

ANNUAL REPORT
to the
GOVERNMENTS
of
THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
Washington, D.C. Ottawa, Ontario
30 SEPTEMBER 1971



COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

C A N A D A • U N I T E D S T A T E S

CANADIAN SECTION

G. M. MacNABB, Chairman
A. F. PAGET, Member

UNITED STATES SECTION

J. M. CALDWELL, Chairman
J. W. NEUBERGER, Member

31 December 1971

The Honourable William P. Rogers
The Secretary of State
Washington, D.C.

The Honourable J. J. Greene
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.

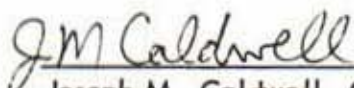
In accordance with the provisions of Article XV paragraph 2(e), there is submitted herewith the seventh Annual Report, dated 30 September 1971, of the Permanent Engineering Board.

The report sets forth results achieved and benefits produced under the Treaty for the period from 1 October 1970 to 30 September 1971.

Respectfully submitted:

For the United States

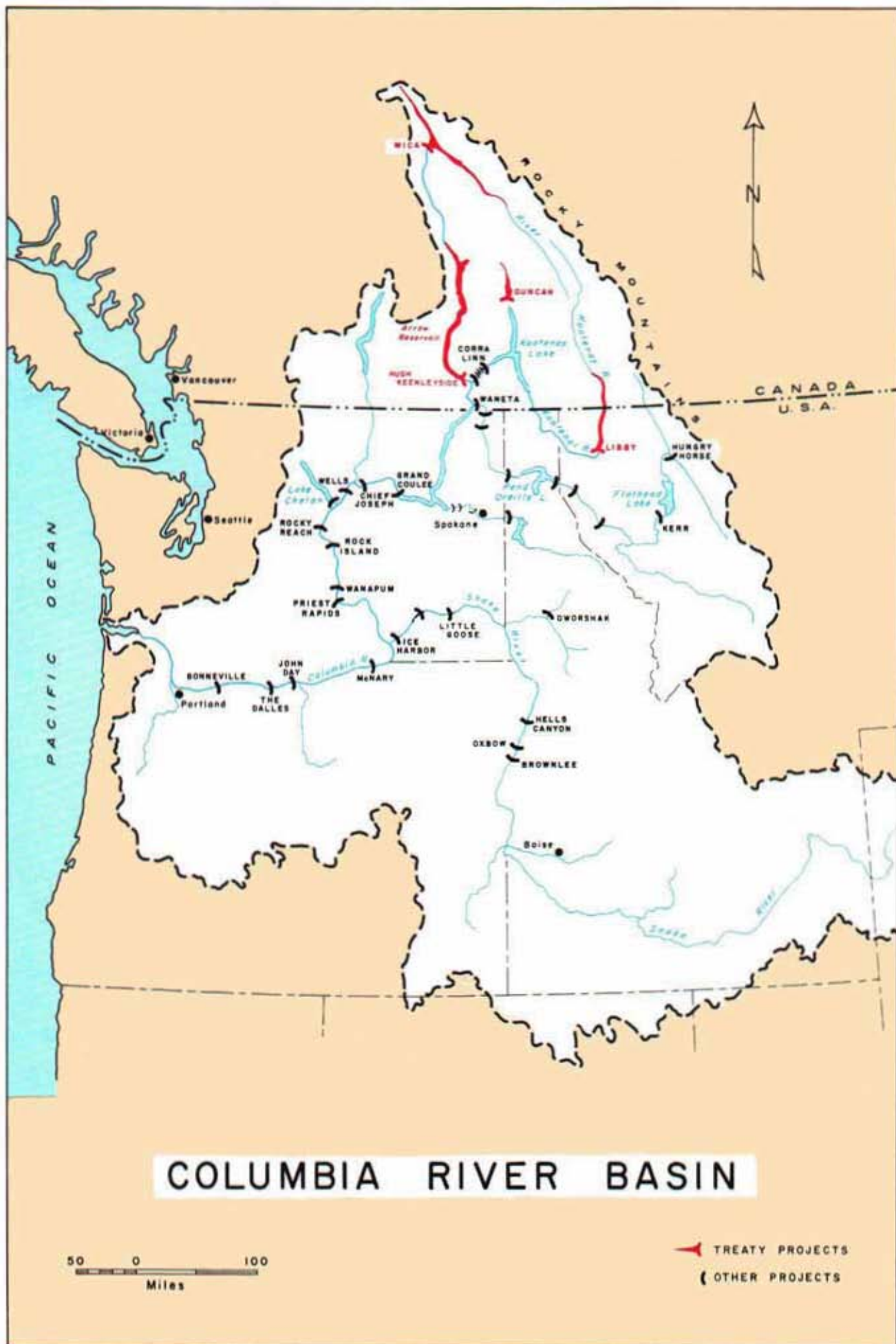
For Canada


Joseph M. Caldwell, Chairman


G.M. MacNabb, Chairman


John W. Neuberger


A.F. Paget



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Ottawa, Canada

30 September 1971

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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 seventh 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. Project construction, progress of Entity studies, operation of the Arrow and Duncan reservoirs, and the resulting benefits are described.

Two Board meetings and one meeting of the Board with the Entities were held during the reporting period. The Board also inspected the Mica and Libby projects during the month of September 1971. Work on both projects is on schedule.

The Arrow and Duncan reservoirs have been operated in accordance with the objectives of the Treaty, the terms of the operating plans developed by the Entities, and the interim flood control operating plan for Duncan and Arrow reservoirs.

Studies pertaining to development of the hydrometeorological network and power and flood control 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 1970 to 30 September 1971, 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.



HUGH KEENLEYSIDE DAM

Columbia River, British Columbia

The dam at the outlet of Arrow reservoir during the freshet.

Features of the Treaty and Related Documents

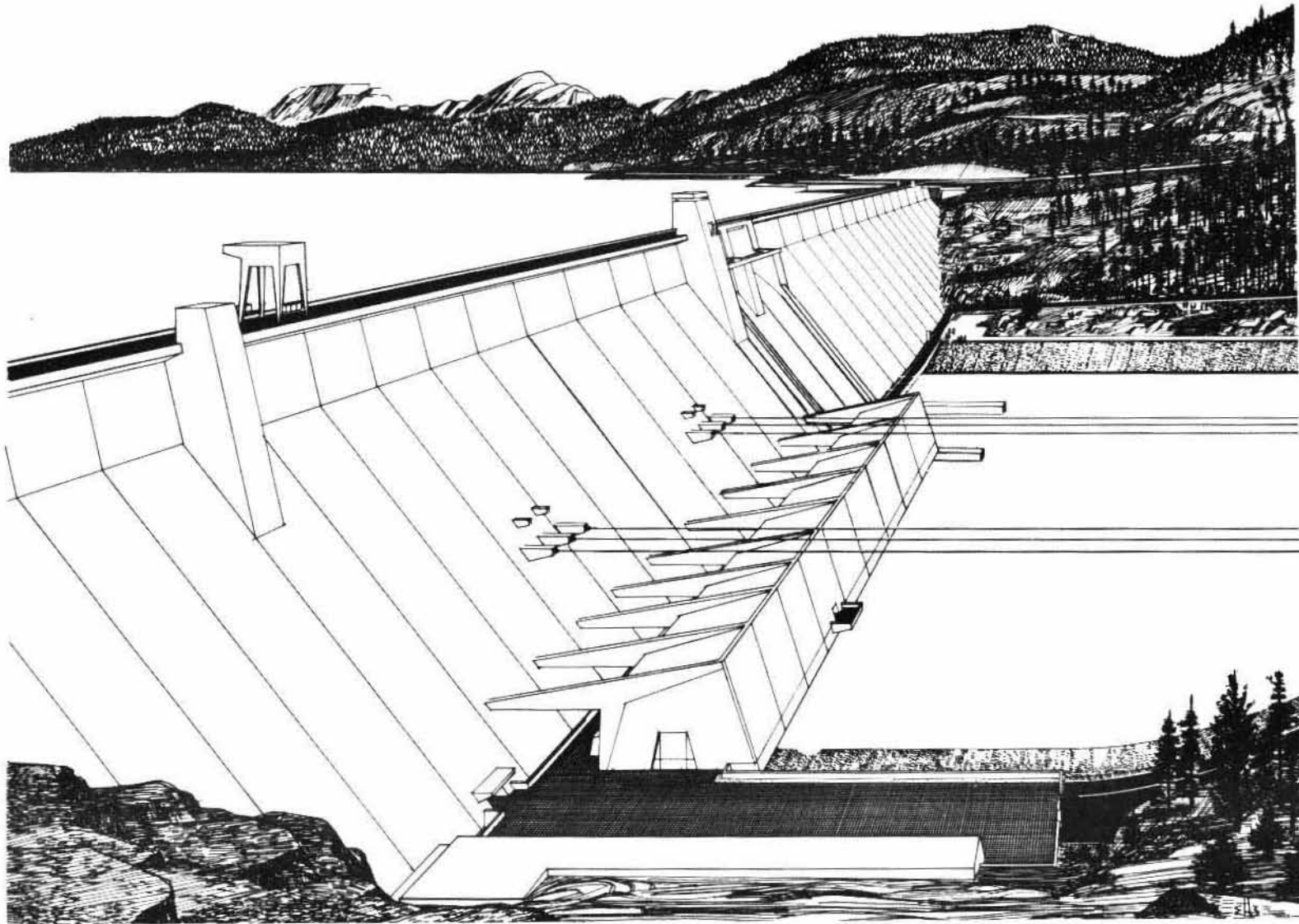
The essential features of the Treaty are as follows:

- (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) Canada has the option of making specific diversions of the Kootenay 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



LIBBY PROJECT

Kootenai River, Montana

Artist's conception of the dam and powerhouse designed to blend with the landscape.

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. Joseph M. Caldwell has replaced Mr. Wendell E. Johnson as Chairman of the United States Section of the Board.

RESERVOIR BRIDGE

Looking downstream
over Libby reservoir
area in Montana.
September 1971.



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.

LIBBY DAM

Upstream face
at left abutment.
September 1971.



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.



MICA PROJECT Viewed from upstream showing dam, power intakes and spillway control works.
May 1971.

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.



DUNCAN DAM

The dam and reservoir.

Duncan River, British Columbia

ACTIVITIES OF THE BOARD

Meetings and Field Inspections

The first meeting of the Board during the report year was held in Toronto, Ontario on 13 November 1970. The second meeting of the Board was held in San Francisco, California on 18 May 1971 followed by a meeting with the Entities to review and discuss Entity studies and general progress under the Treaty. The Board inspected the Mica and Libby projects on 8 and 9 September 1971 to assess construction progress and on 10 September visited the Hanford project and other facilities at Richland, Washington.

MICA PROJECT
Spillway control
structure from upstream.
October 1971.



Reports Received

The Board received semi-annual progress reports from the Entities. These reports included construction progress reports on the Mica and Libby projects, a record of documents approved by the Entities and a general outline of reservoir operations and activities.

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. The Entities also provided the following documents and reports:

- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1969 to 30 September 1970
- Report on Operation of Columbia River Treaty Projects 1 August 1969 through 31 July 1970
- Determination of Downstream Power Benefits Resulting from Canadian Storage for Operating Year 1975-76, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Hydroelectric Operating Plan for Canadian Storage, Operating Year 1975-76, plus a copy of the Entities' agreement on this document
- Columbia River Treaty Detailed Operating Plan for Canadian Storage 1 July 1970 through 31 July 1971, plus a copy of the Entities' agreement on this document
- Initial Filling of Mica Reservoir

- Addendum to report "Initial Filling of Mica Reservoir"
- Columbia River Treaty Hydrometeorological System Treaty Facilities, Recommendation No. 7
- Columbia River Treaty Hydrometeorological Supporting Facilities.

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

- Agreement on Columbia River Treaty Hydrometeorological System Treaty Facilities, Recommendation No. 7
- Detailed Operating Plan for Columbia River Treaty Storage 1 July 1971 through 31 July 1972, plus a copy of the Entities' agreement on this document
- Report on Operation of Columbia River Treaty Projects 1 August 1970 through 31 July 1971
- Report of Columbia River Treaty Canadian and United States Entities for the period 1 October 1970 to 30 September 1971.

During the report year arrangements were made for additional storage in the Arrow and Whatshan reservoirs. Copies of letters pertaining to this storage were provided to the Board by the Canadian Entity. The operation of this additional storage is discussed on page 35.

Report to Governments

The sixth Annual Report of the Board was submitted to the two governments on 31 December 1970.

MICA PROJECT

Chute spillway with
control structure.
Discharge is from
diversion tunnel.
October 1971.



PROGRESS

General

The results achieved under the terms of the Treaty include progress on construction of the Treaty projects and on studies regarding development of the hydrometeorological network, power and flood control operating plans, and the annual calculation of downstream power benefits. Duncan Dam was placed in operation on 31 July 1967. The Arrow project was declared operational on 10 October 1968 and the dam was named the Hugh Keenleyside Dam on 9 June 1969. Both projects were completed well in advance of Treaty requirements and continued to produce power and flood control benefits during this report year. The Duncan and Hugh Keenleyside Dams are shown in the pictures on pages 13 and 3 and the locations of the Treaty projects on Plate 1.

Construction Progress of the Treaty Projects

Mica Project

Mica dam, the largest of the Treaty projects, is scheduled by the Sales Agreement for initial operation on 1 April 1973.

The general arrangement of structures for the Mica project is shown on Plate 2. The main dam will have a nearly vertical impervious core supported between zones of coarser material. The two 45-foot diameter diversion tunnels are located in the left abutment. Spillway facilities and control works to provide regulated discharges from storage are being constructed in the left abutment and power facilities will be located underground in the right abutment.



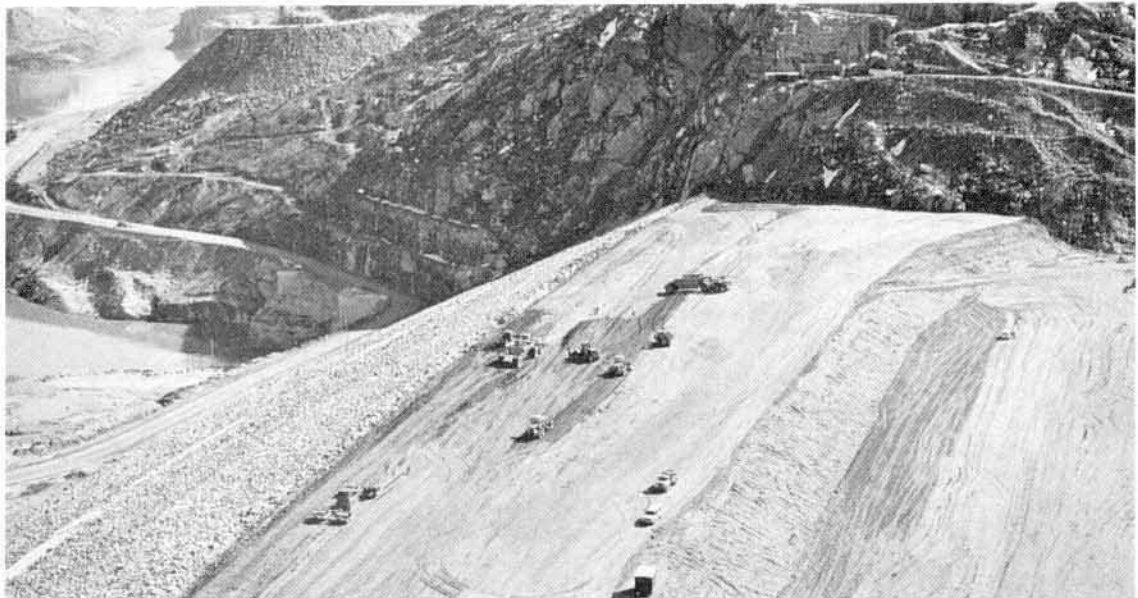
MICA PROJECT

Downstream face of dam with chute spillway over diversion tunnel outlets.

Columbia River, British Columbia

September 1971.

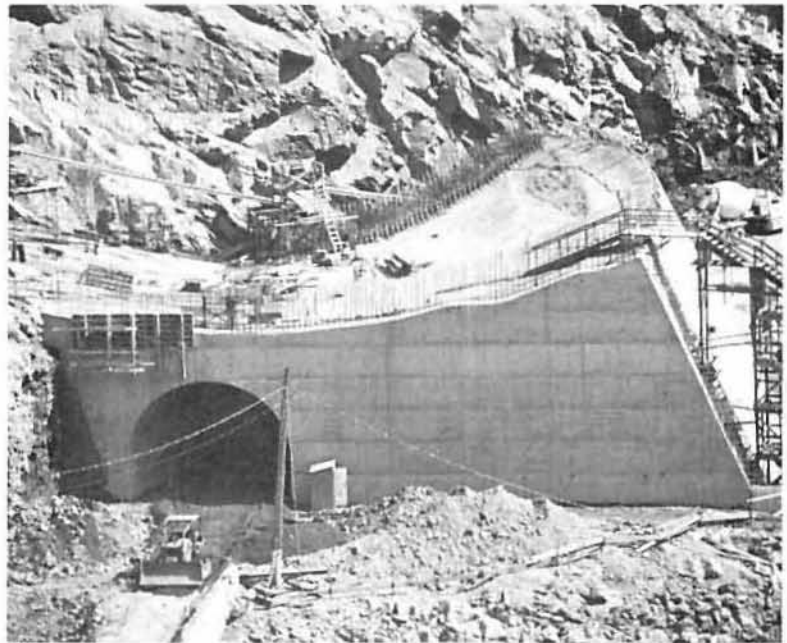
Construction of the dam is on schedule. At the end of the previous report year the main dam fill was 430 feet above the bedrock foundation, placing concrete for the spillway structure was well advanced and excavation of the spillway chute and power intakes was nearly complete. By the end of this report year approximately 35,500,000 cubic yards or 83 percent of the total embankment had been placed. The main dam fill is now 635 feet above the bedrock foundation and when complete will reach a total height of about 800 feet. The crest of the dam is being widened to 110 feet as a precautionary measure to ensure safety of the structure against overtopping which might result if a landslide were to occur in the reservoir area. General progress of the main fill is shown on Plate 3 and in the picture on page 19.



MICA PROJECT Machines placing fill on upstream side of dam near left abutment.
May 1971.

MICA PROJECT

Flip bucket
at bottom of
spillway chute.
August 1971.



The spillway is nearly complete and construction of the outlet works is well advanced. About half of the concrete lining in the power intake tunnels has been placed and excavation of rock for the gate shafts is about 75 percent complete.

The British Columbia Hydro and Power Authority has announced that generating facilities will be installed at Mica and that the underground powerhouse will provide space for six units with a total capacity of 2,610,000 kw. The first two 435,000 kw generators are scheduled for service in 1976.

The project area is shown on Plate 4. Clearing operations in the reservoir are continuing.

Libby Project in the United States

Libby dam is the fourth and last of the Treaty projects to be placed under construction. Initial phases, including highway and railroad relocations, were commenced in June 1966. In accordance with Article XII of the Treaty the dam is to be operational by 30 June 1973.

The general arrangement of the structures is shown on Plate 5, and the reservoir area and the required highway and railroad relocations are depicted on Plate 6. The concrete gravity dam will be capable of storing water up to elevation 2459 feet, and the reservoir, with a total length of 90 miles, will extend some 42 miles into British Columbia. Procurement and preparation of the land required for the portion of the reservoir in Canada is, in accordance with the terms of the Treaty, the obligation of the Canadian Government. By subsequent agreement between Canada and the Province of British Columbia on 8 July 1963, British Columbia undertook responsibility for these flowage costs in Canada.

Overall project construction is 65 percent complete or about 6 percent behind schedule. Work necessary to fulfill the requirements of the Treaty, however, is on schedule and full operation of storage is scheduled by 30 June 1973.

The dam is 91 percent complete and is on schedule. Construction progress is shown in the picture on page 32. The river is diverted through the three temporary sluices and concrete placement is progressing on low monolith 33. The last of the three temporary sluices will be closed between 1 March and 25 April 1972 and the initial pool filling to the spillway crest elevation 2405 will begin.



LIBBY PROJECT

Kootenai River, Montana

The dam from upstream showing mass concrete nearing completion and selective withdrawal system under construction.
September 1971.

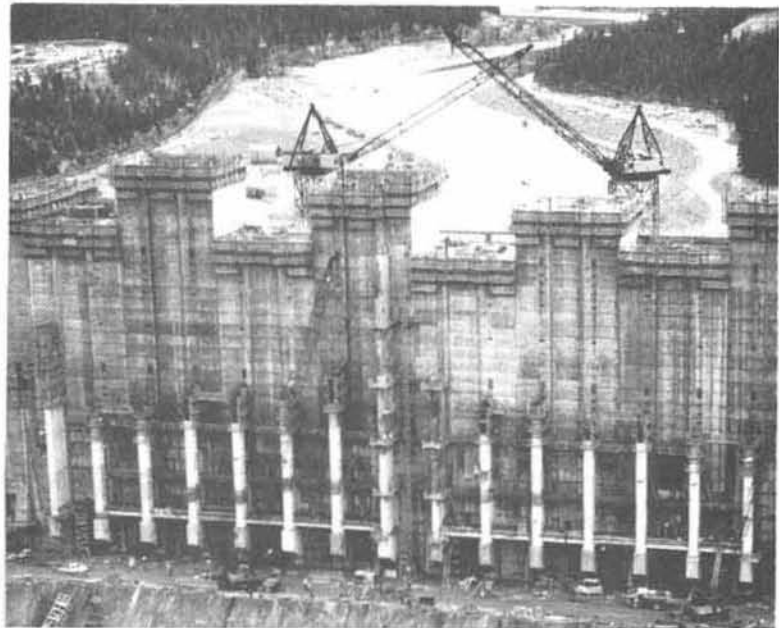
A contract was awarded in February 1971 for construction of a selective withdrawal structure which will make it possible to draw water for the turbines from various levels in the reservoir in order to improve the quality of water release. A contract to supply the initial four generators was awarded in July 1971 and completion is scheduled for April 1976.

The detour highway route from Eureka to Libby on the west side of the reservoir is scheduled to be open to traffic in November 1971. The Burlington Northern Railroad relocation is complete and traffic was transferred to the new line in November 1970.

Lake clearing continued with all contracts awarded except the clearing contract for the town of Rexford and miscellaneous cleanup which is scheduled for award in October 1971. All clearing is scheduled to be complete prior to the partial pool raise to elevation 2405 by April 1972.

LIBBY PROJECT

Construction of selective withdrawal system to permit release of water from various levels in the reservoir.
September 1971.



Libby Project in Canada

About 3,720 acres of the 9,500 acres of private property to be acquired by the Province of British Columbia have been purchased to date. To ensure that clearing can be completed before the reservoir is filled, expropriation proceedings have been instituted in several cases and will be followed in others as required. Clearing of 7,450 acres of land is complete and a further 1,650 acres remain to be cleared.

The new Canadian Pacific rail crossing of the Kootenay River north of the reservoir at Fort Steele and the relocation of track between Cranbrook and Fort Steele are complete and the old railway bridge at Wardner has been removed. The engineering study to evaluate track modifications between Fort Steele and Wardner is now finished and this work will be undertaken early in 1972.

Of the 29.4 miles of new road necessitated by flooding, 16 miles are now complete and the remaining 13.4 miles are under construction. The Wardner highway bridge shown in the picture on page 39 and the Canadian Pacific Railway overpass at Wardner are almost finished, Kikomun bridge piers are complete, and construction of the Gold Creek bridge substructure has begun. All four bridge projects are on schedule.

Mapping showing safelines for the reservoir perimeter has been produced for private and Crown land and is being used as a guide by the Province in its program of land acquisition.

LIBBY PROJECT

Reservoir preparation
in Canada.
August 1971.



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.

In the preceding report year the Entities, with the concurrence of the Board, adopted Recommendation No. 6 which outlines an interim plan for exchange of hydrometeorological data. In this report year the Entities advised the Board that they had agreed that this interim plan should remain in effect until a revised interim plan was completed. The Board is considering this extension.

During the report year the Entities, with the concurrence of the Board, adopted Hydrometeorological Recommendation No. 7 which provides a consolidated listing of all Treaty Facilities. The Entities also provided the Board with a similar listing of Supporting Facilities.

Power Operating Plans

The Treaty and related documents provide that before any of the Canadian storage becomes operative the Entities will agree on operating plans and downstream power benefits for each year until the total of 15,500,000 acre-feet of storage in Canada becomes operative. In addition, based on the terms of the Treaty, the Entities are to agree annually on operating plans and on the resulting downstream power benefits for the sixth succeeding year of operation.

In the preceding report year the Entities agreed on hydroelectric operating plans for Canadian storage for the operating year 1975-76. The operating plan, which was reviewed by the Board early in this report year, did not depart substantially from the plan for the operating year 1974-75. Completion of the operating plan for operating year 1976-77 has been delayed due to the complexity of including, for the first time, generation at the Mica project.

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 1971. A detailed operating plan for the operating year ending 31 July 1972 was forwarded to the Board shortly after the end of the report year.

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.

Early 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 1975-76. The Board has completed its review of this document and concludes that it meets the requirements of the Treaty. The calculation of downstream power benefits for the operating year 1976-77 is based on the studies required to develop the operating plan and has also been delayed due to including generation at Mica.

LIBBY DAM

Powerhouse excavation,
spillway stilling basin
and discharge from
temporary sluices,
September 1971.



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.

In the 1968-69 report year the Entities reached agreement on an interim flood control plan for the Duncan and Arrow reservoirs which will govern flood control operations until the next project under the Treaty becomes operational. The Entities provided the Board with a copy of the interim plan at that time.

In this report year the Entities continued to study the effects of discharges from the Duncan and Libby projects on the existing International Joint Commission Order for regulation of Kootenay Lake.

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, (see Plate 1) are tabulated in Appendix C for this report year.

REXFORD, MONTANA

Relocated farther east,
out of the
Libby reservoir area.
September 1971.



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 "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", the "Detailed Operating Plan for Canadian Storage 1 July 1970 through 31 July 1971" and the "Detailed Operating Plan for Canadian Storage 1 July 1971 through 31 July 1972". Operations were in accordance with committee directives normally issued on a weekly basis.

Power Operation

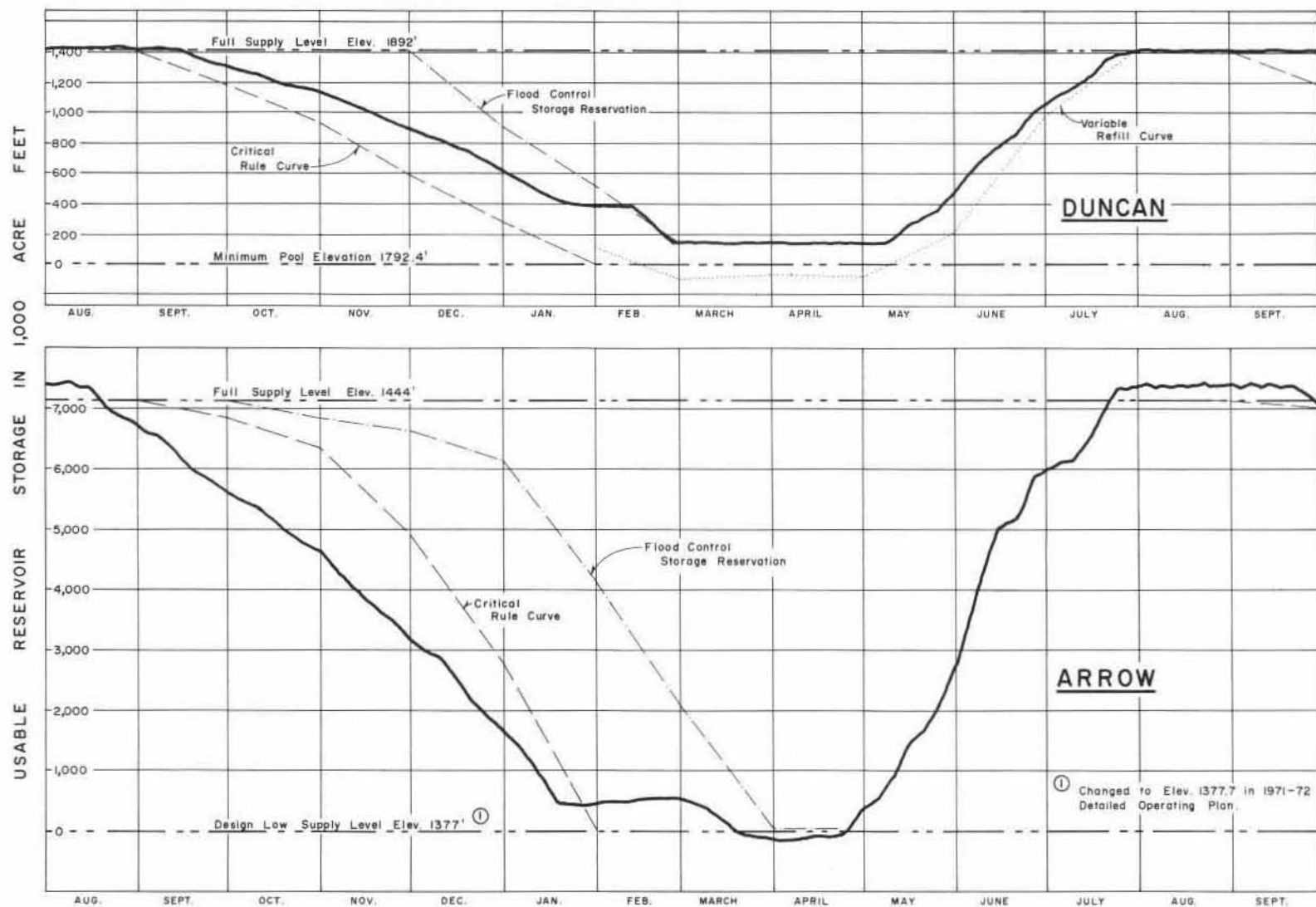
Both the Duncan and Arrow reservoirs were fully operational during the report year and provided reservoir storage to supplement natural streamflow during the storage draft season. Both reservoirs filled completely during the 1971 freshet in a manner consistent with flood control and hydroelectric requirements. An agreement to use extra storage from the Arrow reservoir at the end of the storage draft season was not implemented, but an additional two feet of water was stored above normal full reservoir level as described in the following section.

MICA PROJECT

Power intakes.
May 1971.



Operation of the two reservoirs is illustrated on page 33 by hydrographs which show actual reservoir levels and some of the more important rule curves which govern operation of the Treaty storage. 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 storages have also been provided to the Board.



HYDROGRAPHS - Duncan and Arrow reservoir levels for the 14-month period ending 30 September 1971.

In August and September of the preceding report year natural inflows were well below average and use of Treaty reservoir storage commenced in August 1970. Continued low runoff resulted in the Treaty storage being below critical rule curve until late January 1971 when generally high streamflows decreased the need to release storage.

The Duncan reservoir provided about 1.28 million acre-feet of reservoir storage. Most of this storage was drafted between 13 September 1970 and 19 January 1971 in a manner that contributed to good water usage at downstream plants in Canada and in the United States. The remainder was drafted during the latter part of February to provide required flood control storage space and, due to generally high inflows at the time, was spilled past the Kootenay River plants. Outflows were limited by agreement to a maximum of 10,000 cfs. The reservoir filled to elevation 1892 feet on 30 July 1971 and remained full until the end of the report year.

Release of storage from the Arrow reservoir, which began in August 1970, continued until the middle of January when streamflows throughout the basin increased to above normal levels and system demand could be met without the use of Treaty storage. The remaining storage was released during March and when the reservoir reached its normal minimum level of 1377 feet a total of 7.25 million acre-feet of stored water had been provided. Controlled storing for flood control in the lower Columbia River commenced on 14 May 1971 and continued through May and June. The reservoir reached normal full pool elevation 1444 on 22 July and, by special agreement outside the Treaty for two feet of additional storage

space, it reached elevation 1446 on 29 July. On 22 September drafting of this extra storage commenced and at the end of the report year the reservoir was at elevation 1443.75, slightly below normal full pool.

Additional Storage on Arrow Reservoir

By agreement between British Columbia Hydro and Power Authority and Bonneville Power Administration, two feet of storage was provided on Arrow reservoir during the period July through September 1971 in addition to the storage which Canada is required to supply under the terms of the Treaty. Operation of this storage above the normal full reservoir elevation of 1444 feet is illustrated in the hydrograph on page 33. This agreement also provided for the release of water from the Whatshan reservoir. A separate agreement outside the Treaty to draft three feet of additional storage below normal minimum level of the Arrow reservoir was not implemented because above-normal runoff was experienced in the latter part of the storage release season.

Under Article IV(5) of the Treaty the Board has a responsibility to ensure that operation of additional storage does not reduce the flood control and hydroelectric benefits obtainable from operation of the Treaty storage. The Entities informed the Board of the arrangements for provision of additional storage and of their agreement that its operation would not conflict with any of the arrangements made in connection with the Treaty. The Board concurs with the Entities in this matter.

Flood Control Operation

The Entities agreed to operate Treaty storage for flood control during the 1971 freshet in accordance with the objectives of the document "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs". Both reservoirs were operated in accordance with these procedures. Benefits from flood control operation are described on page 37.

LIBBY PROJECT
Reservoir clearing
in Montana.
September 1971.



BENEFITS

Flood Control Payment

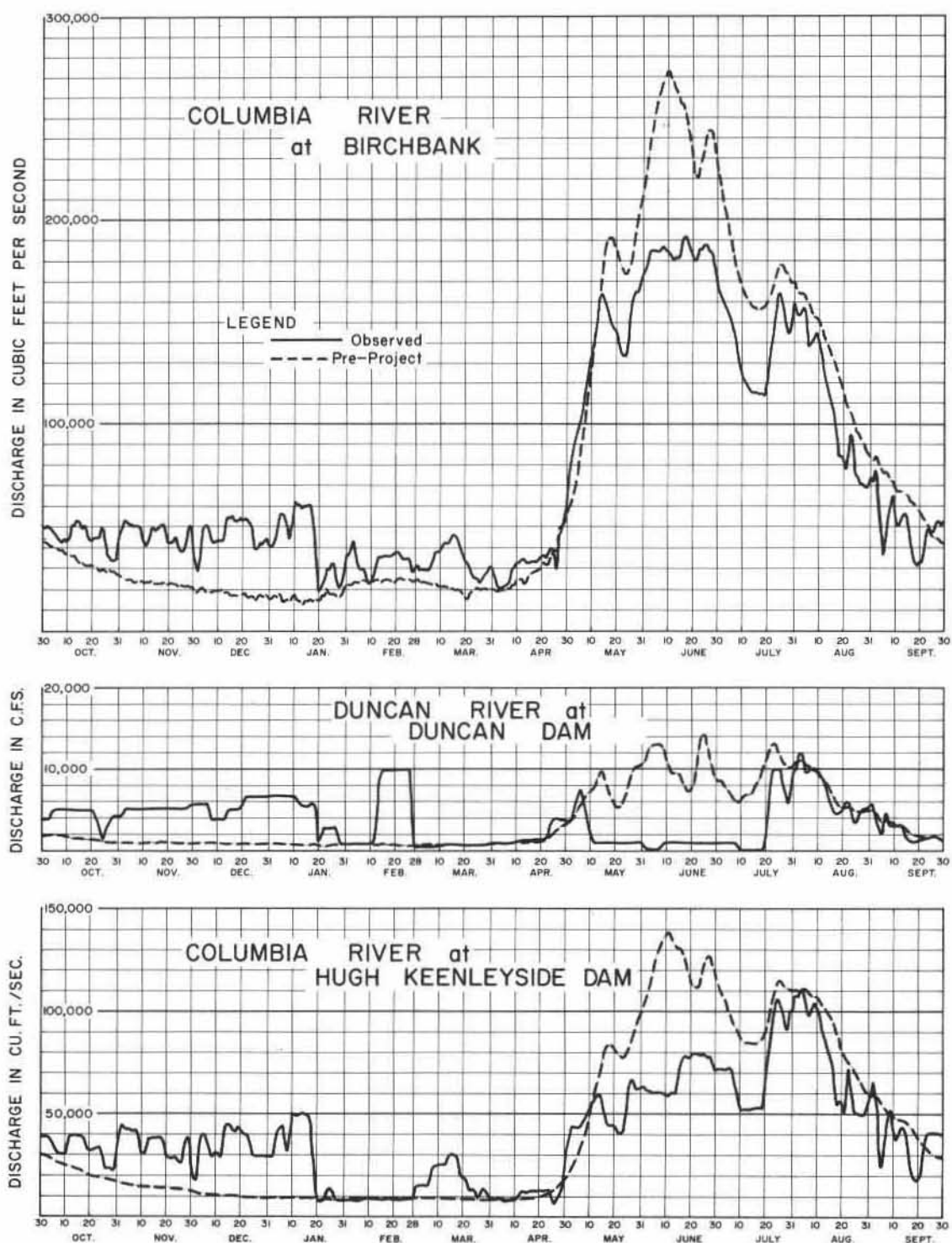
As described in previous reports, full payment has been made to Canada for all flood control benefits provided by the Arrow and Duncan reservoirs under Article IV(2)(a) for the period covered by the Treaty and for early completion of the two projects.

Flood Control Provided

The effect of storage in the Duncan and Arrow reservoirs on flows at the sites and on flows of the Columbia River at Birchbank is illustrated on page 38 by hydrographs which show actual discharges and 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 and Arrow regulation and of the regulation provided by storage on Kootenay Lake have been removed.

It is estimated that the Duncan project reduced the peak stage by about 1.3 feet on Kootenay Lake and that the Arrow and Duncan projects reduced the peak stage of the Columbia River at Trail, British Columbia by about 7 feet.

The operation of Columbia Basin reservoirs for the system as a whole reduced the peak discharge of the Columbia River near The Dalles, Oregon by approximately



HYDROGRAPHS - Observed and pre-project flows for the year ending 30 September 1971.

184,000 cfs to 557,000 cfs. The corresponding reduction in peak stage at Vancouver, Washington amounted to almost five feet. The Arrow and Duncan projects contributed about 27 percent of the total effective storage in the Columbia reservoir system during the period of control of the lower Columbia River.

Power Benefits

Downstream power benefits which arise from operation of the Canadian Treaty Storage were pre-determined and the Canadian 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 storage. The British Columbia Hydro and Power Authority, however, received payment for the additional two feet of storage provided in the Arrow reservoir, for the release of water from the Whatshan reservoir, and for their agreement to provide three feet of additional storage in Arrow reservoir below normal minimum reservoir level.

WARDNER BRIDGE

under construction
for relocated highway
in British Columbia,
Libby Project.
August 1971.



CONCLUSIONS

1. The Duncan and Hugh Keenleyside dams are complete. The Mica and Libby projects are proceeding on schedule.
2. Entity studies pertaining to development of the hydrometeorological network, power and flood control operating plans, and the annual calculation of downstream power benefits are proceeding satisfactorily.
3. The Duncan and Arrow projects have been operated in conformity with the provisions of the Treaty, the detailed operating plans developed by the Entities, and the interim flood control operating plan for Duncan and Arrow reservoirs.
4. The operation of additional storage did not adversely affect the benefits obtainable from operation of the Treaty storage.
5. Finally, the Board concludes that the objectives of the Treaty are being met.

COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

<u>United States</u>	<u>Members</u>	<u>Canada</u>
Mr. Joseph M. Caldwell, Chairman (1) Chief, Engineering Division, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.		Mr. G.M. MacNabb, Chairman Assistant Deputy Minister, Energy Development, Department of Energy, Mines and Resources, Ottawa, Ontario
Mr. John W. Neuberger Deputy Assistant Secretary, Water and Power Resources, Department of the Interior, Washington, D.C.		Mr. A.F. Paget Consulting Engineer, Victoria, B.C.
	<u>Alternates</u>	
Mr. Fred L. Thrall Chief, Water Conservation and Use Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.		Mr. E.M. Clark Regional Engineer, Engineering Division, Water Planning & Operations Branch, Department of the Environment, Vancouver, B.C.
Mr. J. Emerson Harper Assistant and Power Engineering Advisor, Office of the Assistant Secretary for Water and Power Development, Department of the Interior, Washington, D.C.		Mr. H.M. Hunt Chief, Power and Major Licences Division, Water Resources Service, Department of Lands, Forests, and Water Resources, Victoria, B.C.
	<u>Secretaries</u>	
Mr. Verle Farrow Chief, Hydrology and Hydraulics Branch, Civil Works Directorate, Office, Chief of Engineers, U.S. Army, Washington, D.C.		Mr. E.M. Clark Regional Engineer, Engineering Division, Water Planning & Operations Branch, Department of the Environment, Vancouver, B.C.

(1) Vice Mr. Wendell E. Johnson as of 21 April 1971.

COLUMBIA RIVER TREATY ENTITIES

United States

Canada

Mr. H.R. Richmond, Chairman

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

The Honourable R.G. Williston, Chairman

Minister of Lands, Forests and Water
Resources,
Victoria, B.C.

Brigadier General K.T. Sawyer (1)

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

(1) Vice Brigadier General Roy S. Kelley as of 6 September 1971.

RECORD OF FLOWS

AT THE

INTERNATIONAL BOUNDARY

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	49,400	49,900	33,100	40,400	36,700	31,800	27,300	73,700	176,000	164,000	155,000	71,700
2	50,400	53,400	28,700	42,600	41,100	29,100	22,000	81,300	181,000	162,000	154,000	77,100
3	49,000	52,400	39,000	47,400	43,800	29,800	20,300	89,400	185,000	159,000	155,000	70,400
4	48,000	51,400	48,800	56,300	36,600	29,300	20,400	93,100	185,000	156,000	157,000	50,700
5	46,300	51,300	51,100	56,600	30,700	29,200	21,100	98,200	185,000	153,000	152,000	36,700
6	44,600	50,000	50,000	55,800	29,600	29,400	22,100	104,000	185,000	151,000	139,000	41,600
7	43,300	50,600	45,700	51,000	29,800	32,300	23,200	110,000	185,000	146,000	140,000	53,000
8	42,700	50,300	42,500	44,500	27,500	37,900	29,100	117,000	187,000	138,000	142,000	58,800
9	44,100	48,900	42,900	53,000	23,200	38,200	30,200	125,000	186,000	132,000	145,000	64,800
10	42,600	42,500	43,100	63,300	23,600	38,700	32,400	131,000	185,000	123,000	141,000	58,600
11	45,700	40,600	43,700	61,600	26,500	40,400	32,700	138,000	183,000	121,000	136,000	50,200
12	50,900	43,400	43,400	61,000	32,600	42,100	34,100	146,000	181,000	119,000	127,000	50,600
13	51,300	49,700	46,400	59,400	36,100	41,900	34,300	158,000	181,000	118,000	123,000	55,200
14	53,200	49,100	55,000	60,700	35,900	44,000	32,300	164,000	182,000	116,000	117,000	56,600
15	52,200	48,600	54,800	60,400	36,400	46,700	32,400	163,000	182,000	116,000	111,000	53,700
16	49,000	49,300	55,800	61,300	36,400	46,400	33,400	159,000	190,000	116,000	107,000	44,300
17	50,500	50,700	53,000	56,100	36,300	44,900	33,500	154,000	192,000	115,000	96,400	37,500
18	45,500	51,500	53,200	45,800	36,000	40,100	33,400	150,000	189,000	115,000	84,300	32,800
19	43,400	47,200	54,800	31,700	37,000	35,200	34,300	148,000	186,000	114,000	84,300	31,100
20	43,800	42,600	53,900	19,300	38,400	33,400	35,500	146,000	184,000	119,000	83,400	32,700
21	44,800	43,000	54,500	21,500	38,100	32,700	36,400	141,000	180,000	129,000	77,300	32,700
22	44,900	43,100	53,900	24,500	37,000	29,900	35,000	136,000	181,000	137,000	84,300	41,400
23	45,100	45,300	51,400	29,800	34,400	26,300	37,900	134,000	186,000	148,000	95,000	48,800
24	49,300	40,700	48,600	29,600	34,600	26,000	40,000	134,000	186,000	159,000	89,400	49,200
25	47,900	38,600	39,400	32,500	35,000	25,400	38,900	140,000	188,000	164,000	74,300	47,400
26	36,700	38,300	39,500	31,600	32,500	23,200	29,800	154,000	188,000	162,000	73,100	48,000
27	35,900	41,700	42,200	24,800	28,200	25,100	45,800	162,000	185,000	155,000	70,500	52,400
28	33,800	48,500	41,500	21,500	30,500	27,400	48,000	165,000	184,000	148,000	70,600	52,800
29	34,000	50,900	43,900	23,100		28,700	52,400	165,000	177,000	145,000	69,000	51,100
30	34,700	47,100	44,900	27,900		31,000	59,500	169,000	167,000	148,000	69,300	52,900
31	45,400		41,800	36,200		30,800		173,000		159,000	73,500	
Mean	45,100	47,000	46,500	42,900	33,700	33,800	33,600	136,000	184,000	139,000	110,000	50,200

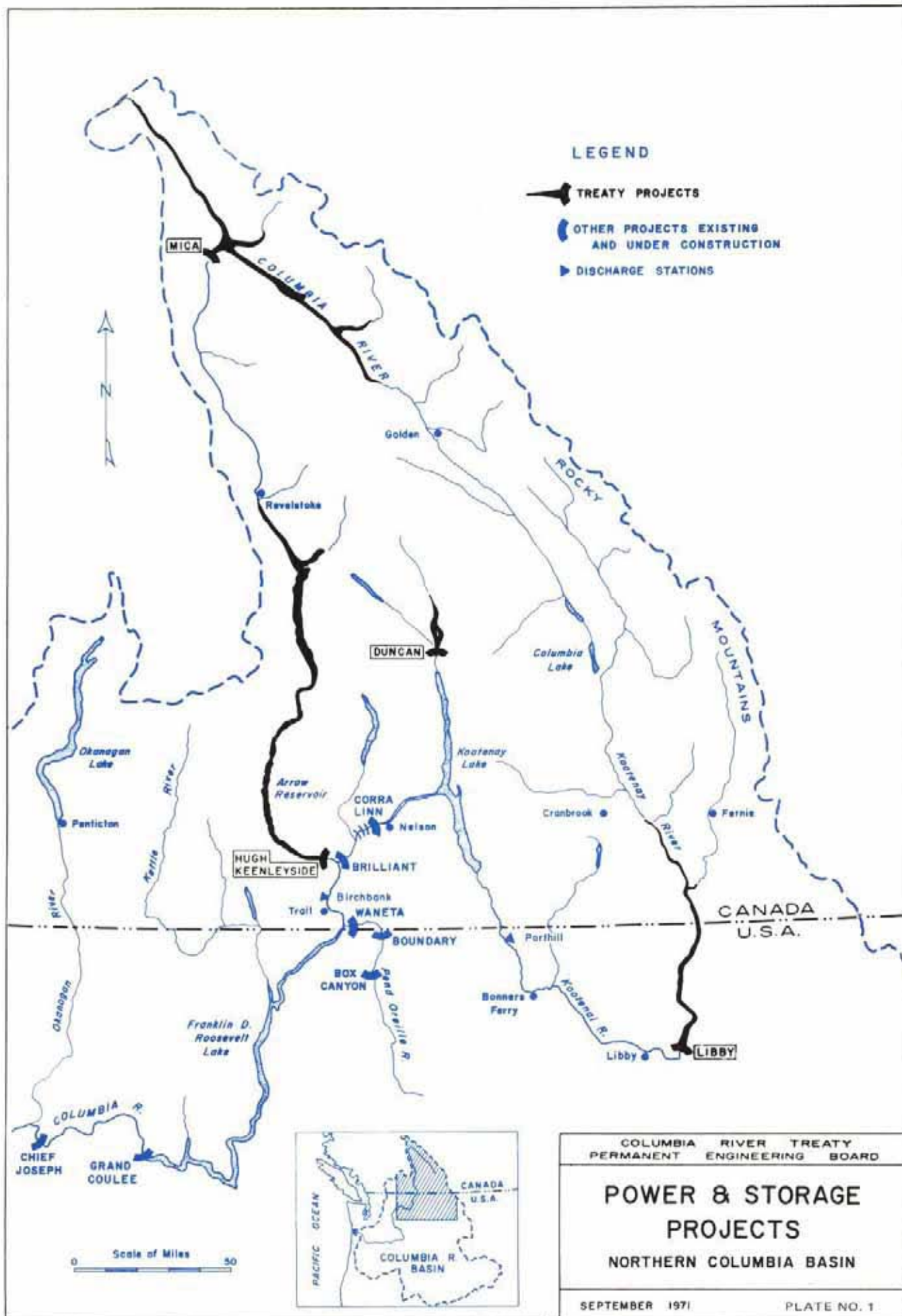
COLUMBIA RIVER AT BIRCHBANK, B.C. - Daily discharges for the year ending 30 September 1971 in cubic feet per second.

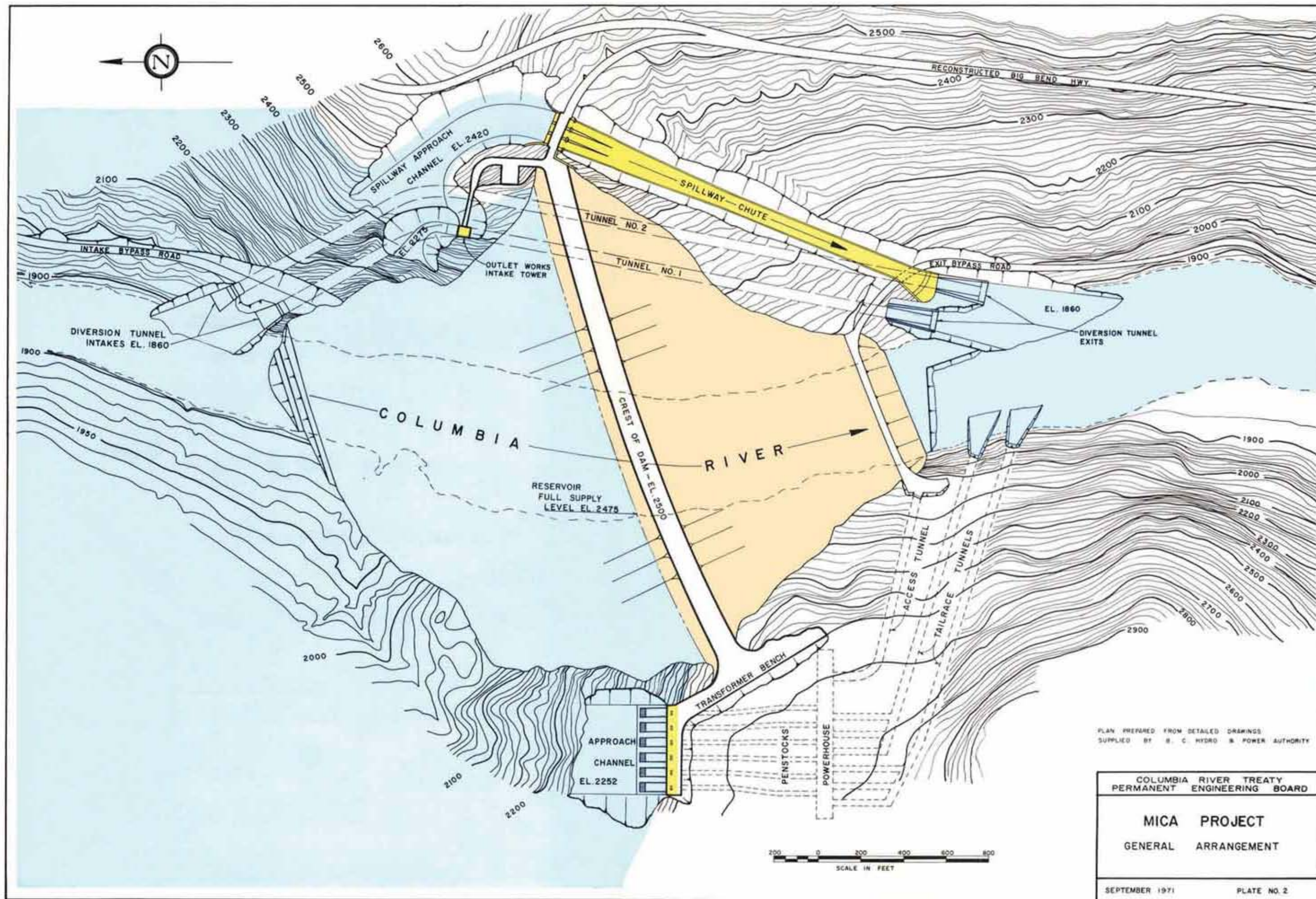
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	5,240	4,990	3,590	4,130	18,400	6,070	6,760	31,800	84,500	39,200	19,800	8,480
2	5,450	4,930	3,620	3,700	19,800	5,760	6,610	33,500	81,200	38,300	19,400	8,800
3	5,450	4,890	3,830	3,440	18,800	5,520	6,500	38,900	76,400	37,900	15,100	9,160
4	5,380	4,810	3,740	3,150	15,800	5,730	6,500	47,500	73,500	37,000	17,500	9,340
5	5,750	4,820	3,670	2,950	13,000	5,540	6,600	57,600	73,200	35,500	18,100	9,130
6	5,670	4,730	3,800	2,770	10,600	5,420	6,990	63,800	75,700	33,400	18,200	8,790
7	5,520	4,700	4,760	2,870	9,140	5,290	7,770	66,500	77,700	31,800	17,900	8,220
8	5,660	4,610	5,730	3,090	8,270	5,180	9,720	67,700	78,600	30,200	17,200	7,880
9	5,900	5,000	5,420	3,360	7,490	5,140	11,500	69,700	77,900	27,900	16,600	7,830
10	5,820	5,290	5,100	3,650	7,750	5,160	14,900	72,800	77,400	27,000	15,900	8,330
11	5,750	5,140	5,000	3,740	7,950	5,340	16,900	75,100	72,700	29,000	15,200	8,180
12	5,790	5,040	4,610	3,360	8,350	5,600	16,200	78,100	64,400	33,300	14,500	7,780
13	5,790	4,980	3,930	3,040	8,530	5,860	14,700	85,000	60,500	35,200	13,800	7,620
14	5,720	4,860	3,900	3,200	8,750	5,830	13,600	88,100	60,300	33,300	13,100	7,430
15	5,530	4,840	4,200	3,410	9,320	5,600	13,300	88,800	60,500	30,600	12,700	7,490
16	5,360	4,720	4,410	3,650	10,300	5,450	14,000	81,900	58,900	29,800	12,200	7,300
17	5,250	4,870	4,570	4,030	10,400	5,430	14,700	69,800	53,900	30,300	11,700	6,890
18	5,280	5,000	4,530	4,380	9,940	5,260	14,600	58,900	49,100	31,700	11,000	6,620
19	5,170	5,140	4,360	5,090	9,260	5,140	13,900	51,200	46,000	32,500	10,500	6,400
20	5,140	5,510	4,330	6,410	8,580	5,050	14,000	45,800	44,700	31,800	10,000	6,480
21	5,010	5,450	3,840	7,430	8,020	5,090	15,600	42,500	45,100	32,000	9,600	6,210
22	5,230	5,400	3,560	7,330	7,550	5,010	19,600	40,600	49,000	32,500	9,240	6,040
23	5,240	4,180	3,290	7,340	7,220	4,950	23,800	41,000	53,100	32,200	9,080	5,980
24	5,360	3,740	2,930	7,070	6,860	4,810	28,900	44,900	57,100	31,500	9,080	5,860
25	5,720	3,870	2,980	7,040	6,850	4,910	32,900	52,100	61,900	30,200	9,160	5,690
26	5,530	3,990	3,050	6,850	6,740	5,230	36,900	60,200	62,900	29,200	9,090	5,550
27	5,400	3,960	3,230	6,590	6,510	5,640	37,700	71,800	58,900	27,800	8,660	5,660
28	5,230	3,700	3,610	6,450	6,320	5,790	36,300	79,700	53,700	23,400	8,330	5,740
29	5,100	3,540	3,790	6,520		5,700	34,400	86,400	47,600	22,100	8,080	5,840
30	5,050	3,570	4,040	7,300		5,930	32,600	90,200	42,200	21,700	7,920	6,140
31	4,960		4,330	11,700		6,500		88,300		20,900	8,110	
Mean	5,430	4,680	4,060	5,000	9,880	5,450	17,600	63,600	62,600	30,900	12,800	7,230

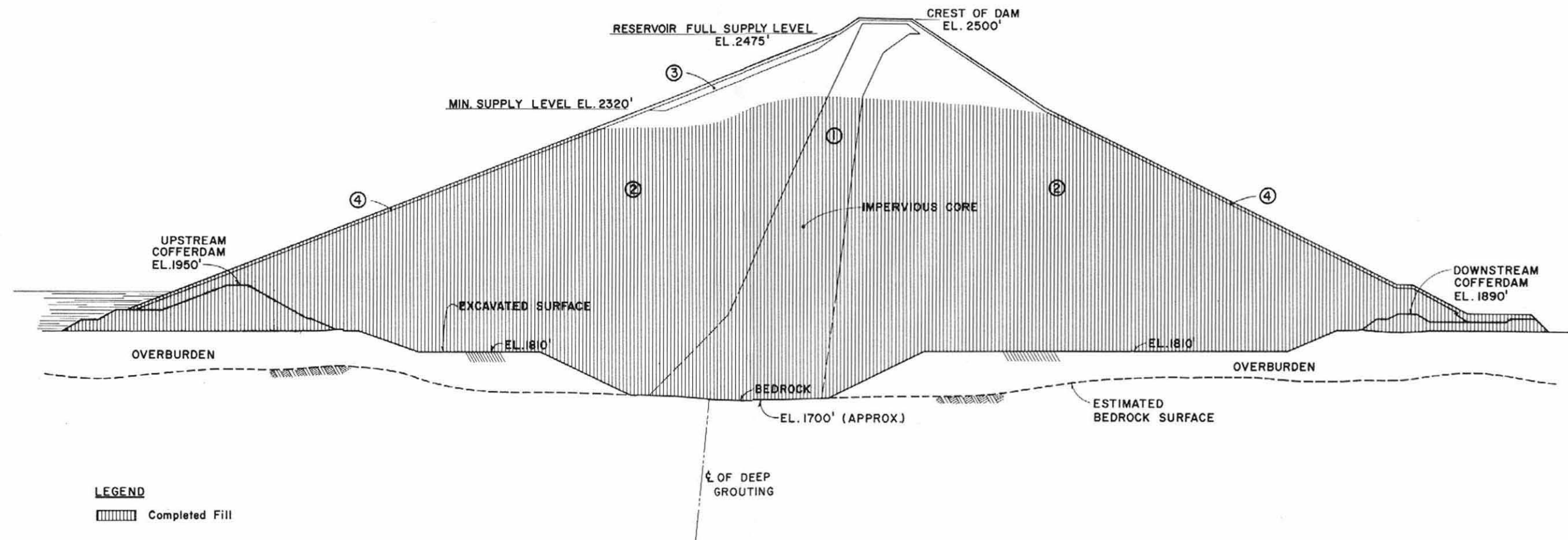
KOOTENAI RIVER AT PORTHILL, IDAHO - Daily discharges for the year ending 30 September 1971 in cubic feet per second.

LIST OF PLATES

	<u>Plate No.</u>
Power and Storage Projects Northern Columbia Basin	1
Mica Project General Arrangement	2
Mica Project Progress Chart of Dam	3
Mica Project General Project Area	4
Libby Project General Arrangement	5
Libby Project Reservoir Area	6





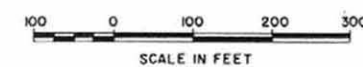


LEGEND

Completed Fill

ZONE	MATERIAL
①	IMPERVIOUS FILL
②	PERVIOUS FILL
③	FILTER
④	RIP RAP

EMBANKMENT SECTION



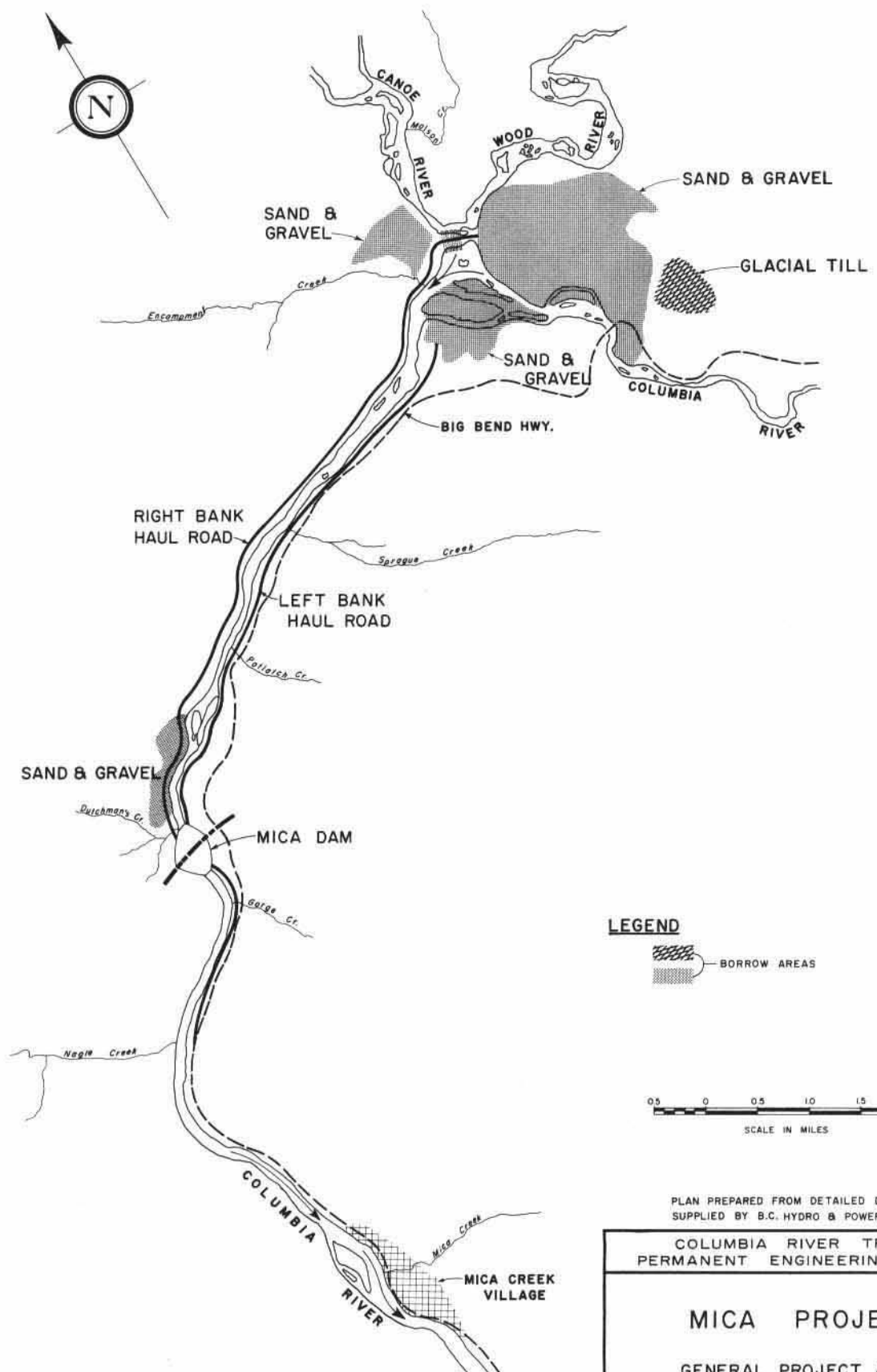
PLAN PREPARED FROM DETAILED DRAWINGS
SUPPLIED BY B.C. HYDRO & POWER AUTHORITY.

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT PROGRESS CHART OF DAM

SEPTEMBER 1971

PLATE NO. 3



LEGEND



PLAN PREPARED FROM DETAILED DRAWINGS
SUPPLIED BY B.C. HYDRO & POWER AUTHORITY.

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

MICA PROJECT

GENERAL PROJECT AREA

SEPTEMBER 1971

PLATE NO. 4

