ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
Washington, D.C. Ottawa, Ontario
30 SEPTEMBER 1976

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA · UNITED STATES

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

UNITED STATES SECTION
H.B. WILLIS, Chairman
Raymond A. Peck Jr., Member

31 December 1976

The Honorable Henry Kissinger
The Secretary of State
Washington, D.C.

The Honourable A. Gillespie
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 twelfth Annual Report, dated 30 September 1976, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1975 to 30 September 1976.

Respectfully submitted:

For the United States

Homer B. Willis, Chairman

J. Emerson Harper

J. Emerson Harper

For Canada

G.M. MacNabb, Chairman

B.E. Marr


MICA
Columbia River
ROCKY MOUNTAINS
N
DUNCAN
Arrow Reservoir
CORRA LINN
Kootenay Lake
Kootenai R.
HUGH KEENLEYSIDE
MANETA
CANADA
U.S.A.
Vancouver
Victoria
Seattle
WELLS
GRAND COULEE
Lake Chelan
CHIEF JOSEPH
Pend Oreille L.
Flathead Lake
LIBBY
HUNGRY HORSE
KERR
Spokane
ROCKY REACH
ROCK ISLAND
WANAPUM
PRIEST RAPIDS
LOWER MONUMENTAL
LOWER GRANITE
DWORSHAK
LITTLE GOOSE
ICE HARBOR
JOHN DAY
BONNEVILLE
Columbia R.
McNARY
Portland
THE DALLES
Snake
HELLS CANYON
OXBOW
BROWNLEE
Boise
Snake River
PACIFIC OCEAN
COLUMBIA RIVER BASIN
50 0 100
Miles
TREATY PROJECTS
OTHER PROJECTS

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to the
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COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Canada**

30 September 1976

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SUMMARY

The twelfth 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.

One Board meeting and one meeting of the Board with the Entities were held during the 12-month period ending 30 September 1976.

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. Reservoir operations contributed only minor flood control benefits in Canada and the United States because of average runoff levels during the flood season. Initial filling of the reservoir at Mica has been accomplished.

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. Downstream power benefits are being calculated by the Entities as required by 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 1975 to 30 September 1976, 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.

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.

MICA DAM
The dam with McNaughton Lake full, September 1976.

Columbia River, 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.

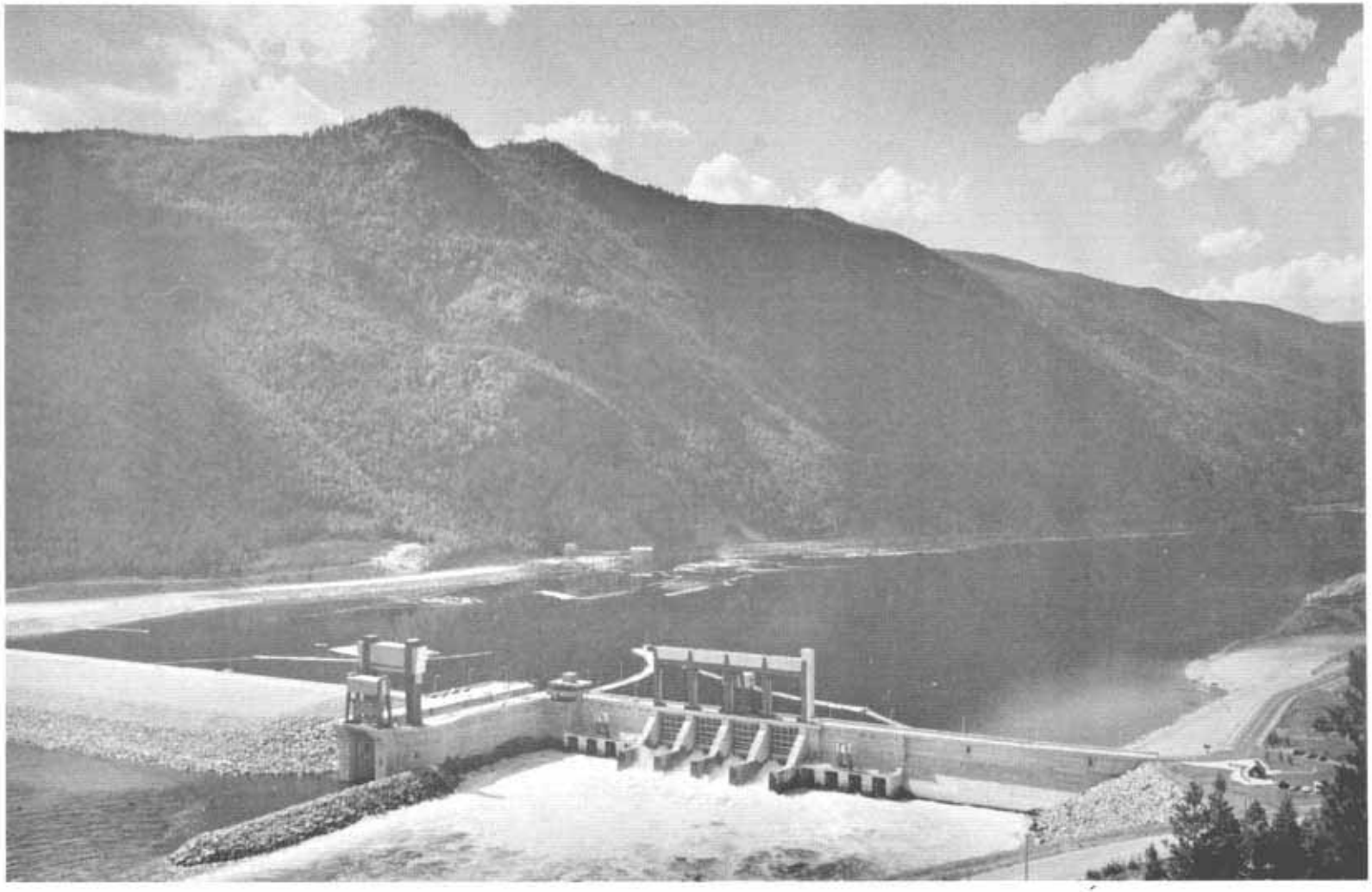
(f) Both Canada and the United States have the right to make diversions of water for consumptive uses and, in addition, after September 1984 Canada has the option of making for power purposes specific diversions of the Kootenay River into the headwaters of the Columbia River.

(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



HUGH KEENLEYSIDE DAM — Columbia River, British Columbia

Earth dam, navigation lock and concrete spillway section controlling Arrow Lakes.

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. 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 the Board members, alternate members and secretaries are shown in Appendix A. It is noted that Mr. Raymond A. Peck, Jr. has replaced Mr. C. King Mallory as a member of the United States Section of the Board.

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;

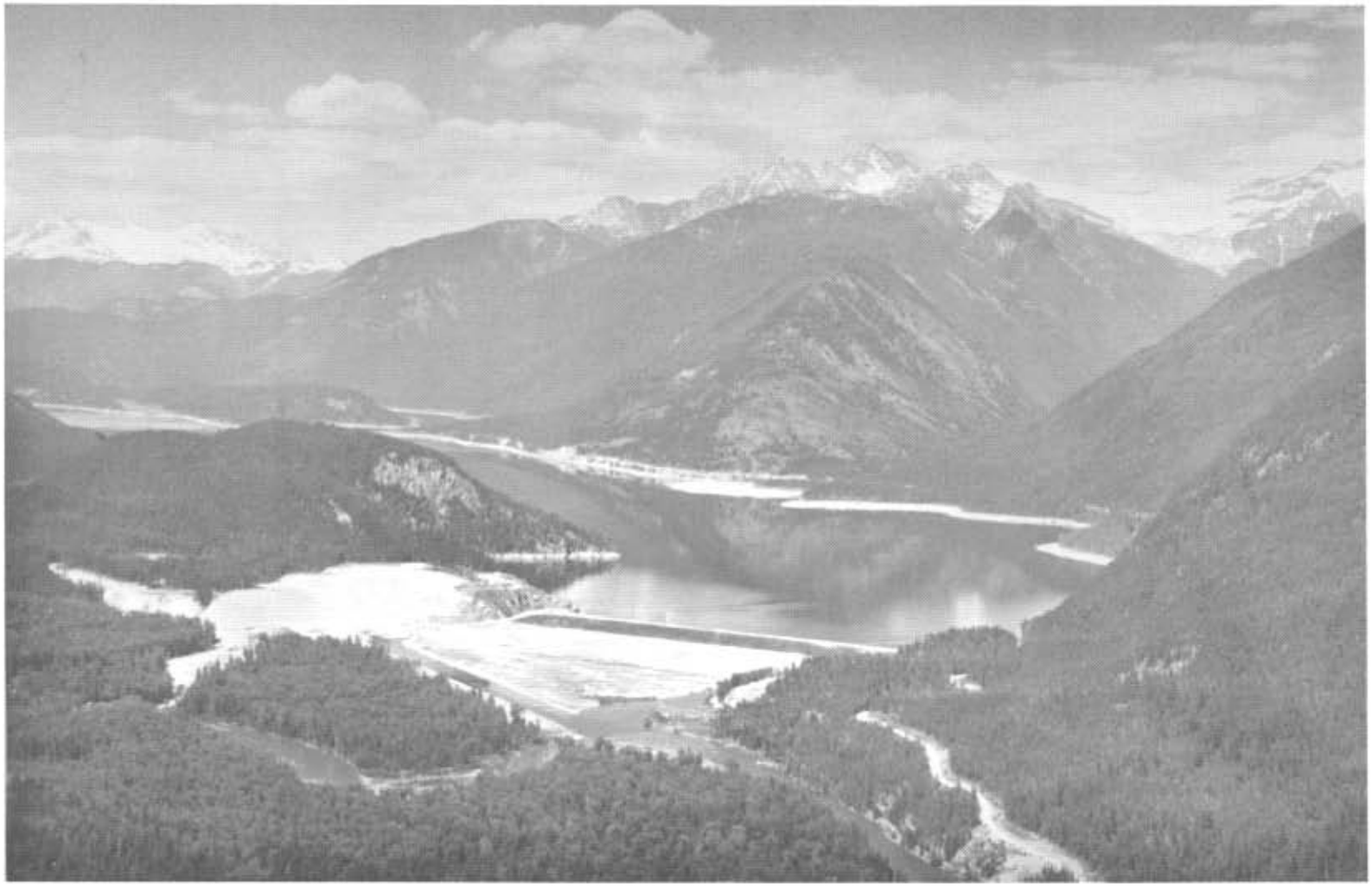
(c) assisting in reconciling differences concerning technical or operational matters that may arise between the entities;

(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 hydro-meteorological system as required by Annex A of the Treaty.



DUNCAN DAM

Duncan River, British Columbia

Tunnels in the rock to the left of the dam discharge water from Duncan Lake.

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. 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. It is noted that Mr. R.W. Bonner has replaced Mr. J.W. Wilson as Chairman of the Canadian Entity.

SWITCHGEAR BUILDING
and tourist facility
at Mica project.

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,

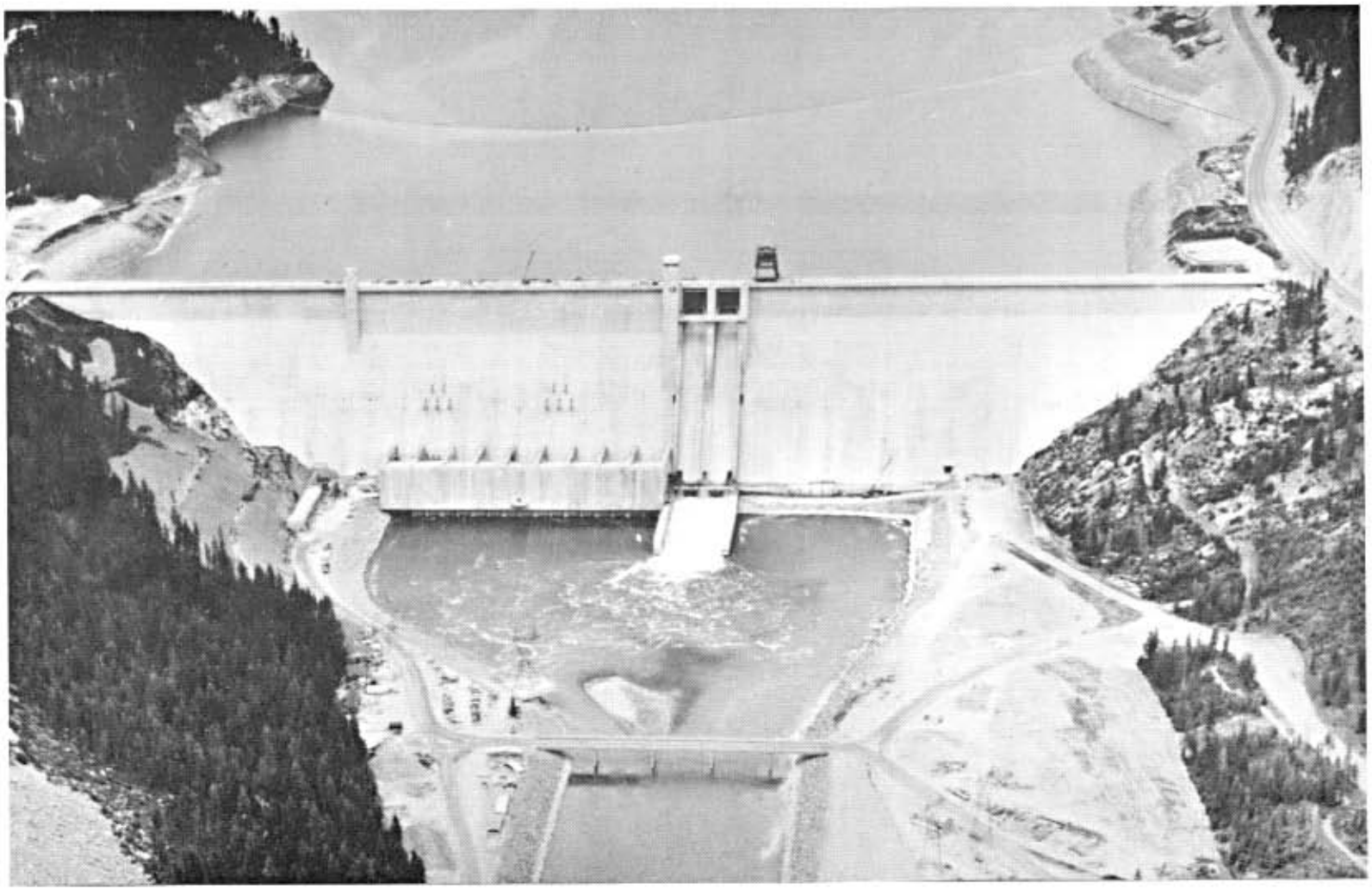
(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled,

(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 calcualtion 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.



LIBBY DAM
The dam, powerhouse and Lake Koocanusa.

Kootenai River, Montana

ACTIVITIES OF THE BOARD

Meetings

The Board met in Ottawa, Ontario on 25 November 1975 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.

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 1974 to 30 September 1975
- Columbia River Treaty Hydroelectric Operating Plan — Assured Operating Plan for Operating Year 1980-81 plus a copy of the Entities' agreement on this document
- Detailed Operating Plan for Columbia River Treaty Storage 1 August 1975 through 31 July 1976, plus a copy of the Entities' agreement on this document

— Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1980-81, plus a copy of the Entities' agreement on this document

— Columbia River Treaty Hydrometeorological System Treaty Facilities, September 1975, plus a copy of the Entities' agreement on this document

— Columbia River Treaty Hydrometeorological Supporting Facilities, September 1975

— Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration on operating procedures to conserve additional storage at Mica, December 1975

— Agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration for provision of an additional two feet of storage in Arrow Lakes reservoir, August 1976.

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 1976 through 31 July 1977, plus a copy of the Entities' agreement on this document

— Columbia River Treaty Hydroelectric Operating Plan — Assured Operating Plan for Operating Year 1981-82, plus a copy of the Entities' agreement on this document

— Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1981-82, 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 1975 to 30 September 1976

— Columbia River Treaty Hydrometeorological System Plan for Exchange of Operational Hydromet Data, 30 September 1976.

Report to Governments

The eleventh Annual Report of the Board was submitted to the two governments on 31 December 1975.

SUTTON CREEK BRIDGE
on State Highway 37
beside Lake Koocanusa
in Montana.

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 primarily in the United States 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 contries. The completion of the Canal Plant on the Kootenay River during the report year has caused the power benefits in Canada to increase substantially. Completion of the powerhouse at Mica Dam will further increase power benefits in Canada.

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

Status of the Treaty Projects

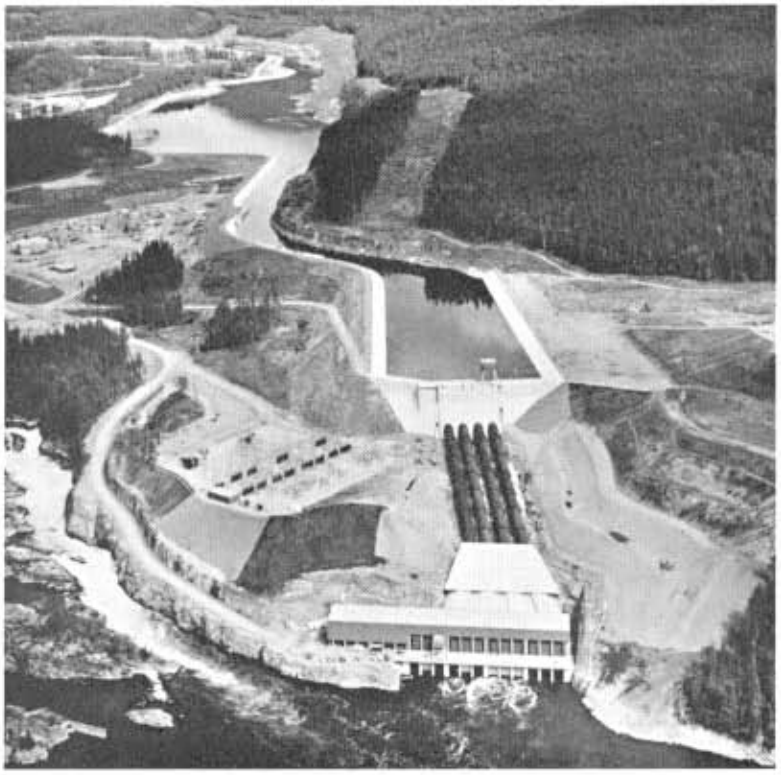
Duncan Project

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.



KOOTENAY CANAL PLANT in British Columbia benefits from storage at Libby and Duncan projects.

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 6 and project data are shown in Table 2 of Appendix D.

Mica Project

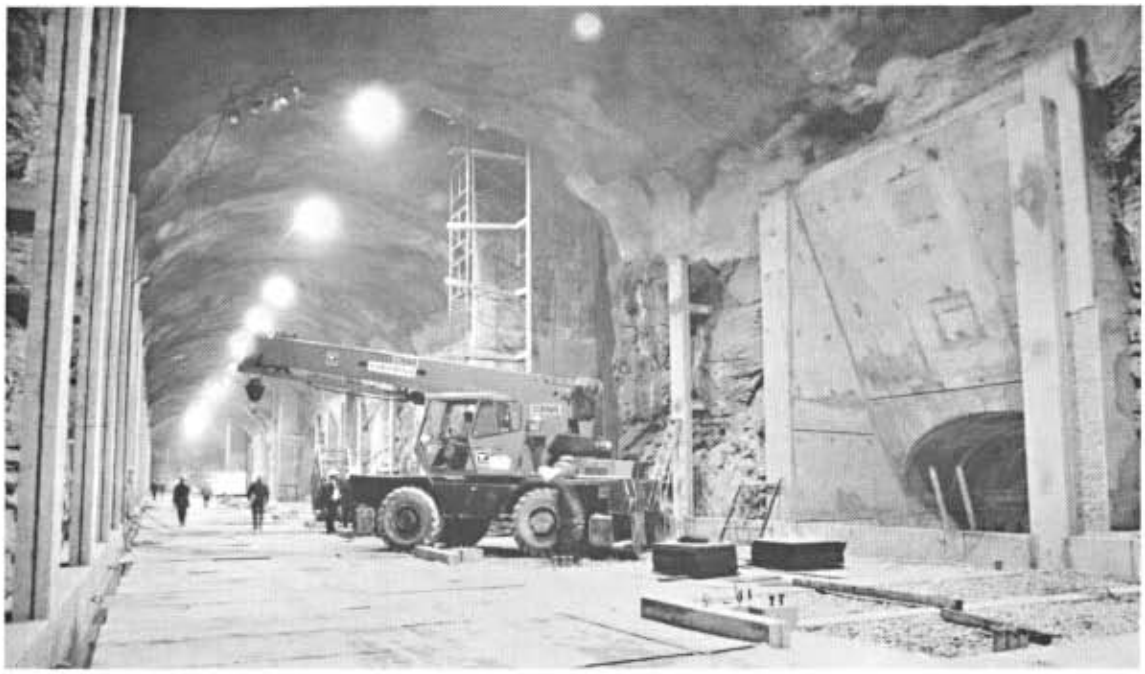
Mica dam, the largest of the Treaty projects, was scheduled by the Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973.

MICA PROJECT, an aerial view of all facilities, September 1976.

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 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.

Work is proceeding on construction of the underground power generating facilities at this site. The first two of the initial four generators are expected to be in service in 1976. There will be space for a total of six 435,000 kw units with a total capacity of 2,610,000 kw.

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



TRANSFORMER CHAMBER underground at Mica powerhouse.

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 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.

Work on the Libby project during 1976 was devoted primarily to the completion of the initial power generating facilities, and by March all four units were completed. Unit 1 was placed into commercial use on 24 August 1975, unit 2 on 24 October 1975, unit 3 on 21 January 1976, and unit 4 on 31 March 1976.

A relatively small amount of construction work is scheduled for 1976-77 including repair of the stilling basin, miscellaneous work on recreation facilities and some improvement of portions of the state highway and forest development roads in the vicinity.

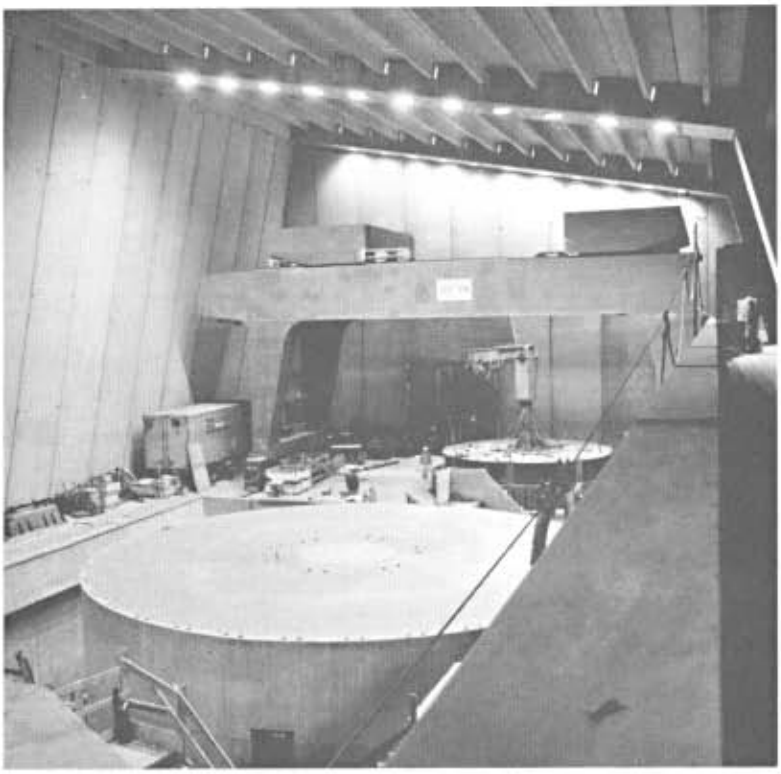
The Libby project is shown in the picture on page 13, and project data are shown in Table 4 of Appendix D.

Libby Project in Canada

Canada has fulfilled its obligation to prepare the land required for the 42-mile portion of Lake Koocanusa in Canada. The Water Resources Service of British Columbia was responsible for co-ordinating the program.

The reservoir began to refill early in April and on 26 April 1976 storing began in the Canadian portion. The reservoir reached its normal full pool elevation of 2459 feet on 29 July 1976.

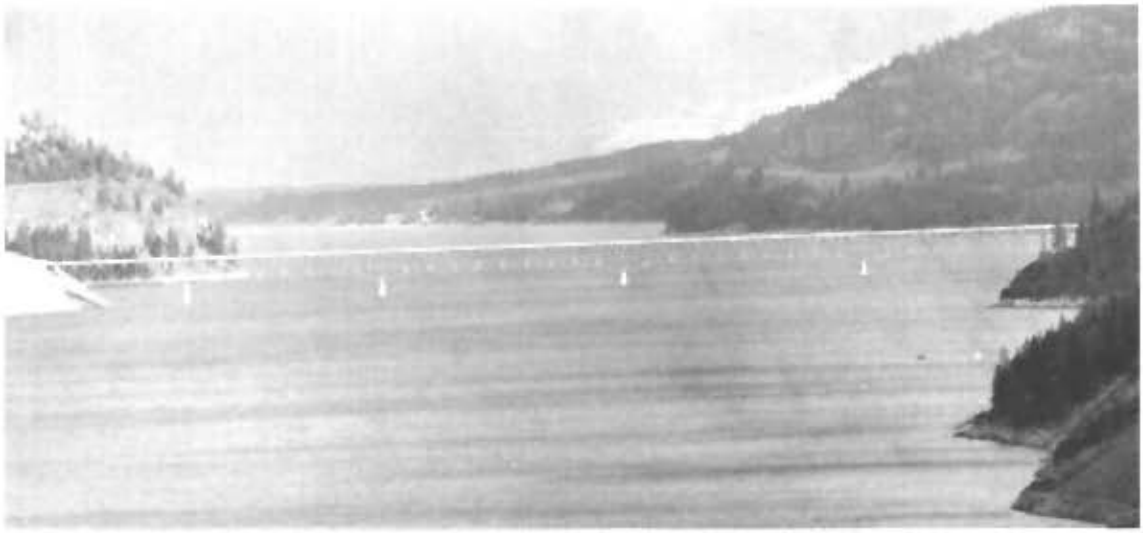
The Forest Service is continuing with a program of piling and burning of debris collected on the shores of the reservoir.



GENERATOR No. 1 in the powerhouse at Libby Dam.

The British Columbia Department of Recreation and Conservation is operating fish screens on Kikomun Creek as part of a fish tagging program for the reservoir. Similar facilities on Linklater and Plumbob Creeks in service the previous year have been removed. The same Department is proceeding with development of waterfront parks and recreational facilities at Kikomun Creek and Wardner and the use of other potential recreational areas around the perimeter of the reservoir is being studied. All new roads,

bridges and modifications to the Canadian Pacific Railway track between Fort Steele and Wardner made necessary by the project were completed in 1972.



RESERVOIR BRIDGE across Lake Koocanusa in Montana.

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 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.

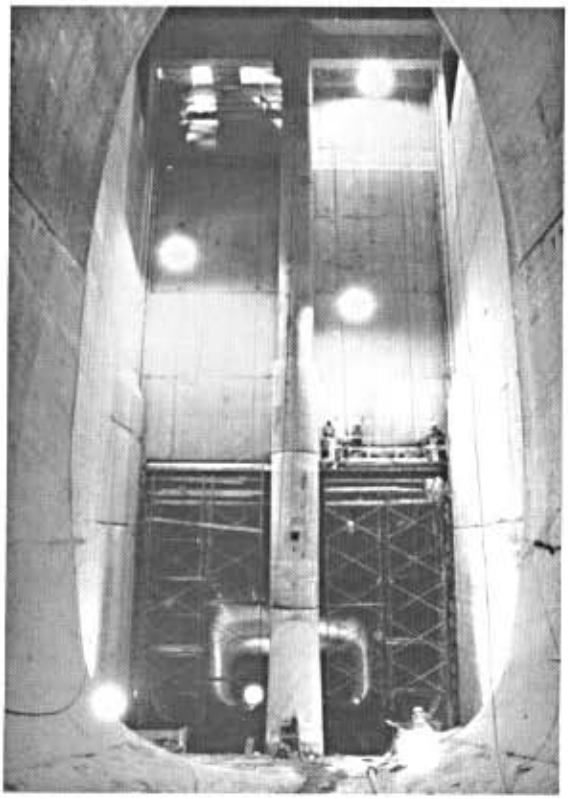
During this report year the Entities, with the concurrence of the Board, adopted a revised list of Treaty Facilities and provided the Board with a revised listing of Supporting Facilities. The Entities continue to use the previous year's agreed plan for exchange of operational hydrometeorological data. After the end of the report year the Entities forwarded a revised plan to the Board.

HYDROMETEOROLOGICAL instruments at Poorman Creek, Montana, transmit data.

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.



DRAFT TUBE GATES
being installed
for Unit No. 1 at Mica powerhouse.

The assured operating plan for operating year 1980-81, 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 1981-82 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 1976. A detailed operating plan

for the operating year ending 31 July 1977 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.

MICA RESERVOIR and the Columbia Mountains in British Columbia.

Annual Calculation of Downstream Benefits

The general requirements for determination of assured operating plans and downstream 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 1980-81. 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. This material facilitated review of the documents by the Board. A report on determination of downstream power benefits for the operating year 1981-82 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.

CHUTE SPILLWAY and outlet works in operation at Mica Dam, July 1976.

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 the "Columbia River Treaty Flood Control Operating Plan", the "Detailed Operating Plan for Columbia River Treaty Storage 1 August 1975 through 31 July 1976", the "Detailed Operating Plan for Columbia River Treaty Storage 1 August 1976 through 31 July 1977", the "Columbia River Treaty Hydroelectric Operating Plan for Canadian Storage Operating Year 1975-76", and the "Columbia River Treaty Hydroelectric Operating Plan, Assured Operating Plan for Operating Year 1976-77". A special agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration on operating procedures to conserve additional storage made it possible to complete the intital filling of the Mica reservoir without violating any of these operating plans. A further special agreement provided for the use of an additional two feet of storage in the Arrow reservoir.

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. After the about average freshet in 1975, followed by a wet July and August, all storages in Canada committed under the Treaty and most other reservoirs in the Pacific Northwest were full.

Runoff was above average throughout this report year. The ample water supply and lower than expected power loads in the northwestern United States resulted in routine power operations. Surplus hydroelectric energy was available in the Bonneville Power Administration system from December through July. The 1976 freshet volume was above average and Treaty storage in the Duncan, Arrow and Mica reservoirs was filled. The surplus water in the system made more readily available through the special agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration made it possible to complete the initial filling of McNaughton Lake, the reservoir behind Mica Dam.

TURBINE RUNNER
ready to install
in Mica powerhouse.

Operation of the reservoirs is illustrated on pages 35 and 36 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 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 at the full pool elevation of 1892 feet and remained close to this elevation until flood control evacuation began in December. From January through March 1976 storage releases were closely coordinated with releases from Libby to ensure compliance with the International Joint Commission's Order controlling Kootenay Lake levels. The reservoir was held at elevation 1807.7 feet until refilling commenced on 7 April. During April releases from Duncan were kept below 1,000 cfs to assist in studies of fish migration below the reservoir. On 28 May reservoir discharges were reduced to 100 cfs. After 8 July discharges were increased in order to reduce the filling rate. The reservoir reached full pool elevation of 1892 feet on 24 July and had been drafted to elevation 1891.5 feet by 30 September 1976.

The Arrow reservoir at the beginning of the report year was at elevation 1443.2 feet. No significant releases were made until January 1976 when lowering of the reservoir at a rate of about 13 feet per month was commenced to provide flood control storage space. The minimum elevation for the year of 1394.3 feet, was reached on 7 April 1976. Lake elevations rose rapidly for a short period after 7 April when some storage was transferred from

McNaughton Lake. For the remainder of the refill period a relatively high rate of discharge was maintained in order to avoid premature filling of the reservoir.

The reservoir reached normal full pool elevation of 1444 feet on 19 July. In accordance with the agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration for use of an additional two feet of storage during the 1976-77 operating year the reservoir was filled to elevation 1446 feet and reached this level on 1 August. At the end of the report year the reservoir was at elevation 1445.4 feet.

McNaughton Lake was at elevation 2405.7 feet on 1 October 1975 and the total storage contents of 13.5 million acre-feet included 6.7 million acre-feet of dead storage. This amount of dead storage was 1.3 million acre-feet less than the amount required for at-site generation. Until 5 December British Columbia Hydro and Power Authority delivered energy to Bonneville Power Administration in lieu of storage releases, in an endeavour to fill the 8 maf of dead storage prior to installation of the Mica generators. These energy deliveries ended when British Columbia Hydro and Power Authority and Bonneville Power Administration agreed to the storing of additional water in McNaughton Lake on the condition that Bonneville Power Administration would be compensated if any losses occurred due to entrapment of water in the reservoir.

Virtually no storage drafts were made until early April when some storage water was transferred to the Arrow reservoir so that it could be released if needed to meet downstream power requirements in April. From 10 May to 20 May discharges were reduced to zero to permit removal of the cofferdam at tailrace tunnel No. 1 and the raising and reinforcing of the cofferdam at tunnel No. 2. The chute spillway was in constant use from mid-July to 14 September to pass excess inflow.

POWERHOUSE
at Libby Dam.

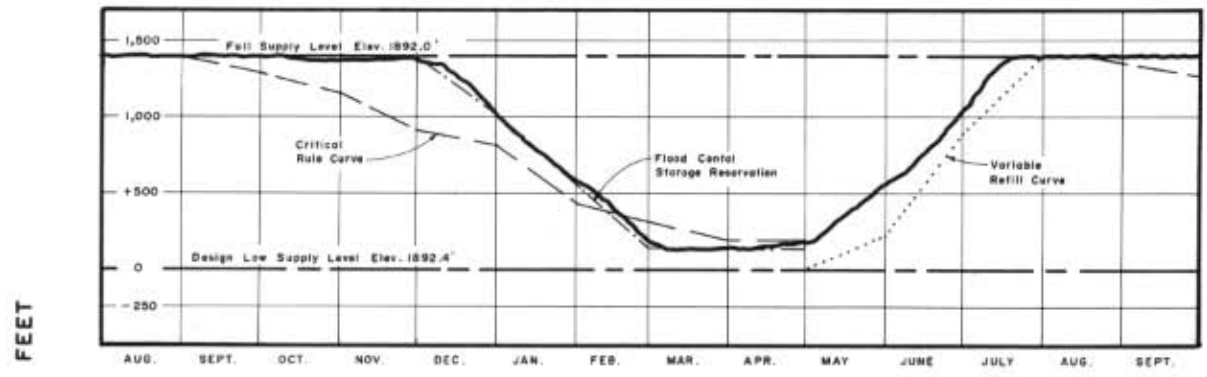
McNaughton Lake was essentially full at the end of July at elevation 2473.2 feet. Some operating space below elevation 2475 feet was maintained to avoid the possibility of exceeding the full pool elevation in this first year of full operation. The maximum reservoir elevation of 2474.9 feet was reached on 25 August and at the end of the report year the reservoir was at elevation 2474.5 feet.

During the report year operation of the Libby project was affected by special needs for construction and testing but these needs were met within the limits of the power and flood control operating plans. Lake Koocanusa at the beginning of the report year was at elevation 2453.0 feet. Operation of the reservoir through the winter was governed by flood control requirements. For the period January through March discharges were restricted in order to comply with the International Joint Commission Order for operation of Kootenay

Lake. In the first week of April drafts for power production lowered the reservoir to its minimum elevation for the year of 2307.3 feet on 6 April. The reservoir was filled to its normal full pool elevation of 2459 feet on 29 July 1976. By the end of September the reservoir had been drawn down to elevation 2457.1 feet.

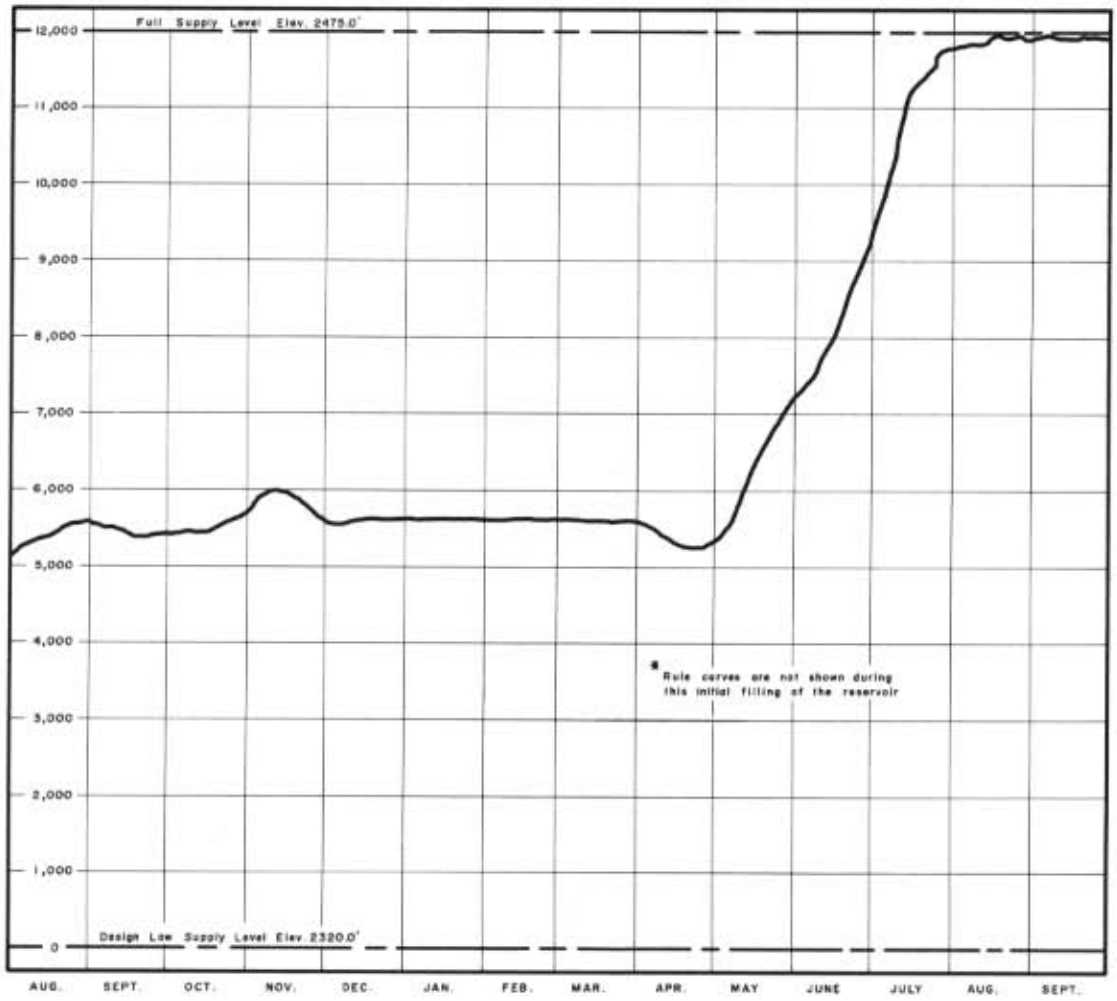
Flood Control Operation

Operation for flood control during the 1976 freshet was in accordance with the Entities' document ''Columbia River Treaty Flood Control Operating Plan''. Storage space at the Duncan, Arrow, Mica and Libby projects was provided prior to the freshet in accordance with that plan and in this year of high inflows flood control requirements determined reservoir levels during the storage draft season. Storing commenced in April and continued through July. Although the 1976 freshet volume was about eight percent larger than forecast, and some ten percent larger than average, no real flood threat was forecast and none occurred. The freshet was controlled to well below damaging discharges.



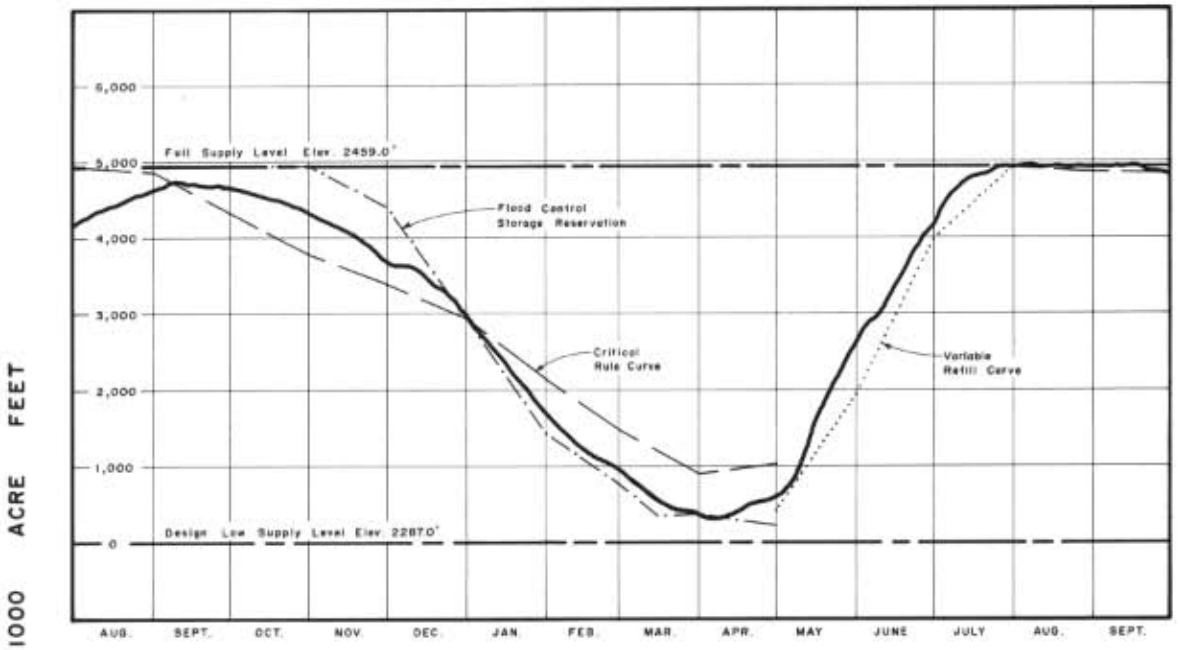
DUNCAN RESERVOIR

USABLE RESERVOIR STORAGE IN 1000 ACRE FEET



MICA RESERVOIR

HYDROGRAPHS — Duncan and Mica reservoir levels for the 14-month period ending 30 September 1976.



LIBBY RESERVOIR

ARROW RESERVOIR

HYDROGRAPHS — Libby and Arrow reservoir levels for the 14-month period ending 30 September 1976.

BENEFITS

Flood Control Provided

Without regulation by upstream reservoirs the 1976 freshet would have produced a normal 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 about five feet and that the Duncan, Arrow, Mica and Libby projects reduced the peak stage of the Columbia River at Trail, British Columbia by about four 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 39 by hydrographs which show both the actual discharges and the pre-project flows that would have occurred if the dams had not been built. It is noted that the pre-project hydrograph 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 637,000 cfs to 419,000 cfs. The corresponding reduction in peak stage at Vancouver, Washington was about eight feet. The unregulated freshet would have been more than bank full at Vancouver but four feet below major flood stage. The Duncan, Arrow, Mica and Libby projects contributed about 40 percent of the total effective storage in the Columbia River system during the peak runoff months of May and June 1976. The regulation by the

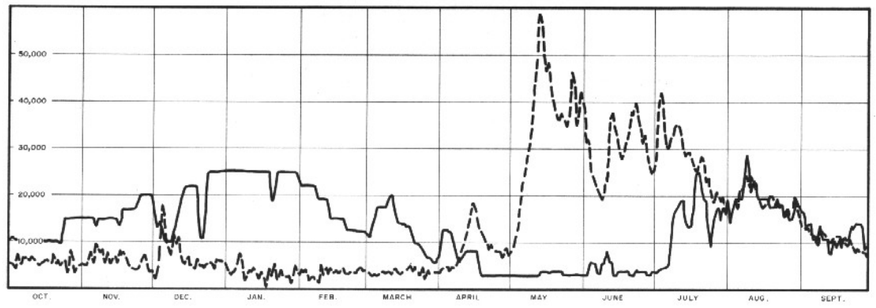
Treaty storage projects during the 1976 freshet period contributed only minor flood control benefits in Canada and the United States.

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.

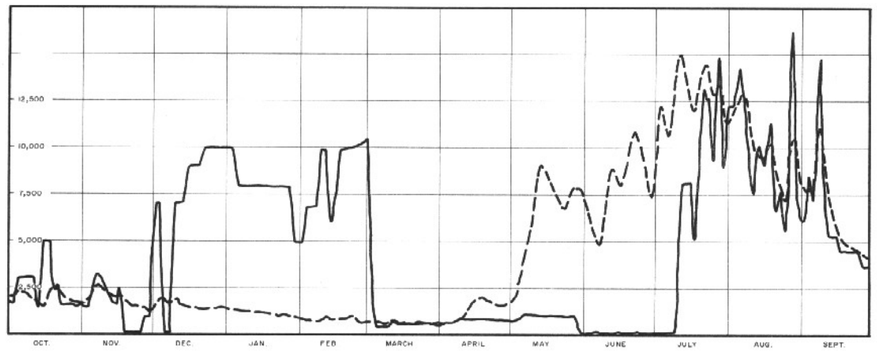
Power Benefits

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 for a 30-year period. 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, are retained wholly within Canada and the benefits from Libby in the United States are not shareable under the Treaty.

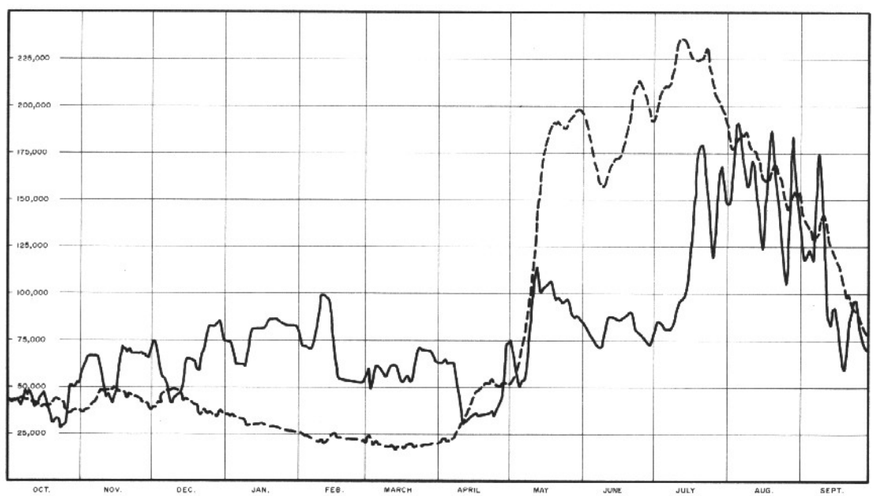
SPILLWAY GATES
in use at Mica Dam,
July 1976.



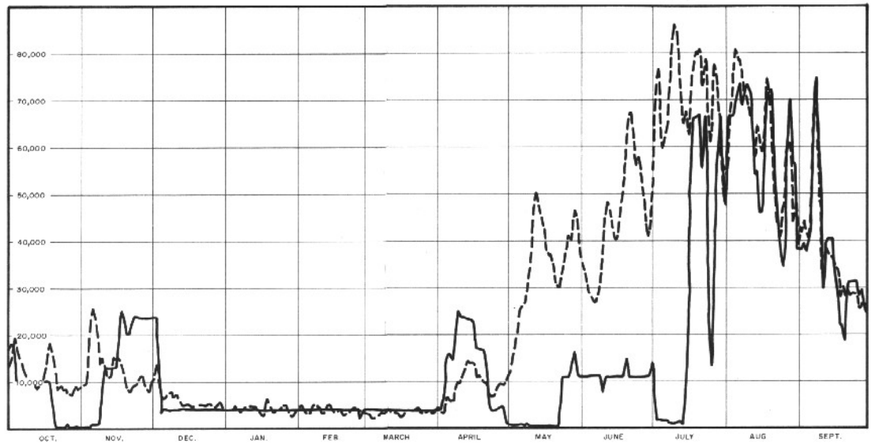
KOOTENAI RIVER AT LIBBY DAM



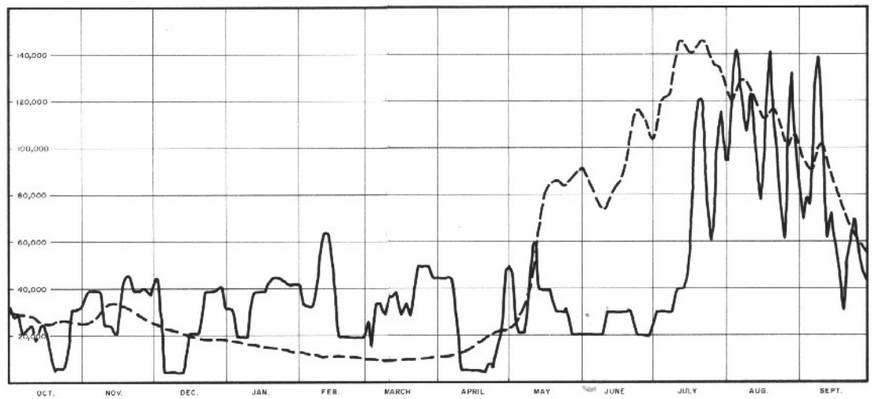
DUNCAN RIVER AT DUNCAN DAM



COLUMBIA RIVER AT BIRCHBANK



COLUMBIA RIVER AT MICA DAM



COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM

LEGEND

Observed Flows

Pre-Project Flows

HYDROGRAPHS — Observed and pre-project flows for year ending 30 September 1976.

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.

2. Initial filling of the Mica reservoir has been accomplished.

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

4. The regulation by the Treaty storage projects during the 1976 freshet period contributed only minor flood control benefits in Canada and the United States because of average runoff conditions.

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

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

United States	Canada
Members	
Mr. Homer B. Willis, Chairman Chief, Engineering Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. G.M. MacNabb, Chairman Deputy Minister, Department of Energy, Mines and Resources, Ottawa, Ontario
Mr. Raymond A. Peck, Jr. 1) Deputy Assistant Secretary for Energy and Minerals, Department of the Interior, Washington, D.C.	Mr. B.E. Marr Deputy Minister, Department of Environment, Victoria, B.C.
Alternates	
Mr. Alex Shwaiko Acting Chief, Planning Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Regional Director, Pacific and Yukon Region, Inland Waters Directorate, Department of the Environment, Vancouver, B.C.
Mr. J. Emerson Harper Assistant and Power Engineering Advisor, Office of the Assistant Secretary for Energy and Minerals, Department of the Interior, Washington, D.C.	Mr. H.M. Hunt Chief, Power and Special Projects Division, Water Resources Service, Department of Environment, Victoria, B.C.
Secretaries	
Mr. Walter W. Duncan Assistant Chief, Hydrologic Engineering Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.	Mr. E.M. Clark Regional Director, Pacific and Yukon Region, Inland Waters Directorate, Department of the Environment, Vancouver, B.C.

1) Vice Mr. C. King Mallory as of 9 January 1976.

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

United States

Mr. Donald P. Hodel, Chairman

Administrator, Bonneville
Power Administration,
Department of the Interior,
Portland, Oregon

Major General Wesley E. Peel

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

Canada

Mr. R.W. Bonner, Chairman 1)

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

1) Vice Mr. J.W. Wilson as of 1 February 1976.

APPENDIX C

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	43,200	59,000	74,700	74,500	77,400	60,200	63,000	68,800	81,700	84,700	152,000	117,000
2	41,900	61,900	74,800	74,200	71,800	48,000	64,300	62,000	79,300	83,900	172,000	119,000
3	42,600	65,600	71,700	74,400	72,000	52,300	62,900	56,400	76,600	81,400	190,000	124,000
4	42,300	66,200	60,600	69,000	71,500	62,300	62,900	49,700	74,700	81,000	191,000	119,000
5	44,100	66,500	55,500	62,700	70,600	61,600	63,300	53,500	73,100	81,000	184,000	117,000
6	39,300	66,400	54,500	62,100	70,600	60,200	62,700	53,200	71,300	80,400	172,000	151,000
7	46,500	66,400	53,200	61,800	73,400	57,300	54,000	60,200	71,300	81,700	163,000	176,000
8	48,600	65,900	42,900	62,100	81,400	54,900	44,500	77,100	71,400	83,700	156,000	166,000
9	45,700	58,700	41,200	61,300	91,500	55,700	35,400	94,800	79,400	89,600	160,000	147,000
10	47,900	49,300	43,800	65,700	99,500	60,700	30,100	110,000	87,100	95,600	171,000	113,000
11	41,900	44,300	45,000	76,000	99,800	62,100	31,200	115,000	87,900	96,000	168,000	86,300
12	39,300	46,300	45,600	81,000	98,700	61,700	32,700	102,000	87,400	96,900	153,000	81,800
13	40,800	43,900	47,200	80,700	97,800	61,300	33,800	100,000	86,300	99,700	137,000	91,200
14	44,300	40,300	52,600	81,200	89,500	57,100	35,300	103,000	85,800	105,000	123,000	92,200
15	45,400	45,000	64,100	81,100	78,600	52,200	36,600	104,000	85,200	117,000	133,000	85,700
16	47,800	48,000	64,900	81,300	64,500	52,700	34,500	105,000	86,500	134,000	148,000	76,200
17	43,100	64,300	65,200	80,900	54,800	56,200	35,200	107,000	87,300	157,000	175,000	63,500
18	36,700	71,200	63,600	83,000	54,300	55,800	35,300	104,000	88,000	172,000	187,000	58,800
19	32,100	70,600	63,700	85,700	53,900	51,900	35,100	97,100	89,900	178,000	174,000	68,100
20	30,500	68,200	59,200	86,200	53,800	55,100	35,400	97,600	90,300	179,000	155,000	85,800
21	33,000	70,400	58,200	86,500	53,800	65,500	35,900	96,800	86,700	174,000	144,000	89,400
22	32,900	67,600	68,300	86,000	53,300	70,600	37,600	95,600	80,300	151,000	132,000	96,600
23	27,700	67,500	69,800	84,900	53,200	69,900	34,000	95,500	79,700	133,000	113,000	96,800
24	29,400	67,700	78,100	84,300	52,900	70,000	36,300	96,800	78,200	118,000	104,000	87,800
25	29,800	67,800	83,100	83,800	52,600	69,900	38,900	95,400	76,900	122,000	117,000	78,700
26	40,800	68,400	82,400	83,000	52,300	69,000	42,900	88,000	75,000	140,000	161,000	72,300
27	50,800	66,600	82,200	82,900	52,200	68,700	51,700	87,000	73,000	162,000	185,000	69,900
28	50,800	67,000	83,800	83,200	51,700	66,100	72,000	87,900	72,100	168,000	165,000	70,800
29	49,200	64,900	85,200	83,200	55,500	63,300	74,000	87,000	74,500	161,000	153,000	71,300
30	52,200	68,900	82,200	82,800		62,900	75,200	84,600	80,200	148,000	144,000	70,500
31	51,800		75,000	82,600		63,000		83,800		147,000	124,000	
Mean	41,700	61,500	64,300	77,700	69,100	60,600	46,200	87,700	80,600	123,000	155,000	98,100

COLUMBIA RIVER AT BIRCHBANK, B.C. — Daily discharges for the year ending 30 September 1976 in cubic feet per second.

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	10,500	16,600	18,900	28,900	26,500	13,700	15,900	13,000	14,100	10,600	14,300	16,700
2	10,800	16,700	17,900	29,000	26,200	13,400	16,900	15,900	13,200	10,000	18,500	15,000
3	10,300	18,000	24,200	29,100	26,000	17,000	16,700	19,200	15,400	9,670	20,300	14,800
4	10,600	19,400	39,700	29,100	25,800	19,500	16,800	22,300	14,100	9,540	19,900	15,100
5	10,800	19,200	39,100	29,100	25,500	19,900	17,500	23,300	13,600	9,600	19,700	11,900
6	10,900	18,400	32,400	28,800	25,500	20,100	15,900	23,500	11,500	9,440	20,200	11,600
7	11,000	16,900	24,200	29,100	25,700	20,300	16,000	25,600	12,800	13,600	27,500	11,800
8	11,400	18,100	20,500	29,100	23,400	20,400	16,500	30,000	16,700	22,600	29,100	13,400
9	10,900	17,900	19,500	29,300	22,800	21,900	20,100	34,900	18,600	21,700	24,000	11,900
10	10,800	18,100	23,300	29,400	22,600	23,600	22,400	37,700	21,800	22,100	23,200	11,600
11	11,500	17,700	24,400	29,200	22,600	24,100	24,600	44,400	17,400	22,500	24,100	11,700
12	11,000	17,200	27,600	29,300	22,700	19,800	27,300	41,000	16,200	21,900	22,900	8,370
13	10,800	16,800	27,800	29,200	20,100	17,800	29,400	36,600	12,700	17,500	20,300	8,200
14	10,900	17,000	28,600	29,300	18,700	17,000	28,200	34,600	11,300	16,900	20,100	11,000
15	10,400	19,000	28,800	29,500	18,500	16,800	26,000	31,900	12,500	16,400	20,200	9,840
16	10,900	19,900	27,900	29,500	18,300	16,600	23,400	28,900	14,100	19,800	20,400	11,100
17	10,800	20,000	27,100	29,800	18,300	16,100	17,500	28,100	16,900	25,500	19,500	9,870
18	10,700	20,400	26,800	29,800	18,200	16,000	14,100	25,800	16,600	27,700	18,500	11,700
19	10,700	19,700	27,100	30,100	17,900	15,400	12,800	24,000	15,500	27,200	18,300	11,300
20	11,000	19,500	23,700	21,800	15,800	13,900	12,000	24,200	13,500	21,400	19,600	11,200
21	11,100	19,300	16,000	26,800	14,900	12,500	11,700	22,800	12,400	20,300	19,500	14,400
22	11,400	19,500	14,500	29,300	14,700	12,300	11,300	21,200	13,000	18,200	19,000	14,100
23	10,400	19,500	22,600	29,700	14,600	11,900	10,600	20,900	12,600	11,600	19,300	14,300
24	14,300	21,200	27,900	29,600	14,800	11,200	10,300	22,700	11,800	9,840	16,900	14,400
25	15,700	22,500	29,100	29,600	15,200	10,500	10,500	23,100	11,500	18,200	17,800	14,400
26	16,100	22,900	29,300	29,500	15,100	9,900	10,900	20,600	10,800	16,700	17,200	12,100
27	16,000	22,500	29,300	29,400	14,900	9,540	10,700	19,000	8,960	18,600	16,600	9,730
28	16,000	22,200	29,100	29,600	14,500	8,580	10,600	20,500	8,880	15,300	19,800	9,660
29	15,900	21,700	29,100	29,800	14,000	8,340	10,700	18,500	10,400	17,400	20,400	9,600
30	16,200	21,600	29,100	29,800		8,260	11,400	16,400	10,600	18,700	17,600	9,330
31	16,700		29,200	27,900		11,200		15,200		18,500	18,000	
Mean	12,100	19,300	26,300	29,000	19,800	15,400	16,600	25,300	13,600	17,400	20,100	12,000

KOOTENAI RIVER AT PORTHILL, IDAHO — Daily discharges for the year ending 30 September 1976 in cubic feet per second.

APPENDIX D

PROJECT INFORMATION

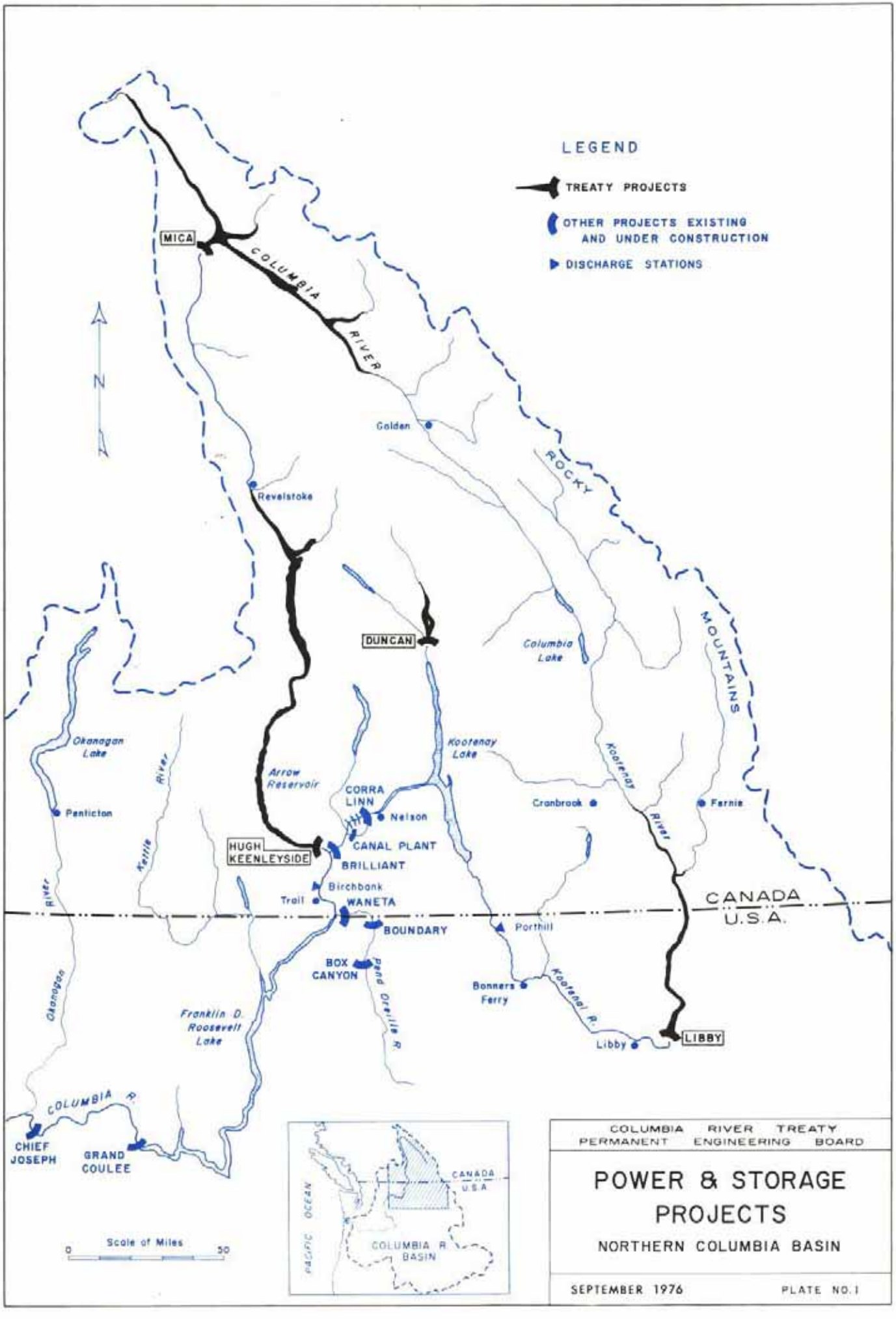

LEGEND
TREATY PROJECTS
OTHER PROJECTS EXISTING AND UNDER CONSTRUCTION
DISCHARGE STATIONS
MICA
COLUMBIA RIVER
N
Golden
ROCKY MOUNTAINS
Revelstoke
DUNCAN
Columbia Lake
Okanagan Lake
Arrow Reservoir
Kootenay Lake
Kootenay River
CORRA LINN
Nelson
Cranbrook
Fernie
Penticton
Kettle River
HUGH KEENLEYSIDE
CANAL PLANT
BRILLIANT
Birchbank
Trail
WANETA
CANADA
U.S.A.
BOUNDARY
Porthill
BOX CANYON
Pend Oreille R.
Bonners Ferry
Kootenai R.
Okanogan River
Franklin D. Roosevelt Lake
Libby
LIBBY
COLUMBIA R.
CHIEF JOSEPH
GRAND COULEE
Scale of Miles
0
50
PACIFIC OCEAN
CANADA
U.S.A.
COLUMBIA R. BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
SEPTEMBER 1976
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	18,432 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	128,000 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	105,600 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 435 mw	2,610 mw
First power planned for	1976
Present undertaking	
4 units at 435 mw	1,740 mw
Head at full pool	600 feet
Maximum Turbine Discharge	
of 4 units at full pool	40,000 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
Present undertaking	
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