.8 |
| Mining | 4,441 | 3.7 | 2,696 | 7.6 | 2,419 | 9.5 | 277 | 2.8 |
| Agriculture | 8,297 | 6.9 | 7,450 | 21.1 | 5,882 | 23.1 | 1,568 | 16.1 |
| Thermal | 57,089 | 47.6 | 14,361 | 40.7 | 13,556 | 53.1 | 805 | 8.3 |
| TOTAL | 120,064 | 100.0 | 35,281 | 100.0 | 25,521 | 100.0 | 9,760 | 100.0 |
| **Consumption** | | | | | | | | |
| Municipal & rural domestic | 1,991 | 18.7 | 673 | 9.8 | 391 | 7.1 | 282 | 20.7 |
| Manufacturing | 1,546 | 14.5 | 377 | 5.5 | 150 | 2.7 | 227 | 16.7 |
| Mining | 2,264 | 21.3 | 2,055 | 29.8 | 1,946 | 35.2 | 109 | 8.0 |
| Agriculture | 4,410 | 41.5 | 3,683 | 53.4 | 2,946 | 53.2 | 737 | 54.2 |
| Thermal | 428 | 4.0 | 108 | 1.6 | 102 | 1.8 | 6 | 0.4 |
| TOTAL | 10,639 | 100.0 | 6,896 | 100.0 | 5,535 | 100.0 | 1,361 | 100.0 |

[1]The following drainage basins are included in Western Canada: Fraser, Okanagan, Columbia, Pacific Coastal, Peace-Athabasca, Milk, Churchill, Nelson, North Saskatchewan, South Saskatchewan, Red-Assiniboine, Winnipeg.

Source: Based on data from Inland Waters Directorate, Environment Canada cited in H.D. Foster and W.R. Sewell, *Water: The Emerging Crisis in Canada*, Appendix Tables 3-6.

The major characteristics of water use in Western Canada can be summarized as follows:

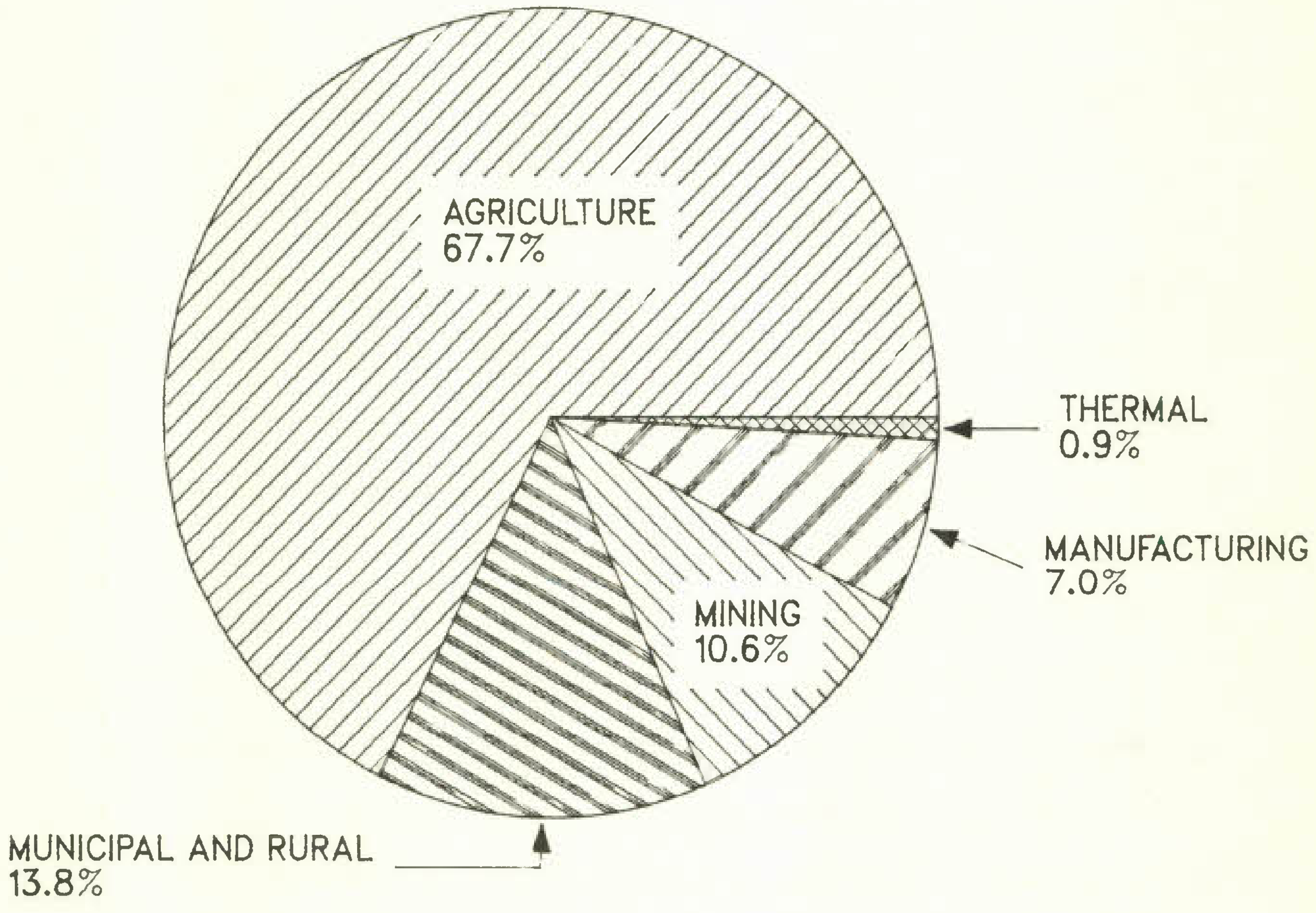
1. Although thermal power production, which requires water for cooling, is the largest withdrawer of water, consumptive use of water in this sector is relatively insignificant (see Figure 3, which is based on the consumptive use figures provided in Table 1).
2. Irrigation is by far the largest consumptive use of water in the western provinces, accounting for over one-half of total consumptive use by even the most conservative estimates.
3. The combined consumption of water for municipal, rural domestic, and manufacturing purposes is small relative to irrigation (the latter being approximately 3 1/2 times as large).
4. There is some confusion regarding the amount of water used consumptively for "mining", specifically for energy-related use. Historically, the use of water for oil field injection to enhance recovery has been important.
5. Total consumptive use of water in Western Canada is approximately one-fifth the level of withdrawals.
6. Western Canada accounts for about 60 percent of the consumptive use of water in Canada, chiefly because of the presence of irrigated agriculture and oil and gas extraction in the west (both predominantly in Alberta).

The main discrepancies in the two sets of data generated by Environment Canada (Environment Canada typically having to rely, in turn, on water use statistics provided by the provinces)

Figure 3

# Consumptive Uses of Water in Western Canada

1980




Source: Based on the Environment Canada data presented in Table 1.

relate to the magnitude of withdrawal use for thermal power production and the amount of consumptive use in "mining". The latter aspect is more worrisome given that consumptive use for thermal purposes is so small.

There are several problems which complicate the compilation of accurate statistics on energy-related water use. The first problem area arises when water used for secondary recovery processes in oil and gas extraction is not included in mining figures (in Alberta, for example, these volumes are not formally included in industrial water use statistics, but relegated to an Appendix). Secondly, it is not clear whether water used for secondary recovery processes should be treated as a consumptive or non-consumptive use, although it generally tends to be regarded as a consumptive use. Similarly, the degree to which contaminated or effluent waters from the energy-cum-mining sector, which are pumped into underground formations, should be regarded as consumptive use is also at issue. Finally, some confusion regarding water withdrawals and consumption for non-conventional energy production may have occurred around 1980, at which time the Syncrude plant was beginning to use recirculated water.

Further study is needed to clarify the current and prospective uses of water in the energy sector. Other priority areas of assessment include water use in irrigated agriculture and various instream uses.

## How Scarce is Water?

The study of current or potential imbalances between "water supply" and "water demand" typically involves the comparison of river flow data with consumptive use figures. Such a comparison between physical water availability and water requirements is not really a comparison of water supply and demand, in the economic sense, because the price of water is not an argument in the supposed water supply and demand functions (Ciriacy-Wantrup 1959).

The consumptive use of water is a much more appropriate yardstick in measuring water use than withdrawals.[1] Water flow and water use information is presented in Table 3 for five drainage basins in Western Canada which are alleged by Environment Canada to be currently or in prospect of experiencing serious water scarcities (Environment Canada 1983). Foster and Sewell (1981) have pointed to these basins as actual or eventual "regions of crisis." How appropriate is such a perspective?

In assessing physical water scarcity, consumptive water use figures are typically contrasted with either mean runoff or some measure of reliable flow: either reliable annual flow (that flow which would be available 90 percent of the time or nine out of ten years) or reliable minimum monthly flow (that flow based on the lowest monthly flow experienced in ten years). An examination of the data in Table 3 reveals that consumptive use in the Okanagan Basin is currently one-third the level of reliable

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[1]The magnitude of withdrawals, however, is relevant to the question of water quality deterioration; for example, most water used in thermal power production is returned to the source but at a higher temperature.

**Table 3. Water Supply, Withdrawal, Consumption, and Agricultural Use in Drainage Basins in Western Canada Which Are Alleged to be Currently or in Prospect of Experiencing Serious Water Scarcities, 1980 and 2000**

(million litres per day)

| | SUPPLY | | WATER USE | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Reliable Flow[1] | | Total Daily Withdrawal | | Total Daily Consumption | | Agricultural Use | |
| Drainage Basin | Annual | Monthly | 1980 | 2000 | 1980 | 2000 | 1980 | 2000 |
| Okanagan | 4,637 | 1,100 | 850 | 1,309 | 355 | 555 | 318 | 477 |
| Milk River | 382 | 0 | 732 | 1,582 | 104 | 160 | 100 | 150 |
| North Saskatchewan | 15,093 | 1,809 | 10,579 | 24,721 | 850 | 1,729 | 91 | 132 |
| South Saskatchewan | 12,502 | 2,982 | 7,119 | 11,660 | 3,287 | 5,281 | 2,564 | 3,814 |
| Red-Assiniboine | 2,864 | 341 | 3,869 | 8,469 | 344 | 569 | 118 | 177 |

[1] Reliable annual flow is that flow which would be available 90 percent of the time, or 9 out of 10 years. Reliable minimum monthly flow is the lowest monthly flow experienced in 10 years. All flow data reflect the effects of natural and artificial storage.

Source: Inland Waters Directorate, Environment Canada as cited in Foster and Sewell, *Water: The Emerging Crisis in Canada*, Appendix Tables 3 and 4.

minimum monthly flow and is projected to rise to about one-half by the year 2000. Indeed, the Okanagan Basin Implementation Board (1982, p. 3) has recently concluded that "under good water management there is enough water in the basin to supply all projected withdrawals and meet fishery and recreation requirements in the main valley lakes and in tributary sub-basins within the foreseeable future."

In the Milk River Basin, an area characterized by large ranches and extensive grazing, agricultural consumptive use is some 95 percent of total consumptive use. Most use takes place along the river valley, primarily by private irrigators pumping water for the irrigation of hay crops or forage. This activity occurs in the summer months when river flows are more plentiful. A preliminary benefit cost study of the potential for increased storage on the Milk River (the most attractive site for a dam being Milk River Site 2) indicated benefit-cost ratios of slightly less than unity (Milk River Basin Study 1981a). Ranchers and farmers in this basin are clearly interested in irrigation expansion, but they anticipate that provincial taxpayers at large would undertake the capital cost of storage. The major questions, then, in the Milk River Basin are not so much those of physical water shortages, but whether there are impediments to the transfer of water from relatively low-valued agricultural use to other uses. Another issue is whether increased storage for further irrigation may be justifiable in terms of social benefits and costs.

In the North Saskatchewan Basin, total consumptive use is currently less than half the short-run reliable supply based on the lowest monthly flow (likely January or February) in ten years. The main increase in consumptive use expected by the year 2000 is in the area of heavy oil development, although water use projections to the end of the century are undoubtedly overstated since many were made in the light of much more optimistic scenarios relating to non-conventional energy development which were prevalent about 1980. Water quality concerns, rather than inadequate water supplies, should constitute more serious public policy questions in the North Saskatchewan Basin in the foreseeable future.

In the Red-Assiniboine Basin, total daily consumptive use is currently equal to reliable minimum monthly flow and is projected in the future to exceed this relatively stringent measure of supply availability. It should be noted, however, that the city of Winnipeg draws its supplies from Shoal Lake in the Winnipeg River Basin, not from the Red-Assiniboine Basin in which it is located.

Fears of inadequate water supplies are most commonly expressed for the South Saskatchewan Basin. Even in this basin, it will be argued, water scarcity is more apparent than real, at least in economic terms. The South Saskatchewan Basin is, by some margin, the most important basin in Western Canada (indeed, in all of Canada) in terms of the consumptive use of water, over three-quarters of which is used currently in irrigation.[2]

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[2]In fact, in a dry year like 1977 when river flows are low and irrigation use is high, some 96 percent of water consumption in

There are at least two major economic difficulties with the "water crisis" or "water scarcity" doctrine. First and foremost, the assessment of current and future use of water is undertaken under the assumption that water is a free good--that is to say, that there is no price for water (current water charges reflect distribution costs and not an intrinsic value for water itself). Where water price is not a determinant of water demand, there are no possibilities for demand management (in terms of movement along a given demand curve: that is, quantity demanded of water declining as the price of water increases). Where water price is not a determinant of water supply, firms are under less pressure to recirculate or re-use water. Water scarcity, therefore, is not merely a matter of physical availability, but is also heavily influenced by society's economic and legal regimes for water. In short, alleged water scarcity is as much a failing of man as a short-coming of "nature".

Secondly, there are various economic alternatives to be considered in coping with severe water shortages in those circumstances, experienced periodically, where total consumptive use exceeds reliable minimum monthly flow. These alternatives include: further storage by society or by the firm itself; rationing to move water to the most essential priorities in the short run; and transferring production, where possible, from February to other months where water supply is less constraining. It is instructive that California coped with its drought in 1977

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[2](cont'd) the South Saskatchewan River Basin was for agriculture--see the recently released SSRBPP summary report (Alberta Environment 1984).

with much less economic dislocation than had been feared, chiefly because urban areas were able to reduce water use some 20 percent (California Department of Water Resources 1982).

It should also be pointed out that a comparison of average daily consumptive use with average reliable short-run supplies masks problems associated with temporal variation in consumptive use. In fact, the problem of physical water shortage is mitigated to the extent that consumptive use peaks in the summer months and not in low flow winter months. Water shortages are more critical, on the other hand, if higher consumptive use also coincides with low flow periods.

In conclusion, the question of water "scarcity" is more complicated than a mere physical comparison of consumptive use with short-run available supplies. It is very debatable, indeed, whether the label "water scarce" should be applied without question to the river basins in Western Canada. Overall, there are many challenges to be met and faced with respect to water availability, but a water crisis is not present or imminent in Western Canada.[3]

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[3] See Rogers (1983) and Castle (1983) for similar perspectives in the United States.

## Agricultural Use and Irrigation Expansion

Although irrigated agriculture is a relatively small segment of the overall agricultural sector in Western Canada, the use of water for irrigation purposes is nevertheless the dominant consumptive use of water in this region. Statistics on irrigated agriculture are somewhat fragmentary and incomplete; the most reliable year by year information is collected for the major irrigation districts in Alberta and the South Saskatchewan River Irrigation Project No. 1 in Saskatchewan.

According to the limited information on irrigation in the 1981 Census, 1,377,000 acres (557,000 hectares) of land were irrigated in the four western provinces in 1980--see Table 4.

**Table 4. Irrigated Area in 1980 in Western Canada Reported in the 1981 Census**

| | Irrigated Area | |
|---|---|---|
| Province | Hectares | Acres |
| Manitoba | 6,935 | 17,136 |
| Saskatchewan | 55,913 | 138,164 |
| Alberta | 393,969 | 973,519 |
| British Columbia | 100,475 | 248,279 |
| Total | 557,292 | 1,377,098 |

Source: Statistics Canada, *Census of Agriculture: Agriculture, Canada, 1981, Cat. 96-901, Table 20.*

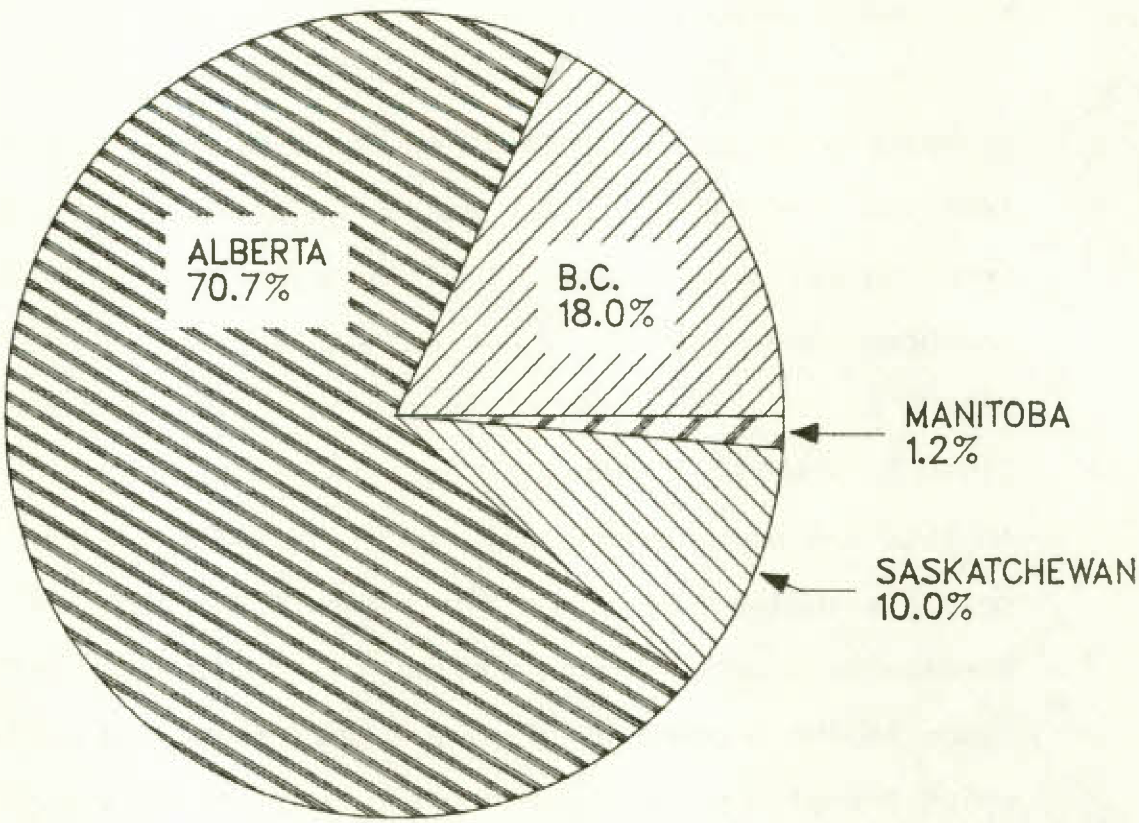
Alberta had nearly 71 percent of this irrigated acreage, British Columbia 18 percent, Saskatchewan 10 percent, and Manitoba slightly over 1 percent (see Figure 4). The area under irrigation was only slightly over 2 percent of the area under crops in Western Canada. Irrigation farmers reported that 72 percent of their irrigated land was irrigated by sprinkler systems.

The foregoing census figures for irrigated acreage are somewhat smaller than other reported figures, presumably because not all extensive private irrigation (where farmers sometimes flood once a year, primarily for hay crops) has been counted. It should also be recognized that the area under irrigation fluctuates from year to year in response to climatic conditions, being relatively higher in years of low rainfall. The Prairie Provinces Water Board (1982a) states that nearly one million acres were irrigated in the three prairie provinces in the Saskatchewan-Nelson basin in 1978 (a higher rainfall year), some 800,000 acres being under district irrigation and 195,000 acres under private irrigation. In Alberta, the thirteen major irrigation districts had over one million acres of irrigable land in 1982, with water actually being applied to approximately 900,000 acres. Most of the water is supplied from the Bow, Oldman, and St. Mary Rivers. There are also estimated to be in excess of 200,000 acres of private irrigation in Alberta (roughly half of which appears to be showing up in the census figures). In Saskatchewan, the government estimates of current irrigation potential in 1980 were 135,000 acres of intensive irrigation (water available throughout the year) and 95,000 acres of

Figure 4

# Irrigated Area by Province in Western Canada

## 1980




Source: Statistics Canada, Census of Canada: Agriculture, Canada, 1981, Cat. 96-901, Table 20.

extensive irrigation (usually only one application per year) (Saskatchewan Agriculture 1982). Between 70 and 80 percent of this irrigable land in Saskatchewan appears to be irrigated in a given year (Canada West Foundation 1982). In Manitoba, irrigated acreage, partially based on groundwater sources, has been expanding quite rapidly over the past decade, although irrigation starts from a very small base in that province. All told, the best estimate of the current irrigated land base in Western Canada would appear to be approximately 1.5 million acres. The amount of water applied to this base rarely exceeds 1.5 acre-feet per acre in any district and more commonly is considerably less than one acre-foot per acre.

Probably the most important economic dimension of irrigation in Western Canada, especially on the prairies, arises from the fact that irrigation is focused on relatively low valued uses. Cropping patterns or mixes for the major irrigation districts in southern Alberta (which comprise nearly two-thirds of Western Canada's irrigated acreage) from 1979 to 1982 are presented in Table 5. The relative proportions of the various crop categories in 1982 are shown graphically in Figure 5. The first fact to be noted is that a high proportion--over 70 percent--of irrigated acreage is sown to grains and hay which, directly or indirectly, leads to the production of cereal grains and red meats, products which are also grown under dryland conditions (with the exception of soft white wheat). Only 12 percent of the irrigated cropland in the irrigation districts in Southern Alberta is in specialty crops--sugar beets, potatoes, and other specialty crops

**Table 5. Crop Acres in the Major Irrigation Districts[1] in Alberta, 1979 to 1982**

(acres)

| | 1979 | 1980 | 1981 | 1982 |
|---|---|---|---|---|
| Total Grains[2] | 411,841 | 421,450 | 446,143 | 475,304 |
| Total Oilseeds[3] | 82,168 | 51,208 | 30,809 | 38,349 |
| Total Hay[4] | 175,623 | 174,943 | 167,676 | 165,805 |
| Total Tame Pasture | 73,810 | 65,197 | 53,105 | 50,793 |
| Total Other Fodder[5] | 33,015 | 29,019 | 37,248 | 23,507 |
| Total Sugar Beets | 32,474 | 33,662 | 35,484 | 31,475 |
| Total Potatoes | 11,396 | 9,662 | 11,153 | 13,329 |
| Total Other Specialty Crops[6] | 55,888 | 75,388 | 48,552 | 60,593 |
| Total Crops Irrigated | 876,215 | 860,529 | 830,170 | 859,155 |
| Total Summerfallow | 13,809 | 14,406 | 8,769 | 8,462 |
| Total Irrigated Cropland | 890,024 | 874,935 | 838,939 | 867,617 |

[1] Does not include data for the Irrigation Districts of Aetna, Leavitt, Mountain View, Ross Creek; in 1981 and 1982, data were not available from the Western Irrigation District which had over 46,000 irrigated acres in 1979.

[2] Wheat, oats, barley, mixed grain, and rye.

[3] Flaxseed, canola/rapeseed, sunflowers, and mustard.

[4] Alfalfa hay and sweet clover hay.

[5] Greenfeed, silage corn, silage, and grass hay.

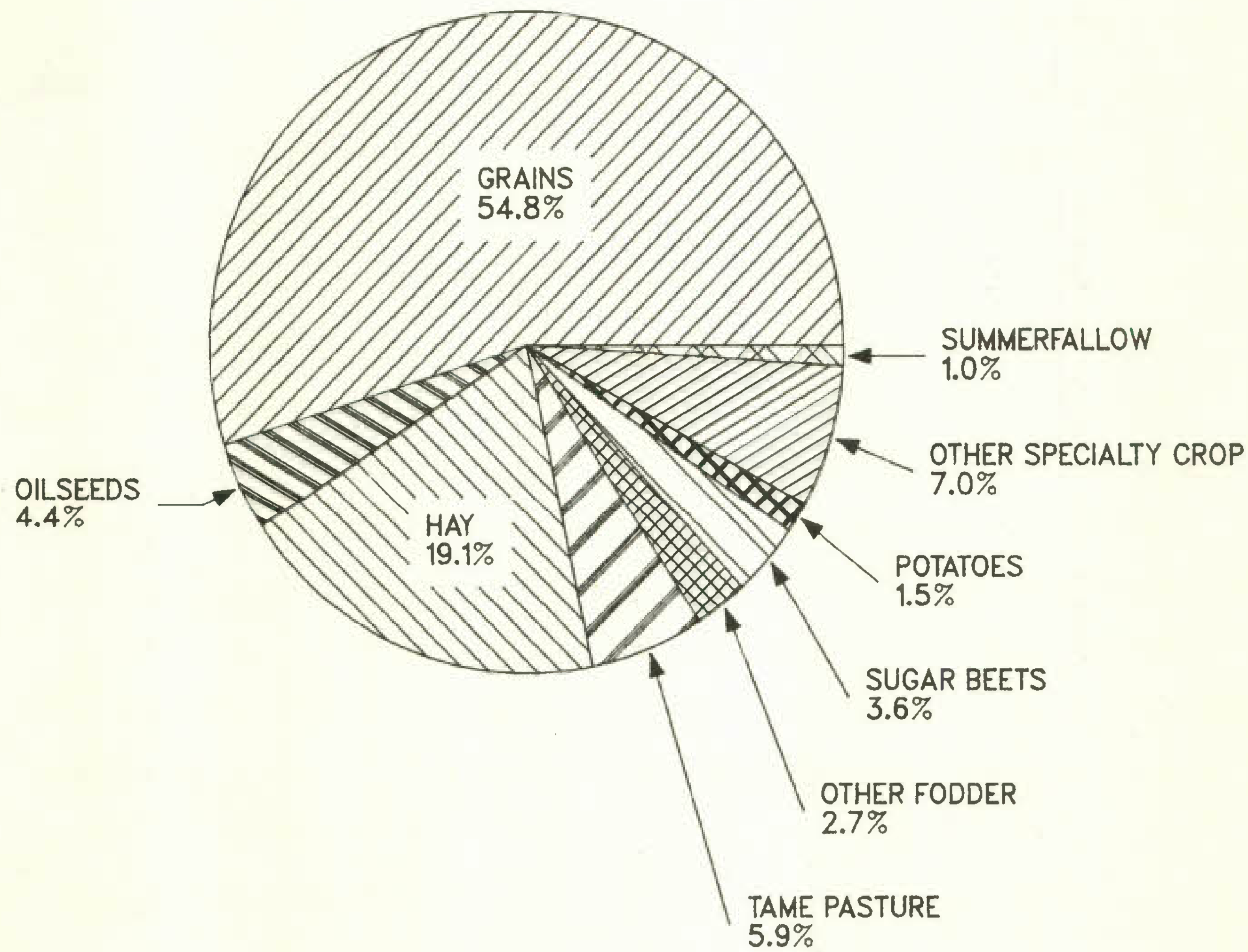
[6] Peas, canning corn, timothy, brome grass, alfalfa seed, sweet clover seed, small seeds, and miscellaneous crops.

Source: Alberta Agriculture, *Agriculture Statistics Yearbook 1982*, Table 11, p. 19.

Figure 5

# Irrigated Cropland in Alberta

1982




Source: Based on the 1982 data in Table 5 which is obtained from Alberta Agriculture, Agriculture Statistics Yearbook 1982.

(including grass seeds and specialty hay crops). The crop mix is not greatly different in the South Saskatchewan River Irrigation District No. 1 near Outlook, which is Saskatchewan's most intensive irrigation area. There, in 1982, some 65 percent of the irrigated land was in cereals (some 54.4 percent in traditional cereals and 10.4 percent in special cereals, particularly soft white wheat), 18 percent in grass and legumes, 13 percent in oilseeds, 2 percent in pulses, and only 2.3 percent in vegetables, chiefly potatoes (Saskatchewan Agriculture 1983). Even in the Okanagan Basin, where more intensive use of water is undertaken for fruit production, there has been little change in the amount of irrigated land since 1970 (Okanagan Basin Implementation Board 1982)--in part because of the continuing economic pressures on the Canadian fruit industry.

There is considerable scope, in physical terms and disregarding economic factors, for irrigation expansion on the prairies. In Alberta alone, irrigated acreage could be nearly doubled to about 2 million acres using internal basin supplies (which would necessitate further storage, particularly on the Oldman River). A further area of six million acres in the South Saskatchewan River Basin in southern and east-central Alberta is believed to be potentially irrigable[4] but would require imported (out-of-basin) water supplies (Underwood McLellan 1982). The major issue in irrigation expansion, however, is not that of physical feasibility but of economic feasibility and efficiency.

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[4]More detailed physical analysis, especially of soils, is needed to substantiate the six million acres figure.

In the first instance, it is difficult to avoid the conclusion that current irrigation systems in Western Canada, particularly in Alberta and Saskatchewan, are "under-utilized" in the sense that they are used rather extensively and for low valued crops.[5] Hence, prior to further expansion in irrigation, an initial priority should be to rehabilitate existing systems and to intensify cropping patterns within them. Secondly, doubts still remain about the relative economic merits of irrigation for traditional grain crops on the prairies and about irrigation expansion when grains and forage would inevitably dominate the prospective cropping mix. There are modestly optimistic prospects for the western grains and oilseed sector in the coming decade (Veeman and Veeman 1984). However, grains expansion from the dryland base, as opposed to the irrigation sector, would likely be more socially efficient and equitable. Additional grain production could likely be achieved more cheaply through the use of society's (private and public) resources for dryland production as compared to irrigation expansion. Moreover, the benefits from expanded dryland production would be far more widely distributed among prairie producers.

Irrigated agriculture on the prairies, given current and prospective crop mixes, is only a marginal economic investment in terms of social returns and costs. There are other goals of economic policy as well as efficiency--including enhanced stability, improved income distribution, and regional

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[5]Low valued in the sense of relatively low gross, and particularly net, returns per acre which, in turn, tends to be associated with low marginal values of water.

development. Nevertheless, it has been historically difficult to justify irrigation projects on the prairies[6] in terms of economic efficiency. The most recent and extensive studies of irrigation expansion on the prairies have focused on the Oldman Basin (Oldman River Study Management Committee 1978), including an economic study of irrigation expansion (Anderson 1978). Two conceptual problems in these studies cast doubt on the purported economic merits of development alternatives in the Oldman Basin, especially those associated with on-stream storage (that is, a dam on the Oldman River, for example, at the Three Rivers site). The first problem consists of the inclusion of secondary benefits in the efficiency analysis (Veeman 1978a; Gysi 1980) while the second problem involves the assumed zero opportunity costs of additional capital and labor which are required when converting from dryland to irrigated agriculture (Phillips, McMillan, and Veeman 1980). Adjustments for these two factors generate benefit-cost ratios for alternatives involving dams to be near, or somewhat less than, unity.[7] The economics of rehabilitation projects, off-stream storage in the Oldman Basin, and irrigation

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[6]This also tends to be the case for irrigation projects in the Great Plains area south of the border in the United States--see, for example, the Garrison study in North Dakota by Pfeiffer (1978), who found that federal agencies tended to overestimate project benefits and underestimate project costs. Revised benefit-cost ratios, properly calculated, ranged from 0.44 to 1 to 0.77 to 1.

[7]The case for the inclusion of secondary benefits on the benefit side, given a provincial accounting stance, is perhaps arguable within the context of recent economic conditions. However, the analyst must be convinced that the condition of less than fully employed labor and capital resources is chronic. Most economists (and indeed this is reflected in the thinking of the Treasury Board in Canada) are very reluctant to justify projects, at least in efficiency terms, on the basis of secondary benefits.

expansion where most of the major works are already in place (as in Saskatchewan) appear to be somewhat stronger than new projects involving on-stream storage.

In addition to raising concerns about economic efficiency, the proposals for increased on-stream storage on the Oldman River bring forth serious economic reservations about the likely impact of the planned irrigation expansion on income distribution. Given the relatively low water rates currently assessed on irrigated acreage, irrigation farmers would not likely meet the operation and maintenance costs associated with a proposed Oldman dam, nor contribute to the recovery of capital costs. Water resource projects are politically visible and prone to "distributive politics" (Howe 1979b)--involving the spreading of costs over taxpayers at large and the concentration of benefits within a localized group of beneficiaries. Water development projects such as the Oldman Dam would redistribute income from the non-agricultural sector to the agricultural sector--which may, or may not, be in the public interest, depending on one's views of the relative standard of living of farm families.

In the Oldman case, it appears likely that a proposed dam would adversely affect the personal distribution of income within agriculture (irrigation farm families being more affluent than other farm families in Alberta) and the regional distribution of income (census districts surrounding Lethbridge generally having above average income levels). At the moment, provincial policy in Alberta calls for no direct underwriting of the capital costs of new water projects or the rehabilitation of major structural works by either primary beneficiaries (irrigation farmers) or secondary beneficiaries. The latter group consists of backward-linked input supply firms, forward-linked processing firms, and the service sector in the irrigation community. Under these circumstances, irrigation expansion is clearly in the self-interest of individual farm families and of irrigation communities, even if such proposals may be questionable from the provincial point of view.

Public policy in Western Canada, particularly in Alberta and Saskatchewan, should be directed at improving and making better use of irrigation projects already in place. Special efforts must be made to widen the base for specialty crops which involve higher valued water uses, although there are formidable barriers for this to occur. The main specialty crop in Southern Alberta is sugar beets, a crop which has been relatively static in planted area during the last 25 years at some 30,000 to 35,000 acres. It is very unlikely that this acreage will increase because the highly concentrated sugar refining industry can obtain sugar more cheaply through imports in most years. The domestic market for vegetables in Western Canada is rather small and, with the exception of such products as potatoes and carrots, local production faces intense competition from imports. Given that demand for many specialty crops tends to be price inelastic, larger crops can often lead to reduced revenues for producers, unless there are export demand prospects. There are important ways, however, in which prairie grains expansion might help to strengthen the economics of irrigation on the prairies. In particular, there is the possibility that a higher proportion of the irrigated acreage might be devoted to soft white spring wheats, oilseeds, and corn--crops which may have higher net returns per acre.[8]

In addition to intensifying production patterns on existing irrigated land, the irrigation system currently in place in southern Alberta must be rehabilitated and irrigation efficiency considerably improved. Many of the older works are under-sized; canal branches often follow the contour of the land and are very prone to seepage; much water is wasted. The Government of Alberta has instituted a five-year program (1980-1985) to improve the irrigation system, with expenditures totalling $334 million allocated as follows (Cookson and Schmidt, 1980): $150 million for rebuilding and enlargement of the main irrigation canal and headworks systems; $74 million for the development of off-stream and internal storage; $10 million for works in east-central Alberta; and $100 million for the rehabilitation of the water distribution systems within the irrigation districts (the latter on an 86/14 percent cost share basis between the province and the districts). The Alberta government has also committed itself to building a dam on the Oldman River (estimated at a cost of $140

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[8]Soft white wheat, for example, is estimated to yield 85 bushels per acre in Alberta, generate a gross return of $333 per acre (assuming a price level of $144 per metric ton), and provide a net return (over cash and non-cash costs) to land and management of $104 per acre. Traditional red spring wheat grown under irrigation, on the other hand, is budgeted to yield 65 bushels per acre, generate a gross return of $269 per acre (assuming a higher price level of $152 per metric ton), and provide a net return to land and management of only $40 per acre. By way of comparison, the estimated net return for sugar beets (circa 1982) was $290 per acre, for alfalfa $157 per acre, and for potatoes $141 per acre (Couldwell 1983).

million in 1980) and must budget funds for the structure in the mid-1980s. The current stringent fiscal mood in the province and the much slower growth rate of the Alberta Heritage Savings Trust Fund, which would likely be the source of financing for the dam, may lead to considerable fiscal pressure for the postponement of the project until a later date.

As well as questions relating to irrigation, there are important improvements that should be made in land and water use on the Prairies under dryland conditions (Rennie, 1978). An improved dryland production strategy, which would both enhance production and conserve land and water resources, involves the reduction of summerfallow, the increased use of chemical fertilizer and lime, and the more efficient use of snow and water resources (Veeman 1980a). In essence, it is hoped that new approaches to snow trapping together with improved methods of dryland moisture conservation might generate the valuable extra inch or two of water which has historically been saved, very inefficiently, through the practice of summerfallowing. This strategy would also assist in combatting soil salinity, which is now suspected to affect about 10 percent of Saskatchewan's improved acreage and roughly 5 percent of total prairie acreage. As the past director-general of Agriculture Canada's western region research branch has suggested (Guitard 1982):

> "If we are to maximize Canada's crop production capability, particularly on the prairies where most of the land exists, we must realize that we cannot depend on irrigation which has a limited potential because of availability of water nor on summerfallow which is both moisture-use inefficient and destructive of our basic resource. Rather we must rely on production systems that

> are essentially devoid of summerfallow except for special purposes and that do not depend on the importation of water."

Much further research needs to be done, however, on the agronomic and economic details of dryland prairie production systems involving extended cropping rotations and less summerfallow.

## Industrial Related Uses of Water

Water uses in manufacturing, mining (including energy production), thermal power production, and hydroelectric generation are outlined and discussed in this section. Water is used by mining and manufacturing industries in Western Canada for processing, cooling, and waste discharge. These uses require sizable withdrawals of water, although the proportion actually consumed is quite small. However, a larger share of withdrawals is consumed in mining relative to manufacturing because of the water lost through deep well injection in the secondary recovery of oil.

There have been few studies of actual industrial water use in the major river basins in Western Canada. A background report prepared by MacLaren Engineers (1980) for the Canada West Foundation provides the most complete overview available of industrial water requirements in the region (although estimates of water withdrawals and consumption are not generated for the Okanagan basin). The data in MacLaren's study are based mainly on provincial water license information and questionnaire surveys that were conducted by the Federal and Alberta governments in 1972 and 1976. There were no studies on industrial water use prior to this period. Water license information poses problems in estimating water demand since license allocations do not properly reflect actual use patterns. In fact, there are plants which operate without licenses while some licenses allocate insufficient or excessive volumes of water relative to plant requirements. The results of questionnaire surveys may not represent the actual situation in those river basins where there are few plants or where a single large plant is the dominant industrial water user (MacLaren 1980, p. 25).

Industrial activity in the MacKenzie River drainage basin is primarily located in the Athabasca River and Peace River sub-basins. Water withdrawals in the Athabasca River sub-basin total 330,300 cubic metres per day ($m^3/d$), of which 242,000 $m^3/d$ is used by processing plants and oilsands extraction and processing operations. Approximately 91 percent of withdrawals is consumed by these facilities (MacLaren 1980, Table 4.1). The Syncrude plant at Fort McMurray withdraws a combination of surface water from the Athabasca River (roughly 146,000 $m^3/d$) and recirculated waste water from the tailing ponds (about 185,000 $m^3/d$) for processing. Suncor is allocated less than half the volume of water authorized to Syncrude (MacLaren 1980, p. 31). If the Alsands project is brought onstream, fresh water requirements three years after plant start-up, when recirculation will be instituted, may total 78,000 $m^3/d$ (CWF 1982, Table 81). Further development of the Athabasca Oil Sands will substantially increase withdrawals from the Athabasca River, with no return flow expected. It is predicted that water requirements could reach between 500,000 and 1 million $m^3/d$ should production in the Athabasca Oil Sands increase to 1 million barrels per day (CWF 1982, p. 379). The coal mining industry in the Athabasca River sub-basin withdraws 1,500 $m^3/d$ of water, of which almost half is consumed. The manufacturing of Kraft pulp, mainly in Hinton, consumes 4,000 $m^3/d$ of water, or 4.6 percent of withdrawals. In the Peace River sub-basin, both fresh water and recycled water are used by the forest products industry for the manufacturing process of Kraft pulp. About 82,000 $m^3/d$ of water is withdrawn and 20,100 $m^3/d$ of water is consumed for this purpose (MacLaren 1980, Table 4.1). The petroleum industry is the second most important user of water in the sub-basin, although requirements are only roughly 12,000 $m^3/d$, of which more than 80 percent is consumed (CWF 1982, p. 380). Shell Canada is currently investigating the potential recovery of oil in the Peace River Oil Sands. Any significant oil sands development could substantially affect water use in the region.

The Saskatchewan-Nelson Basin encompasses most of the central and southerly regions of Alberta, Saskatchewan and Manitoba. Approximately half of the total surface water withdrawals in this drainage basin for industrial purposes occur within the North Saskatchewan River sub-basin. The petroleum, coal and chemical products sector in the North Saskatchewan River sub-basin withdraws 75,000 $m^3/d$ of surface water, of which 46,000 $m^3/d$ is consumed. This high consumption rate may result from injection of industrial effluent into groundwater (MacLaren 1980, Table 5.1). The water using industries in this sector consist of two large petroleum refineries and several gas processing plants, together with chemical products manufacturers which produce fertilizer, ammonia, sulphuric acid, copper sulfate, herbicides, wood preservatives and antifreeze (MacLaren 1980, p. 36). The Cold Lake oil sands project, although pending for an indeterminant amount of time, could substantially affect water usage in the sub-basin since Esso Resources may be required to pump water from the North Saskatchewan River to its oil sands recovery plant site in the Churchill River basin. The output of the facility could potentially reach 22,200 $m^3/d$ of synthetic crude requiring 93,000 $m^3/d$ of water of which 57 percent would be consumed (CWF 1982, p. 366). The most important water withdrawals in the North Saskatchewan River sub-basin are made by the pulp and paper industry, which produces bleached Kraft pulp near Prince Albert, Saskatchewan. Although surface water withdrawals total 81,000 $m^3/d$, consumption in comparison is negligible (3,000 $m^3/d$). Water withdrawals for coal, salt and sodium sulphate mines total 25,100 $m^3/d$, of which 4,000 $m^3/d$ is consumed (MacLaren 1980, Table 5.1, p. 37).

The petroleum and chemical products industry is the most important industrial water user in the Red Deer River sub-basin. Withdrawals of water by the gas processing plants and the Alberta Gas Ethylene Plant in Joffre total 12,000 $m^3/d$ of which 600 $m^3/d$ is actually consumed (MacLaren 1980, Table 5.1). In the southern sub-basins it is anticipated that an increase will occur in the conjunctive use of groundwater and surface water by industry because of the less reliable surface flows (MacLaren 1980, p. 49).

Potash mining occurs in the South Saskatchewan River sub-basin and represents the only industrial water use in the Qu'Appelle River sub-basin. Lake Diefenbaker provides most of the water required by the 5 potash plants located in the former sub-basin (CWF 1982, p. 368). Surface and groundwater are used conjunctively for potash mining in the lower Qu'Appelle River sub-basin. However, about 6,500 $m^3/d$ of surface water is withdrawn and entirely consumed by one of the mines in this area (CWF 1982, Table 74). A potash mine near Regina is entitled to consume 10,000 $m^3/d$ of surface water (CWF 1982, p. 369). Some potash mining activity is anticipated to begin in Manitoba in the Assiniboine River sub-basin.

Water is entirely consumed in the secondary recovery of oil in Alberta and Saskatchewan since it is injected into formation. Oil field injection figures are presented separately from other industrial uses because Alberta issues licenses for this purpose in perpetuity and it is not possible to tell from the licenses which oil fields are actually in production (MacLaren 1980, p. 56). When water is not used, the license is not cancelled as long as the company retains the lease. About 80 percent of the water used for oil field injection in Alberta is surface water, the remainder being groundwater (MacLaren 1980, p. 56). Consumption peaked at 88,657 $m^3/d$ in 1974 and then fell steadily to 53,687 $m^3/d$ in 1982, the lowest level since 1969 (Alberta Environment 1983, Table A). This significant decline may be attributed to the use of other methods for the secondary recovery of oil, such as gas injection. Water use for secondary oil recovery may increase substantially in the future if steam injection schemes became commercially viable (Alberta Environment 1983, p. A1). The Athabasca River sub-basin consumes the most water for oil field injection, followed by the North Saskatchewan River and the Peace River sub-basins. Only groundwater is licensed for oil field injection in Saskatchewan. In 1980, 81,000 $m^3/d$ of water was licensed for this purpose, although actual use was likely somewhat less (CWF 1982, p. 373). There is only one license for oil field injection in Manitoba.

Water withdrawals are not permitted for industrial use in the Milk River sub-basin, located in the Alberta area of the Missouri drainage basin. Industry is not likely to expand into this extremely dry area, except perhaps for the purpose of producing sodium sulphate (MacLaren 1980, p. 52). There is potential for an increase in uranium mining activity in the Churchill drainage basin. Further development of this industry will only affect the quantity of water withdrawals since consumptive use is virtually zero (MacLaren 1980, p. 53). The Cold Lake Oil Sands project would be located in the Churchill drainage basin. Water withdrawals could possibly come from local surface waters, although they will more likely originate from the North Saskatchewan River. Regardless of the source of water withdrawals for the project, treated wastewater will likely be discharged into the Churchill drainage system (CWF 1982, p. 375).

Water withdrawals are substantial for thermal power production, although consumptive use is very low. Thermal plants require water consumptively as a process input for the production of steam but the major use is for cooling. Water discharged from thermal plants is in a heated condition and thus raises water temperatures, which in turn reduces the amount of dissolved oxygen and the absorptive capacity of water bodies. Greater recirculation rates, which may be attributed mainly to the substitution of cooling ponds for once-through cooling methods in many plants, have contributed to the steady decline over the past decade in water withdrawals for thermal power generation (Alberta Environment 1983, p. 41). However, the consumptive use of water has grown larger since improved cooling methods involve increased evaporation. In 1980, 10,943 $m^3/d$ of water was withdrawn for thermal power generation in Saskatchewan (Kulshreshtha 1983, Table 1). The rated capacity of the 5 thermal plants was 1,688 megawatts (MW). These plants generated about 80 percent of electric energy during that year (CWF 1982, Table 87). Water withdrawals and recirculation in the thermal power generation sector in Alberta, which totalled 2,807,377 $m^3/d$ and 3,087,589 $m^3/d$ respectively in 1981, significantly exceed the rates achieved in the petroleum and natural gas and manufacturing sectors. Gross water use was 5,894,926 $m^3/d$ in 1981, of which 77,405 $m^3/d$ was consumed. This represents the lowest consumption rate of the three sectors (Alberta Environment 1983, pp. 26-27). Thermal power generation activity is located mainly in the North Saskatchewan River sub-basin in Alberta, which accounted for 94 percent of total withdrawals by the industry and 92 percent of consumption in 1981. Production occurs on a minor scale in the South Saskatchewan River and Peace River sub-basins (Alberta Environment 1983, Table 7). Thermal power production in Manitoba is used only to meet peak load demands and during low flow years when hydroelectric power generation is insufficient to meet electric energy demand. In 1980, the two thermal plants in this province supplied only 0.5 percent of total electricity (CWF

1982, p. 396). There are no thermal power plants in the Peace River and Liard River sub-basins in British Columbia.

Hydroelectric power generation is an instream water use since it involves harnessing the power of flowing water to drive turbines (CWF, p. 298). Only very small quantities of water are consumed in the production process, through evaporation from reservoirs. However, hydro developments affect other water users by regulating streamflow (Environment Canada 1983, p. 89).

There are currently 3 hydroelectric power plants in Saskatchewan, located on the Churchill, South Saskatchewan and Saskatchewan Rivers. The average electric power generated by these plants is 290 MW, although installed capacity totals 560 MW (CWF 1982, Table 85). Future capacity will likely be developed on the Saskatchewan River.

In recent years, thermal power generation has become more important than hydroelectric power generation in Alberta, the latter being relegated to the role of supplying peaking power (Laycock 1979, p. 5). Alberta has 13 hydroelectric power plants, located on the Bow and North Saskatchewan Rivers. The installed capacity totals 790 MW, although the average power used is only 210 MW (CWF 1982, Table 85). In the short run, it is anticipated that increased demand for electric power will be met in Alberta by additional coal-fired power plants. However, it is not as clear in the longer run whether net benefits would be greater for further thermal power development or hydroelectric power development. Potential sites for large hydroelectric projects exist on both the Peace River, where average power production could total 2,970 MW, and the Slave River, where average power generation could reach 1,120 MW (CWF 1982, Table 85).[9]

Manitoba currently has 12 hydroelectric power plants in operation, with a total capacity of 3,630 MW and an average production of 2,400 MW (CWF 1982, Table 85). There is currently a surplus of electric energy supply in this province and at forecast growth rates of demand, additional electric power generation will not be required before the mid-1990s. When more hydroelectric power generation is needed, development will likely occur on the Nelson River or on the Churchill Diversion route (CWF 1982, p. 391).

Considerable hydroelectric power production in Western Canada occurs in the Peace River sub-basin in British Columbia. There are currently two plants in operation in this area which benefit from the Williston Lake reservoir formed behind the Bennett Dam (CWF 1982, p. 401). Installed capacity totals 3,100 MW whereas average power generation totals 1,880 MW (CWF 1982, Table 85). Hence, there is currently a surplus of power production in British Columbia. The annual growth in electric energy demand is predicted to be only 3.9 percent for the next 11 years compared to a growth rate of 4.5 percent for the preceding 11 years (Sigurdson 1983). Prospects in the short-run for selling electric power to the U.S., as was previously done on a limited scale, are not promising. No major additions to the hydroelectric power system, beyond a few smaller projects to be brought onstream by 1986, are forseen in the short term (Sigurdson 1983).

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[9] Installed capacity for the latter project would be in the order of 1700 to 2000 MW (Alberta Environment 1982, p. 1).

However, if demand conditions should change, further major hydroelectric developments would likely occur on the Peace and Liard Rivers, which together could generate an additional 5,660 MW of power on average (CWF 1982, Table 85).

## The Role of Water in Regional Economic Development

In this section, the role of water in facilitating or restraining economic growth in Western Canada is examined. Historically, water, particularly as a mode of transportation, was reasonably important in determining the pattern of economic development in Western Canada. Today, in the 1980s, the availability of water, given existing supplies in various basins, would appear to be neither a necessary nor a sufficient condition for regional economic development, with the probable exception of the areal expansion of irrigated agriculture. Furthermore, the availability of water is not a major factor in an industry's macro-location decisions (such as whether it should locate operations in Western Canada or a specific province), but can be more important in micro-location decisions (such as the choice of site within a province or within a specific locale).

It is true that certain volumes of water are needed to sustain both population and economic growth in any region. However, water allocated for domestic and municipal consumptive purposes generally tends to be a relatively small proportion of total water use. It is thus untrue that economic growth will be choked off if water is unavailable in large quantities (Erlenkotter *et al* 1979). Howe, in one of the pioneering studies (1968) of the role of water in regional economic development in the United States, concluded that water did not constitute an over-riding bottleneck to rapid economic growth in the water deficit regions, nor did its presence in large quantities in other regions ensure rapid growth. Although water is an essential input for all types of economic activity, it can be transported, conserved, recycled, reused, and reallocated at sufficiently low cost. Hence, the abundance of water in the natural environment is not a necessary condition for the occurrence of most types of economic activity (Howe 1968, p. 488).

More recently, two excellent studies (Kelso, Martin, and Mack 1973; Kneese and Brown 1981) of the relationship between water supply and economic growth in the arid south-western region of the United States, an area under more stress than Western Canada, also conclude that water need not be a constraint to economic growth. After assessing the situation in Arizona, Kelso, Martin, and Mack (1973, p. 256) reach the following conclusion:

> "Water supplies in the state are adequate for continuous growth of the state's economy. What are needed are policy actions to facilitate changing structure of the state's economy and the transferability of water among uses and locations of use. Currently, the water problem is a management, an institutional, a policy problem--a problem of demands for water more than one of supplies--a problem of man-made rather than of nature-made restraints."

In a wider study of the four states of Arizona, Utah, Colorado, and New Mexico, Kneese and Brown (1981, p. 64) reach a similar viewpoint:

> "In accepting the limited nature of the region's water supplies, however, acceptance of the apparent but untrue corollary that limited water places an absolute limit on development within the region must be avoided. Any rigid, immutable barriers within the region created by limited water are more a construction of human beings than they are a matter of physical reality. In particular, it is the human institutions that prevent in the state of Arizona and elsewhere the transfer of water from agricultural uses into other, more highly valued uses. Also it is social insistence on artificially low prices for municipal water that creates the apparent rigid barriers to residential or other development in many of the urban areas of the region."

Historically, the choice of industrial location for the mining, manufacturing, and thermal power sectors in Western Canada has been based on factors other than the availability of water. Although some have contended that industrial expansion in the semi-arid southern basins in the prairies could be constrained by water shortages in the future, this should not, and need not, occur. In the first instance, a substantial increase in industrial activity would require only limited additional water supplies relative to current irrigation usage. The major key to future industrial water use in semi-arid areas, however, lies with increased recirculation and reuse of water (Tate and Reynolds 1983). In industry, water costs are a relatively small proportion of total costs, even in such water-intensive industries as pulp and paper, primary metals, sugar beet processing, thermal electric generation, and steel (Bower 1966). At the Interprovincial Steel Company (IPSCO) plant in Regina, for example, water costs are only 0.25 percent of total production costs (Tulloch 1983). Technological change with respect to both recirculation and reuse have made industry much less dependent on abundant water supplies. Tate and Reynolds (1983, p. 10) cite that the average gross water use in steel production in Canada is approximately 65,000 gallons per ton (with water intake roughly half this volume); yet, at a Kaiser plant in California, the average gross water use is only 1,600 gallons per ton.

Rational water pricing structures are one means by which water withdrawals could be reduced in water-short regions. In fact, it has been demonstrated that industrial water in most uses is quite responsive to price. Thus, higher prices for water would provide the incentive for industrial plants to increase recirculation and use water more efficiently in order to reduce withdrawals (Tate and Reynolds 1983, pp. 11-12). On the other hand, water demand is very price inelastic in those industries where water is required mainly for cleaning and sanitary purposes (Kulshreshtha, 1983, p. 14). Effluent charges for pollution control could also be an effective policy instrument in promoting both water recirculation and improved water quality in water-short regions.

In general, the availability of water, beyond some minimal amount, has a very low order of impact on industrial location decisions (Kneese 1965; Howe 1968; Erlenkotter *et al* 1979). Economic development in Western Canada is far more conditioned by other factors: the ability of the region to develop a comparative advantage in the production of goods and services for the regional market, the Canadian market, and international markets; transportation factors; the availability of capital, labor, and entrepreneurial talent; and many other factors unrelated to water (Erlenkotter *et al* 1979). While the availability of water is not a major determinant of industrial macro-location decisions, it can be a more important determinant of micro-location decisions. There are clearly water-related constraints to the development of thermal power plants in the eastern region of Saskatchewan or in east-central Alberta. Similarly, the proposed heavy oil developments near Cold Lake or near Lloydminster in the Battle

River region may be forced to rely on water which is piped from the North Saskatchewan River. Most tar sands development, fortunately, is located near the Athabasca River, a relatively abundant source of water. The major policy concern in this area is water quality (possible pollution of the Athabasca River from tailing pond effluent or leakage) rather than water quantity. The future gasification or liquefaction of coal may have to be directed to water basins where water supplies are more abundant. However, as a general rule, the availability of water is not a major factor in determining the pace, or even the location, of economic development in Western Canada.

Furthermore, as the western regional economy undergoes structural change, the service sectors are likely to provide a higher proportion of the GDP of the region and may well become potential growth industries for the western economy. Since the service sectors are generally not major industrial water users, considerable growth in this area in Western Canada can likely be accommodated with only very limited pressures on industrial water supplies.

A final point of interest is the role of water in "diversification" of the regional economy or in so-called "balanced economic development." These terms have several connotations (Drugge and Veeman 1980; Plain 1981). As has been discussed, it is doubtful whether water plays a major role in determining either industrial structure or macro-location decisions made by industry. However, water and water projects may be important vehicles through which the regional distribution of income and wealth within provinces may be altered. In addition, the availability of water certainly plays a role in the scope for expansion of irrigated agriculture. There are serious concerns in both regards. Water and water projects are typically a clumsy policy tool for redistributing either regional or personal income or wealth. Secondly, the economic merits of irrigation expansion remain in considerable doubt. In short, there are currently few convincing arguments, in terms of either efficiency or equity, which warrant the use of water and water projects as a major policy instrument for either broadening the regional economic base or rectifying imbalances in regional economic activity within provinces.

## Interbasin Water Transfers and Water Export

Since the 1960s, the transfer of water across basins in Western Canada and across the border into the United States has been proposed, typically by water resource engineers, as a possible solution to the alleged water scarcity problems of western North America. The most publicized and grandiose scheme, the North American Water and Power Alliance (NAWAPA) proposal, was put forward initially in 1963 (Foster and Sewell 1981, p. 30). It envisaged the transfer southward of over one hundred million cubic decametres of water per year from Western Canada, Alaska, and the Pacific Northwest to the American Southwest, chiefly to the Lower Colorado basin and the High Plains. Social scientists, especially economists, have tended to be highly skeptical of such schemes. In fact, no detailed study of the benefits and costs of such proposals involving Western Canadian water has yet been undertaken since intercontinental transfers have not been seriously embraced by either the American or Canadian government.

Canada already engages in considerable interbasin transfer of water, although virtually all of this diversion is for hydro power production. The most significant interbasin transfer in Western Canada is the Churchill diversion in Manitoba from the Churchill River to the Nelson River for hydro power purposes. Water is also transferred in southern Alberta as irrigation water originally diverted from the Bow River is used outside the Bow basin and return flows eventually flow into the Oldman and Red Deer Rivers. In Saskatchewan, small flows are transferred from the South Saskatchewan River to the Qu'Appelle, largely for purposes of municipal water supply and improvement of water quality. Further details of existing and potential interbasin transfers within Western Canada and of the various private proposals for international water transfer are outlined in Canada West Foundation (1982), Laycock (1983), and Quinn (1977b). Not only are there examples of interbasin water transfer within Western Canada but there are also instances, albeit very minor, of water export and cases of hydro power export (as under the Columbia River Treaty) to the United States.

In Alberta, the provincial government has expressly disavowed any intent of water export. Water would be transferred between northern and southern basins of the province solely for the purpose of irrigation and economic development within Alberta or, perhaps, within the prairie region. Engineering plans for interbasin water transfer in the prairie region were initially outlined in the Prairie Rivers Improvement, Management and Evaluation (PRIME) program in Alberta (Alberta Department of Agriculture 1969) and in the work of the Saskatchewan Nelson Basin Board (1972) on possible storage and transfer options. With the election of the Conservative government in Alberta in 1971, the PRIME program was shelved for the rest of the decade.

Political interest in interbasin transfer was revived in late 1979 when Mr. Henry Kroeger, then Minister of Transportation in the Alberta Cabinet and now Chairman of the Alberta Water Resources Commission, formed an Advisory Committee on Water to study the question of water transfer. The general thrust of this

Committee's report, leaked initially in the Alberta Legislative Assembly in late 1981, was that 22 million cubic decametres of water could be transferred from the Peace River to irrigate a further six million acres in southern and east-central Alberta (Alberta *Hansard* 1981; Laycock 1981). The underlying rationale put forward to support such interbasin transfer rested on: (1) the alleged need to alleviate the world food problem; (2) the presumption that some of Alberta's water (without further storage and transfer) was being "wasted"; (3) the desire to convert the accumulating petroleum resource rents in the Alberta Heritage Savings Trust Fund into investment in Alberta's renewable resources; and (4) the view, largely misconceived, that water transfer was needed to assure future provincial economic growth and, in particular, to "make the deserts bloom." No attempt was made by the Committee to give a preliminary indication of the potential economic and environmental costs and benefits of massive transfers from the southern tributaries of the Mackenzie system.

To date, the Government of Alberta has not officially endorsed interbasin water transfer. Stated policy objectives focus on the need to utilize fully water within individual basins before turning to the possibility of importing water from northern basins. Further research is being conducted on the physical desirability of further irrigation in various regions in southern Alberta as well as on the scope for drainage in northern Alberta. The political and economic climate in Alberta in 1983 and 1984 is much less conducive to the possibility of massive expenditure on interbasin water transfers than was the mood prevailing at the end of the provincial boom in 1980 and 1981. It is possible that the Alberta government might consider one or two relatively low cost transfer options. For example, water could be transferred from the Clearwater River, a tributary of the North Saskatchewan River, to the Red Deer River Basin at relatively low cost, although special efforts would have to be taken to avoid adverse impacts on trout fishing in west-central Alberta (Gregg 1983). Despite the prevailing mood of fiscal restraint, the Alberta government announced in August, 1984 that it would proceed with the Three Rivers Dam on the Oldman River--partly in response to the adverse drought conditions in southern Alberta during the summer of 1984. The prospects of funding major interbasin transfers of water within Alberta during the next decade or two, however, appear very unlikely. In fact, prior to any serious consideration of major water transfers, attention will likely be centered on the question of further storage on the Bow River.

There are several economic characteristics or issues associated with interbasin water transfers that must be recognized (Howe 1979a, Fisher 1979, and Howe and Easter 1971). Interbasin transfers typically involve very large economic costs, probable environmental costs, and rather inadequate benefit streams. Such transfer proposals are typically capital-intensive and involve large transport costs per unit of water (Castle 1983). Most transfer schemes are also energy-intensive because of their large pumping and tunnelling requirements. With rising energy costs in the last decade, the economics of major interbasin transfers became even less attractive. However, where power recovery is possible, interbasin transfer becomes more viable. Finally, interbasin water transfers involve critical questions concerning timing. Indeed, there may be advantages to delaying huge, costly projects if cheaper alternative sources of water can be used in the meantime or if it is possible that better information about environmental effects may become available.

Interbasin water transfers (including international transfers involving water export) can be assessed, from an economic point of view, in terms of the standard economic criteria of efficiency and equity. In benefit-cost terms, following the work of Howe and Easter (1971) and Fisher (1979), an interbasin transfer is economically feasible if its benefits exceed its costs:

$$[DB(M)+SB(M)]+[DB(T)+SB(T)] > [DC(X)+SC(X)]+SC(C)+TC+EC \quad (1)$$

where DB is the direct benefit from the water, DC is the direct cost (of foregone water), SB and SC are secondary benefits and costs (if they can be legitimately included), TC is the cost of the water transfer system, and EC is the environmental cost of the transfer (assuming that these environmental costs have not been already included in TC). The letters in brackets are:

M = region importing water (or the area of water destination),

X = region exporting water (or the area of water origin),

T = region through which water is transferred, and

C = region whose output is competitive with M.

Inequality (1) merely states that the direct and secondary benefits, to importing and transfer regions, must exceed the direct and secondary costs, to exporting and competitive regions, plus the cost of the water transfer facilities and any environmental costs of the project (Fisher 1979, p. 138 and p. 142).

To be economically efficient, the costs of an interbasin water transfer project should be less than the costs of the best alternative for resolving the water problem. Ideally, public expenditure on water transfer should provide rates of return which are at least as high as alternative uses of scarce public investment funds. From the preliminary evidence at hand, there are grave reservations about the economic feasibility and efficiency of prospective interbasin transfers on a major scale, either within Western Canada or between Canada and the United States, at least within the foreseeable future. Major interbasin transfers within western North America must be justified primarily in terms of irrigated agriculture, the sector which dominates the consumptive use of water but whose marginal value of additional water is relatively low. In southern Alberta, for example, where projects involving on-stream storage of waters internal to the Oldman Basin are just on the margin of economic feasibility, it is hard to escape the conclusion that more costly transfers of water from the main stems of the Athabasca and Peace River into south and east-central Alberta would fall short of the criterion of economic feasibility.

The strongest empirical evidence on the economics of interbasin transfers comes from American study of the possibility of water importation from the Mississippi and Missouri Rivers into the Ogallala-High Plains region (eastern Colorado, western Kansas, Nebraska, eastern New Mexico, north-western Oklahoma, and western Texas), a region where the underlying groundwater aquifer is being depleted and major reversions from irrigated acreage to dryland agriculture may occur (Frederick and Hanson 1982, Beattie 1981, and Lansford *et al* 1983). Water importation into the High Plains of Texas, for example, would require a canal about 860 miles long and would have 30 pumping plants to lift the water 2,700 feet along the route. The costs of importing water into the High Plains dwarf any reasonable expectation regarding irrigation water returns (Beattie 1981, p. 294). They range from $352 to $880 an acre-foot (in 1977 U.S. dollars), not including any environmental costs or any cost allowance for getting water from terminal storage positions to the farms--see Table 6. As Beattie (1981, p. 298) concludes: "Clearly, from the point of view of the U.S. as a whole, massive investment to augment the declining Ogallala is not economically efficient--not now or in the foreseeable future." A recent New Mexico Study (Lansford *et al* 1983) also reaches the conclusion that water importation does not appear to be a viable policy alternative and that voluntary water conservation by farmers would be the preferred alternative.

Major interbasin water transfers appear even more inefficient when their impacts on the environment are taken into account. Admittedly, some transfers on the prairies could involve

**Table 6. Agricultural Marginal Water Value and Import Cost Per Acre-Foot, 1977 Dollars, American High Plains Region**

| Subregion | Agricultural MVP | Import Cost |
|---|---|---|
| Northern Ogallala | 44.17 | 360-410 |
| Central Ogallala | 44.42 | 352-880 |
| Southern Ogallala | 19.67 | 482-745 |

Source: Beattie 1981, p. 296.

the generation of environmental benefits, particularly in river basins such as the Battle or Souris which are characterized by periods of very low flows. On the whole, however, these improvements would appear to be greatly out-weighed by the prospective environmental costs of transfer, which range from adverse impacts on ecosystems to possible change of climate. In the Canadian context, the concern is that environmental damage arising from any intercontinental transfer scheme might be especially serious in Northern Canada.

In terms of equity impacts, interbasin water transfer typically involves a major redistribution of income to the region receiving the water (Castle 1983; Beattie 1981). This is particularly the case in both Canada and the United States where taxpayers at large might be expected to underwrite most, if not all, of the costs of transfer projects; and beneficiaries--such as farmers who receive primary benefits or firms which benefit from increased irrigation activity--might make little or no contribution to capital costs. Thus, water projects desired at the local or regional level may not necessarily be in the wider public interest (when using a national or provincial/state accounting stance). Under these circumstances, "water often becomes a convenient political tool for doing something for one's constituents" (Castle 1983, p. 10).

In nearly every case, areas of water origin oppose interbasin water transfer (Quinn 1973), perhaps more so for political than economic reasons. In addition to impacts on the regional distribution of income, interbasin water transfers may have impacts on the personal or size distribution of income; as suggested previously, these impacts are likely to be regressive in the case of massive transfers of water into southern Alberta.

At present, Canada has not formulated a definitive water export policy[10] and is in a weak position to assess the merits of international water transfer. However, Canada should develop economic perspectives on water export. There is no easy or categorical "yes" or "no" answer which can be given to the question of whether Canada should export water. The answer depends on the circumstances, scale, and relative benefits and costs (as well as their incidence) of the specific case in mind. It is certainly possible to envisage situations in which it might be economically viable and mutually beneficial to move water short distances across the border, particularly to service municipal or industrial needs in areas adjacent to the border. Major international transfers over long distances appear much more dubious.

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[10]It could be argued that the implicit policy in place during the past two decades has been a negative stance toward water export.

There are several aspects to consider in developing a more rational water export policy. First, a sensible balance has to be struck between those who view water as being, in principle and for nationalistic and/or environmental reasons, an item not to be traded and those who see water only in terms of its consumptive uses, ignoring its role in terms of ecological and instream uses. Neither polar position is tenable. Most economists recognize that water is a resource commodity which, under some circumstances, can be priced, marketed, and traded like other commodities, despite its particular characteristics which greatly affect its development and allocation (Gray 1983). In principle, water is a candidate for export on condition that there truly exists water surplus to the immediate and future needs of Canadians (including requirements for ecological and other instream uses); the export sale of water can generate substantive net benefits to Canada; the income distributional consequences of water export (for example, the incidence of substantial economic or environmental costs on northern or western people) are not unduly adverse; and the decision to export water could be reversed at some future date. In reality, there are serious concerns with each of these provisos and the prospects for water as a staple resource export in the remainder of this century are extremely weak.

Currently, Canada is in a poor position to determine whether there is indeed water which is surplus to immediate and future Canadian needs. The most deficient area of knowledge relates to the instream uses of water. In particular, we know little about the ecological needs for water in the Mackenzie system and yet it is from the southern tributaries of the Mackenzie (such as the Peace, Athabasca, and Liard) that Western Canadian water for export might be diverted. Even with study, the amount of water needed for ecological and other instream uses is apt to remain uncertain and subject to debate and controversy. It is interesting to note, however, that the Pacific North-West region of the United States--another potential donor region to the dry South-West--is calculated to have some water which is surplus to both consumptive and instream uses at the moment and also to the year 2000 (Howe 1980, Table 1). It is certainly possible that a more complete assessment of Canadian current and future water demands might also show the existence of potential "surpluses" in Western and Northern Canada.

Even if it could be shown that Western and Northern Canada had water surplus to their needs (and this is by no means evident), water export is most unlikely. Indeed, as outlined previously, the economics of water transfer appear extremely poor when water is transferred over long distances (and, at times, uphill) to serve mainly agricultural uses. Many infeasible western water projects have been authorized and funded in the past in the United States when political lobbying for water over-rode economic arguments. It is sometimes argued that the possibility of immense political and legal difficulties and costs of re-allocating water from low-valued agricultural use might lead to political solutions favouring water importation. However, there appears to be a growing realization in the western United States--certainly evidenced in the writings of academics--that the thorny questions of altering water institutions to facilitate water re-allocation out of low-valued agricultural use to other emerging uses must be tackled. (Given that 88 percent of consumptive use of western waters is currently in agriculture, the transfer of even 10 percent of agricultural use to other uses would involve significant quantities of water.) Moreover, there is increasing recognition in the American South-West that semi-arid areas will have to adapt to existing water supplies with little, if any, possibility of high-cost water importation (Kelso, Martin, and Mack 1973; Kneese and Brown 1981).

Even if economic arguments could be marshalled for water export, there would be substantial political opposition in Canada to such a possibility.[11] Further economic concerns in any water export policy would involve the degree of compensation for Canadian water and the conditions, if any, for discontinuing export sales. Although there is a strong likelihood that people in zones exporting water might exaggerate the degree to which loss of water would impede future economic development in their area, a realistic water export policy would have to recognize and provide for the anticipated future needs of the donor region. Any export price for water should entail an intrinsic opportunity cost value for the water itself and not merely be based on delivery costs. Canadians are apt to be skeptical, too, about

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[11] A further complicating political factor is that Western Canadians are apt to oppose moves by the federal government to trade (Western) Canadian water for access to United States markets for goods from Central Canada (see Thompson 1983), but might be more supportive if the *quid pro quo* involved access to American markets for Western Canadian exports of natural gas, petrochemicals, red meats, or forest products.

water export to the United States if the United States has not seriously considered water importation from the Columbia River or the Mississippi-Missouri systems to the American South-West.

In short, neither massive interbasin transfers within Western Canada nor major transfers of water to the United States appear at all likely in the foreseeable future. There may be limited scope for a few modest and small-scale transfers, either internal in Western Canada or across the border, where these prove feasible--more likely in circumstances involving higher-valued urban, industrial, or recreational use. At the moment, the Western Canadian hydro power sector, at least in Manitoba and British Columbia, is suffering from excess capacity and the possibility of power export sales to the United States, despite announcement of a sale by Manitoba south of the border, appears rather limited in the short and medium term.

## Water Policy

The water resources of Western Canada could be managed more effectively if policy changes or initiatives were implemented in five important areas: (1) the formulation of a national, and thence a western, strategy for water; (2) the increased use of prices, charges, and other economic incentives as demand management tools for many private uses of water by irrigators, firms, and households; (3) the reform of provincial water rights to facilitate greater flexibility in the reallocation of water to higher-valued uses in the future; (4) increased attention to the protection and enhancement of the instream uses of water and overall water quality; and (5) the development or modification of water institutions and organizations at levels ranging from the local to the international.

### *Toward A Western Water Policy*

Serious efforts must be undertaken to develop a water strategy and policy for Western Canada which, in turn, must be part of a wider national policy for water. Canada has never had a definitive water policy statement. Furthermore, it must be recognized that it is difficult to formulate any once-and-for-all policy. Still, every decade or two, it is useful for any nation to assess its water resources, attempt to forecast future demands, and analyze the problems and policy issues which are arising. For example, the National Water Commission which reported in the United States in 1973 was charged to tell the nation "what it has done right, what it has done wrong, and what it is not doing that it should be doing" (Quinn 1977a). Australia has just completed a major assessment of its water resources and water issues to the year 2000 (Australia, Department of Resources and Energy 1983). Canada, too, needs a *Water 2000* study.[12]

The concerns and difficulties in outlining and implementing a national water policy are ably discussed by Foster and Sewell (1981) and Quinn (1977a). Although the federal government must take a more assertive leadership role in such an undertaking, the successful development of a national policy for water would entail considerable federal/provincial co-operation. Jurisdiction over water is divided. The provinces hold considerable power through their ownership of water resources and consequent legislative authority. On the other hand, the federal government has legislative authority, originally via the British North America Act of 1867 and now by the Constitution Act of 1982, in such spheres as fisheries, navigation, and the regulation of interprovincial and international trade. The final recommendations of the Inquiry on Federal Water Policy may serve as a starting point for discussion towards a national water policy.[13] A possible mechanism for future study of Canada's water resources and water policy could involve a National Water Commission, established under federal auspices but involving

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[12]Since this section of the paper was originally written, the Government of Canada, through Environment Canada, has launched an Inquiry on Federal Water Policy chaired by Peter H. Pearse which is due to report by August, 1985--see Inquiry (1984).

[13]However, the terms of reference of the independent inquiry are confined to the examination of emerging water issues that fall within federal jurisdiction, including interjurisdictional dimensions; identification of available water supplies and future requirements; and assessment of the extent and direction of water research that should be undertaken and supported by the federal government.

significant provincial input.

Whether one is dealing with water policy at the national or Western Canadian level, that policy must be firmly embedded in a wider strategy for economic development. While much current planning for water on a river basin level has brought some improvements, such strategy suffers if it is divorced from agricultural, irrigation, energy development, and industrial strategies. For example, future increases in consumptive use of water in Western Canada are particularly dependent on the pace of irrigation expansion and energy development. As such, water policy cannot be separated from wider strategies relating to agricultural development (including the respective roles to be played by dryland and irrigated agriculture) or relating to energy development (for example, the pace of tar sands and heavy oil development, the role of hydro-power and hydro-power exports, and the "needs" for water for thermal cooling). It is also important that policy for water be carefully integrated with land use planning.

It is imperative that a more comprehensive strategy for water be developed at the national and thence at the regional level in Canada. It is too simplistic to argue that we face impending water quantity and quality crises or even that water issues will be to the 1980s and 1990s what energy issues were to the 1970s. Nonetheless, there are many emerging challenges in water resource management and policy. Moreover, we have been reacting to water proposals or initiatives heretofore on a piece-meal basis (the current debate over the Slave River Dam being a case in point) without a sufficiently clear and wide perspective of water policy as a whole.

*Water Pricing*

In view of the relatively high and rising costs of augmenting water supplies in Western Canada, more attention should be given to demand management and water conservation measures, which are apt to be the least-cost options in future water management strategy. It is widely recognized that water can no longer be treated as a free good and that more effective charging or pricing mechanisms must be instituted for many of the private (and partially consumptive) uses found on the farm, in the firm, or in the household. It must be stressed that more effective pricing of water is only part of an overall management strategy for water. Indeed, it is naive to think that market solutions would be a panacea for all water problems.

Changing water charging practices could be an effective policy instrument in constraining the demand for water in irrigated agriculture, industrial use, and residential use. For example, many households in Calgary which lack water metering and face a flat rate charge for water are alleged to use some 40 percent more water than corresponding households in Edmonton (although a complicating factor is that there is suspected to be more leakage in the Calgary delivery system). A similar situation exists in Saskatchewan, with Regina residents using more water than residents in Saskatoon. In irrigation districts in southern Alberta, irrigation water is not volumetrically measured or metered and irrigators presently pay a flat rate of about $10 per acre. The benefits and costs of shifting to volumetric measurement of irrigation water and charging on the basis of per unit volume used should be assessed.

A distinction can be drawn between demand management (using rising water prices to reduce quantity demanded along a given demand curve) and conservation measures (which shift the position of the demand curve for water). A critical dimension of demand management is the responsiveness of quantity demanded to small changes in price--the familiar economic concept of the price elasticity of demand for water. Prior to 1970, many economists tended to regard the price elasticity of demand for resources such as energy and water as relatively price inelastic. The experience with energy in the past decade and evolving empirical information from water studies now leads most observers to conclude that water demand would be more sensitive to price changes. In residential use, demand for initial basic needs (drinking water) is likely quite price inelastic, whereas demand for most household use (long showers, lawn watering) is quite elastic. In both industrial and irrigation use, rising water prices would induce substantial technological change (increased recirculation in industrial water processes) and various kinds of substitutions (in irrigation, for example, the substitution of other inputs for water and the likely switch to crops which use water more efficiently).

More clarity is needed regarding the economic basis for water pricing. Randall (1981) identifies three possible bases: (1) resource cost--what it costs to supply (develop and distribute) water; (2) opportunity cost--the value of water in its best alternative use; and (3) social cost--whichever is greater, resource or opportunity cost, plus inclusion of the unpriced external effects of water supply. In an idealized, static, competitive world with no externalities, marginal resource cost, marginal opportunity cost, and marginal social cost would all be equal. As a general rule, water charges in Western Canada have been related to some concept of resource cost. However, irrigation charges, at best, relate to the operation and maintenance costs faced by irrigation districts. There is seldom consideration of recovery of capital costs for dams and major canal structures nor any levy or depreciation charge for eventual replacement. Rehabilitation expenditures at the irrigation district level in Alberta are currently cost-shared with the provincial government, the province paying 86 percent of such costs. As a consequence, irrigation farmers face only a fraction of the full resource costs of supplying water. Furthermore, as Erlenkotter *et al* (1979) points out, the cost of new water confers a scarcity value on existing supplies.

It is not politically easy to raise water charges. Higher water prices could involve income and capital losses for irrigation farmers, for instance, and the ability of some irrigation farmers to pay, particularly those growing low valued crops, may be limited. Nevertheless, it is hard to avoid the conclusion that water charges for agricultural, industrial, and residential use must be progressively raised in the 1980s and 1990s if water is to be used more efficiently. One possible pricing option to be considered involves increasing block charges for water, with initial units priced relatively low but with charges for successive blocks rising toward the true scarcity value of water. Such an option, currently in place in the Australian state of South Australia for irrigation water, would be more politically attractive and yet engender considerable efficiency advantages.

There is nearly universal agreement among economists in many nations that demand management must be given much higher priority. Economic demand management is not without its problems. But, "like growing old, it looks more attractive when compared to the alternatives" (Erlenkotter *et al*, 1979, p. 191).

*Water Rights Reform*

The restructuring and reform of provincial systems of water rights in Western Canada is another high priority area for policy attention. The current system of water rights in the western provinces is basically a system of administrative apportionment--a license or permit system upon which has been grafted the temporal priorities typically associated with the doctrine of prior appropriation. The policy concern is that the current system of water rights (they vary slightly by province) will prove too rigid and inflexible in the course of economic growth and change. These water rights systems can be respecified to facilitate the more ready transfer of water to higher-valued uses.

The historical development and current status of water rights in the Western Canadian provinces is outlined by Percy

(1977), Gisvold (1956), and Beerling (1984). In the prairie provinces, the present system of surface water rights grew out of the provisions of the Northwest Irrigation Act of 1894. The historic English system of common law riparian rights was virtually replaced (except for domestic uses) by a system of administrative apportionment under which ownership and control of surface water resources was vested in the Crown and the Crown allocated water to users through a license system.[14] The system of water rights on the prairies did not, in fact, become a system of prior appropriation ("first in time, first in right") (Gisvold 1956) but it was nevertheless considerably influenced by and assumed some of the temporal priorities found in such water law in the western United States (Percy 1977). The current rules of priority are based on the date of application for a license and, in the unlikely event of application on the same date, on a list of preferred uses. The highest priority in Alberta, for example, is for domestic purposes, followed by municipal, irrigation, industrial, water power, and other uses. In this temporal priority system, just as under the law of prior appropriation, a senior licensee can receive the entire amount of his alloted water supply before a junior licensee is entitled to receive any water (Percy 1977).

Prior appropriation, as a legal doctrine, does not prevail in the prairie provinces because the Crown has ultimate authority

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[14]There is some controversy as to whether the legislation involved in various provincial water acts has actually abrogated (extinguished) riparian rights, or whether they are eliminated only as streamflow is allocated through licensing (Campbell, Pearse, and Scott 1972).

to grant use of and manage water resources. The Lieutenant Governor in Council, under emergency conditions, can suspend any water use license and transfer water to other uses. The prairie water resources acts contain provisions for the transfer of water from lower to higher valued use, according to the list of perferential uses, upon appeal by the higher-valued user to the responsible Minister. Under these circumstances, transfer is allowed at the discretion of the Minister and upon payment of compensation to the senior, but lower-valued, user. In addition, the Crown can reserve as-yet-unlicensed water. Nonetheless, these mechanisms for the reallocation of water are suspected to be inadequate as water conflicts mount. In practice, a system of temporal priorities is in place, water rights are tied to designated parcels of land or to specific undertakings, and the transfer of water to higher-valued uses, while possible on paper, is apt to prove too inflexible, politically difficult, and administratively cumbersome.

Indeed, the current system of water rights can be assessed in terms of the intervening criteria of security and flexibility which might serve as proxies to indicate whether increases in regional income might be facilitated over time (Ciriacy-Wantrup 1964). The current system is reasonably secure: there are some problems, clearly, with the physical security of supply in low flow years, but the degree of tenure security is quite high. The present system, however, gets low marks in terms of flexibility: the transfer of water to higher-valued uses will undoubtedly be impeded in the course of regional economic development at some point in the future.

There are ways in which the current systems of water rights in the western provinces could be modified to facilitate future reallocation of water to higher-valued uses and users. In particular, the advantages, disadvantages and practicality of a system of transferable water entitlements--as proposed recently by Randall (1981) for Australia--needs to be seriously studied in the context of Western Canada. The existing system of (attenuated) property rights for water could be respecified to enable the development of a modified market mechanism for water rights for some, though not all, water uses. Rights to water would have to be more clearly specified in terms of volume, reliability, timing, and point of delivery. Holders of water rights would be free to sell their rights to other users, subject to the condition (and backed up by the veto power of the management authority) that changes in the points of diversion or adverse downstream effects were not causing undue harm. The provincial governments might introduce such schemes initially within a specified locality, perhaps solely among irrigators. Over time, the water rights market and transferability might be extended to include sale of water rights between different spatial areas and between agricultural and non-agricultural uses.

Though not without its problems and difficulties, a modified market mechanism in transferable property rights for water (strictly speaking, rights to use water because the Crown would retain ownership rights) is suggested to have several advantages (Randall, 1981; Moy 1981; Musgrave, 1983). It would significantly reduce transfer costs in the re-allocation of water vis-a-vis the current restricted methods of transfer. Secondly, a system of transferable water rights would lead to incentives to economize on the use of water. In the transactions process, the price or market value of water would be revealed, generating information for the management authority about the real value of supply augmentation. Finally, in the situation where property rights for water were initially distributed to users on the basis of past use (rather than, say, auctioned), current irrigators could find the new system politically acceptable and a "Pareto safe" move. Current irrigators would not see the value of their overall capital assets decline, although the capitalized value of water would be separated from the capital value of land (whereas, at present, the value of water is capitalized into the overall value of irrigated land). Overall, provincial management authorities, who might resist such schemes, should regard them as a potential means of assisting their administrative duties. Decentralized market and pricing systems can be useful policy instruments in some water spheres, particularly where the private use of water is concerned.

*Water as Environment*

Continued government involvement will be necessary to maintain and, when practical, to restore and enhance the instream uses of water and overall water quality. The beneficial instream uses of water include: recreation and boating, the provision of fish and wildlife habitat, aesthetic enjoyment, navigation, scientific study, and assimilative capacity to dilute some forms of pollution. Many of these uses (excepting the dilution of wastes) involve the provision of amenity services. As a general rule, the amenity services of the natural environment are increasing in value relative to manufactured goods. The population of Western Canada, like those in many richer, industrial nations, is increasingly concerned about the provision of such services.[15] Typically, amenity services associated with the water environment have public good characteristics, are largely non-consumptive in nature, and provide extra-market benefits to people. It is crucial that such uses be accorded more prominence in policy strategy and policy-making. The most recent planning document in the State of California (entitled *Policies and Goals for California Water Management: The Next 20 Years*) does give appropriate attention to instream uses and water quality and in this regard shows the direction which water policy in Western Canada should be taking.

Some instream uses of water--particularly those relating to the provision of ecological and habitat services--may be considerably dependent on the "flushing" and physical changes caused by periodic maximum river flows or, at least, the large run-off flows each spring. Some amenity services--such as wild river canoeing--are typically dependent on maintaining rivers in their natural state. Such factors must be considered in decisions whether to preserve or develop the waters of certain rivers as

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[15] Indeed, it is arguable that water quality dimensions may be as important, if not more important, to many industrial location decisions than water quantity--particularly for the attraction of "high technology" and service industries whose employees would value a clean environment.

well as in decisions about the scope and type of storage if development is the preferred option.

Economists must become more involved in the identification and assessment of the instream uses of water, in the development of frameworks for distinguishing possible trade-offs between instream uses and other uses, and in the development of efficient and equitable institutional and policy measures to protect instream uses. The most important policy change which could be suggested by economists with respect to water quality improvement is the possible imposition of transferable emission permits or effluent charges for point sources of pollution.

*Improvement in Water Institutions*

In addition to questions of reforming economic institutions involving water property rights and prices, there are several important areas for the reform of water institutions and organizations. These range from improvements in local water institutions (including irrigation districts) to improved regional water management authorities and re-vitalized international authorities such as the International Joint Commission.

Perhaps the most important institutional arrangement which must be established, however, is an on-going institutional vehicle for the identification and resolution of water issues between the provinces and the federal government. As Foster and Sewell (1981, p. 88) emphasize: "The present set of structures is clearly lacking in the type of institution that can carry out the hard bargaining necessary to establish national water priorities, overcome emerging problems and develop Canada-wide policies to manage the resource."

## Summary and Conclusions

1. The regional income of Western Canada could be increased over time through sounder development and allocation of water resources. The use of economic criteria and instruments in water management would aid in wiser development (or, at times, in avoiding development) of the resource as well as assisting in allocating water to higher valued purposes. Moreover, the standard of living of Western Canadians can be enhanced if more serious attention is paid to the increasingly important amenity services of water which are typically non-consumptive and extra-market in nature.
2. Further study is needed to clarify the current and future uses of water in three important areas: irrigated agriculture, energy-related uses, and instream uses. Current consumptive use in agriculture is not known with great certainty (given the difficulties of estimating delivery and field losses, evapotranspiration by crops, and return flows). Future agricultural use is heavily dependent on the pace of irrigation expansion, which needs to be analyzed in terms of the market potential and production possibilities for both irrigated and dryland crop and animal production. It is especially critical that the future demand for irrigation water be analyzed in an economic framework, where the price of water is an argument in the demand function for water. Considerable confusion exists presently with respect to the amounts of water used in energy production. Future use is contingent upon many uncertainties: the degree to which water

will be used in secondary recovery procedures in conventional oil and gas fields; the pace at which "old" petroleum will be depleted in Western Canada; the pace at which non-conventional energy development (tar sands and heavy oil production) will be brought on stream; and the degree to which water pricing policy and technological change might influence water use in this sector. Finally, the instream uses of water in Western Canada, although difficult to measure with any precision, should be assessed and estimated quantitatively wherever possible to enable improved water policy and planning. The United States has such measures, crude as they may be, for its major basins and it is imperative that Canada begin making such estimates and that instream uses of water be accorded more significance in planning documents (as they are, for example, in the most recent water planning study for California). Thus, current and future use in irrigation, in energy production, and for instream purposes are three high priority areas for future assessment and analysis. Too little attention is being paid to these priority areas by all parties: the federal government, the respective provincial governments in Western Canada, university and private sector researchers, and various user groups.

3. Agriculture is by far the largest consumptive user of water in Western Canada. The priorities for irrigated agriculture should not be expansion of the irrigation system but rather making better use of the existing system that is in place.

Further irrigation expansion appears only marginally feasible in terms of social benefits and costs. This is chiefly attributable to two main factors: the increasing (long run) marginal cost of developing new water supplies, and the constraints imposed on the benefit side by the very low proportion of specialty, higher-valued crops in the irrigation cropping mix. Policy attention should be directed to: the rehabilitation of the existing irrigation system and the general improvement of irrigation efficiency, especially in southern Alberta; the provision of additional infrastructure, such as off-stream storage in Alberta or in-filling of the South Saskatchewan system where the Gardiner dam is already in place, if such marginal extensions can be shown to be worthwhile social investments; and, finally, the over-riding necessity to continue efforts to increase the "intensity" of crop production under irrigation (for instance, through less conventional grains and pasture and more speciality crops or, at least, crops in which the marginal value of water is somewhat higher).

4. More policy and research attention must be given to water management in dryland agriculture. The prairie region faces several serious land quality problems including loss of natural fertility, erosion, salinization, and acidification. It appears necessary that prairie agriculture move to extended cropping rotations in which summerfallow plays a lesser role and the critical extra inch or two of water traditionally conserved by summerfallowing is generated

through better husbanding of rainfall and snow resources. Although both the federal and provincial governments are aware of the foregoing land and water problems and have taken some action, a more concerted effort is needed at both levels to tackle these problems.

5. Regional economic growth, particularly non-agricultural growth, in Western Canada is neither greatly facilitated nor hindered by the availability of water. In fact, water availability is not a major determinant of industrial macro-location decisions in Western Canada but can, on occasion, be a more important factor in micro-location decisions. Water does not pose a significant constraint to industrial development chiefly because of the potential for flexibility associated with technical change and the considerable possibilities for recirculating and reusing water. Current technical processes for nonconventional energy production are relatively water-intensive. However, tar sands development near the Athabasca River raises more serious questions about water quality and pollution rather than water availability. Future heavy oil development in the Cold Lake and Battle River regions need not be constrained if water is piped from the North Saskatchewan River. There is also good reason to believe, based on the historical experience of water use in North American industry, that technical processes in energy development might also be altered to economize on the use of water if water availability and/or cost become a major problem.

6. Massive interbasin transfers of water within Western Canada, from preliminary indications, appear to have prohibitive economic costs and raise very serious environmental concerns. Despite the fact that current interbasin transfer projects appear economically infeasible and inefficient (and likely so by a wide margin), such projects typically involve major income transfers to the zone to which water is transferred, given current pricing and repayment arrangements. As a consequence, politicians and residents in the zone of water destination generally are strongly in favor of interbasin transfer projects, which are largely funded by taxpayers at large. However, given the current economic difficulties of the Western Canadian economy and the prevailing mood of fiscal restraint, major expenditures for interbasin water transfer in Western Canada seem most unlikely in the near or medium term.
7. The export of water on any major scale to the United States seems unlikely in the foreseeable future. Nevertheless, Canada must begin to develop an explicit perspective and policy on water export. This policy, in turn, must be based on more careful assessment of Canada's own future uses, especially those related to instream and ecological purposes. It is not clear whether Canada has water surplus to its future needs nor whether the United States is a readily identifiable market for Canadian water. The international transfer of water over long distances, primarily for agricultural purposes or to avoid reallocation out of

existing agricultural use, is prohibitively costly. The western states will likely be forced to grapple more effectively with the political and legal difficulties of water reallocation and the reform of water institutions. Economic considerations which should be incorporated in any Canadian water export policy include: pricing arrangements which reflect an intrinsic value for the water itself and not merely delivery costs; compensation for environmental damage in Canada; and adequate assessment and protection of the future needs of the donor basin.

8. It is imperative that a comprehensive strategy and policy for water be developed in Canada at the national and then at the regional level. Canada needs to assess its water resources, identify emerging water issues and problems to the year 2000, and outline policy directions for improving water management. To be successful, this effort must be a combined undertaking by both the federal and provincial governments. The forthcoming report of the Inquiry on Federal Water Policy should be a stepping stone in the right direction. It is important, however, that this work be followed by efforts to incorporate provincial input more directly and explicitly in the formulation of a truly national, as opposed to a merely federal, water policy. Over time, it will also be necessary to develop an on-going institutional vehicle to identify and resolve water issues between the provinces and the federal government. Water policy cannot be divorced from strategies for agricultural, industrial, energy, and overall economic

development. Moreover, water policy should be closely integrated with land use planning.

9. In most developed nations, demand management is increasingly being recognized as a considerably lower cost solution to water management problems relative to supply augmentation. Serious consideration must be given to the more effective pricing of water in Western Canada, particularly for residential, agricultural, and industrial uses. Water can no longer be treated as a free good. Hence, water pricing policy must not only address the resource cost of developing and distributing water but must also take into account opportunity cost concepts (the value of water in its best alternative use) and unpriced external effects of water supply. As Castle (1983) points out, the great challenge for water policy in the 1980s will be to provide signals that will lead to the consideration of water as an increasingly scarce resource. Most Canadians have not yet adopted this perspective.

10. Further efforts must be made to restructure and reform provincial systems of water rights to facilitate the transferability of water to higher-valued uses in the course of economic development. The existing systems of administrative apportionment, which typically include temporal priority aspects and which tie water to designated parcels of land, will prove too inflexible. The western provinces should be encouraged to consider and introduce, at least on an experimental basis, a system of transferable

market entitlements to water for some water uses. Such systems could facilitate the establishment of temporary rental markets for water together with the permanent sale of water rights and thereby enable the transfer of water to higher-valued use.

11. Very little attention has been paid to issues of ground water use and quality in this paper. For many farm families and rural communities in Western Canada, ground water is an important source of water for domestic use and livestock. Inadequate and/or poor quality drinking water remains a problem for many rural prairie residents (Canada West Foundation 1982; Roy 1983). Ground water contamination is primarily a problem near cities where suburban acreages may lack good sewage treatment. Unlike the situation in most western American states, ground water is an extremely minor source of irrigation water in Western Canada. Ground water, however, is a somewhat more important source of water for energy and industrial uses.

12. Although the focus of this paper has been on water quantity issues and the consumptive use of water, it must be recognized that public water policy in Western Canada should be equally concerned with water quality issues and the protection and enhancement of instream water uses.

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