ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 SEPTEMBER 1993

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A • U N I T E D S T A T E S

February 28, 1994

The Honourable Warren Christopher
The Secretary of State
Washington, DC

The Honourable A. Anne McLellan
Minister of Energy,
Mines and Resources
Ottawa, Ontario

Dear Secretary of State Christopher and Minister McLellan:

Reference is made to the Treaty between the United States of America and Canada, relating to co-operative development of the water resources of the Columbia River basin, signed at Washington, DC, on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the twenty-nine Annual Report, dated 30 September 1993, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1992 to 30 September 1993.

Respectfully submitted:

For the United States

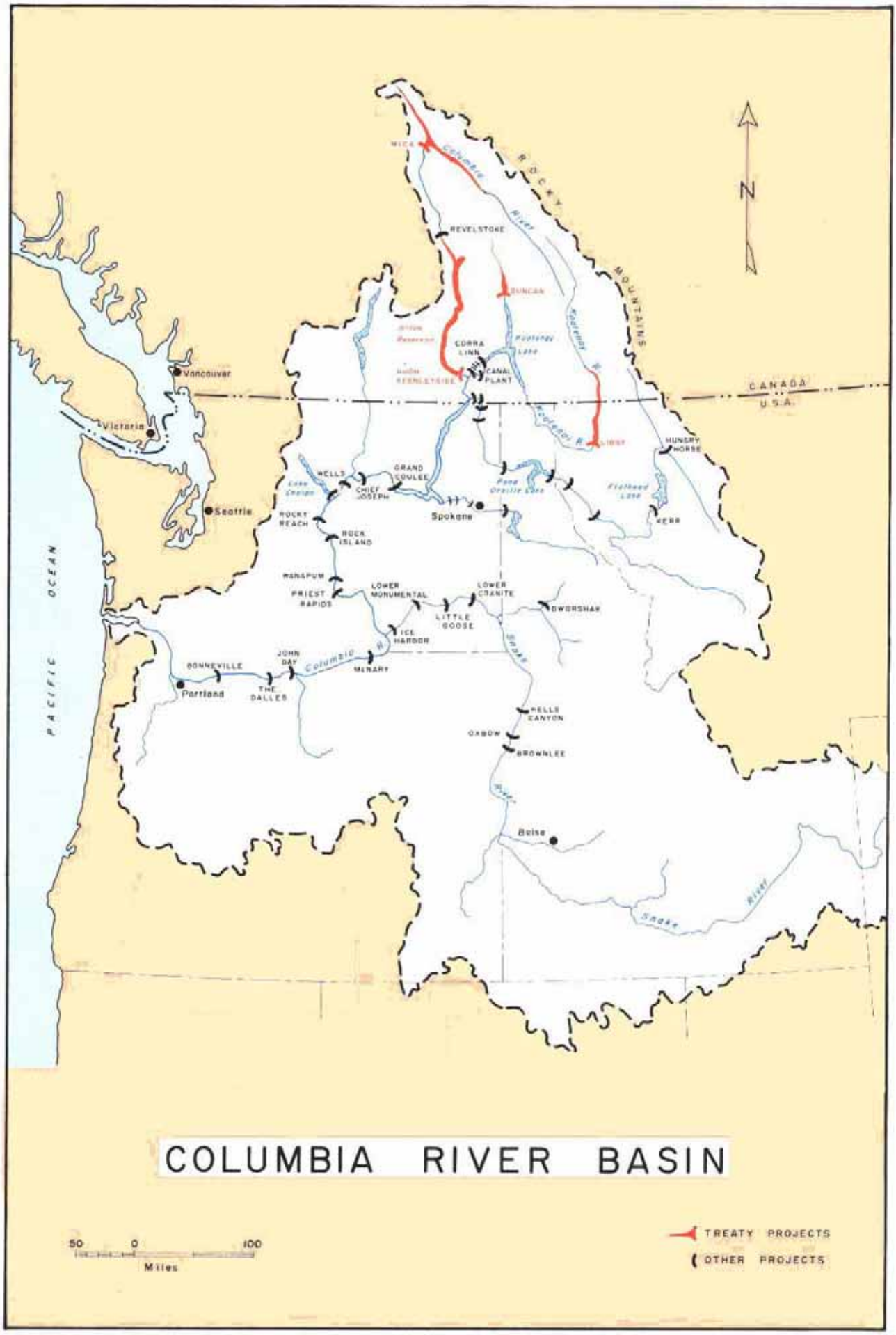
John D. Elmore, Chairman

Ronald H. Wilkerson

For Canada

John Allan, Chairman

David Burpee



COLUMBIA RIVER BASIN

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CONTENTS

LIST OF PHOTOGRAPHS

Photographs supplied by the British Columbia Hydro and Power Authority and the U.S. Army Corps of Engineers

HYDROGRAPHS

APPENDICES

ACKNOWLEDGEMENT

This report is dedicated to Mr. Herbert H. Kennon, Chairman of the United States Section of the Permanent Engineering Board from 27 March 1990 to 29 January 1994.

Mr. Kennon has been directly involved in comprehensive development of the Columbia River basin water resources throughout his professional career, including serving for 7 years as the United States Entity Coordinator for the Columbia River Treaty.

His high professional values and experiences resulted in an outstanding contribution to the United States and Canada in the management of basin water resources.

Members of the Permanent Engineering Board and the Engineering Committee are proud to have had the opportunity of working with him, and wish him the best on his retirement from the Board.

SUMMARY

The twenty-ninth Annual Report of the Permanent Engineering Board is submitted to the governments of the United States and Canada in compliance with Article XV of the Columbia River Treaty of 17 January 1961. The status of projects, progress of Entity studies, operation of the Duncan, Arrow, Mica and Libby reservoirs, and the resulting benefits are described.

The Duncan, Arrow, Mica and Libby storage projects were operated throughout the year in accordance with the objectives of the Treaty and the terms of operating plans developed by the Entities. Operations under the 1990 non-Treaty storage agreement between the Entities relating to the use of non-Treaty storage, refill enhancement for Mica and Arrow reservoirs, and initial filling of non-Treaty reservoirs did not conflict with Treaty operations. Flood control operations on a daily basis were not required this year (pages 27-37).

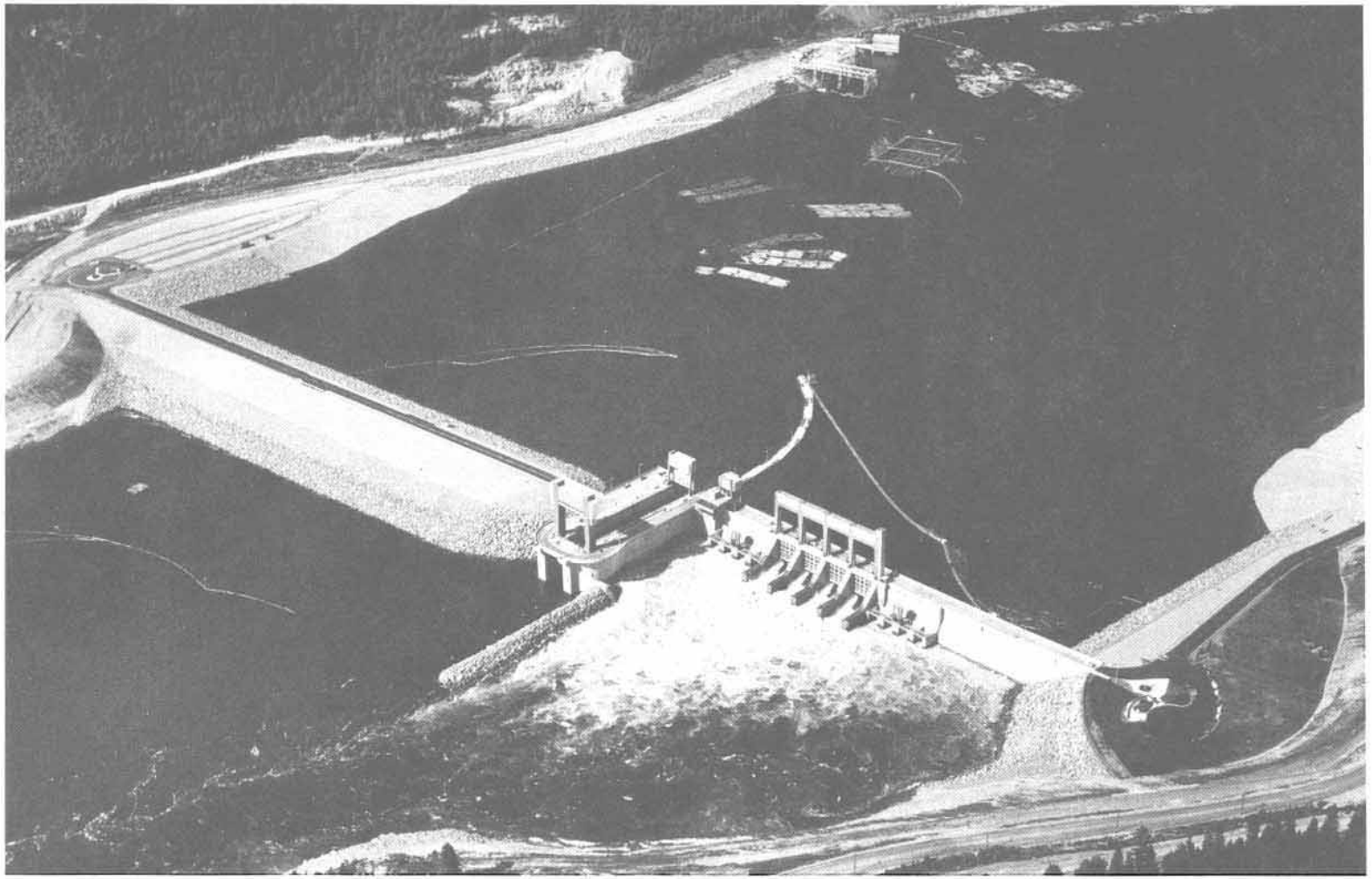
Studies by the Entities pertaining to development of the hydrometeorological network, power operating plans, and calculations of downstream power benefits have been continued by the Entities to ensure compliance with the terms of the Treaty. The Entities did not, however, reach agreement on certain aspects of the method of calculating the downstream power benefits and did not submit the report *Assured Operating Plan and Determination of Downstream Power Benefits for the Operating Year 1998-1999* in accordance with the agreed upon schedule. (pages 20-25)

The objectives of the Treaty for the 1992-93 report year have been met.

INTRODUCTION

The Columbia River Treaty provides for the cooperative development of the water resources of the Columbia River basin. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties is to "make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty."

This Annual Report, which covers the period 1 October 1992 through 30 September 1993, describes activities of the Board, progress being achieved by both countries under the terms of the Treaty, operation of the Treaty projects, and the resulting benefits. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included. The report refers to items currently under review by the Entities, provides discussion regarding the operations of the Treaty reservoirs and of the resulting power and flood control benefits, and presents the conclusions of the Board.



Hugh Keenleyside Dam - Columbia River, British Columbia

Concrete spillway and discharge works with navigation lock and earth dam.

THE COLUMBIA RIVER TREATY

General

The Columbia River Treaty was signed in Washington, D.C. on 17 January 1961 and was ratified by the United States Senate in March of that year. In Canada ratification was delayed. Further negotiations between the two countries resulted in formal agreement by an exchange of notes on 22 January 1964 to a Protocol to the Treaty and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.

The Canadian Entitlement Purchase Agreement was signed on 13 August 1964. Under the terms of this agreement, Canada's share of downstream power benefits resulting from the first thirty years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964 the Treaty and Protocol were formally ratified by an exchange of notes between the two governments. The sum of $253.9 million (U.S. funds) was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date, at a ceremony at the Peace Arch Park on the International Boundary, the Treaty and its Protocol were proclaimed by President Johnson of the United States, Prime Minister Pearson of Canada, and Premier Bennett of British Columbia.

Features of the Treaty and Related Documents

The essential undertakings of the Treaty are as follows:

(a) Canada will provide 15.5 million acre-feet of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes, and Duncan Lake in British Columbia.

(b) The United States will maintain and operate hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved streamflow resulting from operation of the Canadian storage. Canada will operate the storage in accordance with procedures and operating plans specified in the Treaty.

(c) The United States and Canada will share equally the additional power benefit available in the United States as a result of river regulation by upstream storage in Canada.

(d) On commencement of the respective storage operations, the United States will make payments to Canada totalling $64.4 million (U.S. funds) for flood control provided by Canada.

(e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby reservoir would extend some 42 miles into Canada, and Canada would make the necessary Canadian land available for flooding.

(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984

Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

(g) Differences arising under the Treaty which cannot be resolved by the two countries may be referred by either country to the International Joint Commission or to arbitration by an appropriate tribunal as specified by the Treaty.

(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

The Protocol of January 1964 amplified and clarified certain terms of the Columbia River Treaty. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Exchange of Notes and Attachment Relating to Terms of Sale of January 1964 and the Canadian Entitlement Purchase Agreement of 13 August 1964 (the Sales Agreement) provided that the Treaty storages would be operative for power purposes on the following dates:

Duncan storage	-	1 April 1968
Arrow storage	-	1 April 1969
Mica storage	-	1 April 1973

PERMANENT ENGINEERING BOARD

General

Article XV of the Columbia River Treaty established a Permanent Engineering Board consisting of two members to be appointed by Canada and two members by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board were also stipulated in the Treaty and related documents.

Establishment of the Board

Pursuant to Executive Order No. 11177 dated 16 September 1964, the Secretary of the Army and the Secretary of the Interior, on 7 December 1964, appointed two members and two alternate members to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977, the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each member was authorized to appoint an alternate member. On 11 December 1964, the two governments announced the composition of the Board.

The names of Board members, alternate members, and secretaries are shown in Appendix A. It is noted that on 29 January 1994, Mr. John P. Elmore succeeded Mr. Herbert H. Kennon as a member for the United States, and Mr. Paul D. Barber replaced Mr. Elmore as an alternate member for the United States. On 18 January 1994, Mr. David Burpee succeeded Mr. Vic Niemela as an alternate member for Canada.

The names of the current members of the Board's Engineering Committee are also shown in Appendix A.

Duties and Responsibilities

The general duties and responsibilities of the Board to the governments, as set forth in the Treaty and related documents, include:

(a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada-United States of America boundary;

(b) reporting to Canada and the United States of America whenever there is substantial deviation from the hydroelectric and flood control operating plans and if appropriate including in the report recommendations for remedial action and compensatory adjustments;

(c) assisting in reconciling differences concerning technical or operational matters that may arise between the Entities;

(d) making periodic inspections and requiring reports as necessary from the Entities and with a view to ensuring that the objectives of the Treaty are being met;

(e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter which it considers should be brought to their attention;

(f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America;

(g) consulting with the Entities in the establishment and operation of a hydrometeorological system as required by Annex A of the Treaty.

Duncan Dam - Duncan River, British Columbia

The earth dam with discharge tunnels to the left and spillway to the right.

ENTITIES

General

Article XIV(1) of the Treaty provides that Canada and the United States shall each designate one or more Entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the Entities are specified in the Treaty and its related documents.

Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, the Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity with the Administrator to serve as Chairman. Pursuant to the Department of Energy Organization Act of 4 August 1977, the Bonneville Power Administration was transferred to the Department of Energy. Order In Council P.C. 1964-1407 dated 4 September 1964 designated the British Columbia Hydro and Power Authority as the Canadian Entity.

The names of the members of the two Entities are shown in Appendix B. It is also noted that Mr. Marc Eliesen succeeded Mr. Norman Olsen as Chair of the Canadian Entity effective 30 November 1992.

Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents, Article XIV(2) of the Treaty requires that the Entities be responsible for the following:

(a) coordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty;

(b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control;

(c) calculation of the amounts payable to the United States for standby transmission services;

(d) consultation on requests for variations made pursuant to Articles XII(5) and XIII(6);

(e) the establishment and operation of a hydrometeorological system as required by Annex A;

(f) assisting and cooperating with the Permanent Engineering Board in the discharge of its functions;

(g) periodic calculation of accounts;

(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled;

(i) preparation of proposals to implement Article VIII and carrying out any disposal authorized or exchange provided for therein;

(j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled including

such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss;

(k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in Annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the Entities with any other matter coming within the scope of the Treaty.

ACTIVITIES OF THE BOARD

Meetings

The Board met in Vancouver, British Columbia on 3 December 1992 to review progress under the Treaty, and to finalize the Board's annual report for the year ending 30 September 1992. The Board met with the Entities on the same day to discuss the Entities' studies and general progress. The Board also met on 20 May 1993 in Portland, Oregon to review the Entities' operating plans, and the annual schedule for the Board and Engineering Committee. The Board agreed at this meeting to change its annual meeting from December to the following February. The timing of the Board's annual report to the governments would also be changed from the end of December to the end of February. The Board met with the Entities on the same day for a briefing on the Entities' report *Columbia River Treaty, Forecast of Canadian Entitlement to Downstream Power Benefits, Entitlement Forecast Studies*, dated April 1993.

Reports Received

Throughout the report year, the Entities maintained contact with the Board and the Board's Engineering Committee. Operating data concerning the Treaty storage projects were made available to the Board.

In addition, the Entities provided the following documents and reports to the Board:

- Annual Report of the Columbia River Treaty, Canadian and United States Entities for the period 1 October 1991 through 30 September 1992;

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1992 through 31 July 1993, plus a copy of the Entities' agreement;

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994, dated September 1993, plus a copy of the Entities' agreement dated 10 November 1993;

- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1997-98, October 1992, plus a copy of the Entities' agreement;

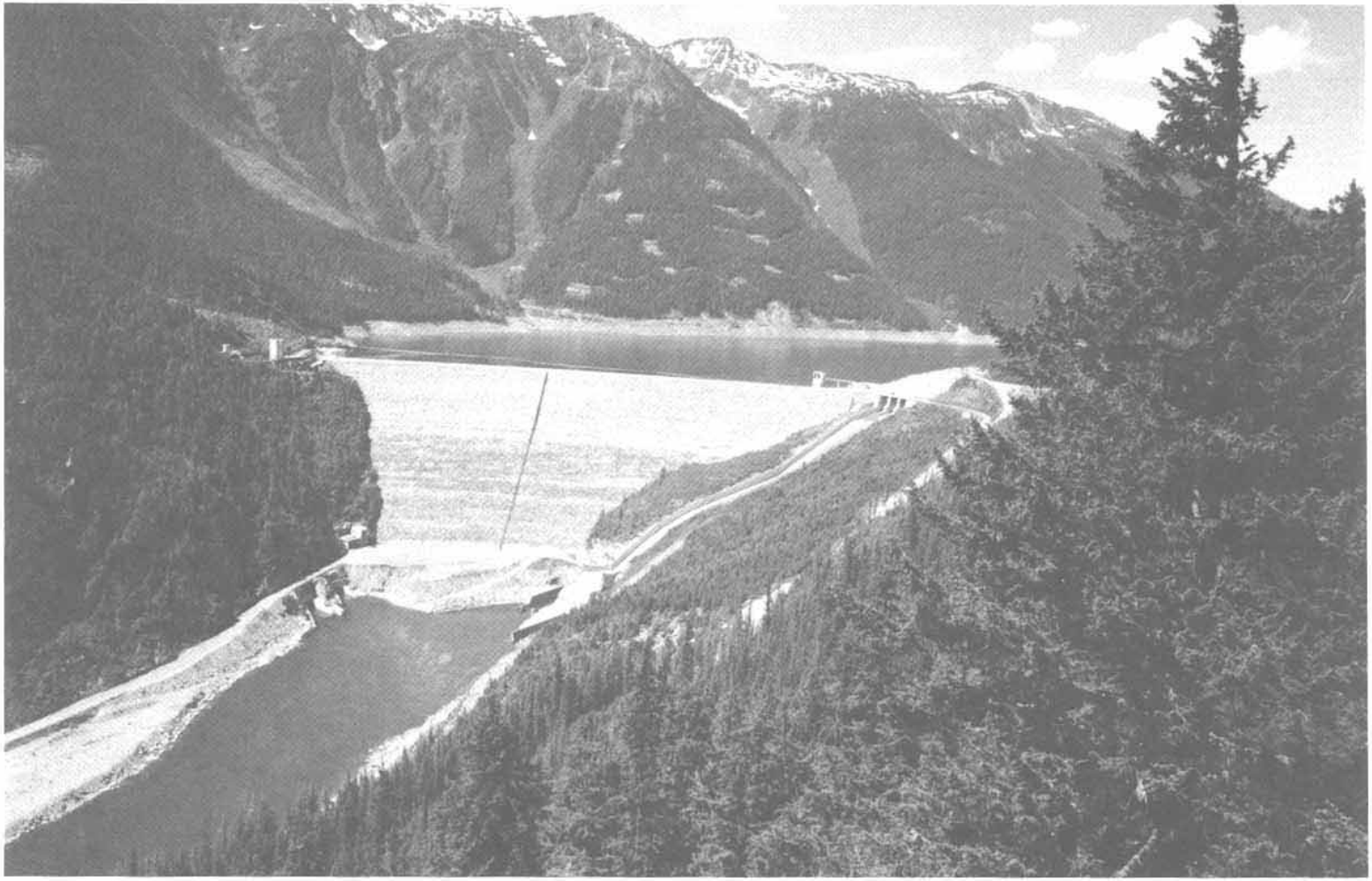
- Columbia River Treaty, Forecast of Canadian Entitlement to Downstream Power Benefits, Entitlement Forecast Studies, April 1993.

Subsequent to the end of this report year, the Board received the following report from the Entities:

- Annual Report of the Columbia River Treaty Canadian and United States Entities for the period 1 October 1992 - 30 September 1993.

Report to Governments

The twenty-eighth Annual Report of the Board was submitted to the two governments on 31 December 1992.



Mica Dam - Columbia River, British Columbia

The earth dam showing the spillway at the right. The underground powerhouse is at the left.

PROGRESS

General

The results achieved under the terms of the Treaty include construction of the Treaty projects, development of the hydrometeorological network, annual preparation of power and flood control operating plans, and the annual calculation of downstream power benefits. The three Treaty storage projects in British Columbia - the Duncan, Arrow and Mica projects - produce power and flood control benefits in Canada and the United States. The Libby storage project also provides power and flood control benefits in both countries. In the United States, increased flow regulation provided by Treaty projects facilitated the installation of additional generating capacity at existing plants on the Columbia River. In Canada, completion of the Canal Plant on the Kootenay River in 1976, installation of generators at Mica Dam in 1976-77, and the completion of the Revelstoke project in 1984 have caused power benefits to increase substantially. This amounts to some 4,000 megawatts of generation in Canada that may not have been installed without the Treaty. In addition, the installation of generating capacity at Hugh Keenleyside Dam and at the Murphy Creek Site near Trail, British Columbia is planned for the future.

The Treaty provides Canada with an option, which commenced in 1984, of diverting the Kootenay River at Canal Flats into the headwaters of the Columbia River. The British Columbia Hydro and Power Authority completed engineering feasibility and detailed environmental studies of the potential diversion. No further activities are planned at this time.

The locations of the above projects are shown on Plate 1 in Appendix D.

Status of the Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled in the Sales Agreement for operation by 1 April 1968 and was the first of the Treaty projects to be completed. It became fully operational on 31 July 1967, well in advance of Treaty requirements.

The earthfill dam is about 130 feet high and extends 2,600 feet across the Duncan River valley, approximately six miles north of Kootenay Lake. The reservoir behind the dam extends for about 27 miles and provides 1,400,000 acre-feet of usable storage, which is all committed under the Treaty. There are no power facilities included in this project.

The project is shown in the picture on page 9, and project data are provided in Table 1 of Appendix D.

Arrow Project

The Hugh Keenleyside Dam, at the outlet of the Arrow lakes, was the second Treaty project to be completed. It became operational on 10 October 1968, well ahead of the date of 1 April 1969 scheduled by the Sales Agreement. The project at present has no associated power facilities; however, installation of generators is planned for the future.

The dam consists of two main components: a concrete gravity structure which extends 1,200 feet from the north bank of the river and includes the spillway, low-level outlets, and navigation lock; and an earthfill section which rises 170 feet above the riverbed and which extends 1,650 feet from the navigation

lock to the south bank of the river. The reservoir, about 145 miles long, includes both the Upper and Lower Arrow Lakes, and provides 7,100,000 acre-feet of Treaty storage.

The project is shown in the picture on page 2, and project data are provided in Table 2 of Appendix D.

Mica Project

Mica Dam, the largest of the Treaty projects, was scheduled by the Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973.

Mica Dam is located on the Columbia River about 85 miles north of Revelstoke, British Columbia. The earthfill dam rises more than 800 feet above its foundation and extends 2,600 feet across the Columbia River valley. It creates a reservoir 135 miles long, Kinbasket Lake, with a total storage capacity of 20,000,000 acre-feet. The project utilizes 12,000,000 acre-feet of live storage of which 7,000,000 acre-feet are committed under the Treaty.

Although not required by the Treaty, a powerhouse was added to the project by B.C. Hydro and Power Authority. The underground powerhouse has space for a total of six 434-megawatt units, with a total capacity of 2,604 megawatts. At present, four generators are in operation for a total of 1,736 megawatts.

The project is shown in the picture on page 15, and project data are provided in Table 3 of Appendix D.

Libby Project in the United States

Libby Dam is located on the Kootenai River, 17 miles northeast of the town of Libby, Montana. Construction began in the spring of 1966; storage has been fully operational since 17 April 1973. Commercial generation of power began on 24 August 1975, which coincided with the formal dedication of the project. The concrete gravity dam is 3,055 feet long, rises 370 feet above the riverbed and creates Lake Koocanusa, which is 90 miles long and extends 42 miles into Canada. Lake Koocanusa has a gross storage of 5,869,000 acre-feet, of which 4,980,000 acre-feet are usable for flood control and power purposes. The Libby powerhouse, completed in 1976, has four units with a total installed capacity of 420 megawatts.

Construction of four additional units was initiated during fiscal year 1978, and the turbines have been installed. However, Congressional restrictions imposed in the 1982 Appropriations Act provide for completion of only one of these units. That unit became available for service late in 1987. The total installed capacity for the five units is 525 megawatts.

The Libby project is shown in the picture on page 24, and project data are provided in Table 4 of Appendix D.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. British Columbia Hydro and Power Authority is now responsible for reservoir maintenance, debris clean-up and shoreline activities.

Hydrometeorological Network

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for detailed programming of flood control and power operation. This system includes snow courses, meteorological stations and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on further development of the Treaty Hydrometeorological System.

In developing the hydrometeorological network, the Entities, with the concurrence of the Board, adopted a document in 1976 which defines the Columbia River Treaty Hydrometeorological System Network and sets forth a method of classifying facilities into those required as part of the Treaty System and those of value as Supporting Facilities. During the 1976-77 report year, the Entities, with the concurrence of the Board, adopted a plan for exchange of operational hydrometeorological data. That plan is still in force.

In the 1985-86 report year the Entities provided the Board with the report *Revised Hydrometeorological Committee Documents*, dated November 1985. The list of hydrometeorological facilities included in this document, which constitute the network, was updated by the Entities in 1987, 1989 and 1990.

Power Operating Plans and Calculation of Downstream Benefits

The Treaty and related documents require the Entities to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation. These operating plans, prepared five years in advance, are called assured operating plans. They represent the basic commitment of the Canadian Entity to operate the Treaty storage and provide the

Entities with a basis for system planning. Canada's commitment to operate under an assured operating plan is tied directly to the benefits produced by that plan. At the beginning of each operating year, a detailed operating plan, which includes the Libby reservoir, is prepared on the basis of current resources and loads, to obtain results that may be more advantageous to both countries than those which would be obtained by operating in accordance with the assured operating plan.

Near the end of the 1987-88 report year, the Entities signed two agreements relating to changes in the principles and procedures used in preparing the assured operating plans and in calculating downstream power benefits. These agreements were based on Entity studies of the impact of several proposed changes to Treaty reservoir operating procedures and to the determination of downstream power benefits. The Entities' report, *Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans*, dated December 1991, provides guidelines for preparation of the operating plans and incorporates the Entities' agreements.

The Entities' report, *Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1992-93*, was provided to the Board in 1988. The report established the operating rule curves for the Duncan, Arrow, and Mica Treaty reservoirs and calculated the downstream power benefits resulting from the operation of the Treaty reservoirs for the 1992-93 operating year. Actual operations of the Treaty reservoirs, during the 1992-93 operating year, were regulated under the rule curves set out in the Entities' report, *Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1992 through 31 July 1993*. The Entities provided this report to the Board early in the 1992-93 report year. The detailed operating plan for 1992-93 contained relatively minor changes from the assured operating plan for the same year. As noted above, the detailed operating plans do not change the downstream power benefits.

In September 1993, the Entities provided the Board with the report, *Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994.* This detailed operating plan essentially implements the assured operating plan for the 1993-94 operating year, which was dated July 1989. The agreement between the Entities to the detailed operating plan for 1993-94 was forwarded to the Board in December 1993.

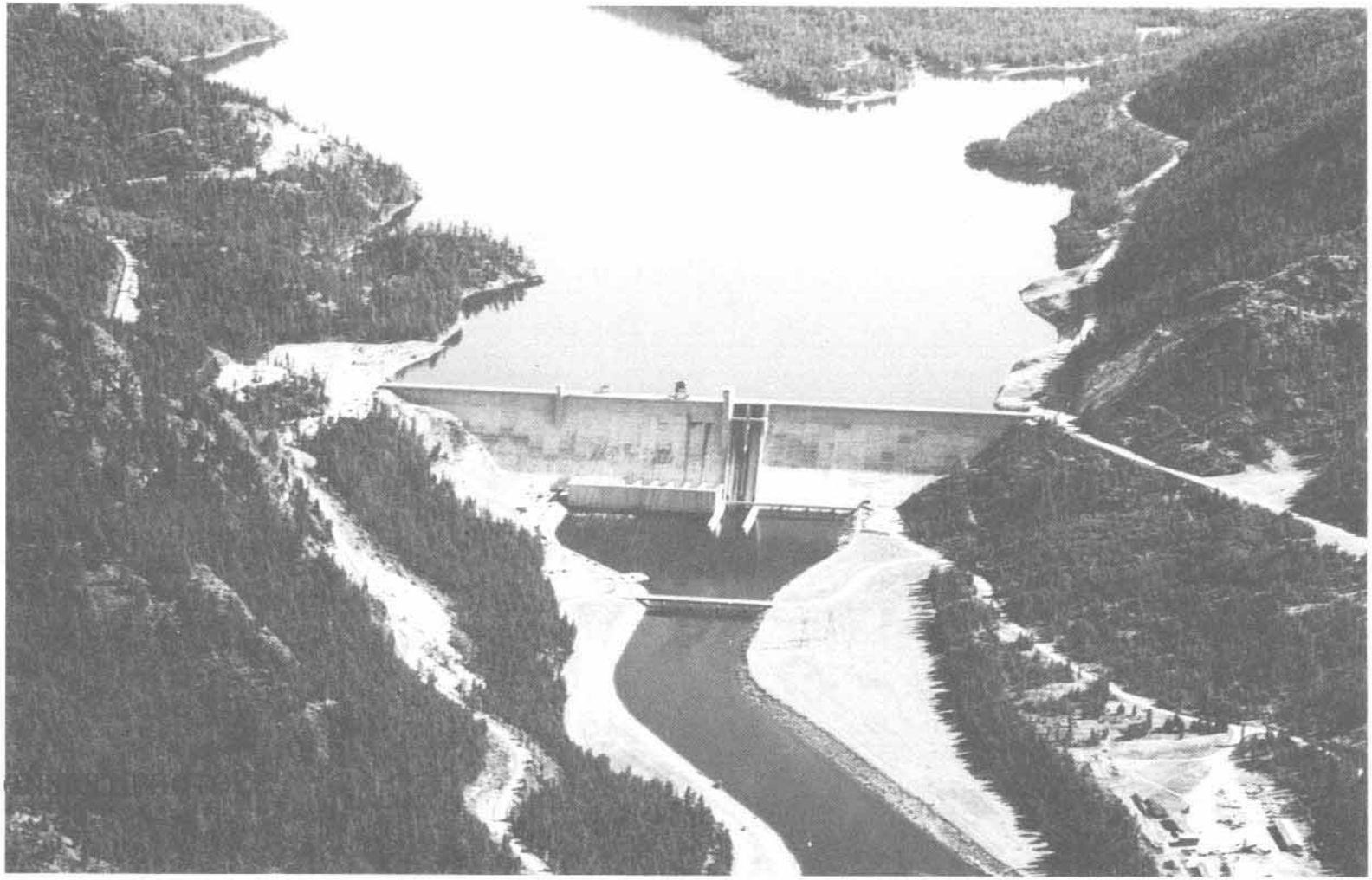
In October 1992, the Entities provided the Board with the report, *Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1997-98.* The report was prepared using the agreed upon principles and procedures noted above. For the first time, however, the report provided for the delivery to British Columbia of a portion of the Canadian entitlement to the downstream power benefits. This addition was required because the Canadian entitlement to the downstream benefits, stemming from the operation of the Duncan reservoir, will cease to be covered by the terms of the Sales Agreement beginning 1 April 1998. The Treaty requires that the Canadian entitlement be returned to a point near Oliver, British Columbia, unless the Entities agree to an alternative delivery point. In July 1992, the Entities agreed that the Canadian entitlement would be delivered through existing interconnections between the transmission systems of the B.C. Hydro and Power Authority and the Bonneville Power Administration until 31 March 2003.

The Entities had agreed to provide the Board with the assured operating plan and determination of the downstream power benefits for the operating year 1998-99 by 31 October 1993. However, the report has been delayed because the Entities have differing interpretations of certain provisions in the Treaty documents concerning the operating plans and calculation of the downstream power benefits. One of these issues is whether the Treaty mandates the use of monthly reservoir balances for the whole Canadian Treaty storage, or whether half-months can be used. The second concerns the extent to which requirements

on the operation of the downstream U.S. hydroelectric facilities, other than those required for power generation and flood control, are to be reflected in the assured operating plan and calculation of the power benefits. The third issue concerns differences in the interpretation of the Treaty's definition of the term "critical period" for power operation. The Entities have kept the Board informed of their differences on these issues.

In May 1993, the Entities briefed the Board on their report, *Columbia River Treaty - Forecast of Canadian Entitlement to Downstream Power Benefits - Entitlement Forecast Studies*. The objectives of the study were to estimate the Canadian entitlement to the downstream power benefits for the period from 1998-99 to 2023-24, and to assess the impacts of a range of alternatives on the issues noted above. In September 1993, the Entities advised the Board that their report concerning assured operating plan and the determination of the downstream power benefits for 1998-99 would be delayed because of these three issues.

The Entities are continuing to consider these issues.



Libby Dam - Kootenai River, Montana

The dam and reservoir, Lake Koocanusa. The powerhouse is at the left of the spillway.

The Board notes that since 1984 there have been agreements between the B.C. Hydro and Power Authority and the Bonneville Power Administration concerning non-Treaty storage and that these agreements have not interfered with operations under the Treaty; rather, they extend the concepts of the Treaty and are expected to benefit both the B.C. Hydro and Power Authority and the Bonneville Power Administration.

The Northwest Power Planning Council was established by an Act of Congress in 1980 to prepare, among other things, a program for improvement of fish and wildlife in the Columbia River basin in the United States. This effort has continued to evolve and has included the Water Budget and Flow Augmentation programs.

The Board notes that the assured operating plans are to provide for optimum operation for power and flood control in accordance with the requirements of the Treaty. The Board has also noted, however, that the Entities may agree to provide water for fish migration under detailed operating arrangements providing this does not conflict with Treaty requirements.

Flood Control Operating Plans

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada.

The *Columbia River Treaty Flood Control Operating Plan* defines flood control operation of the Duncan, Arrow, Mica and Libby reservoirs. This plan was received from the Entities and reviewed by the Board in the 1972-73 report year and is still in effect.

Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay rivers at the Canada-United States of America boundary. Flows for this report year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho and for the Columbia River at Birchbank, British Columbia.

OPERATION

General

The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storages and to direct operation of these storages in accordance with the terms of the Treaty and subsequent Entity agreements.

During the report year the Treaty storage in Canada was operated by the Canadian Entity in accordance with:

- Columbia River Treaty Flood Control Operating Plan;
- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1992 through 31 July 1993;
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1992-93;
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1993-94;
- Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans, December 1991.

In addition, the following agreements were in effect during this period:

- An agreement between the British Columbia Hydro and Power Authority and the Bonneville Power Administration dated 9 April 1984 relating to the following

  - Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration Relating to (a) Initial Filling of non-Treaty Reservoirs, (b) The Use of Columbia River non-Treaty Storage and (c) Mica and Arrow Reservoir Refill Enhancement

  - Contract between Bonneville Power Administration and Mid-Columbia Purchasers Relating to Federal and Canadian Columbia River Storage;

- Agreement executed by the United States of America Department of Energy acting by and through the Bonneville Power Administration and British Columbia Hydro and Power Authority relating to: (1) Use of Columbia River non-Treaty Storage, (2) Mica and Arrow Refill Enhancement and (3) Initial Filling of non-Treaty Reservoirs, signed 9 July 1990;

- Columbia River Treaty Entity Agreement on Principles for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits, July 1988;

- Columbia River Treaty Entity Agreement on Changes to Procedures for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefit Studies, August 1988;

- Letter agreement, dated 22 June 1992, between the Bonneville Power Administration and British Columbia Hydro and Power Authority to provide for the exchange of storage between Duncan and Libby reservoirs;

- Columbia River Treaty Entity Agreement on Aspects of the Canadian Entitlement Return for April 1, 1998 through March 31, 2003, dated 28 July 1992;

- An agreement, dated 12 February 1993, between the Bonneville Power Administration and British Columbia Hydro and Power Authority to provide for storage and release from Mica Treaty space during the period February to June 1993 to enhance downstream fish flows in the United States;

- An agreement, dated 15 April 1993, between the Bonneville Power Administration and British Columbia Hydro and Power Authority on the operation of non-Treaty storage during the period April through July 1993 to enhance streamflows in Canada for trout spawning at Norns Creek, to enhance streamflows for fish downstream in the United States during July, and to allow British Columbia Hydro and Power Authority power benefits from storage during May and June 1993;

- An agreement, dated 13 May 1993, between the Bonneville Power Administration and British Columbia Hydro and Power Authority for the period June through December 1993 providing for the use of the Duncan and Arrow reservoirs to reduce the outflow from the Libby reservoir during the summer months; and

- An agreement, dated 16 July 1993, between the Entities to facilitate the temporary transfer of storage from the Mica reservoir to the Hungry Horse reservoir during the period July through September 1993.

Power Operation

The three Treaty reservoirs - Duncan, Arrow and Mica - and the Libby reservoir in the United States were in full operation throughout this report year.

The report year was preceded by a year with low winter snow packs and a warm dry spring. During the summer of 1992, Treaty storage did not fill. By the start of the report year depletion had begun and the Treaty storage was approximately 63 per cent full. The coordinated Columbia River system reached only 68.6 per cent of its capacity during the summer.

Below average precipitation continued through the fall and winter of 1992-93, and the system remained under conservation operation rules throughout the winter until April. The Columbia coordinated system emptied in terms of firm energy capability, and it was necessary to purchase energy from outside the system in order to maintain a 2,400 megawatt deficit in February. The Treaty storage also emptied and overdrafted into the non-treaty storage at Mica reservoir, reaching a peak overdraft of 2,562 million acre-feet on May 5. During this period, the coordinated system reservoirs were not physically empty due to the water set aside for the water budget and flow augmentation programs for the following summer. These programs were designed to assist the salmon migration down the Columbia River and provide flows in the Kootenai River to assist in the spawning of the Kootenai white sturgeon.

May began a period of above average precipitation that lasted through August. The resulting increased stream flows, along with the release of 6.9 million acre-feet of water stored under the flow augmentation programs and the low power demand during this period, caused the coordinated power system to produce surplus energy from May through July.

At the end of August, dry conditions returned to the basin and, since the reservoirs had not filled, operations returned to the conservation mode. Treaty storage continued to fill throughout September, and at the end of the report year had reached approximately 68.6 per cent of full capacity.

In 1992, B.C. Hydro and Power Authority and the Bonneville Power Administration agreed to transfer storage water from Duncan reservoir to Lake Koocanusa. This was accomplished by decreasing discharges from the Libby dam while, at the same time, increasing discharges from the Duncan reservoir. This was undertaken to help mitigate the effects of low inflows and very low water levels on Lake Koocanusa, thereby enhancing summer recreation possibilities in Canada and the United States. A similar agreement was used in the summer of 1993 when Mica and Arrow were used to reduce the outflow from Libby. As a result, Lake Koocanusa was about 6 feet higher than it otherwise would have been. The transferred water was returned by December 31, 1993.

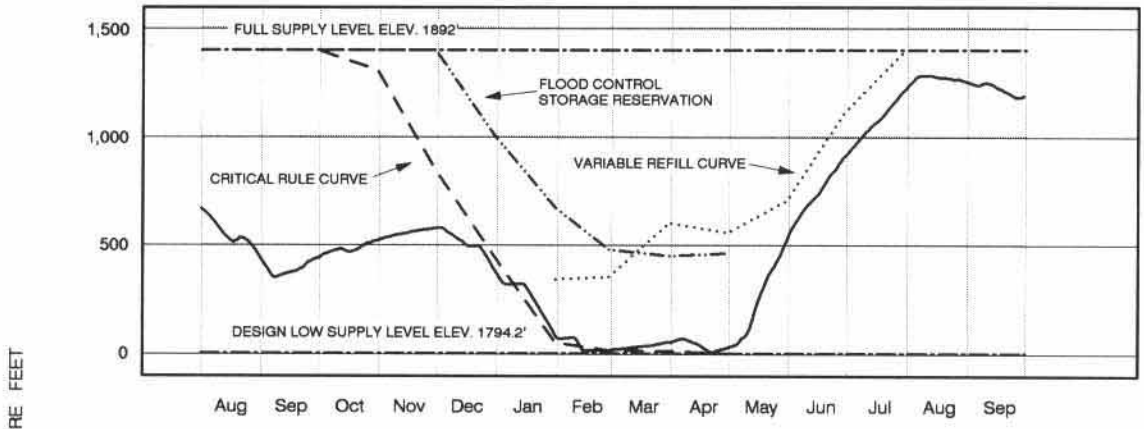
A further agreement between the Entities facilitated the temporary transfer of 54.5 ksfd of storage from Mica reservoir to the Hungry Horse reservoir in the Pend Oreille River basin in the United States. The agreement reduced the amount of spill at the Waneta project, resulting in an energy gain for Canada. This water was returned to Canadian storage in September.

Operation of the reservoirs is illustrated on pages 33 and 34 by hydrographs that show actual reservoir levels and some of the more important rule curves that

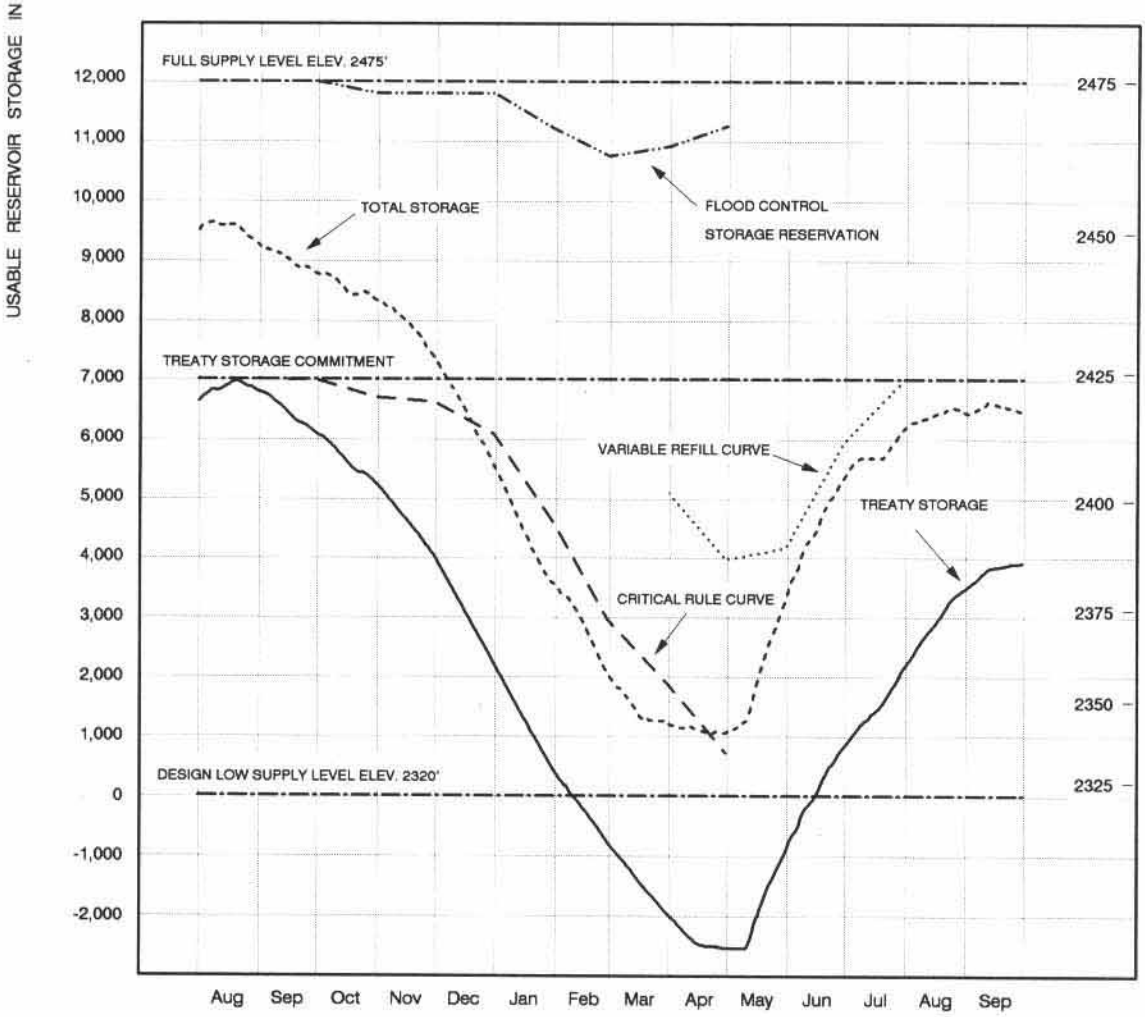
govern operation of the Treaty storage. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels that will permit evacuation of the reservoir to control the forecast freshet. The Critical Rule Curve shows minimum month-end reservoir levels required to meet the anticipated power demands under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves that apply to the operation of the combined Treaty storage have also been provided to the Board.

Mica reservoir began the report year at elevation 2,443.0 feet, about 32 feet below full supply level, after having been 99.6 percent full in August 1992. Releases during October through May were kept as low as possible but, in spite of this, Treaty storage emptied by mid-February. Treaty withdrawals then continued, overdrafting into the non-Treaty storage at Mica reservoir. The reservoir level reached a record low of 2,340.4 feet on 23 April, five feet below the previous lowest recorded level since the reservoir was formed. Subsequently, on 5 May, the Treaty storage overdraft reached its maximum of 2.56 million acre-feet.

In spring, the reservoir began filling due to rapid snow melt. However, due to low snow packs, this lasted for a short time, and average June and July stream flows fell to 60 percent of normal. While precipitation was higher than normal from June through August, Mica only reached a peak elevation of 2,419.4 feet on 12 September. This is 55 feet below the reservoir's full elevation—47 per cent of full reservoir volume. At the end of September 1993, Mica reservoir was at elevation 2,418.0 feet and Treaty storage in the reservoir was 3.891 million acre-feet, 56 percent of the allotted Treaty storage space.

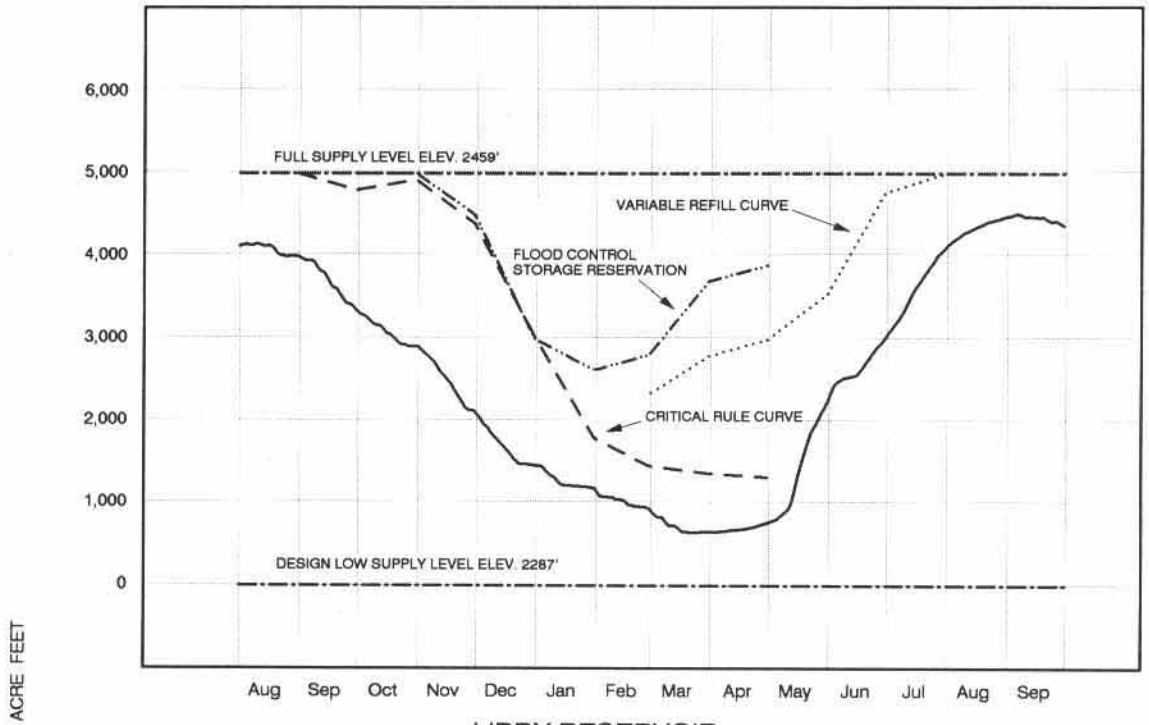


DUNCAN RESERVOIR

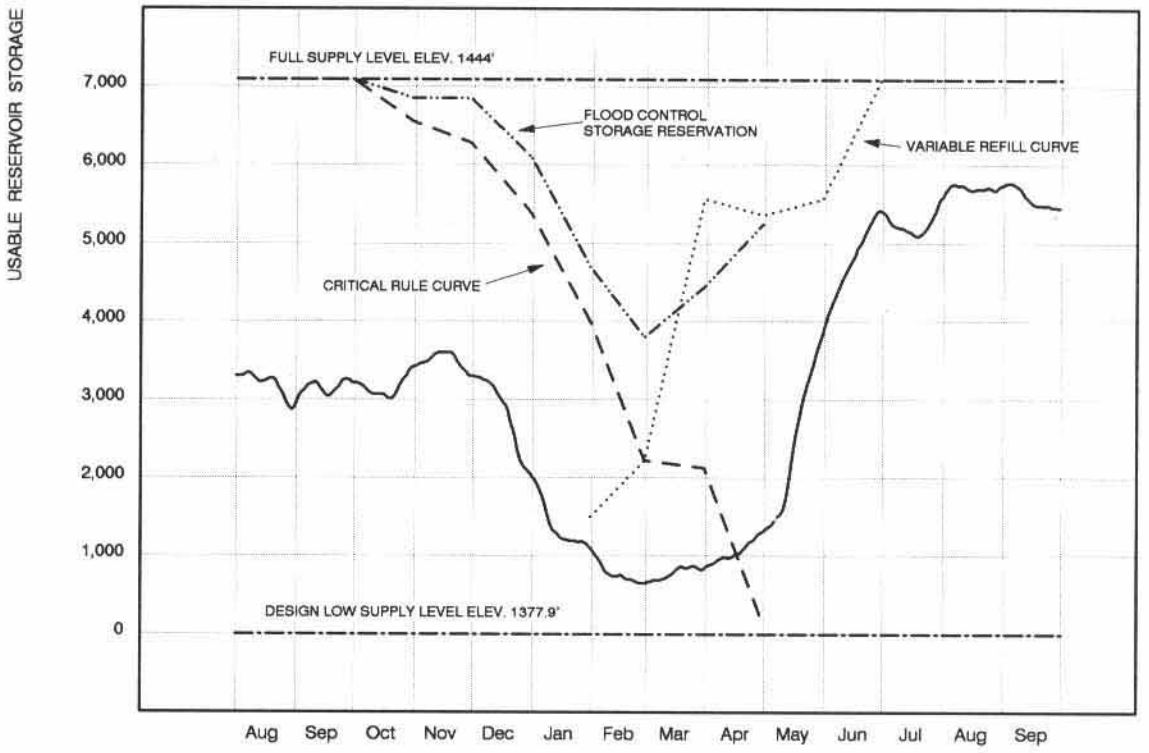


MICA RESERVOIR

HYDROGRAPHS - Duncan and Mica reservoir levels for the 14-month period ending 30 September 1993.



LIBBY RESERVOIR



ARROW RESERVOIR

USABLE RESERVOIR STORAGE IN 1,000 ACRE FEET

HYDROGRAPHS - Libby and Arrow reservoir levels for the 14-month period ending 30 September 1993.

Arrow reservoir began the report year at elevation 1,411.6 feet, 32.4 feet below full. Drafting through the first half of October brought the elevation on 19 October to 1,409.7 feet. Then, through November, water release rates were reduced and the reservoir filled slightly. Draft rates began rising to meet the high electricity demand of winter. This brought the reservoir to its low elevation of 1,385 feet recorded on 26 February.

During the period 20 March to 13 May, outflows were kept low for the fishery studies taking place downstream at Norns Creek and to protect trout spawning grounds at the Norns Creek Fan. At the same time, there were high inflow rates and, by the end of June, Arrow Treaty storage was almost full when storage temporarily transferred to Libby and Mica reservoirs was considered. Discharges drafted the reservoir slightly in the first half of July. Then the Mica reservoir began releasing water, which kept Arrow near 1,433 feet during the last month of the summer recreation season and brought the reservoir to its maximum height of 1,433.5 feet on 4 September. At the end of September 1993, Arrow reservoir was at elevation 1,430.8 feet.

At the start of the report year, Duncan reservoir was rising slowly under minimum outflows after having filled only partially during the summer of 1992. The reservoir began the report year at elevation 1,831.9 feet, holding approximately one-third of the Duncan storage capacity. Only minimum flows were released until 4 December, filling the reservoir to elevation 1,841.8 feet, before drafting began again. During the period 10 October to 18 December, storage that had been transferred earlier in the year to Libby reservoir under an agreement between Bonneville Power Administration and B.C. Hydro, was returned to Duncan reservoir.

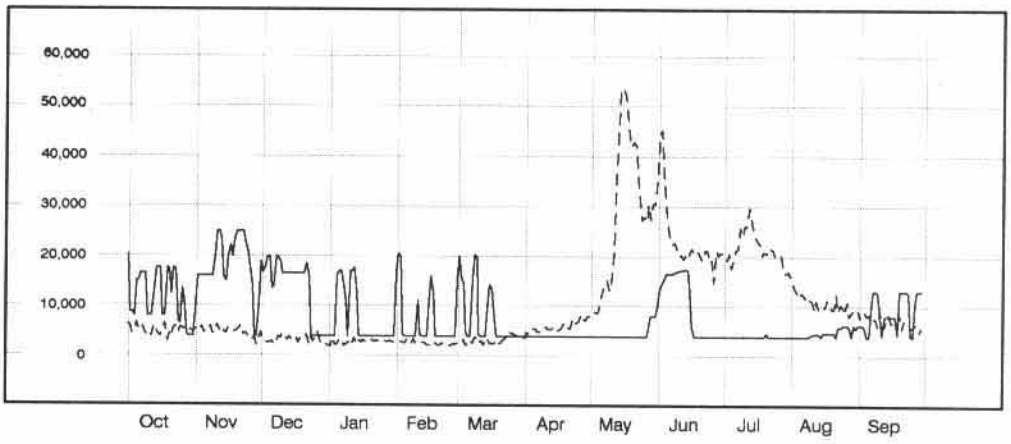
Through December and January the reservoir was drafted, then was held near empty at approximately 1,800 feet throughout February, March and April. The minimum level for the year, 1,794.9 feet, was reached on 22 April. Refill began 6 May and continued under minimum discharges until 6 August when the reservoir level peaked at 1,885.5 feet. The reservoir held between 1,885 and 1,880 feet until the end of the report year, and was at elevation 1,880.0 feet, twelve feet below full, on 30 September.

Libby reservoir began the report year at elevation 2,420.3 feet, 38.7 feet below full. During the previous summer, B.C. Hydro and Bonneville Power agreed to transfer water from the Duncan to the Libby reservoir to enhance summer recreation on Lake Koocanusa. To complete the agreement, the Libby reservoir was drafted into December to return the stored water back to the Duncan reservoir.

To meet winter power demands, the reservoir drafted through 23 March when it reached its lowest level for the year at 2,323.0 feet. Then minimum flows were released until 28 May. Between 28 May and 17 June discharges were increased to provide 20,000 cubic feet per second at Bonners Ferry in an attempt to entice Kootenai white sturgeon in the area to spawn. When this fishery operation ended, Lake Koocanusa was at 2,400 feet elevation, 59 feet from full pool. In a attempt to improve the reservoir levels, B.C. Hydro and Bonneville Power agreed to transfer storage to Libby reservoir by releasing water from the Mica and Arrow reservoirs instead of from Libby Dam. This transfer took place in June and July, bringing the reservoir to its maximum elevation of 2,448.2 feet on 6 September. At the end of September 1993, Libby reservoir was at elevation 2,444.9 feet, 14.1 feet below full pool elevation.

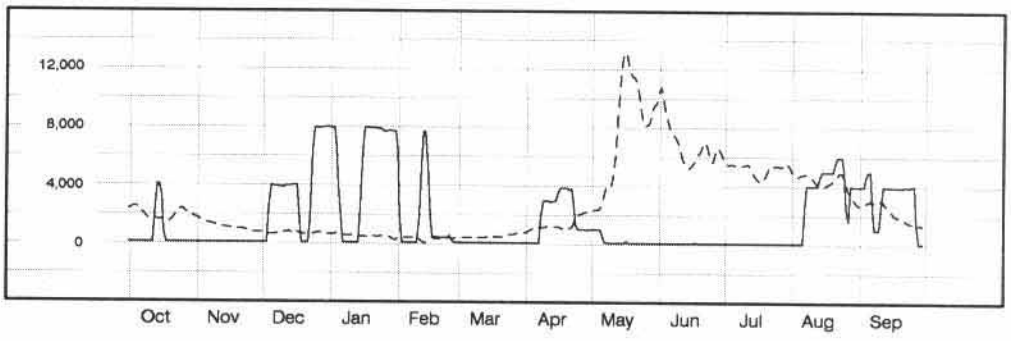
Flood Control Operation

During the 1993 freshet, flood control was provided by normal refill of Treaty projects and other storage reservoirs in the Columbia River basin. Daily operation of reservoirs for flood control was not required. The freshet was controlled to well below damaging levels.

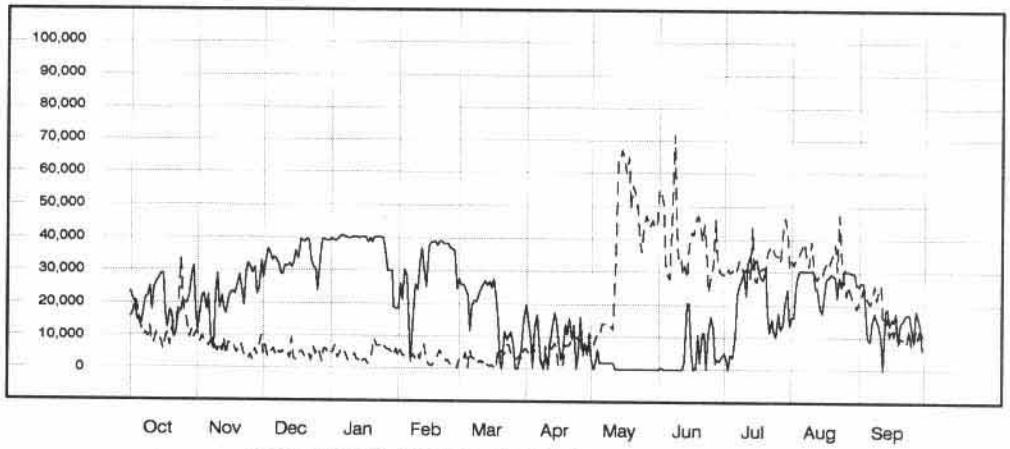


KOOTENAI RIVER AT LIBBY DAM

DISCHARGE IN CUBIC FEET PER SECOND



DUNCAN RIVER AT DUNCAN DAM

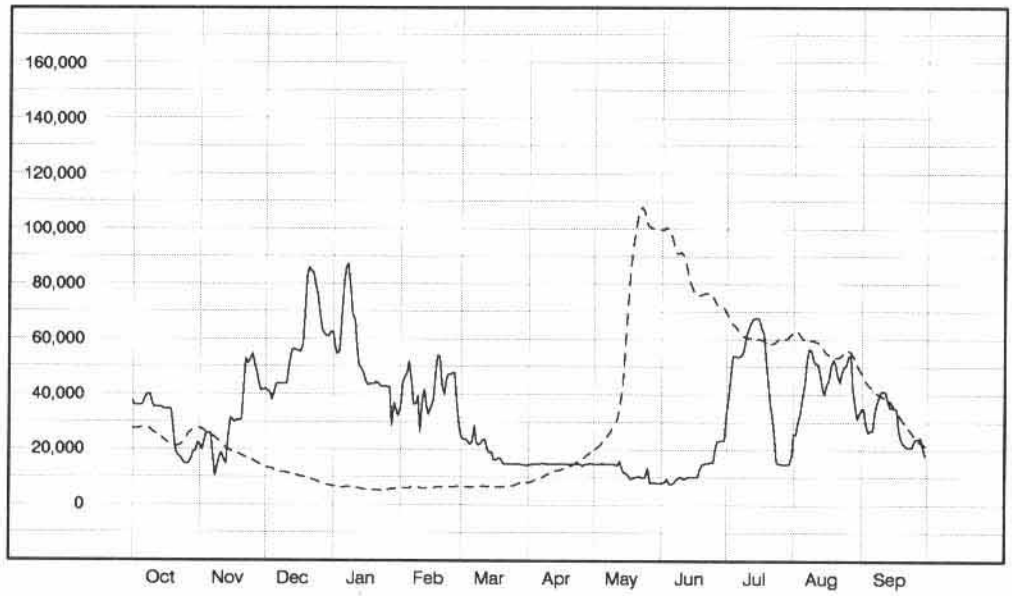


COLUMBIA RIVER AT MICA DAM

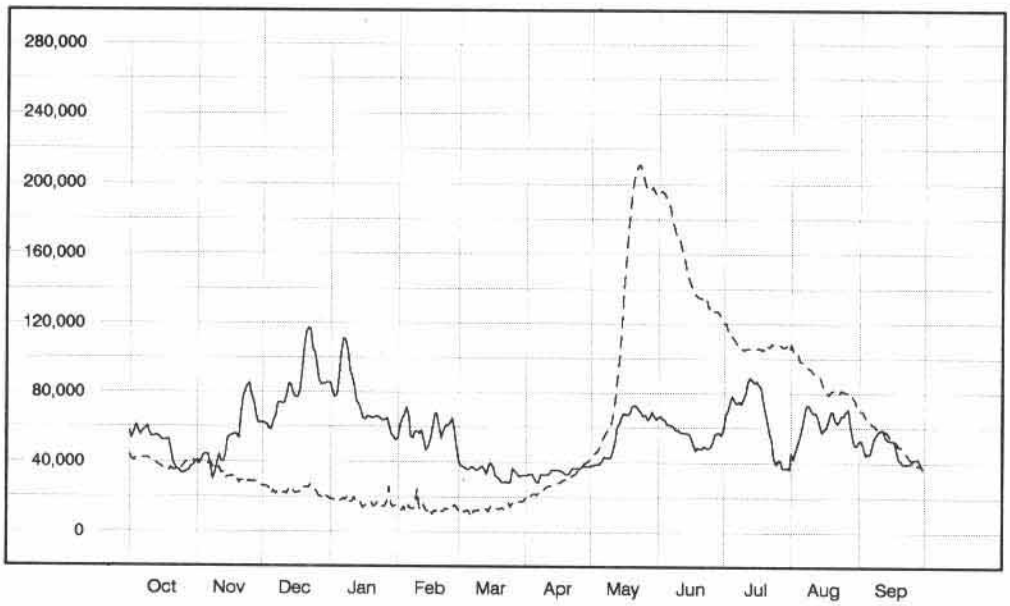
——— Observed Flows
– – – Pre-Project Flows

HYDROGRAPHS - Observed and pre-project flows
for year ending 30 September 1993

DISCHARGE IN CUBIC FEET PER SECOND



COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM



COLUMBIA RIVER AT BIRCHBANK

——— Observed Flows
– – – Pre-Project Flows

HYDROGRAPHS - Observed and pre-project flows
for year ending 30 September 1993

BENEFITS

Flood Control Provided

Without regulation by upstream reservoirs, the 1993 freshet would have produced below average freshet levels at Trail, British Columbia, but high inflows from the Snake River would have caused significant flood damage in the United States.

It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by about 5.9 feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about 12.4 feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on pages 37 and 38 by hydrographs which show both the actual discharges and the flows that would have occurred if the dams had not been built. It is noted that the hydrograph showing pre-project conditions for Birchbank has been computed on the assumption that the effects of Duncan, Arrow, Mica and Libby regulation and of the regulation provided by the Corra Linn development on Kootenay Lake have been removed.

The operation of Columbia Basin reservoirs for the system as a whole reduced the natural annual peak discharge of the Columbia River near The Dalles, Oregon from about 602,000 cfs to 382,000 cfs.

All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.

Power Benefits

Downstream power benefits in the United States, which arise from operation of the Canadian Treaty storage, were pre-determined for the first thirty years of operation of each project and the Canadian one-half share was sold in the United States under the terms of the Canadian Entitlement Purchase Agreement. The United States Entity delivers capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. The benefits of additional generation made possible on the Kootenay River in Canada as a result of regulation provided by Libby, and generation at the Mica and Revelstoke projects, are retained wholly within Canada. The benefits from Libby regulation, which occur downstream in the United States, are not shared under the Treaty.

During the operating year, 1 August 1992 through 31 July 1993, the downstream power benefits accruing to each country from the Treaty storage were 593.7 megawatts of average annual energy and 1,476.9 megawatts capacity.

The Canadian Entitlement Purchase Agreement terminates in stages beginning in 1998. The portion of Canada's share of downstream power benefits attributable to each of the Treaty projects is the ratio of each project's storage to the whole of the Canadian Treaty storage. The table below summarizes Canada's share of the downstream power benefits returnable from each project:

Treaty Storage	Date Returnable	Share of Canadian Entitlement (%)
Duncan	1 April 1998	9.0
Arrow	1 April 1999	45.8
Mica	1 April 2003	45.2

After 1 April 2003, Canada's share of downstream benefits is fully returnable.

Other Benefits

By agreement between the Entities, streamflows are regulated for non-power purposes such as accommodating construction in river channels and providing water to assist the downstream migration of juvenile fish in the United States. These arrangements are implemented under the Detailed Operating Plan and provide mutual benefits.

CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the Treaty. Operation reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and the 1990 non-Treaty storage agreement between the Entities relating to the use of non-Treaty storage, refill enhancement of Mica and Arrow reservoirs, and initial filling of non-Treaty reservoirs. Operation under this agreement did not conflict with normal Treaty operations.

2. The Entities have reached agreement on the Detailed Operating Plan for Columbia River Treaty Storage for 1993-94.

3. The Entities are continuing to develop the hydrometeorological network as required by the Treaty. The Entities are continuing to discuss the operating plans and the determination of the downstream power benefits for 1998-99.

4. As reported in the Board's 1991-92 Annual Report, the Entities reached an interim agreement for the return to Canada of the Canadian Entitlement to the downstream power benefits for the period 1 April 1998 through 31 March 2003, which specifies methods and points of delivery of downstream benefits to Canada.

5. The Entities are continuing to develop long-term plans for the disposition of of the Canadian entitlement to the downstream power benefits commencing in operating year 1997-98.

6. Water storage transfer agreements between the B.C. Hydro and Power Authority and the Bonneville Power Administration did not interfere with Treaty operations during the year.

7. The objectives of the Treaty were met during the report year.

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. John Elmore, Chairman[1] Chief, Operations, Construction and Readiness Division Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. David Oulton, Chairman Assistant Deputy Minister Energy Sector Energy, Mines and Resources Canada Ottawa, Ontario
Mr. Ronald Wilkerson 4655 Highway 200 East Missoula, Montana	Mr. John Allan Deputy Minister Environmental Assessment Victoria, B.C.
Alternates	
Mr. Paul Barber[2] Chief, Engineering Division Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. David Burpee[3] Director, Electricity Branch Energy Sector Energy, Mines and Resources Canada Ottawa, Ontario
Mr. Thomas Weaver Assistant Administrator for Engineering Western Area Power Administration Department of Energy Golden, Colorado	Dr. Donald Kasianchuk Comptroller of Water Rights Ministry of Environment, Lands & Parks Victoria, B.C.
Secretaries	
Mr. Shapur Zanganeh Hydraulics & Hydrology Branch Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. David Burpee[4] Director Electricity Branch Energy, Mines and Resources Canada Ottawa, Ontario

[1] Vice Mr. Herbert Kennon as of 29 January 1994.
[2] Vice Mr. John Elmore as of 29 Janury 1994.
[3] Vice Mr. Vic Niemela as of 18 January 1994.
[4] Vice Mr. Mac Clark as of 3 December 1992.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Record of Membership

United States		Canada	
Members			
Mr. Wendell Johnson[1]	1964-1970	Mr. Gordon McNabb[1]	1964-1991
Mr. Morgan Dubrow[1]	1964-1970	Mr. Arthur Paget	1964-1973
Mr. John Neuberger	1970-1973	Mr. Valter Raudsepp	1973-1974
Mr. Joseph Caldwell[1]	1971-1973	Mr. Ben Marr	1974-1987
Mr. Homer Willis[1]	1973-1979	Mr. Tom Johnson	1987-1988
Mr. King Mallory	1973-1975	Mr. Douglas Horswill	1989-1991
Mr. Raymond Peck, Jr.	1976-1977	Mr. John Allan	1991-
Mr. Emerson Harper	1978-1988	Mr. David Oulton[1]	1991-
Mr. Lloyd Duscha[1]	1979-1990		
Mr. Ronald Wilkerson	1988-		
Mr. Herbert Kennon[1]	1990-1994		
Mr. John Elmore[1,2]	1994-		
Alternates			
Mr. Fred Thrall	1964-1974	Mr. Mac Clark	1964-1992
Mr. Emerson Harper	1964-1978	Mr. Jim Rothwell	1964-1965
Mr. Alex Shwaiko	1974-1987	Mr. Hugh Hunt	1966-1988
Mr. Thomas Weaver	1979-	Dr. Donald Kasianchuk	1988-
Mr. John Elmore	1990-1994	Mr. Vic Niemela	1992-1994
Mr. Paul Barber[3]	1994-	Mr. David Burpee[4]	1994-
Secretaries			
Mr. John Roche	1965-1969	Mr. Mac Clark	1964-1992
Mr. Verle Farrow	1969-1972	Mr. David Burpee[5]	1992-
Mr. Walter Duncan	1972-1978		
Mr. Shapur Zanganeh	1978-		

[1] Chairman
[2] Vice Mr. Herbert Kennon as of 29 January 1994
[3] Vice Mr. John Elmore as of 29 January 1994
[4] Vice Mr. Vic Niemela as of 18 January 1994
[5] Vice Mr. Mac Clark as of 3 December 1992.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

ENGINEERING COMMITTEE

Current Membership

United States	Canada
Members	
Mr. Shapur Zanganeh, Chairman Hydraulic & Hydrology Branch Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Mr. Neill Lyons, Chairman Environmental Conservation Branch Environment Canada North Vancouver, B.C.
Mr. Gary Fuqua Office of Energy Resources Bonneville Power Administration Portland, Oregon	Mr. David Burpee Electricity Branch Energy, Mines and Resources Canada Ottawa, Ontario
Mr. Larry Eilts Western Area Power Administration Department of Energy Golden, Colorado	Mr. Roger McLaughlin Energy Resources Division Ministry of Energy, Mines and Petroleum Resources Victoria, B.C.
Mr. Earl Eiker Hydraulics & Hydrology Branch Directorate of Civil Works H.Q., U.S. Army Corps of Engineers Washington, D.C.	Dr. Bala Balachandran (Acting) Power and Special Projects Ministry of Environment, Lands & Parks Victoria, B.C.
Alternates	
Mr. Richard Mittelstadt Water Management Division U.S. Army Corps of Engineers North Pacific Division Portland, Oregon	
Mr. Steve Wright Bonneville Power Administration Department of Energy Washington, D.C.	

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

United States	Canada

Members

Mr. Randall Hardy, Chairman
Administrator, Bonneville Power Administration
Department of Energy
Portland, Oregon

Major General Ernest Harrell
Division Engineer
U.S. Army Engineer Division, North Pacific
Portland, Oregon

Mr. Marc Eliesen, Chairman[1]
President and CEO
British Columbia Hydro and Power Authority
Vancouver, British Columbia

[1]Vice Mr. Norman Olsen as of 30 November 1992.

APPENDIX C

Record of Flows

at the

International Boundary

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	57,600	40,600	62,900	85,500	54,000	41,700	32,700	38,100	66,000	60,000	45,600	53,000
2	53,700	38,800	62,200	80,900	61,400	38,100	32,900	38,500	66,700	67,500	42,400	53,000
3	57,900	41,300	61,100	77,300	64,600	37,400	33,300	38,800	65,000	71,000	46,600	49,400
4	61,100	44,100	59,000	78,800	66,700	37,100	33,400	38,800	65,000	75,600	51,600	44,500
5	57,900	44,500	58,600	89,300	71,300	36,000	30,900	39,200	62,200	78,400	55,100	45,600
6	55,400	44,500	63,600	103,000	66,000	36,000	28,600	41,000	61,800	74,900	61,800	45,600
7	57,600	39,200	66,700	112,000	55,400	37,400	28,800	43,400	61,800	74,200	67,800	50,100
8	59,300	30,200	74,200	111,000	54,000	36,700	32,900	43,100	60,400	74,900	73,100	54,700
9	60,700	33,200	74,200	104,000	57,600	35,700	33,100	42,700	58,600	73,500	73,100	56,500
10	57,600	39,900	73,800	92,900	57,600	36,000	33,100	43,100	59,000	76,600	71,000	58,300
11	54,700	44,100	73,500	89,700	56,500	37,100	33,200	46,300	57,600	80,200	68,500	59,000
12	54,700	40,600	78,800	83,300	58,300	37,800	34,100	52,300	57,200	86,500	68,900	59,000
13	55,400	40,300	85,100	74,900	53,000	35,700	35,700	60,400	57,200	89,000	66,700	55,100
14	55,100	44,500	84,800	73,100	47,000	33,300	35,700	62,900	56,900	87,600	61,400	53,700
15	54,000	53,700	79,100	69,900	49,100	38,100	35,700	66,400	56,900	86,200	57,900	53,300
16	52,600	55,100	77,300	65,300	53,000	39,900	35,700	68,200	54,700	86,900	59,000	53,000
17	52,600	55,400	77,300	64,600	58,300	37,400	35,300	67,500	51,200	85,100	60,400	53,000
18	53,000	56,200	80,500	66,400	67,800	32,100	34,800	67,500	47,000	82,600	63,900	48,000
19	53,000	55,800	90,400	66,000	68,200	31,500	33,600	68,500	48,700	77,000	69,200	42,400
20	47,000	53,700	107,000	65,300	61,800	30,400	33,400	72,000	48,000	69,600	69,200	41,300
21	39,600	64,600	115,000	65,700	54,000	28,900	34,100	72,700	48,000	62,900	64,600	39,900
22	37,100	77,300	118,000	66,400	57,900	28,800	36,400	71,700	49,400	56,900	62,900	39,600
23	35,700	81,900	117,000	66,000	61,100	29,100	36,700	69,900	48,400	53,700	64,300	39,600
24	34,800	83,700	106,000	65,000	61,400	28,400	36,700	68,900	48,400	43,400	67,100	39,600
25	33,500	85,500	103,000	64,300	62,200	28,600	36,700	66,700	49,400	39,200	67,100	41,000
26	34,000	78,800	95,000	64,300	65,300	36,700	36,400	67,500	52,300	42,000	69,200	42,400
27	34,300	74,500	86,900	65,300	59,700	34,900	37,800	64,600	56,500	41,700	71,000	42,400
28	34,700	66,000	84,800	61,100	48,400	34,100	37,800	66,000	57,200	37,100	62,200	42,700
29	37,400	62,500	85,100	56,500		32,100	37,800	69,200	57,200	37,100	54,000	39,600
30	37,800	62,500	85,800	55,100		32,700	37,800	67,100	55,800	37,400	50,500	36,700
31	39,600		85,800	53,000		32,600		65,000		36,400	50,500	
Mean	48,700	54,400	83,000	75,400	59,000	34,600	34,500	57,700	56,200	66,000	61,800	47,700

COLUMBIA RIVER AT BIRCHBANK, B.C.—Daily discharges in cubic feet per second for the year ending 30 September 1993

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	21,300	5,930	13,700	5,880	6,110	5,560	8,280	12,100	16,500	6,970	6,750	6,920
2	21,000	11,100	18,100	6,000	18,500	16,300	8,540	12,800	19,200	6,770	6,700	7,270
3	18,600	16,200	17,000	5,990	21,200	18,100	9,170	13,300	21,200	6,830	6,460	7,270
4	10,400	16,400	18,600	6,140	18,400	15,800	10,100	13,200	21,300	6,840	6,430	7,270
5	9,680	16,400	20,000	6,850	6,570	15,600	10,700	13,800	21,500	6,780	6,250	6,670
6	15,500	16,300	20,200	17,900	5,610	7,370	10,500	17,000	22,000	6,800	6,240	5,460
7	16,700	16,500	12,300	18,500	5,460	5,590	9,880	18,600	21,700	6,870	5,980	5,430
8	17,200	16,700	16,600	17,900	5,490	5,660	9,520	17,500	21,400	6,870	5,900	10,600
9	17,200	16,900	20,100	14,700	5,440	17,000	9,820	15,600	21,100	6,960	5,760	13,500
10	16,800	16,800	20,300	9,790	5,270	20,600	10,600	15,000	21,300	7,220	5,580	13,700
11	9,920	21,900	18,700	7,720	5,280	18,400	10,600	15,700	21,200	7,160	6,050	12,800
12	9,430	25,700	16,900	19,200	11,100	7,010	10,200	17,900	21,000	7,450	6,030	9,220
13	9,610	26,000	16,900	20,700	5,620	5,610	9,820	23,300	21,200	7,690	5,940	6,320
14	13,400	22,200	16,900	21,300	5,250	5,580	9,500	26,600	21,200	7,860	6,120	9,060
15	18,100	16,800	16,900	11,500	5,350	5,650	9,230	27,200	21,100	7,870	6,210	9,310
16	18,400	14,800	16,800	5,730	5,120	11,000	9,040	28,400	20,900	8,030	6,020	9,330
17	18,000	21,200	16,700	5,520	12,000	15,400	9,000	26,900	15,300	7,970	6,410	9,230
18	9,780	23,400	16,600	5,410	15,900	15,000	9,290	24,700	9,250	7,980	6,330	9,100
19	9,680	21,200	16,700	5,400	11,900	9,960	10,100	22,700	7,470	7,930	6,350	8,510
20	17,800	24,800	16,800	5,260	5,660	6,180	10,300	21,200	7,280	7,850	6,180	7,450
21	17,500	25,900	16,800	5,170	5,500	5,990	10,200	20,100	7,230	8,160	6,160	13,500
22	14,300	26,100	16,800	5,500	5,470	6,010	10,300	18,600	7,520	8,420	6,230	13,900
23	18,000	26,200	19,600	5,460	5,550	6,410	10,400	16,800	7,690	7,890	5,670	14,000
24	16,700	26,100	13,900	5,260	5,520	8,840	10,500	15,300	7,780	7,740	6,990	14,000
25	8,620	23,000	5,930	5,360	5,480	9,220	10,600	14,200	7,610	7,670	7,010	12,400
26	7,880	19,900	5,580	5,380	5,480	8,810	11,600	13,800	7,390	7,730	7,270	5,920
27	13,700	17,900	5,860	5,520	5,460	8,630	12,700	13,400	7,080	7,820	7,350	5,680
28	12,300	14,600	5,620	5,750	5,410	8,650	12,500	13,100	7,030	7,540	7,250	12,900
29	6,250	6,600	5,330	5,610		8,660	12,000	15,100	7,020	7,390	71,100	14,000
30	6,000	5,930	5,440	5,550		8,460	12,000	16,400	7,180	6,960	5,940	14,100
31	5,860		5,720	5,510		8,240		15,500		6,920	7,210	
Mean	13,700	18,600	14,600	8,950	8,040	10,200	10,200	17,900	14,900	7,450	6,380	9,830

KOOTENAI RIVER AT PORTHILL, IDAHO—Daily discharges in cubic feet per second for the year ending 30 September 1993

PROJECT INFORMATION

Power and Storage Projects,

Project Data

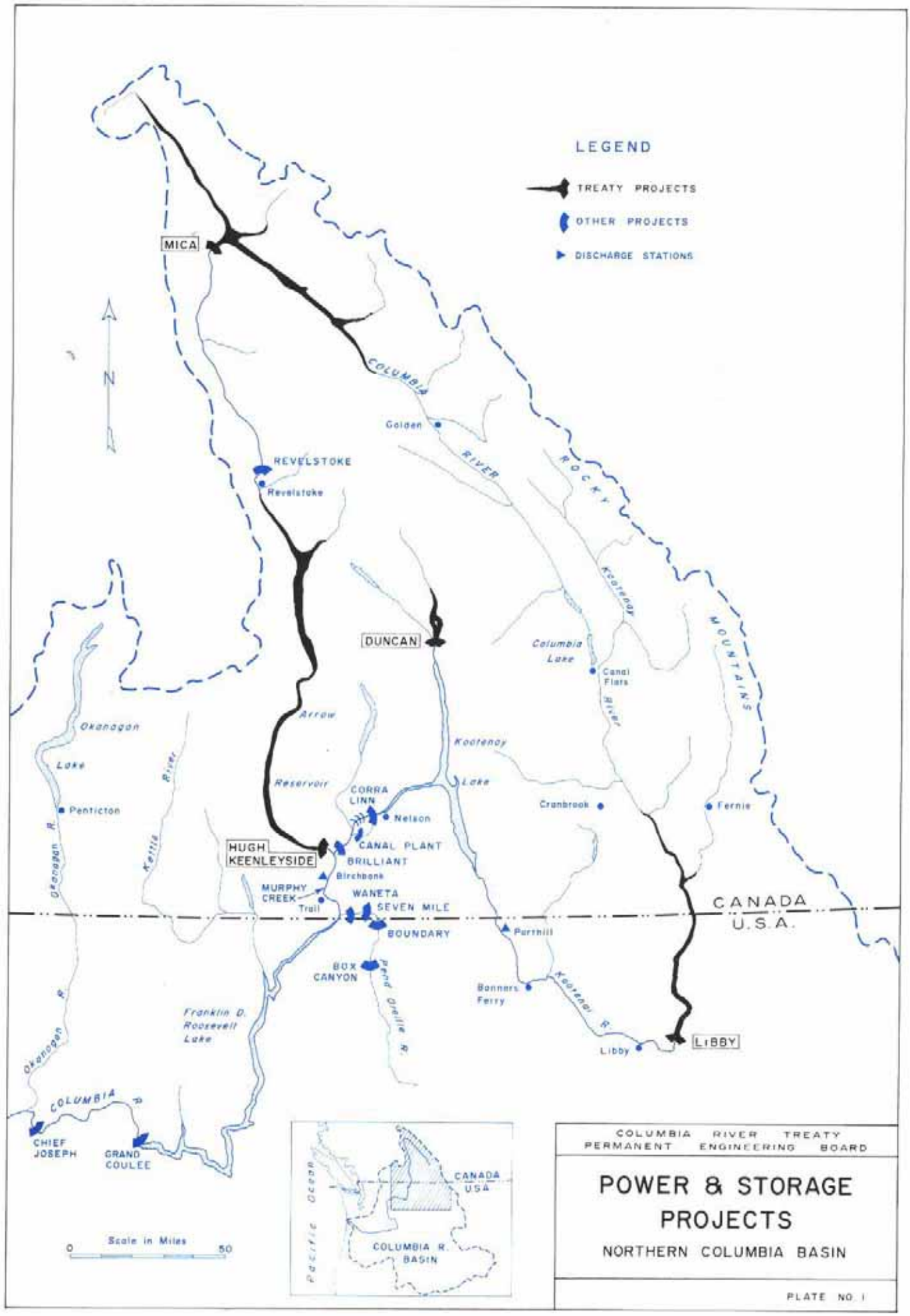

LEGEND
TREATY PROJECTS
OTHER PROJECTS
DISCHARGE STATIONS
MICA
REVELSTOKE
Revelstoke
Golden
COLUMBIA
RIVER
ROCKY
MOUNTAINS
Kootenay
DUNCAN
Columbia Lake
Canal Flats
Arrow Reservoir
Kootenay Lake
Okanagan Lake
Penticton
Okanagan R.
Kettle River
CORRA LINN
Nelson
HUGH KEENLEYSIDE
CANAL PLANT
BRILLIANT
Birchbank
MURPHY CREEK
Trail
WANETA
SEVEN MILE
BOUNDARY
CANADA
U.S.A.
Cranbrook
Fernie
Porthill
BOX CANYON
Pend Oreille R.
Franklin D. Roosevelt Lake
Okanogan R.
Bonners Ferry
Kootenai R.
Libby
LIBBY
COLUMBIA
CHIEF JOSEPH
GRAND COULEE
Scale in Miles
0
50
Pacific Ocean
CANADA
USA
COLUMBIA R. BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
PLATE NO. 1

TABLE 1

DUNCAN PROJECT

Duncan Dam and Duncan Lake

Storage Project

Construction began	17 September 1964
Storage became fully operational	31 July 1967

Reservoir

Normal Full Pool Elevation	1,892 feet
Normal Minimum Pool Elevation	1,794.2 feet
Surface Area at Full Pool	18,000 acres
Total Storage Capacity	1,432,400 ac-ft
Usable Storage Capacity	1,400,000 ac-ft
Treaty Storage Commitment	1,400,000 ac-ft

Dam, Earthfill

Crest Elevation	1,907 feet
Length	2,600 feet
Approximate height above riverbed	130 feet
Spillway - Maximum Capacity	47,700 cfs
Discharge tunnels - Maximum Capacity	20,000 cfs

Power Facilities

None

TABLE 2

ARROW PROJECT

Hugh Keenleyside Dam and Arrow Lakes

Storage Project

Construction began	March 1965
Storage became fully operational	10 October 1968

Reservoir

Normal Full Pool Elevation	1,444 feet
Normal Minimum Pool Elevation	1,377.9 feet
Surface Area at Full Pool	130,000 acres
Total Storage Capacity	8,337,000 ac-ft
Usable Storage Capacity	7,100,000 ac-ft
Treaty Storage Commitment	7,100,000 ac-ft

Dam, Concrete Gravity and Earthfill

Crest Elevation	1,459 feet
Length	2,850 feet
Approximate height above riverbed	170 feet
Spillway - Maximum Capacity	240,000 cfs
Low Level Outlets - Maximum Capacity	132,000 cfs

Power Facilities

None

TABLE 3

MICA PROJECT

Mica Dam and Kinbasket Lake

Storage Project	
Construction began	September 1965
Storage became fully operational	29 March 1973
Reservoir	
Normal Full Pool Elevation	2,475 feet
Normal Minimum Pool Elevation	2,320 feet
Surface Area at Full Pool	106,000 acres
Total Storage Capacity	20,000,000 ac-ft
Usable Storage Capacity	
Total	12,000,000 ac-ft
Commitment to Treaty	7,000,000 ac-ft
Dam, Earthfill	
Crest Elevation	2,500 feet
Length	2,600 feet
Approximate height above foundation	800 feet
Spillway - Maximum Capacity	150,000 cfs
Outlet Works - Maximum Capacity	37,400 cfs
Power Facilities	
Designed ultimate installation	
6 units at 434 mw	2,604 mw
Power commercially available	December 1976
Presently installed	
4 units at 434 mw	1,736 mw
Head at full pool	600 feet
Maximum Turbine Discharge	
of 4 units at full pool	38,140 cfs

TABLE 4

LIBBY PROJECT

Libby Dam and Lake Koocanusa

Storage Project	
Construction began	June 1966
Storage became fully operational	17 April 1973
Reservoir	
Normal Full Pool Elevation	2,459 feet
Normal Minimum Pool Elevation	2,287 feet
Surface Area at Full Pool	46,500 acres
Total Storage Capacity	5,869,000 ac-ft
Usable Storage Capacity	4,980,000 ac-ft
Dam, Concrete Gravity	
Deck Elevation	2,472 feet
Length	3,055 feet
Approximate height above riverbed	370 feet
Spillway - Maximum Capacity	145,000 cfs
Low Level Outlets - Maximum Capacity	61,000 cfs
Power Facilities	
Designed ultimate installation 8 units at 105 mw	840 mw
Power commercially available	24 August 1975
Presently installed 5 units at 105 mw	525 mw
Head at full pool	352 feet
Maximum Turbine Discharge of 5 units at full pool	26,500 cfs