ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 SEPTEMBER 1994

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A • U N I T E D S T A T E S

CANADIAN SECTION
J. D. OULTON, Chairman
J. Allan, Member

UNITED STATES SECTION
J. P. ELMORE, Chairman
R. H. Wilkerson, Member

February 28, 1995

The Honourable Warren Christopher
The Secretary of State
Washington, DC

The Honourable A. Anne McLellan
Minister of Natural 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 thirtieth Annual Report, dated 30 September 1994, of the Permanent Engineering Board.

The report sets forth results achieved under the Treaty for the period from 1 October 1993 to 30 September 1994. The report concludes that the requirements of the Treaty were not met during the report year.

Respectfully submitted:

For the United States

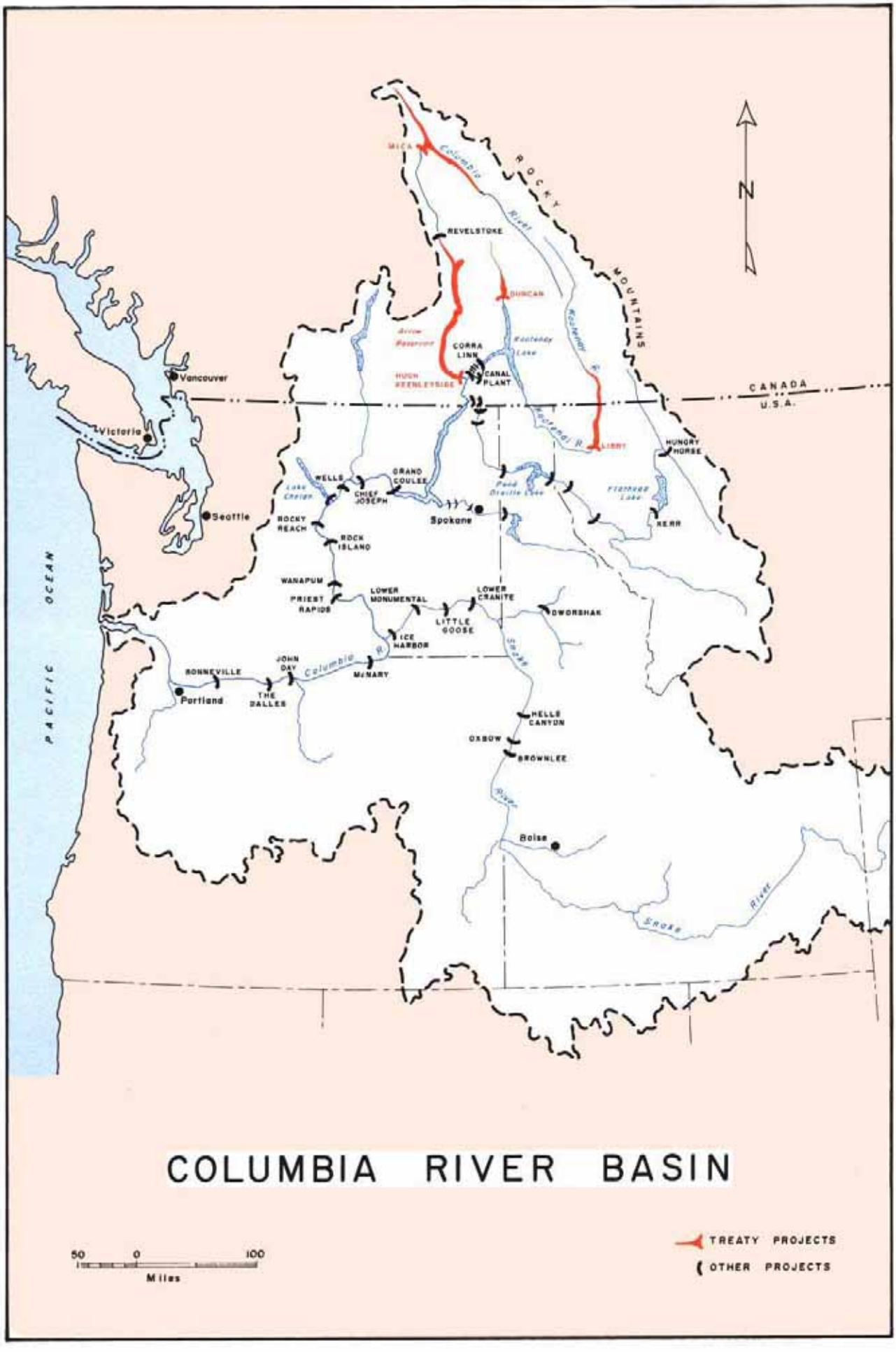
John P. Elmore, Chairman

Ronald H. Wilkerson

For Canada

David Oulton, Chairman

John Allan



COLUMBIA RIVER BASIN

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

30 September 1994

CONTENTS

LIST OF PHOTOGRAPHS

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

HYDROGRAPHS

APPENDICES

SUMMARY

The thirtieth 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 and subsequent agreements 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 22-35).

As noted in the Board's last Annual Report, disagreements concerning the calculation of the Treaty downstream power benefits prevented the Entities from submitting to the Board the report *Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1998-99* in accordance with the requirements of the Treaty. During the current reporting year, the Entities actively pursued negotiations to resolve their differences and have kept the Board informed on their progress. The Board was satisfied that there was sufficient progress during the year toward a resolution of this issue that a report to the governments in advance of the Annual Report was not warranted.

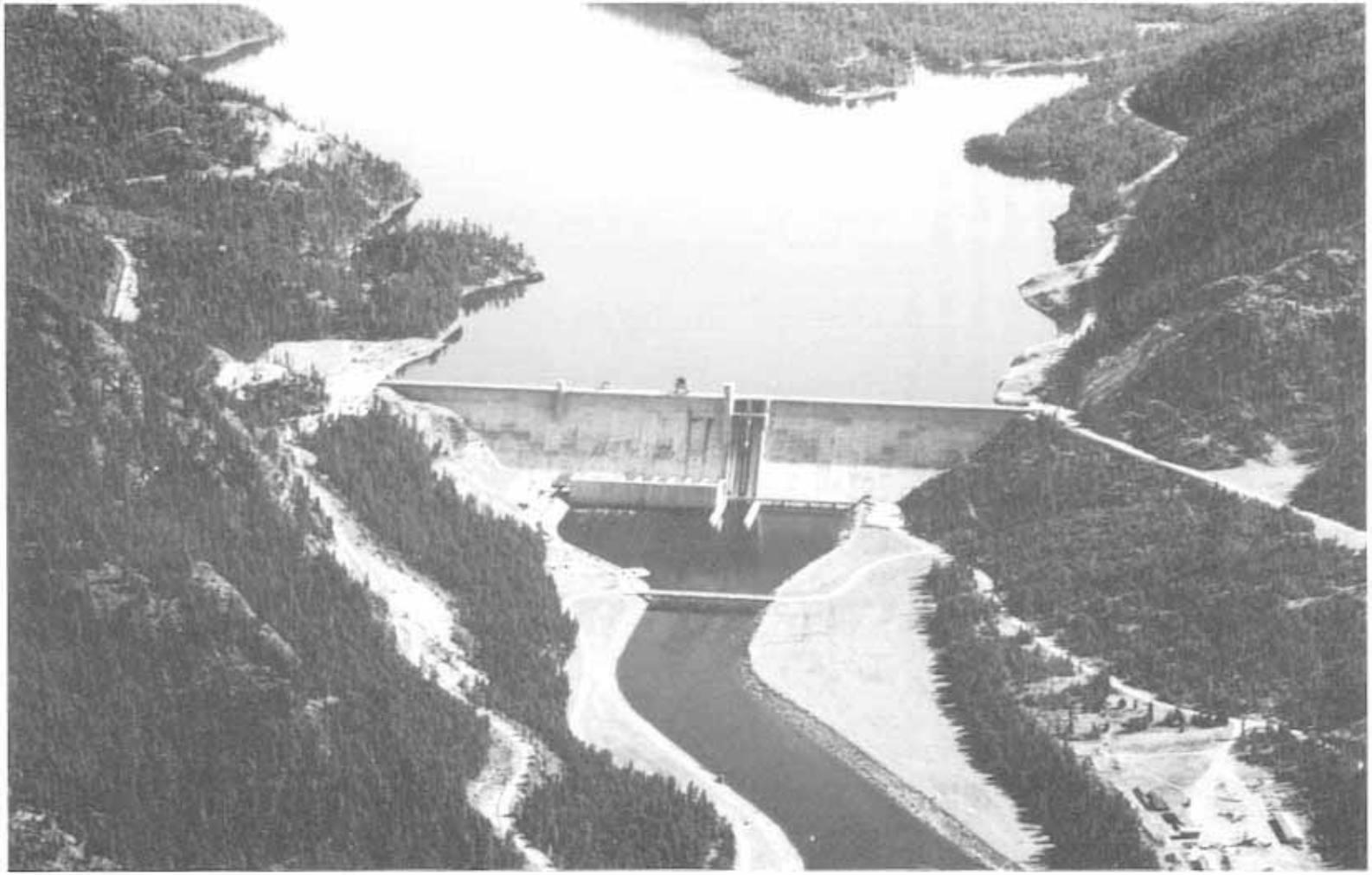
The Entities resolved their disagreements and the *Assured Operating Plan and Determination of Downstream Power Benefits* reports for the years 1998-99 and 1999-2000 were completed. However, the U.S. Entity has not signed the Entity agreements on the reports pending a determination under the *Endangered Species Act* regarding consultation on fishery operations in the U.S. portion of the Columbia River basin (pages 17-19).

For the reason noted above, the Board concludes that the requirements of the Treaty are not being fully 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 1993 through 30 September 1994, 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.



Libby Dam - Kootenai River, Montana
The dam and reservoir, Lake Koocanusa. The powerhouse is at the left of the spillway.

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 a 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 stream flow 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 on 1 April 1968; Arrow storage on 1 April 1969; and Mica storage on 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 Canadian 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;

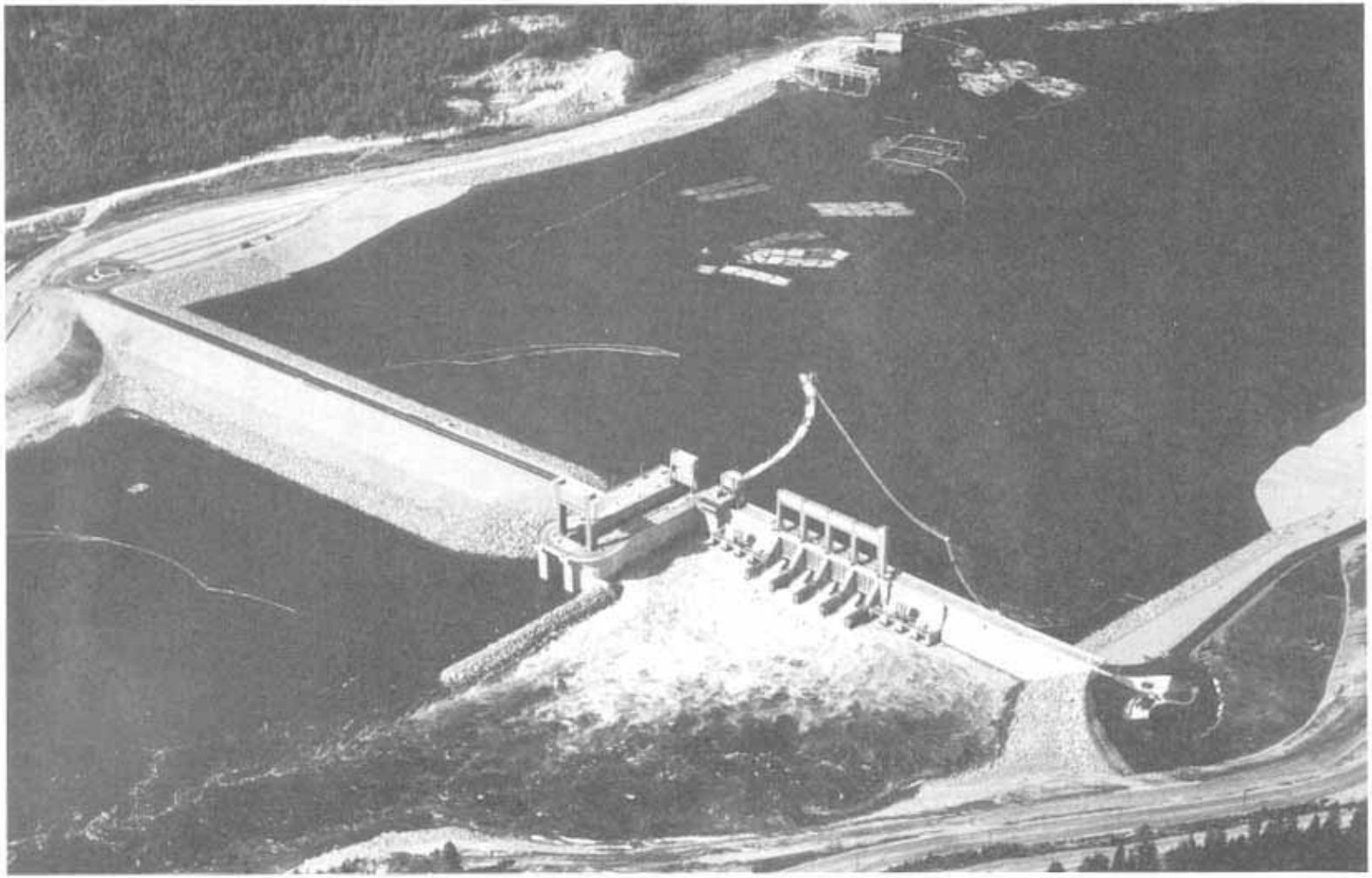
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the Entities;

(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.



Hugh Keenleyside Dam - Columbia River, British Columbia

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

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 noted that Mr. John Laxton succeeded Mr. Mark Eliesen as Chair of the Canadian Entity effective 16 May 1994.

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 on 2 February 1994 in Portland, Oregon, to review progress under the Treaty, and finalize the Annual Report for the year ending 30 September 1993. The Board met with the Entities on the same day to discuss the Entities' progress towards resolving disagreements related to the critical stream flow period, the operating procedures for the U.S. base hydro system, and the use of time periods of less than a full month in operating plans. These disagreements were delaying the completion of the Entities' report *Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1998-99.*

The Board met on 7 June 1994 in Vancouver, British Columbia, to discuss measures the Board could take to encourage the Entities to resolve their disagreements and complete the outstanding reports on the assured operating plans and determination of the downstream power benefits. The Board met with the Entities on the same day for a briefing on the Entities' respective positions on above noted disagreements. The Board and Entities also agreed on a schedule for completion of the Entities' reports *Assured Operating Plan and Determination of the Downstream Power Benefits* for the years 1998-99 and 1999-2000.

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 to the Board:

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

- 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;

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1994 through 31 July 1995, dated August 1994, plus a copy of the Entities' Agreement dated September 1994;

- Letter Agreement between Staff Members of the Bonneville Power Administration and Staff Members of the British Columbia Hydro Power Authority Providing for the Storage and Return of Energy to

Enable Optimal Balancing of System Reservoirs Considering Trade-offs Between Power and Non-power Requirements, dated 10 March 1994;

- Legal Opinion Provided by the Canadian Entity entitled "Use of Half-Months in AOP and DDPB Studies", dated 25 April 1994;

- Columbia River Treaty Entity Agreement on Operation of Treaty Storage for Non-power Uses for January 1 through July 31, 1994, dated 18 May 1994;

- Letter of Clarification Concerning Provisional Draft Storage and Return and Energy Payments to the Canadian Entity, dated 9 August 1994.

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

- Annual Report of the Columbia River Treaty, Canada and United States Entities for the period 1 October 1993 - 30 September 1994, dated November 1994;

- Memorandum of Agreement between the Administrator of the Bonneville Power Administration, Department of Energy, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of Army (United Stated Entity) and the Province of British Columbia and British Columbia Hydro and Power Authority (Canadian Entity) on the Delivery and Disposition of the Canadian Entitlement under the Columbia River Treaty, dated 8 September 1994;

- Draft Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1998-99, dated October 1994;

- Draft Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 1999-2000, dated November 1994;

- Draft Entity Agreement on the Resolution of AOP and DDPB Issues for the 1998/99, 1999/2000 and 2000/2001 Assured Operating Plan and Determination of Downstream Power Benefit Studies.

Report to Governments

The twenty-ninth Annual Report of the Board was submitted to the governments of Canada and the United States of America on 28 February 1994.

Duncan Dam - Duncan River, British Columbia

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

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 committed under the Treaty. There are no power facilities included in this project.

The project is shown in the picture on page 12, and project data are provided in Table 1 of Appendix D.

Arrow Project

The Hugh Keenleyside Dam, at the outlet of the Arrow Lake, 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 river bed 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 7, 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 19, 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 river bed 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 2, 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 stream flow 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 the 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 1993-94*, was provided to the Board in 1989. 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 1993-94 operating year.

Actual operations of the Treaty reservoirs, during most of the 1993-94 operating year, were regulated under the rule curves set out in the Entities' report, *Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994*. The Entities provided this report to the Board in December, 1993. The detailed operating plan for 1993-94, for the first time, included firm energy shifting into the first year of the critical period, a provisional draft operation for the U.S. Entity, and compensation for the Canadian Entity. The detailed operating plan for 1993-94 essentially implemented the assured operating plan for the same year. In September 1994, the Entities provided the Board with the report, *Detailed*

Operating Plan for Columbia River Treaty Storage, 1 August 1994 through 31 July 1995.

The Entities were to provide the Board with their report, *Assured Operating Plan and Determination of the Downstream Power Benefits for Operating Year 1998-99*, by October 1993; however, as noted in the Board's Annual Report for 1993, the Entities were unable to complete the report because of differing interpretations of certain provisions of the Treaty affecting the calculation of the downstream power benefits. In December 1993, the Entities informed the Board that they were unable to submit the report because they were not able to agree on the definition of the *critical stream flow period*, a significant element in the determination of the capacity component of the downstream power benefits.

At its meeting with the Entities on 2 February 1994, the Board encouraged the Entities to resolve their differences as soon as possible and offered to assist in this endeavour. The Board noted its concern that the Entity report, *Assured Operating Plan and Determination of the Downstream Power Benefits for Operating Year 1998-99*, had not been completed as scheduled, and that there was an urgency in getting a resolution of the outstanding issues in order to allow for the completion of the Entity report.

The Board and Entities met again on 7 June 1994, at which time the Entities presented their respective positions concerning the outstanding issues. The Entities reported that negotiations between the government of British Columbia and the Bonneville Power Administration concerning the delivery and disposition of the Canadian entitlement to the downstream power benefits might render moot the remaining disagreement between the Entities in calculating the downstream power benefits. The Entities agreed to advise the Board by mid-July, 1994, concerning the outlook for an agreement on the guiding principles for the disposition and delivery of the Canadian entitlement. If the negotiations were successful, the Entities agreed to complete the outstanding assured operating plan by October 1994. At the same time, the Board made preparations to assist the Entities in resolving their disagreements. On 15 July 1994, the Entities advised the Board that progress was being made on the negotiations, and a memorandum of negotiators' agreement on the principles for the disposition and delivery of the Canadian entitlement was announced on 8 September 1994.

The negotiators' agreement concerning the delivery and disposition of the Canadian entitlement did not resolve the disagreements between the Entities concerning the definition of the critical stream flow period used in the calculation of the Treaty capacity benefits. Rather, the negotiators' agreement proposes that the Bonneville Power Administration would purchase, in advance, the Canadian capacity entitlement in excess of 950 megawatts until 2024. The province of British Columbia would take delivery of the remaining 950 megawatts, unless the total Canadian capacity entitlement fell below 950 megawatts—current forecasts

indicate that it is unlikely the total Canadian capacity entitlement will fall under 950 megawatts under either the Canadian or U.S. Entity's definition of the critical stream flow periods. Thus, the negotiators' agreement is expected, in foreseeable circumstances, to remove the uncertainty surrounding the amount of the Canadian entitlement to the capacity benefits created by the disagreement between the Entities on the critical stream flow period. The negotiators' agreement is to be implemented through a series of detailed agreements which remain to be negotiated. Further, the Treaty requires that a sale of the Canadian entitlement in the United States be authorized by an exchange of notes between the two governments.

The Entities advised the Board that the Entity reports on the determination of the downstream power benefits for 1998-99 and 1999-2000 will present two capacity benefits resulting from the use of both the Canadian and U.S. Entities' definitions of the critical stream flow period. By letter dated 29 July 1994, the Board advised the Entities that presenting two determinations of the capacity benefits in the reports will be reviewed for consistency with the Treaty.

With the negotiators' agreement in place, the Entities' reports *Assured Operating Plan and Determination of Downstream Power Benefits* for the operating years 1998-99 and 1999-2000 were completed. The Entity agreements on these reports were signed by the Canadian Entity. However, the agreements were not signed by the U.S. Entity pending a determination under the *Endangered Species Act* regarding consultation on fishery operations in the U.S. portion of the Columbia River basin. As a result, the reports, together with the covering Entity agreements, have not been received by the Board.

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

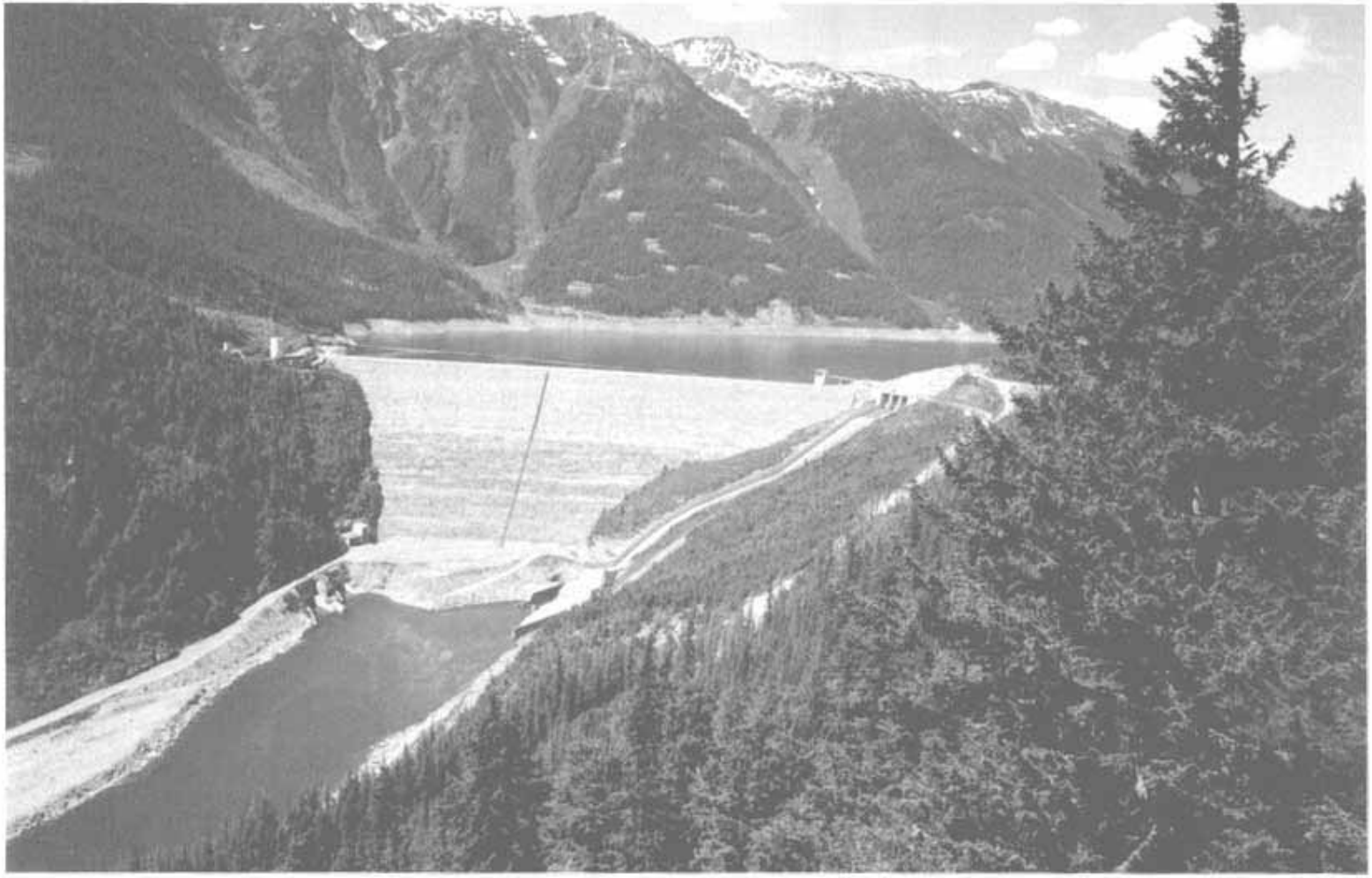
Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay rivers at the Canada-United States of America boundary. Flows for this report year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho and for the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

Non-Treaty Storage

Since 1984 there have also been agreements between the B.C. Hydro and Power Authority and the Bonneville Power Administration concerning non-Treaty storage. 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.

Operations for Fish

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. In this regard, the Board notes that the assured operating plans and the determination of downstream power benefits 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.



Mica Dam - Columbia River, British Columbia
The earth dam showing the spillway at the right. The underground powerhouse is at the left.

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 the following:

- Columbia River Treaty Flood Control Operating Plan;
- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1993 through 31 July 1994;
- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1994 through 31 July 1995, dated August 1994;
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1993-94;
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1994-95;
- 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 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

- Columbia River Treaty Entity Agreement on Operation of Treaty Storage for Non-power Uses for January 1 through July 31, 1994, dated 18 May 1994.

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 summer of above average precipitation followed by a warm dry September. The coordinated Columbia River System reached only 72.9 per cent of its capacity during that summer. By the start of the report year, depletion had begun and the Treaty storage was approximately 71 per cent full, with the system operating to the third year critical rule curves; that is, as if it were in the third year of a drought period.

Below average precipitation continued through the fall and winter of 1993-94 until March. The system operated under conservation operation rules through April to ensure water was available for the 1994 juvenile fish flow augmentation. Warm weather in April depleted much of the snowpack and the dry trend resulted in low runoff. Conservation operation rules were again instituted in June and July.

Operation of the reservoirs is illustrated on pages 23 and 24 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 reservoir levels 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.

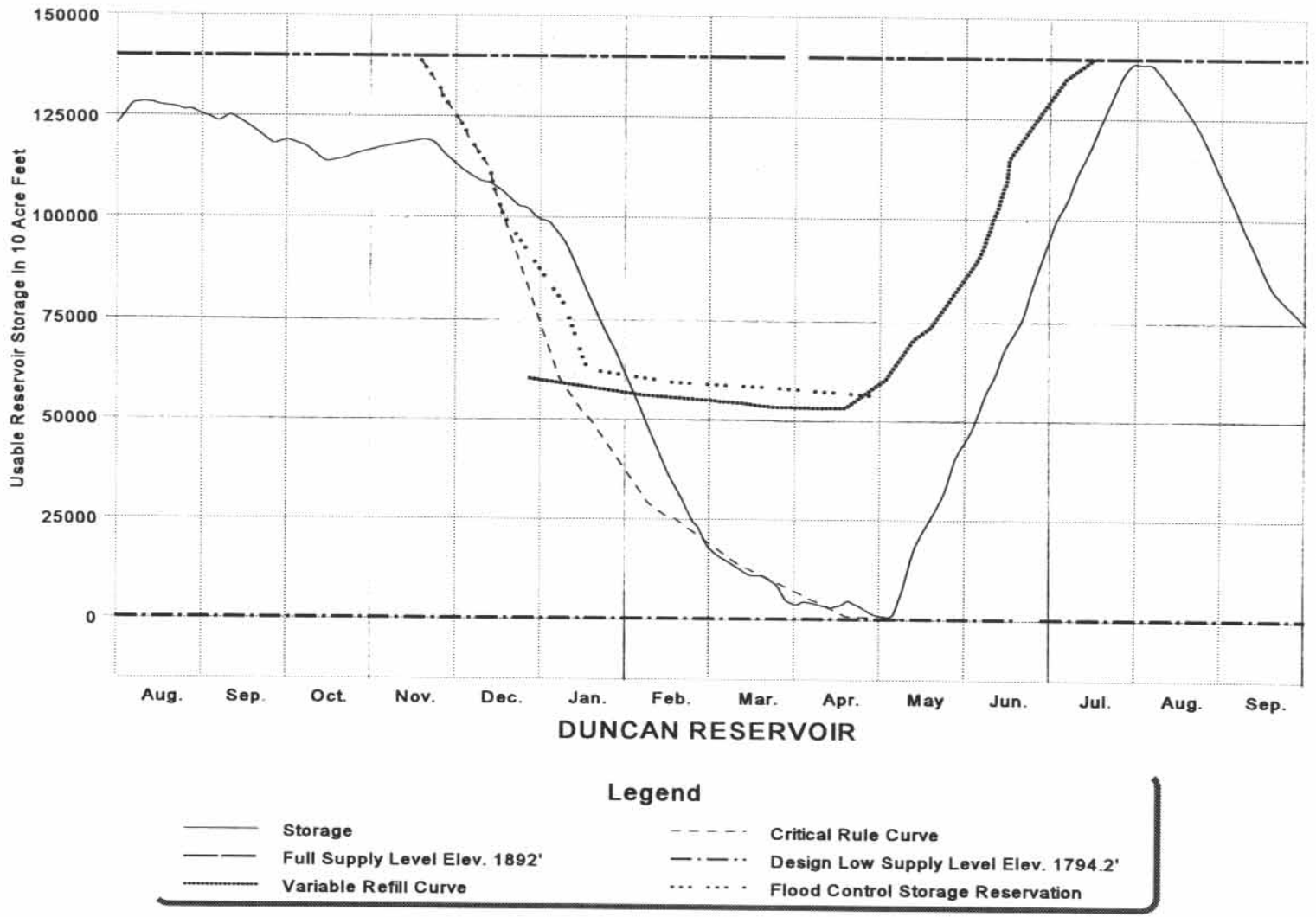
Mica reservoir began the report year at elevation 2,418.0 feet, about 57 feet below full supply level, after having reached a record low peak elevation of 2,419.4 feet in September 1993. Releases throughout the winter caused Mica Treaty storage to empty by 28 February. Treaty withdrawals then continued, overdrafting into the non-Treaty storage at Mica reservoir. Treaty storage at Arrow and Duncan reservoirs compensated for this Treaty storage overdraft. The reservoir level reached a low of 2350.8 feet on 20 April, about ten feet above the previous year's record low level. On 16 April, the Treaty storage overdraft reached its maximum for the year at 0.96 million acre-feet.

Late in the spring, the reservoir began filling due to rapid snow melt and reduced reservoir outflows. Refill continued through most of the summer, and the reservoir reached a peak elevation of 2437.9 feet on 15 August. This is 37.1 feet below the reservoir's full supply level and 69 per cent of full reservoir volume. Storage draft resumed in September. At the end of the report year, Mica reservoir was at elevation 2,430.1 feet and Treaty storage in the reservoir was 5.82 million acre-feet, 83 percent of the allotted Treaty storage space.

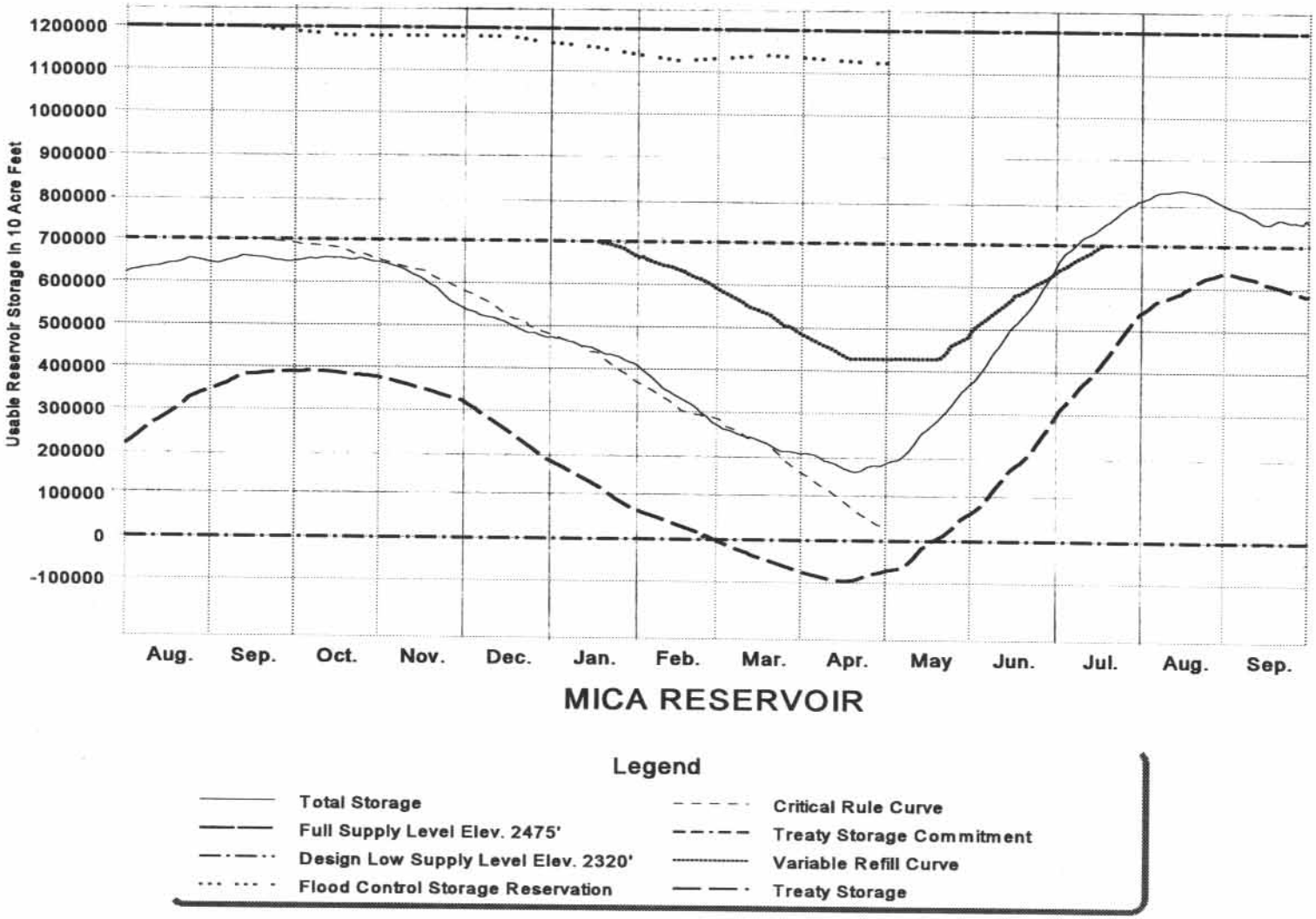
Arrow reservoir began the report year at elevation 1,430.8 feet, 13.2 feet below full. Drafting through December brought the elevation to 1,415.8 feet at the end of the month. Draft rates were reduced through early January, then rose again in late January and early February to meet the high electricity demand of winter. From late February to late March, outflows were kept low to protect trout spawning grounds at the Norns Creek Fan downstream from the Arrow Dam. The reservoir reached its lowest elevation of the year at 1,389.1 feet on 28 March.

During the freshet period, Arrow reservoir was operated under the terms of an Entity agreement for non-power uses of Treaty storage which allowed the Entities to maintain higher levels at Arrow than would otherwise have been allowed under normal operation. In July, increasing releases from Mica brought

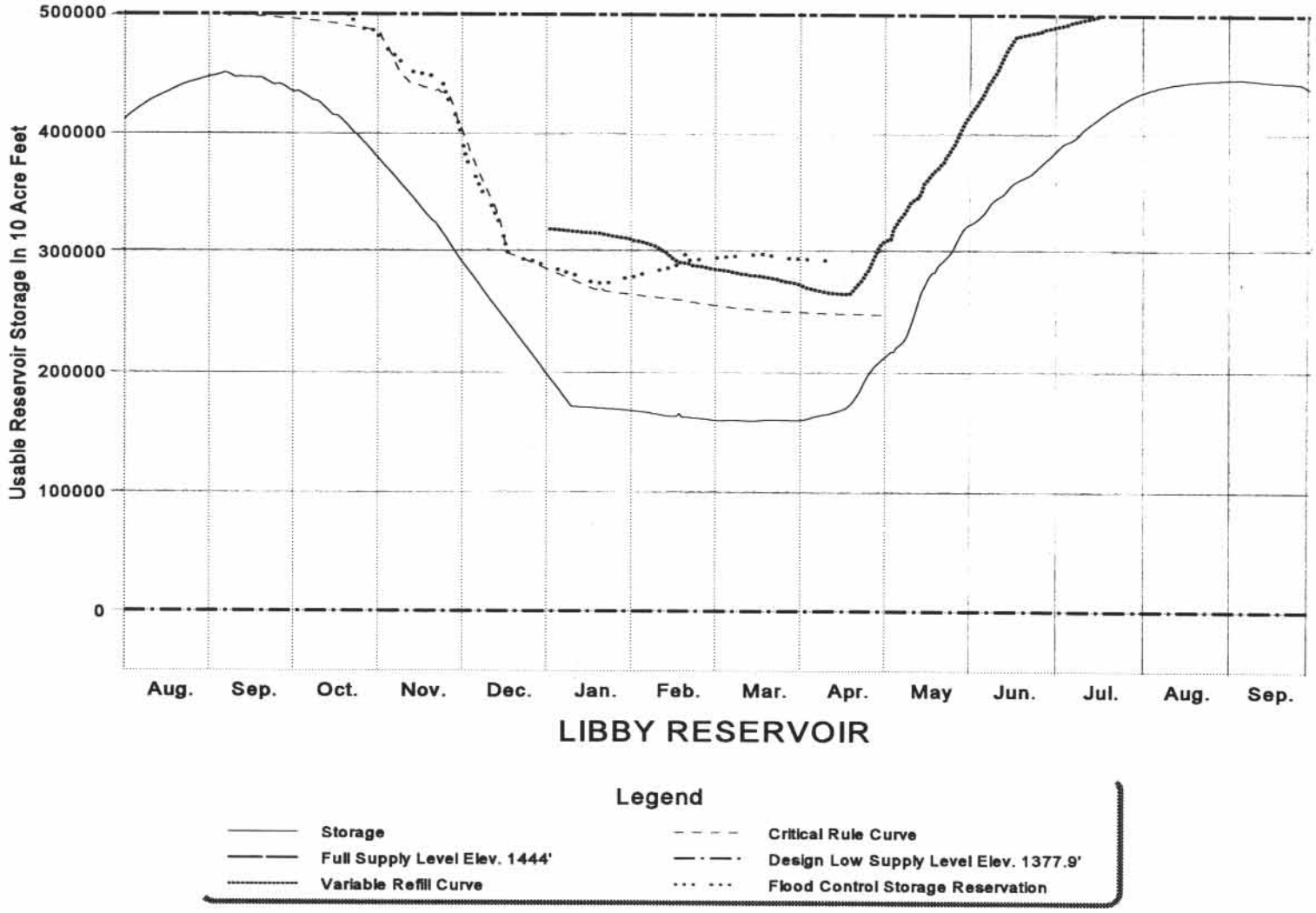
the Arrow reservoir to its maximum elevation of 1,426.5 feet on 26 July, 17.5 feet below full. Through August and September, levels fluctuated between 1421 and 1426 feet; by the end of September 1994, the reservoir was at elevation1,421.0 feet.



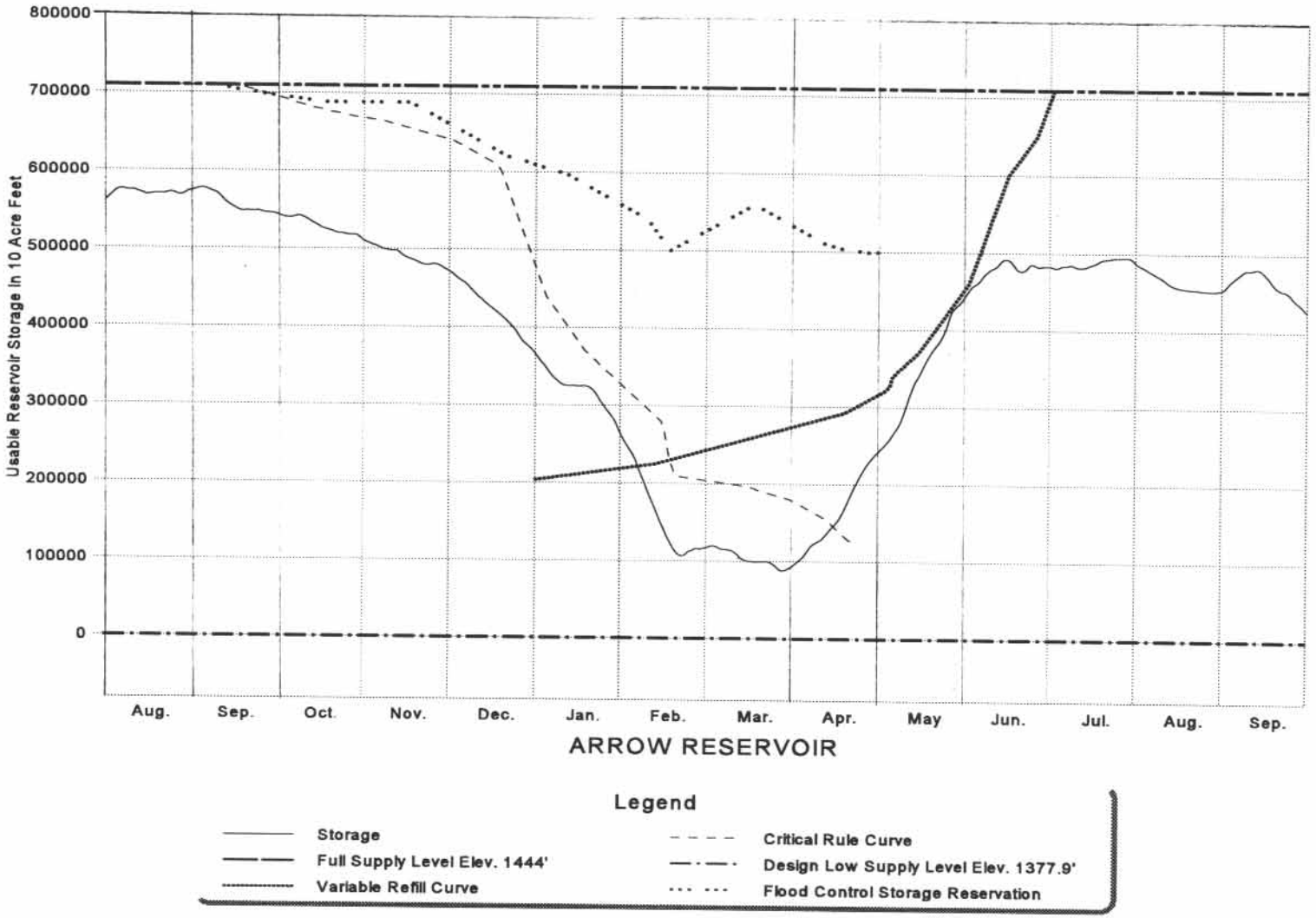
HYDROGRAPHS - Duncan Reservoir Levels - for the 14-month period ending 30 September 1994



HYDROGRAPHS - Mica Reservoir Levels - for the 14-month period ending 30 September 1994



HYDROGRAPHS - Libby Reservoir Levels - for the 14-month period ending 30 September 1994



HYDROGRAPHS - Arrow Reservoir Levels - for the 14-month period ending 30 September 1994

Duncan reservoir did not fill during the summer of 1993 and began the report year at elevation 1,880.0 feet, 12 feet below full. The reservoir was drafted at various rates through the winter and spring and reached its lowest elevation for the year at 1,794.9 feet, 0.5 feet above empty, on 4 May. Discharges were then reduced to the minimum flow until 22 July, then increased to slow the rate of refill. The reservoir reached its peak elevation for the year at 1,891.5 feet on 30 July. In August, discharge was increased to compensate for a reduction in Arrow Treaty discharge and to support Kootenay Lake levels. Duncan reservoir was at elevation 1,852.6 feet, 39.4 feet below full, on 30 September.

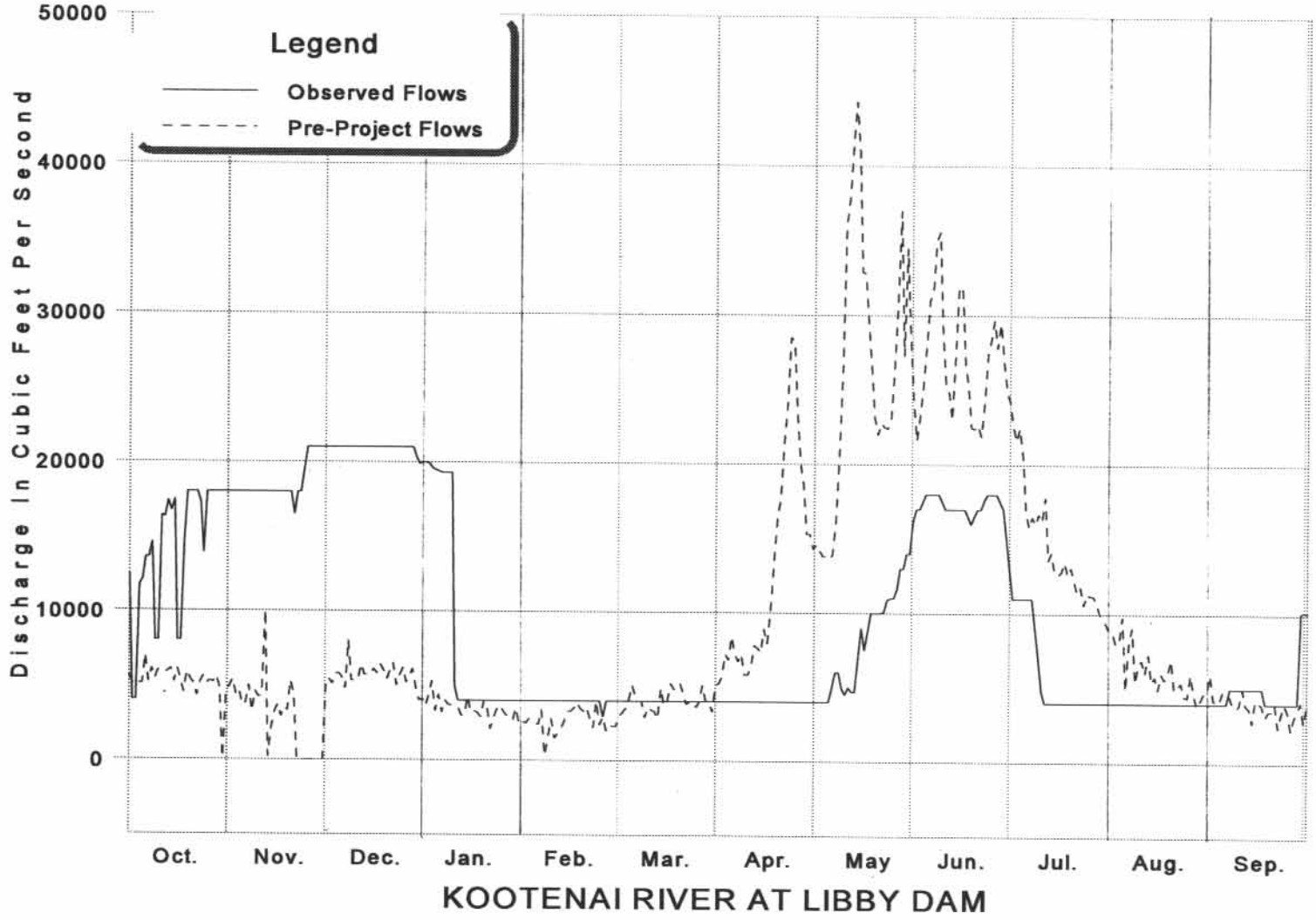
Libby reservoir did not completely refill during the summer of 1993, and began the report year, with drafting of the reservoir already begun, at elevation 2,444.9 feet, 14.1 feet below full. In mid-October, Libby outflow was increased to fulfil a request by the Montana Department of Fish, Wildlife, and Parks, and to return storage to the Duncan reservoir under the Libby-Duncan storage transfer agreement.

Minimum flows were released from 10 January to 6 May due to a low runoff volume forecast and low inflows. The reservoir reached its minimum level of 2,364.9 feet on 15 March 1994. Discharges were then increased from 10 May to 10 July to entice spawning Kootenay white sturgeon into the Kootenay River reach near Bonners Ferry, and to assist flow augmentation to benefit Lower Columbia River salmon.

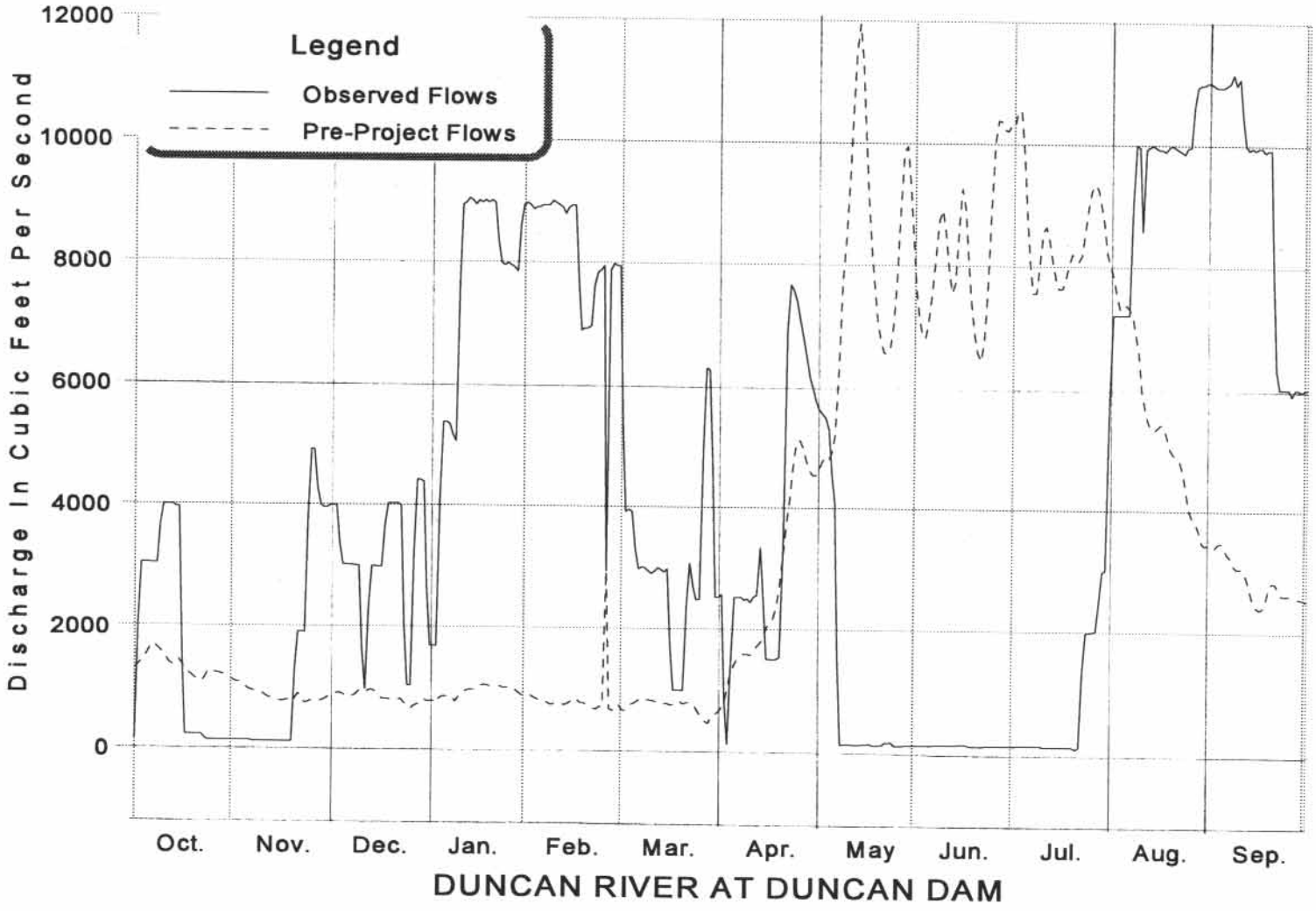
An agreement between the State of Montana, the Corps of Engineers, and the Bonneville Power Administration resulted in no draft from Libby between 10 July and 5 September, at which time the reservoir reached its maximum level at 2,447.2 feet. At the end of September, the Libby reservoir was at elevation 2,445.5 feet, 13.5 feet below full pool elevation.

Flood Control Operation

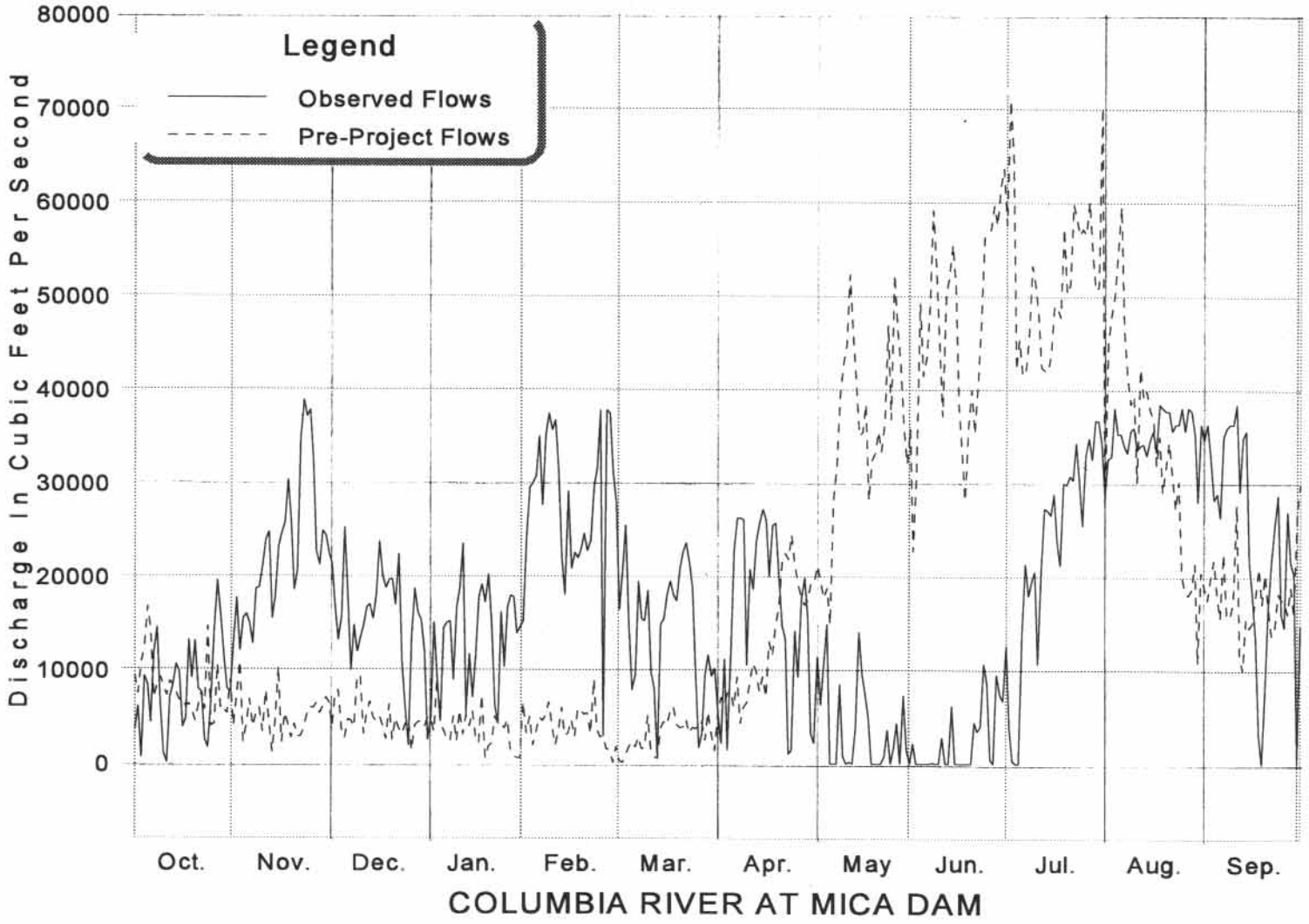
During the 1994 freshet, flood control was provided by normal refill of Treaty projects and other storage reservoirs in the Columbia River basin. Daily operation of reservoirs for flood control was not required. The freshet was controlled to well below damaging levels.



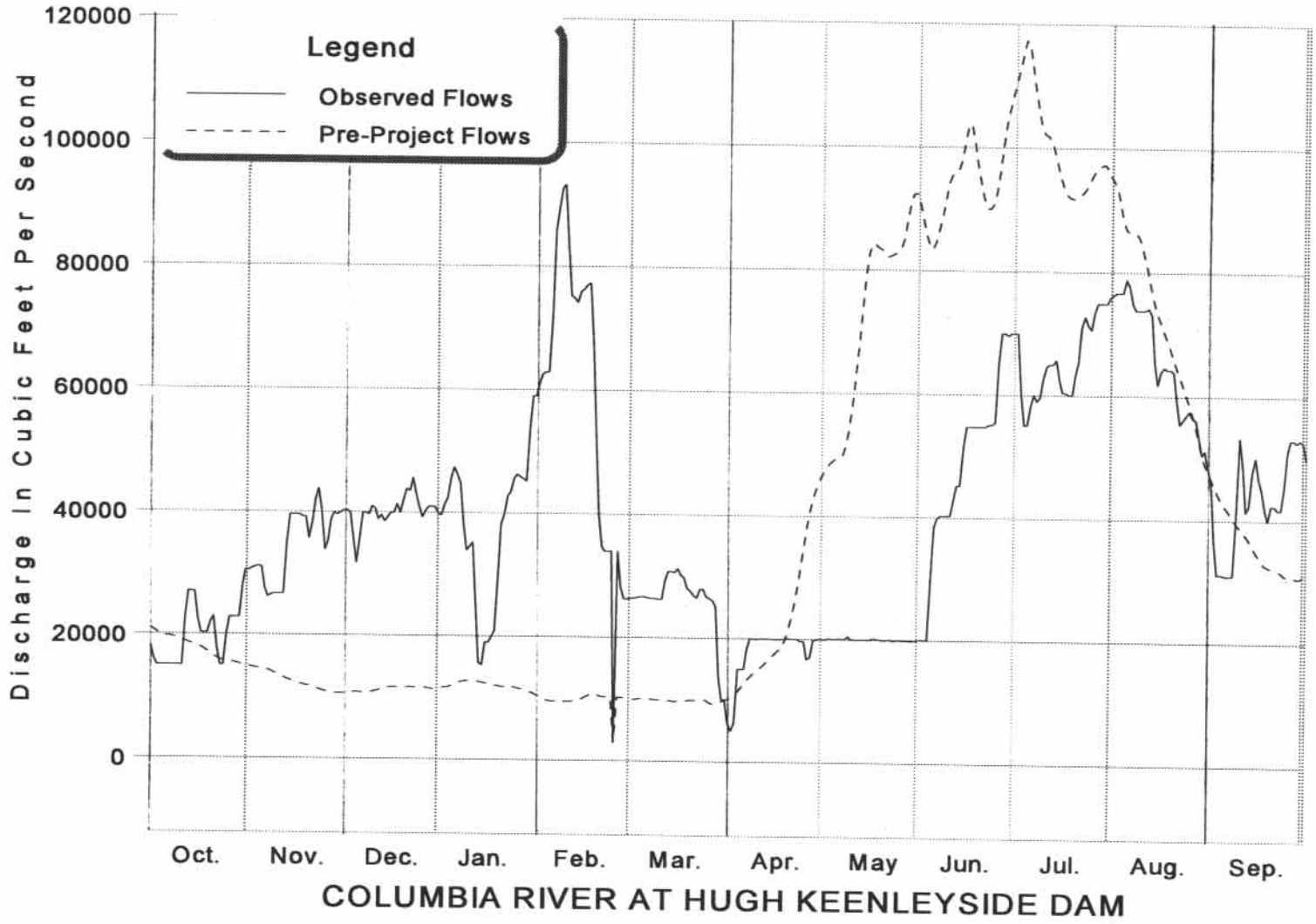
HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1994



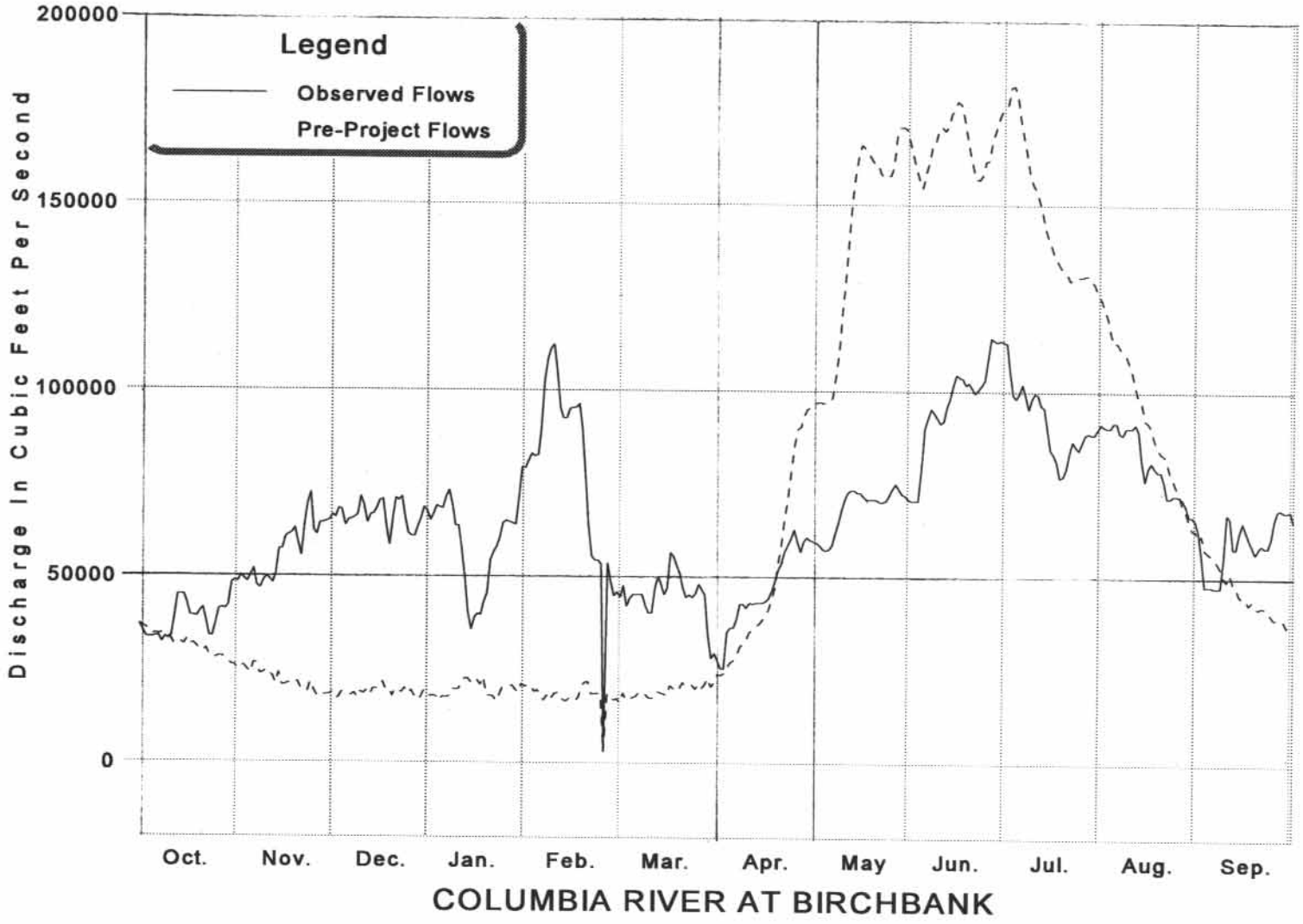
HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1994



HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1994



HYDROGRAPHS - Observed and pre-project flowsfor the year ending 30 September 1994



HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1994

BENEFITS

Flood Control Provided

Without regulation by upstream reservoirs, the 1994 freshet would have produced below average freshet levels at Trail, British Columbia and at the Dalles, Oregon, and would not 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 2.9 feet, and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about 6.7 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 26 and 27 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 372,000 cfs to 224,300 cfs.

All payments required by Article VI(1) of the Treaty as compensation for flood control provided by the Canadian Treaty storage has been made by the United States to Canada; the final payment were 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 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, the 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, as well as generation at the Mica and Revelstoke projects, are retained by 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 1993 through 31 July 1994, the downstream power benefits accruing to each country from the Treaty storage were

determined, according to the procedures set out in the Treaty and Protocol, to be 655.7 megawatts of average annual energy and 1,266.5 megawatts of capacity.

The Canadian Entitlement Purchase Agreement expires in stages over the period 1998 to 2003. 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, stream flows 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 during the report year. The operation reflected detailed operating plans developed by the Entities, the flood control operating plan for Treaty reservoirs, and other agreements between the Entities.

2. The downstream power benefits to each country were 655.7 megawatts of average annual energy and 1,266.5 megawatts of capacity for the report year. There were limited flood control benefits due to the low freshet in the spring of 1994.

3. The Entities reached agreement on the *Detailed Operating Plan for Columbia River Treaty Storage* for the 1994-95 operating year.

4. The Entities are continuing to operate the hydrometeorological network as required by the Treaty.

5. The Bonneville Power Administration and the Government of the Province of British Columbia concluded a memorandum of agreement on the principles for the delivery and disposition of the Canadian Entitlement to downstream power benefits on 8 September 1994 and are continuing to work towards detailed agreements.

6. The memorandum of agreement is expected to result in a sale to the Bonneville Power Administration of the Canadian entitlement to the capacity benefits exceeding 950 megawatts. The sale would remove the uncertainty with respect to the amount of the Canadian entitlement to the capacity benefits created by the disagreement between the Entities concerning the calculation of the capacity benefits. The memorandum of agreement allowed the Entities to complete and the outstanding *Assured Operating Plan and Determination of Downstream Power Benefits* reports.

7. The U.S. Entity has not signed the covering Entity agreements on the *Assured Operating Plan and Determination of Downstream Power Benefits* reports. As a result, the reports for the operating years 1998-99 and 1999-2000 have not been received by the Board in conformance with the requirements of the Treaty.

8. **The requirements of the Treaty were not met during the report year.**

APPENDIX A

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Members

United States	Canada
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 Department of Natural Resources Ottawa, Ontario
Mr. Ronald Wilkerson 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 Department of Natural Resources Ottawa, Ontario
Mr. Thomas Weaver Lakewood, 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 Director Electricity Branch Department of Natural Resources 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.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

Record of Membership

United States

Members

Mr. Wendell Johnson[1]	1964-1970
Mr. Morgan Dubrow	1964-1970
Mr. John Neuberger	1970-1973
Mr. Joseph Caldwell[1]	1971-1973
Mr. Homer Willis[1]	1973-1979
Mr. King Mallory	1973-1975
Mr. Raymond Peck, Jr.	1976-1977
Mr. Emerson Harper	1978-1988
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. Emerson Harper	1964-1978
Mr. Alex Shwaiko	1974-1987
Mr. Herbert Kennon	1997-1990
Mr. Thomas Weaver	1979-
Mr. John Elmore	1990-1994
Mr. Paul Barber[3]	1994-

Secretaries

Mr. John Roche	1965-1969
Mr. Verle Farrow	1969-1972
Mr. Walter Duncan	1972-1978
Mr. Shapur Zanganeh	1978-

Canada

Members

Mr. Gordon McNabb[1]	1964-1991
Mr. Arthur Paget	1964-1973
Mr. Valter Raudsepp	1973-1974
Mr. Ben Marr	1974-1987
Mr. Tom Johnson	1987-1988
Mr. Douglas Horswill	1989-1991
Mr. John Allan	1991-
Mr. David Oulton[1]	1991-

Alternates

Mr. Mac Clark	1964-1992
Mr. Jim Rothwell	1964-1965
Mr. Hugh Hunt	1966-1988
Dr. Donald Kasianchuk	1988-
Mr. Vic Niemela	1992-1994
Mr. David Burpee[4]	1994-

Secretaries

Mr. Mac Clark	1964-1992
Mr. David Burpee	1992-

[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

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
Sales & Customer Service
Bonneville Power Administration
Portland, Oregon

Mr. David Burpee
Electricity Branch
Department of Natural Resources
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
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

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

Canada

Members

Mr. John Laxton, Chairman[1]
Chair, British Columbia Hydro and Power Authority
Vancouver, British Columbia

[1]Vice Mr. Marc Eliesen as of 16 May 1994.

APPENDIX C

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	14,300	18,700	21,300	20,800	5,400	5,430	8,120	13,100	23,100	16,100	5,500	5,170
2	12,400	18,800	21,400	21,000	5,350	5,620	8,800	12,600	23,500	14,300	5,460	5,490
3	6,090	18,600	21,300	20,800	5,320	5,700	9,900	12,400	23,100	14,300	5,470	5,230
4	5,850	18,700	21,400	20,600	5,350	6,540	10,800	12,300	24,000	14,300	5,690	5,400
5	11,800	18,600	21,800	20,600	5,260	7,360	10,800	12,500	25,300	14,200	5,600	5,350
6	13,500	18,600	21,500	20,600	5,430	7,260	10,700	13,000	25,100	13,800	5,340	5,340
7	15,000	18,700	21,600	20,800	5,320	6,890	10,300	15,100	26,100	13,500	5,400	5,880
8	15,100	18,700	21,700	20,400	5,520	6,660	9,760	18,600	25,700	13,100	5,510	5,960
9	14,500	18,700	21,900	20,300	5,770	6,570	9,470	20,600	24,900	11,200	5,470	5,990
10	9,230	18,600	22,100	18,300	5,830	6,320	9,390	21,100	23,600	9,600	5,480	6,060
11	9,130	18,700	21,900	6,930	6,030	6,250	9,630	21,100	22,700	7,200	5,490	6,060
12	16,000	18,700	21,900	5,860	5,910	6,280	10,100	21,300	22,500	6,680	5,500	6,000
13	17,900	18,700	21,800	5,970	5,790	6,320	11,100	20,800	22,900	6,410	5,300	6,000
14	18,000	18,700	21,600	6,020	5,510	6,400	11,600	18,500	23,500	6,380	5,310	5,920
15	18,500	18,600	21,700	5,940	5,310	6,460	11,100	18,900	23,200	6,170	5,090	5,920
16	18,000	19,000	21,400	5,970	5,370	6,660	10,900	21,400	23,000	6,110	5,150	5,980
17	9,820	19,100	20,700	5,830	5,510	7,330	12,000	19,700	23,800	5,860	5,110	5,900
18	9,360	18,900	20,000	5,960	5,280	7,750	15,000	19,000	23,200	5,950	5,290	5,250
19	17,500	18,500	19,900	5,860	5,480	8,400	18,500	19,700	22,400	5,910	5,310	5,220
20	19,000	18,900	19,800	5,790	5,470	8,280	21,400	19,800	22,800	5,730	5,180	5,220
21	19,100	18,000	19,900	5,670	5,430	7,850	23,300	20,000	22,700	5,610	5,210	5,160
22	19,100	18,600	19,900	5,670	5,330	7,520	25,100	20,200	22,100	5,570	5,110	4,990
23	18,500	18,700	20,000	5,710	5,240	7,320	24,400	19,900	22,500	5,510	5,260	4,990
24	16,800	18,400	19,900	5,640	5,510	7,100	22,400	20,300	22,600	5,540	5,130	4,980
25	17,200	19,900	19,800	5,630	5,390	6,960	20,100	20,300	22,200	5,600	5,160	4,930
26	19,000	20,800	19,900	5,530	5,340	6,870	17,800	20,500	22,400	5,490	5,240	4,980
27	18,800	20,800	19,800	5,710	5,390	6,840	16,000	20,900	22,900	5,510	5,390	4,960
28	18,600	21,200	19,700	5,530	5,330	6,840	14,800	20,600	21,800	5,580	5,220	5,010
29	18,600	21,700	19,800	5,530		6,900	13,900	20,400	20,600	5,520	5,140	9,930
30	18,600	21,500	20.300	5,470		7,170	13,500	21,900	18,300	5,450	5,200	10,200
31	18,600		20,700	5,420		7,580		21,700		5,460	5,290	
Mean	15,290	19,140	20,850	10,500	5,470	6,880	14,000	18,700	23,100	8,310	5,320	5,780

COLUMBIA RIVER AT BIRCHBANK, B.C.—Daily discharges in cubic feet per second for the year ending 30 September 1994

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	36,700	48,400	66,400	65,000	81,200	44,500	27,500	59,700	70,600	113,000	90,800	56,500
2	35,100	50,100	65,700	66,700	83,000	47,700	25,400	59,300	70,600	106,000	90,400	48,000
3	33,400	49,100	68,200	68,900	82,300	42,000	25,300	58,600	70,600	99,200	90,400	48,000
4	33,300	48,400	67,800	68,500	82,600	44,100	35,100	57,600	78,800	98,200	91,800	48,000
5	33,300	50,100	63,600	68,200	89,700	45,200	36,400	57,200	90,100	99,600	91,800	47,700
6	33,500	51,900	65,000	71,300	103,000	45,200	36,400	57,600	92,900	102,000	89,000	47,700
7	33,700	47,300	65,300	73,100	108,000	45,200	38,800	58,600	95,300	98,900	88,600	47,700
8	31,900	46,600	65,700	68,900	111,000	45,200	42,700	61,800	94,300	95,300	90,400	55,100
9	33,400	48,700	66,400	63,600	112,000	42,400	42,700	64,600	92,900	98,200	90,400	67,500
10	32,800	49,800	71,300	63,600	105,000	40,300	41,700	68,200	91,500	99,600	90,400	66,400
11	33,700	49,100	68,900	57,900	95,300	40,300	43,100	71,000	92,200	99,200	91,500	58,300
12	38,800	48,000	64,300	49,800	92,500	47,000	42,700	72,700	96,100	96,400	89,700	58,300
13	44,800	50,500	66,400	40,300	92,500	50,100	43,100	73,500	98,200	95,700	81,600	62,500
14	44,800	57,200	66,700	35,700	95,000	48,000	43,100	73,500	102,000	90,100	76,300	65,300
15	44,800	57,200	68,200	38,800	95,300	45,200	43,100	72,700	105,000	84,400	79,800	63,200
16	42,400	60,400	70,300	39,900	95,300	47,000	43,400	72,700	104,000	83,300	81,200	60,700
17	39,200	61,100	70,600	39,600	96,400	56,500	44,100	71,700	103,000	81,200	79,800	59,000
18	39,200	61,400	63,200	43,100	89,700	55,400	46,300	71,000	102,000	77,000	78,800	56,900
19	38,800	62,900	58,300	45,600	77,000	53,000	48,700	71,000	102,000	77,300	78,800	58,300
20	40,300	59,000	65,300	54,400	63,600	50,900	51,900	71,000	101,000	79,500	75,900	59,300
21	41,300	55,400	71,000	56,500	55,400	47,000	53,700	71,000	99,600	83,700	71,700	58,600
22	37,800	63,600	70,300	57,900	54,400	44,500	56,900	70,300	101,000	86,900	71,700	58,600
23	33,700	69,600	71,300	60,400	54,400	45,200	58,600	70,300	102,000	85,500	72,400	61,100
24	33,700	72,400	65,700	64,300	53,300	44,500	60,400	70,600	103,000	84,400	72,400	65,700
25	37,100	62,200	61,400	65,000	53,700	45,600	62,900	72,000	109,000	86,500	72,000	68,500
26	41,000	61,100	60,700	64,600	48,700	48,000	59,700	73,800	114,000	88,600	71,300	68,900
27	41,300	64,300	60,700	64,300	44,800	46,600	56,900	75,200	114,000	89,000	69,600	68,200
28	41,000	64,300	63,200	63,900	45,900	45,200	59,700	73,800	113,000	88,600	66,700	68,200
29	42,000	64,600	65300,	71,300		34,400	60,700	72,400	114,000	88,600	66,700	68,500
30	48,000	65,000	68,500	79,500		28,100	60,000	72,000	113,000	90,100	65,700	65,300
31	48,700		67,500	79,100		29,400		71,000		91,500	62,900	
Mean	38,400	56,700	66,200	59,700	80,800	45,000	46,400	68,300	97,900	91,500	80,000	59,500

KOOTENAI RIVER AT PORTHILL, IDAHO—Daily discharges in cubic feet per second for the year ending 30 September 1994

APPENDIX D

PROJECT INFORMATION

Power and Storage Projects,

Northern Columbia Basin	Plate No. 1

Project Data

Duncan Project	Table No. 1
Arrow Project	Table No. 2
Mica Project	Table No. 3
Libby Project	Table No. 4

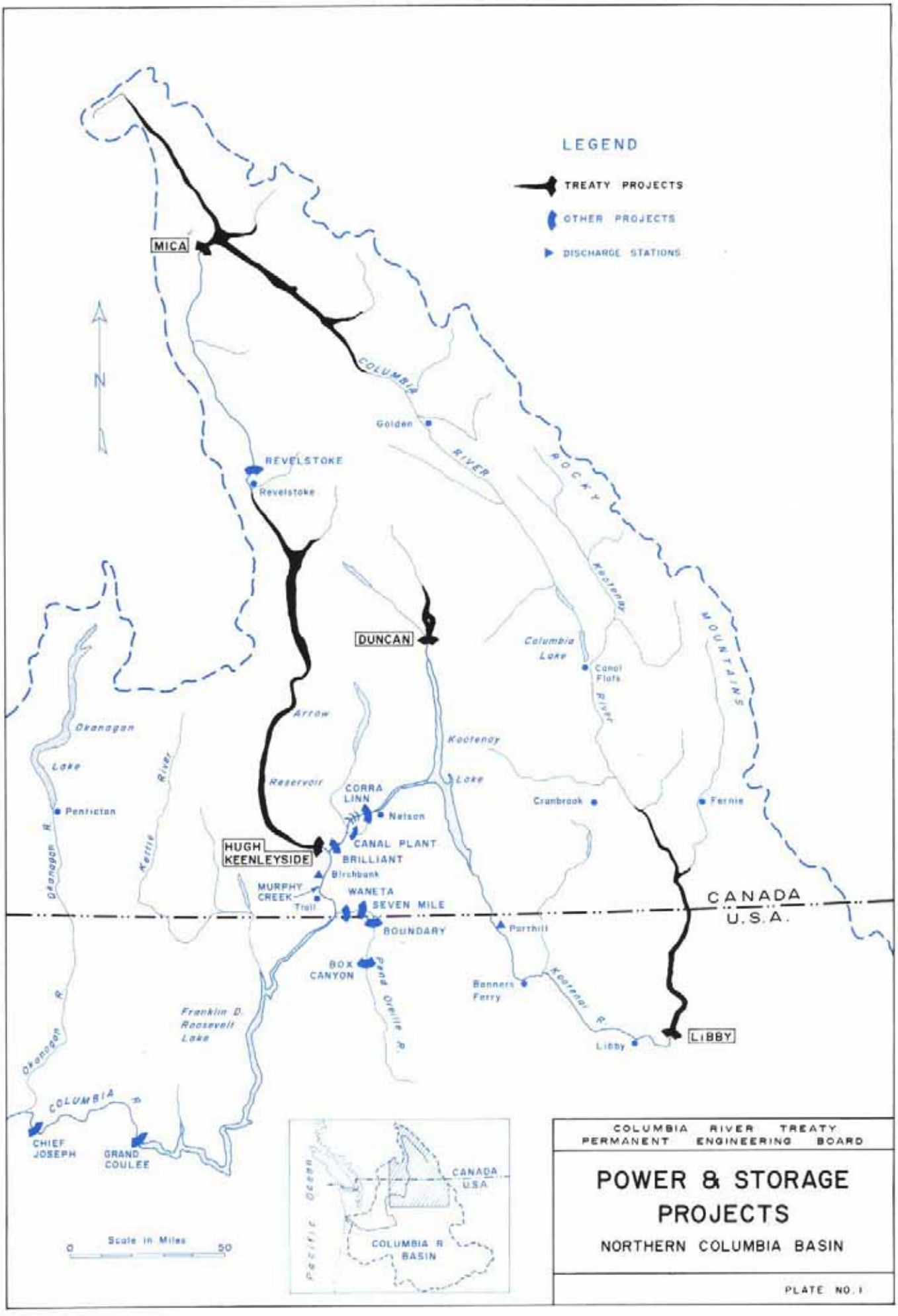

LEGEND
TREATY PROJECTS
OTHER PROJECTS
DISCHARGE STATIONS
MICA
N
COLUMBIA
Golden
RIVER
ROCKY
REVELSTOKE
Revelstoke
DUNCAN
Columbia Lake
Canal Flats
Kootenay
MOUNTAINS
Arrow
Reservoir
Okanagan
Lake
Penticton
Okanagan R.
Kettle River
Kootenay
Lake
CORRA LINN
Nelson
CANAL PLANT
BRILLIANT
HUGH KEENLEYSIDE
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
U.S.A.
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