# ANNUAL REPORT
to the
# GOVERNMENTS
of
# THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 SEPTEMBER 1979

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA · UNITED STATES

CANADIAN SECTION
G.M. MacNABB, Chairman
B.E. Marr, Member

UNITED STATES SECTION
L.A. DUSCHA, Chairman
J.E. Harper, Member

31 December 1979

The Honorable Cyrus Vance
The Secretary of State
Washington, D.C.

The Honourable R.J. Hnatyshyn
Minister of Energy, Mines and
Resources
Ottawa, Ontario

Gentlemen:

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, D.C., on 17 January 1961.

In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the fifteenth Annual Report, dated 30 September 1979, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1978 to 30 September 1979.

Respectfully submitted:

For the United States

Lloyd A. Duscha, Chairman

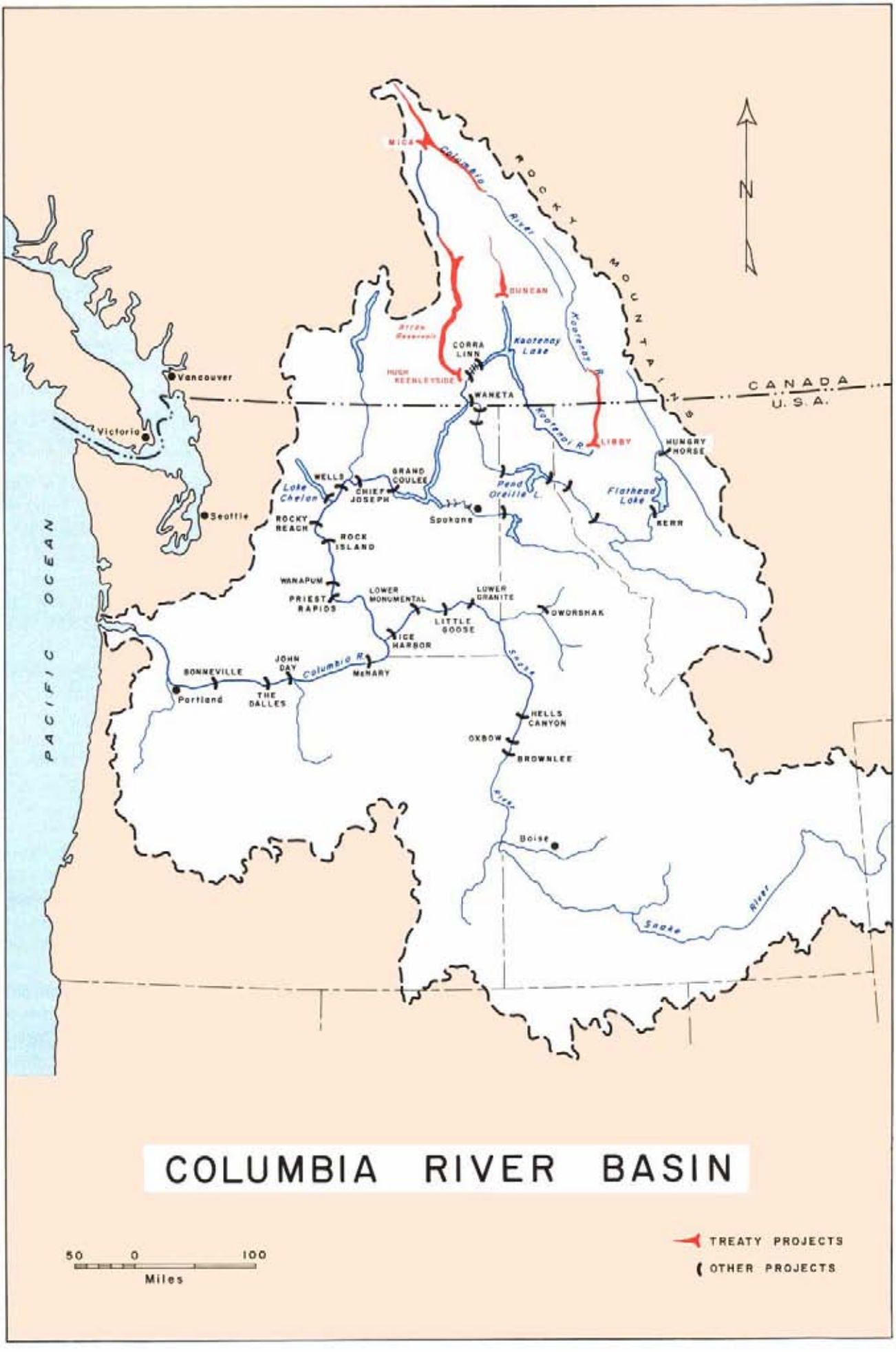
J. Emerson Harper

J. Emerson Harper

For Canada

G.M. MacNabb, Chairman

B.E. Marr




# COLUMBIA RIVER BASIN

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**COLUMBIA RIVER TREATY**
**PERMANENT ENGINEERING BOARD**

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

**30 September 1979**

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

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## SUMMARY

The fifteenth 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.

Two Board meetings and one meeting of the Board with the Entities were held during the 12-month period ending 30 September 1979. The Board also carried out its biennial inspection of the Treaty dams.

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. Although reservoir operations reduced peak freshet flows the unregulated peaks would not have caused any significant flood damages in either country.

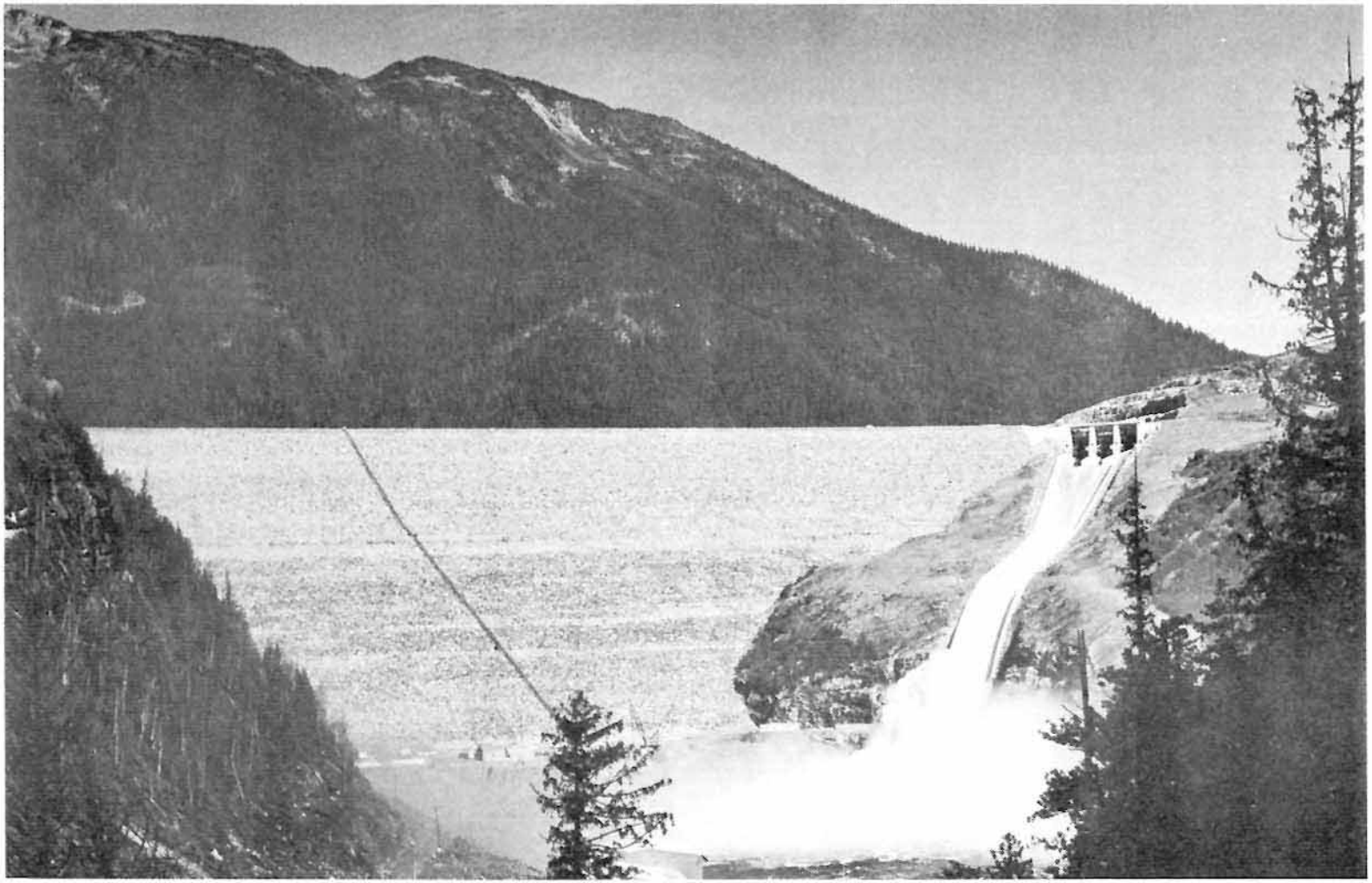
Studies pertaining to development of the hydrometeorological network and power operating plans are being continued by the Entities to ensure operation of the projects in accordance with the terms of the Treaty.

The Board concludes that the objectives of the Treaty are being met.

## INTRODUCTION

The Columbia River Treaty, which provides for co-operative development of the water resources of the Columbia River basin, was signed in Washington, D.C. on 17 January 1961 by representatives of the United States and Canada. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties would be 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 1978 to 30 September 1979, 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. The report also states that, in the opinion of the Board, the objectives of the Treaty are being met. Summaries of the essential features of the Treaty and of the responsibilities of the Board and of the Entities are included.



MICA DAM
The earth dam with the spillway in use.

Columbia River, British Columbia

## 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, Prime Minister Pearson, 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 generated 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.

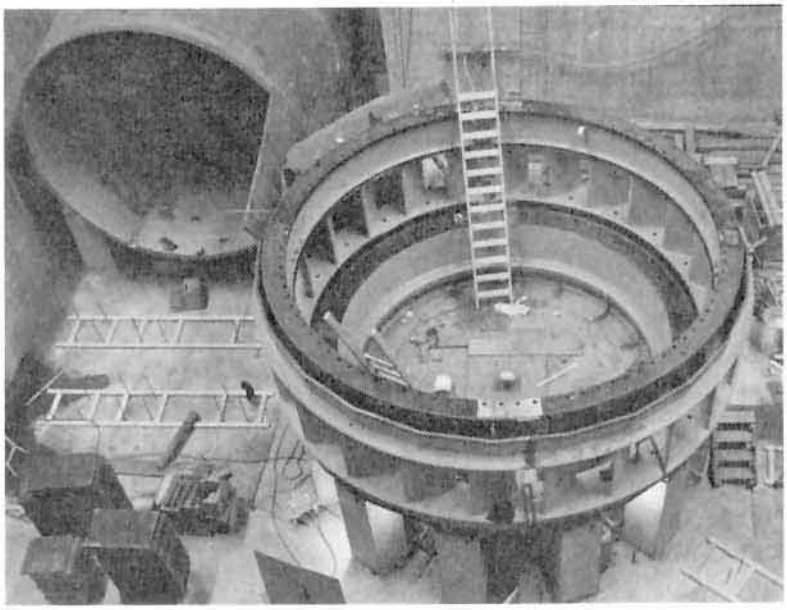
(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

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

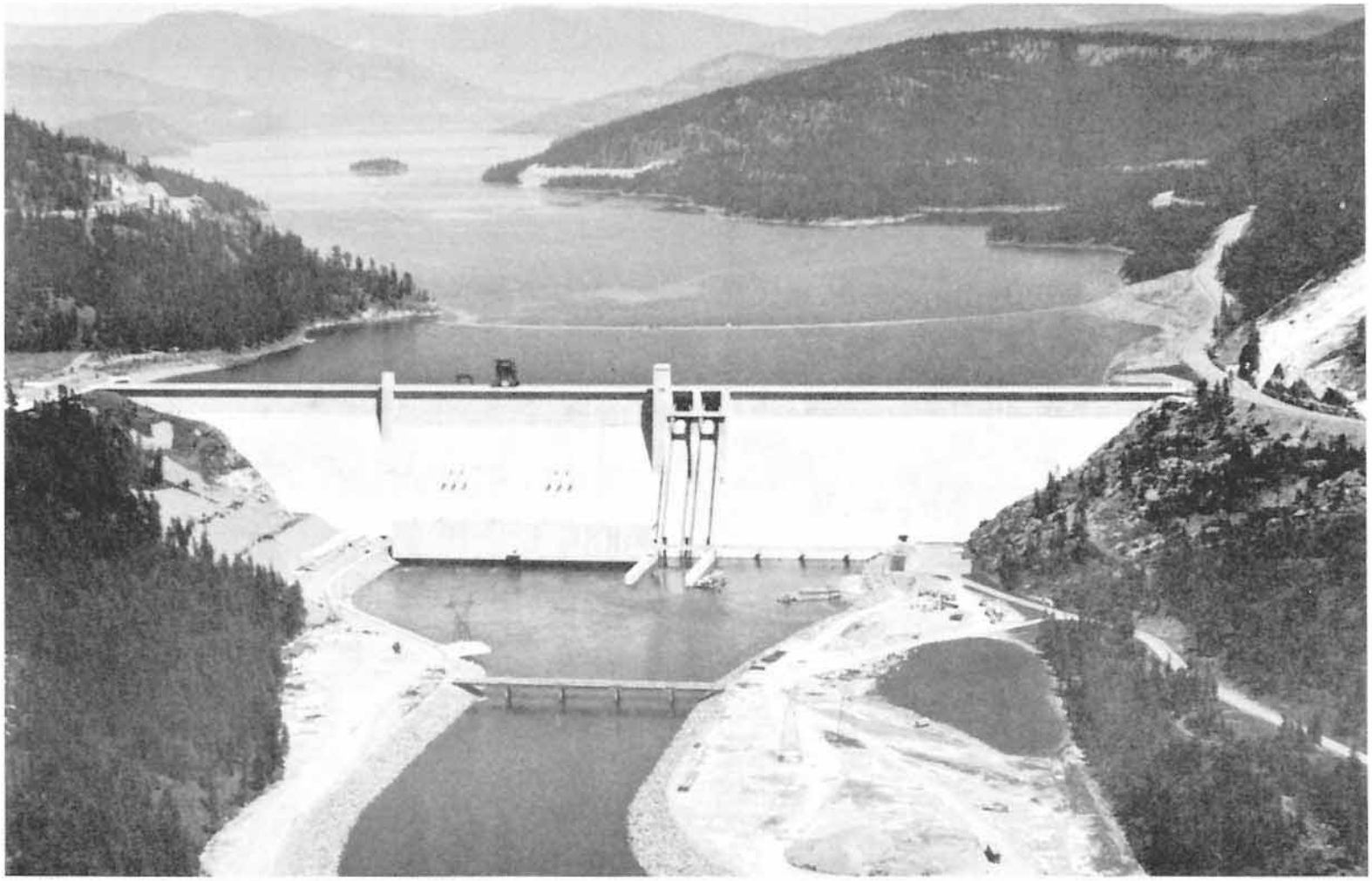
(h) The Treaty shall remain in force for at least 60 years from its date of ratification, 16 September 1964.

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 Canadian Entitlement Purchase Agreement of 13 August 1964 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 |



ADDITIONAL UNITS:
Construction to increase generator capacity at Libby powerhouse.



LIBBY DAM
Overview of dam and Lake Koocanusa. The powerhouse is at the left of the spillway.

Kootenai River, Montana

## 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 23 August 1979 Mr. Lloyd A. Duscha replaced Mr. Homer B. Willis as Chairman of the United States Section of the Board and that Mr. Thomas L. Weaver was appointed an alternate member effective 1 February 1979.

## Duties and Responsibilities of the Board

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;

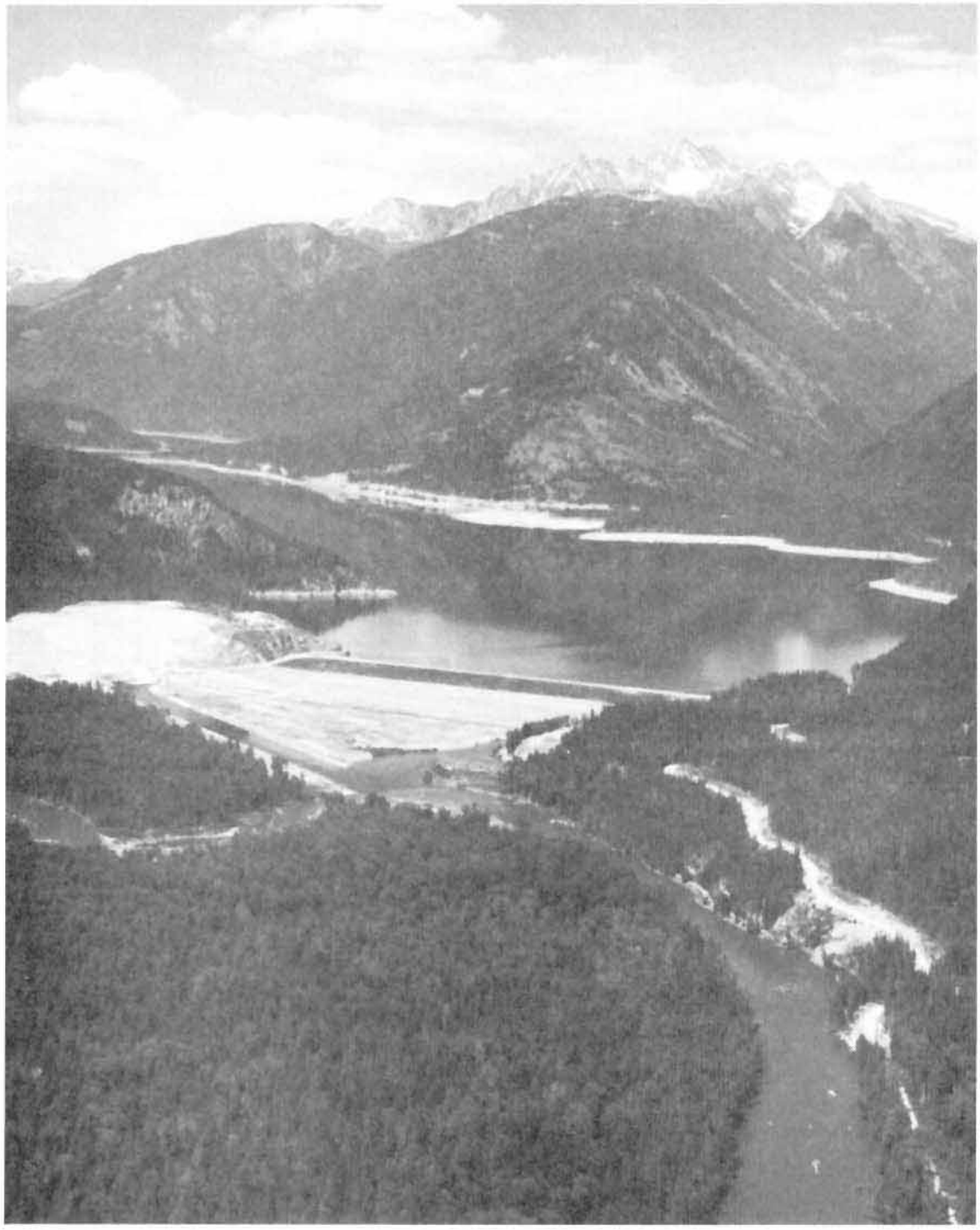
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(d) making periodic inspections and requiring reports as necessary from the entities 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 and Duncan Lake. Discharge tunnels are to the left of the dam.

## ENTITIES

### General

Article XIV(1) of the Treaty provides for the designation by Canada and the United States of entities which are empowered and charged with the duty of formulating and executing the operating arrangements necessary to implement the Treaty. Provision is made for either government to designate one or more entities. The powers and duties of the entities are specified in the Treaty and related documents.

### Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration, 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 these appointments are now made by the Secretary of the Army and the Secretary 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 for the purposes of the Treaty.

The names of the members of the two entities are shown in Appendix B.

Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents the Treaty requires that the entities be responsible for:

(a) co-ordination 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 of America 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 co-operating 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.

REVELSTOKE PROJECT
downstream cofferdam and
excavation for
concrete dam
and powerhouse.

## ACTIVITIES OF THE BOARD

### Meetings

The first meeting of the Board during the report year was held in Victoria, British Columbia on 28 November 1978 to review progress under the Treaty and to discuss preparation of the Board's Annual Report. The Board met with the Entities on the same day to discuss Entity studies and general progress. The second meeting of the Board was held in Revelstoke, British Columbia on 27 August 1979. On 27 and 28 August the Board made its biennial inspection of the Mica and Hugh Keenleyside dams. The Board also viewed from the air the Duncan and Libby dams and the waterways which would be affected by the Kootenay River diversion, as well as visiting the Revelstoke project downstream from Mica where a new dam and powerhouse are under construction.

### Reports Received

Throughout the report year the Canadian Entity provided the Board with weekly reports on operation of the Canadian storage reservoirs and with daily flow forecasts during the freshet season for the northern part of the Columbia River basin. The United States Entity provided monthly reports on the operation of the Libby storage reservoir. The Entities also provided copies of computer printouts of studies for the Assured Operating Plan and downstream power benefit calculations, and the following documents and reports:

- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1977 to 30 September 1978

- Columbia River Treaty Hydroelectric Operating Plan - Assured Operating Plan for Operating Year 1983-84, plus a copy of the Entities' agreement on this document

- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1978 through 31 July 1979, plus a copy of the Entities' agreement on this document

— Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1983-84, plus a copy of the Entities' agreement on this document

— Columbia River Treaty, Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans dated 1 May 1979, plus a copy of the Entities' agreement on this document.

Subsequent to the end of this report year the Board received the following documents and reports from the Entities:

— Detailed Operating Plan for Columbia River Treaty Storage 1 August 1979 through 31 July 1980, plus a copy of the Entities' agreement on this document

— Columbia River Treaty Hydroelectric Operating Plan — Assured Operating Plan for Operating Year 1984-85, plus a copy of the Entities' agreement on this document

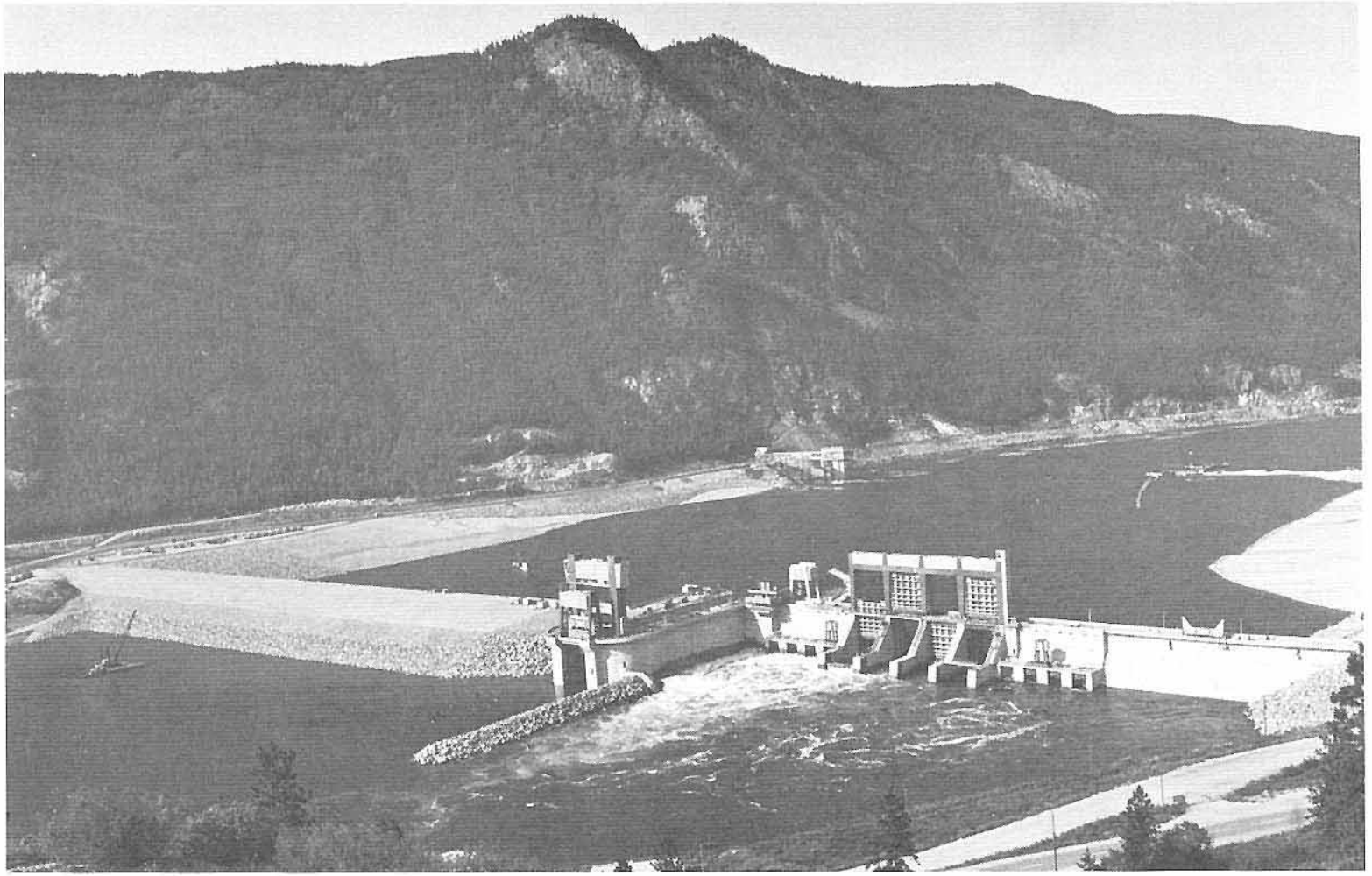
— Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1984-85, plus a copy of the Entities' agreement on this document

— Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1978 to 30 September 1979

— Draft report of the Columbia River Treaty Hydrometeorological Committee which includes revised listings of Treaty and Support Facilities and a revised Plan for Exchange of Data.

## Report to Governments

The fourteenth Annual Report of the Board was submitted to the two governments on 31 December 1978.



HUGH KEENLEYSIDE DAM
Earth dam at the outlet of Arrow Lakes with navigation lock and discharge works.

Columbia River, British Columbia

## PROGRESS

### General

The results achieved under the terms of the Treaty include construction of the Treaty projects, progress in developing the hydrometeorological network, 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, are now in operation and supply power benefits and flood control benefits in both Canada and the United States. The Libby storage project in Montana is in operation and provides power and flood control benefits in both countries. Completion of the Canal Plant on the Kootenay River in 1976 and installation of generators at Mica Dam during 1976 and 1977 have caused the power benefits in Canada to increase substantially. Completion of the Revelstoke project, now under construction, will result in a further substantial increase in power benefits in Canada. By 1985 some 4,000 megawatts of generation in Canada that would otherwise not have been installed will be benefiting from the operation of Treaty storage. This capacity will be installed at Mica and Revelstoke on the Columbia River and at the Canal Plant on the Kootenay River.

The Treaty provides Canada with the option of diverting the Kootenay River into the headwaters of the Columbia River commencing in 1984. British Columbia Hydro and Power Authority is currently studying both the engineering and environmental aspects of the potential diversion at Canal Flats.

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

## Status of the Treaty Projects

### Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled by 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, about 130 feet high, is located on the Duncan River a few 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 which is shown in the picture on page 9.

Characteristics of the project are shown 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 has no associated power facilities.

The dam consists of two main components: a concrete gravity structure which includes the spillway, low level outlets and navigation lock and an earthfill section which rises 170 feet above the riverbed. 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 15 and project data are shown 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 creates a reservoir 135 miles long, McNaughton Lake, with a 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. The reservoir filled for the first time during the summer of 1976.

The underground powerhouse has space for a total of six 434 megawatt units with a total capacity of 2,604 megawatts. The first two generators were placed in service late in 1976 and the last of the initial four units commenced operation in October 1977.

The dam is shown in the picture on page 2 and project data are shown in Table 3 of Appendix D.

MICA DAM,
power intakes
and McNaughton Lake.

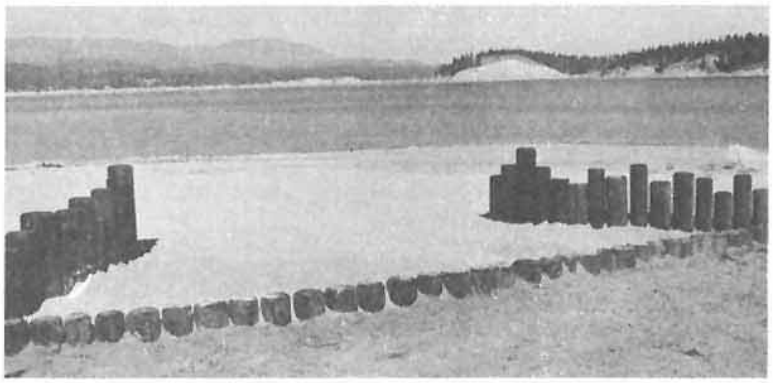
## Libby Project in the United States

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, and commercial generation of power began on 24 August 1975, coincident with formal dedication of the project. The concrete gravity dam 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 5,809,000 acre-feet, of which, 4,934,000 acre-feet are usable for flood control and power purposes. The present installed capacity at the Libby powerhouse is 420 megawatts.

Work on the Libby project during the report year included completion of a new concrete deck and sidewalks on the David Thompson bridge in December 1978, and of the Murray Springs fish hatchery and the Tobacco Plains recreation area near Eureka, Montana, in June 1979. The Rexford Bench campground was about 87% complete at the end of September 1979. Additional slope instrumentation on the left abutment was installed by January 1979. Sluice repairs which started in June 1979 were 47% complete at the end of September, with completion scheduled in December 1979. Site restoration and landscaping downstream of Libby Dam was begun in June 1979 and at the end of the report year was 70% complete.

Construction of the Libby Additional Units and Reregulating Dam project was initiated during the previous report year. A contract for the manufacture and installation of the turbines for the four additional units in the main dam was 62% complete by September 1979. Work on the haul bridge for the reregulating dam began in April 1978 but was stopped by Court Order in November of the same year. Further construction activity on the reregulating dam is uncertain at this time. The basic issues centre on alleged lack of congressional authorization for the project, inadequacies in the project environmental impact statement, violation of coordination requirements of the Endangered Species Act, and other laws relating to project justification, environment and cultural resources. A preliminary injunction issued on 8 September 1978 ordered a halt to construction of the project, except those items

REXFORD BENCH SWIMMING AREA on Lake Koocanusa in Montana.



necessary for complying with legal requirements and enhancement of the environment. At a hearing before the Ninth Circuit Court of Appeals on 2 November 1978 the United States Corps of Engineers was allowed to continue work on the main Libby Dam project including the four additional power units, but the preliminary injunction on the reregulating dam was left in effect. On 15 March 1979 a split three-judge panel of the Ninth Circuit Court of Appeals held that Congress had not properly consented to the construction of Libby Reregulating Dam; however, it held that the installation of the four additional units in the main dam had been authorized. A further appeal was denied and the Justice Department has decided not to appeal the ruling to the Supreme Court at this time. Further construction on the reregulating dam must wait legal or legislative resolution of this matter.

The Libby project is shown in the picture on page 6 and project data are shown in Table 4 of Appendix D.

## Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile long portion of Lake Koocanusa in Canada. Coordinated by the Province of British Columbia's Ministry of Environment, fishery and wildlife mitigation studies are being continued; parks facilities are being enhanced and potential sites investigated for future development. The 660-foot four-span Bailey bridge across the reservoir at Kikomun Creek has been upgraded by installation of permanent steel decking.

## 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.

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. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities, makes recommendations on establishing the Treaty Hydrometeorological System.

During the 1976-77 report year the Entities, with the concurrence of the Board, adopted a revised plan for exchange of operational hydrometeorological data. That plan is still in force. A further revision for exchange of operational data and a revised listing of Treaty hydrometeorological facilities have been drafted by the Entities. These were received by the Board after the end of the report year.

Progress is being made in automating the collection and processing of hydrometeorological data in the Columbia River system. During the year the "Columbia River Operational Hydromet System", a computer system that has capability for direct input of data from other computer terminals and for the retrieval of data reports from its own data bank, began full time operation in Portland, Oregon. The Canadian Entity began utilizing this system during the year on a test basis and arrangements for automatic, computer-to-computer interface with this facility are being discussed. Progress was also made in other areas such as modelling techniques, and the use of satellite imagery.

## Power Operating Plans

The Treaty and related documents provide that the Entities are 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 and provide the Entities with a basis for system planning. At the beginning of each operating year a detailed operating plan 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.

The assured operating plan for operating year 1983-84, received by the Board early in the report year, includes generation at the Mica project and is based on the operation of the system for optimum generation in both countries. The Board has reviewed this plan and concludes that it is consistent with the terms of the Treaty and does not depart substantially from previous plans. The assured operating plan for 1984-85 was provided to the Board after the end of the report year.

Early in this report year the Entities provided the Board with a detailed operating plan for Canadian storage for the operating year ending 31 July 1979. A detailed operating plan for the operating year ending 31 July 1980 was forwarded to the Board after the end of the report year. These plans contain criteria for operating the Arrow, Duncan, Mica and Libby reservoirs.

During the report year the Entities provided the Board with a report on revised principles and procedures for preparation and use of hydroelectric operating plans. This report is under review.

## Annual Calculation of Downstream Benefits

The general requirements for determination of assured operating plans and down-

stream power benefits are summarized in the first paragraph of the preceding section.

In this report year the Entities provided the Board with a copy of their agreed document outlining downstream power benefits resulting from Canadian storage for the operating year 1983-84. The Board has completed its review of this document and concludes that it meets the requirements of the Treaty. Copies of the three computer studies used in the final calculations for the determination of downstream benefits and which also provide the basis of the hydroelectric operating plan were forwarded to the Board by the Entities. A report on determination of downstream power benefits for the operating year 1984-85 was received from the Entities after the end of the report year.

## 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.

## Flow Records

Article XV(2)(a) of the Treaty specified that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenay Rivers at the Canada-United States of America boundary. Actual recorded flows for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia, Plate 1, are tabulated in Appendix C for this report year.

## 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 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 1978 through 31 July 1979
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1978 through 31 July 1980
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1978-79
- Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1979-80

In addition, one special agreement was in effect during this period. The "Agreement to Enhance Filling of Mica Reservoir", signed by the Entities in May 1978, remained in effect until the end of July 1979.

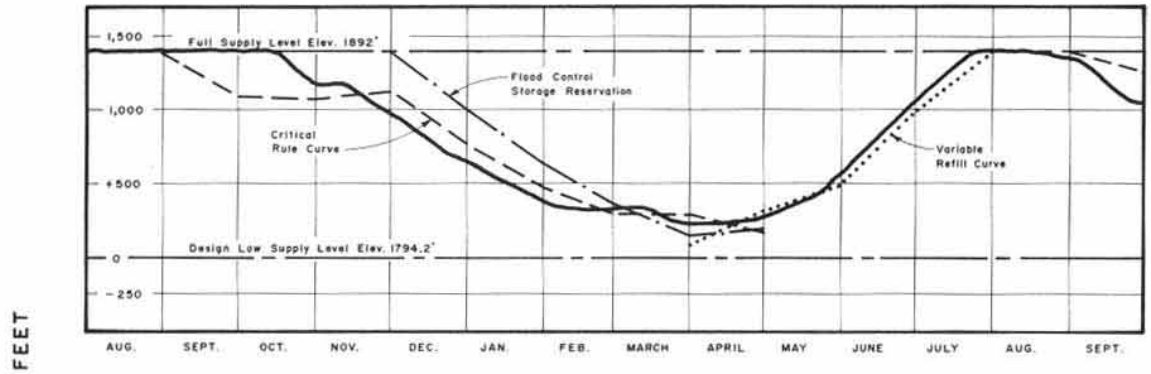
## Power Operation

The three Canadian Treaty reservoirs, Duncan, Arrow, and Mica, and the Libby reservoir in the United States were in full operation throughout this report year. All reservoirs in the Columbia River system had filled by the end of the freshet in 1978 and were still essentially full at the beginning of this report year. However, precipitation has been generally low throughout this report year and system storage gradually experienced operating deficits in relation to operating rule curve levels. By 31 July 1979, the end of the specified refill season, system reservoirs were a total of four million acre-feet below full content and at the end of the report year this deficiency had grown by about one-half million acre-feet.

Secondary energy was only available to United States markets at times when release requirements to assist downstream migration of juvenile fish, or to meet minimum release specifications, forced generation which was out of phase with firm load needs.

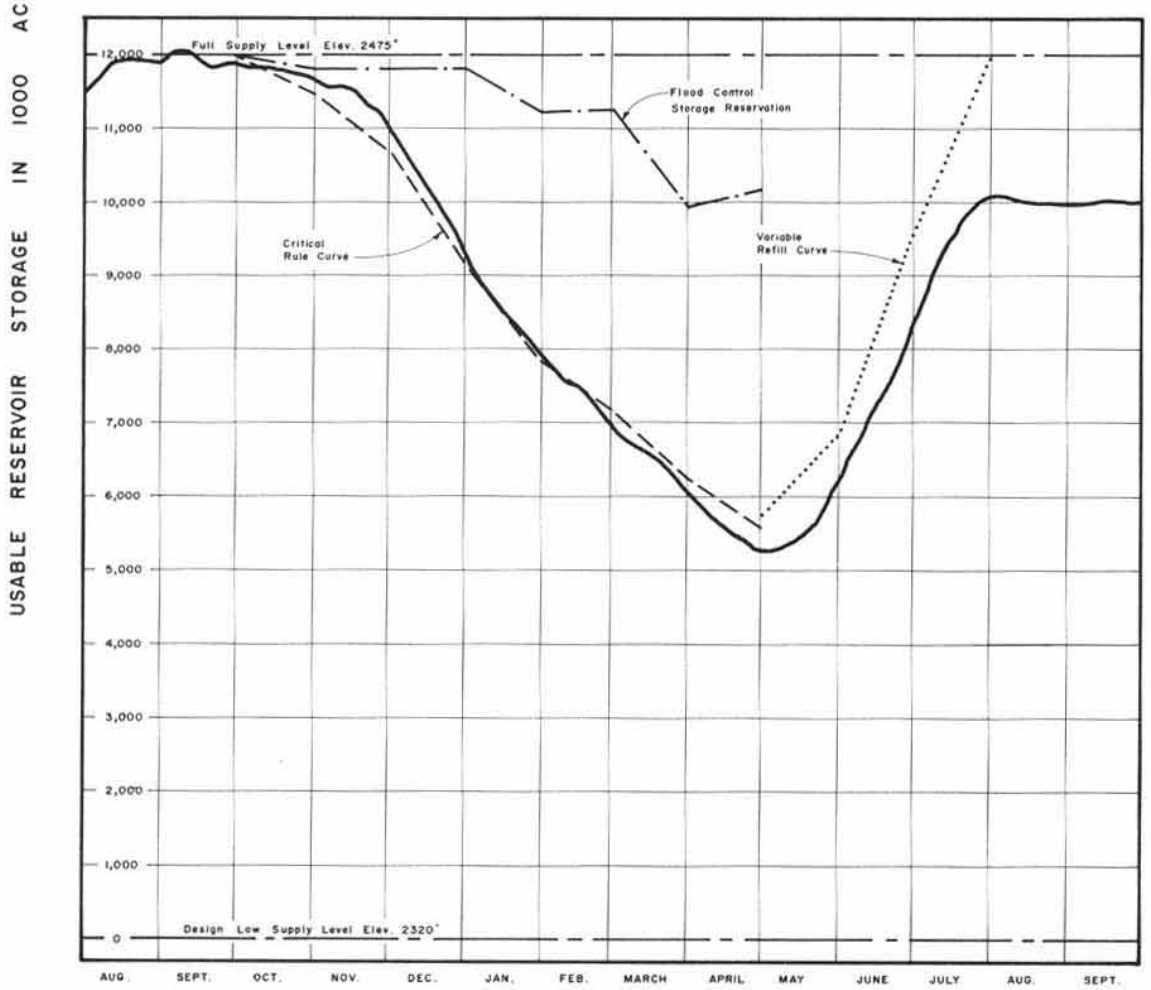
During the November to April period British Columbia Hydro and Power Authority exercised its option under the "Agreement to Enhance Filling of Mica Reservoir" to draft one-half million acre-feet of non-Treaty storage from Mica and to receive the energy generated therefrom at downstream United States projects. In the latter part of the summer, system conditions permitted the transfer of some British Columbia Hydro and Power Authority non-Treaty storage from Mica to Arrow reservoir and this helped to maintain levels in the Arrow Lakes during the recreation season.

Operation of the reservoirs is illustrated on pages 26 and 27 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storages. The Flood Control Storage Reservation curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control the forecasted freshet. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under adverse water supply conditions. The Variable Refill Curve shows reservoir elevations necessary to



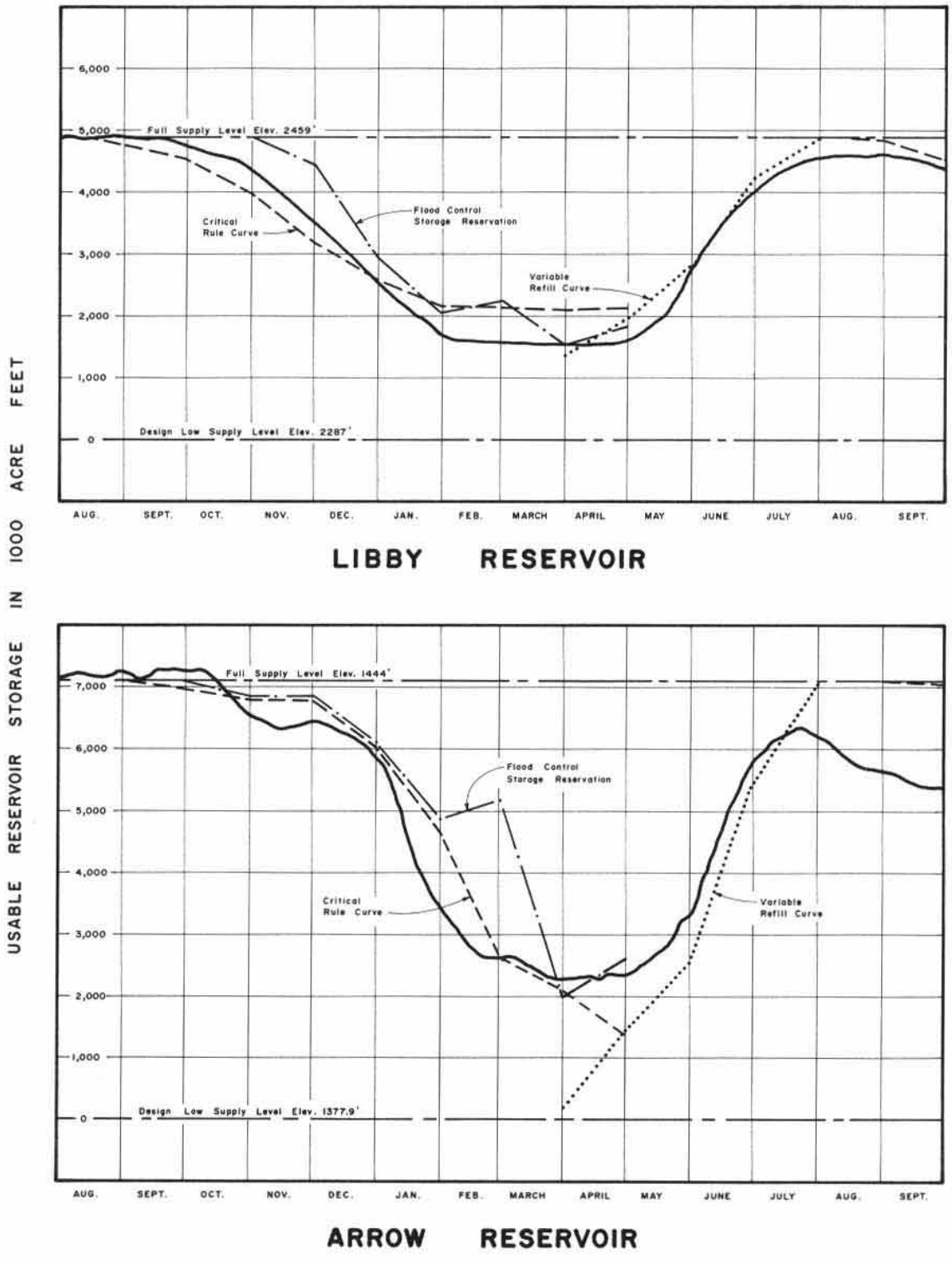

**DUNCAN RESERVOIR**

USABLE RESERVOIR STORAGE IN 1000 ACRE FEET




**MICA RESERVOIR**

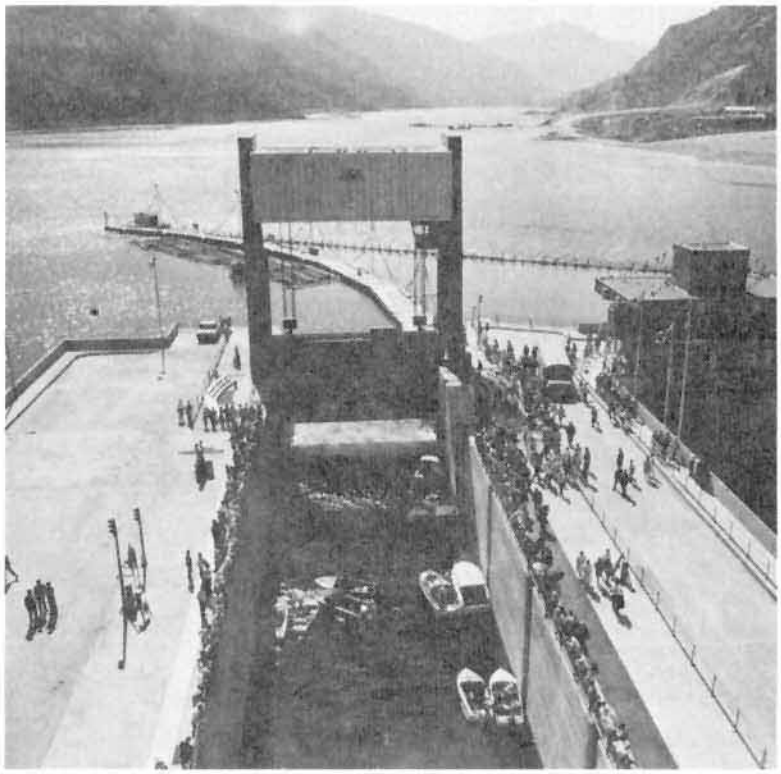
HYDROGRAPHS – Duncan and Mica reservoir levels for the 14-month period ending 30 September 1979.




HYDROGRAPHS – Libby and Arrow reservoir levels for the 14-month period ending 30 September 1979.

ensure refilling the reservoir by the end of July with a reasonable degree of confidence. Similar rule curves which apply to operation of the combined Canadian Treaty storages have also been provided to the Board.

At the beginning of the report year the Duncan reservoir was essentially full at elevation 1891.8 feet. Drafting of storage began in mid-October 1978. Outflow was reduced to minimum for one week in early November to lessen spill at the Kootenay Canal Plant when generating units were not operating. Operation during the first months of 1979 was in accordance with rule curves based on freshet volume forecasts and the minimum elevation for the year was 1815.9 feet on 31 March. At the beginning of April outflows were reduced to minimum to assist in refilling the reservoir. The reservoir filled on 21 July and drafting commenced again in late August. At the end of the report year the elevation of the reservoir was 1871.8 feet.



NAVIGATION LOCK
in service at
Hugh Keenleyside Dam
at Arrow Lakes outlet.

The Arrow reservoir was at elevation 1445.2 feet at the beginning of the report year. This surcharge above full pool elevation, 1444.0 feet, had been caused by heavy rains in the Upper Columbia Basin in September. Drafting of storage began about mid-October and discharges were increased after the first of the year when volume inflow forecasts became available. The reservoir reached elevation 1403.0 feet on 27 March and remained close to that elevation until filling began at the beginning of May. On 21 April outflow was reduced to minimum to accommodate the installation of a large sewer outfall near Trail, British Columbia. Reservoir outflows during May and June were determined by power requirements and by the need to release water to assist the downstream migration of juvenile fish in the United States. The reservoir reached a maximum elevation of 1438.1 feet on 23 July and drafting commenced immediately. During the remainder of the recreation season an effort was made to minimize lowering of lake levels and on 30 September 1979 the reservoir was at elevation 1430.1 feet.

At the beginning of this report year McNaughton Lake was at elevation 2474.0 feet. Drafting of storage began in November and discharges were increased during December and January to meet winter loads. Drafting continued until the reservoir reached its lowest elevation, 2403.7 feet, on 3 May. In February a snowslide destroyed several transmission towers causing a total disruption of service for several days. During May Mica releases were reduced when other storage, which was released to assist the migration of juvenile fish, resulted in extra generation in the United States. Again, at the end of the month, outflow was reduced to permit removal of a floating bridge which had been used to bypass highway traffic at the Revelstoke project. The reservoir reached its highest elevation of 2456.7 feet on 4 August 1979 and remained near that elevation until the end of the report year. On 30 September the elevation was 2455.6 feet.

During the operating year British Columbia Hydro and Power Authority exercised its option under the "Agreement to Enhance Filling of Mica Reservoir" to draft one-half million acre-feet of non-Treaty storage from Mica and to receive the resulting energy generated at downstream United States projects. This provides about five feet of operating space in the reservoir which can be used to protect construction at the Revelstoke project downstream.

At the beginning of this report year Lake Koocanusa was almost full at elevation 2455.1 feet. Outflows were limited by restrictions at the Libby reregulating construction site. With the removal of that restriction in late October, Libby was drafted at close to powerhouse capacity through November and December. During January releases for flood control and power purposes were continued. Early in February these releases were substantially reduced when volume forecasts indicated a smaller freshet volume would be available. Discharges remained low until the end of the report year. The reservoir reached its minimum elevation of 2364.0 feet on 9 April 1979 and on 19 August peaked at 2451.4 feet. Drafting began early in September and at the end of the report year reservoir elevation was 2446.7 feet.

## Flood Control Operation

Operation for flood control during the 1979 freshet was in accordance with the Entities' document "Columbia River Treaty Flood Control Operating Plan" and required storage space was provided in all reservoirs prior to the freshet. The freshet was controlled to well below damaging levels by regulating discharges for power purposes and for the best operation to refill.

RECREATION BEACH
on Lake Koocanusa
in British Columbia.

## BENEFITS

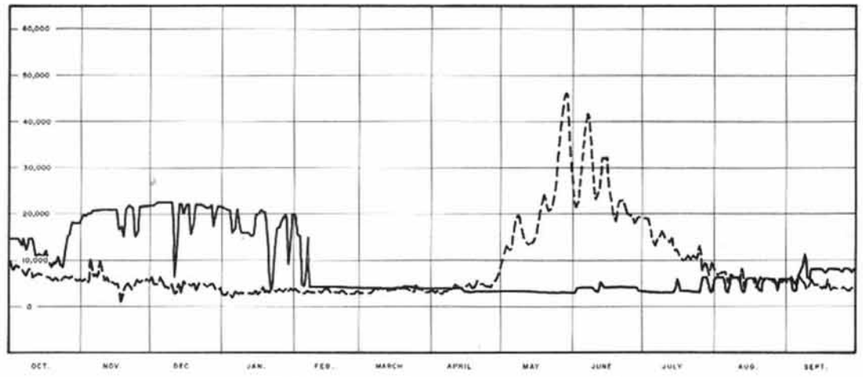
### Flood Control Provided

Without regulation by upstream reservoirs the 1979 freshet would have produced a less than average peak discharge at The Dalles, Oregon, and would have caused little flood damage. In Canada, even without the four storage projects constructed as a result of the Treaty, the peak discharge of the Columbia River at Trail would not have reached damaging levels.

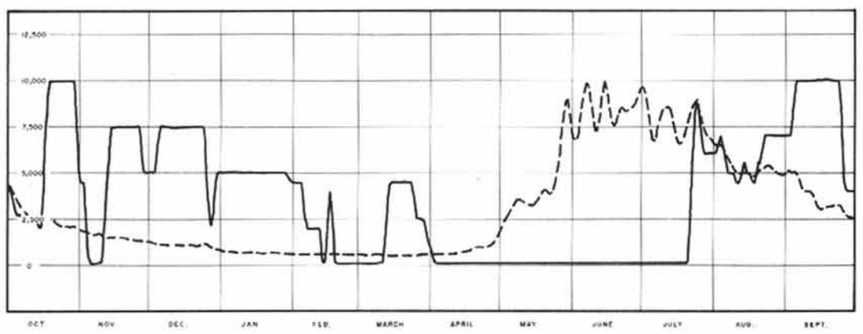
It is estimated that the Duncan and Libby projects reduced the peak stage on Kootenay Lake by almost six feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about eight feet. The effect of storage in the Duncan, Arrow, Mica and Libby reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 32 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 480,000 cfs to 306,000 cfs. Regulation by the Treaty storage projects during the 1979 freshet period contributed only minor flood control benefits in Canada and the United States.

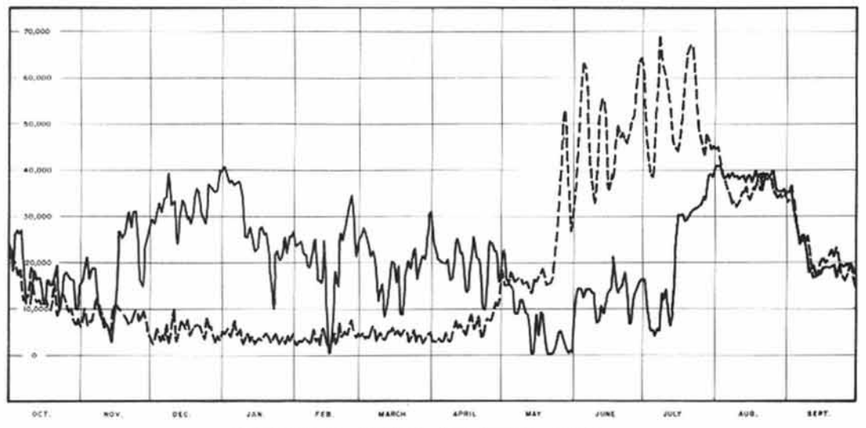
All payments required by Article VI(1) as compensation for flood control provided by the Canadian Treaty storage projects have been made by the United States to Canada; the final payment was made on 29 March 1973 when the Mica project was declared operational.




KOOTENAI RIVER AT LIBBY DAM

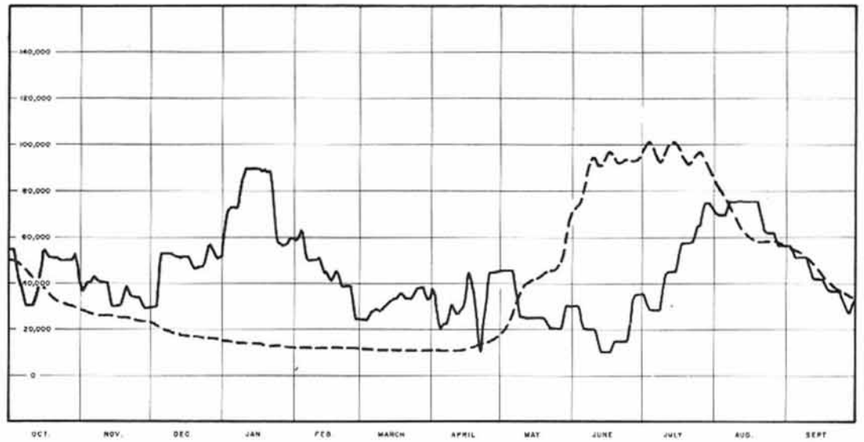



DUNCAN RIVER AT DUNCAN DAM

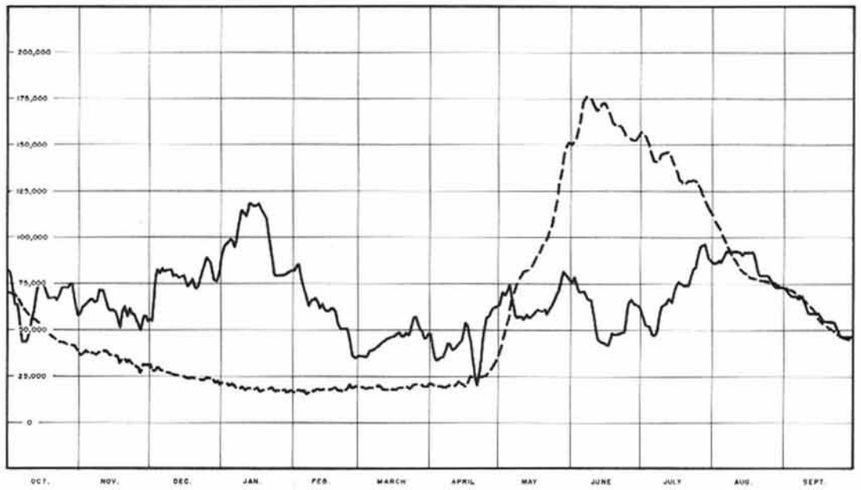



COLUMBIA RIVER AT MICA DAM

DISCHARGE IN CUBIC FEET PER SECOND




COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM




COLUMBIA RIVER AT BIRCHBANK

LEGEND

——— Observed Flows

– – – – Pre-Project Flows

HYDROGRAPHS— Observed and pre-project flows for year ending 30 September 1979.

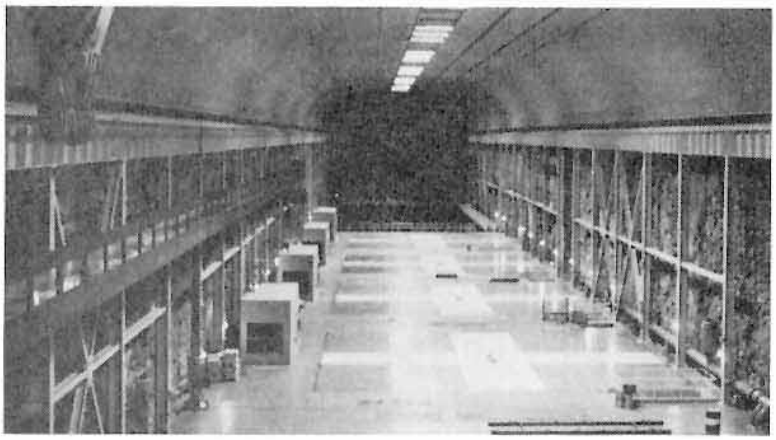
## Power Benefits

Downstream power benefits in the United States which arise from operation of the Canadian Treaty Storage were pre-determined 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 delivered capacity and energy to Columbia Storage Power Exchange participants as purchasers of the Canadian Entitlement. No additional downstream power benefits were realized during the year from the operation of Treaty dams other than the added generation made possible on the Kootenay River in Canada and additional generation in the United States system resulting from regulation provided by Libby. The Kootenay River benefits in Canada, under Article XII of the Treaty, and generation at the Mica project are retained wholly within Canada while the benefits from Libby in the United States are not shareable under the Treaty.

## Other Benefits

Streamflows have been manipulated 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 supplement Treaty operating plans and have not created conflicts with operations under those plans. The effects have been beneficial in both countries in accordance with the intent of the Treaty.

UNDERGROUND POWERHOUSE, deck over the generators, at Mica Dam.



## CONCLUSIONS

1. The Duncan, Arrow, Mica and Libby projects have been operated in conformity with the provisions of the Treaty, the detailed operating plans developed by the Entities, and the flood control operating plan for Treaty reservoirs. Special operating arrangements have accommodated other interests without harming system operation and were consistent with the intent of the Treaty.

2. Entity evaluations pertaining to development of the hydrometeorological network, power operating plans, and the annual calculation of downstream power benefits are proceeding satisfactorily.

3. Regulation by the Treaty storage projects during the 1979 freshet period contributed only minor flood control benefits in Canada and the United States because of below average runoff conditions.

4. Finally, the Board concludes that the objectives of the Treaty are being met.

# COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

| United States | Canada |
|---|---|
| **Members** | |
| Mr. Lloyd A. Duscha, Chairman 1)<br>Chief, Engineering Division,<br>Civil Works Directorate,<br>Office, Chief of Engineers,<br>U.S. Army,<br>Washington, D.C. | Mr. G.M. MacNabb, Chairman<br>President,<br>Natural Sciences & Engineering Research Council, Canada,<br>Ottawa, Ontario |
| Mr. J. Emerson Harper<br>Office of Power Marketing Coordination,<br>Department of Energy,<br>Washington, D.C. | Mr. B.E. Marr<br>Deputy Minister,<br>Ministry of Environment,<br>Victoria, B.C. |
| **Alternates** | |
| Mr. Alex Shwaiko<br>Chief, Planning Division,<br>Civil Works Directorate,<br>Office, Chief of Engineers,<br>U.S. Army,<br>Washington, D.C. | Mr. E.M. Clark<br>Regional Director,<br>Pacific and Yukon Region,<br>Inland Waters Directorate,<br>Department of the Environment,<br>Vancouver, B.C. |
| Mr. Thomas L. Weaver 2)<br>Assistant Administrator,<br>Power Management and Operation and Maintenance,<br>Western Area Power Administration,<br>Department of Energy,<br>Golden, Colorado | Mr. H.M. Hunt<br>Chief, Power and Special Projects Division,<br>Ministry of Environment,<br>Victoria, B.C. |
| **Secretaries** | |
| Mr. S.A. Zanganeh<br>Hydrologic Engineering Section,<br>Engineering Division,<br>Civil Works Directorate,<br>Office, Chief of Engineers,<br>U.S. Army,<br>Washington, D.C. | Mr. E.M. Clark<br>Regional Director,<br>Pacific and Yukon Region,<br>Inland Waters Directorate,<br>Department of the Environment,<br>Vancouver, B.C. |

1) Vice Mr. Homer B. Willis as of 23 August 1979.
2) As of 1 February 1979.

APPENDIX A

## COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

### Record of Membership

| United States | | | Canada | | |
|---|---|---|---|---|---|
| **Members** | | | | | |
| Mr. Wendell E. Johnson | 1) | 1964-1970 | Mr. G.M. MacNabb | 1) | 1964- |
| Mr. Morgan E. Dubrow | | 1964-1970 | Mr. A.F. Paget | | 1964-1973 |
| Mr. John W. Neuberger | | 1970-1973 | Mr. V. Raudsepp | | 1973-1974 |
| Mr. Joseph B. Caldwell | 1) | 1971-1973 | Mr. B.E. Marr | | 1974- |
| Mr. Homer B. Willis | 1) | 1973-1979 | | | |
| Mr. C. King Mallory | | 1973-1975 | | | |
| Mr. Raymond A. Peck, Jr. | | 1976-1977 | | | |
| Mr. J. Emerson Harper | | 1978- | | | |
| Mr. Lloyd A. Duscha | 1) | 1979- | | | |
| **Alternates** | | | | | |
| Mr. Fred L. Thrall | | 1964-1974 | Mr. E.M. Clark | | 1964- |
| Mr. J. Emerson Harper | | 1964-1978 | Mr. J.T. Rothwell | | 1964-1965 |
| Mr. Alex Shwaiko | | 1974- | Mr. H.M. Hunt | | 1966- |
| Mr. Thomas L. Weaver | | 1979- | | | |
| **Secretaries** | | | | | |
| Mr. John W. Roche | | 1965-1969 | Mr. E.M. Clark | | 1965- |
| Mr. Verle Farrow | | 1969-1972 | | | |
| Mr. Walter W. Duncan | | 1972-1978 | | | |
| Mr. S.A. Zanganeh | | 1978- | | | |

1) Chairman

APPENDIX B

## COLUMBIA RIVER TREATY ENTITIES

### United States

Mr. S. Sterling Munro, Chairman

Administrator, Bonneville
Power Administration,
Department of Energy,
Portland, Oregon

Brigadier General Richard M. Wells

Division Engineer, North
Pacific Division,
Corps of Engineers,
U.S. Army,
Portland, Oregon

### Canada

Mr. R.W. Bonner, Chairman

Chairman, British Columbia
Hydro and Power Authority,
Vancouver, B.C.

APPENDIX C

# RECORD OF FLOWS

# AT THE

# INTERNATIONAL BOUNDARY

| Day | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 82,500 | 58,600 | 55,800 | 93,100 | 81,900 | 35,900 | 47,900 | 64,400 | 74,900 | 58,300 | 85,700 | 72,700 |
| 2 | 81,800 | 62,800 | 54,600 | 95,400 | 84,700 | 35,200 | 38,600 | 70,200 | 79,100 | 53,000 | 86,600 | 70,500 |
| 3 | 76,100 | 63,500 | 67,400 | 96,800 | 86,100 | 35,300 | 33,500 | 68,400 | 74,200 | 52,000 | 87,300 | 68,200 |
| 4 | 64,100 | 64,700 | 83,300 | 98,400 | 77,500 | 34,700 | 33,800 | 71,600 | 70,100 | 52,300 | 85,900 | 68,500 |
| 5 | 64,200 | 66,300 | 80,000 | 98,400 | 72,000 | 38,700 | 35,100 | 75,200 | 70,200 | 47,700 | 89,200 | 68,100 |
| 6 | 58,100 | 66,800 | 83,600 | 94,500 | 68,800 | 39,000 | 35,100 | 70,000 | 71,000 | 46,600 | 92,200 | 68,300 |
| 7 | 43,800 | 64,800 | 81,300 | 98,600 | 62,200 | 38,700 | 38,000 | 59,000 | 68,400 | 47,800 | 91,900 | 66,200 |
| 8 | 43,500 | 65,300 | 82,300 | 108,000 | 66,100 | 40,200 | 43,100 | 56,300 | 66,600 | 53,600 | 91,600 | 68,200 |
| 9 | 43,500 | 71,700 | 82,600 | 115,000 | 66,300 | 40,900 | 42,400 | 57,600 | 66,600 | 62,000 | 91,700 | 63,700 |
| 10 | 46,900 | 71,900 | 83,000 | 113,000 | 67,200 | 42,000 | 39,200 | 56,800 | 62,200 | 62,900 | 91,900 | 59,300 |
| 11 | 53,900 | 71,800 | 79,000 | 111,000 | 65,300 | 43,200 | 39,300 | 55,400 | 52,700 | 63,300 | 92,100 | 58,800 |
| 12 | 59,000 | 65,500 | 80,200 | 118,000 | 61,200 | 43,800 | 40,600 | 57,400 | 44,400 | 66,400 | 92,000 | 59,100 |
| 13 | 66,400 | 60,900 | 78,500 | 118,000 | 64,000 | 44,800 | 42,100 | 56,300 | 44,300 | 66,700 | 90,300 | 59,300 |
| 14 | 75,900 | 60,800 | 78,900 | 117,000 | 60,900 | 45,400 | 43,400 | 56,400 | 43,200 | 64,000 | 91,900 | 59,600 |
| 15 | 78,500 | 61,100 | 79,300 | 117,000 | 59,700 | 46,100 | 49,100 | 57,800 | 42,600 | 69,300 | 92,000 | 59,400 |
| 16 | 76,500 | 60,300 | 77,500 | 118,000 | 60,100 | 46,100 | 54,200 | 59,600 | 41,600 | 75,400 | 92,100 | 56,900 |
| 17 | 71,800 | 57,900 | 72,900 | 116,000 | 61,800 | 47,400 | 52,700 | 60,400 | 44,300 | 75,000 | 92,200 | 54,400 |
| 18 | 67,300 | 50,900 | 74,700 | 114,000 | 61,400 | 48,200 | 47,700 | 60,200 | 47,600 | 74,300 | 91,800 | 54,400 |
| 19 | 67,500 | 59,700 | 77,900 | 112,000 | 58,900 | 46,500 | 36,300 | 59,900 | 47,000 | 73,300 | 86,800 | 54,300 |
| 20 | 67,700 | 63,100 | 72,700 | 111,000 | 52,900 | 46,100 | 28,000 | 60,500 | 47,400 | 73,900 | 80,100 | 54,300 |
| 21 | 67,400 | 57,100 | 72,000 | 103,000 | 50,800 | 48,400 | 19,300 | 58,100 | 47,500 | 73,400 | 78,800 | 54,200 |
| 22 | 66,000 | 62,300 | 74,300 | 90,400 | 50,900 | 47,100 | 31,600 | 60,500 | 47,900 | 78,500 | 78,800 | 54,000 |
| 23 | 69,900 | 58,500 | 79,700 | 79,900 | 51,100 | 46,900 | 38,400 | 62,200 | 48,200 | 82,400 | 78,800 | 50,600 |
| 24 | 73,000 | 58,700 | 82,700 | 78,900 | 51,100 | 55,800 | 50,900 | 65,800 | 54,500 | 82,900 | 78,600 | 46,700 |
| 25 | 73,300 | 55,400 | 89,000 | 79,200 | 45,500 | 57,600 | 56,400 | 68,000 | 63,700 | 91,200 | 78,600 | 46,300 |
| 26 | 73,000 | 53,600 | 87,700 | 79,200 | 35,900 | 55,700 | 57,300 | 70,200 | 66,300 | 94,800 | 75,600 | 46,400 |
| 27 | 72,900 | 49,200 | 84,900 | 79,200 | 34,600 | 50,500 | 60,700 | 76,500 | 64,500 | 95,900 | 73,000 | 46,200 |
| 28 | 75,700 | 57,400 | 77,000 | 79,800 | 35,400 | 49,700 | 61,400 | 81,200 | 64,000 | 96,500 | 72,900 | 46,100 |
| 29 | 75,300 | 57,800 | 76,000 | 81,100 | | 45,300 | 61,900 | 79,600 | 63,300 | 90,100 | 72,800 | 46,300 |
| 30 | 66,200 | 54,800 | 78,200 | 82,000 | | 45,700 | 62,200 | 78,100 | 62,600 | 88,100 | 72,800 | 53,000 |
| 31 | 57,400 | | 82,000 | 81,600 | | 48,600 | | 77,300 | | 87,400 | 72,900 | |
| Mean | 66,400 | 61,100 | 77,700 | 99,300 | 60,500 | 44,800 | 44,000 | 64,900 | 58,000 | 70,900 | 84,800 | 57,800 |

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1979 in cubic feet per second.

| Day | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15,000 | 19,400 | 22,600 | 21,400 | 16,400 | 5,210 | 6,070 | 19,000 | 11,600 | 5,490 | 6,720 | 6,920 |
| 2 | 15,000 | 19,200 | 22,500 | 21,400 | 15,300 | 4,930 | 6,070 | 19,100 | 12,300 | 5,860 | 6,770 | 6,850 |
| 3 | 15,100 | 20,000 | 22,600 | 21,500 | 14,300 | 4,880 | 5,940 | 18,600 | 12,800 | 5,700 | 6,710 | 4,860 |
| 4 | 15,100 | 21,500 | 22,100 | 21,200 | 6,090 | 4,900 | 5,740 | 19,300 | 13,000 | 5,640 | 6,790 | 4,730 |
| 5 | 14,900 | 21,700 | 22,100 | 20,900 | 6,260 | 4,990 | 5,700 | 24,400 | 12,800 | 5,160 | 4,530 | 6,900 |
| 6 | 13,600 | 21,300 | 22,200 | 20,900 | 13,800 | 5,230 | 5,840 | 26,900 | 13,100 | 4,880 | 4,300 | 8,100 |
| 7 | 13,000 | 21,100 | 22,400 | 21,000 | 5,390 | 5,870 | 6,360 | 24,700 | 12,100 | 5,110 | 6,600 | 10,100 |
| 8 | 14,200 | 21,000 | 22,600 | 21,100 | 4,670 | 6,640 | 6,850 | 21,500 | 10,900 | 4,890 | 6,860 | 9,650 |
| 9 | 14,800 | 21,300 | 22,900 | 20,800 | 4,700 | 6,600 | 7,190 | 18,300 | 10,100 | 4,670 | 6,930 | 6,710 |
| 10 | 14,800 | 21,300 | 19,100 | 20,700 | 4,800 | 6,270 | 7,540 | 16,500 | 9,250 | 4,280 | 6,910 | 6,340 |
| 11 | 12,800 | 21,000 | 9,490 | 20,600 | 4,760 | 6,040 | 7,580 | 15,300 | 8,970 | 4,410 | 6,860 | 8,270 |
| 12 | 11,400 | 21,000 | 16,900 | 20,500 | 4,850 | 6,000 | 7,360 | 15,300 | 10,500 | 4,750 | 4,740 | 8,380 |
| 13 | 11,800 | 21,100 | 22,200 | 20,600 | 5,360 | 6,070 | 7,150 | 15,600 | 9,020 | 4,680 | 4,530 | 8,440 |
| 14 | 11,100 | 21,100 | 22,600 | 20,300 | 5,600 | 6,100 | 6,480 | 16,200 | 8,770 | 4,630 | 6,720 | 8,490 |
| 15 | 11,400 | 21,100 | 20,300 | 21,500 | 5,560 | 6,040 | 6,350 | 17,100 | 8,460 | 6,400 | 6,840 | 8,450 |
| 16 | 11,700 | 19,700 | 22,200 | 20,700 | 5,260 | 6,210 | 6,340 | 18,600 | 8,150 | 4,450 | 6,660 | 8,010 |
| 17 | 12,200 | 16,900 | 22,300 | 20,600 | 5,080 | 6,420 | 6,680 | 19,500 | 7,860 | 4,550 | 6,750 | 7,670 |
| 18 | 10,000 | 16,900 | 14,200 | 20,400 | 5,060 | 6,510 | 7,870 | 18,700 | 7,590 | 4,720 | 6,750 | 8,380 |
| 19 | 8,940 | 19,200 | 20,300 | 20,400 | 5,080 | 6,610 | 8,110 | 18,100 | 7,510 | 4,690 | 4,560 | 8,430 |
| 20 | 9,870 | 21,000 | 22,000 | 20,200 | 5,070 | 6,650 | 7,810 | 17,200 | 7,340 | 4,530 | 4,480 | 8,460 |
| 21 | 9,710 | 21,500 | 22,200 | 13,300 | 5,180 | 6,630 | 7,480 | 17,000 | 7,190 | 4,400 | 6,640 | 8,480 |
| 22 | 10,900 | 21,500 | 22,000 | 13,400 | 5,040 | 6,470 | 7,350 | 17,800 | 7,030 | 4,180 | 6,580 | 8,540 |
| 23 | 9,470 | 18,700 | 21,900 | 18,800 | 4,940 | 6,340 | 7,280 | 18,700 | 6,890 | 4,160 | 6,620 | 8,280 |
| 24 | 10,300 | 15,400 | 22,100 | 19,400 | 4,850 | 6,430 | 7,130 | 19,900 | 6,640 | 4,530 | 6,780 | 8,010 |
| 25 | 12,700 | 19,800 | 21,700 | 19,700 | 4,830 | 6,760 | 7,080 | 20,200 | 6,610 | 4,730 | 6,800 | 8,700 |
| 26 | 15,400 | 21,600 | 21,600 | 20,000 | 4,880 | 6,970 | 7,430 | 20,000 | 6,460 | 6,600 | 6,590 | 8,600 |
| 27 | 17,400 | 21,900 | 18,800 | 20,100 | 4,950 | 6,860 | 8,400 | 19,000 | 6,240 | 6,790 | 4,710 | 8,560 |
| 28 | 17,800 | 22,100 | 20,100 | 19,800 | 5,030 | 6,690 | 10,000 | 16,900 | 5,990 | 6,940 | 7,050 | 7,640 |
| 29 | 17,900 | 22,100 | 21,100 | 17,700 | | 6,500 | 12,500 | 14,500 | 5,490 | 4,620 | 7,000 | 8,580 |
| 30 | 17,800 | 22,200 | 21,200 | 19,000 | | 6,270 | 16,000 | 12,900 | 5,210 | 4,420 | 6,970 | 8,270 |
| 31 | 18,000 | | 21,300 | 19,400 | | 6,240 | | 11,900 | | 6,340 | 7,080 | |
| Mean | 13,400 | 20,400 | 20,900 | 19,900 | 6,540 | 6,140 | 7,520 | 18,400 | 8,860 | 5,070 | 6,280 | 7,930 |

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1979 in cubic feet per second.

APPENDIX D

# PROJECT INFORMATION

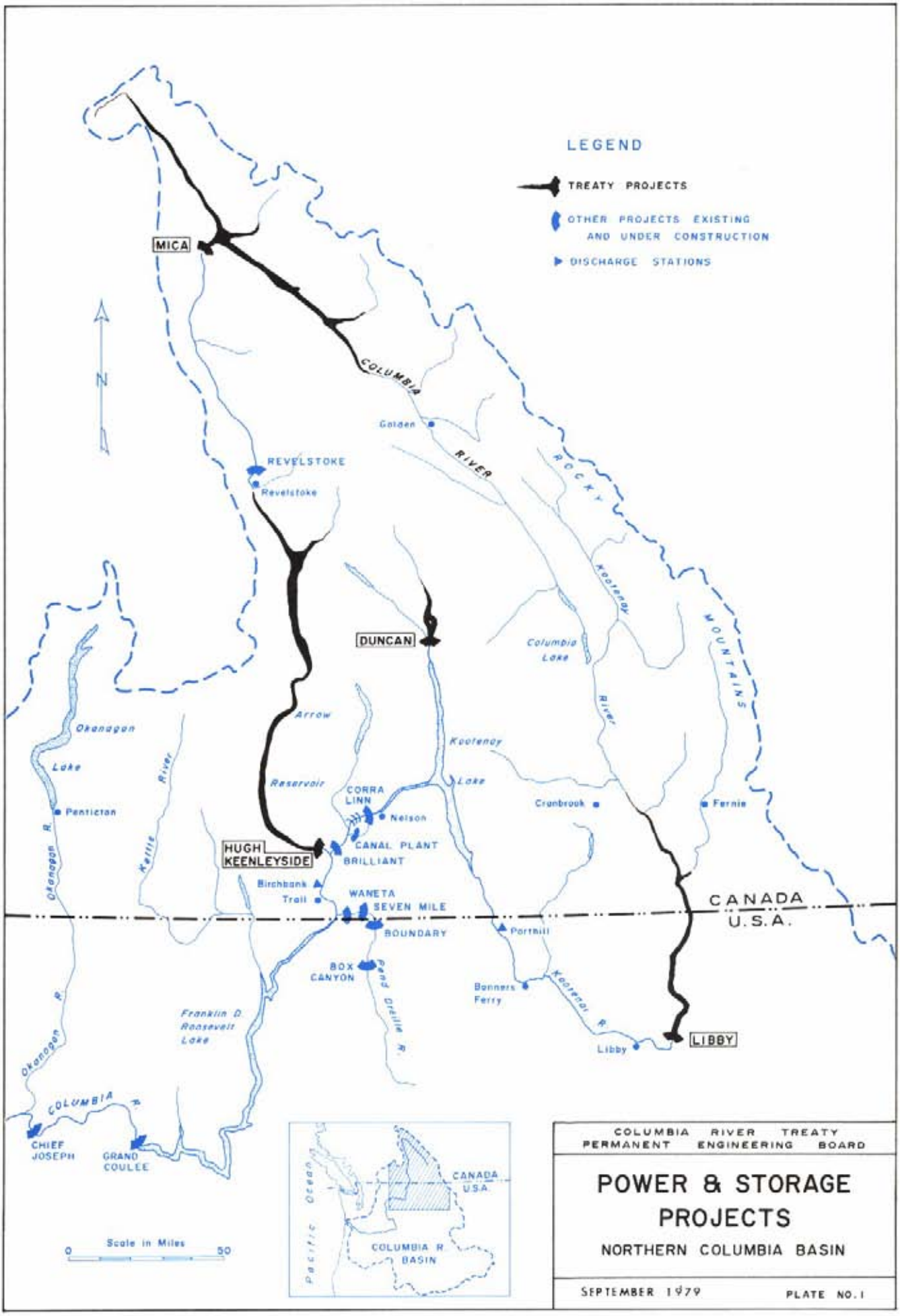

LEGEND
TREATY PROJECTS
OTHER PROJECTS EXISTING AND UNDER CONSTRUCTION
DISCHARGE STATIONS
N
MICA
COLUMBIA
Golden
RIVER
ROCKY
MOUNTAINS
REVELSTOKE
Revelstoke
DUNCAN
Columbia Lake
Kootenay River
Arrow Reservoir
Kootenay Lake
Okanagan Lake
Penticton
Okanogan R.
Kettle River
CORRA LINN
Nelson
CANAL PLANT
BRILLIANT
HUGH KEENLEYSIDE
Birchbank
Trail
WANETA
SEVEN MILE
BOUNDARY
CANADA
U.S.A.
Cranbrook
Fernie
Portbill
BOX CANYON
Pend Oreille R.
Bonners Ferry
Kootenai R.
Libby
LIBBY
Franklin D. Roosevelt Lake
Okanogan R.
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
SEPTEMBER 1979
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 | 1,432,500 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 McNaughton Lake

| | |
|---|---|
| Storage | |
| 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 | 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 | 5,809,000 ac-ft |
| Usable Storage Capacity | 4,934,000 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 | |
| 4 units at 105 mw | 420 mw |
| Head at full pool | 352 feet |
| Maximum Turbine Discharge | |
| of 4 units at full pool | 19,625 cfs |