REPORT ON OPERATION OF COLUMBIA RIVER TREATY PROJECTS

1 AUGUST 1969 THROUGH 31 JULY 1970

COLUMBIA RIVER TREATY OPERATING COMMITTEE

NOVEMBER 1970

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OPERATION OF COLUMBIA RIVER

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COLUMBIA RIVER TREATY OPERATING COMMITTEE

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REPORT ON

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I. INTRODUCTION

The Treaty between Canada and the United States of America relating to the cooperative development of the water resources of the Columbia River Basin requires that storage reservoirs constructed under the Treaty be operated for the purposes of increasing hydroelectric power generation and flood control in the United States and Canada.

The Columbia River Treaty Operating Committee was established on 19 September 1968 by the United States and Canadian Entities to be responsible for preparing and implementing annual operating plans to achieve the purposes of the Columbia River Treaty. Under its terms of reference the Operating Committee prepares an annual report reviewing the preceding year's operation of Treaty storage reservoirs. This is the second report and covers the operating year 1 August 1969 through 31 July 1970. The report reviews and records the actual operation of the Duncan and Arrow projects for power and flood control and the major effects of their operation downstream in Canada and the United States. Both projects were fully operational for power and flood control during the year covered by this report.

During the year power and energy related to the Canadian share of the hydroelectric power generation was delivered to the participants of the Columbia Storage Power Exchange. These deliveries were in accordance with the terms of the Canadian Entitlement Purchase Agreement and associated agreements between United States interests. The CSPE is a group of utilities in the United States who purchased the Canadian entitlement and exchanged such entitlement with the Bonneville Power Administration for specified amounts of power and energy.

II. OPERATING CRITERIA

A. General

The Columbia River Treaty requires that the reservoirs constructed in Canada be operated pursuant to hydroelectric operating plans developed thereunder. Annex A of the Treaty provides for the development of 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 immediately preceding each operating year, 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 Interim Flood Control Operating Plan of 12 November 1968, both developed by the Operating Committee, establish the general criteria of operations.

The Assured Operating Plan established Operating Rule Curves for Duncan and Arrow during the 1969-70 operating year. The Operating Rule Curves provide guidelines for refill levels as well as drawdown levels. They were derived from Critical Rule Curves, Assured Refill Curves, and simulated Variable Refill Curves and are consistent with flood control requirements, as described in the Principles and Procedures. The Flood Control Storage Reservation Curves were established to conform to the Interim Flood Control Operating Plan.

The Detailed Operating Plan established Operating Rule Curves based on power loads and resource data available just prior to the operating year for use in actual operations. The Variable Refill Curves and flood control requirements subsequent to January 1 are determined on the basis of seasonal volume runoff forecasts during actual operations.

B. Power Operation

The Detailed Operating Plan 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 within the limits of the Critical Rule Curves, Assured Refill Curves, Variable Refill Curves and the Flood Control Storage Reservation Curves determined in accordance with the Detailed Operating Plan.

C. Flood Control Operation

The Interim 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 consists of evacuating and holding available, insofar as possible, storage space sufficient to control the maximum flood that may occur under forecast conditions. Runoff volume forecasts are the criteria for determining the volume of storage space required.

Flood control operation of the Columbia River Treaty projects during the refill period is controlled in part by the computed initial controlled flow. 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 establish the operations of the flood control storage. These forecasts were prepared daily by the Cooperative Columbia River Forecasting Unit for periods of 30 to 45 days using both moderate and severe snowmelt sequences.

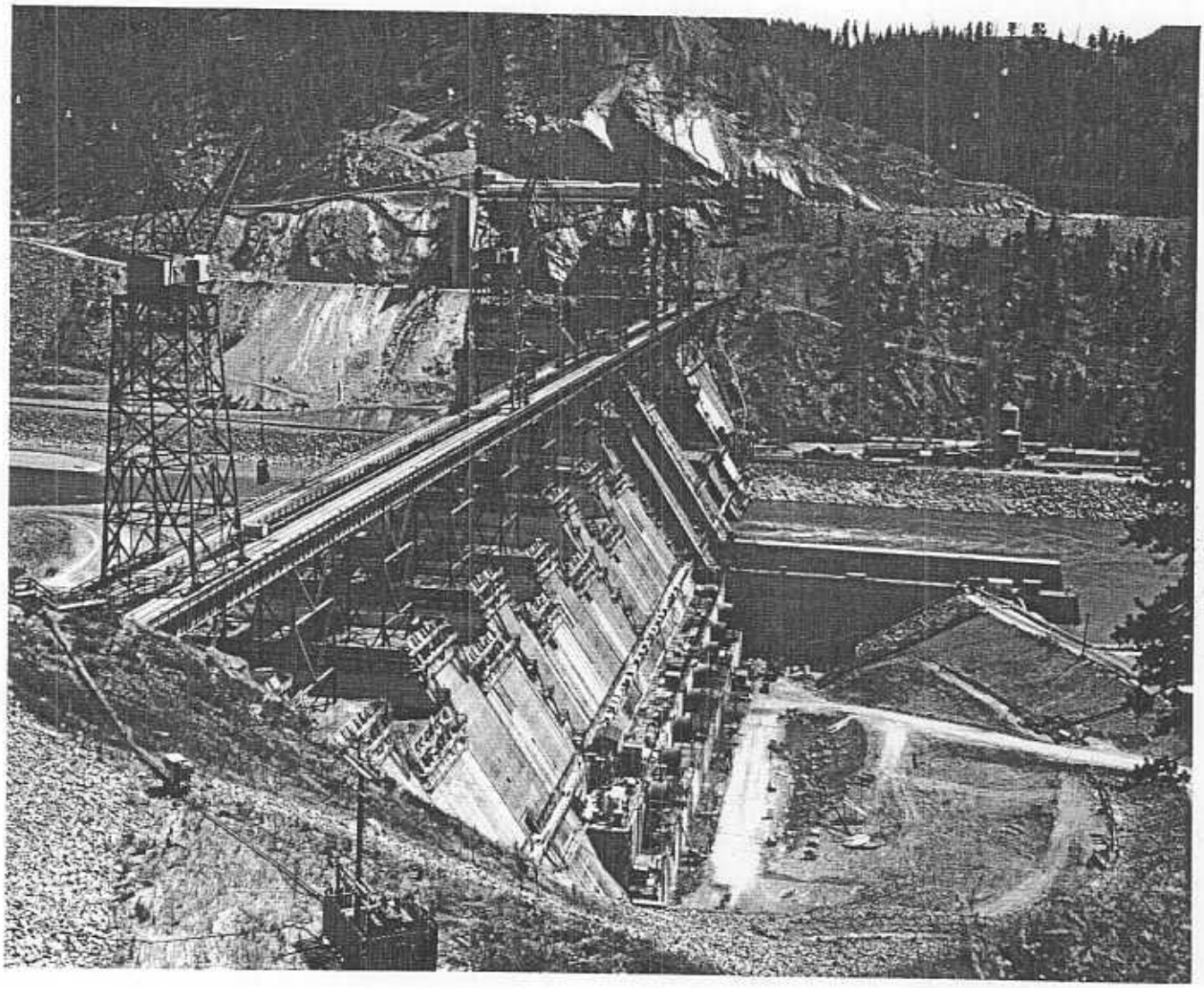
D. Implementation of Storage Operation

During the drawdown period, the Canadian Treaty storage was operated on the basis of a regular weekly request for storage release. Several mid-week revisions were made during the operating year as agreed by the Operating Committee. The Operating Committee consulted with West Kootenay Power and Light Company regarding the operation of Kootenay Lake prior to establishing the amounts and distribution of the Canadian storage releases. This coordination was necessary because of the effects operation of Duncan storage and storage in the United States upstream from Waneta Dam has on West Kootenay Power and Light Company's operation. The operation of Kootenay Lake, in turn, affects the downstream projects in Canada and in the United States.

The regular weekly requests for the release of stored water for power purposes were directed to the whole of Canadian storage. The Canadian Section, after consultation with the United States Section and the West Kootenay Power and Light Company, decided upon the distribution of the release between Arrow and Duncan reservoirs.

During the periods of flood control operation, the daily discharges of Duncan and Arrow were specified by the United States Section after consultation with the Canadian Section. The daily discharges were based upon the flood control criteria of the Interim Flood Control Plan and the streamflow forecasts.

LIBBY DAM PROJECT



Upstream view of Libby damsite showing construction progress as of August 1970. This U.S. Corps of Engineers storage dam on the Kootenai River will create a reservoir extending 40 miles into British Columbia. Initial construction includes an installation of four 105,000 kilowatt generators and provisions for four additional future units.

U.S. Corps of Engineers Photograph

III. WEATHER AND RIVER CONDITIONS

The warm and dry summer weather pattern came to an end in mid-September 1969 as the first fall storms of the season moved across the Columbia Basin. Precipitation was generally very light in October and November and large areas in the northern half of the basin had less than half of the average amount. A major change in weather patterns occurred during the second week of December, bringing in a series of storms which produced above-normal precipitation over the western half of the Columbia Basin. However, the northern portions of the basin in British Columbia, northern Idaho and western Montana were north of the storm track and received only light precipitation. January 1970 was one of the wettest months on record for most of the basin, again with the exception of the British Columbia portion. The resulting 5-month (October-February) precipitation totals ranged from less than 60 percent of average in the upper Kootenay and Columbia Basins in British Columbia to more than 140 percent of average in southeastern Oregon. On 1 March 1970 the geographical pattern of snowpack was similar to that of precipitation, with only 60 to 85 percent of average snow water equivalent in most northern areas.

The sequence of precipitation and temperature after 1 March 1970 is shown in detail on Charts 1 and 2. Chart 1 applies to the upper Columbia and Kootenay Basins in British Columbia and Chart 2 is for the entire Columbia River Basin above The Dalles, Oregon. In the derivation of the basin-average indexes, the wet areas which produce the most runoff are weighted heavier than the dry areas which usually produce less runoff. As shown on the charts there is a degree of similarity of the weather sequences over the British Columbia areas as compared to those of the total basin.

Table 1 lists the seasonal volume inflow forecasts for Duncan and Arrow Lakes and the unregulated runoff of Columbia River at The Dalles. The forecasts for the two treaty projects were prepared by B. C. Hydro and Power Authority and those for the lower Columbia River by the U.S. Weather Bureau - Corps of Engineers Cooperative Columbia River Forecasting Unit. Both the most probable and the 95 percent probable values are tabulated for the Duncan and Arrow inflow forecasts. As shown on Table 1, the forecasts were updated each month, starting 1 January, as the season advanced. Also shown on Table 1 are the actual volumes for the April-August 1970 season.

The resulting patterns of streamflow which were produced by the temperature and precipitation sequences are shown on Charts 3-8. The unregulated streamflows may be noted from the project inflow hydrographs on Charts 3, 4 and 6 and the computed unregulated discharges on Charts 5 and 7. During the main snowmelt season the natural runoff volume was below normal at all points on the main stem Columbia River.

IV. STORAGE OPERATION

A. Duncan Operation

As shown on Chart 3, the Duncan reservoir full pool elevation of 1892 feet was maintained until draft of water for downstream generation commenced in late August 1969. The draft continued until 23 September 1969 when, with Duncan reservoir at elevation 1879 feet, the occurrence of high flows in the Kootenay River in Canada made further draft from the Duncan reservoir unusable to downstream Canadian generating plants. Until 26 November 1969 all further draft from Canadian storage occurred at the Arrow reservoir. After 26 November 1969, Duncan was drafted at a relatively uniform rate until it reached its Variable Refill Curve elevation of 1802 feet early in March 1970.

Beginning 1 January 1970, forecasts of volume inflow to Duncan were made on the first of each month. These forecasts are shown on Table 1. Variable Refill Curves were determined from these forecasts as illustrated on Table 3. The Variable Refill Curves are shown on Chart 3.

During March 1970, Duncan releases were reduced to the minimum of 100 cubic feet per second to enable the reservoir to fill on its Variable Refill Curve.

The February 1970 volume inflow forecast for Duncan for April through August 1970 was 1.9 million acre-feet as shown on Table 1. With this forecast the Interim Flood Control Plan required that 1.2 million acre-feet of flood control storage space be evacuated at Duncan which would result in a reservoir elevation of 1817.6 feet. However, the reservoir was already substantially below this elevation and no special evacuation at Duncan was required for flood control.

During the reservoir refill period the Duncan discharges were almost continuously maintained at 100 cubic feet per second. Several days before the reservoir refilled on 26 July 1970 the Duncan releases were increased to reduce the rate of change of outflow from the project once it filled.

In summary, the operation of the Duncan reservoir for the operating year was considered to be routine.

B. Arrow Operation

Chart 4 shows the Arrow inflow, outflow and lake elevations for the period 1 July 1969 to 31 July 1970. Low natural streamflows occurred in August 1969 and water was initially drafted from the Arrow reservoir on 7 August 1969 to serve power requirements. The storage draft was maintained until 11 September 1969, when inflows in the Lower Columbia had increased permitting storage draft to be discontinued.

Both Arrow and Duncan were below their Critical Rule Curves for part of August 1969 and all of September 1969 to provide provisional energy for industrial loads in the United States. The two reservoirs recovered to their Critical Rule Curves by about the first of October 1969.

On 6 October 1969, storage releases were resumed and continued until the reservoir reached the normal low pool elevation of 1377 feet on 24 January 1970. This was well in advance of the requirement of the Detailed Operating Plan for 1969-70 that elevation 1377 feet be reached by 1 March 1970. This elevation was maintained until the end of February 1970 when further draft was commenced to lower the Lower Arrow Lake to elevation 1374 feet. This additional storage draft was made to raise the river elevation at Castlegar and permit continued operation of the ferry and also to allow ferry ramps in the reservoir to be extended to lower elevations. The Operating Committee arranged for storage of this water in F. D. Roosevelt Lake at Grand Coulee for later use if required to serve loads. However, this water was not required and was spilled at the start of the spring freshet.

Until Mica reservoir becomes operational Arrow is an annual refill reservoir; that is, there is adequate inflow every year to insure refilling from the lowest to the highest operating levels. For this reason the computation of Variable Refill Curves for Arrow is not required by the Principles and Procedures until Mica is in operation.

The 1 April 1970 seasonal volume runoff forecast for the Columbia River at The Dalles, for the period 1 April 1970 to 31 August 1970, was 83.0 million acre-feet. This required that 7.1 million acre-feet of flood control storage space be evacuated and maintained at Arrow, to the extent

MICA PROJECT

Aerial view of damsite showing construction progress as of August 1970. Principle features shown are the downstream face of the dam, outlet works and spillway construction.

B.C. Hydro Photograph

physically possible, until the river flow at The Dalles equaled the Initial Controlled Flow. Because of the additional storage draft at Arrow the reservoir was 3 feet below the required flood control level on 1 April 1970.

Filling of the reservoir commenced about 1 May 1970 under free flow conditions and continued until 28 May 1970. At that time Arrow outflows were reduced to control Arrow reservoir refilling and flows at The Dalles. About 1 July 1970 Arrow outflows were increased substantially for several days to aid the installation of flashboards at Grand Coulee.

Throughout the period from May through July 1970, weekly calibration tests were performed on the low level ports and sluices at Arrow. For 3 weeks in June 1970 the Arrow outflows were increased for about a 24-hour period each week to allow suitable measurements to be taken.

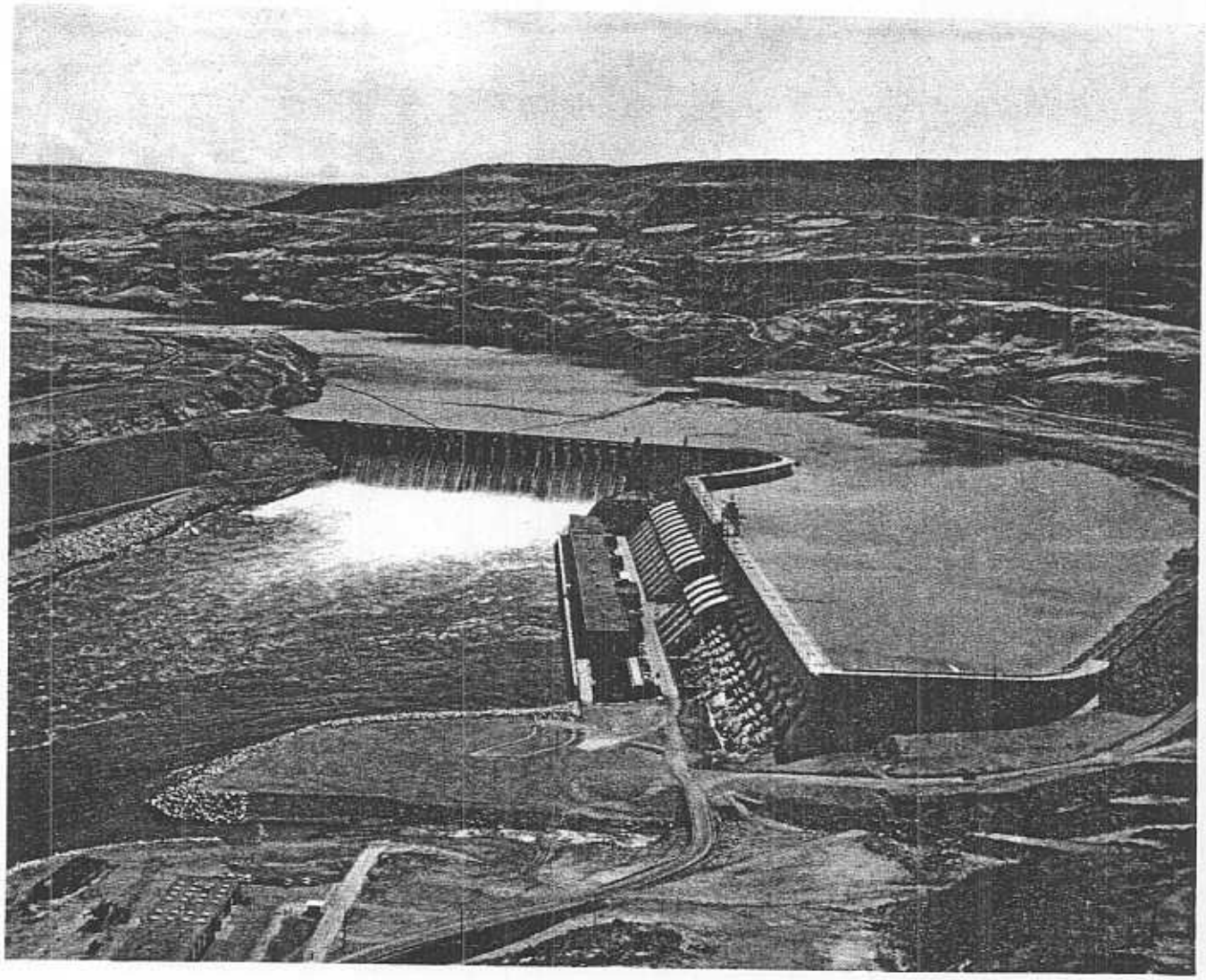
On 7 July 1970, B. C. Hydro and Power Authority and Bonneville Power Administration agreed that B. C. Hydro would provide an additional two feet of storage in the Arrow reservoir. The United States Federal and non-Federal agencies agreed that this filling objective would be accomplished by 1 August 1970 since water could not be stored past that date. It was agreed that the additional water should be stored, as much as possible, out of spill that would otherwise have occurred at the downstream projects in the United States. On 10 July 1970, the elevation of the Arrow reservoir had reached its normal full pool elevation of 1444 feet. Six days later the surcharge storage had been filled and the elevation reached 1446 feet.

V. DOWNSTREAM EFFECTS OF TREATY PROJECT OPERATION

A. Power

Beginning 1 April 1969, the power and energy provided for under the Columbia Storage Power Exchange Agreements and attributable to Arrow were delivered under the provisions of these agreements. Delivery of power

CHIEF JOSEPH DAM



Chief Joseph Dam is a U.S. Army Corps of Engineers project on the Columbia River downstream from the Canadian Treaty projects. Principle features shown are the spillway section, forebay and powerhouse. Provision was made in the initial construction for an additional eleven generating units.

U.S. Corps of Engineers Photograph

and energy attributable to Duncan, which began 1 April 1968, under the same authority, continued through the 1969-70 operating year. The power and energy generated at power projects in the United States for this purpose during the period 1 April 1969, through 31 March 1970, was 572 average megawatts, at rates up to 972 megawatts. Subsequent to 31 March 1970, the energy amount remained 572 average megawatts, but the maximum rate of generation increased to 980 megawatts.

The United States Pacific Northwest Coordinated Systems' firm load-resource balance showed about 200 average megawatts firm energy in excess of estimated firm loads during the draft period of 15 August 1969 through 15 April 1970. The potential secondary energy requirements of the Coordinated Systems was about 1400 megawatts.

Extreme low streamflows experienced during the period from late July through mid-September 1969 made it necessary to curtail secondary energy deliveries from the United States Columbia River Power System from 1 August 1969 through 30 September 1969. During this period, provisional storage drafts were made at Arrow and Hungry Horse reservoirs. Direct service to Federal System secondary energy loads in the Pacific Northwest was restored 1 October 1969 when heavy rainfall in the upper Columbia River Basin substantially increased the Federal System's power supply. These increases in streamflow enabled recovery of Arrow reservoir to its rule curve. Secondary energy deliveries from the Federal System were also limited during the first half of December and full curtailment again became necessary during the period 13 January through 20 January due to drops in temperature and sharply receding streamflows requiring heavy storage drafts for firm loads. No power supply deficiencies were experienced during the balance of the operating year.

B. Flood Control

Operation of Duncan project reduced the peak stage of Kootenay Lake by about 0.8 foot. The combined regulation of Arrow and Duncan projects reduced the peak discharge of Columbia River at Birchbank, British Columbia, 17 miles upstream from the international boundary, from a computed unregulated value of 229 thousand cubic feet per second to an actual peak of 139 thousand cubic feet per second. The corresponding reduction of stage at Trail, British Columbia, amounts to an estimated 11 feet. Chart 5 shows the hydrograph of unregulated discharge at Birchbank for the period April through July 1970. Chart 5 also shows the 15-year average discharge at Birchbank.

The regulation of Arrow and Grand Coulee projects was closely coordinated during the flood control season. As shown on Chart 6, the actual peak inflow to F. D. Roosevelt Lake at Grand Coulee was 264 thousand cubic feet per second on 10 June 1970 when the outflow was 151 thousand cubic feet per second. The computed unregulated peak inflow was 375 thousand cubic feet per second.

The computed unregulated peak discharge of Columbia River at The Dalles was 634 thousand cubic feet per second on 8 June 1970. Coordinated flood control regulations of the overall Columbia Basin system of reservoirs resulted in an observed peak discharge at The Dalles of 426 thousand cubic feet per second, which occurred on 28 May. The corresponding reduction of peak stage at Vancouver, Washington, was from an unregulated stage of 21.3 feet to an observed maximum stage of 14.0 feet. Bankfull stage at Vancouver,

a key index station for evaluating flooding on the lower Columbia River, is considered to be 16 feet.

A comparison of the 1969-70 observed discharge and the average monthly observed discharge for the period 1953-67 for Columbia River at The Dalles is shown on Chart 7. Chart 8 separates the effects of Duncan, Arrow and United States storage regulation on Columbia River at The Dalles during the period May through July 1970. Arrow contributed about thirty percent and Duncan about five percent of the total effective storage during the period of flood control regulation for the lower Columbia River.

REFERENCES

The following documents governed the operation of the Columbia Treaty Projects during the period 1 August 1969 through 31 July 1970.

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

2. "Hydroelectric Operating Plans for Canadian Storage During the Operating Years 1969-70 Through 1974-75", dated 15 February 1969.

3. "Detailed Operating Plan for Canadian Storage During the Operating Year 1 July 1969 Through 31 July 1970", dated 2 October 1969.

4. "Interim Flood Control Operating Plan for Duncan and Arrow Reservoirs", dated 12 November 1968.

TABLE 1

SEASONAL VOLUME RUNOFF FORECASTS
MILLIONS OF ACRE FEET
1970

Forecast Date - 1st of:	Duncan Lake Inflow		Arrow Lake Inflow		Unregulated Runoff Columbia River at The Dalles, Oregon
	Most Probable 1 Apr - 31 Aug.	95% Probable Date - 31 Jul.	Most Probable 1 Apr. - 31 Aug.	95% Probable Date - 31 Jul.	Most Probable 1 Apr. - 31 Aug.
January	1.94	1.36	21.6	16.5	71.6
February	1.91	1.38	21.2	16.3	88.3
March	1.89	1.36	20.9	15.7	79.2
April	1.89	1.36	20.3	15.1	83.0
May	1.88	1.32	19.7	13.9	82.4
June	1.83	1.01	19.5	10.6	79.8
July					80.0
Actual	1.77		18.8		82.3

TABLE 2

COMPUTATION OF INITIAL CONTROLLED FLOW
COLUMBIA RIVER AT THE DALLES, OREGON
20 MAY 1970

Forecast of May - August Unregulated Runoff Volume, MAF		74.8
Less Observed Runoff Volume 1-19 May, MAF		7.1
Less Upstream Storage Corrections, MAF		
Arrow	5.0	
Duncan	1.2	
Hungry Horse	1.6	
Flathead Lake	0.5	
Noxon	0.1	
Pend Oreille	0.5	
Grand Coulee	3.5	
Brownlee	0.4	
John Day	0.3	
TOTAL		13.1
Forecast of Adjusted Residual Runoff Volume, MAF		54.6
Observed Regulated Flow on 20 May, KCFS		331
Plus Adjustment for Category IV Projects, KCFS		56
Adjusted Mean Daily Flow on 20 May, KCFS		387
Computed Initial Controlled Flow (From Chart 1, of Interim Flood Control Plan), KCFS		390

TABLE 3

DUNCAN RESERVOIR COMPUTATION
OF VARIABLE REFILL CURVES

	Forecast Date	Initial	1970 Jan. 1	Feb. 1	Mar. 1	Apr. 1	May 1	Jun 1
1.	Probable Feb.-Sep.inflow,KSFD		1100.3	1084.8	1074.9	1079.8	1077.1	1051.4
2.	95% forecast error,KSFD		213.4	162.8	144.7	127.3	111.3	103.4
3.	95% confidence Feb-Sep inflow,KSFD 1/		886.9	922.0	930.2	952.5	965.8	948.0
4.	Observed Feb 1-date inflow KSFD		0.0	0.0	20.7	40.4	68.2	212.6
5.	Residual 95% date-Sep inflow,KSFD 2/		886.9	922.0	909.5	912.1	897.6	735.4
6.	Assumed date-July 31 inflow, % volume		0.757	0.757	0.753	0.749	0.739	0.691
7.	95% confidence date - July 31 inflow KSFD 3/		671.4 8/	698.0	684.8	683.2	663.3	508.2
	Assumed Feb 1 - Jul 31 inflow, % volume		100.0					
	Assumed Feb 1 - Jul 31 inflow, KSFD 4/		671.4					
	Min. Feb 1 - Jul 31 outflow, KSFD		18.1					
	Min. Jan 31 reservoir content, KSFD 5/		62.9					
	Min. Jan 31 reservoir elev., ft. 6/		1805.1					
	Jan 31 Energy Content Curve, ft. 7/	1812.9	1805.1					
	Assumed Mar 1 - Jul 31 inflow, % volume		98.02	98.02				
	Assumed Mar 1 - Jul 31 inflow, KSFD 4/		658.1	684.2				
	Min. Mar 1 - Jul 31 outflow, KSFD		15.3	15.3				
	Min. Feb 28 reservoir content, KSFD 5/		73.4	47.3				
	Min. Feb 28 reservoir elev., ft. 6/		1807.0	1802.1				
	Feb 28 Energy Content Curve, ft. 7/	1813.9	1807.0	1802.1				
	Assumed Apr 1 - Jul 31 inflow, % volume		96.04	96.04	98.01			
	Assumed Apr 1 - Jul 31 inflow, KSFD 4/		644.8	670.4	671.2			
	Min. Apr 1 - Jul 31 outflow, KSFD		12.2	12.2	12.2			
	Min. Mar 31 reservoir content, KSFD 5/		83.6	58.0	57.2			
	Min. Mar 31 reservoir elev., ft. 6/		1808.8	1804.2	1804.0			
	Mar. 31 Energy Content Curve, ft. 7/	1815.4	1808.8	1804.2	1804.0			
	Assumed May 1 - Jul 31 inflow, % volume		90.88	90.88	92.83	94.66		
	Assumed May 1 - Jul 31 inflow, KSFD 4/		610.2	634.3	635.7	646.7		
	Min. May 1 - Jul 31 outflow, KSFD		9.2	9.2	9.2	9.2		
	Min. Apr 30 reservoir content, KSFD 5/		115.2	91.1	89.7	78.7		
	Min. Apr 30 reservoir elev., ft. 6/		1814.2	1810.1	1809.9	1807.9		
	Apr 30 Energy Content Curve, ft. 7/	1818.1	1814.2	1810.1	1809.9	1807.9		
	Assumed Jun 1 - Jul 31 inflow, % volume		71.60	71.60	73.04	74.50	78.76	
	Assumed Jun 1 - Jul 31 inflow, KSFD 4/		480.7	499.8	500.2	509.0	522.4	
	Min. Jun 1 - Jul 31 outflow, KSFD		6.1	6.1	6.1	6.1	6.1	
	Min. May 31 reservoir content, KSFD 5/		241.6	222.5	222.1	213.3	199.9	
	Min. May 31 reservoir elev., ft. 6/		1833.1	1830.4	1830.4	1829.1	1827.2	
	May 31 Energy Content Curve, ft. 7/	1835.2	1833.1	1830.4	1830.4	1829.1	1827.2	
	Assumed Jul 1 - Jul 31 inflow, % volume		33.55	33.55	34.26	34.98	36.94	46.89
	Assumed Jul 1 - Jul 31 inflow, KSFD 4/		225.3	234.2	234.6	239.0	245.0	238.3
	Min. Jul 1 - Jul 31 outflow, KSFD		3.1	3.1	3.1	3.1	3.1	3.1
	Min. Jun 30 reservoir content, KSFD 5/		494.0	485.1	484.7	480.3	474.3	481.0
	Min. Jun 30 reservoir, elev., ft. 6/		1865.9	1864.8	1864.8	1864.2	1863.5	1864.3
	Jun 30 Energy Content Curve, ft. 7/	1870.3	1865.9	1864.8	1864.8	1864.2	1863.5	1864.3
	July 31 Energy Content Curve, ft.	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ Line 1 - Line 2
2/ Line 3 - Line 4
3/ Line 5 x Line 6
4/ Preceding Line x Line 6
5/ Full content (716.2 KSFD) plus preceding line less line preceding that with a minimum content of 4.8
6/ From reservoir elevation - storage content table dated April 24, 1968.
7/ Lower of elevation on preceding line or elevation determined prior to year (Initial).
8/ February 1 - July 31

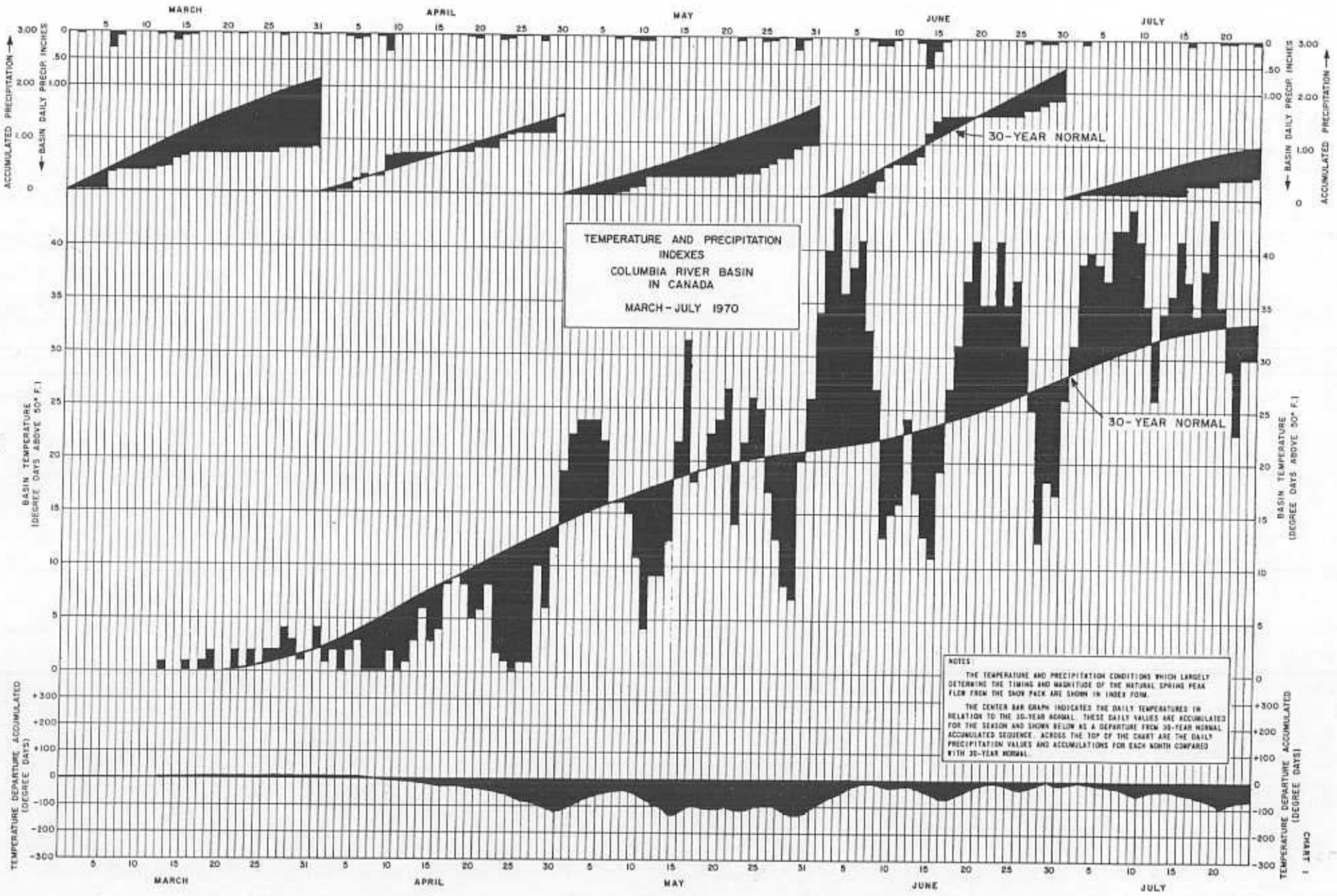

TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN IN CANADA
MARCH - JULY 1970
MARCH
APRIL
MAY
JUNE
JULY
ACCUMULATED PRECIPITATION
BASIN DAILY PRECIP. INCHES
30-YEAR NORMAL
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50° F.)
TEMPERATURE DEPARTURE ACCUMULATED (DEGREE DAYS)
NOTES
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM.
THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ARE ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL.

CHART 1

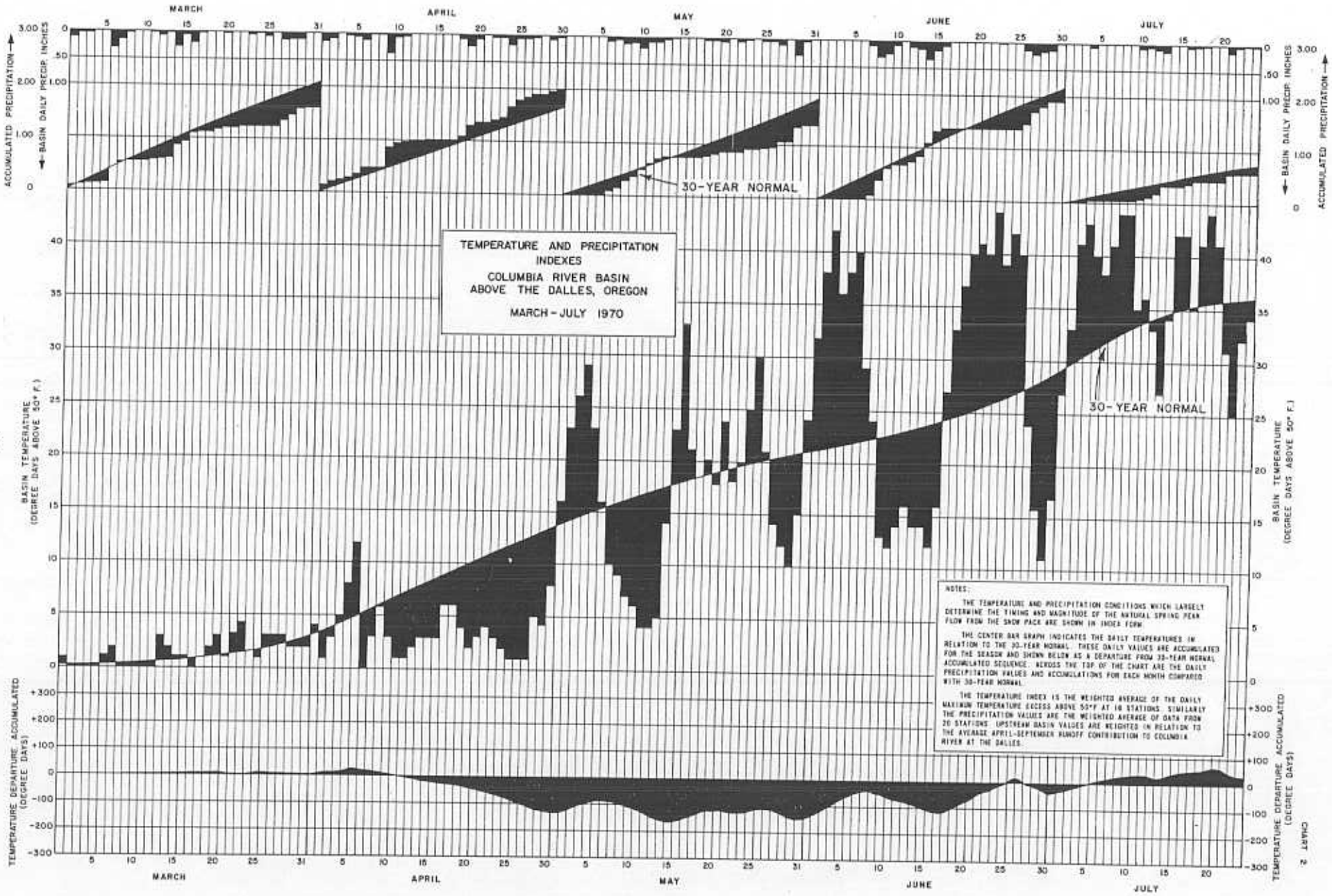

TEMPERATURE AND PRECIPITATION INDEXES
COLUMBIA RIVER BASIN
ABOVE THE DALLES, OREGON
MARCH - JULY 1970
MARCH
APRIL
MAY
JUNE
JULY
30-YEAR NORMAL
30-YEAR NORMAL
ACCUMULATED PRECIPITATION
BASIN DAILY PRECIP. INCHES
BASIN TEMPERATURE (DEGREE DAYS ABOVE 50° F.)
TEMPERATURE DEPARTURE ACCUMULATED (DEGREE DAYS)
NOTES:
THE TEMPERATURE AND PRECIPITATION CONDITIONS WHICH LARGELY DETERMINE THE TIMING AND MAGNITUDE OF THE NATURAL SPRING PEAK FLOW FROM THE SNOW PACK ARE SHOWN IN INDEX FORM.
THE CENTER BAR GRAPH INDICATES THE DAILY TEMPERATURES IN RELATION TO THE 30-YEAR NORMAL. THESE DAILY VALUES ARE ACCUMULATED FOR THE SEASON AND SHOWN BELOW AS A DEPARTURE FROM 30-YEAR NORMAL ACCUMULATED SEQUENCE. ACROSS THE TOP OF THE CHART ARE THE DAILY PRECIPITATION VALUES AND ACCUMULATIONS FOR EACH MONTH COMPARED WITH 30-YEAR NORMAL.
THE TEMPERATURE INDEX IS THE WEIGHTED AVERAGE OF THE DAILY MAXIMUM TEMPERATURE EXCESS ABOVE 50°F AT 18 STATIONS. SIMILARLY THE PRECIPITATION VALUES ARE THE WEIGHTED AVERAGE OF DATA FROM 20 STATIONS. UPSTREAM BASIN VALUES ARE WEIGHTED IN RELATION TO THE AVERAGE APRIL-SEPTEMBER RUNOFF CONTRIBUTION TO COLUMBIA RIVER AT THE DALLES.

CHART 2

CHART 3
DUNCAN

REGULATION OF DUNCAN
1 JULY 1969 – 31 JULY 1970

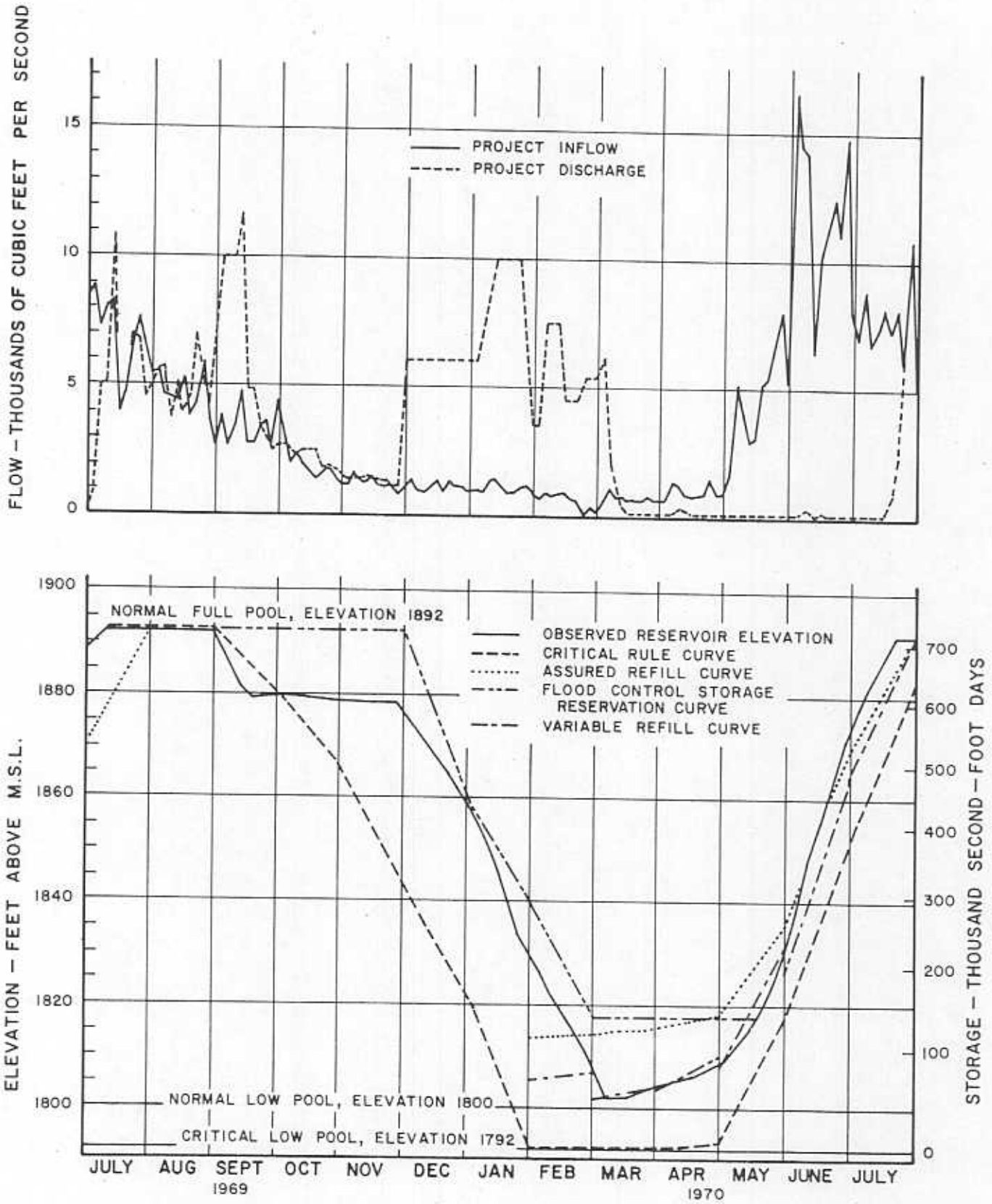
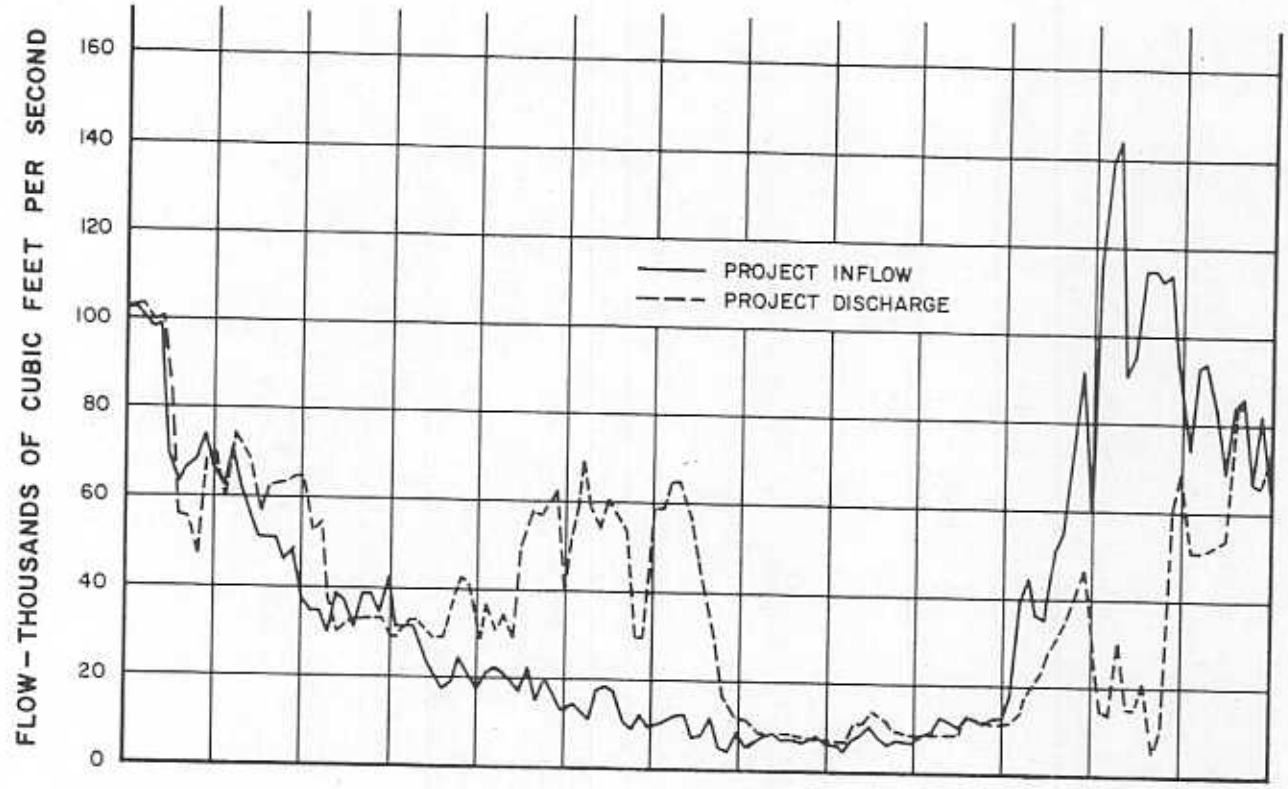
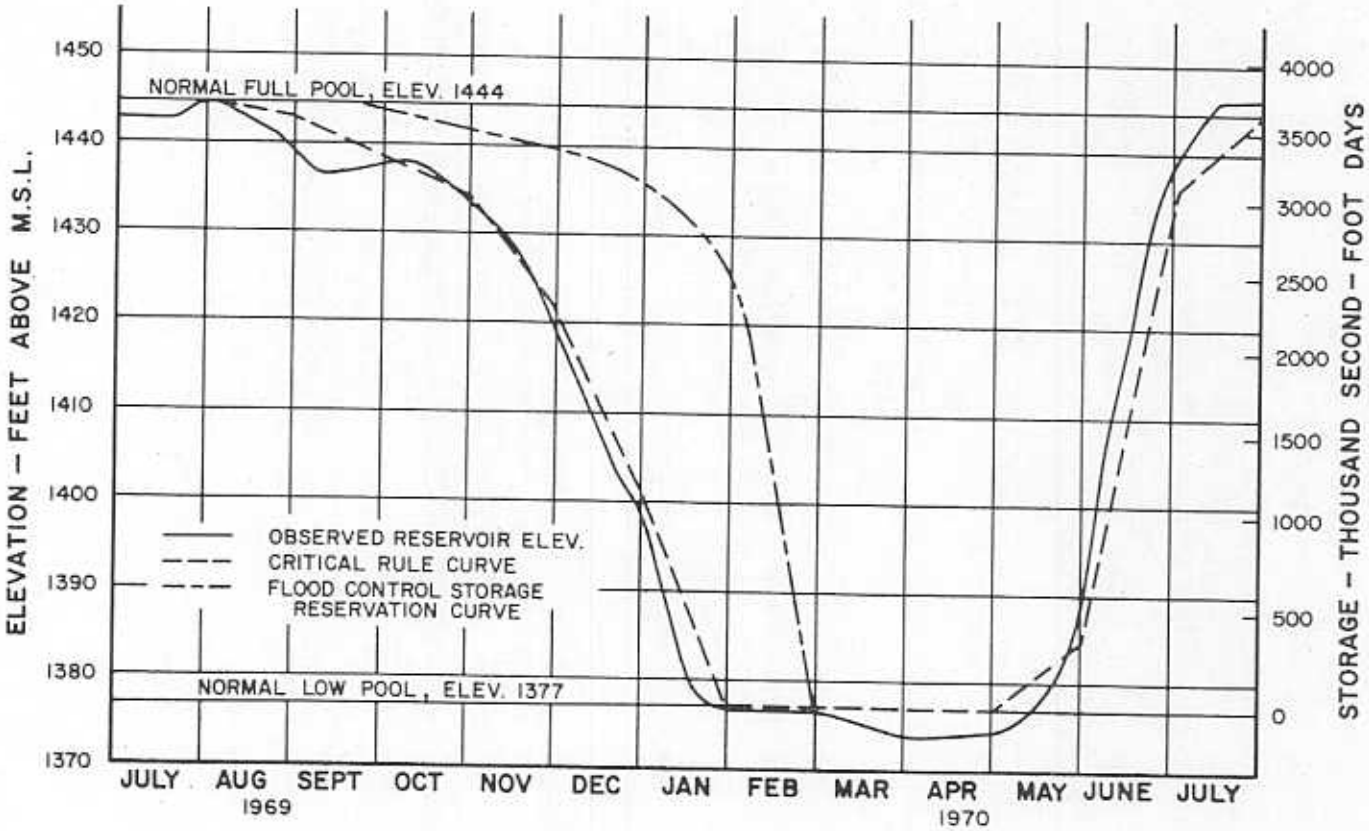


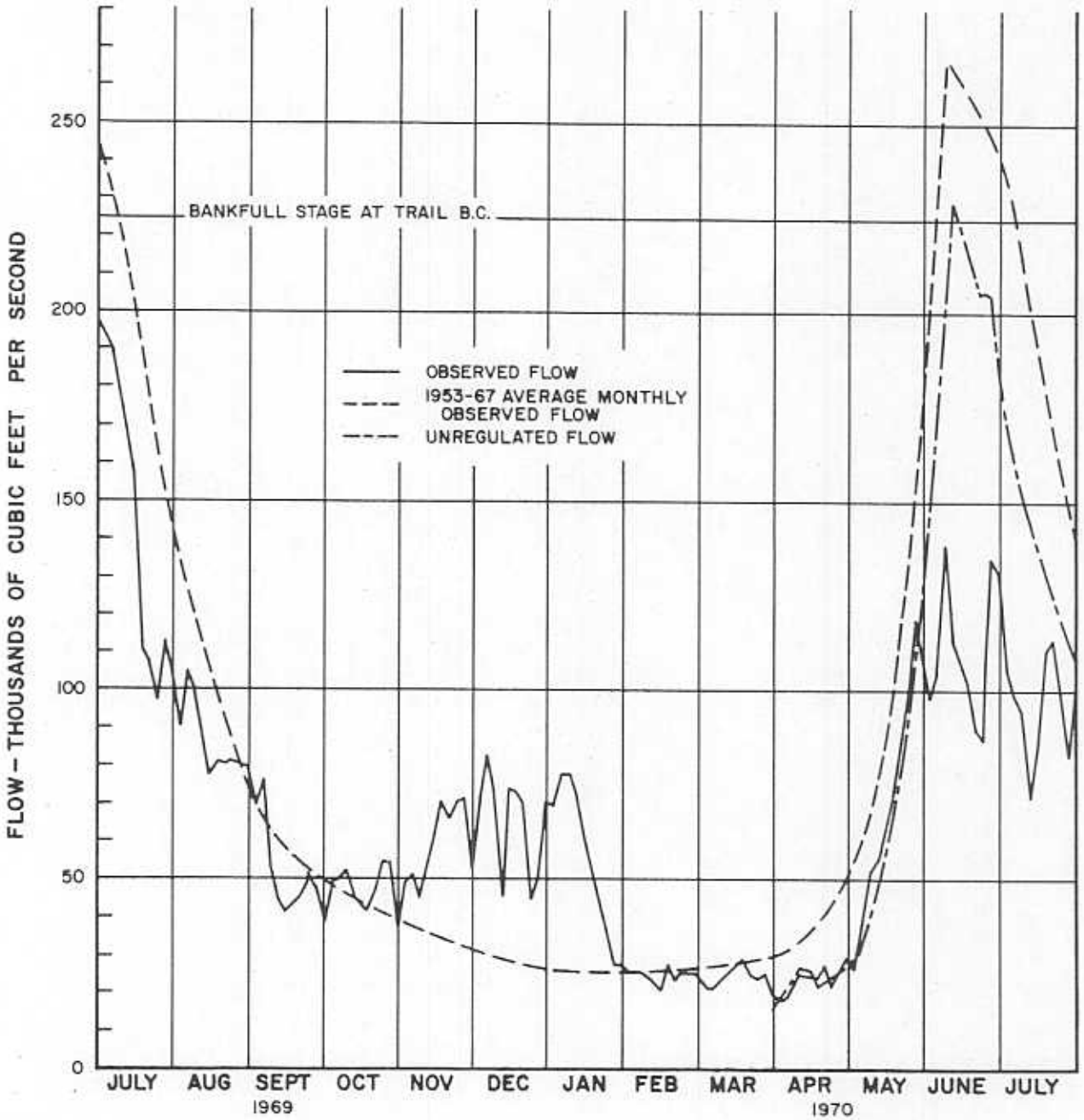
CHART 4
ARROW

REGULATION OF ARROW
1 JULY 1969 – 31 JULY 1970





COLUMBIA RIVER AT BIRCHBANK
1 JULY 1969 – 31 JULY 1970



REGULATION OF GRAND COULEE
1 JULY 1969 – 31 JULY 1970

CHART 6
GRAND COULEE

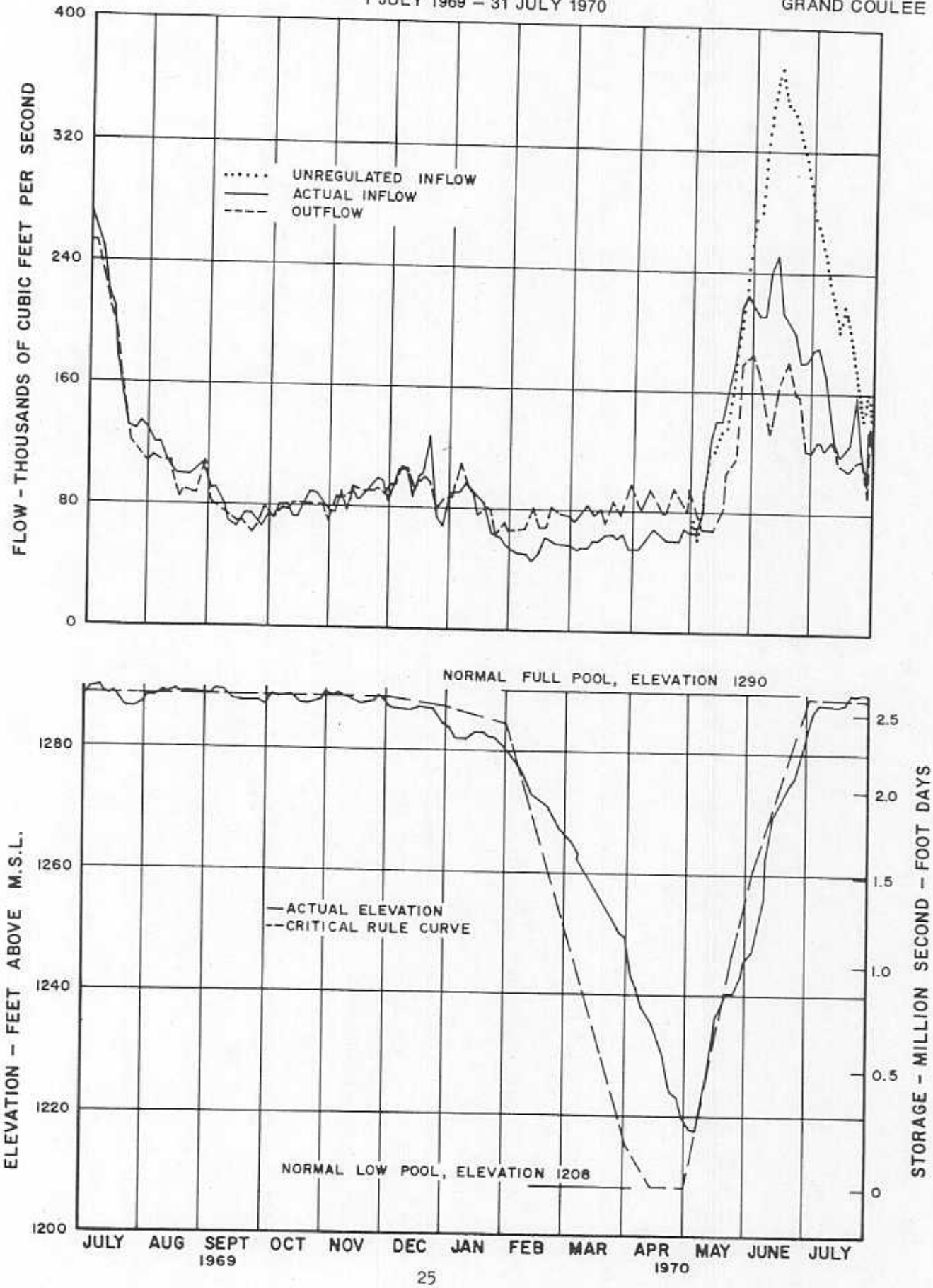
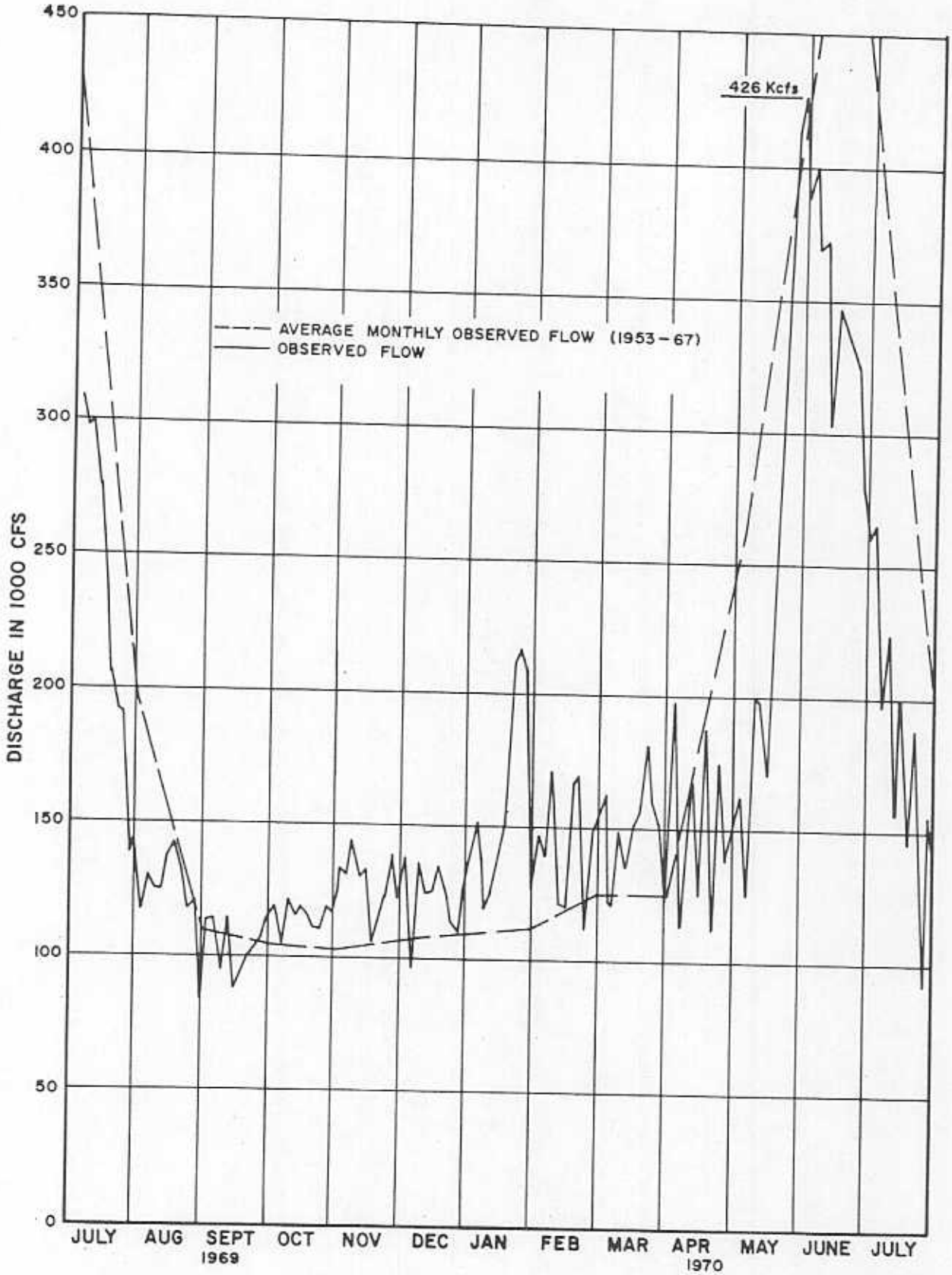
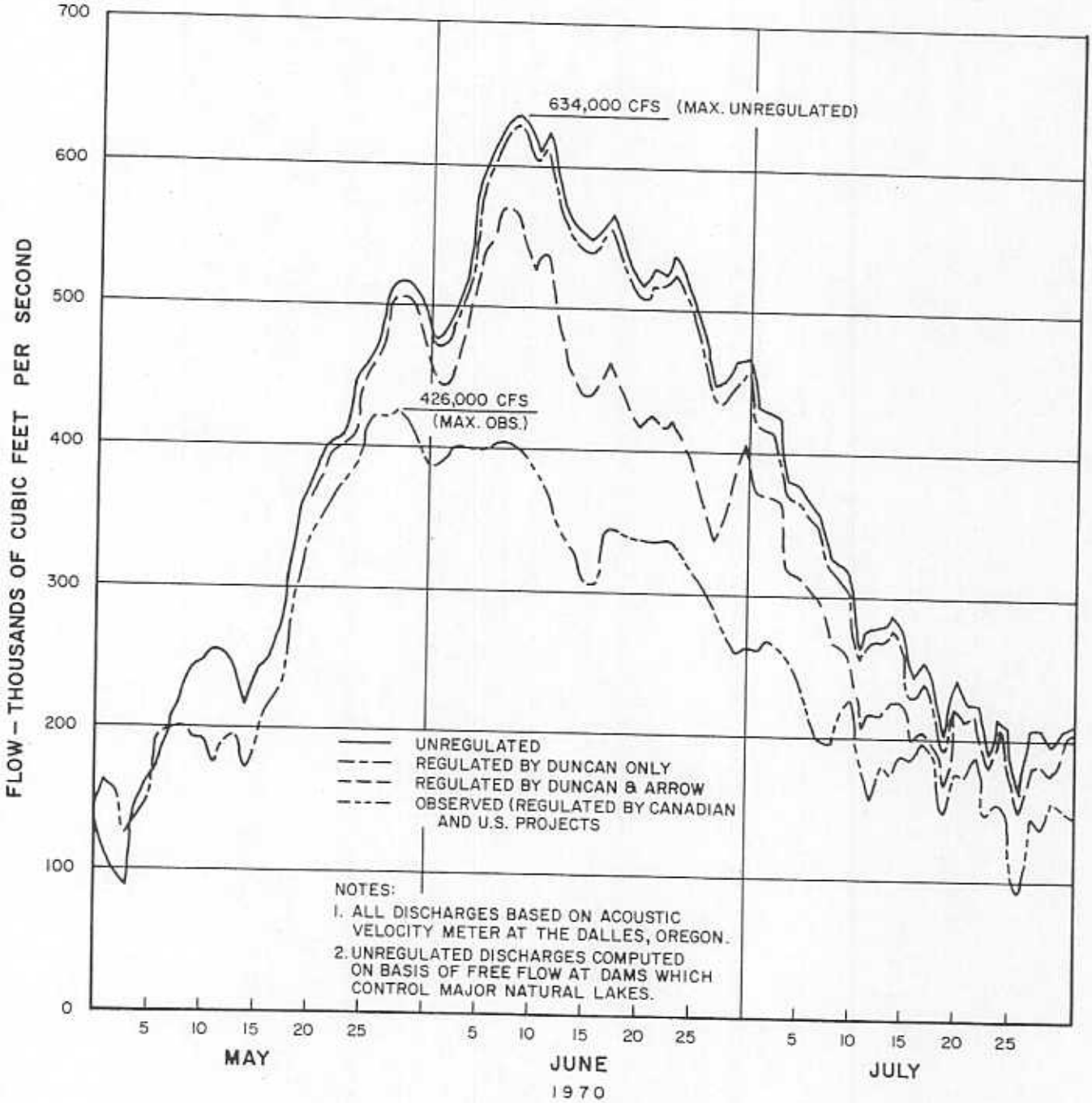


CHART 7
THE DALLES

COLUMBIA RIVER AT THE DALLES
1 JULY 1969 – 31 JULY 1970



COLUMBIA RIVER AT THE DALLES
1 MAY 1969 – 31 JULY 1970