SUSTAINABILITY AND HYDRO DEVELOPMENT IN THE COLUMBIA RIVER BASIN

by

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ABSTRACT

This thesis examines the concept of sustainability and the implications of large-scale hydroelectric development for the sustainability of communities in the Canadian portion of the Columbia River Basin. A literature review of sustainability provides a background for discussion and a working definition of sustainability is proposed for consideration throughout the study. An overview of the Canadian experience with hydro development and its ecological, social and economic impacts provides a context within which to consider issues related to sustainability.

The Columbia River Basin is the setting of a case study of sustainability and hydro development in British Columbia. The Kootenay region has been affected by extensive hydro projects since the early 1900s on the Kootenay River and most significantly by large dams built on the Columbia system as a result of the Columbia River Treaty. Communities in the Kootenays have borne a large share of the impacts of these dams. The resulting degradation of fisheries, wildlife and forests has jeopardized the integrity of the region's resource base and its capability to enhance the quality of life of those living within the Columbia River drainage basin.

Future hydroelectric planning should address the sustainability of the ecological, social and economic systems affected by this land use change and ensure that local communities are included in project decision-making. Increased awareness of the consequences of large-scale hydro projects during planning stages may enable sustainable development to occur.

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1. INTRODUCTION

We live in a world of imperfect knowledge. Each one of us is faced with a variety of decisions every day and must develop appropriate criteria upon which to base decisions. In this thesis, it is argued that sustainability is a concept which provides us with a framework for reaching better decisions through the integration of environmental, social and economic systems, and through the empowerment of people to take a greater role in local resource management.

The purpose of this thesis is to assist in the clarification of what is meant by sustainability and how this concept may be useful in hydroelectric development and water resources planning. This subject was chosen in an effort to consider the role of environmental stewardship amidst the increasing number of controversies related to large hydro projects throughout Canada. Although the development of hydro megaprojects has provided many Canadians with a relatively inexpensive and abundant supply of electricity, the damming of many of this country's largest rivers has caused a wide range of ecological and social problems. Those who reap the benefits from the use of this energy do not always bear its social and environmental costs.

A case study of hydro development in the Columbia River basin of British Columbia provides a useful setting for the examination of sustainability issues associated with this type of resource development. The introduction of large hydro dams into a mountainous resource-dependent region with competing interests for the use of limited flat and productive valley bottoms has caused significant environmental, social and economic problems for those who depend on the region's resource base. This thesis will attempt to explain the parameters of this resource management issue and offer suggestions for the consideration of sustainability in future hydro project planning.

1.1 Rationale

In recent years, resource use conflicts have been the focus of much political controversy. Increasingly, individuals and interest groups are challenging resource allocation decisions made by governments and large corporations. Frustrated by their limited access to decision-making some environmental activists have resorted to road blockades, tree spiking, boycotts, political lobbying and court proceedings to communicate their dissatisfaction with resource use decisions.

Contemporary concerns regarding sustainability suggest that many previous practices of resource exploitation solely for economic benefit are no longer sufficient. The public is demanding greater consideration of the social and environmental consequences of large-scale industrial developments. The concept of sustainability provides a framework for the examination of long-term resource values that are inadequately represented when private sector profit maximization is the sole or principal decision criterion.

1.11 Canadian Energy Resource Development

Canadian energy resources have been developed through the construction of megaprojects, as these large-scale engineering enterprises have been viewed as effective tools for implementing federal and provincial economic and political goals. Governments have favoured megaprojects due to their ability to accomplish regional development goals and gain regional political support.

Large energy projects have usually been announced with great fanfare and promises of large numbers of jobs (although generally short-term) which can be credited to the government in power.

While Canadians have benefitted from the industrial growth and improved standard of living attributable to the development of energy resources, it has become increasingly apparent that the real social and environmental costs of energy projects have not been fully considered during project planning or implementation. Energy resource development can cause significant problems for communities located near the site of energy production or for those living along transportation or transmission corridors. Residents of large urban centres tend to prosper from the long-term benefits of energy projects, while those dwelling near project sites are often left without adequate resources to compensate for or mitigate the residual effects.

The extraction and development of many of Canada's primary sources of energy have occurred in remote northern locations, where the large-scale exploitation of resources has disrupted surrounding communities whose well-being depends largely on the state of the natural environment. Oil and gas development in northern Canada has jeopardized the integrity of the Arctic environment through the construction of pipelines and periodic occurrence of oil spills, and has triggered socio-economic problems resulting from the imposition of economic values from southern urban markets on local communities (Berger 1977). The production of toxic wastes and leakage of mine tailings from uranium mining activities at Elliott Lake, Ontario has contaminated water, fish and wildlife and necessitated long-term waste management planning which may affect the health of local communities and future development opportunities (Nuclear Fuel Waste Management Environmental Assessment Panel 1991). The damming of many of

Quebec's northern rivers flowing into James Bay has caused the drowning of caribou, the accumulation of mercury in fish, the disruption of hunting and fishing economies, causing many social and economic hardships for aboriginal communities whose livelihood was strongly linked to these resources (Berkes 1988).

During the 1980s, a growing awareness of environmental problems related to the production and consumption of energy resulted in debate over the viability of various energy resources. The discovery of the relatively new phenomena of acid rain and global warming focused concern on the consequences of burning fossil fuels. The accident at Chernobyl (1986) generated widespread apprehension about the safety of the operation of nuclear plants throughout the world. Oil spills such as the Exxon Valdez (1989) drew attention to the risks imposed on marine and shoreline ecosystems by the transportation of oil. Many Canadians questioned their dependence on fossil fuels and their interest in nuclear energy.

The development of energy resources was considered by the World Commission on Environment and Development (WCED) as part of its mandate of "a global agenda for change". Since the WCED endorsement of the concept of sustainable development in its report "Our Common Future" (1987), Canada and many other countries have endeavoured to include environmental and social factors in economic development policies. However, the implementation of sustainable development has been fraught with controversy regarding the interpretation of the meaning of this term. The pursuit of sustainability or sustainable development has been addressed by energy policy makers and has become a criteria in energy project decision making.

In comparison with other energy sources, hydroelectric dams have been perceived as one of the most environmentally friendly forms of energy generation (Standing Committee on Energy, Mines and Resources 1993, 85). Since the generation of hydroelectricity is renewable and does not produce any "pollution", many people favour this form of energy production over nuclear or the combustion of fossil fuels. While there is some merit to these views, the construction and operation of hydro dams results in a different set of impacts, those related to the displacement of people, fish, wildlife, vegetation and sediments. The flooding and diversion of large water systems causes a wide assortment of changes to natural ecosystems and social communities and many impacts do not become evident until years later.

1.12 Hydroelectric Development and Sustainability

Canada is fortunate in its rich endowment of water resources. The construction of dams to control the flow of water systems has been primarily for the purpose of hydroelectric generation. Ninety-five per cent of the water stored behind large dams in Canada is associated with the generation of hydroelectricity (Day and Quinn 1992, 176). Hydroelectricity represents approximately 10% of Canadian primary energy production, and supplies 12.9% of domestic demand for primary energy as reported by Statistics Canada/Energy, Mines and Resources Canada (1993).

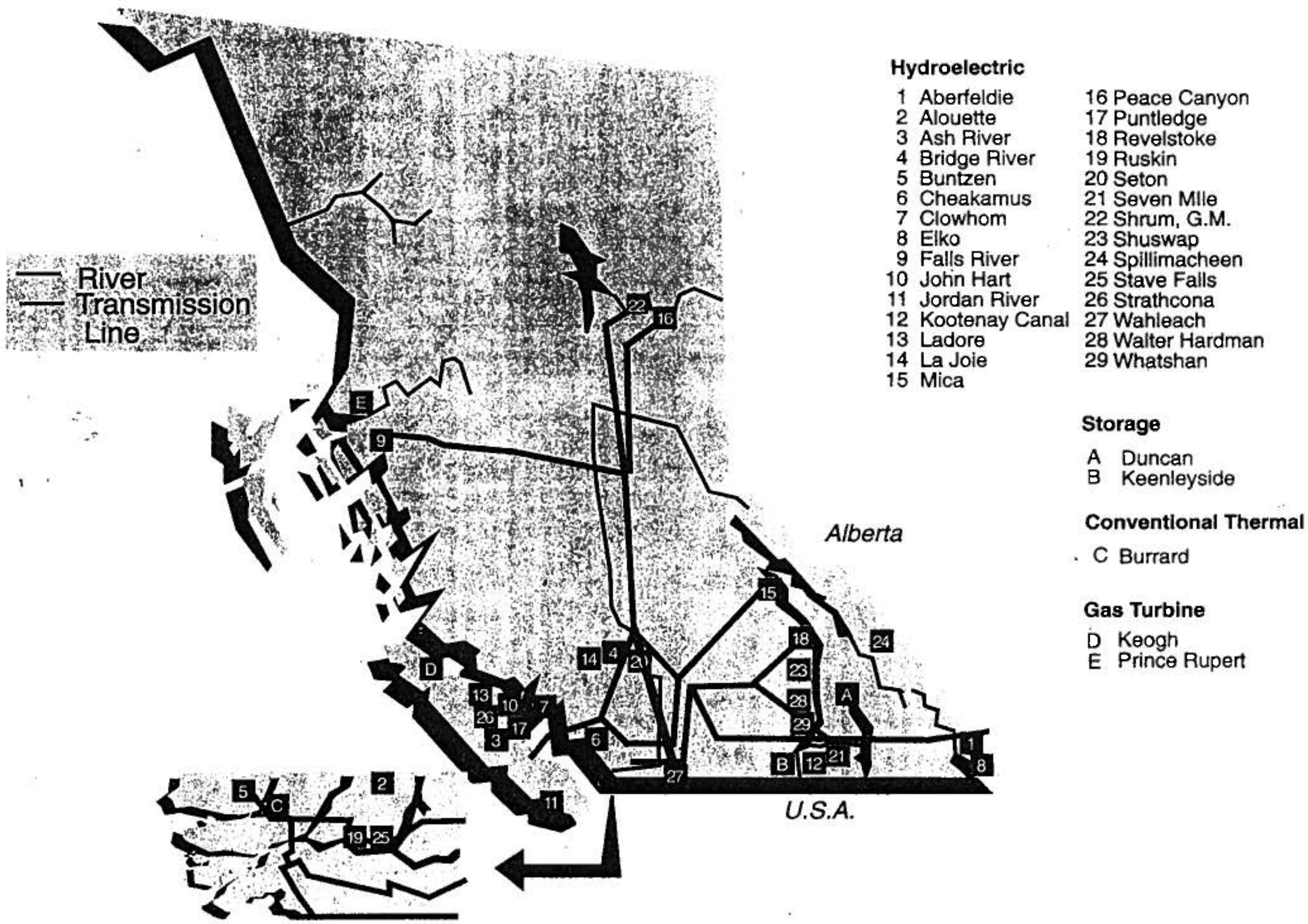
Although the hydroelectric potential of Canadian rivers varies across the country, the large rivers flowing from the mountains of British Columbia produce sufficient energy to meet the majority of electricity demands within this province. Hydroelectricity provides 11,000 MW (87%) of the 12,700 MW of electrical generating capacity installed in the province. The remaining 1,700 MW (13%) is generated through thermal production. More than 70% of provincial electricity is produced from dam systems on the Peace and Columbia Rivers (British Columbia Energy Council 1992, 10).

Most of the electricity produced in British Columbia is supplied by the province's public utility, B.C. Hydro. The provincial utility has a total generating capacity of 10,500 MW, which it supplies through 29 hydroelectric generating stations, two gas turbines, one thermal plant and three diesel generators (Figure 1). West Kootenay Power is a private utility based in south eastern British Columbia with a total capacity of 205 MW, supplied by four hydroelectric plants. Numerous other small public and private utilities, generate approximately 2000 MW through hydroelectric power and cogeneration of wood residue (B.C. Energy Council 1992, 10).

Canadian hydro development has occurred largely in remote areas and, until recently, with little concern for its long-term implications other than electricity generation and economic development. Post-project assessments of the consequences of hydro dam activity on surrounding communities and ecosystems have documented many of the immediate and long-term impacts of this energy source (The Peace-Athabasca Delta Project Group 1972; Baxter and Glaude 1980; Day and Quinn 1992). Communities have been displaced, fish and wildlife habitat has been lost, recreational opportunities have been foregone, and people have been forced to adopt different lifestyles as a result of the changes to regional resource bases. In many cases, it is aboriginal people, who have traditionally been most closely linked to the land, who have experienced the most substantial losses (Berkes 1988; Day and Quinn 1992).

After several decades of experience with large hydro dams, Canadians are particularly aware of many of the impacts of hydro development. The majority of Canada's large river systems have

Figure 1. The B.C.Hydro Electric System



Source: B.C. Hydro (1993k), p. 3

been dammed with substantial electrical generation projects on the Peace, Columbia, Churchill, James Bay and Churchill Falls networks. These hydro projects were all constructed since the 1960s and some offer opportunities for further development.

While many Canadians have benefitted from the abundant and relatively inexpensive supply of hydroelectricity produced within this country, the majority of costs of this form of power generation have been significantly underestimated. Most of the benefits derived from the development of many of Canada's largest rivers have been received by those living in large metropolitan centres, hundreds of kilometres from large dam sites and their consequences. The concentration of resource use decision-making in large corporate agencies in urban heartlands has jeopardized the sustainability of human and wildlife communities living near hydro dams.

Since the late 1980s, there have been a growing number of conflicts related to the development of hydroelectric resources across Canada. The Rafferty-Alameda Dam in Saskatchewan, the Oldman Dam in Alberta, and the two phases of hydro development on James Bay in Quebec, have generated much public concern over questions of equity for those impacted by project construction (Rafferty-Alameda Project Environmental Assessment Panel 1991, Oldman River Dam Environmental Assessment Panel 1992, Hydro Quebec 1992), and have caused much uncertainty for dam builders and government policy-makers. All three sets of projects have been challenged by environmental groups and aboriginal organizations in numerous court cases, in an unprecedented show of support for the appreciation of environmental and social issues related to hydro megaprojects (Robinson 1993).

The examination of sustainability in the context of hydro development provides an opportunity to evaluate some of the past problems associated with the harnessing of water resources, and some of the consequences for present and future generations who have been left with the challenge of meeting their needs with the constraints imposed by hydro dam operations. Since British Columbia depends almost exclusively on hydroelectric energy to meet its power requirements, this province is a useful setting in which to study sustainability. Its large rivers originate in mountainous and snow-capped terrain and provide substantial hydroelectric opportunities for the residents of this province.

1.13 The Columbia River Basin as a Case Study

Although British Columbia has harnessed the power of its water resources since the 1850s, its present reliance on hydroelectric generation is a result of W.A.C. Bennett's "Two River Policy". Premier Bennett recognized the power generating capabilities of the Peace and Columbia Rivers, and favoured their ability to stimulate provincial economic growth. Although the federal government supported the development of the Columbia River, the premier was anxious to reap the benefits of both hydroelectric systems, and succeeded in gaining financing for the Peace through American payments for joint development of the Columbia River. Construction of large hydro dams along both river systems occurred simultaneously during the late 1960s. Peace and Columbia River dams continue to provide the majority of electrical capacity within British Columbia (Figure 1).

While dams in the Canadian portion of the Columbia River basin were first built on the Kootenay River at the turn of the century, the largest hydro projects in the region were developed as a result of the Columbia River Treaty. The governments of Canada and the United States signed this agreement in 1961 in a cooperative effort to regulate the Columbia for their mutual interests in flood control and power generation. The Columbia River is the fourth largest river in North America, originating high in the Canadian Rockies, and flowing through Washington and Oregon, before emptying into the Pacific Ocean (Figure 2).

Hydro dams on the Columbia River system in southeastern British Columbia (Table 1) now generate approximately half of the electricity produced by BC Hydro, and regulate water levels for one of the world's largest hydroelectric systems (Figure 3). While hydro development in the Kootenays has created some short-term employment and economic benefits for communities in the region, the majority of advantages have accrued in the form of relatively inexpensive and abundant electricity for urban residents of the Lower Mainland in British Columbia, and the U.S. Pacific Northwest. Many of the long-term costs have been experienced in terms of lost resources for those living in the Kootenays. Regional variations in B.C. Hydro electricity generation and demand are illustrated in Figure 4.

This thesis focuses on sustainability in the Columbia River basin, a region of communities that are heavily dependent on resource-based industries, and one in which extensive hydro development has caused ongoing problems due to the creation of reservoirs and fluctuating reservoir levels (Figure 5). This region, known as the Kootenays, presents an interesting area for a case study due to the large-scale development of hydro resources that has occurred over the last twenty-five years, the possibility to address social equity concerns through the renegotiation of 1998 downstream benefits according to the Columbia River Treaty, and the recent initiatives that have been undertaken to manage the consequences of this permanent legacy

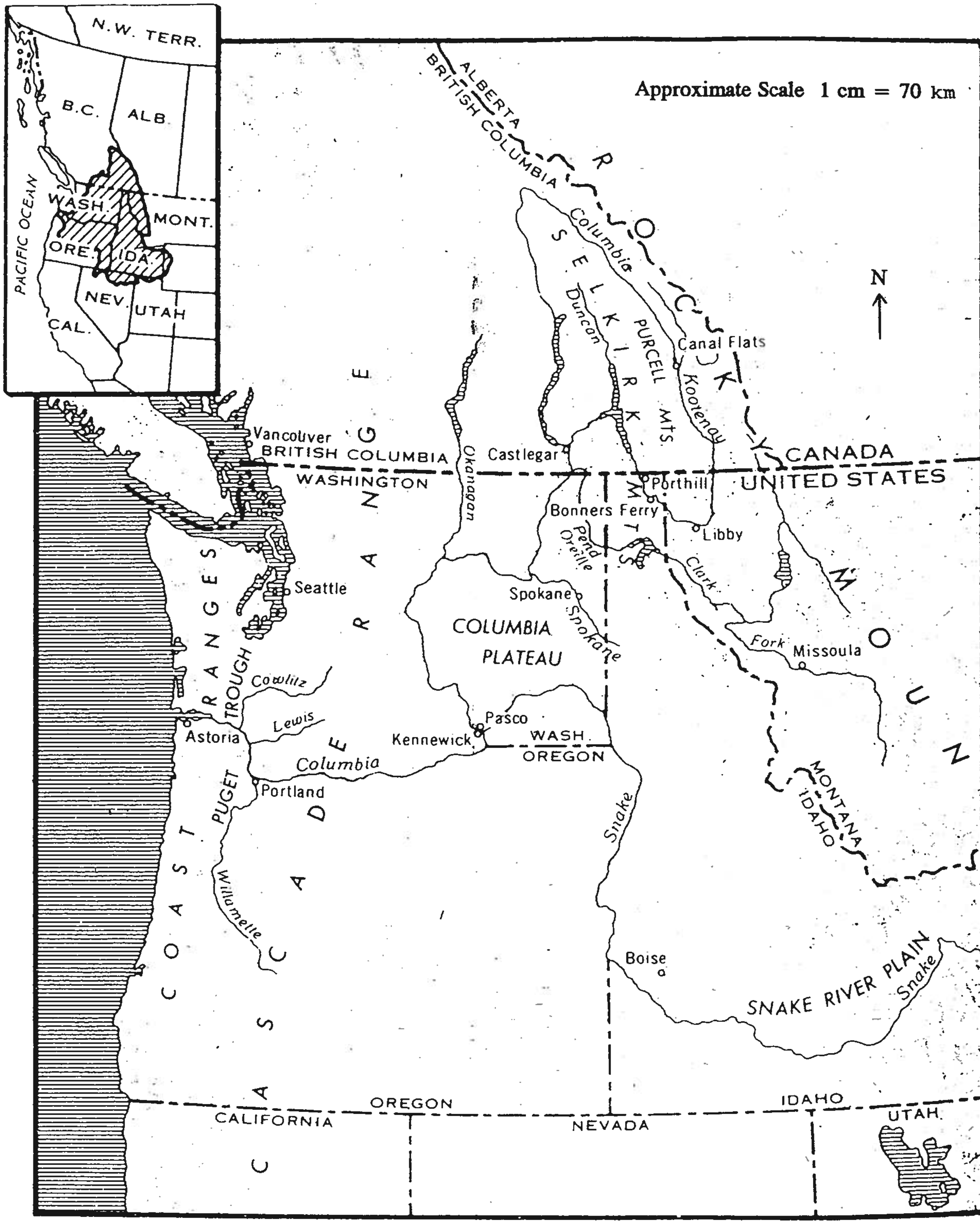


Figure 2. The Columbia River Basin.

Source: Krutilla (1967), p. 16

Table 1 - HYDROELECTRIC DEVELOPMENT IN THE COLUMBIA RIVER BASIN

River/Creek	Dam/Diversion	Completion Date	Hydroelectric Plant	Capacity (MW)	Reservoir	Surface Area (ha)	Operating Authority
Columbia River System							
Columbia River	Mica	1973	Mica	1736	Kinbasket	43200	B.C. Hydro
	Revelstoke	1984	Revelstoke	1843	Revelstoke	10125	B.C. Hydro
	Keenleyside	1968	-	-	Arrow Lakes	52600	B.C. Hydro
Pend d'Oreille	Seven Mile	1980	Seven Mile	594	Seven Mile	370	B.C. Hydro
	Waneta	1954	Waneta	375	Waneta	99	Cominco
Cranberry Creek	Coursier Lake	?	-	-	Coursier Lake	200	B.C. Hydro
	Walter Hardman	?	Walter Hardman	8	Cranberry Headpond	?	B.C. Hydro
Whatshan	Whatshan	1972	Whatshan	50	Whatshan Lake	1700	B.C. Hydro
Spillimacheen River	Spillimacheen	1955	Spillimacheen	4	Spillimacheen	2	B.C. Hydro
Kootenay River System							
Bull River	Aberfeldie	1922	Aberfeldie	5	Aberfeldie	26	B.C. Hydro
Elk River	Elko	1924	Elko	12	Elko	?	B.C. Hydro
Duncan River	Duncan	1967	-	-	Duncan	7140	B.C. Hydro
Kootenay River	City of Nelson	1896	City of Nelson	?	Kootenay Lake	?	City of Nelson
	Corra Linn	1932	Corra Linn	51	Kootenay Lake	38760	West Kootenay Power
	Upper Bonnington	1907	Upper Bonnington	59	Upper Bonnington	38	West Kootenay Power
	Lower Bonnington	1897	Lower Bonnington	41	Lower Bonnington	19	West Kootenay Power
	South Slocan	1928	South Slocan	53	South Slocan	26	West Kootenay Power
	Kootenay Canal	1976	Kootenay Canal	528	-		B.C. Hydro
	Brilliant	1943	Brilliant	129	Brilliant	569	Cominco

Source: Compiled from B.C. Hydro (1993k); and Hirst (1991), p. 85-87.

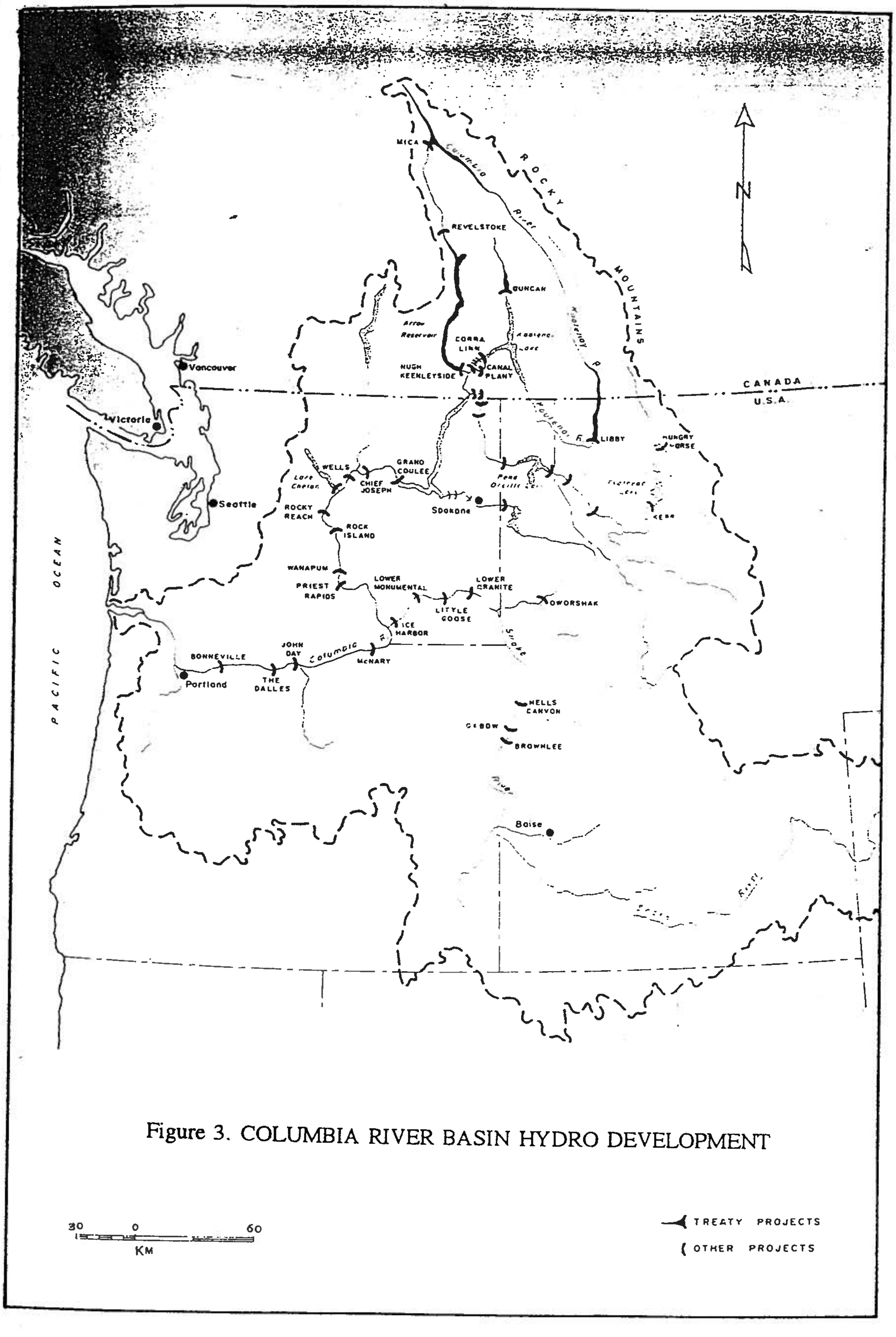
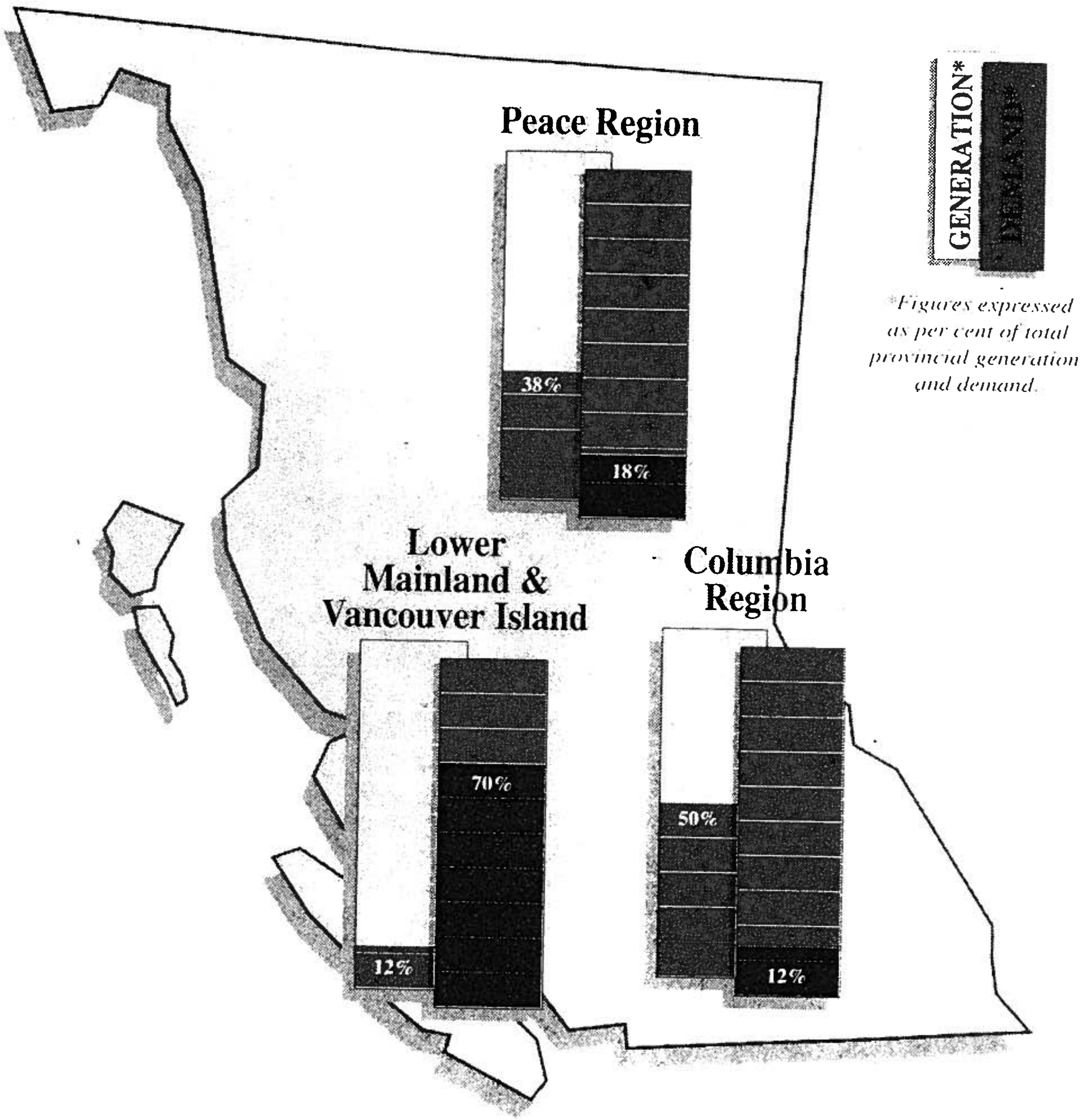


Figure 3. COLUMBIA RIVER BASIN HYDRO DEVELOPMENT

Figure 4. **The Generation — Demand Balance**



Source: B.C. Hydro (1993k), p. 5

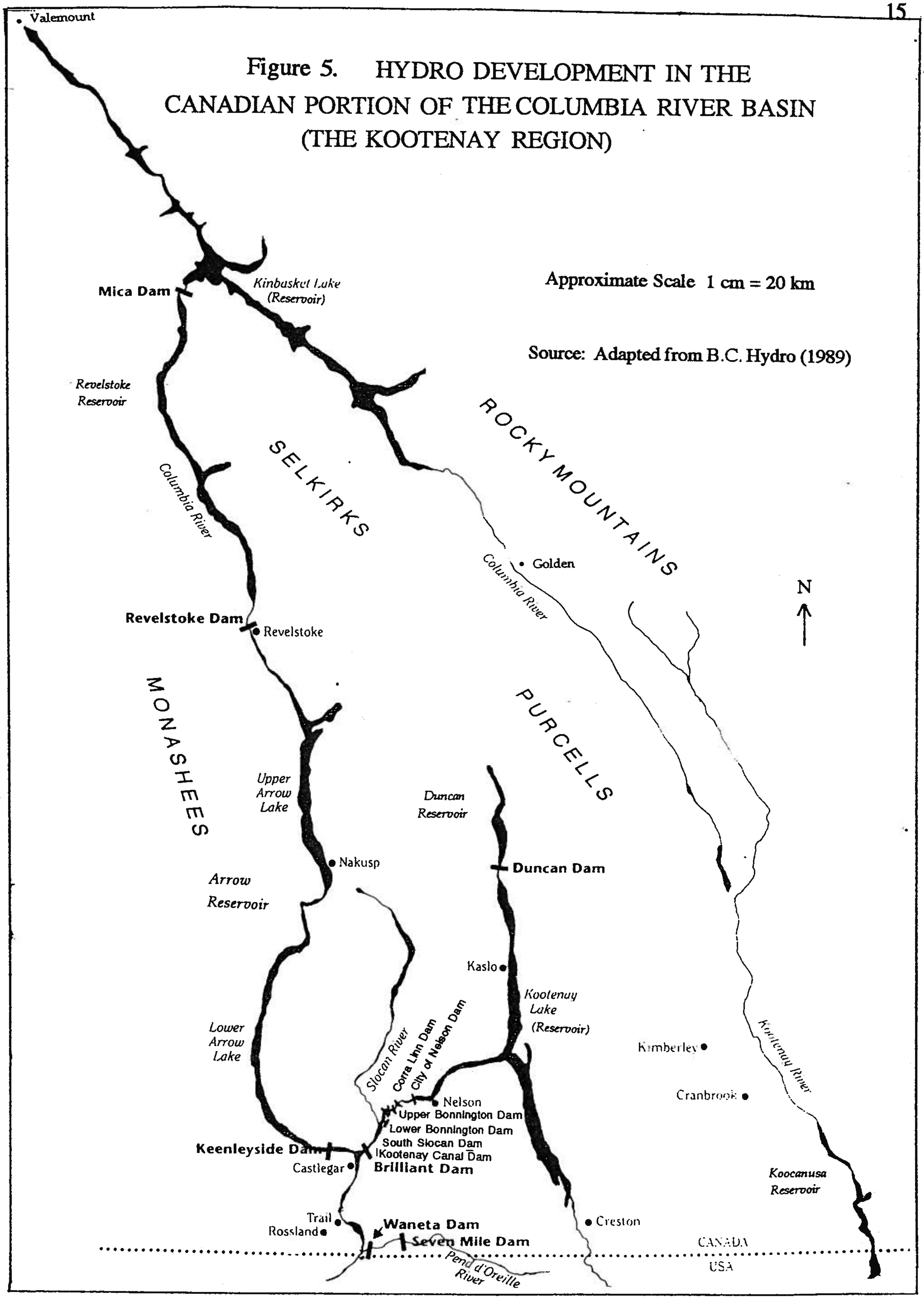


Figure 5. HYDRO DEVELOPMENT IN THE CANADIAN PORTION OF THE COLUMBIA RIVER BASIN (THE KOOTENAY REGION)
Approximate Scale 1 cm = 20 km
Source: Adapted from B.C. Hydro (1989)
Valemount
Mica Dam
Kinbasket Lake (Reservoir)
Revelstoke Reservoir
Columbia River
SELKIRKS
ROCKY MOUNTAINS
Golden
Columbia River
N
Revelstoke Dam
Revelstoke
MONASHEES
PURCELLS
Upper Arrow Lake
Duncan Reservoir
Nakusp
Duncan Dam
Arrow Reservoir
Kaslo
Kootenay Lake (Reservoir)
Lower Arrow Lake
Slocan River
Corra Linn Dam
City of Nelson Dam
Nelson
Upper Bonnington Dam
Lower Bonnington Dam
South Slocan Dam
Kootenay Canal Dam
Keenleyside Dam
Castlegar
Brilliant Dam
Kimberley
Cranbrook
Kootenay River
Koocanusa Reservoir
Trail
Rossland
Waneta Dam
Seven Mile Dam
Creston
CANADA
USA
Pend d'Oreille River

to future generations. Emphasis is placed on defining sustainability and understanding the implications of hydroelectric development on the sustainability of surrounding communities.

1.2 Research Question and Objectives

While hydroelectric projects have been viewed as a favourable means of generating electricity and stimulating economic development, they have also created resource use conflicts in nearby areas. Since Canadians and particularly residents of British Columbia continue to rely on water resources for the generation of electricity, and as hydro project conflicts are costly and time-consuming for governments, industry, interest groups and individuals, it is necessary to examine the controversial issues related to hydroelectric development. The concept of sustainability provides a framework for considering some of the problems related to dams and their effects on local communities.

This thesis examines the following question:

> How has hydroelectric development affected sustainability in the Columbia River basin?

The research objectives are summarized as follows:

1. to define sustainability;
2. to examine the sustainability of areas affected by hydroelectric development through a case study of the Columbia River basin;
3. to develop of a set of indicators to evaluate the impacts of hydro development on

sustainability; and

4. to recommend measures through which sustainability could be included in future hydro project planning.

1.3 Approach

This thesis is interdisciplinary in nature, and uses a case study to examine the effects of extensive hydro development on the sustainability of communities sharing the resources of a common watershed. The following discussion outlines the interdisciplinary approach, the rationale for a regional (watershed) focus, and the justification for the use of a case study.

1.31 Interdisciplinary Approach

Since the concept of sustainability involves the integration of economic, social and environmental systems, an examination of sustainability is inherently interdisciplinary. The research for this thesis has involved the study of various aspects of economics, sociology, ecology, and political science in an effort to understand some of the problems related to the concept of sustainability. While the author is more familiar with some of these disciplines than others, an attempt has been made to emphasize the aspects of each field that are most helpful in understanding sustainability.

Interdisciplinary research requires some context to give meaning to its approach. This study was undertaken within the field of environmental resource management as this resource-based approach provides some useful frameworks for drawing links among elements of what have been traditionally known as science or arts disciplines. Although environmental resource management has developed from biophysical studies of forests, fish and wildlife, it is now evolving to consider resource use conflicts and the socio-economic factors that affect management decisions of natural resources.

1.32 Regional/Watershed Focus

A regional or watershed approach is the most appropriate for this study since many communities within the Columbia River basin share similar experiences with past and ongoing hydro dam operations. Recent community efforts to organize as a region for increased political visibility generated useful information for regional analysis. Although the consideration of sustainability of those living in the Kootenays must acknowledge extra-regional issues due to social and political linkages with other parts of British Columbia, as well as bioregional or geographical relationships with communities downstream in the Pacific Northwest, this study focuses on the Canadian portion of the Columbia River Basin.

The subject of this research appeared to be quite timely as it coincided with the formation of the Columbia River Treaty Committee, a regional organization developed to address political concerns related to the impacts of hydro development in the Kootenays. During the course of research, issues related to Columbia River hydro projects achieved increased political visibility due to problems related to low reservoir levels during the summers of 1992 and 1993, combined with upcoming negotiations related to the 1998 return of downstream power benefits, known as the Canadian Entitlement.

1.33 Case Study

This thesis uses a case study as a means of examining sustainability and its implications for hydro development. According to Robert K. Yin (1989, 14), a case study is an appropriate method to conduct research under the following conditions:

1. to answer how and why a situation is occurring;
2. when no control over behavioural events is required; and
3. when the focus is on contemporary events.

A case study is a relevant method to undertake this research as the previously stated objectives concur with the three conditions described above:

1. This thesis has focused on addressing:

   (a) how the concept of sustainability has evolved, and why it is important, and

   (b) how hydroelectric projects have caused problems related to resource management and why these problems have occurred;

2. The study of hydro development in the Columbia River basin requires an examination of events that have already occurred or are presently occurring. No control over behavioural events is required; and

3. While this thesis has endeavoured to review the history of past hydro development to understand how the current situation has evolved, the present emphasis on the

concept of sustainability, as well as opportunities for including this concept in future hydro-related planning, necessitate a focus on contemporary events.

The interdisciplinary nature of case studies usually requires that multiple sources of information be used to gain a thorough understanding of the problem under examination. This case study has involved:

1. a literature review of (a) sustainability and (b) impacts of hydroelectric projects;
2. interviews with (a) representatives of communities within the Columbia River basin, (b) B.C. Hydro officials, and (c) provincial government representatives;
3. observation of impacts related to hydro development;
4. participation at conferences addressing sustainability, in particular the Columbia-Kootenay Symposium held in Castlegar June 18-20, 1993; and
5. the development of indicators of sustainability.

1.4 Implications and Limitations of Approach

Although an interdisciplinary study is a useful approach to understand the parameters of the research described, there are certainly limitations of this type of study. The interpretation of sustainability adopted for this thesis has focused on the integration of environmental, social and economic factors in decision-making. While others have encompassed cultural, political and spiritual factors in their definitions of sustainability, this thesis limits its consideration to three main factors which embrace most of the other elements considered by researchers and policy-makers.

The use of hydroelectric projects and their impacts as a case study is only one example of the application of sustainability in resource-based decision-making. However, the examination of hydro dams presents an opportunity to evaluate many of the social equity concerns related to megaproject decision-making. While some of the impacts of Columbia River basin dams are fairly site-specific, the overall consequences of this region's experiences have been experienced universally with hydro developments throughout Canada, and possibly around the world. The consideration of sustainability provides a framework for evaluating the cumulative combinations of site-specific impacts accompanying large dam projects.

The methods used to accomplish the research objectives of this thesis are outlined in the previous discussion of the case study. Since a case study entails the use of several methods of data collection, and since this study has involved the selection of appropriate methods in a sequential process, the explanation of the specific procedures undertaken are described in more detail where appropriate (chapters 4 and 5). The process of developing a set of indicators of sustainability relied on conclusions reached through interviews, participation at public forums and conferences, and a review of relevant information, and is explained in this context.

The author has endeavoured to understand many of the issues significant to people living in the Kootenays and to those involved with hydroelectric project operations. However, knowledge of the communities visited is limited to that learned through field trips, and comprehension of the complicated subject of hydroelectric systems is restricted to that gained from literature and discussions with B.C. Hydro officials.

1.5 Organization

The following chapters provide a theoretical framework for the consideration of environmental and social, as well as economic factors in decision-making for large-scale resource development projects. A case study is used to provide specific examples of how large hydro dams have affected the integrity of the regional resource base and influenced access to the use of resources, generating conflicts, in addition to power.

Chapter 2 reviews literature on the evolution of the concept of sustainability and its relevance to hydro development. It explains the origins of the term and discusses current themes and the specific emphasis addressed in this thesis. Past experiences with hydro dams are outlined, and key characteristics of hydro projects are examined in terms of their significance for sustainability. A definition of sustainability is proposed for consideration throughout the thesis.

Chapter 3 summarizes the case study of the Columbia River Basin. Research methods are discussed in greater detail, and the history of hydro development in the Kootenays is explained. Impacts of past projects are described, policy initiatives are outlined and recent community organization efforts are summarized.

The significance of the information gained from the case study is analyzed through the use of indicators in chapter 4. The methods used to develop a set of indicators are explained. Nine indicators are evaluated in terms of their ability to illustrate how hydro development has affected sustainability in the Kootenays.

Chapter 5 contains conclusions and recommendations for the consideration of sustainability in future hydro project planning. The effects of hydro development on the resource base of the Kootenays are summarized. Opportunities for shared decision-making in regional sustainability issues are identified.

In this thesis, the term "ecological" is used to describe the system of relationships existing between organisms and their natural surroundings. Although humans are part of ecological systems, the use of this term will focus largely on relationships among other living organisms. The use of the term "social" pertains to the relationships occurring between people and involves activities aimed at the satisfaction of various basic needs (food and shelter) or supplementary needs (recreation, spirituality, human rights). The term "economic" refers to the network of activities related to the production, distribution and consumption of goods and services, i.e. forestry operations, social welfare policies. The use of the word "environmental" denotes the wide range of interactions occurring between humans and other living organisms.

2. SUSTAINABILITY

Sustainability is an evolving concept that has received increasing recognition since the 1980s. Originating from the management of renewable resources, it is a framework that is now being used to consider the interconnectedness of social, environmental and economic issues during a period of history when there is growing awareness of the links between environmental crises and socio-economic problems. Sustainability and the related idea of "sustainable development" have become popular terms following their endorsement by the World Commission on Environment and Development in the Brundtland Report, Our Common Future (1987).

Sustainability is a concept discussed by a wide range of people concerned with environmental and social aspects of development. In general, sustainability refers to the ability to manage human and natural resources as life support systems for present as well as future generations. This idea is the subject of much debate, and considerable effort is being directed towards the development of a common vision of its meaning. In order to understand the significance of sustainability, it is helpful to examine how it has been defined and used previously. The following discussion attempts to summarize the evolution of sustainability and identify some of the critical aspects of its interpretation by policy-makers. It concludes with a description of sustainability in the context of this thesis.

2.1 Origins of Sustainability

The idea of sustainability has been derived from references in the natural sciences to the management and harvesting of renewable resources. Lélé (1991), Toman (1992) and Brown et al. (1987) discuss the origins of the term sustainability in their respective efforts to define the concept, emphasizing its significance in forestry and fisheries management. They explain that resource managers have adopted the concept of managing self-renewing stocks for "maximum sustainable yield," in an effort to limit harvests to the amount that can be reproduced within the following year.

Ecologists have since applied the concept of sustainability to ecological systems. Sustainability is often linked to the idea of "carrying capacity", meaning a recognition that an area is only capable of supporting a certain number of living organisms due to ecological limits. Lélé (1991, 609) states that many now understand sustainability to be "the existence of the ecological conditions necessary to support human life at a specific level of well-being through future generations," and refers to this as ecological sustainability.

More recently, the consideration of sustainability has embraced ideas related to social conditions, as well as the renewability of natural resources. Lélé (1991, 610) notes that when the International Union for the Conservation of Nature and Natural Resources (IUCN) made sustainability issues popular with its World Conservation Strategy, its primary focus was on ecological sustainability, and it was later criticized for not addressing the difficult questions concerning politics and economics. Brown and others (1987, 716) believe that while ecological sustainability focuses on natural biological processes, continued productivity and functioning of ecosystems, social sustainability addresses the satisfaction of basic human needs such as food and shelter, as well as other social necessities such as security, freedom, education, employment and recreation (as suggested by Maslow 1970).

The concept of a social dimension to sustainability represents the need to confront social problems related to those human needs that extend beyond the satisfaction of physical comfort. Decision making has placed a large emphasis on economic efficiency and profit maximization at the expense of environmental and social values. The concept of sustainability questions this assumption by addressing the social and environmental, as well as economic problems that affect the long-term ability to fulfill our needs.

One of the most difficult issues related to social sustainability is distributional equity. Western societies have developed through the promotion of neoclassical economics, with the assumption that economic growth will improve social welfare through the trickling down of the benefits acquired by the wealthy. This allocation of power and resources has been questioned and new models of decision-making and economic development are being pursued in an effort to address income disparity, access to and ownership of resources, and inclusivity in decision-making (Boothroyd 1991b).

2.2 Sustainable Development

The recent emphasis on sustainability is largely related to the concept of "sustainable development", a term originating from the IUCN in its 1980 World Conservation Strategy. It was later popularized in "Our Common Future", the 1987 report of the World Commission on Environment and Development (WCED). This Commission, chaired by Gro Brundtland of Norway, was established in 1983 by the General Assembly of the United Nations, and was given the mandate to develop a "global agenda for change" in its examination of international environmental issues.

The Brundtland Commission accomplished its task during a period of time when the world faced unprecedented economic and environmental crises. A series of environmental incidents with significant international implications shocked people around the world (WCED 1987, 3). Some of the most noteworthy included: the pesticide leak at a Union Carbide factory at Bhopal, India (1984); widespread drought in Africa (1984/85); and the release of radiation from the nuclear facility at Chernobyl (1986), in the former USSR. Scientific studies on the consequences of global warming and ozone depletion by chlorofluorocarbons (CFCs) were also released (World Meteorological Organization 1985, Brasseur 1987), compounding the international sense of global environmental degradation.

In addition to feeling the effects of environmental catastrophes, western nations experienced the worst recession since the 1930s. During the mid 80s, welfare states around the world suffered from high interest rates, high unemployment, high levels of inflation and no real increases in wages since the boom years in the 1970s. Boothroyd (1991a, 277) demonstrates the severity of these economic conditions in his discussion of challenges to the welfare state in Canada.

The Brundtland Commission embraced the idea of sustainable development in an international effort to address problems emerging from the separation of environmental and economic policies. Sustainable development was proposed as a strategy for development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, 8). Throughout its report the term is used in reference to the linking of ecological and economic systems to prevent further degradation to existing processes and components and to facilitate the goal of economic growth.

The recent interest in sustainability is a direct result of the endorsement of sustainable development by the World Commission on Environment and Development. Although various aspects of these concepts have been embraced under other terms such as "stewardship", or "conserver society", originating from the field of natural resource management, as well as from environmental and development movements, the WCED has achieved international recognition for its emphasis of the importance of addressing global sustainability. Further interest in the development of world-wide cooperation on sustainability issues resulted in the United Nations Conference on Environment and Development in Rio de Janeiro in 1992.

2.3 Criticisms of Sustainable Development

Since the publication of the Brundtland report, there has been considerable debate over the definition of sustainable development and the role of economic growth in its implementation. Many believe that the concept of sustainable development is an oxymoron, insisting that perpetual economic development, when interpreted as growth, can never be sustainable since the Earth has a finite supply of resources (Rees 1989). The social and environmental goals of a sustainable existence, one that indefinitely nourishes and perpetuates life, may be irreconciable with the requirements of long-term economic growth (Engel 1990, 10).

The WCED (1987) supports new growth on the first page of its report:

> We see instead the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base. And we believe such growth is absolutely essential to relieve the great poverty that is deepening in much of the developing world.

The WCED endorsement of continued economic growth has sparked controversy as adoption of this policy may preclude global goals of environmental stewardship and social equity. Those who perceive "sustainable development" as a contradiction of terms, maintain that the promotion of development in terms of economic growth actually reduces the ability to live sustainably (Rees 1989). In fact, a more equitable distribution of resources may require that those who already benefit from the use of a wide range of resources may have to reduce their consumption to enable others to merely survive. This requires a reduced consumption of many of the goods that western societies take for granted, and contradicts mainstream conservative ideas of development, which have been interpreted to mean the accumulation of wealth through continued economic growth.

Daly and Cobb (1989, 71) address the problematic juxtaposition of the two terms in sustainable development, but endorse the use of this phrase, emphasizing that "development" should be distinguished from "growth". Costanza and Daly (1991, 43) concur, emphasizing the qualitative nature of the former and the quantitative focus of the latter. They explain that an improvement in human welfare can occur by pushing more matter-energy through the economy or by squeezing more human satisfaction out of each unit of matter-energy used. Growth is viewed as a throughput increase that is destructive of natural capital or the stock of natural resources, while development constitutes an efficiency increase that does not degrade the integrity of the resource base.

Due to the ambiguity surrounding the meaning of sustainable development, there has been some skepticism regarding whether this concept represents any real change in approach to the conservation of resources or distribution of wealth. Boothroyd (1991a, 286), in his review of the sustainable development debate, calls the WCED support for renewed economic growth a classic compromise:

> It listed the problems identified by the ecologists and came up with a solution that would comfort the economists: more growth.

Although the Brundtland report clearly indicated the extent of environmental problems that we face currently, and suggested that significant institutional and legal changes are necessary, it has been criticized for its support of continued economic growth and its assumption that wealth will trickle down from the profits of the affluent to those who earn lower incomes:

> While the WCED does recommend some major, and appropriate, social reforms, it avoids the call for a re-evaluation of development by economic growth - undoubtedly because the kind of social reorganization this requires would be unpalatable to the captains of the industrialized minority. (Gardner and Roseland 1989a, 30)

This type of criticism has stimulated much deliberation about how to ensure that development is socially, and not just ecologically, sustainable.

The concept of sustainable development, although clouded by controversy, raises some very difficult but important questions related to the distribution of power and the sharing of resources. These questions form the base of many current resource use conflicts and are integral to making equitable decisions. As the linkages between resource management and social equity concerns become more evident, the pursuit of sustainable development may lead to integrated long-term cooperative approaches to determining the appropriate and acceptable distribution of resources.

2.4 The Evolving Concept of Sustainability

To avoid the complications surrounding the meaning of sustainable development, there is an increasing tendency to examine the concept of "sustainability", a term gaining favour due to its emphasis on the idea of living in harmony with the limits of one's surroundings, without the complication of the various interpretations of "development". The following are examples of recent definitions that reflect the current emphasis on sustainability:

> "the existence of the ecological conditions necessary to support human life at a specified level of well-being through future generations" (Lélé 1991, 609)

> "the persistence over an apparently indefinite future of certain necessary and desired characteristics of the socio-political system and its natural environment" (Robinson et al. 1990, 39)

> "a relationship between dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems, in which: (a) human life can continue indefinitely; (b) human individuals can flourish; (c) human cultures can develop; but in which (d) effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system" (Costanza 1991, 85)

The first definition is a simple representation of the predominant theme of sustainability and refers to the perpetuation of systems necessary for survival. The second definition focuses on the need to consider long time-frames, and emphasizes the persistence of social systems. The third definition reinforces the concept that sustainability is a process and recognizes the importance of qualitative development and ecological constraints on economics. While the recognition of ecological limits has been a central theme in the development of the concept of sustainability, discussions of sustainability have since evolved to embrace concerns regarding social equity, and the fundamental assumptions upon which our economic systems and, hence, the allocation of resources are based.

The following discussion summarizes some of the key issues addressed by the concept of sustainability. Since this topic is often characterized as comprised of three aspects - ecological, social and economic sustainability (Brown et al. 1987, Shearman 1990, BC Round Table 1992), the most significant attributes of these three perspectives are described according to the recurring themes of carrying capacity, social equity, and ecological economics.

2.41 Carrying Capacity

The central theme to sustainability is the idea of living within certain limits, and this is usually understood as ecological limits. The ecological concept of carrying capacity is often referred to when discussing sustainability, implying that there are physical, chemical, and biological factors that limit the extent to which an area can support life. By adhering to these natural constraints it is believed that a steady state system or ecological stability, may be achieved.

Since many communities are now consuming resources from outside their land base and producing waste at rates greater than its land can absorb, many large urban centres are "artificially" extending the carrying capacity of the land they occupy. Rees (1993) has undertaken research to determine what he calls the "ecological footprint" of human activities. He estimates that if the whole world consumed resources and produced waste at the same rate as Vancouver, it would require two "phantom planets" to satisfy worldwide needs. Rees' work has important implications for sustainability as it raises questions concerning the allocation of resources, the efficiency of resource use, and the assimilative capacity of a region to accomodate its generation of waste.

The idea of biodiversity is included under the rubric of sustainability due to the recognition that all species deserve respect for their living conditions regardless of their use to humanity, and also due to the wide range of functions that living organisms perform as part of human life support systems (IUCN/UNEP/WWF 1991, 28). The preservation of a wide diversity of species ensures ecosystem stability as a rich variety of species allows an ecosystem greater adaptability to change, and therefore better long-term resilience. Biodiversity is now widely perceived as being a critical element in ensuring sustainability (WCED 1987, 147; Gadgil 1993).

2.42 Social Equity

One of the newer concerns being addressed by the concept of sustainability is that of social equity. Sustainability is now being used to describe the need to ensure intergenerational equity, the idea that future generations should have sufficient resources to meet their needs; as well as intragenerational equity, the equitable distribution of resources between different groups or societies existing currently. Even if present generations are capable of living within the ecological limits imposed by our common pool of resources, the misallocation of resources between nations or interest groups may jeopardize sustainability in the immediate future.

Intergenerational equity is viewed as a fundamental component and an overriding ethic of sustainability, yet economic practices in pursuit of economic growth favour the current generation, and may jeopardize opportunities for future populations (Toman 1992, Dovers 1990). For example, the economic practice of discounting is justified by the assumption that people prefer current benefits over those received in the future, and results in the exploitation of natural resources for the benefit of those living in the present. This contradicts one of the central themes of sustainability, that present decisions should not impair the prospects of future generations to maintain or improve their living standards (Repetto 1986, 15). As well as maximizing the benefits of present consumers through inadequate consideration of the welfare of future generations, and questionable value judgements regarding the selection of an appropriate discount rate, discounting also favours human development over the well-being of other species (Daly and Cobb 1989, 155).

In addition to the consideration of equity issues between generations, many of those attempting to give meaning to sustainability believe that its mainstream interpretation has not addressed intragenerational equity issues adequately. In any community or political jurisdiction, decisions must be made regarding what is to be sustained, by and for whom, and for how long. These questions conjure up a wide range of equity issues, in particular, who should be given the authority to make these decisions.

Gardner and Roseland (1989a, 29) emphasize that true equity depends not only on the sharing of wealth, but also of power. They believe that principles of equity and social self-determination depend largely on control over fundamental natural resources (Gardner and Roseland (1989b, 43). As central governments have not made the fundamental changes that are needed to ensure equitable development, changes may be more effective at the grass-roots level (Durning 1989). Comanagement arrangements and community land trusts are presented as models of community-based resource management systems that incorporate equity in their operations (Gardner and Roseland 1989b; Hilts and Mitchell 1993; McGonigle 1990).

2.43 Ecological Economics

Since economics has been developed as the study of the production, distribution and consumption of goods and services, it is only appropriate that sustainability should be incorporated in this discipline. The recently evolving field of ecological economics is beginning to address concerns related to economic development limits which have relevance for sustainability.

Much of the substance of ecological economics is based on a criticism of neo-classical economics. Ecological economists emphasize the need to recognize constraints imposed by ecological processes in economic evaluation. They insist that although many resources are renewable, a resource base is finite. The rate of regeneration of a particular resource may be slower than desired by its consumers, and alternative goods may not satisfy needs to the same extent. Repetto (1986, 16) uses accounting terms to express this ideology, stating that natural resources should be managed so that society lives off the dividends of resources, ensuring that the resource base is maintained as an asset for future generations.

Daly and Cobb criticize many of the fundamental principles of economics in "For the Common Good" (1989) beginning with a discussion of the fallacy of misplaced concreteness in the discipline of economics. They explain how the extensive use of abstraction has enabled this study to ignore social and environmental concerns by deeming anything that doesn't fit economic theory to be an "externality" (Daly and Cobb 1989, 34-37). They argue that the development of economic markets has failed to serve the common good due to emphasis on efficiency, and not justice or sustainability (Daly and Cobb 1989, 35-61). The measurement of economic success has focused largely on using indicators of market activity rather than economic welfare (Daly and Cobb 1989, 62-84).

In the first volume of the journal Ecological Economics, Ehrlich (1989, 10) criticizes economics for having operated under the assumption that humans can satisfy their needs from an unlimited supply of natural capital. He argues that they have overemphasized the ability to substitute one resource for another to avoid scarcity, and believes there are many indications that opportunities for substitution are really quite limited.

The recognition of the importance of environmental limits and social preferences may contribute greatly to the study of economics. As sustainability relies on the capability of a resource base to endure, as well as a more equitable distribution of resources (Gardner and Roseland 1989a, Boothroyd 1991b), there is a need to accommodate these concerns in economic analysis. Ecological economics should assist in the provision of information towards a more sustainable economic system.

2.5 Sustainability in Policy Making

The concept of sustainability is currently being interpreted and adopted in policy making in British Columbia and throughout the rest of Canada. The stimulus for consideration of sustainability has arisen from the global commitment to sustainable development, as embraced by the WCED. Canada's contribution to the pursuit of this goal is summarized in The Green Plan. The development of this national plan as well as the establishment of various federal, provincial and municipal policy advisory groups, such as the National, and British Columbia, Round Tables on the Environment and the Economy, represent major efforts to integrate evolving ideas about sustainability in public sector decision making.

Although sustainability and sustainable development are often used interchangeably to represent similar ideas in policy making, some groups have made a concerted effort to distinguish their mandate as being the former rather than the latter. Evidently, this is due to the fact that the concept of sustainable development remains firmly linked to the idea of economic growth (Standing Committee on Energy, Mines and Resources 1993, 32). The BC Round Table prefers to address sustainability rather than sustainable development, as this group believes that the former provides "a clearer message" (BC Round Table 1992, 11). This preference to examine sustainability is shared by various other policy groups in British Columbia, and is evident in workshop discussions, policy statements and reports.

Regional and local round tables are also engaged in the interpretation of sustainability. There are over thirty of these community or region-based initiatives underway in British Columbia (Leach 1993). Local round tables are characterized by having a broad mandate to address sustainability through their multi-stakeholder, consensus-based and continuing nature (BC Round Table 1991, 4). The Fraser Basin Management Board (FBMB) is an example of a watershed-based round table operating throughout a large region in British Columbia. The FBMB has adopted a vision of "sustainability together," referring to the development of a management program "that will balance environmental health, economic renewal and community viability throughout the (Fraser) Basin" (Fraser Basin Management Board 1993, 5). This watershed board was established in 1992 and may serve as a model for future round tables in river basins.

2.51 Environmental, Social and Economic Sustainability

The necessity to examine the relationships between the environment, society and the economy is a common theme among those seeking to interpret sustainability. The National Round Table

(1990, 6) states that a sustainable society "is one that is sustainable in environmental, economic and socio-political terms." The BC Round Table (1992, 15) refers to the same three aspects of sustainability and warns that they are on a collision course. A similar view is expressed by the federal and British Columbia governments (1993, 2) in the State of the Environment Report for British Columbia:

> An appropriate ecological perspective on sustainability starts with a view of the whole and an understanding that the environment, society and economy are part of a mutually supporting system. All of the elements in the system are interdependent. Removing or altering even one, can have serious complications for the whole system.

The desire to integrate environmental, social and economic systems in decision-making is a natural extension of ecological thinking. As the links between human activities and the environment become more evident, the need to understand the interactions between various elements in one system and their consequences for those of another, is important. Decisions based solely on economic criteria avoid the reality of their consequences for components of social and environmental systems, and ignore the fact that living organisms often behave according to natural processes or values that may not be addressed by economic theory. If not adequately considered, ecological processes or social organizations (i.e. interest groups) may even cause deliberate or unintentional adverse effects on economic policies; whereas, their inclusion in planning presents opportunities for the enhancement of relationships between elements and whole systems.

The common effort to link the environment, society and the economy has resulted in an increasing interest in the development of indicators of sustainability. The idea of establishing indicators to measure progress towards sustainability arises from the realization that better information is needed for comprehensive decision making. Although economic indicators are already widely established and accepted, there is a lack of commonly accepted comparable measurements to represent environmental and social conditions. While units of economic systems, such as currency, are consistent within Canada, environmental and social units of measurement vary regionally or locally, making them difficult to compare and evaluate. Policy makers believe there is a need to develop indicators that are meaningful and consistent to monitor key changes and trends (British Columbia and Environment Canada 1993, 4).

2.52 Shared Decision Making and Sustainability

Shared decision making is another recurring theme identified by many in their examination of sustainability. While there has been an increasing interest in involving the public in decision making during the last two decades, participation in the context of sustainability is evolving even further, embracing ideas of direct citizen control. This represents a greater recognition of the public and interest groups, beyond the idea of mere consultation through the generally accepted process of public hearings. The endorsement of greater degrees of public participation in policy-making represents a significant departure from past practices that relied on representative democracy, restricting the direct involvement of citizens (Tester 1992).

Individuals, groups and communities are seeking processes that give them greater control over decisions affecting community sustainability. Community development planning through local round tables and public forums on future community visions enables members of communities to contribute to decisions that suit community interests, not just those that satisfy provincial policies or shareholders of distant corporations or urban centres. As stated by The Greenprint for Canada Committee (1989, 7), a coalition of Canadian environmental, conservative and aboriginal communities, in its recommendations for a federal environmental agenda:

> Local communities must always have a say in economic decisions that directly affect their lives. The voices of people most vulnerable to the adverse environmental impacts of resource extraction must especially count.

Policy makers recognize the desire for greater public participation in decision making and are taking steps to incorporate greater involvement by geographic/local communities, First Nations and interest groups. The concept of empowerment of stakeholders in decision-making is especially evident throughout those addressing sustainability in British Columbia. The BC Round Table recommends that participatory and consensus-based decision-making processes be included as part of provincial planning (BC Round Table 1993, 21). In developing a provincial land use strategy for British Columbia, the Commission on Resources and Environment (CORE) has decided that its mandate is best fulfilled through the concept of consensus or shared decision making (CORE 1992, 25). The Fraser Basin Management Board consists of multiple stakeholders operating on consensus-based decision making, and coordinates cooperative management to ensure sustainability in the Fraser Basin (Fraser Basin Management Board 1993, 4).

2.6 Sustainability and Hydroelectric Development in Canada

Early hydroelectric project planning in Canada focused primarily on engineering and geotechnical issues, neglecting socio-economic and environmental concerns (Day and Quinn 1992, 177). Large power projects were celebrated as engineering marvels that would facilitate higher standards of living and create new recreational opportunities around reservoirs (Halleran

1974). There was little environmental assessment or public debate about the advantages and disadvantages of water resource developments until the 1970s (Day and Quinn 1992, 19).

Canada encouraged the construction of large dams as part of its investment in energy megaprojects during the 1960s and 70s (Douglas and Battle 1983, 27). The large-scale development of water resources was stimulated by increasing demand for electricity related to post-war affluence and government policies favouring low energy prices (Brooks 1981, 22). Dams were built on the assumption that they would be beneficial to society as a whole (Baxter and Glaude 1980, 24), and were rationalized by economic criteria.

Although some of Canada's first dams were financed privately, the large-scale nature of later projects required a similar scale of funding, and public sector utilities were established to regulate hydroelectric development (Dorcey 1986, 482). Since dam-building was a relatively new technology in this country, provincial electrical utilities were faced with learning from experience. Emphasis on economic expansion goals overshadowed the evaluation of environmental and social concerns (Dorcey 1986, 482).

Public expenditures on large water resource projects were justified through the utilitarian principles of cost-benefit analysis. Since hydro development projects require large reservoirs for water storage, the expropriation of land and the forced relocation of previous valley residents have been justified in terms of the greater electricity benefits received by society. This reasoning is based on the utilitarian assumption that when benefits from public use of property exceed those from private use, expropriation will increase societal welfare (Schwindt 1992, 21).

While cost-benefit analysis provides a mechanism for comparative analysis of different project proposals, it is primarily concerned with economic efficiency, and has been widely criticized due to the difficulties associated with the evaluation of environmental costs and benefits, and for its inability to address distributional issues (Swartzman 1982, 53; Riek 1987; OECD 1992, 33-34). Although the Pareto improvement principle implies that the "winners" of a cost-benefit evaluation should redistribute some of their gains to the "losers," this case for compensation is usually hypothetical and compensation is not actually paid (Trumbull 1990, 207) or is rarely sufficient to cover the losses incurred.

The construction of hydro projects has uprooted people from their homes and disrupted communities in valleys designated as future reservoir sites. Hydro development along the St. Lawrence Seaway during the 1950s flooded 20,000 acres, eliminated eight communities and dislocated 6500 people, causing much bitterness among previous residents (Bocking 1972, 69). Cheslatta Band members living along Alcan's Kemano spillway route in northern British Columbia were forced to relocate in 1952 and "for a time lost all dignity and succumbed to despair and alchohol" (Carrier Sekani Tribal Council 1985). The rapid influx of workers to Hudson's Hope overloaded local health and social services during construction of the Bennett Dam (Pollon and Matheson 1989).

Although the effects of displacement and disruption of communities adjacent to dam sites were experienced almost immediately, many long-term environmental impacts were not appreciated fully until many years after dams were in operation. As the scale of Canadian hydroelectric projects increased, society became more concerned about the consequences of these large-scale developments (Day and Quinn 1992, 19). The ecological effects of large hydro projects were examined and subjected to public review through the establishment of environmental assessment processes. Although dam builders became familiar with some general kinds of impacts, their implications for sustainability only became evident some years later.

2.61 Environmental Impacts of Dams

Canadians first became aware of the environmental impacts of large dams in Canada as a result of the W.A.C. Bennett Dam and its consequences on the Peace-Athabasca Delta, several hundred kilometres downstream. In 1971, the governments of Canada, Alberta and Saskatchewan initiated an interdisciplinary study of the impacts of the Bennett Dam, constructed in 1968. The Peace-Athabasca Delta Project Group concluded that the regulation of water flow on the Peace has interrupted the normal flooding cycle of the river as it flows through the Delta, disrupting the lives of the wildlife and people that depend on one of the few remaining wetland deltas on the continent. Previously, hydrological and ecological processes maintained a delicate balance for plant and animal life through seasonal water level fluctuations (The Peace-Athabasca Delta Project Group 1972).

The examination of environmental and socio-economic impacts of dams was initiated through the development of environmental assessment processes. The impacts of federal projects were required to be considered according to the establishment of the federal Environmental Assessment and Review Process (EARP) in 1973. According to EARP, federal departments are required to assess the consequences of their decisions during early project planning stages, and the identification of significant impacts or public concern may lead to a referral for a public review by an environmental assessment panel (Federal Environmental Assessment Review Office

1987). The first federal public review of a hydro development project was at Wreck Cove on Cape Breton Island and was completed in 1976.

Provincial environmental assessment has lagged behind federal processes. Throughout the late seventies, the primary opportunity for public review of a hydro project in British Columbia was through a hearing initiated by the Water Comptroller in consideration of an application for a water licence under the Water Act (Dorcey 1987, 18). The Environment and Land Use Committee developed an assessment process and conducted its first review of a BC Hydro dam proposal on the Pend d'Oreille River in 1974. There was no comprehensive legislation for environmental assessment until the establishment of the Energy Project Review Process (EPRP) in 1980. The scope and procedural aspects of public hearings to address environmental issues were strengthened under the EPRP, resulting in the first rejection of a B.C. Hydro proposal (Site C on the Peace River) by the provincial government, in 1983 (Missler 1988).

In light of increased public concern arising from hydro projects on the Peace and Churchill Rivers, and around James Bay, Baxter and Glaude (1980) reviewed the environmental effects of Canadian dams and reservoirs, focusing on how hydro development has affected aquatic ecosystems. This national survey summarized Canadian experience with impacts according to the following general categories: effects of flooding and pre-clearing of vegetation; problems related to water level fluctuation in the reservoir drawdown zone; effects of impoundment on water quality; erosion, sedimentation and modification of the new shoreline; downstream effects of changes in flow regime; impacts of impoundments on fish populations; seismic activity induced by impoundments; climate effects of impoundments; impacts of infrastructure construction; and effects of impoundments on humans.

Although Baxter and Glaude did not discuss any effects of the damming of the Columbia River, they provided a thorough description of many of the environmental consequences of Canada's major hydro developments documented prior to 1980, and suggested that the general impacts of dams were reasonably well understood. However, they advised that the site-specific nature of environmental impacts prevents accurate prediction for any one hydro project and concluded,

> A combination of ecological understanding and sympathetic consideration of the feelings and aspirations of the people likely to be affected should go a long way towards the prevention of undesirable environmental and social consequences of the further development of Canada's water resources. (Baxter and Glaude 1980, 26)

Berkes (1988, 207) has examined many of the environmental and social impacts of hydroelectric development at James Bay, and concludes that Baxter and Glaude were premature in declaring that the consequences of dams were well understood. He states that five of the six major impacts of concern to local Cree communities were not predicted correctly, and maintains that the success of impact prediction for major hydro dams in Canada has generally been low (Berkes 1988, 217).

The impoundment of large areas of water has caused several long-term effects that have only become significant some years later. Although Baxter and Glaude had dismissed evidence of elevated mercury concentrations in fish in the Smallwood Reservoir of Labrador and in the Southern Indian Lake in Manitoba, the accumulation of mercury in fish has been a major concern around James Bay, resulting in the closure of fisheries in La Grande reservoirs (Berkes 1988, 208). Although mercury levels in La Grande reservoirs peaked within the first five years of inundation, it is now generally believed that mercury concentrations should return to baseline conditions within 20 to 30 years, although ongoing studies will reveal whether continuous erosion of organic material will maintain elevated levels of toxicity (Day and Quinn 1992, 139). According to Hydro-Québec (1992, 26),

> The significant increase in mercury levels in fish, resulting from the release of methylmercury in the new reservoirs, has proved to be the greatest environmental impact of the La Grande Rivière development.

The recent suggestion that reservoirs may contribute to accelerated global warming is another example of how large-scale flooding may cause long-term disturbances to ecological processes. Current research indicates that the inundation of forested land may contribute to "greenhouse gas" emissions since bacterial decomposition and methane production have been found to occur much faster after sediments are flooded (Environment Canada 1993, 1). Estimates of fluxes of carbon dioxide and methane per unit of energy produced may be as significant as similar emissions from fossil fuel electricity generation (Rudd et al. 1993).

Throughout the study of environmental impacts of hydroelectric development in Canada, it is evident that aboriginal communities have experienced a large portion of the environmental impacts of hydro dams (Sykes 1973, 22; Berkes 1988; Day and Quinn 1992, 20). Aboriginal societies are particularly vulnerable to the impacts of hydro development as traditionally they have been closely linked with the land and dependent on its resources (Baxter and Glaude 1980). Although Hydro-Québec maintains that Phase I hydro development of the La Grande complex has not upset the ecological balance of northern Quebec (Hydro-Québec 1992, 3), Cree hunters have noted a reduction in their wildlife harvests from the La Grande valley since 1979 (Berkes 1988, 209) and bioaccumulation of mercury has been detrimental to those who depend on local fish for food (Day and Quinn 1992, 140). Flooding related to the Bennett Dam has caused fish and wildlife losses in the Peace River area, particularly significant for the Saulteau band, since ninety-five per cent of its members live off the land (Cameron 1991, 5).

2.62 Hydro Dams and Resource Use Conflicts

While a substantial amount of knowledge has been gained regarding the predictability of the biophysical impacts of dams, there has been no effort to evaluate the effects on resources or the trade-offs experienced by various resource users affected by hydro development (Day and Quinn 1992, 178). The operation of a large hydro dam on a river system results in the domination of water rights by a single user, most often a provincial utility managed to satisfy the demands of distant power needs. This leaves previous users of the river and its surroundings with little or no ability to use resources or participate in water use decisions. Community values are underestimated and deemed to be worth less than the benefits derived from regulation for power generation or other priorities of a larger society.

Day and Quinn explain that the identification of environmental impacts has been addressed through mitigation and compensation, and resolved after receiving project approval. They provide the following words of caution:

> Questions of the sustainability of interacting environmental components, and human populations dependent on them have consistently been ignored. These areas require serious consideration in the future. (Day and Quinn 1992, 178)

In addition to losing fish and wildlife, and the socio-economic problems associated with this loss of food, income and livelihood, communities near dam sites often experience unanticipated changes in access to resources due to ongoing hydro operations. For example, access to traditional Cree hunting territories has been disrupted by Hydro-Québec's La Grande dam complex. Crees lost access to hunting territories across the lower La Grande during late winter and spring when higher flows of warmer water prevented the formation of ice, which had formerly provided a safe way across the river (Berkes 1988, 211). Road construction has increased access to Cree hunting territories, causing the overexploitation of some wildlife and the partial breakdown of the family-based traditional hunting territory system.

Although environmental impact assessment activities such as public hearings have improved opportunities for public participation in public sector decision-making, processes such as the federal EARP have been criticized, among other things, for their narrow scope, limited public participation and advisory nature (Tester 1992, 38; Bowden and Curtis 1988, 101; Rees and Boothroyd 1987, 4). In many cases, environmental assessment has occurred after critical project decisions have already been made. Although La Grande and Churchill-Nelson hydro projects were subjected to some degree of assessment, this evaluation occurred after project decisions to proceed (Day and Quinn 1992, 19).

While hydro dams are promoted as a means of generating economic benefits, they have also been responsible for increasing national debt (Schrecker 1984, 5; IUCN et al. 1991, 137; Day and Quinn 1992, 179). Hydro projects require extensive capital investment, which is usually borrowed internationally. Since building costs frequently exceed initial estimates, electrical utilities become trapped in spiralling payments as they must sell more energy to repay debts, build more to sell, and borrow to build. The opportunity cost of hydro megaprojects is substantial when the actual costs of its completion are compared to initiatives where the same capital could be more efficiently invested elsewhere (Schrecker 1984, 4).

Since the late 1980s, there have been a growing number of conflicts related to the development of hydroelectric resources across Canada and the inadequate consideration of environmental and socio-economic consequences by federal and provincial governments. Governmental reluctance to review the impacts of dams such as Rafferty-Alameda in Saskatchewan, the Oldman Dam in Alberta, and James Bay hydro dams in Quebec, and a British Columbia court order specifically exempting the Kemano diversion project from environmental review, have generated public concern over questions of equity for those impacted by project construction (Tester 1992, 39; Day and Quinn 1992). Frustrated with the federal government's lack of enforcement of its EARP guidelines, environmental groups, aboriginal organizations and individuals have initiated an unprecedented number of court challenges to hydro development proposals resulting in substantial delays and additional costs to dam proponents (Robinson 1993). The Cree have been so successful in conveying the extent of their losses from James Bay hydro projects that New York State cancelled its proposed purchase of electricity from Hydro-Québec (McKenna and McNish 1992).

Public opposition to large dam projects has resulted in the strengthening of federal and provincial environmental impact assessment legislation. The 1989 Rafferty-Alameda decision by the Federal Court of Canada ruled that the EARP Guidelines Order was binding and not discretionary as previously assumed, and has precipitated the introduction of the Canadian Environmental Assessment Act. This legislation is undergoing amendments and may clarify federal responsibilities when enacted. British Columbia has recently introduced a bill to combine its three existing processes (the Energy Project Review Process, the Mine Development Assessment Process, and the Major Project Review Process) into comprehensive environmental assessment legislation (Cashore 1993, 1).

2.63 Hydro Development and Resource Stewardship

After several decades of experience with large dams in Canada, it is evident that the myriad of problems related to the construction of hydroelectric megaprojects are fundamentally a result of our system of resource stewardship. This assertion is clearly stated by Day and Quinn (1992, 177) in their evaluation of Canadian experience with hydroelectric development:

> At the heart of the problem is the current system of resource governance. Canadian water management has for too long been based on elitist, secretive, and closed decision-making systems which are marred by interjurisdictional rivalries and lack of cooperation among federal, provincial, regional and local actors.

Lee (1989) expresses a similar opinion, insisting that the issue of governance must be addressed if the concept of sustainability is to be taken seriously. This conclusion results from an examination of fish and wildlife enhancement initiatives that have been launched by the Northwest Power Planning Council to mitigate the impacts of large-scale hydro development on the American portion of the Columbia River. Lee asserts that sustainable development can only occur when institutional arrangements are able to balance the complexity of human and economic objectives with natural boundaries and biological rhythms.

The control over natural resources is identified as being critical to the sustainability of communities that depend on a continuing supply of local resources. When decision-making power over resource exploitation is concentrated in the hands of a few, the stability of resource-dependent settlements may become jeopardized, as explained by McGonigle (1990, 81) with particular reference to British Columbia, using a quote from a native/environmental conference:

> Most of the land use conflicts that native peoples and environmentalists have been involved in are a reflection of a certain kind of political-economic system which encourages uncontrolled, widespread and short-term exploitation of natural resources - a process carried out in British Columbia by large corporations and facilitated by government policy and administration. In economic terms, it represents wholesale liquidation of natural resources capital, and the diversion of the profits into the hands of a few. (Anonymous 1989)

Although the exploitation of natural resources may jeopardize the integrity of a resource base for future generations, environmental degradation may occur because people lack options (Repetto 1988, 2). People may choose to persist with unsustainable harvesting practices because they have inadequate knowledge, resources, property rights or other basic institutions to make decisions that would ensure their long-term access to natural capital. Effective management of resource systems requires remedies to provide opportunities to address the market and policy failures that have led to the liquidation of natural capital.

2.64 Local Control of Resources and Shared Decision Making

Greater local participation in resource use decision making is seen as the solution to problems stemming from the centralization of resource use decision making (Bromley, 1989, 56; McGonigle 1990, 80; Pinkerton 1991). Empowerment of local individuals and authorities to manage their resources has been endorsed for the following reasons: local people may have a greater long-term interest in ensuring the continuation of their resource base than external commercial enterprises that come and go (IUCN et al. 1991, 58); local knowledge of natural history and resource harvesting concerns provides inexpensive and useful information, as documented in the study of co-operative management of fisheries (Rettig, Berkes and Pinkerton 1989, 285); and meaningful public involvement in resource decision making results in a higher level of public satisfaction with management outcomes, as substantiated by research on community forestry initiatives (Duinker et al. 1991, 134).

While Canadians are generally demanding greater participation in environmental issues (Tester 1992, 40), British Columbia appears to be at the forefront of a movement towards more participatory resource management decisions. The traditional approach of managing resources by statutory decisions has not worked effectively (CORE 1992, 25), so the government of British Columbia has initiated several new processes to encourage shared decision making. This concept of shared decision making has been interpreted to mean that,

> "... those with authority to make a decision and those who will be affected by that decision are empowered to jointly seek an outcome that accommodates rather than compromises the interests of all concerned .... The cornerstone of a shared decision-making process is its cooperative, problem-solving approach." (CORE 1992, 25)

British Columbia has established a number of multi-stakeholder shared decision-making initiatives during the 1990s to address resource use conflicts occurring in the province: the BC Round Table has been given the mandate to examine and advise on sustainability and its implementation in provincial policy-making; the Fraser Basin Management Board was created to address the management of resources within the Fraser River drainage basin; and the Commission on Resources and Environment (CORE) has focused on developing land use plans for the resolution of resource use conflicts in specific valleys designated by the province. These advisory groups are comprised of a wide range of members including representatives of First Nations, environmentalists, industry, municipalities, and the provincial government.

In the Pacific Northwest, multi-stakeholder institutions have been established to mitigate the effects of hydro power development on the American portion of the Columbia River through the Pacific Northwest Electric Power Planning and Conservation Act (1980). The Northwest Power Planning Council, formed as a result of an interstate agreement, has the authority to bind federal agencies by its decisions and is comprised of two appointees from each of the four states of the Pacific Northwest (Washington, Oregon, Idaho and Montana). In 1982, the Council established a Columbia River Basin Fish and Wildlife Program, which coordinates a wide variety of American interests in Columbia River resources including 11 state and federal agencies, 13 tribes, 8 utilities and numerous interest groups (Lee 1989, 11). The goal of the program is to double salmon production in the basin without losing biological diversity (Northwest Power Planning Council 1992, 17).

Co-management has been viewed as an integral part of achieving community self-government and is key to the implementation of environmentally sustainable and culturally appropriate economic development (Berkes et al. 1991, 3). The concept of co-management has developed around common property resources, such as fisheries and forests, that are susceptible to exploitation by individuals, corporations and state agencies (Pinkerton 1993, 37) and combines elements from local and state management systems.

> Co-management arrangements in general involve genuine power sharing between community-based managers and government agencies, so that each can check the potential excesses of the other. (Pinkerton 1993, 37)

Co-management reinforces self-reliance and local stewardship of resources, and enables local ecological knowledge and cultural traditions to be included in resource management plans. Many of these ideas have been supported by community economic development (CED) enthuisiasts who seek to take some degree of control over the local economy back from the markets and the state, recognizing that communities may desire to manage resources to achieve a broad range of community goals (Boothroyd and Davis 1991, 1).

> Co-management thus goes hand-in-hand with CED as an integrated community strategy to use limited local resources more efficiently by redirecting the benefits locally under local control, rather than mortgaging the resource base still further to the extractive needs of external, large-scale economic interests. (McGonigle 1990, 79)

Berkes and Feeny (1990, 53) believe that some of the best examples of co-management have arisen with respect to the management of resources around James Bay, a region that has experienced a wide range of impacts as a result of a series of large hydro projects. Aboriginal people have traditionally managed resources communally, and this practice has been acknowledged and protected through the 1975 <u>James Bay and Northern Quebec Agreement</u> (JBNQA), signed between the Cree, the Inuit, the governments of Canada and Quebec, and three Quebec crown corporations (James Bay Energy Corporation, James Bay Development Corporation, and Hydro-Québec). Although the Cree and Inuit signed the JBNQA under pressure from the hydroelectric project construction schedule,

> This changed them, almost overnight, from being complete outsiders to the resource decision-making process, to being co-equals with government resource managers in a formalized institutional structure. (Berkes 1989a, 191)

Hydro development plans in northern Quebec have set a precedent for establishing user group participation in resource decision-making in Canada (Berkes 1989a, 190). Berkes (1989a, 204) explains that what distinguishes James Bay co-management from other shared decision-making arrangements is the existence of a formal political agreement. The JBNQA represents the government of Quebec's resolution of outstanding land settlement issues relating to the extension of its boundaries in 1912, and was precipitated by provincial hydroelectric development plans for James Bay. Negotiations with aboriginal peoples began in 1972, were delayed by a successful court challenge of the hydro project initiated by the Quebec Association of Indians, and resumed when the Quebec Superior Court recognized the legitimacy of native land claims in the area in 1973 (Indian and Northern Affairs Canada 1992, 1).

The JBNQA has gone far beyond the settlement of land claims in its efforts to address aboriginal rights. The JBNQA defines the rights of Cree and Inuit regarding land ownership and management of resources, self-government, economic development, the administration of justice, health and social services and environmental protection. In fact, the birth of the Cree Nation, and its movement towards self-government through the establishment of co-management arrangements has been attributed to this agreement (MacGregor 1989, 274, 280; Day and Quinn 1992, 168).

2.7 Implications for Sustainability

Hydroelectric development has occurred without full consideration of the range of its consequences on ecological, social or economic systems. The generation of large supplies of electricity through the installation of dam systems has been promoted to stimulate economic development in remote areas, and to provide power for industrial centres. While the establishment of substantial and secure sources of electricity contributes to the welfare of energy consumers outside the hydro project area, the land use changes caused by the interruption of natural ecosystem processes in the vicinity of dam operations may affect the sustainability of local communities.

Although there was little concern for the ecological impacts of hydroelectric development in early dam project planning, increased interest in ecology and environmental impact assessment has led to the documentation of many of the impacts affecting aquatic and terrestrial ecosystems. While project planners are now familiar with many of the most common characteristics of dam-related disturbances, several long-term consequences, such as the bioaccumulation of mercury, and the contribution of gaseous emissions from reservoirs to global warming, have only been recognized years later. These impacts are a result of complex and cumulative ecological processes, and may be significant for nearby communities, as well as larger populations outside the river basin, whose sustainability relies on the integrity of certain fish species or a particular climatic regime.

The social implications of hydro development are less well understood. While post-project evaluations have addressed ecological consequences, contributing knowledge for future water resource planning, social issues have not been examined with the same thoroughness. Social impact assessment and common property resource theory have delved into this domain, enlightening policy-makers on ways in which hydro development has affected human behaviour and social interactions. However, much of this research relies on measuring the secondary impacts of how humans are affected by environmental changes, which may not be determined for a number of years, and requires asking difficult questions regarding the distribution of overall benefits and costs. The development of processes to include those people affected by dams in project planning and ongoing operations may increase awareness of sustainability issues through the sharing of local knowledge, and the questioning of the utilitarian assumption that maximizing the benefits of the greatest number of people justifies the losses of a few.

Dam projects have been promoted as being favourable for economic development. While they have stimulated local economies during construction periods, and have transmitted large supplies of energy for distant urban development, surrounding communities do not receive many long-term economic benefits from hosting hydroelectric projects. The flooding of forests, and fish and wildlife habitat, and related changes in resource use access, may significantly impair the economic sustainability of resource-dependent communities through degradation of the resource base and the related reduction of economic development opportunities. Compensation programs established to address environmental and social impacts represent an effort to redistribute the economic benefits of hydro projects, but have failed to provide sufficient compensation for the wide range of impacts experienced near dam sites. In addition, dam projects have caused some public utilities to incur substantial loans, increasing the debt load for all of society.

Resource use conflicts caused by the domination of hydroelectricity production over other uses of a common resource base have resulted in a variety of outcomes. Some situations have evoked considerable controversy and have been addressed through court actions (e.g., Rafferty-Alameda, Oldman, James Bay). A multi-stakeholder group has been established to address the diversity of interests around the American portion of the Columbia River. Co-management arrangements acknowledging aboriginal rights to resources in the James Bay region have combined local residents and government representatives in resource base decision-making.

The sustainability of communities which depend on the resource base affected by large-scale hydroelectric development is related to the ability of hydro project decision-makers to integrate ecological, social and economic factors in the regulation of water resources. The ability to integrate the various components and processes interacting between ecological, social and economic systems may be a function of a particular resource management regime. Institutional arrangements that emphasize shared decision making may offer new opportunities to improve conditions for sustainability for those who have borne the costs of dam-related impacts.

2.8 Sustainability as Defined in this Thesis

To avoid the confusion surrounding the meaning of sustainable development, this thesis examines the concept of sustainability, a term which is being used more frequently to describe the idea of living in harmony with the limits and opportunities of one's surroundings. Throughout most of this work the term "sustainability" is used to represent a goal to which communities and nations strive. "Sustainable development" is referred to as a process, framework or strategy to achieve societal goals. However, due to the tendency of people to use these two concepts interchangeably, the two terms may be mentioned within a different context, as defined by others.

The following definition is proposed for consideration throughout this thesis:

> Sustainability is a long-term societal goal to maintain and enhance quality of life through the balance of ecological, social and economic systems.

While many previous definitions of sustainability have emphasized the constraints imposed by biophysical limits, it is necessary to move beyond this somewhat "negative" approach to sustainability. For example, we are beginning to understand that the government decision to undertake large-scale flooding of land, causes the oxidation of mercury into a more toxic form, which bioaccumulates in fish, is consumed by humans, and results in health and related social problems, which may require substantial financial remedies (e.g., replacement of food sources, health treatment, loss of fishing and guiding income, and increased welfare costs). Although it is useful to recognize the limits exerted by one element or system on another, it is also important to seek the opportunities to enhance the quality of a system through the activities of another.

The consideration of sustainability could stimulate the creative use of resources that would open up possibilities for the appreciation of environmental, social and economic values. We may not yet be familiar with the idea of more cooperative community-based approaches to resource management that may enable the enhancement of one system to benefit another. An example might be the establishment of a community development corporation that pools common financial resources to stimulate local social initiatives to manage watershed resources sustainably (with other goals besides profit maximization).

This thesis examines various aspects of sustainability relevant to the hydroelectric development of the Columbia River Basin. A literature review of the history of hydroelectric projects provides a Canadian context within which to consider sustainability issues related to this type of energy development and land use change. A case study of the Kootenay region of British Columbia examines the chronology of significant decisions and events that have affected surrounding communities. A set of indicators of sustainability are suggested as a means of evaluating the ability of ecological, social and economic systems to enhance one another in support of life.

3. REGIONAL IMPACTS OF HYDROELECTRIC DEVELOPMENT IN THE COLUMBIA RIVER BASIN

> Dams built in the 1960s and 1970s brought considerable disruption to the lives of the people living in the region of the Columbia River Basin. People were displaced; land, farming, and forestry resources were lost; few permanent jobs and little financial benefit returned to the area once construction was finished. Meanwhile, the rest of the province benefited from the electricity created. The people of the Columbia River Basin region have long maintained that they were shortchanged in this regard. (B.C. Hydro 1993d, 18).

The Columbia River supports much of the life within the Kootenays region of southeastern British Columbia, and provides many resources for the American Pacific Northwest. It is the fourth largest river in North America in terms of its length, 1936 km, and flow, with extremes of 250 cubic metres per second (cms) and 10,700 cms measured near the American border. The waters of the Columbia travel 744 km from their source at Columbia Lake, high in the Canadian Rockies, before crossing the American border south of Castlegar, B.C., and continue another 1192 km through Washington, forming the border between Washington and Oregon, and emptying into the Pacific Ocean (International Joint Commission 1959, Mallette 1991, B.C. Hydro 1993f) (Figure 2).

The international drainage basin of the Columbia encompasses an area of 259,000 mi.^{2} (720,000 km^2) (U.S. Department of Energy et al. 1991, 5). Approximately 25% of the basin's total flow originates in Canada, draining an area of 39,500 mi.^{2} (64,800 km^2) north of the border. Eighty-five per cent of this watershed is situated in the United States. The major tributaries of the Columbia River are the Kootenay, also originating in British Columbia, and the Snake, which flows through the American Pacific Northwest region.

The Canadian portion of the Columbia River Basin flows through a mountainous region known as the Kootenays, a scenic area characterized by a series of north-south oriented valleys separated by high mountain ranges. This region has been classified as the southern interior mountains ecoprovince, spanning the Columbia Mountains to the north and the Rocky Mountains to the east, including the Monashee, Selkirk and Purcell ranges (Figure 5). The western slopes of these ranges receive substantial amounts of precipitation, and heavy winter snowfall. Dense conifer forests are common, although dry forests occupy southern valleys. High altitude terrain consists of alpine tundra and barren rock (British Columbia and Environment Canada 1993, 78).

The Kootenays region supports a population of 250,000 in five regional districts (Smienk 1993b), representing approximately 5% of the provincial total (British Columbia and Environment Canada 1993, 78). Residents of this area live in communities along river valleys, with development extending from regional centres at Cranbrook, Nelson, Castlegar and Revelstoke. The nine hundred members of the Ktunaxa/Kinbasket Tribal Council, comprising four Ktunaxa Bands and one Shuswap Band, live on five reserves on the Kootenay River near Cranbrook, Creston and Grasmere, and near the source of the Columbia River at Windermere and Invermere (Ktunaxa/Kinbasket Tribal Council 1992, 3). Many Italian, German and Doukhobour residents of the Kootenays migrated to this region during past mining, forestry and agriculture booms (British Columbia 1976, 36).

Communities within the Columbia River Basin have developed as a result of the extraction of regional resources. Since this region relies heavily on the harvest of wood and mineral resources, the extent of the resource base is extremely important, especially since much of the land is on steep mountain slopes or beneath rivers, lakes and reservoirs. Valley bottoms are highly desirable for timber production, wildlife habitat, farming, recreation and human settlements. Competing interests for the use of resources in these valleys have caused social conflict within and between communities. Tourism is being promoted as a means of economic diversification in an effort to moderate the susceptibility of resource-based economies to the cyclical swings of external commodity markets (B.C. Central Credit Union 1989).

The Columbia River Treaty, signed between Canada and the United States in 1961, has resulted in large-scale hydro development within the Columbia River Basin (Figure 3). In addition to existing structures on the Kootenay River, the construction of one American and three Canadian Treaty dams, as well as additional projects within the basin, have added significant flood control and power generating capacity to this international river system. With approximately 500 dams on the Columbia and its tributaries (Mallette 1991, 14), this river hosts one of the largest hydroelectric systems in the world, generating an average of 18,500 MW of electricity annually (U.S. Department of Energy et al. 1991, 6). Canadian Treaty projects play a key role in storing water due to their strategic position near the source of the river system.

The development of hydroelectric resources in the Kootenays has raised questions concerning the distribution of costs and benefits related to the large-scale generation of electricity. While the region receives some flood control and electricity supply benefits, the majority of Columbia River Treaty benefits have been experienced by power consumers in large urban centres in the Lower Mainland of British Columbia, and in the American Pacific Northwest. Dams along the Canadian portion of the Columbia River system now provide power generation capacity of approximately 5,000 MW, representing 50% of total provincial generation, yet local consumption accounts for only 12% of provincial electricity demand (B.C. Hydro 1993e) (Figure 4).

Hydroelectric development in the Columbia River Basin has affected the integrity of the regional resource base and continues to affect the lives of local residents. Local communities believe that they have borne an unfair amount of the costs of supplying energy to the rest of the province.

The following is a case study of hydroelectric development in the Columbia River Basin. It begins with a description of the methods used to examine the impacts of hydro development. The resource dependency of this region is outlined, and the relevance of the Columbia River Treaty is summarized. Impacts of hydro operations are described, and B.C. Hydro's policy response is reviewed. The formation of the Columbia River Treaty Committee is explained, providing a focus for further discussion of the consequences of ongoing dam operations. This section concludes with a summary of the major impacts of Columbia River Basin dams, as perceived by the residents of the Kootenays.

3.1 Methods

Multiple sources of information were used to collect data for a case study of the Columbia River Basin. The principal means of assembling evidence of the impacts of hydro development in this drainage basin included the following:

1. literature review on: sustainability, impacts of large dams, and the Columbia River Treaty;
2. direct observation of communities and dam sites in the Kootenays;
3. interviews with community members, government representatives and BC Hydro officials;
4. participant observation at meetings and public forums; and
5. development of indicators of sustainability.

The first approach to understanding hydro development and its significance in the Columbia River Basin was through a review of literature on related subjects. Recent interpretations of the concept of sustainability provided a framework for the consideration of hydro development and its impacts on ecological, social and economic systems. An examination of environmental impact studies related to the effects of large dams indicated the wide range and magnitude of consequences of hydro megaprojects. A review of the history of the Kootenays region and the politics of the Columbia River Treaty provided background information related to past and ongoing environmental, social and economic problems in the Kootenays region.

Observation of communities and dam sites in the Kootenays provided an appreciation of the preponderance of hydro dams and their implications for the sustainability of this region. Visits to the principal population centres gave a visual perspective of community development in the Kootenays. Human settlement and land use patterns were observed through trips along the narrow lakes contained within the steep mountain ranges of the Monashees, Selkirks and Purcells (Figure 5). Tours of dams and observation of their impacts on surrounding aquatic and terrestrial ecosystems provided information on dam operations and the nature and magnitude of their consequences for ecological systems.

Interviews with community members, government representatives and BC Hydro officials assisted in the interpretation of the significance of dam-related activities in the Columbia River Basin. Interviews were conducted with mayors, councillors and/or First Nations representatives of the following communities during three week-long visits during August, October and November, 1992: Castlegar, Cranbrook, Golden, Kaslo, Kimberley, the Ktunaxa/Kinbasket First Nation of the St. Mary's Reserve, Nakusp, New Denver, Nelson, Revelstoke, Rossland, Salmo, Silverton, Slocan, and Trail. These interviews provided an overview of the history of effects of large dams operating within the region and furnished additional local contacts. Community leaders facilitated introductions to regional planners, representatives of interest groups, and individuals with helpful information. A list of the interviews conducted is contained in Appendix 1.

Interviews with community members were semi-structured and revolved around the following subjects:

1. community development plans;
2. hydro projects near the community;
3. environmental, social and economic impacts of hydro projects; and
4. helpful contacts in the community.

Residents of the Kootenays were very eager to share information regarding the impacts of hydro development in their region. Many long-time residents remain bitter about issues related to the expropriation of land and the adequacy of compensation arising from the construction of Columbia River Treaty dams almost thirty years ago. Since many of these concerns have already been documented by Wilson (1973), Halleran (1974) and Wilson and Conn (1983) this study focuses primarily on the present and ongoing impacts of dam operations in the Kootenays.

Interviews with BC Hydro officials at dam sites and in the Lower Mainland clarified details concerning dam operations and the implications of the Columbia River Treaty. BC Hydro engineers and managers described dam activities during tours of the Mica, Revelstoke, and Hugh Keenleyside Dams on the Columbia, and of Kootenay Canal on the Kootenay River. Interviews with officials in Vancouver provided information on BC Hydro policy. Presentations made by senior managers at the "Columbia River Treaty Seminar" in Burnaby in November 1992, as well as at BC Hydro's "Sixth Annual Electric Energy Forum" in Victoria in May 1993 outlined hydroelectric system planning problems and their political significance.

Government representatives provided information concerning their involvement with the management of resources in the Kootenays, and provincial efforts to prepare for downstream benefits negotiations. Officials from the Ministry of Environment, Lands and Parks were especially helpful with respect to details of dam impacts.

Information compiled as a result of the establishment of a regional organization to address the effects of Columbia River hydro dams was particularly helpful. The formation of the Columbia River Treaty Committee (CRTC) in 1991 stimulated discussion of regional hydro-related impacts, and focused interest on the evaluation of past losses, opportunities for participation in negotiations concerning the settlement of downstream benefits in 1997, and issues related to low reservoir levels during the summer of 1992.

To gain a perspective on community-specific issues and impacts experienced throughout the entire region, the author attended the September 1992 meeting of the Association of Kootenay Boundary Municipalities (AKBM) in Vernon, and the Columbia-Kootenay Symposium held in Castlegar, June 1993. Presentations made at the latter event provided a synthesis of the various problems resulting from hydro development along the Columbia and Kootenay Rivers. Statements made by various individuals, interest groups and communities, as well as provincial government representatives (including three Provincial Cabinet Ministers) and BC Hydro officials, highlighted common concerns and specific problems experienced at particular locations along the Columbia River system.

Issues identified by local individuals and groups during interviews, CRTC meetings and at the Columbia-Kootenay Symposium, were fairly consistent and provided the basis for much of the focus of the case study. Although the provincial government and BC Hydro have addressed similar issues, their documentation of Kootenay region concerns was limited, partly due to broader mandates requiring that they balance the interests of one region with other jurisdictions for which they are responsible. This study therefore endeavours to focus on the issues perceived to be most significant to the residents of the Kootenays.

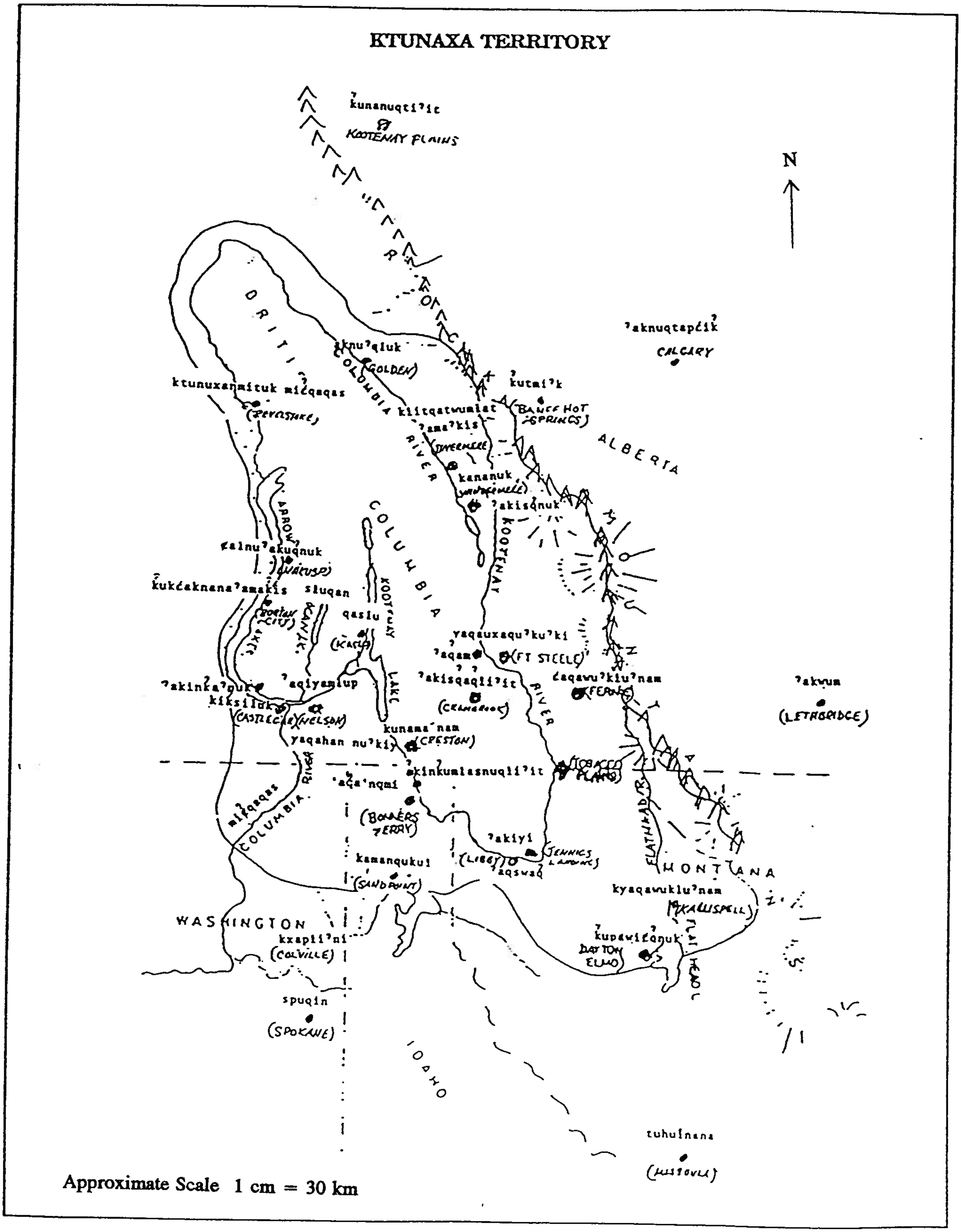
An understanding of the Columbia and Kootenay drainage basins is necessary to appreciate the significance of the role of these rivers in ensuring the sustainability of ecological, social and economic systems in both Canada and the United States. The examination of sustainability involves some knowledge of fluvial processes and their impacts on terrestrial ecosystems, as well as consideration of socio-political borders.

3.2 Resource Dependency in the Kootenays

To appreciate the significance of hydro projects to the sustainability of the Kootenays region, it is necessary to place this form of industrial development in context with the history of human settlement in the region. Generally, settlement has occurred in a linear manner along river channels in steep mountain valleys (Rawson and Wiles 1967). Some of the key factors which have influenced community development in the Kootenays are: heavy reliance on the extraction of natural resources (Kootenay Task Force 1974), cyclical occurrences of economic booms and busts (B.C. Central Credit Union 1989), and a consistent peripheral relationship to Vancouver and other distant markets (McCann 1983; Barnes et al. 1992). The following is a brief summary of resource-based community development in the region.

The Ktunaxa Nation were the first people known to inhabit southeastern British Columbia. For over 10,000 years the Ktunaxa people occupied most of the land contained within the northern portion of the Columbia River Basin (Figure 6). Traditionally, Ktunaxa territory was shared

Figure 6. Map of Tribal Lands



Source: Ktunaxa/Kinbasket Tribal Council (1992), p. 2

with the Kinbasket people of the Shuswap Nation, and consisted of the land bordered by the Arrow Lakes, the Big Bend of the Columbia River, the eastern slopes of the Rocky Mountains, and extended south to Missoula, Montana and Bonner's Ferry, Idaho (Ktunaxa/Kinbasket Tribal Council 1992). This region is now known as the Kootenays.

The Ktunaxa culture was based on reverence and respect for all living things. Co-existence with nature was determined by seasonal, spiritual and community needs, and was reflected in a sophisticated governing system with judicial, social, economic, spiritual and educational components. The Ktunaxa people were nomadic, following vegetation and hunting cycles throughout their territory (Ktunaxa/Kinbasket Tribal Council 1992).

The first encounter of the Ktunaxa with early European settlers occurred with the arrival of David Thompson, a British explorer travelling through the Rocky Mountain Trench. Thompson's initial contact in 1800 (Ktunaxa/Kinbasket Tribal Council 1992), marked the beginning of colonialism in the Kootenays. Through the meeting of the two cultures, the Ktunaxa began trading their furs for manufactured goods such as knives, cooking pots and axes. Thompson initiated the region's first resource-based industry, the fur trade, during his many voyages through the Rocky Mountain Trench from 1807 until 1811 (Atkins 1977).

The lucrative fur trade in the Kootenays, which flourished during the first half of the nineteenth century, quickly lost its significance with the discovery of gold in 1856. An unprecedented number of people migrated into the region as miners rushed in to claim mineral rights. Much of the impetus for new settlement in the Kootenays arose from the establishment of mining camps situated near newly discovered mineral deposits in Boundary country, the southern Rocky

Mountain Trench, and in tributaries of the Columbia north of Revelstoke (Kootenay Task Force 1974).

The Ktunaxa lost control over their traditional territories when British Columbia joined Canada in 1871. The 1867 British North America (BNA) Act outlined the jurisdiction of the newly formed federal government of Canada, and authorized it to rule on matters relating to Indians and the lands reserved for them. By 1888, the Ktunaxa were confined to reserves (Ktunaxa/Kinbasket Tribal Council 1992). Tensions developed between the aboriginal people of the Kootenays and immigrating settlers, as the previous occupants of Ktunaxa territory observed their best pieces of land being taken away and awarded to new immigrants (Kootenay Task Force 1984).

The establishment of the fur trade, and subsequent gold rush were the first of a series of booms and busts that drew people to the Kootenays. During the late 1800s and throughout the twentieth century, the development of the Kootenays was characterized by cyclical occurrences of prosperity and recessionary conditions associated with resource development initiatives. Forestry, mining, agriculture and, more recently, hydroelectric development have provided the basis for economic development and community settlement in this region.

Forestry booms related to Canadian settlement and international demand for lumber were affected by war activity and economic market conditions. The construction of the Canadian Pacific Railroad, the opening of the Panama Canal, settlement in the Prairies and the Kootenays, and resource consumption during World War II resulted in the development of Revelstoke and Golden as lumber towns, and the later establishment of Nelson, Nakusp and Salmo as regional and provincial centres for wood products.

Mining rushes were precipitated by the initial discovery of gold, followed by discoveries of silver, lead, zinc, gold, copper and coal that led to the creation of settlements at Kaslo, Slocan, Rossland, Sandon, Nelson, Nakusp and Kimberley (Kootenay Task Force 1974). Mining development fluctuated according to international demand for minerals, and was especially linked to military demand during the two world wars. Smelters were established at Greenwood, Grand Forks, Trail, Marysville, Boundary Falls and Nelson (Kootenay Task Force 1974).

The cultivation of fertile land along the Arrow and Kootenay Lakes resulted in a "fruit rush" during the early twentieth century, leading to development in the Slocan Valley, along the Arrow Lakes and at Grand Forks (Affleck 1976, 99). Agricultural development and cattle ranching were introduced by Doukhobours and English settlers (Kootenay Task Force 1974). Agriculture prospered until the Depression of the 1930s (Affleck 1976, 99).

The construction of hydro dams along the Kootenay River created periods of economic growth in the central Kootenays, while the large scale development of Columbia River water resources generated significant boom and bust cycles, affecting community development near dam sites. West Kootenay Power and Cominco projects along the Kootenay River were built for municipal purposes and for the mineral processing needs of Cominco. The considerable influx of workers required for the construction of large Columbia River Treaty dams to provide power for extra-regional needs caused cycles of booms and busts affecting the development of areas around Nelson, Castlegar, Revelstoke, Nakusp and Trail (Government of British Columbia 1976, 205).

The Kootenays have developed as a resource-bearing hinterland, providing raw materials for markets in Vancouver, as well as for centres in Britain, eastern Canada, the United States, and most recently the Pacific Rim (Wynn 1992; Barnes et al. 1992). While much decision-making for resource-based industries has occurred in Vancouver, the acquisition of forestry and mining companies by multinational corporations has landed Vancouver in the role of a broker operating between resource buyers and sellers. This concentration of power in large financial centres has caused further isolation of the resource-producing periphery, leaving small one-industry towns, such as those in the Kootenays, susceptible to the fluctuations of world financial and resource markets (North and Hardwick 1992, 230).

3.3 The Columbia River Treaty

Although the Columbia River Treaty led to a significant increase in hydro development within the Kootenays region, and was responsible for the initial damming of the Columbia, the region was already somewhat familiar with smaller hydro projects along the Kootenay and Pend-d'Oreille Rivers. The region's first hydro installations began with a power plant constructed on the Kootenay in 1896, still operated by the City of Nelson, and a small Pelton wheel unit at Sandon, a mining town near New Denver, in 1897 (Cominco Magazine 1962). This was followed by a series of hydro dams constructed by West Kootenay Power and Cominco along the Kootenay between Nelson and Castlegar, as well as the development of the Waneta Dam on the Pend d'Oreille in 1954. Table 1 summarizes the history of hydro development in the Kootenay region.

The large-scale development of water resources was undertaken by British Columbia under its policy of "hydro-industrialization" in the late 1960s and during the 1970s. The construction of large hydro dams was part of W.A.C. Bennett's plan for development of the remote regions of the province during the period of his administration as premier from 1952 until 1972. Bennett's "Two River Policy" led to extensive hydro development on both the Peace and the Columbia river systems (Krutilla 1967; Swainson 1979; Tomblin 1990).

Bennett believed that provincial control over the generation of power was essential for his province-building goals, and was instrumental in the formation of B.C. Hydro as a crown corporation in 1962. Although the federal government favoured the development of the Columbia River alone, Premier Bennett believed that the province would benefit from damming both rivers. A series of amalgamations of the various hydro utilities operating in the province ensured the development of markets for the Peace and Columbia power projects (Swainson 1979; Tomblin 1990; Vining 1981).

Hydroelectric development on the Canadian portion of the Columbia was stimulated by joint Canadian and American interest in harnessing the powerful flows of this international river. In 1944, the Governments of Canada and the United States requested that the International Joint Commission (IJC) examine whether bilateral cooperation on future water resource development on the Columbia would be practical and advantageous. Both countries favoured increased opportunities for hydroelectric generation, and the benefits of flood control were reinforced when a 1948 flood inundated part of Trail, B.C., claimed 50 lives, made 38,000 homeless, and destroyed the community of Vanport, Oregon (Canada 1964b, 16; Swainson 1979, 42).

The selection of water development sites was a lengthy process requiring substantial engineering studies and economic evaluations. The International Columbia River Engineering Board was established by the IJC and, in 1959, presented three water development plans based on the identification of a number of large storage reservoir sites in Canada that would benefit both countries. Years of technical studies and negotiations resulted in cost-benefit analyses of over one hundred combinations of sites, and led to the selection of the Arrow Lakes, Duncan Lake and Mica as reservoirs, as well as the preservation of a variety of possible Kootenay River diversions (Canada 1964b).

Although the reservoir sites were ranked and constructed in order of their benefit-cost ratios, many of the political and economic aspects of these sites and their alternatives have been questioned. Controversies focused on the dubious economics of the Libby Dam, the greater displacement of people and land use resulting from the selection of the non-diversion plan over the diversion of the Columbia into the Kootenay, and the implications of dam site proposals on future diversion plans which would flood the Columbia Trench to enable massive power exports through the proposed North America Water and Power Alliance (Krutilla 1967, Waterfield 1970, Swainson 1979).

Canada and the United States signed the Columbia River Treaty in 1961 in an effort to coordinate hydro operations for mutual benefit. The Treaty focuses on Canadian regulation of water in the upper portion of the Columbia for the purposes of power generation and flood control. It stipulates certain restrictions on hydro development and diversions on the Columbia and its tributary, the Kootenay River, and outlines procedures for the calculation of U.S. payment to Canada for benefits received (Canada 1964a,b; Krutilla 1967).

The Columbia River Treaty provides for the appointment of Canadian and American Entities to aid its implementation. In 1963, Canada and British Columbia agreed that British Columbia would receive all rights to the payment of the Canadian Entitlement, and B.C. Hydro was named the Canadian Entity. The American Entity is the Administrator of Bonneville Power Administration (BPA) and the Division Engineer, North Pacific Division, U.S. Corps of Engineers. A Permanent Engineering Board reviews the operations of both Entities to ensure that Treaty obligations are met (B.C. Hydro 1993a).

The agreement was ratified in 1964, at which time Canada's role in moderating the flow of the Columbia was acknowledged through payments for power and flood control benefits received downstream. The Canadian Entitlement to half of the downstream benefits received for U.S. power generation over a thirty-year period was sold to a group of American electrical utilities, at British Columbia's request, for a one-time payment of $273.3 million. Canada received a total of $69.3 million for flood control benefits, half of the U.S. flood control benefits received over a sixty-year period, and was paid in stages as each of the storage dams was completed. Canada also received an additional $9.2 million for early completion of the Duncan and Keenleyside dams. (B.C. Hydro 1983).

In accordance with the Columbia River Treaty, Canada built three dams: the Mica and Hugh Keenleyside Dams on the Columbia River, and the Duncan Dam above Kootenay Lake, whose waters enter the Columbia via the Kootenay River. Duncan Dam was completed in 1967, followed by Keenleyside in 1968, and Mica in 1972, resulting in 15.5 million acre-feet of storage. Although all three dams were designated as storage facilities, they were designed to accommodate additional power generation capability for Canada. B.C. Hydro has since benefitted from Treaty storage through the addition of power generation at Mica, and through later construction of the Kootenay Canal (1976), Seven Mile (1980) and Revelstoke (1985) Dams (B.C. Hydro 1993a).

The Treaty also provided the option for the United States to build a dam near Libby, Montana on the Kootenay River, within five years of Canadian ratification. The United States insisted on the inclusion of the Libby project, with its questionable economic efficiency, due to the importance of flood control near Bonners Ferry, Idaho (Krutilla 1967, 100). The Libby Dam was completed in 1973, adding five million acre-feet of storage in the Koocanusa Reservoir while flooding 42 miles (67 km) of shoreline in Canada (Spritzer 1979).

The terms of the Columbia River Treaty apply for a period of sixty years after the ratification date, and may be prolonged indefinitely. Either Canada or the United States may terminate the Treaty at any time with ten years written notice. While the payment or return of downstream benefits resulting from power generation will be negotiated for the second period of thirty years in 1997, Canada has already been remunerated for flood control benefits, and is obliged to provide a certain amount of flood control as long as the Treaty dams are in service, with no further payment (Canada 1964a,b; Krutilla 1967).

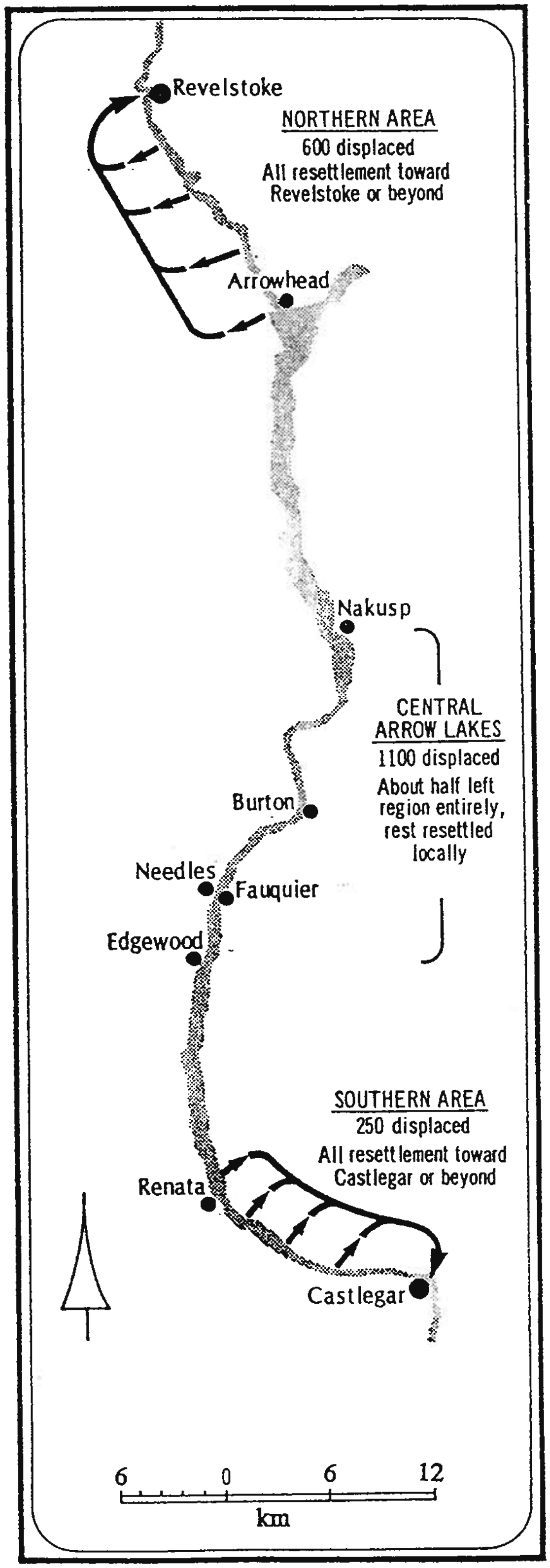
Subsequent to the Columbia River Treaty, B.C. Hydro and BPA signed the Non-Treaty Storage Agreement in 1984 to provide effective use of additional storage behind Mica Dam in a more coordinated manner. This Agreement was initially to last for ten years, but in 1990 the two agencies agreed to expand the additional 2 million acre-feet storage to 4.5 million acre-feet, and extended the Agreement until 2003. The further power generating capability of this storage is shared between B.C. Hydro and BPA (U.S. Department of Energy et al. 1991, 23).

3.4 The Impacts of Columbia and Kootenay River Dams

The impacts of the Columbia River Treaty and ensuing hydro development on communities in the Canadian portion of the Columbia River Basin varied throughout different stages of hydro project activity. Two thousand residents of Burton, Fauquier, Edgewood, Renata and Arrowhead on the Arrow Lakes experienced emotional and financial hardships as they were forced to relocate completely due to flooding for reservoir creation (Figure 7). Many members of other communities near dam sites, such as Revelstoke and Castlegar, prospered through dam-related employment and the provision of services for the large number of workers imported to work during dam construction. Generally, each project generated its own local boom and bust cycle, causing periods of high economic activity near dam sites before and during construction, followed by difficult financial situations for communities left with the burden of managing expanded municipal services once the dam builders moved on (Waterfield 1970; Wilson 1973).

Aboriginal communities within the Columbia River basin received little warning of hydro development plans within their traditional territory (Phillips et al. 1992). The Ktunaxa/Kinbasket First Nation experienced direct fishing and hunting losses due to the blockage of fish passage and the flooding of winter range along the Kootenay River, resulting from the construction of the Libby Dam. After losing their principal sources of food supply and livelihood, many people who had lived independently moved onto the St. Mary's Reserve. Aboriginal heritage sites consisting of the pictographs and pit houses of the Senatcheggs, a lake tribe already extinct, were inundated beneath the Arrow Reservoir and are commemorated by a totem pole at the

Figure 7. THE DISPLACEMENT - RESETTLEMENT PATTERN



Source: Wilson (1973), p. 6

relocated Edgewood townsite.

Halleran (1974) outlines many of the immediate effects of Columbia River Treaty dams in his film, "The Reckoning". He emphasizes the emotional suffering and financial losses experienced by those whose land was expropriated, and summarizes the loss of regional resources due to flooding and habitat loss as follows: 81,727 acres of forested land; 18,000 acres of farmland; 8000 deer; 600 elk; 1500 moose; 2000 black bear; 70,000 ducks and geese; and a decline in giant rainbow trout productivity.

In a 1981 survey administered to resettled residents of the Arrow Lakes by independent researchers, interviewees conveyed the opinion that the Arrow Lakes area was perceived as "somewhat less livable" since hydro development. Local residents had adapted to the consequences of living along a reservoir, and for the first time experienced the exposure of banks as a result of shoreline fluctuations, the occurrence of dust storms from bank exposure, and the inability to use boats and pontoons when stranded by occasional summer draw-downs (Wilson and Conn 1983). The incomplete removal of timber and debris before reservoir flooding delayed the use of Mica and Duncan reservoirs for recreation and transportation, resulting in conflicts between BC Hydro, salvage operators and recreationists (Szaraz 1981).

Although much of the bitterness related to the resettlement of individuals and communities as a result of initial reservoir creation has subsided (Wilson and Conn 1983), it is evident that many believe that the ongoing operation of Columbia River Basin dams has affected the integrity of the resource base of the Kootenays. Since there has been no comprehensive report on the overall impacts of hydro development in the Columbia River Basin, the following discussion documents some of the most well-known impacts of large dams in the Kootenays, those related to the resource base of the region. While some of these consequences have been recorded, literature on this subject is quite limited. This summary integrates documented references with information provided by residents of the area.

3.41 Impacts of Dams on Fish

The impacts of Columbia River Basin dams on fisheries have been widely acknowledged and are probably the most extensively documented consequences of hydro development in this region. The Columbia River system is unique in sustaining the most productive rainbow trout fishery in North America, and a diversity of other indigenous fish species, including: Dolly Varden char, yellowstone cutthroat trout, kokanee, mountain whitefish, burbot and white sturgeon; as well as the following introduced species: eastern brook trout, brown trout, walleye, and chinook salmon. However, many of these fisheries have declined significantly with the construction of dams on the Columbia River system (Maher 1961; Andrusak 1981; Mallette 1991; Hirst 1991).

The development of a long network of hydroelectric dams has been detrimental to migrating fish that depended on the Columbia River system to travel between freshwater streams and the ocean (Northwest Power Planning Council 1992; U.S. Department of Energy et al 1991). Salmon and steelhead runs in the Columbia River ranged between 10 million and 16 million during the mid-1800s, but have since decreased to approximately 2.5 million fish. While industrial development and overfishing have contributed to the substantial reduction of fish runs in the Columbia River basin, hydroelectric development is believed to have caused the most significant portion of this loss, between five to 11 million fish (Northwest Power Planning Council 1992, 17).

The completion of the Grand Coulee Dam in northern Washington in 1941 approximately halved the total salmon production of the entire river system through habitat loss, and closure of access to previous spawning grounds in the Kootenays on the upper Columbia, eliminating the salmon fishery in the Canadian portion of the river with the exception of the land-locked kokanee (Mallette 1991). The Columbia River Treaty has further contributed to salmon losses since the extra storage provided in Canada has reduced the spring freshets that previously assisted smolt migration downstream (Muckleston 1990).

Within the Canadian portion of the Columbia, hydro development has significantly disrupted fish populations in a number of ways: blocking access to spawning channels, trapping nutrients behind dams, creating hazards and changing fish habitat through manipulation of the natural flow regime. These dam-induced changes have reduced the capacity of previous fisheries on the Columbia, Kootenay and Pend d'Oreille Rivers (British Columbia 1974, 6-73; Mallette 1991; Woods 1993). Target numbers for compensation of fisheries impacts resulting from the Revelstoke Dam have amounted to 500,000 kokanee, 1,000 rainbow trout and 4,000 bull trout (Hirst 1991, 4).

Hydro projects have flooded a substantial amount of spawning habitat and prevented access to remaining spawning grounds upstream (Sigma Engineering 1990; Mallette 1991). The Mica and Keenleyside dams have reduced the capacity of the Arrow Lakes to support a sport fishery by estimates of 50 percent (British Columbia 1974, A10-8). The cumulative effect of the installation and operation of the Revelstoke Dam in addition to the two previous Treaty dams has had a devastating impact on kokanee, Dolly Varden char, rainbow trout, mountain whitefish and white sturgeon, due to their loss of access to previous spawning habitat on the Arrow Lakes and has resulted in cumulative losses of 75% of spawning habitat (Mallette 1991). The Duncan Dam has caused similar problems for fish, reducing spawning habitat such that it supports only one tenth of the previous kokanee population (Hirst 1991, 73), and destroying spawning grounds for a race of large rainbow trout, that has since become extinct (Mallette 1991).

Dams have blocked a substantial flow of nutrient supplies, enhancing the productivity of certain types of fish upstream, while preventing the flow of nutrients downstream. During the initial stages of impoundment, reservoir productivity increases due to the rapid supply of nutrients introduced through flooding of organic rich lands; however, this phenomena is usually followed by a decline in productivity, as nutrient levels stabilize or even decrease, resulting in oligotrophic conditions. The completion of the Revelstoke Dam resulted in a short-term pulse in nutrient concentrations followed four years later by a decline to levels below detection (Smith 1990, 324). The blockage of nutrients behind the Duncan and Libby Dams has caused significant declines in kokanee populations downstream in Kootenay Lake (Mallette 1991; British Columbia and Environment Canada 1993, 81). However, fishers on Kinbasket Reservoir have noted increased productivity of stocked kokanee behind the Mica Dam (Baltakis 1992; Arlt, Gutzman and Sim 1992).

The supersaturation of nitrogen as sluice gates force air into plunging water, causes fish to suffer from gas bubbles in their tissues, similar to what divers know as the bends, and has caused fish kills downstream of the Libby (Bocking 1972, 59) and Hugh Keenleyside dams (British Columbia and Environment Canada 1993, 80). Fisheries studies along the Columbia River between the Keenleyside Dam and the U.S. border indicate that the highest incidence of gas bubble truama has occurred in sucker species below the dam (Hildebrand 1991).

The construction of dams along the Columbia and Kootenay river systems has transformed the previous naturally flowing aquatic environment into a series of reservoirs, resulting in a change in species composition from riverine species, primarily mountain whitefish, to lake-oriented species such as bull trout, kokanee and sucker species (Smith 1989, Mallette 1991). The replacement of highly valued sportsfish with coarse species has changed fishing opportunities. The Seven Mile and Waneta Dams on the Pend d'Oreille River have transformed a prime fishing and recreation area into a wasteland where signs warn visitors to stay away from the water due to the risk of banks caving in (Mallette 1991).

3.42 Impacts of Dams on Wildlife

Literature on the environmental impacts of Columbia basin hydro development on wildlife is quite limited. Although reports published before the construction of Columbia River basin dams predicted wildlife losses focusing on displacement caused by the flooding of habitat (British Columbia 1965a,b,c; British Columbia 1974; British Columbia Hydro and Power Authority 1976), there has been little post-project evaluation of impacts.

In assessing the impacts of the Revelstoke Dam, Missler (1988) observes that wildlife impacts have been difficult to evaluate due to a lack of baseline information, and the cumulative nature of impacts associated with the entire hydroelectric system in the Columbia Basin. Bradley (1993) concurs explaining that wildlife issues were not considered important when Columbia River dams were built, and the evaluation of impacts is complicated due to the number of factors influencing wildlife populations and habitats. Missler's study noted potential impacts on moose, caribou, deer and grizzly as a result of flooding of riparian habitat. She documents deer, moose and caribou fatalities resulting from vehicle collisions, and records deer and moose drownings, similar to those occurring due to reservoir drawdown after ice formation on the Libby Reservoir (Reid 1976, 5-45; Missler 1988, 137).

It is generally believed that the principal impact of Columbia River Basin hydro projects on wildlife has been the loss of riparian habitat (Mallette 1991; Phillips et al. 1992; Arlt, Gutzman and Sim 1992; Woods 1993). Due to the region's harsh climatic and topographic conditions, the flooding of riparian land has reduced the region's capacity to support wildlife populations, and may have increased crowding pressures on adjacent populations. Since the availability of winter ranges limits the distribution and abundance of ungulates (British Columbia 1974, 6-69) the loss of low elevation winter range along the Kinbasket, Revelstoke, Arrow and Koocanusa Reservoirs, as well as along the Pend d'Oreille River has reduced the habitat available to moose, elk, deer and caribou.

The flooding of land for the Kinbasket Reservoir behind Mica Dam was predicted to cause severe or significant losses for most big game, small game, migratory game, upland game, fur and non-game species. The loss of 520 km of riparian vegetation, 400 hectares of permanent wetland, 1100 hectares of seasonal wetland, almost 400 hectares of meadows and 28,000 hectares of forest land was expected to cause wildlife losses through dislocation, increased migration barriers and hazards (e.g., floating debris, water drawdown during ice formation). The greatest losses were predicted for species dependent on wetland habitat: the elimination of many aquatic fur-bearers (beaver, muskrat, otter and mink), waterfowl and raptors (osprey, peregrine falcon, bald eagle, and red-tailed hawk) was anticipated within the Mica basin; and extensive habitat losses were foreseen for moose, black bear, elk, deer, coyote, and ruffed grouse (British Columbia 1974, A4-25).

Wildlife losses in the Kinbasket area have been confirmed through local observations and an environmental impact assessment report. Hunters, guides and conservation officers have observed lower numbers of wildlife within the Kinbasket Reservoir region. Local residents believe that the loss of habitat inundated by the reservoir has decreased moose, caribou, bear, and elk populations (Arlt, Gutzman and Sim 1992; Schuck 1992; Cibulka 1992). A study commissioned by B.C. Hydro to examine the impacts of increasing the capacity of its non-treaty storage behind the Mica Dam, concludes that reservoir level fluctuations combined with other factors such as steep terrain severely limit the production of aquatic/wetland wildlife around the reservoir (Triton 1990, 157).

A report prepared for B.C. Hydro indicates that riparian habitat losses were particularly significant on the Arrow Reservoir south of Revelstoke, and were more moderate between Revelstoke and Mica where steeper slopes reduced the extent of habitat loss at low elevations. The greatest impact along the Revelstoke Reservoir was the loss of upland winter range on moderate valley slopes, while similar losses along the Arrow Reservoir were only important in key areas. The flooding of 111 km^2 (11,100 ha) of riparian habitat to create the Arrow Reservoir caused extensive losses for species such as white-tailed deer, mule deer, moose, beaver, otter, waterfowl species, and a wide range of bird and mammal species that relied on riparian habitats. The loss of 11,500 hectares along the Revelstoke Reservoir has affected caribou, moose, grizzly bear, black bear, beaver, otter, waterfowl and a wide range of river based riparian species (Sigma Engineering 1990).

First Nations people living near the Koocanusa Reservoir have observed decreasing populations of wildlife since the flooding of the Kootenay River behind the Libby Dam. The inundation of grasslands along the Rocky Mountain Trench has removed extensive range land for ungulates (Phillips et al. 1992).

3.43 Impacts of Dams on Forests

The impacts of dams in the Columbia River Basin on forestry are described by Szaraz (1981). He explains that dam builders and forest resource users both compete for access to valley bottoms. Hydro development has withdrawn forest land from production, disrupted access to resources, and changed transportation patterns, thereby increasing costs incurred by forestry operators. While the dam-induced withdrawal of forest land from the regional timber supply may not be significant, the consequences for local forestry may be different.

According to Szaraz (1981, 82), the inundation of forest land for the creation of reservoirs at Duncan, Keenleyside, Mica, Revelstoke and Seven Mile, has removed 38,481 ha from forest production, representing an annual cut of 142,204 m^3. Regional forest withdrawal may amount to a total of 50,000 ha or 180,000 m^3 annually when flooding at Libby, transmission lines and other indirect impacts are considered. This withdrawal represents four percent of the 1977 cut level for Crown-managed forests in the region, although the impacts of each dam vary slightly with respect to their reduction of local timber supplies (Szaraz 1981, 67): Mica Dam (6.5%), Revelstoke Dam (3.6%), Hugh Keenleyside Dam (2.7%), Duncan Dam (0.8%) and Seven Mile (negligible). Since Szaraz' approximation of the surface area of the reservoir behind Mica (30,511 ha) underestimated the actual area (42,500 ha according to Triton 1990, 52; 44,549 ha as calculated by British Columbia 1974, A4-25), local and regional forest losses are likely higher than estimated above. Equivalent proportions of current cut levels have not been estimated due to difficulties involved in accounting for changes in administrative boundaries, and evolving forest practice restrictions to protect wildlife habitat, water quality and visual considerations.

Local forestry operations may have been affected by forest withdrawal to a greater extent, particularly since 64% of the forest flooded for the Kinbasket Reservoir consisted of good and medium forest site classes (as specified by the Ministry of Forests) and the respective proportion of similar site classes comprised 98% of the forest inundated for the Revelstoke Reservoir (Szaraz 1981, 60-61). The proportion of good and medium forest land flooded for the Mica Dam is similar to its representation within the Golden Timber Supply Area (67%) and within the Kootenay Region (63-65%). However, the area flooded for Revelstoke contained a higher proportion of good and medium sites than occurring locally within the Revelstoke area (88%) or the Kootenay Region (63-65%). Szaraz suggests that intensive silviculture may provide some degree of mitigation of forest withdrawal impacts.

In addition to losing timber supply, local logging operators have incurred increased costs associated with reduced access to forest resources, as well as the construction and maintenance of additional transportation infrastructure (Szaraz 1981, Ricards 1992, Bennett 1993). The flooding of highly productive forests in low and relatively flat areas has led to increased logging costs since remaining forests are further away and harder to access on steep slopes. Previous logging roads were flooded and were expensive to replace as new roads traverse steeper terrain and travel a greater distance around the enlarged area of the reservoir. Log drives between Mica Creek and Revelstoke, and between Duncan and Kootenay Lakes are no longer possible.

The use of boats on Kinbasket Reservoir (behind the Mica Dam) requires log dewatering facilities and maintenance for boat ramps due to fluctuating reservoir levels (Figure 8).

3.44 Impacts of Dams on Agricultural Land

Due to the limited availability of arable land in British Columbia (approximately three percent in 1961) the flooding of land capable of supporting agriculture was one of the considerations during Columbia River Treaty negotiations (Krutilla 1967, 101; Waterfield 1970, 78). The proposal to divert the Kootenay River into the Columbia was rejected partly because of government reluctance to flood both of the fertile valley bottoms along the Arrow Lakes and the Rocky Mountain Trench.

Prior to Treaty-related hydro projects, farming communities had developed along the Arrow Lakes, the Creston Flats and along the Rocky Mountain Trench in the East Kootenays (British Columbia 1976, 68). Orchards and farms along the Arrow Lakes provided a local source of fruit and vegetables for residents of the Kootenays. Dairy products, grains, vegetables and fruit were cultivated with the dyking of the fertile floodplain around Creston. Cattle and hay production occurred on ranches along the Kootenay River in the East Kootenays.

Hydro projects within the Columbia River basin have reduced the agricultural capability of the Kootenays through the flooding of farm land along the Arrow Lakes and the Kootenay River, while improving flood control for arable land on the Creston Flats. While many farmers in communities along the Arrow Lakes believed their land to be of high soil fertility, a federal Department of Agriculture report dismissed its importance nationally citing high land clearing

Figure 8. Logging Operations on Kinbasket Reservoir (October 1992)

costs (although costs were higher elsewhere), the need for irrigation (ignoring the abundant and inexpensive water from the Arrow Lakes) and the spread of disease (which was no problem in dry years) (Waterfield 1970, 133). Approximately 40,000 acres (16,200 ha) of farm land (38% of total farm land in the Central Kootenay Regional District according to the 1966 census) were flooded behind the Keenleyside Dam (Waterfield 1970, 68). The creation of the Koocanusa Reservoir inundated some of the most productive range land along the Kootenay River (Halleran 1974; Phillips et al. 1992). However, water flow regulation resulting from the same dam, the Libby Dam, improved the agricultural potential of the Creston floodplain due to the added flood protection received (British Columbia 1986).

3.5 Impacts of Dams on Water Supplies

Municipal water supplies have been affected by Columbia River Basin hydro projects. The construction of the Hugh Keenleyside dam has resulted in conflict over the financing of the supply of domestic water for Trail. B.C. Hydro originally drilled groundwater wells to provide water to this community when hydro-related turbidity made river water unfit for domestic use. The ongoing financing for Trail's water supply has caused disputes between BC Hydro and the City of Trail (Royds 1991). However, B.C. Hydro has been devolved of further responsibility for Trail's water supply as a result of a decision reached through arbitration (Geissler 1994).

3.5 Environmental Policy at B.C. Hydro

B.C. Hydro has acknowledged the significance of the impacts of its dams on the inhabitants of the Columbia River Basin, and is embarking on new initiatives to address past problems.

Commitments expressed in B.C. Hydro's "Corporate Strategic Plan" for 1993 indicate its willingness to accept responsibility for the consequences of hydro development in the Kootenays.

B.C. Hydro's policy of accountability for the environmental and social impacts of its hydroelectric operations has evolved as a result of experience gained during two and a half decades of large-scale dam projects. Initially, this provincial utility had little interest in environmental policy during hydroelectric planning for the Columbia River Basin, as dam proposals were subjected to minimal environmental regulation.

B.C. Hydro has now adopted a more long-term conservation-minded approach to resource use in its electricity planning. It is monitoring the environmental consequences of its operations and implementing programs for mitigation and enhancement of fish and wildlife affected by hydroelectric projects. Major compensation programs have been developed to address ongoing environmental problems in the Columbia River Basin. New energy supply options are being investigated with emphasis on demand-side management to avoid the construction of more large projects, and various aspects of sustainability are being included in B.C. Hydro's strategic policy.

3.51 Environmental Regulation of B.C. Hydro Dams

Many of B.C. Hydro's projects were licensed under the provincial Water Act (1960). This piece of legislation was not designed to deal with broader environmental issues, and the application of this legislation to Hydro's projects was criticized by many opponents of the utility's plans (Missler 1988).

Residents of the Arrow Lakes region were frustrated with The Water Act's licence approval process for Columbia River dams. The Water Comptroller allowed public hearings to occur after substantial agreements had already been made between Canada and the United States regarding the conditions of The Columbia River Treaty. Local people felt powerless to affect any planning decisions. Their frustration was increased when informed that they could not discuss the Arrow Lakes projects or their justification during the public hearings. Residents were also intimidated by Hydro's strength in numbers and confrontational approach when questioning local people (Waterfield 1970, 87; Wilson 1973, 18; Missler 1988).

Further provincial legislation addressing resource use had little effect on B.C. Hydro. The utility was not subjected to the requirements of the Pollution Control Act established in 1967. The Environment and Land Use Act (1971) dealt with some aspects of hydro development and led to related Guidelines on Linear Developments (1977), Guidelines on Benefit-Cost Analysis (1977) and Environmental and Social Impact Compensation/Mitigation Guidelines (1980). The B.C. Energy Act (1973) was developed with the intention to regulate energy utilities, but its mandate was not extended to include B.C. Hydro, the largest producer of electrical energy in the province (Missler 1988).

The continued development of large scale energy projects in British Columbia and increasing awareness of their environmental impacts led to the formation of The Energy Project Review Process (EPRP), in 1980. This legislation was a significant improvement over its predecessor (The Water Act) in its ability to address environmental issues and improve the public hearings process through its definite structure and procedural sequence for selection and licensing. As of 1988, B.C. Hydro's Site C proposal for the Peace River was the only Hydro project reviewed through the EPRP (Missler 1988).

Site C was rejected by the EPRP Panel and this rejection was accepted by the provincial government. This rejection shows the potential strength of the new evaluation measures provided through the EPRP legislation, as B.C. Hydro had never been refused approval of its projects previously. The proposal was rejected on the grounds that it was unnecessary, as Hydro had overestimated future energy demand, and because Hydro had not proven that Site C was the best project due to a lack of consideration of reasonable alternatives (Riek 1987).

3.52 Compensation/Mitigation

The issue of compensation has been at the heart of much of the discussion of hydro-related problems. Many of the problems associated with compensation for the initial expropriation and resettlement of people displaced by Columbia River Dams are documented by Wilson (1973) and Wilson and Conn (1983). Although Wilson criticizes B.C. Hydro and the provincial Social Credit government for various decisions and approaches to the management of social and economic impacts on the residents of the Arrow Lakes, he states that government officials accomplished their difficult jobs "for the most part, with understanding and humanity." He concludes that although compensation was not generous, it was adequate.

As a result of a 1970 survey of relocated families along the Arrow Lakes, Wilson (1973, 146) remarks that the question of compensation dominated most of the responses he received. While the majority of owners of the 1280 properties affected accepted compensation offers, seventy-eight cases involved some degree of expropriation. The resettlement of residents involved the relocation of the communities of Burton, Fauquier and Edgewood at three new sites. In a follow-up survey in 1981, Wilson and Conn (1983) found that opinion regarding adequacy of compensation remained divided; however, some of the bitterness towards B.C. Hydro had abated.

Wilson (1973, 150) addresses the problems related to compensation for those living along the Arrow Lakes, emphasizing the difficulties in attaining fair replacement for losses. As the estimation of value is subjective, the evaluation of "intangibles" such as scenic views and friendships was not easily translated into dollars. The assessment of property values varied according to the appraiser involved. Although compensation was determined by market value, the replacement value may have been more appropriate since large-scale hydro project planning had removed any real property market in the communities affected. The lengthy process of compensation settlement created hardships for those remaining in almost abandoned communities.

The Government of British Columbia agreed to the flooding of 13,600 acres (5500 ha) of Canadian land for the creation of the Koocanusa reservoir between 1973 and 1975. In return, British Columbia was entitled to retain the full share of downstream benefits received at Kootenay Canal rather than returning half to the operators of Libby, as is the procedure for Columbia River Treaty dams (Spafford 1994). Few details are available regarding compensation as most of the land along the Kootenay River was public land. However, members of the Ktunaxa/Kinbasket Tribal Council recall that people were relocated from the area with inadequate compensation. Aboriginal communities received little warning and no compensation for their loss of food supply (fish and wildlife) and livelihood (Phillips et al. 1992).

The question of compensation continues to be an important part of ongoing concerns related to hydro development in the region. While the sense of injustice regarding past compensation for properties persists with some residents, many more are concerned about compensation for lost resources (Ricard 1992; Moore 1992; Demmon 1992). Community representatives believe that hydro projects have reduced the size of their land base and the quality of their water. These changes have affected the integrity of and access to water, timber, fish and wildlife resources, and are particularly significant to communities dependent on resource-based industries (Smienk 1992).

The consideration of compensation issues requires an understanding of the overall costs and benefits incurred as a result of hydro development in the Kootenays during the first thirty years of the Columbia River Treaty. Since the majority of costs and benefits resulted from construction of the large Columbia River Treaty Dams by B.C. Hydro, these dams are the focus of discussion regarding compensation. Table 2 compares the cooperative hydro development option (involving Canada and the U.S.) with the independent development option (just Canada) as summarized by Newton (1994). Further details are described by Krutilla (1967), Canada (1964a,b), Wilson (1973) and Swainson (1979).

As actual costs of Columbia River Treaty hydro development ($600.3 million) were greater than original estimates (447.7 million as reported in Canada 1964b, 96) both the cooperative and independent options result in net losses (Table 2), instead of the predicted net gain of $53.4 million. Assuming that the Mica Dam would have been built regardless of international cooperation (this assumption is validated by the subsequent development of several other dams in addition to Mica), the development of Columbia River dams would have resulted in greater

Table 2. COMPARISON OF TREATY VS. NON-TREATY COSTS AND BENEFITS

Cooperative (Canada-U.S.) Hydro Development		Independent (Canada) Hydro Development	
Actual Dam Costs (Canadian capital costs in $million Can.)			
Duncan	32.9 (1967$)		
Arrow	196.7 (1968$)		
Mica	364.1 (1973$)	Mica	364.1 (1973$)
road replacement	4.0		
Libby reservoir clearing	2.6		
Total dam costs	600.3	Total dam costs	364.1
Actual Benefits (U.S. payments and Canadian benefits in $million Can.)			
U.S. downstream power benefits	273.3	nil	
U.S. flood control benefits	69.3		
Canadian downstream power benefits at Kootenay Canal	6.7		
payment of interest on money already spent by Canada	129.8		
Total benefits (as of 1974)	479.1	Total benefits	-
Net Benefits ($million Can.)			
benefits	479.1	benefits	-
costs	- 600.3	costs	- 364.1
Net benefits	-121.3	Net benefits	-364.1

Notes

* The above costs and benefits indicate accounting costs (in year spent) not economic costs (constant dollars), or the total of a stream of payments (over several years) and are therefore difficult to compare. However, they present a general approximation of the costs and benefits for the first thirty years of the Columbia River Treaty as incurred between 1967 and 1974.

* Costs include operating costs and compensation for real estate

Source: Newton (1993)

losses, an additional $242.8 million, if undertaken independent of the United States. However, the real long-term benefit of the Columbia River Treaty is believed to be the power generation at Mica and subsequent power dams (e.g., Revelstoke). The resulting benefits from this large supply of relatively inexpensive electricity and the ensuing economic development are difficult to evaluate but may compensate for the direct net losses incurred (Newton 1993).

This discussion is not intended to provide a comprehensive cost-benefit analysis of Columbia River dam projects but serves as a basis for the consideration of compensation issues. Actual dam costs shown in Table 2 include compensation for real estate along the Arrow Lakes, but do not include compensation for foregone resource use (e.g., fish, wildlife and forest losses), the subject of much of this study. Some losses have been estimated and are included where appropriate in the case study. However, there has been no regional evaluation of environmental impacts or their equivalent dollar value. The failure of cost-benefit analysis to estimate environmental resource values of the Columbia River is addressed by Mallette (1991).

The lack of valuation of environmental costs makes it difficult to review the real costs of Columbia River dams or determine an appropriate level of compensation. B.C. Hydro has undertaken various forms of compensation as outlined in the following discussion. Compensation payments and programs have been based on their ability to generate benefits rather than compensate losses (Newton 1993).

A further U.S. payment or return of downstream power benefits for the second term of the Treaty could provide a means of redistributing some of the benefits received by British Columbia as a whole, to the region that continues to incur costs from the operation of Columbia River dams. The previous one-time payment of downstream power benefits was received by the province with no formal compensation arrangements between the province and the region affected by hydro development.

Compensation and mitigation of environmental impacts from Columbia Basin hydro projects have occurred as a result of requirements in provincial water licences. Licences issued prior to the 1960s did not require environmental assessment or compensation for impacts (B.C. Hydro 1992d). As all of the large hydro projects in the basin were licensed after 1962, they have all required varying degrees of compensation or mitigation for environmental, social and economic impacts (Table 3).

Water licenses for Columbia River Treaty dams were less exigent regarding environmental matters than those issued subsequently. According to licences issued to Treaty dams in 1962, B.C. Hydro was required to undertake reservoir clearing, ensure public access, pay for fish and wildlife studies, and complete remedial measures for fish and wildlife protection. In addition to fish and wildlife studies, the Kootenay River diversion licence issued in 1971 required dam operators to maintain a minimum flow. The 1974 Pend d'Oreille licence for the Seven Mile Dam stipulates the development of fish and wildlife programs, and this was further strengthened by an Order under the Water Act directing B.C. Hydro to pay $1.8 million to plan and implement a fish and wildlife habitat management programme for the Pend d'Oreille Valley. The Revelstoke Dam, licensed in 1976, has been subject to the greatest number of specifications regarding compensation and mitigation procedures (Table 3).

B.C. Hydro has completed a large number of projects to mitigate and compensate for its

TABLE 3 - ENVIRONMENTAL REQUIREMENTS FOR B.C. HYDRO WATER LICENCES

Dam	Licence Date	Environmental Requirements of Water Licence														
		reservoir clearing	public access	fish and wildlife study	fish and wildlife remediation	minimum flow	fish and wildlife programs	recreational facilities	fish and wildlife biologists	environ-mental guidelines	mitigation for local community	compen-sation	Project Coordinating Comm. (PCC)	biologists consult with PCC	Community Impact Committee	transfer of logs around dam
Duncan	1962	x	x	x	x											
Keenleyside [1]	1962	x	x	x	x											
Mica (storage)	1962	x	x	x	x											
Kootenay Canal	1971			x		x										
Mica (power)	1972															
Seven Mile [2]	1974	x	x				x									
Revelstoke [3]	1976	x					x	x	x	x	x	x	x	x	x	x

Notes:

Other project-specific commitments in addition to water licence requirements

[1] Recreation Agreement
[2] Fish and Wildlife Compensation Program
[3] Parks Agreement, Water Act Order re water supply, Water Act Order re Trust Fund Account

Source: Ministry of the Environment Water Licences, and Sigma Engineering Ltd. 1990.

operations on the Columbia system. However, B.C. Hydro acknowledges that some water licence stipulations were limited to one-time payments and have not provided adequate or effective payment to meet the needs of those living in the region (B.C. Hydro 1992d, 4). Details regarding compensation and mitigation efforts are summarized in two B.C. Hydro reports addressing the status of environmental and recreation compensation (Sigma Engineering 1990; Davidson 1992).

Fisheries and wildlife compensation and mitigation efforts have included payments for fish and wildlife studies, the completion of remediation measures and the establishment of fish enhancement programs. Compensation has focused on terrestrial and aquatic habitat loss as a result of the initial flooding and blockage of access to spawning grounds, with little concern for the consequences of ongoing dam operations. Since most compensation was financed by B.C. Hydro, but implemented by provincial ministries, B.C. Hydro's involvement has not been visible, and in some cases, provincial ministries may have directed compensation payments to other environmental projects in the area, rather than to specific hydro-related mitigation projects. The development of major compensation programs by B.C. Hydro is an attempt to gain leadership and accountability in the mitigation of its dam projects (Birch 1994).

Some of the most significant fish enhancement initiatives have included the development of spawning channels and hatcheries. The Meadow Creek spawning channel (1967) was created in a prime spawning area on a tributary to the Lower Duncan River to mitigate kokanee losses associated with the Duncan reservoir, and has maintained approximately 175,000 spawners annually; however, this has not replaced even 50 percent of the natural pre-project levels, enumerated as 2.8 million on the lower Duncan River in 1966 (Hirst 1991, 20). The Hill Creek hatchery (1980) on Upper Arrow Lake, and Mackenzie Creek spawning channel (1981), were designed to replace annual losses of 500,000 kokanee, 1,000 rainbow trout and 4,000 bull trout, resulting from construction of the Revelstoke Dam (Hirst 1991, 5); this hatchery has been successful in achieving returns of over 235,000 kokanee annually since 1988 (150,000 spawners produce approximately 500,000 kokanee for the sport fishery), and releases of rainbow trout and bull trout have consistently exceeded the losses attributed to the Revelstoke project (British Columbia Environment 1994).

In recognition of the ongoing impacts of its dam operations, particularly the alteration of flow regimes and nutrient loading, B.C. Hydro has initiated various efforts to address fish problems. Spawning conditions for white sturgeon and rainbow trout are being studied downstream of Keenleyside, to examine the reproductive capability of sturgeon, and to ensure sufficient flow regimes to protect rainbow trout spawning grounds, temporarily dewatered during 1991 (B.C. Hydro 1992d). Barriers and impediments to fish on Joseph Creek are being examined in cooperation with the Ktunaxa/Kinbasket Nation. B.C. Hydro has been involved in the addition of phosphorus to Kootenay Lake to improve nutrient levels for kokanee and Gerrard trout (B.C. Hydro 1993g).

The compensation and mitigation of the impacts of hydro development on wildlife in the Columbia River Basin have not been fully addressed. Wildlife impacts have received less emphasis than those experienced by fish. There are several reasons for the limited attention to wildlife: there is a lack of baseline data since few wildlife studies were done before dam construction (Missler 1988); dam-related impacts have been harder to assess since wildlife range is larger and more dispersed than fish contained within rivers (Woods 1993); and opportunities to replace lost habitat within the river basin are limited (British Columbia 1974, A4-4).

Wildlife compensation has focused on funding population and habitat research, often within broad management programs. Most of the initiatives have been directed towards the mitigation of waterfowl and big game species as they have been directly affected by the loss of riparian habitat, and are also important because of their hunting value. Some of the most comprehensive efforts have addressed habitat within the Creston wetlands, and around the Seven Mile and Revelstoke Dams.

B.C. Hydro has participated in wildlife and waterfowl habitat enhancement at Duck Lake in the Creston Valley Wildlife Management Area, established by the provincial Creston Valley Wildlife Act. The protection of wildlife and waterfowl within 7,000 ha of floodplain along the Kootenay River has resulted in the establishment of a waterfowl breeding population on the Creston flats, where none existed before (Wilson 1992). Although the Creston wetlands have not been affected by B.C. Hydro operations, this area is downstream of the Libby Dam operated by Bonneville Power Authority and is managed to compensate for water level fluctuations. B.C. Hydro's involvement in this project reflects its interest in replacing wetland losses experienced in other parts of the Columbia Basin.

Water licences for the more recent Seven Mile and Revelstoke Dams have required the establishment of fish and wildlife programs. B.C. Hydro's involvement has consisted largely of financial contributions toward management plans developed by provincial ministries. Wildlife projects at Seven Mile have emphasized management of white-tailed deer due to the loss of critical winter range for this species (Sigma 1990). Revelstoke mitigation has focused on habitat management for caribou, moose, deer, grizzly bear and waterfowl (Sigma 1990).

Generally, compensation for forestry impacts has consisted of the replacement of roads and log transport facilities, due to the flooding of previous access roads and interruption of log floating practices. B.C. Hydro contributed $2.3 million toward the $4 million cost of the West Columbia Road, along the Kinbasket Reservoir, under the condition that it would have no further obligations for Mica forestry impacts. The balance was paid by the B.C. Forest Service as a credit on stumpage to Evans Products Ltd., who paid for the road extension through normal stumpage procedures. Evans Products was unsuccessful in obtaining a similar stumpage credit for the East Columbia Road due to inaccurate cost estimates (Szaraz 1981, 103).

In accordance with provisions to accommodate the handling of forest products in the water licence for the Keenleyside Dam, B.C. Hydro incorporated a lock into its dam structure, upgraded access roads and financed the construction of a loading-out transfer unit for log dumping (Szaraz 1981, 92).

Although the Duncan Dam water licence stipulated the accommodation of forestry operations, the major logging operator, Kootenay Forest Products, could not convince the Water Comptroller or B.C. Hydro to include a spillway or flume to facilitate log transport. Instead the B.C. Forest Service built a bridge and B.C. Hydro financed an access road, that was later upgraded by the Forest Service to meet forestry standards (Szaraz 1981, 89).

Compensation to forestry operations affected by the Revelstoke Dam consisted of the replacement of logging roads and ferry landings, as well as the construction of a dewatering facility to accommodate the transfer of logs around the dam, as required by the water licence issued (Lagore 1994).

B.C. Hydro has undertaken a large number of community projects to address impacts to recreation caused by its dams. Most of its efforts have focused on the Arrow Reservoir, and were initially related to the resettlement of Burton, Edgewood and Fauquier, and the upgrading of existing facilities at Nakusp to accommodate some of those who relocated to this centre. Recreation improvements have included: reservoir debris clearing, establishment of provincial parks, recreation facilities and community centres, boat launches, airport improvements, bank stabilization and landscaping, golf courses enhancement, archeological studies, visitor centres at dam sites, tourism development, arts council funding and property acquisition (Davidson 1992). A joint committee consisting of members of the community of Revelstoke, provincial government departments and B.C. Hydro has been initiated to examine recreational planning opportunities for the Revelstoke Reservoir, and may serve as a model for recreational planning in the Columbia River basin (B.C. Hydro 1993j).

The accumulation of debris in reservoirs as a result of incomplete forest clearing before clearing, as well as from windfall and logging practices has restricted use of certain reservoirs for recreation and transportation (Figure 9). Due to the ongoing nature of this problem, B.C. Hydro developed a debris management strategy in 1992, and has taken initiatives for reservoir clearing due to public perception that the utility is responsible for its accumulation even though some of the debris originates elsewhere (Gurnsey 1994). Ongoing debris clearing activities are focused on the Kinbasket and Duncan reservoirs. The other reservoirs on the Columbia system are relatively clear of debris, although the exposure of stumps on the Arrow Reservoir continues to

Figure 9. Debris on Kinbasket Reservoir (Summer 1991)

Photo courtesy of Paul Ricard (Evans Forest Products) be hazardous for boating. Floating debris in the Kinbasket reservoir has been reduced to 550 ha from a surface area of 2428 ha in 1979 (B.C. Hydro 1993j, 27).

The periodic occurrence of low water levels on the Arrow Reservoir has exposed shorelines, resulting in the development of dust storms in Revelstoke and Nakusp (Johnson 1992, Conn 1992). The Upper Arrow Dust Control Program has been in operation for six years in an effort to reduce the incidence of this nuisance. Rye grain has been planted within the drawdown zone of the reservoir to reduce slope erosion during wind storms, and ongoing studies will attempt to identify vegetation types that tolerate frequent water level fluctuations (B.C. Hydro 1993j).

Water level fluctuations on Koocanusa Reservoir have exposed burial sites of importance to the Ktunaxa/Kinbasket First Nation. The erosion of land within the drawdown zone has made the burial sites susceptible to degradation and vandalism. Although the Koocanusa Reservoir is operated by the Bonneville Power Authority, B.C. Hydro funded an archaeological study of the reservoir area and financed the removal and reinterment of aboriginal artifacts along the shoreline (Gurnsey 1994).

B.C. Hydro recognizes that some resource issues have not been addressed by government agencies or its own organization and is therefore undertaking major project compensation programs. In 1991, B.C. Hydro established the Mica Fisheries and Wildlife Compensation Program to provide funding for impacts associated with the completion of the Mica Dam and the Non-Treaty Storage Agreement. Preliminary studies were conducted to develop five-year plans for fish and wildlife enhancement and management in the Kinbasket and Revelstoke watersheds (B.C. Hydro 1992d, 4). Community workshops were held in Golden, Revelstoke and Valemount to assist B.C. Hydro and the Ministry of Environment in identifying priorities for future fish and wildlife enhancement (B.C. Hydro 1991b).

In 1993, B.C. Hydro announced the establishment of the Columbia Basin Fish and Wildlife Compensation Program. Annual contributions of $3.2 million from a $65 million fund supplied by B.C. Hydro will finance the enhancement of fish and wildlife affected by hydroelectric development throughout the Columbia River basin and will incorporate the program already developed to address similar initiatives for the Mica Reservoir. This fund is larger than its predecessor, designed to compensate for similar impacts along the Peace River ($11 million), reflecting the geographical diversity and larger population of the Kootenay region (B.C. Hydro 1993g).

The initiation of the Columbia Kootenay Fish and Wildlife Compensation Program is an acknowledgement that hydroelectric development causes a range of long-term impacts that may not be known or suspected, and that cannot be mitigated through one-time payments or replacements, as originally believed. Although mitigation and compensation projects may be able to replace some resource and recreation losses, they may not be able to restore previous terrestrial and aquatic systems to their previous state, or make up for foregone development opportunities. Smienk (1992) notes the inadequacy of mitigation or compensation to address unanticipated impacts, such as the long-term implications of mercury accumulation, a consequence of large-scale damming around James Bay. Battersby (1992) states that hydro development around Revelstoke has reduced the land available for community development, and although B.C. Hydro pays grants-in-lieu-of taxes for the use of local land, this payment does not replace taxation or the loss of economic activity that could have occurred otherwise.

The "taxation" procedures of B.C. Hydro facilities are somewhat complicated, but are worth considering with respect to compensation for the use of land and services under the jurisdiction of municipalities, regional districts and the province. The following information on taxation was provided through correspondence (Wright 1993a) and discussion (Wright 1993b) with Orville Wright, Property Tax Manager, at B.C. Hydro.

B.C. Hydro is exempt from all property taxes, according to section 52 of the Hydro and Power Authority Act, but compensates communities, regional districts and the provincial government for the use of land, water and services through school taxes, water rentals and grants-in-lieu-of taxes. Table 4 indicates the distribution of taxes and grants paid on the operation of B.C. Hydro facilities in the Columbia River Basin to municipalities, school districts, regional districts and the provincial government.

B.C. Hydro is required to pay annual grants to municipalities and regional districts as specified in order-in-council 1218 (1965). In 1982, a further order-in-council (2091) proclaimed that B.C. Hydro would be exempt from school taxes on land and improvements related to the generation of power on the Columbia, Peace, and Pend d'Oreille Rivers. Although this utility does not pay school taxes on dam facilities, it does pay school taxes on transmission lines, warehouses, and non-dam structures.

B.C. Hydro has paid annual grants to municipalities and regional districts instead of similar taxes since 1965; however, the recognition that some municipalities could receive larger portions of their tax base if the same hydroelectric facilities were operated by private utilities, and were subject to municipally determined tax rates, resulted in the promulgation of order-in-council 934

Table 4. B.C. HYDRO

1992 PROPERTY TAXES, GRANTS, and WATER RENTALS

Central Kootenay R.D.	School Taxes	Local Taxes and Grants	Water Rentals	Total
Castlegar	-	$67,677	-	$67,677
Nakusp	$16,797	24,530	-	41,327
New Denver	5,077	3,665	-	8,742
Silverton	1,501	1,300	-	2,801
School Dist. 07	3,531,658	5,797	-	3,537,455
School Dist. 09	105,707	7,548	-	113,255
School Dist. 10	951,558	4,658	-	956,216
School Dist. 86	676,888	6,153	-	683,041
Central Kootenay R.D.	-	360,630	$20,218,418	20,579,048
Sub-total	**$5,289,186**	**$481,958**	**$20,218,418**	**$25,989,562**
East Kootenay R.D.				
Cranbrook	$100,540	$151,656	-	$252,196
Fernie	26,309	28,229	-	54,538
Kimberley	43,056	24,850	-	67,906
Sparwood	182,595	71,468	-	254,063
Radium Hot Springs	9,046	2,029	-	11,075
Elkford	27,797	73,803	-	101,600
Invermere	13,154	15,012	-	28,166
School Dist. 01	674,169	53,534	-	727,703
School Dist. 02	1,050,755	42,555	-	1,093,310
School Dist. 03	117,645	21,333	-	138,978
School Dist. 04	377,277	1,354	-	378,631
East Kootenay R.D.	-	8,781	$692,582	701,363
Sub-total	**$2,622,343**	**$494,604**	**$692,582**	**$3,809,529**
Kootenay Boundary R.D.				
School Dist. 11	$394,574	$22,529	-	$417,103
School Dist. 12	211,318	187	-	211,505
School Dist. 13	228,382	-	-	228,382
Kootenay Boundary R.D.	-	312,930	$17,607,150	17,920,080
Sub-total	**$834,274**	**$335,646**	**$17,607,150**	**$18,777,070**
Columbia Shuswap R.D.				
Revelstoke	$121,584	$1,003,217	-	$1,124,801
Salmon Arm	174,514	85,758	-	260,272
Golden	39,031	47,588	-	86,619
School Dist. 18	91,667	15,233	-	106,900
School Dist. 19	1,165,751	25,301	-	1,191,052
School Dist. 89	2,701,311	136,471	-	2,837,782
Columbia Shuswap R.D.	-	597,345	$98,481,807	99,079,152
Sub-total	**$4,293,858**	**$1,910,913**	**$98,481,807**	**$104,686,578**
GRAND TOTAL	$13,039,661	$3,223,121	$136,999,957	$153,262,739

Source: B.C. Hydro

in 1991. This statute stipulates that B.C. Hydro is required to make annual grants-in-lieu of property taxes in addition to those paid previously in compensation for the use of land for dams, reservoirs, power houses and the Burrard Thermal Generating Plant. The rates relevant to individual municipalities and regional districts are specified.

"Taxation" policies for B.C. Hydro have been created to ensure that provincial rate payers receive affordable electricity consistently throughout the province. If municipally determined tax rates were applied to B.C. Hydro, as is the case for private utilities, B.C. Hydro would be forced to pay a higher proportion of the municipal tax base. This policy would enable municipalities and regional districts in the Columbia River Basin to reduce the present tax rates applied to other tax payers within their municipality or district, and would require provincial tax payers and/or B.C. Hydro rate payers to increase their portion of the payment for hydroelectric facilities. Various representatives of communities in the Kootenays insist that taxation of B.C. Hydro could be applied in a manner that would be more fair to those who reside within the region that produces up to 50% of the province's electricity capacity and, similarly, have expressed interest in receiving some portion of future downstream benefits.

3.53 Monitoring

B.C. Hydro has conducted numerous monitoring studies related to the environmental aspects of its operations in the Columbia River Basin. Most of its monitoring efforts have focused on elements of aquatic systems, due to the direct impact of dams on this ecosystem. Aquatic studies have focused on monitoring changes to fish populations, aquatic productivity and nutrient balances in reservoirs; testing for total dissolved gases from operations at the Keenleyside Dam;

and defining operational impacts of hydrological changes in rivers and reservoirs on organisms dependent on natural flows. Researchers are also studying means to prevent fish from passing through turbines at older power plants (B.C. Hydro 1992d).

Mercury concentrations have been measured and will continue to be monitored in Columbia River Basin reservoirs. The analysis of samples of water collected between 1981 and 1985, and zooplankton during 1985 and 1986 showed no indication of the presence of mercury. However, mercury was consistently detected in fish muscle tissue in the five Columbia River Basin reservoirs sampled. A 1985 study revealed that out of a total sample of 35 fish, two char from Whatshan Lake, one of the oldest Columbia reservoirs, had mercury concentrations exceeding 0.5 ug/g, the recommended level for commercial harvest. Mercury in char sampled from the Revelstoke reservoir were all below the 0.5 ug/g, although 20% exceeded 0.2 ug/g, the current medically significant limit (Smith 1987).

The role of carbon releases from Columbia River Basin reservoirs is being monitored as part of the "B.C. Carbon Project", a provincial examination of the carbon cycle balance. B.C. Hydro reservoirs cover approximately one percent of the total area of the province, and may represent important sources and sinks of carbon dioxide. The B.C. Hydro carbon study focuses on the carbon balance of its reservoirs, and will be used in conjunction w'th similar studies to examine the carbon balance of British Columbia, and its implications for global warming (Schellhase 1993).

B.C. Hydro is participating in research conducted by the Columbia River Integrated Environmental Monitoring Program (CRIEMP). This program was initiated in 1991 in an effort to coordinate various aquatic monitoring programs established by industrial and government organizations. The CRIEMP Committee hopes that coordination of data collection may provide a greater understanding of the impacts of dam operations and other industrial activities on the Columbia River Basin, and has prepared design, data, and reconnaissance reports. Data interpretation is in progress, and may require lengthy analysis due to the difficulty of studying an aquatic system with fluctuating flows and problems related to the attribution of impacts to a particular industrial activity (Beattie-Spence 1993).

3.54 New Supply Options

While previously dependent on strategies for increasing electrical energy supply, B.C. Hydro now favours demand management alternatives while options for additional supply are being investigated (B.C. Hydro 1993i). Programs such as Power Smart and Resource Smart have proven that substantial energy savings can be gained through conservation and improved energy efficiency. Power Smart has continually surpassed expectations regarding its potential since its inception (Marsh 1992) and is being promoted as an effective means of minimizing environmental impacts.

B.C. Hydro's Corporate Business Plan (1991 a) outlines its preferred sources of electricity supply. It ranks its options in the following order:

1. Power Smart
2. Coordination and Purchases
3. Resource Smart
4. Private sector generation
5. New hydro generation in developed basins
6. New hydro generation in undeveloped basins

This list of priorities clearly shows a shift in emphasis on energy sources. New power generation projects, the traditional approach to electrical supply needs, are currently considered to be expensive and detrimental to the environment.

Future hydroelectric planning for the Columbia River Basin involves seven Resource Smart initiatives at existing hydro facilities, and two proposals for new generating plants. Energy efficiency improvements are in progress on Kootenay Canal turbines, and the diversion of Barnes Creek to provide additional water to the Whatshan Plant is being studied. Hydroelectric plans for what is known as the Lower Columbia Development involve the addition of generators at five existing dams: Seven Mile, Waneta, Brilliant, Keenleyside and Duncan; and the installation of new facilities at Murphy and Border, downstream of Keenleyside on the Columbia River. The two new projects have not been included in the current 20 year plan, but are considered as future options (B.C. Hydro 1992c).

The repatriation of downstream benefits from Columbia River Treaty power generation could result in an additional supply of power to British Columbia in 1998. However, delivery of the Canadian Entitlement would require the construction of new transmission lines on both sides of the border. In addition to evaluating downstream benefits, the province is considering two other alternatives: negotiation of U.S. payment for the construction of power generation facilities in British Columbia that would provide an equivalent amount of energy, or the reselling of some or all of the Entitlement (B.C. Hydro 1993e).

3.55 New Policy Initiatives

Past experience with hydroelectric developments has led B.C. Hydro to establish new environmental policy initiatives. B.C. Hydro's recent efforts represent its greatest emphasis on environmental concerns in its thirty years of existence. The following is a summary of the principal components of its current environmental policy, with particular emphasis on aspects affecting the Columbia River Basin.

B.C. Hydro has adopted a new strategic initiative, "to develop and maintain a leadership role in environmental stewardship", in its Corporate Strategic Plan (1993). Specific actions to be addressed include: development of regional environmental initiatives to address the impacts of power production, identification of operations impacts, sharing of environmental expertise, and communication with the public. The six-member Environmental Committee of the Board of Directors assists B.C. Hydro in fulfilling its environmental leadership role (B.C. Hydro 1993j).

The adoption of regular reporting on environmental aspects of its operations will provide a means for B.C. Hydro to monitor its progress in meeting environmental objectives. B.C. Hydro published its second annual "Report on the Environment" in 1993 and is conducting environmental audits of various aspects of its operations.

B.C. Hydro has recognized the impacts of its hydroelectric operations on fish and wildlife, and in addition to ongoing research and mitigation at specific dam or transmission sites, established the Peace and Mica major compensation programs to address the impacts of dam operations on the land and water resources of the Peace and Columbia basins. These compensation programs consist of fish and wildlife studies and enhancement initiatives, and will be used as models for similar programs in other watersheds. Efforts are being made to involve local communities in the planning and implementation of program activities (B.C. Hydro 1993j).

Issues related to hydroelectric development in the Columbia River Basin have taken on a higher profile at B.C. Hydro during recent years. B.C. Hydro has made a corporate commitment to address the concerns of those living in this region in one of its strategic initiatives. The corporation seeks to invest in increased recreational and economic development opportunities for communities in the Columbia River Basin, using models developed in the Peace River Basin (B.C. Hydro 1993i, 4).

In keeping with its efforts to address dam-related issues in the Columbia River basin, B.C. Hydro has undertaken a number of initiatives to include Kootenays residents in basin-wide planning (Geissler 1994). In recognition of the need for clarification of Columbia River Treaty details, and in response to concerns arising from unresolved hydro development issues, twenty-five public meetings were held within the region in 1989. Due to the high level of interest shown at these meetings, B.C. Hydro's Board of Directors established The Columbia River Advisory Committee (CRAC), consisting of a group of representatives from seven communities with a Board member as chairperson, to provide recommendations on the provincial utility's operations in the region.

CRAC has been effective in providing communities with information related to the Columbia River Treaty, and in serving as a forum for the discussion of unresolved hydro development issues. Major issues have been resolved, such as the removal of B.C. Hydro's registered interest on the Columbia Marshes flood reserve between Canal Flats and Golden, in acknowledgement of the utility's decision not to proceed with proposals for the diversion of the Kootenay River in the near future. Decision-making structures have been established to undertake specific initiatives, such as the formation of a committee to address dust control problems at Revelstoke.

Although CRAC has provided a forum to address ongoing hydro development issues, various other initiatives have arisen from its work, and this group is no longer active (Geissler 1994). B.C. Hydro initiated the Columbia River Basin Operating Program to enable a management team within the utility to address a wide range of operational issues. Involvement of Kootenays representatives has been further strengthened through the appointment of three residents of this region to B.C. Hydro's Board of Directors.

Further efforts to involve the Kootenays in hydroelectric planning consist of a new Columbia Basin office and public consultation concerning the Electrical System Operating Review (ESOR). The establishment of a B.C. Hydro regional office in Castlegar in April 1993 indicates the utility's commitment to the ongoing management of hydro development issues as well as to increasing employment and economic development opportunities in the Columbia Basin region (B.C. Hydro 1993g). Participation by residents in the ESOR, B.C. Hydro's province-wide review of its hydroelectric system, should assist in the optimization of other goals besides power generation and flood control. Working groups with representation from different sectors have been established by seven communities to work with B.C. Hydro officials in the evaluation of tradeoffs between power and other uses of water such as economic development, recreation, and fish habitat (Geissler 1994).

The initiation of the Columbia Kootenay Fish and Wildlife Compensation Program in 1993 represents B.C. Hydro's most comprehensive compensation effort. Programs established under the Columbia Kootenay Fish and Wildlife fund will be administered by joint management and technical committees of the Ministry of Environment, Lands and Parks, and B.C. Hydro, with involvement from local communities. The Mica compensation program will continue to operate for another year, and will then be incorporated into the comprehensive program for the Columbia basin (B.C. Hydro 1993g).

3.6 Columbia River Treaty Committee

The Columbia River Treaty Committee (CRTC) was formed in 1991 to address the impacts of hydro development in the Columbia River Basin. Representatives of the Association of Kootenay Boundary Municipalities established this regional committee as a result of their belief that communities in the Kootenays have not received fair treatment for their role in hydro project operation. The Committee seeks a more equitable arrangement through establishing an equal partnership with provincial decision-makers. Some of its main objectives are: to restore the integrity of the environment and native heritage sites, to generate more local benefits from hydro operations through partial ownership or taxes, and to have the same development potential as other regions through compensation for economic losses (Smienk 1992).

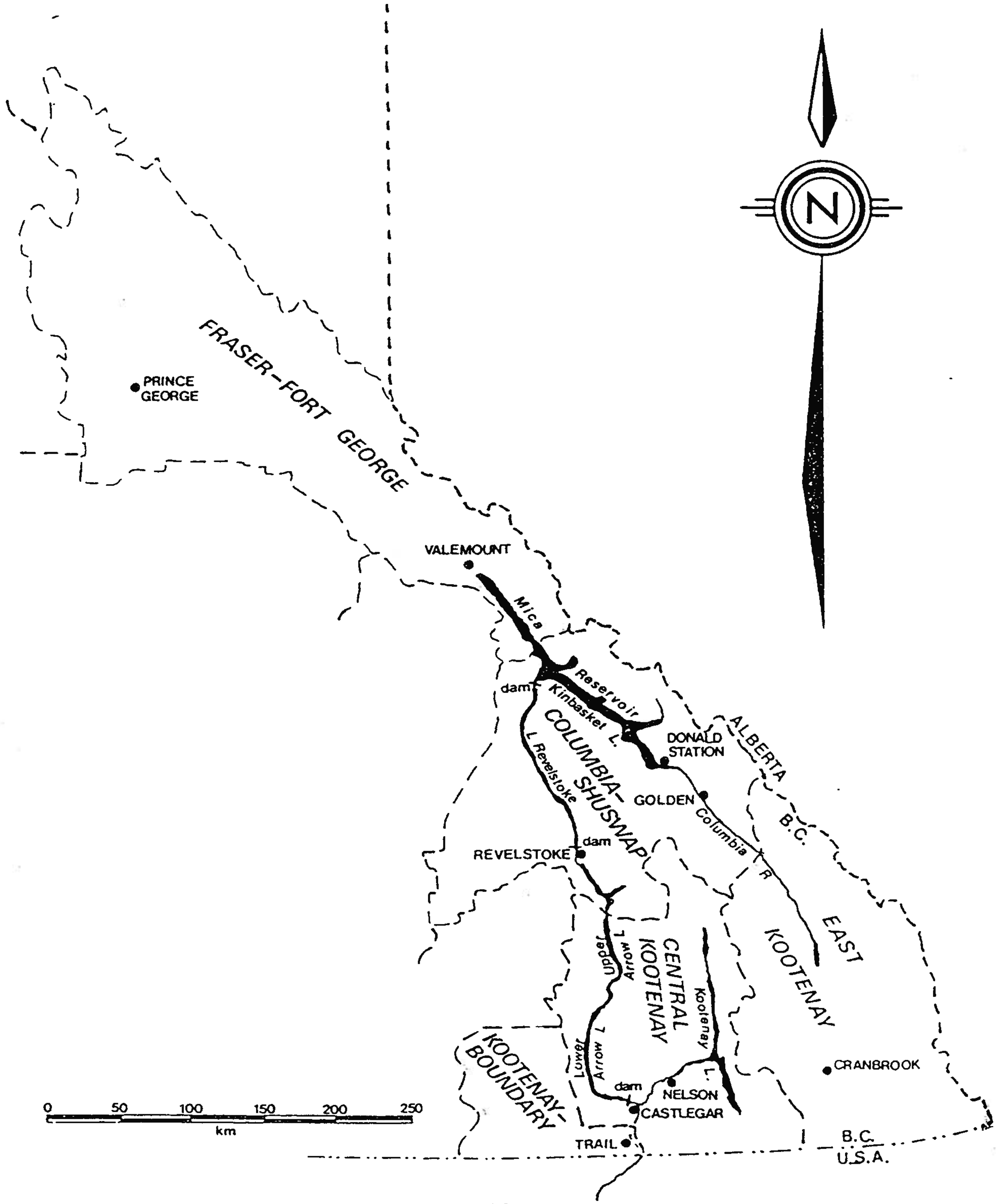
During the summer of 1992, the CRTC held a workshop with community representatives from the five regional districts operating in the Kootenays (Figure 10) and the Ktunaxa/Kinbasket Tribal Council to discuss their mutual interest in the consequences of hydro dam operations in the region. Table 5 contains a summary of the impacts identified at the workshop. Representatives of communities throughout the Kootenays agreed that the Columbia River Treaty had caused "substantial economic devastation" in many parts of the region (Fairbairn and Kumar 1992).

At a subsequent meeting of the Association of Kootenay Boundary Municipalities in September, the establishment of the CRTC was endorsed and the structure of the Regional Steering Committee was decided upon. The Regional Steering Committee now consists of two representatives (mostly mayors and councillors) from each of five regional districts, as well as two representatives from the Ktunaxa/Kinbasket Tribal Council. The primary mode of decision-making is based on reaching a consensus.

Each of the five regional districts and the Ktunaxa/Kinbasket Tribal Council have contributed $10,000 toward funding for the CRTC. This cooperative affiliation provides regional support for mutual interests in local resource management issues (Smienk 1993). The Ktunaxa Nation is pursuing many similar issues through its land claim, presented to the Canadian government in 1981 (Ktunaxa/Kinbasket Tribal Council 1992).

While residents of the Kootenays are aware of many of the impacts of hydro development in this region, the CRTC has stimulated interest in Columbia Basin hydro development through two main events: the recent occurrence of extremely low water levels in Columbia and Kootenay

Figure 10. **Regional District Boundaries**



Source: Triton (1990), p. 96

Table 5. **SUMMARY OF TREATY IMPACT BY REGION**

MUNICIPALITY/AREA	SUMMARY OF ECONOMIC IMPACTS
VALEMOUNT	19,000 acres of forestry, tributary creek dried up, water shortage
NAKUSP	Fluctuating lake levels, property erosion, fisheries, affects tourism, debris problem
AREA E	Libby Dam -- stripping nutrients, sterile Kootenay lake, fishing species -- especially trout
CASTLEGAR	fluctuating lake level as much as 70 feet, export of resources, high discharge of oxygen, high flows, eroding land
CITY OF REVELSTOKE	Forestry, 800,000 cubic meters, approximately $52 million per year loss; tourism value lost, maintain minimum lake levels at least in summer, some economic funds for the Region, 97% of water to south
GOLDEN	Loss of transporation, loss of forest, wildlife, popular hunting lost -- 11 fishing lakes, lake level low, serious economic effects
COLUMBIA/SHUSWAP	Province reneged on its economic role for the Region, no or little consulation process
FRASER FORT GEORGE - VALEMOUNT	Loss of timber, recreation, fishing, draw of the timber affecting McBride up stream, loss of hot springs -- Williston Lake
TRAIL	Whole Region receiving benefit from flood control, negative impact on fishing, tourism, transfer of benefits from one Region to another, e.g. recreation to Champion Lake vs. Syringa Creek -- loss of water supply to Trail -- new water treatment plant at a cost of $8 million required for Trail
R.D.C.K.	Same impacts as outline in other areas
R.D.E.K.	Libby Reservoir, lost land, agriculture, mining, tourism, hardship, some recognition to the effect of climate to lake levels
ROSSLAND	Adverse impact on touristm, adverse impact on some infrastructure, economic loss to this Region
TRIBAL COUNCIL - NAKUSP	16 major dams, native fisheries, economic loss, archaeology sites exposed, people moved

Source: Fairbairn and Kumar (1992), p. 16

River reservoirs during the summers of 1992 and 1993; and the 1997 return of downstream benefits. These two "events" have focused attention on the Columbia River Treaty and its implications for present and future residents of the Kootenays.

3.61 Low Reservoir Levels

During the summers of 1992 and 1993, water levels in Columbia River Basin reservoirs were particularly low and did not refill to their normal full levels (Figure 11). Low water levels have resulted from two consecutive years of light winter snowfalls with corresponding small releases of moisture from snowpacks at the source of the Columbia and Kootenay Rivers, combined with deep drafts of water for power generation (particularly due to the colder winter of 1992/93), Columbia Treaty obligations, and recent American efforts to assist juvenile salmon migration and white sturgeon spawning through increased spring water releases (B.C. Hydro 1993b).

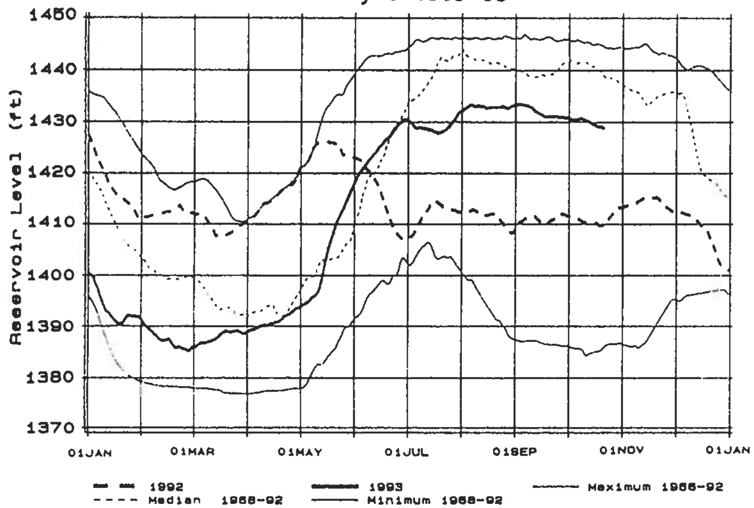
B.C. Hydro (1992b) recorded the following water levels on Columbia River Basin reservoirs during July/August of 1992:

Mica:	2452 ft. (747 m) - 23 ft. (7 m) below full
Arrow:	1415 ft. (431 m) - 29 ft. (9 m) below full
Duncan:	1856 ft. (566 m) - 36 ft. (11 m) below full
Libby:	2440 ft. (744 m) - 19 ft. (6 m) below full

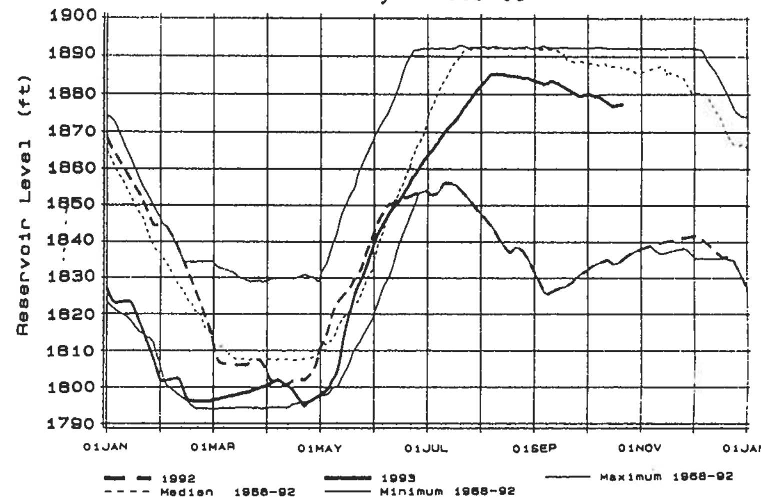
The 1992 low level registered at Duncan was the lowest in its twenty-five years of operation. Although reservoir levels at Mica, Arrow and Libby were also low during this period, even

Figure 11. Columbia River Basin Reservoir Levels

Arrow Reservoir Levels
Summary for 1968–93

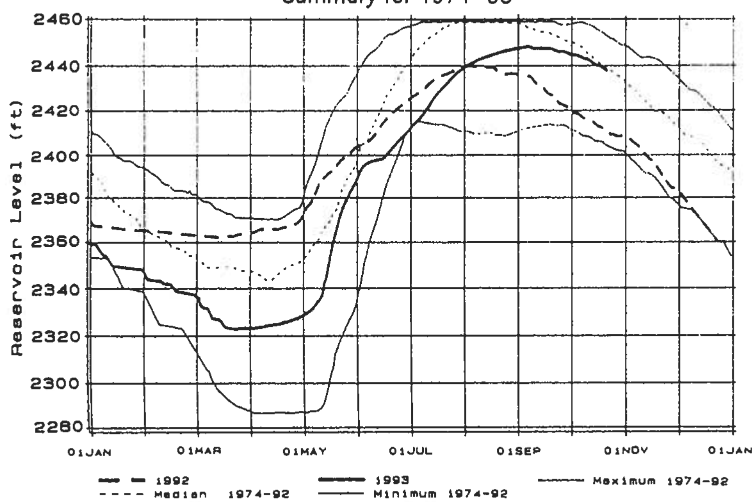


Duncan Reservoir Levels
Summary for 1968–93



Source: Adapted from B.C. Hydro

Libby Reservoir Levels
Summary for 1974–93



Mica Reservoir Levels
Summary for 1976–93

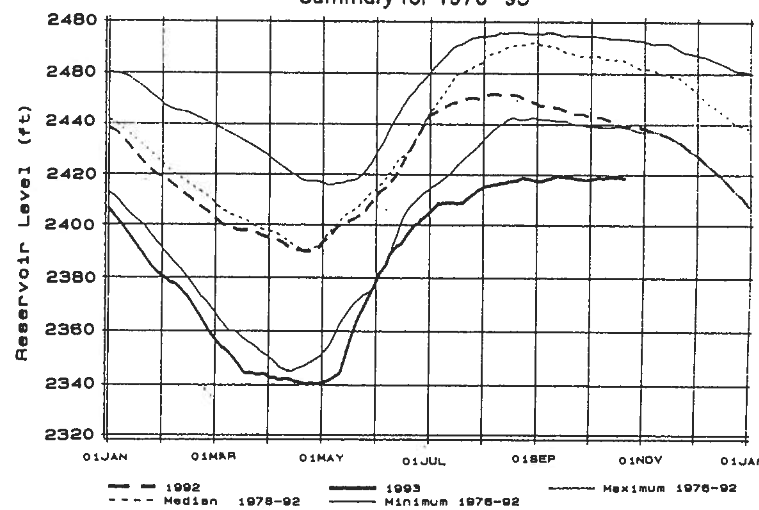
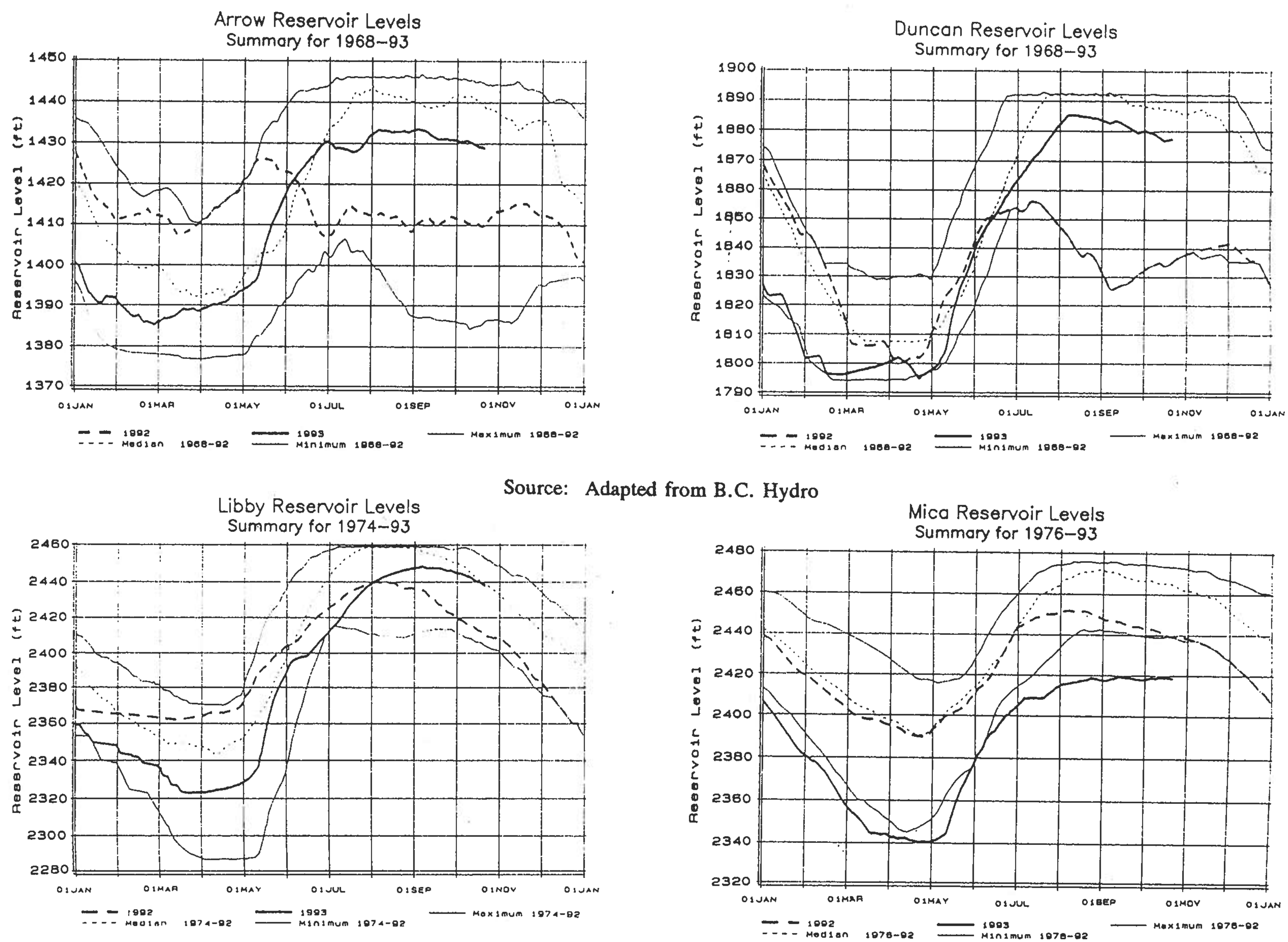


Figure 11. Columbia River Basin Reservoir Levels



Source: Adapted from B.C. Hydro

lower levels have been recorded at other times during the history of their operation (B.C. Hydro 1992b).

Low water levels in Kinbasket, Koocanusa, Arrow and Duncan reservoirs during the summers of 1992 and 1993 have caused a variety of problems for residents of the Kootenays. Low water levels have affected fish by restricting access to certain tributaries, inhibiting spawning, increasing fishing pressure by concentrating fish in smaller areas, and increasing the likelihood of fish passing through hydroelectric turbines. Low levels affect farming as fences may need to be extended to control livestock. Exposed mud flats have caused dust storms and are perceived as an eyesore. Boat ramps were not constructed for such low levels and have reduced access to water for recreation, fishing, tourism and logging operations. Aboriginal burial sites along the Koocanusa Reservoir have been uncovered by water level fluctuations, and artifacts have been removed (B.C. Hydro 1993b, Phillips et al. 1992, Bennett 1993).

During the summer of 1992, the Arrow Lakes were particularly affected by low reservoir levels (Figure 11). Low levels normally experienced earlier in the spring were delayed until the summer as a result of a B.C. Hydro agreement to store additional water in the Arrow Reservoir for release in May and June, to assist fish migration in the United States (B.C. Hydro 1992b). Low water levels disrupted boating, swimming and fishing in the reservoir, and exposed banks caused dust storms and reduced the scenic nature of the area (Figure 12). Communities along the Arrow Reservoir believe that these impacts are particularly significant to their economic development, as many are trying to reduce their dependency on forestry by promoting tourism as a means of economic diversity (Johnson 1992, Hamling 1992).

Figure 12. Wharf extension at Nakusp during low levels on the Arrow Reservoir (August 1992)

B.C. Hydro has taken several initiatives to address some of the low water level problems experienced during the past two summers through revisions to its operating plans. It has reduced exports of non-firm (non-guaranteed) energy, increased energy production at Burrard Thermal Plant, bought energy from other utilities, and transferred storage requirements from one reservoir to another in an effort to maintain adequate levels of water for the various users of its reservoirs. Reservoir levels have been adjusted to assist fish spawning downstream of Arrow, and recreational users. Fencing has been made available to farmers, and boat ramps have been extended (B.C. Hydro 1993b).

Although Arrow Reservoir levels improved during the summer of 1993, as a result of a U.S. agreement to not use water stored in the Arrow Reservoir for its fish migration program, low levels were experienced in other reservoirs during this period. Low water levels in the Koocanusa Reservoir have disrupted fisheries, recreation and tourism for communities living upstream from the Libby Dam (Cutts 1993, Parker 1993, B.C. Hydro 1993b). Low levels in the Kinbasket Reservoir delayed logging operations and required an extension of the boat ramp at Valemount to enable recreational use of the reservoir (Bennett 1993, B.C. Hydro 1993b).

3.62 Downstream Benefits

The negotiation of downstream benefits for the second thirty-year period of the Columbia River Treaty has also sparked interest in hydro development issues in the Kootenays. In recognition of Canada's role in regulating the Columbia River for the purposes of power generation, it was awarded one half of all of the power generated downstream at the Grand Coulee Dam. Since Canada did not foresee a need for this power due to its abundance of untapped water resources in British Columbia, it was decided that its downstream benefits would be sold for a period of thirty years. Current negotiations will result in a 1997 announcement of British Columbia's new agreement regarding either the return of power generated downstream to a point near Oliver, B.C. (the default scenario) or a renegotiated settlement for payment, as agreed during the first thirty years (B.C. Hydro 1993c).

In interviews with residents of the Kootenays, many insisted that some portion of the downstream benefits should be given to those living with the consequences of hydro development. Communities in the Columbia River Basin believe that they were not treated fairly during Columbia River Treaty negotiations and consider the 1997 negotiations regarding downstream benefits as an opportunity to assert their concerns with past, present and future implications of dam operations. The distribution of some portion of downstream benefits to communities in the Kootenays would recognize their role in the regulation of water resources, assist the financing required to manage the effects of hydro development, and compensate for losses related to foregone opportunities for community development.

3.63 The Columbia-Kootenay Symposium

In late May and early June of 1993, the CRTC organized meetings in seven communities in the Columbia River Basin to provide a public forum for the discussion of Columbia River Treaty issues. The purpose of these meetings was to share information from local residents, provincial government and B.C. Hydro representatives related to cooperative processes for past, present and future hydro development concerns and future development possibilities. Meetings were held in Valemount, Kaslo, Revelstoke, Golden, Nakusp, Castlegar and Cranbrook.

Representatives from communities throughout the Kootenays were invited or nominated to attend the regional "Columbia-Kootenay Symposium" in Castlegar, June 18-20. Approximately 30 provincial government representatives (including the Ministers of Energy, Mines and Petroleum Resources; Economic Development, Small Business and Trade; and Labour and Consumer Services) and six BC Hydro officials were invited to participate, make presentations and assist with information clarification; however, the majority (approximately one hundred) of participants represented community interests within the region.

The first half of the symposium focused on the identification of past problems related to hydro dams in the region. Presentations and small group sessions enabled Kootenay residents to express their opinions to provincial decision-makers and share information with those who have similar concerns from other parts of the region. The latter half of the symposium addressed future development ideas. Participants discussed priority issues for community development and attempted to develop creative solutions to address hydro-related problems.

The following themes were identified in a summary report of the Columbia-Kootenay Symposium (Salasan Associates 1993):

1. People of the Columbia-Kootenay Basin are closely linked to its land, lakes and rivers;
2. There is a need to redress the impacts of past hydro development;
3. Residents of the Kootenays seek empowerment to make decisions regarding the future of their region;
4. Empowerment requires access to useful information;
5. The region should receive some share of downstream benefits;

6. In addition to applying downstream benefits to mitigation and economic development within the Columbia-Kootenay Basin, some portion should be directed toward regional water management and the development of alternative energy sources for the province;
7. Local people should participate in reservoir management decisions;
8. The duration of energy, storage and water commitments to the United States should be limited to allow flexibility to respond to changing needs and economic conditions;
9. A local authority should manage funds for economic development within the region;
10. Future development should "meet the test of sustainability" through a process of "full cost accounting" that considers economic, social and environmental interests;
11. Development initiatives should be community-based but coordinated regionally to achieve maximum benefit; and
12. The provincial government, First Nations and local governments should respond to ideas presented in the Symposium in a timely manner.

The establishment of the CRTC was strongly endorsed throughout the symposium, and the three provincial ministers in attendance committed themselves to developing a cooperative partnership with this organization in future decisions involving the river systems of the Kootenays. Two small group sessions developed resolutions expressing their support for the formation of a Columbia River Basin management board or authority, emphasizing the need for a multi-stakeholder group that would participate in regional resource use decisions.

3.7 Evaluation of Implications of Hydro Development on the Columbia River Basin

Residents of the Kootenays have lived with the effects of hydro development and are well aware of its implications for their communities. Hydro development has replaced the natural cycles of rivers, lakes and wetlands with a series of reservoirs with unseasonal water level fluctuations. The regulation of the Columbia River system for power generation and flood control has resulted in changes to the integrity of the regional resource base, land use modification, and has affected the ability of local communities to make resource use decisions.

B.C. Hydro has acknowledged the disruption that its dams have caused to the lives of those dwelling within the Columbia River Basin, and is making efforts to compensate and mitigate for past and ongoing impacts. New hydroelectric planning policies endeavour to undertake a more comprehensive approach to mitigating and compensating the impacts of hydro development, and including local communities in resource base decision-making.

The information collected during the case study indicates that many of the direct consequences of the operation of large dams in the Kootenays are commonly understood, although further research is necessary to monitor ongoing impacts. Fisheries impacts have been particularly well documented. Wildlife impacts have not received the same level of attention. Although local residents are aware of the links between resource and land use changes, and their significance for future community development, there has not been much documentation of their interdependence.

Residents of the Kootenays are familiar with the general nature of the Columbia River Treaty;

however, misunderstandings concerning operating details have generated confusion and frustration. Information related to the Columbia River Treaty and the preparation of operating plans has been largely controlled by B.C. Hydro and the provincial government (Swainson 1986). Communities near dam sites believe that their interests have not been considered adequately in hydroelectric planning, and seek greater control over the use of their resource base.

The formation of the CRTC, and the organization of the Columbia-Kootenay Symposium have empowered the region to assert its rights to the stewardship of resources within the Columbia River Basin. This regional initiative has stimulated a cooperative effort to address resource use issues and may assist communities, B.C. Hydro and the provincial government in the examination of the implications of hydro development impacts on the long-term sustainability of resources and the communities that depend upon them.

In an effort to clarify some of the most significant impacts of the operation of hydro dams in the Columbia River Basin, two tables were prepared summarizing many of the issues identified during the community meetings preceding the Columbia-Kootenay Symposium (Tables 6 and 7). The concerns addressed during these meetings and at the regional forum encompass most of the impacts and community development issues raised by the various sources consulted throughout my research.

Table 6 is a compilation of the negative impacts of hydro development, perceived throughout the region. The positive impacts experienced are summarized in Table 7. The impacts identified by community members are organized according to the three main stages of hydro

Table 6a - NEGATIVE IMPACTS OF COLUMBIA RIVER BASIN DAMS, AS IDENTIFIED BY RESIDENTS OF THE KOOTENAYS

Hydro Development Stage: Dam Construction

Hydro Development Activity Causing Land Use Change	Ecological Impacts	Social Impacts	Economic Impacts	Policy Options
construction activities		changes to community structure and infrastructure →	→ boom-bust economy	community participation during project planning
				thorough evaluation of alternatives
				small projects
				community investment funds
				alternative technologies
				cogeneration
				energy conservation
				low power rates for host communities
				appropriate compensation for relocation
				improvement of local education systems
				development of local research centres
blockage of nutrients behind dam	loss of nutrients for fish →	→ loss of food source		nutrient loss strategies
		→ loss of fishing, recreation and tourism →	→ loss of income and taxes from fishing, recreation and tourism	
transmission lines	hazard to wildlife	hazard to human health		underground power lines
	spread of weeds	eyesore		

Note: Tables 6a, 6b, 6c and 7 were compiled from comments included in "Columbia River Treaty Committee Local Community Meeting Notes". Comments have been categorized as indicated to assist the interpretation of relationships between dam-related activities and ecological, social and economic impacts to communities in the Kootenays. Links between dam activities and impacts are indicated by reading across the table. Links between impacts are indicated with arrows.

Table 6b - NEGATIVE IMPACTS OF COLUMBIA RIVER BASIN DAMS, AS IDENTIFIED BY RESIDENTS OF THE KOOTENAYS

Hydro Development Stage: Flooding

Hydro Development Activity Causing Land Use Change	Ecological Impacts	Social Impacts	Economic Impacts	Policy Options
loss of land base	depletion of natural resource base and reduction of biodiversity due to loss of soil, forests, and rich riparian zones in flat, low areas along river valleys	→ loss of sovereignty	→ loss of community-led economic development	increase land availability for community projects
	→	→ loss of land for community expansion	→	
	→	→ loss of heritage	→	
	→	→ loss of forestry, mining, agriculture, recreation, and tourism	→ reduced economic diversity due to loss of income and taxes from forestry, mining, agriculture, recreation, and tourism	research impacts
				compensation
				develop holistic forestry
		inadequate compensation	→	encourage tourism
	→	→ conflicts over remaining land base	→	
	→	→ loss of homes and communities		
		sense of injustice		
		truama-induced health problems		
		loss of transport links	→ loss of economic development opportunities	improve road system and airport
		loss of infrastructure (power and telephone)	→ increased replacement cost for infrastructure	improve infrastructure
	loss of waterfowl and wildlife habitat and increased pressure on remaining land base	→ loss of food source and loss of hunting	→ loss of income and taxes from hunting	community management of fish and wildlife
				increase wildlife habitat
				research impacts
				compensation
larger water body	climate change	→ more wind		
	→	→ reduced logging season due to freezing of reservoir	→ increased forestry costs and loss of income and tax from forestry	
	riverine fish habitat replaced by lacustrine habitat	→ loss of sports fishery	→ loss of income and taxes from fishing, recreation and tourism	fish enhancement
incomplete clearing of trees before flooding	water quality degradation	→ loss of fishing, recreation and tourism as debris is an eyesore and a hazard	→ loss of income and taxes from fishing, recreation and tourism	remove stumps

Table 6c - NEGATIVE IMPACTS OF COLUMBIA RIVER BASIN DAMS, AS IDENTIFIED BY RESIDENTS OF THE KOOTENAYS

Hydro Development Stage: Dam Operation

Hydro Development Activity Causing Land Use Change	Ecological Impacts	Social Impacts	Economic Impacts	Policy Options
fluctuating water levels in reservoirs	unseasonal variation in water flow regime	→ change in relationship with land		local participation in decisions
				use downstream benefits to implement community management
				forego financial benefits to ensure appropriate water levels
				dam operation agreements should be short-term
				install turbines at Keenleyside Dam to stabilize water levels
	loss of fish habitat, variable access to fish habitat, and changing fish habitat conditions	→ loss of food source and loss of fishing, recreation and tourism	→ increased fisheries management costs and loss of income and taxes from fishing, recreation and tourism	community management of fish and wildlife
				research on fish enhancement
				increased funding for fish and wildlife management
		logging dump site maintenance and boat launching access problems	→ increased forestry costs and loss of income and taxes from fishing, recreation and tourism	establish minimum water levels
				improve access to water
				improve non-reservoir-based recreation
		water intakes unusable	→ increased water supply costs	improve community infrastructure
		flooding	→ increased maintenance costs	
	erosion	exposure of aboriginal heritage sites		bank stabilization
		property loss	→ loss of property value	
	dust storms	nuisance		
	reduced water flows	health impacts of concentrated pulpmill effluent		industrial waste management
B.C. Hydro tax exemption			loss of taxes	B.C. Hydro could pay municipal taxes similar to other industries

Table 7 - POSITIVE IMPACTS OF COLUMBIA RIVER BASIN DAMS, AS IDENTIFIED BY RESIDENTS OF THE KOOTENAYS

Hydro Development Stages	Hydro Development Activity Causing Land Use Change	Ecological Impacts	Social Impacts	Economic Impacts
Dam Construction	dam and road construction		road improvements	transportation benefits
				short-term jobs
	compensation			some financial gain to property owners through compensation
Flooding	larger water body	climate change	→ more moderate climate	
			more lakeview lots	
			increased water transport	
			marginal recreation (depends on water levels)	
Dam Operation	flood control		property security	economic benefits
	power generation		power benefits for B.C. and U.S.; some power benefits in Kootenays	→ long-term employment and economic development in B.C.; some long-term employment and economic development in Kootenays
	regulation of water flow	reduced turbidity	→ improved navigation	→ fishing, recreation and tourism benefits
	visitor centre *			tourism benefits
	compensation *		parks and marina improvements	→ fishing, recreation and tourism benefits

Note: * Although the visitor centre and compensation programs have actually resulted from policy initiatives rather than land use change, they have been included as their impacts have been noted by Kootenay residents.

development (construction, flooding and ongoing operations) that have influenced land and resource use changes within the Columbia River Basin. Issues have been categorized as ecological (affecting the relationships between living organisms and their surroundings), social (affecting the relationships between people) or economic (affecting the relationships involved in the production, distribution and consumption of resources) impacts, and suggestions for compensation, mitigation or community development have been considered as development policy options.

3.71 Evaluation of the Negative Impacts of Hydro Development

When read horizontally, Table 6 indicates the impacts of various stages of hydro development. Many of the specific activities associated with these stages have resulted in land use changes that have caused ecological, social and economic impacts. The activities identified in the first column of Table 6 do not represent a complete list of activities, but highlight those most directly connected to impacts of importance to Kootenay residents. Although empty spaces imply an absence of impacts, this may not always be the case, as this table was prepared based on perceptions expressed during community meetings. The table may not be a complete compilation of impacts; however, it summarizes the principal issues discussed throughout this examination of hydro development in the Kootenays.

Communities are well aware of the relationships between ecological, social and economic impacts of hydro project activities. For example, it is fairly widely understood that the blockage of nutrients behind dams has reduced the nutrient supply available to fish, causing decreased fishing, recreation and tourism opportunities, resulting in a loss of income from fishing, recreation and tourism. These linkages have been noted with arrows on Table 6. Impacts of dam development were expressed independent of related consequences (without arrows) when linkages were less certain.

When read vertically, Table 6 shows the overall adverse changes that have occurred to ecological, social and economic systems. These cumulative impacts provide useful information regarding implications for sustainability of these three systems. In general, they can be summarized as follows.

According to the perceptions of Kootenay residents, **ecological impacts** can be described in terms of their effects on ecological productivity. In general, fish nutrients and habitat have declined, and variable unseasonal aquatic conditions make it difficult for fish populations to maintain their previous levels of productivity. The flooding of wildlife habitat has reduced the capability of river valleys to support wildlife populations. The flooding of forest land has reduced the regional forest base and may have affected biodiversity.

The **social impacts** described by Kootenays residents represent a general feeling that regional "livability" has changed. The sense of happiness or satisfaction derived from living in a particular place or region has been disturbed. Residents have stated that they have experienced injustice through various stages of hydro development and are frustrated with their lack of inclusion in decision-making. The installation of hydroelectric facilities on productive land and water in valley bottoms has led to various resource use conflicts. Fluctuating reservoir levels and exposed stumps and shorelines are a nuisance and pose hazards for people and wildlife. Residents of the Kootenays are closely linked to the land and resent the loss of fishing, recreation and tourism resulting from ongoing dam operations, and are unhappy with changes to the aesthetic appeal of their scenic landscape.

The **economic impacts** described by Kootenay residents can be summarized as affecting opportunities for economic development. The reduction in size, quality and access to forest, fish, wildlife and water resources as a result of past and ongoing hydro operations is believed to have caused reduced employment and a smaller tax base for communities dependent on resource-based and related industries. Forestry operators have borne increased costs to continue their logging businesses. Some municipalities have had to replace infrastructure affected by hydro development, or are faced with continued maintenance costs for infrastructure expanded for the short-term use of hydro project workers. Lost aboriginal and other heritage sites may jeopardize land claims and future economic development based on heritage information. Overall, residents believe that the region's resource base has been diminished, resulting in fewer opportunities for future economic development.

Future compensation, mitigation and development possibilities, as identified by community residents, have been listed under "Policy Options." Some suggestions address changes to encourage community participation in resource management and new development initiatives, while others identify specific areas for compensation or mitigation efforts. Many of these ideas emphasize enhancement of the resource base and related improvements in community infrastructure or access to decision-making.

In examining the potential of policy options to address the impacts of hydro development, it is helpful to consider the impacts in terms of the three stages outlined in Table 6. Many of the impacts of dam construction have already occurred and are to a large extent irreversible, unless the actual dam structure was removed, as considered for a dam that has blocked fish runs on the Elwha River in Washington (Egan 1993). Although compensation and mitigation programs may offset some of the adverse impacts experienced, many of the policy options suggested are recommendations for future hydro project planning, and represent efforts to avoid the repetition of similar problems when meeting energy needs in the future.

Opportunities to address the impacts of flooding the valley bottoms of the Kootenay and Columbia Rivers are limited similarly to those resulting from dam construction. Essentially, the majority of land which was flooded several decades ago will remain under water, and the residents of the region must face the consequences of this change to the land base, although certain infrastructure improvements may mitigate some of the residual impacts.

Impacts arising from dam operation represent a different set of problems which have a greater ability to be addressed due to their ongoing nature. The fluctuation of water levels in reservoirs is the most significant activity resulting from ongoing dam operations that continues to affect land and water use, resource management and economic development. Although reservoir levels are determined according to Columbia River Treaty and Non-Treaty Storage Agreements, there is some flexibility in the various operating plans that implement international obligations, and the distribution of benefits will be reviewed in 1997 downstream benefit negotiations. Many of the policy options suggested by Kootenay residents may indeed be possible, through consideration of trade-offs between power and other uses of Columbia River Basin water; however, the forfeit of power benefits may cause financial losses to the province. Community participation in decision-making may provide the central opportunity to affect policy changes on issues significant to local residents.

3.72 Evaluation of the Positive Impacts of Hydro Development

In reviewing the contents of Table 7, it is evident that the benefits of hydro development are generally perceived by residents of the Kootenays to be fewer in number than the detrimental impacts.

The local benefits of dam construction are viewed as being largely economic and social, and relatively short-term in nature. Employment advantages were relatively short-term in nature and are considered as past benefits, as ongoing hydro operations employ few residents of the Kootenays as compared to those employed in the Lower Mainland. Some property owners realized one-time financial gains from B.C. Hydro compensation. Road improvements are restricted to certain areas around dam sites and should be balanced against losses to road networks experienced elsewhere.

The benefits of flooding are fairly specific to several communities. They consist of social advantages derived from a more moderate climate, the increased availability of lakeview lots, increased water transport (although this is partly offset by fluctuating water levels), and marginally improved recreational opportunities (also affected by changing water levels).

Current dam operations have contributed some social and economic benefits to the Kootenays. Flood control, for example, is considered a social and economic benefit. Power generation produces energy, employment and economic development benefits for the United States, and

British Columbia, and stimulates similar advantages to a lesser degree in some parts of the Kootenays. The regulation of water flow reduces turbidity, improving navigation in some parts of the river system. The improvement of parks and marinas and the development of a tourist centre through B.C. Hydro has enhanced certain opportunities for fishing, recreation, and tourism in specific areas.

When the information from Table 7 is interpreted vertically, the overall consequences of hydro-related benefits can be summarized. Generally, there are few ecological benefits perceived as ensuing from hydro development. While the Kootenays derive some social benefits from hydro development, the large majority are directed towards power consumers throughout British Columbia and the U.S. Pacific Northwest. Some residents of the Kootenays receive power services from West Kootenay Power, and therefore do not benefit from B.C. Hydro's large hydro projects.

Economic benefits to the Kootenays are largely believed to have accrued during dam construction through short-term employment, economic development (e.g., hydro-related construction, housing development, expansion of retail services) and financial gains to some property owners. The majority of benefits from employment and economic development are widely considered to flow to power consumers in large urban centres in British Columbia and in the U.S. Pacific Northwest. Dam operation employs some local residents; however, since power rates are the same throughout the province, local power generation by B.C. Hydro does not attract industrial development to the region. The adverse impacts on fishing, recreation and tourism identified in Table 6 are viewed by residents as outweighing any benefits received by these sectors.

3.73 Implications of Hydro Development for the Kootenays

The natural processes and relationships among rivers, trees, fish and wildlife, and the human populations that dwell within the mountainous countryside known as the Kootenays have been disturbed. People living in the region believe that the integrity of their fish, wildlife and forest resource base has been jeopardized. They feel unhappy about their lack of control over conditions that affect their lifestyle. The withdrawal of land from a resource base that is naturally limited by physiographic conditions represents foregone economic development opportunities, and decreases the future options available for resource-dependent communities.

According to the perceptions of Kootenays residents, the negative impacts of hydro development appear to have been much greater than the benefits received within the region. The majority of benefits resulting from hydro projects have been experienced by power consumers and industrial enterprises outside of the Kootenays: in the Lower Mainland and in the U.S. Pacific Northwest. Those living with the effects of large dams in the Columbia River basin believe they have not been compensated adequately for the losses they have incurred.

B.C. Hydro and provincial government officials recognize the problems that local communities have experienced as a result of hydro development. They have acknowledged that compensation has been inadequate and have established a basin-wide compensation program. While the payment of compensation may help to address the unfair share of costs that have been borne by the Kootenay region, it does not ensure that communities will be included in future hydro project decisions. B.C. Hydro has committed itself to involving residents of the region in its planning initiatives. However, as there is no co-management agreement or formal recognition of a regional advisory group, there is no guarantee of rights for local people to ensure their access to the local resource base.

While this evaluation of the positive and negative aspects of dams in the Columbia River basin does not measure the magnitude of impacts experienced, it provides a basis for understanding the number, type and duration of issues arising from hydro development over a period of approximately thirty years. To gain a more meaningful appreciation of the significance of some of the impacts identified by Kootenay residents, key issues are examined in greater detail through the use of indicators in the next chapter.

4. INDICATORS OF THE IMPACTS OF HYDRO DEVELOPMENT ON SUSTAINABILITY

Information gained from literature, interviews with residents of the Kootenays, and participation in community forums suggests that hydro development in the Columbia River Basin has changed certain conditions relevant to the operation of ecological, social and economic systems interacting within the region. In a mountainous region where harsh climatic and physiographic factors limit the diversity of activities that can occur, the land situated in low and relatively flat margins along valleys provides the most favourable characteristics for a wide variety of land uses, as human and non-human communities tend to establish their activities along the shores of river systems where the most productive renewable resources are easily accessible. Residents believe that some dam-related changes have affected the well-being of various elements of their surroundings and have influenced the opportunities for access to key elements of these systems.

To understand the importance of hydro development impacts in the Kootenays it is useful to identify some of the key problems experienced in this region through the analysis of indicators. While the previous discussion has outlined a wide range of consequences of Columbia River Basin dams, this chapter will examine specific issues in an effort to determine the extent to which dams have affected ecological, social and economic conditions. The use of indicators allows one to examine the state of ecological, social and economic systems, as well as periods of change or stress. The evaluation of sustainability enables the consideration of resilience and adaptability of these three systems and what this means for long-term goals of ecological, community and social stability. The information arising from the examination of indicators can then be compared to the perceptions described in the previous chapter.

An evaluation of the significance of the impacts of hydro development in the Columbia River Basin requires the use of suitable criteria. As this thesis examines the consequences of hydroelectric dams and their implications for sustainability, it is necessary to adopt an evaluation method that addresses key aspects of sustainability. Since there are no well-established methods for testing sustainability, this section will outline a set of indicators that have been selected for this purpose.

The development of indicators represents an effort to monitor the state of a system(s) and any trends and/or progress towards desirable societal goals. To appreciate the significance of the impacts described previously, and describe them in the context of sustainability, it is useful to test these perceptions with measurements of values or conditions that are important to people and their quality of life. Indicators may not be able to determine cause and effect relationships with certainty; however, the use of a variety of measures that reflect issues identified by community members may assist residents of the Kootenays, hydro development planners, and resource managers in gaining some basic insights regarding the implications of land use change related to industrial activities, and the significance for sustainability of their communities.

4.1 Indicators

In recognition of the need to improve environmental information, policy makers have encouraged the development and use of indicators. An indicator is a useful piece of information that tells a story about the state of larger systems. Although indicators are intended to demonstrate the general conditions of a system, they may be able to establish cause and effect relationships, and facilitate the monitoring of trends. With respect to environmental concerns, indicators can provide early warning signals and provide information on the extent to which human activity is causing environmental stress (Environment Canada 1991, 2). For example, the presence of trout or salmon in freshwater streams is considered to be an indicator of a healthy aquatic ecosystem. The demise or absence of an indicator species may signify a decline in ecological productivity, resulting from human or non-human activity.

The "indicators movement" has arisen largely in response to the perception that economic indicators have been overly emphasized in terms of their ability to monitor societal well-being. During the mid-1960s, many social scientists assisted in the development of social indicators in an effort to provide more meaningful sets of information for social policy makers (Carley 1981, 1). A similar interest among those concerned with ecological integrity and the state of the environment has resulted in research on ecological and environmental indicators. Although socio-economic indicators such as unemployment rates, gross national product and literacy rates are now commonly used, the establishment of appropriate environmental indicators has lagged behind other types of indicators. The development of environmental indicators is considered important in order to monitor progress towards sustainability.

Recent interest in developing indicators of sustainability has arisen from the recogition of the interaction of ecological, social and economic systems, and the need to find methods for measuring progress towards this societal goal. Policy makers have realized that there is a lack of information addressing the links between the various elements of these systems and are attempting to establish useful sets of data that contribute to the understanding of the myriad of relationships that play a role in sustainability. Policy groups focusing on sustainability, such as the BC Round Table and the Fraser Basin Management Board, are undertaking research on establishing this type of indicators.

The concept of developing indicators of sustainability is relatively new. Although many different types of data have been suggested (IUCN, UNEP and WWF 1991; United Nations 1991; Oregon Progress Board 1992), there has been little testing of the suitability of various indicators. The governments of Canada and British Columbia have published sets of experimental indicators in their recent state of the environment reports (Environment Canada 1991; British Columbia and Environment Canada 1993). These two reports have been particularly helpful in providing examples of indicators.

Some of the main criticisms of the use of indicators as a methodology are those outlined by Willms and Gilbert (1991, 5) with particular reference to social indicators. Incomplete knowledge or theory on behaviour and relationships of components in systems has led critics to doubt the causality that indicators endeavour to establish. Many question the value neutrality of indicators, suggesting that their selection and use is subjective, and therefore believe that all bias should be made explicit. The ambiguous nature of the concept of sustainability, and related ideas of ecological integrity, healthy communities and economic stability make them difficult to measure as the interpretation of these themes varies widely.

While these constraints are certainly relevant to the use of indicators, this method has been undertaken with the belief that the information generated from this type of analysis may spark further discussions and enlighten those involved in the consideration of sustainability and hydro-related matters. Indicators may not provide answers to ongoing problems; however, if they succeed in enabling stakeholders with different interests to ask more questions and inform themselves further on common issues, than they can be viewed as being a useful technique for resource management policy analysis. The use of indicators in this study also contributes to the ongoing evaluation of this method as a technique for examining sustainability.

The initiation of work on indicators of sustainability is the cumulative effect of the previous results of the indicators movement. The following discussion on indicators and the methodological approach adopted in this thesis will explain how various aspects of past and current indicators research have been incorporated into the examination of sustainability and hydroelectric development in the Columbia River Basin.

4.2 Development of Indicators

The selection of indicators may be undertaken with respect to measuring progress towards societal goals or, conversely, indicators may be chosen to gain information regarding a problem that has already occurred and is significant with respect to present and future conditions. In this thesis, indicators are used to measure the effects of previous and ongoing human activity in order to understand its significance for future sustainability. However, the problems studied through the identification of indicators are also related to goals for continuing community development, or sustainable development.

The approach used to develop a set of useful indicators for this study is similar to that described by Carley in his summary of progress from the social indicators movement (Carley 1981, 85). Carley outlines a theoretical approach to be undertaken according to the following steps:

1. Development of a problem statement;
2. Formulation of an explicit causal model;
3. Operationalisation of the problem statement into relationships between indicators and variables; and
4. Testing of the model.

According to Carley's formal approach, the results of the Columbia Basin case study are summarized in three problem statements. While numerous sources of information were used throughout the thesis research, the opinions of the residents of the Kootenays, as compiled in Tables 6 and 7, serve as the basis for the formulation of these summary statements. This set of information is the most comprehensive set of community views assembled to date and is generally representative of most of the major areas of concern identified during the case study. The three problem statements can be expressed as follows:

1. Ecological productivity has been disturbed;
2. Social living conditions have been degraded; and
3. Economic development opportunities have been restricted.

To test these statements in terms of their consequences for sustainability, it is necessary to develop hypotheses that link these statements to hydro development. While the development of a comprehensive conceptual model relating hydro development to sustainability is beyond the scope of this thesis, some fundamental relationships can be established from literature and from field investigations in the Columbia Basin. The review of literature on the impacts of hydroelectric projects across Canada and internationally, as well as the theoretical conclusions reached through the evolution of common property resources theory, supports the general hypotheses repeated consistently by people living with the consequences of Columbia River dams. The hypotheses corresponding to the above problem statements are:

1. Hydro development has reduced the ecological productivity of the Kootenays;
2. Hydro development has reduced the ability of local residents to participate in the management of regional resources, and has decreased the desirability of living conditions; and
3. Hydro development has removed land from the regional resource base, restricting the availability of land for economic development, and has caused conditions that make ongoing and future community development more costly.

These three hypotheses can be tested through the identification of key issues. Tables 6 and 7 provides the basis for choosing sustainability issues relevant to hydro development. Three issues, and related indicators, are used to test each of the three corresponding hypotheses. While there is no statistical significance corresponding to the use of three issues or indicators, this number is reasonable for the scope of this thesis. Relying on merely one indicator for each system would not provide an adequate basis upon which to draw general conclusions since indicators are useful for highlighting the state of certain critical pieces of information, but may not be able to establish definite causal relationships between specific elements of systems. The development of any more than three indicators per system would require a large degree of analysis that may not contribute substantially to the clarification of sustainability.

The issues identified for indicator analysis are as follows:

Ecological systems

a) reduced fish productivity

b) reduced wildlife habitat

c) ecosystem integrity disturbed

Social systems

a) community stability/boom-bust effects

b) reduced recreation opportunities

c) little public participation in dam decision-making

Economic systems

a) restricted economic diversity/tourism opportunities

b) high unemployment

c) reduced resource base and increased forestry costs

These indicators were selected based on their ability to portray the issues of concern to residents of the Kootenays. Other indicators were examined but were rejected if relatively clear links with hydro development could not be established or if they did not assist in the clarification of sustainability issues.

The development of indicators is summarized in Table 8. A brief review of the nine issues reveals that they are non-comparative in nature. Therefore, there is no common unit (e.g.,

Table 8 - INDICATORS OF SUSTAINABILITY

Problem	Hypothesis	Issue	Indicator
1. Ecological productivity disturbed	hydro development has reduced ecological productivity	reduced fish productivity	kokanee fish populations
		reduced wildlife habitat	ungulate habitat capability
		ecosystem integrity disturbed	net primary productivity
2. Social living conditions degraded	hydro development has limited community participation in decision-making and caused undesirable living conditions	boom and bust effects	population of Revelstoke
		reduced recreational opportunities	angler hours
		little community participation in decision-making	opportunities for public participation
3. Economic development opportunities restricted	hydro development has withdrawn land and resources from regional resource base, and increased costs for community development	restricted economic development opportunities	tourism room revenues
		high unemployment	unemployment rates
		reduced resource base and increased forestry costs	accessibility to timber supply

dollars) that can be used to evaluate them. To attempt to do so would result in the loss of meaningful information.

The non-comparative nature of the indicators selected is a result of the need to measure elements of different systems while also considering scale or hierarchical appropriateness (Costanza, Norton and Haskell 1992, 8; Karr 1992, 231). Some issues reflect concerns over resources or quality of life (e.g., fish) that are considered to be of intrinsic value, while others address community diversity (e.g., economic diversity) or integrate aspects of greater systemic processes (e.g., participation in decision-making). Although researchers in the indicators movement have distinguished between some general purposes for gathering information through the use of indicators, a clear system of classification has not been established. Generally, there is recognition of the distinction between measuring something because of its intrinsic value, its role in maintaining those things that are important to communities, or its usefulness in explaining key processes that determine the overall health of a system.

While the identification of key issues is relatively simple, the progression from an issue to the development of an indicator requires the consideration of the five attributes that comprise an indicator (Willms and Gilbert 1991, 3). Each indicator consists of information pertaining to: subject, property, place, time and statistical measurement. For example, the decision to examine reduced recreational opportunities as an issue requires further decisions resulting in the specification of the annual total of rod hours of residents and non-residents on Kootenay Lake from 1953-1986 as an indicator of fishing activity. Table 9 shows the nine indicators selected for use in this study and their attributes.

Table 9 - INDICATOR ATTRIBUTES

Subject	Characteristic	Place	Time	Indicator
fish	population	Kootenay Lake	1964-1991	annual kokanee populations at Meadow Creek
wildlife	habitat	Kinbasket Reservoir area	pre- and post-impoundment (1970,1974)	land capability for ungulates before and after the Mica Dam
ecosystem	productivity	Kootenay region	pre- and post-impoundment	net primary productivity
community	stability	Revelstoke	1963-1991	annual population of Revelstoke
recreation	opportunities	Kootenay Lake	1953-1986	annual rod hours on Kootenay Lake
social systems	opportunities for community participation in decision-making	Kootenay region	1940s-1994	public participation in Columbia River dam planning
economic systems	diversity	Kootenay region	1985-1992	annual tourism room revenues for regional districts in the Kootenays
employment	stability	Kootenay region	1963-1992	annual unemployment rates for regional districts in the Kootenays
forestry	constraints on economic development	Golden Timber Supply Area	pre- and post-impoundment	accessibility to timber supply in Golden TSA

In selecting indicators to study the issues identified, it is necessary to establish some general criteria to judge the suitability of particular sets of data. The following criteria were used to determine the suitability of indicators for this study. These criteria are some of the most common identified by those pursuing the development of environmental or sustainability indicators (Environment Canada 1991, 4; IUCN, UNEP, and WWF 1991, 198; British Columbia and Environment Canada 1993, 4; B.C. Round Table 1993, 49). An indicator should be:

1. meaningful in the clarification of the most important issues identified by residents of the Kootenays;
2. technically valid;
3. sensitive to dam-induced changes;
4. relatively easy and inexpensive to monitor;
5. useful for policy-makers; and
6. fairly easy to understand conceptually.

Another criterion frequently used is sensitivity to regional variations. As this study is by its very nature limited to a regional or watershed focus, indicators have been selected primarily because of their inherent regional importance, therefore, this criterion has been omitted. There has been no effort made to compare the information obtained from the development of indicators appropriate for this drainage basin to similar data in other watersheds.

The selection of indicators was achieved through testing various sets of data according to the criteria identified. This information is summarized in Appendix 2. The most important aspects of this evaluation are addressed in the discussion of each of the nine indicators. B.C. Hydro officials, government representatives and academic advisors were consulted regarding the validity of potential indicators. Although it would have been helpful to consult residents of the Kootenays upon whose ideas the indicators were based, financial and travel limitations prevented this from occurring.

Since the criteria above emphasize the importance of the use of indicators to various groups of humans, it is necessary to recognize the assumption that the development of indicators is done largely to satisfy the information needs of humans. While research conducted for this study has endeavoured to include non-human parameters, it is unrealistic to ignore the fact that most information is collected because of its importance to human functions. In their characterization of ecosystem responses to stress, Harwell et al. (1990, 96) state, "the single most useful criterion to apply to measure ecosystem health is the requirement of relevance to issues of concern to humans". These authors believe that a change in an ecosystem is only considered relevant if it relates directly or indirectly to something affecting humans.

Harwell et al. (1990, 105) provide a useful set of purposes for the classification of types of indicators in their research on indicators and ecological stress. After identifying desirable pieces of ecological knowledge as "ecological endpoints", they classify the development of indicators according to the following purposes:

1. intrinsic importance (indicator is endpoint);
2. early warning indicator (rapid indication of potential effect - used when endpoint is slow or delayed in response);
3. sensitive indicator (reliability in predicting actual response - used when endpoint is relatively insensitive); and
4. process/functional indicator (endpoint is process).

The nine indicators selected can be classified according to these four indicator types if the issues are considered as endpoints for which there is a need for greater knowledge. While indicators may have been chosen for one purpose initially, during the process of information gathering for each indicator, additional related data frequently contributed to the usefulness of the indicators for other purposes. The relevance of each indicator is discussed in the following sections.

Within the indicators movement, there has been much discussion regarding the use of quantitative versus qualitative indicators (Carley 1981; Potvin 1991). Quantitative indicators tend to be viewed more favourably as they are relatively easy to monitor for changes if consistent measurements are made. However, some aspects of sustainability may not be well represented by numbers. For example, some of the most important issues related to the analysis of public participation in decision-making involve the consideration of timing of events, the scope of public hearings, and the effectiveness of public involvement. While these factors could be measured in terms of numbers of days of hearings, or cost of public participation activities, these quantitative measurements may not be the most effective way of examining the root of the issue.

Both quantitative and qualitative indicators are used in this study. In a society where facts are generally linked to statistics, the development of qualitative measures may require a greater degree of creative thought. However, this effort is worthwhile as questions of sustainability are often linked to quality of life concerns.

The use of single indicators or the aggregation of data into a composite index is another subject widely debated among those establishing indicators. While some argue that a composite index summarizes more information and may be easier to use for comparative purposes, others insist that helpful details are lost in aggregation (Carley 1981, 33; Potvin 1991, 10). For the purposes of this thesis, a set of single indicators is used to show a range of effects relevent to the concept of sustainability, and no effort has been made to combine this information for the reason stated previously.

The evolving field of ecological economics has contributed the concept of natural capital to the search for sustainability indicators (Victor 1991). Recognizing the first law of thermodynamics, that energy cannot be created or destroyed, and the second law of thermodynamics, that the conversion of heat energy into a usable form results in the degradation of some of this energy to a more dispersed and less useful form, the concept of natural capital attempts to measure the renewability of the natural stock of resources. While not stated explicitly, the examination of the conservation of a finite set of resources is one of the central premises underlying the use of ecological indicators in this study. However, indicators of sustainability arising from the concept of natural capital are still considered as being fairly weak by those developing this concept within ecological economics (Pearce and Atkinson 1993, 1).

4.3 Difficulties Encountered During Indicator Selection

Many difficulties were encountered with respect to the selection of indicators. The main problems related to this process were a result of the following factors: the non-comparative nature of ecological, social and economic boundaries or scales; the relatively complex chronology of hydro development in the Columbia River Basin; the lack of consistent time series data; and the interdisciplinary nature of this study of sustainability. Similar methodological limitations have been outlined by others researching indicators (Willms and Gilbert 1991, 6; Potvin 1991, 11). They are outlined briefly to clarify the context within which indicators are evaluated.

The collection of data within a watershed requires the consideration of ecological, social and economic boundaries. Information that could serve as an indicator is often categorized within groupings appropriate to each of these three systems, and it may not be possible to disaggregate data specific to only the watershed portion of the units used. For example, unemployment rates are averaged and reported according to regional districts. However, some of the regional district boundaries in the Kootenays embrace areas outside of the Columbia River drainage basin, the region examined in this study. It is therefore difficult to determine to what degree the regional district average represents the watershed portion of this socio-economic unit.

The selection of appropriate spatial and temporal scales created problems due to the difficulty associated with defining the boundaries of dam-related impacts. Unless the scale of specific impacts is already established, the examination of events during a particular time period or geographic area may not reveal meaningful information. This problem is further complicated by the lack of understanding of ecological and socio-economic systems, and changing human values. The attempt to identify impacts at their relevant scale of occurrence has resulted in the selection of indicators at various scales within the three systems examined.

The examination of the effects of establishing six reservoirs, as well as the cumulative impacts of previous dams on the Kootenay River, within the Columbia River Basin requires the consideration of the chronology of each of these dam projects. The comparison of dam or reservoir-specific data is fairly difficult due to varying ecological, social and economic conditions at each site, inconsistent baseline measurements, and the implications of the effects of earlier dams on the planning of later projects. Generally, issues related to individual projects had to be considered within the context of their separate, and overlapping histories. As comparative data were often not available, or would have required extensive transformation, few of the indicators selected represent the entire water basin. Instead, indicators were chosen for their ability to reflect issues of particular concern to communities near specific dam projects.

A large effort was made to collect time series data to illustrate conditions before, during, and after the construction of dam projects. However, this endeavour was difficult to accomplish as few sets of data are collected consistently over the approximately thirty years that large dams have been operating in the Kootenays. Ecological surveys were not conducted in a comprehensive manner during the preparation or implementation of the Columbia River Treaty due to their lack of political significance at that time. Therefore, there is little baseline information upon which to evaluate the effects of hydro development. The collection of economic data tends to vary according to political budgets and priorities, and the reporting of information according to categories and economic regions is often subject to change. This variation makes it difficult to compare data such as labour force occupation over time.

The challenge of examining the relationships within and between ecological, social and economic systems can be overwhelming and requires some general knowledge regarding basic principles of a wide range of subjects, such as wildlife biology, local forestry operations, and resource economics. This thesis is written in the context of resource management, therefore it links aspects of disciplines which are often examined separately, but relies on the judgement of those with expertise in specific fields. In selecting indicators, this study attempts to identify the most significant factors that define the state of some of the important aspects of the systems interacting within the Columbia River Basin. Indicators have been chosen for their ability to provide meaningful, although generalized, information, so that they are useful to the public, hydroelectric planners, policy-makers and academics.

Since this study is regional in nature, indicators were selected to represent regional concerns. However, due to site-specific factors affecting events at various locations, it was often easier to focus on the occurrence of a regional issue by examining conditions in one particular area. The selection of locations was governed by the significance of the issue and availability of information. Although an effort was made to represent various parts of the Kootenay region, the specific concerns of some areas are not represented as well as others. While many of the indicators used are of importance to First Nations, communities in the East Kootenays, and northern residents near Valemount, their issues are not discussed to the same extent as those pertaining to the central Kootenays where data are more accessible.

4.4 Ecological Indicators

Ecological indicators were chosen in an effort to identify some of the key aspects of hydro development that have affected the ability of ecological systems to support life, as well as to enhance the operations of social and economic systems. Ecological indicators were selected to develop a general overview of the ecological integrity of the Columbia River basin. Since the functions and productivity of an ecosystem rely on a wide range of components, key indicators were selected according to their intrinsic value, their critical role in maintaining ecological integrity, and their ability to reflect larger ecological system processes.

While Harwell et al. (1990, 96) state that "the single most useful criterion to apply to measure ecosystem health is the requirement of relevance to issues of concern to humans", this thesis recognizes that ecological components such as fish, trees and animals have intrinsic value and play important roles in sustaining a healthy ecosystem for the benefit of other forms of life, as well as humans. According to this assumption, ecological indicators should be selected based on their function within an ecosystem. In reality, it is difficult to adhere to this principle since research is usually conducted on species of particular value to humans.

The ecological indicators selected reflect the importance of certain key species to people living in the Kootenays. Due to the high level of interest in the sport fishery, big game hunting and forestry in this resource-based region, there is a greater quantity of information available on the species that are the focus of these activities. While data availability and human interest have certainly influenced the selection of indicators, an effort has been made to acknowledge the role of these indicators in contributing to the continuation of ecological processes regardless of their significance to humans.

Several types of ecological indicators have been chosen in an effort to measure the impacts of hydro development on ecological integrity. The measurement of kokanee fish populations enables the analysis of impacts on a particular species of fish and is valuable in terms of the direct and indirect (concern for the welfare of its predator, Gerrard trout) intrinsic value of this fish. The analysis of information pertaining to land capability to support ungulates is an indirect intrinsic indicator of the health of big game populations. Consideration of net primary productivity as a process indicator enables the examination of the integrity of large-scale ecosystem functions.

4.41 Fish - Kokanee Salmon Populations

Fish are often used as indicators of the state of aquatic ecosystems. Water bodies that support healthy trout and salmon populations are generally believed to be relatively uncontaminated and productive. The use of kokanee salmon, a land-locked salmonid, as an indicator of the ecological state of Kootenay Lake has already been endorsed by the British Columbia and federal governments (British Columbia and Environment Canada 1993, 80) and has also been selected for use in this study because of its intrinsic value.

Fisheries biologists are particularly interested in kokanee salmon due to their importance to the sport fishery in Kootenay Lake, an easily accessible and highly productive sports fishery that has attracted anglers from all over North America since the 1950s (Pearse and Laub 1969, 11). Kokanee have been one of the most abundant sport fish and are particularly popular as a summer fishery in this lake (Andrusak 1981, 3). Kokanee also play an important role as food for Gerrard trout, renowned in Kootenay Lake for their trophy size.

The effects of dams on kokanee are well documented. The most immediate consequence of dam construction is the prevention of access to previous spawning grounds. The recognition of this loss has resulted in the establishment of the Meadow Creek spawning channel, an attempt to enhance fish productivity through the replacement of lost habitat with a long channel of gravel beds along a tributary of the north arm of Kootenay Lake.

Dams have also been responsible for nutrient retention. Increased sedimentation behind the Duncan and Libby Dams has reduced the downstream supply of nutrients available to phytoplankton, which feed the zooplankton consumed by kokanee and other fish in a food chain that relies on a continuous flow of nutrients from upstream sources (Daley et al. 1981; British Columbia and Environment Canada 1993, 81) The regulation of the Duncan and Kootenay Rivers has changed the hydrological regime of Kootenay Lake, resulting in the removal of the June freshet, previously responsible for flushing nutrients downstream, and changing the time of year when nutrients, although greatly reduced, are supplied to the lake (Daley et al. 1981, 93).

Kootenay Lake kokanee consist of three racially distinct populations that tend to inhabit the north, south or west arms of the lake. The productivity of these three separate populations varies as a result of such site-specific factors as: quality and quantity of spawning grounds, fishing pressure and food supply. Kokanee populations at Meadow Creek (the north arm) have been selected as an indicator as these populations are relatively easy to count in narrow blocked sections of the spawning channel, and are therefore believed to be relatively accurate (Parkinson 1993).

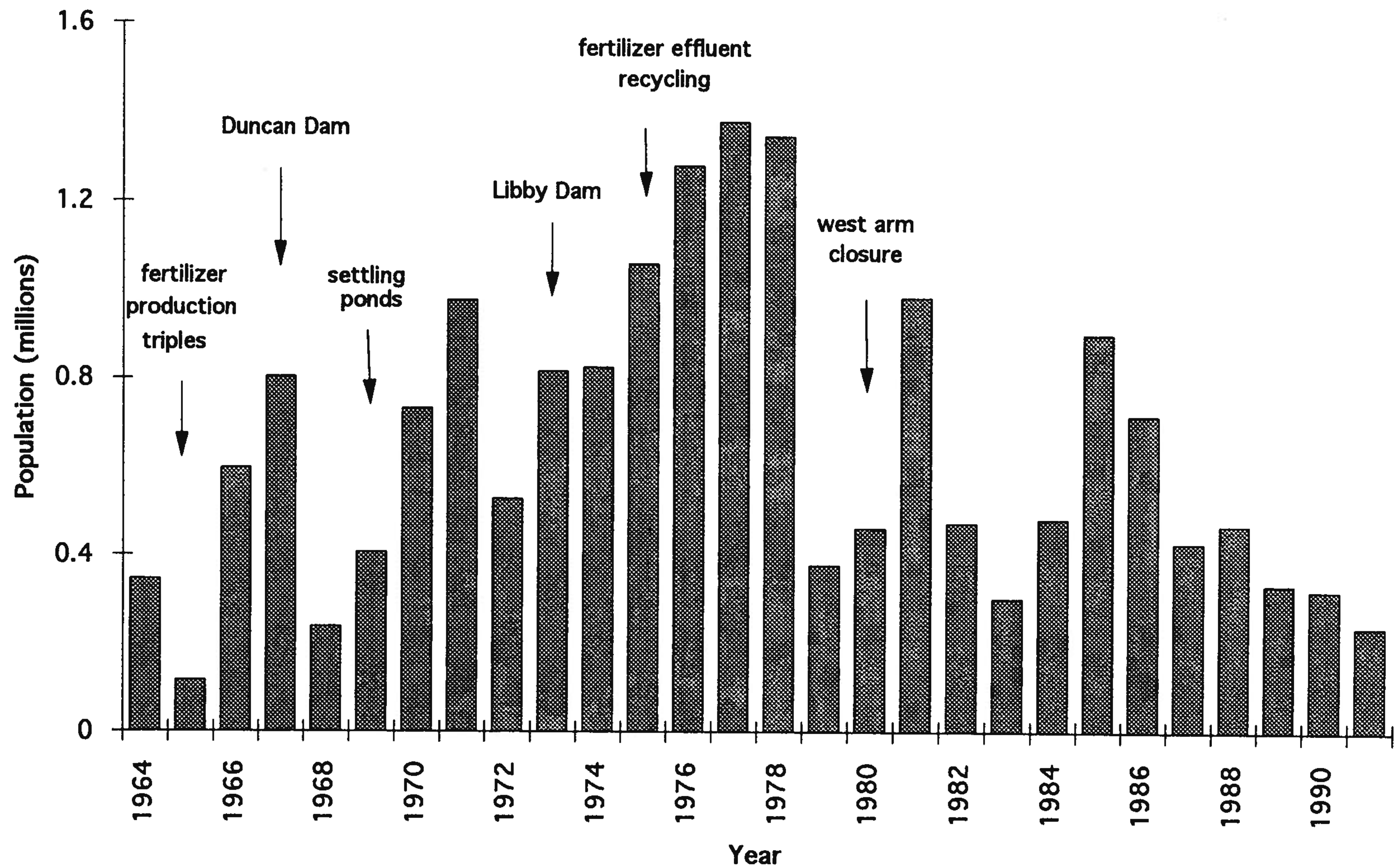
Discussion

The analysis of kokanee populations in Kootenay Lake is quite complicated due to the chronology of human-induced events affecting the ecological characteristics of this lake, in addition to the natural occurrence of hydrological, biological and chemical cycles. Figure 13 shows the fluctuation of kokanee populations in Meadow Creek, from 1964 until 1991. Meadow Creek flows into the Duncan River between the Duncan Dam and Kootenay Lake (Figure 14).

In general, Figure 13 can be interpreted as showing a general increase in kokanee populations peaking in the late 70s, followed by a decline through the 1980s. These trends can be largely attributed to the establishment of the Meadow Creek spawning channel, phosphorus loading variation due to fertilizer plant emissions and nutrient retention behind the Libby dam, and predator enhancement techniques (Parkinson 1993). Although this discussion addresses the main factors identified as influencing population size, some fluctuations may be the result of natural population cycles, and may be related to the four-year reproductive cycle of Meadow Creek kokanee.

Prior to the regulation of the Duncan and Kootenay Rivers as a result of the Columbia River Treaty, the ecological functions of the Kootenay River system had already been significantly disturbed by industrial and fisheries management activities. In 1949, a small shrimp-like organism, *mysis relicta*, was introduced into Kootenay Lake to improve the supply of food for

Figure 13. Kokanee Populations in Kootenay Lake - Meadow Creek



Source: adapted from British Columbia and Environment Canada (1993), p. 81

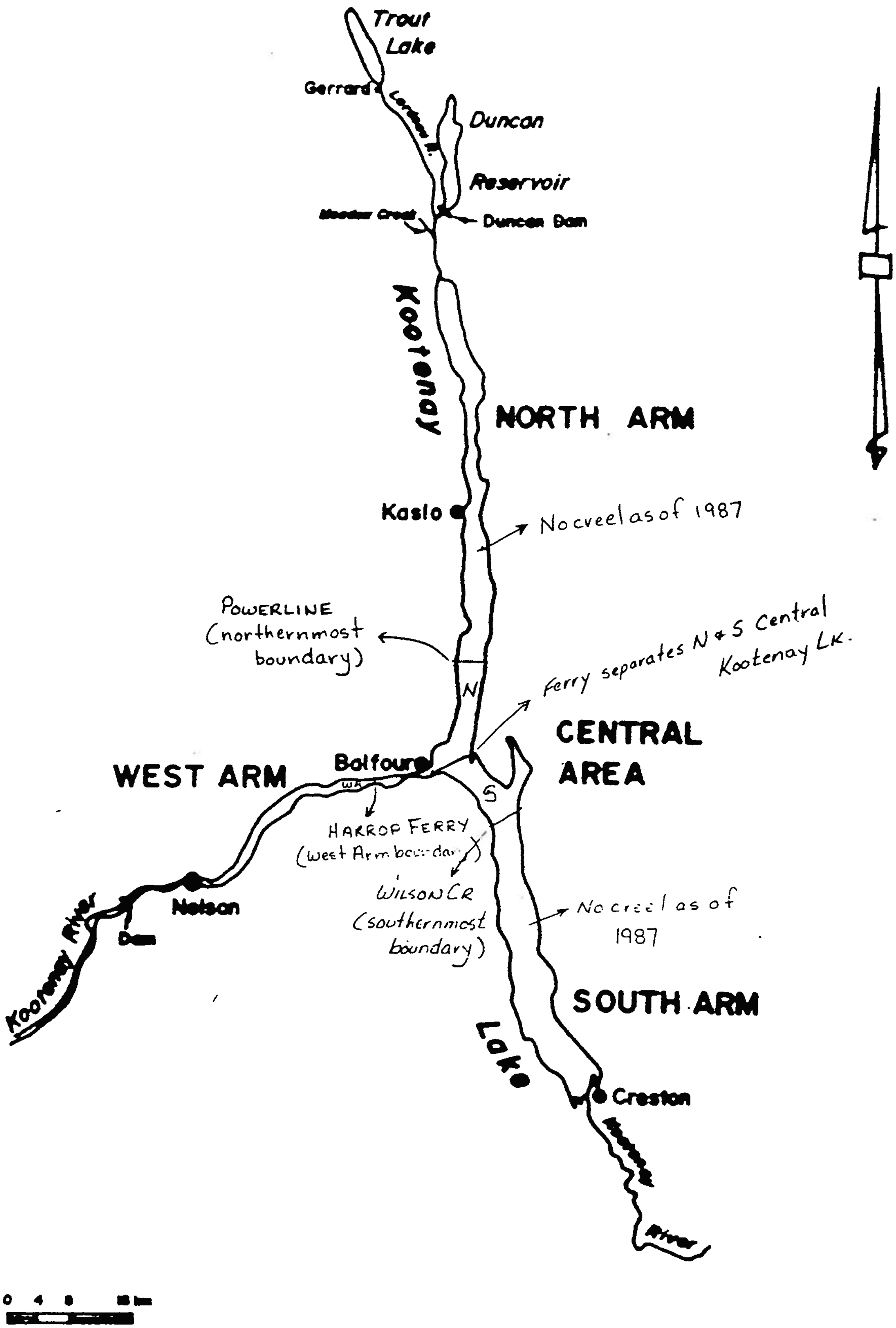


Figure 14. Kootenay Lake with designated areas.

Source: Andrusak (1987), p. 3.

the aquatic food chain (Hirst 1991, 23). The mysis proved to be too large for consumption by juvenile Gerrard trout, and in fact competed for the same zooplankton that fed the kokanee.

Several years later, the 1953 opening of a fertilizer plant near Kimberley, and its resulting discharges of phosphates into the St. Mary River, a tributary to the Kootenay River, supplied substantial amounts of nutrients (Whateley 1972, 21) to both the mysis and the kokanee. Phosphorus inputs increased when fertilizer production doubled in 1962, and tripled in 1965. This additional source of phosphorus is believed to have contributed to the eutrophication of Kootenay Lake during the 1950s and 60s, resulting in an abundance of kokanee, particularly in the west and north arm of the lake (Hirst 1991, 23). Since Meadow Creek populations were traditionally lower than those in the rest of the lake, before the creation of a spawning channel, this trend is not reflected in Figure 13.

The major impact of the Duncan Dam (1967) on kokanee was its blockage of access to spawning habitat upstream. Bull (1965) estimated that of over 4 million kokanee spawners in the Duncan-Lardeau system, 2.8 million would not reach their normal spawning grounds behind the dam. This loss was somewhat mitigated by the establishment of the Meadow Creek spawning channel, in 1967, the same year the dam was completed. The rising population sizes in Figure 13 illustrate how improved spawning conditions in Meadow Creek contributed to increased productivity. Since the pre-impoundment supply of nutrients from the Duncan River was relatively small, the Duncan Dam caused little effect on the overall supply of nutrients to Kootenay Lake (Daley et al. 1981, 82).

Phosphorus loadings to Kootenay Lake were greatly reduced by the combination of stricter pollution controls on phosphorus emissions and the construction of the Libby Dam (1973). The 1969 introduction of settling ponds to control phosphorus releases from the fertilizer plant, followed by complete fertilizer effluent recycling in 1975, reduced nutrient supplies to the Kootenay system (Daley er al. 1981, 75). Nutrient retention behind the Libby dam has caused significant reductions (45-50%) of phosphorus downstream (Daley et al. 1981, 82). While the 1973 operation of the Libby dam on the Kootenay River combined with the complete recycling of fertilizer effluent reduced nutrient supplies to the river system, the effect on Meadow Creek populations may have been delayed and partially mitigated by enhanced spawning conditions.

As water levels in Kootenay Lake do not vary as much as those of the reservoirs on the Columbia and Kootenay Rivers, kokanee are not significantly disturbed by reservoir drawdown. Water levels on Kootenay Lake have the least variation in the Columbia system, fluctuating only a few metres annually.

Increased numbers of kokanee accompanied by high fishing success rates attracted large numbers of anglers throughout the 1970s until fish populations crashed dramatically (Hirst 1991, 23), resulting in a closure of the west arm kokanee fishery in 1980 (Andrusak 1981, 4). The west arm closure caused increased angling effort in the north and south arms, contributing to the reduction of kokanee populations in subsequent years (Hirst 1991, 23).

The dramatic decline of kokanee productivity results from the cumulative effect of a number of factors. While large numbers of kokanee survived predation from Gerrard trout and anglers during periods of high productivity, increasing sedimentation of Meadow Creek spawning channel combined with decreased supplies of nutrients, may have made this population more vulnerable to competition between natural and stocked kokanee, and consumption by efficient Gerrard trout enhanced through stocking and strict fishing regulation (Parkinson 1993).

During the early 1990s, kokanee productivity has been limited by reduced phosphorus availability, due to the elimination of phosphate in effluents, nutrient retention behind the Libby Dam, and the competition for this nutrient by *mysis*. Since there is no known method to remove *mysis*, and as the Libby dam continues to impede nutrient flow, in 1992, fisheries managers implemented a phosphorus addition program to ensure sufficient food supply (British Columbia and Environment Canada 1993, 81). As fisheries management programs continue to focus on the Gerrard trout sport fishery, the preservation of kokanee populations are believed to be important for the productivity of Gerrard trout.

Conclusion

The analysis of kokanee populations requires an examination of the complex interactions occurring between various components of the aquatic ecosystem, as well as an understanding of the various industrial activities affecting kokanee, and knowledge of fisheries management strategies that have been implemented. The study of fisheries is complicated by the fact that many interactions occur underwater, and are often not perceived by humans until the consequences become obvious some time later. The impacts of a specific human activity or fisheries management technique may not be evident until a full reproductive cycle has transpired.

Since the effects of the Duncan Dam on accessibility to spawning grounds, and the nutrient retention caused by the Libby dam are well recognized, it is probable that these factors have contributed to the decline of kokanee, although the establishment of the Meadow Creek spawning channel may have offset their consequences. Future fisheries management programs will have to address the ongoing problems related to dam operations. However, this may require the modelling of dam-related consequences with other variables such as availability of nutrients, quality and quantity of spawning grounds, predator efficiency, and fishing pressure.

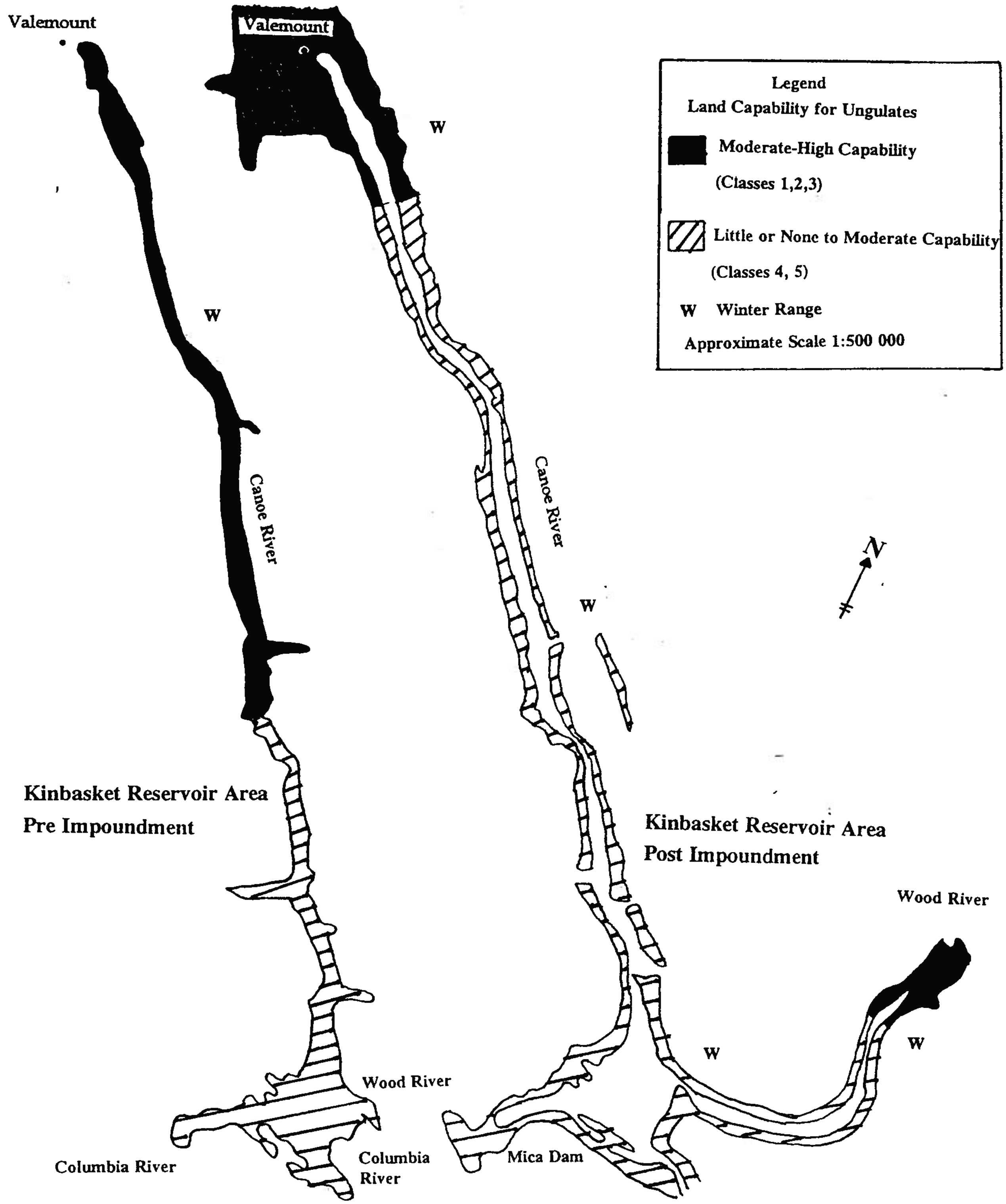
4.42 Wildlife - Land Capability for Ungulates

The selection of this indicator is based on concerns expressed by residents regarding the impacts of dams and reservoirs on local wildlife populations. The Rocky Mountain Trench provides particularly good habitat for moose, deer, caribou and elk. These animals are valued highly by wildlife observers as well as big game hunters. Wildlife studies confirm that the effects of flooding valleys within the Kootenays region has reduced the ability of the Columbia River Basin to support wildlife (British Columbia 1974). Therefore, the capability of land to support ungulates is an indirect indicator of a species of intrinsic value to humans.

Although the examination of the land capability to support ungulates is a useful measure of the impacts of reservoir flooding on available habitat of big game species, this indicator has been selected for its conceptual nature, and cannot be interpreted too accurately. Since the Canada Land Inventory (CLI) mapping with respect to capability for ungulates in the Kootenays region was undertaken during the late 1960s and early 70s, and in many cases was never repeated, the classifications shown in Figures 15 and 16 are somewhat outdated and represent fairly generalized information. Biologists consulted during the development of this indicator emphasized that the classes portrayed in this mapping are not very accurate and are being

Figure 15

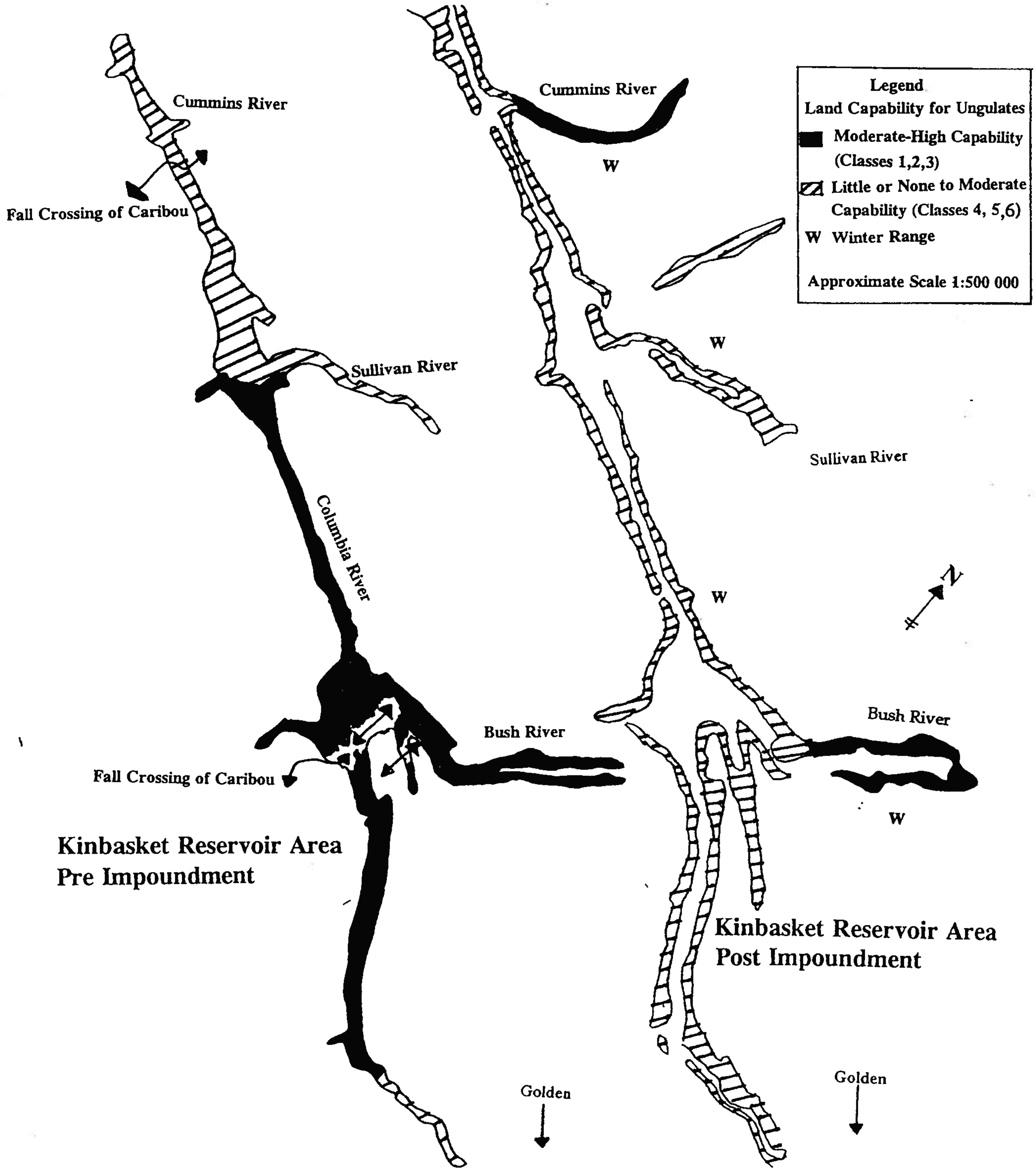
Land Capability for Ungulates Before and After Mica Dam (Northern Section of Kinbasket Reservoir)



Source: Energy Mines and Resources Canada Land Inventory - Land Capability for Wildlife Ungulates (1975)
Capability Classification (1970)
British Columbia (1974)

Figure 16

Land Capability for Ungulates Before and After Mica Dam (Southern Section of Kinbasket Reservoir)



Source: Energy Mines and Resources Canada Land Inventory - Land Capability for Wildlife Ungulates (1975)
Capability Classification (1970)
British Columbia (1974)

revised.

Since there is little baseline information for wildlife at the time of dam construction in the Columbia River Basin, and as pre- and post-impoundment ungulate habitat information was mapped and readily available for the Kinbasket Reservoir, this reservoir was selected in an effort to examine impacts on regional ability to support ungulates. While similar mapping for areas along the Arrow, Duncan, Kootenay, Revelstoke and Koocanusa Reservoirs is available, in some cases it was only evaluated after reservoir flooding, and for others classification was done before but not following impoundment. The publication of the Mica Reservoir Region Resource Study, commissioned by the British Columbia Environment and Land Use Committee (1974), provided a post-impoundment map that enabled a comparison with the pre-impoundment state, as classified in in 1968 and 1970 according to the CLI map (Energy, Mines and Resources Canada, 1974).

Although it is possible to make an approximate estimate of the amount of land lost from various CLI classes with the use of a planimeter, skepticism expressed by biologists regarding the accuracy of the information provided from CLI maps suggests that this may not be a worthwhile endeavour. Therefore, this indicator is presented for conceptual interpretation in an effort to illustrate the limited availability of land that is capable of supporting ungulates with and without reservoir flooding.

Discussion

Figures 15 and 16 illustrate land capability for ungulates around the Kinbasket Reservoir before and after the construction of the Mica Dam. From visual inspection of the representations of ungulate habitat in the reservoir area before and after flooding, it appears that moose, elk and deer lost a substantial portion of high capability habitat along the Canoe (Figure 15) and Columbia (Figure 16) Rivers, particularly at the confluence of the Bush River and the Columbia. A sizeable area of lower capability habitat was submerged around the former "Big Bend" area, where the Columbia River is joined by the Wood and the Canoe Rivers, before bending southward (Figure 15). Figures 15 and 16 only depict the habitat in the immediate reservoir region. Steep mountain ranges to the east and west present limitations which reduce the ability to support ungulates, however, wide valleys at both ends of the reservoir (near Valemount and Golden) offer relatively large sections of high capability habitat particularly important for winter range.

Several discrepancies are evident from the comparison of pre- and post-impoundment representations of wildlife habitat. The British Columbia Environment and Land Use Committee (ELUC), which published the post-impoundment map depicted in Figures 15 and 16, notes the variation from the original pre-impoundment classifications developed by the Canada Land Inventory (CLI) survey (British Columbia 1974, A4-12). The ELUC states that its map complements the original CLI map, but includes several smaller areas of good ungulate capability along some tributary valleys that were omitted from the original CLI map; e.g., the high capability areas along the Wood and Cummins Rivers (Figure 15).

The ELUC estimated that the reservoir would flood 105,000 acres (42,500 ha) of wildlife habitat including wetlands, riparian zones and natural meadows, causing reductions in populations of moose (70%), deer (50%), elk (40%) and caribou (10%), as well as the displacement of most aquatic animals and waterfowl (British Columbia 1974, A4-26, 6-70). Since there were approximately 340,000 acres (137,600 ha) of winter range below the elevation of 3,500 feet (1067 m) (British Columbia 1974, 6-69), the inundation of 105,000 acres (42,500 ha) of relatively high capability habitat represents a withdrawal of approximately one third of the original winter range, and a substantial reduction in variety of habitat which cannot be replaced at higher elevations.

It is difficult to ascertain the significance of the loss of habitat beneath the Kinbasket Reservoir due to the lack of accurate information existing before the establishment of the reservoir. Ungulates that previously relied on narrow strips of habitat along the valley bottom may have moved elsewhere, increasing the competition for limited food and shelter in adjacent areas, or may have chosen to accept less favourable conditions along the steep slopes of the reservoir. Habitat fragmentation may interfere with population size, dispersal and local species diversity as many animals occupy a range of different habitat types according to demographic needs (Lubchenco et al. 1991, 371).

Since the critical factor affecting the distribution and abundance of ungulates in the reservoir area is the availability of winter ranges (British Columbia 1974, 6-69), it is probable that wildlife losses have been severe, especially since there is little opportunity to replace habitat within the Kinbasket reservoir region (British Columbia 1974, 1-11). Habitat destruction has been identified as the chief cause of global extinction of species (Lubchenco et al. 1991, 392).

In addition to affecting ungulates through habitat loss, the reservoir poses an accident hazard and acts as a barrier to migration. Floating debris is a hazard to moose and caribou attempting to cross the reservoir. Winter reservoir drawdown can cause accidents after ice formation for moose, elk, deer and caribou due to ice breakage. The additional area covered by water acts as a barrier to migrating species such as caribou (British Columbia 1974, A4-23).

The loss of big game as a result of the creation of the Kinbasket reservoir affects local hunting. Hunters and guides have noted decreased numbers of ungulates around the Kinbasket reservoir area since its creation (Schuck 1992; Arlt, Gutzman and Sim 1992). The annual value of guiding for moose, caribou, deer and elk hunting prior to impoundment ($308,800) was predicted to decrease by approximately 50% after flooding due to the potential harvest being halved (British Columbia 1974, A4-18, A4-31). Due to the lack of information on the use and value of wildlife in the Mica basin prior to flooding, the value of non-consumptive losses was assumed to be equal to consumptive losses in the same study. The total capital value of all wildlife resources (excluding waterfowl) in the Mica basin was evaluated as $10.9 million (discounted at 8%) before flooding and $5.6 million after reservoir creation, representing a loss of 50% of the original value of wildlife resources (British Columbia 1974, 1-12).

While the loss of habitat shown in Figures 15 and 16 is clearly a result of the establishment of the Kinbasket Reservoir, there are other factors which may affect the significance of this loss in terms of its implications for sustainability. Local forestry operations, forest fires, landslides, competition among ungulates and other types of wildlife, hunting pressure, and wildlife management practices all play a role in the determination of the significance of the habitat loss described. A thorough examination of all of these factors is beyond the scope of this thesis. Therefore, the evaluation of the significance of habitat loss depends primarily on its comparison with the portion remaining, in terms of the capability of the reservoir region to support ungulates.

Conclusion

The reduction of wildlife habitat resulting from the Kinbasket Reservoir has decreased the capability of this region's ability to support ungulates, and presumably other wildlife groups that depend on wet and flat valley bottoms. As there is little opportunity to replace the good habitat lost within the reservoir region, it may be assumed that local wildlife losses may be severe.

While it may not be possible to predict the significance of this loss to the integrity of ungulate populations, one may speculate on the foregone wildlife observation and hunting opportunities that this represents. If ungulate populations have in fact left the area, preferring more favourable habitat elsewhere, wildlife observers, local hunters and guiding outfits that relied on this region may suffer from reduced wildlife numbers, and may incur greater travelling costs, or withdraw from the pursuit of these activities.

4.43 Ecological Integrity - Net Primary Productivity

People living in the Kootenays are concerned that hydro development has reduced their resource base (Table 6). The inundation of highly productive valleys has diminished their total stock of forest land, and has withdrawn riparian habitat from wildlife. Fluctuating water levels continue to alter fish habitat in reservoirs. Some residents believe that these physical changes have affected their relationship with the land, and there is a sense that the ecological integrity of the region has been disrupted.

While the concept of ecological integrity is rather vague, it is generally used in referral to the idea of ecosystem health or environmental quality. The examination of ecological integrity usually involves the discussion of concepts such as energy fluxes (e.g., gross and net productivity, biomass) nutrient flows (e.g., horizontal transport), community structure (e.g., biological diversity) and system characteristics (e.g., succession, stability). Generally, research on ecological integrity seeks to determine how well an ecosystem functions.

In this discussion, net primary productivity is used as an indicator of ecological integrity. Net primary productivity is a measure of the rate of production of usable energy available for consumption by other organisms. The ability to make energy available to support the growth of vegetation, and the consumers of plants and trees varies among different types of ecosystems. With respect to hydro development, net primary productivity is examined in an effort to consider the changes in the production of usable energy that occur when a terrestrial ecosystem is replaced with an aquatic ecosystem. This indicator is not capable of representing all of the factors that contribute toward the "health" of an ecosystem but is an important and common measurement of energy transfers throughout ecological systems.

Discussion

Due to the harsh constraints imposed by the climate and physiography of mountainous regions, valleys contain the most productive ecosystems within this type of landscape. Vegetation, wildlife and human populations tend to concentrate in valleys where higher rates of ecological productivity favour plant growth, providing greater opportunities to obtain some of the basic requirements of life, nutrient supplies and shelter. In the Columbia River basin, forest ecosystems have occupied these highly productive zones.

Forest productivity rates in the Columbia River Basin are some of the highest in Canada (Canada 1970). The interior cedar-hemlock zone is the most productive, characterized by western hemlock and western redcedar forests growing along lower to middle elevations of the Purcell and Selkirk mountains of the interior wet belt of British Columbia. The interior douglas fir zone consists of douglas fir and ponderosa pine forests bordering the Kootenay River, as well as savannah-like grass lands that provide important summer range for livestock, mule deer and elk in drier regions. According to the Canada Land Inventory classification system, portions of the forest land along the Columbia River and Arrow Lakes have been classified as having the highest capability to support the growth of commercial species such as hemlock and cedar. Class one forest land is capable of producing mean annual increments of greater than 7.8 m^3/ha/yr (Canada 1970).

Forests fulfill many ecological functions that contribute to the ecological integrity of local and global environments (Soussan and Millington 1992). Locally, trees provide wildlife habitat, prevent soil erosion, and influence hydrological and microclimate regimes through their regulation of water flows and air temperature. Globally, forests provide large supplies of oxygen through respiration, and are an effective carbon sink reducing the rate of global warming through their storage of carbon. The wide range of habitat contained in forests provides many key conditions supporting biodiversity. One of the most fundamental characteristics of forest land that distinguishes it from other types of ecosystems is its relatively high ability to produce usable energy for consumption by other organisms.

The productivity of an ecosystem relies on the ability of energy to be received and transferred between various organisms within a food chain. The rate at which incoming solar radiation is initially converted into chemical energy or biomass through photosynthesis is known as gross primary productivity. As plants receive energy they break down some of the chemical energy they are able to capture through the process of respiration. The rate at which usable energy is produced and made available to other organisms after respiration has occurred is known as net primary productivity. The production of usable energy can be measured in terms of energy (kcal/m^2/yr) or dry organic matter (also known as biomass) produced (g/m^2/yr).

Primary productivity of vegetation is of fundamental importance to an ecosystem as this determines its carrying capacity (Lieth 1975, 203). The availability of energy for use at the lowest trophic level of an ecosystem is effectively the principal limiting factor that determines the variety of organisms that can be supported by an area. Ecosystems with higher net primary productivity may be able to maintain a greater biomass or volume of organisms per unit area than those producing less usable energy.

Forests are capable of producing a relatively high rate of usable energy per unit of area when compared with other ecosytem types. Figure 17 shows average net primary productivity for various types of ecosystems. Forests in general, are surpassed only by estuaries and wetlands in net primary productivity.

Hydroelectric development in the Columbia River Basin has caused the inundation of approximately 50,000 hectares of wooded land. The replacement of forests with another type of ecosystem affects a wide range of ecological processes. One of the most fundamental changes

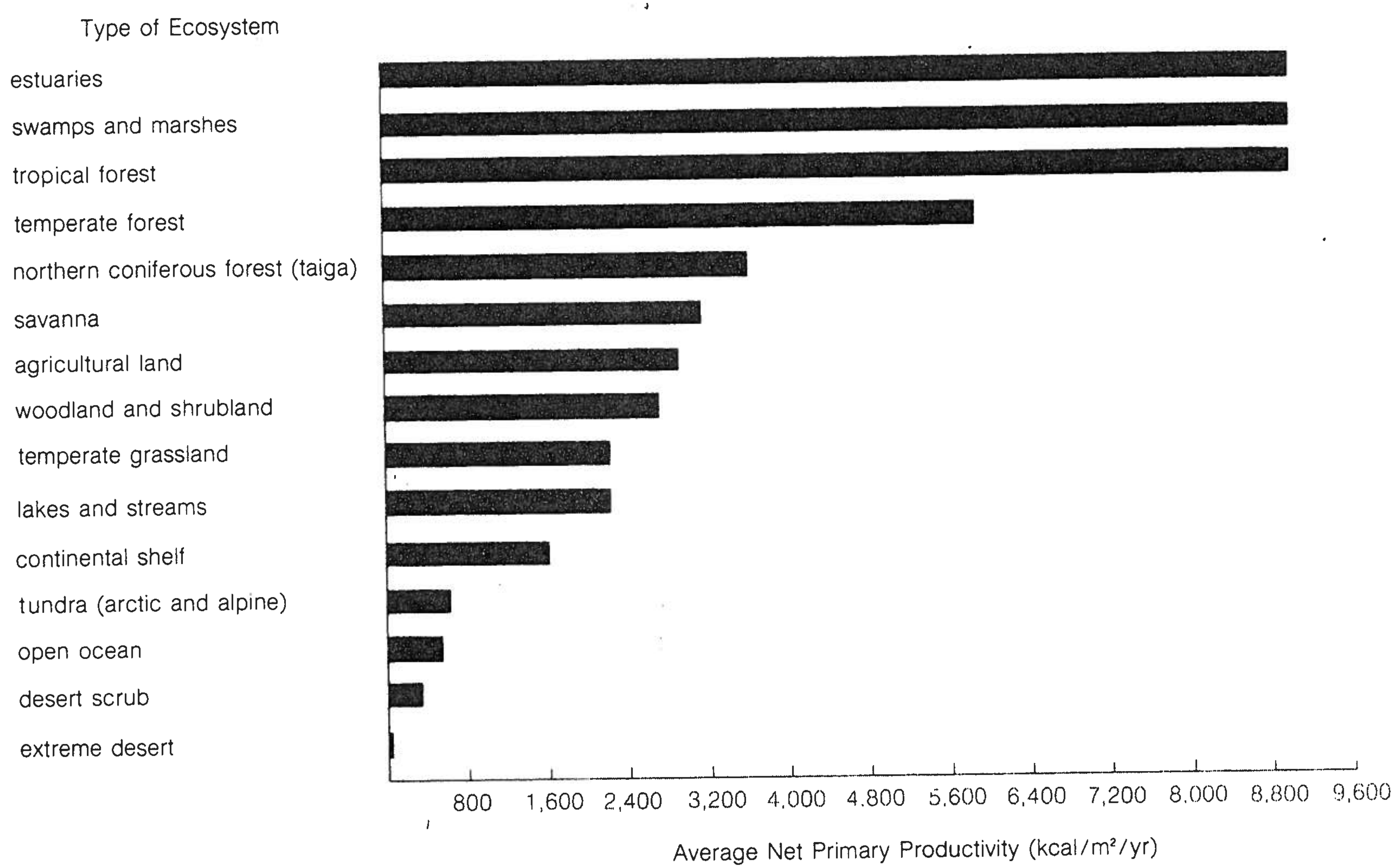


Figure 17. Estimated average net primary productivity by plants in major types of ecosystems.

Source: Miller (1982), p. 72

that occurs is the alteration of the net primary productivity.

The flooding of forest land to create hydroelectric reservoirs results in a reduction of net primary productivity as forest ecosystems are replaced with less productive aquatic ecosystems. This difference in net primary productivity is due to the greater transparency of air which provides more light intensity for terrestrial organisms than that which is available to aquatic organisms, as well as the higher concentration of nutrients found in soil and available for plant uptake through root systems as compared to the random distribution of nutrients in aquatic ecosystems (McNaughton and Wolf 1979, 124).

Although estimates of net primary productivity of ecosystem types vary, measurements of this rate of energy transfer indicate that forest ecosystems produce three or four times more usable energy than aquatic ecosystems. According to Figure 17, lakes and streams produce on average 2300 kcal/m^2/yr, approximately one third of the usable energy available from temperate forests of a similar size (6000 kcal/m^2/yr). McNaughton and Wolf (1979, 587) indicate that lentic (standing water) and lotic (running water) ecosystems produce 800 kcal/m^2/yr, less than one quarter of the net primary productivity of temperate coniferous forests (3760 kcal/m^2/yr). Since net primary productivity varies with geographic location and is greater with increased radiation, low elevation and high moisture levels (Spurr and Barnes 1980, 504), this variation may account for the different ranges of net primary productivity that have been attributed to ecosystem types.

In addition to examining the net primary productivity through the consideration of energy, it is possible to make general estimates of resulting changes through biomass production, the measurement of the mass of carbon produced in a year. Since few measurements are available for the study area, this discussion relies on general estimations of aquatic and terrestrial ecosystems.

Net primary productivity measured during May, June and August at four stations on Kootenay Lake in 1964 (before Duncan and Libby Dams) ranged from 35 - 827 $mg/m^2/day$ (Daley et al. 1981). Assuming 245 growing season days per year (Kimmel et al. 1990), Kootenay Lake productivity rates ranged from 9 - 203 $g/m^2/yr$, slightly lower or equal to the 200 $g/m^2/yr$ estimate (McNaughton and Wolf 1979, 587) provided for lentic and lotic systems, and a similar approximation of 250 $g/m^2/yr$ as the mean net primary productivity for lakes and streams (Spurr and Barnes 1980, 507).

Although recent data on the net primary productivity of Kootenay Lake were not available, current biomass production appears to be lower than that measured in 1964. The previous rates reflected increased nutrient loadings from the leakage of phosphates from the fertilizer plant on St. Mary's River. The reduction of phosphorus loadings as a result of improvements in emission control, as well as the the blockage of nutrients behind the Libby and Duncan Dams upstream have further affected primary productivity rates on Kootenay Lake. Declining fisheries productivity (see section 5.41) and recent phosphorus addition initiatives indicate oligotrophic conditions (a low supply of nutrients) and low net primary productivity. Studies of aquatic conditions in the Kinbasket, Revelstoke and Arrow Lakes Reservoirs conclude that these reservoirs are low in biological productivity (Smith 1990; Triton 1990 31, 41).

A comparison of biomass productivity estimates for aquatic and temperate coniferous ecosystems suggests that ecological productivity is lower within flooded portions of the Columbia River Basin than for forests within the same region. The forest cleared or submerged for the creation of the five major reservoirs (Arrow, Mica, Revelstoke, Libby and Duncan) represents an area of approximately 50,000 ha. Using the net biomass production rates of 200 $g/m^2/yr$ for lentic and lotic systems, and 800 $g/m^2/yr$ as suggested for temperate coniferous forests (McNaughton and Wolf 1979, 587) the corresponding annual production of biomass is approximately 400,000 tonnes of carbon in forests or 100,000 tonnes of carbon in aquatic organisms. The ratio of biomass production of these two ecosystems (4:1) may actually be greater as the mean net primary productivity of temperate evergreen forests has also been estimated as 1300 $g/m^2/yr$ (Spurr and Barnes 1980, 506) and the low productivity of reservoirs in the Columbia River Basin may result in lower rates of biomass production than have been measured for lakes and streams. Higher accuracy could be obtained through consideration of actual density of wood which varies with forest maturity.

The low net primary productivity of reservoirs in the Columbia system differs from trends identified in an international comparison of the primary productivity of reservoirs and natural lakes. Kimmel et al. (1990, 141) conclude that reservoirs tend to be more productive than lakes. This survey of the productivity of water bodies throughout the world determined that of 102 lakes sampled, 46% were oligotrophic (low supply of nutrients), 40% were mesotrophic, and 14% were eutrophic (high supply of nutrients). In contrast, data from studies of 64 reservoirs, indicated that 16% were oligotrophic, 52% were mesotrophic, and 33% were eutrophic. The phytoplankton productivity for reservoirs ranged from 67-3975 $mgC/m^2/day$, while similar measurements for lakes varied from 3-5529 $mgC/m^2/day$. However, this study made no effort to link productivity with the time elapsed since impoundment, a critical factor since productivity increases during the first few years following inundation as nutrients from flooded soil are introduced into the aquatic ecosystem.

The oligotrophic conditions characteristic of reservoirs in the Columbia River system are likely a result of such factors as turbidity, temperature, lake morphology, flow regime and climate. The cold turbid waters in this regulated river system flush quickly through deep reservoirs in a temperate climate resulting in low levels of nutrients for consumption by aquatic organisms. The exception to the low ecological productivity in Columbia reservoirs has occurred during the first four years following impoundment due to the increased nutrient supply from recently inundated soil (British Columbia 1965c, 19; Smith 1990).

In addition to comparing the net primary productivity of temperate coniferous forests with aquatic ecosystems, it is necessary to consider the particular case of reservoirs as modified aquatic ecosystems. The hydrological regime of reservoirs is substantially different from that of lakes and rivers. Although the flow of water passing through both types of water systems varies throughout the year, reservoir fluctuations may be unseasonal and more pronounced.

The annual variation in electricity demand and related water storage does not correlate to the natural hydrological cycle of rivers. Natural river systems have high flow rates after snowmelt during the spring and early summer, followed by low discharges during the winter. Conversely, water systems regulated for the production of electricity require high flows during the winter when the demand for power is greatest, and low flows during the summer when electrical demand is correspondingly low. The regulated version of the hydrological cycle may not correspond to the life cycles of resident biota.

Annual fluctuations in water levels as a result of the modified hydrological cycle are often greater than natural variation. While water level changes may increase terrestrial and aquatic productivity by washing new supplies of nutrients into the water for consumption by aquatic species and exposing decomposed aquatic organisms along shorelines for terrestrial consumers, the ecological value of repeated fluctuations depends on the magnitude, frequency and rates of water level changes, and the morphometry of the water body (Petts 1990, 243). Processes such as erosion, resuspension, entrainment and redistribution of sediments may greatly reduce or eliminate primary productivity, as has occurred in the drawdown zone of the Arrow Lakes (Triton 1990, 45).

Hydroelectric regulation results in perpetual unseasonal variation in reservoir water levels and may represent a stress on what would otherwise be natural ecosystems. While some ecosystems flourish under the influence of certain kinds of disruptions termed as "disturbances", the imposition of severe disruptions may cause "stress" leading to the degradation or debilitation of natural processes. Primary productivity is an indicator of ecological stress as stress disrupts energy processing and necessitates increased respiration for system maintenance, diverting energy away from growth and production (Rapport and Regier 1992). Terrestrial and aquatic organisms may expend larger amounts of energy surviving within the drawdown zone of reservoirs with large fluctuations where wetlands have not reestablished (e.g., Kinbasket, Koocanusa, Duncan and Arrow Reservoirs).

Wetlands that are able to thrive under continual disturbance produce high rates of net primary productivity. The removal of this type of ecosystem may have important implications for larger water systems if wetlands serve as central organizing features of the entire system (Rapport and

Regier 1992). Although the total area of wetlands existing before and after hydro development in the Columbia River basin is not documented in this study, it is worthwhile to note the ecological value of this ecosystem. The Mica Reservoir Region Resource Study anticipated the destruction of all wetlands of importance to nesting, staging and migrating waterfowl in the Rocky Mountain Trench between Valemount and Douglas as a result of the creation of the Kinbasket Reservoir behind the Mica Dam (British Columbia 1974, A5-1).

Conclusion

Net primary productivity varies from one ecosystem type to another. The replacement of forest ecosystems with reservoirs has caused a reduction in primary productivity and loss of biomass along the shores of the Columbia and Kootenay River systems. While part of this terrestrial ecosystem has been replaced with an equivalent size of aquatic area, this does not result in a similar transfer of productivity or biomass.

A reduction in primary productivity does not necessarily mean that ecological integrity has been reduced as many other ecological processes interact to fulfill the essential functions of ecological systems. Different ecosystems transfer energy at different rates to fulfill various roles within the larger ecosphere. However, the perpetual unseasonal fluctuation of water levels may affect the ecological integrity of terrestrial and aquatic ecosystems as species occupying this habitat must continually adapt to changing conditions that are not synchronous with ecological processes occurring on larger scales.

While one type of ecosystem is not necessarily better or worse from an ecological viewpoint, certain ecosystems tend to have more value from a human perspective. Changes in primary productivity may have social and economic implications for local communities. People who rely on the presence of forests, fish and wildlife for economic and recreational pursuits may be affected by the diminished supply of resources available from their surrounding environment and its reduced carrying capacity. The intensification of silviculture, the maintenance of fish spawning channels and increased wildlife habitat management may enable greater levels of productivity in existing ecosystems affected by hydro development. However, these mitigation options may necessitate tradeoffs, e.g., the preservation of wildlife habitat may require reduced forestry in certain areas, the regulation of water levels to provide appropriate spawning conditions may mean decreased power generation opportunities. Mitigation efforts will also require continued economic support.

4.5 Social Indicators

Social indicators were chosen in an effort to identify some of the key aspects of hydro development that have affected the ability of social systems to support life, as well as to enhance the operations of ecological and economic systems. These indicators are intended to represent how dam operations have affected the lives of the people living in their vicinity; in general, the "livability" of the Kootenays. Although social and economic factors are often intertwined and are sometimes labelled according to the term "socio-economic", this analysis separates the two.

The three indicators considered to represent social conditions are intended to measure feelings of contentment, control and harmony in the lives of those living in the Columbia Basin. Since residents of the Kootenays perceive themselves as being strongly linked to their natural surroundings, their overall satisfaction with their lives may be affected by any substantial change to what they consider to be their normal or usual environment. Changes may disrupt feelings of contentment with a particular lifestyle, and cause tensions to arise between different groups, resulting in varying degrees of conflict. The ability of individuals and groups to adapt to or manage change through their social interactions determines their social sustainability.

The three indicators selected to examine social sustainability provide information at three levels of social interactions. The consideration of the population size of Revelstoke serves as an early warning indicator of changes occurring as a result of boom-bust effects at the community level. Fishing activity trends enable the evaluation of the intrinsic value of individual or community recreation. The analysis of opportunities for public participation in dam-related decision-making enables the consideration of the effectiveness of large-scale processes within the social system.

4.51 Community Stability - Population of Revelstoke

To obtain an indicator of community stability, the changing population size of Revelstoke was examined. Many resource-dependent communities are concerned about long-term stability, having experienced various periods of growth and decline associated with the fluctuations of external resource markets. The use of Revelstoke population as an indicator enables the examination of social interactions occurring at the community level.

Various communities in the Kootenays have been affected by the consequences of the development of large-scale hydroelectric dams in their vicinity. The series of hydro megaprojects constructed between 1964 and 1985 have caused disruptions to local communities as a result of the "boom and bust" phenomena associated with large industrial projects. Residents of these communities have complained about the effects of the rapid influx of large numbers of labourers on the social and economic fabric of their communities, and maintain that there are ongoing consequences related to over-expanded infrastructure that continue to cause problems locally.

The City of Revelstoke has been affected by two periods of hydro development. Revelstoke provided services for the Mica Dam, constructed between 1965 and 1973, and was the centre of activity for work on the Revelstoke Dam, built between 1977 and 1985. As the rapid growth of a city affects many services and organizational arrangements that shape the desirability of living in a place, an examination of population trends provides information about social disruption that may affect sustainability.

Although other factors besides hydroelectric development may have influenced population changes in Revelstoke, the impacts of local megaprojects on such a small community are relatively easy to measure due to their immediate and obvious consequences on their surroundings. Linkages have been well documented by provincial and municipal governments, B.C. Hydro and by the DPA Group (socio-economic consultants).

Discussion

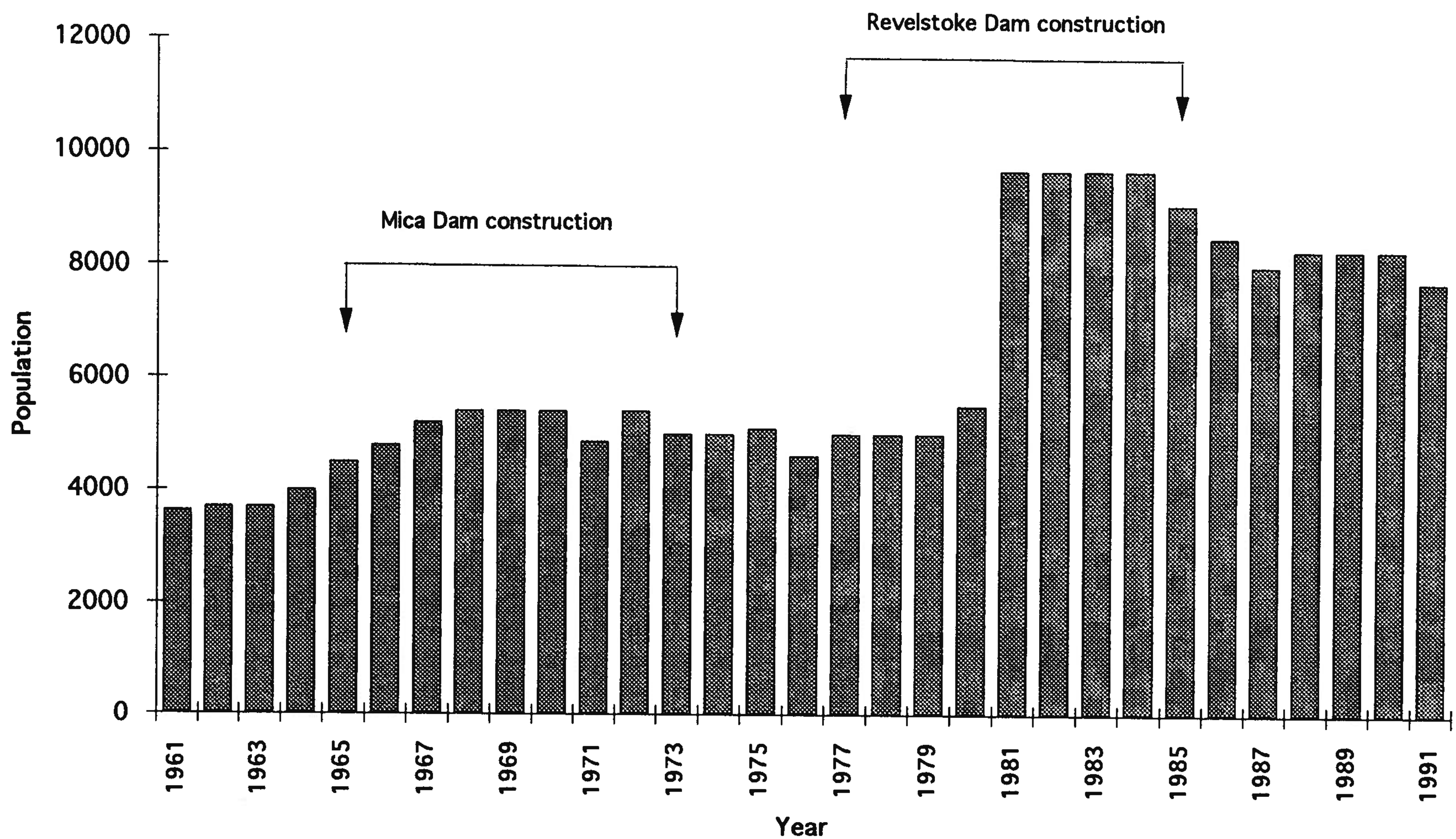
Revelstoke has developed through a series of industrial booms, primarily in response to railway and forestry operations. Prospectors drawn to this vicinity by the discovery of gold in the 1860s established mining camps along tributaries of the Columbia, north of Revelstoke (The Kootenay Task Force 1974). Mining activity was followed by railway construction in the late 1880s, with work camps located at Revelstoke and Golden. The expansion of the Canadian Pacific Railway (CPR) stimulated the sawmill industry by creating demand for railway ties and lumber. The installation of the main office of the CPR in the late 1800s, followed by the establishment of local forestry and lumber processing enterprises, have been responsible for Revelstoke's development throughout most of the twentieth century (DPA 1986, 12).

Figure 18 illustrates Revelstoke's population between 1961 and 1991. Two periods of growth are evident from this graph. The first expansion occurred during the early 1960s, resulting in a 49% increase from 1961 until 1968. After a period of stabilization throughout the 70s, the city experienced very rapid growth (76%) between 1980 and 1981. Although Revelstoke maintained its larger size for several years, its populaton has since decreased, but has remained higher than pre-1981 levels.

Revelstoke experienced growth between 1960 and 1965 as a result of the construction of the Trans Canada Highway and the expansion of the CPR. With improved transportation links, the initiation of tourism opportunities diversified the local economy (DPA 1986, 12).

Construction of the Mica Dam, 136 km north of Revelstoke, provided a new stimulus for development. The population of Revelstoke increased in response to dam construction activity, occurring from 1965 until 1973. The peak of construction occurred in 1972, and declined as the dam became operational in 1973.

Figure 18. Population of Revelstoke



Source: compiled from: British Columbia. Municipal Statistics (1961-1991).

Although a community was established at the Mica dam site to accommodate many of the workers and relieve pressure on Revelstoke, rapid population growth in and around Revelstoke caused various effects on its residents. Dam-related employment increased local income levels, exceeding the 1971 average in the Kootenay region by 17%. However, social, health, educational and recreational services were all strained by the additional demands placed on this community, and were deemed to be inadequate for future population expansion. In addition to these problems, the provincial government identified heavy winter snowfall, limited water supply, and a lack of housing availability as constraints to further development (British Columbia 1976, 257).

The population of Revelstoke was fairly stable between the completion of the Mica Dam in 1973, and the start of construction of the Revelstoke Dam in 1977. Rather than leaving the area, it is likely that many workers and their families stayed in Revelstoke in anticipation of continued hydroelectric employment through construction of the Revelstoke Dam.

During the initial construction stages of the Revelstoke dam, Revelstoke's population size remained relatively constant. However, the community expanded substantially in 1981. In 1982, at the peak of construction activity, there were 2926 hydro construction jobs. Of these, 410 jobs were filled by local residents, and 2516 were filled by in-migrants (DPA 1986, 65). This large influx of workers, some of them accompanied by their families, had a substantial impact on Revelstoke, comprising over 25% of its 1982 population of 9682.

Job creation, and the resulting stimulation of the local and regional economy are the main benefits received by Revelstoke. Employment provided by dam construction insulated

Revelstoke from the economic recession of the early 1980s (DPA 1986, 67) (see Figure 23 and discussion on unemployment in section 4.62). Hydro-related jobs paid high hourly wages to a largely male workforce for periods of several months. While the short-term nature of hydro employment did not result in high annual wages (DPA 1986, 59), these jobs created competition for tradesmen and skilled workers, and displaced workers from the forestry and railway sectors. Labour shortages required the recruitment of less skilled workers from outside the region (DPA 1986, 75). While many unemployed employable residents of Revelstoke gained jobs from the dam activity, the number of people who required social assistance during the same period increased by 43% due to inflation of food and housing costs. This rate was higher than the 37% total provincial increase during the construction period, 1979 to 1984 (DPA 1986, 114).

High levels of income created an income disparity between those with highly paid dam jobs and others on fixed incomes, such as the elderly and the unemployed. Local inflation affected housing and food prices. Housing prices almost doubled from 1975 to 1980, then declined during the peak period of construction as workers preferred to rent rather than own. However, with the exception of the first two to three years of dam construction, the rate of housing price increase was lower in Revelstoke (60%) than in the province as a whole (81%) from 1975 to 1984. Rental rates for two and three bedroom apartments were substantially higher than provincial averages from 1981 to 1983 (DPA 1986, 19). According to the DPA socio-economic impact monitoring study, this problem could have been addressed through the provision of rent subsidies and food allowances (DPA 1986, 147).

The expanded population of Revelstoke resulted in increased demands on social services provided in the community. B.C. Hydro contributed to municipal infrastructure improvements (water and sewer systems, community planning, waste disposal), mobile home parks, schools, libraries and recreational services. Police, fire protection, human resources, mental health care and hospitals provided increased levels of service without B.C. Hydro assistance, responding to moderate increases in crime, fire alarms, counselling and medical needs. However, the number of dentists and physicians was insufficient to meet the needs of the larger population (DPA 1986, 149).

In accordance with the 1976 water licence for the Revelstoke Dam, two provincial government committees were formed to monitor impacts: the Revelstoke Project Co-ordinating Committee, and the Community Impact Committee. These two committees addressed impact management and mitigation, as outlined in the water licence. In addition, a local citizens' group, comprised of local government representatives and members of the general public, was established outside of the water licence requirements to act as an advisory body on mitigation and compensation matters. Relationships between this local group and the two other committees were not well defined initially, and in 1980, after three years of monitoring, the citizens' monitoring program was discontinued (DPA 1986, 14).

The completion of the Revelstoke Dam resulted in a gradual population decline in Revelstoke, beginning in 1985 (Figure 18). This population decrease coincided with the closure of the Goldstream mine in 1984, and reduced sawmilling activity in 1986. However, employment generated by rail jobs associated with CPR tunnelling and double-tracking at Rogers Pass offset the loss of other jobs from 1984 until 1988 (British Columbia 1986).

Respondents to a post-project survey conducted during the last year of project construction indicated that their lives had not changed substantially as a result of the Revelstoke project. Some of the most immediate impacts recorded during the downturn of construction activity, were: increased housing availability, some recreation and transportation improvements, decreased employment and income, loss of some friendships with people who had moved on, and increased demand for mental health and human resources services (DPA 1986, 134).

The DPA evaluation of the social impacts of the Revelstoke Dam concludes that local residents generally perceived the project as a net gain, however, they listed four main concerns: residents received an unfair (small) share of dam-related jobs; local businesses did not profit as much as anticipated; residents in nearby Sicamous perceived that their community was not compensated as fairly as Revelstoke in terms of municipal infrastructure; and Sicamous residents were generally dissatisfied with B.C. Hydro's community relations. While DPA concluded that the overall impacts of the Revelstoke Dam are positive, stating that some of the adverse downturn impacts are "part of the natural consequences of development and progress in society" (DPA 1986, 151), these consultants suggested that some issues could have been better addressed, such as price inflation, inadequacy of health care, and fear of dam failure. They emphasized that the compensation and mitigation requirements of the Revelstoke water licence were inadequate and that local involvement in compensation/mitigation planning is essential.

In the early 1990s, Revelstoke's population has been sustained through ongoing forestry and railway activity, and increasingly relies on tourism and the service industry (Battersby 1992). In their examination of the basic sector dependence of Revelstoke in 1990, Horne and Penner (1992, 11) show that this city relies on several sectors for its income: "other basic" e.g., administration and services (29%), forestry (27%), pensions (18%) and accommodation and food services (12%). This municipality does not dependent on any megaproject currently; however, it is strongly influenced by government forest policy.

With a smaller population and corresponding tax base, residents of Revelstoke continue to pay ongoing maintenance costs for expanded infrastructure established during dam-building. This places a heavy burden on the remaining population. Although B.C. Hydro initially contributed to improving the water supply and sewage system, funded fire trucks, and pays annual grants and taxes to the municipality amounting to $1,003,217 in 1992 (B.C. Hydro 1993h), the local population believes it finances an unfair share of what is now unnecessary infrastructure (Battersby 1992).

Revelstoke also faces constraints with respect to local development opportunities due to its limited land base which has been diminished due to the area occupied by hydroelectric operations (Battersby 1992). B.C. Hydro has contributed funding towards local park development, recreational facilities, and erosion control for a golf course (Davidson 1992). However, the mayor insists that neither mitigation and compensation, nor the payment of annual grants and taxes, are considered adequate replacement for the loss of potential economic activity that could occur without hydro development such as forestry, tourism and farming (Battersby 1992).

Conclusion

The construction of the Mica and Revelstoke dams has caused significant population changes for the community of Revelstoke. Some of its residents may have enjoyed prosperous times during the "boom", and have had to adapt their lifestyles during the "bust" period, to return to the somewhat more "normal" growth levels of this city. Certain sectors of the community, such as those on fixed incomes, bore more of the adverse impacts than those employed during dam construction. Future project planners should ensure that project impact assessments consider the full range of costs and benefits incurred by people living in surrounding areas.

In examining the long-term implications of hydro development on sustainability, it may be necessary to consider the effects of land base constraints and oversized infrastructure on the remaining population of Revelstoke. Future hydroelectric planning should consider some of the disruptions experienced at Revelstoke and take measures to avoid the repetition of similar problems. In examining implications for social sustainability, planners should take care to ascertain which groups will experience benefits or incur costs, and not assume that the benefits enjoyed by some will be distributed throughout all groups of society. Redistributional measures may need to be introduced to share some of the benefits generated through dam construction with groups who may not receive direct gains.

4.52 Recreational Fishing - Rod Hours

The measurement of recreational opportunities, through the use of angling activity in rod hours, provides an indication of the extent to which recreational needs are met within the region. Various social interaction needs are filled through the pursuit of recreation, and since outdoor activities are popular in the Kootenays, an examination of fishing trends facilitates the assessment of one aspect of social sustainability in this region. The monitoring of fishing activity provides an indicator of the intrinsic value of recreation to residents of the Columbia River Basin.

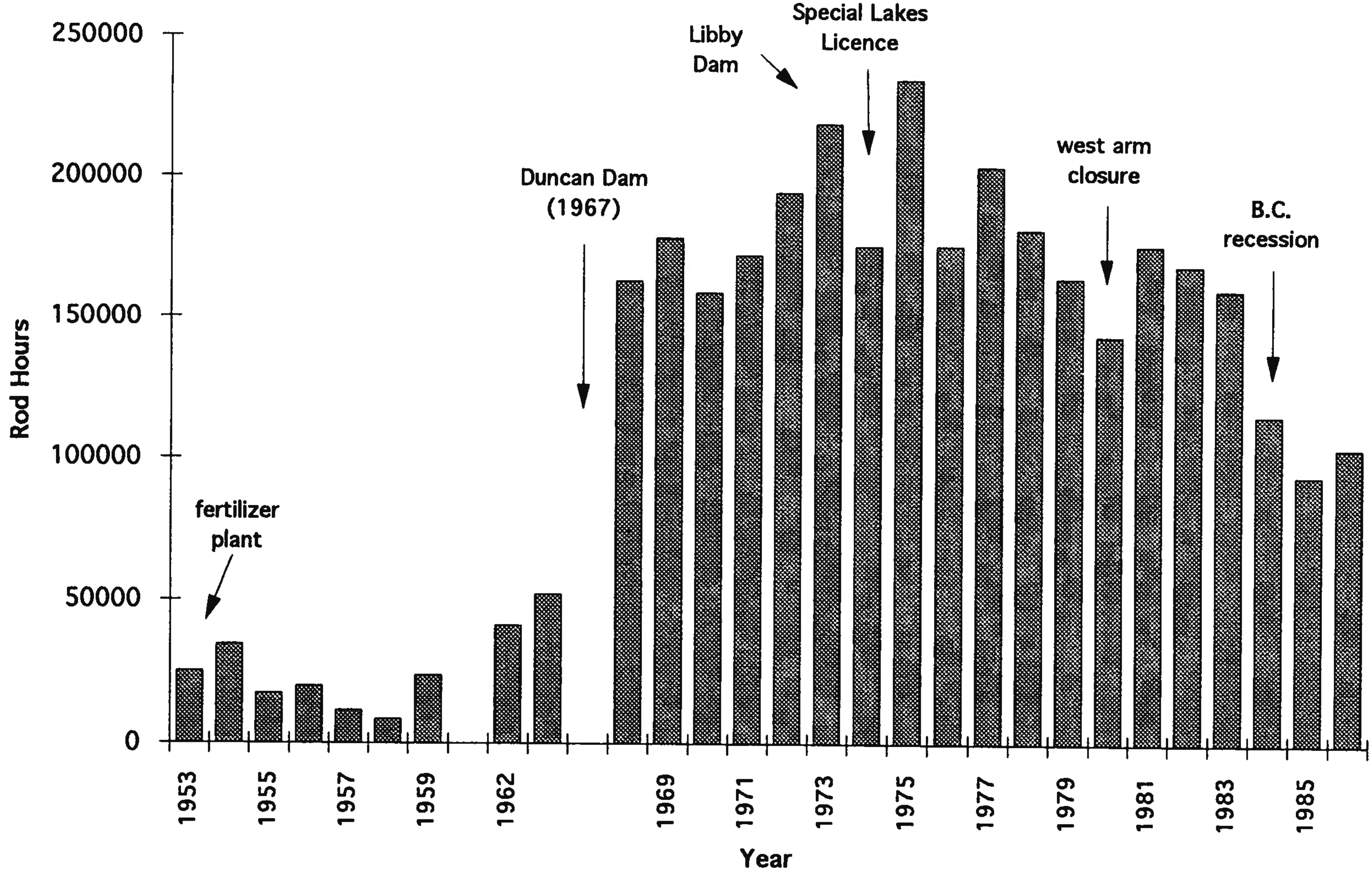
Kootenay Lake is renowned for hosting one of the most productive fisheries in British Columbia. Anglers from all over North America have been drawn to this lake due to its wide variety of sport fish, principally rainbow trout, Dolly Varden, kokanee, mountain whitefish and burbot (Pearse and Laub 1969, 11). Although the trophy size Gerrard trout are the most favourable species of the sport fishery (Cartwright 1961, 27), kokanee have become a popular summer fishery due to high fishing success rates (Andrusak 1981, 5). As of 1987, kokanee represented the majority of the lake's total catch (Andrusak 1987, 6).

Local residents value the Kootenay Lake sport fishery due to the important role it plays in terms of recreation, rather than income as there has never been a commercial fishery on this lake (Pearse and Laub 1969, 34). Since people living in the Columbia Basin feel strongly attached to its rivers and lakes, water-based activities are very popular forms of recreation. The significance of angling in Kootenay Lake may have particularly increased in recent years due to unfavourable conditions in other reservoirs where substantial water level fluctuations have disrupted fisheries and angling accessibility. The value of Kootenay Lake fishing has been estimated as being a large portion of the $18 million (in 1981) value of the sport fishery in the Kootenay region (Hirst 1991, 23).

Discussion

Figure 19 portrays changes in angling effort on Kootenay Lake from data collected by provincial fisheries officials from 1953 until 1986. Unfortunately, annual surveys of the entire sport fishery were not conducted some years (1960, 1961 and 1964-1967), and have been discontinued as of 1987. However, sufficient information is available to discern the general implications of

Figure 19. Annual Rod Hours on Kootenay Lake



Source: compiled from: Cartwright (1961) p. 28; B. C. Fish and Game Branch (1965) p. 24; Andrusak (1987) dam activity on fishing trends.

Kootenay Lake angling focuses largely on trophy sized rainbow trout of Gerrard stock, and kokanee. Gerrard trout can grow up to 18 kg and the average fish caught weighs approximately 6 kg. Kokanee are smaller growing up to 4 kg and weighing an average of 1 kg (Andrusak 1987, 4). Fishing activity occurs in three areas of the lake, as these fish tend to reside within distinct populations located in the north, south or west arms of the lake. For the purposes of this study, the total rod hours for all populations of all five sport fish (rainbow trout, kokanee, Dolly Varden, burbot and whitefish) is used as an indicator. While fishing effort for various species may change annually, Figure 19 summarizes the overall trends of the sport fishery.

Generally, angling in Kootenay Lake has increased substantially since 1953, reaching a peak in 1975, and declining afterwards. Cartwright (1961, 29) suggests that increased angling activity in the late 1950s may have been triggered by an upward trend in catch success, resulting from greater numbers of fish. Increased fish productivity may have occurred due to the greater availability of nutrients arising from phosphorous emissions from a fertilizer plant opening on the Kootenay River in 1953. Rising settlement in the Kootenay region resulted in increasing numbers of local anglers in the region. Some portion of this fishing activity may be attributed to the influx of workers on Columbia River Treaty dams during the 1960s.

Fishing pressure increased through the early 1970s in response to rising populations and fish sizes, until 1975. The requirement for anglers to obtain a Special Lakes licence in 1974, to ensure a high quality fishing experience based on large size Gerrard trout (Andrusak 1987, 4), may have caused an initial reaction that reduced anglers in this year (Andrusak 1981, 9). The decreasing catch success since 1975 was originally believed to be a result of overfishing and poor stream production. However, the corresponding 1980 closure of the west arm kokanee and the construction of two spawning channels have not reinstated this population, and declining lake productivity appears to be affecting all three stocks of kokanee (Andrusak 1987, 17). Although the closure of the west arm fishery resulted in decreased fishing throughout various parts of the lake, the slight increase in effort shown in 1981 may be a result of some anglers relocating to other areas.

The decreasing productivity of Kootenay Lake has been attributed to nutrient retention behind the Libby Dam, completed in 1975. Fish populations may have also suffered from a lack of access to major spawning and rearing grounds (Andrusak 1981, 12) due to the construction of the Duncan Dam.

In addition to reduced lake productivity, angling pressure has weakened through the 1980s due to the complete closure of the west arm kokanee fishery, and the economic recession experienced throughout British Columbia during the mid 1980s. This recessionary trend has also reduced angling in the Arrow Lakes, and is reflected in provincial fishing statistics which did not show improvement until 1986 (Andrusak 1987, 6). Slight decreases in size may account for some decline in fishing effort in the north arm fishery in 1985 and 1986 (Andrusak 1987, 18).

Data on the number of rod hours spent on Kootenay Lake have been collected from creel census programs. A creel census is conducted by fisheries officers who survey anglers while they are fishing. Surveys are done on random days representative of each day of the week, and daily totals are multiplied by the frequency of similar days (Saturday, Sunday or weekdays) in a month to obtain monthly estimates. In recognition that the creel census cannot register all anglers, recorded estimates have been increased by 20%, and slightly further adjusted by 25% since 1982 (Andrusak 1987, 3). The measurement of angling effort in rod hours may be somewhat inaccurate due to the small degree of error from the method of calculating monthly estimates, and the adjustment of recorded hours for census inefficiency. However, the creel census has been the standard method used to monitor fishing effort by provincial fisheries officials.

Conclusion

Although fishing has been an important recreational activity in the Kootenays, fishers have reduced their use of Kootenay Lake since 1975, although data were not available for the period after 1986. Kootenay Lake is a focal point for regional recreation due to its scenic qualities and accessibility within the surrounding terrain which is predominantly mountainous. Residents are concerned about the decline in fisheries productivity in the region, as their trophy-sized fish have been a source of pride for several decades.

Ecological problems affecting the sport fishery have concerned the people of the Kootenays, and specifically anglers who have enjoyed the high quality fishing experience that this lake offers. If local communities are interested in developing more recreation or tourism opportunities, they may wish to promote one of the natural assets for which they are already well known. However, they must also recognize that previous trophy size fish have likely been the product of high phosphorus loading, which is not a "normal" condition of Kootenay Lake. While some fisheries management strategies may be able to enhance sport fish productivity, the ongoing regulation of the Duncan River and the Kootenay River, both of the principal sources of flow into Kootenay Lake jeopardizes the productivity of the resource upon which fishers focus and discourages the pursuit of this form of recreation.

If communities in the Kootenays perceive angling to be an important part of their lifestyle, then fishing activity should be considered in the preparation of dam operating plans. Representatives of local communities, B.C. Hydro and government officials should meet to discuss opportunities for the inclusion of fisheries concerns in future reservoir management.

4.53 Social Systems - Participation in Decision-Making

The examination of participation in decision making provides an indicator of social sustainability at a systems level. As the management of natural resources usually involves decision-making by stakeholders with varying degrees of overlapping jurisdictions, the extent to which different social groups participate may indicate how well communication and feedback loops operate within a system of social interactions. The focus of this indicator is on public participation in dam-related decision-making at the community level, as this is a major concern of residents of the Kootenays.

The importance of local participation in decision-making was emphasized by many of those interviewed (Smienk 1992; Demmon 1992; Johnson 1992) and was identified as being one of the major issues related to hydro development in the Columbia River Basin at the Columbia-Kootenay Symposium, and at previous community meetings (Table 6). B.C. Hydro has recognized that its dam operations have disrupted the lives of Kootenay residents and has made a commitment to seek greater involvement with local governments and community organizations in its future hydroelectric planning (B.C. Hydro 1993d, 18).

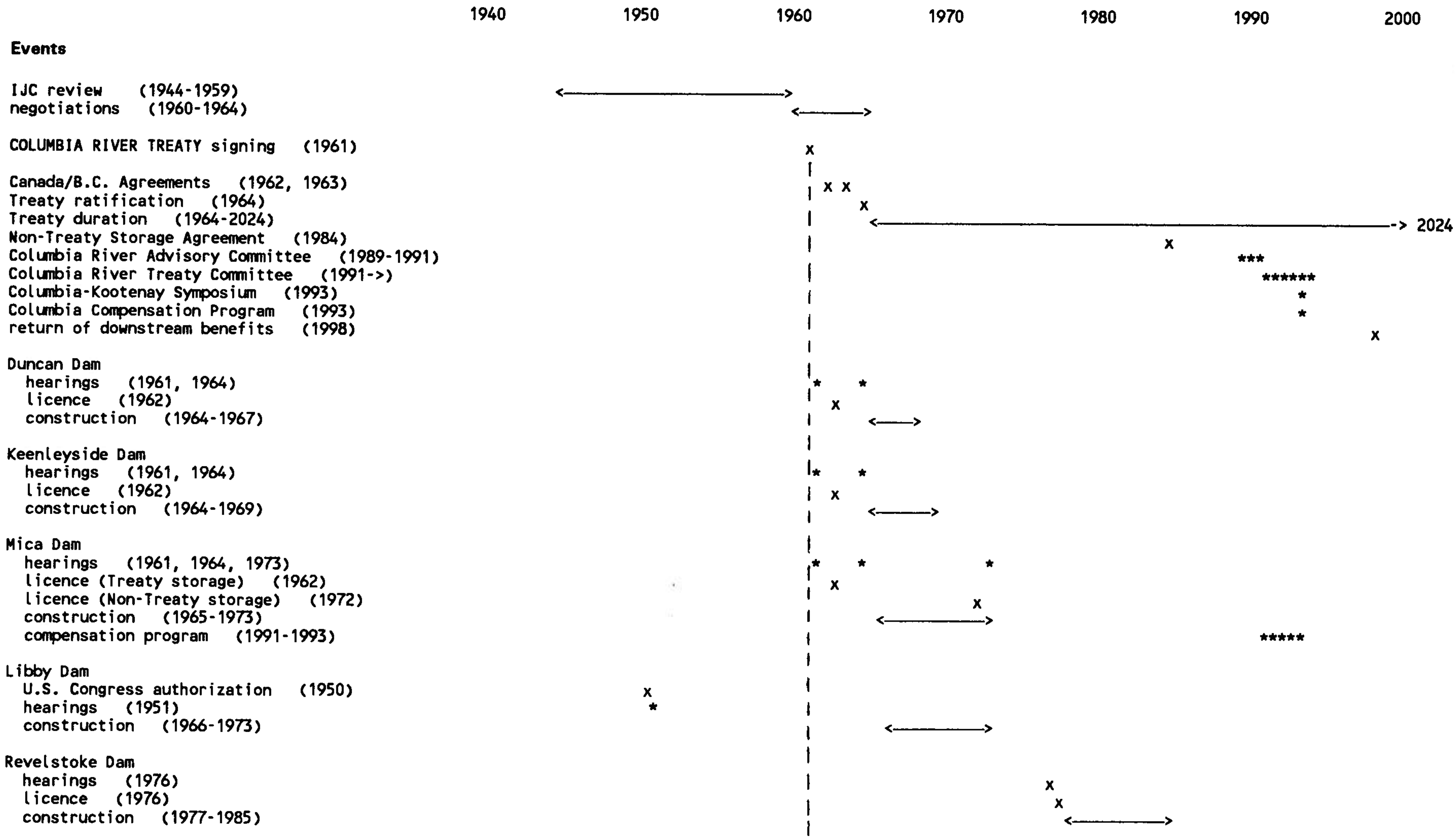
Since both B.C. Hydro and local communities have expressed interest in increasing the extent of public participation in hydroelectric decision-making, this indicator is helpful in the evaluation of past and present initiatives, and may provide clues as to how efforts could be directed in the future. While the analysis of this indicator is relatively subjective, the use of a project management diagram assists the interpretation of the chronology of events related to the Columbia River Treaty.

Discussion

Figure 20 summarizes the most significant opportunities for public participation in decision-making related to the signing and implementation of the Columbia River Treaty, and subsequent dam projects. Opportunities for participation in decision-making consisted mainly of public hearings. As most of the key development decisions were made before public hearings, and since the terms of reference given to the Water Comptroller were narrow, the effectiveness of public hearings was quite limited (Waterfield 1970, 87; Wilson 1973, 18). More recently, local groups have been asked to assist in the development of fish and wildlife compensation programs. The Columbia-Kootenay Symposium and the community meetings that preceded it were the first example of a community-based effort to address regional hydro development issues.

The lack of concern for public involvement in Columbia River planning is evident from the initial stages of Treaty preparation, and has created much resentment among residents of the Kootenays. Public hearings were not held until after the signing of the Columbia River Treaty,

Figure 20. PUBLIC PARTICIPATION IN COLUMBIA RIVER DAM PLANNING



Notes: x decision
<——> continuing activity
* public participation activity

Sources: Compiled from Ministry of the Environment Water Licences, Waterfield (1970), Wilson (1973), British Columbia (1974), Spritzer (1979), Swainson (1979, 46), B.C. Hydro (1993k), Smienk (1993), Geissler (1994) on January 17, 1961. Several days of Water Comptroller hearings were then arranged in each of the communities of Revelstoke, Nakusp, Castlegar and Kaslo during September, October and November of 1961 to discuss the water licences for the Duncan, Keenleyside and Mica Dams. Local residents perceived these hearings as a "farce" due to the limited mandate which prevented substantive discussion of the justification of the various projects, and instead addressed licensing conditions and compensation, indicating that the fate of the Kootenays residents was already decided (Waterfield 1970; Wilson 1973).

After the signing of the Main and Supplementary British Columbia and Canada Agreements in 1963 and 1964, another set of hearings was held. In April and May, 1964, hearings were held in Parliament before the House of Commons' Standing Committee on External Affairs. The Treaty passed by a vote of 92 to 16 in the House of Commons in June, with only 108 members present out of a total of 264. The Senate passed the Treaty without a formal vote and without dissent (Wilson 1973, 24). The Treaty was ratified September 16, 1964.

Although the relocation of Arrow Lakes residents from Burton, Edgewood and Fauquier was achieved with the involvement of community groups, B.C. Hydro's overall performance drew criticism and led to the impression that project management decisions were being directed from Vancouver. Jim Wilson, the planner responsible for B.C. Hydro's resettlement, notes that the resettlement program lacked a central figurehead in the Arrow Lakes area, and the absence of a local contact contributed to the feeling of powerlessness experienced by residents of relocating communities (1973, 173).

In a follow-up survey conducted by Wilson in 1970, respondents indicated that the question of compensation overshadowed the entire resettlement program (Wilson 1973, 146). With its authority to expropriate, the government held a large degree of control over compensation decisions. Wilson (1973, 145) concludes that this negative perception of B.C. Hydro may not actually represent their true performance, but portrays their role in a situation which was inevitable according to the decision-making practices at that time.

Although Arrow Lakes residents were somewhat involved in planning for the relocation of their communities along the new reservoir, further public discussion of substantive issues did not occur until after the construction of the Mica Dam in 1973. In recognition of the minimal study of the impacts of the establishment of the Kinbasket Reservoir on surrounding resources, the British Columbia Environment and Land Use Committee conducted an examination of resource use in the Kinbasket Reservoir region in May, several months after the completion of the dam. This post-project evaluation included four days of additional public hearings, held in July in Castlegar, Revelstoke, Golden and Valemount (British Columbia, 1974, 1-2). Presentations focused on wildlife, forestry and recreation issues related to the consequences of hydroelectric development in the Mica region. The ELUC report emphasizes the high value that local communities place on recreation. Participants stated that the people of the Kootenay region believe they have borne the brunt of problems resulting from hydro development, and that their values have not been considered adequately (British Columbia 1974, 8-2).

The International Joint Commission held public hearings regarding construction of the Libby Dam on the Kootenay River in Montana, in Cranbrook in March 1951. Discussion of the consequences of the flooding of Canadian land occurred after the U.S. Congress had already authorized the construction of the dam in 1950 (Swainson 1979, 46).

The 1984 Non-Treaty Storage Agreement was signed without any public consultation, and was similarly extended in a subsequent agreement in 1990. Since the additional storage provided through these agreements was already authorized by the original water storage licence for Mica, no hearings were deemed to be necessary (Kendall 1993).

B.C. Hydro established the Columbia River Advisory Committee in 1989, so that representatives of the Kootenays could discuss unresolved hydro development issues and provide recommendations on the provincial utility's operations in the region. This committee reviewed various B.C. Hydro initiatives and established working groups to address specific problems, such as grass seeding to reduce dust storms along the Arrow reservoir (Newton 1993). CRAC is no longer active as its function has been replaced with other initiatives to include communities in B.C. Hydro's decision-making (Geissler 1994).

The establishment of fish and wildlife compensation programs in the 1990s indicates a political willingness to acknowledge that communities in the Columbia River Basin have experienced resource use problems as a result of hydroelectric decision-making. The Columbia Basin compensation program, as well as its predecessor focusing solely on Mica, have attempted to incorporate a greater degree of public participation in this resource enhancement program. The Mica compensation program, initiated in 1991, has involved consultation with members of local communities in an effort to incorporate local ideas into the identification of fish and wildlife management priorities (B.C. Hydro 1991b).

The establishment of the Columbia River Treaty Committee (CRTC) in 1991 represents a significant community-based effort to participate in hydro-related decisions affecting the lives of those living with the consequences of dam operations. The CRTC consists of representatives (mostly mayors and councillors) of the five regional districts and tribal councils in the Columbia River Basin. Its mandate is to ensure that the provincial government addresses social, economic and environmental impacts of hydro development, and to insist a portion of the downstream benefits resulting from hydro operations in the region is returned to the Kootenays. This organization is attempting to regain some control over regional resource use and decision-making through a regional coordination of information sharing and lobbying on issues related to hydro development in the Kootenays.

The 1993 Columbia-Kootenay Symposium, organized by the Columbia River Treaty Committee, provided a unique multi-stakeholder forum for the discussion of many of the impacts and community development issues related to hydro development in the region. This initiative is particularly significant as it is a product of regional efforts to address dam-related problems, and was not initiated by B.C. Hydro or the provincial government. Community representatives presented their concerns, summarizing those expressed in seven previous community meetings. Resentment regarding past injustices was verbalized through the discussion of hydroelectric impacts throughout the region, and participants then identified opportunities for future community development strategies.

B.C. Hydro has included Columbia River Basin communities in its Electrical Systems Operating Review. Working groups have been established in seven communities to assist in the identification of issues relevant to the operation of dams in the region.

Conclusion

Public participation has not been given much priority before, during and immediately after hydro development. Up until the last few years, the majority of effort has been focused on public hearings, which have been largely informative in nature, meaning that the public has been informed of future development plans. This is consistent with public information programs across Canada and within British Columbia. However, since the late 80s, during a time of increasing societal environmental awareness, B.C. Hydro has made a greater effort to include those who live near its dam sites in consultation processes.

While public participation initiatives have evolved considerably from the limited scope and late timing of water licence hearings for Columbia River Treaty dams, individuals, communities and the Columbia River Treaty Committee are demanding a greater role in the control of decisions regarding watershed resources. Previous hydroelectric planning has been made without adequate consideration of local concerns and community development priorities. In some cases, the reduced availability of land due to reservoir creation has heightened conflicts between various resource users. Residents feel that they cannot manage their resources to achieve the futures to which they would like to aspire.

The development of the CRTC shows how regional bonds have formed to address adverse conditions experienced throughout the Columbia Basin. The strengthening of the identity of the Kootenay region, through the work of the CRTC and other regional initiatives, may enhance the social sustainability of those communities affected by hydro dams. Cooperative efforts to regain some control over resource use decisions may go a long way towards improving the desirability of living conditions in this region. The continuation of work by the Columbia River Treaty Committee, or some other regional organization, should assist in the inclusion of Kootenay residents in regional resource base decision making.

B.C. Hydro and provincial government officials could assist in providing opportunities for public participation by opening up resource use decisions to include those who are directly affected by the outcome. Communities impacted by ongoing dam operations could be included in future planning for the return of downstream benefits, as well as information collection for the Electrical Systems Operating Review. Participation in decision-making processes that affect local resource use may empower those who have previously felt detached from the stewardship of their surroundings, and may provide new opportunities for information sharing.

4.6 Economic Indicators

Economic indicators were chosen in an effort to identify some of the key aspects of hydro development that have affected the ability of economic systems to support improvement in quality of life, as well as to enhance the operations of ecological and social systems. Economic indicators are used in this analysis to examine how dam operations have affected the ability of local communities to pursue economic activities from their resource base. Since resource-based industries have generated the majority of income for human settlements throughout the Kootenays, the withdrawal of land or water from local development in a region with severe land use constraints may have significant consequences for economic development or economic diversity, a goal of many communities dependent on forestry or mining across British Columbia.

Land use decisions in one area may have critical effects on economic activities of adjacent areas. The designation of priorities for the management of a strip of land or water body can limit or enhance activities conducted previously on the same or nearby land or water. Economic opportunities may be affected by changes in access to resources, changes to environmental operating conditions (e.g., reservoir fluctuations), or uncertainty due to changes in decision-making and the communication of decisions. The following discussion uses economic indicators related to resource use in the Kootenays to monitor how hydro development has affected economic development opportunities in surrounding communities.

Economic indicators have been selected to examine the effects of hydro development on economic aspects of sustainability. Tourism is of interest because of its role in contributing towards economic diversity, a goal of many resource-dependent communities. Unemployment data provide an indication of the employment situation at the community level and may act as an early warning indicator with respect to related social problems. Concerns related to accessibility to timber supply are important to the forestry sector and are also of significance to the local community due to its high dependence on this industrial sector.

4.61 Economic Diversity - Tourism Room Revenues

Many communities in the Kootenays are encouraging tourism as a means of economic diversification. At the Columbia-Kootenay Symposium, representatives from various parts of the region expressed their frustration with the boom and bust cycles associated with previous industrial development. Participants view the scenic quality of their surroundings as an attraction that could stimulate economic activity in the region (Salasan 1993).

Initially, regional developers viewed dams and reservoirs as being assets for tourism (British Columbia 1970, 49). It was predicted that tourists would be drawn to the region to observe some of Canada's largest engineering accomplishments, and to enjoy a wide range of recreational opportunities based around the region's six reservoirs. Several decades later, some of the adverse impacts of this form of regional development have become apparent. Local mayors and economic development planners are concerned that various aspects of hydro development, particularly the low reservoir levels experienced on the Kinbasket, Arrow and Koocanusa reservoirs, may cause adverse effects on tourism.

Room revenues are a useful measure of tourism due to the ability of this indicator to reflect the number of tourist dollars flowing into a community, unlike some other tourism data related to highway traffic or golf courses which would include some component of local travel or recreation.

Discussion

The scenic beauty of the mountains, valleys and waterways of the Kootenays is the principal attraction for tourism in this region. A large proportion of tourism in the Kootenays is based on touring and outdoor, adventure and sport activities. Popular activities of visitors to the region include sport fishing, recreational boating, hunting, golf, and various types of skiing (downhill, cross-country, heli-skiing, cat-skiing), wilderness and beach/lakeshore experiences (DPA Group 1990).

Although the aesthetic appeal of the mountains and waterways throughout the Kootenays has been widely recognized for its ability to stimulate tourism, this form of economic development remains relatively unexploited and largely undeveloped due to the lack of good highway access to this region (British Columbia 1986). The completion of the Coquihalla highway in 1986 has since improved accessibility to the northern portion of the Columbia River Basin. However, road and air access continues to constrain tourism in this region (DPA Group 1990).

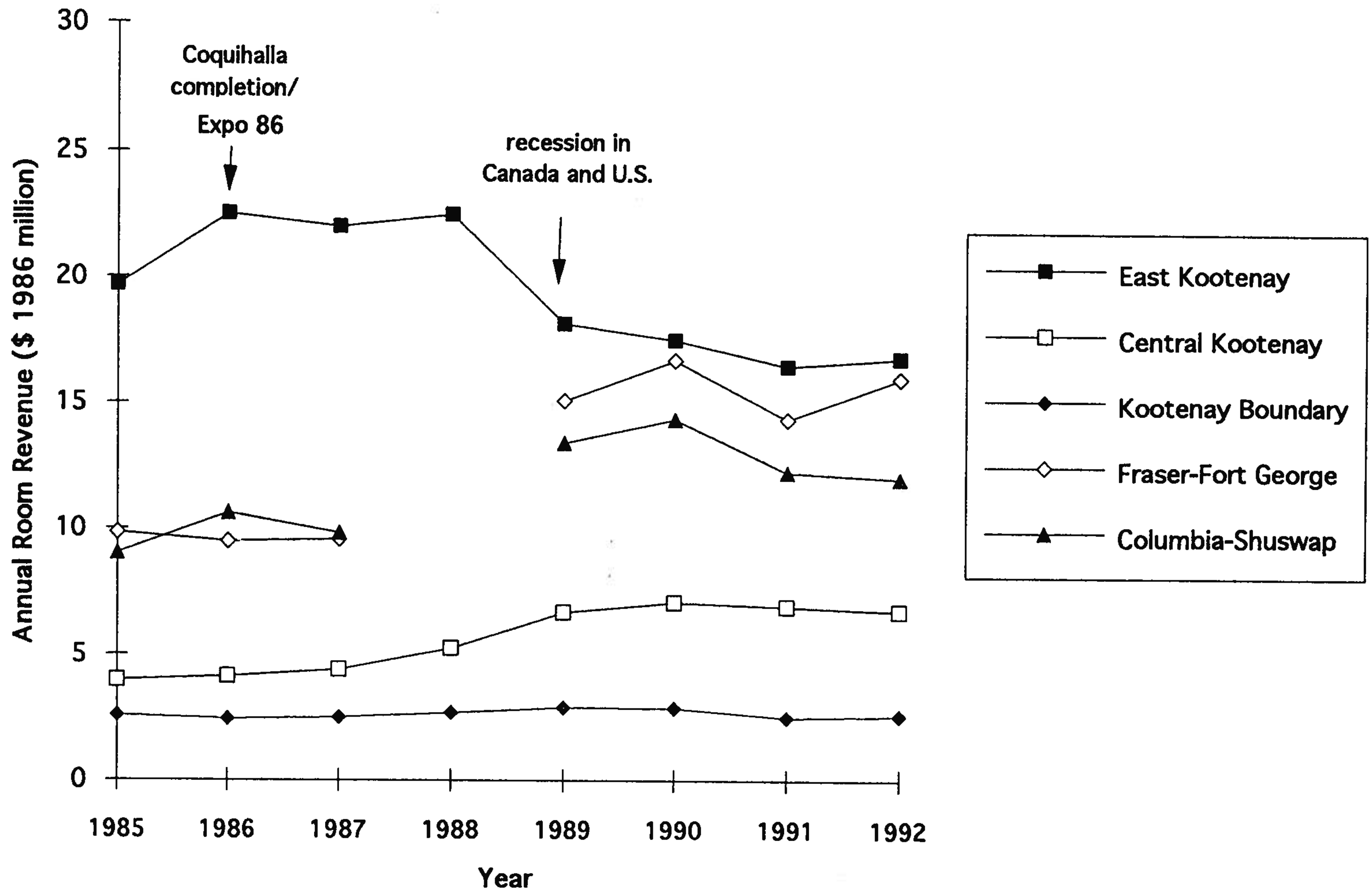
Visitor spending throughout the Kootenays is generally lower than in other parts of the province. Non-resident tourism expenditures are particularly low in the tourism area known as "Kootenay Country" (generally the Central Kootenay Regional District), representing a mere 1% of non-resident provincial tourism, as only 4% of all visitor parties to British Columbia stayed one or more nights in this area. Tourism expenditures in the Kootenay Country area are lower than the provincial average and less than in any other tourism area in the province. This is largely a result of the large number of tourists that visit with friends and relatives (42% of visitors to Kootenay Country in 1989), the focus on independent outdoor recreation activities, and the absence of other attractions such as shopping or nightlife entertainment (Campbell, Goodell and Associates 1990). In 1989, visitors to this area spent $29 per person per day, staying an average of 2.61 nights, compared to the provincial average of $55 per person per day and regional visits of 3.08 nights during a visit of 5.83 days within the province (Campbell, Goodell and Associates 1990, 5).

Although most communities in the Kootenays continue to rely on forestry and mining for local income and employment, many local residents would like to encourage tourism as a means of stimulating economic diversification. The large amount of interest in this form of development was noted by the authors of a 1990 study addressing tourism development opportunities in the region. The region's natural aesthetic features play an integral role in a resulting tourism strategy that relies strongly on the development of adventure travel, outdoor recreation, nature and wilderness experiences (DPA Group 1990, 13).

Figure 21 shows the annual expenditures on accomodation for the five regional districts that represent parts of the Columbia River Basin. Figure 21 represents actual room revenues (before tax) in constant ($1986) dollars, so that the effects of inflation are removed. The data are limited to the years following 1985, as this information was not gathered previously. Data for 1988 are not available in two cases.

Room revenue is a useful indicator for tourism, since the majority of expenses on accommodation are made by non-residents. Visitors to the Kootenays spend less on accommodation than the provincial average of approximately $15/day (only $6.17 out of the average $29/day on tourism in Kootenay Country; $11.29 out of the average $36/day on tourism in the B.C. portion of the Rocky Mountains), due to the wide use of campgrounds and visits with family and friends. Although accommodation expenses do not represent a large portion of visitor spending, these expenses are one of the largest components of tourism revenues, exceeding all other components in the Rocky Mountains, and matching restaurant revenues in Kootenay Country. In addition, room revenue trends may correspond to food expenditures since those who choose to pay more for indoor accomodation are likely to contribute more tourism dollars through spending on meals than campground users. Revenues from campgrounds could also be used as an indicator; however, recent data from relevant areas were not as readily available as the information obtained for room revenues.

Figure 21. Annual Room Revenue in the Kootenays



Source: compiled from British Columbia, Ministry of Government Services, Central Statistics Branch (1993)

Tourism trends are a result of a variety of factors, such as weather, access, economic conditions and special events. While it is difficult to interpret the cumulative impacts of all of these influences, there are some key considerations that can be used to explain the tourism trends shown.

According to Figure 21, room revenues in the East Kootenay generate the most income in the region, although its dominance over other regions is diminishing. East Kootenay tourism has declined since 1988, while tourism in all other regional districts has increased gradually between 1986 and 1989, and then stabilized or slightly declined, with the exception of Fraser-Fort George which increased in 1992. These trends generally correspond to provincial room revenues, which have slowed in growth since 1990 (British Columbia 1992). Although a portion of the Fraser Fort George Regional District is situated within the Columbia River basin, this area is ignored in the following analysis as it is likely that the majority of these revenues pertain to tourism near Prince George, which is outside of the study area.

Several important events occurred in 1986 which have had significant effects on tourism in the Kootenays. The completion of the Coquihalla in time for Expo '86 in Vancouver increased access to the northern portion of the Kootenays, and stimulated tourism throughout British Columbia as visitors travelled to and from Vancouver. Decreasing accommodation expenditures since 1989 may be a result of the diminishing effects of Expo, and recessionary economic conditions in Canada and the United States, combined with increasing tourism interest in other parts of the province.

In an effort to reduce dependency on the fluctuations of external markets for forest and mineral resources, communities in the Kootenays are interested in promoting tourism to diversify their economies. Some representatives of these municipalities are concerned about barriers to tourism imposed by the operation of large hydro dams.

The consideration of the consequences of hydro development on tourism requires an examination of its positive contributions in terms of the development of dam and reservoir tourist attractions, in contrast with its adverse impacts on the scenic nature of the local environment and access to water-based recreation. Dam sites in the Kootenays have been developed as tourist attractions through the establishment of visitor centres and dam tours. The enhancement of recreation areas and parks along reservoirs has improved recreational opportunities along some sections of the shoreline.

However, local mayors and economic development officers are concerned that low reservoir levels in recent years may reduce the aesthetic appeal of activities focused on the lakeshore. Hydro development has blocked waterways, limiting international and intraregional travel, and reducing boating opportunities in free-flowing water. Fluctuating reservoir levels have affected angling due to adverse effects on fish populations, and all types of boating opportunities have been impacted by the hazardous presence of stumps that were flooded but never cleared, and reduced accessibility when wharves are inadequate to reach low water levels.

The positive effects of hydro development on tourism in the Kootenays are difficult to discern from Figure 21. While dam tours have likely contributed to tourism in the vicinity of dam sites, without a survey of dam visitors it is impossible to deduce whether dam tours attract and prolong visits, or whether they merely replace other activities in the region. It is unlikely that dam visits are the principal purpose of regional tourism as this activity is not mentioned by respondents to regional tourism surveys (Campbell, Goodell and Associates 1990).

The establishment of a visitor centre at the Revelstoke Dam has attracted tourists travelling through the Kootenays. Since the opening of the Revelstoke visitor centre coincides with the completion of the Coquihalla and additional tourism resulting from Expo, it is not possible to establish the degree to which Revelstoke dam visitors contribute to regional tourism, especially as all three of these factors continue to influence tourism within the Columbia-Shuswap regional district (although the effects of Expo may be diminishing). However, the number of annual visitors (including a local component) to the Revelstoke visitor centre has varied from 47,379 in 1987 to 65,668 in 1992, suggesting that many travellers spend several more hours in the Revelstoke vicinity than they might have otherwise. Improved highway travel plays a role in facilitating these visits, and dam tours may draw tourists away from other tourist facilities.

B.C. Hydro has made financial contributions toward the enhancement of many parks and recreation areas throughout the Kootenays (Davidson 1992), and it is likely that these improvements have increased tourism in certain areas. However, it is difficult to evaluate the degree to which these enhancements have affected tourism as this requires extensive tabulation of park information and would require site inspections.

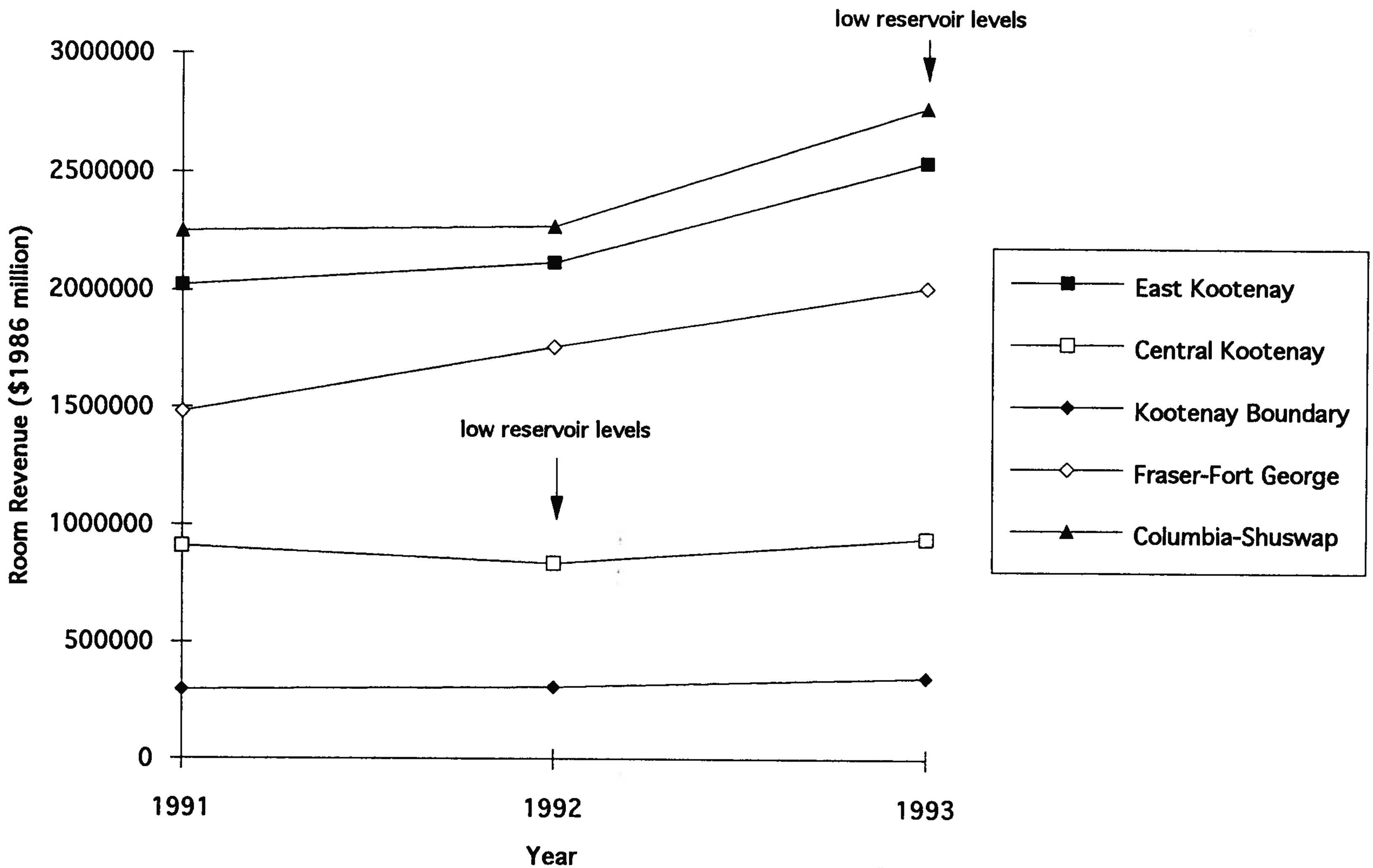
The principal adverse effects on tourism that have been attributed to hydro development are largely a result of fluctuating reservoir levels. Although sport fishing and hunting opportunities have been affected due to fish and wildlife habitat degradation as described in the discussion of previous indicators, this section will focus on the effects of low reservoir levels.

Tourism studies of the Central Kootenay area along the Arrow reservoir have recognized the detrimental consequences of large drawdowns with respect to tourism development. Recreation opportunities have been significantly reduced due to problems related to reduced boating access, and debris accumulation in the water and along the shoreline, which affects boating safety and aesthetic appeal (Marshall Macklin Monaghan 1982b, 24; DPA Group 1990, 2-2). Local mayors and tourism operators have expressed concern over these impacts on regional tourism (Johnson 1992).

To assess the effects of low reservoir levels on regional tourism, it is necessary to examine the room revenue expenditures for the areas affected during the specific months when low levels occur, although drawdown effects on fish may affect fishing-related tourism during other times of the year. Figure 22 shows monthly room expenditures for the five regional districts during the peak tourism season (July), when low reservoir levels during 1992 and 1993 (Figure 11) are perceived to have reduced tourism.

While room expenditures in all regional districts in the Kootenays decreased during June and August of 1992 compared to the previous year with the exception of Fraser-Fort George, accommodation use increased during July throughout the region with the exception of the Central Kootenay Regional District. Room revenue expenditures of approximately \$837,900 (\$1986) in July 1992, represent an 8% decline from the previous year's expenditures of \$908,700 (\$1986), while similar spending in other regional districts increased 1 - 5%, excluding the 19% increase in Fraser-Fort George. Provincial average growth from July 1991 was 2.9%, corresponding to an almost negligible change in the number of U.S. border crossings (0.2%) during July. The 8% decline in the Central Kootenay Regional District experienced during July

Figure 22. Room Revenue in the Kootenays During July, 1991 - 1993



Source: compiled from British Columbia, Ministry of Government Services, Central Statistics Branch (1993).

represents some degree of variation from the rest of the Kootenay area, and the province, and coincides with the occurrence of particularly low reservoir levels on the Arrow reservoir.

Changes in total room revenues are representative of fluctuations in numbers of visitors to an area, and an increase or decrease in room rates could affect the volume of tourists and overall room revenues. However, it is unlikely that room rates in the Kootenays would have changed substantially from one year or season to the next or that increases would dissuade visitors to any noticeable extent.

Other tourism statistics support the fact that increased numbers of visitors were travelling through the northern part of the Kootenays during July of 1992, yet do not explain the decline in the Central Kootenay area. Traffic patterns along the Coquihalla and the Trans Canada at Rogers Pass concur with room expenditures, decreasing during June and August 1992 compared with the previous year's volumes, and increasing during July 1992. The number of visitors to the Revelstoke visitor centre also shows decreases from the previous year during June and August, and an increase during July of 1992.

Attendance at the three national parks within the Kootenays (Glacier, Revelstoke and Kootenay), as well as at Jasper National Park near Valemount, showed little or no change from the previous year (-2 to 5%) from June until August, with the exception of a 12% decline at Kootenay National Park during August 1992. Daily mean temperatures recorded at the park and throughout the Central Kootenay Regional District were higher than historical averages (1961-1990) in June, and similar to past averages during July and August. Rain was generally lower than average at the park and throughout the Kootenays in June, followed by relatively average local precipitation in July, although rainfall in the park was 60 - 90% higher than average. August rainfall throughout the Central Kootenay Regional District was average.

British Columbia Parks officials believe that attendance at the various provincial parks along the Arrow Reservoir decreases when water levels are low since people visit these parks primarily to enjoy shoreline or water-based activities. Park employees have become aware of the impacts of low reservoir levels as a result of complaints from campers, reduced visitors and decreased revenues. Attendance at Syringa Provincial Park near Castlegar can be used as a barometer of local campground use due to its popularity during the summer. During 1992, the number of parties camping overnight at Syringa from mid-May until mid-September declined by 20.2% from 1991, and day use decreased by 14.1% during the same time. Although reservoir levels improved during the summer of 1993, overnight camping declined a further 6.1% from 1992 as a result of poor weather conditions, although day use increased by 8.3% (Price 1993).

The effects of reservoir drawdown on tourism in communities near the Arrow, Libby and Kinbasket reservoirs was evident during summer visits by the author in 1992 and 1993. The exposure of steep shorelines of coarse sediment partially covered with debris diminished the aesthetic appeal of these three water bodies. Athough the wharf at the Nakusp marina was extended by BC Hydro, many smaller wharves along the Arrow reservoir were unusable during August 1992. Debris and stumps remaining in the reservoir pose a hazard to boating safety, and are a continuing concern even during higher reservoir levels, as overheard by the author during an August 1993 observation of a lone water skier on the Arrow reservoir.

Statistics related to highway traffic, Revelstoke visitor centre records, national and provincial park attendance, and local weather all indicate favourable conditions for tourism in the Kootenays during the summer of 1992. However, the decrease in room revenues in Central Kootenay, as well as declines in attendance at Kootenay National Park and Syringa Provincial Park suggest that tourism in the Central Kootenay area may have been affected by dam operations on the Arrow reservoir. While some portion of these declines may represent normal variation, it is likely that tourism was affected by the occurrence of low reservoir levels, due to the significance of outdoor activities and water-based recreation to local tourism. Field observations and interviews with local mayors corroborate this proposition.

The impacts of low reservoir levels on the Koocanusa and its implications for East Kootenay tourism are more difficult to assess. Although large reservoir fluctuations are acknowledged as a hindrance to local recreational opportunities (Marshall Macklin Monaghan Limited 1982a, 15), the impacts of particularly low levels during the summer of 1993 are not evident from the increasing room revenues experienced in July of this year (Figure 22), although this does not remove the possibility that revenues might have been higher.

Analysis of the factors used to examine tourism in the Central Kootenay area is limited by the lack of similar statistics for the East Kootenays. Highway data are not collected to the same extent in the southeastern portion of the Kootenays and there are no nearby national parks to monitor visitor attendance.

However, low levels on the Koocanusa reservoir are believed to have affected tourism in the East Kootenays, especially during the summer of 1993. The effects of Koocanusa water level fluctuations on tourism has been outlined by participants at the Columbia-Kootenay Symposium, and by those attending the preceding community meetings, as well as by a local campground operator. Recreational opportunities have been degraded due to the exposure of muddy shorelines and the inability to use existing wharves during low water levels. Tourists who would normally use campgrounds along the shoreline are reducing the length of their visits or leaving the area altogether (Cutts 1993).

Low reservoir levels on the Kinbasket reservoir during the summers of 1992 and 1993 have likely affected local tourism development possibilities, rather than existing tourism or recreation facilities. There has been little recreational development on this water body due to lack of access and facilities, and remoteness (British Columbia 1974, 6-60), and problems related to reservoir level fluctuations since the completion of the Mica Dam in 1973.

Room revenues for July in the Columbia-Shuswap Regional District varied little from 1991 to 1992, but have since increased. The variables discussed previously with respect to the CKRD (highway statistics, weather, Revelstoke visitor centre attendance and national park records), apply similarly to the analysis of tourism in the vicinity of the Kinbasket reservoir, behind the Mica Dam. Although the lack of substantial change in revenue from July of the previous year corresponds to the provincial trend for this time period, local mayors and tour operators are concerned that drawdown is affecting tourism development opportunities.

Anglers, hunters and outfitters have experienced difficulties pursuing their recreational interests due to hydro development in the Kinbasket Reservoir area. Some areas that were previously reached by travel along logging roads, are now limited to boat access. Boating is constrained by wharf lengths during drawdown periods, and is hazardous due to the presence of stumps and debris (Baltakis 1992; Arlt, Gutzman and Sim 1992; Schuck 1992).

Conclusion

The examination of room revenues, and additional tourism-related statistics suggests that low reservoir levels have affected tourism in the Kootenays during the summers of 1992 and 1993. Tourism along the Arrow Reservoir has been particularly affected as it has already been established as a popular area to visit, and shoreline and water-based activities play a prominent role in local tourism. Ongoing problems related to reservoir drawdown on the Koocanusa and Kinbasket reservoirs may not have reduced existing tourism to the same extent, but may continue to inhibit the development of water-based activities.

Since many communities are interested in encouraging economic diversity through the development of tourism, the impacts of reservoir drawdown may be significant to future economic sustainability of the Kootenays. Although the severity of these impacts varies annually according to water levels established by climatological conditions at the source of the Columbia and Kootenay Rivers, as well as demands for water and electricity further downstream, communities desiring to promote tourism would benefit from their concerns being included in reservoir operation planning.

This analysis has examined many of the most common factors affecting tourism, and specifically room revenues along the Arrow, Koocanusa and Kinbasket reservoirs. Other conditions affecting tourism at particular communities along the reservoirs, such as local events, may also contribute to local variation.

4.62 Employment Stability - Unemployment Rates in the Kootenays

Unemployment rates are an indicator of economic stability in terms of employment at the community level, and may provide useful information as an early warning indicator of economic and related problems. As employment satisfies some basic human needs, the examination of the proportion of those unemployed in a specific area enables one to deduce to what extent a population is unable to meet its fundamental requirements or to what degree a group may be dependent on external assistance. Unemployment trends may be useful in reflecting the general economic stability of a community or region.

Unemployment is a major concern in the Kootenay region due to the cyclical occurrence of booms and busts associated with dependence on resource-based industries. Although the construction of hydro dams stimulates substantial short-term employment, residents of the Kootenays are dissatisfied with the small number of long-term jobs resulting from this use of local water and land resources. Columbia Basin hydro development does not alleviate ongoing employment problems in the Kootenay region. Some residents believe that resource use problems resulting from dam operations constrain opportunities for economic activity, and may actually influence unemployment rates (Table 6).

Unemployment rates are often used as a measure of socio-economic welfare. While the general familiarity with this indicator makes it conceptually easy to understand, its links with specific sectors of the economy, such as hydroelectricity, may not be as obvious. It is also worth noting that although unemployment rates provide a general idea of economic activity in an area, the use of this general statistic does not elucidate which groups of society are unemployed.

Discussion

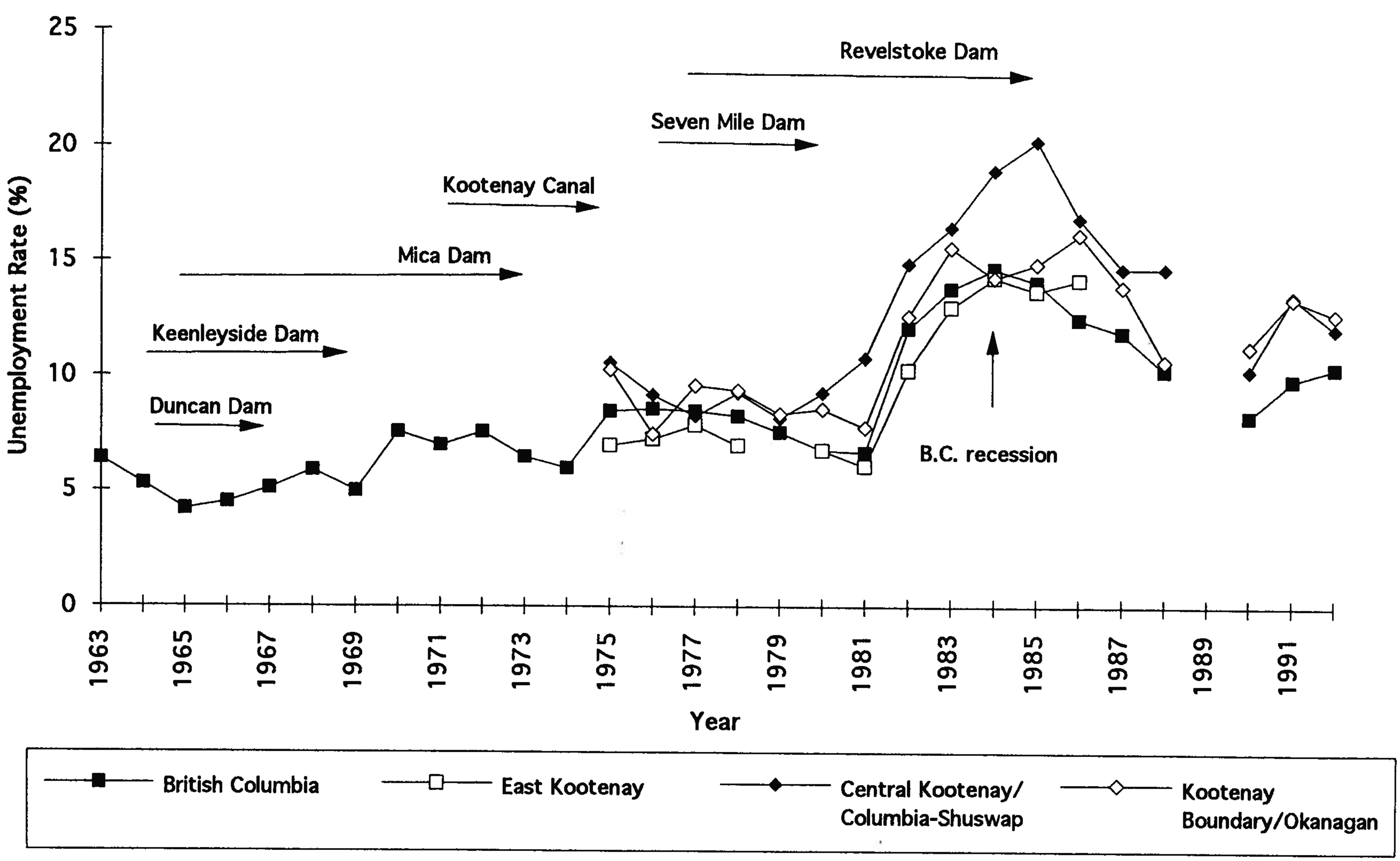
The discussion of unemployment rates shown in Figure 23 is limited by the availability of data on economic regions. Statistics Canada did not publish regional divisions of unemployment rates before 1975. However, the information portrayed in Figure 23 enables a reasonable examination of the effects on unemployment of the Mica, Kootenay Canal, Seven Mile and Revelstoke projects.

Figure 23 shows a slow increase in the average unemployment rate for British Columbia from the early 1960s onward, until the recession in the mid 80s caused a significant increase. The provincial unemployment rate has since declined, but appears to be rising again in the early 90s. Unemployment trends in British Columbia are similar to those for Canada since the 1960s; however, national increases peaked at approximately 12% in the early 80s, while British Columbia's rates rose to 14.7% in 1984 (Statistics Canada, 1992).

The Economic Council of Canada attributes British Columbia's unemployment trends to increasing structural unemployment and international commodity prices. Although British Columbia's structural unemployment increased throughout the 1960s and 70s, high commodity prices during the 70s kept unemployment low. In 1979, world commodity prices fell and provincial unemployment rates increased dramatically as the provincial economy relies heavily on forestry and mining industries. Recovery from this plunge was delayed by the rise in structural unemployment, previously hidden by favourable commodity prices (Gera 1991, 51).

Unemployment rates for the three economic regions in the Kootenays generally follow provincial

Figure 23. Unemployment Rates in British Columbia



Source: compiled: from Statistics Canada (1992). Labour Force Annual Averages; DPA Group (1986) p. 54; B.C. (1976) p. 206.

trends with some regional variation (Figure 23). Economic region 910 (East Kootenay Regional District) has lower rates, while region 920 (Central Kootenay and Columbia-Shuswap Regional Districts) has had higher unemployment, surpassing region 930 (Kootenay Boundary, Okanagan-Similkameen, Central Okanagan and North Okanagan Regional Districts) until the early 90s.

The East Kootenays have relied heavily on mining at Fernie and Kimberley, along with forestry and agriculture around Cranbrook. These industries have been affected by the rise in commodity prices, and have resulted in regional employment rates that parallel the provincial average while remaining slightly lower until 1986. Although the eastern section of the Kootenays has not hosted large dam construction activity, its unemployment may have been offset by forest clearing before flooding of the Kootenay River to create the Koocanusa reservoir behind the Libby Dam in Montana, in 1975. Recent unemployment rates are not available for this economic region as data are statistically insignificant.

The Central Kootenay and Columbia-Shuswap Regional Districts have experienced the worst unemployment within the Kootenays. Unemployment rates in this area were similar to the provincial average during the late 1970s, but increased dramatically through the early 80s reaching a high of 20.3 % in 1985. They have since declined, but remain higher than the provincial average. This area depends largely on forestry for employment, and has therefore been susceptible to labour reductions due to increased mechanization, diminishing supply, increased international competition (Barnes et al. 1992, 184) and high union wages (Gera 1991, 44).

The development of four large dams in this area from the 1970s until the 80s provided some short-term insulation from increasing unemployment rates. Many workers employed near Revelstoke on the Mica project (1973) were able to use similar skills on later Revelstoke dam construction (1985), reducing unemployment for this community. Although the number of unemployed employable applicants decreased significantly as a result of dam-related jobs at Revelstoke, non-resident workers also brought dependents requiring social assistance (DPA Group 1986, iv). Nelson and Castlegar labourers found employment on the Kootenay Canal project (1976), which was followed by the Seven Mile Dam (1980).

Unemployment increased substantially in the Central Kootenay and Columbia-Shuswap area, reaching a high of 20.3% in 1985. While the large hydroelectric development project at Revelstoke partially alleviated unemployment in the Revelstoke and Sicamous-Malakwa area, maintaining unemployment rates in the range of 9.9% (1981) to 11.3 % (1985), dam activity may have only delayed the inevitable problem of growing unemployment in this region (DPA 1986, 128). Some of the high unemployment in 1985 is a direct result of the completion of work on the Revelstoke dam and represents those who had not yet relocated, as well as the closure of the Goldstream mine in 1984. Railway jobs associated with CPR tunnelling and double-tracking at Rogers Pass offset some unemployment from 1984 until 1988. Unemployment rates have declined as workers previously employed on the Revelstoke project have resettled within or outside the region.

As economic region 930 encompasses the Okanagan area as well as Kootenay Boundary Regional District, it is difficult to discuss what portion of the unemployment in this economic region pertains to the Kootenays. Unemployment rates follow provincial patterns, but tend to be higher. The Cominco smelter at Trail has been responsible for the majority of employment in the Kootenay Boundary Regional District. The construction of the Seven Mile Dam on the Pend d'Oreille River alleviated some unemployment around Trail in the late 70s; however, unemployment in this area has risen in response to falling mineral prices and increased labour productivity as a result of modernization (British Columbia 1986).

B.C. Hydro continues to play a role in alleviating unemployment in the Kootenays, although fewer people are employed near the sites of energy production for ongoing dam operation than during construction activities. Of the 6,468 regular and temporary people employed by B.C. Hydro as of January 1994 (Prior 1994), 207 (3 %) were residents of the Kootenays (Ferraro 1994).

Conclusion

Large hydroelectric projects have provided considerable short-term employment for residents and migrant workers in the Kootenays. Dam-related jobs have reduced unemployment in communities near dam sites during dam construction, but have also contributed to high unemployment during the immediate post-project period. While buffering communities near project sites from external economic conditions, dam employment may just postpone eventual unemployment.

While large hydro development projects have alleviated unemployment in the Kootenays for short periods, they do not contribute substantially to long-term economic sustainability for local communities. Dams in the Kootenays largely provide employment for engineers and planners in Vancouver, where most of B.C. Hydro's central decision-making is done. Future hydro projects could be scheduled consecutively to provide continuous employment for a regional labour force, although economic forecasts and labour mobility would also need to be considered. Work activity should be planned to avoid the large flux of unemployed workers that has followed the completion of large dams.

4.63 Forestry Constraints - Accessibility to Timber Supply

The Kootenay region is strongly dependent on forestry for regional income. Logging operations, sawmills and pulp mills have provided employment for residents of the Kootenays since the construction of the Canadian Pacific Railroad when logging camps were first established in the region. The sale of forest products contributes a large share of regional income.

Hydroelectric development within the Columbia River basin has caused economic hardships for forestry operations. The series of large hydro projects built during the 1960s until the mid-80s has withdrawn timber from local supply areas, affected accessibility to timber supply and increased operating costs. Compensation has been limited to the replacement of logging roads (Szaraz 1981).

While forestry contributes to local economies throughout the region, its role is most important to Golden, and the Castlegar-Arrow Lakes area (Horne and Penner 1992). Forestry operations in the Golden Timber Supply Area (TSA) have been affected by hydro development more severely than any other timber supply areas within the Kootenays. The examination of accessibility to timber supply within the Golden Timber Supply Area is an indicator of the ongoing economic constraints that affect forestry in the Kootenays.

Discussion

The economies of many communities in the Kootenays depend largely on forestry. This is evident from studies on community economic dependence completed for the British Columbia Forest Resources Commission (Horne and Penner 1992), later revised for the BC Round Table (Horne and Robson 1993). Table 10 indicates the percentage of employment income derived from the various basic sectors of the British Columbia economy for areas in the Kootenays region, as calculated by Horne and Robson (1993). The data in Table 10 are based on the 1986 census and have been updated with 1990 estimates (Horne and Penner 1992, 3). Although these estimates may have changed somewhat since then, they represent general trends in the Kootenays.

The consideration of basic sector dependence provides useful information that clarifies the significance of resource use issues to those living in the Kootenays. Table 10 indicates that the Kootenays region is highly dependent on forestry, with some areas benefiting from mining and pension incomes. Forestry dependence varies from 4% in the Trail-Rossland area to 56% in the vicinity of Golden. Forestry provides a substantial portion of income to the Castlegar-Arrow Lakes area as well as McBride-Valemount (both 45%), and plays an important role in the economies of Nelson (28%), Invermere (26%), Cranbrook-Kimberley (20%) and Revelstoke (20%).

Economic constraints on forestry are particularly significant to the local economy of Golden due to its high level of dependence on this sector and its lack of economic diversity. According to the 1986 labour force census, forestry employed 410 (11.2%) of the total labour force of 3,655

Table 10. **Basic Sector Dependence**

% of Basic Sector	FOR	MIN	F&T	AG	TOU	H&E	OTH	UN	PEN	INV	TRA	SOC
EAST KOOTENAY												
Fernie Area	14	44	0	2	5	0	2	7	12	9	3	2
Cranbrook-Kimberley Area	20	2	0	2	4	3	10	8	23	17	3	6
Invermere Area	26	3	0	4	31	0	0	8	12	12	2	2
CENTRAL KOOTENAY												
Castlegar-Arrow Lakes Area	45	1	0	1	5	5	1	8	17	10	3	4
Creston Area	16	3	0	12	5	1	5	8	27	16	3	5
Nelson Area	28	3	0	2	8	2	4	8	23	15	3	4
Salmon Arm Area	24	1	0	5	2	0	10	7	26	17	3	5
Golden Area	56	2	0	1	8	0	3	8	8	9	2	3
Revelstoke Area	20	1	0	1	12	0	23	7	16	12	3	4
OKANAGAN - BOUNDARY												
Peachland Area	13	7	0	10	1	6	10	9	24	12	3	4
Kelowna Area	6	2	0	7	3	0	11	7	29	28	3	5
Grand Forks-Greenwood Area	35	3	0	4	6	3	6	5	20	12	2	4
Trail-Rossland Area	4	43	0	0	6	3	1	5	22	12	2	2
Vernon Area	17	1	0	4	6	0	14	8	25	19	3	3
Spallumcheen Area	23	1	0	13	1	0	9	7	20	13	3	10
Princeton Area	29	28	0	2	5	0	1	7	13	9	2	4
Oliver-Osoyoos Area	4	2	0	17	7	0	7	6	31	21	2	3
Penticton Area	7	2	0	5	7	1	9	7	33	22	2	4
LILLOOET - THOMPSON												
Squamish Area	32	2	0	2	16	0	11	9	10	12	3	3
Lillooet Area	36	1	0	2	11	0	12	8	14	8	3	4
Ashcroft Area	17	18	0	9	7	3	11	7	14	9	3	3
Merritt Area	36	8	0	8	3	0	8	7	12	9	3	6
Kamloops Area	12	10	0	4	2	1	18	9	20	15	3	5
North Thompson Area	54	1	0	6	4	0	8	6	9	6	2	3
CARIBOO - FORT GEORGE												
Smithers-Houston Area	44	8	0	3	10	0	5	7	7	10	3	3
Burns Lake Area	51	0	0	4	5	2	5	7	9	11	3	3
Vanderhoof Area	59	2	0	4	5	0	2	6	8	9	3	3
Williams Lake Area	45	4	0	5	7	0	2	8	10	10	3	5
Quesnel area	50	2	0	4	3	1	4	8	10	11	3	6
Prince George Area	47	2	0	2	5	0	11	8	7	10	3	5
McBride-Valemont Area	45	0	0	4	14	2	10	6	8	7	2	2

The abbreviations used for the economic sectors are as follows

- FOR Forestry
- MIN Mining
- F&T Fishing and Trapping
- AG Agriculture
- TOU Tourism
- H&E Health and Education
- OTH Other Basic Industries (including government and parts of manufacturing, transportation, construction, etc.)
- UN Unemployment Insurance
- PEN Pension
- INV Investment
- TRA Other Transfer Payments
- SOC Social Assistance Payments

Source: Horne and Robson (1993), p. 9

in this village (British Columbia 1989). While this number does not seem large in itself, harvesting operations are directly responsible for the employment of other workers in forestry-related occupations and contribute indirectly to the creation of jobs in the service sector. Due to the strong influence of forestry on Golden's economy, its economic diversity is relatively low compared to other communities in the communities and has been estimated as having a value of 47 on a scale with a maximum of 100 (Horne and Robson 1993, 13).

Forestry jobs are viewed favourably due to their relatively high weekly earnings and their ability to generate additional employment locally. Compared to other basic sectors in British Columbia, average weekly earnings for forestry-related manufacturing jobs ($741.32 before taxes) and forestry jobs ($724.25) are surpassed only by mining ($869.32) (Horne and Penner 1992, A-10). Of all industries operating provincially, forestry creates the largest number of additional jobs in non-basic sectors (Horne and Penner 1992, A-7). Each forestry job creates a total of 0.197 jobs in sectors such as transportation, wholesale trade, business services and construction. Mining is second in importance, creating 0.135 non-basic jobs for every mining job. Forestry manufacturing results in 0.092 additional non-basic jobs.

The creation of reservoirs associated with hydro development throughout the Columbia River basin has affected forestry operations by reducing access to forest resources in a number of ways. The type of problems encountered throughout the region are relatively similar and can be broadly grouped in three categories: loss of most accessible timber supply, reduced access to remaining forest resources, and increased reservoir operating costs. Hydro development impacts on forestry are clearly attributed to reservoir creation and have resulted in a permanent withdrawal from the forest resource base and perpetual additional logging costs (Szaraz 1981;

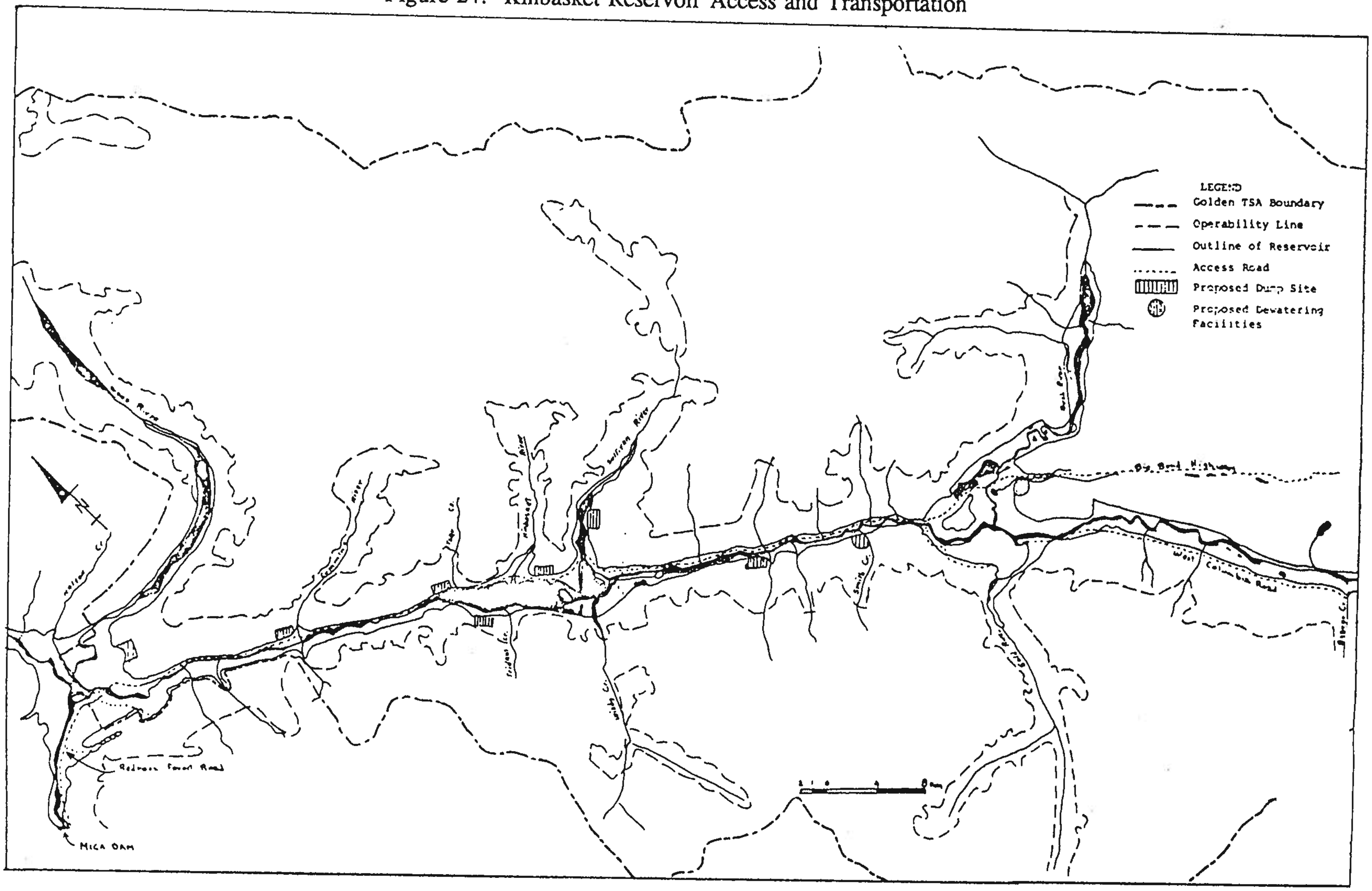
Triton 1990; Thibodeau 1991; Bennett 1993; Table 6). Since the discussion of accessibility requires an understanding of the spatial arrangement of logging areas, transport routes and physiographic characteristics of a reservoir and its surroundings, accessibility issues have been conveyed through the use of pre- and post-impoundment maps (Figures 24 and 25).

Although forest operators throughout the region have been affected by the same general resource use constraints as a result of hydro development, the consequences for some companies have been more severe than for others. The inundation of land behind the Mica Dam to create the Kinbasket Reservoir has caused particularly costly harvesting problems for operators along this reservoir. The flooding of between 25,765 ha (Thibodeau 1991, 2) and 35,000 ha (Coombs 1994) of land along the Rocky Mountain Trench represents the largest withdrawal of forest area of all the reservoirs within the Columbia River basin. Estimates of the area of the forest land flooded range from 16,219 ha (Szaraz 1981, 57) to 28,000 ha (70,000 acres) (British Columbia 1974, A4-25).

The Golden TSA consists of forests dominated by spruce, Douglas-fir and lodgepole pine. The total area of the Golden TSA is 921,321 ha, of which 592,279 ha (64.3%) is non-forest land due to the mountainous terrain, 302,056 ha (32.8%) is Crown forest land and 26,896 ha (2.9%) is non-Crown forest land. After reductions to productive Crown forest, the current timber harvesting land base is 174,599 ha (19% of total area) with a total volume of timber of 33,000,000 m^3, of which 27,500,000 m^3 is of merchantable age (British Columbia 1993,4). The current annual allowable cut (AAC) is 650,000 m^3.

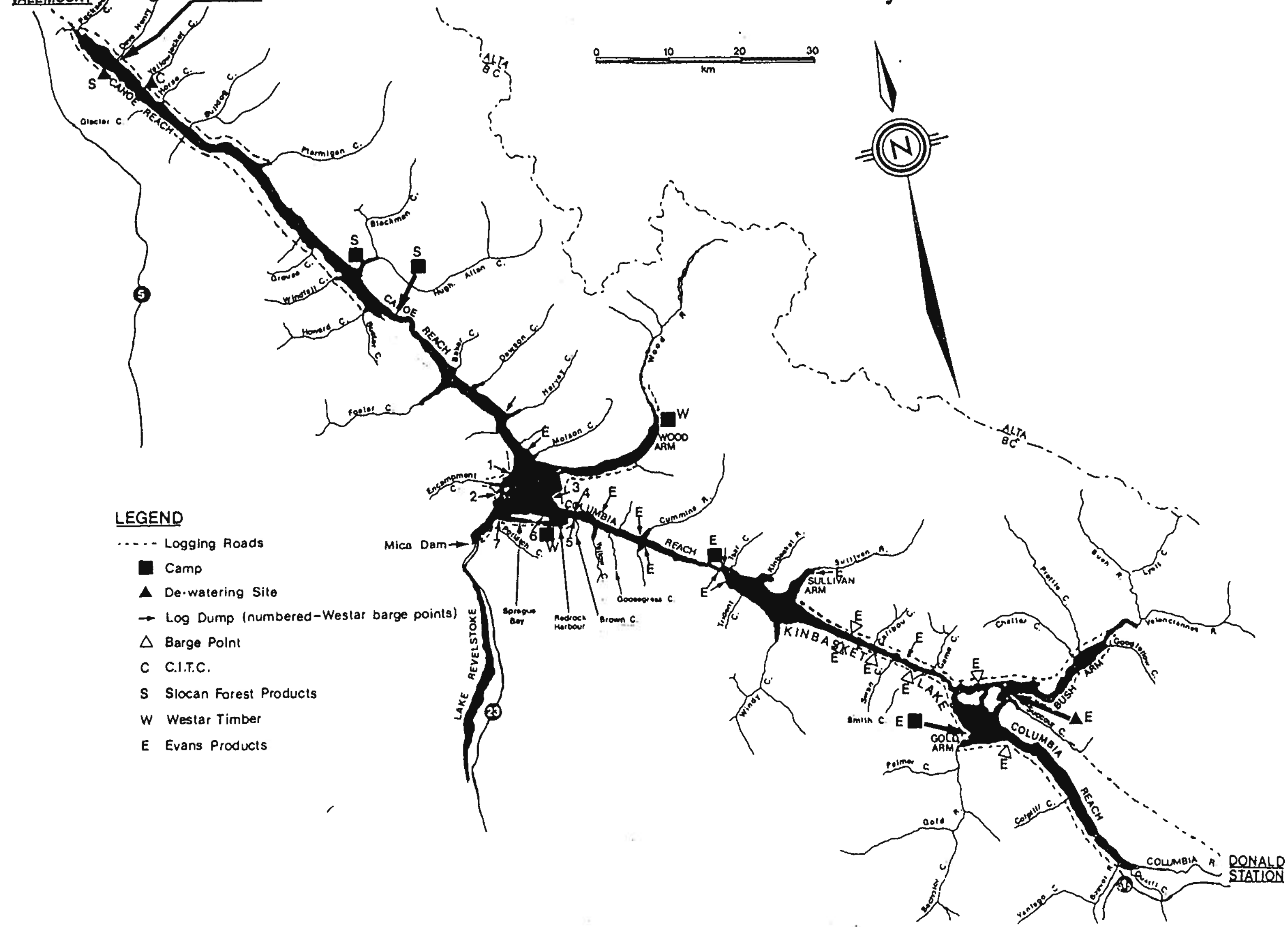
While smaller amounts of land are withdrawn annually for parks, transfers to private ownership,

Figure 24. Kinbasket Reservoir Access and Transportation



Source: Szaraz (1981), p. 94

Figure 25. Kinbasket Reservoir Forestry Activities



Source: Triton (1990), p. 101

and other purposes, the construction of the Mica Dam has resulted in the largest withdrawals of forest land from the Golden TSA. The inundation of forest land behind the Mica Dam caused a direct and permanent reduction of 11,491 ha of some of the most productive and most accessible forest land from the harvesting area of this TSA (Figure 24) as well as the subsequent transfer of 11,728 ha to the Revelstoke TSA (Thibodeau 1991).

At the time of the construction of the Mica Dam, Golden's main supply of timber was from the Golden TSA, formerly the Kinbasket Public Sustained Yield Unit (PSYU). The creation of the Kinbasket Reservoir resulted in a direct annual loss of 75,393 m^3, or 9% of the AAC at the time. This loss was caused due to the initial inundation of productive forest land, and because of a reallocation of forest land from the northern portion of the PSYU previously accessible to Golden operators by the Big Bend Highway and later transferred to Revelstoke in the late 1970s, after the flooding of this highway limited accessibility to Yellow-Potlack Creek. As Evans Forest Products is the major forest operator within the TSA, this company has incurred many of the impacts of hydro development, and is the focus of much of the following discussion. With a licence equivalent to 73% of the 1991 AAC, Evans' annual loss amounts to 54,750 m^3 (Thibodeau 1991).

The withdrawal of forest land from the Golden TSA represents a permanent loss of access to forest resources and a reduction in related jobs and local income. The value of the annual production loss from the Kinbasket PSYU (which covers the same general area as the Golden TSA) has been estimated as $689,080 (British Columbia 1974, Table 6.1). Temporary reductions to the forest resource base, such as losses resulting from fire (6,200 m^3/yr) or insects (12,800 m^3/yr) may regain productivity, while other reductions relating to the preservation of riparian areas (1,015 ha) or recreational trails are reversible. Aside from hydro-related withdrawal, the only other potential long-term loss from the resource base would be the area rendered unproductive from poor harvesting operations (1,200 ha) (British Columbia 1993b).

The creation of the Kinbasket Reservoir has caused further reductions to local timber supply as a result of wildlife enhancement initiatives and road building. The recognition of the importance of wildlife habitat losses from Kinbasket Reservoir flooding has led to efforts to enhance remaining habitat within the area. The preservation of marginal riparian habitat along side drainages has caused deferrals of 80,000 m^3 of harvesting proposals over the two years preceding 1991 (Thibodeau 1991, 3). The replacement of roads inundated by the reservoir has resulted in increased road density on the remaining land base and has also reduced the forest land available for harvesting (Thibodeau 1991, 3).

In addition to removing a portion of the resource base from local use, accessibility to the timber supply around Golden has decreased as a result of reservoir flooding. The creation of the Kinbasket Reservoir resulted in the inundation of the Big Bend Highway, the central transport route for forestry operations within the Golden TSA (Figure 24). This 117 km highway has been replaced with a total of 200 km of roads comprising the Bend-East side system to Sullivan River and the West Columbia Road to Wayne Creek. Although most of this network was financed by Forest Service funding or B.C. Hydro, Evans Forest Products extended the Sullivan River Forest Road from Boulder Creek to the top of Sullivan Arm at a capital investment of $1,076,000 amortized over 20 years (Thibodeau 1991, 11).

Reduced access to the local timber supply has increased forestry costs in a number of ways besides initial road construction (Figure 26). The replacement of the public Big Bend highway system with logging roads has resulted in increased road maintenance costs for Evans Forest Products. These costs amount to $1.37/m³ for the Sullivan-Bend section (shown as "East-Bend Maintenance" in Figure 26) and $2.40/m³ for the West Columbia Road (Thibodeau 1991, 11). The additional maintenance costs of the replacement roads along the Sullivan-Bend section cannot be recovered as would have been possible if the Big Bend Highway was still in place, as these logging roads do not connect to a public highway, and therefore cannot be credited against stumpage, unlike the West Columbia Road which connects to the TransCanada Highway.

Hauling costs have increased due to the reduced accessibility to the sawmill at Donald. Hauling wood from areas only accessible by water increases transport costs due to the multiple stages involved in this type of transport: loading and hauling to a dump, booming, towing and reloading, and hauling to Donald. Water transport hauling costs are $13.23/m³. In comparison, hauling costs along the east side of the reservoir are $11.63/m³ (shown as "East Side Road Cycle" in Figure 26) and include an extra cost of $3.45/m³ due to the additional 40 km of road required to travel around flooded drainages (Thibodeau 1991, 11).

The steep terrain bordering the reservoir poses difficulties and increased costs for harvesting as well as road construction (Ricard 1992). Since the most gradual forested slopes of the reservoir area are now inundated, remaining forest stands are less accessible as they are on steep terrain. Logging costs have increased due to the need to use cables in place of conventional harvesting practices. Logging costs are on average $1.14/m³ higher than they would have been without the withdrawal of forests that could have been harvested conventionally, as indicated in Figure 26 (Thibodeau 1991, 6).

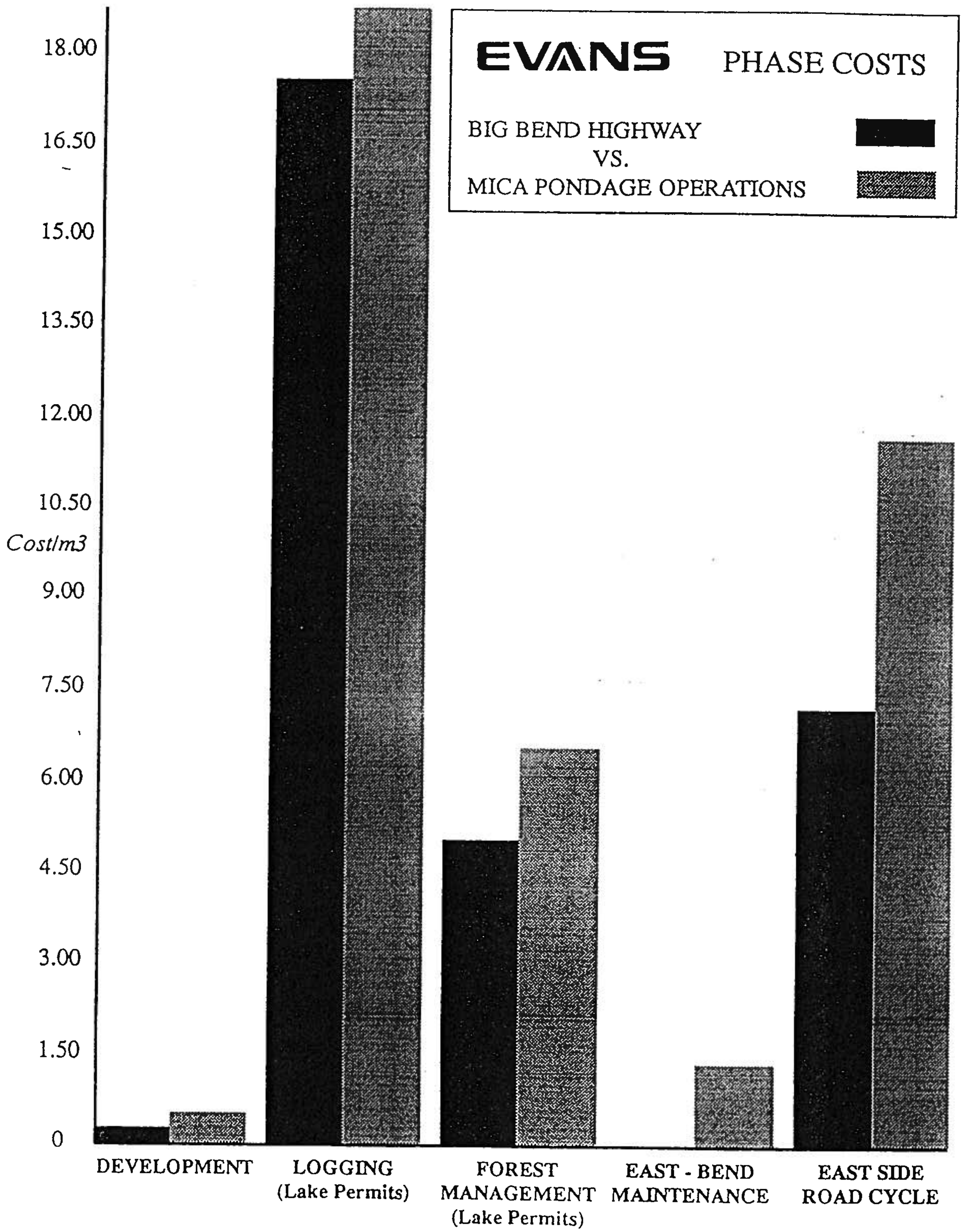


Figure 26. Evans Forest Products' Costs on Kinbasket Reservoir

Source: Thibodeau (1991)

Forest management and development costs are higher due to reduced accessibility and use of water transport. Tree planting bids for comparable sites are higher where water transport is required ($0.39/m^3 instead of $0.26/m^3). Related silviculture administration support costs result in additional costs of $1.50/m^3, depicted as "Forest Management" in Figure 26. Development costs including mapping, road layout, cruising and pre-harvest silviculture preparation account for $0.25/m^3 in addition to normal costs (Figure 26) (Thibodeau 1991, 10).

The use of the reservoir for log transport causes problems and additional costs for forestry operators. Fluctuating water levels limit forestry operations and have required the use and maintenance of boat ramps at varying levels along the abrupt slopes within the drawdown zone (Ricard 1992).

After the inundation of the Big Bend Highway logs previously hauled by trucks were transported by water. Water transport has reduced the logging season to an average of five months per year, generally mid-June or early July to mid-October, due to water level fluctuations and weather hazards during October and November. However, low water levels in 1989 delayed reservoir use until mid-July (Triton 1990, 104). Slocan Forest Products experienced similar delays in 1993 when low water levels delayed forestry operations by a month from mid-May to June and necessitated additional expenses of $30,000 for boat ramp extensions (Bennett 1993).

Water transport operations have required investment in additional infrastructure such as log dumps with ramps at various levels, dewatering and reloading facilities (Figure 25), as well as additional supervision and administrative costs. Evans estimates that approximately 12 log dumps each costing $15,000 will be required to fully develop forestry operations along the reservoir excluding the costs of boats and loaders (Thibodeau 1991, 4). In 1989, the additional costs of water transport (strapping, dumping, towing, dewatering and reloading) amounted to \$7.00 per metre (Thibodeau 1991, 5). Occasionally, even the use of boat ramps at low elevations does not alleviate water transport difficulties as protruding stumps prevent passage in some areas (Triton 1990, 104). Wave and ice action, as well as accumulation of debris requires ongoing ramp maintenance (Ricard 1992).

In his analysis of the impacts of hydro development on forestry in the Kootenay region, Szraz (1981, 185) concludes that changes to access and transportation patterns were more significant than the withdrawal of timber supply, even around the Kinbasket Reservoir (since the volume cut was always below the maximum net AAC). Szaraz notes that the economic impacts of forest land withdrawal are conveyed to local and provincial economies in terms of loss of forestry employment, value-added, regional income and government revenue operators; increased operating costs without adequate mitigation for changes to transportation and access patterns results in a greater sensitivity to market conditions.

While Szaraz's conclusions continue to be relevant to the preceding summary of economic constraints on forestry, the withdrawal of forest land may become more significant as current AACs are reduced, as predicted for the Golden TSA, in recognition that current harvesting rates cannot be maintained. The current harvesting rate of 650,000 m^3/yr will decline by 7% to 605,000 m^3/yr during the first decade, with further decreases of 10% each decade until the long-term harvest rate of 309,000 m^3/yr is achieved 80 years from now (British Columbia 1993b).

Conclusion

Hydroelectric development has reduced accessibility to timber supply within the Columbia River Basin. Operators along the Kinbasket Reservoir have experienced economic constraints as a result of the withdrawal of some of the most productive and accessible timber within the Golden TSA, reduced accessibility to the remaining timber supply, as well as increased costs resulting from accessibility difficulties caused by reservoir operations. Due to the high dependence on forestry, and the relatively high multiplier effect of forestry on related employment in the nonbasic sector, economic constraints on forestry could have serious consequences for Golden, and other communities in the region.

While lost forest resources are essentially a provincial loss due to their location on Crown land, they also represent lost income and taxes for local communities. Reduced access is also felt locally, but of little concern provincially. However, additional costs affiliated with reservoir operating fluctuations present an opportunity where costs could be defrayed when considered as a cost of generating electricity. Alternatively, electricity benefits could be foregone in favour of creating favourable reservoir conditions for forestry operations. Intensive silviculture may improve the timber supply available for the future, but may be limited by the physiographic constraints affecting productivity in the region.

4.7 Indicator Trends

The analysis of indicators in the preceding sections enables some general conclusions regarding trends related to hydro development and its relationship with sustainability. The following summary identifies the cumulative impacts of hydro development on ecological, social and economic systems operating within the Columbia River Basin. The overall implications for sustainability of the region are discussed.

4.71 Ecological Indicators

The ecological indicators used to examine sustainability show a general decrease in ecological productivity and ecological integrity. Kokanee populations, land capability to support wildlife and net primary productivity have declined, supporting the hypothesis that ecological productivity has decreased. While many of the ecological impacts of hydro development in the Columbia River basin may still not be understood or documented, it is relatively well established that the large-scale hydro projects operating in the region have disrupted fish and wildlife habitat and ecological processes that maintain the integrity of the ecosystems they inhabit.

Mitigation and compensation programs have made a contribution toward restoring some of the ecological integrity of the region, and have focused largely on fisheries habitat enhancement and restocking. The success of these initiatives is more easily evaluated for fisheries than for wildlife as there is little baseline information on wildlife prior to hydro development. The impacts on broad ecological processes such as nutrient cycling, energy fluxes and global warming may be difficult to determine and complex to address.

The regulation of the flows of the Columbia and Kootenay Rivers has replaced naturally varying ecosystems with aquatic and terrestrial systems managed for human purposes. Ecological integrity has declined and may reach a new equilibrium with lower productivity if left undisturbed. The enhancement of fish and wildlife may require continuous management by humans.

4.72 Social Indicators

The social indicators used in this study depict communities that have undergone many changes due to resource development booms and busts. While this trend may continue as a result of economic activity by other industrial sectors, it is unlikely that future hydro development will trigger such large impacts on communities in the Columbia River basin. Generally, hydro-related population changes have stabilized, certain recreational opportunities such as fishing have declined, and the previous limitations inhibiting local participation in decision-making have been improved opening up new possibilities for local management of resources. While these findings corroborate the hypothesis that hydro development has changed local resource use and created undesirable living conditions, this premise varies largely according to community and sectors within each community. Certain groups such as those on low incomes, fishers, and those without access to decision-making may have been particularly affected by specific changes resulting from the construction and operation of large dams.

Increased community participation in the planning of hydroelectric operations appears to be a critical element in addressing many of the social issues concerning residents of the Kootenays. Improved opportunities for local involvement arising from community and regional initiatives, as well as from B.C. Hydro should increase awareness of the impacts of dams on community services, recreation and access to information and decision-making. Community participation in resource management decisions may lead to more effective management enabling the identification of issues and goals relevant to community and not just provincial needs.

4.73 Economic Indicators

The economic indicators examined highlight some of the economic conditions in the Kootenays. Unemployment is rising as in the rest of British Columbia; however, unemployment rates have remained higher in the Kootenays. Large resource-based corporations such as B.C. Hydro, exploit resources from this region for the creation of jobs and economic activity in Vancouver, Victoria and the Pacific Northwest. Although communities are interested in economic diversification, tourism revenues from accomodation are decreasing in terms of real dollars. Economic development opportunities are constrained by the harsh physiographic conditions of the region.

Although it is difficult to attribute particular economic problems experienced in the Kootenays directly to hydro development based on the indicators used, it is fairly obvious that hydro projects have generated short-term employment increases and may have only postponed the eventual occurrence of economic difficulties in this region. The majority of long-term economic benefits in terms of jobs and electricity are received by residents of Vancouver, Victoria and the Pacific Northwest.

The hypothesis that hydro development has diminished the regional resource base, and restricted economic development through reduced land availability and increased development costs has been partially confirmed through the consideration of impacts on forestry, tourism and to some extent unemployment. However, a more complete verification of this premise would require detailed examination of the constraints and opportunities that influence sectors such as mining, agriculture, recreation and other types of economic development.

Extrapolation of the information conveyed through the examination of ecological and social indicators provides additional substantiation of concerns regarding resource-based economic development. Any type of economic development relying on fish or wildlife (e.g., guiding, tourism, recreation) may be restricted by the diminished size of these resources. Productive forest land has been withdrawn from forestry operations resulting in a loss of timber harvesting (although evolving forest practices may have restricted some of this harvesting anyway for the protection of fish and wildlife habitat) and decreased accessibility to remaining stands. Maintenance of municipal infrastructure, expanded as a result of population increases during dam construction, may cause ongoing costs for communities affected.

Generally, dams have caused some adverse conditions for economic development. While they may not be overwhelming, they are significant for resource-based communities with a restricted range of natural assets.

5. CONCLUSIONS

This thesis has examined how issues related to sustainability have been addressed with respect to hydroelectric development in the Columbia River basin. Since the damming of rivers is increasingly viewed as a desirable method of generating electricity in comparison with other electricity sources, this study has explored how hydro projects have affected the ability of surrounding areas to satisfy or enhance their quality of life through a balance of ecological, social and economic systems. The use of a case study focused discussion on the circumstances particular to the Columbia River system, and provided issues which were examined through the development of indicators of sustainability. Many of the problems addressed are representative of similar situations encountered in other regions affected by hydro development, and serve as a means of identifying resource management issues specific to this type of energy production and land use change.

The definition of sustainability used in this thesis was developed through a survey of literature on this concept, and proved useful in providing a framework for examining the impacts of dams on ecological, social and economic factors within nearby communities. While previously it has been assumed that hydroelectric projects provide a means of regulating water (with little concern for its role in maintaining critical ecological processes) for economic purposes with the belief that benefits will improve social living conditions, decades of experience with dams on the Columbia and Kootenay Rivers shows that the relationships among ecological, social and economic systems are not easily controlled. The interactions between the various elements of these networks must be delicately balanced if the integrity of each is to be maintained.

The results of the case study are consistent with the findings of the literature review on sustainability issues relevant to hydro development, although few studies have specifically addressed the linkages among ecological, social and economic impacts with the exception of research on common property resources. The impacts of Columbia River dams on ecological, social and economic systems are typical of large hydro projects across Canada. The establishment of a regional organization to ensure that the concerns of local communities are addressed in hydro project planning is relatively unique among non-aboriginal communities but parallels some of the initial efforts of First Nations affected by dam complexes around James Bay.

One of the major conclusions reached in the investigation of the impacts of hydro development on sustainability in the Kootenays is that large dam projects cause significant changes to land and resource use. The inundation of productive valley bottoms disrupts previous resource use and creates conflict over the remaining land available. The resulting changes in landscape, quality and quantity of resources, access to resources, resource use costs and ongoing operating conditions jeopardize the ability of the region to satisfy or improve the quality of life for those who live there.

The ecological sustainability of the Kootenay region has been degraded through the disruption of natural processes. The productivity of fish, wildlife and forests has decreased and the implications for long-term ecological processes are uncertain. Although fish, wildlife and forest losses were predicted during project planning, little effort was made to prevent or compensate for these losses effectively. The decreased ability of the region to support certain species may have long-term implications for ecological relationships within the area. The consequences of this ecological damage is a smaller and less valuable resource base for communities that rely on their terrestrial and aquatic surroundings to sustain their basic needs.

The ecological impacts of hydro development have affected the social sustainability of the Kootenays. Changes in resource use conditions and access have reduced the quality of life for those living in the vicinity of dam projects. Since people in the Kootenays identify strongly with their physical environment, they have likely all been affected by recreation use constraints and their restricted access to resource use decisions. This has imparted a sense of frustration and disempowerment to those living with the repercussions of dam projects.

The analysis of opportunities for public participation in decision-making as an indicator shows that recent initiatives to include local people in hydro project planning are an example of larger social processes that may sustain communities and enhance quality of life. Ironically, while hydro projects may have jeopardized the functioning of social systems within communities (after the initial boom-bust cycle), the necessity to address ongoing problems may have reinforced social sustainability in the long run. Regional links have been strengthened socially and politically and may result in the creation and reinforcement of more effective structures for decision making in the future.

Ecological problems affecting the resource base have also influenced the economic sustainability of the Columbia River basin. The withdrawal of land from the limited supply of productive and accessible resources available within this mountainous region has reduced the opportunities for economic development such as forestry, farming, outfitting and lakeshore recreation and tourism development. The flooding of fish habitat, incomplete clearing of timber, and ongoing water level fluctuations prevent fish, wildlife and people from taking advantage of water resources and reduce possibilities for fishing, hunting, logging, recreation and tourism development. These activities have been highly valued in the past and those that continue to use reservoirs for these purposes must incur additional costs. Dam construction has provided short-term employment for local workers, but has generated long-term resource use constraints.

When the balance of ecological, social and economic sustainability is reviewed, it is clear that hydro development has proceeded under the premise that societal welfare will improve specifically through an emphasis on economic development. This economic development has been for the benefit of society, or in this case the province of British Columbia, and not the long-term sustainability of the local communities affected. Ecological systems have been largely ignored in previous hydro planning. Although there is a much greater interest in ecological impacts presently, many of the long-term effects on ecosystems remain uncertain. While it has been assumed that the presumed economic benefits of project construction would spill over into social welfare improvements, hydro development has disturbed the activities of certain social groups and has affected their ability to control resource use decisions critical to overall sustainability.

Hydro development has disrupted the sustainability of communities within the Columbia River basin. While some of the changes that have occurred may be addressed through specific policy initiatives, others are irreversible unless dams are removed. Mitigation and compensation programs have been introduced to address the past neglect of ecological systems; however, there may be natural limits to the extent of enhancement possible. Opportunities to remedy social sustainability are promising and are largely dependent on communities having a voice in decision-making. Economic development initiatives will require creativity and new approaches that consider the resource base, its opportunities and its limitations. Environmentally-friendly development could be encouraged and could focus on resource management strategies that enhance ecological productivity.

The consideration of sustainability clearly raises questions of distributional equity. The case study of the hydroelectric development Columbia River Basin shows that the large-scale regulation of river systems benefits those who consume the electricity transmitted hundreds of kilometres away while leaving local communities unable to manage the impacts of this exploitation of resources. This conclusion is supported by the experience of communities in the vicinity of large dam projects in Canada and throughout the world. However, the unique chronology of hydro development in the Kootenays, the international treaty that regulates water flow within the larger Columbia River drainage basin, and the recent community initiatives to establish more control over local resource use decisions provide specific opportunities to address past concerns of distributional equity.

Although communities within the Columbia River Basin benefit from additional flood control resulting from the provisions of the Columbia River Treaty, they are dissatisfied with the extent that power generation has superceded all other uses of the Columbia River system. The regulation of the Columbia and Kootenay Rivers by provincial and American utilities has resulted in the degradation of certain common property resources by "external" parties whose development goals have not integrated the concerns of those living in the vicinity of hydroelectric projects. The ecological, social and economic impacts of this deterioration of the resource base jeopardize regional sustainability.

The development of a set of indicators of sustainability was a useful method of testing the significance of hydro-related issues with respect to their ability to affect societal goals for the enhancement of quality of life, as well as the validity of some of the perceptions of local communities. Indicators provided a means of focusing on key issues or problems, establishing links between hydro development and specific impacts, and discussing the extent of particular consequences and their relevance to local communities. Indicators served as a way of telling a story about the events surrounding the current state of ecological, social and economic systems. Qualitative indicators were useful in representing conceptual issues when quantitative information alone was unable to convey meaningful information.

Indicators were chosen primarily for their importance to issues of concern to local communities in an effort to clarify some of the confusion surrounding the wide range of impacts resulting from a century of hydro development and three decades of large-scale dam operations within the region. The ongoing monitoring of the indicators identified in this thesis or others deemed to be appropriate for the Columbia River basin may assist in the identification of problems and the evaluation of compensation and mitigation measures related to hydro development. Indicators do not provide solutions in themselves, but stimulate the discussion of issues and may serve to identify concerns that have not been adequately addressed previously.

The selection of indicators may have influenced the conclusions reached in this study. While the use of different indicators for ecological systems could have highlighted conditions specific to other species or processes, it is likely that similar implications for sustainability would have been reached. Other social indicators may have revealed issues of concern to specific groups or communities; however, the monitoring of public participation and community involvement in resource decision-making provided critical information that could affect the outcome of regional sustainability, and if ignored would result in different conclusions. The selection of economic indicators gave an overview of economic conditions in the Kootenays but could be strengthened through additional indicators on land use and specific hydro-related costs and benefits incurred by key economic sectors. Many of the economic issues pertaining to specific resource use groups were identified in interviews with residents and provide information in addition to the indicators used showing that sustainability may have been jeopardized by the constraints imposed on certain economic development opportunities.

The examination of sustainability and hydro development in the Columbia River basin provides a basis upon which to make recommendations for future resource management decisions and hydroelectric project planning. The regulation of water resources causes long-term changes in resource and land use. Ongoing and future hydro projects should recognize the magnitude of these changes through the consideration of impacts on ecological, social and economic systems. The winners and losers of hydroelectric development should be clearly identified so that the broader benefits received by society can be distributed to those who bear the majority of costs. The participation of communities in local resource use decisions should assist in the provision of information relevant to hydroelectric operations, and may prevent further degradation of the resource base.

With specific reference to the Columbia River basin, the continuous disruption of the ecological relationships between natural aquatic and terrestrial ecosystems will likely necessitate perpetual management of fish, wildlife and forests to provide levels of productivity that can sustain those who have depended on these and resources with related trophic relationships. The degree of management required may be greater than that applied to mitigate other land use changes such as clearcuts, since hydroelectric projects require continuous regulation of water flows, while the modification of forest and adjacent water ecosystems arising from clearcuts occurs largely from a one-time harvesting effort and aside from periodical silviculture interventions, natural processes are left to reestablish similar or desirable forest types until the next rotation period (e.g., eighty or a hundred years) unless irreparable damage is caused by poor forestry practices.

Resource use conflicts arising from hydro development may be addressed through the inclusion of user groups in water management decisions. Community-led initiatives as well as B.C. Hydro efforts have begun to integrate local, regional and provincial concerns into hydro-related resource use decisions and community development plans. While shared decision-making may require lengthy processes involving many players, the ongoing nature of dam operations in the region will necessitate continual communication between resource users and may assist in the development of working arrangements for other resource management problems in the Kootenays. The concerns of First Nations (although not explicitly incorporated into indicators) should be addressed as they have been excluded from the resource base decisions that have affected them for over a hundred years, since British Columbia joined Canada.

Recent initiatives by communities and B.C. Hydro to collaborate on hydro-related resource use decisions may represent the initial stages of co-management, a more cooperative effort to blend community needs with those of the Province, and possibly the Pacific Northwest. Joint mechanisms may facilitate regional sustainability by improving communication links and management programs so that they accommodate the needs of local as well as provincial development. The recognition of community development goals through joint management arrangements, as well as the identification of barriers to fulfilling quality of life improvements, could enhance opportunities for community economic development enabling local individuals and organizations to initiate ideas based on community strengths without reliance on the private sector or the state.

Analysis of the ongoing and interrelated problems related to hydro projects in the Columbia River basin suggests that existing institutional arrangements may be inadequate to address sustainability issues. The long-term and interjurisdictional nature of dam impacts and their relationships with ecological, social and economic systems requires a broad range of knowledge beyond the scope of any one agency. The ability to effectively manage the various dam-related problems experienced in the Kootenays requires the involvement of utilities, municipalities, First Nations, government departments, industries, and interest groups, as well as international cooperation from utilities and other stakeholders in the United States.

The establishment of a river basin management board might ensure that the wide range of issues related to sustainability among different user groups in the Columbia River basin is addressed on an ongoing and cooperative basis. A multi-stakeholder advisory board consisting of representation from the previous groups mentioned could integrate plans for activities within the river basin to avoid conflicts and enhance development (social and cultural as well as economic) opportunities. While such an organization might create an additional level of bureaucracy and would require multiple sources of financing, it may be the only effective means to ensure that community, regional and provincial issues are addressed. A Columbia River Basin Management Board could focus its agenda on hydroelectric issues initially and expand its mandate to include broader resource management concerns when necessary.

Economic development within the Columbia River basin will require creative ideas to ensure the sustainability of communities in the area. Ecological constraints should be considered in any resource-based development initiatives since various parts of the resource base are already degraded. Forestry operations should attempt to enhance wildlife habitat and prevent further fish habitat degradation. Tourism development should not jeopardize the integrity of the main attractions of the area such as fish, wildlife, forests and waterways. Since economic development will continue to be constrained by the impacts of dam developments, there should be some mechanism that will ensure that the region producing half of the provincial electricity supply receives a greater share of resulting benefits.

Current provincial negotiations on the return of downstream benefits pertaining to the second stage of the Columbia River Treaty should consider the distribution of some portion of the power or financial benefits received by the Province to the Kootenay region. This transfer of benefits would assist communities and government departments that are currently unable to address ongoing hydro-related problems or are spending higher proportions of their budgets on these issues at the expense of other community concerns. Additional financing of mitigation and compensation efforts would create opportunities for local employment and may provide ecological knowledge and sustainable development leading to overall improvements in the quality of life of those living in the Kootenays.

The information collected and analyzed during this study suggests that the sustainability of communities affected by hydro development in the Columbia River basin has not been considered adequately in project planning. The lack of concern or valuation of dam impacts on environmental resources has resulted in ecological degradation, as well as unpredicted mitigation and resource use costs. The majority of long-term benefits of large dam construction have been received by electric power consumers in urban centres in British Columbia and the Pacific Northwest, while the residents of the Kootenays have incurred costs in terms of a reduced quality of life resulting from hydro-related changes to their ecological, social and economic systems. Although past hydroelectric planning has not accommodated the sustainability of surrounding areas, there may be opportunities to change this trend and enable this form of development to occur if local information and development goals are integrated into project decision-making.

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APPENDIX 1 - INTERVIEWS

The following is a summary of substantive interviews conducted during thesis research. Numerous other people provided various other details in response to brief information requests.

Interviewee	Affiliation	Date	Location
B.C. Hydro			
Lorne Marsh	Director of Environment	92/03/24	Vancouver
F.G. Hathorn	Manager of Environmental Resources	92/04/14	Vancouver
Al Geissler	Manager, Columbia-Kootenay Program	92/08/23	Vernon
" "		94/02/01	(telephone)
Rick Larson	Manager for West Kootenay Production Area	92/08/28	Kootenay Canal
Dennis Duncan	Operations Supervisor, Revelstoke Production Area	92/10/26	Revelstoke Dam
Jane Newlands	Public Affairs Coordinator Trainee	93/01/28	Vancouver
Lach Russel	Manager of Columbia River Program	93/01/28	Vancouver
Glen Singleton	Acting Manager, Environmental Resources	93/05/25	Vancouver
Tim Newton	Senior Planning Consultant (Vancouver)	93/06/14	(telephone)
Orville Wright	Property Tax Manager (Vancouver)	93/09/16	(telephone)
Bob Bradley	Senior Biologist (Vancouver)	93/10/12	(telephone)
Dave Wilson	Environmental Biologist (Vancouver)	93/10/25	Vancouver
Gary Birch	Senior Coordinator for Columbia Projects and Compensation (Vancouver)	94/01/31	(telephone)
Colin Guernsey	Manager, Social Resources	94/02/09	(telephone)
British Columbia Government Officials			
Walter Cibulka	Conservation Officer, Ministry of Environment, Lands and Parks	92/10/27	Golden
Dave Clapperton	Resource Officer, Silviculture, Ministry of Forests	92/10/28	Golden
Eric Parkinson	Head of Lakes Unit, Fisheries Research, Ministry of Environment, Lands and Parks	93/03/26 93/11/02	Vancouver Vancouver
Guy Woods	Regional Wildlife Biologist, Ministry of Environment, Lands and Parks (Nelson)	93/07/05	(telephone)
Martin Monkman	Acting Economist, Central Statistics Branch, Ministry of Government Services	93/11/16	(telephone)

Community Representatives

Evo Depretto	Mayor of Silverton	92/08/24	Silverton
Rosemarie Johnson	Mayor of Nakusp	92/08/24	Nakusp
Karen Hamling	Village Councillor for Nakusp	92/08/24	Nakusp
Donald Scarlett	Kootenay-Okanagan Electric Consumers Association	92/08/24	Kaslo
Gordon Brookfield	Alderman for New Denver	92/08/25	New Denver
Bernard Czelenski	Mayor of Slocan	92/08/25	Slocan
Richard Burton	small hydro operator	92/08/25	New Denver
Don Harasym	Regional District of Central Kootenay	92/08/26	Nelson
William Ramsden	Mayor of Nelson	92/08/26	Nelson
Josh Smienk	Chairman of Columbia River Treaty Committee	92/08/26	Nelson
" "		93/03/07	(telephone)
" "		93/08/05	(telephone)
" "		94/03/06	(telephone)
Audrey Moore	Mayor of Castlegar	92/08/26	Castlegar
Phil Berukoff	Alderman for Salmo	92/08/27	Salmo
Fred Demmon	Mayor of Golden	92/09/23	Vernon
" "		92/10/27	Golden
Stan Lim	Councillor for Golden	92/09/23	Vernon
Geoff Battersby	Mayor of Revelstoke	92/09/23	Vernon
" "		92/10/26	Revelstoke
Mark McKee	Councillor for Revelstoke	92/09/23	Vernon
" "		92/10/26	Revelstoke
Maureen Conn	Teacher	92/10/26	Revelstoke
John Baltakis	Fishing camp owner	92/10/27	Golden
Paul Ricard	Logging Superintendent, Evans Forest Products	92/10/28	Golden
Rod Drown	Columbia-Shuswap Regional District	92/10/28	Golden
Grant Arlt, Carl Gutzman, Tom Sim	Golden District Rod and Gun Club	92/10/27	Golden
Brian Schuck	Outfitting operator	92/10/28	Golden
Mike Patterson	Mayor of Cranbrook	92/11/24	Cranbrook
James Ogilvie	Mayor of Kimberley	92/11/23	Kimberley
Larry Haber	Director, Economic Development, City of Kimberley	92/11/23	Kimberley
Garry Jenkins	Councillor for Rossland	92/11/25	Rossland
Jack McDonald	resident of Rossland	92/11/25	Rossland

Victor Kumar	City Treasurer, Trail	92/11/25	Trail
Dieter Bogs	Councillor for Trail	92/11/25	Trail
Richard Dean	resident of Rossland	92/11/25	Rossland
<u>First Nations</u>			
Lexine Phillips, Thomas Munsen, Garry Merkel, Allan Hunter	Ktunaxa/Kinbasket Tribal Council, Department of Land and Resources	92/11/24	St. Mary's Reserve
<u>Others</u>			
Al Mallette	EnvironRec Research (Vancouver)	92/11/03	(telephone)
Greg Mallette	EnvironRec Research	93/09/07	Vancouver
Jim Wilson	former Vice Chairman and regional development planner, B.C. Hydro	93/04/15	Vancouver

APPENDIX 2 - INDICATOR EVALUATION

Problem: ecological productivity has been disturbed

Hypothesis: hydro development has reduced ecological productivity

Issue: dams have blocked fish migration and nutrient flow, flooded wetlands, and have created an unseasonal flow regime with fluctuating water levels that disrupt fish productivity

Indicator: kokanee fish populations in Kootenay Lake

Evaluation Criteria:

a) public concern
fish losses are significant to local residents (Table 6, Smienk 1992, Moore 1992, Johnson 1992)

b) technical validity
the impacts of dams on Kootenay Lake fish is well-established (Daley et al. 1981; Mallette 1991; Hirst 1991; British Columbia and Environment Canada 1993, 81)

c) sensitivity to change
dams directly affect fish populations through prevention of migration, nutrient blockage, water level changes, and variable aquatic conditions; however, some variation may result from natural population cycles

d) monitoring ability
fisheries management funding may need to be increased to conduct ongoing monitoring and related research

e) usefulness to policy-makers
provides a focus for compensation, mitigation, management strategies, downstream benefits

f) conceptual understanding
implications for fish are easily understood; linkages with human and economic systems understood locally, not as significant to external decision-makers

Other Factors Influencing the Indicator:

- introduction of mysis relicta, an organism that competes for the same zooplankton as kokanee (British Columbia and Environment Canada 1993, 81);
- phosphorus loading from leaking fertilizer plant (reduced levels after pollution control in 1975) and phosphorus addition programs (recently) (British Columbia and Environment Canada 1993, 81);
- changing degrees of fishing effort (Narver 1984).
- fisheries management decisions (e.g. operation of spawning channels, enhancement of predators such as Gerrard trout, fisheries regulation of catch)

INDICATOR EVALUATION

Problem: ecological productivity has been disturbed

Hypothesis: hydro development has reduced ecological productivity

Issue: reservoir flooding has reduced wildlife habitat, affecting wildlife populations in the basin

Indicator: land capability for ungulates in Kinbasket Reservoir region

Evaluation Criteria:

a) public concern
wildlife losses are significant to local residents (Table 6, Demmon 1992, Battersby 1992, Arlt et al. 1992)

b) technical validity
the East Kootenay mountain ranges and the Rocky Mountain Trench provide ideal habitat for many ungulates (Pearse and Bowden 1966; Environment and Land Use Committee 1978);
loss of riparian habitat has caused a severe impact on wildlife populations around the Mica reservoir (British Columbia 1974, 1-11)

c) sensitivity to change
reservoir flooding has removed most of the best wildlife habitat along valley systems of the reservoir

d) monitoring ability
wildlife management funding may need to be increased to conduct ongoing monitoring and related research

e) usefulness to policy-makers
provides a focus for compensation, mitigation, management strategies, downstream benefits

f) conceptual understanding
implications for wildlife residency within this area are easily understood, however, wildlife may migrate elsewhere; linkages with human and economic systems understood locally, not as significant to external decision-makers

Other Factors Influencing the Indicator:

- habitat changes due to forestry policy, forest fires, and human activities
- species competition for habitat

INDICATOR EVALUATION

Problem: ecological productivity has been disturbed

Hypothesis: hydro development has reduced ecological productivity

Issue: reservoir flooding has reduced the amount of land in the most ecologically productive zones within the basin

Indicator: net primary productivity

Evaluation Criteria:

a) public concern

much of the most productive forest, in the valley bottoms of the Columbia River, has been flooded (Battersby 1993; Table 6)

before the inundation of valley bottoms, more land was available to support a diversity of land use activities, limited to the flat productive shorelines of water bodies (Hamling 1992, Table 6)

residents of the Kootenays believe that their relationship with the land and water in the region has changed (Table 6)

b) technical validity

the most productive land in the Kootenay region is located in valley bottoms along the Columbia and Kootenay Rivers (Szaraz 1981, 23)

overall capability of region to support fish and wildlife has been reduced as habitat flooded has not been replaced by equivalent aquatic habitat due to unseasonal fluctuations in reservoir levels (Woods 1993)

the net primary productivity of temperate forests is greater than that for lakes and rivers (Golley 1971; Miller 1982, 72)

c) sensitivity to change

net primary productivity is a function of limnological conditions, nutrient availability, moisture, climate and vegetation, and changes only when one of these factors changes

the inundation of forest land for reservoir creation affects net primary productivity

d) monitoring ability

forest productivity is monitored by the Ministry of Forests monitoring of aquatic productivity requires specific studies

e) usefulness to policy-makers

provides an indication of land use capability and the state of ecological systems

f) conceptual understanding

although the analysis of ecological productivity requires some understanding of ecological principles, the concept of various types of land capability zones is fairly easy to comprehend

Other Factors Influencing the Indicator:

- changes due to forestry policy, forest fires, and human activities
- climate change

INDICATOR EVALUATION

Problem: social living conditions have been degraded

Hypothesis: hydro development has reduced the ability of local residents to participate in the management of regional resources, and has decreased the desirability of living conditions

Issue: in- and out-migration of a large labour force during dam construction has caused rapid changes in community stability

Indicator: population size of communities affected by dam construction

Evaluation Criteria:

a) public concern
community stability has been disturbed by boom and bust cycles (Table 6, Battersby 1992)

b) technical validity
hydro projects have caused population fluctuations and related social impacts on adjacent communities in the Kootenays (Wilson 1973; British Columbia 1976, 205; Wilson and Conn 1983)

c) sensitivity to change
fluctuating demand for labour during dam construction causes immediate population changes

d) monitoring ability
municipal population statistics are collected annually

e) usefulness to policy-makers
provides a focus for compensation, mitigation, grant allocations, downstream benefits

f) conceptual understanding
implications for local communities understood locally, not as significant to external decision-makers

Other Factors Influencing the Indicator:

- external economic conditions
- other forms of industrial development

INDICATOR EVALUATION

Problem: social living conditions have been degraded

Hypothesis: hydro development has reduced the ability of local residents to participate in the management of regional resources, and has decreased the desirability of living conditions

Issue: hydro development has occurred with little community participation in decision-making and has reduced the ability of communities to manage their resources

Indicator: opportunities for public participation in hydro-related decision-making

Evaluation Criteria:

a) public concern

local residents believe they have little control over resource use decision-making as there have been few opportunities for their participation in hydro project planning or operations (Scarlett 1992, Smienk 1992, Table 6)

b) technical validity

Columbia River Basin hydro projects have proceeded with little consultation with local communities (Waterfield 1970, Wilson and Conn 1983, Missler 1988)

c) sensitivity to change

the participatory nature of hydro project decision-making varies with public, corporate and political support for shared decision-making

d) monitoring ability

the degree of participatory decision-making undertaken requires the development of a chronology of public participation efforts, and an analysis of such factors as decision-making authority, scope, timing, and access to information

e) usefulness to policy-makers

provides an indication of the degree to which communities have been included in resource use decisions, and may assist in the understanding of ecological, social and economic problems related to resource use conflicts

f) conceptual understanding

while there is a general understanding of the need to include those affected by a decision during decision-making, the subject of participatory decision-making raises questions related to the distribution of power, and opinions on appropriate levels of empowerment and participation may vary

Other Factors Influencing the Indicator:

- political pressures at provincial, national and international levels

INDICATOR EVALUATION

Problem: social living conditions have been degraded

Hypothesis: hydro development has reduced the ability of local residents to participate in the management of regional resources, and has decreased the desirability of living conditions

Issue: hydro development has reduced fishing opportunities through impacts to fish productivity

Indicator: annual rod hours on Kootenay Lake

Evaluation Criteria:

a) public concern

productivity of local sport fishery has decreased (Table 6)

b) technical validity

importance of sport fishery to residents and non-residents (Pearse 1969, 35; Hirst 1991, 23)
fishing on Kootenay Lake has been popular since the 1930s, however, angling hours have declined since the mid-70s (Hirst 1991, 23)

c) sensitivity to change

fishing effort is related to previous catch rates and may lag a year or more in response to dam-related fish population changes

d) monitoring ability

requires an annual survey of anglers (creel census)

e) usefulness to policy-makers

since residents of the Kootenays have strong links with their natural surroundings, the popularity and pursuit of fishing as a form of recreation or sport provides information regarding the ability of the region to fulfill social or recreational needs; the existence of a significant sport fishery provides incentives for recreational and tourism development

f) conceptual understanding

the importance of fishing to residents and non-resident anglers is well understood locally, but may not be significant to external decision-makers

Other Factors Influencing the Indicator:

- fish size
- competition between fish species
- fisheries management decisions (e.g. fisheries closures, hatcheries)
- popularity of fishing and angler congestion
- availability of alternative sports or recreational activities within the region
- fuel and transport prices
- highway access to fisheries
- changes in population size of local communities
- weather

INDICATOR EVALUATION

Problem: economic development opportunities have been restricted

Hypothesis: hydro development has removed land from the regional resource base, restricting the availability of land for economic development, and has caused conditions that make ongoing and future development more costly

Issue: hydro development has affected tourism

Indicator: annual room revenue expenditures for the Kootenays

Evaluation Criteria:

a) public concern
many communities would like to reduce their dependency on forestry through tourism development, however low reservoir levels jeopardize tourism (Johnson 1992; Demmon 1992)

b) technical validity
tourism is being encouraged as an economic diversification strategy in the Kootenays (British Columbia 1989; B.C. Central Credit Union 1989, 5)
hydro development has affected recreation along the Arrow reservoir (Marshall Macklin Monaghan 1982b, 24; DPA Group 1990, 2-2); the Koocanusa reservoir (British Columbia 1976, 208; Marshall Macklin Monaghan 1982a, 15)

c) sensitivity to change
low reservoir levels cause immediate effects on tourism due to unattractive shorelines and reduced access to water-based recreation (Cutts 1993)

d) monitoring ability
room rental expenditures are collected annually for taxation purposes by provincial government

e) usefulness to policy-makers
policy-makers are interested in tourism, as it is frequently promoted as a means towards economic diversification

f) conceptual understanding
the contribution of accomodation revenue towards a local economy is easily understood

Other Factors Influencing the Indicator:

- weather
- external economic conditions
- competing tourism areas
- business and cultural events, e.g., Expo
- transportation access

INDICATOR EVALUATION

Problem: economic development opportunities have been restricted

Hypothesis: hydro development has removed land from the regional resource base, restricting the availability of land for economic development, and has caused conditions that make ongoing and future development more costly

Issue: hydro development has affected employment

Indicator: annual unemployment rates for the Kootenays

Evaluation Criteria:

a) public concern

dam construction causes employment booms and busts, and does not create long-term employment for local residents; dam impacts on the resource base reduce employment opportunities (Table 6; Salasan 1993, 7; Spicer 1993; Bennett 1993)

b) technical validity

unemployment rates may increase after project construction until labour force finds new employment or relocates (Reid 1976, 6-23)

hydro development eliminates other resource uses that provide employment opportunities (Reid 1976, 6-59; Szaraz 1981, 186; Waterfield 1970, 63)

c) sensitivity to change

unemployment rates for small communities are likely to respond rapidly with changes in major industrial activity

d) monitoring ability

unemployment rates are calculated frequently by federal and provincial governments

e) usefulness to policy-makers

unemployment rates are generally considered to be key measures of economic conditions within a community

f) conceptual understanding

the significance of unemployment is well understood by all sectors of society

Other Factors Influencing the Indicator:

- external economic conditions
- other industrial activity

INDICATOR EVALUATION

Problem: economic development opportunities have been restricted

Hypothesis: hydro development has removed land from the regional resource base, restricting the availability of land for economic development, and has caused conditions that make ongoing and future development more costly

Issue: hydro development has reduced the resource base and increased forestry costs

Indicator: accessibility to timber supply in Golden Timber Supply Area

Evaluation Criteria:

a) public concern

inundation of some of the most productive forest land has reduced the volume of wood available for harvesting; flooding of previous road systems has reduced accessibility to timber supply and increased operating costs due to water transport; fluctuating water levels result in additional costs due to ramp maintenance and debris removal as well as reduced access to timber supply (Triton 1990; Thibodeau 1991; Bennett 1993; Table 6)

b) technical validity

British Columbia Forest Service recognizes that forest operators have incurred financial losses as a result of hydro development (Clapperton 1992)

flooding of the Big Bend highway has handicapped the forest industry around Golden (British Columbia 1974, 6-23, Szaraz 1981, 118))

hydro-related forest land withdrawal has decreased opportunities for employment, value added, and regional income; increases in operating costs when reduced access and transport problems are not mitigated lead to a greater sensitivity to market conditions (Szaraz 1981, 186)

c) sensitivity to change

the flooding of productive forests and logging roads has caused immediate increased costs for forestry operators; ongoing reservoir level fluctuations reduce access to timber supply and increase operation costs

d) monitoring ability

forestry companies and the government map forestry operations; forestry companies calculate the costs of their operations and are able to quantify the extent of their losses due to hydro development

e) usefulness to policy-makers

forestry is the most important economic sector in British Columbia and in the Kootenay region

f) conceptual understanding

the contribution of forestry to employment and regional income is easily understood; hydro-related constraints to forestry are also easy to comprehend

Other Factors Influencing the Indicator:

- external economic conditions and competing forestry operations