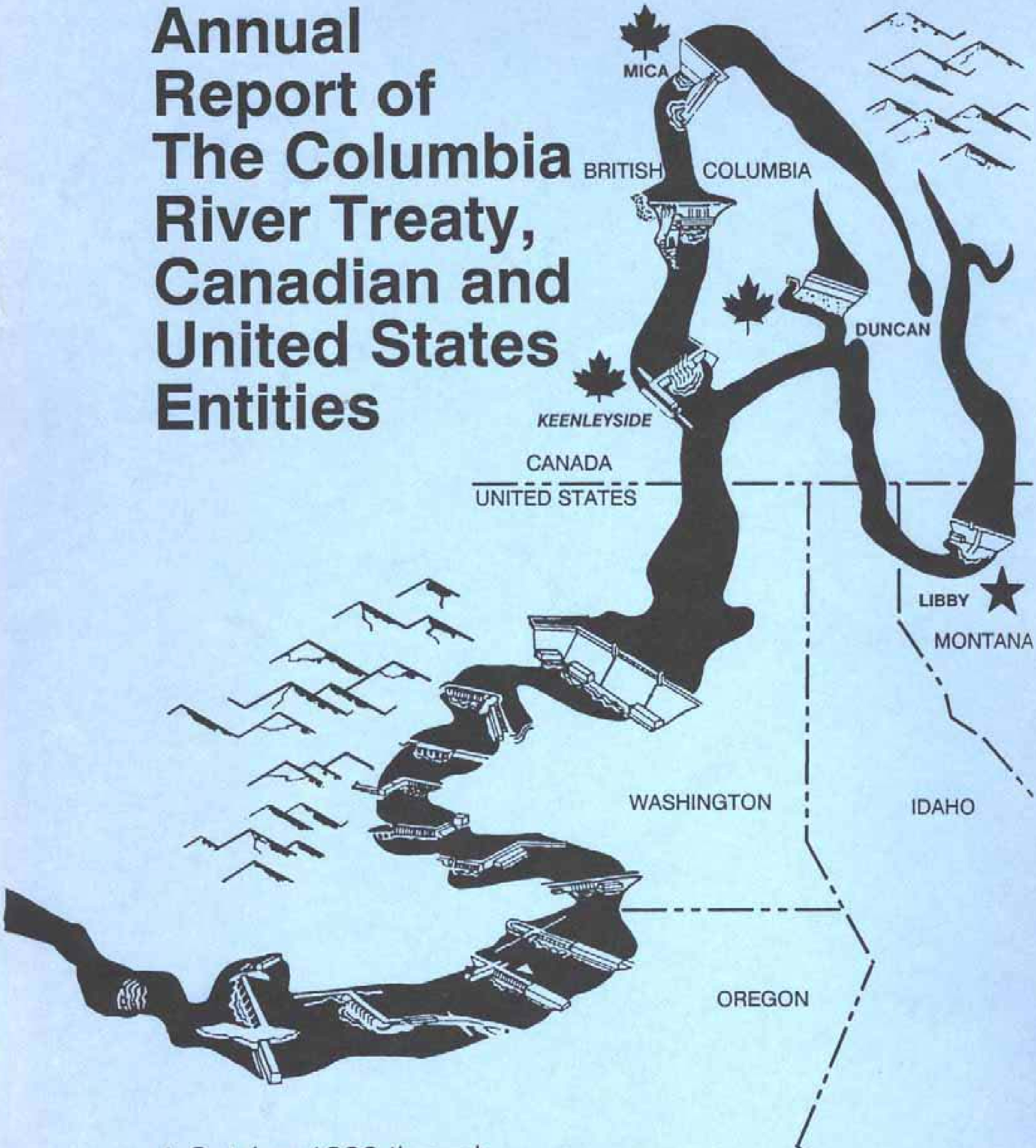
Annual Report of The Columbia River Treaty, Canadian and United States Entities



1 October 1992 through
30 September 1993

November 1993

ANNUAL REPORT OF
THE COLUMBIA RIVER TREATY
CANADIAN AND UNITED STATES ENTITIES

FOR THE PERIOD

1 OCTOBER 1992 - 30 SEPTEMBER 1993

Errata - 2 February 1994
Annual Report of the Columbia River Treaty, Canadian and United States Entities
1 October 1992 through 30 September 1993

The following changes should be made in names and titles in the Entities' Annual Report:

Page 3

CANDIAN ENTITY

Mr. Marc Eliesen, Chairman
President and CEO, British Columbia
Hydro and Power Authority
Vancouver, B.C.

Page 4

CANADIAN ENTITY COORDINATOR

H.D. Kenneth Epp, Coordinator
President and CEO of POWEREX
Vancouver, B.C.

Page 7

Permanent Engineering Board
CANADIAN SECTION

John Allan, Member
Victoria, B.C.

Executive Summary

Entity Agreements

Agreements approved by the Entities during the period of this report include:

- Detailed Operating Plan for Columbia River Treaty Storage, 1 August 1992 through 31 July 1993, dated November 1992.

- The Assured Operating Plan, and Determination of Downstream Power Benefits for Operating Year 1997-98, dated October 1992.

System Operation

The coordinated system filled to 68.6 percent of Actual Energy Regulation (AER) storage capacity by 31 July 1992. As a result, third year firm energy load carrying capability (FELCC) was adopted for the 1992-93 operating year. Actual storage capacity was filled to 76%. From August through April the system proportionally drafted to meet FELCC. May through July had the system meeting Energy Content Curves (ECC).

The 1 January 1993 water supply forecast for the Columbia River at The Dalles (Jan-Jul) was 92.6 MAF, or 87 percent of average, the same as for 1992. This forecast indicated that secondary energy would be available. However, the Federal System was operated conservatively to ensure that about 3 MAF above the energy content curve (ECC) would be provided for the 1993 juvenile fish flow augmentation. Energy was purchased to keep the reservoirs (Grand Coulee and Libby) above ECC. The early spring remained dry and forecasted runoff continued to drop until April when the trend turned upward. The actual observed runoff was 88.0 MAF, or 83 percent of average and the sixteenth lowest since 1929.

The peak daily average flow observed at The Dalles was 386,500 cfs. The lower Columbia River was regulated in May, June and July to meet requests for fish flows delivering the Water Budget and Flow Augmentation volumes. The observed coordinated system storage content reached 77 percent of capacity on 31 July 1993. However, the energy content reached in the Actual Energy Regulation (AER) for Firm Energy Load Carrying Capability (FELCC) was only 73 percent of full. This value was used to determine the Firm Energy Load Carrying Capability (FELCC) for the 1993-94 operating year. Because the energy content AER reached only 73 percent full, third year FELCC was adopted for the 1993-94 operating year. From 1 August 1992 through 31 March 1993 generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange Agreement, was approximately 305 average megawatts at rates up to 844 megawatts. From 1 April through 31 July 1993 the delivery was 293 average megawatts, at rates up to 755 megawatts. All CSPE power was used to meet Pacific Northwest loads.

Treaty Project Operation

The Treaty projects were operated throughout the year in accordance with the 1992-93 Detailed Operating Plan and the Flood Control Operating Plan.

Mica treaty storage reached 99.6 percent of full content on 21 August 1992. However, due to a substantial Treaty overrun and depletions in the NTS account, the reservoir elevation was only 2451.2 feet. By 31 December the reservoir level had dropped to elevation 2407.4 feet. Treaty storage was fully depleted by 11 February 1993. The reservoir reached its lowest level, elevation 2340.4 feet , 5 feet below its previous record low level, on 23 April 1993. From then on, Mica's treaty storage refilled, reaching 56 percent full (1962 ksfd) on 30 September 1993. The maximum level for 1993, elevation 2419.4 feet, was reached on 12 September. This is 57 feet below full pool and 23.8 feet below the previous lowest peak.

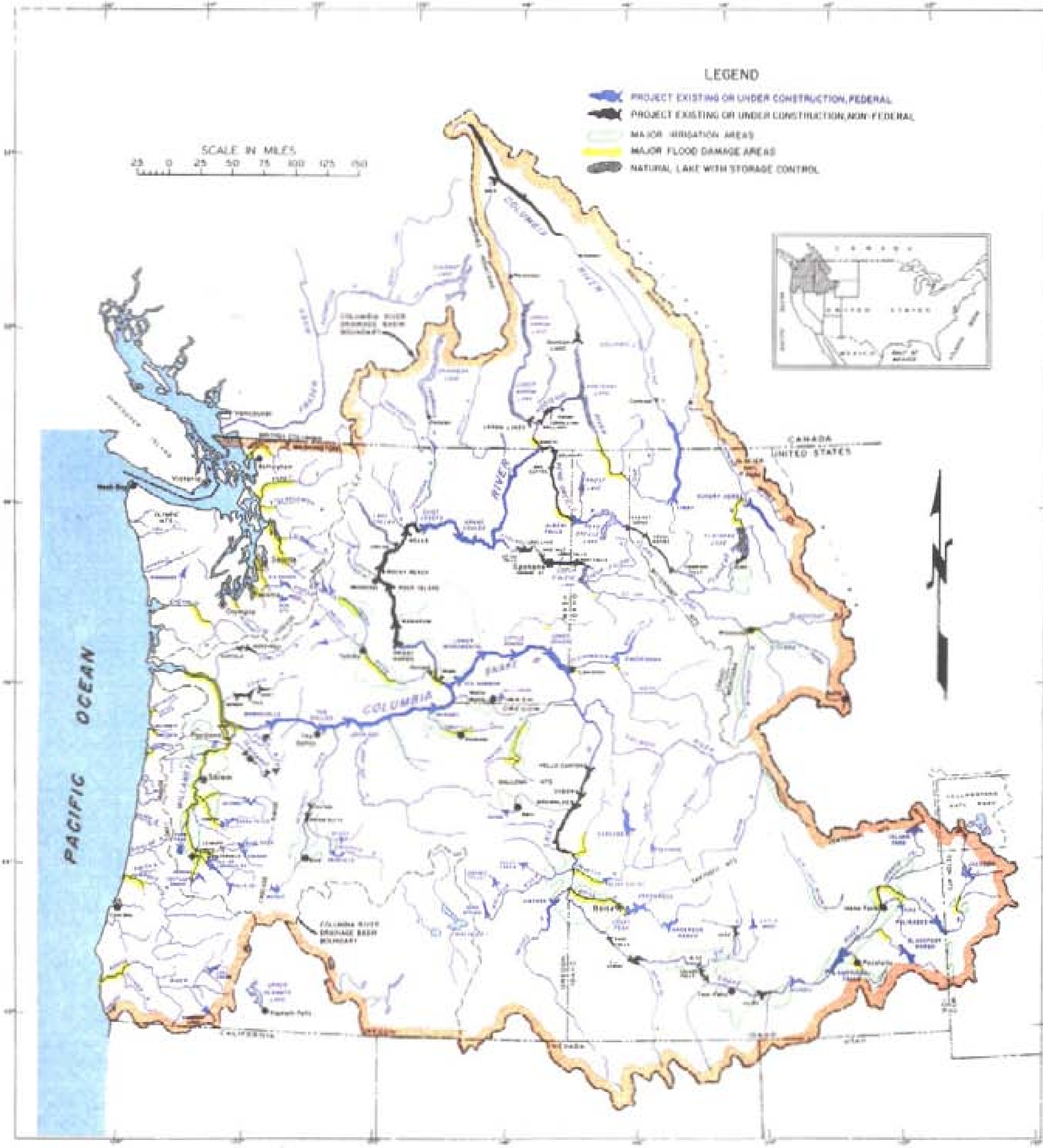
During the 1992 operating year, Arrow reached its maximum level of elevation 1412.4 feet on 31 July 1992. The reservoir drafted during August to elevation 1408.3 feet. Reduced October and November outflows filled the reservoir with the level reaching elevation 1415.2 feet on 17 November 1992. Heavy releases during the December and January cold snap drafted Arrow, reaching a minimum elevation of 1385.2 feet on 26 February 1993. Starting in mid-May, high inflows and low outflows filled the reservoir to elevation 1430.4 feet by 30 June. Treaty storage was essentially full at 98.5 percent. During July, Mica discharges were increased to reduce the substantial Treaty underrun and maintain Arrow levels. The Arrow level was maintained in the range of 1431-1434 feet from mid-July through September.

Duncan reservoir did not fill during the 1992 operating year being 44 feet below full pool at elevation 1848.0 on 31 July 1992. Treaty storage was 48 percent full. A special Libby/Duncan transfer of 465 ksfd had drafted the reservoir giving record low summer levels. The 31 August reservoir level was elevation 1832.6 feet. During October-December, the Duncan outflows were near 100 cfs and most of the Libby/Duncan storage transfer was returned to Duncan between 10 October and 18 December, filling the lake to elevation 1841.8 feet by 4 December. December releases drafted the pool to elevation 1827.9 feet, 40 feet below last year's level on 31 December. Duncan reached its lowest level during the operating year, elevation 1794.9 feet, on 22 April 1993. Minimum releases during May-July helped refill the reservoir to elevation 1881.9 feet by 31 July. Continued filling had the reservoir reaching its peak elevation of 1885.4 feet on 10 August. Between 3 July and 19 July, 132 ksfd was transfered out of Canadian storage as a result of a Libby/Duncan

Transfer Agreement. However, to minimize spill at Kootenay River plants, this water was released from Mica rather than Duncan. This storage will be returned between 1 September and 31 December.

During the 1992 operating year, Libby reached its maximum level, elevation 2439.8 feet (19 feet below full) on 4 August 1992. The reservoir began its drawn down in mid-August. On 12 October, Libby began releasing the 465 ksfd of Libby/Duncan transfer. In late October and November a special operation for Montana Department of Fish, Wildlife, and Parks and power requirements resulted in the lake being drafted to elevation 2359.5 feet by 31 December. A minimum level of elevation 2323.0 feet was reached on 23 March. From mid-March through mid-August the Libby outflow was maintained near minimum, 4,000 cfs, except for a two week period in June. Between 1-15 June the outflow was increased to provide a flow near 20,000 cfs at Bonners Ferry, ID. About 400 ksfd was released during this period as part of a white sturgeon spawning study. The reservoir reached its highest elevation of 2448.2 feet on Labor Day, 6 September 1993; about 11 feet below full.

COLUMBIA RIVER AND COASTAL BASINS



1993 Report of The Columbia River Treaty Entities
Contents

		Page
	EXECUTIVE SUMMARY	ii
I.	INTRODUCTION	1
II.	TREATY ORGANIZATION	3
	Entities	3
	Entity Coordinators	4
	Columbia River Treaty Operating Committee	5
	Columbia River Treaty Hydrometeorological Committee	6
	Permanent Engineering Board	7
	PEB Engineering Committee	8
	International Joint Commission	9
III.	OPERATING ARRANGEMENTS	11
	Power and Flood Control Operating Plans	11
	Assured Operating Plan	12
	Determination of Downstream Power Benefits	12
	Detailed Operating Plan	13
	Entity Agreements	13
	Long Term Non-Treaty Storage Contract	14
IV.	WEATHER AND STREAMFLOW	15
	Weather	15
	Streamflow	16
	Seasonal Runoff Forecasts and Volumes	18
V.	RESERVOIR OPERATION	20
	General	20
	Mica Reservoir	22
	Revelstoke Reservoir	23
	Arrow Reservoir	24
	Duncan Reservoir	25
	Libby Reservoir	27
	Kootenay Lake	29
	Storage Transfer Agreements	30

1993 Report of The Columbia River Treaty Entities
Contents (continued)

Page

VI. POWER AND FLOOD CONTROL ACCOMPLISHMENTS 31

General 31
Power 31
Flood Control 36

FIGURES

Columbia River and Coastal Basins vi
Columbia River Treaty Organization 10

TABLES

1 Unregulated Runoff Volume Forecasts 37
2 Variable Refill Curve, Mica Reservoir 38
3 Variable Refill Curve, Arrow Reservoir 39
4 Variable Refill Curve, Duncan Reservoir 40
5 Variable Refill Curve, Libby Reservoir 41
6 Initial Controlled Flow Computation 42

CHARTS

1 Seasonal Precipitation 43
2 Snowpack 44
3 Temperature & Precipitation Winter Indices for Basin Above The Dalles 44
4 Temperature and Precipitation Summer Indices for Basin Above The Dalles 45
5 Temperature and Precipitation Summer Indices for Basin In In Canada 45
6 Regulation of Mica 46
7 Regulation of Arrow 47
8 Regulation of Duncan 48
9 Regulation of Libby 49
10 Regulation of Kootenay Lake 50
11 Columbia River at Birchbank 51
12 Regulation of Grand Coulee 52
13 Columbia River at The Dalles, Jul 92-Jul 93 53
14 Columbia River at The Dalles, Apr-Jul 93 54
15 Relative Filling, Arrow and Grand Coulee 55

I Introduction

This annual Columbia River Treaty Entity Report is for the 1993 Water Year, 1 October 1992 through 30 September 1993. It includes information on the operation of Mica, Arrow, Duncan, and Libby reservoirs during that period with additional information covering the reservoir system operating year, 1 August 1992 through 31 July 1993. The power and flood control effects downstream in Canada and the United States are described. This report is the twenty-seventh of a series of annual reports covering the period since the ratification of the Columbia River Treaty in September 1964.

Duncan, Arrow, and Mica 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 in Canada is required to be operated for the purposes of flood control and increasing hydroelectric power generation in Canada and the United States of America. In 1964, the Canadian and the United States governments each designated an Entity to formulate and carry out the operating arrangements necessary to implement the Treaty. The Canadian Entity is the British Columbia Hydro and Power Authority (B.C. Hydro). The United States Entity is the Administrator of the Bonneville Power Administration (BPA) and the Division Engineer of the North Pacific Division, Army Corps of Engineers (ACE).

The following is a summary of key features of the Treaty and related documents:

1. Canada is to provide 15.5 million acre-feet (maf) of usable storage. (This has been accomplished with 7.0 maf in Mica, 7.1 maf in Arrow and 1.4 maf in Duncan.)

2. For the purpose of computing downstream benefits the U.S. hydroelectric facilities will be operated in a manner that makes the most effective use of the improved streamflow resulting from operation of the Canadian storage.

3. The U.S. and Canada are to share equally the additional power generated in the U.S. resulting from operation of the Canadian storage.

4. The U.S. paid Canada a lump sum of the $64.4 million (U.S.) for expected flood control benefits in the U.S. resulting from operation of the Canadian storage.

5. The U.S. has the option of requesting the evacuation of additional flood control space above that specified in the Treaty, for a payment of $1.875 million (U.S.) for each of the first four requests for this "on-call" storage.

6. The U.S. constructed Libby Dam with a reservoir that extends 42 miles into Canada and for which Canada made the land available.

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

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

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

10. In the Canadian Entitlement Purchase Agreement of 13 August 1964, Canada sold its entitlement to downstream power benefits to the United States for 30-years beginning at Duncan on 1 April 1968, at Arrow on 1 April 1969, and at Mica on 1 April 1973.

11. Canada and the U.S. are each to appoint Entities to implement Treaty provisions and are to jointly appoint a Permanent Engineering Board (PEB) to review and report on operations under the Treaty.

II Treaty Organization

Entities

There were two meetings of the Columbia River Treaty Entities (including the Canadian Entity Representative and U.S. Coordinators) during the year on the morning of 3 December 1992 in Vancouver, B.C., and the afternoon of 20 May 1993 in Portland, OR. The members of the two Entities at the end of the period of this report were:

UNITED STATES ENTITY

Mr. Randall W. Hardy, Chairman
Administrator, Bonneville Power Administration
Department of Energy
Portland, Oregon

Major General Ernest J. Harrell
Division Engineer
North Pacific Division
Army Corps of Engineers
Portland, Oregon

CANADIAN ENTITY

Mr. Marc Eliesen, Chairman
~~Chairman,~~ President & CEO British Columbia
Hydro and Power Authority
Vancouver, B.C.

Mr. Eliesen succeeded Mr. Norman Olsen effective 30 November 1992.

The Entities have appointed Coordinators and two joint standing committees to assist in Treaty implementation activities. These are described in subsequent paragraphs. The primary duties and responsibilities of the Entities as specified in the Treaty and related documents are:

1. Plan and exchange information relating to facilities used to obtain the benefits contemplated by the Treaty.
2. Calculate and arrange for delivery of hydroelectric power to which Canada is entitled and the amounts payable to the U.S. for standby transmission services.
3. Operate a hydrometeorological system.
4. Assist and cooperate with the Permanent Engineering Board in the discharge of its functions.

5. Prepare hydroelectric and flood control operating plans for the use of Canadian storage.

6. Prepare and implement detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under assured operating plans.

7. 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.

Entity Coordinators

The Entities have appointed members of their respective staffs to serve as coordinators or focal points on Treaty matters within their organizations.

The members are:

UNITED STATES ENTITY COORDINATORS

Sue F. Hickey, Coordinator
Asst. Administrator for Office of
Energy Resource, Bonneville Power
Administration
Portland, Oregon

Robert P. Flanagan, Coordinator
Director, Planning and Engineering
North Pacific Division
Army Corps of Engineers
Portland, Oregon

Pamela A. Kingsbury, Secretary
Energy Resource Specialist, Canadian Treaty
Section
Division of Power Resources
Bonneville Power Administration
Portland, Oregon

CANADIAN ENTITY COORDINATOR

H.D. Kenneth ~~EPP~~ Epp, Coordinator
President & CEO of POWEREX
Vancouver, B.C.

Graeme L. Simpson, Secretary
Resource Planning Engineer
BC Hydro and Power Authority
Vancouver, BC

Mr. Epp was appointed to succeed Mr. Forrest and Mr. Simpson was appointed as Secretary effective 7 May 1993. Ms. Hickey succeeded Mr. Sienkiewicz effective 19 July 1993.

Columbia River Treaty Operating Committee

The Operating Committee was established in September 1968 by the Entities and is responsible for preparing and implementing operating plans as required by the Columbia River Treaty, making studies and otherwise assisting the Entities as needed. The Operating Committee consists of eight members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Mark Maher, BPA, Co-Chairman	Timothy J. Newton, BCH, Chairman
Nicholas A. Dodge, ACE, Co-Chairman	Ralph D. Legge, BCH
Russell L. George, ACE	Kenneth R. Spafford, BCH
Steven A. Montfort, BPA	Gary H. Young, BCH

Mr. Maher was appointed to succeed Robert D. Griffin, effective 1 March 1993.

There were six meetings of the Operating Committee during the year. The dates, places and number of persons attending those meetings were:

Date	Location	Attendees
16 November 1992	Vancouver, B.C.	16
21 January 1993	Portland, OR.	18
25 March 1993	Vancouver, B.C.	17
19 May 1993	Bonneville, OR	17
13 July 1993	Vancouver, B.C.	15
29 September 1993	Portland, OR	16

The Operating Committee coordinated the operation of the Treaty storage in accordance with the current hydroelectric and flood control operating plans. This aspect of the Committee's work is described in following sections of this report which have been prepared by the Committee with the assistance of others. During the period covered by this report, the Operating Committee completed the 1992-93 Detailed Operating Plan (DOP), the 1997-98 Assured Operating Plan, and a report forecasting the Canadian Entitlement entitled "Columbia River Treaty Forecast of Canadian Entitlement to Downstream Power Benefits, Entitlement Forecast Studies," dated April 1993.

Columbia River Treaty Hydrometeorological Committee

The Hydrometeorological Committee was established in September 1968 by the Entities and is responsible for planning and monitoring the operation of data facilities in accord with the Treaty and otherwise assisting the Entities as needed. The Committee consists of four members as follows:

UNITED STATES SECTION	CANADIAN SECTION
Bruce E. MacKay, BPA Co-Chairman	William Chin, BCH, Chairman
Douglas D. Speers, ACE, Co-Chairman	Brian H. Fast, BCH, Member

There was one meeting of the Hydrometeorological Committee, on 5 November, at the BPA Dittmer Control Center in Vancouver, WA. The committee reviewed the 1992 volume forecast results, hydromet station changes, and developments in telemetry and forecast procedures. It also addressed the revision made in the discharge rating curves for Keenleyside project. In general, data was exchanged smoothly with no major problems.

Permanent Engineering Board

Provisions for the establishment of the Permanent Engineering Board (PEB) and its duties and responsibilities are included in the Treaty and related documents. The members of the PEB are presently:

UNITED STATES SECTION
Herbert H. Kennon, Chairman,
Washington, D.C.
Ronald H. Wilkerson, Member
Missoula, Montana

John P. Elmore, Alternate
Washington, D.C.
Thomas L. Weaver, Alternate
Golden, Colorado
S.A. Zanganeh, Secretary
Washington, D.C.

CANADIAN SECTION
David Oulton, Chairman
Ottawa, Ontario
John ~~Allen~~, Member Allan
Victoria, B.C.

Don A. Kasianchuk, Alternate
Victoria, B.C.
Vic Niemela, Alternate &
Secretary
Vancouver, B.C.

In general, the duties and responsibilities of the PEB are to assemble records of flows of the Columbia River and the Kootenay River at the international boundary; report to both governments if there is deviation from the hydroelectric or flood control operating plans, and if appropriate, include recommendations for remedial action; assist in reconciling differences that may arise between the Entities; make periodic inspections and obtain reports as needed from the Entities to assure that Treaty objectives are being met; make an annual report to both governments and special reports when appropriate; consult with the Entities in the establishment and operation of a hydrometeorological system; and, investigate and report on any other Treaty related matter at the request of either government.

The Entities continued their cooperation with the PEB during the past year by providing copies of Entity agreements, operating plans, downstream power benefit computations, corrections to hydrometeorological documents, and the annual Entity report to the Board for their review. The annual joint meeting of the PEB and the Entities was held on the afternoon of 3 December 1992 in Vancouver, B.C. A special joint meeting of the PEB and the Entities was held on 20 May 1993 in Portland, OR., to discuss the Entities' resolution of the computation of capacity credit limits.

PEB Engineering Committee

The PEB has established a PEB Engineering Committee (PEBCOM) to assist in carrying out its duties. The members of PEBCOM at the end of the period of this report were:

UNITED STATES SECTION

S.A. Zanganeh, Chairman
Washington, D.C.
Gary L. Fuqua, Member
Portland, Oregon
Earl E. Eiker, Member
Washington, D.C.
Larry Eilts, Member
Golden, Colorado
Stephen J. Wright, Alternate Member
Washington, D.C.
Richard L. Mittelstadt, Alternate Member
Portland, Oregon

CANADIAN SECTION

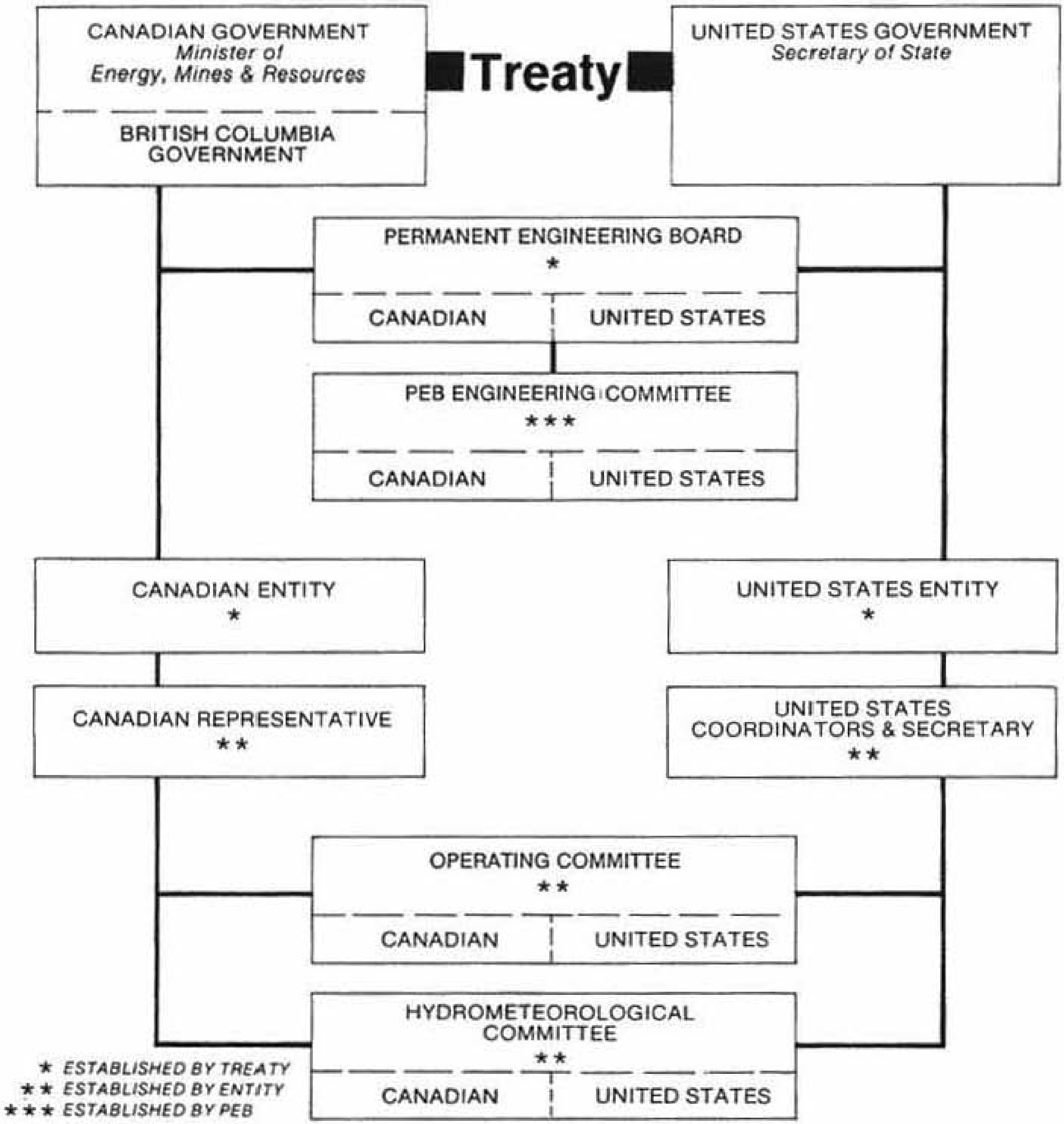
R.O. "Neil" Lyons, Chairman
Vancouver, B.C.
David Burpee, Member
Ottawa, Ont.
Roger McLaughlin, Member
Victoria, B.C.
Bala Balachandran, Member
Victoria, B.C.

International Joint Commission

The International Joint Commission (IJC) was created under the Boundary Waters Treaty of 1909 between Canada and the U.S. Its principal functions are rendering decisions on the use of boundary waters, investigating important problems arising along the common frontier not necessarily connected with waterways, and making recommendations on any question referred to it by either government. If a dispute concerning the Columbia River Treaty could not be resolved by the Entities or the PEB it may be referred to the IJC for resolution before being submitted to a tribunal for arbitration.

The IJC has appointed local Boards of Control to insure compliance with IJC orders and to keep the IJC currently informed. There are four such boards west of the continental divide. These are the International Kootenay Lake Board of Control, the International Columbia River Board of Control, the International Osoyoos Lake Board of Control and the International Skagit River Board of Control. The Entities and their committees conducted their Treaty activities during the period of this report so that there was no known conflict with IJC orders or rules.

Columbia River Treaty Organization



III Operating Arrangements

Power and Flood Control Operating Plans

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 that 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 the use of current estimates of loads and resources. The Protocol to the Treaty provides further detail and clarification of the principles and requirements of the Treaty.

The "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans" dated December 1991 together with the "Columbia River Treaty Flood Control Operating Plan" dated October 1972, establish and explain the general criteria used to plan and operate Treaty storage during the period covered by this report. These documents were previously approved by the Entities.

The planning and operation of Treaty Storage as discussed on the following pages is for the operating year, 1 August through 31 July. The planning and operating for U.S. storage operated according to the Pacific Northwest Coordination Agreement has been changed to the same period. Most of the hydrographs and reservoir charts in this report are for a 13 month period, July 1992 through July 1993.

Assured Operating Plan

The Assured Operating Plan (AOP) dated September 1988 established Operating Rule Curves for Duncan, Arrow, and Mica during the 1992-93 operating year. The Operating Rule Curves provided guidelines for draft and refill. They were derived from Critical Rule Curves, Assured Refill Curves, Upper Rule Curves, and Variable Refill Curves, consistent with flood control requirements, as described in the 1991 Principles and Procedures document. The Flood Control Storage Reservation Curves were established to conform to the Flood Control Operating Plan of 1972.

Determination of Downstream Power Benefits

For each operating year, the Determination of Downstream Power Benefits resulting from Canadian Treaty storage is made five years in advance in conjunction with the Assured Operating Plan. For operating year 1992-93 the estimate of benefits resulting from operating plans designed to achieve optimum operation in both countries indicated no loss in energy or dependable capacity, therefore no energy delivery was required during the period 1 August 1991 through 31 March 1992. For operating year 1993-94 the estimate of benefits resulting from operating plans designed to achieve optimum operation in both countries was less than that which would have prevailed from an optimum operation in the United States only. Therefore, in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement, the Entities agreed that the United States was entitled to receive 2.3 megawatts of dependable capacity and no energy during the period 1 April 1993 through 31 July 1993. Suitable arrangements were made between the Bonneville Power Administration and B.C. Hydro for delivery of this capacity.

Detailed Operating Plan

During 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" (DOP), dated November 1992. The DOP established criteria for determining the Operating Rule Curves for use in actual operations. Except for minor changes at Arrow during the spring months, the DOP used the AOP critical rule curves for Canadian Projects. The Variable Refill Curves and flood control requirements subsequent to 1 January 1993 were determined on the basis of seasonal volume runoff forecasts during actual operation. Results of the Actual Energy Regulation were used to determine the triggering of releases from Mica. The regulation of the Canadian storage was conducted by the Operating Committee on a weekly basis throughout the year.

Entity Agreements

During the period covered by this report, two agreements were officially approved by the Entities. The following tabulation indicates the date each of these were signed and gives a description of the agreement:

Date Agreement Signed by Entities	Description
4 December 1992	Detailed Operating Plan on Columbia River Treaty Storage, 1 August 1992 through 31 July 1993, dated November 1992.
23 November 1992	Assured Operating Plan, Determination of Downstream Power Benefits for Operating Year 1997-1998, dated October 1992.

Long Term Non-Treaty Storage Contract

In accordance with the 9 July 1990 Entity Agreement which approved the contract between B.C. Hydro and BPA relating to the initial filling of non-Treaty storage, coordinated use of non-Treaty storage, and Mica and Arrow refill enhancement, the Operating Committee monitored the storage operations made under this Agreement throughout the operating year to insure that they did not adversely impact operation of Treaty storage required by the Detailed Operating Plan.

IV Weather and Streamflow

Weather

The 1993 water year, a period of extreme weather conditions, was preceded with mild weather in August and September with little significant precipitation to dampen the 4-6 years of drought that have plagued the area (Charts 1 and 3). October fared a little better with two storms affecting the area: one at mid month and the other at the end of the month. The latter storm was more intense but did not produce a lot of precipitation because it moved quickly through the basin to California. Other moderate storms followed until mid-November when the low pressure began drawing more air from the arctic and sending it into the basin. This pattern continued, with only brief respites, until early January when the jetstream, along with the flow of moist air, moved into central California, bringing even colder and dryer air across the basin. This weather pattern continued throughout the winter season, with the storm brushing the southern border of the basin and leaving the northern portion with little precipitation. After mid-January the jetstream again moved northward and established itself for a week's stay on the Oregon coast, producing moderate precipitation and temperatures. During the last week of the month the jet moved into British Columbia, leaving the Northwest under a dry airmass. This pattern lasted until mid-February when arctic air, with a trajectory over the ocean, produced moderate precipitation over the basin. During the last two weeks of February the temperatures gradually returned to normal while the precipitation remained in the normal range. This basic weather pattern continued until 10 May when a strong low pressure system was established off the northern California coast, drawing very warm and dry southwest desert air into the Northwest (Charts 4 and 5). During this 10-day period temperatures rose to an unusual 15 degrees F above normal and produced significant snowmelt, especially to lower elevation snowpacks. As the low moved northeastward the southern branch of the jet moved into the region with moisture that mixed with cooler air from the north to produce showers, an unusually large number of thunderstorms, and even a few tornados over the southern portion of the basin. This atmospheric flow pattern continued into August, with only a few interruptions by more seasonal weather. Temperatures were frequently 20 degrees F below normal and precipitation averaged more than twice monthly normals in many sub-basins.

The final monthly precipitation indices for the Columbia Basin above The Dalles are shown below for the 1993 water year. These indices are based on 60 stations and are computed at the end of each month after all the data are collected. Also shown in the table are the monthly indices as a percent of the 30-year average (1961-1990).

WY 93 Indices

Month	Precipitation (in.)	Precipitation (%)	Month	Precipitation (in.)	Precipitation (%)
Oct 92	1.39	85	Apr 93	2.31	145
Nov 92	2.50	92	May 93	2.05	113
Dec 92	2.78	92	Jun 93	3.01	166
Jan 93	2.45	83	Jul 93	2.51	230
Feb 93	0.93	44	Aug 93	1.62	131
Mar 93	2.00	106	Sep 93	0.58	41
			Water Year	23.95	103

Streamflow

The observed inflow and outflow hydrographs for the Treaty reservoirs for the period 1 July 1992 through 31 July 1993 are shown on Charts 6 through 9. Observed flows with the computed unregulated flow hydrographs for the same 13-month period for Kootenay Lake, Columbia River at Birchbank, Grand Coulee, and The Dalles are shown on Charts 10, 11, 12, and 13, respectively. Chart 14 is a hydrograph of observed and two unregulated flows at The Dalles during the April through July 1993 period, including a plot of flows occurring if regulated only by the Treaty reservoirs.

Composite operating year unregulated streamflows in the basin above The Dalles were near slightly less than last year, with only May exceeding the norm. The October through September runoff for The Dalles was 82 percent of the 1961-90 average. The peak regulated discharge for the Columbia River at The Dalles was 386,500 cfs on 17 May 1993. The 1992-93 monthly unregulated streamflows and their percent of the 1961-90 average monthly flows are shown in the following table for the Columbia River at Grand Coulee and at The Dalles. These flows have been corrected for storage in lakes and reservoirs to exclude the effects of regulation.

	Columbia River at Grand Coulee in cfs		Columbia River at The Dalles in cfs	
Time Period	Natural Flow	Percent of Average	Natural Flow	Percent of Average
Aug 92	66,400	63	87,230	63
Sep 92	46,100	71	64,410	67
Oct 92	49,340	102	71,830	84
Nov 92	36,720	76	64,680	71
Dec 92	25,370	60	52,400	56
Jan 93	24,640	60	60,420	61
Feb 93	19,860	43	56,830	49
Mar 93	43,240	73	137,570	97
Apr 93	95,990	82	204,600	91
May 93	287,600	109	471,890	112
Jun 93	190,810	58	319,020	64
Jul 93	147,230	77	202,800	79
Year	86,110	76	149,470	79

Seasonal Runoff Forecasts and Volumes

Observed 1993 April through August runoff volumes, adjusted to exclude the effects of regulation of upstream storage, are listed below for eight locations in the Columbia Basin:

Location	Volume In 1000 Acre-Feet	Percent of 1961-90 Average
Libby Reservoir Inflow	5479	86
Duncan Reservoir Inflow	1575	77
Mica Reservoir Inflow	8918	78
Arrow Reservoir Inflow	17397	77
Columbia River at Birchbank	32372	80
Grand Coulee Reservoir Inflow	49576	81
Snake River at Lower Granite Dam	22451	98
Columbia River at The Dalles	80713	87

Forecasts of seasonal runoff volume, based on precipitation and snowpack data, were prepared in 1993 as usual for a large number of locations in the Columbia River Basin and updated each month as the season advanced. Table 1 lists the April through August volume inflow forecasts for Mica, Arrow, Duncan, and Libby projects, and for unregulated runoff for the Columbia River at The Dalles. Also shown in Table 1 are the actual volumes for these five locations. The forecasts for Mica, Arrow, and Duncan inflow were prepared by B.C. Hydro, and those for the lower Columbia River and Libby inflows were prepared by the U. S. Columbia River Forecasting Service. The 1 April 1993 forecast of January through July runoff for the Columbia River above The Dalles was 76.6 MAF and the actual observed runoff was 88.0 MAF.

The following tabulation summarizes monthly forecasts since 1970 of the January through July runoff for the Columbia River above The Dalles compared with the actual runoff measured in millions of acre-feet (MAF). The average January-July runoff for the 1961-1990 period is 105.9 MAF.

The Dalles Volume Runoff Forecasts in MAF (Jan-Jul)

Year	Jan	Feb	Mar	Apr	May	June	Actual
1970	82.5	99.5	93.4	94.3	95.1		95.7
1971	110.9	129.5	126.0	134.0	133.0	135.0	137.5
1972	110.1	128.0	138.7	146.1	146.0	146.0	151.7
1973	93.1	90.5	84.7	83.0	80.4	78.7	71.2
1974	123.0	140.0	146.0	149.0	147.0	147.0	156.3
1975	96.1	106.2	114.7	116.7	115.2	113.0	112.4
1976	113.0	116.0	121.0	124.0	124.0	124.0	122.8
1977	75.7	62.2	55.9	58.1	53.8	57.4	53.8
1978	120.0	114.0	108.0	101.0	104.0	105.0	105.6
1979	88.0	78.6	93.0	87.3	89.7	89.7	83.1
1980	88.9	88.9	88.9	89.7	90.6	97.7	95.8
1981	106.0	84.7	84.5	81.9	83.2	95.9	103.4
1982	110.0	120.0	126.0	130.0	131.0	128.0	129.9
1983	110.0	108.0	113.0	121.0	121.0	119.0	118.7
1984	113.0	103.0	97.6	102.0	107.0	114.0	119.1
1985	131.0	109.0	105.0	98.6	98.6	100.0	87.7
1986	96.8	93.3	103.0	106.0	108.0	108.0	108.3
1987	88.9	81.9	78.0	80.0	76.7	75.8	76.5
1988	79.2	74.8	72.7	74.0	76.1	75.0	73.7
1989	101.0	102.0	94.2	99.5	98.6	96.9	90.6
1990	86.5	101.0	104.0	96.0	96.0	99.5	99.7
1991	116.0	110.0	107.0	106.0	106.0	104.0	107.1
1992	92.6	89.1	83.5	71.2	71.2	67.8	70.4
1993	92.6	86.5	77.3	76.6	81.9	86.1	88.0

V Reservoir Operation

General

The 1993 operating year was characterized by below average precipitation during August-February and above normal March-August. Temperatures basically were below normal August-February, going above normal early in the snowmelt season, finishing with June and July below normal. The snowmelt season was characterized by continued cold, wet conditions. At The Dalles, the observed January-July runoff was 83 percent of average, eleven percent higher than the April forecast, and four percent lower than the January forecast.

The operating year began with the coordinated reservoir system officially filling to 68.59 percent of storage capacity on 31 July 1992. As a result, third year firm energy load carrying capability (FELCC) was adopted for the 1992-93 operating year. The breakpoint of 68.58 percent would have required adopting fourth year FELCC.

In August the system began operating between CRC4 and empty in accordance with proportional draft requirements. The system operated between third and fourth year rule curves from September through January. During February and March the system was empty (according to Actual Energy Regulation), operating at 975 MWa and 1372 MWa below system FELCC. However, purchases and imports made prior to and during this time, were used to meet system loads. April saw the system slightly recover and operate between CRC3 and empty. During May through July, the system inflows were high enough to meet FELCC without proportionally drafting.

The 1 January water supply forecast was 92.6 maf for the January-July period, or 87 percent of the 1961-90 average. Subsequent forecasts through April reflected a decreasing trend, with the April forecast 72 percent of normal. During April through July, above normal precipitation turned the forecasts upward with the June showing runoff forecasts volumes of 81 percent of normal.

In April, the system was in proportional draft between second and third year critical rule curves, however, BPA had more than 3 MAF stored in the system above PDP. At the beginning of the 15 April-15 June flow augmentation period, the water budget and 3 MAF were used to provide an average period flow at The Dalles. Following the release of National Maine Fisheries Service's Biological Opinion on 26 May the flows were regulated to meet target flows during June and July at McNary. During May, June and July, the average outflow at McNary was 286,000 cfs, 222,000 cfs and 161,000 cfs, respectively.

Daily flood control regulation was not required during the 1993 snow melt season. The year's observed peak flow at The Dalles was 386,500 cfs on 17 May. The much above normal temperatures in May caused the peak to be considerably higher than the calculated Initial Control Flow values which were varying between 210,000 and 275,000 cfs. Last year's peak was 232,300 cfs. The system reached 73 percent of its full energy capacity in the Actual Energy Regulation (AER) on 31 July 1993, resulting in third-year FELCC being adopted for the 1993-94 operating year. The observed refill was 77% of energy capacity, providing some reservoir operating storage above the proportional draft level going into the new operating year.

Mica Reservoir

As shown in Chart 6, Mica reservoir (Kinbasket Lake) was at elevation 2450.2 feet, approximately 25 feet below full pool elevation of 2475 feet, on 31 July 1992. The reservoir reached its maximum elevation of 2451.8 feet on 7 August. Treaty storage continued to fill until 21 August at which point it contained 3514.6 ksfd (99.6% full).

Summer discharges from Mica were maintained at approximately 40,000 cfs to mitigate low Arrow reservoir levels. This was significantly higher than the releases specified in the DOP, and a 500 ksfd overrun was accumulated. September and October releases averaged about 20,000 cfs, and the overrun was fully corrected by 10 November 1992. Lower-than-DOP releases were continued, however, to protect Mica reservoir levels and preserve winter peaking capabilities. On 31 December 1992 the underrun was 354 ksfd.

Despite the large underrun, record low Mica elevations were experienced for much of the winter. The 31 December 1992 elevation at Mica was 2407.4 feet, approximately 7 feet below the previous minimum for this date. Mica bottomed out at a new record low of 2340.4 feet (5 feet below previous) on 23 April 1993. The underrun on that date was 650 ksfd.

Treaty storage was fully depleted by 11 February 1993. Releases required by the DOP continued to draft the account, and the overdraft peaked at 1292 ksfd on 5 May.

Unusually high temperatures in May resulted in a rapid snow melt. Between 11 May and 13 May, inflow to Kinbasket Lake increased from 10,000 cfs to 64,000 cfs and the reservoir began filling rapidly. The record low snowpack could nct support these inflows for long, however, and they quickly dropped off to 40-50 kcfs. The peak inflow for the year was 75,400 cfs on 8 June. This was an isolated rainfall event, however, and the second highest was 64,700 cfs on 14 May.

Unseasonably cool temperatures and a depleted snowpack combined to produce streamflows approximately 60% of average in June and July. During this period, Mica releases were increased to support Arrow reservoir levels for summer recreation, and to correct the record underrun. The latter reached a peak of 921 ksfd on 6 July.

On 9 July, Mica discharges were increased to facilitate discharge reductions from Hungry Horse which would reduce inflow and spill at Waneta. The storage transfer was stopped on 17 July, by which time 54.5 ksfd had been accumulated. This water was returned during September without spill at Seven Mile or Waneta.

The Mica reservoir continued to fill at a reduced rate in July, August, and September, and reached a peak of 2419.4 feet on 12 September. Treaty storage on the same date was only 1648 ksfd (47 % of full).

Revelstoke Reservoir

During this operating year, the Revelstoke project was basically operated as a run-of-the-river plant, maintaining the reservoir level within two feet of its normal full pool elevation of 1880 feet. In early January, however, the reservoir was drawn down approximately 5 feet to provide additional peak generation required during a protracted cold snap.

In May, the reservoir was drawn approximately 3 feet below full pool to provide the operating flexibility necessary to address rapidly increasing inflows. The reservoir level was returned to its normal operating range when the threat of spill passed.

Arrow Reservoir

As shown in Chart 7, Arrow reservoir filled to elevation 1412.4 feet by 31 July 1992. Discharges ranged from 45,000 to 65,000 cfs from mid-July to the end of August, and the reservoir drafted to elevation 1408.6 feet despite maximum discharges from Mica. During this period, the overrun from Mica was increased from 350 ksfd to 500 ksfd.

The project basically passed inflow in September and the first half of October and the elevation on 19 October was 1409.7 feet. Reduced discharges in late October and November filled the reservoir slightly, and the maximum elevation of 1415.2 feet was recorded on 17 November 1992. The Arrow Treaty storage continued to fill for a few days and reached 1933 ksfd on 21 November. At about the same time (10 November) the Mica overrun was reduced to zero, and an underrun initiated to maintain Mica's peaking capability.

Discharges averaged approximately 60,000 cfs in December and January, and peaked at 87,000 cfs during the cold snap in early January. The high flows rapidly drafted both the reservoir and Arrow Treaty storage. On 31 January 1993 recorded levels were elevation 1391.7 feet and 1000 ksfd respectively.

Discharges of about 45,000 cfs in February continued the draft at a slightly slower rate. Minimums for both reservoir elevation (1385.2 feet) and Arrow Treaty storage (670 ksfd) were recorded on 26 February.

From 20 March to 13 May, discharges were held at 15,000 cfs to protect trout redds at the Norns Creek fan, and the reservoir filled steadily. In mid May, freshet flows on the Kootenay River provided a backwater effect, and Arrow discharges were reduced to 8,000 cfs. The combined effect of low discharges and high inflows greatly increased the rate of filling. By 30 June, the reservoir elevation reached 1430.4 feet, and Arrow Treaty storage was basically full at 3525 ksfd (98.5%).

Discharges of up to 67,700 cfs drafted the reservoir slightly in the first half of July. Increased discharges from Mica were initiated to reduce the substantial underrun and help maintain Arrow reservoir levels. This action reduced the underrun from a peak of 906 ksfd on 6 July, to 299 ksfd on 31 August, and kept the reservoir near elevation 1433 feet during the last month of the summer recreation season.

Duncan Reservoir

As shown in Chart 8, the Duncan reservoir filled to elevation 1848.0 feet by 31 July 1992, well below the full pool elevation of 1892.0 feet. Treaty storage in Duncan on this date was 339 ksfd (48% of full).

A special Duncan/Libby storage transfer moved 465 ksfd to Libby between 9 June and 7 August 1992. Maximum discharges of 10,000 cfs in early August drafted the reservoir rapidly. Record low summer reservoir levels were experienced, despite being above the proportional draft point (due to Arrow releases). The reservoir ended August at elevation 1832.6 feet.

Minimum flows of 100 cfs were discharged from Labor Day (7 September) to 4 December, by which time the reservoir had filled to elevation 1841.8 feet. Included in this low flow period was the return of most of the Duncan/Libby water. The return commenced on 10 October, and was completed on 18 December.

December discharges varied from minimum to 8,000 cfs, but averaged approximately 3,900 cfs for the month. By 31 December 1992, the reservoir had been drawn down to elevation 1827.9 feet, 40 feet below the 31 December 1991 level.

During January the outflow averaged 5,400 cfs and by 31 January the reservoir reached elevation 1803.2 feet, and contained only 41 ksfd of Treaty storage. Inflow to the reservoir in February could not keep up with the average release of 1,600 cfs, and the reservoir drafted further, ending the month at 1796.4 feet. This was well below the drawdown level required for flood control.

Minimum flows in March did little to increase reservoir levels, and two weeks of flows averaging 3,500 cfs in mid-April effectively emptied the reservoir. The minimum elevation for the year was 1794.9 feet recorded on 22 April 1993.

In May, minimum releases and high inflows resulted in rapid filling of the reservoir. The peak inflow for the year was 15,900 cfs recorded on 14 May. The 31 May elevation was 1837.7 feet.

Minimum discharges were maintained through June and July, and the reservoir continued to fill steadily. On 31 July, the reservoir had reached elevation 1881.9 feet, and was 87% full (617 ksfd). Filling continued until 10 August, at which time the reservoir peaked at 1885.4 feet and 648 ksfd (91.8% full).

Between 3 July and 19 July, 132 ksfd was transferred out of Canadian storage as part of the 1993 Duncan/Libby storage transfer agreement. The Canadian Entity chose to release this water from Mica/Arrow rather than Duncam, and this action cut back releases at Libby and reduced spill at Brilliant. This water will be returned between 1 September and 31 December 1993.

Libby Reservoir

As shown in Chart 9, Libby did not completely refill following the 1992 runoff, with Lake Koocanusa starting the operating year at elevation 2439.1 feet, 20 feet below full. The lake reached its highest level of elevation 2439.8 on 5 August 1992.

Lake Koocanusa was drafted from mid-August into late December, with the powerhouse load factoring from full load to minimum releases on weekdays and 4,000 cfs to 8,000 cfs on weekends. On 10 October, Libby began releasing 465 ksfd of Libby/Duncan transfer stored earlier in the summer to enhance lake refill. During late October and November , outflows were controlled for Montana Department of Fish, Wildlife, and Parks transect surveys. The elevation on 31 December was 2359.5 feet; this level was about 16 feet above the proportional draft point. Inflows during the October-December period were 92 percent of average.

In January, water supply forecasts for the upper Columbia Basin drainage were about 90 percent of average. Libby's forecast was 88 percent. With a lake elevation near 2360, no draft was required to meet the 15 March flood control requirement of elevation 2390 feet. The Libby outflow was load factored the first of January to meet loads created by the region's cold snap. During 15 January thru 15 March, the outflow remained at 4,000 cfs except for periods of load factoring to meet system demands. The lake reached its low level of elevation 2323.0 feet on 23 March 1993. The minimum flow of 4,000 cfs was maintained from 15 March until 28 May when outflow was increased to 8,000 cfs as part of study to attract white sturgeon into the reach near Bonners Ferry for spawning. Warm weather in mid-May started the snowmelt runoff, but it was short lived. The peak inflow of the season was only 54,000 cfs and very early in the season on 16 May 1993. By the end of May, the pool level was near elevation 2387 feet. Much of June and July saw inflows in the 20,000 cfs range, 59 and 105 percent of average, respectively.

During the first half of June, 400 kaf of stored augmentation water was released to maintain flows of near 20,000 cfs at Bonners Ferry to encourage sturgeon spawning. At the end of this operation on 17 June, Libby reservoir was near elevation 2400 feet, 59 feet from full pool. In an attempt to improve the maximum level that the reservoir would reach, BC Hydro and BPA reached an agreement, known as the Duncan-Libby Transfer Agreement, that permitted BC Hydro to store water in Libby reservoir by releasing water from Canadian Treaty storage. On 17 June 1993, the outflow was reduced to 4,000 cfs with BC Hydro replacing the Libby flow that BPA was requesting with flow from Mica/Arrow. This arrangement continued through July and Libby reservoir filled to elevation 2438.8 feet on 31 July 1993. Universal Studios, filming in the Kootenai Falls area, were provided flows near 4700 and 6300 cfs so that stunt work they were doing in the river could be done safely.

By Labor Day, 7 September, the reservoir had reached its maximum level, elevation 2448.2 feet. The January-July observed runoff was 5321 kaf, 83 percent of average.

Kootenay Lake

As shown in Chart 10, Kootenay Lake was at elevation 1743.4 feet (Queens Bay gage) on 31 July 1992, and the lake was already being constrained by the IJC summer maximum operating level (1743.32 feet at the Nelson gauge). Inflow was passed throughout the month of August to maintain this level. In September, the higher Fall/Winter IJC level permitted filling, and the lake level rose to 1744.3 feet by 30 September. During October, November and December 1992, Kootenay Lake was operated between elevations 1744.2 feet and 1745.0 feet to minimize spill at Brilliant.

Kootenay Lake began drafting in early January, in accordance with the IJC curve, and continued to draft in February and March. The minimum level for the year was elevation 1738.95 feet on 4 April 1993.

In early May, a rapid increase in temperature initiated higher inflows, and the lake filled rapidly. Discharges were increased accordingly, and the maximum release for the year was 44,100 cfs on 24 May. The peak elevation of 1745.8 feet was recorded on 3 June. The near record low snowpack could not maintain the inflows, and the lake level dropped steadily over the next six weeks despite high Libby discharges (approximately 17,000 cfs) initiated to support sturgeon spawning. On 26 June, the Nelson gauge dropped below the critical IJC level of 1743.32 feet and the lake level was maintained below this level for the balance of the summer.

Storage Transfer Agreements

An agreement was reached in June 1992 between BC Hydro and BPA to store BC Hydro water in Libby. The agreement involved operating Duncan and Libby in such manner that water was essentially transferred from Duncan to Libby, so that Libby reservoir would be at a higher elevation than it would have reached otherwise, and therefore enhancing the summer recreation possibilities in Canada and U.S. Ultimately, 465.3 ksfd of water was transferred from Duncan to Libby. The water was transferred back to Duncan reservoir by 18 December 1992.

A similar agreement was used in the summer of 1993 when Duncan/Arrow were used to reduce the outflow from Libby. This operation resulted in about 130 ksfd less water being released from Libby and the lake reaching a level that was about 6 feet higher than it otherwise would have been. This water will be returned by 31 December 1993.

A further agreement between the Entities facilitated the temporary transfer of 54.5 ksfd of storage from Mica to Hungry Horse. The agreement reduced the amount of spill at the Waneta project, resulting in a significant energy gain for Canada. This water was returned to Canadian storage in September.

VI Power and Flood Control Accomplishments

General

During the period covered by this report, Duncan, Arrow, Mica, and Libby reservoirs were operated in accordance with the Columbia River Treaty. Specifically, the operation of the reservoirs was governed by:

1. "Detailed Operating Plan for Columbia River Treaty Storage - 1 August 1992 through 31 July 1993," dated November 1992.
2. "Columbia River Treaty Flood Control Operating Plan," dated October 1972.

Consistent with all Detailed Operating Plans prepared since the installation of generation at Mica, the 1992-93 Detailed Operating Plan was designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States, in accordance with paragraph 7 of Annex A of the Treaty. The 1992-93 Assured Operating Plan, prepared in 1988, was used as the basis for the preparation of the 1992-93 Detailed Operating Plan.

Power

The Canadian Entitlement to downstream power benefits from Duncan, Arrow and Mica for the 1992-93 operating year had been purchased in 1964 by the Columbia Storage Power Exchange (CSPE). In accordance with the Canadian Entitlement Exchange Agreement dated 13 August 1964, the U.S. Entity delivered capacity and energy to the CSPE participants. The generation at downstream projects in the United States, delivered under the Canadian Entitlement Exchange was 305 average megawatts from 1 August 1992 through 31 March 1993 and 293 average megawatts from 1 April through 31 July 1993. Capacity deliveries were up to 844 megawatts from 1 August 1992 through 31 March 1993 and 755 megawatts from 1 April through 31 July 1993.

The Coordinated System proportional draft point (PDP) at the beginning of the 1992-93 operating year was 68.6% full which resulted in the system adopting a 3rd-year firm energy load carrying capability (FELCC) from the critical period studies. Due to persistent low inflows, the system continued to proportionally draft from August through April to meet FELCC. The system PDP reached empty during February and March, failing to meet FELCC by about 2,400 MW-Months. This was the first time that the Coordinated System had failed to develop the FELCC defined in the critical period studies. The system produced surplus energy during May through July when Arrow and Grand Coulee refilled to their Operating Rule Curve (ORC), but most headwater reservoirs operated on minimum flow trying to refill. The system PDP reached 72.9% full on 31 July 1993, and the system again adopted 3rd-year FELCC from the critical period studies.

The following table shows the status of the energy stored in Coordinated System reservoirs at the end of each month compared to the ORC or PDP during the 1992-93 operating year. Normal full Coordinated System reservoir storage is approximately 63,700 megawatt-months (MW-Mo). All figures are 1000 MW-Mo.

END OF PERIOD ENERGY STORAGE

	Coordinated System			Canadian Treaty		
MON	ORC/PDP K-MWMos	Actual K-MWMos	Difference K-MWMos	ORC/PDP K-MWMos	Actual K-MWMos	Difference K-MWMos
Aug 92	40.5	45.8	5.3	14.9	12.9	-2.0
Sep 92	36.1	42.0	5.9	14.3	13.0	-1.3
Oct 92	32.2	38.9	6.7	14.1	12.9	-1.2
Nov 92	26.6	34.6	8.0	11.5	11.9	0.4
Dec 92	18.0	26.9	8.9	16.6	7.9	1.3
Jan 93	9.1	18.9	9.8	3.6	3.6	0.0
Feb 93	3.5	14.5	11.0	1.0	2.2	1.2
Mar 93	3.7	16.8	13.1	0.6	3.1	2.5
Apr 93	8.4	22.7	14.3	1.4	4.0	2.6
May 93	29.0	38.6	9.6	8.4	8.6	0.2
Jun 93	41.2	45.8	4.6	12.6	12.6	0.0
Jul 93	47.1	49.5	2.4	15.1	14.8	-0.3

Operations for juvenile fish in both Canada and the U.S. influenced project operations in both countries. In April, May and June flexibility at Grand Coulee, Arrow and Mica was used to insure that the outflow of Arrow did not go below about 15 kcfs in order to protect trout habitat at Norns Creek in British Columbia. Libby released 400 kaf of water during June that had been stored above PDP levels to assist the spring salmon outmigration and provide flows for a test during white sturgeon spawning periods.

BPA developed and implemented an extensive purchasing strategy to meet projected energy deficits, provide for flow augmentation in the United States and other nonpower requirements during an extremely low flow period. The following table is a summary of the federal purchases (in average

MW) during August 1992 through July 1993 that are in addition to those provided in the operating plan that were needed to meet firm loads.

FEDERAL PURCHASES (aMW)

Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
846	371	382	417	1025	2530	1805	1487	6729	0	0	143

Beginning in July, the U.S. and Canadian entities agreed to store in Libby and Hungry Horse with Canadian treaty water. During July, Libby and Hungry Horse reduced their outflows while Canadian treaty storage was drafted to produce the same flow at the border. The purpose for the reservoir balancing was to increase Lake Koocanusa elevation for recreational opportunities in Canada and to reduce spill at the Kootenay River plants project in Canada. Hungry Horse discharge was reduced to reduce spill at Waneta.

The following table shows BPA nonfirm and surplus sales in megawatt hours (MWh) to Northwest and Southwest utilities during the 1992-93 operating year.

BPA NONFIRM AND SURPLUS SALES (MWh)

PERIOD	TO NORTHWEST UTILITIES		TO SOUTHWEST UTILITIES	
	NONFIRM	SURPLUS FIRM	NONFIRM	SURPLUS FIRM
AUG 92	0	0	0	144,895
SEP 92	0	0	0	0
OCT 92	0	109,041	0	0
NOV 92	0	112,500	0	0
DEC 92	0	121,500	0	0
JAN 93	0	111,600	0	0
FEB 93	0	136,640	0	0
MAR 93	280,807	99,909	96,182	0
APR 93	198,708	960	91,119	95,530
MAY 93	1,211,072	0	1,420,112	84,475
JUN 93	1,049,726	174,800	762,328	122,031
JUL 93	707,082	90,000	837,441	74,452
TOTAL	3,447,395	956,950	3,391,870	1,488,642

Flood Control

The Columbia River Basin reservoir system, but not the Columbia River Treaty projects, was operated on a short-term daily basis for flood control between 15 May and 11 June 1993. Although the Upper Columbia Basin experienced low snowpack, the system went on flood control operation in the lower river due to high flows (near 190,000 cfs) in the Snake River. Grand Coulee started the flood control season nearly full, seven feet below full pool. By mid-May the elevation was near elevation 1286.0 feet and the outflow was 120,000 cfs. The John Day outflow was being controlled near 360,000 cfs. By 19 May, Grand Coulee was releasing 150,000 cfs with John Day being controlled to 380,000 cfs. By 11 June, Grand Coulee's flood control allowable level had been raised to elevation 1289 and with falling inflows in the upper basin, the flood control operation was terminated. The observed and unregulated hydrographs for the Columbia River at The Dalles between 1 April 1993 and 31 July 1993 are shown on Chart 14. The unregulated peak flow at The Dalles would have been 602,000 cfs on 23 May 1993 and it was controlled to a maximum of 386,500 cfs on 17 May 1993.

The observed peak stage at Vancouver, Washington was 13.4 feet on 18 May 1993 and the unregulated stage would have been 21.6 feet on 23 May 1993. Chart 15 documents the relative filling of Arrow and Grand Coulee during the principal filling period, and compares the regulation of these two reservoirs to guidelines in the Treaty Flood Control Operating Plan. Because this year's runoff volume forecast was small and Arrow was drafted very low for power, there was no flood control operation at Arrow after 30 April as the curve on Chart 15 did not guide the operation after that date.

Computations of the Initial Controlled Flow (ICF) for system flood control operation were made in accordance with the Treaty Flood Control Operating Plan. Computed Initial Controlled Flows at The Dalles was 278,000 cfs on 1 January 1993, 275,000 cfs on 1 February, 234,000 cfs on 1 March, 210,000 cfs on 1 April, and 275,000 cfs on 1 May. As mentioned earlier, the observed peak flow at The Dalles was 386,500 cfs. Data for the 1 May ICF computation are given in Table 6.

Table 1

Unregulated Runoff Volume Forecasts
Million of Acre-Feet
1993

Forecast Date - 1st of	Duncan Most Probable 1 April - 31 August	Arrow Most Probable 1 April - 31 August	Mica Most Probable 1 April - 31 August	Libby Most Probable 1 April - 31 August	Columbia River at The Dalles, Oregon Most Probable 1 April - 31 August
January	1.8	21.2	10.6	5.6	81.5
February	1.8	19.3	9.6	5.3	77.3
March	1.7	17.7	8.8	4.6	70.3
April	1.7	18.4	9.2	4.4	67.4
May	1.7	18.2	9.0	4.6	73.1
June	1.8	19.5	9.8	4.6	77.6
Actual	1.6	17.9	8.9	5.5	80.7

NOTE: These data were used in actual operations. Subsequent revisions have been made in some cases.

TABLE 2
1993 Variable Refill Curve
Mica Reservoir

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE JAN1-31JULY INFLOW,KAF		8683.2	7828.9	7070.9	7230.9	6705.9	7313.6
& IN KSFD		4377.8	3947.1	3564.9	3645.6	3380.9	2687.3
95% FORECAST ERROR FOR DATE,IN KSFD		682.7	551.3	513.4	460.4	440.9	470.5
95% CONF.DATE-31JULY INFLOW,KSFD 1/		3695.1	3395.8	3051.5	3185.2	2940.0	2216.8
ASSUMED FEB1-JUL31 INFLOW,% OF VOL.		100.00					
ASSUMED FEB1-JUL31 INFLOW,KSFD 2/		3695.1					
FEB MINIMUM FLOW REQUIREMENT,CFS 3/		3000.0					
MIN FEB1-JUL31 OUTFLOW,KSFD 4/		2980.1					
MIN JAN31 RESERVOIR CONTENT,KSFD 5/		2814.2					
MIN JAN31 RESERVOIR CONTENT,FEET 6/		2456.2					
JAN31 ECC,FT. 7/------------------>		2456.2					
BASE ECC=, FT........................	2469.8						
LOWER LIMIT, FT......................	2417.2						
ASSUMED MAR1-JUL31 INFLOW,% OF VOL.		97.70	97.90				
ASSUMED MAR1-JUL31 INFLOW,KSFD 2/		3610.1	3317.7				
MAR MINIMUM FLOW REQUIREMENT,CFS 3/		7290.0	8460.0				
MIN MAR1-JUL31 OUTFLOW,KSFD 4/		2896.1	3008.7				
MIN FEB28 RESERVOIR CONTENT,KSFD 5/		2815.1	3220.2				
MIN FEB28 RESERVOIR CONTENT,FEET 6/		2456.2	2464.2				
FEB28 ECC,FT. 7/------------------>		2456.2	2463.5				
BASE ECC, FT........................	2463.5						
LOWER LIMIT, FT......................	2408.3						
ASSUMED APR1-JUL31 INFLOW,% OF VOL.		95.30	95.30	97.50			
ASSUMED APR1-JUL31 INFLOW,KSFD 2/		3521.4	3236.2	2975.2			
APR MINIMUM FLOW REQUIREMENT,CFS 3/		7840.0	9160.0	25000.0			
MIN APR1-JUL31 OUTFLOW,KSFD 4/		2670.1	2746.4	3663.0			
MIN MAR31 RESERVOIR CONTENT,KSFD 5/		2677.8	3039.4	4202.9			
MIN MAR31 RESERVOIR CONTENT,FEET 6/		2453.5	2460.4	2469.8			
MAR31 ECC,FT. 7/------------------>		2451.4	2451.4	2451.4			
BASE ECC, FT........................	2451.4						
LOWER LIMIT, FT......................	2395.7						
ASSUMED MAY1-JUL31 INFLOW,% OF VOL.		90.40	90.40	92.40	94.80		
ASSUMED MAY1-JUL31 INFLOW,KSFD 2/		3340.4	3069.8	2819.6	3019.6		
MAY MINIMUM FLOW REQUIREMENT,CFS 3/		21100.0	21400.0	25000.0	25000.0		
MIN MAY1-JUL31 OUTFLOW,KSFD 4/		2434.9	2471.6	2913.0	2913.0		
MIN APR30 RESERVOIR CONTENT,KSFD 5/		2634.9	2931.0	3608.5	3422.6		
MIN APR30 RESERVOIR CONTENT,FEET 6/		2452.4	2458.5	2469.8	2462.4		
APR30 ECC,FT. 7/------------------>		2439.6	2439.6	2439.6	2439.6		
BASE ECC, FT..........................	2439.6						
ASSUMED JUN1-JUL31 INFLOW,% OF VOL.		72.60	72.60	74.20	76.00	80.20	
ASSUMED JUN1-JUL31 INFLOW,KSFD 2/		2682.6	2465.4	2264.2	2420.8	2357.9	
JUN MINIMUM FLOW REQUIREMENT,CFS 3/		26540.0	26960.0	32000.0	32000.0	30506.7	
MIN JUN1-JUL31 OUTFLOW,KSFD 4/		1780.8	1808.2	2138.0	2138.0	2040.3	
MIN MAY31 RESERVOIR CONTENT,KSFD 5/		2627.3	2872.1	3388.9	3246.4	3211.6	
MIN MAY31 RESERVOIR CONTENT,FEET 6/		2452.5	2457.2	2467.5	2460.0	2463.8	
MAY31 ECC,FT. 7/------------------>		2441.6	2441.6	2441.6	2441.6	2441.6	
BASE ECC, FT	2441.6						
ASSUMED JUL1-JUL31 INFLOW,% OF VOL.		35.90	35.90	36.70	37.60	39.60	49.40
ASSUMED JUL1-JUL31 INFLOW,KSFD 2/		1326.5	1219.1	1119.9	1197.6	1164.2	1095.1
JUL MINIMUM FLOW REQUIREMENT,CFS 3/		31760.0	32240.0	38000.0	38000.0	36293.3	36773.3
MIN JUL1-JUL31 OUTFLOW,KSFD 4/		984.6	999.4	1178.0	1178.0	1125.1	1140.0
MIN JUN30 RESERVOIR CONTENT,KSFD 5/		3187.2	3309.5	3573.2	3509.6	3490.0	3529.2
MIN JUN30 RESERVOIR CONTENT,FEET 6/		2463.5	2465.9	2469.8	2467.3	2469.1	2469.8
JUN30 ECC,FT. 7/------------------>		2458.8	2458.8	2458.8	2458.8	2458.8	2458.8
BASE ECC, FT........................	2458.8						
JUL 31 ECC, FT......................		2470.1	2470.1	2470.1	2470.1	2470.1	2470.1

1/ FOR ARROW AND DUNCAN: THE LOWER LIMIT WILL BE THE HIGHER OF THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS OF THE PREVIOUS MONTH (V)ECC LESS THE QUANTITY ONE FOOT TIMES THE NUMBER OF DAYS IN THE CURRENT MONTH. FOR MICA: THE LOWER LIMIT WILL BE THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS.
2/ LINE 1 MINUS LINE 2.....3/ LINE 3 MINUS LINE 4.....4/ PRECEDING LINE X LINE 5
5/ FULL CONTENT (3529.2 KSFD) PLUS LINE PRECEDING THAT LESS LINE 2.
6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE. DATED FEB 21, 1973.
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR.

TABLE 3
1993 Variable Refill Curve
Arrow Reservoir

	INITIAL	JAN 1 LOCAL	FEB 1 LOCAL	MAR 1 LOCAL	APR 1 LOCAL	MAY 1 LOCAL	JUN 1 LOCAL
PROBABLE JAN1-31JULY INFLOW,KAF		10045.1	9181.1	8124.3	7965.0	7129.4	4690.7
& IN KSFD		5064.4	4628.8	4096.0	4015.7	3594.4	2364.9
95% FORECAST ERROR FOR DATE,IN KSFD		822.5	651.0	572.3	474.5	457.7	508.1
95% CONF.DATE-31JULY INFLOW,KSFD 1/		4241.9	3977.8	3523.7	3541.2	3136.7	1856.8
ASSUMED FEB1-JUL31 INFLOW,% OF VOL.		100.00					
ASSUMED FEB1-JUL31 INFLOW,KSFD 2/		4241.9					
MIN FEB1-JUL31 OUTFLOW,KSFD 4/		4399.3					
MICA REFILL REQUIREMENTS, KSFD 8/		2980.1					
MIN JAN31 RESERVOIR CONTENT,KSFD 5/		757.0					
MIN JAN31 RESERVOIR CONTENT,FEET 6/		1394.8					
JAN31 ECC,FT. 7/------------------>		1399.0					
BASE ECC, FT........................	1418.6						
LOWER LIMIT, FT.....................	1399.0						
ASSUMED MAR1-JUL31 INFLOW,% OF VOL.		97.00	97.00				
ASSUMED MAR1-JUL31 INFLOW,KSFD 2/		4114.6	3858.5				
MIN MAR1-JUL31 OUTFLOW,KSFD 4/		4210.0	4401.5				
MICA REFILL REQUIREMENTS, KSFD 8/		2896.1	3008.7				
MIN FEB28 RESERVOIR CONTENT,KSFD 5/		778.9	1113.9				
MIN FEB28 RESERVOIR CONTENT,FEET 6/		1395.2	1402.0				
FEB28 ECC,FT. 7/------------------>		1395.2	1402.0				
BASE ECC, FT........................	1418.7						
LOWER LIMIT, FT.....................	1379.4						
ASSUMED APR1-JUL31 INFLOW,% OF VOL.		93.70	93.70	96.60			
ASSUMED APR1-JUL31 INFLOW,KSFD 2/		3974.7	3727.2	3403.9			
MIN APR1-JUL31 OUTFLOW,KSFD 4/		4000.5	4177.0	6296.0			
MICA REFILL REQUIREMENTS, KSFD 8/		2670.1	2746.4	3663.0			
MIN MAR31 RESERVOIR CONTENT,KSFD 5/		935.3	1283.0	2808.7			
MIN MAR31 RESERVOIR CONTENT,FEET 6/		1398.4	1405.2	1431.9			
MAR31 ECC,FT. 7/------------------>		1398.4	1405.2	1424.7			
BASE ECC, FT........................	1424.7						
LOWER LIMIT, FT.....................	1379.0						
ASSUMED MAY1-JUL31 INFLOW,% OF VOL.		85.50	85.50	88.10	91.40		
ASSUMED MAY1-JUL31 INFLOW,KSFD 2/		3626.8	3401.0	3104.3	3236.6		
MIN MAY1-JUL31 OUTFLOW,KSFD 4/		3551.4	3684.1	5276.0	5276.0		
MICA REFILL REQUIREMENTS, KSFD 8/		2434.9	2471.6	2913.0	2913.0		
MIN APR30 RESERVOIR CONTENT,KSFD 5/		1069.3	1391.0	2838.3	2706.0		
MIN APR30 RESERVOIR CONTENT,FEET 6/		1401.1	1407.2	1432.4	1430.2		
APR30 ECC,FT. 7/------------------>		1401.1	1407.2	1423.7	1423.7		
BASE ECC, FT........................	1423.7						
ASSUMED JUN1-JUL31 INFLOW,% OF VOL.		61.20	61.20	63.10	65.10	71.20	
ASSUMED JUN1-JUL31 INFLOW,KSFD 2/		2596.0	2434.4	2223.4	2305.3	2233.4	
MIN JUN1-JUL31 OUTFLOW,KSFD 4/		2740.5	2821.0	3788.0	3788.0	3501.5	
MICA REFILL REQUIREMENTS, KSFD 8/		1780.8	1808.2	2138.0	2138.0	2040.3	
MIN MAY31 RESERVOIR CONTENT,KSFD 5/		1943.3	2158.0	3006.2	2924.3	3807.4	
MIN MAY31 RESERVOIR CONTENT,FEET 6/		1417.3	1421.0	1435.1	1433.8	1444.0	
MAY31 ECC,FT. 7/------------------>		1417.3	1421.0	1430.9	1430.9	1430.9	
BASE ECC, FT........................	1430.9						
ASSUMED JUL1-JUL31 INFLOW,% OF VOL.		25.70	25.70	26.40	27.80	30.40	42.70
ASSUMED JUL1-JUL31 INFLOW,KSFD 2/		1090.2	1022.3	930.2	984.4	953.6	792.8
MIN JUL1-JUL31 OUTFLOW,KSFD 4/		1551.9	1594.6	2108.0	2108.0	1955.9	1998.7
MICA REFILL REQUIREMENTS, KSFD 8/		984.6	999.4	1178.0	1178.0	1125.1	1140.0
MIN JUN30 RESERVOIR CONTENT,KSFD 5/		3056.7	3152.5	3579.6	3525.2	3456.8	3579.6
MIN JUN30 RESERVOIR CONTENT,FEET 6/		1435.8	1437.3	1444.0	1443.2	1442.1	1444.0
JUN30 ECC,FT. 7/------------------>		1435.8	1437.3	1444.0	1443.2	1442.1	1444.0
BASE ECC, FT........................	1444.0						
JUL 31 ECC, FT..................		1444.0	1444.0	1444.0	1444.0	1444.0	1444.0

1/ FOR ARROW AND DUNCAN: THE LOWER LIMIT WILL BE THE HIGHER OF THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS OF THE PREVIOUS MONTH (V)ECC LESS THE QUANTITY ONE FOOT TIMES THE NUMBER OF DAYS IN THE CURRENT MONTH. FOR MICA: THE LOWER LIMIT WILL BE THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS.....2/ LINE 1 MINUS LINE 2.....3/ LINE 3 MINUS LINE 4.....4/ PRECEDING LINE X LINE 5.....5/ FOR ARROW LOCAL: FULL CONTENT (3579.6 KSFD) LESS LINE PRECEDING PLUS LINE PRECEDING THAT LESS LINE PRECEDING THAT. FOR ARROW TOTAL: FULL CONTENT (3579.6 KSFD) PLUS TWO PRECEDING LINES LESS LINE PRECEDING THAT.....6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE. DATED FEB 21, 1973.
7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR....8/ FOR ARROW LOCAL: MICA MINIMUM POWER DISCHARGES. FOR ARROW TOTAL: MICA FULL CONTENT LESS ENERGY CONTENT CURVE.

TABLE 4
1993 Variable Refill Curve
Duncan Reservoir

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE JAN1-31JULY INFLOW,KAF		1549.0	1554.6	1426.7	1414.6	1314.6	984.6
& IN KSFD		782.2	783.8	719.3	713.2	662.8	496.4
95% FORECAST ERROR FOR DATE,IN KSFD		112.4	97.8	93.4	91.9	84.8	85.7
95% CONF.DATE-31JULY INFLOW,KSFD 1/		669.8	686.0	625.9	621.3	578.0	410.7
ASSUMED FEB1-JUL31 INFLOW,% OF VOL.		100.00					
ASSUMED FEB1-JUL31 INFLOW,KSFD 2/		669.8					
FEB MINIMUM FLOW REQUIREMENT,CFS 3/		100.0					
MIN FEB1-JUL31 OUTFLOW,KSFD 4/		137.2					
MIN JAN31 RESERVOIR CONTENT,KSFD 5/		173.2					
MIN JAN31 RESERVOIR CONTENT,FEET 6/		1825.1					
JAN31 ECC,FT. 7/------------------>		1825.1					
BASE ECC, FT........................	1834.2						
LOWER LIMIT, FT.....................	1794.2						
ASSUMED MAR1-JUL31 INFLOW,% OF VOL.		97.90	97.90				
ASSUMED MAR1-JUL31 INFLOW,KSFD 2/		655.7	671.6				
MAR MINIMUM FLOW REQUIREMENT,CFS 3/		100.0	100.0				
MIN MAR1-JUL31 OUTFLOW,KSFD 4/		134.4	140.2				
MIN FEB28 RESERVOIR CONTENT,KSFD 5/		184.4	174.4				
MIN FEB28 RESERVOIR CONTENT,FEET 6/		1826.8	1825.2				
FEB28 ECC,FT. 7/------------------>		1826.8	1825.2				
BASE ECC, FT........................	1835.2						
LOWER LIMIT, FT.....................	1794.2						
ASSUMED APR1-JUL31 INFLOW,% OF VOL.		95.40	95.40	97.50			
ASSUMED APR1-JUL31 INFLOW,KSFD 2/		639.0	654.4	610.2			
APR MINIMUM FLOW REQUIREMENT,CFS 3/		1076.0	1124.0	1700.0			
MIN APR1-JUL31 OUTFLOW,KSFD 4/		131.3	137.1	207.4			
MIN MAR31 RESERVOIR CONTENT,KSFD 5/		198.1	188.5	303.0			
MIN MAR31 RESERVOIR CONTENT,FEET 6/		1828.7	1827.3	1843.4			
MAR31 ECC,FT. 7/------------------>		1828.7	1827.3	1833.3			
BASE ECC, FT........................	1836.9						
LOWER LIMIT, FT.....................	1794.2						
ASSUMED MAY1-JUL31 INFLOW,% OF VOL.		89.50	89.50	91.50	93.80		
ASSUMED MAY1-JUL31 INFLOW,KSFD 2/		599.5	614.0	572.7	582.8		
MAY MINIMUM FLOW REQUIREMENT,CFS 3/		1076.0	1124.0	1700.0	1700.0		
MIN MAY1-JUL31 OUTFLOW,KSFD 4/		99.0	103.4	156.4	156.4		
MIN APR30 RESERVOIR CONTENT,KSFD 5/		205.3	195.2	289.5	279.4		
MIN APR30 RESERVOIR CONTENT,FEET 6/		1829.8	1828.3	1841.5	1840.2		
APR30 ECC,FT. 7/------------------>		1829.8	1828.3	1833.8	1833.8		
BASE ECC, FT........................	1833.8						
ASSUMED JUN1-JUL31 INFLOW,% OF VOL.		68.60	68.60	70.20	72.00	76.70	
ASSUMED JUN1-JUL31 INFLOW,KSFD 2/		459.5	470.6	439.4	447.3	443.3	
JUN MINIMUM FLOW REQUIREMENT,CFS 3/		1076.0	1124.0	1700.0	1700.0	1529.3	
MIN JUN1-JUL31 OUTFLOW,KSFD 4/		65.6	68.6	103.7	103.7	93.3	
MIN MAY31 RESERVOIR CONTENT,KSFD 5/		312.6	303.8	370.1	362.2	355.8	
MIN MAY31 RESERVOIR CONTENT,FEET 6/		1844.4	1843.3	1852.1	1851.1	1850.3	
MAY31 ECC,FT. 7/------------------>		1844.4	1843.3	1848.3	1848.3	1848.3	
BASE ECC, FT	1848.3						
ASSUMED JUL1-JUL31 INFLOW,% OF VOL.		32.20	32.20	32.90	33.70	35.90	46.80
ASSUMED JUL1-JUL31 INFLOW,KSFD 2/		215.3	220.9	205.9	209.4	207.5	192.2
JUL MINIMUM FLOW REQUIREMENT,CFS 3/		1076.0	1124.0	1700.0	1700.0	1529.3	1577.3
MIN JUL1-JUL31 OUTFLOW,KSFD 4/		33.4	34.8	52.7	52.7	47.4	48.9
MIN JUN30 RESERVOIR CONTENT,KSFD 5/		523.8	519.8	552.6	549.1	545.7	562.5
MIN JUN30 RESERVOIR CONTENT,FEET 6/		1870.9	1870.5	1874.5	1874.1	1873.6	1875.7
JUN30 ECC,FT. 7/------------------>		1870.9	1870.5	1871.9	1871.9	1871.9	1871.9
BASE ECC, FT	1871.9						
JUL 31 ECC, FT..................		1892.0	1892.0	1892.0	1892.0	1892.0	1892.0

1/ FOR ARROW AND DUNCAN: THE LOWER LIMIT WILL BE THE HIGHER OF THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS OF THE PREVIOUS MONTH (V)ECC LESS THE QUANTITY ONE FOOT TIMES THE NUMBER OF DAYS IN THE CURRENT MONTH. FOR MICA: THE LOWER LIMIT WILL BE THE ELEVATION NEEDED TO PROTECT AGAINST A RECURRENCE OF 1936-37 STREAMFLOWS.

2/ LINE 1 MINUS LINE 2.....3/ LINE 3 MINUS LINE 4.....4/ PRECEDING LINE X LINE 5

5/ FULL CONTENT (705.8 KSFD) PLUS LINE PRECEDING THAT LESS LINE 2.

6/ FROM RESERVOIR ELEVATION - STORAGE CONTENT TABLE. DATED FEB 21, 1973.

7/ LOWER OF ELEVATION ON PRECEDING LINE OR ELEVATION DETERMINED PRIOR TO YEAR.

TABLE 5
1993 Variable Refill Curve
Libby Reservoir

	INITIAL	JAN 1	FEB 1	MAR 1	APR 1	MAY 1	JUN 1
PROBABLE JAN1-31JULY INFLOW,KAF		5722.0	5337.6	4658.4	4469.2	4673.1	4669.2
& IN KSFD		2884.8	2691.0	2348.6	2253.2	2356.0	2354.1
95% FORECAST ERROR FOR DATE,IN KSFD		886.8	606.4	552.5	533.4	474.5	367.5
OBSERVED JAN1-DATE INFLOW, IN KSFD		0.0	82.5	152.5	251.2	425.1	1298.3
95% CONF.DATE-31JULY INFLOW,KSFD 1/		1998.1	2002.1	1643.6	1468.6	1456.4	688.2
ASSUMED FEB1-JUL31 INFLOW,% OF VOL.		97.14					
ASSUMED FEB1-JUL31 INFLOW,KSFD 2/		1940.9					
FEB MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0					
MIN FEB1-JUL31 OUTFLOW,KSFD 4/		724.0					
MIN JAN31 RESERVOIR CONTENT,KSFD 5/		1293.6					
MIN JAN31 RESERVOIR CONTENT,FEET 6/		2399.0					
JAN31 ECC,FT. 7/------------------>		2399.0					
BASE ECC, FT.........................	2417.8						
LOWER LIMIT, FT....................	2287.7						
ASSUMED MAR1-JUL31 INFLOW,% OF VOL.		94.47	97.25				
ASSUMED MAR1-JUL31 INFLOW,KSFD 2/		1887.6	1947.1				
MAR MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0	4000.0				
MIN MAR1-JUL31 OUTFLOW,KSFD 4/		612.0	612.0				
MIN FEB28 RESERVOIR CONTENT,KSFD 5/		1234.9	1175.4				
MIN FEB28 RESERVOIR CONTENT,FEET 6/		2395.2	2391.5				
FEB28 ECC,FT. 7/------------------>		2395.2	2391.5				
BASE ECC, FT.........................	2415.0						
LOWER LIMIT, FT.....................	2287.0						
ASSUMED APR1-JUL31 INFLOW,% OF VOL.		91.24	93.92	96.58			
ASSUMED APR1-JUL31 INFLOW,KSFD 2/		1823.0	1880.4	1587.4			
APR MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0	4000.0	4000.0			
MIN APR1-JUL31 OUTFLOW,KSFD 4/		488.0	488.0	488.0			
MIN MAR31 RESERVOIR CONTENT,KSFD 5/		1175.5	1118.1	1411.1			
MIN MAR31 RESERVOIR CONTENT,FEET 6/		2391.5	2387.6	2405.8			
MAR31 ECC,FT. 7/------------------>		2391.5	2387.6	2405.8			
BASE ECC, FT.........................	2412.2						
LOWER LIMIT, FT.....................	2287.0						
ASSUMED MAY1-JUL31 INFLOW,% OF VOL.		83.21	85.65	88.08	91.20		
ASSUMED MAY1-JUL31 INFLOW,KSFD 2/		1662.6	1714.8	1447.7	1339.4		
MAY MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0	4000.0	4000.0	4000.0		
MIN MAY1-JUL31 OUTFLOW,KSFD 4/		368.0	368.0	368.0	368.0		
MIN APR30 RESERVOIR CONTENT,KSFD 5/		1215.9	1163.7	1430.8	1539.1		
MIN APR30 RESERVOIR CONTENT,FEET 6/		2394.0	2390.7	2407.0	2412.9		
APR30 ECC,FT. 7/------------------>		2394.0	2390.7	2407.0	2411.3		
BASE ECC, FT	2411.3						
LOWER LIMIT, FT.....................	2287.0						
ASSUMED JUN1-JUL31 INFLOW,% OF VOL.		56.86	57.50	59.13	61.22	67.13	
ASSUMED JUN1-JUL31 INFLOW,KSFD 2/		1136.1	1151.2	971.9	899.1	977.7	
JUN MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0	4000.0	4000.0	4000.0	4000.0	
MIN JUN1-JUL31 OUTFLOW,KSFD 4/		244.0	244.0	244.0	244.0	244.0	
MIN MAY31 RESERVOIR CONTENT,KSFD 5/		1618.4	1603.3	1782.6	1855.4	1776.8	
MIN MAY31 RESERVOIR CONTENT,FEET 6/		2417.2	2416.3	2425.5	2429.2	2425.2	
MAY31 ECC,FT. 7/------------------>		2417.2	2416.3	2425.5	2429.2	2425.2	
BASE ECC, FT.........................	2434.4						
LOWER LIMIT, FT.....................	2287.0						
ASSUMED JUL1-JUL31 INFLOW,% OF VOL.		19.41	19.98	20.54	21.27	23.32	34.74
ASSUMED JUL1-JUL31 INFLOW,KSFD 2/		387.8	400.0	337.6	312.4	339.6	239.1
JUL MINIMUM FLOW REQUIREMENT,CFS 3/		4000.0	4000.0	4000.0	4000.0	4000.0	4000.0
MIN JUL1-JUL31 OUTFLOW,KSFD 4/		124.0	124.0	124.0	124.0	124.0	124.0
MIN JUN30 RESERVOIR CONTENT,KSFD 5/		2246.7	2234.5	2296.9	2322.1	2294.9	2395.4
MIN JUN30 RESERVOIR CONTENT,FEET 6/		2447.4	2446.9	2449.7	2450.8	2449.6	2454.0
JUN30 ECC,FT. 7/------------------>		2447.4	2446.9	2449.7	2450.8	2449.6	2454.0
BASE ECC, FT.........................	2456.6						
LOWER LIMIT, FT.....................	2287.0						
JUL 31 ECC, FT...................		2459.0	2459.0	2459.0	2459.0	2459.0	2459.0
JAN1-JUL31 FORECAST,-EARLYBIRD,MAF 8/		91.7	90.8	74.9	78.9	83.2	82.3

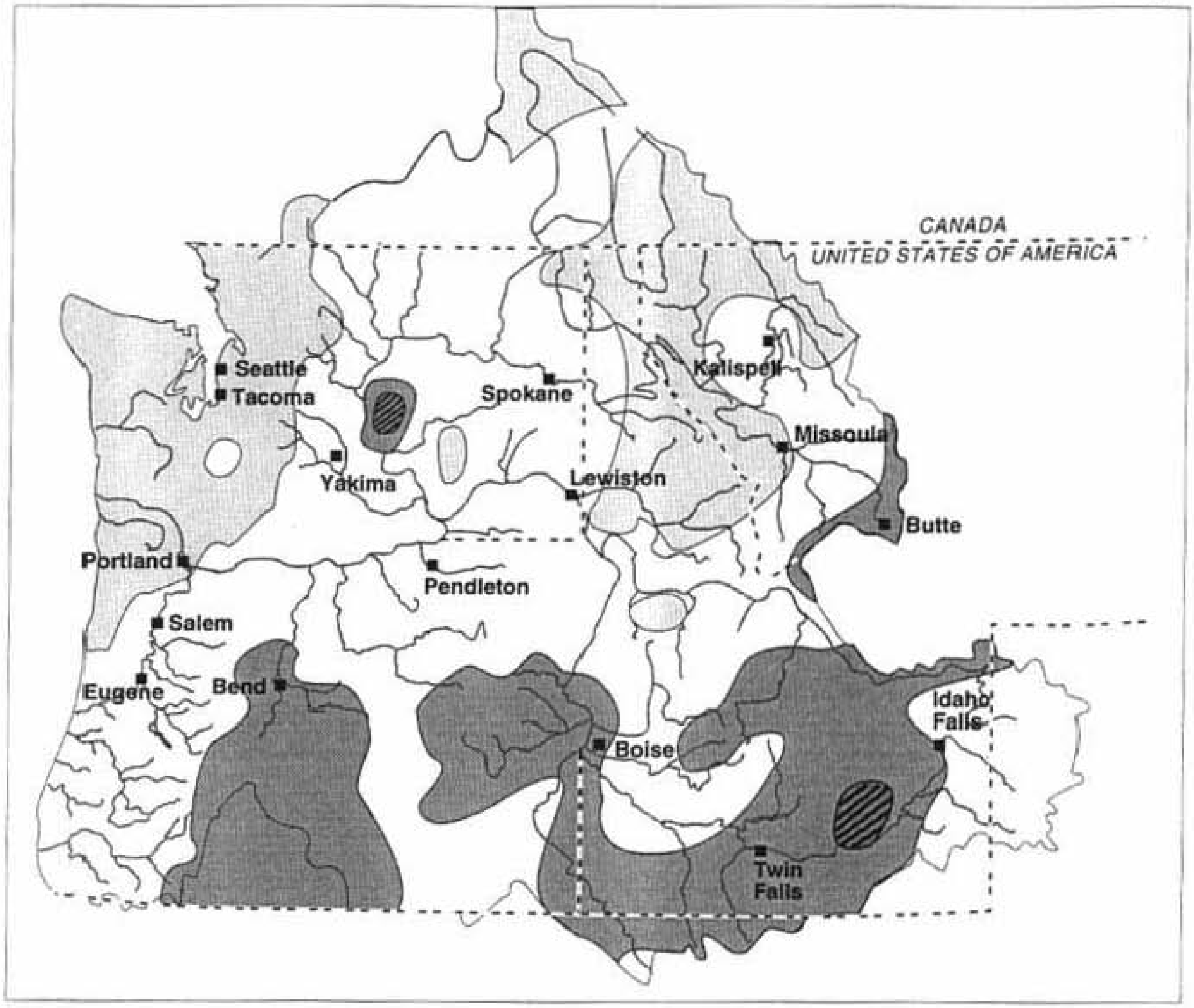
1/ EXPECTED INFLOW MINUS (95%ERROR & JAN1-DATE INFLOW)............2/ PRECEDING LINE TIMES LINE 1/
3/ BASED ON POWER DISCHARGE REQUIREMENTS, DETERMINED FROM 8/....4/ CUMULATIVE MINIMUM OUTFLOW FROM 3/,
FROM DATE TO JULY.....5/ FULL CONTENT (2510.5 KSFD), PLUS 4/, AND MINUS 2/.....6/ ELEV. FROM 5/, INTERP.
FROM NWPP STORAGE CONTENT TABLE.....7/ ELEV. FROM 6/, BUT LIMITED < BASE ECC, & > ECC LOWER LIMIT
8/ FORECAST AT THE DALLES USED TO CALCULATE THE POWER DISCHARGE REQUIREMENTS FOR 3/

Table 6

Computation of Initial Controlled Flow
Columbia River at The Dalles
1 May 1993

1 May Forecast of May-August Unregulated Runoff Volume, MAF		61.0
Less Estimated Depletions, MAF		1.5
Less Upstream Storage Corrections, MAF		
MICA	4.9	
ARROW	5.0	
DUNCAN	1.3	
LIBBY	3.1	
LIBBY + DUNCAN UNDER DRAFT	-0.0	
HUNGRY HORSE	1.2	
FLATHEAD LAKE	0.5	
NOXON RAPIDS	0.0	
PEND OREILLE LAKE	0.5	
GRAND COULEE	0.6	
BROWNLEE	0.0	
DWORSHAK	0.3	
JOHN DAY	0.2	
TOTAL	17.6	19.1
Forecast of Adjusted Residual Runoff Volume, MAF		41.9
Computed Initial Controlled Flow from Chart 1 of Flood Control Operating Plan, 1,000 cfs		251.0

Chart 1
Seasonal Precipitation
Columbia River Basin
October 1992 - March 1993
Percent of 1961 -1985 Average



- Precipitation very high and more than 150% of average
- Precipitation high and more than 120% of average
- Precipitation low and more than 80% of average
- Precipitation very low and more than 50% of average

Information prepared by
NATIONAL WEATHER SERVICE
Northwest River Forcast Center
Portland, Oregon

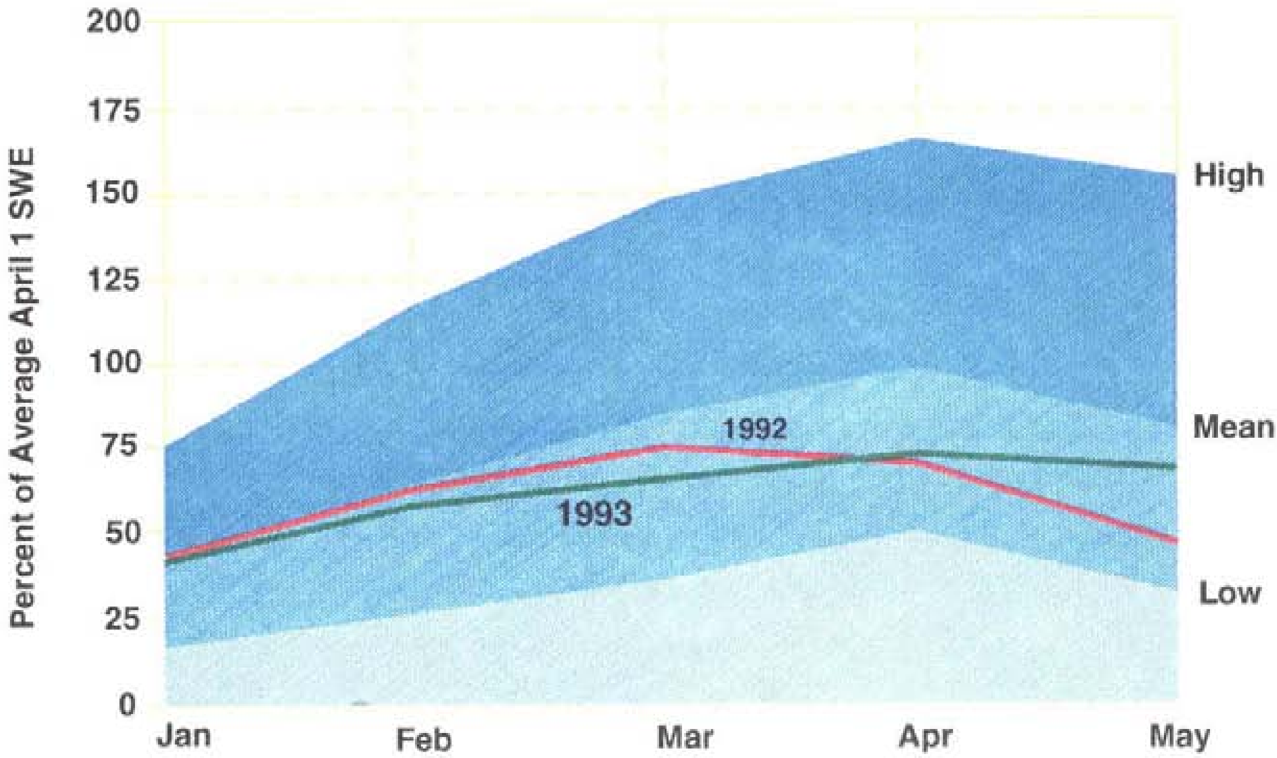
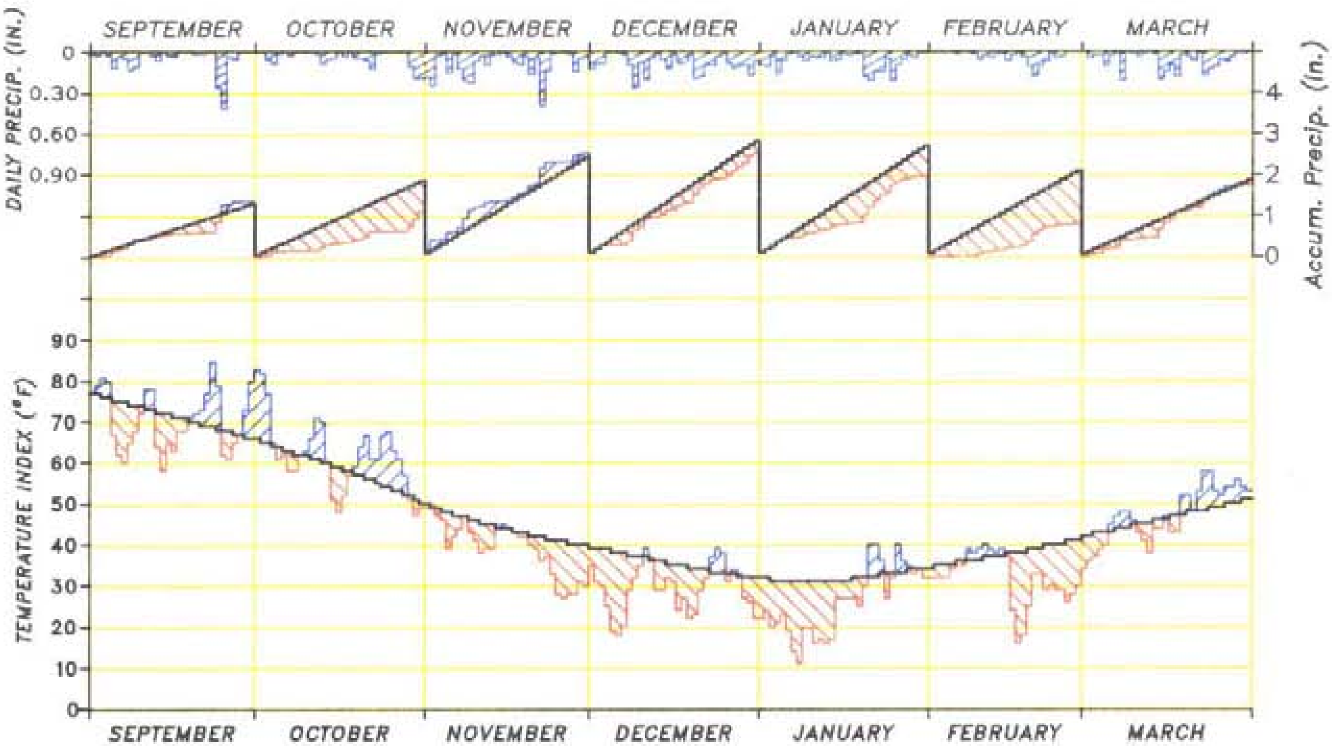
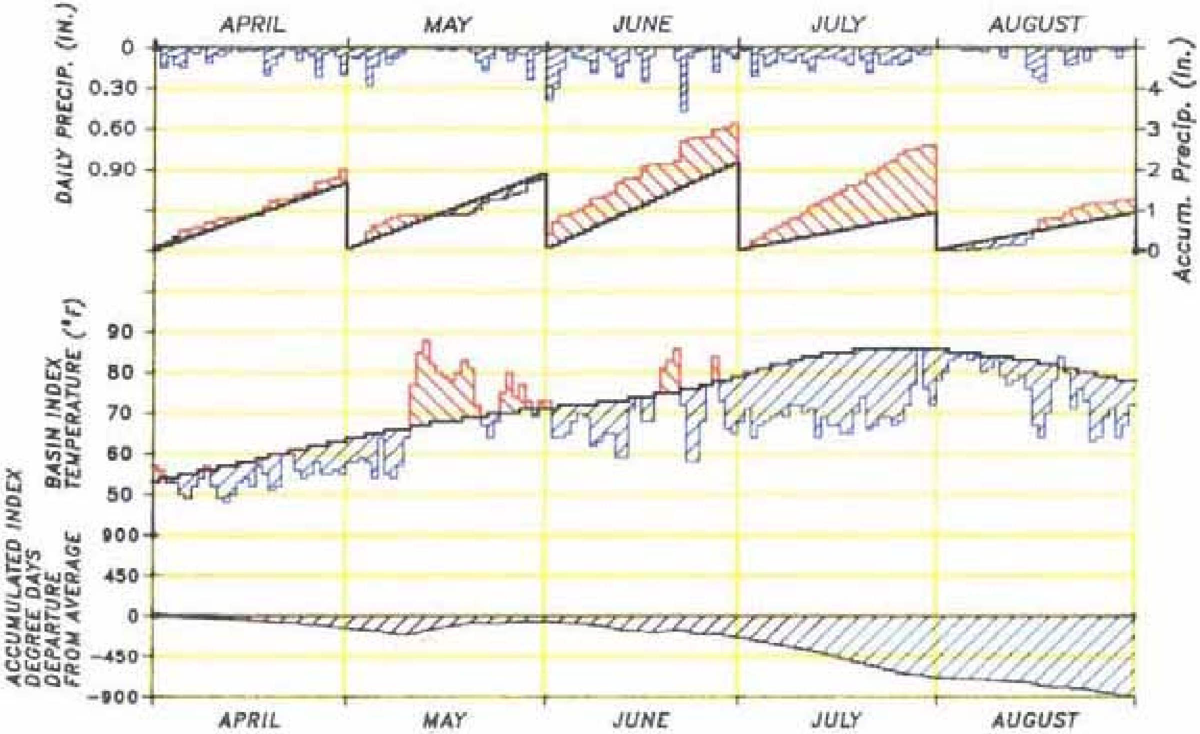


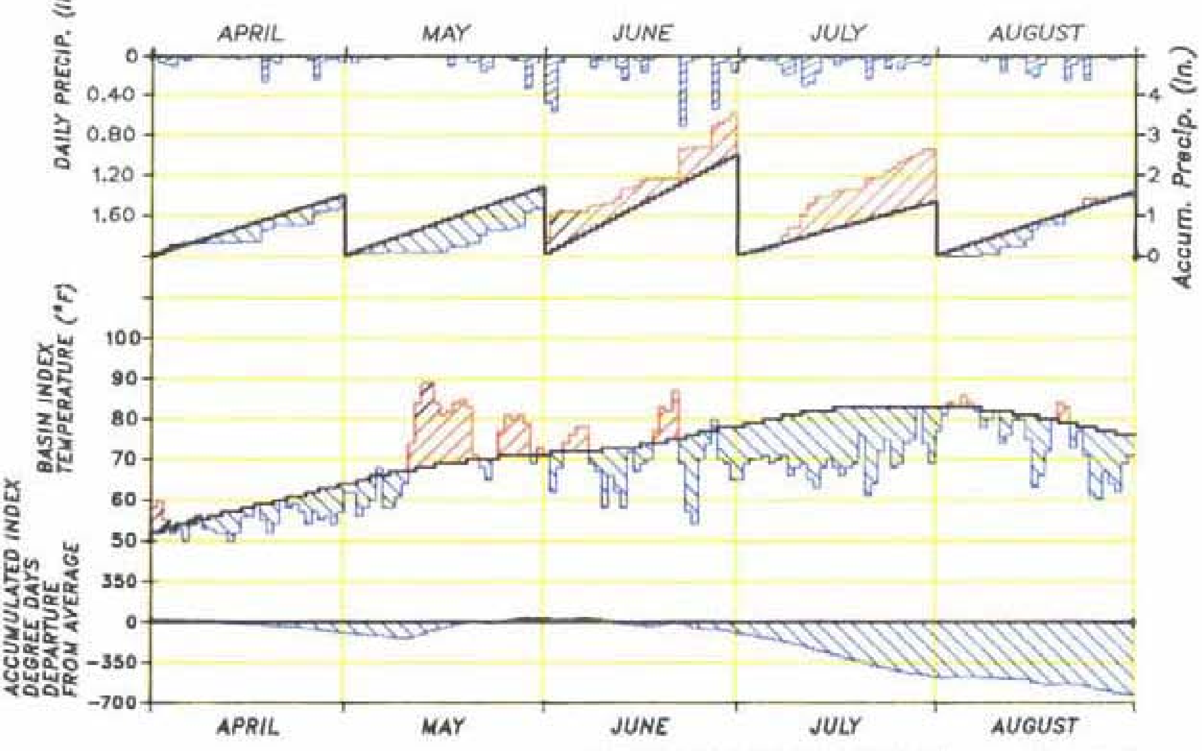
Chart 2
Columbia Basin Snowpack



WINTER SEASON Chart 3
TEMPERATURE AND PRECIPITATION INDEX 1992–1993
Columbia River Basin Above The Dalles, OR



1993 SNOWMELT SEASON CHART 4
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin Above The Dalles, OR



1993 SNOWMELT SEASON Chart 5
TEMPERATURE AND PRECIPITATION INDEX
Columbia River Basin In Canada

Chart 6
Regulation of Mica
1 July 1992 – 31 July 1993

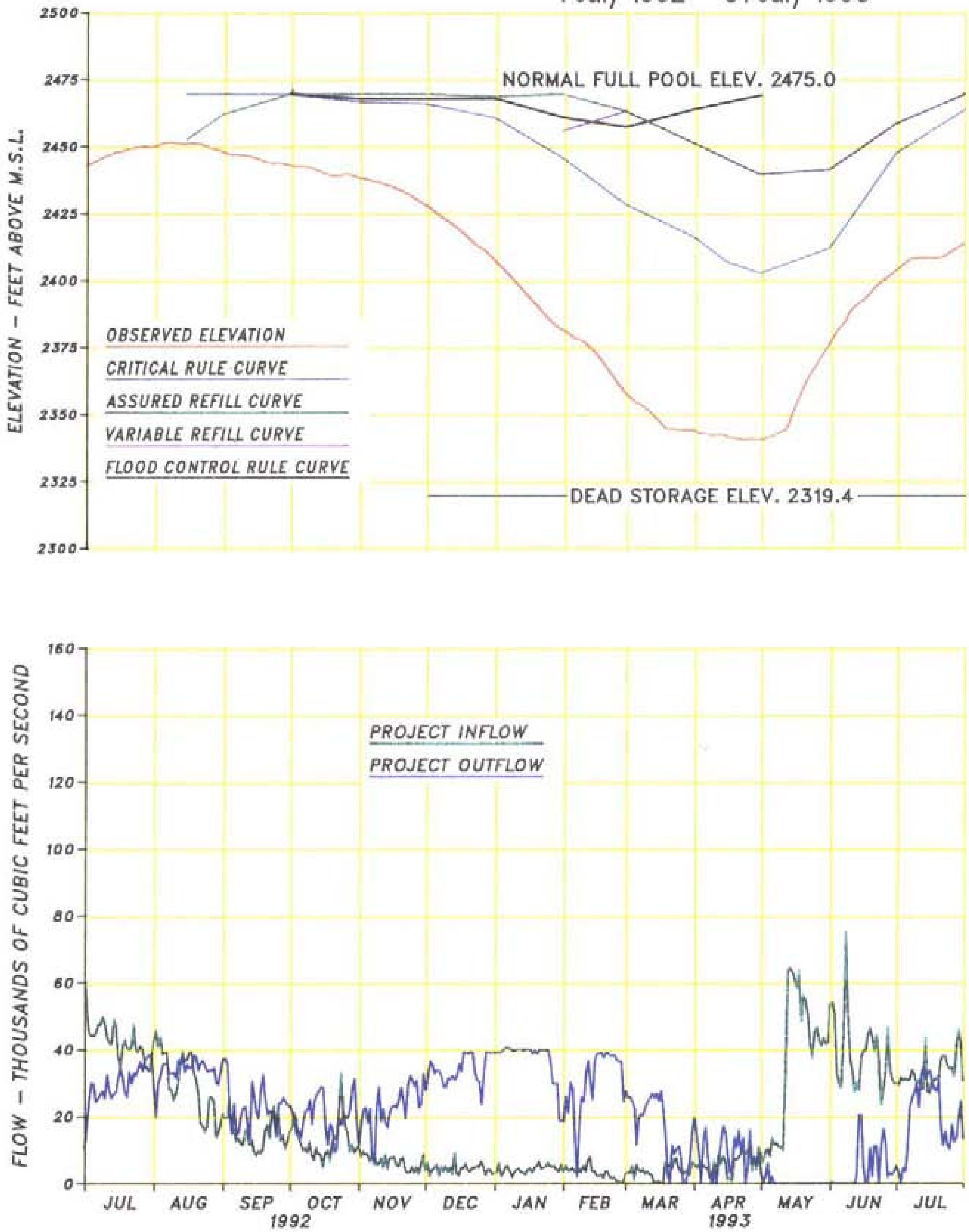
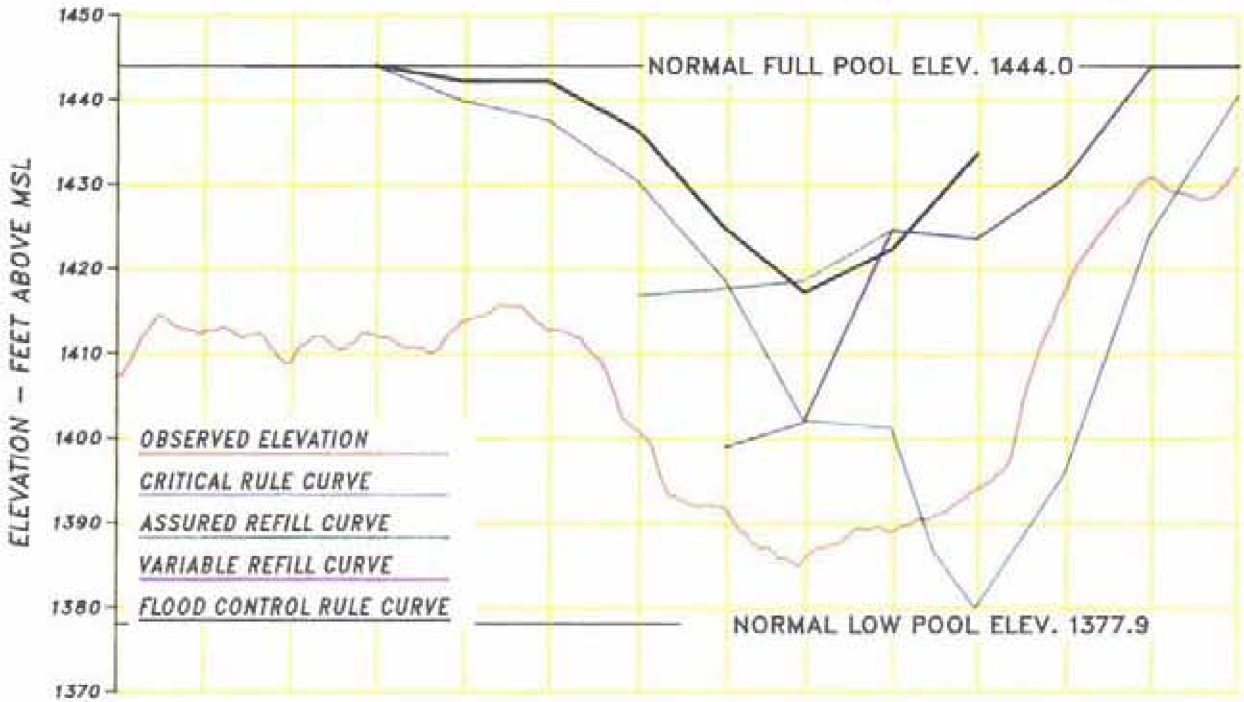


Chart 7
Regulation of Arrow
1 July 1992 – 31 July 1993



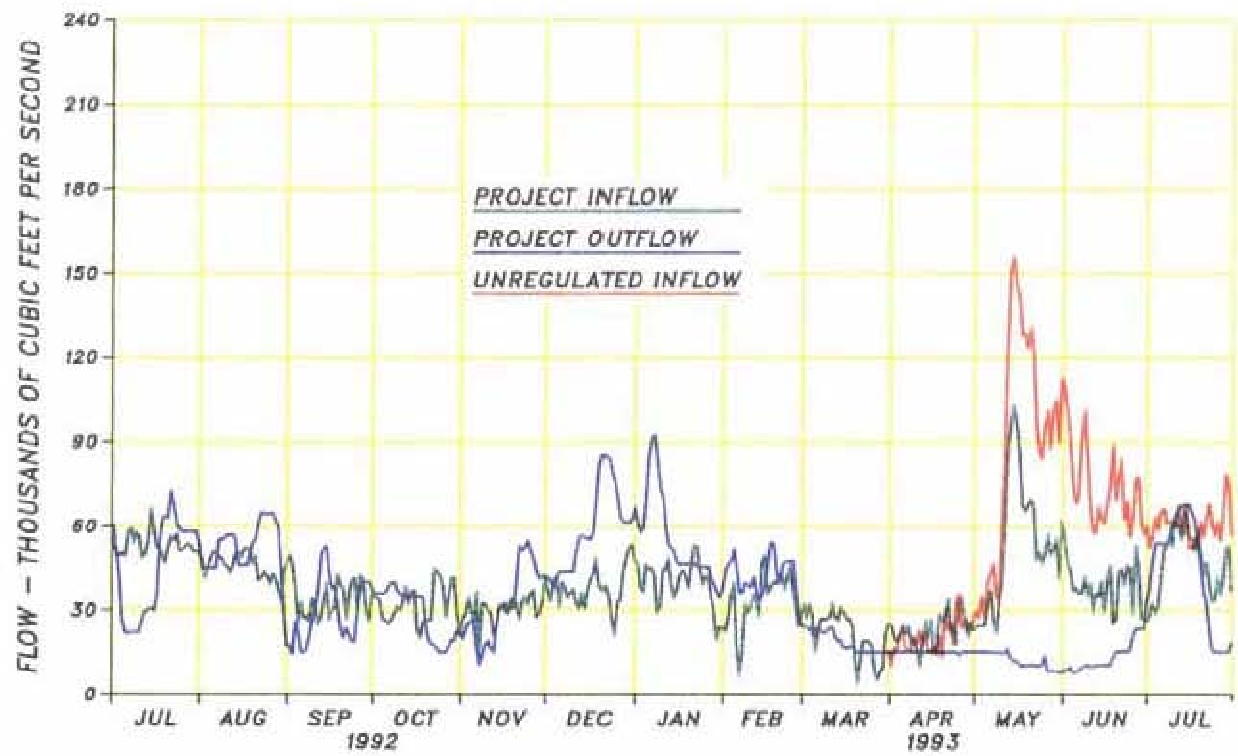
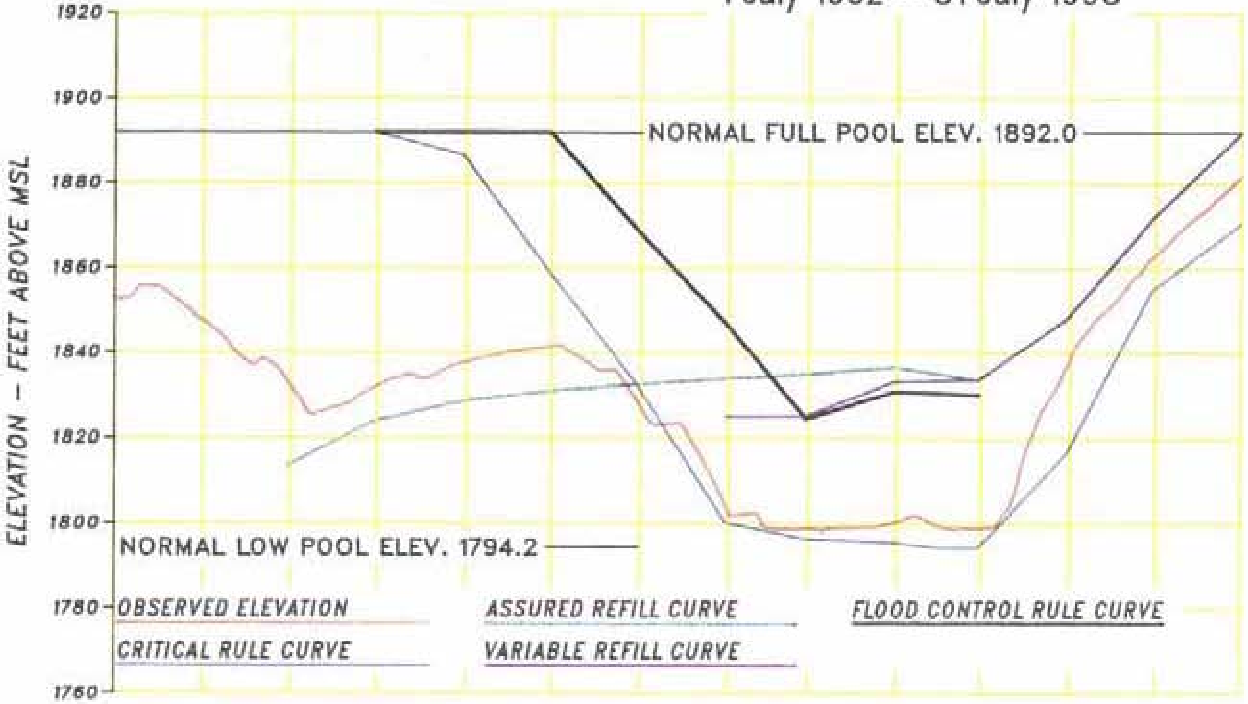


Chart 8
Regulation of Duncan
1 July 1992 – 31 July 1993



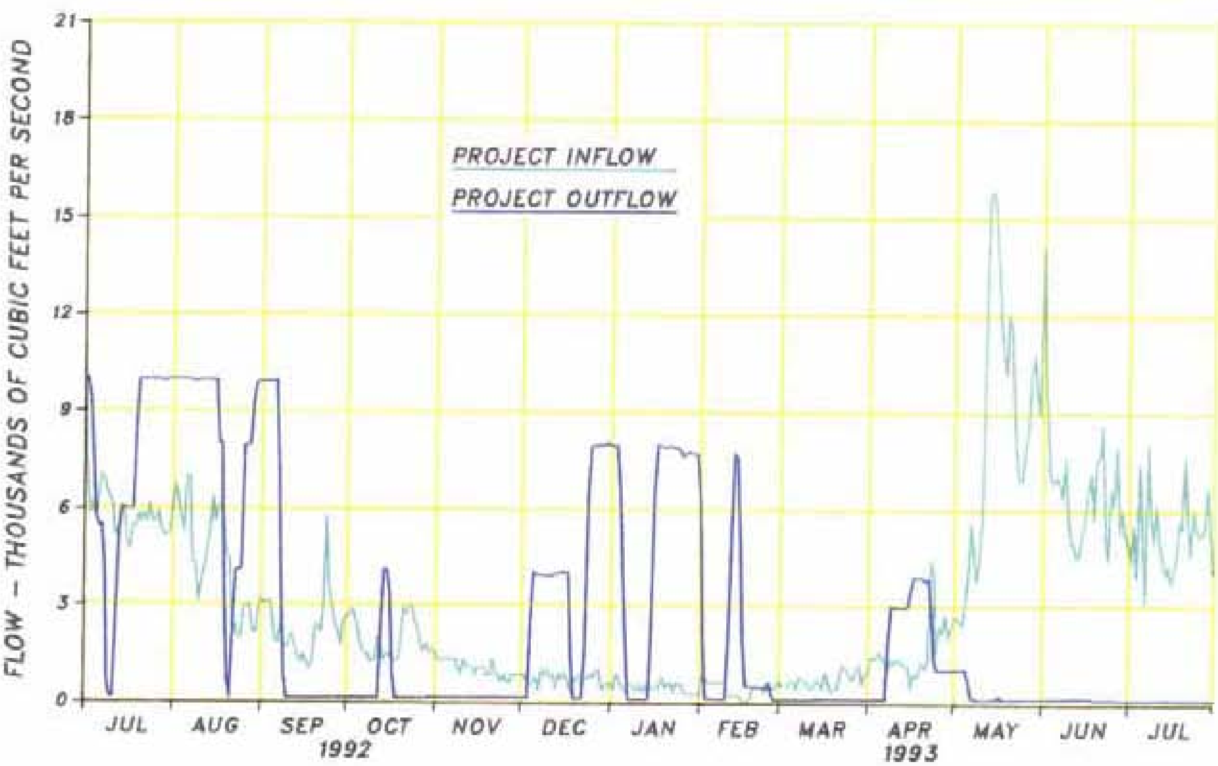
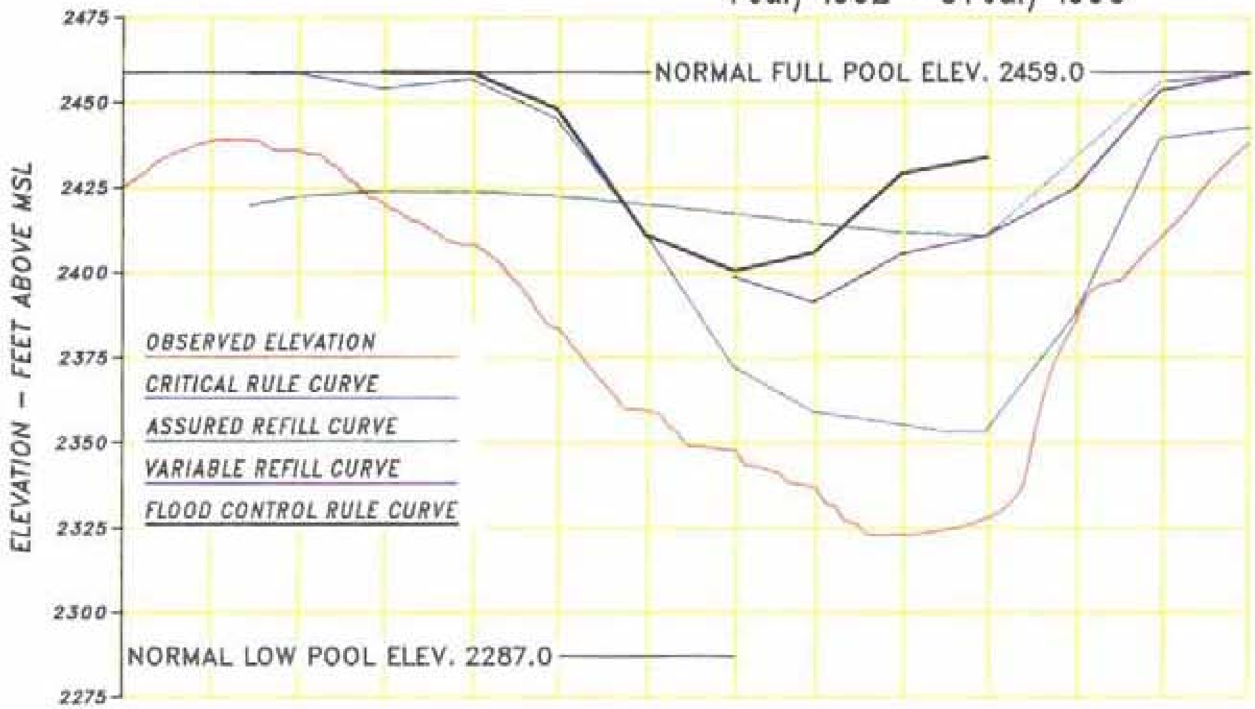


Chart 9
Regulation of Libby
1 July 1992 - 31 July 1993



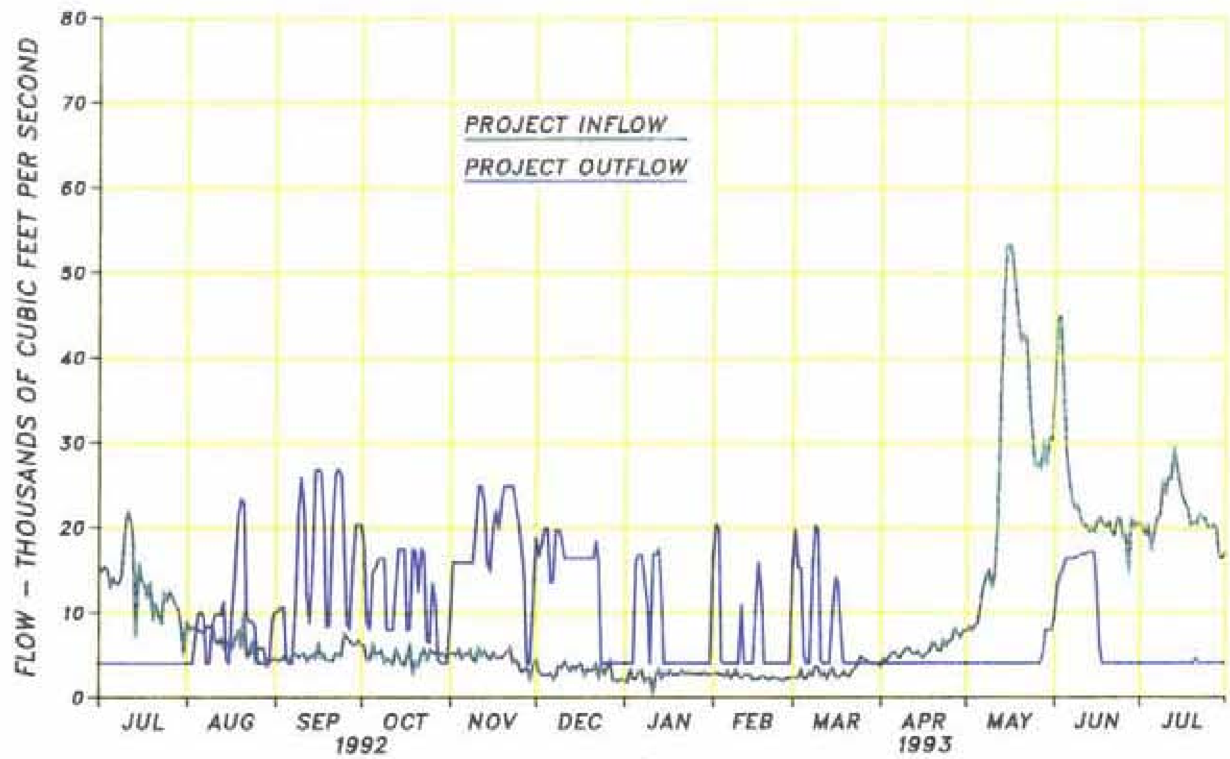


Chart 10
Regulation of Kootenay Lake
1 July 1992 – 31 July 1993

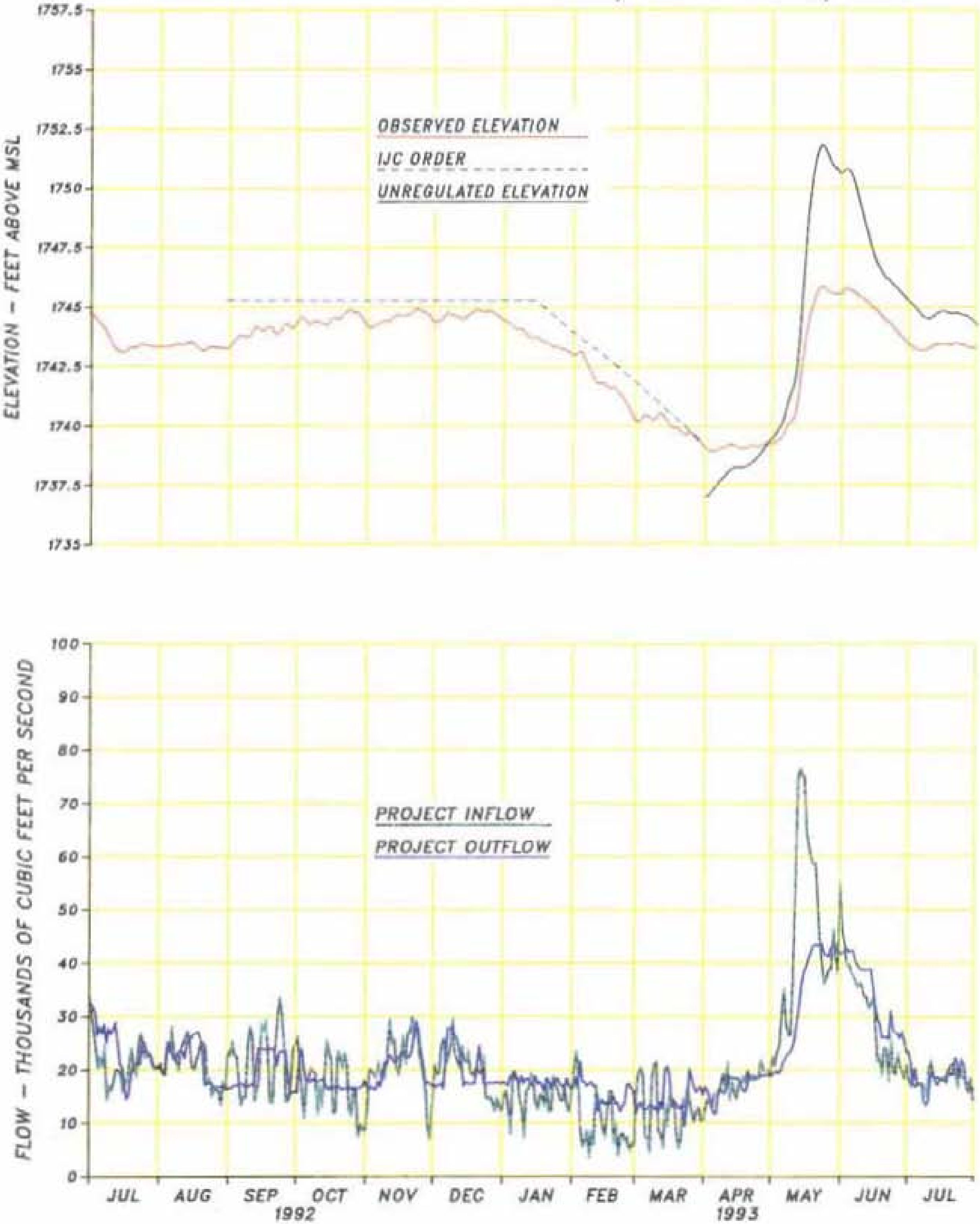


Chart 11
Columbia River at Birchbank
1 July 1992 – 31 July 1993

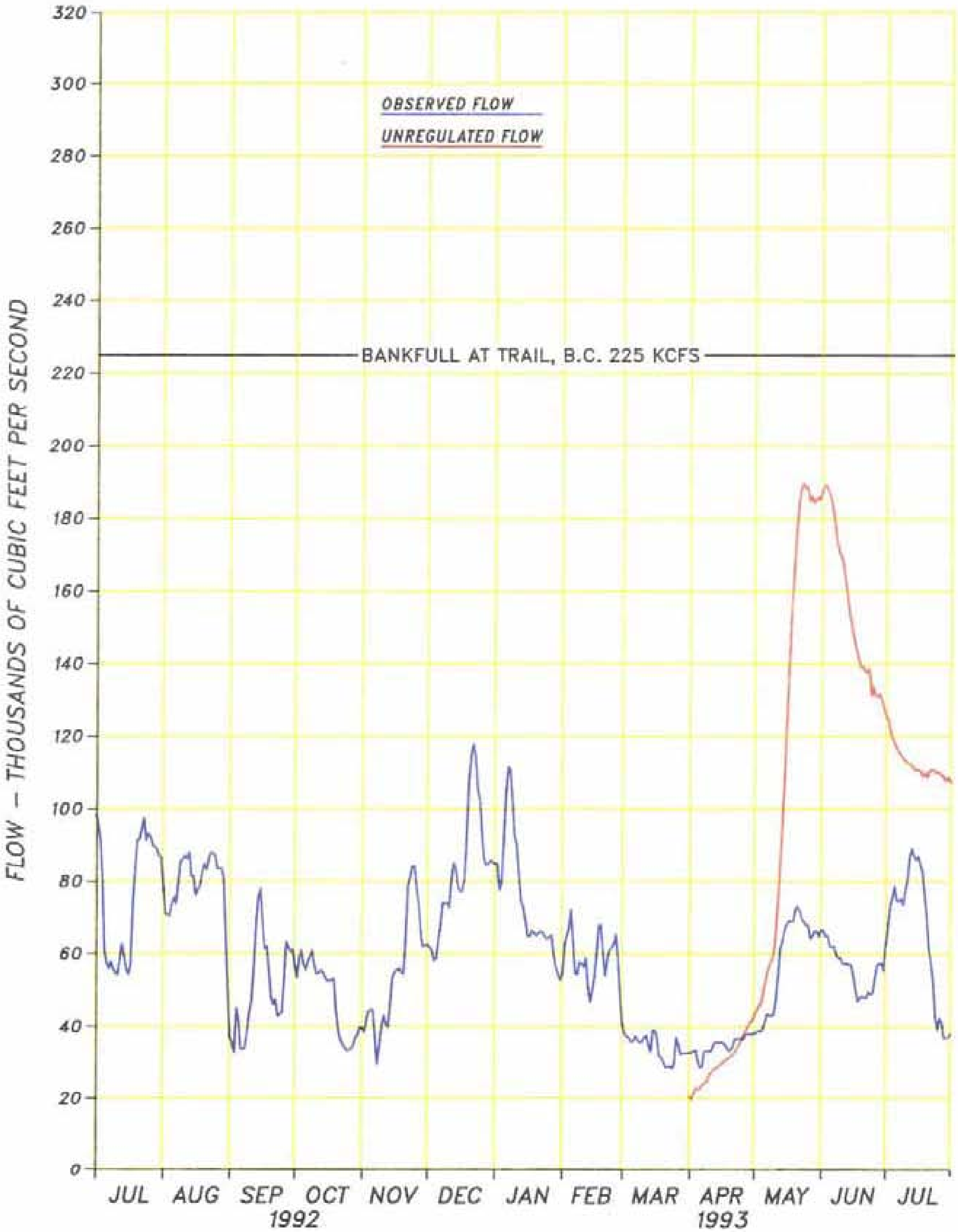
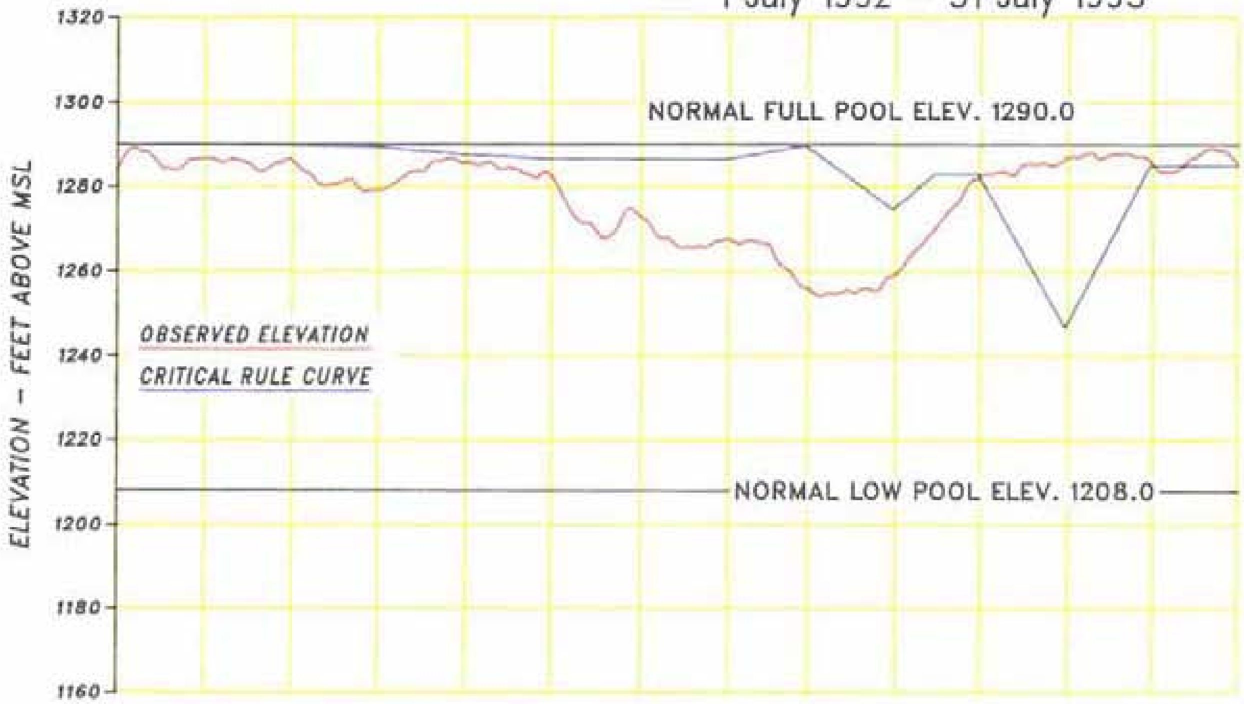


Chart 12
Regulation of Grand Coulee
1 July 1992 – 31 July 1993



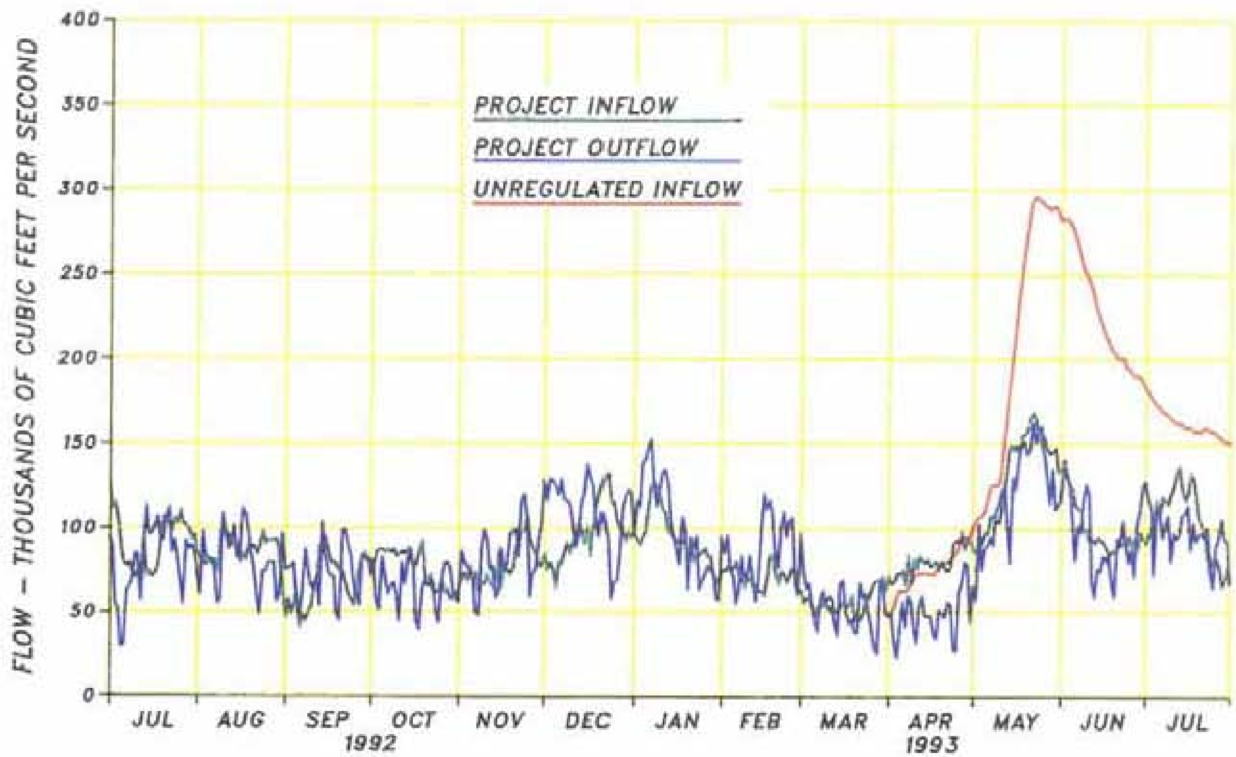


Chart 13
Columbia River at The Dalles
1 July 1992 - 31 July 1993

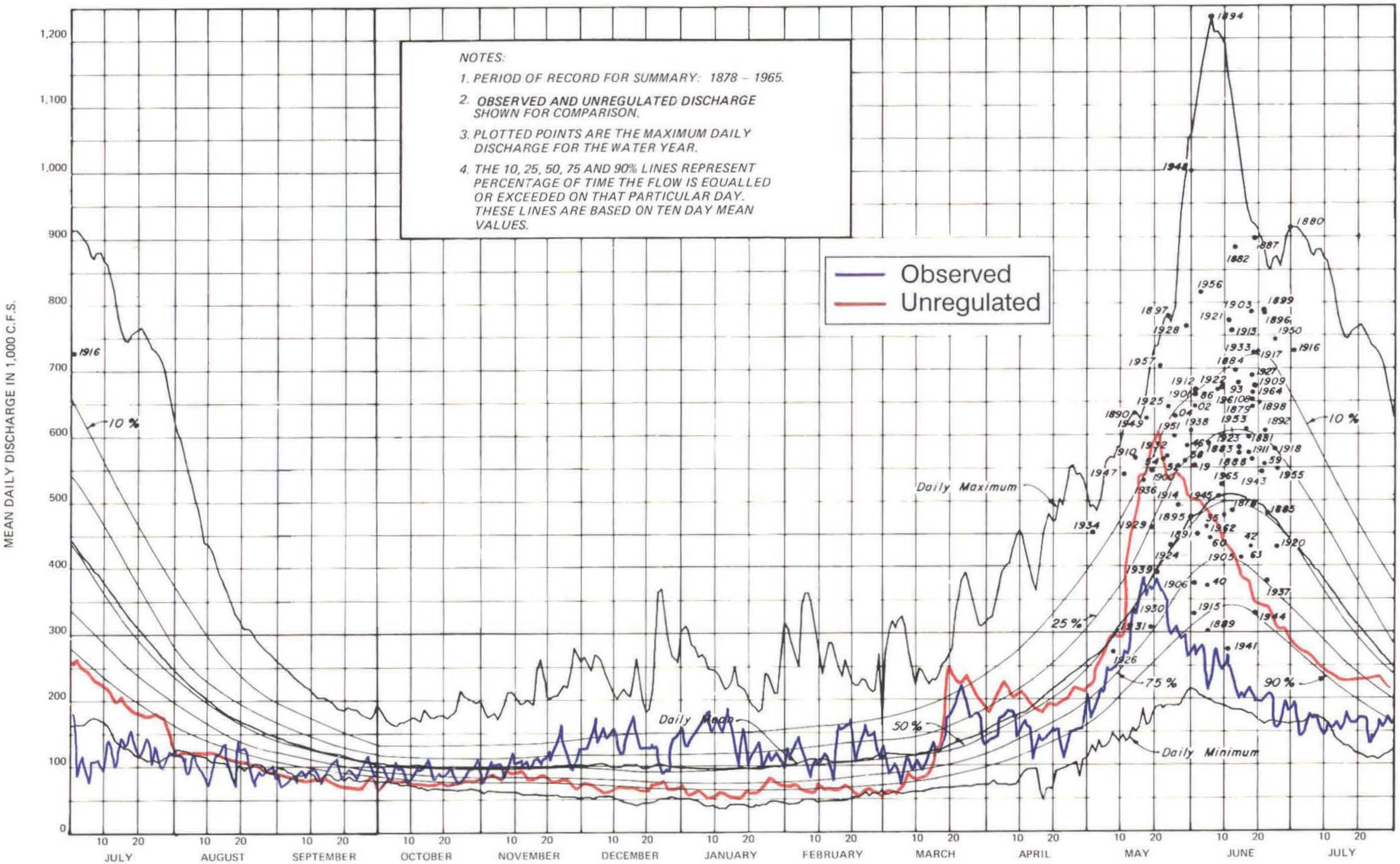
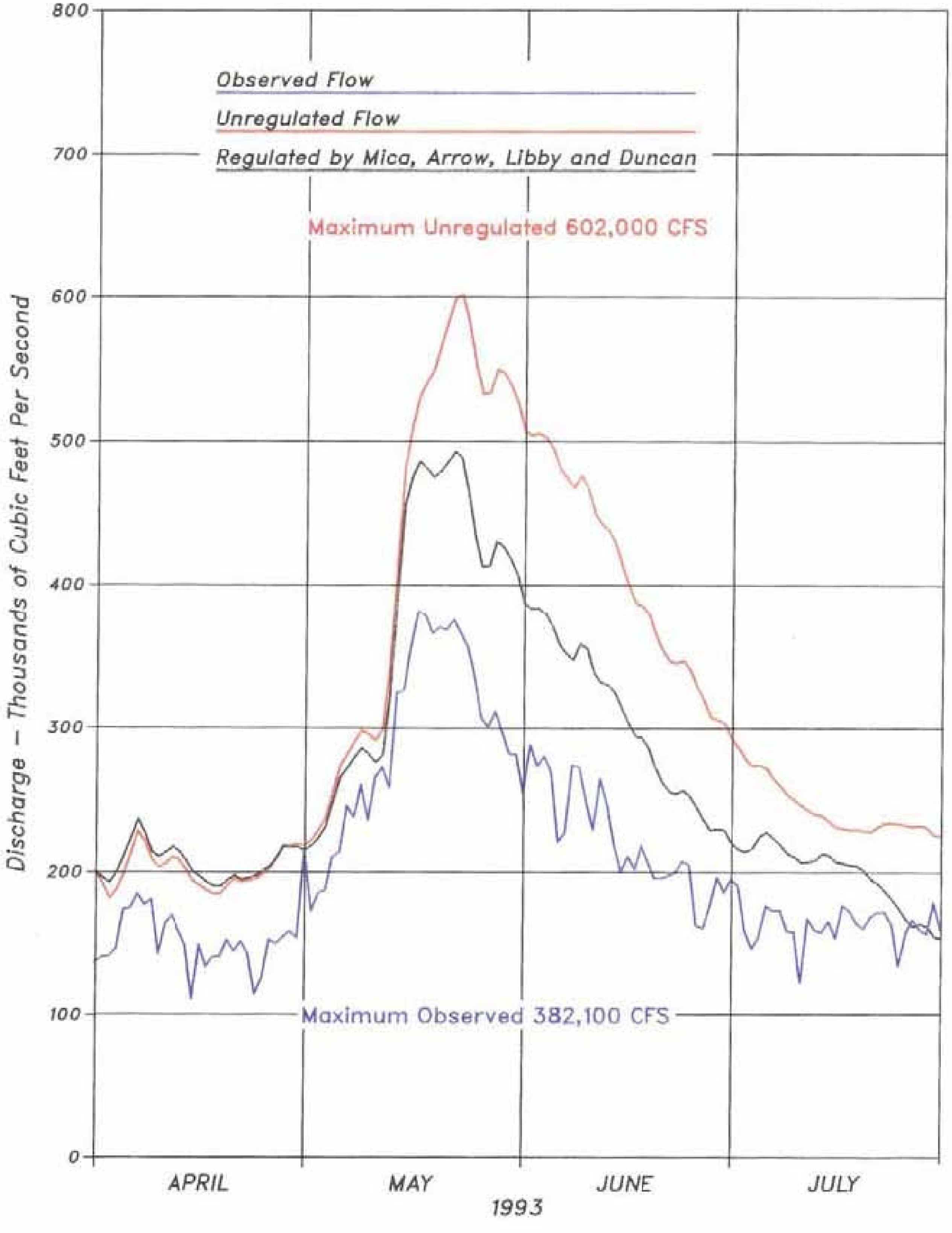


Chart 14
Columbia River at The Dalles
1 April 1993 – 31 July 1993



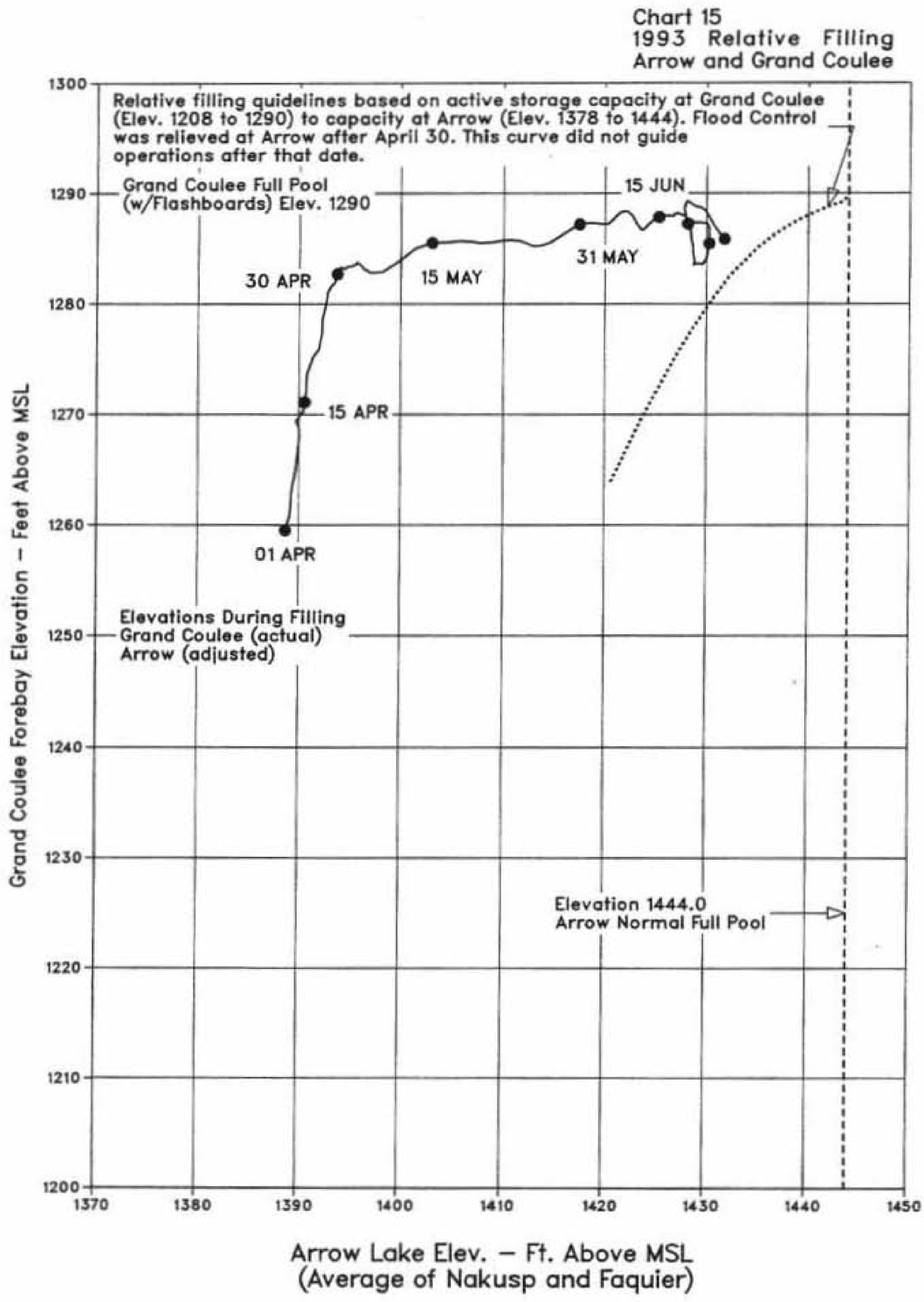


Chart 15
1993 Relative Filling
Arrow and Grand Coulee
Relative filling guidelines based on active storage capacity at Grand Coulee (Elev. 1208 to 1290) to capacity at Arrow (Elev. 1378 to 1444). Flood Control was relieved at Arrow after April 30. This curve did not guide operations after that date.
Grand Coulee Full Pool (w/Flashboards) Elev. 1290
15 JUN
31 MAY
30 APR
15 MAY
15 APR
01 APR
Elevations During Filling
Grand Coulee (actual)
Arrow (adjusted)
Elevation 1444.0
Arrow Normal Full Pool
Grand Coulee Forebay Elevation – Feet Above MSL
1300
1290
1280
1270
1260
1250
1240
1230
1220
1210
1200
1370
1380
1390
1400
1410
1420
1430
1440
1450
Arrow Lake Elev. – Ft. Above MSL
(Average of Nakusp and Faquier)