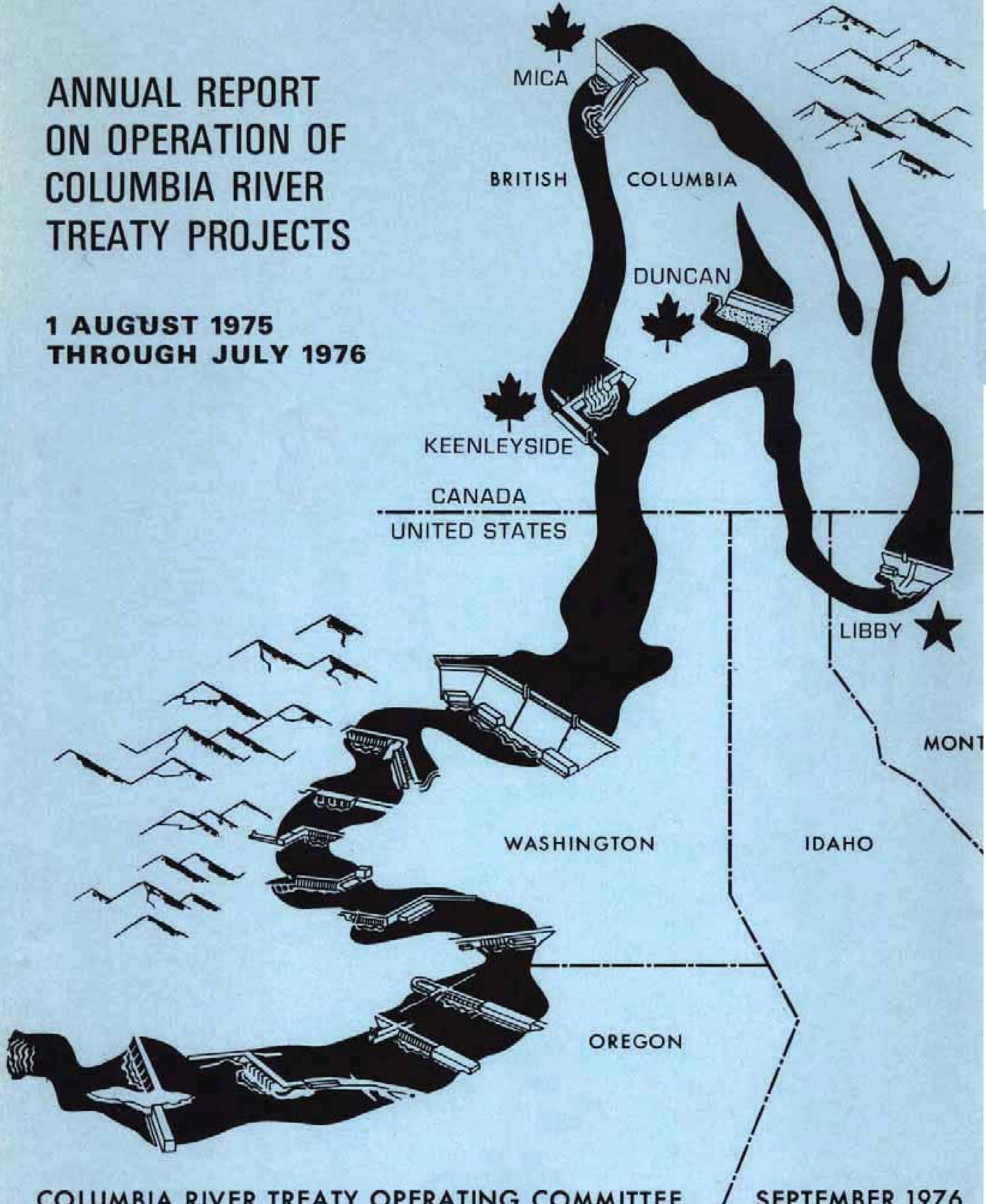
ANNUAL REPORT ON OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1975 THROUGH JULY 1976



COLUMBIA RIVER TREATY OPERATING COMMITTEE

SEPTEMBER 1976

REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1975 THROUGH 31 JULY 1976

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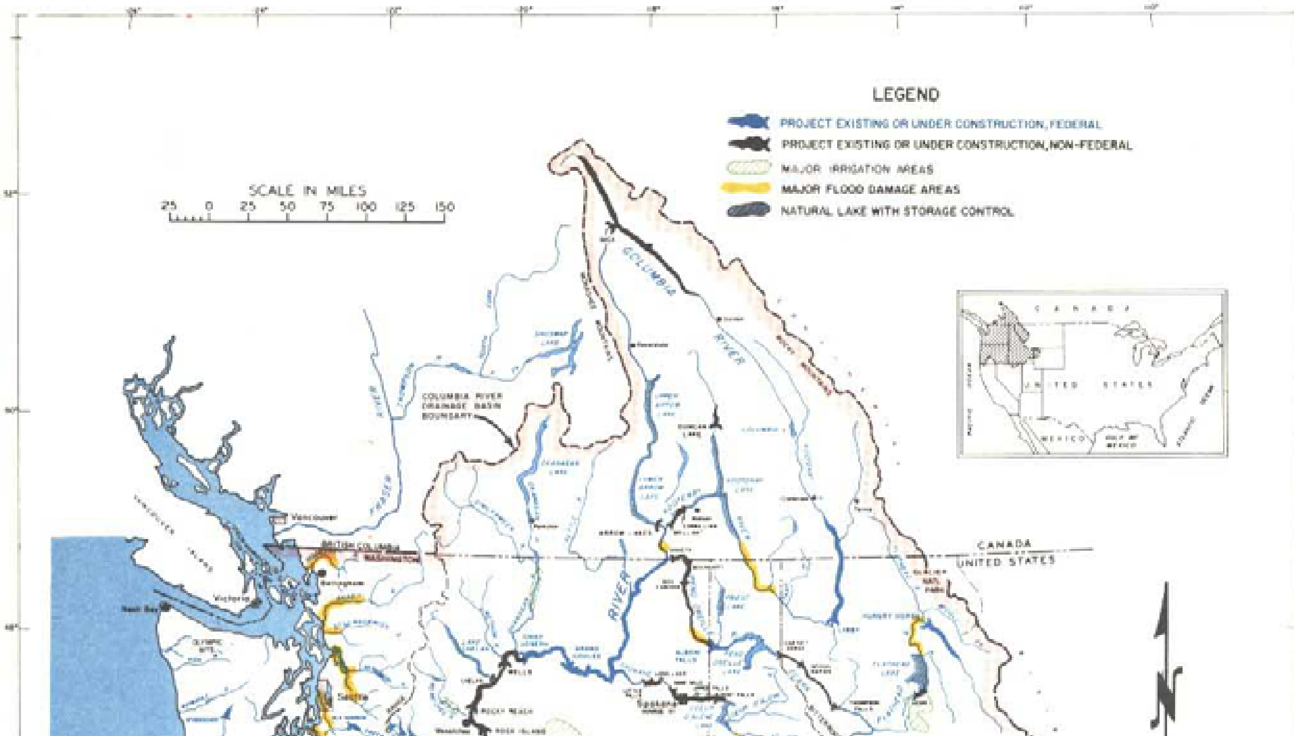


REPORT ON

OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1975 THROUGH 31 JULY 1976

I. INTRODUCTION

A. AUTHORITY

Duncan, Arrow, and Mica (McNaughton) reservoirs in Canada and Libby reservoir in the United States of America were constructed under the provisions of the Columbia River Treaty of January 1961. Treaty Storage is required to be operated for the purpose of increasing hydroelectric power generation and flood control in the United States of America and in Canada. In 1964, the Canadian and United States governments each designated an Entity to formulate and carry out the operating arrangements necessary to implement the Treaty. The Canadian Entity is British Columbia Hydro and Power Authority; the United States Entity is the Administrator, Bonneville Power Administration and the Division Engineer, North Pacific Division, Corps of Engineers.

The Columbia River Treaty Operating Committee, established in September 1968 by the Entities, is responsible for preparing and implementing operating plans as required by the Columbia River Treaty. This report records and reviews the operation of McNaughton, Arrow, Duncan, and Libby reservoirs for power and flood control during the period 1 August 1975 through 31

July 1976, including the major effects downstream in Canada and in the United States of America.

B. OPERATING PROCEDURE

Throughout the period covered by this report, storage operations were implemented by the Operating Committee in accordance with the Detailed Operating Plan for Columbia River Treaty Storage, dated September 1975. During the drawdown season from mid-August 1975 to late April 1976 the regulation of the Canadian Treaty storage content was normally determined by the Operating Committee on a weekly basis. During the remainder of the refill period, storage operations were determined on a weekly basis.

II. WEATHER AND STREAMFLOW

A. WEATHER

The weather in July and August 1975 was predominantly wet and mild throughout the Columbia River Basin, but this pattern changed to one of the driest Septembers on record. Early in October the warm Indian summer was cut short by the beginning of the winter Pacific storms that resulted in above normal precipitation in October and December in most parts of the Basin. A particularly warm, intense storm in early December caused severe flooding in western Washington and depleted the snowpack in the interior basin. Throughout the rest of the snow accumulation season, precipitation averaged near normal for the Columbia Basin as a whole. The geographical distribution of the accumulated October through April precipitation for the basin, expressed as a percentage of the 1958-1972 average, is shown on Chart 1. The Snake River Basin received the greatest precipitation for the season as shown, while most areas in the rest of the basin were near average. Chart 2 depicts the sequence of precipitation and temperatures that occurred throughout the winter, as measured by index stations in the basin.

By 1 April 1976 snow accumulation was near or slightly above normal for most areas of the basin, except for the upper Snake basin and the Cascade mountains where heavier snowpacks existed. Above normal temperatures in early April and again in early May initiated active snowmelt in the basin; however, the 1976 melt season was notable in that it was dominated by well below-normal temperatures during the summer season. This pattern can be seen on Charts 3 and 4. Chart 3 applies to the Columbia River Basin above The Dalles, Oregon; and Chart 4 applies to the upper Columbia and Kootenay River Basins in Canada. Since the major portion of the runoff which occurs during this season is produced by snowmelt, the temperatures shown are of special significance to system reservoir regulation in that they largely influence the pattern of streamflow.

B. STREAMFLOW

The near-normal streamflow that was experienced at the end of the 1975 runoff season continued into October, but above normal precipitation that fell in late 1975 increased streamflow to well above average for most of the winter period. Streamflow was 194% of average for the basin as a whole in December as the result of intense storm activity in the early part of the month. Total runoff at The Dalles during the October through March period was 122% of the 1958-72 average, ranking 17th highest in the 98 year period of record.

Periods of warm temperatures in April and May of 1976 resulted in above normal unregulated streamflow at The Dalles for those months. This streamflow at The Dalles was dominated by the much above average runoff occurring in the upper Snake River basin. Cool temperatures during late May and June moderated and delayed runoff from the upper Columbia portion of the basin, so that June unregulated streamflow as measured at The Dalles was only 81% of the 1958-72 average. Flows increased in late June and July producing maximum inflows to the Canadian reservoirs. Maximum observed mean daily inflow for Mica was 86,000 cfs on 9 July; for Arrow 140,000 cfs on 18 July; and for Duncan 17,300 cfs on 30 June. Libby project inflow reached the maximum for the year, 58,800 cfs, on 11 May. The natural streamflow patterns for the year are shown on the inflow hydrographs for the Treaty reservoirs, Charts 5, 6, 7, and 8. Observed and computed unregulated hydrographs for Kootenay Lake, Columbia River at Birchbank, Grand Coulee Dam, and The Dalles are shown on Charts 9, 10, 11, and 12, respectively.

C. SEASONAL RUNOFF VOLUMES

The volume and distribution of runoff during the snowmelt season is of great importance because the reservoir regulation plans are determined in part by the expected runoff volume. Runoff volume forecasts, based on precipitation and snowpack data, were prepared for a large number of locations in the Columbia River Basin and updated each month as the season advanced. Table 1 lists the seasonal volume inflow forecasts for Mica, Arrow, Duncan, and Libby projects and the unregulated runoff of the Columbia River at The Dalles. The forecasts for Mica, Arrow, and Duncan inflow were prepared by B. C. Hydro and Power Authority; and those for the Lower Columbia River and Libby inflow were prepared by the Unites States Columbia River Forecasting Service. Also shown on Table 1 are the actual volumes for these five locations.

Observed April-August runoff volumes, adjusted for upstream storage effects, are listed for eight locations in the following tabulation:

Streamflow & Location	Thousands of Acre-Feet	Percent of 1958-72 Average
Libby Reservoir Inflow	7,416	103
Duncan Reservoir Inflow	2,410	110
Mica Reservoir Inflow	13,471	111
Arrow Reservoir Inflow	27,485	114
Columbia River at Birchbank	48,526	112
Grand Coulee (FDR) Reservoir Inflow	74,237	114
Snake River at Lower Granite Dam	28,765	125
Columbia River at The Dalles	114,136	116

Comparison of the above tabulation with the seasonal precipitation map on Chart 1 reveals the general relationship between snow-accumulation season and precipitation and snowmelt season runoff when expressed in percent of average.

III. RESERVOIR OPERATION

A. McNAUGHTON RESERVOIR

Reservoir Evacuation Period. As indicated on Chart 5, McNaughton Lake was at elevation 2402.1 feet on 31 July 1975 and continued to fill until it reached elevation 2407.6 feet on 29 August 1975. No additional dead storage had been accumulated during the 1975 Operating Year, and at 1 August 1975 there was still 1.83 million acre-feet (maf) of dead storage to fill.

From 28 August 1975 to 5 December 1975, B. C. Hydro delivered thermal and purchased energy to Bonneville Power Administration (BPA) in lieu of storage releases from McNaughton Lake to insure that the 8 maf of dead storage space would be filled prior to the scheduled in-service date of the Mica generating units in September 1976. These deliveries increased Mica dead storage by 1.06 maf.

On 5 December 1975 the thermal deliveries ended when a "Special Agreement for Conserving Additional Mica Storage" came into effect. The agreement, between B. C. Hydro and BPA, proved beneficial to both parties. It allowed B. C. Hydro to discontinue the use of thermal generation to assure the filling of McNaughton Lake dead storage, and it permitted BPA to operate its resources more efficiently through greater flexibility in storage operation.

Virtually no storage draft occurred at McNaughton Lake during the period from September through March due to heavy winter precipitation in the Columbia River Basin, lower than forecast loads in the United States Pacific Northwest area, and operation of McNaughton Lake under the agreement noted above. Minimum discharges were made from McNaughton Lake from early December 1975 through March 1976. Discharges were increased to 24,000 cubic feet per second (cfs) during part of April to transfer sufficient stored water to the Arrow reservoir to insure the downstream power requirements could be met through April.

Refill Period. Only 410 thousand second-foot-days (ksfd) of McNaughton Lake live storage had been evacuated for downstream power requirements by 30 April 1976, and the snowmelt runoff forecasts indicated a slightly above normal runoff potential for the Columbia River basin as a whole. Simulation studies indicated there would be sufficient inflow to McNaughton Lake that would be surplus to United States downstream power requirements to permit McNaughton Lake to be filled to its full pool elevation of 2475.0 feet by the end of the refill period (i.e. 31 July 1976).

On the basis that McNaughton Lake would be full by the end of July, there was a high probability (later confirmed) that early August inflows in excess of 60,000 cfs would have to be discharged from McNaughton Lake. This meant that the tailrace cofferdam protecting the Mica powerhouse outlet works (tailrace tunnel No. 2) had to be raised, some construction equipment and materials had to be relocated, and rip-rap on downstram staging areas had to be reinforced.

Between 10 May and 20 May, discharges were reduced to zero to allow removal of the tailrace cofferdam protecting tailrace tunnel No. 1. This work was completed by 21 May, and discharges of approximately 10,000 cfs were made until 28 June, when McNaughton Lake exceeded elevation 2445.0 feet, the elevation required for the first of two spillway tests. The purpose of the first test was to determine the optimum combination of spillway/outlet works discharges to minimize wave action and erosion in the tailrace area. A second spillway test was performed commencing on 13 July, with McNaughton Lake at elevation 2468.0 feet to check the spillway gate drive system and operation of the gate seals. Both tests were successful with the spillway and outlet works performing as had been predicted from previous model studies. This operation was consistent with the U. S. Entity request that the 2.08 million acre-feet (maf) flood control space at Mica be filled beginning 21 May. The filling for flood control was completed 24 June.

After completion of the second spillway test until the end of the refill period, McNaughton Lake discharges ranged up to 67,000 cfs and the elevation of McNaughton Lake reached elevation 2473.2 feet on 31 July 1976. These unavoidably high discharges created extreme spray conditions in the tailrace area, resulting in very poor visibility and erosion problems and interfering with powerhouse construction activity until mid-August when the high discharge was reduced.

The total water stored in McNaughton Lake on 31 July 1976 was distributed as follows:

Treaty storage	3529.20 ksfd	(7.0 maf)
Dead storage	4033.20 ksfd	(8.0 maf)
B. C. Hydro non-Treaty storage	2462.38 ksfd	(4.9 maf)
Total	10,024.78 ksfd	(19.9 maf)

It should be noted that the total water in storage reached 15.0 maf 25 May 1976, the initial filling objective under the Treaty. The 1976 volume inflow forecasts and the Variable Refill Curve computations for McNaughton reservoir are shown in Table 2.

B. ARROW RESERVOIR

Reservoir Evacuation Period. As indicated on Chart 6, at 31 July 1975 the Arrow reservoir was 0.2 feet above its normal full pool elevation of 1444.0 feet. During July 1975 a maximum of 2.1 feet of water had been stored in Arrow to compensate for anticipated involuntary storage at Mica during 1975 due to discharge limitations.

The Arrow reservoir remained close to elevation 1444.0 feet through August and September 1975. On 24 October 1975 the winter flood control rules for the Arrow reservoir were relaxed and the reservoir was surcharged 0.4 feet above the maximum Flood Control Storage Reservation Curve of 1444.0 feet. This assisted B. C. Hydro in its Mica construction program but was conditioned on the reservoir again reaching the curve by mid-November.

Due to wet weather and reduced United States power requirements throughout the winter, no significant storage releases occurred until January when reservoir draft for flood control purposes began at an average rate of 13 feet per month through to the end of March. At its 9 March meeting, the Operating Committee agreed that the Arrow flood control requirement would be considered to be below elevation 1446.0 feet rather than 1444.0 feet for the 1976 operations. This enabled a 132.1 ksfd reduction in storage draft for flood control. On 7 April the reservoir reached elevation 1394.3 feet, its lowest elevation during the 1975-76 Operating Year and approximately 16 feet above the normal low pool elevation of 1377.9 feet. This marked the end of the storage draft season and a rapid rise in elevation took place shortly after 7 April due to an increased storage draft from McNaughton Lake and minimum outflow requrements from the Arrow reservoir. Chart 6 indicates this pattern as well as the short periods of filling in September and October.

Refill Period. During early May, Arrow reservoir discharges up to 60,000 cfs where required for downstream power generation. Thereafter, the discharges ranged between 20,000 cfs and 40,000 cfs, significantly above minimum values to prevent early refill of the Arrow reservoir.

For the first time since the Mica project became operational in April 1973, the Arrow project had to pass the McNaughton Lake uncontrolled inflow as well as the local Arrow Lakes inflow. These discharges began on 15 July and flows reached 182,000 cfs at Trail, B. C., 40,000 cfs below flood stage. The reservoir reached the normal full pool elevation of 1444.0 feet on 19 July, and elevation

1446.0 feet on 1 August 1976 on the basis of an agreement between B. C. Hydro and BPA for use of this additional 2 feet (132.1 ksfd) of stored water during the 1976-77 Operating Year.

The 1976 volume inflow forecasts and the Variable Refill Curve computations for Arrow are shown in Table 3.

C. DUNCAN RESERVOIR

Reservoir Evacuation Period. As indicated on Chart 7, Duncan reservoir was at normal full pool elevation of 1892.0 feet on 1 August 1975 and was maintained at approximately this elevation until the end of November. Evacuation primarily for flood control purposes commenced on 1 December 1975 and continued until 2 March 1976 when the reservoir elevation reached 1807.7 feet. During this period, releases were closely coordinated with Libby releases to ensure compliance with the International Joint Commission Order on Kootenay Lake.

Since there was sufficient water for downstream Canadian (B. C. Hydro and Cominco/West Kootenay Power) and United States power requirements, the reservoir was held at elevation 1807.7 feet, approximately 14 feet above the normal low pool elevation of 1794.2 feet, until reservoir refill commenced on 7 April. During April 1976 Duncan releases were kept below 1000 cfs to assist studies of fish migration below the reservoir.

Refill Period. The Duncan reservoir elevation began to rise in early April with rising inflow. On 28 May Duncan outflows were reduced to 100 cfs for purposes of flood control and reservoir refill, and outflows were maintained at that value until 9 July when they were increased in order to slowdown the reservoir filling rate. The Duncan reservoir normal full pool elevation of 1892.0 feet was reached on 24 July 1976. Table 4 shows the 1976 volume inflow forecast and the Variable Refill Curve computations for Duncan.

D. LIBBY RESERVOIR

Reservoir Evacuation Period. Lake Koocanusa failed to reach full pool, elevation 2459.0 feet, in 1975 because of the delayed runoff and less than forecasted seasonal inflow. Libby outflows were maintained near 2,000 cfs through mid-August to attain maximum filling for the project dedication on 24 August 1975. Discharges were increased to 3,000 cfs 18 August to provide adequate water for Montana Fish and Game studies downstream of Libby. Following the dedication, discharges were maintained near 4,000 cfs, the capacity of the one available unit.

Lake Koocanusa continued to fill and reached a maximum elevation of 2455.5 feet on 9 September. Air vent tests for the sluices, conducted 10-11 September, required rapid fluctuations of the outflow and releases of up to 45,000 cfs for short periods. Following the test, outflows were set at 10,000 cfs to reduce downstream fluctuations and begin seasonal draft to provide 2 million acre-feet of flood control space by 1 January 1976.

Project releases were curtailed 16-17 September due to spray interfering with the powerhouse roofing contractor, 10-24 October due to high inflows to Grand Coulee, 1-3 December for Deep Creek Bridge work and contractor work in Libby stilling basin, 4-8 December due to high inflows to Kootenay Lake, and 19-21 December for relocation of water line in Deep Creek Bridge construction area. Libby discharge was increased to 25,000 cfs 22 December because the reservoir was above flood control rule curve. Flows were reduced briefly to 5,000 cfs 19 January to recover a city dump truck in the river at Libby, Montana. Beginning 30 January, Libby outflows were restricted by Kootenay Lake evacuation schedule. Libby continued to release as much flow as Kootenay Lake restriction would permit through March. Low flows and power demands caused Lake Koocanusa to draft below its flood control requirement the first week of April to a minimum elevation of 2307.3 on 6 April.

Four power units at Libby were placed in commercial use during the year: unit 1, 24 August; unit 2, 24 October; unit 3, 21 January; and unit 4, 31 March.

Refill Period. Libby outflows were maintained near 8,000 cfs from 6-15 April and the lake filled slowly as shown on Chart 8. Outflows were reduced to 3,000 cfs 16 April and maintained between 3,000 and 5,000 cfs through 5 July when Lake Koocanusa reached elevation 2450.0 feet and outflows were adjusted to slow the rate of fill and maintain some contingency space for potential late season snowmelt. Lake Koocanusa reached normal full pool elevation 2459.0 feet 29 July 1976. The 1976 volume inflow forecast and the Variable Refill Curve computations for Libby are shown on Table 5.

IV. DOWNSTREAM EFFECTS OF STORAGE OPERATION

A. POWER

General. During the period covered by this report the Treaty storage was operated in accordance with the 1975-76 Detailed Operating Plan designed to achieve optimum power generation downstream in the United States of America. In 1964 the Canadian Entitlement to downstram power benefits for the 1975-76 Operating Year was purchased by Columbia Storage Power Exchange (CSPE) and exchanged with BPA for specified amounts of power and energy. Deliveries of power and energy specified under the Canadian Entitlement Exchange Agreements and attributable to Arrow, Duncan, and Mica under the provisions of these agreements were made during the 1975-76 Operating Year.

The generation at downstream projects in the United States delivered under the Canadian Entitlement Exchange Agreement was 739 average megawatts at rates up to 1379 megawatts, 1 August 1975 through 31 March 1976, and 719 average megawatts at rates up to 1373 megawatts, 1 April 1976 through 31 July 1976. During the period 1 April 1975 through 31 March 1976, the CSPE participants assigned 163 average megawatts at rates up to 300 megawatts to Pacific Southwest utilities.

Beginning 1 April 1976 the assignment was 160 average megawatts at rates up to 300 megawatts. CSPE power not assigned to Pacific Southwest utilities was used in Pacific Northwest loads.

Review of 1975-76 Operations. Power operations during 1975-76 reflected the extremely favorable weather and streamflow conditions that occurred throughout the year. All major Pacific Northwest reservoirs, except Libby, were full on 1 August 1975.

The Centralia Steamplant again operated at lower levels than anticipated with unit 1 forced out of service in early February because of turbine blade failures. The Hanford Nuclear Plant also produced less than expected. Unit 2 was not placed in service until the end of November due to turbine blade problems. The plant was shutdown in mid-April due to contract problems with the operators of the reactor. The Trojan Nuclear Plant began generating test power on 22 December and was declared available for commercial operation on 20 May. Loss in production at thermal plants was more than offset by the unusually high streamflows received. Some energy surplus to Pacific Northwest needs was available for export in all months but October and November.

On 29 and 30 July 1975, BPA restricted direct service to its industrial nonfirm loads. BPA again restricted direct-service during the periods 9-25 August and 4 September - 18 October. During those periods the industrial customers supplied their nonfirm loads with firm energy purchased from BPA. No industrial production was lost because of lack of electrical power supply. Secondary energy deliveries to investor-owned utilities were curtailed during the same periods. Their requirements were met by use of their thermal generation and purchases of higher cost generation from other utilities.

Heavy rains and warm weather during the first few days of December caused very sharp rises in streamflow throughout the Columbia Basin. As a result, on 6 December the Federal System began deliveries of surplus energy that could not be conserved in Northwest reservoirs to markets outside the Pacific Northwest Region. After the middle of December, significant amounts of water were drafted from Canadian Treaty storage, Libby, and Dworshak to meet end of the month flood control requirements. These storage drafts resulted in BPA continuing to market surplus energy for the balance of December and through the first two weeks of January. Load-resource studies based on actual 1 January reservoir contents and forecast volume runoff for the period 1 January through 31 July indicated sufficient water to serve all Pacific Northwest energy requirements and refill reservoirs with substantial amounts of surplus energy. On 14 January BPA declared surplus available for markets outside the Northwest. This condition prevailed for the balance of the Operating Year. During the period July 1975 through June 1976 BPA exported 13 billion kilowatthours of surplus energy to the Pacific Southwest.

BPA and most other Pacific Northwest utility loads significantly underran estimates during 1975-76. BPA's total energy load averaged 10 percent below estimate. Pacific Northwest Coordinated System energy and peakloads underran estimates by about 7 and 15 percent, respectively. These underruns were mainly attributable to temperate weather, energy conservation and depressed economic conditions. The nonfirm component of BPA's industrial load averaged 15 percent lower than the previous year. However, the trend in the industrial load reversed late in the year and by June 1976 the average nonfirm industrial load was 728 megawatts compared with 394 megawatts during June 1975.

B. FLOOD CONTROL

Lower Columbia River Regulation. The 1976 flood nearly matched that of 1975 in runoff and streamflow magnitude. Without regulation by upstream reservoirs, the 1976 peak flow at The Dalles, Oregon, would have been 637,000 cfs on 16 May; the actual peak was 419,000 cfs on 14 May. In comparison, the corresponding 1975 flows were 670,000 cfs and 423,000 cfs, respectively. At Vancouver, Washington, a key gaging station for evaluating flooding on the lower Columbia River, the maximum stage during the spring flood was 14.6 feet on 15 May. The computed unregulated stage at Vancouver was 22.2 feet. These values compare with a bankfull stage of 16 feet and a major flood stage of 26 feet.

Chart 12 shows the 1975-76 flows at The Dalles for both observed and unregulated conditions. These hydrographs are shown compared with the summary hydrograph of previously observed flows at The Dalles. Chart 13 shows the flow at The Dalles for the spring flood period in 1976. On this chart the effects of regulation by Mica, Arrow, Duncan, and Libby projects are separated from those of all other major storage projects in the Columbia River Basin. The

Treaty projects contributed about 40 percent of the total storage volume for flood control regulation for the Lower Columbia River during the peak runoff months of May and June 1976.

The flood control regulation of the Lower Columbia River is significantly affected by the operation of Grand Coulee project. Chart 11 shows the regulation by Grand Coulee during the period July 1975-July 1976. The observed peak inflow to Grand Coulee was 253,000 cfs on 18 May, when the outflow was 160,000 cfs. The computed unregulated peak inflow was 339,000 cfs on 29 May. The basis for the computation of the Initial Controlled Flow of 430,000 cfs for the Columbia River at The Dalles, Oregon, is shown on Table 6.

Chart 14 documents the relative filling of Arrow and Grand Coulee during the principal filling period, and compares the coordinated regulation of the two reservoirs to guidelines in the Flood Control Operating Plan. The guidelines shown on Chart 14 are based on relative space available on 6 May. The relative filling was not closer to the guidelines because major flooding was not forecasted and because B. C. Hydro desired to retain space for potentially high inflows to Arrow later in the season than normal. There was also a desire to fill Grand Coulee earlier for irrigation pumping and other purposes.

Local Regulation. No significant local flood control problems were encountered in 1975. Unregulated discharges at Bonners Ferry, Idaho, would have caused stages approximately 3 feet over the bankfull stage of 27 feet and 6 feet below the top of the levees, 36 feet. The operation at Libby Reservoir reduced the Kootenay River flow to a nondamaging stage of 16 feet and permitted use of roads and lands that are normally inundated. The combined operation of Libby and Duncan reservoirs in controlling inflows to Kootenay Lake improved the seasonal operation of the lake and reduced the peak stage of Kootenay Lake by about 5 feet as indicated on Chart 9.

The operation of Mica and Arrow projects reduced the maximum flow at Birchbank in July from an unregulated 226,000 cfs to 180,000 cfs; however, heavy precipitation in August resulted in the maximum observed discharge for the year of 191,000 cfs on 3 August.

V. OPERATING CRITERIA

A. GENERAL

The Columbia River Treaty requires that the reservoirs constructed in Canada be operated pursuant to flood control and hydroelectric operating plans developed thereunder. Annex A of the Treaty stipulates that the United States Entity will submit flood control operating plans and the Canadian Entity will operate in accordance with flood control storage diagrams or any variation which the Entities agree will not be adverse to the desired aim of the flood control plan. Annex A also provides for the development of hydroelectric operating plans five years in advance to furnish the Entities with an Assured Operating Plan for Canadian Storage. In addition, Article XIV.2.k of the Treaty provides that a Detailed Operating Plan may be developed to produce more advantageous results through use of current estimates of loads and resources. The Protocol to the Treaty provides further detail and clarification of the principles and requirements of Annex A. The Principles and Procedures of 25 July 1967, together with the Columbia River Treaty Flood Control Operating Plan dated October 1972, both developed by special task forces, establish the general criteria of operations.

The Assured Operating Plan dated 1 July 1970 established Operating Rule Curves for Duncan, Arrow, and Mica for the 1975-76 Operating Year. The Operating Rule Curves provided guidelines for refill levels as well as drawdown levels. They were derived from Critical Rule Curves, Assured Refill Curves, and simulated Variable Refill Curves, consistent with flood control requirements, as described in the Principles and Prodecures. The Flood Control Storage Reservation Curves were established to conform to the Flood Control Operating Plan.

The Detailed Operating Plan dated September 1975 established data and criteria for determining the Operating Rule Curves for use in actual operations. At the request of the Canadian Entity these criteria included the Critical Rule Curves for Duncan, Arrow, and Mica agreed in the 1975-76 Assured Operating Plan dated 1 July 1970. The Variable Refill Curves and flood control requirements subsequent to 1 January 1976 were determined on the basis of seasonal volume runoff forecasts during actual operation.

B. POWER OPERATION

The Detailed Operating Plan dated September 1975 was designed to achieve optimum power generation downstream in the United States, consistent with project operating limits and flood control requirements.

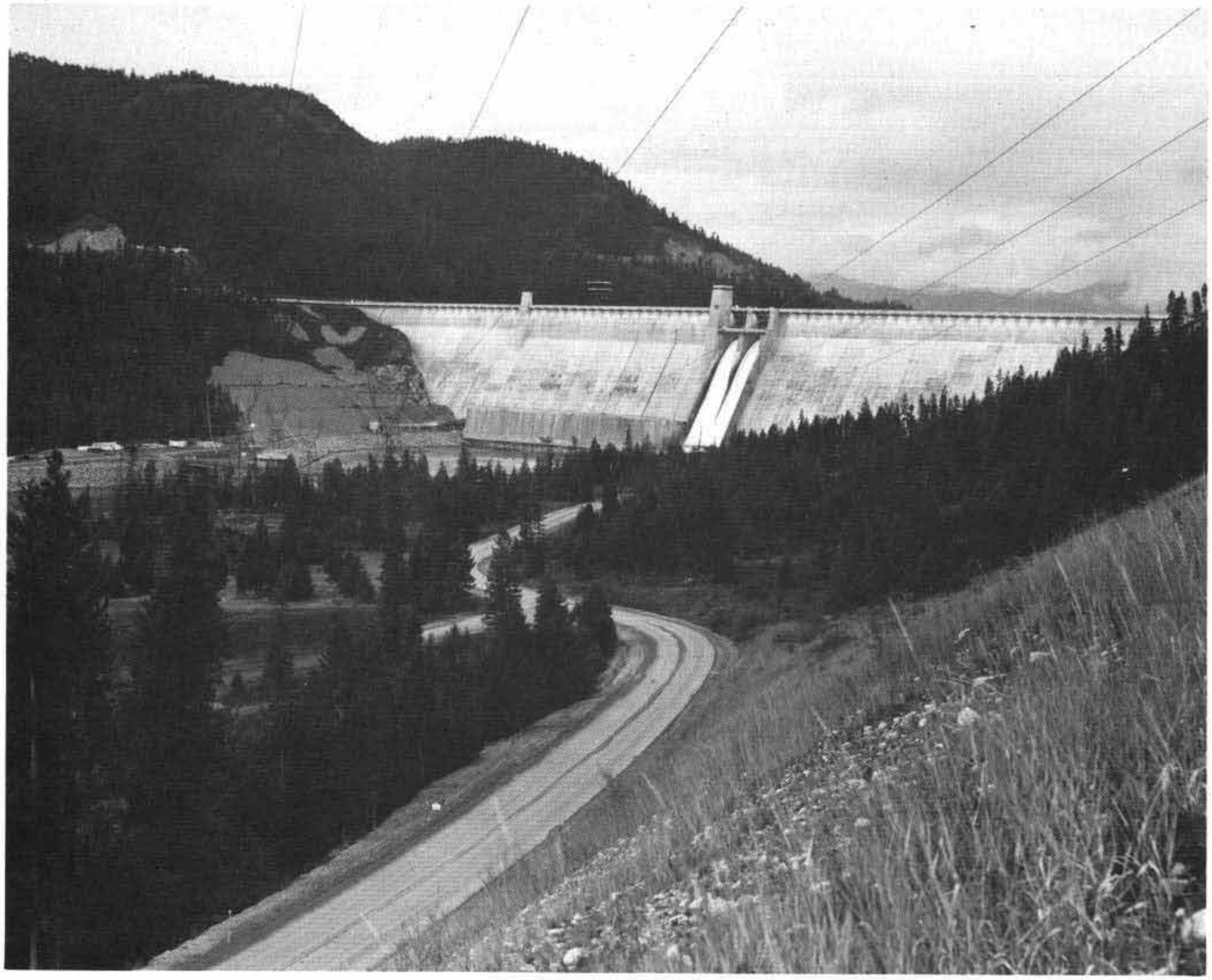
The power facilities in the United States which are downstream from the Treaty storage projects are all operated under the Pacific Northwest Coordination Agreement dated September 1964. Optimum generation in the United States was assured by the adoption, in the Assured and Detailed Operating Plans, of criteria and operating guides designed to coordinate the operation of Treaty projects with the projects operating under the Agreement. Optimum operation of Treaty reservoirs was accomplished, for the actual water condition experienced, by operating with reference to the Critical Rule Curves, Assured Refill Curves, Variable Refill Curves, Flood Control Storage Reservation Curves, and related criteria determined in accordance with the Detailed Operating Plan.

C. FLOOD CONTROL OPERATION

The Flood Control Operating Plan was designed to minimize flood damage both in Canada and in the United States. The flood control operation during the drawdown period consisted of evacuation and holding available storage space, consistent with refill criteria, sufficient to control the maximum flood that may occur under forecast conditions. Runoff volume forecasts determined the volume of storage space required.

Flood control operation of the Columbia River Treaty projects during the refill period was controlled in part by the computed Initial Controlled Flow of Columbia River at The Dalles. Other operating rules and local criteria were utilized to prepare day-to-day streamflow forecasts for key points in Canada and the United States and to establish the operations of the flood control storage. These forecasts were prepared daily during the snowmelt season by the Columbia River Forecasting Service for periods of 30 to 45 days using both moderate and severe snowmelt sequences.

View of Mica spillway discharge of approximately 70,000 cfs on 13 July 1976. In the lower right hand portion of the photograph can be seen the heavy spray conditions on the powerhouse access road which impaired construction activity during part of July and August 1976.
B.C. Hydro and Power Authority Photograph



An August 1975 view of Libby Dam on the Kootenay River. The first generating unit came on-line in August 1975 and the fourth unit in March 1976. The powerhouse total capacity with 4 units is 483 megawatts. The Powerhouse also includes skeleton bays for 4 additional units scheduled for 1983 and 1984 installation.

U.S. Army Corps of Engineers Photograph

John Day Dam and Lake Umatilla viewed from the left bank of the Columbia River. The powerhouse includes 16 generating units with a total capacity of 2484 megawatts. There are skeleton bays for 4 additional units. The navigation lock measures 86 by 675 ft. with a maximum lift of 113 ft. The project also provides benefits for flood control, irrigation and recreation.

U.S. Army Corps of Engineers Photograph

Table 1

UNREGULATED RUNOFF VOLUME FORECASTS
MILLIONS OF ACRE-FEET
1976

	DUNCAN	ARROW	MICA	LIBBY	UNREGULATED RUNOFF COLUMBIA RIVER AT THE DALLES, OREGON
Forecast Date - 1st of	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Apr - 31 Aug	Most Probable 1 Jan - 31 Jul
January	2.20	24.24	12.37	7.38	113.0
February	2.19	24.48	12.53	6.98	116.0
March	2.23	25.63	12.80	7.07	121.0
April	2.23	24.90	12.70	7.23	124.0
May	2.22	24.91	12.70	7.34	124.0
June	2.25	25.26	12.79	7.57	124.0
Actual	2.41	27.49	13.47	7.42	122.0

Note: These data are as used in actual operations. Subsequent revisions have been made in some cases.

McNAUGHTON RESERVOIR COMPUTATION FORM
95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE
1976

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1. PROBABLE FEB 1-JULY 31 INFLOW, KSFD 1/		5179.7	5245.1	5353.5	5259.6*	5309.5	5383.7
2. 95% FORECAST ERROR, KSFD		773.0	613.9	548.4	552.1	521.4	498.1
3. 95% CONFIDENCE FEB 1-JULY 31 INFLOW, KSFD 2/		4406.7	4631.2	4803.1	4707.3	4788.1	4885.6
4. OBSERVED FEB 1-DATE INFLOW, KSFD				115.6	219.2	499.1	1566.7
5. 95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		4406.7	4631.2	4689.5	4488.1	4289.0	3318.9
ASSUMED FEB 1-JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB 1-JULY 31 INFLOW, KSFD 4/		4406.7					
MIN. FEB 1-JULY 31 OUTFLOW, KSFD		543.0					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 5/		831.5*					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 6/	2362.9	2336.3					
JAN 31 VARIABLE REFILL CURVE, FT. 7/		2336.3					
ASSUMED MAR 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
ASSUMED MAR 1-JULY 31 INFLOW, KSFD 4/		4314.2	4633.9				
MIN. MAR 1-JULY 31 OUTFLOW, KSFD		459.0	459.0				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 5/		377.8*	377.8*				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 6/	2350.8	2319.1	2319.1				
FEB 28 VARIABLE REFILL CURVE, FT. 7/		2319.1	2319.1				
ASSUMED APR 1-JULY 31 INFLOW, % VOLUME		95.6	95.6	97.6			
ASSUMED APR 1-JULY 31 INFLOW, KSFD 4/		4212.8	4427.4	4577.0			
MIN. APR 1-JULY 31 OUTFLOW, KSFD		366.0	366.0	366.0			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 5/		0	0	0			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 6/	2339.1	2304.1	2304.1	2304.1			
MAR 31 VARIABLE REFILL CURVE, FT. 7/		2304.1	2304.1	2304.1			
ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		91.4	91.4	93.3	95.6		
ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		4027.7	4239.9	4375.3	4290.6		
MIN. MAY 1-JULY 31 OUTFLOW, KSFD		276.0	276.0	276.0	276.0		
MIN. APR 30 RESERVOIR CONTENT, KSFD 5/		0	0	0	0		
MIN APR 30 RESERVOIR ELEVATION, FT. 6/	2328.6	2304.1	2304.1	2304.1	2304.1		
APR 30 VARIABLE REFILL CURVE, FT. 7/		2304.1	2304.1	2304.1	2304.1		
ASSUMED JUN 1-JULY 31 INFLOW, % VOLUME		74.2	74.2	75.8	77.6	81.2	
ASSUMED JUN 1-JULY 31 INFLOW, KSFD 4/		3269.8	3436.4	3554.6	3482.8	3582.7	
MIN. JUN 1-JULY 31 OUTFLOW, KSFD		183.0	183.0	183.0	183.0	183.0	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		442.4	275.8	157.6	229.4	229.5	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 6/	2346.5	2321.6	2315.1	2305.7	2313.3	2313.3	
MAY 31 VARIABLE REFILL CURVE, FT. 7/		2321.6	2315.1	2305.7	2313.3	2313.3	
ASSUMED JUL 1-JULY 31 INFLOW, % VOLUME		36.0	36.0	36.8	37.6	39.4	48.5
ASSUMED JUL 1-JULY 31 INFLOW, KSFD 4/		1586.4	1667.2	1725.7	1687.5	1689.9	1609.7
MIN. JUL 1-JULY 31 OUTFLOW, KSFD		93.0	93.0	93.0	93.0	93.0	93.0
MIN. JUN 30 RESERVOIR CONTENT, KSFD 5/		2035.8	1955.0	1896.5	1934.7	1932.3	2012.5
MIN. JUN 30 RESERVOIR ELEVATION, FT. 6/	2388.1	2376.4	2374.0	2368.6	2373.4	2373.4	2375.8
JUN 30 VARIABLE REFILL CURVE, FT. 7/		2376.4	2374.0	2368.6	2373.4	2373.4	2375.8
JULY 31 VARIABLE REFILL CURVE, FT.	2414.40	2414.4	2414.4	2414.4	2414.4	2414.4	2414.4
NOTE - ACCUMULATED DEAD STORAGE IS		3648.1	3648.1	3648.1	3648.1	3648.1	3648.1

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1-LINE 2
3/ LINE 3-LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (3529.2) PLUS PRECEDING LINES LESS LINE PRECEDING THAT (USABLE STORAGE).
6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE DATED MARCH 25, 1974 (FOOTNOTE 5 PLUS ACCUMULATED DEAD STORAGE)
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED BY ADDING DEAD STORAGE TO INITIAL CONTENTS.
* LOWER LIMIT, BASED ON 1936-37 HYDRO CONDITIONS

TABLE 3

ARROW LAKES COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1976

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUNE 1
1. PROBABLE FEB 1 - JULY 31 INFLOW, KSFD 1/		10644.4	10748.5	11278.3	10977.4	11033.7	11268.0
2. 95% FORECAST ERROR, KSFD		1779.8	1409.0	1296.7	1154.7	1123.8	1070.3
3. 95% CONFIDENCE FEB 1 - JULY 31 INFLOW, KSFD 2/		8864.6	9339.5	9981.6	9822.7	9909.9	10197.7
4. OBSERVED FEB 1 - DATE INFLOW, KSFD				294.3	638.8	1348.3	4018.7
5. 95% CONFIDENCE DATE - JULY 31 INFLOW, KSFD 3/		8864.6	9339.5	9687.3	9183.9	8561.6	6179.6
ASSUMED FEB 1 - JULY 31 INFLOW, % VOLUME		100.0					
ASSUMED FEB 1 - JULY 31 INFLOW, KSFD 4/		8864.6					
MIN. FEB 1 - JULY 31 OUTFLOW, KSFD		905.0					
MICA REFILL REQUIREMENTS, KSFD 5/		3114.6					
MIN. JAN 31 CONTENTS, KSFD 6/		829.5*					
MIN. JAN 31 ELEVATION, FT. 7/		1396.4					
JAN 31 VARIABLE REFILL CURVE, FT. 8/	1410.7	1396.4					
ASSUMED MAR 1 - JULY 31 INFLOW, % VOLUME		97.4	97.4				
ASSUMED MAR 1 - JULY 31 INFLOW, KSFD 4/		8634.1	9096.4				
MIN. MAR 1 - JULY 31 OUTFLOW, KSFD		765.0	765.0				
MICA REFILL REQUIREMENTS, KSFD 5/		3343.3	3151.4				
MIN. FEB 28 CONTENTS, KSFD 6/		365.2*	365.2*				
MIN. FEB 28 ELEVATION, FT. 7/		1386.6	1386.6				
FEB 28 VARIABLE REFILL CURVE, FT. 8/	1403.5	1386.6					
ASSUMED APR 1 - JULY 31 INFLOW, % VOLUME		94.3	94.3	96.8			
ASSUMED APR 1 - JULY 31 INFLOW, KSFD 4/		8359.3	8806.9	9377.3			
MIN. APR 1 - JULY 31 OUTFLOW, KSFD		610.0	610.0	610.0			
MICA REFILL REQUIREMENTS, KSFD 5/		3529.2	2529.2	3529.2			
MIN. MAR 31 CONTENTS, KSFD 6/		0	0	0			
MIN. MAR 31 ELEVATION, FT. 7/		1377.9	1377.9	1377.9			
MAR 31 VARIABLE REFILL CURVE, FT. 8/	1401.6	1377.9	1377.9	1377.9			
ASSUMED MAY 1 - JULY 31 INFLOW, % VOLUME		87.3	97.3	89.6	92.6		
ASSUMED MAY 1 - JULY 31 INFLOW, KSFD 4/		7738.8	8153.1	8679.8	8504.3		
MIN. MAY 1 - JULY 31 OUTFLOW, KSFD		460.0	460.0	460.0	460.0		
MICA REFILL REQUIREMENTS, KSFD 5/		3529.2	3529.2	3529.2	3529.2		
MIN. APR 30 CONTENTS, KSFD 6/		0	0	0	0		
MIN. APR 30 ELEVATION, FT. 7/		1377.9	1377.9	1377.9	1377.9		
APR 30 VARIABLE REFILL CURVE, FT. 8/	1392.4	1377.9	1377.9	1377.9	1377.9		
ASSUMED JUN 1 - JULY 31 INFLOW, % VOLUME		63.4	63.4	65.1	67.3	72.6	
ASSUMED JUN 1 - JULY 31 INFLOW, KSFD 4/		5620.2	5921.4	6306.4	6180.8	6215.7	
MIN. JUN 1 - JULY 31 OUTFLOW, KSFD		305.0	305.0	305.0	305.0	305.0	
MICA REFILL REQUIREMENTS, KSFD 5/		3086.8	3253.4	3371.6	3299.8	3299.7	
MIN. MAY 31 CONTENTS, KSFD 6/		1351.2	1216.5	949.8	1003.6	968.6	
MIN. MAY 31 ELEVATION, FT. 7/		1406.5	1403.9	1398.7	1399.8	1399.1	
MAY 31 VARIABLE REFILL CURVE, FT. 8/	1408.2	1406.5	1403.9	1398.7	1399.8	1399.1	
ASSUMED JUL 1 - JULY 31 INFLOW, % VOLUME		26.3	26.3	27.0	27.9	30.1	41.4
ASSUMED JUL 1 - JULY 31 INFLOW, KSFD 4/		2331.4	2456.2	2615.6	2562.3	2577.0	2558.4
MIN. JUL 1 - JULY 31 OUTFLOW, KSFD		155.0	155.0	155.0	155.0	155.0	155.0
MICA REFILL REQUIREMENTS, KSFD 5/		1493.4	1574.2	1632.7	1594.5	1596.9	1516.7
MIN. JUN 30 CONTENTS, KSFD 6/		2896.6	2852.6	2751.7	2766.8	2754.5	2692.9
MIN. JUN 30 ELEVATION, FT. 7/		1433.3	1432.6	1431.0	1431.2	1431.0	1430.0
JUN 30 VARIABLE REFILL CURVE, FT. 8/	1434.9	1433.3	1432.6	1431.0	1431.2	1431.0	1430.0
JULY 31 VARIABLE REFILL CURVE, FT.	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1 - LINE 2
3/ LINE 3 - LINE 4
4/ PRECEDING LINE X LINE 5
5/ MICA FULL CONTENT VARIABLE REFILL CURVE FROM MICA VRC COMPUTATION FORM
6/ FULL CONTENT (3579.6 KSFD) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT
7/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED FEBRUARY 28, 1974
8/ LOWER OF THE ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)
* LOWER LIMIT, BASED ON 1936-37 HYDRO CONDITIONS

DUNCAN RESERVOIR COMPUTATION FORM
95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE
1976

		INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
1.	PROBABLE FEB 1-July 31 INFLOW, KSFD 1/		959.8	953.2	972.9	971.2	966.3	986.6
2.	95% FORECAST ERROR, KSFD		157.1	129.7	121.3	121.8	117.8	103.2
3.	95% CONFIDENCE FEB 1-JULY 31 INFLOW, KSFD 2/		802.7	823.5	851.6	849.4	848.5	883.4
4.	OBSERVED FEB 1-DATE INFLOW, KSFD				22.5	42.0	89.2	311.8
5.	95% CONFIDENCE DATE-JULY 31 INFLOW, KSFD 3/		802.7	823.5	829.1	807.4	759.3	571.6
	ASSUMED FEB 1-JULY 31 INFLOW, % VOLUME		100.0					
	ASSUMED FEB 1-JULY 31 INFLOW, KSFD 4/		802.7					
	MIN. FEB 1-JULY 31 OUTFLOW, KSFD		18.1					
	MIN. JAN 31 RESERVOIR CONTENT, KSFD 5/		113.7*					
	MIN. JAN 31 RESERVOIR ELEVATION, FT. 6/		1816.0					
	JAN 31 VARIABLE REFILL CURVE, FT. 7/	1834.0	1816.0					
	ASSUMED MAR 1-JULY 31 INFLOW, % VOLUME		97.9	97.9				
	ASSUMED MAR 1-JULY 31 INFLOW, KSFD 4/		785.8	806.2				
	MIN. MAR 1-JULY 31 OUTFLOW, KSFD		15.3	15.3				
	MIN. FEB 28 RESERVOIR CONTENT, KSFD 5/		47.7*	47.7*				
	MIN. FEB 28 RESERVOIR ELEVATION, FT. 6/		1804.5	1804.5				
	FEB 28 VARIABLE REFILL CURVE, FT. 7/	1835.3	1804.5	1804.5				
	ASSUMED APR 1-JULY 31 INFLOW, % VOLUME		95.5	95.5	97.5			
	ASSUMED APR 1-JULY 31 INFLOW, KSFD 4/		766.5	786.4	808.4			
	MIN. APR 1-JULY 31 OUTFLOW, KSFD		12.2	12.2	12.2			
	MIN. MAR 31 RESERVOIR CONTENT, KSFD 5/		0	0	0			
	MIN. MAR 31 RESERVOIR ELEVATION, FT. 6/		1794.2	1794.2	1794.2			
	MAR 31 VARIABLE REFILL CURVE, FT. 7/	1837.2	1794.2	1794.2	1794.2			
	ASSUMED APR 16-JULY 31 INFLOW, % VOLUME		94.6	94.6	96.5	98.5		
	ASSUMED APR 16-JULY 31 INFLOW, KSFD 4/		759.4	779.0	800.1	795.3		
	MIN. APR 16-JULY 31 OUTFLOW, KSFD		10.7	10.7	10.7	10.7		
	MIN. APR 15 RESERVOIR CONTENT, KSFD 5/		0	0	0	0		
	MIN. APR 15 RESERVOIR ELEVATION, FT. 6/		1794.2	1794.2	1794.2	1794.2		
	APR 15 VARIABLE REFILL CURVE, FT. 7/	1835.7	1794.2	1794.2	1794.2	1794.2		
	ASSUMED MAY 1-JULY 31 INFLOW, % VOLUME		90.4	90.4	92.3	94.7		
	ASSUMED MAY 1-JULY 31 INFLOW, KSFD 4/		725.6	744.4	765.3	764.6		
	MIN. MAY 1-JULY 31 OUTFLOW, KSFD		9.2	9.2	9.2	9.2		
	MIN. APR 30 RESERVOIR CONTENT, KSFD 5/		0	0	0	0		
	MIN. APR 30 RESERVOIR ELEVATION, FT. 6/		1794.2	1794.2	1794.2	1794.2		
	APR 30 VARIABLE REFILL CURVE, FT. 7/	1834.2	1794.2	1794.2	1794.2	1794.2		
	ASSUMED JUN 1-JULY 31 INFLOW, % VOLUME		71.4	71.4	72.9	74.8	79.0	
	ASSUMED JUN 1-JULY 31 INFLOW, KSFD 4/		537.1	588.0	604.4	603.9	599.8	
	MIN. JUN 1-JULY 31 OUTFLOW, KSFD		6.1	6.1	6.1	6.1	6.1	
	MIN. MAY 31 RESERVOIR CONTENT, KSFD 5/		138.8	123.9	107.5	108.0	112.1	
	MIN. MAY 31 RESERVOIR ELEVATION, FT. 6/		1819.8	1817.5	1814.9	1815.0	1815.6	
	MAY 31 VARIABLE REFILL CURVE, FT. 7/	1848.6	1819.8	1817.5	1814.9	1815.0	1815.6	
	ASSUMED JULY 1-JULY 31 INFLOW, % VOLUME		32.5	32.5	33.1	34.0	35.9	45.5
	ASSUMED JULY 1-JULY 31 INFLOW, KSFD 4/		260.9	267.6	274.4	274.5	292.6	260.1
	MIN. JULY 1-JULY 31 OUTFLOW, KSFD		3.1	3.1	3.1	3.1	3.1	3.1
	MIN. JUN 30 RESERVOIR CONTENT, KSFD 5/		448.0	441.3	434.5	434.4	436.3	448.8
	MIN. JUN 30 RESERVOIR ELEVATION, FT. 6/		1861.8	1861.0	1860.1	1860.1	1860.4	1861.9
	JUN 30 VARIABLE REFILL CURVE, FT. 7/	1872.0	1861.8	1861.0	1860.1	1860.1	1860.4	1861.9
	JULY 31 VARIABLE REFILL CURVE, FT.	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ DEVELOPED BY CANADIAN ENTITY
2/ LINE 1-LINE 2
3/ LINE 3-LINE 4
4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (705.8) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
6/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED JUNE 20, 1974
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR (INITIAL)
* LOWER LIMIT, BASED ON 1936-37 HYDRO CONDITIONS

LIBBY COMPUTATION FORM

95 PERCENT CONFIDENCE FORECAST AND VARIABLE REFILL CURVE

1976

	INITIAL	JAN. 1	FEB. 1	MAR. 1	APR. 1	MAY 1	JUN. 1
1. 95% CONFIDENCE JAN 1 - JULY 31 INFLOW, KSFD 1/		2778.3	2709.9	2749.7	2748.7	2597.0	1549.2
2. OBSERVED JAN 1 - DATE INFLOW, KSFD		0.0					
3. RESIDUAL 95% DATE - JUL 31 INFLOW, KSFD 2/		2778.3	2709.9	2749.7	2748.7	2597.0	1549.2
ASSUMED FEB 1 - JUL 31 INFLOW, % VOLUME		96.94					
ASSUMED FEB 1 - JUL 31 INFLOW, KSFD 3/		2693.3					
MIN. FEB 1 - JUL 31 OUTFLOW, KSFD		362.0					
MIN. JAN 31 RESERVOIR CONTENT, KSFD 4/		156.0					
MIN. JAN 31 RESERVOIR ELEVATION, FT. 5/		2306.4					
JAN 31 VARIABLE REFILL CURVE, FT. 6/	2402.0	2347.3					
ASSUMED MAR 1 - JUL 31 INFLOW, % VOLUME		94.17	97.14				
ASSUMED MAR 1 - JUL 31 INFLOW, KSFD 3/		2616.3	2632.4				
MIN. MAR 1 - JUL 31 OUTFLOW, KSFD		306.0	306.0				
MIN. FEB 28 RESERVOIR CONTENT, KSFD 4/		176.9	160.9				
MIN. FEB 28 RESERVOIR ELEVATION, FT. 5/		2308.8	2306.9				
FEB 28 VARIABLE REFILL CURVE, FT. 6/	2400.6	2314.6	2314.6				
ASSUMED APR 1 - JUL 31 INFLOW, % VOLUME		90.79	93.66	96.42			
ASSUMED APR 1 - JUL 31 INFLOW, KSFD 3/		2522.4	2538.1	2651.3			
MIN. APR 1 - JUL 31 OUTFLOW, KSFD		244.0	244.0	244.0			
MIN. MAR 31 RESERVOIR CONTENT, KSFD 4/		208.9	193.2	80.0			
MIN. MAR 31 RESERVOIR ELEVATION, FT. 5/		2312.4	2310.7	2297.3			
MAR 31 VARIABLE REFILL CURVE, FT. 6/	2399.3	2312.4	2310.7	2297.3			
ASSUMED MAY 1 - JUL 31 INFLOW, % VOLUME		81.71	84.29	86.77	90.00		
ASSUMED MAY 1 - JUL 31 INFLOW, KSFD 3/		2270.1	2254.2	2385.9	2473.8		
MIN. MAY 1 - JUL 31 OUTFLOW, KSFD		184.0	184.0	184.0	184.0		
MIN. APR 30 RESERVOIR CONTENT, KSFD 4/		401.2	387.1	685.4	213.2		
MIN. APR 30 RESERVOIR ELEVATION, FT. 5/		2332.3	2330.9	2320.1	2312.9		
APR 30 VARIABLE REFILL CURVE, FT. 6/	2398.0	2332.3	2330.9	2320.1	2312.9		
ASSUMED JUN 1 - JUL 31 INFLOW, % VOLUME		52.75	54.42	56.02	58.10	64.56	
ASSUMED JUN 1 - JUL 31 INFLOW, KSFD 3/		1465.0	1474.7	1540.4	1597.0	1676.6	
MIN. JUN 1 - JUL 31 OUTFLOW, KSFD		122.0	122.0	122.0	122.0	183.0	
MIN. MAY 31 RESERVOIR CONTENT, KSFD 4/		1143.7	1134.6	1068.9	1028.0	993.1	
MIN. MAY 31 RESERVOIR ELEVATION, FT. 5/		2389.9	2389.3	2385.1	2382.4	2380.1	
MAY 31 VARIABLE REFILL CURVE, FT. 6/	2423.4	2389.9	2389.3	2385.1	2382.4	2380.1	
ASSUMED JUL 1 - JUL 31 INFLOW, % VOLUME		18.97	19.57	20.15	20.90	23.22	35.97
ASSUMED JUL 1 - JUL 31 INFLOW, KSFD 3/		427.0	530.3	554.1	474.5	603.0	557.2
MIN. JUL 1 - JUL 31 OUTFLOW, KSFD		62.0	62.0	62.0	62.0	93.0	93.0
MIN. JUN 30 RESERVOIR CONTENT, KSFD 4/		2022.3	2019.0	1995.2	1990.5	1977.3	2038.8
MIN. JUN 30 RESERVOIR ELEVATION, FT. 5/		2438.0	2437.9	2436.7	2436.5	2455.4	2438.8
JUN 30 VARIABLE REFILL CURVE, FT. 6/	2449.7	2438.0	2437.9	2436.7	2436.5	2435.9	2438.8
JULY 31 VARIABLE REFILL CURVE, FT.		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0

1/ .50417 TIMES SUM OF TWO SUB-BASIN 95% INFLOW FORECASTS, (KAF)
2/ LINE 1 MINUS LINE 2
3/ PRECEDING LINE X LINE 3
4/ FULL CONTENT (2487.3 KSFD) PLUS PRECEDING LINE LESS LINE PRECEDING THAT
5/ FROM RESERVOIR ELEVATION-STORAGE CONTENT TABLE DATED MARCH 17, 1972
6/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR, BUT NOT LESS THAN THE LOWEST RULE CURVE

COMPUTATION OF INITIAL CONTROLLED FLOW
COLUMBIA RIVER AT THE DALLES, OREGON
1 MAY 1976

1 May forecast of May - August Unregulated Runoff Volume, MAF		94.1
Less Estimated Depletions, MAF		1.5
Less Upstream Storage Corrections, MAF		
Mica	6.4	
Arrow	5.0	
Libby	4.4	
Duncan	1.2	
Hungry Horse	1.4	
Flathead Lake	.5	
Noxon	.1	
Pend Oreille Lake	.5	
Grand Coulee	4.9	
Brownlee	.5	
Dworshak	1.6	
John Day	.2	
TOTAL	26.7	26.7
Forecast of Adjusted Residual Runoff Volume, MAF		65.9
Computed Initial Controlled Flow (From Chart 1, of Interim Flood Control Plan), KCFS		430.0

COLUMBIA RIVER BASIN
OCTOBER 1975 – APRIL 1976 PRECIPITATION
PERCENT OF 1958–73 AVERAGE

CHART 1
SEASONAL
PRECIPITATION

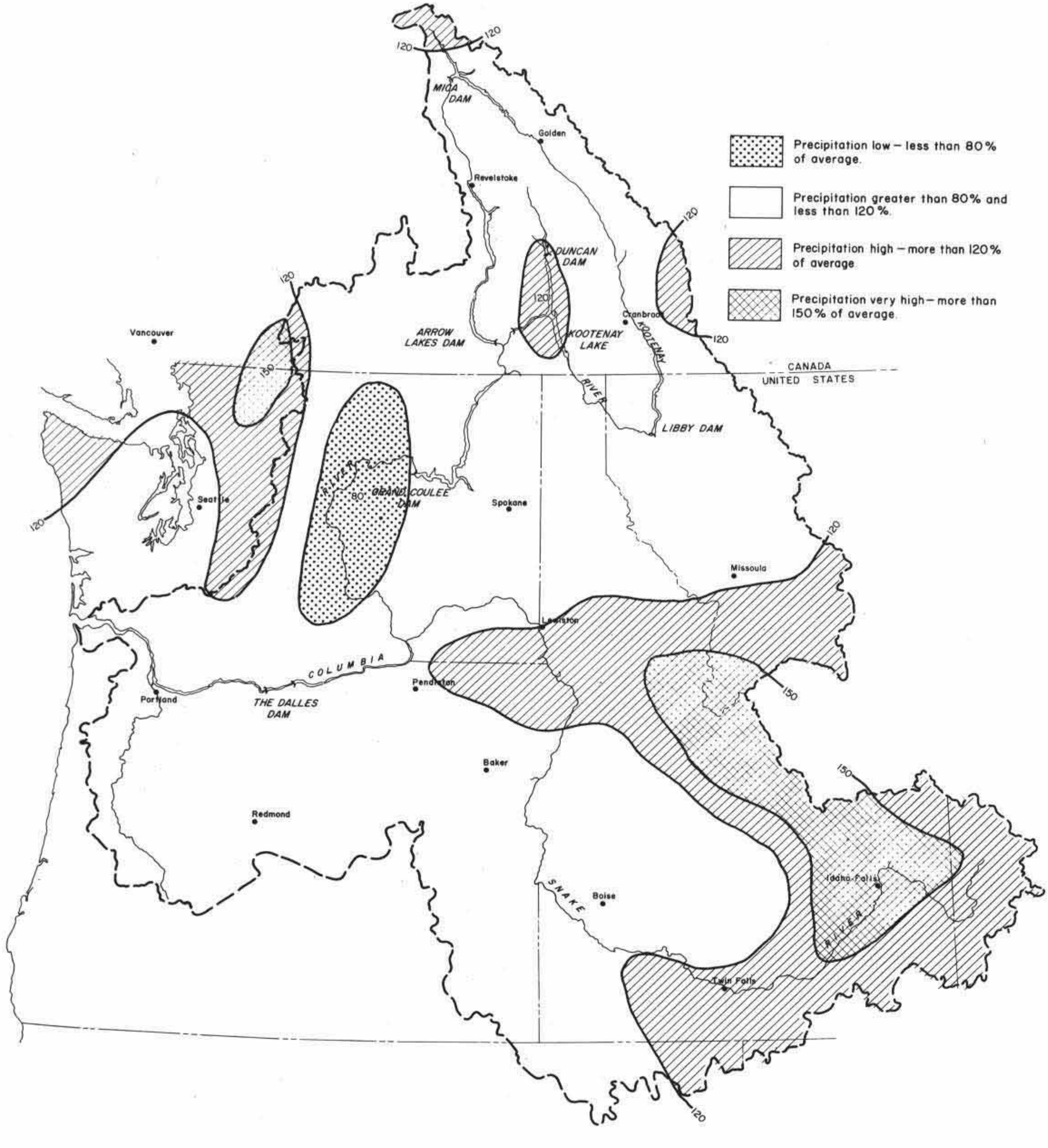


CHART 2

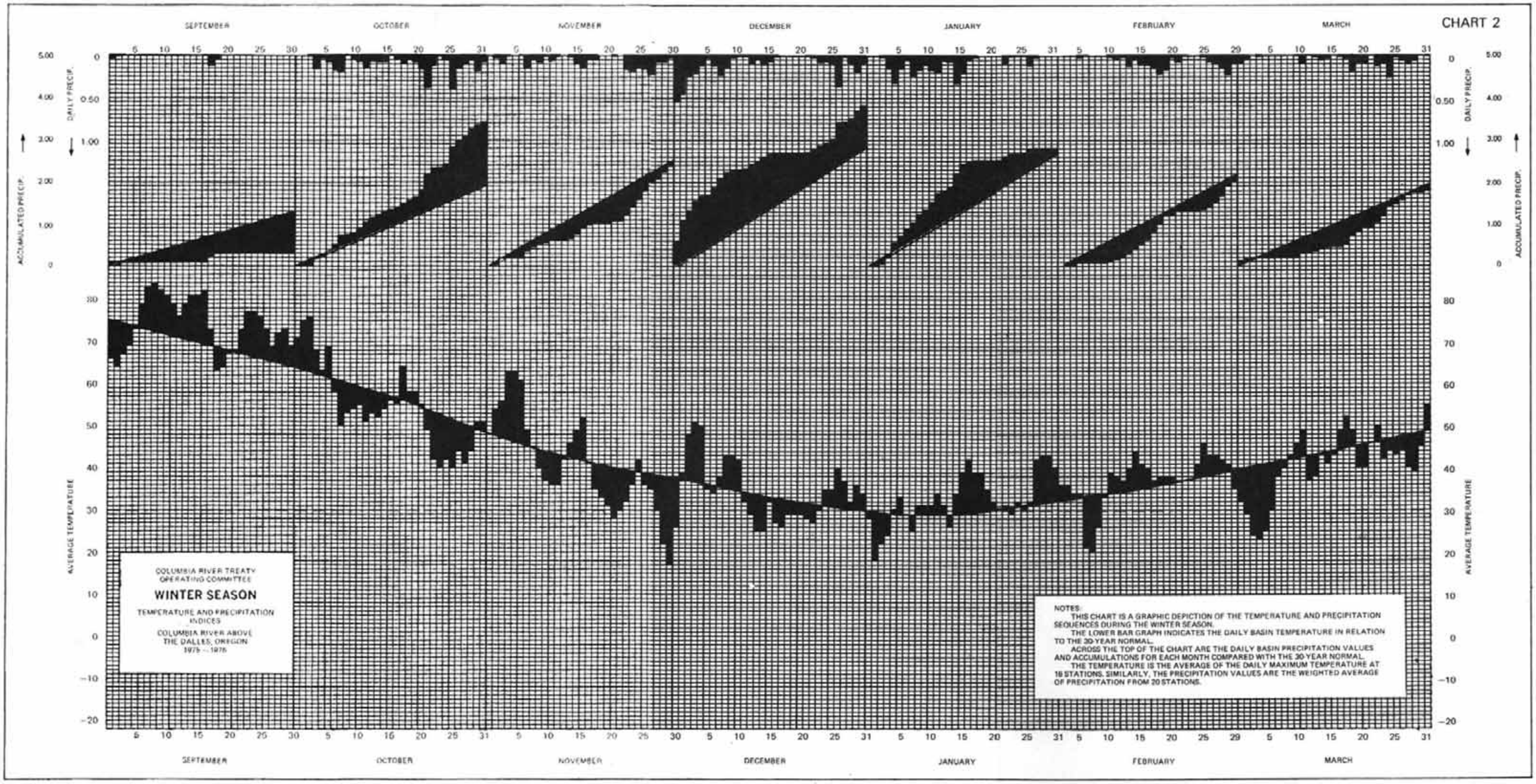
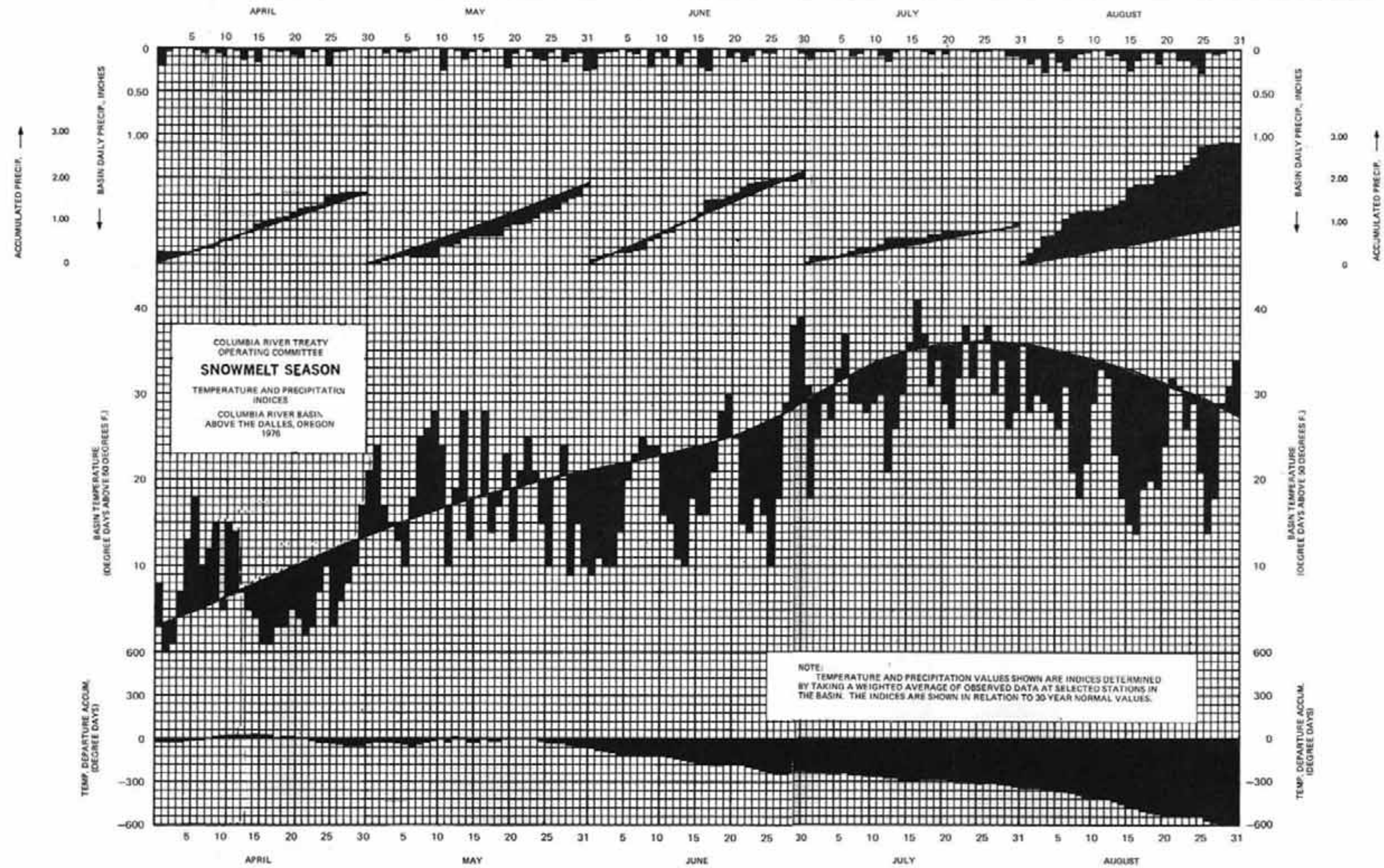
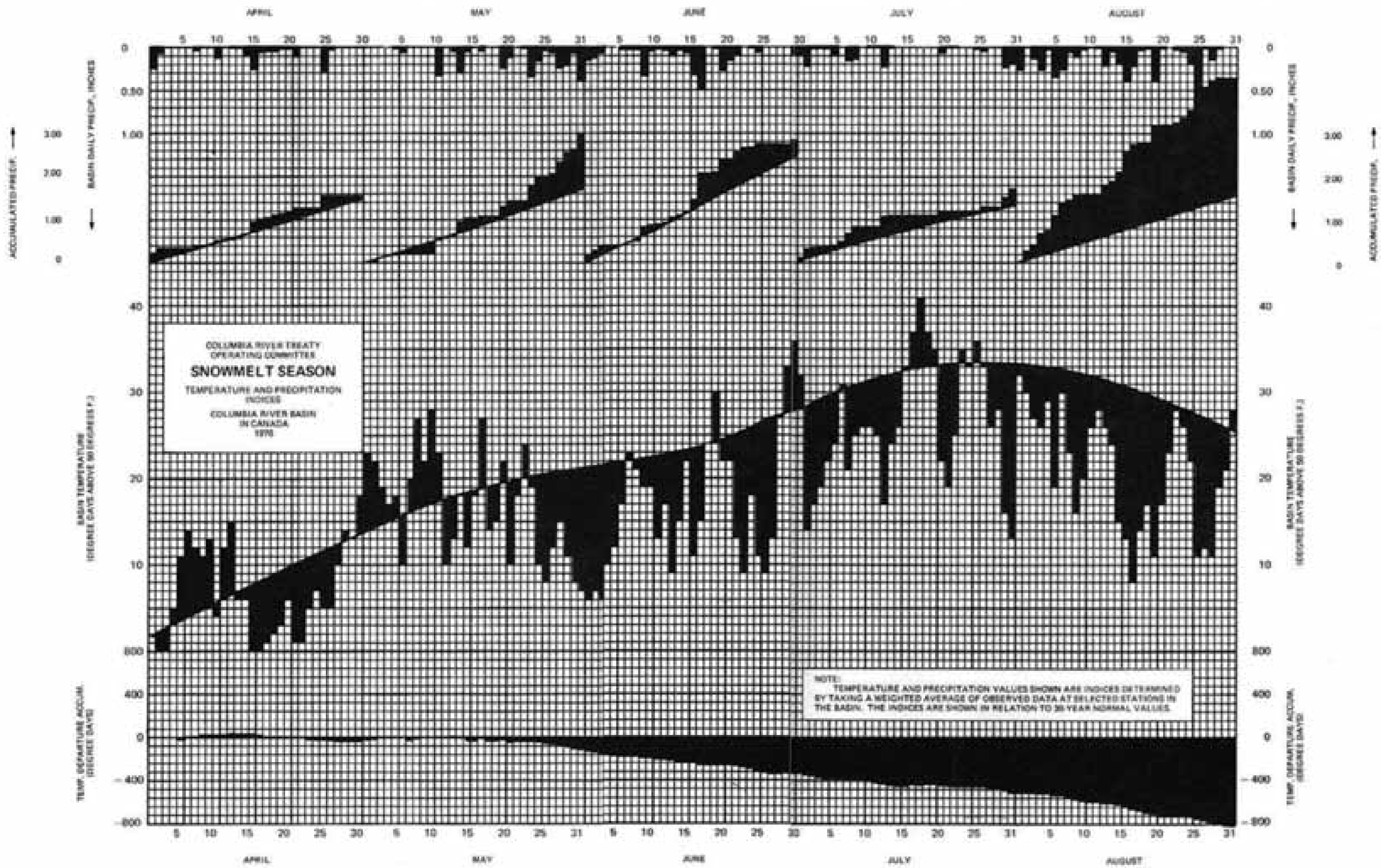

SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
DAILY PRECIP.
ACCUMULATED PRECIP.
AVERAGE TEMPERATURE
COLUMBIA RIVER TREATY
OPERATING COMMITTEE
WINTER SEASON
TEMPERATURE AND PRECIPITATION
INDICES
COLUMBIA RIVER ABOVE
THE DALLES, OREGON
1975 – 1976
NOTES:
THIS CHART IS A GRAPHIC DEPICTION OF THE TEMPERATURE AND PRECIPITATION SEQUENCES DURING THE WINTER SEASON.
THE LOWER BAR GRAPH INDICATES THE DAILY BASIN TEMPERATURE IN RELATION TO THE 30-YEAR NORMAL.
ACROSS THE TOP OF THE CHART ARE THE DAILY BASIN PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH THE 30-YEAR NORMAL.
THE TEMPERATURE IS THE AVERAGE OF THE DAILY MAXIMUM TEMPERATURE AT 16 STATIONS. SIMILARLY, THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF PRECIPITATION FROM 20 STATIONS.

CHART 3



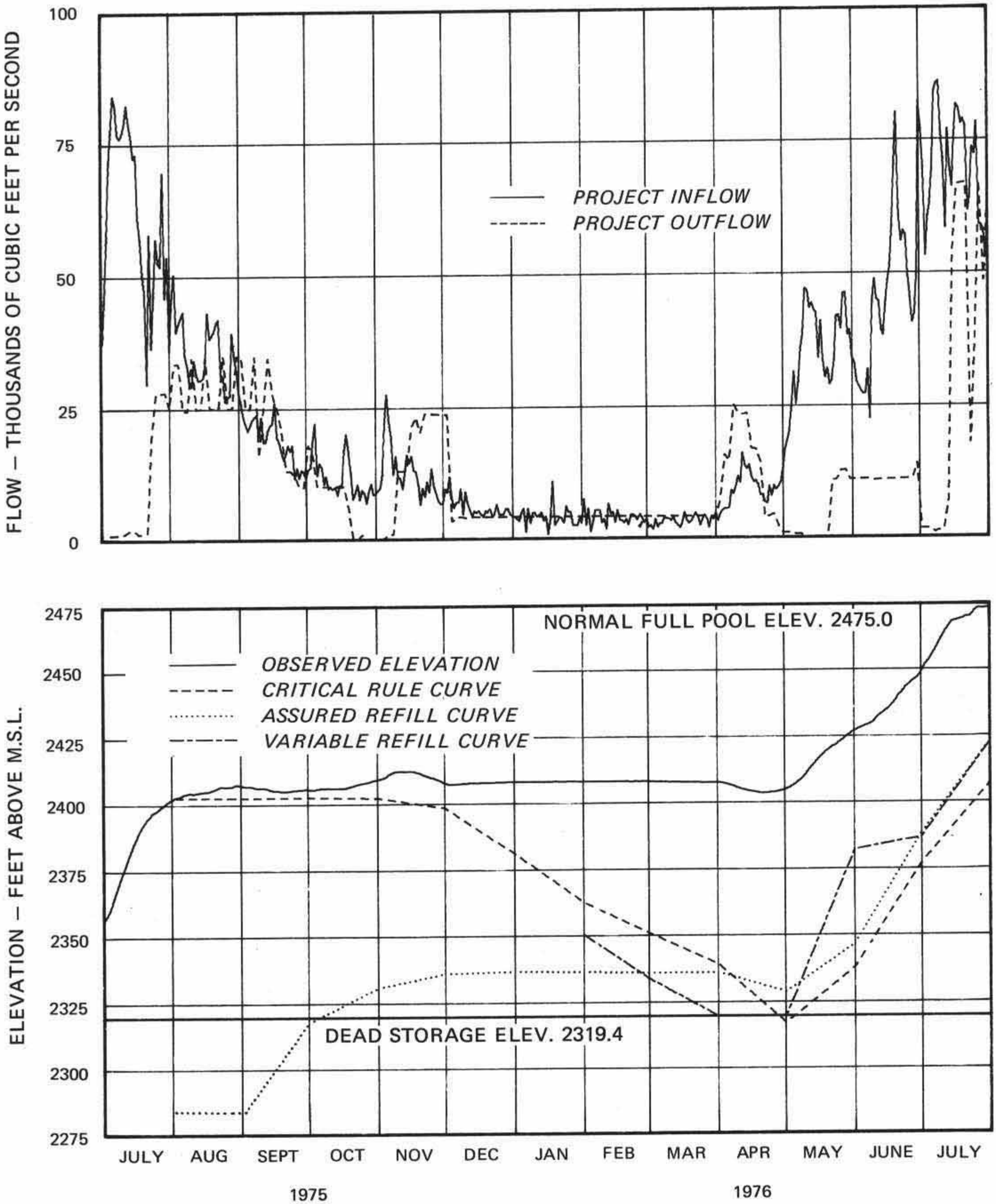
APRIL 1976

CHART 4

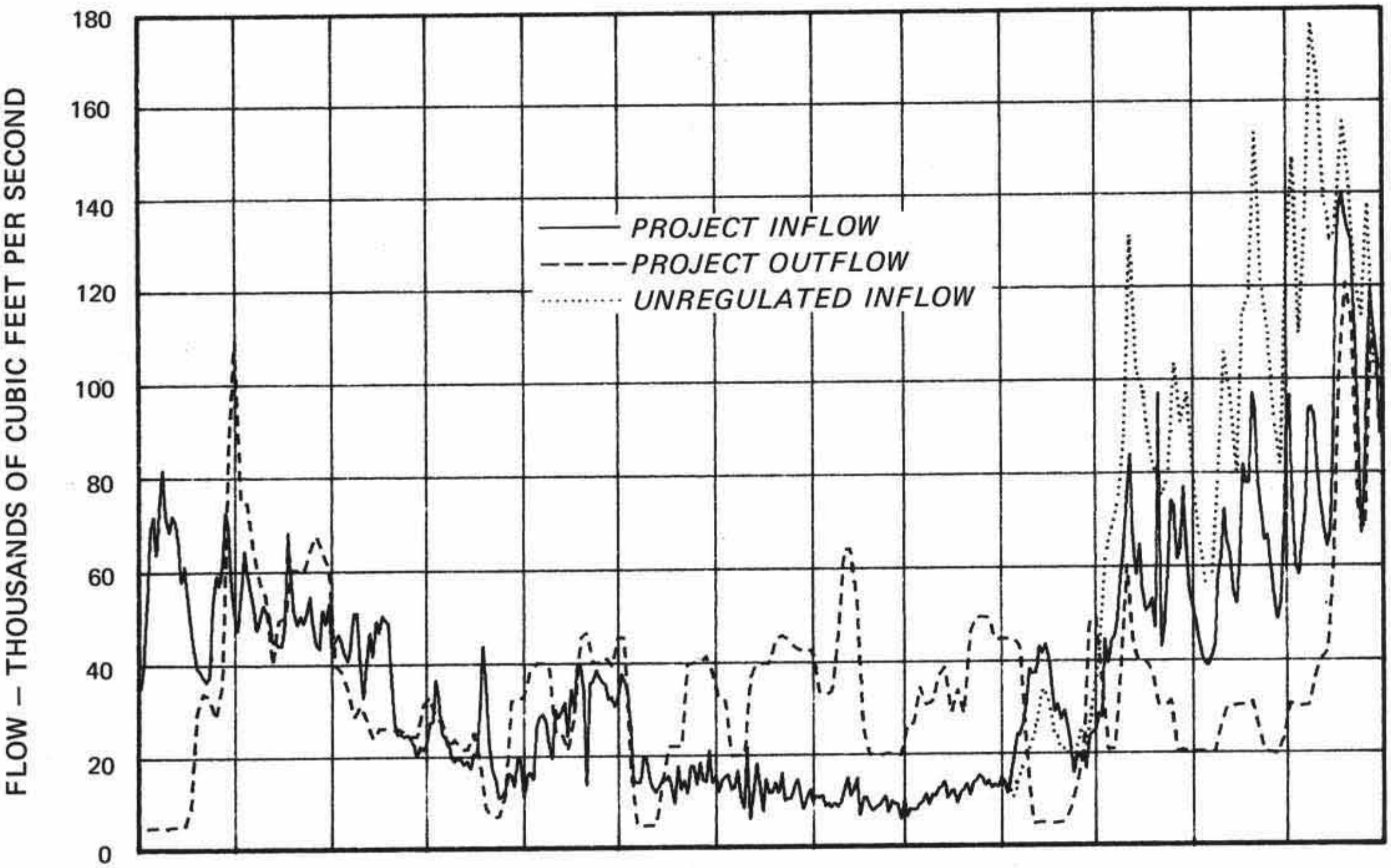


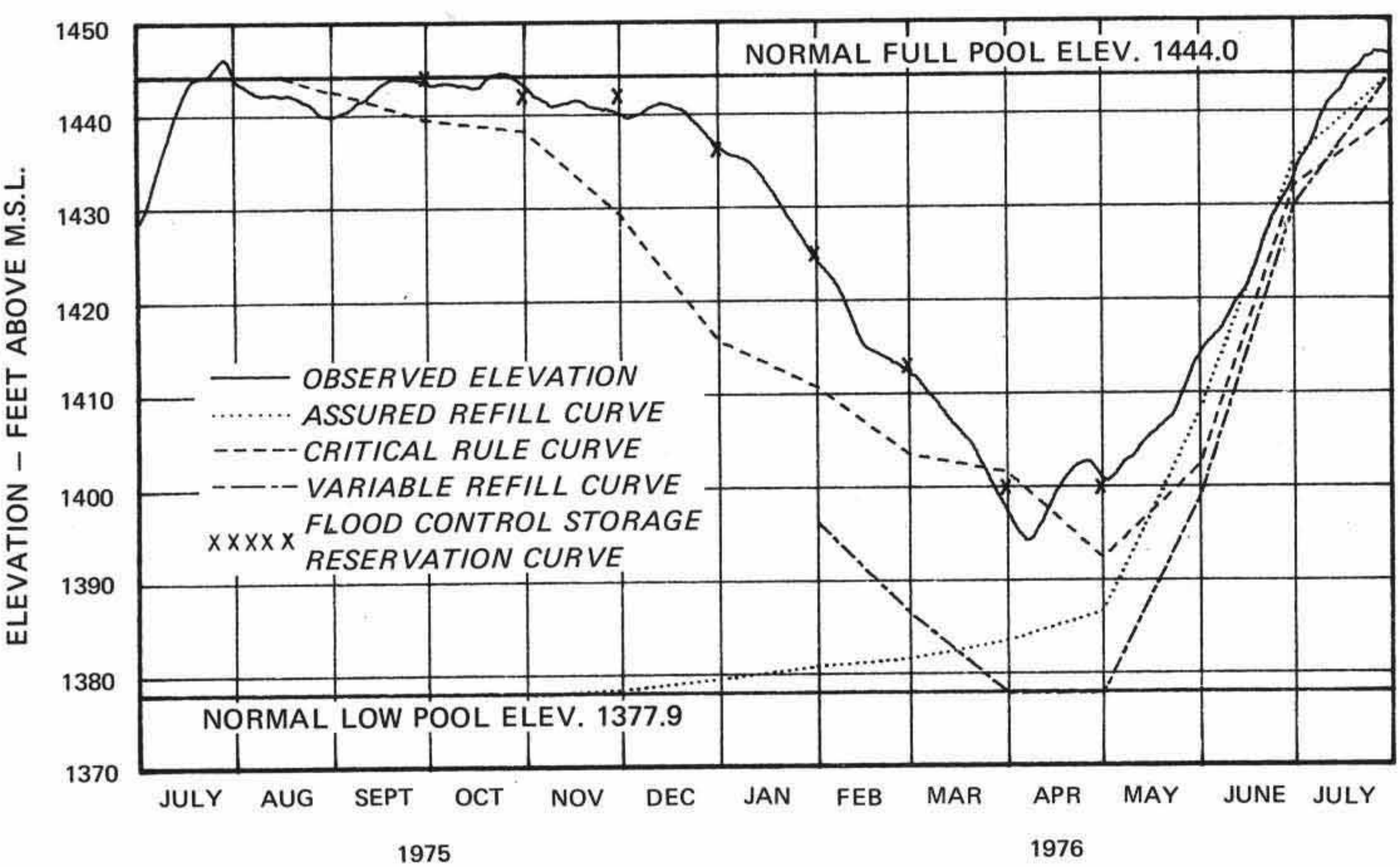
APRIL 1976

REGULATION OF MICA
1 JULY 1975 – 31 JULY 1976

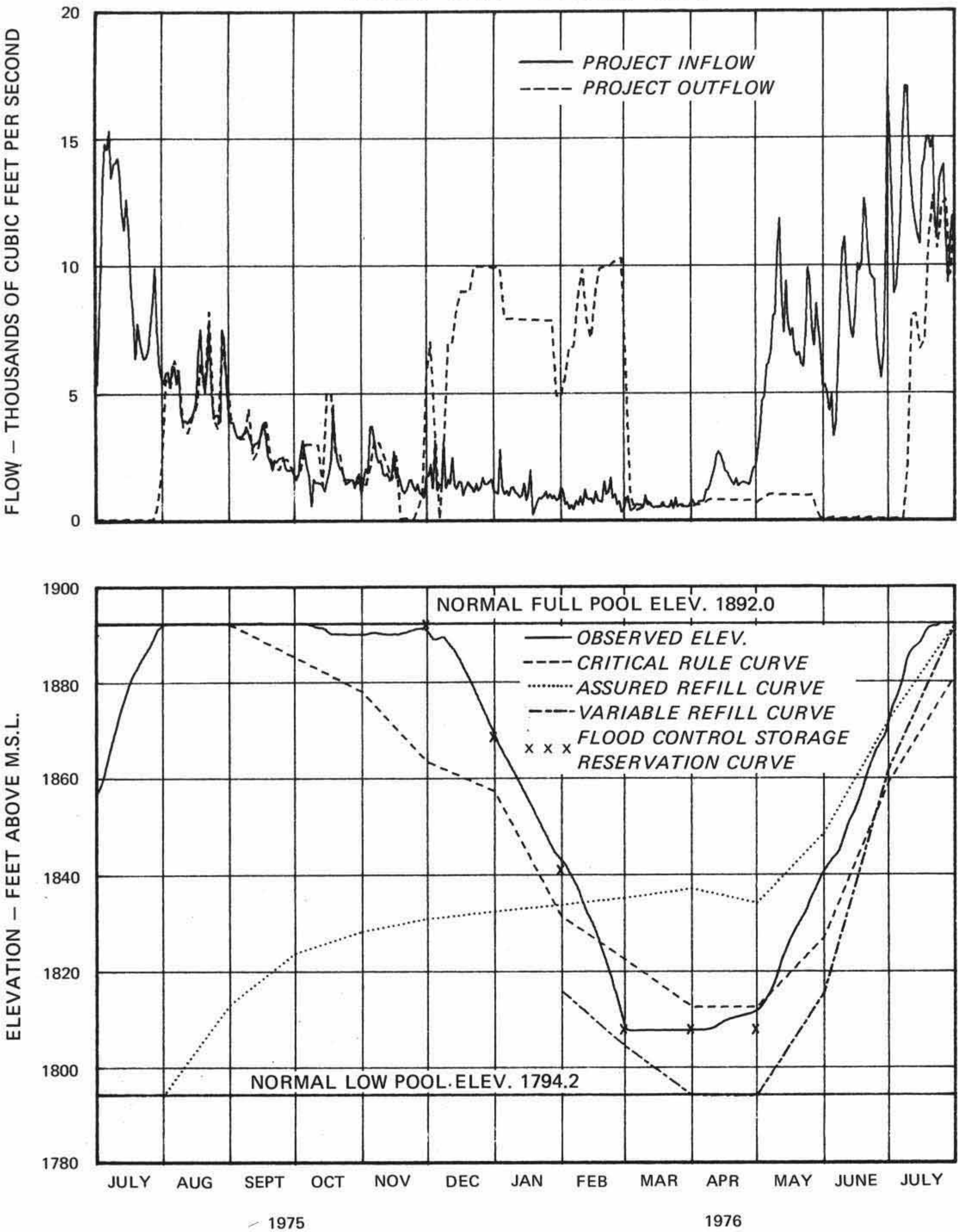


REGULATION OF ARROW
1 JULY 1975 – 31 JULY 1976

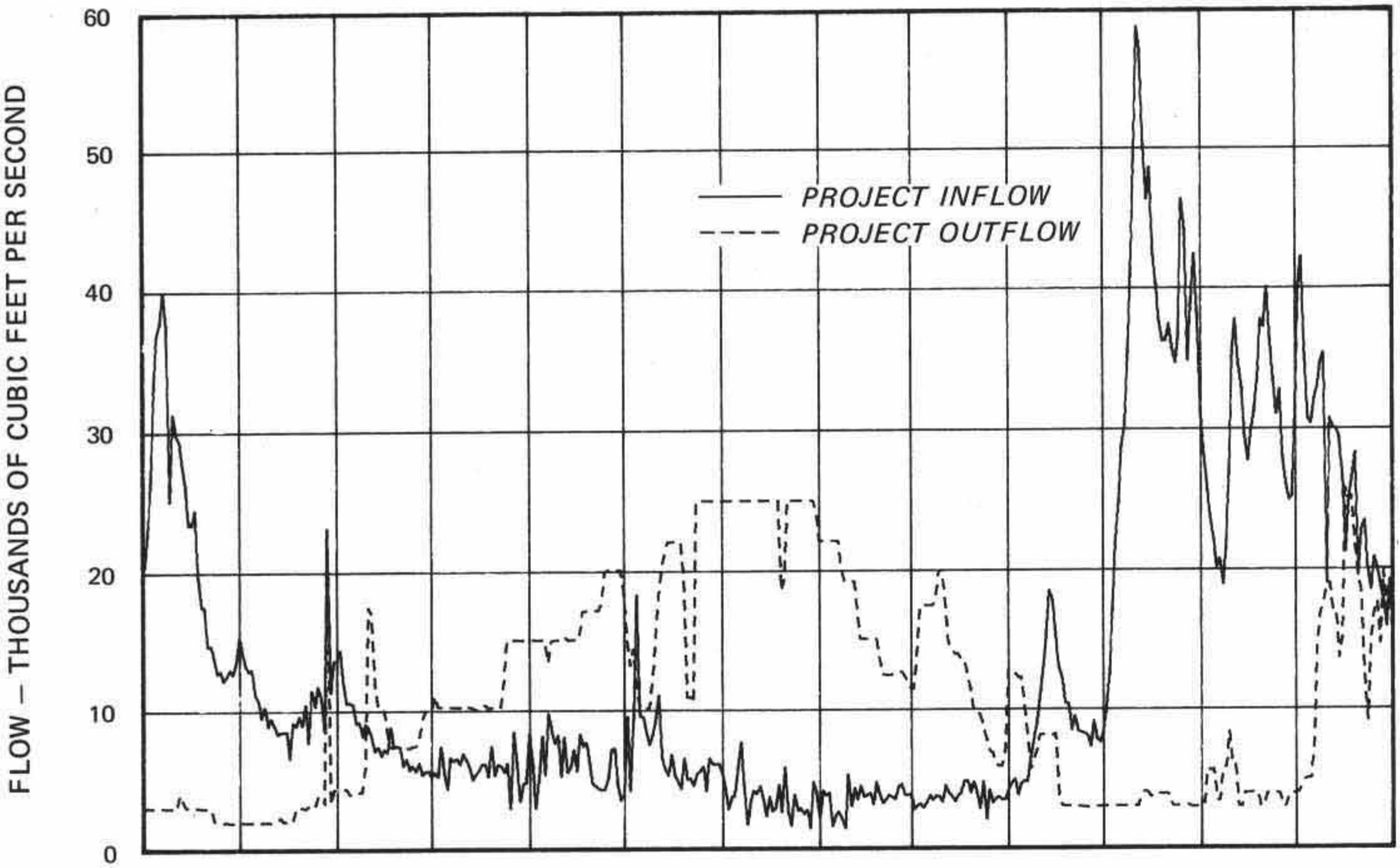


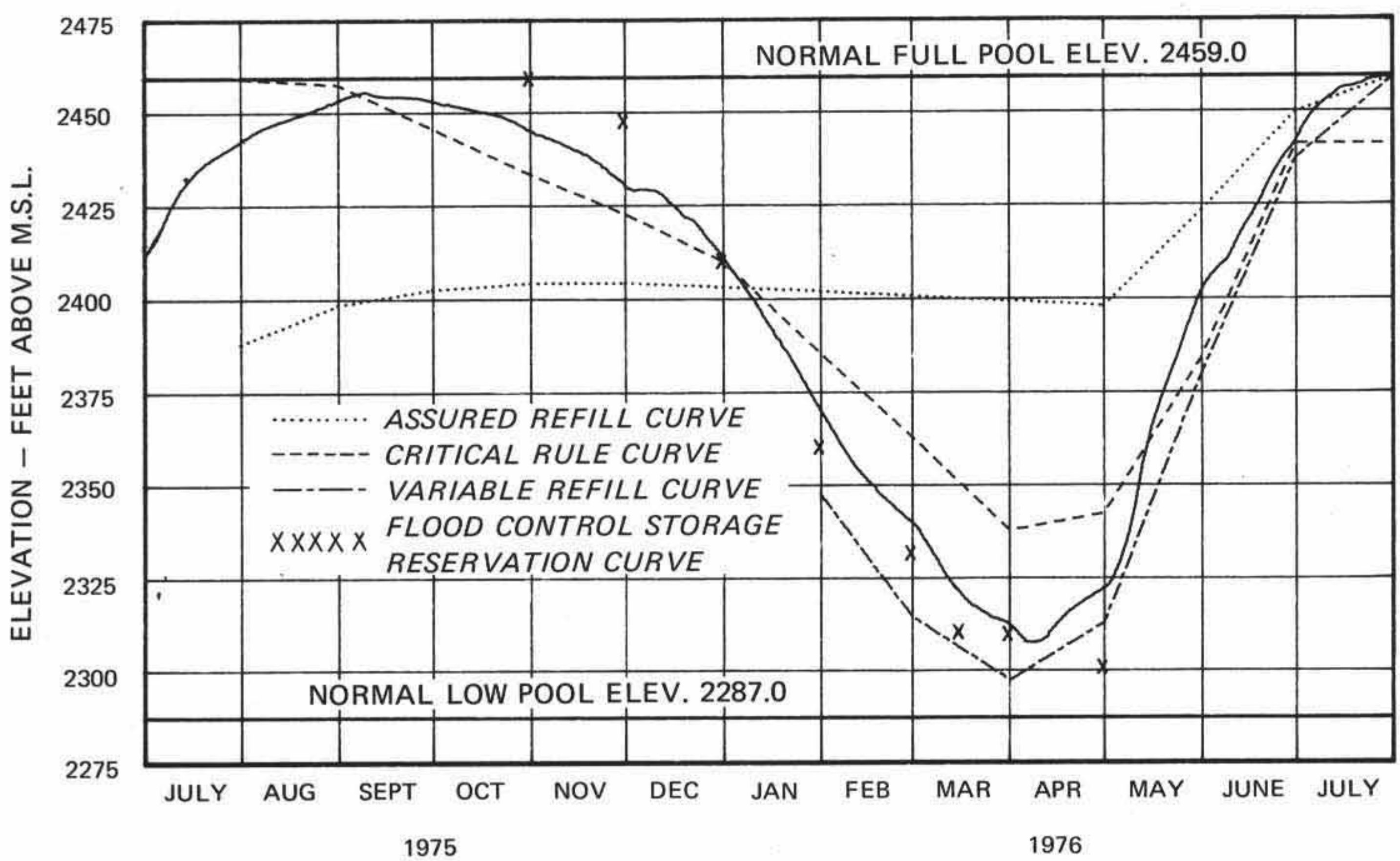


REGULATION OF DUNCAN
1 JULY 1975 – 31 JULY 1976

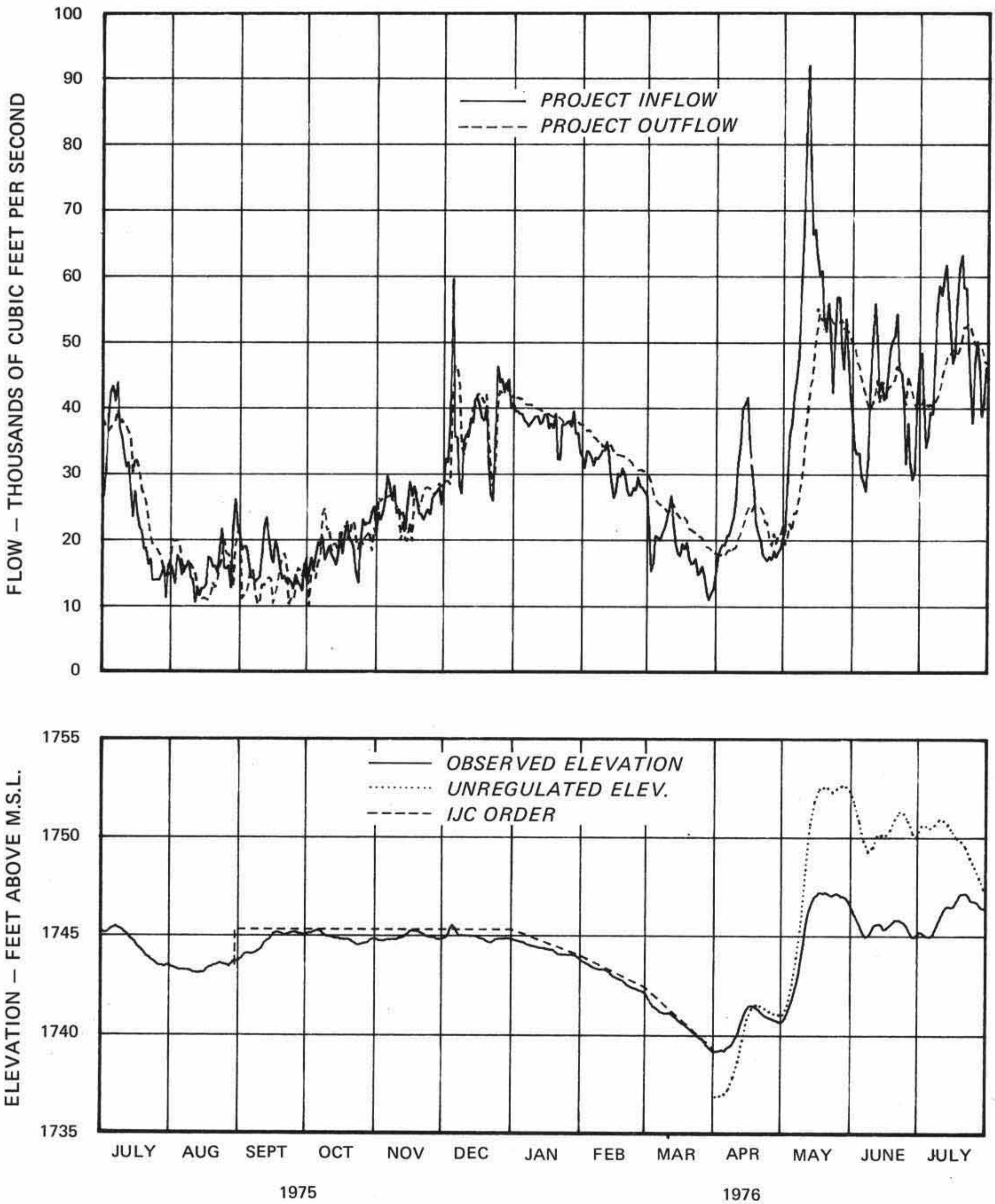


REGULATION OF LIBBY
1 JULY 1975 – 31 JULY 1976

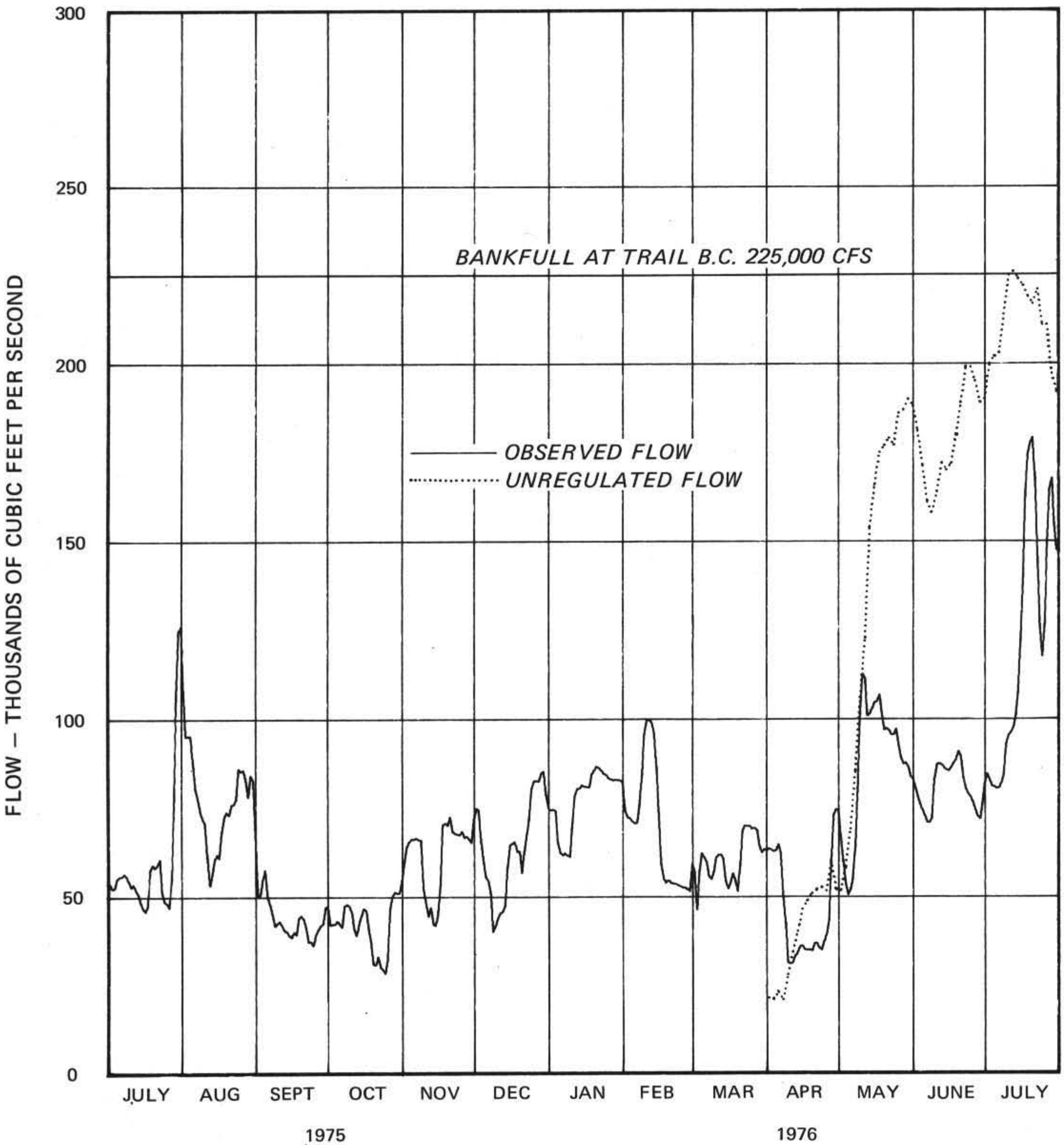




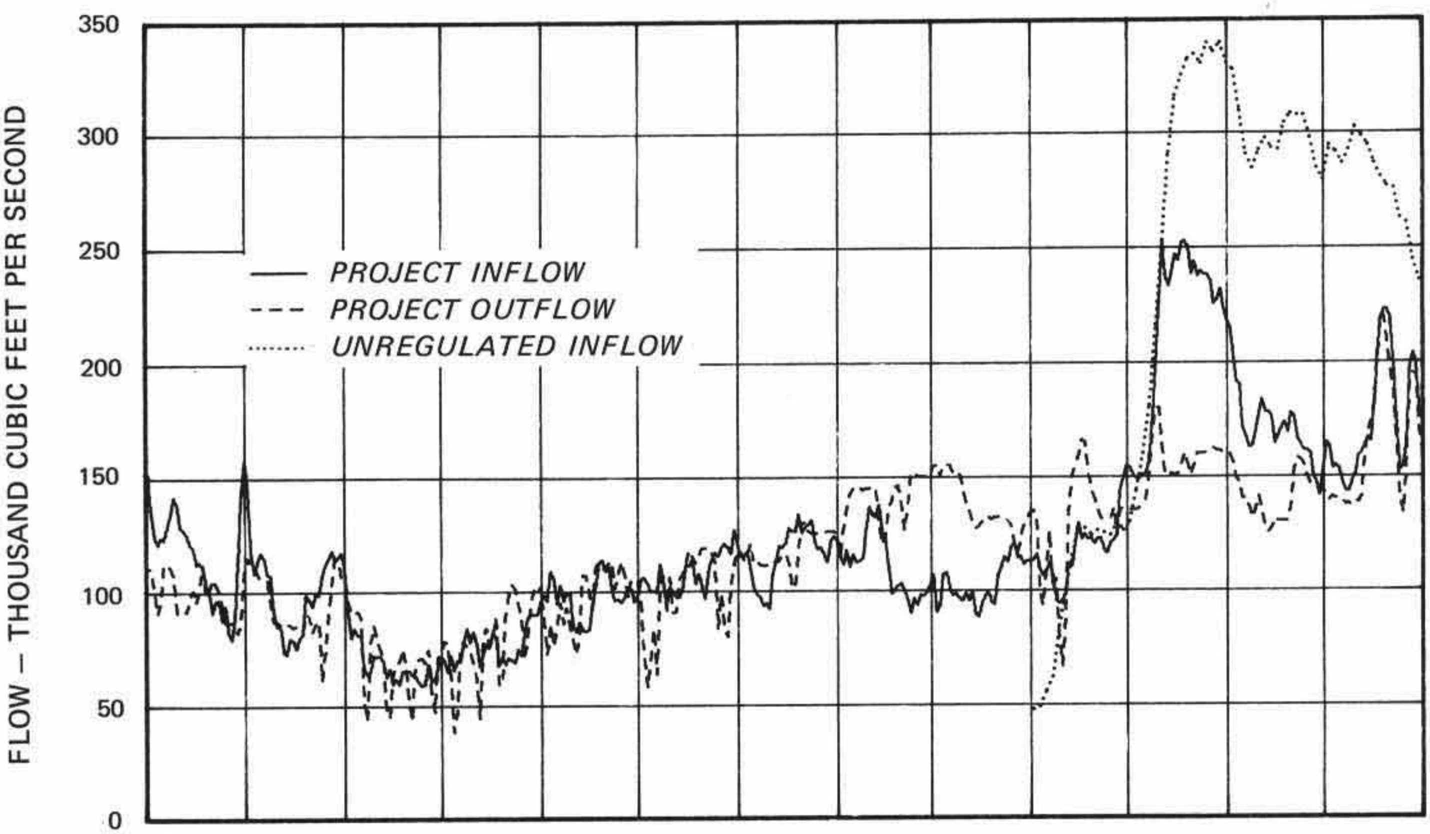
REGULATION OF KOOTENAY LAKE
1 JULY 1975 – 31 JULY 1976



COLUMBIA RIVER AT BIRCHBANK
1 JULY 1975 – 31 JULY 1976



REGULATION OF GRAND COULEE
1 JULY 1975 – 31 JULY 1976



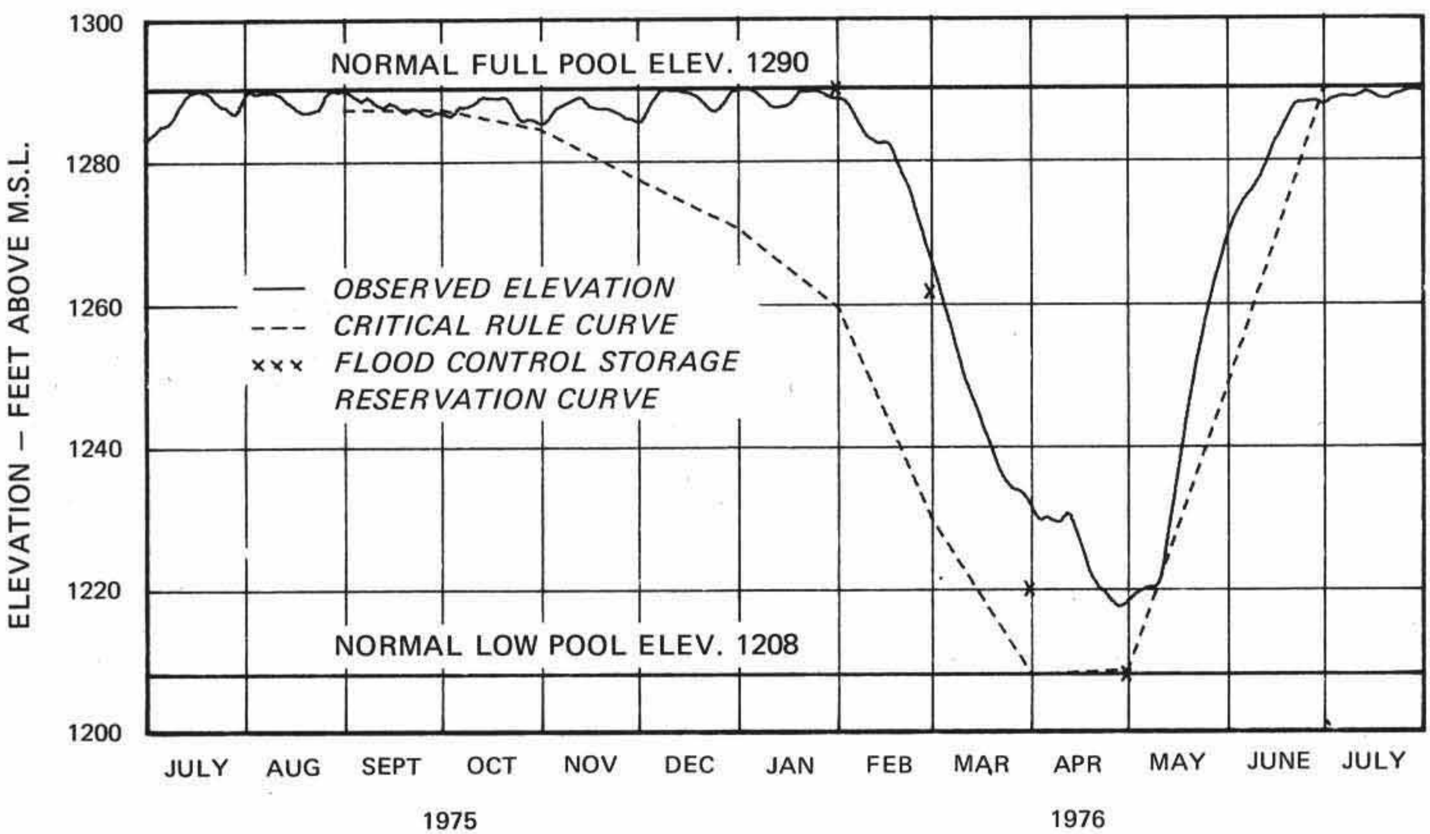
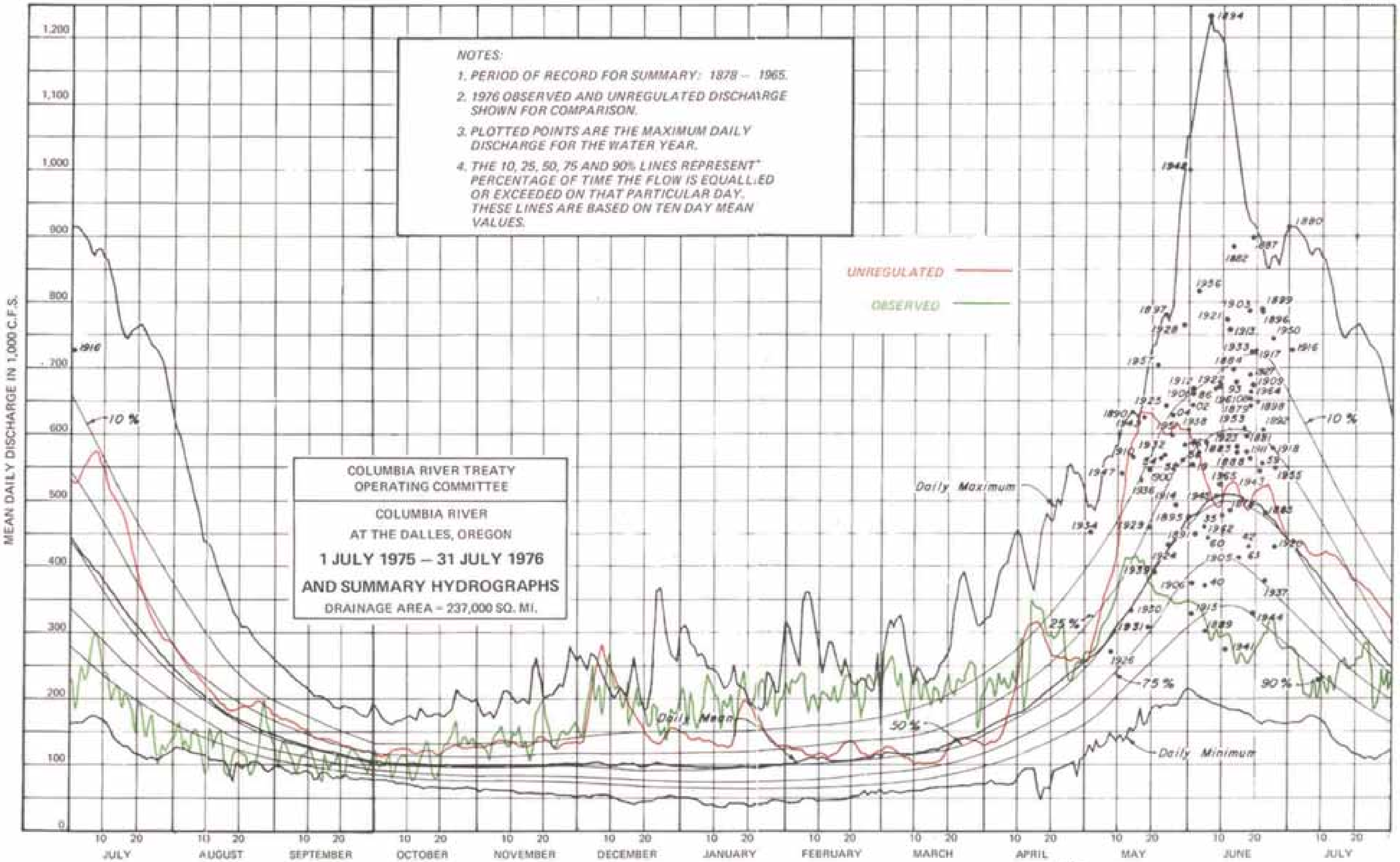


CHART 12



NOTES:
1. PERIOD OF RECORD FOR SUMMARY: 1878 – 1965.
2. 1976 OBSERVED AND UNREGULATED DISCHARGE SHOWN FOR COMPARISON.
3. PLOTTED POINTS ARE THE MAXIMUM DAILY DISCHARGE FOR THE WATER YEAR.
4. THE 10, 25, 50, 75 AND 90% LINES REPRESENT PERCENTAGE OF TIME THE FLOW IS EQUALLED OR EXCEEDED ON THAT PARTICULAR DAY. THESE LINES ARE BASED ON TEN DAY MEAN VALUES.
COLUMBIA RIVER TREATY OPERATING COMMITTEE
COLUMBIA RIVER
AT THE DALLES, OREGON
1 JULY 1975 – 31 JULY 1976
AND SUMMARY HYDROGRAPHS
DRAINAGE AREA – 237,000 SQ. MI.
UNREGULATED
OBSERVED
MEAN DAILY DISCHARGE IN 1,000 C.F.S.
Daily Maximum
Daily Mean
Daily Minimum
10 %
25 %
50 %
75 %
90 %
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY

COLUMBIA RIVER AT THE DALLES
1 APRIL 1976 – 31 JULY 1976

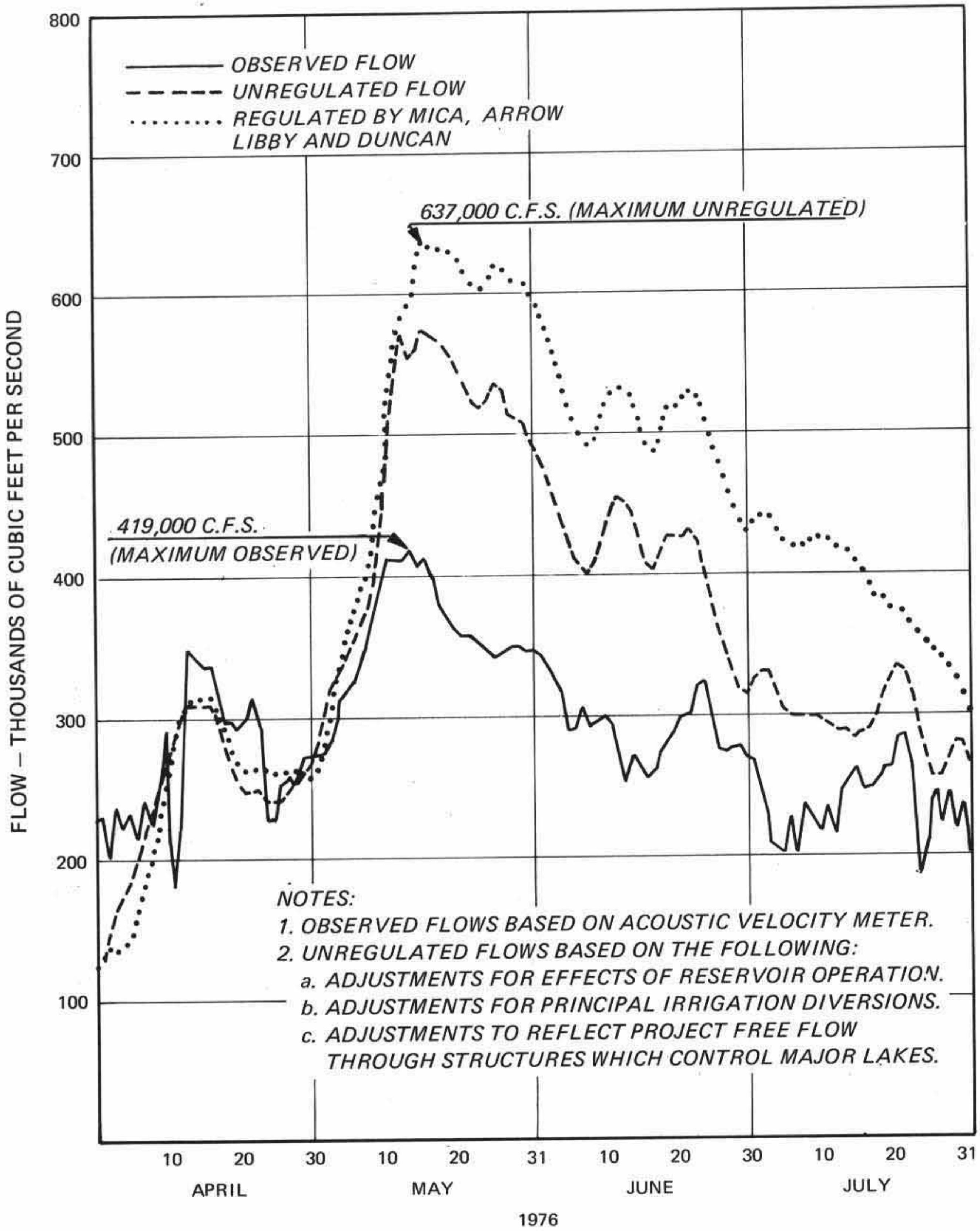
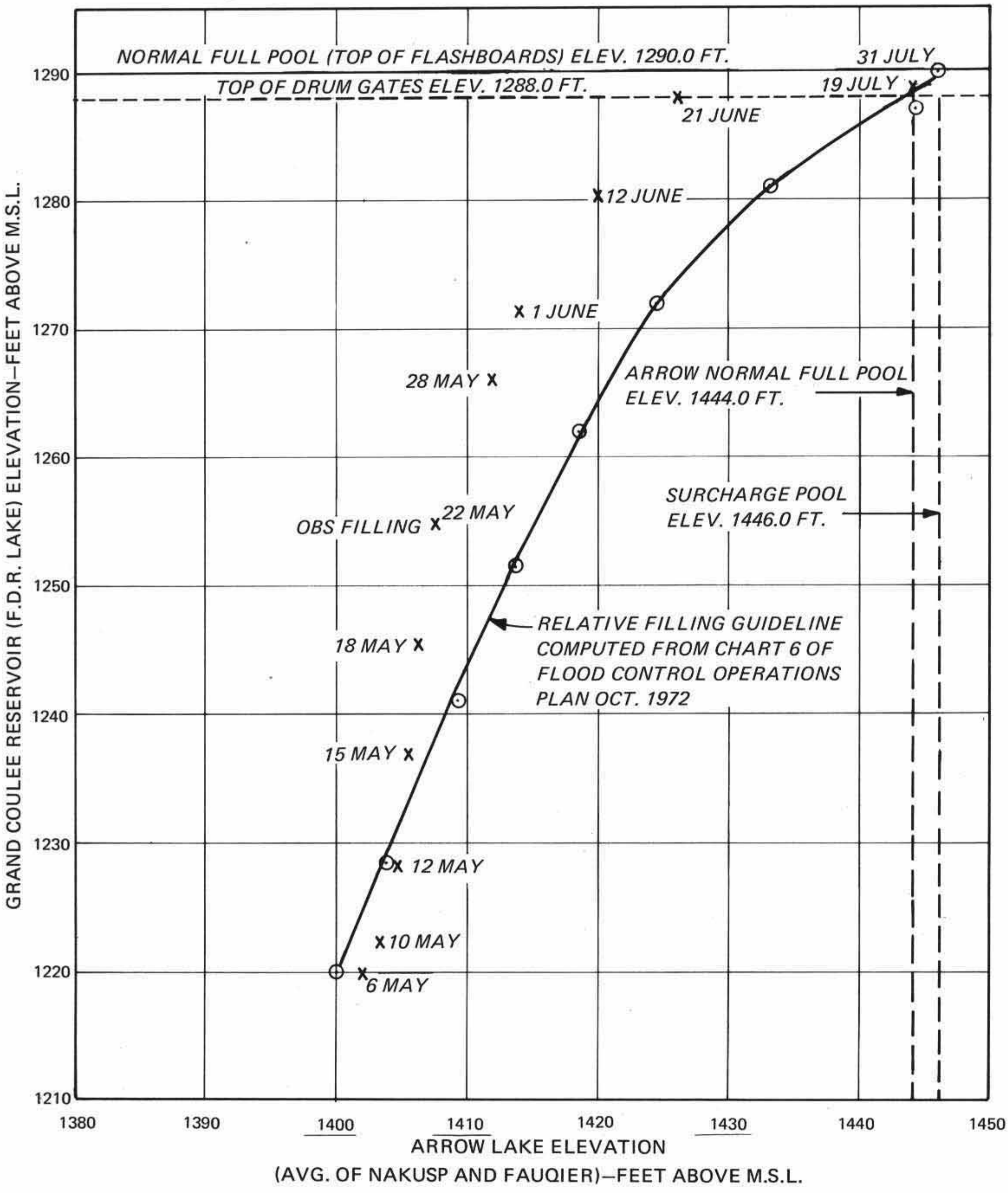


CHART 14
ARROW AND
GRAND COULEE

RELATIVE FILLING
ARROW AND GRAND COULEE



REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period 1 August 1975 through 31 July 1976:

1. "Principle and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage," dated 25 July 1967.

2. "Columbia River Treaty Hydroelectric Operating Plans for Canadian Storage, Operating Year 1975-76," dated 1 July 1970.

3. "Columbia River Treaty Detailed Operating Plan for Canadian Storage, 1 August 1975 through 31 July 1976," dated September 1975.

4. "Columbia River Treaty Flood Control Operating Plan," dated October 1972.

5. "Program for Initial Filling of Mica Reservoir" dated 26 July 1967.