SOME ECONOMIC ASPECTS OF WATER RESOURCES DEVELOPMENT IN WESTERN CANADA

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Roy Leask Flett

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ABSTRACT

The evaluation of public investment in water resources development has traditionally been carried out within the framework of benefit-cost analysis; a particular form of analysis, which has its roots in the efficiency-competitive theory of resource allocation. This thesis argues that, basically because of its competitive assumptions and its objective of maximizing net efficiency benefits, benefit-cost analysis, as it is currently applied at least, may not be the most appropriate criterion upon which to base public investment decisions. The broad outlines of water resources development in the future are more likely to be determined, as they have in the past, not solely by the desire to achieve an efficient allocation of resources but also by a more broadly based objective reflecting the widely held belief (whether true or not) that water is a dynamic influence in fostering both economic and social advancement.

The Columbia River experience is discussed as a case in point. The final selection of projects under the Columbia River Treaty does not approximate the most efficient system of basin development. The choice of the Treaty projects, while they have in many cases been rationalized in terms of traditional economic techniques, can only be fully explained by the fact that neither of the parties to the Treaty had as their principle objective the maximization of net basin efficiency benefits. The Columbia River experience can best be understood through examination of the particular economic development policies of the parties involved. The

thesis proposes and discusses an alternative approach to public investment criteria, the developmental approach, which, it is claimed,may be a more relevant way of evaluating future water resources development in Western Canada.

ACKNOWLEDGEMENTS

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INTRODUCTION

Water is not a simple commodity, but rather a complex multiplicity of commodities, or goods, each of which has considerable value to mankind. To begin with, water is essential to life itself since every living organism requires a certain amount for its continued growth and development. In addition, it is a source of hydroelectric energy, a means of transportation, a place for human recreation, the natural habitat of fish and wildlife, a medium for pollution abatement, and a necessary input for many industries and manufactures. Water can also be harmful, wreaking havoc and destruction under conditions of flooding. In any case, its importance in human affairs can hardly be exaggerated.

The uses of a water resource are closely interrelated, and often the development of particular patterns of water use preclude the further development of the resource for other uses. This problem of conflict between water uses, and the competition for the various commodities supplied by a water resource is accentuated as population grows and higher levels of economic development are reached. The economics of water resources development, then, is concerned with allocating scarce water resources between competing uses and also with allocating other scarce resources (capital and labour) to the development of water projects. The problems with which water

economics must deal in fulfulling these functions are many and varied.

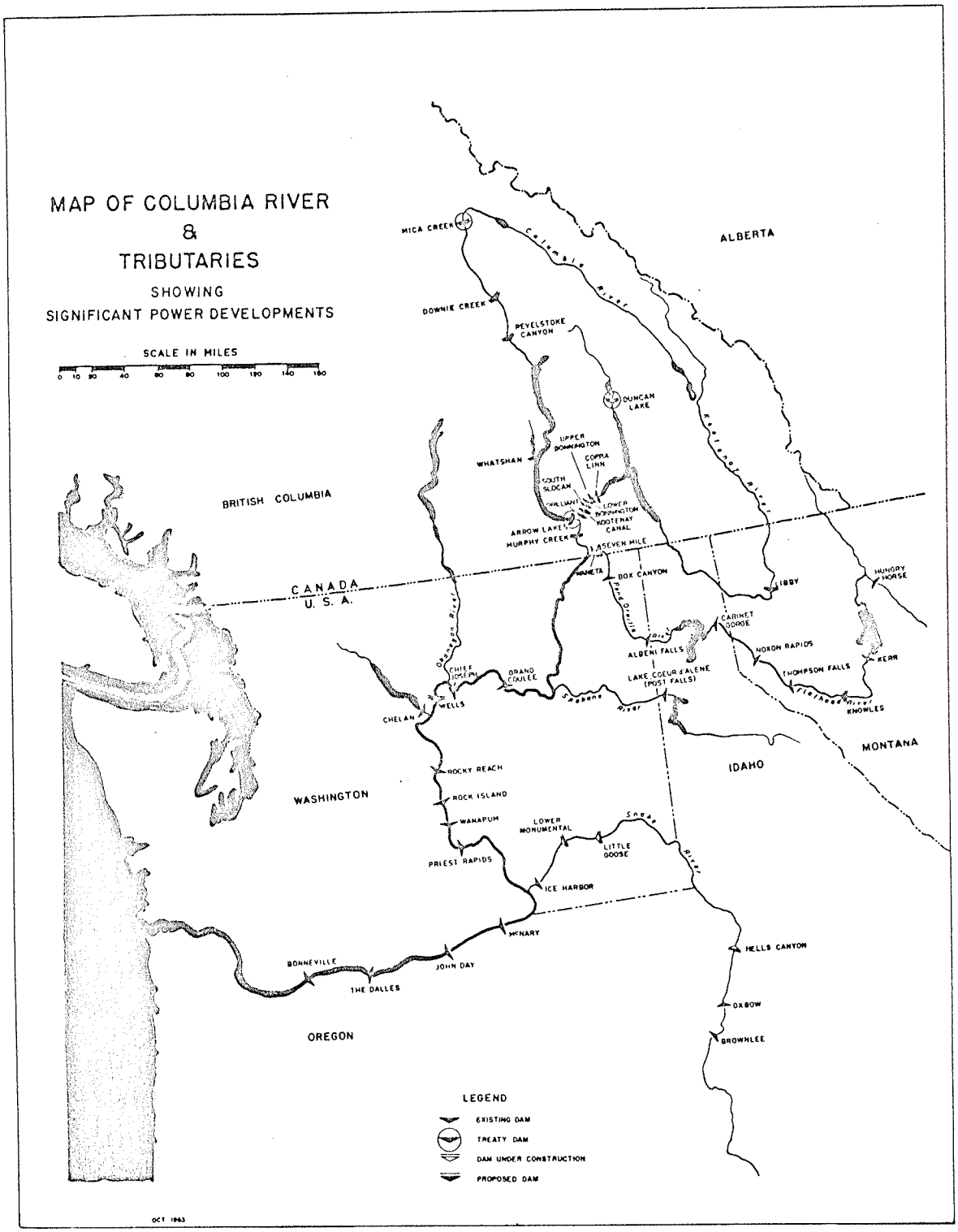
At the international level, these problems are compounded many times. The major river basins of the world pay little attention to political boundaries, and it is not surprising that the international allocation of water resources has been a source of conflict between nations since the earliest times. The complexity of the problems associated with these conflicts has increased in recent years, and we can expect this trend to continue as the problems faced by the less developed countries in developing their water resources are compounded by the problems of general economic development.

The Columbia River is one of the largest international rivers in the world and the cooperative development of its water resources by Canada and the United States represents an achievement of considerable significance in the relations between the two countries. The Columbia River Treaty has set a precedent in international relations in that it represents one of the first occasions in history where two sovereign powers have agreed to develop an international waterway under a formula designed to serve the mutual advantage of both. The treaty also sets a precedent in the sense that the lessons of the Columbia experience are likely to have considerable significance for future water resources development in Canada, particularly in Western Canada, where much of future water resources development is likely to be carried out in cooperation with the United States or in concert with the United States' needs for an increased supply of water.

The Columbia River development has already been examined from many different perspectives. The perspective of this paper is essentially economic, although socio-political factors are also examined where they are found to override economic considerations.

The first Chapter traces the history and origins of the development plan envisaged by the Columbia River Treaty as a necessary background for the rest of the study. Chapters II and III deal with the theoretical aspects and approaches to the economics of water resources development and these are discussed in terms of the Columbia River experience. Chapter IV explores the future course of water resources development in Western Canada and the implications of the Columbia experience for this future. The final Chapter summarizes the conclusions of the study.

Illustration 1



The Columbia River Basin In B.C. And The U.S.

Source: Columbia River Development. British Columbia Hydro and Power Authority, March 24, 1964.

CHAPTER I

HISTORY AND ORIGINS OF THE COLUMBIA RIVER DEVELOPMENT

The drainage basin of the Columbia River and its main tributaries encompasses a total area of some 259,000 square miles. Of this total the basin of the Columbia itself makes up only about 40 per cent, while the basins of the Snake, Clark Fork-Pend Oreille and Kootenay rivers account for 40 per cent, 10 per cent and 8 per cent respectively.[1] Although only about 15 per cent of the entire Columbia basin is in Canada,[2] its international character has, in the past, exemplified the types of problems that are associated with boundary waters. This Chapter provides a brief history of developments in the Columbia basin so as to facilitate the analysis of the succeeding Chapters.

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[1] International Columbia River Engineering Board, Water Resources of the Columbia River Basin. Report to the International Joint Commission. (Ottawa and Washington, March 1, 1959), p. 33.

[2] The Canadian portion, however, contributes almost 30 per cent of the average annual run-off. See Water Resources Development, Columbia River Basin. Report by the Division Engineer, U.S. Army Engineer Division, North Pacific to the Chief of Engineers, U.S. Army, (June 1958), p. 126.

I. THE BOUNDARY WATERS TREATY

One of the earliest attempts to deal cooperatively with a particular problem, that of navigation rights, in the Columbia basin came in 1846 with the signing of the Northwest Boundary Treaty which gave to British subjects the right to navigate the Columbia to the ocean.[3] Other problems naturally arose along the international boundary as the west was opened up to settlement, and similar efforts aimed at the solution to these types of problems led to the conclusion of the Boundary Waters Treaty in 1909.[4] The latter treaty made specific provisions for the adjustment of differences that existed at the time - the diversion of water for power purposes at Niagara Falls (Article V), and the apportionment between the two countries of the St. Mary and Milk Rivers for irrigation (Article VI). More importantly, however, the treaty provided for the adjustment and settlement of future questions that might arise, concerning water, along the 3,500

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[3] Treaty Establishing The Boundary In The Territory On The Northwest Coast Of America, Lying Westward Of The Rocky Mountains. Washington, June 15, 1846.

[4] "Treaty Between The United States And Britain Relating to Boundary Waters, And Questions Between The United States and Canada," The Columbia River Treaty, Protocol and Related Documents (Ottawa: Queen's Printer, February 1964), pp. 7-16.

mile international boundary.[5] The two countries further agreed to establish and maintain an International Joint Commission (Article VIII) composed of six commissioners, three from each country. This Commission was given complete and final jurisdiction in approving of uses, obstructions and diversions of boundary waters on either side of the border which would affect the natural level or flow of boundary waters on the other side (Article VIII). The Commission received similar jurisdiction in respect to works in waters flowing from boundary waters or in waters at a lower level than the boundary in rivers flowing across the boundary (Article IV).

The rules and principles under which the International Joint Commission was to be governed in considering applications under Articles III and IV were established by Article VII. Article IX provided for the reference to the Commission for examination and report of any other questions or matters of difference involving the rights, obligations or interests of either country. Article X further provided that such questions be referred to the Commission for decisions by the consent of both countries.

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[5]For a cogent look at the problems that have arisen, see L.M. Bloomfield and G.F. Fitzgerald, Boundary Water Problems of Canada and the United States: The International Joint Commission, 1912-1958. (Toronto: Carswell, 1958).

The bilateral approach to the management of the water resources of common river basins enunciated in the treaty, however, was limited to some extent by the qualification contained in Article II:

> Each of the High Contracting Parties reserves to itself..., the exclusive jurisdiction and control over the use and diversion, whether temporary or permanent, of all waters on its own side of the line which in their natural channels would flow across the boundary or into boundary waters.[6]

The Boundary Waters Treaty was ratified by both countries in 1910. The International Joint Commission was duly established and held its first meeting on June 10, 1912.[7] Since that time, it has continued to function as an effective body for resolving and reporting on the great variety of problems that have arisen along the United States - Canada boundary.

The application of the Boundary Waters Treaty and the operation of the International Joint Commission cannot be better illustrated than by reference to the Columbia River basin where, prior to 1944, the I.J.C. had dealt with thirteen applications regarding specific problems concerning the Columbia River and its tributaries.[8]

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[6] Boundary Waters Treaty, op. cit., p. 8.

[7] Bloomfield and Fitzgerald, op. cit., p. 14.

[8] Ibid., pp. 122-34, 158 and 161 where the I.J.C. dockets nos. 23, 27, 29, 30, 34, 43, 45, 47, 42, 48, 44 and 49 are summarized.

II. WATER RESOURCES DEVELOPMENT IN THE COLUMBIA BASIN

Development of the hydroelectric power resources of the Columbia River in the United States portion of the basin began just prior to the beginning of this century, but it was not until 1933 that the first major hydro project, Rock Island, was built in the state of Washington. The Bonneville dam, the first of the major federal projects, commenced producing in June of 1938, and it was followed in late 1941 by the first power generation from Grand Coulee. The coordinated operation of the various power systems in the Pacific Northwest began in 1923, and the individual utility companies were further integrated by the creation of the Bonneville Power Administration in 1937 and its subsequent development of transmission facilities. Both federal and non-federal hydroelectric development were interrupted by World War II,but by 1959 most of the power resources of the United States portion of the Columbia basin had been almost fully planned and well developed.[9]

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[9]Water Resources of the Columbia River Basin, op. cit. Appendix V, pp. 9-33. Most of the early power projects were run-of-the-river plants on tributary streams with little storage capacity and the proposed plans of development were notable for their absence of any major storage projects. Of the few good storage sites that had not been developed, conflicts among their competing uses for power, fish and wildlife conservation and parkland meant that it was unlikely that they would ever be developed. For a list of elements for potential improvement of the system at that time see Appendix V, p. 36 of the same report.

In Canada, however, the situation was quite different, and a great many potential storage sites existed since the power resources of the Canadian portion of the Columbia basin were virtually undeveloped. The only developments of any significance were in West Kootenay on the Kootenay River, at Waneta on the Pend d'Oreille, and at Whatshan. The installed capacity of these plants was less than 500,000 kilowatts. In contrast, the installed capacity in the United States portion of the basin was about 8.5 million kilowatts.[10]

It was recognized early in this century that the storage imbalance in the basin system as a whole could best be corrected through cooperative development. The first positive step toward such development came in 1944 when the governments of Canada and the United States requested the International Joint Commission to determine the best uses that could be made of these resources in regard to power, flood control, irrigation, reclamation, domestic water supply, navigation, fish and wildlife preservation, and "other beneficial purposes".[11] Pursuant to this reference an international investigation of the basin was initiated.

The International Joint Commission decided that this investigation could best be conducted by a board of four engineers, to be chosen in

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[10] Ibid., (Main Report), pp. 45-46.

[11] See Appendix 1 where this reference is reproduced, infra , p. 121-2)

equal number from the federal services of each country. The International Columbia River Engineering Board (I.C.R.E.B.) was thereupon established and this Board, in order to expedite work on the reference, in turn set up the International Columbia River Engineering Committee to take charge of field operations and to assist in the required studies. Two representatives of each country were named to constitute the Committee, a United States alternative member was appointed, and the province of British Columbia was subsequently extended representation. A "work group" made up of Committee assistants was also established, and work on the reference began shortly thereafter.

In 1944, the authorities in the United States (the Army Corps of Engineers, the Bureau of Reclamation and other agencies) already had quite extensive knowledge of the water resources in their part of the basin and the uses to which these resources might be put.[12] In Canada, however, the situation was, again, quite different. According to one eminent Canadian authority, accurate topographical maps of

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[12]Under the Rivers and Harbours Act of 1927 Congress had directed the Corps to prepare a report on the development of the Columbia in regard to navigation, flood control, hydroelectric power, and irrigation. This report was submitted in 1932. The National Resources Committee carried out a similar study (Regional Planning, Part I - Pacific Northwest. Washington, D.C.: U.S. Government Printing Office, May 1935) a few years later, and so did the Department of the Interior (The Columbia River. Washington, D.C.: U.S. Government Printing Office, February 1947).

the Canadian portion of the Columbia basin did not even exist in 1944.[13] The first task of the Canadian section of the I.C.R.E.B., then, was to plan and organize surveys and studies so as to obtain sufficient information on the water resources of the Columbia to permit further planning. The information thus gathered was coordinated with that already available on the United States side. In October of 1945 the Board submitted a preliminary report to the International Joint Commission recommending that further development was desirable, but that much more work had to be done before any positive recommendations toward this development could be made.[14]

The studies of the I.C.R.E.B. continued for the next fourteen years, culminating on March 1, 1959 with the report entitled Water Resources of the Columbia River Basin.[15] This report concluded that the best use of the resources involved could be made only by implementing a comprehensive development plan for the basin as a whole.

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[13]A.G.L. McNaughton, Minutes of Proceedings and Evidence, House of Commons, Standing Committee on External Affairs, Tuesday, March 1, 1955, pp. 35-36.

[14]Water Resources of the Columbia River Basin, op. cit., p. 3.

[15]Ibid. The report consisted of a main volume and six appendices covering various parts of the basin and economic studies.

To this end, the report outlined three alternative schemes each of which was comparable in scope but which utilized different combinations of storage sites.[16] Power studies were made of these three preliminary plans and although the Copper Creek diversion plan was judged to be best in terms of power production, its margin of superiority was not great enough to justify its selection as representing the best use of sites and water resources.[17] The I.C.R.E.B. study, furthermore, took no cognizance of the international boundary and upon instructions from the International Joint Commission made no attempt to apportion the costs and benefits for each specific project; nor was any attempt made to outline a method of cooperative development under which such costs and benefits could be shared by the two countries.

This latter question, however, as to how the benefits of cooperative development were to be shared, was one of the major points of contention between the two countries. In this regard, three kinds of interferences with the natural condition of stream flow had to be considered, since all were relevant to the Columbia reference. In the first category of interference, the downstream country could build a dam or other obstruction on the river which would have the effect of raising water levels above the boundary in the upstream country.

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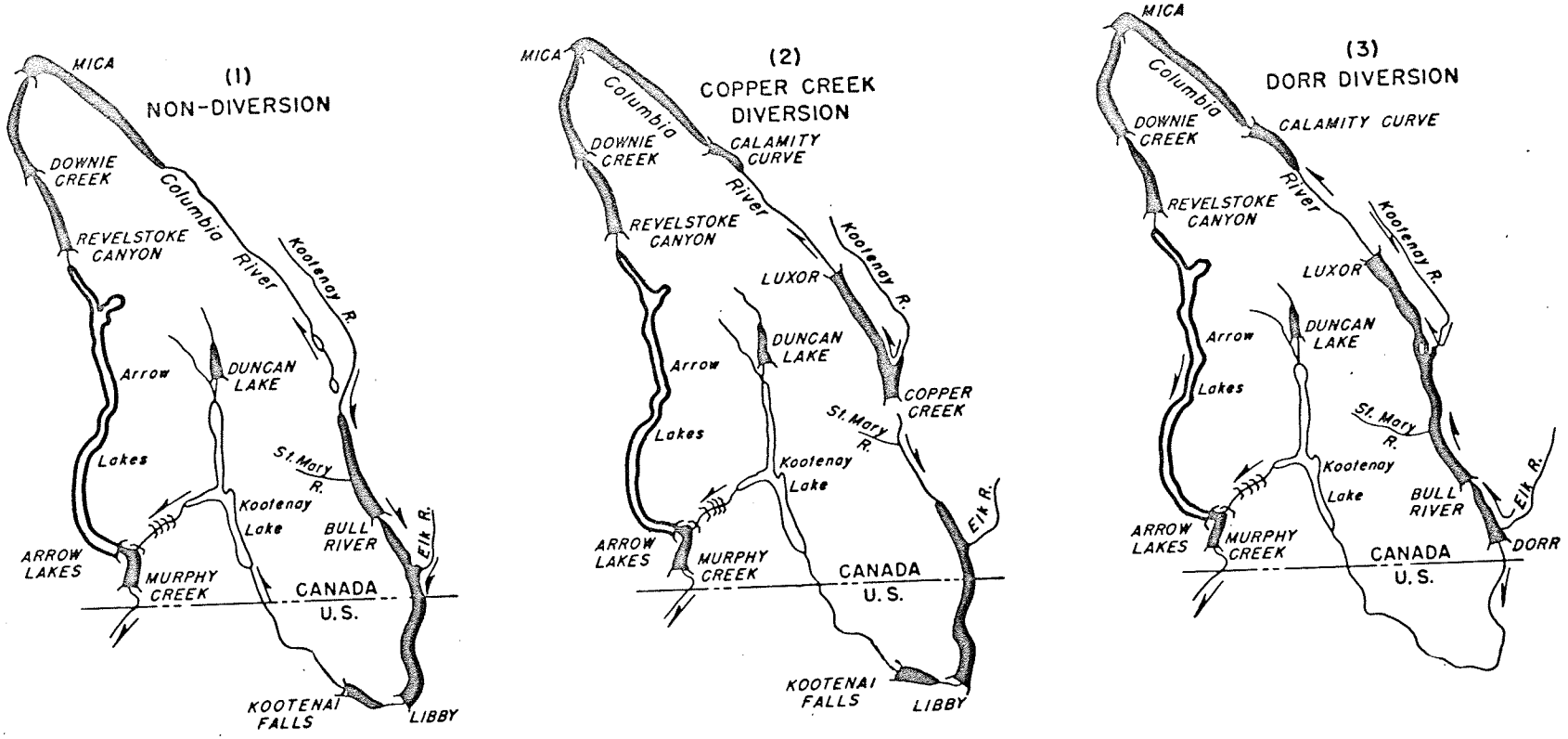
[16] See Illustration 2.

[17] Water Resources of the Columbia River Basin, op. cit., pp. 109-110.

Illustration 2

PLANS OF DEVELOPMENT [a]



[a]The plans downstream from Murphy Creek are identical.

Source: International Columbia River Engineering Board, Water Resources of the Columbia River Basin. Report to the International Joint Commission, March 1959, p. 67.

(This was the kind of interference involved in the construction of the proposed Libby dam). Under Article IV of the Boundary Waters Treaty, of course, this type of interference was forbidden unless approved by the I.J.C. which, under Article VIII, in turn, was required to insure that suitable and adequate provision was made "for the protection and indemnity against injury of all interests on the other side of the line that may be injured thereby."[18]

In the second category of interference was the question of the storage of waters in the upstream country and its release in regulated flows or otherwise. If the release was regulated, then this constituted a valuable service to the power plants in the downstream country by making additional water available for power generation during periods of low flow. Since the downstream country (in this case the United States) had no legal right to such a service, the answer to this question revolved around how the downstream country would recompense the upstream country (in this case Canada) for such a service. The treaty of 1909 did not provide for such a situation.

In the third category of interference with natural flow, the upstream country (Canada) could divert the flow of a river in whole or in part while the river remained within its territory. Under the provisions of Article II of the treaty of 1909, the upstream state was

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[18] Boundary Waters Treaty, op. cit., p. 11.

lawfully entitled to do this and if injury, as a result of such a diversion, resulted in the downstream country, the injured parties were to be given access to the courts of the upstream country on terms of full equality with the citizens of that country.[19]

Solutions to the questions in the first two categories of interference with natural flow hinged on what became known as "downstream benefits" - the power potential which was credited to the downstream state as a result of storage or regulated flow provided by the upstream state. The principle that such benefits should be divided, i.e., that the downstream state recompense the upstream state, perhaps in terms of power in exchange for the resources contributed to the projects, was recognized in both Canadian and United States practice,[20] but prior to the Columbia River development, downstream benefits had never formally been admitted in an agreement between the two countries.

In the early 1950's the middle phase of the U.S. Army Engineers proposed development of the American part of the Columbia basin had called for some ten million kilowatts of capacity in the main plants to be provided by some twenty million acre-feet of storage.[21] In order to

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[19] Ibid., p. 8.

[20] For an example of a recognition of this principle in domestic practice in the United States, see Appendix 2, infra , p. 123.

[21] Minutes of Proceedings and Evidence, op. cit., Appendix "C", May 12 and May 13, 1954, p. 201.

provide 4.25 million acre-feet of this total, the United States applied to the International Joint Commission in 1951 for permission to build a dam near Libby, Montana. This represented an interference in flow of the first category discussed above since the proposed dam would have raised the water level at the boundary (on the Kootenay River) by 150 feet and would have flooded back into Canada some 42 miles. For this flooding the United States was willing to compensate only the owners using the land to be flooded; no compensation was offered for the 150 feet of head that lay in Canada, nor for the almost one quarter of the proposed total storage. In fact, at this stage of the dispute, the United States was not even willing to admit that downstream benefits existed let alone talk about how they should be divided.

The Libby application was subsequently withdrawn in 1953, ostensibly because of contenious local issues surrounding the project's construction in the United States,[22] but it was resubmitted again in 1954. There was little in the new application, however, to indicate that the United States had changed its stand.

At the same time, however, the I.J.C. studies had progressed to the point where Canada was much more aware of the uses that could be made of her share of the Columbia's water resources. Canadian

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[22]There is some evidence, however, that the U.S. was miffed by Canadian demands for a share of the Libby benefits. See, for example, M. Barkway, "Big Hassle Ahead Over Columbia Power," Financial Post, March 13, 1954, p. 11.

development of the Columbia could follow one of three basic alternatives, with a number of possible variants: (1) No diversion of either the Columbia or the Kootenay; (2) diversion of the Upper Kootenay into the Columbia and the use of these waters in Canada and then in the United States; and (3) diversion of the Upper Columbia into the Fraser, including the Kootenay diversion of (2). The possibility that this third alternative might be feasible had considerable influence in changing American thinking in regard to downstream benefit division.[23]

Explicit recognition of the Canadian right to share the downstream benefits of developments on the Upper Columbia was only the first step toward cooperative agreement; the real problem was how these

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[23]See, for example, Columbia River Treaty, Hearings before the Committee on Foreign Relations, United States Senate, 87th Congress, 1st Session, March 8, 1961. (Washington, D.C.: U.S. Government Printing Office), pp. 10, 36 and 39; and "Case of Big Stick", Financial Post, October 15, 1955, p. 10. The exact effects of the diversion threats, however, are difficult to estimate and it seems that, ultimately, the deciding factor in the U.S. recognition of the Canadian right to downstream benefits was British Columbia's decision to go ahead with the Peace River development before the Columbia. (See Minutes of Proceedings and Evidence, op. cit., No. 6, Tuesday, April 14, 1964, p. 332).

benefits were to be shared.[24] In identical letters to the International Joint Commission in January 1959, the governments of the United States and Canada requested the Commission to recommend principles to be applied in determining:

> "(a) the benefits which will result from the cooperative use of storage waters and electrical interconnection within the Columbia River System; and
>
> (b) the apportionment between the two countries of such benefits more particularly in regard to electrical generation and flood control."[25]

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[24]Under the Columbia River Treaty it was finally agreed that each country would receive 50 per cent of the increased power attributible to the Canadian storage. The precise origin of the 50-50 formula, however, is difficult to track down. In the early stages of planning the development (1944-53) the U.S. was unwilling to concede Canada any share of the downstream benefits that might result from cooperative development. Senator A.O. Stanley, Chairman of the American Section of the I.J.C. from 1933 to 1954 insisted that the U.S. would never give Canada a single kilowatt of power. Instead, he believed the U.S. should pay only the damages (in the case of the Libby dam) that the reservoir waters would cause by inundating lands in Canada. General McNaughton, the head of Canadian Section of the I.J.C., however, insisted that Canada was entitled to part of the power that would be produced at the Libby dam. Testifying before the Standing Committee on External Affairs in 1954, McNaughton stated, "A year ago we had only to mention downstream benefits when for all practical purposes our American colleagues would get up and leave the room. They were determined that this question was not going to be raised, because it seemed to be all on one side, and they would not have it." (Minutes and Proceedings, No. 7, May 12, 1954, p. 173).

This impasse left the I.J.C. deadlocked for 7 or 8 years. Senator Dill of the United States claimed that he had originally gotten the idea of a 50-50 split in power benefits from a salmon treaty between the U.S. and Canada, and that it was at least partially as a result of his continued urgings that led to the incorporation of this formula in the Columbia River Treaty. (See, Columbia River Treaty, Hearing before the Committee on Foreign Relations, United States Senate, 87th Congress, 1st session, on Ex. C., March 8, 1961, pp. 61-64).

[25]Minutes of Proceedings and Evidence, op. cit., No. 9, May 1959, pp. 207-208.

As a result, the I.J.C. prepared a report which provided and discussed a set of sixteen principles dealing with project selection, power and flood control benefits.[26] These principles were to serve as the basis for negotiations between the two countries.

III. THE COLUMBIA RIVER TREATY

Delegations from each of the two countries were appointed on January 25, 1960, and the formal negotiations began on February 11. After seven formal meetings the delegations produced a progress report outlining the basic terms for an agreement on the cooperative development of the Columbia.[27] Negotiations ended with the formal signing of the Columbia River Treaty.[28] Under this agreement, Canada undertook to build three dams, one at Mica Creek, one at the outlet of Arrow Lakes, and one at the outlet of Duncan Lake, which would provide 15.5 million acre-feet of storage and which would be built within a nine year period following the final ratification date.[29]

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[26] Report of the International Joint Commission, United States and Canada, On Principles for Determining and Apportioning Benefits From Cooperative Use of Storage Of Waters and Electrical Inter-Connection Within The Columbia River System. (Washington, D.C., December 1959). This report is reproduced in Appendix 3, infra , pp. 124-41.

[27] Report to the Governments of the United States and Canada (October 19, 1960, mimeographed).

[28] Treaty Between Canada And The United States of America Relating To Cooperative Development Of the Water Resources Of The Columbia River Basin. Signed in Washington on January 17, 1961, in Canada, Department of External Affairs, The Columbia River Treaty, Protocol and Related Documents, op. cit., pp. 58 - 81.

[29] A description of the treaty projects is given in Table 1.

TABLE 1
DESCRIPTION OF TREATY PROJECTS

PROJECT	ARROW LAKES	DUNCAN LAKE	MICA CREEK
Location	5 miles upstream from Castlegar	Outlet of Duncan Lake	90 miles upstream from Revelstoke
Drainage Area	14,100 sq. mi.	925 sq. mi.	8,220 sq. mi.
Average Flow	39,000 c.f.s.	3,600 c.f.s.	20,000 c.f.s.
Maximum Recorded Flow	220,000 c.f.s.	21,400 c.f.s.	c.f.s.
Minimum Recorded Flow	4,800 c.f.s.	268 c.f.s.	2,140 c.f.s.
Dam Type	Earthfill	Earthfill	Earth and Rockfill
Dam Height	190 ft.	120 ft.	645 ft.
Dam Crest Length	2,850 ft.	2,600 ft.	2,500 ft.
Dam Volume	8,500,000 cu. yds.	6,400,000 cu. yds.	37,000,000 cu. yds.
Live Storage	7,100,000 ac. ft.	1,400,000 ac. ft.	Stage I-7,000,000 ac. ft. Stage II - 12,000,000 ac. ft.
Length of Reservoir	145 mi.	28 mi.	85 mi.
Completion Period (after Ratification)	5 yrs.	5 yrs.	9 yrs.
Flood Control Payments (U.S. dollars)	52,100,000	11,100,000	1,200,000

SOURCE: Adapted from Table 5, Canada Department of External Affairs, The Columbia River Treaty and Protocol: A Presentation. Ottawa, 1964, p. 80.

These new storages were to be operated so as to produce the maximum flood control and hydroelectric power benefits. Two annexes to the treaty contain principles for the detailed operation of the Canadian storage and for the determination of downstream power benefits. The United States flood control authorities were to present plans based on the principles governing flood control, and the Canadian authorities were to operate the storage facilities under these plans. Release of water for purposes of power were to be made by Canadian authorities under mutually agreed operating plans prepared in conformity with the principles governing power.

In return for the storage function, Canada was entitled to one-half of the downstream benefits as defined under the treaty. Under Annex B of the Treaty the downstream power benefits were to consist of the increase in dependable hydroelectric capacity and average annual usable hydroelectric energy. "Dependable" hydroelectric energy is actually a measure of the capacity of a system to meet peak load demands up to the limits of the generating capacity of the plants in the system. For peak demands to be met during a period of critically low stream flow conditions a system must have a guaranteed source of energy and efficient generating capacity to produce that energy at the rates required by the load. The Canadian storage under the treaty would not provide any additional generating capacity in the United States, but it would supply the increased streamflows necessary to make the capacity already installed there more useful when the

load demanded it. The increase in "average annual usable energy", of course, is the increase in the amount of energy that could be generated in the United States as a result of the Canadian storage. This was to be measured in terms of kilowatt hours on the basis of an agreed period of streamflow record, (1928-1948). Capacity to be credited to the Canadian storage was to be the difference between the average rates of generation in kilowatts during the appropriate critical stream flow periods for the United States base system, with and without the Canadian storage, divided by the estimated average critical period load factor. The increase in usable energy was determined first by calculating the difference between the available hydro energy at the United States base system with and without Canadian storage. It was then agreed as to what part of this difference was usable with and without the Canadian storage and the difference thus agreed was the increase in average usable hydro-electric energy.[30] Canada's share of these benefits were to be returned to the Canadian border for distribution or sold in the United States upon the agreement of both countries.[31] The United States was also required to pay Canada for the primary flood control benefits obtained as a result of the upstream storage dams, $64.4 million (U.S.)

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[30]See the Columbia River Treaty, op. cit., Annex B, p. 78, where the various steps to be used in determing the downstream power benefits are outlined. The actual benefits determined and the Canadian share are outlined in Tables 2 and 3;. Table 4 gives an outline of the elements of the U.S. system.

[31]Ibid., Article V, (2) and Aritcle VIII, (1), pp. 62 and 64.

Table 2

ESTIMATED POWER BENEFITS - 1970 - UNITED STATES AND CANADA

	Project	Share of Increase in Average Annual Usable Energy in Kilowatt Years	Secondary Energy Previously Existing which is "Firmed Up" -Kilowatt Years	Total Increase in Prime Energy in Kilowatt Years[1]	Share of Increase in Dependable Capacity in Kilowatts
Canada	High Arrow	484,000	0	484,000	771,000
	Duncan	75,000	0	75,000	145,000
	Mica Storage	204,000	0	204,000	394,000
	Total	763,000	0	763,000	1,310,000
United States	High Arrow	484,000	161,000	645,000	771,000
	Duncan	75,000	63,000	138,000	145,000
	Mica Storage	204,000	155,000	359,000	394,000
	Total	763,000	379,000	1,142,000	1,310,000

Other power benefits are realized by the United States at the Libby project and downstream in the United States from Libby, and by Canada at the West Kootenay reach in Canada downstream from the Libby and Duncan Lake reservoirs.

(1) There is no additional energy in this column for the United States as a result of the construction of the Canadian Storage. What happens is that energy presently available but not sure at worst possible flow conditions becomes sure at all times, i.e. "firmed up".

Source: Canada, Department of External Affairs, The Columbia River Treaty, Protocol and Related Documents. (Ottawa: Queen's Printer, February 1964), pp. 92 and 93.

Table 3

ESTIMATED CANADIAN SHARE OF DOWNSTREAM POWER BENEFITS FOR THE YEAR 1970

Project	Benefits at the Generators		Benefits Adjusted to a 70 per cent Load Factor and Delivered to Loads(1)	
	Capacity in Kilowatts	Energy in Billions of Kilowatt Hours	Capacity in Kilowatts	Energy in Billions of Kilowatt Hours
High Arrow Lakes	771,000	4.240	684,000	4.194
Duncan Lake	145,000	0.657	118,000	0.724
Mica Storage	394,000	1.761	316,000	1.938
Total for Treaty Projects	1,310,000	6.658	1,118,000	6.856
Estimated Downstream Benefits in the West Kootenay Area in Canada from Duncan and Libby Regulation.			359,000	2.201
Total Benefits at Loads			1,477,000	9.057

(1) In the adjustment to a 70 per cent load factor it is assumed that some Canadian capacity will be exchanged for additional energy.

Source: Canada, Department of External Affairs, The Columbia River Treaty, Protocol and Related Documents. (Ottawa: Queen's Printer, February 1964), pp. 92.

Table 4

BASE SYSTEM

Project	Stream	Stream Miles Above Mouth	Usable Storage Acre-Ft. ('000)	Gross Head Feet	Initial Plant KW (10^3)	Ultimate Plant KW (10^3)
Hungry Horse	S. Fk. Flathead	5	3,161	477	285	285
Kerr	Flathead	73	1,219	187	168	168
Thompson Falls	Clark Fork	209	Pondage	60	30	65
Noxon Rapids	"	170	"	152	336	420
Cabinet Gorge	"	150	"	97	200	300
Albeni Falls	Pend'Oreille	90	1,155	28	43	43
Box Canyon	"	34	Pondage	42	60	60
Grand Coulee	Columbia	597	5,232	343	1,944	3,672
Chief Joseph	"	546	Pondage	171	1,024	1,728
Wells	"	516	"	68	400	668
Rocky Beach	"	474	"	93	712	1,118
Rock Island	"	453	"	38	212	212
Wanapum	"	415	"	84	831	1,330
Priest Rapids	"	397	"	80	789	1,216
Brownlee	Snake	285	974	272	360	541
Oxbow	"	273	Pondage	122	190	238
Ice Harbor	"	10	"	97	270	540
McNary	Columbia	292	"	75	980	1,400
John Day	"	216	"	104	1,080	2,700
The Dalles	"	192	"	86	1,119	1,743
Bonneville	"	145	"	59	518	890
Kootenay Lake	Kootenay	16	673	-	-	-
Chelan	Chelan	0	676	393	48	96
Coeur d'Alene L.	Coeur D'Alene	102	223	-	-	-
Total 24 Projects			13,313[1]	3,128	11,599	19,523

[1]Total usable storage adjusted to 13,000,000 ac. ft.

SOURCE: Treaty Between Canada and the United States of America Relating to Cooperative Development of the Water Resources of the Columbia River Basin. Annex B.

over a nine-year period. Additional payments for secondary flood control over a 60-year period (the life of the treaty), not to exceed $7.5 million, were to be made - the actual amount being dependent upon the number of times the United States called upon Canadian authorities for such flood protection. The United States was also to pay, in electric power, for any power lost by Canada as a result of providing secondary flood control service. It was further agreed that the United States would operate the existing (and future) installations of the base system so as to make the most effective use of the improvement of streamflow resulting from the operation of the Canadian storage.

For its part, the United States was given the option, for a period of five years following the date of ratification, of constructing the Libby dam, and if this option was taken the dam was to be completed within seven years. The United States was to pay the full cost for this structure and Canada was to make available the land which would be flooded by the storage of water. Downstream benefits resulting in either country from the Libby Dam were not to be shared but were to remain with the country in which they accrued.

Both countries were prohibited from diverting water from its natural channels in a way that would alter the flow of any water as it crosses the boundary, for other than consumptive uses, without the consent of the other country. Canada could, however, after 20 year, 60 year and 80 year periods, divert (up to an agreed maximum) water

from the Kootenay to the Columbia River.

The treaty provided for the designation in each country of operating entities which would be responsible for formulating and carrying out the operating arrangements necessary to implement the treaty; and for a Permanent Engineering Board, consisting of two members from each country, which would keep appropriate records, make inspections, and assist in reconciling any differences that might occur between the two countries. Any differences that could not be resolved would be referred to the International Joint Commission and if they could not be resolved there, to an arbitration tribunal. Decisions of these two bodies would be binding on both countries.

Each country was liable to pay compensation to the other for power losses resulting from breaches of the treaty. The treaty was to be in force for at least 60 years and any dam with a longer useful life than the treaty period was to be operated for flood control purposes until the end of its useful life and not just until the end of the treaty period.[32] After 50 years, the treaty could be terminated by 10 years prior notice given by either party.

The treaty was transmitted to the United States Senate on the same day that it was signed, and public hearings on the matter were

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[32]Under Article I of the treaty "useful life" was defined as "the time between the date of commencement of operation of a dam or facility and the date of its permanent retirement from service by reason of obsolecence or wear and tear which occurs not withstanding good maintenance practices."

held on March 8, 1961.[33] Several senators, witnesses from the executive branch, and private individuals appeared in support of the treaty, but no one appeared in opposition to it, nor did the Committee receive any communications opposing the treaty.[34] Consequently, the Senate adopted a resolution approving the treaty of March 16, 1961.

IV. POST-TREATY DEVELOPMENTS

Ratification of the treaty by Canada, however, was not immediately forthcoming, and to understand the developments that took place after the treaty was signed it is necessary to examine why Canada was reluctant to ratify the treaty in 1961. To begin with, the governments at Ottawa and Victoria did not agree as to which was the best way to develop the Columbia. That such disagreement was possible at all, of course, is the result of a unique aspect of the Canadian constitution. Under the British North America Act, the provinces have complete authority over the natural resources within their boundaries, although in some cases, the federal government has concurrent or even overriding jurisdiction.[35] Water resources, then, are under the ownership and control of the provinces in which they occur, except where these waters are navigable, inter-provincial, or international, in which cases they then become the concern of the

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[33] Columbia River Treaty, Hearings before the Committee on Foreign Relations, op. cit.

[34] Report of the Committee on Foreign Relations, Columbia River Treaty, 87th, Congress, 2nd Session, March 15, 1961. (Washington, D.C.: U.S. Government Printing Office).

[35] British North America Act, 1867, 30 Vict. 92(10), (13), (16).

federal government as well.[36] In the case of international waters the senior government is doubly concerned since it has the sole responsibility for the conduct of foreign relations. For any form of cooperative development of the Columbia to take place, therefore, it was imperative that both British Columbia and Canada be in agreement as to how the Canadian part of this development was to be carried out. At the time the treaty was signed such agreement did not exist.[37]

The reasons as to why agreement was lacking date back at least a decade prior to the treaty. In January 1949, following disastrous flooding in the southern portion of the Columbia basin the previous spring, the International Joint Commission received a request from the United States to make a study of the possibilities for storing the floodwater of the Columbia River above the Canadian border. Pursuant to this request, the International Columbia River Engineering Board issued a report on storage in the Arrow Lakes which concluded that the cost of a dam to store several million acre-feet of floodwater would not be justified at that particular time or place.[38] Nevertheless, a number of interests in the United States continued to work to induce

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[36] Ibid., 91(10), (12), (29), and 132.

[37] Minutes of Proceedings and Evidence, op. cit., No. 23, Monday, May 11, 1964, p. 1118.

[38] Water Resources of the Columbia River Basin, op. cit., p. 3.

private organizations to undertake such a dam.[39] Subsequently, on September 17, 1954, the government of British Columbia signed an agreement with the Kaiser Alumimum and Chemical Corporation of the United States. Under this agreement, a dam was to be constructed at the foot of Arrow Lakes at an estimated cost of $30 million to be paid for by Kaiser. The company also agreed to deliver to the province 20 per cent of the additional power that would be generated downstream as a result of the improved storage, and in addition, the province was to receive $275,000 per year in taxes, bringing its share of benefits of the development to almost $1 million annually.[40]

The increase in energy output that Kaiser hoped to share with the Province was to be generated in the United States portion of the Columbia basin at the various installations controlled by the Bonneville Power Administration. For many months Kaiser negotiated with the officials of the Bonneville Power Administration as to division of the downstream power benefits that would be produced by the Arrow Lakes storage, but they were unable to secure enough power to make the scheme financially feasible.[41] Added to this was the

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[39]For example, see the statement of former Senator C.H. Dill, before the Senate Committee, Columbia River Treaty, op. cit., pp. 61-64.

[40]For details of this agreement and its alleged benefits see the House of Commons Debates, February 15, 1955, pp. 1023-38.

[41]Dill, op. cit., p. 62.

serious objections to the scheme raised by the Canadian Government, and as a result the plan failed. Ottawa considered that the Kaiser scheme was tantamount to giving the United States control of Canadian resources, that in the long run such a development would not represent the best use of Canadian resources, and that any development of the Columbia should await the report of the International Joint Commission.[42] To make its objections effective, the federal government passed, in 1955, the International River Improvements Act,[43] which requires the assent of federal government before any dam or obstruction, which would change the flow of that stream at the border, can be built on any international stream. British Columbia, of course, objected to the bill, but ultimately it was forced to yield.[44]

It became evident also, as soon as the United States was willing to admit Canada's right to a share of the downstream benefits, that British Columbia and Canada disagreed on the form which these benefits should take.[45] Traditionally, the policy of the federal government had been to discourage the export of Canadian hydroelectric

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[42]For details of these various objections see, Minutes of Proceedings and Evidence, op. cit., 1955.

[43]An Act Respecting The Construction, Operation And Maintenance of International River Improvement, 1955, 3-4 Elizabeth II, Chapter 47.

[44]For British Columbia's objections, see the testimony of R.W. Bonner before the Standing Committee on External Affairs, Minutes of Proceedings and Evidence, Nos. 8, 9, and 10. Wednesday, April 27, Thursday, April 28, and Friday, April 29, 1955, pp. 263-461.

[45]This was evident as early as 1956, see M. Barkway, "Ottawa Strenghtens Hand in Fight for B.C. Power," Financial Post, July 21, 1956, p. 11.

power.[46] Hence, the federal government's position was that the Canadian share of the downstream power benefits be returned to British Columbia.

The premier of British Columbia, however, had a different idea. As early as 1956, Bennett had become convinced of the desirability of developing the Peace River area of interior British Columbia, and he was of the opinion that this aim could best be achieved with the help of the hydroelectric power that could be made available by exploiting the power potential of the Peace River. Thus, in February of 1957, the British Columbia Government entered into an agreement with a Swedish financier, Axel Wenner-Gren, under which the Wenner- Gren B.C. Development Corporation undertook to spend $5 million to survey the resources of 40,000 square miles of the Peace River area. The Corporation was supposedly prepared to invest $500 million in developing

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[46]Under the Electricity and Fluid Exportation Act of 1907, the export of electricity was subject to a license, the maximum term of which was one year. The policy underlying this Act was to prevent the permanent export of power in any great quantity. In 1938 this principle was reaffirmed under the Electric Power Bill which transferred to Parliament control of all exports of electrical power except in the case of a national emergency. (For a brief history of applications for export of power, debates,prohibitions, etc., see the House of Commons Debates, 3rd Session, 18th Parliament, Vol. 11, 1938, pp. 1191-1236). This policy continued in force until the enactment of the National Energy Board Act in 1959 which permitted exports of power for up to 25 years. However, it was not until the announcment of a National Power Policy in 1963 (see note 49, infra, page 36) that there was any substantial departure from the previous restrictionist attitudes toward large power exports.

these resources, especially the water resources of the Peace River.[47] The original survey was carried out, but for some undetermined reason the venture collapsed in 1960. Its failure corresponded with British Columbia's agreement to commence serious negotiations toward developing the Columbia.

From the very beginning of these negotiations, Ottawa-Victoria dealings were handled by the Canada-B.C. Policy Liason Committee. However, even before actual negotiations began it was evident that the two governments were seeking different goals. British Columbia wanted the development of the Columbia to be tied to that of the Peace, and the sequence of projects envisaged by the province differed from that advocated by the federal government. Ottawa favoured the Dorr Diversion plan with the consequent storages in the East Kootenay. British Columbia, however, was not willing to negotiate on the basis of these latter projects because of the large amount of flooding involved.

These basic differences contributed substantially to the delay in the negotiations, and it was only after Ottawa accepted the British Columbia position that unofficial agreement was reached between Canada and the United States in late 1960. As soon as the fundamentals of this agreement were worked out, the federal government offered to

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[47]For details of the Wenner-Gren scheme see the various articles in the Financial Post, Vol. 51, February 16, 1957, p. 14; Vol. 51, October 19, 1957, p. 10; Vol. 52, September 20, 1958; and Vol. 53, September 5, 1959, p. 8.

participate in financing the Canadian part of the development. However, since this would have meant relinquishing some degree of control over the development, British Columbia decided to develop both the Peace and the Columbia by itself.

This "two-river policy", as it became known, had first been enunciated during the 1960 election campaign during which time there were suggestions to the effect that Peace power at Vancouver would be considerably more expensive than power from the Columbia. To clear the matter up, the British Columbia Energy Board, in December 1960, was assigned the task of collecting comparative information on the Columbia and Peace River power projects. The Board's report concluded that under the assumptions used the cost of power from the two sources would be approximately equal.[48]

It was evident from this report that, for consumers in British Columbia to derive the maximum benefits from their extensive hydroelectric resources, there would have to be some integration and coordination, of power development not only within the province itself but also between the province and Alberta and between the province and the Northwestern United States. In the event that the Peace and Columbia were to be developed jointly, it was evident

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[48]British Columbia Energy Board, Report on the Columbia and Peace Projects. (Victoria, B.C., July 31, 1961), p. 5.

also, that there would be a surplus of power and that if this surplus was to be sold in the United States, then it would be the downstream power benefits of the Columbia that would be the most logical choice to sell, since they were closer to the potential market and would require relatively less transmission costs.

The implications of the Board's report for the economic development policies of British Columbia were immediately apparent, and any uncertainty about the development of the Peace River was dispelled when the province expropriated the B.C. Electric Company, the privately owned utility serving the lower mainland. The power supply for customers in British Columbia would now be decided by government policy, which meant, ultimately, Peace and not Columbia power. This gave the province a superior bargaining position from which to confront Ottawa. If the provincial market (the only market) was to be satisfied by power from the Peace, then the downstream power benefits produced by the cooperative development of the Columbia could only be sold in the United States. Faced with this situation plus growing pressure from the United States to ratify the treaty, the federal government's only alternative was to change its

policy with regard to the export of hydroelectric power.[49]

This change in policy cleared the way for agreement between Victoria and Ottawa (preliminary meetings to this end were held in April of 1962), and in July of 1963, the governments of British Columbia and Canada signed a "Main Agreement" under which the rights and obligations of the province were clearly defined, and provisions were further made for the effective implementation of all the arrangements contemplated in the Columbia River Treaty.[50]

V. THE PROTOCOL AGREEMENT

At the same time, negotiations were taking place between representatives of British Columbia, Canada and the United States with regard to the sale of Canadian downstream benefits.[51] Early in

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[49]This change of policy was subsequently announced on October 8, 1963. In outlining the new National Power Policy the Minister of Trade and Commerce (Mitchell Sharp) stated:

> "...the Government has decided to develop and carry forward effective policies embracing two essential concepts; first, encouraging development of large low-cost power sources and the distribution of the benefits as widely as possible through interconnections between power systems within Canada; second, encouraging power exports and interconnections between Canadian and United States power systems where such induce early development of Canadian power resources." (House of Commons Debates, 1st Session, 26th Parliament, Vol. IV, 1963, p. 3301).

[50]Canada-British Columbia Agreement, July 8, 1964 (Referred to as the Main Agreement). A supplementary agreement was signed on January 13, 1964. Both of these documents are reproduced in The Columbia River Treaty, Protocol and Related Documents, op. cit., pp. 104-109.

[51]Meetings to this end were held in September, October and December of 1962.

1963, the Prime Minister of Canada and the President of the United States agreed to initiate discussions on a Protocol embodying "clarification and adjustments" of the treaty arrangements necessitated by criticisms of the treaty in Canada.[52] The resulting Protocol agreement,[53] incorporated a number of suggested improvements which helped to remove many of the original objections to the treaty.

The Protocol devised new procedures for Canadian participation in determining the need for any flood control requested by the United States, in addition to that covered by the initial payment (Paragraph 1); it eliminated treaty standby transmission charges over the thirty year period of sale of Canada's downstream benefits Paragraph 4 (1); it confirmed Canadian control over the operation of treaty storage for power purposes (Paragraph 7); it provided for increasing Canada's downstream entitlement (Paragraph 8); it reconfirmed Canada's right to divert water at any time for consumptive purposes (Paragraph 6); and it provided for a simultaneous exchange of notes for ratification and completion of the initial sales agreement, thereby insuring a

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[52]See, in particular L. Higgins, "How Chaos Came to the Columbia", Saturday Night, Vol. 77, No. 11, May 25, 1962, pp. 25-27; and "The Columbia River Treaty: A Critical View", International Journal, Vol. 18, No. 2, Spring 1963, pp. 148-65.

[53]"Annex To Exchange of Notes Dated 22 January 1964 Between The Governments of Canada And The United States Regarding The Columbia River Treaty," in The Columbia River Treaty, Protocol and Related Documents, op. cit., pp. 111-14.

market for Canadian downstream benefits (Paragraph 3).

As well as confirming the Canadian desire to sell her downstream benefits, the Protocol established the terms of this sale under which Canada was to receive a lump sum payment of $254.4 million (U.S.) upon ratification of the treaty.[54] Moreover, since the agreement included no right of renewal of the sales contract, Canada was assured of recapturing any downstream benefits remaining after the period of sale.[55]

The signing of the exchanges of notes agreeing to the Columbia River Treaty and Protocol took place in Washington on January 27, 1964, and the agreement was finally ratified formally by Canada on September 16 of the same year.

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[54]See, Attachment Relating to Terms of Sales, ibid., pp. 117-20.

[55]According to a "Background Paper" Prepared for the Canadian government, these benefits would continue after the period of sale at approximately 1.7 billion kilowatt-hours annually, having a value to Canada of $5 to $10 million annually (see, ibid., p. 135.)

CHAPTER II

THE ECONOMICS OF WATER RESOURCES DEVELOPMENT

The public development of water resources has been a policy issue in this country for well over a century at both the provincial and federal levels of government.[1] The policy approach, however, at both levels, has tended to be rather pragmatic and it is only within the last decade or so that economics has come to play a larger role in the policy-making process. Confirmation of this trend is to be found in the rising volume of literature about water economics and related fields that has emerged since the mid-1950's.[2] By far the greatest part of this literature has been devoted to the activity generally known as "benefit-cost analysis." The basic techniques of

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[1]The first legislation governing water use in British Columbia, for example, was contained in the "Goldfields Act" of 1859 which enunciated the principal of beneficial use. (For a brief history of water use legislation in British Columbia see the testimony of R.W. Bonner before the Standing Committee on External Affairs, Minutes of Proceedings and Evidence, No. 8, Wednesday, April 27, 1955, pp. 281-4.) In 1894 the federal government enacted a bill replacing the riparian rights doctrine in the Northwest and giving control of the assignment of water rights to the Department of the Interior. (See the Annual Report of the Department of the Interior, Canada 1894, I., p. 29.)

[2]For an annotated bibliography covering most of the important works see, United States Department of the Interior, Office of Water Resources Research, Bibliography on Socio-Economic Aspects of Water Resources. Prepared by the Battelle Memorial Institute (Washington, D.C.: U.S. Government Printing Office, March 1966.)

this particular form of analysis have a long history and, in the past fifteen years, have been fairly highly developed by economists in the United States.[3]

The purpose of this Chapter, however, is not to provide an exhaustive survey of the literature of benefit-cost analysis since such surveys already exist,and the basic tenets of the traditional form of benefit-cost analysis are well known.[4] Rather, the purpose here is to outline briefly the methodology of project evaluation involved in benefit-cost analysis and to point out some of its shortcomings as an investment criterion. An alternative criterion, "development strategy" is then discussed. This latter alternative, while in some circumstances competitive with benefit-cost analysis and in others complementary, is argued to have more relevance to both the Columbia River development and to the future development of water resources in Western Canada.

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[3]Benefit-cost analysis has, of course,been used fairly extensively in Canada as well. For a bibliography of some published Canadian studies see, W.R.D. Servell, et. al., Guide to Benefit-Cost Analysis. (Resources for Tomorrow), (Ottawa: Queen's Printer, 1962), pp. 47-8. The Guide, in fact, grew out of the desire to make the techniques of benefit-cost analysis more applicable in the Canadian situation.

[4]For an recent well written survey see, A.R. Prest and R. Turvey, "Cost-Benefit Analysis: A Survey," Surveys of Economic Theory: Resource Allocation. Prepared for the American and Royal Economic Associations, (Toronto: MacMillan, 1966) Vol. III, pp. 155-207.

I. THE METHODOLOGY OF PROJECT EVALUATION

The process of investment involves the allocation of current resources, which have alternative uses, to productive activities whose benefits in terms of goods and services accrue at some point in the future. The costs of such investment consist of the goods and services foregone in order that the investment be undertaken, and the investment is considered justified, or economically feasible, only if its anticipated benefits exceed its costs. Essentially, benefit-cost analysis provides a criterion for choosing among investment projects to determine which are economically feasible and which are most desirable, i.e., which of a number of projects designed to serve a given purpose results in the largest net benefits.

In a general sense, the nature and scope of the benefits and costs of a particular water development project are clearly evident: The benefits consist of the gains which accrue to those people who will make use of the goods and services provided by the project; the costs are equal to the value of the goods and services that must be sacrificed to construct, operate and maintain the project. Benefits and costs, however, do not necessarily, nor do they usually occur together. Rather, they occur over time and, then, generally unevenly. A large part of a project's costs, especially its investment or capital costs, typically occurs at the outset of the project's construction, while its benefits do not usually accrue until after the project is

completed and put into operation.

The process of project evaluation involves comparing the time-stream of its benefits that accrue throughout its "economic life"[5] with the time-stream of its costs over the same period. To do this, both benefits and costs must be converted to a common point in time, and, since in most cases the benefit and cost streams differ in duration and profile, this can only be accomplished by assigning a single measure of value to each time-stream. In benefit-cost analysis this is done by discounting the future benefits and costs to their present value using a particular rate of interest or discount.

In practice, however, a number of problems are involved in determining the appropriate rate of discount to be used,and before discussing these it might be best to examine the actual mechanics of project evaluation. To simplify the exposition the following assumptions are made.[6]

1) that the rate of discount is given as i;

2) that the projects's economic life is given as n years;

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[5]The "project" or "economic" life is defined as the period over which useful benefits can be derived from the project.

[6]The exposition here is based on that given in J.S. Bain, et al., Northern California's Water Industry. (Baltimore: John's Hopkins, 1966) pp. 255-63. Bain's discussion of investment criteria is an excellant synthesis of benefit-cost analysis.

3) that the present value of all the project's benefits over its economic life is equal to B, where $B = \sum_{j=1}^{n} \frac{b_j}{(1+i)^j}$, and b_j is a series of prospective benefits in years 1, 2, 3, ..., n;

4) that the present value of all of the project's costs over its economic life is equal to C, where $C = I_o + \sum_{j=1}^{n} \frac{O_j}{(1+i)^j}$, I_o is the initial investment in capital equipment,[7] and O_j is a series of prospective costs for operation, maintenance and replacement in the years 1, 2, 3, ..., n;

5) that no budgetary constraints exist;[8]

6) that there is perfect certainty as to future costs, benefits, prices, etc; and

7) that the scale of the project (as will most likely be the case) can only be increased in discrete increments.

Given these assumptions, then, over a range for which $B > C$ is reached (the point at which the project becomes economically feasible) the project scale should be extended to the point at which $\triangle B$ for the last increment of scale just exceeds $\triangle C$ incurred by

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[7] In this case I_o would represent the present value of the capital costs of the project which would normally be incurred during the first few years to the end of the actual project construction, rather than being spread over the entire life of the project.

[8] In many cases of public investment such constraints are likely to be operative and their existence makes project evaluation considerably more complicated. For the effects of these constraints on the evaluation procedure see Bain, et al., op. cit., pp. 265-7.

adding that increment. Once this point is reached, however, no further increments should be added for which $\triangle B < \triangle C$. Ideally, the project should be separated into as many successive increments as technology and natural conditions permit, and the addition of each successive increment should be justified by showing that for it $\triangle B > \triangle C$ once a range where $B > C$ is reached.

If the decision-making authority is not constrained by any limitations on the funds to be used for water resources development, then presumably it would undertake all of those projects which are economically feasible and which have been designed to their optional scale. In fact, however, public investment in water resources may be subject to budget constraints. In such cases, assuming that the scales of all eligible projects are given and that it is the annual budget for capital outlays that is fixed, then the authority would (if there were no restraint on future operating costs) rank projects in the descending order of $(B - O) / I_o$, where $O = O_o + \sum_{j=1}^{n} \frac{O_j}{(1+i)^j}$, undertaking projects until its annual capital budget was exhausted.[9]

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[9]In actual practice, however, it would not be quite so simple. See Bain, et al., op. cit., p. 266. The problem of project selection subject to budget constraints is discussed throughly by Stephen A. Marglin, "Economic Factors Affecting System Design," Design of Water-Resource Systems. A. Maass, et al. (Cambridge: Harvard University Press, 1962) pp. 159-92.

II. SOME PRACTICAL PROBLEMS IN PROJECT EVALUATION

A. The Choice of a Discount Rate

The rate of interest used in project evaluation performs a complex function and its exact magnitude is crucial because it can affect the types of projects undertaken, their scale, total number, and, ultimately, the total amount of a community's investment in water resources development.[10] The choice of the appropriate rate of interest is complicated by the fact that it serves more than one purpose in benefit-cost analysis - not only does it enable the comparison of benefits and costs at a common point in time, thus balancing future against present consumption, but it also serves as a measure of the opportunity cost of the investment that is displaced by the necessity of providing resources for the project in question. The problem is further complicated by the fact that in evaluating a public resource development the rate of interest must reflect the time preference and opportunity cost of the community as a whole. If the economy was

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[10] It has been estimated, for example, that "if a planning authority uses a 3 per cent discount rate rather than a 5 per cent rate on a project yielding benefits over fifty years, it is approximately equivalent to a 40 per cent difference in the estimates of the costs and benefits. A difference of $\frac{1}{2}$ of 1 per cent in the discount rate on a fifty-year project is roughly equivalent to a difference of $8\frac{1}{2}$ per cent in the estimate of costs and benefits." (G.L. Reuber and R.J. Wonnacot, The Cost of Capital in Canada. Washington, D.C.,: Resources for the Future, 1961, p.3.

perfectly competitive, as is implicitly assumed by the criteria outlined above, then presumably, a single rate of interest would exist that measured both the social time preference (society's evaluation of the worth of the benefits at different points in time) and the social opportunity cost (the measure of the value to society of the next best alternative use to which funds employed in the public project might otherwise have been put). As it is however :

> Conditions for a welfare maximum are not likely to be fulfilled throughout the economy ... (and) ... no single rate of interest will fulfill both functions simultaneously; in a non-optimal world there are two things to be measured and not one. [11]

Much of the writing on benefit-cost analysis has been devoted to the problem of choosing the appropriate rate of interest . One way of solving the problem, suggested by Feldstein, is that it would be best to allow for the social opportunity cost of directly placing a shadow price on the funds used in the project and then to make all intertemporal comparisons with a social time preference rate. [12]

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[11] Prest and Turvey, op. cit., p. 158.

[12] M.S. Feldstein, "The Social Time Preference Discount Rate in Cost Benefit Analysis, " Economic Journal, Vol. LXXIV, June 1964, pp. 360-79.

Unfortunately, however, there is as yet no way in which this suggestion can be practically carried out. Other ways of determining the social rate of discount have also been suggested,[13] but according to Prest and Turvey such notions have yet to find their way into actual empirical analyses.[14] In most cases, the rate of discount is arbitrarily chosen from the observed rates of interest ruling at the time evaluation is carried out. In a specific study done on the cost of financing the Columbia River development, the opportunity cost rate for public funds was calculated to be within the range of 4-5½ per cent,[15] and in the absence of any really valid criteria for choice it would seem that something of this order was appropriate.[16]

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[13]S.A. Marglin, "The Social Rate of Discount and the Optimal Rate of Investment", Quarterly Journal of Economics, Vol. 77, 1963, pp. 95-111.

[14]Prest and Turvey, op. cit., p. 171-2.

[15]Reuber and Wonnacott, op. cit., p. 84.

[16]Although he does not address this question directly, this is the range of rates used by Krutilla in his study of the Columbia River. See, J.V. Krutilla, The Columbia River Treaty: The Economics of an International River Basin Development.(Baltimore: Johns Hopkins, 1967).

B. THE ESTIMATION OF A PROJECT'S ECONOMIC LIFE

The estimation of the length of the period over which a project's costs are spread and over which its benefits must be evaluated is, in absence of perfect certainty, a highly subjective process since different assumptions about life periods may be appropriate for various types of projects. These assumptions depend to a large extent upon the physical facilities involved and the length of their physical life, and upon technological changes, changes in demand, changes in competing outputs, etc. If a high rate of discount is used in computing benefits and costs, errors in estimating the length of project life are likely to be less significant than if a low rate of discount is used. For, if it is assumed that the significant period of economic life is that in which most (say 90 per cent) of the cumulative present value of the project's benefits are obtained, then with a high rate of discount the significant period is relatively short, while with a low rate of discount it is longer.[17]

C. THE SIGNIFICANCE OF PRICES AND PRICE LEVELS

In quantifying benefits and costs, some assumptions must be made about what prices are used to value the inputs and outputs of a project because it is likely that the prices of inputs (outputs) used in

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[17]Sewell, et al., op. cit., pp. 16-17.

evaluating costs may change over time relative to those used for evaluating benefits, or vice versa. All prices, nevertheless, must necessarily be calculated on the same basis. However, where a project is large enough to significantly alter the prices of the inputs and outputs involved (as must certainly have been the case over the period when the Columbia and Peace were being developed at the same time) a general difficulty arises as to how to measure the consumers' or producers' surplus. Normally, the choice is between using current prices, i.e., those prices prevailing without the project, and the anticipated price levels, those prices prevailing with the project. Use of the former, however, will lead to overvaluation of the outputs and undervaluation of the inputs, while use of the latter would lead to the opposite. Traditional benefit-cost analysis, because it is based on the competitive theory of resource allocation, normally values inputs and outputs at the market prices prevailing when the project is being evaluated. Where the effects of one project are allowed to affect the framework in which other participants in the system make decisions, however, one of the basic assumptions of perfect competition is violated. Hence, some adjustments will be necessary, and in such cases benefit-cost analysis must turn "to modified efficiency concepts adopted to the specific case."[18]

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[18]Marglin, "Objectives of Water Resource Development: a General Statement", in Maass, op. cit., p. 58. This point is discussed more fully below. (infra , pp. 59-62). See also, Prest and Turvey, op. cit., 163-4.

D. BENEFIT ESTIMATION

Investment in any particular water development project may be undertaken for a single purpose - one of irrigation, navigation, recreation, wildlife improvement, fish preservation, pollution abatement, domestic, municipal and industrial water supply, flood control, or hydroelectric power - or for a multiple of purposes. Project evaluation requires that the benefits from each of the project purposes be set out in detail along side of the costs incurred to attain these benefits. Of course, the details of such benefits and costs quantification differ for each project purpose, but the main problems in this area revolve around benefit estimation. It is not our purpose here to provide a discussion of all of the problems involved in measuring the benefits of each of the project purposes mentioned above. But, since the most important purposes of the Columbia River development were hydroelectric power and flood control, we will deal with procedures for analyzing these purposes in some detail.[19]

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[19]For a fairly complete discussion of the assumptions and procedures involved in identifying and measuring the effects of the other project purposes and a guide to some of the literature on the subject, see Sewell, et al., Guide to Benefit-Cost Analysis, op. cit., p. 23-30.

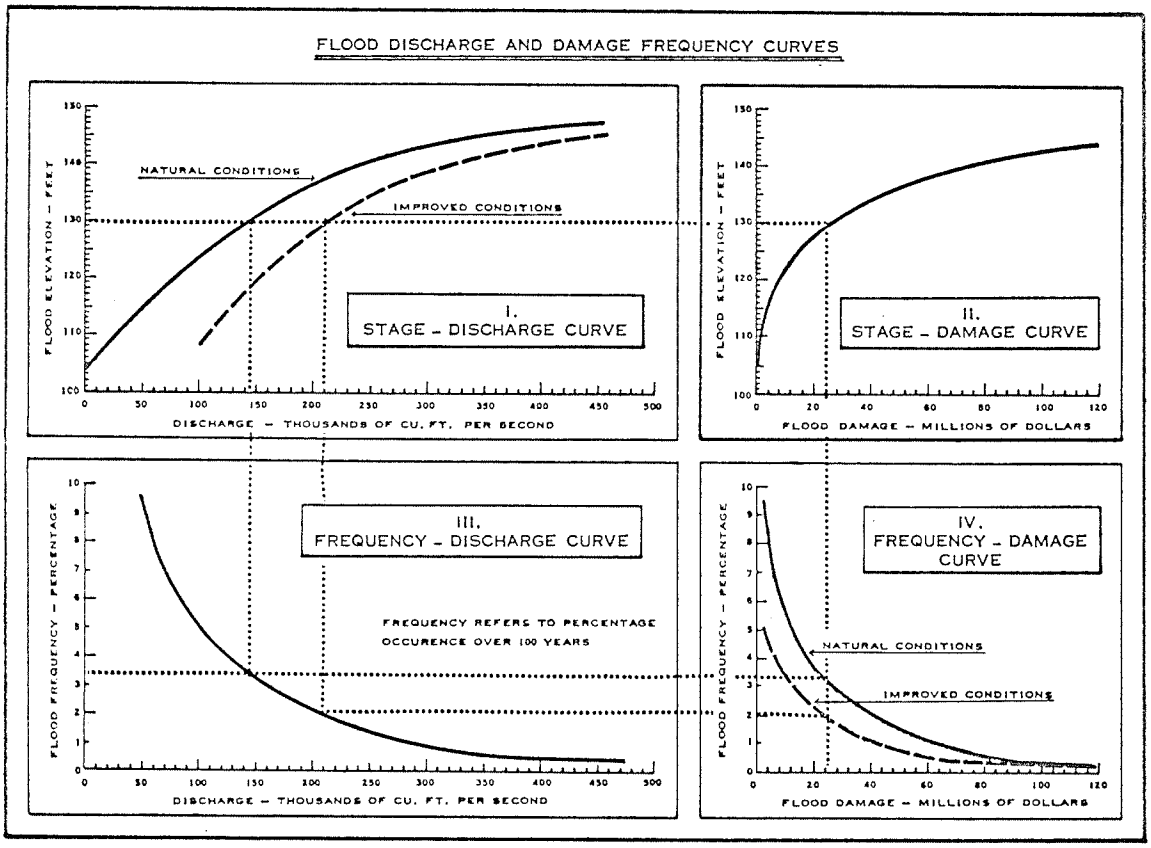
1. FLOOD CONTROL

In general, the benefits of flood control can be categorized in terms of the losses averted. They are represented, therefore, by the reduction in all forms of damage resulting from inundation of land, buildings and property; by the reduction or prevention of indirect damages such as the disruption of business and other activity, loss of income, dislocation of markets, and the interruption of public services; and by reduction in the hazards to health, security and loss of life.

Essential to the evaluation of flood control benefits is the ability to measure the physical problems of flood extent and flood frequency. The frequency of flood levels, as determined from historical records of streamflow is used to estimate the mathematical expectation of annual damage over the project life. The average annual flood damages are determined from a series of graphs: A stage-discharge graph showing the water elevations reached with various flows; a stage-damage graph showing the extent of damage at various water elevations; a frequency-discharge graph showing how often various levels of flow are expected; and a frequency-damage graph (compiled from the first three graphs) showing how often various amounts of damage can be expected (See Figure 1). The total damage, or the average annual damage, can then be compared in the situation with flood protection and in the situation without flood protection. The benefits attributable

to the particular measure or project providing the flood protection is equivalent to the difference between the two damage figures.[20]

Figure 1



Source: W.R.D. Sewell, et al., Guide to Benefit-Cost Analysis. Resources for Tomorrow (Ottawa: Queen's Printer, 1962) p. 24.

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[20] Ibid., pp. 23-24.

Adequate flood control measures can also lead to greater land utilization and property values may be considerably enhanced. The benefits attributable to such "land enhancement" occur in the form of the increased net earnings of the land,and if measured properly they represent real gains that should be incorporated in benefit estimates.[21]

2. HYDROELECTRIC POWER

The benefits of a hydroelectric power development are equivalent to the amount that users would be willing to pay for the power in the absence of the project. In general, these benefits are measured either by estimating the revenues expected from the sale of the power or energy or by estimating the costs of power or energy[22] produced by some alternative means. Private utility companies selling their power directly to consumers would use the first method, while public agencies or publicly owned utility companies are more likely to

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[21]For a detailed discussion of the measurement of the benefits of land enhancement, see Robert Lind, "Flood Control Alternatives and the Economics of Flood Protection", Water Resources Research, Vol. 3, 1967, pp. 345-57.

[22]Power is actually a measure of the rate of doing mechanical work, and electric power, which is equivalent to energy divided by time, is expressed in kilowatts. Energy is a measure of the amount of mechanical work, expressed in kilowatt hours, and is equivalent to power multiplied by time. Power benefits may be calculated in terms of prime power - the average rate at which hydroelectric power can be generated during the critical streamflow period; firm power - determined by dividing prime power by the load factor; or secondary power - that generated in excess of firm power during periods other than the critical streamflow period.

employ the latter method.[23] There is, according to one author, however, a great deal of "fuzzy folklore" surrounding the use of the alternative cost method,[24] especially since it is usually considered that alternative cost sets an upper limit to benefits.[25] Systematic examination of the role of alternative cost in project evaluation, however, has shown that in some cases alternative costs substitute for benefits; in others they provide upper limits to benefit attribution; and in still others they provide minimum target levels that benefits must reach before project selection can take place.[26] In the case of the development of hydroelectric power, if the alternative to a public project is some other public project, then a comparison of costs may eliminate all but one of the projects. However:

> The benefits attributable to a specific governmental action will be limited by the costs of alternative governmental action, but that limitation neither limits the benefits of some governmental action nor does it avoid the necessity of showing absolute merit (benefits greater than cost) of the best public project.[27]

For the purpose of generating hydroelectric power, storage provides improvement in the generation of power at site and in the operation of downstream plants by controlling the release of stored

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[23]This is the position taken in Sewell, et al., Guide to Benefit-Cost Analysis, op. cit., p. 24.

[24]P.O. Steiner, "The Role of Alternative Cost in Project Design and Selection", in A.V. Kneese and S.C. Smith, (eds) Water Research (Baltimore: Johns Hopkins, 1966), pp. 33-47.

[25]For example, see Sewell, et al., op. cit., p. 5.

[26]Steiner, op. cit., p. 34. Some of the difficulties of this method are also pointed out by Prest and Turvey, op. cit., pp. 161-62.

[27]Steiner, op. cit., p. 46.

waters during the dry season. This controlled flow increases the power output of downstream plants creating what have become known as "downstream benefits". The problem of evaluating such benefits is complicated by the necessity, within a power or river system, of assigning a proportion of the benefits to the various structures responsible for their provision. The extent of the downstream benefits can be determined by a comparison of the system output with a new storage project and the system output without the project. Various methods have been used to assign these benefits to individual plants, but none of these is entirely satisfactory.[28]

E. UNCERTAINTY

In the criteria outlined above, perfect certainty with regard to future physical yields, costs, prices, etc., was assumed and the removal of this assumption (which must be done in the practical application of the criteria) raises a number of problems which in order to be solved, again requires the modification of benefit-cost analysis. According to Prest and Turvey, allowances for uncertainty can be made in three different ways: First, in the assessments of the annual level of benefits and costs; second, in the assumptions about the length of the project's economic life; and third, in the choice of the appropriate

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[28]This problem, as discussed in Chapter I, is at the heart of the Columbia River development and is discussed more fully in Chapter III.

discount rate. And accordingly:

> The first is the most appropriate if the risk of dispersion of outcomes (or inputs) is irregularly, rather than regularly distributed with time. If the main risk is that there may be a sudden day of reckoning when benefits disappear or costs soar, the second type of adjustment is needed. The third correction, a premium on the discount rate, is appropriate where certainty is strictly a compounding function of time.[29]

However, none of the suggested methods of adjusting for uncertainty is completely satisfactory since all introduce an arbitrary bias into particular aspects of benefit cost analysis which, as we have seen,already call for highly subjective judgements.

F. PROJECT SEQUENCE AND TIMING

The conclusion of our discussion of the criteria in Part A (above) was that, in the absense of budgetary constraints, all economically feasible projects would be built, and built to their optimal scales. The criteria, however, provided no indication as to when a particular project could be optimally undertaken, or, in the case of a sequence of projects, when each project could be added so as to maximize the benefits obtained from the sequence as a whole. Presumably, any project that could be built now could also be built (say) five years from now, and it is quite possible that building the project then may result in a larger net capital value since its benefits,

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[29]Prest and Turvey, op. cit., p. 171.

which may not be in much demand over the next five years, might not be reduced by the same amount as it costs. There is a general problem involved, then, as to when each project could best be built in the context of optimal "dynamic investment programming." In practice, the solution to this problem involves complex considerations, especially where budget constraints exist.[30] Where such constraints do not exist, the solution is somewhat more simple:

> Each project should be constructed in that year (and thus built at once or deferred, as the case may be) in which its construction will result in the greatest excess of ... (B)... over ... (C) ... as discounted to the present year zero. Thus, not all projects for which ... (B) ... would exceed ... (C) ... if constructed immediately should be built immediately. Some, and perhaps many, should have their construction deferred so as to maximize their present net capital values. If this rule is followed, there will be an optimal allocation of investment over time as well as among alternative uses.[31]

When project evaluation involves determining the optimal sequence of projects in a particular development, as was the case in the Columbia River development, the problem becomes even more difficult.

The sequence in which storage projects are added in a hydroelectric system is important because equal additional increments of storage will ultimately produce diminishing incremental power

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[30]See S.A. Marglin, Approaches to Dynamic Investment Planning (Amsterdam: North Holland, 1963) where the problem of optimal investment in water resource development over time is discussed in detail.

[31]Bain, et al., op. cit., p. 264.

benefits - as the amount of storage in a system grows the drawdown period lengthens, so that a given volume of stored energy produces a smaller gain in prime power.[32] The situation is similar in respect to flood control: equal additional increments of storage provide only diminishing incremental effectiveness, in terms of discharge reduction, as storage projects are added to an existing system of flood control management. The evaluation procedure under these conditions is:

> To simulate the evolution of the system over time, introducing storage projects in each combination in the various possible permutations and comparing the net benefit of each. The combination of projects in that sequence which provides the greatest present worth of net benefits will be the system which is superior, on economic criteria to all the others.[33]

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[32]The "critical drawdown period" is the period between the beginning of storage drafting from full pool elevations to the end of the refilling operation. The average generation over this "critical period" fixes the prime power capability of the system. "Prime power" then, is simply the average rate at which hydro power can be generated during the critical period.

[33]Krutilla, The Columbia River Treaty: The Economics ..., op. cit., p.55. Krutilla provides an excellant discussion of the economic attributes of storage with respect to the Columbia River. (pp. 31-56).

III. BENEFIT-COST ANALYSIS AS A DECISION-MAKING CRITERION

The "benefits" and "costs" which benefit-cost analysis purports to evaluate have meaning only in an abstract sense; they have a concrete significance only if they are defined in terms of a specific objective. The principle objective of the traditional form of benefit-cost analysis is the achievement of "economic efficiency", defined as that "situation in which productive resources are so allocated among alternative uses that any reshuffling from the pattern cannot improve any individual's position and still leave all other individuals as well off as before".[34] More specifically, in the context of water resources development, economic efficiency "identifies a proposed design as economically efficient if no alternative design would make any member of the community better off without making other members worse off."[35] But, regardless of how it is stated this objective is that of achieving a Pareto optimium; an objective which is most typically identified with the analysis of public resources development because the economist's framework for measuring efficiency in this sense is more highly

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[34] J.V. Krutilla and Otto Eckstein, Multiple Purpose River Development (Baltimore, John Hopkins, 1958,), p. 16.

[35] Marglin, "Objectives of Water Resource Development: ...," op. cit., p. 20.

developed than for other objectives. The existence of other objectives, of course, is well recognized, and these include the redistribution of income, the promotion of economic growth and development, the amelioration of fluctuations in trade, prices and employment, and a host of other considerations.

Various attempts have been made to incorporate these other objectives into the framework of traditional benefit-cost analysis. None, however, have been overly successful in terms of practical evaluation procedures. The most usual way of trying to account for objectives other than economic efficiency has been to set up a function designed to maximize efficiency benefits minus efficiency costs, treating other desired objectives as constraints. This is the approach taken by Marglin.[36] However, his analysis is performed under strictly limiting competitive assumptions - the absence of external effects, non-deviation of prices from marginal costs, and independence of prices throughout the economy from the scale of development - and, although he does attempt to describe the effects on his analysis of the removal of these assumptions, his conclusion in regard to the redistribution of income objective is that "widespread departures from these assumptions will, as under the efficiency framework, render our benefit-measurement framework non-operational."[37]

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[36] Ibid., pp. 17-87.

[37] Ibid., p. 85-6.

Another suggestion is that, instead of trying to maximize efficiency subject to constraints which are other desired objectives, benefit-cost analysis could better try to maximize a function in which the desired objectives are given various weights.[38] The problem with such an approach is that the weighting process would by necessity be extremely arbitrary and, coupled with the one dimensional (efficiency) view of welfare, may tend to produce, in Eckstein's words, " a meaningless hodge-podge, or a slighting of all objectives other than expected tangible output".[39] For a multiple objective function to be operational, techniques as refined as those for measuring efficiency costs and benefits would have to be developed for other objectives as well. Then, perhaps, as Maass has suggested, the maximization equation could be solved by specifying a "trade-off ratio" established through the political process.[40]

The major difficulty in the traditional benefit-cost approach to public investment decisions is, in the words of Prest and Turvey, " the inapplicability of investment decision rules derived from a perfectly competitive state of affairs to a world where such a competitive

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[38]Otto Eckstein, "A Survey of the Theory of Public Expenditure Criteria," in J. Buchanan (ed.), Public Finances: Needs, Sources and Utilization (Princeton: Princeton University Press, 1961), pp. 446-9.

[39]Ibid., p. 448.

[40]A. Maass, "Benefit-Cost Analysis: Its Relevance to Public Investment Decisions," Quarterly Journal of Economics, Vol. LXXX, May 1966, p. 210.

situation no longer holds."[41] Benefit-cost analysis is basically a private market criterion, and this together with the unrealistic assumptions upon which it is based, means it has only limited relevance in evaluating the validity of programmes designed primarily to redistribute income or to promote economic development, because such programmes depend upon considerations that can neither be expressed nor recorded in the private market:

> Benefit-cost analysis can provide little assistance in answering the vital question of what kinds of public investment to encourage and what to curtail in cases where the objective of government activity is anything more than a duplication of that undertaken in the private sector of the economy.[42]

It is the opinion of this author, although it might be difficult to prove empirically, that benefit-cost analysis has seldom been used by policy-makers as a decision criterion anyway, and that its role has been largely limited to that of a screening device. This is not necessarily a reason to condemn benefit-cost analysis, for it could be argued that the inclusion of all secondary effects and objectives other than efficiency within the traditional frameworks may not be an impossible task. However, in view of the existing deficiencies already in this framework, it may be more fruitful to explore a different approach to public investment criteria, particularly where it has been established that

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[41] Prest and Turvey, op. cit., p. 165.

[42] L.G. Hines, "The Hazards of Benefit-Cost Analysis as a Guide to Public Investment Policy," Public Finance, Vol. 17, 1962, pp. 101-17.

the main objective of public investment is not solely the attainment of economic efficiency.

The way in which one interprets benefit-cost analysis depends to a large extent upon what role is assigned to government investment in the economy. If one is considering water resource development within the context of a relatively advanced economy such as the United States, where, as Marglin argues, the competitive assumptions have considerable validity[43], then perhaps benefit-cost analysis is an adequate investment criterion. If on the other hand, the economy in question is one which is in an "underdeveloped" or "developing" stage such as Canada, perhaps, where a principle concern of public policy is the promotion of economic growth, then a "development strategy"[44] approach may be a better criterion on which to evaluate public investment in water resource development. In the latter situation, it is argued that there are a number of ways in which the private sector does not perform well, and that because the government can make its decisions on grounds which are different from those used by market decision-makers, it can achieve a higher fulfillment of national

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[43]See Marglin, "Objectives of Water-Resource Development: ...," op. cit., p. 59.

[44]See Timothy King, "Development Strategy and Investment Criteria: Complimentary or Competitive?" Quarterly Journal of Economics, Vol. LXXX, February 1966, pp. 108-20. The name of this approach, "development strategy" is derived from the title of a book by A.O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1958)

objectives than could the private sector acting on its own criterion. That is, the development strategy approach "considers a major task of a government of a developing country to be the stimulation of the private sector to act where it would otherwise fail to do so."[45]

There are several ways, of course, in which the private sector does not perform well at all, and the action of the government sector is demonstrably superior to that of the private sector in providing collective goods and services (such as flood control) and in controlling natural monopolies (such as the generation and distribution of hydroelectric power). Furthermore, in terms of the development strategy approach to public investment, it is precisely by such action that the government sector hopes to induce complementary activities in the private sector so as to lead to a greater degree of economic development.

While in Canada most of investment activities are undertaken by the private sector, public investment, nevertheless, has played a major constructive and initiative role in the past and is likely to continue to do so in the future. This is not to say that the government has any general control over investment, but rather that it is accepted, particularly in the development of natural resources such as water, that some control may be necessary and socially desirable. There are, moreover, few areas of production in Canada from which government investment

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[45]King, ibid., p. 110.

activity is traditionally excluded, and since, as we will see in discussing the Columbia River development, the promotion of economic growth in Canada is at least as important as economic efficiency, the development strategy approach may indeed be a better criterion of investment than benefit-cost analysis.

The way in which government investment seeks to attain this developmental objective is through the external effects that such investment has in the private sector. These effects may be "technical" in the sense that the outputs from a public investment project change the production functions of private firms, or they may be "pecuniary" in the sense that they alter the opportunities for profits within the private sector, either by changing the demand curves for the private sector's outputs or the supply curves for its inputs. However, it is in trying to evaluate these "spillover" effects of public investment that benefit-cost analysis runs into its biggest problems. This point is illustrated particularly well in the treatment by benefit-cost analysis of "secondary benefits" - i.e., benefits other than "efficiency benefits" accruing from a water development project. There has been considerable discussion in the literature about how secondary benefits should be included in project evaluation.[46]

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[46]Some economists have scoffed at the evaluation of such benefits. See, in particular, R.N. McKean, Efficiency in Government Through Systems Analysis. A RAND Corporation Study (New York: Wiley, 1958) pp. 151-67. Other economists have suggested that secondary benefits not be considered at all if the aim of benefit-cost analysis is project selection. See, S.V. Ciriacy - Wantrup, "Benefit-Cost Analysis and Public Resource Development", Journal of Farm Economics, Vol. XXXVII, November 1955, pp. 1181-96.

Prest and Turvey's conclusion is that the problem concerning "secondary benefits"is primarily a matter of second-best allocation problems. In traditional benefit-cost analysis, however, as it is conducted in the field at least, this factor is often neglected, and as Lipsey and Lancaster have shown, following the rules for efficient allocation when optimal conditions are not completely applicable (as is likely to be the case in an economy like Canada's) is not likely to lead to a situation of second best.[47] Thus, while the secondary effects of government investment may be the primary reason for which such investment is undertaken, benefit-cost analysis, at least as it is usually conducted, is rarely capable of evaluating the importance of such effects on the promotion of economic growth. For situations where the secondary effects of public resource development are of primary importance, King sums up the case for a development strategy very well:

> The contrast between development strategy and benefit-cost analysis is marked by the fact that this difficulty about benefit-cost analysis, resulting from the prevalence of pecuniary external effects, is the main route by which development strategy operates. Thus a project in which government action has the greatest effect on prices of

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[47] R.G. Lipsey and Kelvin Lancaster, "The General Theory of Second Best," Review of Economic Studies, Vol. XXIV, 1956-57, pp. 11-32.

> factors and outputs, and thus on the profit making alternatives open to the private sector, is one where benefit-cost analysis, is hardest to apply but where such action has the greatest impact on the economy, and development strategy the greatest chance to work.
>
> In summary, not only does benefit-cost analysis postulate an unsatisfactory goal as the principal national economic objective, but it also fails to see government investment as the creative and constructive force it could be in promoting development in a mixed economy. Development strategy, on the other hand, can exploit especially those areas with which the competitive theory of efficient resource allocation cannot cope adequately. This approach accepts, as benefit-cost analysis does not, that government is a unique type of decision-maker and seeks to use this uniqueness rather than to impose constraints on its action similar to those under which the private sector operates. Benefit-cost analysis has its origins in a system in which a need for government action is assumed away at the start; ... it is only when considering questions of development strategy that we have an approach suited to the type of economy predominant among underdeveloped (and developing) countries today.[48]

The development strategy approach, then, recognizes that the criteria or procedures used to evaluate a public investment project or programme should reflect, not only the objective function of the government, but also the way in which the government is expected to achieve its objective. However, because investment under such an approach is deliberately intended to be disequilibrating, the problems involved in determining even the direction and magnitude of such investment on the achievement of stated government objectives would be very great. To date, sophisticated techniques comparable to those of benefit cost analysis have not been developed to enable the evaluation

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[48]King, op. cit., p. 119.

and selection of projects in terms of the development strategy approach, and such a task is quite beyond the scope of this paper. The important point here is that perhaps economists have been misdirecting their efforts in trying, as King claims, to impose constraints on the government sector similar to those of the private sector; perhaps a more fruitful approach would be in trying to devise investment criteria which are capable of recognizing the constructive and unique role of government investment in the economy, and which can measure the "benefits" and "costs" of such investment in terms of the developmental objective.

Intuitively, at least, the development strategy approach makes a lot of sense, especially since it has already been recognized that the broad outlines of water resources development in North America have been determined not by an economic efficiency approach alone, but also by the view that the abundance of water resources has been and will continue to be a dynamic factor in fostering economic and social development.[49] The course of public water resource development is determined not only by economic forces, but by public viewpoints based on complex social and political factors as well. Much research is needed into the public decision-making process. If the developmental

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[49]In relation to this point see, Irving, K. Fox, "Policy Problems in the Field of Water Resources," in A.V. Kneese and S.C. Smith (eds.), Water Research (Baltimore: Johns Hopkins, 1966) pp. 271-89.

view turns out to be more important and more prevalent than a strict efficiency view, then, in the future we will need a public investment criterion based on some sort of development strategy. Traditional benefit-cost analysis, of course, would not be eliminated, but it would be, perhaps, only part of the evaluation process. It is the contention of this paper that it was the developmental view that was strongest, at least on the part of the Canadian authorities, in the Columbia River case, and also that it is this view that is likely to have a major effect on the development of water resources in Western Canada in the future.

CHAPTER III

THE ECONOMICS OF THE COLUMBIA RIVER EXPERIENCE: A CANADIAN EVALUATION

In the preceding chapters we have discussed the events leading up to and surrounding the signing of the Columbia River Treaty, as well as some of the theoretical aspects of the economics of developing water resources. In this Chapter the Columbia River experience is discussed in terms of the principles outlined in Chapter II; an attempt is made, on the basis of available data, to select the "most efficient" system of development for the Columbia; this system is compared to the system under the treaty; and some conclusions are drawn as to why the treaty system was selected.

I. THE VIEWPOINT OF ANALYSIS

There are three distinct viewpoints involved in the Columbia River development, provincial, national and international, and a fair assessment of the broad social objectives behind the development would be that they involved, as well as economic efficiency, some notion of the promotion of economic growth. The traditional benefit-cost criterion is consistent with the first objective, but evaluation of the second would require analysis in terms of the development strategy approach discussed above. A preliminary judgement of the Columbia River experience, from what we have said so far, would be that much of the misunderstanding

surrounding this development and the variety of opposing views encountered are due chiefly to the failure of most analyses of the development to specify clearly and explicitly the viewpoints and objectives upon which they are based. By the same token, whether the treaty is judged "good" or "bad" depends upon the viewpoints and objectives upon which such a judgement is based. The situation can be clarified somewhat by examining, first of all, the various viewpoints involved and the objectives that might be associated with these viewpoints.

A. THE INTERNATIONAL VIEWPOINT

It can be logically argued that the intention of the original Columbia River reference was that subsequent cooperative development be carried out from an international (or what has alternatively been designated "comprehensive" or "integrated") viewpoint. The basic tenet recognized by this approach is that the hydrologic unity of the basin in planning and development will result in greater net benefits than could be derived from the independent development of the separate parts of the basin. The logical consequence of such an approach is that there is a division of labour between the various parts of the basin, for example, in the case of the Columbia, storage upstream and power generation downstream. This is the type of approach that has come to

be regarded in many quarters as the ideal approach to water management;[1] it is also the approach that was at least implied when the International Joint Commission was asked, "to determine whether a greater use than is now being made of the Columbia River System would be feasible and advantageous";[2] and this was the approach also, from which International Columbia River Engineering Board's study[3] was subsequently undertaken; and finally, this approach was evident in the United States and Canadian governments' request to the International Joint Commission to establish a set of principles to be used in determining and dividing the benefits of cooperative development.[4]

The objective most commonly associated with this integrated or international viewpoint is economic efficiency, and this is the objective that is clearly expressed in the International Joint Commission's "Principles". For example, under the heading, "Selection of Projects", it is stated:

> It would be consistent with customary practice to give first consideration to those projects that are most attractive economically as reflected in the ratio of benefits to costs. ...If projects are developed successively to meet the growing needs for power production and to provide flood protection, the most efficient projects for those purposes should generally be developed first in order to maximize the net benefits to each country.[5]

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[1] W.R.D. Sewell, Comprehensive River Basin Planning: The Lower Mekong Experience. The University of Wisconsin Water Resources Center, June 1966.

[2] Appendix 1, infra , p. 121.

[3] Water Resources of the Columbia River Basin, op cit.

[4] Supra, p. 19, n. 24.

[5] See Appendix 3, infra , pp. 125-6.

Then we have General Principle No. 1:

> Cooperative development of the water resources of the Columbia River Basin, designed to provide optimum benefits to each country, requires that the storage facilities and downstream power production facilities proposed by the respective countries will, to the extent it is practical and feasible to do so, be added in the order of the most favourable benefit-cost ratio, with due consideration of factors not reflected in the ratio.[6]

There can be little doubt that this principle, in spirit at least, reflects the criterion of economic efficiency as outlined in the preceding chapter.[7]

B. THE UNITED STATES' VIEWPOINT

Water resources development in the United States portion of the Columbia River basin has already been discussed briefly. The 1958 report of the Corps of Engineers[8] outlined a "Major Water Plan" for this area which included the Libby dam as one of the principal flood control and power projects. Although Canadian projects for upstream storage were mentioned[9], they were not included as part of the proposed system.

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[6] Ibid., p. 126.

[7] Its rather awkward wording, however, has given cause for substantial misinterpretation. See Krutilla, The Columbia River Treaty: The Economics of an International River Basin Development, op. cit., pp. 59-67.

[8] Water Resources Development, Columbia River Basin. A report by the Division Engineer, U.S. Army Engineers, Division North Pacific, to the Chief of Engineers, United States Army. (Portland, June 1958) Volume 1.

[9] Ibid., pp. 128-30.

The criteria of project evaluation used by the Corps of Engineers generally corresponds to the objective of economic efficiency. Basically, their method of economic appraisal involved the use of a "justification ratio" which compared the contribution of each project to system power plus its non-power benefits, with its costs; a "benefit-cost ratio" which compared each project's alloted share of its contribution to system power, with its costs; and a "last-added check" which was to test the incremental economic feasibility by comparing benefit with cost, considering the project to be last added to the system.[10] In general, however, strict attention was not paid to project sequence; neither was specific attention paid to the optimal project scale, and there is no evidence to suggest that the rate of discount used was in any way calculated to reflect the social time preference and the social opportunity cost (as defined in the previous Chapter).

As far as the cooperative development of the Columbia was concerned, the United States' approach was something less than "comprehensive", since there was a prior commitment to the inclusion of the Libby dam in any such development. At the same time, the authorities in that country were certainly not unaware of the stimulus that such development would have on the economy of the Pacific Northwest.[11] The United States seems also to have been motivated in

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[10] Ibid., pp. 66-69.

[11] See, The Columbia River Treaty, Hearings before the Committee on Foreign Relations, op. cit., p. 45.

negotiating the treaty to satisfy other objectives as well.

> We were anxious that this agreement operate to progressively reduce power costs in British Columbia; firstly and obviously, because if there was going to be an agreement it had to operate in that direction for the Canadians; secondly, we regard Canada as a partner in the free world, and its growth, its economic growth, as being important to the United States.[12]

C. THE CANADIAN VIEWPOINT

We have already discussed the basic disagreement between the governments of Canada and British Columbia with regard to the objectives to be sought in developing the Columbia. In the early stages of the negotiations between Canada and the United States, Canada, it is true, envisaged an international development with the projects in British Columbia providing the storage and the developed head in the United States providing the large blocs of power. However, once it was decided that the responsibility for developing the Columbia rested squarely with the province, the provincial objectives prevailed and the Canadian viewpoint became that of British Columbia. Because the province never did subscribe to the so-called international approach, it will be worthwhile to examine its objectives in some detail.

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[12]See the statement of Ivan B. White to the Senate Foreign Relations Committee, The Columbia River Treaty, ibid., p. 33.

D. THE BRITISH COLUMBIA VIEWPOINT

The province of British Columbia is well endowed with water resources[13] which, particularly for purposes of power generation, are favoured by a high rate of precipitation; a mountainous terrain, which enhances considerably the numerous opportunities for high-head developments; and, in some instances, by possibilities for utilizing even greater head by diverting flow from one watershed to another.[14]

By 1960, most of the small sites near the load centre in the southern part of the province were developed, the energy requirements of the province were increasing rapidly,[15] the development possibilities of the resource rich interior were becoming more and more evident, and it was clear that the expanding load of the province could be met only from large power developments. Against this background, the

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[13] See, Canada Department of External Affairs, A Presentation, op. cit., p. 17, where the undeveloped hydroelectric resources in B.C. are estimated to total 33,845,000 kilowatts. However, inventory of these resources is not yet complete and the final total may be two or three times this amount. (See Minutes of Proceedings and Evidence, op. cit., No. 5, April 13, 1964, pp. 282-83).

[14] In addition to the potential diversion of the Kootenay and the Columbia which have already been discussed, possibilities exist for diverting from the Fraser system via the Chilko River to the Homathko or Southgate Rivers, and from the headwaters of the Yukon to the Taku river, among others.

[15] Between 1945 and 1962, B.C.'s energy requirements increased five times, and it was estimated that by 1985 these requirements would be five times the 1962 total of 15 billion kwh. (Minutes of Proceedings and Evidence, op. cit., No. 7, Appendix F, p.447.)

policy objectives of the British Columbia government with regard to the general development of the province's hydroelectric resources were:

> To develop British Columbia's economic hydro power resources as rapidly as possible by encouraging increased use of electrical energy in the province and by seeking markets elsewhere in Canada and the United States; to reduce the cost of electrical energy in British Columbia to the greatest extent possible, by developing the best projects and sequence of projects first.[16]

With regard to the development of the Columbia, these objectives were made more specific:

> To provide for the maximum economic development of the Columbia in Canada; to obtain the largest possible share of downstream benefits in the United States which would result from the development of the Columbia River in Canada, while retaining control of the Columbia river and its tributaries for future Canadian requirements: and to achieve these objectives with the minimum disturbance to existing settlements, transportation facilities and resource values.[17]

The province felt, and rightly so, that since it had jurisdiction over the water resources of the Columbia, and because it had accepted the responsibility for developing these resources, that it should also be responsible for deciding as to the economic limit of such development. It did not feel, however, that this responsibility extended to an international or comprehensive approach to the development of the Columbia basin. In the words of one government official:

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[16]Ibid., No. 5, April 13, 1964, p. 283.

[17]Ibid., p. 281.

> A practical consideration of Canadian interests cannot ignore the existence of the international boundary ... [Hence] ... as a policy stand ... the British Columbia government took the position that we would store in British Columbia as much water as we could economically be paid for in the United States, and once we determined the amount of water which the United States was willing to pay us for then we got to the stage of placing that water in reservoirs to the maximum advantage of the province of British Columbia.[18]

The province, then, was committed, not to maximizing the gains of cooperative development for mutual sharing between Canada and the United States, but to maximizing the gains that might accrue to Canada alone, i.e., to the province of British Columbia. This objective, however, was but part of the larger objective of promoting the economic development of the interior. Criticism of the province's decision to develop the Peace and Columbia Rivers jointly was welcomed:

> It provides an opportunity for defending the Columbia river treaty arrangements in the context in which they should be defended, which is within the whole pattern of power development policy for British Columbia .... The Peace project did have some advantages to British Columbia which were not measurable [in terms of the cost of power produced] ... Foremost among these is the contribution which it is expected to make to the development of Central and Northern British Columbia. Low-cost power has never been available in this region which with its abundance of natural resources appears to be on the threshold of rapid expansion. The development of this area is a primary objective in British Columbia's economic development policy and should, therefore, be a primary objective in British Columbia's power policy.[19]

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[18] Minutes of Proceedings and Evidence, ibid., pp. 231 and 323.

[19] Ibid., pp. 290 and 292.

In summary, the Columbia River experience provides a case study to examine some of the economic aspects of water resources development, particularly the dichotomy between traditional benefit-cost analysis and development strategy discussed in Chapter II. From the international point of view, planning and design of the basin system would best be accomplished by the comprehensive approach and its related objective of economic efficiency, if indeed this was the principle purpose of cooperation. In British Columbia's case, however, it was not economic efficiency that was the prime objective; rather the "best" program of development had to be one consistent with the provincial government's economic development policy. The Columbia River development, then, may be better examined in terms of a development strategy approach. The following sections of this Chapter examines the optimal efficiency basin system; the treaty system; the differences between the two; and why the treaty system was chosen. The final section attempts to determine if the projects to be built in Canada under the treaty are in any sense (developmental or efficiency) optimal from the point of view of the province of British Columbia.

II. THE OPTIMAL BASIN SYSTEM

Although the water resources of the Columbia River Basin could have been developed for a variety of purposes, the most tangible use was for the production of hydroelectricity. The first consideration, then, was the provision of storage capacity, particularly in the upper

part of the basin, to impound flows during the period of high runoff (May to July) to be used to increase flows during the period of low natural flow - that is, during the winter when the peak demands for power in the region also occurred - for production of power and also for the reduction in flood damage downstream. The I.C.R.E.B. report identified three preliminary plans for such development, each of which contained a number of potentially economic sites designed to utilize as much of the head as possible.[20]

Table 5 lists the comparative data on the various elements of these preliminary plans. Sequences VII, VIII, IX, and IXa, correspond respectively, to the Non-Diversion plan, the Copper Creek Diversion plan, the Dorr Diversion plan, and a variant of the Dorr plan which was favoured by General McNaughton. Sequence IXa differs from Sequence IX in that "High Arrow" dam is eliminated and storage at Murphy Creek is increased to 3.1 million acre-feet. Sequence VII would allow the Columbia and the Kootenay to flow in their natural channels; Sequence VIII and IX, however, would divert an annual average of about 3,600 and 8,000 cubic feet per second (2.6 and 5.8 million acre-feet), respectively, into the Columbia from the Kootenay River. As a result, Sequences VIII, IX and IXa were alternatives to each other as well as to the Non-Diversion plan.

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[20]The proposed sites included in each of these plans can be seen in Illustration 2, supra , p. 14.

TABLE 5

ELEMENTS CONSIDERED FOR PRELIMINARY PLANS OF DEVELOPMENT

	SEQUENCE VII				SEQUENCE VIII				SEQUENCE IX				SEQUENCE IXa			
	Usable storage ac. ft. ('000)	Gross Head ft.	Investment Cost ($000)	Annual Cost ($000)	Usual Storage ac. ft. ('000)	Gross Head ft.	Investment Cost ($000)	Annual Cost ($000)	Usable Storage ac. ft. ('000)	Gross Head ft.	Investment Cost ($000)	Annual Cost ($000)	Usable Storage ac. ft. ('000)	Gross Head ft.	Investment Cost ($000)	Annual Cost ($000)
Bull River	2,794	201	83,600	3,740	-	-	-	-	-	-	-	-	-	-	-	-
Dorr[2]	-	-	-	-	-	-	-	-	881	(-74)	35,900	2,030	881	(-74)	35,900	2,030
Libby	4,045	340	324,800	13,740	4,045	340	312,800	13,170	-	-	-	-	-	-	-	--
Long Meadows	400	193	26,900	1,340	400	193	26,900	1,340	400	193	26,900	1,340	400	193	26,900	1,340
Duncan Lake	1,000	-	24,800	1,100	1,000	-	24,800	1,110	1,400	-	24,800	1,100	1,400	-	24,800	1,100
Kootenay River Plants	1,028	353	40,800	2,140	1,028	353	40,800	2,140	1,028	353	2,400	160	1,028	353	2,400	160
Bull River-Luxor	-	-	-	-	-	-	-	-	3,996	90	10,000	4,830	3,996	90	110,000	4,830
Copper Creek-Luxor	-	-	-	-	2,275	110	54,400	2,490	-	-	-	-	-	-	-	-
Calamity Curve	-	-	-	-	-	120	33,000	1,650	-	120	38,200	1,960	-	120	38,200	1,960
Mica	11,685	566	302,400	13,400	11,685	566	314,800	14,070	11,685	566	327,200	14,740	11,685	566	327,200	14,740
Downie Creek	-	257	123,500	6,070	-	257	138,900	6,860	-	257	146,600	7,260	-	257	146,600	7,260
Revelstoke Canyon	-	169	104,400	5,280	-	169	116,900	5,960	-	169	123,200	6,300	-	169	123,200	6,300
Arrow Lakes	5,165	-	66,400	3,010	5,165	-	66,400	3,010	5,165	-	66,400	3,010	-	-	-	-
Murphy Creek	2,834	77	94,900	4,990	2,834	77	94,900	4,990	2,834	77	94,900	4,990	3,100	77	103,500	5,350
Libby[3]	-	100	-	-	-	100	-	-	-	-	-	-	-	-	-	-
Kootenai Falls	-	160	98,000	4,450	-	160	92,500	4,150	-	-	-	-	-	-	-	-
TOTAL	28,951	2,416	1,290,500	59,260	28,432	2,465	1,317,100	60,930	27,389	1,751	996,500	47,740	23,440	1,651	938,700	45,090

[1]Investment cost includes all construction costs plus interest at 3 per cent for one-half the construction period.

[2]Includes both Dorr(Power) and Dorr (Pumping).

[3]This project was not included in the selected plans of development.

Source: Water Resources of the Columbia River Basin. Report to the International Joint Commission by the International Columbia River Engineering Board, 1959, pp. 66 - 97.

The economic studies made by the I.C.R.E.B. of the various plans were directed primarily toward demonstrating that all of the elements included in each of the preliminary plans were "worthy of consideration for construction".[21] Since the determination of specific benefit-cost ratios was "beyond the scope" of the report, however, it was decided that a project would be considered justified if its estimated costs were less than some or all of its tangible benefits. Power benefits were the largest of the total benefits that could be credited to each project, and as a first step, power benefits alone were assigned to each project. If the power benefits exceeded the annual costs of the project it was assumed justified; if not, a further test was applied to include flood control benefits,and if the projects's benefits still did not exceed its costs,then it was eliminated.[22]

Power benefits were assigned to each project by prorating between storage and head plants. This was done on a somewhat arbitrary basis: no order of development was assumed; all projects were assumed to be constructed and operated in 1985 as a fully coordinated and interconnected system which, in turn, was assumed to be operated to meet the 1985 estimated energy load with a minimum amount of thermal installation and generation; and each element of the

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[21] Water Resources of the Columbia River Basin, op. cit., Appendix VI, p. 1.

[22] Ibid.

various plans was assigned a proportionate part of the total system power outputs (energy and capacity) based upon the estimated contribution of each element in meeting the total load requirements.[23] Thus, although the existence of an incremental method of analysis was recognized[24] no attempt was actually made to consider sequence and timing in the scheduling of when each project was to be built.

The construction costs of the proposed projects included those for the dam and power house, necessary lands, easements and rights-of-way, relocation of railroads, highways, bridges and utilities, and for engineering design, construction supervision, and contingencies. The investment cost of each project was obtained by adding interest at 3 per cent for one-half the construction period. Annual costs, including operation maintenance and replacement costs, were based on interest at 3 per cent and a 50 year amortization period.[25]

No attempt was made in the report to extend each project to its optimal economic size; rather, "the individual elements of the plans were designed to permit maximum useful (power) output under a coordinated plan of operation".[26] For purposes of determining power benefits, the unit value of the hydro power produced was assumed equal to the cost of production by the cheapest alternative means, which was

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[23] Ibid., p. 3.

[24] Ibid., p. 6.

[25] Water Resources of the Columbia River Basin, Appendix VI, ibid., pp. 1 - 2.

[26] Ibid., p. 2.

thermal generation.

For purposes of flood control, the total benefit creditable to upstream reservoirs for the amount of storage that would control the 1894 flood to 800,000 cubic feet per second was calculated to be $23,750,000. These benefits were assigned to each project, again, not with regard to sequence and timing, but by the "system-benefit distribution method" by which the total benefits from achieving the basic flood-control objective were prorated equally to each acre-foot of effective storage needed to achieve that objective.[27]

Because the methods used by the I.C.R.E.B. differ considerably from what has been outlined as the traditional benefit-cost criteria for project evaluation, the data of Tables 5 to 9 are not really sufficient for comparative evaluation. The I.C.R.E.B. was not able to choose between the preliminary development plans on the basis of their own analysis, but the data does give some indication of which is the most efficient. From Table 7, a comparison of Sequences IX and VII shows that the latter is inferior, not only because it yields less power (32 mw and 20 mw respectively, over the critical and 20 year periods), but also because it entails an increase in investment cost of $294.0 million. The same conclusion emerges from Table 8

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[27] Ibid., p. 6.

TABLE 6

INCREASE IN AVERAGE POWER OUTPUT OVER BASE SYSTEM

Sequence	During Critical Period (mw)	During 20 year Period (mw)
VII	9,118	8,038
VIII	9,220	8,168
IX	9,150	8,058
IXa	8,960	7,862

Source: Water Resources of the Columbia River Basin. Report to the International Joint Commission, prepared by the International Columbia River Engineering Board, 1959, p. 98.

TABLE 7

COMPARISON OF SEQUENCE IX WITH OTHER SEQUENCES

	Increment of Sequence VII over Sequence IX	Increment of Sequence VIII over Sequence IX	Increment of Sequence IX over Sequence IXa
Investment Cost ($'000)	294,000	320,600	57,800
Annual Cost ($'000)	11,500	12,190	2,650
Average Power Output			
Critical Period	- 32	70	190
20-Year Period	- 20	110	196

TABLE 8

COMPARISON OF PRELIMINARY PLANS FOR INTERNATIONAL DEVELOPMENT

Sequence	Annual[1] Cost ($000)	Prime[1] Power (MW)	Firm Energy (10^6kwh)	United Cost of at-site Energy (Mills/kwh)	INCREMENT OF SEQUENCES VII, IX & VIII OVER SEQUENCE IXa			INCREMENT OF SEQUENCES IX AND VIII OVER SEQUENCE VII			INCREMENT OF SEQUENCE VIII OVER SEQUENCE IX		
					Annual Cost ($000)	Firm Energy (10^6kwh)	Unit Cost of at-site Energy (Mills/kwh)	Annual Cost ($000)	Firm Energy (10^6kwh)	Unit Cost of at-site Energy (Mills/kwh)	Annual Cost ($000)	Firm Energy (10^5kwh)	Unit Cost of at-site Energy (Mills/kwh)
IXa	45,090	8,960	78,490	.57	-	-	-	-	-	-	-	-	-
VII	59,260	9,118	79,874	.74	14,170	1,384	10.24	-	-	-	-	-	-
IX	47,750	9,150	80,154	.60	2,660	1,664	1.60	-11,510	280	-41.10	-	-	-
VIII	60,930	9,220	80,767	.75	15,840	2,277	6.95	1,670	893	1.87	13,180	613	21.50

[1]Plans of Development from I.C.R.E.B. Report, pp. 94-5 and 98.

although it is shown in a different way. Here Sequence IX is shown to provide some 280 million kilowatt hours of energy more than Sequence VII, but the cost of this additional energy is 42.5 mills/kwh less. A comparison of Sequences IX and VIII (Table 7) shows that the latter yields the greatest over-all increase in power (70 mw and 110 mw) but that the corresponding increase in investment cost is $320.6 million. Similarly, Table 8 shows that this increment in power is prohibitively expensive (21.5 mills/kwh). Finally, comparing Sequence IX with Sequence IXa (Table 7), it is evident that the former provides a considerably increase in power (190 mw and 196 mw) for a relatively small increase in investment cost ($57.8 million). Table 8 shows that this increment in power is quite cheap (1.6 mills/kwh). The inescapable conclusion, then, is that of the various plans proposed by the I.C.R.E.B., the Dorr Diversion plan (Sequence IX) is the most efficient plan for the basin as a whole.[28]

The importance of the viewpoint of analysis can be illustrated by reference to Table 9, which shows, using the same I.C.R.E.B. data, that the best plan for independent development by Canada is not the same as the best international plan. Under independent development

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[28]There is no way of telling, however, whether the I.C.R.E.B. plans are optimal in the sense of the criteria outlined in Chapter II.

TABLE 9

COMPARISON OF PRELIMINARY PLANS FOR INDEPENDENT CANADIAN DEVELOPMENT

Sequence	Annual[1] Cost ($000)	Prime[1] Power (MW)	Firm Energy (10^6 kwh)	Unit Cost of at-site Energy (Mills/kwh)	Increment of Sequences VIII, IXa, and IX over Sequences VIIIa: Annual Cost ($000)	Firm Energy (10^6kwh)	Unit Cost of at-site Energy (Mills/kwh)	Increment of Sequence IX over Sequence IXa: Annual Cost ($000)	Firm Energy (10^6kwh)	Unit Cost of at-site Energy (Mills/kwh)
VIIa[2]	40,398	2,522	22,093	1.83	-	-	-	-	-	-
VII	43,048	2,549	22,329	1.93	-	-	-	-	-	-
VIIIa	42,944	2,758	24,160	1.78	-	-	-	-	-	-
VIII	45,594	2,785	24,397	1.87	2,650	237	11.18	-	-	-
IXa	47,069	2,962	25,947	1.81	4,125	1,787	2.31	-	-	-
IX	49,719	2,989	26,084	1.91	6,775	1,924	3.52	2,650	137	19.34

[1]Plans of Development from I.C.R.E.B. Report, pp. 94-95 and 102

[2]Sequences designated "a" include Murphy Creek but not High Arrow.

Sequence IXa would be the best plan. The increment in unit-cost of at site energy involved in building Sequence IXa rather than Sequence VIIIa is only 2.3 mills/kwh, while the incremental cost of building Sequence IX is a prohibitive 19.34 mills/kwh.

The above analysis shows, then, that for the basin as a whole the Dorr Diversion plan was the best of the plans considered. However, it was not this plan that was finally chosen under the treaty. The treaty called instead for the construction of only three major dams in the Canadian portion of the basin and first-added credit was given for the 15.5 million acre-feet thus provided. A fourth dam was to be built on the Kootenay at Libby, Montana, which would provide an additional 5 million acre-feet of storage. The right given to Canada to divert specific amounts of water from the Kootenay to the Columbia represents a compromise between the diversion and non-diversion plans.[29] The treaty system was to result in a system increase of 2.45 million kilowatts of prime power and in 1960 the total investment cost of the treaty plan was estimated at $1.160 million (U.S.)[30] .

The immediate question that arises is: Why was the treaty plan selected when the Dorr Diversion plan was the most efficient for the

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[29]See The Columbia River Treaty, Article XIII, (2), (3), (4), and (5).

[30]Analysis and Progress Report: Analysis by U.S. Negotiators of the Report to the Governments of the United States and Canada Relative to Cooperative Developments of Water Resources of the Columbia River Basin, October 19, 1960, (mimeographed) pp. 20 and 22.

basin as a whole? The answer lies in the fact that none of the parties concerned were ever firmly committed to the principle that maximum benefits could only be gained by the integrated development of the basin as a whole. Under these circumstances there are two possibilities of analysis: We could take an international point of view, analyzing the experience with the objective of establishing whether certain assumptions underlying the cooperative development were, in fact, borne out by the actual terms of the final agreement; or, accepting that the principles of comprehensive basin planning were not applied, we could elect to analyze the experience to determine if Canada, or British Columbia, at least, succeeded in maximizing its net benefits (efficiency or developmental) in undertaking the development. The remainder of this chapter is concerned with the latter possibility of analysis.

III. SELECTION OF THE TREATY SYSTEM

Canada's position, toward the cooperative development of the Columbia River, can be summed up as follows:

> When Canada considered entering into a cooperative undertaking for the development of the Columbia River basin, great care had to be taken to ensure that the alternative or "best uses" of the river in the national interest were never lost sight of when considering the international advantages.[31]

Canadian considerations, then, revolved around determining first, the most favourable combination of projects which would provide the

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[31]Canada, Department of External Affairs, A Presentation, op. cit., p. 36, See also, supra, pp. 54-55.

best use of the power resources of the Upper Columbia in the national interest of Canada. Careful study of some thirty project locations by the federal Water Resources Branch eliminated all but the Luxor, Calamity Curve, Mica Creek, Downie Creek, Revelstoke Canyon, and Murphy Creek sites on the main stem of the Columbia, which, it was estimated, would develop almost 90 per cent of the 1350 feet of total head available in Canada. At the same time it was recognized that the further 44 feet of head that could be developed at the outlet of Arrow Lakes might be important in any cooperative development.[32] Studies were also undertaken of the Copper Creek, Bull River, Duncan Lake, and Canal Flats projects on the Kootenay River. A series of studies was then carried out to assess the economic desirability of the various schemes for Kootenay, and it was concluded that a diversion with the structure located at Canal Flats was the most favourable scheme.[33]

Because of the possible advantage to Canada that construction of the proposed Libby project might entail, detailed studies were then undertaken reviewing and re-analyzing the various Kootenay diversion proposals. The four combinations of projects, or plans of development

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[32]Water Resources in the Columbia River Basin in Canada: Investigations of the Water Resources Branch, April 1964; and Minutes of Proceedings and Evidence, op. cit., No. 3, April 9, 1964, Appendix "C", pp. 182-97.

[33]Minutes of Proceedings and Evidence, No. 3, Thursday April 9, 1964, Appendix "C", op. cit., Table 2, p. 190.

finally considered then were designated as (1) Non-Diversion Plan, (2) Canal Flats Diversion Plan, (3) Copper Creek Diversion Plan, and (4) Dorr-Bull River Diversion Plan. The first two plans assumed the existence and operation of the Libby project while in the remaining two plans the Libby project would be precluded by diversion of almost the entire flow of the Kootenay. Comparison of these four plans produced the results shown in Tables 10 and 11, which indicate that the best use of the Columbia in Canada for power purposes would be the limited diversion at Canal Flats, requiring only a low, relatively inexpensive structure.[34]

These studies, of course, suffer from many of the same limitations, in terms of the criteria outlined in Chapter II, as the I.C.R.E.B. studies: No attempt was made to find the optimal economic project scale, and, most important, the sequence and timing of project construction was not considered.

At the same time, however, an attempt was made to compare the impact on the economy of the basin of the Canal Flats plan with that of the maximum diversion plan (Dorr-Bull River). The latter, while it would produce a considerably greater amount of firm hydro energy (3,679 million kwh) involved extensive flooding, and it would also have reduced the flow to the downstream plants of the Consolidated Mining and Smelting Company (Cominco) in the West Kootenay where 375 feet

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[34]This conclusion was also supported by two independent studies, one by Crippen Wright and one by Montreal Engineering. These sd studies are summarized in Canada Department of External Affairs, The Columbia River Treaty, Protocol and Related Documents, op. cit., pp. 154-56.

TABLE 10

COMPARISON OF DEVELOPMENT PLANS FOR INDEPENDENT CANADIAN SYSTEM ORGANIZATIONS

(Based on 20-Year Output Studies)
(1928-1948)

	ANNUAL FIRM ENERGY[1]				ANNUAL COST				ENERGY
	Firm Hydro Energy At-Site M Kwh	Firm Hydro Energy At-Load M Kwh	Firm Thermal Energy At-Load M Kwh	Total Firm Energy At-Load M Kwh	At-Site Cost[2] $1,000	Trans-mission Cost[3] $1,000	Thermal Cost[4] $1,000	Total Annual Cost $1,000	Cost At-Load Mills/Kwh
Non-Diversion (Study No. 24/1)	20,411	19,186	3,458	22,644	57,094	28,779	17,290	103,163	4.56
Canal Flats Diversion (Study No. 43/2)	20,980	19,721	2,923	22,644	57,444	29,581	14,615	101,640	4.49
Copper Creek Diversion (Study No. 51/3)	22,610	21,253	1,391	22,644	64,069	31,880	6,955	102,904	4.54
Dorr-Bull River Diversion (Study No. 61/6)	24,900	22,644	0	22,644	70,222	33,966	0	104,188	4.60

[1]Energy outputs from Water Resources Branch power output studies.

[2]At-site cost derived from I.C.R.E.B. estimates and adjusted to $5\frac{1}{2}\%$ interest.

[3]Average system cost for transmission assumed at 1.5 mills/Kwh of energy delivered at Vancouver.

[4]Based on capacity factor of 65%, capital cost of $120.00 per kw of installation and fuel cost of 2.7 mills/Kwh.

Source: Minutes of Proceedings and Evidence, Standing Committee on External Affairs, House of Commons, Second Session, Twenty-sixth Parliament, No. 3, Appendix "C", Thursday, April 9, 1964, p. 192.

Table 11

COMPARISON OF DEVELOPMENT PLANS FOR INDEPENDENT CANADIAN SYSTEM OPERATION
(ON THE BASIS OF FIRM ENERGY OUTPUT UNDER 1985 CONDITIONS)

Development Plan	Annual[1] Cost $1,000	Firm[2] Energy M Kwh	Unit Cost of at-site Energy Mills/Kwh	Increment Over "Non-Diversion" Plan" Annual Cost $1,000	Firm Energy M Kwh	Unit Cost of at-site Energy Mills/Kwh	Increment Over "Canal Flats Diversion Plan" Annual Cost $1,000	Firm Energy M Kwh	Unit Cost of at-site Energy Mills/Kwh
Non-Diversion (W.R.B. Study No. 1)	57,094	20,411	2.80	-	-	-	-	-	-
Canal Flats Diversion (W.R.B. Study No. 2)	57,444	20,980	2.74	350	569	0.62	-	-	-
Copper Creek Diversion (W.R.B. Study No. 4)	64,069	22,610	2.83	6,975	2,199	3.17	6,625	1,630	4.06
Dorr-Bull Diversion (W.R.B. Study No. 6)	70,222	24,090	2.91	13,128	3,679	3.57	12,778	3,110	4.10

[1]Annual costs derived from I.C.R.E.B. estimates except for those of Canal Flats Diversion Structure.

[2]Firm energy outputs based on 20-year Power studies of the Water Resources Branch.

Source: Minutes of Proceedings and Evidence, Standing Committee on External Affairs, House of Commons, Second Session, Twenty-sixth Parliament, No. 3, Appendix "C", Thursday, April 9, 1964, p. 193.

of head and already been developed. The growth and economic prosperity of the Kootenay basin was thought to depend largely on the fortunes of Cominco, which, in turn, were seen as being dependent on the continued supply of low cost power. In view of this, there was little doubt that the limited diversion plan, with the prospects of the stream regulation provided by the proposed Libby project, was the best plan for independent Canadian development. The maximum diversion plan would have taken water away from the generators on the Kootenay River in Canada thereby producing power on the upper Columbia and having a less beneficial effect on the economic development of the Kootenay region.[35] Also, the water diverted under the Dorr-Bull River scheme would not produce the added power output in Canada until generators were installed at Mica and at other locations on the Columbia and this was not scheduled to occur for some time owing to the necessity of having to build the Arrow Lakes project first to obtain the "first-added" credit.[36]

Other considerations significant for the economic development of the Columbia basin involved the loss of productive forest, and to a more limited extent, agricultural land. The agricultural factor, however, even though the maximum diversion plan meant the loss of some 70,000

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[35]Canada, Department of External Affairs, A Presentation, op. cit., p. 43.

[36]Ibid., pp. 62-63.

acres more than the limited diversion plan, was less important than the consequent problems of the Dorr-Bull River plan associated with fish and wildlife, recreation, transportation, and the dislocation of settlements. The extent of these latter problems reinforced the conclusion that the maximum diversion plan was less efficient than the Canal Flats plan.[37]

Nevertheless, Canada began negotiations offering those storages which showed the highest ratios of benefits to costs - High Arrow, Mica, Dorr and Bull River - Luxor. It was realized at the time that although the East Kootenay storages might not be the best bargain for Canada, a first-added credit had to be secured for the other storages ahead of Libby. Before the matter actually reached the state of active negotiations, however, the government of British Columbia decided that the Dorr-Bull River-Luxor proposal, with its vast area of flooding and related problems, was unacceptable.

> Accordingly the task became, from the point of view of the Canadian negotiators, to maintain a package which would still be given first-added position and produce a sufficient return in terms of downstream benefits to represent net advantage to Canada ...; to prevent the Libby dam (which has to be permitted if the flood protection of Dorr-Bull river-Luxor is eliminated) from occupying a position which would detract from the benefit attributed to Canadian storages, while at the same time preserving the benefits from Libby in Canada; and to maintain for Canada the rights of diversion of

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[37] Ibid., pp. 49-50. See also, the testimony of R.G. Williston, Minutes of Proceedings and Evidence, op. cit., No. 5, April 13, 1964, pp. 283-85.

> Kootenay into the Columbia if ultimately desired to increase the output of power from Canadian plants on the Columbia.[38]

The Arrow Lakes project had never been seriously considered as an integral part of an independent Canadian system since it is purely a storage project with a very low head. However, it was recognized early that this project would form a major part of any scheme for cooperative development: First, because it had a high benefit-cost ratio and would thus qualify as first-added to the United States base system under the I.J.C. principles;[39] secondly, it would be available physically, because of its short period of construction, in plenty of time to meet the load requirement forecast by the United States; and thirdly, it was argued that it would give Canada greater flexibility in its operation of storage under the proposed treaty.

The Duncan Lake project had been included in almost all of the alternatives of development in an independent Canadian system, and being an integral part of what was considered the "best use" plan, it was felt that the inclusion of Duncan in a cooperatively developed

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[38]E.D. Fulton, Minutes of Proceedings and Evidence, ibid., No. 23, May 11, 1964, p. 112.

[39]See Minutes of Proceedings and Evidence, op. cit., April 7, 1964, pp. 105-6, where the benefit-cost ratios of the different Canadian storages are calculated under various assumptions about the sequence in which they are added to the United States base system. When first-added to the U.S. base system the benefit-cost ratio was calculated to be 1.8 and when second-added after Duncan, 1.6.

system would entail little extra cost to Canada. The real reason for its inclusion in the treaty system, however, seems to be that Duncan, like Arrow, was a useful tool in negotiations because of its high benefit-cost ratio and its short period of construction. From an international point of view, however, the inclusion of the Duncan project in the treaty system may be questioned because in producing downstream benefits and in increasing power production in the West Kootenay, it is directly competitive with the dam at Libby which is also to be built under the treaty.

The Mica project, of course, is one of the most important elements in the whole development. It was recognized at an early stage as being a key project in any independent development of the basin by Canada, although the very size of the Mica complex made its development doubtful. The construction of Mica, then, required that the basin be developed cooperatively and it was essential from a Canadian point of view that it be given a first-added credit. The task of securing this latter aim, however, was complicated by its long (9 year) construction period and also by the fact that its use to Canada as a power producer not be detracted from by its operation under the terms of treaty.

IV. ASSESSMENT OF THE TREATY SYSTEM

According to Krutilla, for mutual benefits to derive from the cooperative development of an international river basin implies that such development will yield, in aggregate, more than the sum of the

yields from purely domestic possibilities developed by each country independently.

> In this respect, there is a community of interest among riparians in which the more closely an economically efficient system design is approximated, the greater will be the joint gains for mutual sharing. Such a community of interest, however, depends upon one or another of two conditions: (a) absolute mutual confidence that each country will refrain from exploiting an opportunity, should it arise in which a larger share of a reduced total net gain might accrue to its advantage, or (b) a precommitment by parties to the principle that economic criteria will govern the selection of sites as well as the design of the system in such a way that no element is included or excluded which prevents the maximum economies in meeting a mutually desired objective.[40]

From our discussion of the Columbia River experience, however, it is apparent that neither of these conditions were met. Both sides entered negotiations with fixed aims as to what they wanted to achieve, and the objectives on neither side could be subsumed entirely under the label "economic efficiency". The United States, for example, was firmly committed to having the Libby project included as part of the treaty even though it could be shown that this project was not the most efficient. The inclusion of the Libby project was advocated, at least partly, because of the beneficial effect it would have on the general economic development of the immediate area.[41] Canada, by the same

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[40]Krutilla, The Columbia River Treaty: The Economics of an International River Basin Development, op. cit., p. 7.

[41]This is evident from the statements of the different Senators for the States directly concerned with the Columbia development. (See, Columbia River Treaty, Hearings before the Committee on Foreign Relations, op. cit., pp. 3, 4, 5, and 28.)

token, was precommitted to achieving the best use of the Columbia in Canada and what ever could be gained over and above this by cooperative development. This attitude, of course, was consistent with the principle expounded by Krutilla, except that Canada was not above exploiting an opportunity to gain at American expense, particularly since Canadians on all sides were calling the proposed treaty a "sell-out". Neither side, however, seemed mainly concerned with maximizing the efficiency benefits of the basin as a whole. Indeed even in the United States much of the desire to secure the cooperative development of the Columbia rested on the beneficial effects it was expected to have on the economic development of the Pacific Northwest.

Canada's position can be better understood when its objectives in the cooperative development are considered in terms of the economic development policies of British Columbia. Given British Columbia's determination to develop the Peace River because of its contribution toward the fulfillment of its development goals, and in the absence of a desire on the behalf of the United States to obtain the benefits of Canadian storages downstream, it seems unlikely that Canada would have undertaken to develop the Columbia independently in 1964. If one considers the other great power producing rivers in British Columbia along with the fact that their development would likely be more compatible with the economic development of the province, then the Columbia River is a marginal resource. British Columbia's desire

to attain as much as it could in terms of its own objectives over and above what the most efficient independent use of the Columbia might have yielded, then, is entirely understandable.

It is not possible, in terms of development strategy, to determine empirically whether or not British Columbia succeeded in maximizing its developmental benefits. It can be shown, however, that the selection of the treaty plan did not maximize B.C.'s potential efficiency benefits. According to Krutilla, the treaty plan yields 28,065.3 million k.w.h. of firm hydro energy at load, and that the annual cost of the plan is $108,129 thousand.[42] Using the same sources of data one can show that the most efficient basin plan (the Dorr Diversion) yields 29,792.9 million k.w.h. at a total annual cost of only $104,188 thousand.[43] If we add to the cost of the treaty plan an additional $8,616 thousand to cover the cost of thermal power needed to make up the power difference between the two plans, then the annual savings in cost to be gained in building the Dorr Diversion is $12,557 thousand.

It would seem, therefore, that if British Columbia "figured with a very sharp pencil" as Krutilla contends,[44] its decision to opt for the treaty plan must have been made on grounds other than efficiency. The choice of the treaty plan can only be reconciled in the light of B.C.'s stated developmental policies. The province indeed indulged in a good deal of "trading-off" - but in terms of development strategy rather than efficiency.

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[42]Krutilla, op. cit., pp. 128-131.

[43]Minutes of Proceedings and Evidence, op. cit., April 9, 1964, Appendix C, Table 3, p. 192.

[44]Kruilla, op. cit., p. 201.

CHAPTER IV

IMPLICATIONS OF THE COLUMBIA RIVER DEVELOPMENT FOR FUTURE WATER RESOURCES DEVELOPMENT IN WESTERN CANADA

Although the Columbia River Treaty was not intended to be a legal precedent, there is nothing in it to prevent the experience gained in developing the Columbia from having far reaching effects on the future development of water resources in Western Canada. The lessons of the Columbia experience will be especially relevant if the course of future water resources development is moulded by the external or international demand for Canadian water and if such development is undertaken cooperatively by Canada and the United States. This Chapter examines alternative courses that future development might take and discusses some of the implications of the Columbia experience in this regard.

I. FUTURE WATER RESOURCES DEVELOPMENT IN WESTERN CANADA

The future development of the water resources of Western Canada, of course, will depend primarily on the supply of and the demand for water in its various uses in this country and perhaps in the United States. The main problem of the future will be the control and redistribution of the available water supply to meet the demands and the location of an increasing population. Theoretically, the available water supply in Western Canada would be equal to the annual runoff. For the settled

and unsettled areas of Western Canada annual precipitation is equivalent to about 1,100 million acre feet (m.a.f.), of which about half or 550 m.a.f. appears as annual runoff.[1] There is, however, a considerable difference between the supply of water theoretically available and that actually available, so that "unless we assume a vast system of regulating reservoirs, which indeed may be available in due course, it is necessary to take the minimum flow as being all that in practice is available to meet the demand."[2] Calculated on this basis, the supply of water available in the settled and unsettled areas of the Prairie Provinces and British Columbia is about 175 m.a.f.[3] If we add to this the 240 m.a.f. that is supposedly available from the Yukon and MacKenzie Rivers[4], then the total "available" supply of water in Western Canada is of the order of 415 m.a.f.

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[1]These estimates are based on the data in an article by D. Cass-Beggs, "Water as a Basic Resource", Resources For Tomorrow, Volume 1, (Ottawa: Queen's Printer, 1961) p. 178.

[2]Ibid., p. 183.

[3]Using the data from Cass-Beggs, ibid., pp. 175 and 179, the available supply (in acre-feet) is equal to the number of square miles multiplied by 640, multiplied by the lowest monthly runoff in inches.

[4]E. Kuiper, "Canadian Water Export", Engineering Journal July 1966 (reprint 8 pp.)

Ideally, projections of the "demand" for water would be projections of the economic demand, i.e., demand in relation to price. Such an approach, however, is beset with a number of difficulties: In the past, price has very often not been significant because water was virtually a free good; the quality of water has a considerable effect on demand, and complications arise since different uses produce changes in the quality of water which, in turn, affect its acceptability for other uses; also, there are two broad categories of demand to be considered - withdrawal uses, such as for irrigation, thermal power generators, industrial use, etc., and non-withdrawal or flow uses, such as for fish and wildlife improvement, recreation, navigation, pollution abatement, etc. When considering problems of physical supply, however, withdrawal uses are probably the most important.[5] In practice, the most common way of estimating water "demand" has been to extrapolate present trends in water use to get an idea of the future "requirements" for the various uses. The total of these requirements is then considered to be the future demand for water.

On this basis various estimates of the long-term water requirements of Western Canada have been made and these range from 15 to

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[5]About 25 per cent of the water used in withdrawal uses in consumed or lost to the current supply (see, Cass-Beggs op. cit., p. 180.) The 25 per cent figure only represents an average, however, since only about 40-50 per cent of water used for irrigation is returned to current supply, while almost all of the water used for industrial cooling, for example, is returned.

80 m.a.f.[6] The important thing, however, is that regardless of what the exact requirements may turn out to be - and they may well be within the range suggested - they will be but a small proportion of the total available supply. The conclusion to be drawn from this brief exposition of water supply and demand is that there will be a considerable surplus of water over the foreseeable future.

However, while ample water exists, it is not evenly distributed over the whole of Western Canada, nor do the sources of water necessarily correspond spatially with the demands for its use. In the past, the exhaustion of local water supplies usually forced the movement of population to other areas where water was readily available. Such is no longer the case, however, since modern science, technology and engineering have made it possible for man to move water economically, over long distances, to where it can be used to his best advantage.[7] The future trend in water resources development in Western Canada, then, is likely to be that, as local supplies of water are appropriated, increased requirements will make large scale diversions necessary. This trend could be reinforced if water shortages were to develop in the United States which could be alleviated by

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[6]See Cass-Beggs, ibid., p. 184 and Kuiper, op. cit., p. 3.

[7]Several examples of large scale diversion already exist. The Frying Pan-Arkansas project in the U.S. will divert water across the mountains from the Colorado River to the Arkansas River in Colorado; the Feather River project will divert surplus water some 750 miles from northern to southern California; and in Canada, the Alcan development at Kemano receives energy from water whose normal flow has been reversed and diverted through a mountain.

importing water from Canada. This latter aspect of future water development has given rise to a modern philosophy advocating the "continental" development and management of North American water resources.

In conjunction with the emergence of this philosophy a number of schemes have recently been put forward which envisage vast movements of water over the whole continent. Two of the largest of these schemes are those proposed by the Ralph M. Parsons Co. and Professor E. Kuiper.[8]

A major feature of the Parsons plan, or the North American Water and Power Alliance (NAWAPA) as it is called,[9] is that water would be pumped to higher elevations in a collection region using locally produced hydro power; the water could then be diverted to various parts of the continent and used for a variety of purposes. The total drainage area of the collection region is 1.3 million square miles which receives between 15 and 60 inches of rain per year. 110 m.a.f., or about 20 per cent of the total flows of the basin would be collected in Southern Alaska, the Yukon and British Columbia. By a series of

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[8]Another scheme, the Kierans Plan or Grand Canal Concept, proposes diverting surplus water now flowing into James Bay to the Great Lakes. This plan, however, although competitive to some extent to those outlined above, is not technically in Western Canada and is not discussed here.

[9]R.P. Kelly, "Can We Use Water and Power from Alaska? Its Costly, but Feasible", Power Engineering, Vol. 71, No. 1, January 1967, pp. 34-7.

dams and power stations this water would be pumped up into the Rocky Mountain Trench at an elevation of 3,000 feet. The main reservoir is to be the 500 miles of the Trench in central and southern British Columbia. From here water could be pump-lifted to another reservoir in northwest Montana where it could then be made to flow by gravity, via lined canals and tunnels, to serve 33 states of the United States and the 3 northern states of Mexico. At the same time, flows could also be diverted into a Canadian Great Lakes Waterway which would cross Canada linking the Pacific Ocean to the Great Lakes - St. Lawrence complex and would serve the water needs of seven Canadian provinces.

Besides providing water for both withdrawal and non-withdrawal uses, NAWAPA would integrate the power requirements of Canada, the United States and Mexico with the hydro potential of the proposed system thereby meeting a major portion of the power needs of all three countries. The total installed generating capacity of the new system would be about 110,000 mw; 876 billion kilowatt hours of energy per year would be marketable; 263 billion kilowatt hours per year would be required for pumping; and the plan envisages a power distribution system covering the whole continent.

Total investment for the NAWAPA plan would be $100 billion, and it would be built over a 30-year period. Power, however, would be available for sale within the first nine years, and in addition to power benefits, the plan would yield water for multiple-purposes. Presumably, the plan would be a cooperative undertaking involving all three countries.

The plans proposed by Professor Kuiper envisage the utilization of some 230 m.a.f. available from the Nelson, Churchill, MacKenzie and Yukon Rivers of which more than 100 m.a.f. could be exported to the United States and Mexico. The focal point of the Kuiper plan is Lakes Winnipeg and Manitoba which would provide the main areas of storage to be filled by water from the Churchill, Peace and Nelson Rivers and from Lake Athabasca. From here water could be diverted to the Prairie Provinces, the Great Lakes, Texas, and the United States' midwest at costs ranging from $5 to $40 per acre-foot .[10]

If the future development of water resources in Western Canada is to be in the direction and on the scale suggested above, international cooperation will be a necessary condition of development, and planners in both the United States and Canada will be faced with the same range of problems encountered in the Columbia River development: Determination of the objectives to be maximized; benefit and cost estimation in terms of the chosen objectives; the optimal engineering and economic design of each project; selection of the "best" projects or system of projects; and finally, the equitable division of benefits

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[10]Kuiper, op. cit., pp. 4-5. Detailed studies are now being carried out on various aspects of the Kuiper plans. (see the Progress Reports to the University of Manitoba's Inter-disciplinary Study of Water Resources Development and Water Utilization in Western Canada, 1966-67.)

and costs. The following section examines the lessons of the Columbia experience pertinent to the solution of all these problems and also discusses some of the general implications the Columbia experience might provide for future water resource development.

II. LESSONS AND IMPLICATIONS OF THE COLUMBIA RIVER EXPERIENCE

Perhaps the most general, but at the same time the most important implication of the Columbia River experience for future water resources development is the need for more research into the public investment decision-making process. In terms of what we have called the "traditional benefit-cost approach", this means, essentially, that economic considerations should play a larger role in public water policy in the future. It cannot be denied that economic factors have, in the past, been subordinated to other considerations,[11] and certainly

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[11] The reaons for this, according to Professor Sewell, are: 'First, there has been no crisis to trigger a change in the approach to water management. Abundance of resources and availability of alternatives have permitted a leisurely inventorying of possibilities for development and have not encouraged a careful appraisal of the needs of development. Until now there has been no urgency to weigh the value of one water use against other water uses. It is clear, however, that the day is fast approaching when decisions between competing alternatives will have to be made....Secondly, there is a scarcity of social scientists skilled in undertaking studies of non-engineering aspects of water resources development." (See W.R.D. Sewell, "The Columbia River Treaty: Some Lessons and Implications", Canadian Geographer, Vol. X, No. 3, 1966, pp. 155-56.

in the case of the Columbia River the amount of time and money spent on economic studies must have been quite small in comparison with the effort devoted engineering studies.[12] Furthermore, it is significant to note also that the proposed diversion plans outlined above are essentially engineering plans. They have been proposed by engineers, their pertinent economic aspects have been largely matters of assumption, and the discussion of their costs has generally been in financial rather than economic terms.

However, a more general (or perhaps generous) interpretation of the need for more research in to public water decision-making involves the question of whether or not this research should be directed toward techniques designed to better achieve an "economic optimum", or whether it may be more fruitfully directed toward a multidiciplinary search for techniques designed to achieve a "social optimum". The traditional economic techniques, invaluable as they are, suffer (as pointed out in Chapter II) in their application because they are limited. That is, many of the values people normally associate with water resources development cannot be measured satisfactorily

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[12]The difference in order of magnitude is perhaps suggested by the I.C.R.E.B. report on the Columbia River. The five major volumes that constituted this report were devoted almost entirely to engineering studies while economic studies were relegated to a relatively brief appendix.

in quantitative terms within the traditional framework of benefit-cost analysis. Furthermore, there is no reason, other than expediency, that we should equate the optimum aimed at through the use of the current economic concepts (if, indeed, any optimum is achieved) with the "public interest". Thus, while it is true that most public decisions are based to a large extent upon complex technological and economic factors, this does not particularly endow the engineer or the economist with special abilities for determining what is "best". The engineer can evaluate the physical, and the economist the economic consequences of alternative decisions, but are the particular types of values measured by traditional economic analysis really sufficient to judge the worth of a given service or its cost to the individual affected ? This question is difficult to answer but by posing it we are not suggesting that the economist abdicate his responsibility for making value judgements. What we are suggesting is that the economist examine the validity of value judgements already made.

The argument of Chapter II was that benefit-cost analysis, since it derives from the efficiency-competitive model, is lacking as a practical criteria of public water investment when the principle objective is, as in the Columbia River experience, not simply the achievement of static economic efficiency.

> Benefit-cost analysis has been applied usefully and with increasing rigor to public enterprise. Yet the decision-maker who uses this and other criteria cannot jump from the criteria to hard decision without an uncomfortable feeling that he has just passed over a void which may engulf him. The old hand at making such jumps develops composure, yet he realizes he has taken that necessarily heroic leap across the unknown. True, we must learn to live with the unknown; but by reshaping through research, the definitions of our working system, existing criteria will be utilized more effectively and intrasystem and intersystem tradeoffs may be more accurately assessed.[13]

The need, then, as illustrated by the Columbia River experience, is for interdisciplinary studies designed first to determine the "appropriate decision systems" in which water problems are operative; and second, a "social" as opposed to a strictly "economic" investment criteria whereby public investment intended both to solve existing water problems and to attain a higher level of achievement of public objectives can be better evaluated. By concentrating upon the efficient development of water resources, rather than directly attempting to establish the role of water resources in social and economic development, economists have generally fostered a misconception as to what the actual role of water is in both private and public behaviour.

> Has the social scientist compared the concept of water development which says (a) "Governments invest to remove water as a constraint to private development" and as we have argued, to provide a stimulus to private development, with the conventional implication deriving from the objective (b) "We seek an economically optimal water resource allocation within region X and time Y"?[14]

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[13]Stephen C. Smith, "Major Research Problems in the Social Sciences," Water Research, op. cit., p. 505.

[14]Ibid.

The broad outlines of water resource development in the past, as exemplified by the Columbia River experience,have been largely determined by concept (a), while most of the efforts of economists have been directed toward trying to change the rules of the game by which (a) is played to conform to a convenient criteria designed to achieve (b). And as Smith points out,

> Social science could perform a practical as well as scientific service by confronting this issue. The developmental and management criteria under the two systems [(a) and (b)] are quite different and the social scientist should help clarify the differences. In performing this task, there is a role for each of the social groups.[15]

The emergence of such massive diversion schemes as outlined above and the furor which they have caused suggest that the course of water resources development in Western Canada is likely to be determined by the philosophy that a different and more dynamic approach to water management is needed; a philosophy based on the belief that growth and economic development requires, at least in part, the availability of large supplies of low cost water and power, and that future water problems cannot be solved by small incremental changes such as shifting water out of agriculture, increasing water prices, or like measures, since they will only discourage investment in water resources development. However, the effect of such large scale diversions upon economic growth may not be immediately

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[15] Ibid.

apparent if we continue to apply the traditional techniques of project evaluation. For economics to play a more useful role in water policy decision-making, and as a step toward developing a social criteria of public investment, more research should be devoted toward finding analytical techniques which take account of the development strategy objective.

Our discussion of the Columbia River development pointed out the problems involved in cooperative development and the different objectives and viewpoint to be considered when only three separate governments are involved. Large scale diversion proposals of the sort outlined above, involving the cooperation of a considerable number of separate governments, would multiply these problems many times. Because the choice of objectives ultimately determines the criteria of evaluation, and lacking a broad social criterion of public investment, prior agreement as to the objectives to be maximized (efficiency, economic development, or some other consideration) is necessary or each party will have, as in the Columbia case, a vastly different conception as to which system or programme is optimal. The lack of such agreement in developing the Columbia resulted in a treaty system that does not really conform to the objectives of any of the parties involved. It is a compromise agreement. If different objectives exist it would be better for a trade-off of these objectives to take place before a decision is made between various development alternatives. If projects are initially evaluated in terms of one objective

(say economic efficiency) but finally selected in terms of another (say development strategy), there is no assurance that either will be maximized.

Finally, the Columbia River experience may have important implications for the way in which the "benefits" and "costs" of the proposed diversion are to be divided. Professor Kuiper, for example, in estimating the Canadian benefits of exporting water to the United States has suggested that the 50-50 benefit sharing principle devised for the Columbia development could be used.[16] However, there is nothing immutable about this rule. Whether or not it was best for the Columbia development, there is no particular reason why it should be applied under different circumstances. What the Columbia experience makes clear is that all of the parties would have to be explicitly aware of what each other expected to gain by cooperative development. In the case of the proposed diversions, it seems realistic to assume that the United States might be primarily concerned with maximizing efficiency benefits because in spite of the large scale of the projects involved the external effects on the rest of the U.S. economy may not be of such a magnitude to invalidate the assumptions of traditional benefit-cost analysis. With regard to Canada, however, where the largest part of the investment would take place, particularly under the Kuiper plans,

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[16] Kuiper, op. cit., p. 6.

the case would be very different. It is therefore conceivable that Canadian authorities would be more concerned with the external developmental effects of the diversion, and hence a Canadian evaluation of costs and benefits would have to be carried out in terms of this objective Cooperative development, and benefit-sharing under such circumstances would involve, as in the case of the Columbia,a trade-off of objectives; the "benefits", however, as was not the case in the Columbia experience, would have to be made explicit terms of the two principle objectives. Only then could an equitable sharing formula be worked out.

CHAPTER V

SUMMARY OF CONCLUSIONS

In terms of economics, the Columbia River development is one of the most complicated river basin developments yet undertaken. This is so, partly because of the technical complexities of the various alternatives considered, and partly because of the fact that it was an international venture in which several different viewpoints were involved. Chapter I examined the historical background of the development, dwelling particularly on the differences that existed in these viewpoints between the governments of Canada, British Columbia, and the United States. Particular attention in this Chapter was paid to the peculiar constitutional situation that exists in Canada whereby the provinces are the sole owners of their natural resources but require the consent of the federal government to develop a resource such as a river which crosses the international boundary. In the case of the Columbia River development, however, the province's strong position of ownership ultimately forced the federal government to accept the province's viewpoint and goals to be achieved by the development.

The importance of the objectives and viewpoints in the economic analysis of water developments was also stressed in Chapter II where some of the theoretical aspect of water economics were examined. The Chapter dealt with the traditional benefit-cost criteria for selecting the optimal scale of each alternative project, and the choice

of the most efficient project. Some of the practical problems of benefit-cost analysis, including the choice of the appropriate discount rate, the estimation of a project's economic life, benefit estimation, uncertainty, and project sequence and timing, were discussed, and the conclusion that emerged was that the solution to many of these problems, within the assumptions of the benefit-cost framework, somewhat reduced the usefulness of benefit-cost analysis as a practical procedure of project evaluation. We then examined the more general use of benefit-cost analysis as a decision criteria. It was concluded that, primarily because of its existing deficiences and unrealistic assumptions, a more fruitful approach to investment criteria, particularly under the circumstances existing in developing economies might be the "development strategy" approach. This approach has as its main objective the promotion of economic growth which, in a developing economy, was shown to be more meaningful than the traditional efficiency objective. However, sophisticated techniques for project evaluation have not as yet evolved to enable project selection in terms of development strategy, and it was concluded that more research should be directed toward this end.

The examination in Chapter III of the economics involved in the Columbia River development supports the conclusions as to the importance of identifying explicitly the objectives sought in water resources development. The economically efficient development of an international river basin requires that all parties have as their objective

the maximization of the benefits to be achieved by developing the basin as an integrated whole. In the Columbia River case, however, none of the parties concerned were completely committed to this objective. Rather, the difference in objectives and viewpoints dictated that each be concerned with maximizing its own objectives. The result was that these differences had to be resolved by a final treaty arrangement that, according to the available data, was not the most economically efficient system of flood control and hydro development. In terms of British Columbia's economic development policy, however, one must conclude that from a Canadian viewpoint the treaty system was probably more beneficial than the most efficient plan for integrated basin development. This does not require determining whether the efficiency benefit share British Columbia received under the treaty was more than what could have been achieved under an equal sharing of the most efficient scheme, (for indeed, this was shown not to be the case), but only that the treaty scheme was consistent with the province's economic development policies. The efficiency criterion is for the most part an insufficient criterion since neither party was interested only in economic efficiency.

Chapter IV examined some of the alternative possibilities for future water resources development in Western Canada. For this part of the country it was shown that the available supply of water greatly exceeded what was likely to be required in the future. However, because the water supplies of Western Canada are not evenly distributed over its area and because of the anticipated water shortages in the United States,

it would seem reasonable that future water resources development might take the form of large scale diversions. Two of the schemes proposed for carrying out such diversions, NAWAPA and the Kuiper plan, were discussed briefly.

The Columbia River experience is a good example of the fact that the broad outlines of water resource development in the past have generally been determined not by strict economic rationality but by the fact that public resource investment is largely a reflection of the public desire to remove constraints on the action of the private sector thereby stimulating it to act in such a way as to complement the governmental objective of promoting economic growth and development. The conclusion that emerged, then, was that a criterion was needed to evaluate public resource development in terms of a "social optimum" rather than solely in terms of the economically efficient allocation of resources designed to achieve an economic optimum. In terms of future water resources development in Western Canada, the first step toward such a criterion would be the development of techniques designed to evaluate benefits and costs in terms of development strategy.

APPENDIX 1

REFERENCE OF THE COLUMBIA RIVER SYSTEM

Department of
External Affairs
Canada

OTTAWA, March 9, 1944.

SIR:

I have the honour to inform you that in order to determine whether a greater use than is now being made of the waters of the Columbia River System would be feasible and advantageous, the Governments of the United States and Canada have agreed to refer the matter to the International Joint Commission for investigation and report pursuant to Article IX of the Convention concerning Boundary Waters between the United States and Canada, signed January 11th, 1909.

2. It is desired that the Commission shall determine whether in its judgment further development of the water resources of the river basin would be practicable and in the public interest from the points of view of the two Governments, having in mind (A) domestic water supply and sanitation, (B) navigation, (C) efficient development of water power, (D) the control of floods, (E) the needs of irrigation, (F) reclamation of wet lands, (G) conservation of fish and wildlife, and (H) other beneficial public purposes.

3. In the event that the Commission should find that further work or projects would be feasible and desirable for one or more of the purposes indicated above, it should indicate how the interests on either side of the boundary would be benefited or adversely affected thereby, and should estimate the costs of such works or projects, including indemnification for damage to public and private property and the costs of any remedial works that may be found to be necessary, and should indicate how the costs of any projects and the amounts of any resulting damage be apportioned between the two Governments.

4. The Commission should also investigate and report on existing dams, hydro-electric plants, navigation works, and other works or projects located within the Columbia River System in so far as such investigation and report may be germane to the subject under consideration.

5. In the conduct of its investigation and otherwise in the performance of its duties under this reference, the Commission may utilize the services of engineers and other specially qualified personnel of the technical agencies of Canada and the United States and will so far as possible make use of information and technical data heretofore acquired by such technical agencies or which may become available during the course of the investigation, thus avoiding duplication of effort and unnecessary expense.

I have the honour to be,
Sir,
Your obedient servant,

(Sgd.) W.L. MACKENZIE KING,
Secretary of State for External Affairs.

The Secretary,
The International Joint Commission,
Ottawa.

APPENDIX 2

Extract

from proposed Compact Article
recommended by the Columbia Interstate
Compact Commission Power Committee
in a report dated 15 January 1954.

(B) (1) If, with respect both to projects on which plans are prepared as provided in paragraph 2 of (A) and to projects being reviewed as provided in paragraphs 3 of (A) of this article, the proposed development is located wholly or partly in an upstream state (these comprising Idaho, Montana, Utah, and Wyoming) and includes power benefits, the Compact Commission shall

(a) Determine the amount of power and energy attributable to the development that, in its judgment, is equitable for reservation for use in the upstream situs state and what kind of reservation would be reasonable and practicable in the particular case. This determination shall be made by taking account of the amount of power and energy that will be produced at existing and future downstream power plants by reason of the development, as well as power and energy to be developed at the site, the amount of the reservation in the case of a development located wholly in an upstream state, unless the making of a reservation is found to be impracticable, to be not less than the amount of power attributable to at-site generation plus a fair and equitable share of the additional power developed at downstream sites by reason of the release of water stored at the upstream development.

(b) Recommend the inclusion of provisions in the authorizing legislation or the license if such provisions are found to be reasonable and practicable by the legislative body, or the licensing agency, as the case may be, requiring the agency responsible for the operation of the development to make the power and energy covered by the determinations made under (a) of this paragraph available for purchase and use in the upstream situs state. Any such recommendation shall provide that, subject to reasonable notice for withdrawal as demand therefor develops, such power and energy may be made available elsewhere.

APPENDIX 3

REPORT OF THE INTERNATIONAL JOINT COMMISSION ON PRINCIPLES FOR DETERMINING AND APPORTIONING BENEFITS FROM COOPERATIVE USE OF STORAGE OF WATERS AND ELECTRICAL INTERCONNECTION WITHIN THE COLUMBIA RIVER SYSTEM

29 December 1959

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In the preparation of this special report, the Commission utilized as background data all the information available to it on the water resources development needs and possibilities in the Columbia River area. This included the reports of the International Columbia River Engineering Board under the Columbia River Reference, as well as studies of other agencies in both the United States and Canada. A special work group was established to prepare summaries of the available data that would provide a background and orientation and thus facilitate mutual understanding of the situation and conditions under which principles for benefit determination and apportionment would be applied. Also, the Commission approached the problem of formulating principles within the context and intent of the Boundary Waters Treaty of 1909.

The studies of the International Columbia River Engineering Board, as well as other available information, indicate clearly that there are possibilities for cooperative development in the Columbia Basin that could be of mutual advantage to the two countries. Accordingly, the Commission was able to approach the problem of formulating principles for benefit determination and apportionment with information on specific projects for cooperative development which would offer advantages to both countries. The Commission was guided by the basic concept that the principles recommended herein should result in an equitable sharing of the benefits attributable to their cooperative undertakings and that these should result in an advantage to each country as compared with alternatives available to that country. The Commission gave consideration to the practical problems that will be encountered in applying the principles to cooperative arrangements between the two countries on specific projects in the Columbia River Basin. This was done to ensure that the principles would be workable but no attempt was made to spell out in the principles the detailed procedures that will necessarily be delineated when cooperative arrangements are entered into. The Commission recognizes that several administrative and legislative actions in each country may be necessary before these details can be worked out.

The principle benefits in the downstream country from cooperative use of storage of waters within the Columbia River System are improvements in hydro-electric production and prevention of flood damage. Although other benefits would also be realized from such cooperative use, the outlook at this time is that their value would be so small in comparison to the power and flood control values that formulation of principles for their determination and apportionment would not be warranted. This is not intended to preclude consideration by the two Governments of any benefits, tangible or intangible, which may prove to be significant in the selection of projects or formulation of agreements thereon.

The prospective downstream power benefits are transportable and within reasonable transmission distances of the boundary. With adequate electrical interconnection, it would therefore be feasible to share these benefits in kind, that is, share the power itself rather than its value in money. The flood control benefits, however, accrue in specific localities and are not transportable. Cooperative use of storage designed to produce such benefits therefore requires recompense in money or by other means. In addition to providing a means for the return to the upstream country of its share of downstream power benefits, electrical interconnection between the power systems in the upstream and downstream countries opens the possibility of significant economies and advantages in the operation of the interconnected systems in both countries through the cooperative use of generation and transmission facilities.

In view of the foregoing, the Commission's recommendations on principles for benefit determination and apportionment are presented herein in three sections, namely, general principles, power principles and flood control principles.

GENERAL PRINCIPLES

Selection of Projects

A necessary step in the development of cooperative arrangements involving sharing of downstream benefits is the selection of the projects to which such arrangements would apply.

In selecting individual projects from among the available alternatives in both countries for comprehensive development of the Columbia River Basin, it would be consistent with customary practice to give first consideration to those projects that are most attractive economically as reflected in the ratio of benefits to costs. It is suggested that this widely accepted principle be followed in international

cooperative development of the Columbia River Basin to the extent that it may prove practicable and feasible to do so. If projects are developed successively to meet the growing needs for power production and to provide flood protection, the most efficient projects for those purposes should generally be developed first in order to maximize the net benefits to each country. It is recognized, however, that the results to be obtained from possible cooperative projects in the Columbia River Basin will constitute only a part of the total requirements for water resource development and use in the affected regions in both countries. Therefore application of the principle will necessarily be subject to the sovereign responsibilities in each country with respect to many vital and important national interests which must be taken into account in utilizing the water resources in each country. The Commission therefore recommends the following general principles:

General Principle No. 1

Cooperative development of the water resources of the Columbia River Basin, designed to provide optimum benefits to each country, requires that the storage facilities and downstream power production facilities proposed by the respective countries will, to the extent it is practicable and feasible to do so, be added in the order of the most favorable benefit-cost ratio, with due consideration of factors not reflected in the ratio.

Discussion of General Principle No. 1

It is intended in the application of this principle that benefits and costs of the projects given consideration in either country would be determined on the basis of the same or comparable evaluation standards, including such factors as the nature and extent of the benefits to be considered, the evaluation of such benefits, the determination of the initial investment and the computation of the annual costs.

The phase "to the extent that it is practicable and feasible to do so" is included in recognition of the fact that it will not always be possible to adopt a project wholly on the basis of its benefit-cost ratio as compared to other projects in the river basin. There may be important non-monetary factors, not reflected in the benefit-cost ratio, which may require consideration and which may be of compelling influence in choosing projects for construction. Such factors include the disruption of community and regional economies, scenic, historic or aesthetic considerations, the preservation of fish and wildlife, and similar considerations, which cannot be adequately evaluated in monetary terms. Other practical considerations that might preclude the theoretically desirable order of construction of projects would include the following:

(a) the availability of funds, whether from public or private sources, may be an important consideration in the scheduling of projects within each country in an extensive basin-wide plan. This factor alone may require selection of a small project providing urgently needed benefits even though the small project may have a lower benefit-cost ratio than a larger project requiring more funds than are available. On the other hand, it is important to recognize that a small project undertaken for such an immediate consideration might jeopardize an eventual development of far-reaching beneficial consequences.

(b) an urgent need to provide for such purposes as local or regional flood control, navigation, irrigation, or exceptional increases in power requirements may determine the order of project construction rather than the ratio of benefits to costs.

(c) the attitude of affected interests on the flooding of lands and improvements or to the effect of a project on other uses of the water resource may require postponement or abandonment of construction of projects that are the most attractive when viewed solely from the standpoint of their benefit-cost ratio.

General Principle No. 2

Cooperative development of the water resources of the Columbia River basin should result in advantages in power supply, flood control, or other benefits, or savings in costs to each country as compared with alternatives available to that country.

Discussion of General Principle No. 2

This principle was used as a basic concept by the Commission in the preparation of the more specific principles recommended herein, and is recorded for future guidance in the application of those principles.

Trans-Boundary Projects

Projects which could produce downstream benefits to be shared between the two countries may be located entirely in the upstream country, or may be trans-boundary projects in which the benefit-producing potentials of storage and head are partly in each country. Such projects affect the level of water above the boundary and in consequence are subject to Article IV of the Boundary Waters Treaty of 1909. The principles presented elsewhere in this report are applicable directly to storage projects situated entirely in the upstream country and relate to the effects produced in the other. To apply these principles to a trans-boundary project, it is first necessary to assign

to each country an "entitlement" to the storage. This entitlement or share of the benefit-producing potential of the storage would then form the basis for determination and apportionment of downstream benefits between the two countries in accordance with the principles recommended herein. In addition, an entitlement to at-site power generation should be determined based on the benefit-producing potential of the head and flow involved. Also, the respective entitlements to share in any other benefit-producing potentials should be determined if significant.

As a basis for determining the "entitlement" of each country to the benefit-producing potentials of storage and head at trans-boundary projects, the Commission recommends the following general principle:

General Principle No. 3

With respect to trans-boundary projects in the Columbia Basin, which are subject to the provisions of Article IV of the Boundary Waters Treaty of 1909, the entitlement of each country to participate in the development and to share in the downstream benefits resulting from storage, and in power generated at site, should be determined by crediting to each country such portion of the storage capacity and head potential of the project as may be mutually agreed.

Discussion of General Principle No. 3

The "entitlements" determined in accordance with this principle provide a basis for establishing benefit credits. The principle is designed to provide flexibility in the arrangements between the two countries for cooperation on trans-boundary projects. The entitlement of a country computed in accordance with this principle would be the basis for determining the share of downstream benefits due that country in accordance with the other principles presented in this report for projects wholly in one country.

POWER PRINCIPLES

The setting in which principles for determining and sharing power benefits from the cooperative use of upstream storage in the Columbia River system would be applied is one in which significant changes are likely to occur within the life of projects that might be considered for development at this time. At present the power loads in the United States portion of the Columbia Basin and adjacent areas of the Pacific Northwest are supplied almost entirely from hydro-electric plants.

The downstream generating plants in the United States are now in a position to benefit materially from storage regulation upstream primarily through improvement of the dependable capacity and useable energy of the downstream plants. As the more economically attractive hydro plants are developed progressively, it will become necessary and advantageous to add thermal plants to the system until ultimately the Pacific Northwest power system in the United States will become predominantly thermal.

In the course of this change, the character of the benefits to downstream hydro-electric plants in the United States from storage will change to benefits in the form of peaking capacity and thermal replacement energy and may change in value.

In Canada, the hydro-electric power potential has not yet been developed to a comparable extent. For this reason, the type of change envisioned in the United States is unlikely to occur in the Canadian portion of the Columbia River Basin and adjoining areas until a considerable period of time has elapsed.

In the light of the foregoing, the Commission has found it necessary in its formulation of principles for determination and sharing of power benefits to allow for changing conditions during the specified period that a cooperative development agreement or any extension thereof would be effective. The principles recommended below for the determination and apportionment of power benefits are believed to be sufficiently flexible to provide for equitable arrangements to permit taking into due account the changing conditions expected.

Application of the power principles to conditions in the Columbia basin would require electrical interconnection between the power systems of the two countries to make possible delivery of the upstream country's share of the power produced in the downstream country from the use of stored waters. Although such delivery could be accomplished initially with a somewhat limited degree of interconnection, the Commission is of the opinion that provision should be made for the eventual development of a broader, long-range plan for cooperative operation of the interconnected power systems of the two countries. Accordingly, the power principles include in addition to those governing cooperative use of stored waters, a principle providing for interconnection and coordination of the major power systems in the Columbia basin and adjoining areas in both countries so as to permit the power utilities of the two countries to gain the advantages of cooperative arrangements in power system operations.

Power Principle No. 1

Downstream power benefits in one country should be determined on the basis of an assured plan of operation of the storage in the other country.

Discussion of Power Principle No. 1

This principle is basic to a determination of the dependable capacity and usable energy that can properly be credited to operation of upstream storage for the benefit of hydro-electric power generation downstream. Emphasis is placed particularly on the concept of an assured plan of operation of the storage with the expectation that the downstream system will be developed and operated so as to make optimum use of the stream flow regulation provided.

It is a generally accepted engineering principle in the electric power field that any power supply which is classified as "firm" or "dependable" must be deliverable on such a schedule or plan as to assure availability of the power at the times when it is needed to serve the load, particularly during peak load periods. It is, therefore, highly important that river-flow regulation be provided under an agreed operating plan or rule curve that will assure the dispatch of water by the owner of storage facilities to the owners of downstream hydro plants in such a manner as to meet the needs of the latter for delivery of firm power to their customers. Such a plan of operation will provide the maximum downstream power benefit consistent with the degree of coordination agreed upon.

It is expected that a general plan of operation of the upstream storage project will be estimated for the entire period of the agreement with the understanding that mutually satisfactory adjustments in the long-range plan of operation can be made from time to time as necessary. This general provision for adjustment is additional to the flexibility for changes by either country which may be specifically provided for in the agreement. Factors that may bring about the need for adjustments in the operating plan are covered in the discussion of Power Principle No. 2.

Power Principle No. 2

The power benefits attributable to an upstream storage project should be estimated in advance to the extent possible to the mutual satisfaction of the upstream and downstream countries. These estimates of power benefits should be subject to review in accordance with the agreed principles every five years, or more often as may be agreed, to take into account in subsequent estimates any change in

previously assumed conditions and to insure optimum utilization of the storage and accurate determination of future benefits.

Discussion of Power Principle No. 2

This principle is intended to provide in advance of construction of upstream storage reservoirs a long-range estimate of the expected benefits of the international cooperative undertaking. The estimate of benefits, expressed in power, or in monetary terms if necessary, would be determined on the basis of the current assured plan of operation as described under Power Principle No. 1 and in accordance with Power Principle No. 3.

It is contemplated that the appropriate agencies in each country will collaborate in the preparation of the estimate and that it will cover the entire period of the international agreement. Any extension of the agreement would also require similar estimates. It should be based on the relevant conditions of load and power supply expected to prevail during the period of the agreement. The assumed power supply should include the projects, both hydro-electric and steam-electric, considered most likely to be constructed to meet the long-range needs of the power systems concerned.

In estimating the long range power benefits attributable to upstream storage and in the periodic reviews provided for in this principle, due recognition should be given to the adjustments in storage operation that are likely to be required to meet power loads and other water use needs in either country. Factors in either country which could change and thus alter the role of storage include: the magnitude and characteristics of the power loads to be served, installed generating capacity available in the hydro-electric plants on the affected systems, the amount of thermal generating capacity available and the requirements of other water uses. The time and effect of such changes should be anticipated by the appropriate Canadian and United States agencies as far in advance as possible and taken into account either by provision in the assured plan of operation or by agreement on mutually satisfactory adjustment as a result of the periodic review of the plan to operation and long-range estimate as provided for in this principle.

In addition to the primary purpose of furnishing a long-range estimate of the benefits of the international cooperative undertaking the advance estimate and periodic reviews are expected to serve several other purposes. The agencies affected will be afforded a basis for anticipating the probably long-range use or role of the storage in the respective countries so that other developments on the affected power systems can be planned well in advance and timely provision made for their construction as required by each country. Assurance as to use

of the storage would facilitate advance planning of the transmission systems required to coordinate the storage operation with generating plants on the interconnected power systems. Information provided from the estimates would also aid the two countries in determining the timing and value of other projects of international scope in which they may be jointly interested.

Power Principle No. 3

The amount of power benefits considered to result in the downstream country from regulation of flow of storage in the upstream country should be determined in advance by computing the difference between the amount of power that would be produced at the downstream plants with the storage regulation and the amount that would be produced without such regulation. This determination would be made on the assumption that upstream storage is added at an agreed-upon level or condition of storage and power supply. The storage credit position of the upstream storage thus established should be preserved throughout the period of the agreement.

Discussion of Power Principle No. 3

Application of the with and without principle involves several significant determinations and procedures to insure that the upstream storage receives proper credit for its contribution toward meeting the load. Because of the fact that successive units of storage capacity added to a system of projects result in decreasing amounts of regulatory effect per unit, the time at which a project is considered as added to the system in relation to the time at which other storages are added affects the amount of regulatory effect and accompanying firm power benefit with which a particular storage project may be credited. Thus the conditions under which a project is considered as added determines its "credit position".

Under this principle, it is intended that the storage credit position of an upstream storage reservoir be determined on the assumption that it is added at an agreed-upon level or condition of storage and power supply, This "level" or "condition" might be defined by relating it to a "base system". The "base system" would be comprised of all developments existing at the time of negotiation of an agreement together with developments actually under construction at that time.

Since many estimates and computations have already been made on the basis of data available during the Commission's consideration of these principles, it is suggested that negotiations undertaken in the near future utilize as a base system the developments existing and under construction on January 29, 1959, the date of the two Governments'

request for this report. The pertinent storage developments in the current base system are:

Project	Usable Storage
Kootenay Lake	673,000 acre-feet
Hungry Horse	2,982,000
Flathead Lake	1,217,000
Albeni Falls	1,153,000
Coeur d'Alene Lake	225,000
Grand Coulee	5,072,000
Chelan	676,000
Brownlee	1,034,000
	13,032,000 acre-feet

If negotiations are undertaken or continued at a time when major changes have occurred, a revised base system should be agreed upon. Conditions of International Joint Commission Orders of Approval affecting any of these developments would continue to be applicable.

It is contemplated that the representatives of the two governments who negotiate arrangements under these principles would agree on the order in which the storages they have under consideration would be considered as added to the base system so that a credit position for each such storage could be established. It is intended under this principle to provide that the credit positions of the storages thus established will not be adversely affected by the addition of subsequent storage and that the storage credit of such agreed upon storages may increase or decrease only as the role of storage generally in the system changes.

Power Principle No. 4

The amount of power benefits determined to result in the downstream country from regulation of flow by storage in the upstream country would normally be expressed as the increase in dependable hydroelectric capacity in kilowatts under an agreed upon critical stream flow condition, and the increase in average annual useable hydroelectric energy output in kilowatts-hours on the basis of an agreed upon period of stream flow record. Since this procedure requires relating the increased power production to the loads to be met in the downstream country and adjustment of the upstream country's entitlement to conform more nearly to its load requirements, consideration might be given in the negotiations to the adoption of arrangements

that would be less dependent upon consideration of the load patterns in each country.

Discussion of Power Principle No. 4

In determining the increase in dependable hydro capacity and in useable energy output at downstream plants resulting from upstream regulation, the estimates should be based on the ability of those plants, enlarged as necessary, to serve the coordinated system loads in the downstream country expected to be realized during the periods under consideration.

The critical flow period used to determine hydro plant outputs available for supporting dependable capacity on the downstream load would be that corresponding with the agreed-upon level or condition of storage and power supply as contemplated in Power Principle No. 3.

Estimates of increase in average annual useable energy output at the affected downstream plants should be based on an agreed upon period of stream flow record which is expected to give results representative of long term conditions.

It is expected that both dependable capacity and energy benefits will result during the early and intermediate stages of the storage operation, but during the later stages the power benefit may consist only of increased useable energy.

Whether the objectives are to produce the maximum firm power, peaking capacity or thermal replacement energy, the power useable on the downstream load is the basis for determing the monetary value of the power resulting from the cooperative arrangements. Such value as defined later in Power Principle No. 5 would serve as the basis for adjusting the upstream country's entitlement as between capacity and energy, to amounts of equivalent total value, which conform more nearly to the requirements of the upstream country's load.

Power Principle No. 5

Whenever it is necessary to place a monetary value on downstream power benefits arising in one country from storage operation in the other country, the value should be the estimated cost to the downstream country of obtaining equivalent power from the most economical alternative source available except where the appropriate Canadian and United States agencies specifically agree on some other basis of evaluation.

Discussion of Power Principle No. 5

This principle is intended to provide a basis for the evaluation, in monetary terms, of downstream capacity and energy benefits attributable to upstream storages for whatever purposes such monetary evaluation may be required: but is intended to have application only in those cases where appropriate monetary values for specific purposes are not otherwise agreed upon by the appropriate United States and Canadian agencies. It is further intended that where such monetary values are agreed upon by the agencies, for any period during the life of the covering agreement, the value so agreed upon shall over-ride the provisions of this principle.

The alternative source used as a basis for the evaluation should be the most likely source available to furnish an amount of power equivalent to the power being evaluated and might be hydroelectric, thermal or some combination thereof.

Power Principle No. 6

The power benefits determined to result in the downstream country from regulation of flow by storage in the upstream country should be shared on a basis such that the benefit, in power, to each country will be substantially equal, provided that such sharing would result in an advantage to each country as compared with alternatives available to that country, as contemplated in General Principle No. 2. Each country should assume responsibility for providing that part of the facilities needed for the cooperative development that is located within its own territory. Where such sharing would not result in an advantage to each country as contemplated in General Principle No. 2, there should be negotiated and agreed upon such other division of benefits or other adjustments as would be equitable to both countries and would make the cooperative development feasible.

Discussion of Power Principle No. 6

It is assumed that each country would bear all capital and operating costs for facilities it would provide in its own territory to carry out the cooperative development. The upstream country's share of the power would be transmitted to the boundary by the downstream country at such points as may be most economical to the downstream country. Other points could be selected upon request of the upstream country provided that any excess costs to the downstream country are paid by the upstream country. Losses in transmission of the power to the international boundary from the points of generation would be borne by the upstream country. The voltage at which power would be delivered to the upstream country would be mutually agreed upon but such voltage should be a level that is in common use on the downstream

power system through which the transfers of power are to be made.

The load factor at which the upstream country's share of power is delivered should also be agreed upon in advance. Basically, the downstream country should not be required to provide more facilities for generation and transmission to furnish the upstream country its entitlement of power than would be required if the power were to be used in the downstream country at the load factor generally applicable to its affected hydro plants.

Power Principle No. 7

In addition to benefits from cooperative use of stored water, interconnection and coordination of the electric power systems to the extent that they are practicable and desirable, would also provide many mutual benefits which should be shared. Coordination being a continuing function would require specific arrangements on the part of the operating agencies as the need arises.

Discussion of Power Principle No. 7

The first six power principles recommended in this report are directed to determination and apportionment of benefits which would result from international cooperation in the use of stored waters. These are basically hydraulic benefits which can be realized by storing flood flows during the spring and summer months and releasing the stored waters during the fall and winter months when they can be put to use for production of firm power at the storage site and downstream. Electrical interconnection between the power systems of the two countries would be required to make possible delivery of the upstream country's share of the power produced in the downstream country from the use of stored waters, but the interconnection capacity provided for this purpose would be only that needed to accomplish such delivery. This limited degree of interconnection would not, however, make possible the greater benefits that would accrue to the two countries from a comprehensive plan of interconnection and coordination.

Such coordination should be recognized in the development of the agreed upon plan of upstream storage operation and in the computation of system power benefits. Separate arrangements may be required for sharing coordination benefits because the electrical coordination envisaged could extend geographically beyond the service areas of the generating plants or power systems directly benefitted by the release of stored waters from storage projects constructed by the upstream country. It is recognized that the power systems in British Columbia are not now developed to the same extent as in the United States portion of the Columbia River basin, but it is the intention of this principle to

provide for long-range international cooperation between the systems of the two countries as they continue to develop in the future.

Under arrangements for coordination, it would be expected that all participating power systems would retain their local autonomy but would necessarily operate their generation and transmission facilities under the terms of appropriate agreements with a view to maximizing mutual benefits. The arrangements should set forth the broad operating principles to be observed and should be written in sufficient detail to describe the specific purposes and objectives.

FLOOD CONTROL PRINCIPLES

Among the sections in the United States to which principles for flood control benefit determination and sharing would be applicable are the Kootenai River downstream from Bonners Ferry, Idaho, and the lower main stem of the Columbia River. These areas now have partial protection against flooding and there are plans for utilization of storage in the United States to be developed primarily for power purposes in such a way that ultimately a high degree of protection against major floods would be obtained. As successive blocks of storage for flood control purposes are added to the system, the amount of flood damage that can be prevented per unit of flood control storage decreases. Accordingly, the value that can be assigned to upstream storage for flood control purposes is greater for projects to be constructed in the near future than for those to be built later. Also, in the Columbia Basin the hydrologic and hydraulic characteristics are such that storage can be operated in the interests of flood control to a considerable extent with little, if any, interference with the operation of the same storage project in the interests of power generation.

These factors, as well as other information available to the Commission, have been taken into account in formulating the following principles for determination and sharing of flood control benefits which may result from cooperative development of storage in the Columbia River Basin.

Flood Control Principle No. 1

Flood control benefits should be determined on the basis of an assured plan of operation and flood control regulations agreed to in advance.

Discussion of Flood Control Principle No. 1

The assured plan of operation for flood control would not be a separate plan of operation but rather a joint or composite plan of operation of a given storage project in the interests of flood control as well as for other purposes, principally power, The plan of operation for any reservoir included in the flood control plan, therefore, should be worked out initially so as to obtain the best combination of benefits for all purposes. In the Pacific Northwest meteorological and hydrological conditions and the requirements for storage operations in the interests of power and flood control are such that little, if any, loss of ability to maximize power benefits is required to accommodate flood control. In any event, the plan of operation worked out in accordance with these principles would be the basis for determination of the flood control and power benefits to be shared.

Once the plan of operation is agreed to, normal operations for both power and flood control would be in accordance with that plan. It is to be expected that both the upstream storage interests and the downstream power flood control interests may wish from time to time to request or suggest deviations from the plan. If such deviations would involve an adverse effect on the other party at interest it would be expected that a basis for compensating for the adverse effect would also be proposed. Such deviations would then be made possible if the deviations and any required compensation were mutually acceptable to both parties. If the upstream country wished to have the option of using alternative storage to provide equivalent downstream flood control effects as contemplated in the plan of operation, such option should be provided for in the agreement.

It is assumed that acts of God, emergencies, and other events over which neither party has control, would be interpreted and handled in the manner usually contemplated in a "force majeure" clause in an agreement.

Flood Control Principle No. 2

The downstream flood control benefit of the upstream storage to be operated in accordance with an agreed-upon flood control plan should be estimated in advance on the basis of the effectiveness of such storage in meeting the flood control objectives applicable in the downstream country at the time the upstream storage is provided.

Discussion of Flood Control Principle No. 2

This principle places prospective Canadian storage to be operated in accordance with an agreed-upon flood control plan in exactly the same

position that any concurrently prospective United States storage for flood control purposes would have. The effectiveness of all flood control storage is measured in terms of the flood control objectives applicable at the time the storage is to be provided and the effectiveness determined at that time is applicable for the entire life of the project in question or for the period of agreement in the case of Canadian storage.

In the United States the current primary flood control objective is to obtain storage sufficient to control a flood of the magnitude of that of 1894 at The Dalles to 800,000 cfs. All additional storage in the United States or Canada necessary to achieve this objective (approximately $7\frac{1}{2}$ million acre feet of storage usable for flood control) would, if included in the flood control plan, be given equal credit on the basis of the effectiveness of each acre foot of such storage in controlling floods at The Dalles. Storage either in the United States or Canada added after the necessary amount has been reached to control the 1894 flood to 800,000 cfs. would, if included in the flood control plan, be evaluated at a lesser rate based on the average value of all additional storage needed to control the 1894 flood at The Dalles to 600,000 cfs.

Local flood control objectives have also been identified in other parts of the basin especially on the Kootenai River downstream from Bonners Ferry where control of the 1894 flood to a maximum of 60,000 cfs. is desirable. Storage either in the United States or Canada should be entitled to credit on the basis of satisfying such local objectives.

Flood Control Principle No. 3

The monetary value of the flood control benefit to be assigned to the upstream storage should be the estimated average annual value of the flood damage prevented by such storage.

Discussion of Flood Control Principle No. 3

The average annual value of flood damage prevented by upstream storage can be computed by conventional methods using stage-frequency and damage-frequency relationships. The methods are described and their application illustrated in the most recent report of the Corps of Engineers on the Columbia River Basin recently submitted by the Division Engineer, U.S. Army Engineer Divsion, North Pacific, to the Chief of Engineers under the title "Water Resources Development, Columbia River Basin" dated June 195 ?

Flood Control Principle No. 4

The upstream country should be paid one-half of the benefits as measured in Flood Control Principle No. 3, i.e., one-half of the value of the damages prevented.

Discussion of Flood Control Principle No. 4

In the event that application of this principle should indicate a payment to the upstream country greater than the estimated cost of alternative means of obtaining equivalent flood control in the United States the requirement of General Principle No. 2 that there should be an advantage as compared with available alternatives would not be satisfied and consideration should be given to this circumstances in the negotiations.

Flood Control Principle No. 5

The amount due to the upstream country under the foregoing principles should be determined in advance of construction of each storage project. Payments to cover the entire period that the arrangements are to be effective should be made in cash as a lump sum or as periodic amounts as may be agreed upon to the mutual satisfaction of the upstream and downstream countries.

Discussion of Flood Control Principle No. 5

The payment of a lump sum or periodic amount as may be agreed upon would, of course, be subject to the authorization of such payment by the Congress of the United States. Requests for such authorization could be presented to the Congress for consideration as soon as a definite arrangement between the two countries became available as a basis for the request.

Flood Control Principle No. 6

In the event of the downstream country requesting special operation for flood control of storage included in the assured plan of operation, beyond the type of operation provided for in such assured plan, the upstream country should be compensated for any loss of power which may result therefrom. In the event of the downstream country requesting the operation, for flood control, of storage not included in the assured plan, the upstream country should similiarly be compensated for any loss of power which may be sustained by the upstream country and in addition should be paid on the basis of half the damages prevented by the operation of the storage in question.

Discussion of Flood Control Principle No. 6

This principle is included to provide for emergency operations to meet unusual flood producing conditions not covered in the assured plan of operation discussion under Principle No. 1. As long as operations for flood control remain in conformity with the assured plan of operation, there would be no compensation beyond that provided for in the other power and flood control principles.

If, however, unusual flood producing conditions should occur and, at the request of the downstream country, the upstream country should draw down its storages included in the assured plan to a greater extent or at a different time or in any manner not provided for in the assured plan of operation, the downstream country should compensate the upstream country for the loss of power sustained in providing the additional flood protection. That is, if such action caused a loss of power as compared with the results that would have been possible by adhering to the assured plan of operation, then the upstream country would be reimbursed for the loss of power at its plants and for the decrease in its share of power in the downstream country's plants. The reimbursement could be either in cash or in power as might be mutually agreed upon. In any event, the downstream country should give assurances that it would furnish sufficient power to meet minimum load requirements of the upstream country if the loss of power were so great as to adversely affect the upstream country's ability to meet the loads from its own resources.

The foregoing arrangements will apply also to upstream storage not in the flood control plan but which is operated in response to the request of the downstream country to give emergency relief. In this case, however, the downstream country should, in addition to the compensation to the upstream country for power loss, make a payment to the upstream country on the basis of half the damages prevented.

Signed at Washington this twenty-ninth day of December 1959.

Eugene W. Weber

A.G.L. McNaughton

Francis L. Adams

J. Lucien Dansereau

D.M. Stephens

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