

# Annual Report to the Governments of the United States and Canada

**Columbia River Treaty  
Permanent Engineering Board**



Washington, D.C. | Ottawa, Ontario

30 September 2004





**COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD**  
C A N A D A • U N I T E D S T A T E S

**CANADIAN SECTION**

T. WALLACE, Chair  
T. Newton, Member

**UNITED STATES SECTION**

S.L. STOCKTON, Chair  
R.H. Wilkerson, Member

28 February 2005

The Honorable Condoleezza Rice  
Secretary of State  
Washington, D.C.

The Honourable R. John Efford  
Minister of Natural Resources  
Ottawa, Ontario

Dear Secretary Rice and Minister Efford:

We refer you to the Treaty between the United States of America and Canada relating to cooperative development of the water resources of the Columbia River Basin, signed at Washington, D.C., on 17 January 1961.

In accordance with the provisions of Article XV, paragraph 2(e), we are submitting the fortieth *Annual Report of the Permanent Engineering Board*, dated 30 September 2004. The report documents the results achieved under the Treaty for the period from 1 October 2003 to 30 September 2004.

As noted in last year's Annual Report, the assured operating plans (AOPs) and determinations of downstream power benefits (DDPBs) for operating years 2006–2007, 2007–2008, and 2008–2009 had not been completed due to the continuing efforts of the Entities to refine and validate an updated study process. Paragraph 9 of Annex A of the Treaty requires the Entities to prepare an AOP and the associated DDPB for the sixth succeeding year of operation. These three documents were received in February 2004, and the delay did not impact on Treaty operations. Accordingly, the objectives of the Treaty have been met. The Entities are currently drafting the 2009–2010 AOP and DDPB documents.

Respectfully submitted:

For the United States

Steven Stockton, Chair

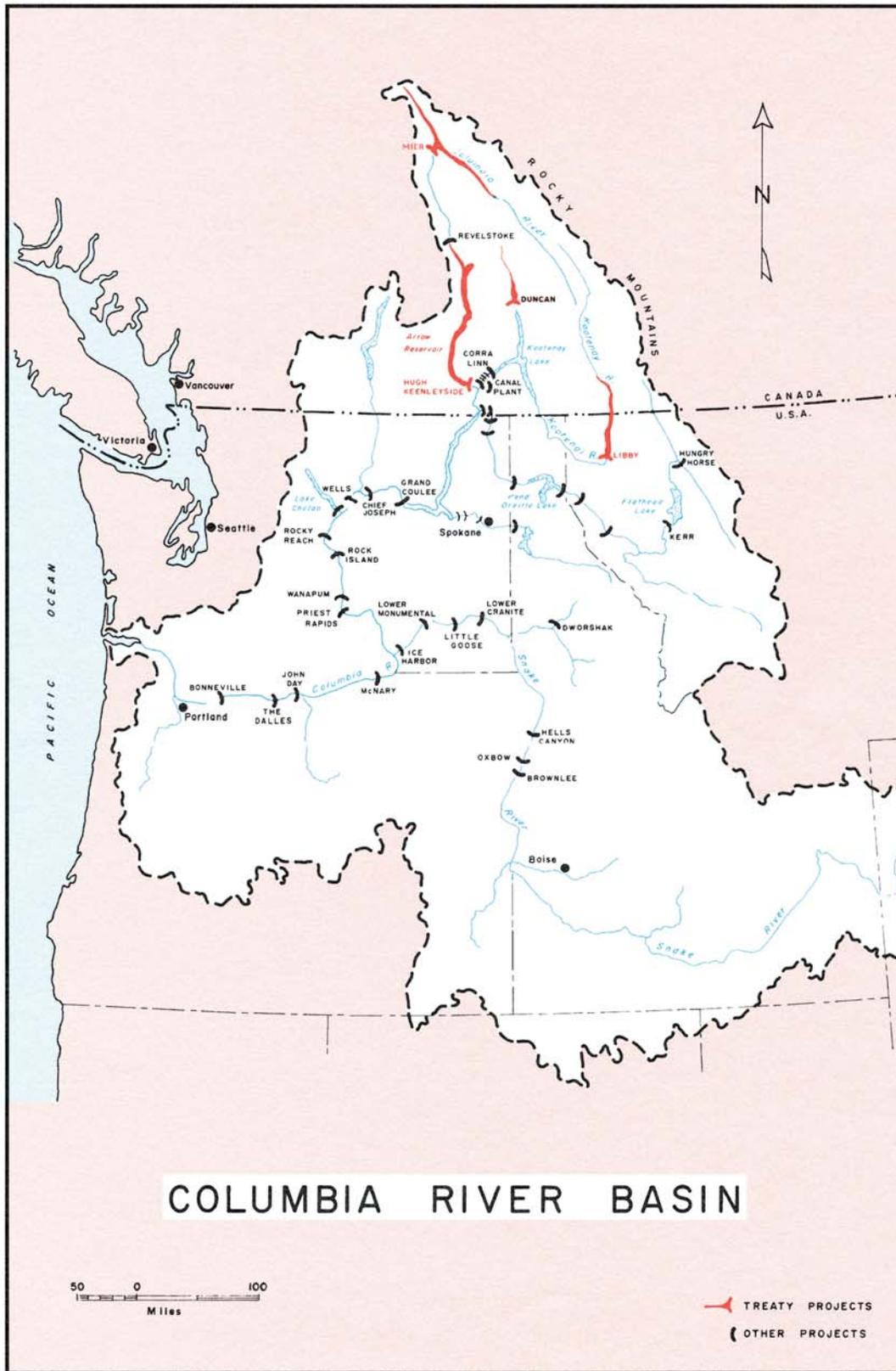
For Canada

Tom Wallace, Chair

Ronald Wilkerson

Tim Newton







**Annual Report  
to the  
Governments of the  
United States and Canada**

**Columbia River Treaty  
Permanent Engineering Board**



# contents

## TABLE OF CONTENTS

Letter of Transmittal	
ABBREVIATIONS AND ACRONYMS .....	vi
<b>SUMMARY</b> .....	vii
<b>INTRODUCTION</b> .....	1
<b>THE COLUMBIA RIVER TREATY</b> .....	3
General .....	3
Features of the Treaty and Related Documents .....	3
<b>PERMANENT ENGINEERING BOARD</b> .....	5
General .....	5
Establishment of the Board .....	5
Duties and Responsibilities .....	5
<b>ENTITIES</b> .....	8
General .....	8
Establishment of the Entities .....	8
Powers and Duties of the Entities .....	8
<b>ACTIVITIES OF THE BOARD</b> .....	10
Meetings .....	10
Reports Received .....	10
Report to the Governments .....	11
<b>TREATY IMPLEMENTATION</b> .....	13
General .....	13
Treaty Projects .....	13
Duncan Project .....	13
Arrow Project .....	14
Mica Project .....	14
Libby Project in the United States .....	15
Libby Project in Canada .....	15

Hydrometeorological Network .....	15
Power Operating Plans and Calculation of Downstream Power Benefits .....	17
Transmission Developments .....	18
Flood Control Operating Plan .....	19
Flow Records .....	19
Non-Treaty Storage .....	19
Fisheries Operations .....	19
<b>OPERATIONS UNDER THE TREATY .....</b>	<b>21</b>
General .....	21
System Storage .....	24
Mica Reservoir .....	25
Arrow Reservoir .....	25
Duncan Reservoir .....	25
Libby Reservoir .....	26
Federal Columbia River Power System .....	26
Flood Control Operations .....	27
Duncan Reservoir Levels .....	28
Mica Reservoir Levels .....	29
Libby Reservoir Levels .....	30
Arrow Reservoir Levels .....	31
Kootenai River at Libby Dam .....	32
Duncan River at Duncan Dam .....	33
Columbia River at Mica Dam .....	34
Columbia River at Hugh Keenleyside Dam .....	35
Columbia River at Birchbank .....	36
<b>TREATY BENEFITS .....</b>	<b>37</b>
Flood Control Benefits .....	37
Power Benefits .....	38
Other Benefits .....	38
<b>CONCLUSIONS .....</b>	<b>40</b>
<b>LIST OF PHOTOGRAPHS</b>	
Libby Dam .....	2
Hugh Keenleyside Dam .....	7
Duncan Dam .....	12
Mica Dam .....	20
Revelstoke Dam .....	39

*Photographs supplied by the British Columbia Hydro and Power Authority and the U.S. Army Corps of Engineers*

**LIST OF HYDROGRAPHS**

Duncan Reservoir Levels .....	28
Mica Reservoir Levels .....	29
Libby Reservoir Levels .....	30
Arrow Reservoir Levels .....	31
Kootenai River at Libby Dam .....	32
Duncan River at Duncan Dam .....	33
Columbia River at Mica Dam .....	34
Columbia River at Hugh Keenleyside Dam .....	35
Columbia River at Birchbank .....	36

**APPENDICES**

A: Columbia River Treaty Permanent Engineering Board .....	41
B: Columbia River Treaty Entities .....	45
C: Record of Flows at the International Boundary .....	47
D: Project Information .....	51

**ABBREVIATIONS AND ACRONYMS**

aMW	.....	Average Megawatts
AOP	.....	Assured Operating Plan (from 1 August to 31 July)
BC Hydro	.....	British Columbia Hydro and Power Authority
BiOp	.....	Biological Opinion
BPA	.....	Bonneville Power Administration
CEPA	.....	Canadian Entitlement Purchase Agreement
CRTOC	.....	Columbia River Treaty Operating Committee
CTS	.....	Canadian Treaty storage
cfs	.....	Cubic feet per second
DDPB	.....	Determination of Downstream Power Benefits
DOP	.....	Detailed Operating Plan (from 1 August to 31 July)
FCOP	.....	Flood Control Operating Plan
FWS	.....	U.S. Fish and Wildlife Service
km <sup>3</sup>	.....	Cubic kilometers
kcfs	.....	Thousand cubic feet per second
kV	.....	Kilovolts
LCA	.....	Libby Coordination Agreement
m	.....	Meters
m <sup>3</sup> /s	.....	Cubic meters per second
Maf	.....	Million acre-feet
MW	.....	Megawatts
NMFS	.....	National Marine Fisheries Service
NTSA	.....	Non-Treaty Storage Agreement
ORC	.....	Operating Rule Curve
PEB	.....	Permanent Engineering Board
PEB reporting year	.....	1 October to 30 September, same as water year
PEBCOM	.....	PEB Engineering Committee
TSR	.....	Treaty Storage Regulation
USACoE	.....	U.S. Army Corps of Engineers
VarQ	.....	Variable discharge flood control

# SUMMARY

*The fortieth Annual Report of the Permanent Engineering Board is submitted to the governments of Canada and the United States in compliance with Article XV of the Columbia River Treaty of 17 January 1961. This report describes Treaty projects, storage operations, and the resulting benefits achieved by each country for the period from 1 October 2003 to 30 September 2004.*

As reported in this document, the objectives of the Treaty have been met. The assured operating plans (AOPs) and determinations of downstream power benefits (DDPBs) for operating years 2006–2007, 2007–2008 and 2008–2009 have been received. The Entities are currently drafting the 2009–2010 AOP and DDPB documents.

**The entitlement to the downstream power benefits accruing to each country from Treaty storage for the reporting period was determined, according to the procedures set out in the Treaty and Protocol, to be 537.3 average megawatts (aMW) of energy and 1176.4 megawatts (MW) of capacity from 1 October 2003 to 30 September 2004.**

Utilizing the section of the 1999 Disposal Agreement for mutually agreed arrangements, the Province of British Columbia disposed of entitlement energy

directly in the United States at rates of up to 400 MW during the period 1 July 2004 to 31 October 2004.

The Duncan, Arrow, and Mica projects were operated in compliance with the Treaty during the period covered by this report. The operation reflects detailed operating plans developed by the Entities, the Flood Control Operating Plan for Treaty reservoirs, and other agreements between the Entities. The reporting year was characterized by below-normal flow conditions in the Columbia River Basin. There was no significant flooding within the Basin.

The Entities continued to operate the hydrometeorological network as required by the Treaty. Although the primary responsibility of the Columbia River Treaty Hydrometeorological Committee is to plan and monitor the operation of the data facilities, a significant part of the reporting

year focused on evaluating the new Libby water supply forecast procedures developed by the U.S. Army Corps of Engineers. The Committee provided technical guidance and evaluation regarding the new procedures, resulting in a recommendation to the Columbia River Treaty Operating Committee (CRTC) to incorporate new forecasts into Treaty procedures. It also recommended the Dworshak early season forecast. In addition, the Hydrometeorological Committee took on the responsibility of developing and maintaining the documentation of the forecast procedures for Mica, Arrow, Duncan, Libby, Dworshak, and Hungry Horse. Documentation was made available to the CRTC in July 2004.

# INTRODUCTION

*The Columbia River Treaty provides for the cooperative development of the water resources of the Columbia River Basin. Article XV of the Treaty established a Permanent Engineering Board and specified that one of its duties is to “make reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty.”*

This Annual Report, which covers the period 1 October 2003 through 30 September 2004, describes the activities of the Board, Treaty projects, storage operations, and the resulting benefits achieved by each country. It also presents summaries of the essential features of the Treaty and of the responsibilities of the Board and the Entities.

The report refers to items currently under review by the Entities; provides details on calculating flood control and power benefits, and on operation of Treaty reservoirs and flow discharges at the border; and presents the conclusions of the Board.



Libby Dam and Lake Kootenai – Kootenai River, Montana  
The dam and reservoir, Lake Kootenai. The powerhouse is to the left of the spillway.

# river treaty

## THE COLUMBIA RIVER TREATY

### General

*The Columbia River Treaty was signed at Washington, D.C., on 17 January 1961, and was ratified by the United States Senate in March of that year. In Canada, ratification was delayed. Further negotiations between the two countries resulted, on 22 January 1964, in a formal agreement by an exchange of notes to a Protocol to the Treaty, and to an Attachment Relating to Terms of Sale. The Treaty and related documents were approved by the Canadian Parliament in June 1964.*

The Canadian Entitlement Purchase Agreement (CEPA) was signed on 13 August 1964. Under the terms of this agreement, Canada's share of downstream power benefits resulting from the first 30 years of scheduled operation of each of the storage projects was sold to a group of electric utilities in the United States known as the Columbia Storage Power Exchange.

On 16 September 1964, the Treaty and Protocol were formally ratified by an exchange of notes between the two countries. The sum of US\$253.9 million was delivered to the Canadian representatives as payment in advance for the Canadian entitlement to downstream power benefits during the period of the Purchase Agreement. On the same date, at a ceremony at the Peace Arch Park on the International Boundary, the Treaty and its Protocol were proclaimed by President Johnson of the United States,

Prime Minister Pearson of Canada, and Premier Bennett of British Columbia.

### Features of the Treaty and Related Documents

The essential undertakings of the Treaty are as follows:

- (a) Canada will provide 19.1 km<sup>3</sup> (15.5 Maf) of usable storage by constructing dams near Mica Creek, the outlet of Arrow Lakes, and Duncan Lake in British Columbia.
- (b) The United States will maintain and operate the hydroelectric power facilities included in the base system and any new main-stem projects to make the most effective use of improved streamflow resulting from operation of the Canadian storage. Canada will operate the storage in

accordance with the procedures and operating plans specified in the Treaty.

- (c) The United States and Canada will share equally the additional power benefit available in the United States as a result of river regulation by upstream storage in Canada.
- (d) On commencement of the respective storage operations, the United States will make payments to Canada totaling US\$64.4 million for flood control provided by Canada.
- (e) The United States has the option of constructing a dam on the Kootenai River near Libby, Montana. The Libby Reservoir would extend some 67.6 km (42 miles) into Canada, and Canada would make the necessary Canadian land available for flooding.
- (f) Both Canada and the United States have the right to make diversions of water for consumptive use and, in addition, after September 1984, Canada has the option of making specific diversions of the Kootenay River into the headwaters of the Columbia River for power purposes.
- (g) Differences arising under the Treaty that cannot be resolved by the two countries may be referred by either country to the International Joint Commission or to

arbitration by an appropriate tribunal as specified by the Treaty.

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

The Protocol of January 1964 amplified and clarified certain terms of the *Columbia River Treaty*. The Attachment Relating to Terms of Sale signed on the same date established agreement that under certain terms Canada would sell in the United States its entitlement to downstream power benefits for a 30-year period. The Exchange of Notes and Attachment Relating to Terms of Sale of January 1964 and the CEPA of 13 August 1964 (the Sales Agreement) provided that the Treaty storage would be operative for power purposes on the following dates: Duncan storage on 1 April 1968; Arrow storage on 1 April 1969; and Mica storage on 1 April 1973. As of the date of this report, all sales under the Sales Agreement have expired.

# engineering

## PERMANENT ENGINEERING BOARD

### General

*Article XV of the Columbia River Treaty establishes a Permanent Engineering Board consisting of two members to be appointed by Canada and two members to be appointed by the United States. Appointments to the Board were to be made within three months of the date of ratification. The duties and responsibilities of the Board are also stipulated in the Treaty and related documents.*

### Establishment of the Board

On 7 December 1964, pursuant to Executive Order No. 11177 dated 16 September 1964, the Secretary of the Army and the Secretary of the Interior each appointed a member and an alternate member to form the United States Section of the Permanent Engineering Board. Pursuant to the Department of Energy Organization Act of 4 August 1977, the appointments to the United States Section of the Board are now made by the Secretary of the Army and the Secretary of Energy. The members of the Canadian Section of the Board were appointed by Order in Council P.C. 1964-1671 dated 29 October 1964. Each Canadian member was authorized to appoint an alternate member. On 11 December 1964, the two governments announced the composition of the Board.

The names of Board members, alternate members and secretaries are shown in Appendix A, as are the names of the current members of the Board's Engineering Committee.

### Duties and Responsibilities

The general duties and responsibilities of the Board to the governments, as set forth in Article XV(2) of the Treaty and related documents, include:

- (a) assembling records of the flows of the Columbia River and the Kootenay River at the Canada–United States of America boundary;
- (b) reporting to Canada and the United States of America whenever there is substantial deviation from the

- hydroelectric and flood control operating plans and, if appropriate, including in the report recommendations for remedial action and compensatory adjustments;
- (c) assisting in reconciling differences concerning technical or operational matters that may arise between the Entities;
- (d) making periodic inspections and requiring reports as necessary from the Entities, with a view to ensuring that the objectives of the Treaty are being met;
- (e) making reports to Canada and the United States of America at least once a year of the results being achieved under the Treaty and making special reports concerning any matter that it considers should be brought to their attention;
- (f) investigating and reporting with respect to any other matter coming within the scope of the Treaty at the request of either Canada or the United States of America; and
- (g) consulting with the Entities on the establishment and operation of a hydrometeorological system as required by Annex A of the Treaty.



Hugh Keenleyside Dam (Arrow Lakes) – Columbia River, British Columbia  
Concrete spillway and discharge works with navigation lock and earthfill dam.  
The new 185-MW power plant is on the north abutment (left bank).

# ENTITIES

## General

*Article XIV(1) of the Columbia River Treaty provides that Canada and the United States of America shall each designate one or more Entities to formulate and execute the operating arrangements necessary to implement the Treaty. The powers and duties of the Entities are specified in the Treaty and its related documents.*

### Establishment of the Entities

Executive Order No. 11177, previously referred to, designated the Administrator of the Bonneville Power Administration (BPA), the Department of the Interior, and the Division Engineer, North Pacific Division, Corps of Engineers, Department of the Army, as the United States Entity, with the Administrator to serve as Chair. Pursuant to the *Department of Energy Organization Act* of 4 August 1977, the BPA was transferred to the Department of Energy. Order in Council P.C. 1964-1407, dated 4 September 1964, designated the British Columbia Hydro and Power Authority (BC Hydro) as the Canadian Entity.

The names of the members of the Entities are shown in Appendix B.

### Powers and Duties of the Entities

In addition to the powers and duties specified elsewhere in the Treaty and related documents, Article XIV(2) of the Treaty requires that the Entities be responsible for the following:

- (a) coordination of plans and exchange of information relating to facilities to be used in producing and obtaining the benefits contemplated by the Treaty;
- (b) calculation of and arrangements for delivery of hydroelectric power to which Canada is entitled for providing flood control;

- (c) calculation of the amounts payable to the United States of America for standby transmission services;
- (d) consultation on requests for variations made pursuant to articles XII(5) and XIII(6);
- (e) establishment and operation of a hydrometeorological system as required by Annex A;
- (f) assisting and cooperating with the Permanent Engineering Board in the discharge of its functions;
- (g) periodic calculation of accounts;
- (h) preparation of the hydroelectric operating plans and flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled;
- (i) preparation of proposals to implement Article VIII, and carrying out of any disposal authorized or exchange provided for therein;
- (j) making appropriate arrangements for delivery to Canada of the downstream power benefits to which Canada is entitled, including such matters as load factors for delivery, times and points of delivery, and calculation of transmission loss; and
- (k) preparation and implementation of detailed operating plans that may produce results more advantageous to both countries than those that would arise from operation under the plans referred to in annexes A and B.

Article XIV(4) of the Treaty provides that the two governments may, by an exchange of notes, empower or charge the Entities with any other matter coming within the scope of the Treaty.

# activities

## ACTIVITIES OF THE BOARD

### Meetings

*The Board held its 71st meeting on 11 February 2004 in Portland, Oregon. In conjunction with this meeting, the Board also held its 52nd joint meeting with the Entities.*

The following topics were discussed at the meeting: transmission issues and return of the Canadian entitlement; fisheries operations; revised principles and procedures for preparing assured operating plans (AOPs); results of the proposal to streamline Entity study processes; and impacts of U.S. resource agencies' Biological Opinions (BiOps) on Treaty operations.

### Reports Received

Throughout the reporting year, the Entities maintained contact with the Board and the Board's Engineering Committee. Information pertinent to the operation of Treaty storage projects was made available to the Board.

Since the last Annual Report, the Board has received the following documents involving the operation of Columbia River Treaty storage:

- Columbia River Treaty Operating Committee Agreement on Operation of Treaty Storage for Non-power Uses from 1 December 2003 through 31 July 2004, signed 15 December 2003
- Columbia River Treaty Entity Agreement on the Principles and Procedures for Preparing and Implementing Hydroelectric Operating Plans for Operation of Canadian Treaty Storage, signed 16 December 2003

*This agreement is similar to previous agreements implemented to utilize Treaty storage for non-power uses. These uses include the following: (1) providing flows for Canadian trout spawning for the April through June period; (2) enhancing the capability in the U.S. of providing spring and summer flow augmentation for salmon and steelhead by storing 1 Maf of water in Arrow by late April; (3) enhancing Arrow Lakes levels by ensuring progressive refill; (4) providing a minimum discharge objective at Arrow during January through March 2004 for the purpose of protecting eggs deposited on the streambed by Mountain Whitefish during December 2003 through January 2004; (5) improving the U.S. capability to meet flow objectives for salmon at Vernita Bar below Priest Rapids Dam during the period of December 2003 through early May 2004. This agreement supplements the 2003–2004 Detailed Operating Plan (DOP).*

*This agreement implements the principles and procedures that serve as a guide for preparing and using the AOPs and DOPs for the operation of Columbia River Treaty storage.*

- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Years 2006–2007, 2007–2008, and 2008–2009, dated January 2004

*These three documents provide information on the operating plan for Columbia River Treaty storage and resulting downstream power benefits for the period 1 August through 31 July for the years 2006–2007, 2007–2008, and 2008–2009*

- Columbia River Treaty Entity Agreement on the Assured Operating Plan and Determination of Downstream Power Benefits for the 2006–2007, 2007–2008, 2008–2009 Operating Years, signed 4 February 2004

These three agreements implement the AOPs and Determinations of Downstream Power Benefits (DDPBs) that provide information on the operating plan for Columbia River Treaty storage and resulting downstream power benefits for the period 1 August through 31 July for the years 2006–2007, 2007–2008, and 2008–2009.

- Detailed Operating Plan for Columbia River Storage for 1 August 2004 through 31 July 2005, dated June 2004

*This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the operating year from 1 August 2004 through 31 July 2005.*

- Columbia River Treaty Entity Agreement on the Detailed Operating Plan for Columbia River Storage for 1 August 2004 through 31 July 2005, signed 25 June 2004

*This document is the agreement between the Entities to implement the DOP for Columbia River storage during the period 1 August 2004 through 31 July 2005.*

- Columbia River Treaty Operating Committee Agreement on Implementation Procedures for Flood Control Reallocation for the 2004–2005 Operating Year, signed 28 June 2004

This agreement instructs the U.S. Army Corps of Engineers (USACoE) to calculate and distribute flood control rule curves for Mica, Arrow, and Grand Coulee using the 5.03/4.44 km<sup>3</sup> (4.08/3.6 Maf) flood control allocation between Mica and Arrow. The effect of the allocation and power drafts at upstream projects will be included in the Grand Coulee flood control rule curves.

- Annual Report of the Columbia River Treaty, Canadian and United States Entities, for the period 1 October 2003 through 30 September 2004, dated October 2004

This report summarizes the operation of Treaty projects and other activities of the Entities for the period 1 October 2003 through 30 September 2004.

The Board received no documents involving the operation of Columbia River non-Treaty storage during this reporting year.

## Report to the Governments

The thirty-ninth Annual Report of the Board, dated 27 February 2004, was submitted to the governments of Canada and the United States of America.



Duncan Dam – Duncan River, British Columbia  
The earthen dam with discharge tunnels to the left and spillway to the right.

# TREATY IMPLEMENTATION

## General

*Implementation of the Treaty resulted in the construction of the Treaty projects, development of the hydrometeorological network, annual preparation of power and flood control operating plans, and annual calculation of downstream power benefits. The three Treaty storage projects in British Columbia — the Duncan, Arrow, and Mica projects — produce flood control and power benefits in both Canada and the United States. The Libby storage project in the United States also provides flood control and power benefits in both countries. In the United States, increased flow regulation provided by Treaty projects facilitated the installation of additional generating capacity at existing plants on the Columbia River. In Canada, completion of the Canal Plant on the Kootenay River in 1976, installation of generators at Mica Dam in 1976–1977, and completion of the Revelstoke project in 1984, all owned by BC Hydro, have resulted in additional power benefits. These benefits amount to some 4000 MW of generation capacity in British Columbia that might not have been installed without the Treaty. In addition, the construction of a two-unit, 185-MW hydropower plant adjacent to the Hugh Keenleyside Dam was completed in 2002. Additional generating units at Revelstoke and Mica dams in Canada are being considered for the future.*

The Treaty provides Canada with an option, which commenced in 1984, of diverting the Kootenay River at Canal Flats into the headwaters of the Columbia River. BC Hydro undertook certain engineering feasibility and environmental studies of the potential diversion. No further activities have occurred since that time.

Further to the expiration of the Sales Agreement in 1998, 1999, and 2003, the Board has monitored issues relating to the transmission and return of the Canadian entitlement, and the restructuring of electricity markets. It has also reviewed

the impacts of U.S. resource agencies' BiOps on Treaty operations.

The locations of the Treaty projects are shown in Appendix D, Plate No. 1.

## Treaty Projects

### Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled in the 30-year Sales Agreement for operation by 1 April 1968, and was the first of the Treaty projects to be completed. It became fully operational on 31 July 1967,

well in advance of Treaty requirements. The Sales Agreement for Duncan expired 31 March 1998.

The earthfill dam is about 39.6 m high (130 feet) and extends 792.5 m (2600 feet) across the Duncan River valley, approximately 9.7 km (6 miles) north of Kootenay Lake. The reservoir behind the dam extends for about 43.5 km (27 miles) and provides 1.73 km<sup>3</sup> (1.4 Maf) of usable storage, which is committed under the Treaty. No power facilities are included in this project.

The project is shown on page 12, and project data are provided in Appendix D, Table 1.

#### **Arrow Project**

Hugh Keenleyside Dam, at the outlet of the Arrow Lakes, was the second Treaty project to be completed. It became operational on 10 October 1968, well ahead of 1 April 1969, the date scheduled in the 30-year Sales Agreement. The Sales Agreement for Arrow expired 31 March 1999.

The dam consists of two main components: a concrete gravity structure that extends 366 m (1200 feet) from the north bank of the river and includes the spillway, low-level outlets, and navigation lock; and an earthfill section that rises 52 m (170 feet) above the riverbed and extends 503 m (1650 feet) from the navigation lock to the south bank of the river. The reservoir, about 233 km (145 miles) long, includes both the Upper and Lower Arrow lakes and provides 8.8 km<sup>3</sup> (7.1 Maf) of Treaty storage.

The new 185-MW power plant at the Arrow Project, owned by Arrow Lakes Power Corporation, is located on the north abutment (left bank). An intake approach channel of about 1493 m (4900 feet) runs along the north end of the concrete dam and diverts the waters of the Arrow Reservoir through a powerhouse located

in a rock outcrop 396 m (1300 feet) downstream. The generating facility contains two 92.5-MW Kaplan turbines. The facility is connected by a new 230-kV transmission line to the Selkirk substation for integration into BC Hydro's existing power grid. The installation of the generating units was completed in the spring of 2002, and the power production at the new generating facility is incidental to releases for Treaty purposes. This new power plant will reduce spill at Keenleyside Dam and will provide environmental benefits by reducing entrained gases that are harmful to fish.

In April 2004, the concrete lining at the base of the intake approach channel was damaged at one location, and the power plant was shut down for about three months while repairs were undertaken. The owners are investigating a permanent solution to address the problem.

The project is shown on page 7, and project data are provided in Appendix D, Table 2.

#### **Mica Project**

Mica Dam, the largest of the Treaty projects, was scheduled under the 30-year Sales Agreement for initial operation on 1 April 1973. The project was declared operational and commenced storing on 29 March 1973. The Sales Agreement for Mica expired 31 March 2003.

The dam is located on the Columbia River about 137 km (85 miles) north of Revelstoke, British Columbia. The earthfill dam rises more than 244 m (800 feet) above its foundations and extends 793 m (2600 feet) across the Columbia River valley. It is the tallest dam in North America. It creates a reservoir 217 km (135 miles) long, called Kinbasket Lake, with a total storage capacity of 24.7 km<sup>3</sup> (20 Maf). The project utilizes 14.8 km<sup>3</sup> (12 Maf) of live storage, of which 8.6 km<sup>3</sup> (7 Maf) are committed under the Treaty.

Although not required by the Treaty, BC Hydro added a powerhouse to the project.

The underground powerhouse has space for a total of six generating units. So far, four generators have been installed, with a maximum capacity of 1805 MW.

The project is shown on page 20, and project data are provided in Appendix D, Table 3.

### **Libby Project in the United States**

Libby Dam is located on the Kootenai River, 27.4 km (17 miles) northeast of the town of Libby, Montana. Construction began in the spring of 1966, and storage has been fully operational since 17 April 1973. Commercial generation of power began on 24 August 1975, which coincided with the formal dedication of the project. The concrete gravity dam is 931 m (3055 feet) long, rises 113 m (370 feet) above the riverbed, and creates Lake Koocanusa, which is 145 km (90 miles) long and extends 67.6 km (42 miles) into Canada. Lake Koocanusa has a gross storage of 7.2 km<sup>3</sup> (5.869 Maf), of which 6.1 km<sup>3</sup> (4.980 Maf) are usable for flood control and power purposes. When completed in 1976, the Libby powerhouse had four units with a total installed capacity of 420 MW.

Construction of four additional generating units was initiated during fiscal year 1978, but Congressional restrictions imposed in the 1982 Appropriations Act provided for completion of only one of these units. That unit became available for service late in 1987. The total installed capacity for the five units is 525 MW. Recent U.S. legislation (Public Law 104-303, 12 Oct. 1996) authorizes the USACoE to complete generating units 6 through 8. No action was taken in this regard during this reporting period.

The Libby project is shown on page 2, and project data are provided in Appendix D, Table 4.

### **Libby Project in Canada**

Canada has fulfilled its obligation to prepare the land required for the 67.6-km (42-mile) portion of Lake Koocanusa in Canada. British Columbia is responsible for reservoir debris clean-up on the Canadian side of the border.

## **Hydrometeorological Network**

One of the responsibilities assigned to the Entities by the Treaty is the establishment and operation, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for the detailed programming of flood control and power operation. This system includes snow courses, meteorological stations, and streamflow gauges. The Columbia River Treaty Hydrometeorological Committee, formed by the Entities in 1968, makes recommendations on further development of the Treaty Hydrometeorological System.

In 1976, the Entities, with the concurrence of the Board, adopted a document that defined the Columbia River Treaty Hydrometeorological System, and outlined a method of classifying facilities into those required as part of the Treaty system and those of value as supporting facilities. In 1977, the Entities, with the concurrence of the Board, adopted a plan for the exchange of operational hydrometeorological data.

As a result of the emergence and adoption of more sophisticated streamflow forecasting procedures, the number of stations used in the Treaty studies increased from 866 in 1992 to about 1500 in 2000. Considerable effort was required to classify and prepare the documentation produced by network stations on a regular basis.

In consultation with the Board, effective 1 October 2001, the Entities adopted a revised method for classifying the stations used in the Treaty studies. The Entities eliminated the practice of categorizing each data station as either "Treaty" or "Support." Instead, a new classification, "Treaty/Support," was adopted for stations that are used directly or indirectly to monitor, plan and operate Treaty projects. The Entities communicate with data collection agencies on a regular basis to remain informed of the status of the network, and take the necessary steps to ensure that the monitoring, planning and operation of Treaty facilities are not adversely affected by any changes to the hydrometeorological network. The format of future Hydrometeorological Committee documents was revised to include only changes to the network, as opposed to complete listings of all stations.

The first Annual Report of the Hydrometeorological Committee to include these changes was completed in 2003.

During the reporting year, the Hydrometeorological Committee spent considerable time evaluating the new Libby water supply forecast procedures developed by the USACoE, although its primary responsibility is to plan and monitor the operation of data facilities. The Hydrometeorological Committee provided technical guidance and evaluation of these procedures, resulting in a recommendation to the Columbia River Treaty Operating Committee (CROTC) to incorporate new forecasts into Treaty procedures. The USACoE developed equations, including two early-season forecast procedures for November and December. After careful evaluation and assessment, the December through June forecast equations were recommended to the CROTC for adoption. These equations were approved in February 2004. The Hydrometeorological Committee also recommended

the Dworshak early season forecast, which was also approved by the CROTC.

In addition to evaluating new forecast procedures, the Hydrometeorological Committee took on the responsibility of developing and maintaining the documentation of the forecast procedures for Mica, Arrow, Duncan, Libby, Dworshak, and Hungry Horse. This documentation was made available to the CROTC in July 2004.

The summer of 2004 marked the completion of the 2000 Level Modified Flows Study, which fulfilled the Treaty obligation to update irrigation depletions. The Bonneville Power Administration undertook the development of the study, but the data submittal and review of the study were a cooperative effort by all Treaty committees and staff.

During the year, the Hydrometeorological Committee dealt with the following operational issues:

1. Heavy rainfall in British Columbia during the month of October caused the fall precipitation parameters in the water supply forecast procedures to take on more influence than hydrologically reasonable. In consultation with the Northwest River Forecast Center, an agreement was reached to use normal values for precipitation rather than observed values. The use of normal precipitation values for October persisted throughout the water supply season.
2. On several occasions, discrepancies appeared between the observed Canadian streamflow data submitted by the BPA for Treaty Storage Regulation (TSR) purposes and observations recorded by BC Hydro. While BC Hydro submits its data to the Columbia River Operations Hydromet System in the U.S., the BPA obtains its data from the Northwest River Forecast Center's runoff processor program. Data from the latter is

obtained through the Columbia River Operations Hydromet System, but it has been found that the runoff processor program did not always provide the same data as BC Hydro. In order to address this issue, BC Hydro began sending daily inflow, outflow and elevation data directly to the Northwest River Forecast Center. The issue is still unresolved, however, interim coordination of submittals is in place until the data differences can be eliminated.

3. Station closures and changes continued to be an issue in 2004. This situation occurred in British Columbia, with causes ranging from forest fire site destruction to funding reductions. In general, the shrinking of the network is an issue that will continue into 2005 and will have to be carefully monitored for impacts to Treaty planning and operation.

## Power Operating Plans and Calculation of Downstream Power Benefits

The Treaty and related documents require the Entities to develop and agree on an assured operating plan annually for the sixth succeeding year from the current year. This AOP, prepared five years in advance, represents the basic commitment of the Canadian Entity to operate the Treaty storage in Canada (Duncan, Arrow, and Mica) and provides the Entities with a basis for system planning. At the same time, Canada's commitment to operate under an AOP is tied directly to the benefits produced by that plan. The calculation of downstream power benefits, which defines the power benefits accruing to each country under the Treaty, is also prepared five years in advance based on the Treaty operation criteria contained in the AOP. At the beginning of each operating year, a detailed operating plan, or DOP, which includes the three Treaty storage projects

in Canada, is prepared on the basis of current resources and loads to obtain results that may be more advantageous to both countries than those obtained by operating in accordance with the AOP. To supplement the DOP, the Entities may enter into agreements throughout the year regarding the operations of Treaty storage that provide mutual benefits to both Entities. Since 2000, the operating plan for the Libby project in the United States has been presented separately and has not been included in the DOP. Further details on Libby operations are presented below.

During the reporting year, the actual operations of the Treaty storage in Canada were regulated under the rule curves set out in the Entities' Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2003 through 31 July 2004, dated July 2003, and in accordance with additional agreements between the Entities signed during the year. The 2003–2004 DOP for Canadian storage was based on the operating criteria and hydroregulation studies contained in the 2005–2006 AOP, together with any changes agreed to by the Entities. This is a deviation from past practice as this was the first time a DOP was prepared using the operating criteria from a different operating year's AOP. This was done because the Entities spent significant effort and used rigorous analysis to prepare the 2005–2006 AOP and believed that it would produce more advantageous results than those of the previous AOPs, including smoother operation of the Canadian storage. The Canadian entitlement was not changed because it is determined separately by the downstream power benefits calculations.

Beginning with the 2000–2001 DOP, the operating criteria and expected operations of the Libby project are no longer included in the annual DOP. Information on Libby operations is presented separately in the Libby Operating Plan prepared by the U.S. Entity. Operations at Libby are based

on coordinated operations of the U.S. hydro system which take into account the BiOps and associated non-power requirements of the U.S. Fish and Wildlife Service (FWS) and of the National Marine Fisheries Service (NMFS), now the National Oceanic & Atmospheric Administration Fisheries Service. One of the main measures defined in the BiOp concerns changing the customary seasonal release rates from Libby Dam so that spring and summer outflows would be higher, and fall and winter outflows lower, than in the past. In addition, in January 2003, the USACoE adopted the variable discharge flood control (VarQ) for operations at Libby on an interim basis. VarQ is the conditional use of reserved flood control storage to provide augmentation flows for fisheries during the spring period. VarQ is used only when dry-to-moderate hydrologic runoff conditions are forecasted.

The Libby Coordination Agreement (LCA), signed on 16 February 2000, addressed some of the issues concerning salmon and white sturgeon fisheries operations at the Libby Project, and allowed the Entities to coordinate reservoir releases and agree to AOPs and DDPBs without having to fully resolve the matter in dispute at that time. The LCA essentially suspends the active issues of disagreement, potentially until 2024, unless either Entity chooses to terminate early, on 30 days' notice. Details of the LCA are presented later in the report under "Operations Under the Treaty." The Entities have successfully implemented the LCA for the past four years.

A lengthy dispute between the Entities during the early 1990s regarding the calculation of downstream power benefits was resolved by signing the *Entity Agreement on Resolving the Dispute on Critical Period Determination, the Capacity Entitlement for the 1998–1999, 1999–2000, and 2000–2001 AOP/DDPBs, and Operating Procedures for the*

*2001–2002 and Future AOPs*. If this issue is raised in the future, the Board will re-examine the matter by using its earlier recommendations as guidelines for the appropriate Treaty interpretation, and for the application of the critical streamflow period definition and the established operating procedures. A more detailed discussion of this issue is contained in the 1996 and 1997 annual reports of the Board.

The arrangements for returning the Canadian entitlement to British Columbia across existing transmission lines are based on the *Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for April 1, 1998 through September 15, 2024*, signed 29 March 1999. This agreement provides arrangements for the delivery of the Canadian entitlement, including the point of delivery, method of accounting for transmission losses, and guidelines for scheduling.

In addition to the delivery agreement referred to above, the terms and conditions for the disposal of portions of the Canadian entitlement within the United States are based on the Agreement on Disposals of the Canadian Entitlement Within the United States for April 1, 1998 through September 15, 2024 Between Bonneville Power Administration, Acting on Behalf of the U.S. Entity, and the Province of British Columbia, signed 29 March 1999.

Both the delivery agreement and the disposal agreement became effective on 31 March 1999 through an exchange of diplomatic notes between Canada and the United States.

## Transmission Developments

The BPA continues to work on potential new transmission construction, configurations and operational practices to secure entitlement

returns to the Canada-U.S. border. During this reporting period, the BPA partially implemented curtailment procedures which would have placed entitlement return deliveries on an equal footing with other firm Pacific Northwest customers during curtailment periods. However, there were technical problems in implementing these procedures, and additional work remains to be done. The Canadian entitlement was delivered as scheduled 99.9 percent of the time, and the remaining 0.1 percent delivered within seven days of the schedule.

The BPA announced the creation of a Northwest task force that will publish a draft report in 2005 defining standards for transmission adequacy. Public comments will be sought on the draft plan, and a final report will then be issued.

## Flood Control Operating Plan

The Treaty provides that Canadian storage reservoirs will be operated by the Canadian Entity in accordance with operating plans designed to minimize flood damage in the United States and Canada. The *Columbia River Treaty Flood Control Operating Plan (FCOP)*, dated October 1972, was received from the Entities and reviewed by the Board in the 1973 reporting year, and was in effect until October 1999. The revised plan, dated October 1999 and updated in May 2003, defines the flood control operations of the Duncan, Arrow, Mica, and Libby reservoirs during the period covered in this report.

## Flow Records

Article XV(2)(a) of the Treaty specifies that the Permanent Engineering Board shall assemble records of flows of the Columbia and Kootenai

rivers at the Canada-U.S. boundary. Flows for this reporting year are tabulated in Appendix C for the Kootenai River at Porthill, Idaho, and for the Columbia River at Birchbank, British Columbia.

## Non-Treaty Storage

Since 1984, agreements have also been reached between BC Hydro and the BPA concerning the use of non-Treaty storage. These agreements do not interfere with operations under the Treaty. They do extend the concepts of the Treaty and benefit both BC Hydro and the BPA. As per contract terms, release rights under the Non-Treaty Storage Agreement terminated effective 30 June 2004. The extended provision of the agreement requires that active non-Treaty storage space in Mica be refilled within seven years (the deadline is 30 June 2011). The parties to the agreement have indicated their interest in negotiating a new Non-Treaty Storage Agreement.

## Fisheries Operations

Many U.S. reservoirs are presently operated in accordance with BiOps issued by the FWS and the NMFS under the *Endangered Species Act*. Treaty reservoirs in Canada are operated in accordance with the requirements of Fisheries and Oceans Canada. These efforts continue to evolve. In this regard, the Board notes that the AOP and DDPB are to be based on optimal operations for power and flood control in accordance with the requirements of the Treaty. The Board continues to maintain its long-standing position that the Entities may develop DOPs to address fisheries' needs, providing these actions do not conflict with Treaty objectives.



Mica Dam and Lake Kinbasket – Columbia River, British Columbia  
The spillway is on the right of the earthfill dam, and the underground powerhouse is on the left.

# OPERATIONS UNDER THE TREATY

## General

*The Columbia River Treaty Operating Committee was established by the Entities to develop operating plans for the Treaty storage, and to direct the operation of this storage in accordance with the terms of the Treaty and subsequent Entity agreements. These plans follow the water year from August to July of the following year. Although the Permanent Engineering Board reporting period is 1 October 2003 to 30 September 2004, Treaty operations thereunder are based on the Treaty operating year of 1 August 2003 to 31 July 2004. Additional information for 1 August 2004 to 30 September 2004 is based on the Treaty operating year 1 August 2004 to 31 July 2005.*

Treaty storage in Canada was operated by the Canadian Entity in accordance with the documents listed below. Treaty storage in the United States at the Libby project was operated by the U.S. Entity according to the 2003 FCOP, the 2000 LCA, and the guidelines set forth in the FWS and the NMFS 2000 BiOps.

- Columbia River Treaty Entity Agreement on Principles for Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits, dated July 1988

*This agreement states the principles for changes to the preparation of the AOP and DDPB. These changes involve revisions to the information to be used in studies, such as the definition of the power loads and generating resources in the Pacific Northwest area, streamflows*

*to be used, estimates of irrigation withdrawals and return flows, and other related information.*

- Columbia River Treaty Entity Agreement on Changes to Procedures for the Preparation of the Assured Operating Plan and Determination of Downstream Power Benefit Studies, dated August 1988

*This agreement states the specific procedures to be used in implementing the previous agreement on Principles for Preparation of the Assured Operating Plan and Determination of Downstream Power Benefits.*

- Agreement executed by the United States of America Department of Energy, acting by and through the Bonneville Power Administration, and the British Columbia Hydro and Power Authority

relating to: (a) Use of Columbia River Non-Treaty Storage, (b) Mica and Arrow Refill Enhancement, and (c) Initial Filling of non-Treaty Reservoirs, signed 9 July 1990

*This agreement provides information relating to the initial filling of Revelstoke Reservoir, the coordinated use of some of the Columbia River non-Treaty storage, and actions taken to enhance the refill of the reservoirs impounded by the Mica and Arrow dams.*

- Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for 1 April 1998 through 15 September 2024, signed 29 March 1999

*This agreement provides arrangements for the delivery of the Canadian entitlement, including the point of delivery, method of accounting for transmission losses, and guidelines for scheduling. The Agreement became effective on 31 March 1999 through an exchange of diplomatic notes between the United States and Canada. Execution of this agreement supersedes and terminates the Columbia River Treaty Entity Agreement on Aspects of the Delivery of the Canadian Entitlement for 1 April 1998 through 15 September 2024 between the Canadian Entity and the United States Entity, dated 20 November 1996, and the Entity Agreement of the same name, dated 26 March 1998, which never reached its effective date.*

- Agreement on Disposals of the Canadian Entitlement Within the United States for 1 April 1998 through 15 September 2024 Between the Bonneville Power Administration, Acting on Behalf of the U.S. Entity, and the Province of British Columbia, signed 29 March 1999

*This agreement describes the arrangements by which British Columbia may dispose of the Canadian entitlement in the United States.*

- Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2003–2004, dated 16 February 2000

*This document provides information on the operating plan for Columbia River Treaty storage and resulting downstream power benefits for the period 1 August 2003 through 31 July 2004.*

- Columbia River Treaty Entity Agreement Coordinating the Operation of the Libby Project with the Operation of Hydroelectric Plans on the Kootenay River and Elsewhere in Canada, signed 16 February 2000

*The LCA addresses issues concerning the operation of the Libby project and allows the Entities to coordinate reservoir operations and agree to AOPs and DDPBs without having to alter their respective positions on the validity of the Libby fisheries operations under the Treaty.*

- Columbia River Treaty Entity Agreement Relating to Extension of the Expiration Date of the Non-Treaty Storage Agreement, signed 28 June 2002

*This agreement between the Entities extends the use of Columbia River non-Treaty storage, Mica and Arrow refill enhancements, and the initial filling of non-Treaty storage to 24:00 PST on 30 June 2004.*

- Columbia River Treaty Flood Control Operating Plan, updated May 2003

*This plan prescribes the criteria and procedures by which the Canadian Entity will operate the Mica, Duncan, and Arrow reservoirs to achieve desired flood control objectives in the United States and Canada. Criteria for the Libby Reservoir were included in the plan to meet the Treaty requirement to coordinate its operation for flood control protection in Canada. The plan was originally prepared in October 1972. The 1999 plan provides current information, incorporates new storage reservation diagrams, and clarifies procedures. The plan was updated in May 2003.*

- U.S. Entity Approval Relating to Amendatory Agreement No. 1 to the 1997 Pacific Northwest Coordination Agreement, signed 13 June 2003

*This agreement amends the 1997 Pacific Northwest Coordination Agreement to include definitions, adds text related to previously received interchange energy, and replaces text related to interchange pricing, accounting, and review of charges.*

- Detailed Operating Plan for Columbia River Storage for 1 August 2003 through 31 July 2004, dated July 2003

*This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the operating year from 1 August 2003 through 31 July 2004.*

- Columbia River Treaty Entity Agreement on the Detailed Operating Plan for Columbia River Storage for 1 August 2003 through 31 July 2004, signed 7 July 2003

*This agreement between the Entities implements the DOP for Columbia River Storage during the period 1 August 2003 through 31 July 2004.*

- Columbia River Treaty Operating Committee Agreement on Operation of Treaty Storage for Enhancement of Mountain Whitefish Spawning for the period 27 September 2003 through 30 April 2004, signed 3 October 2003

*This agreement supplements the 2003–2004 DOP. The purpose of this agreement is to provide the Canadian Entity with enhanced spawning protection for Mountain Whitefish below Keenleyside Dam and to provide the U.S. Entity with increased flexibility in the operation of Treaty storage. This is accomplished by a provisional draft from Keenleyside Reservoir from 4 September 2003 through 22 December 2003, or the beginning of whitefish spawning. Storage will occur from 1 January 2004 through 20 January 2004, unless otherwise agreed. All provisional drafts will be returned by 30 April 2004 but shall not detrimentally impact whitefish during the March 2004 incubation period.*

- Columbia River Treaty Operating Committee Agreement on Operation of Treaty Storage for Non-power Uses from 1 December 2003 through 31 July 2004, signed 15 December 2003

*This agreement is similar to previous agreements implemented to utilize Treaty storage for non-power uses. These uses include: (1) providing flows for Canadian trout spawning for the April through June period; (2) enhancing the capability in the U.S. of providing spring and summer flow augmentation for salmon and steelhead by*

storing 1 Maf of water in Arrow by late April; (3) enhancing Arrow Lakes levels by ensuring progressive refill; (4) providing a minimum discharge objective at Arrow during January through March 2004 for the purpose of protecting eggs deposited on the streambed by Mountain Whitefish during December 2003 through January 2004; (5) improving the U.S. capability to meet flow objectives for salmon at Vernita Bar below Priest Rapids Dam from December 2003 through early May 2004. This agreement supplements the 2003–2004 DOP.

- Detailed Operating Plan for Columbia River Storage for 1 August 2004 through 31 July 2005, dated June 2004

*This document provides the general guidelines, operating criteria, and reservoir rule curves for the operation of the three Treaty reservoirs (Mica, Arrow, and Duncan) in Canada for the operating year from 1 August 2004 through 31 July 2005.*

- Columbia River Treaty Entity Agreement on the Detailed Operating Plan for Columbia River Storage for 1 August 2004 through 31 July 2005, signed 25 June 2004

*This agreement between the Entities implements the DOP for Columbia River storage during the period 1 August 2004 through 31 July 2005.*

- Columbia River Treaty Operating Committee Agreement on Implementation Procedures for Flood Control Reallocation for the 2004–2005 Operating Year, signed 28 June 2004

*This agreement instructs the USACoE to calculate and distribute flood control rule curves for Mica, Arrow, and Grand Coulee using the 5.03/4.44 km<sup>3</sup> (4.08/3.6 Maf) flood*

*control allocation between Mica and Arrow. The effect of the allocation and power drafts at upstream projects will be included in the Grand Coulee flood control rule curves.*

- Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans for Operation of Canadian Treaty Storage, dated 16 December 2003

*This document serves as a guide for the preparation and use of hydroelectric operating plans, such as the AOP and DOP, for operation of the Columbia River Treaty storage.*

## System Storage

The 2003–2004 operating year began with Canadian Treaty storage (CTS) at 17.0 km<sup>3</sup> (13.8 Maf) or 88.7 percent full and below the TSR level of 89.6 percent full. Due to this initial storage condition, CTS continued to draft proportionally well below the Operating Rule Curve (ORC) throughout the operating year. During February through June, the coordinated system recovered to the ORC, with the exception of Mica, which was limited by target storage and minimum flow requirements. The CTS again drafted below the ORC in July 2004 to create the firm load-carrying capability of the coordinated system. Actual CTS on 31 July 2004 reached 88.5 percent full, slightly below the TSR level for CTS of 89.1 percent full, and near the level at the beginning of the operating year.

The 1 January 2004 water supply forecast for the Columbia River at The Dalles for January through July was 99.3 km<sup>3</sup> (80.5 Maf), or 75 percent of the 1971–2000 average. This January forecast was

similar to the January final forecast in 2001, which was a drought year. Precipitation was somewhat above average in October and November, but sagged to slightly below average for the period of January through August. The seasonal precipitation for the water year was slightly above average upstream of Grand Coulee (104 percent). Flow at The Dalles remained below average through the water year. The observed January through July flow volume at The Dalles was 102.3 km<sup>3</sup> (82.95 Maf), 77 percent of the 1971–2000 average. The unregulated flow at The Dalles in 2004 was 11 546 m<sup>3</sup>/s (407.368 kcfs) on 31 May 2004, and a regulated peak flow of 8184 m<sup>3</sup>/s (289 kcfs) occurred on 29 May 2004.

Operations of the three Canadian reservoirs — Mica, Arrow, and Duncan — and the Libby Reservoir in the United States, are illustrated on pages 28 to 31 for the 13-month period from 31 August 2003 to 30 September 2004. The hydrographs show actual reservoir levels (Storage Curve) and key rule curves which govern the operations of the Treaty storage. The Flood Control Rule Curve specifies maximum month-end reservoir levels which will permit evacuation of the reservoir to control precipitation and snowmelt events. The Critical Rule Curve shows minimum month-end reservoir levels which should be maintained to enable the anticipated power demands to be met under the most adverse water supply conditions. The Variable Refill Curve shows the reservoir elevations necessary to ensure refilling of the reservoir by the end of July with a reasonable degree of confidence.

#### **Mica Reservoir**

Mica (Kinbasket) Reservoir, after temporarily cresting at an elevation of 744.32 m (2442 feet) on 23 August 2003, established a slightly higher

peak elevation of 744.57 m (2442.8 feet) on 29 October 2003, 9.81 m (32.2 feet) below full pool. The higher elevation in October was the result of high inflows due to a rainfall event, setting daily and monthly rainfall records at two climate stations. From the peak elevation in October, the reservoir drafted steadily, reaching a minimum elevation of 718.47 m (2357.2 feet) on 12 April 2004. Influenced by a low initial level and below-normal seasonal inflows, the reservoir refill level during 2004 was well below normal, reaching a maximum elevation of 625 m (2050.5 feet) on 30 September 2004, 7.35 m (24.5 feet) below full pool.

#### **Arrow Reservoir**

Arrow Reservoir reached its maximum elevation of 439.09 m (1440.6 feet) on 4 July 2003. The coordinated hydro-system was on proportional draft from August 2003 through January 2004. This contributed to Arrow Reservoir being drafted much earlier than normal, reaching 427 m (1400.9 feet) by 31 December 2003 and a minimum elevation of 425.23 m (1395.1 feet) on 31 March 2004. The reservoir refilled to a maximum elevation of 436.24 m (1431.3 feet) on 12 August 2004, 3.9 m (12.7 feet) below full pool. The operation of Arrow Reservoir was modified during the operating year under two CRTOC agreements. These agreements helped to enhance the success of whitefish and rainbow trout spawning and their emergence downstream of the Arrow project in British Columbia, and to provide additional power and non-power benefits in the United States.

#### **Duncan Reservoir**

Duncan Reservoir reached a maximum elevation of 576.46 m (1891.3 feet) on 19 Aug 2003, 0.22 m (0.7 feet) below full pool. From September 2003

through April 2004, Duncan discharge was used to supplement inflow into Kootenay Lake and to provide spawning and incubation flows for fish. The reservoir drafted to a minimum elevation of 547.24 m (1795.4 feet) on 26 April 2004, 0.37 m (1.2 feet) above empty. Reservoir discharge was reduced to the minimum of 3 m<sup>3</sup>/s (100 cfs) on 11 May to initiate reservoir refill. The reservoir refilled to a maximum elevation of 576.45 m (1891.2 feet) on 16 August 2004, 0.23 m (0.8 feet) below full pool.

### **Libby Reservoir**

Libby Reservoir achieved the BiOp draft limit in August 2003, and was operated for power objectives from September through December 2003. In 2004, Libby was operated according to the VarQ operating rule. VarQ is the conditional use of reserved flood control storage to provide augmentation flows for fisheries during the spring period. VarQ is used when dry-to-moderate hydrologic runoff conditions are forecasted. The minimum elevation of Lake Kootenay was 731 m (2398.4 feet) on 24 March 2004. By the end of April, the lake was 10.4 m (34 feet) below the VarQ elevation. In June, Libby Dam was operated to provide a pulse flow up to 453.1 m<sup>3</sup>/s (16 kcfs) to maintain high velocity in the sturgeon spawning area. This operation kept Lake Kootenay from filling by 30 June, as planned. Following the pulse flow operation, releases were ramped down to 354 m<sup>3</sup>/s (12.5 kcfs) on 27 June, and held at that level to 3 September. The maximum elevation of 746.9 m (2450.3 feet) was achieved on 22 July. Elevation at the end of August was 745.2 m (2445 feet). The April through August runoff above Libby was 5.77 km<sup>3</sup> (4.7 Maf), 75 percent of average.

Due to unfavorable hydrologic conditions in Canada, the CRTOC did not pursue a storage

transfer agreement to store water in Libby and release it from CTS during the period of July to August 2003. During the summer of 2004, a tentative storage transfer agreement was reached but not implemented. Since Libby Reservoir was not expected to refill after the sturgeon operation ended in June, agencies in the U.S. reached an executive agreement in late July to optimize refill and meet fisheries' requirements by releasing a steady 354 m<sup>3</sup>/s (12.5 kcfs) through the July–August period. The intent was to have Lake Kootenay end August at elevation 743.4 m (2439 feet), but a late August rain event raised the reservoir above the target elevation. The executive agreement superseded the tentative CRTOC storage transfer agreement.

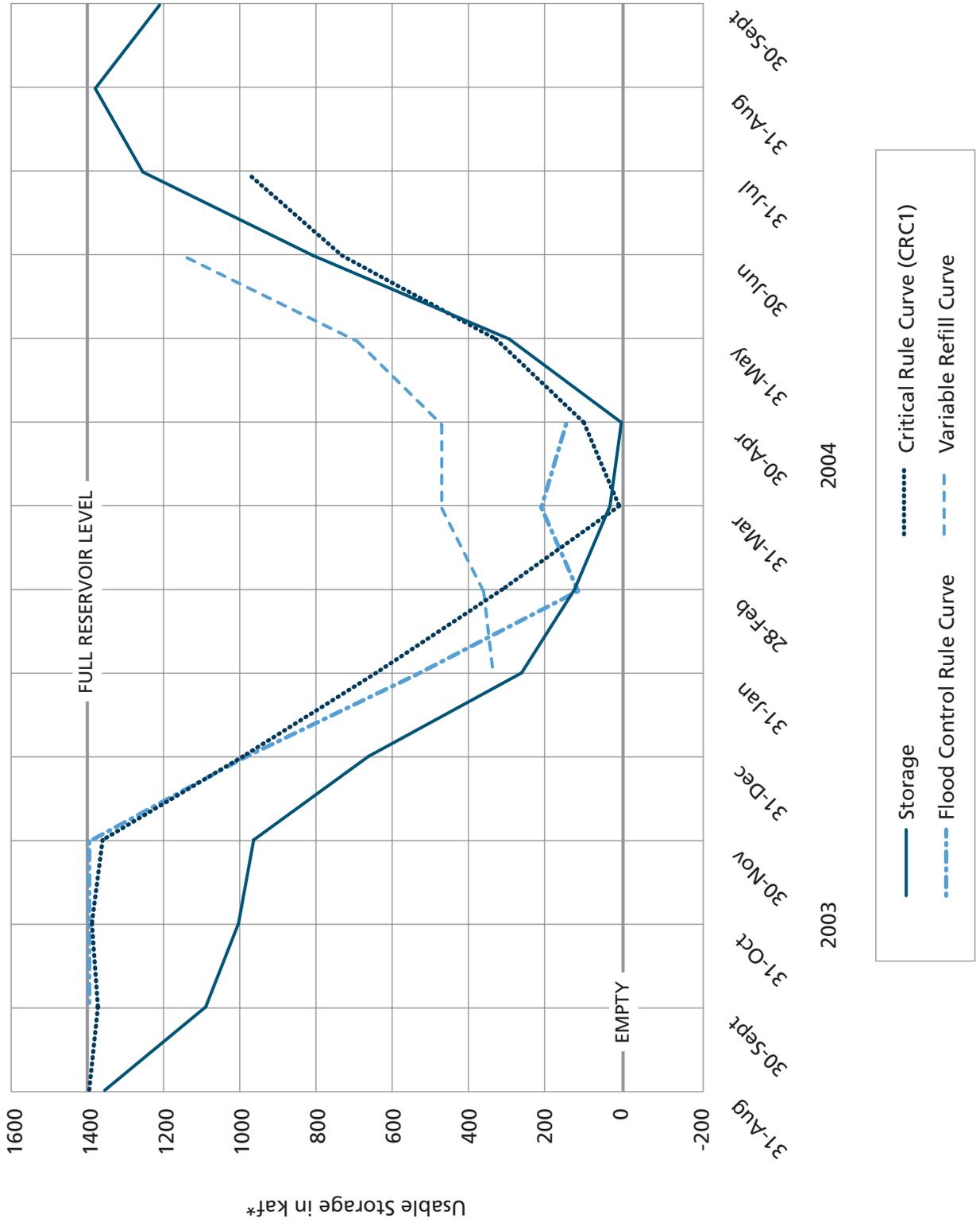
### **Federal Columbia River Power System**

The U.S. Federal Columbia River Power System was operated to meet chum needs below Bonneville Dam from 13 November 2003 through May 2004. U.S. reservoirs were operated to achieve the 10 April flood control elevation as per the NMFS 2000 BiOp for juvenile fish needs. Low inflow from January through March allowed Dworshak to refill to this target. For 2004, Libby Dam released the volume of water requested by the FWS to meet downstream Kootenay River sturgeon needs. The U.S. storage projects were targeted to be full by 30 June 2004 as per the BiOp, but Libby failed to refill because of the sturgeon releases in June. Projects were then drafted to the NMFS 2000 BiOp draft limits for 31 August. Libby released steady outflow through July and August as per an executive agreement and drafted only 4.27 m (14 feet) from full. Dworshak Dam reached the draft limit in September.

## Flood Control Operations

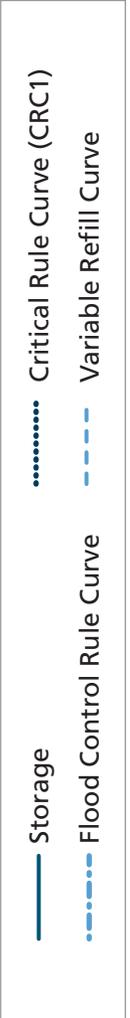
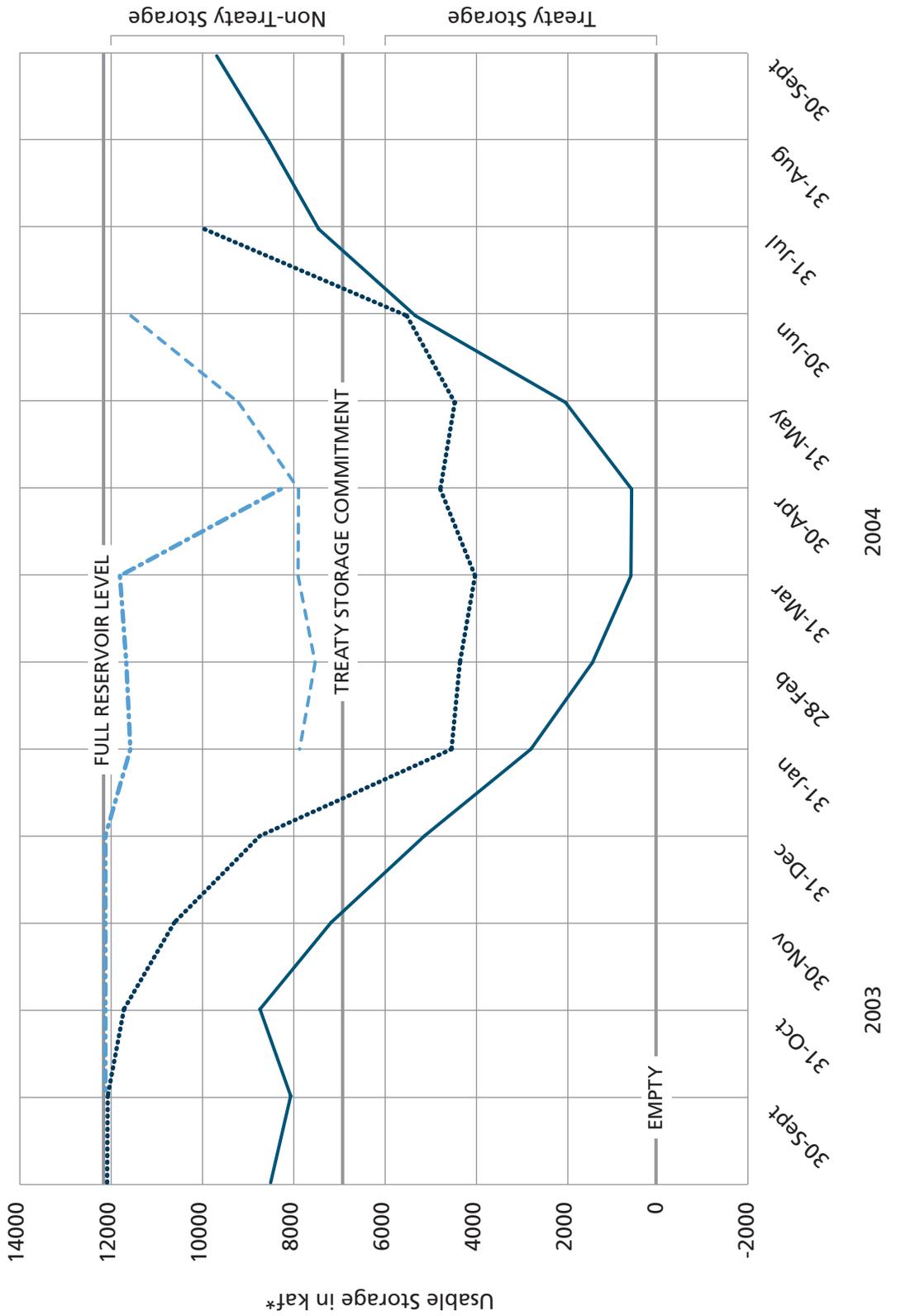
With the 2004 water supply forecasts well below average across the Columbia River Basin, the reservoir system, including the Columbia River Treaty projects, required minimal draft for flood control in preparation for the spring freshet. Projects were operated according to the FCOP, updated in May 2003, resulting in no major flooding in the Basin. The regulated peak flow at The Dalles, Oregon, was 8184 m<sup>3</sup>/s (289 kcfs) on 29 May 2004, and the unregulated flow was estimated at 11 536 m<sup>3</sup>/s (407.37 kcfs) on 31 May 2004. The peak stage observed at Vancouver, Washington, was 2.96 m (9.7 ft) on 31 January 2004, and the estimated unregulated stage was 4.33 m (14.2 ft) on 31 May 2004.

### Duncan Reservoir Levels



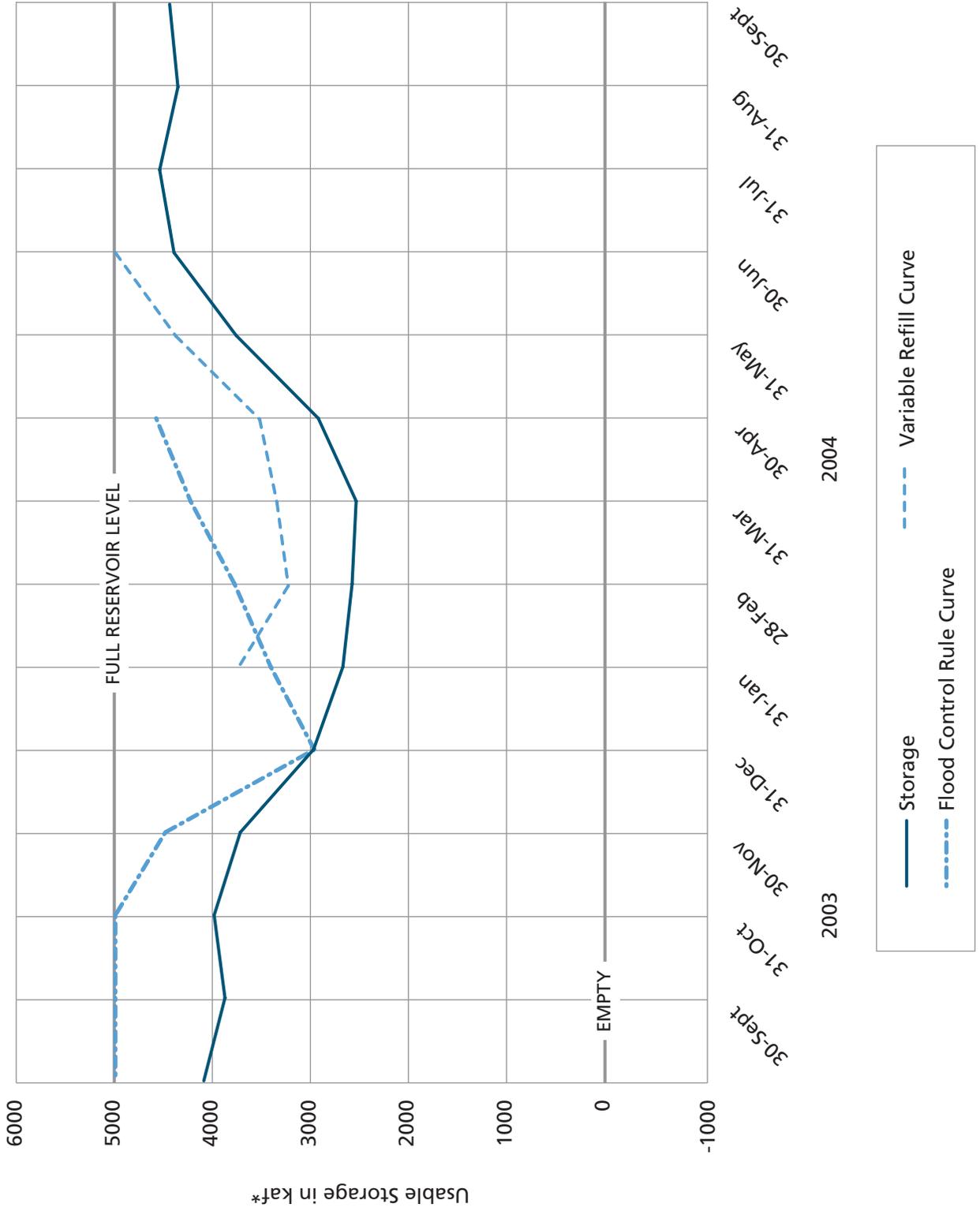
\* kaf = thousand acre-feet

# Mica Reservoir Levels



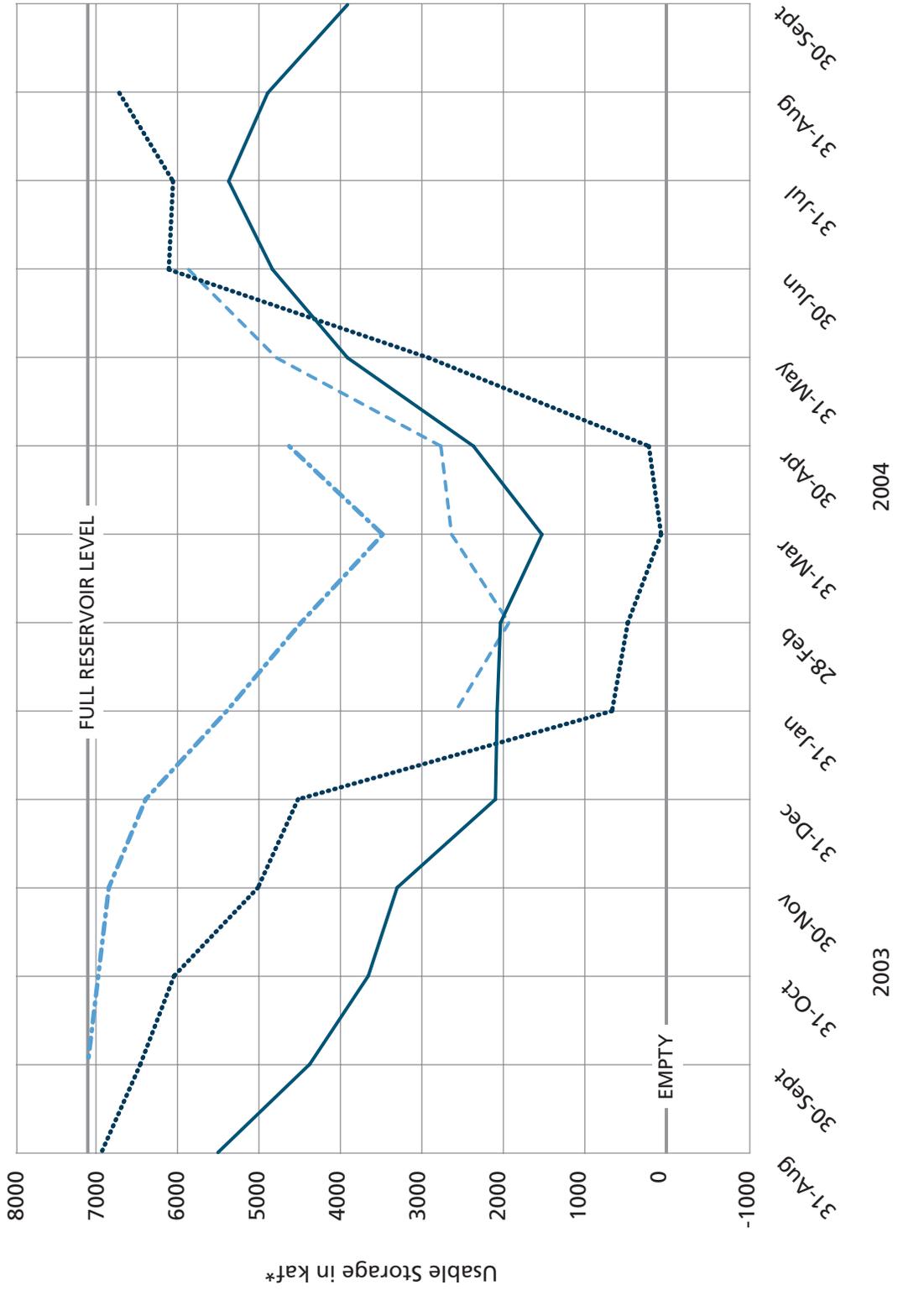
\* kaf = thousand acre-feet

# Libby Reservoir Levels



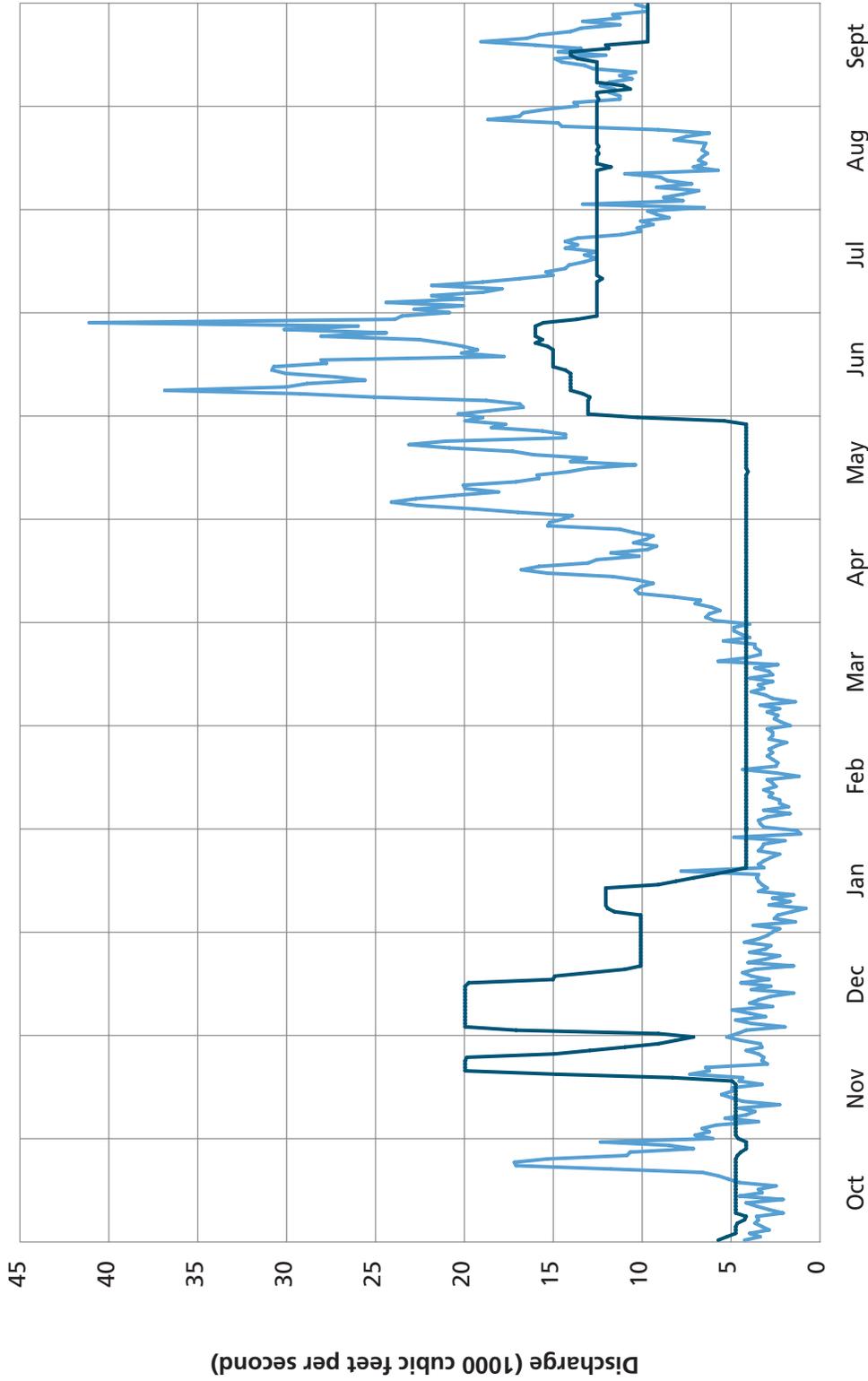
\* kaf = thousand acre-feet

# Arrow Reservoir Levels



\* kaf = thousand acre-feet

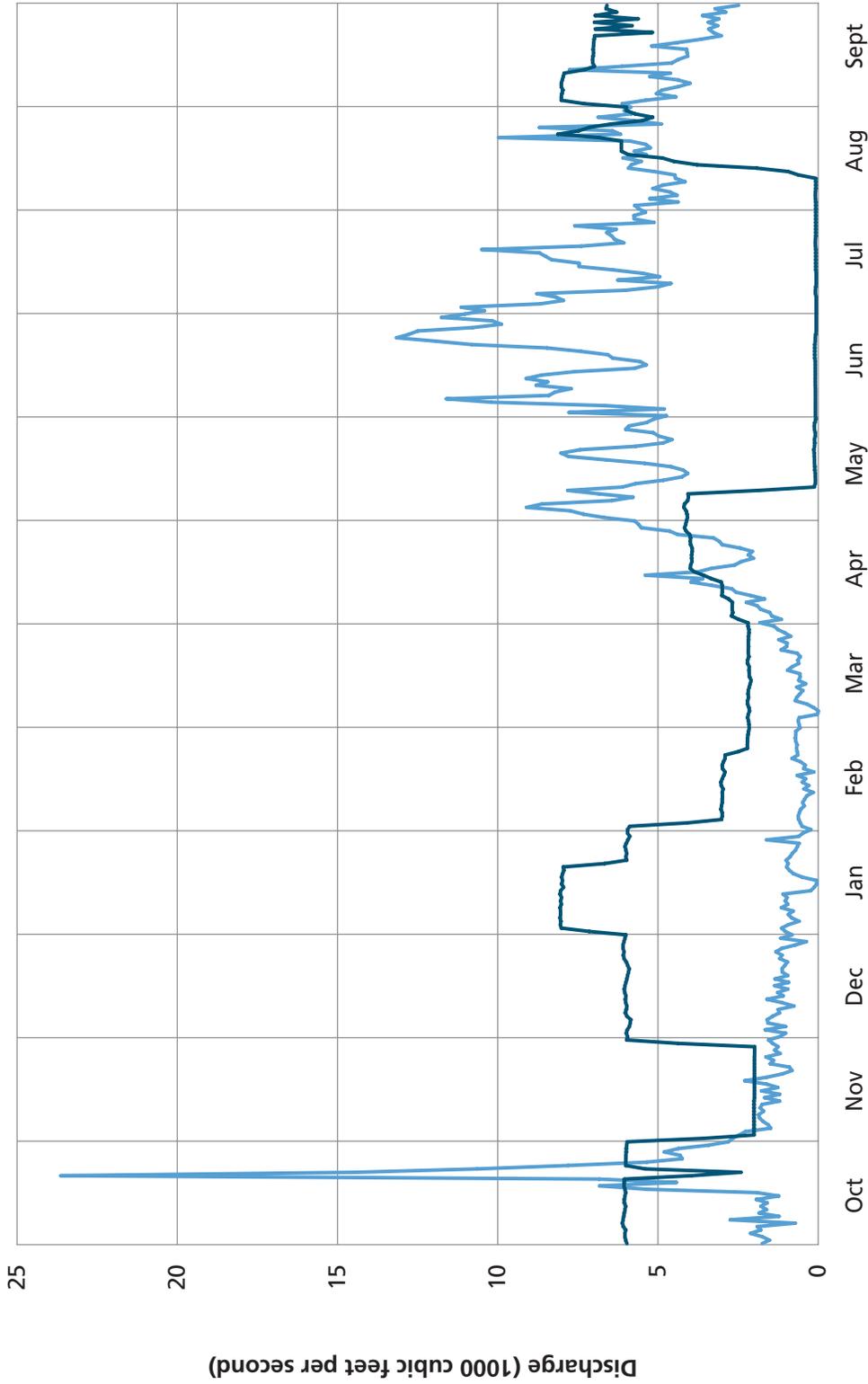
### Kootenai River at Libby Dam



Estimated natural flow and regulated flow for the year ending September 30, 2004



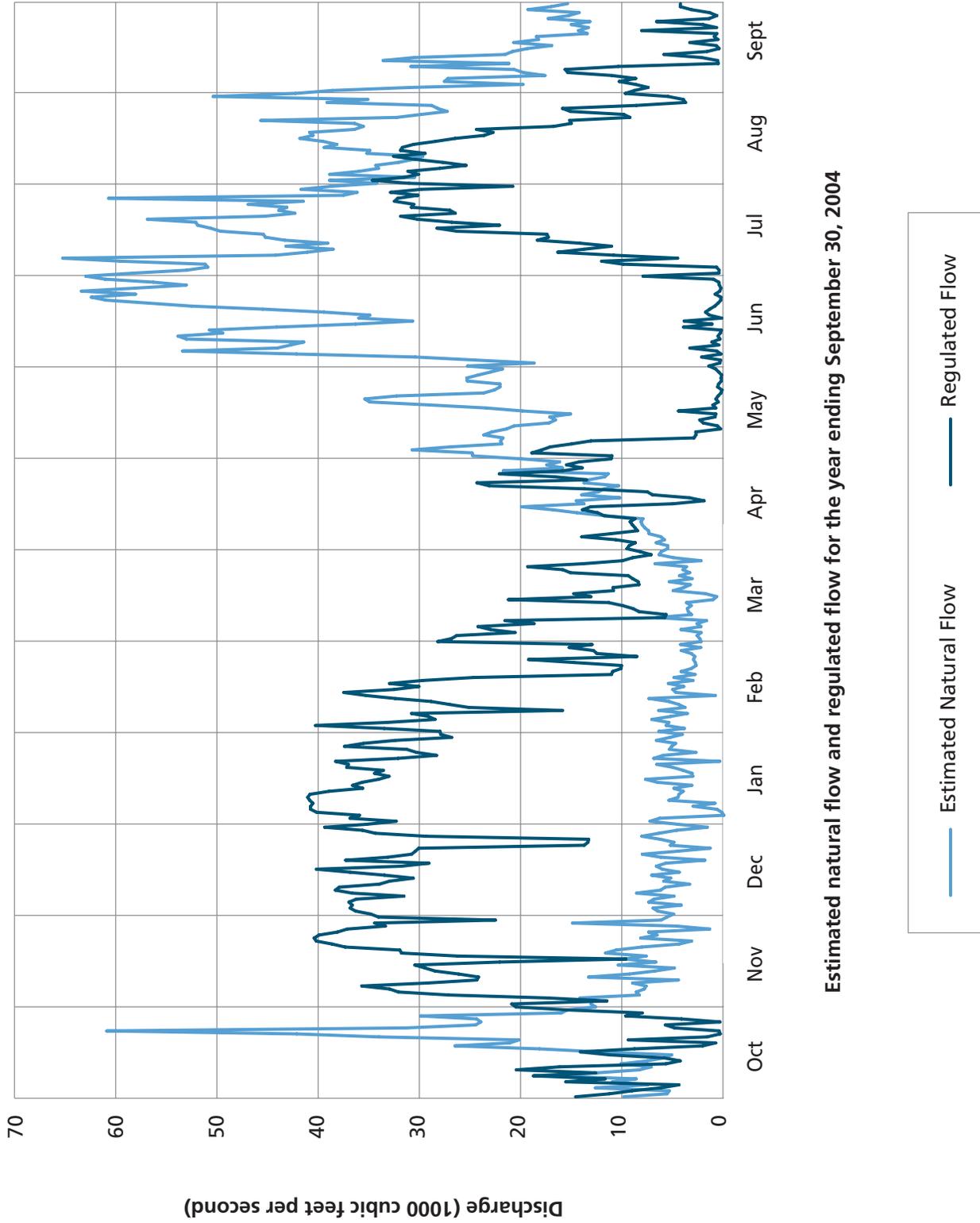
### Duncan River at Duncan Dam



Estimated natural flow and regulated flow for the year ending September 30, 2004

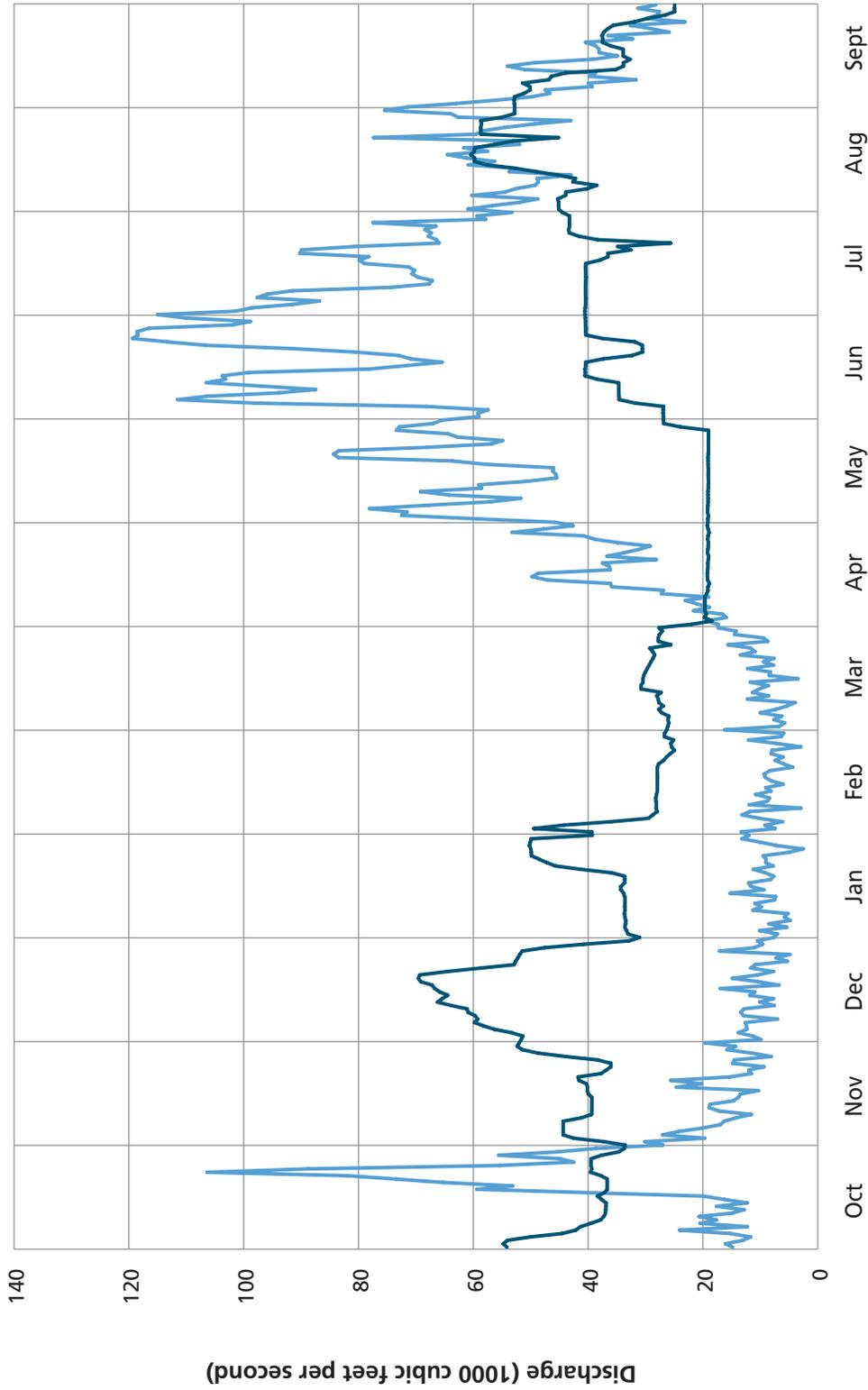


### Columbia River at Mica Dam



Estimated natural flow and regulated flow for the year ending September 30, 2004

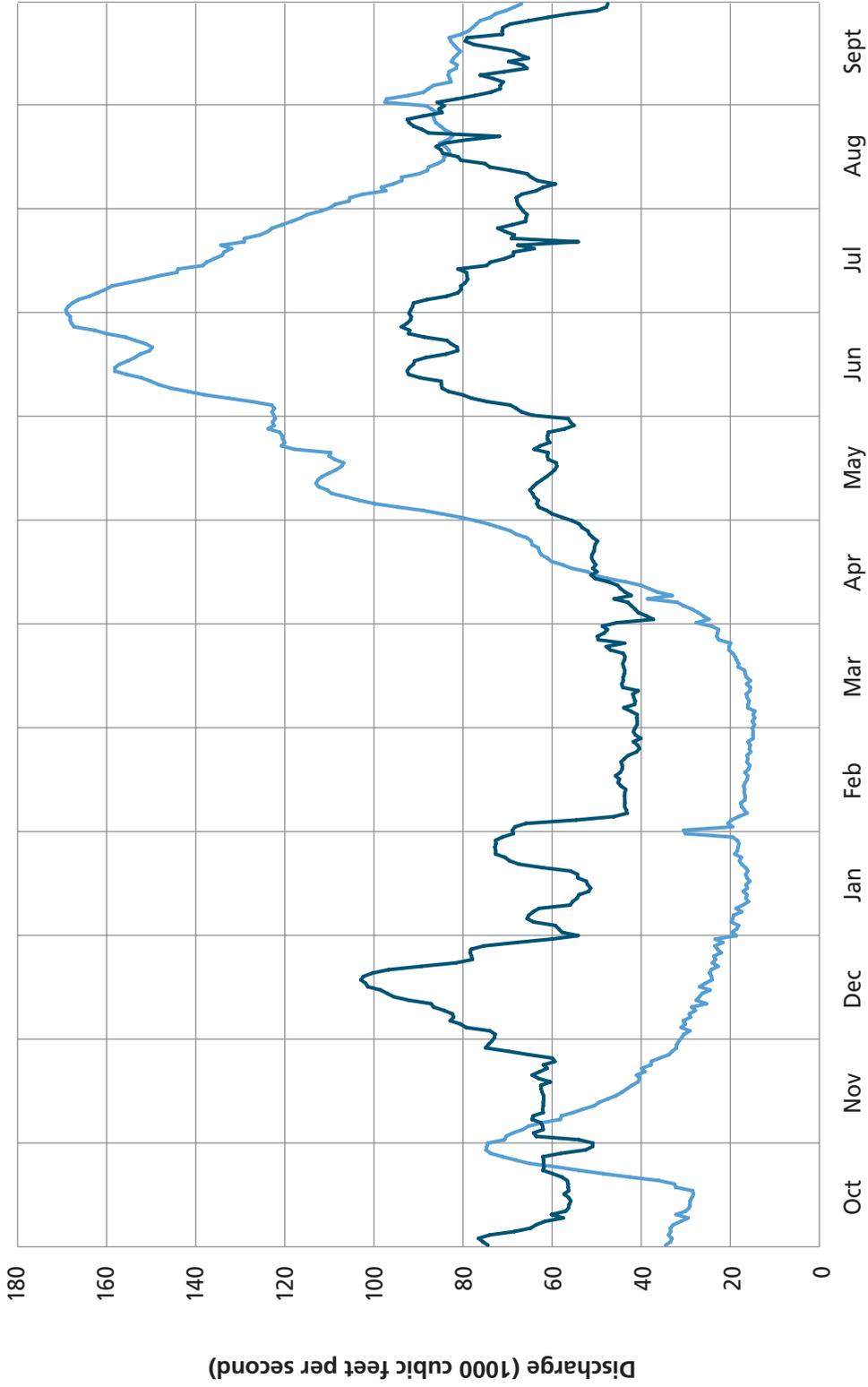
### Columbia River at Hugh Keenleyside Dam



Estimated natural flow and regulated flow for the year ending September 30, 2004



### Columbia River at Birchbank



Estimated natural flow and regulated flow for the year ending September 30, 2004



# TREATY BENEFITS

## Flood Control Benefits

*There was no Columbia River flooding during the 2003–2004 operating year. With natural flows well below average, operations for flood control were not a major factor, and storage operations did keep peak flows below flood control levels. The peak regulated flow and river stages are shown in the tables below.*

### Columbia River Stream Flow at The Dalles, Oregon

Date	Peak Regulated Flow m <sup>3</sup> /s (cfs)	Date	Peak Unregulated Flow m <sup>3</sup> /s (cfs)
29 May 2004	8184 (289 000)	31 May 2004	11 536 (407 370)

### Columbia River Stage at Vancouver, Washington (Flood Stage is 4.9 meters [16.0 feet])

Date	Peak Regulated Stage meters (feet)	Date	Peak Unregulated Stage meters (feet)
31 Jan 2004	2.96 (9.7)	31 May 2004	4.33 (14.2)

It is estimated that the Duncan and Libby projects reduced the peak stage of Kootenay Lake by about 0.576 m (1.89 feet). The Duncan, Arrow, Mica, and Libby projects reduced the peak stage of the Columbia River at Trail, just upstream of Birchbank, British Columbia, by about 2.48 meters (8.14 feet). It should be noted that both

regulated and unregulated peak stages at Kootenay Lake and Birchbank were well below flood stages. The hydrographs on pages 28 to 36 illustrate the effect of storage in the Duncan, Arrow, Mica, and Libby reservoirs on flows at the project sites and on flows of the Columbia River at Birchbank. These show the actual discharges

and the flows that would have occurred if the dams had not been built. The hydrograph showing pre-project conditions for Birchbank has been computed on the assumption that the effects of Duncan, Arrow, Mica, and Libby regulation, and of the regulation provided by the Corra Linn development on Kootenay Lake, have been removed.

### Power Benefits

Downstream power benefits in the United States, which arise from operation of the CTS, were predetermined for the first 30 years of operation of each project, and the Canadian share was sold in the United States under the terms of the CEPA. The U.S. Entity delivered capacity and energy to Columbia Storage Power Exchange participants, the purchasers of the Canadian entitlement. Canada retains the benefits of additional generation made possible on the Kootenay River in Canada as a result of regulation provided by Libby, as well as generation at the Mica, Revelstoke, and Arrow projects. The benefits of Libby regulation, which occur downstream in the United States, are not shared under the Treaty.

The CEPA expired in stages from 1998 to 2003. The portion of Canada’s share of downstream power benefits attributable to each of the Treaty projects is the ratio of each project’s storage to the whole of the CTS. The table below summarizes Canada’s share of the downstream power benefits from each project:

Treaty Storage	Date Returned	Share of Canadian Entitlement (%)
Duncan	1 April 1998	9.0
Arrow	1 April 1999	45.8
Mica	1 April 2003	45.2

As of 1 April 2003, Canada’s share of downstream benefits has been fully returnable.

From 1 August 2003 to 30 September 2004, the U.S. Entity delivery of the Canadian entitlement to downstream power benefits was 537.3 aMW at rates of up to 1176 MW.

An agreement between the Entities, signed on 20 November 1996, sets out the details of delivery points and the reliability of delivery for the downstream power benefits returnable to Canada beginning 1 April 1998 and completed on 1 April 2003. Further, on 31 March 1999, the agreement permitting disposal of the Canadian entitlement directly in the United States was adopted through an exchange of diplomatic notes. The Province of British Columbia was designated as the Canadian Entity for the purpose of the disposal. Utilizing the section of the Disposal Agreement for mutually agreed arrangements, the Province of British Columbia disposed of entitlement energy directly in the United States during the period 1 July 2004 to 31 October 2004. During these four months, 506 000 MWh were sold directly to the U.S. at a maximum rate of 400 MW.

### Other Benefits

By agreement between the Entities, streamflows are regulated for non-power purposes, such as accommodating construction in river channels and providing water to meet fisheries’ needs in both countries. These arrangements are implemented under the DOP and other agreements to provide mutual benefits.



Revelstoke Dam – Columbia River, British Columbia  
The earthfill dam is located on the west bank of the river, and the concrete gravity dam in Little Dalles Canyon.  
The powerhouse is in the riverbed, immediately downstream of the concrete dam.

# CONCLUSIONS

1. The Duncan, Arrow, and Mica projects were operated in compliance with the Treaty during the period covered by this report. Operations reflected the DOPs developed by the Entities, the FCOP for Treaty reservoirs, and other agreements between the Entities
2. Flow conditions in the Columbia Basin for the operating year 1 August 2003 to 31 July 2004 were below average. Seasonal flow volume at The Dalles was 77 percent of average for January through July 2004. CTS began the year at 88.7 percent full, and ended the year at 88.5 percent full.
3. The entitlement to the downstream power benefits accruing to each country from Treaty storage for the reporting period was determined, according to the procedures set out in the Treaty and Protocol, to be 537.3 aMW of energy and 1176.4 MW of capacity from 1 October 2003 to 30 September 2003.
4. Utilizing the section of the 1999 Disposal Agreement for mutually agreed arrangements, the Province of British Columbia disposed of entitlement energy directly in the United States at rates of up to 400 MW during the period 1 July 2004 to 31 October 2004.
5. With the 2004 water supply forecasts well below average across the Columbia River Basin, the reservoir system, including the Columbia River Treaty projects, required minimal draft for flood control in preparation for the spring freshet. No major flooding occurred. Flow at The Dalles remained below average throughout the water year. The observed January through July flow volume above The Dalles was 102.3 km<sup>3</sup> (82.95 Maf), 77 percent of the 1971–2000 average. The unregulated peak flow at The Dalles was estimated at 11 546 m<sup>3</sup>/s (407.368 kcfs) on 31 May 2004, while a regulated peak flow of 8184 m<sup>3</sup>/s (289 kcfs) occurred on 29 May 2004.
6. The Entities continued to operate the hydrometeorological network as required by the Treaty. The Columbia River Treaty Hydrometeorological Committee took on the responsibility of developing and maintaining the documentation of the forecast procedures for Mica, Arrow, Duncan, Libby, Dworshak, and Hungry Horse. This documentation was made available to the CRTOC in July 2004.
7. The Board therefore concludes that the objectives of the Treaty have been met. The 2006–2007, 2007–2008, and 2008–2009 AOPs/DDPBs have been received, and the Entities are currently drafting the 2009–2010 AOP and DDPB documents.

# **APPENDIX A**

## **COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD**

## APPENDIX A

### COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

#### United States

#### Canada

##### Members

---

Mr. Steven Stockton, P.E., Chair  
Director of Programs Management  
South Pacific Division  
U.S. Army Corps of Engineers  
San Francisco, CA

Mr. Tom Wallace, Chair  
Director General  
Electricity Resources Branch  
Natural Resources Canada  
Ottawa, Ontario

Mr. Ronald H. Wilkerson  
Consultant  
Missoula, Montana

Mr. Tim Newton, P.Eng.  
Consultant  
Vancouver, British Columbia

##### Alternates

---

Mr. Robert A. Pietrowsky  
Director, Institute of Water Resources  
Headquarters, U.S. Army Corps of Engineers  
Washington, D.C.

Mr. David Burpee  
Special Advisor to the Director General  
Electricity Resources Branch  
Natural Resources Canada  
Ottawa, Ontario

Mr. George Bell  
Consultant  
Lake Oswego, Oregon

Mr. James Mattison, P.Eng.  
Director, Water Management Branch  
Land and Water British Columbia Inc.  
Victoria, British Columbia

##### Secretaries

---

Mr. Jerry W. Webb, P.E.  
Principal Hydrologic & Hydraulic Engineer  
Hydrology, Hydraulics & Coastal  
Community of Practice Leader  
Headquarters, U.S. Army Corps of Engineers  
Washington, D.C.

Ms. Eve Jasmin  
Senior Policy Advisor  
Renewable and Electrical  
Energy Division  
Electricity Resources Branch  
Natural Resources Canada  
Ottawa, Ontario

**COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD****Record of Membership****United States****Canada****Members**

Mr. Wendell Johnson <sup>1</sup>	1964–1970	Mr. Gordon McNabb <sup>1</sup>	1964–1991
Mr. Morgan Dubrow	1964–1970	Mr. Arthur Paget	1964–1973
Mr. John Neuberger	1970–1973	Mr. Valter Raudsepp	1973–1974
Mr. Joseph Caldwell <sup>1</sup>	1971–1973	Mr. Ben Marr	1974–1987
Mr. Homer Willis <sup>1</sup>	1973–1979	Mr. Tom Johnson	1987–1988
Mr. King Mallory	1973–1975	Mr. Douglas Horswill	1989–1991
Mr. Raymond Peck, Jr.	1976–1977	Mr. John Allan	1991–1999
Mr. Emerson Harper	1978–1988	Mr. David Oulton <sup>1</sup>	1991–1996
Mr. Lloyd Duscha <sup>1</sup>	1979–1990	Mr. Daniel Whelan <sup>1</sup>	1996–2002
Mr. Ronald Wilkerson	1988–	Mr. Charles Kang	1999–2001
Mr. Herbert Kennon <sup>1</sup>	1990–1994	Mr. Jack Ebbels	2001–2003
Mr. John Elmore <sup>1</sup>	1994–1996	Mr. Tim Newton	2003–
Mr. Steven Stockton <sup>1</sup>	1996–	Mr. Tom Wallace <sup>1</sup>	2004–

**Alternates**

Mr. Fred Thrall	1964–1974	Mr. Mac Clark	1964–1992
Mr. Emerson Harper	1964–1978	Mr. Jim Rothwell	1964–1965
Mr. Alex Shwaiko	1974–1987	Mr. Hugh Hunt	1966–1988
Mr. Herbert Kennon	1987–1990	Dr. Donald Kasianchuk	1988–1996
Mr. Thomas Weaver	1979–1997	Mr. Vic Niemela	1992–1994
Mr. John Elmore	1990–1994	Mr. David Burpee	1994–
Mr. Paul Barber	1994–1995	Mr. Jack Farrell	1996–1997
Mr. Daniel Burns	1995–1997	Mr. Prad Kharé	1997–1999
Mr. George Bell	1997–	Mr. James Mattison	1999–
Mr. Earl Eiker	2000–2004		
Mr. Robert Pietrowsky	2004–		

**Secretaries**

Mr. John Roche	1965–1969	Mr. Mac Clark	1964–1992
Mr. Verle Farrow	1969–1972	Mr. David Burpee	1992–2003
Mr. Walter Duncan	1972–1978	Ms. Eve Jasmin	2003–
Mr. Shapur Zanganeh	1978–1995		
Mr. Richard DiBuono	1995–2000		
Mr. Robert Bank	2000–2004		
Mr. Jerry Webb	2004–		

<sup>1</sup> Chair

**COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD  
ENGINEERING COMMITTEE**

**Current Membership**

**United States**

**Canada**

**Members**

---

Mr. Jerry W. Webb, P.E.  
Principal Hydrologic & Hydraulic Engineer  
Hydrology, Hydraulics & Coastal  
Community of Practice Leader  
Headquarters, U.S. Army Corps of Engineers  
Washington, D.C.

Mr. Kamau Sadiki  
Water Management Division  
U.S. Army Corps of Engineers  
Northwestern Division  
Portland, Oregon

Mr. Michael Cowan, P.E.  
Office of Technical Services  
Western Area Power Administration  
Lakewood, Colorado

Mr. James Fodrea, P.E.  
U.S. Bureau of Reclamation  
Pacific Northwest Region  
Boise, Idaho

Mr. Roger McLaughlin, P.Eng., Chair  
Electricity Policy Branch  
Ministry of Energy and Mines  
Victoria, British Columbia

Ms. Eve Jasmin  
Renewable and Electrical Energy Division  
Natural Resources Canada  
Ottawa, Ontario

Dr. Bala Balachandran, P.Eng.  
Water Management Branch  
Land and Water British Columbia Inc.  
Victoria, British Columbia

Mr. Ivan Harvie, P.Eng.  
Renewable and Electrical Energy Division  
Natural Resources Canada  
Calgary, Alberta

# **APPENDIX B**

## **COLUMBIA RIVER TREATY ENTITIES**

## APPENDIX B

### COLUMBIA RIVER TREATY ENTITIES

#### United States

#### Canada

#### Members

---

Mr. Steven Wright, Chair  
Administrator and Chief Executive Officer  
Bonneville Power Administration  
Department of Energy  
Portland, Oregon

BG William T. Grisoli, Member  
Division Engineer  
Northwestern Division  
U.S. Army Corps of Engineers  
Portland, Oregon

Mr. Larry Bell, Chair  
British Columbia Hydro and Power Authority  
Vancouver, British Columbia

# **APPENDIX C**

## **RECORD OF FLOWS AT THE INTERNATIONAL BOUNDARY**

### Kootenai River at Porthill, Idaho

Daily discharges in thousands of cubic feet per second for the year ending 30 September 2004

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1	6.7	5.8	11.3	11.3	6.3	6.0	10.5	14.8	20.8	16.3	14.4	14.1
2	6.4	6.1	19.3	11.5	5.8	5.9	10.4	16.0	20.9	16.5	14.3	14.3
3	6.1	6.2	21.1	11.2	5.9	5.9	10.0	18.3	20.6	16.2	14.1	14.0
4	6.1	5.9	21.4	11.1	5.9	5.8	9.9	19.9	20.6	16.3	14.2	14.2
5	6.0	5.8	21.4	11.1	6.1	5.9	10.8	19.8	21.1	16.2	13.9	12.0
6	5.8	5.8	21.4	12.5	5.8	5.9	11.7	18.1	22.1	15.5	14.3	13.3
7	5.4	5.9	21.6	13.2	5.8	5.8	12.5	16.5	23.2	15.7	15.0	13.7
8	5.5	5.9	21.5	12.5	5.6	6.0	13.5	16.4	22.4	16.5	14.1	14.4
9	5.6	6.0	21.5	12.7	5.5	6.1	15.6	16.3	21.1	15.3	14.5	14.5
10	5.9	5.9	21.6	13.0	5.5	6.5	15.7	15.5	20.7	15.2	14.2	14.5
11	5.9	6.0	21.5	13.1	5.4	6.8	15.0	14.6	20.5	15.3	14.3	15.0
12	5.8	6.1	21.3	13.2	5.4	6.8	14.7	13.9	20.4	15.3	14.1	14.7
13	5.8	6.0	21.4	12.7	5.3	7.0	15.5	12.8	20.0	14.9	13.9	14.9
14	5.9	6.0	21.5	10.3	5.4	6.9	17.3	11.9	20.9	14.6	14.2	15.4
15	5.8	6.0	21.5	9.1	5.6	6.9	18.8	11.4	20.7	15.0	14.0	15.8
16	5.9	5.9	20.2	8.4	5.7	6.8	17.6	11.6	20.2	15.1	14.0	16.0
17	5.8	6.0	16.6	7.5	5.6	6.9	15.9	11.8	20.2	15.4	13.9	15.0
18	5.8	9.5	15.8	6.4	5.7	7.3	14.7	12.2	20.0	15.0	14.2	15.3
19	5.9	20.0	13.7	5.5	5.6	8.2	13.5	13.0	19.5	14.4	14.0	13.6
20	5.9	22.0	12.0	5.5	5.7	8.5	13.0	13.3	19.3	14.1	13.8	13.4
21	6.0	22.0	11.3	5.5	5.7	8.2	12.4	14.0	19.4	14.0	13.7	13.8
22	6.3	22.0	11.4	5.4	5.6	7.8	11.7	15.0	19.6	14.2	14.0	12.6
23	6.0	22.0	11.4	5.4	5.6	7.9	11.7	15.7	19.4	14.4	14.4	12.9
24	6.0	20.0	11.3	5.7	5.6	8.6	11.8	13.9	19.5	14.5	14.5	13.5
25	6.0	16.0	11.2	5.3	5.6	9.3	11.8	13.0	19.4	14.6	14.5	12.9
26	5.9	14.3	11.2	5.4	5.7	9.4	11.7	13.1	19.3	14.6	15.4	12.8
27	5.7	12.3	11.2	5.5	5.8	9.2	12.7	14.0	19.4	14.4	15.1	12.9
28	5.3	10.5	11.1	5.5	5.9	9.1	15.0	15.2	18.6	14.2	14.8	12.1
29	6.0	9.7	11.2	5.5	5.9	9.0	15.7	15.2	17.3	14.0	14.8	11.6
30	5.8	9.1	11.1	6.0	--	8.9	14.7	15.4	17.1	14.0	14.9	12.3
31	5.9	--	11.0	6.3	--	9.4	--	19.0	--	14.2	14.8	--
<b>Mean</b>	<b>5.9</b>	<b>10.5</b>	<b>16.3</b>	<b>8.8</b>	<b>5.7</b>	<b>7.3</b>	<b>13.7</b>	<b>14.8</b>	<b>19.6</b>	<b>14.8</b>	<b>14.4</b>	<b>13.7</b>

## Columbia River at Birchbank, British Columbia

Daily discharges in thousands of cubic feet per second for the year ending 30 September 2004

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1	75.1	54.8	73.6	58.6	69.1	42.2	46.3	56.3	65.2	92.7	67.8	86.4
2	76.2	64.3	73.5	59.3	66.6	41.8	38.1	58.6	67.6	92.3	68.4	82.0
3	77.2	64.9	74.6	60.0	55.4	41.7	39.7	60.8	68.7	91.9	68.6	78.0
4	74.7	62.8	80.0	64.9	47.0	41.8	41.5	61.9	70.1	91.7	68.7	74.4
5	69.2	62.9	81.2	66.3	44.0	41.8	42.2	63.7	75.3	88.7	67.5	72.3
6	65.6	63.2	83.5	66.0	44.2	43.2	43.1	64.2	78.7	84.3	64.3	72.3
7	64.3	65.3	82.8	65.0	44.6	44.8	43.8	63.9	80.7	81.8	62.8	71.7
8	62.3	65.0	83.0	63.7	44.5	42.3	46.9	64.7	83.9	81.1	60.0	74.0
9	58.3	62.7	84.9	56.7	44.5	42.2	43.1	65.1	85.3	81.1	64.1	76.8
10	60.9	62.9	87.2	56.2	44.6	42.5	44.4	65.7	85.5	80.1	65.5	71.5
11	57.7	62.7	87.8	55.2	44.5	42.7	45.4	65.0	85.5	79.6	66.3	66.4
12	57.1	62.7	92.7	54.8	44.3	41.5	46.1	64.2	90.2	79.8	70.1	67.3
13	57.0	62.6	96.1	52.6	45.4	45.0	48.2	63.1	92.8	79.9	74.7	70.5
14	56.6	62.7	97.6	52.2	46.0	45.2	51.2	62.0	93.1	81.8	75.8	66.0
15	57.1	63.0	99.0	52.8	45.7	44.9	52.0	61.0	92.7	75.4	81.2	68.0
16	58.1	63.2	102.0	53.2	46.6	44.9	50.7	60.2	91.7	74.5	81.7	69.3
17	57.1	63.2	102.4	55.0	45.5	44.6	51.7	59.7	91.5	71.4	85.2	73.6
18	57.2	61.2	103.5	55.1	45.1	44.5	51.0	59.8	88.9	69.4	85.6	78.2
19	57.2	63.8	102.9	56.6	45.1	44.8	51.6	61.6	84.4	69.3	86.7	80.1
20	57.4	65.2	100.9	62.9	45.4	45.0	52.0	61.8	81.9	64.8	84.8	79.7
21	58.5	63.5	97.3	68.2	44.7	44.6	51.8	61.6	81.9	68.4	79.7	71.8
22	60.6	61.9	90.0	70.3	43.7	44.5	51.4	64.8	83.3	54.9	72.5	71.9
23	62.8	62.7	82.3	71.3	41.9	44.9	51.3	63.4	84.3	69.8	88.4	71.7
24	62.6	60.1	78.6	73.4	41.3	47.8	51.2	61.3	89.3	69.2	89.8	70.2
25	62.7	60.7	78.7	73.3	41.6	48.7	50.6	61.8	92.8	71.2	91.7	66.0
26	62.8	70.6	78.9	73.3	40.9	50.5	52.4	61.6	94.4	69.7	93.1	57.1
27	51.0	69.0	75.9	65.1	49.5	46.6	51.8	82.7	102.2	109.0	85.0	70.3
28	58.8	75.6	76.0	73.4	42.2	50.6	52.8	57.9	93.2	66.7	89.5	50.8
29	53.3	75.0	68.6	71.8	42.6	49.1	54.1	55.9	92.4	66.6	85.4	48.7
30	51.7	74.2	60.8	69.4	--	48.4	54.7	56.7	92.2	66.3	86.0	48.3
31	51.7	--	55.0	69.6	--	49.5	--	57.2	--	67.2	84.9	--
<b>Mean</b>	<b>61.4</b>	<b>64.3</b>	<b>85.0</b>	<b>63.1</b>	<b>46.2</b>	<b>44.9</b>	<b>48.4</b>	<b>61.5</b>	<b>85.0</b>	<b>76.0</b>	<b>77.5</b>	<b>69.9</b>



# APPENDIX D

## PROJECT INFORMATION

### Power and Storage Projects

Northern Columbia Basin

Plate No. 1

#### Project Data

Duncan Project

Table No. 1

Arrow Project

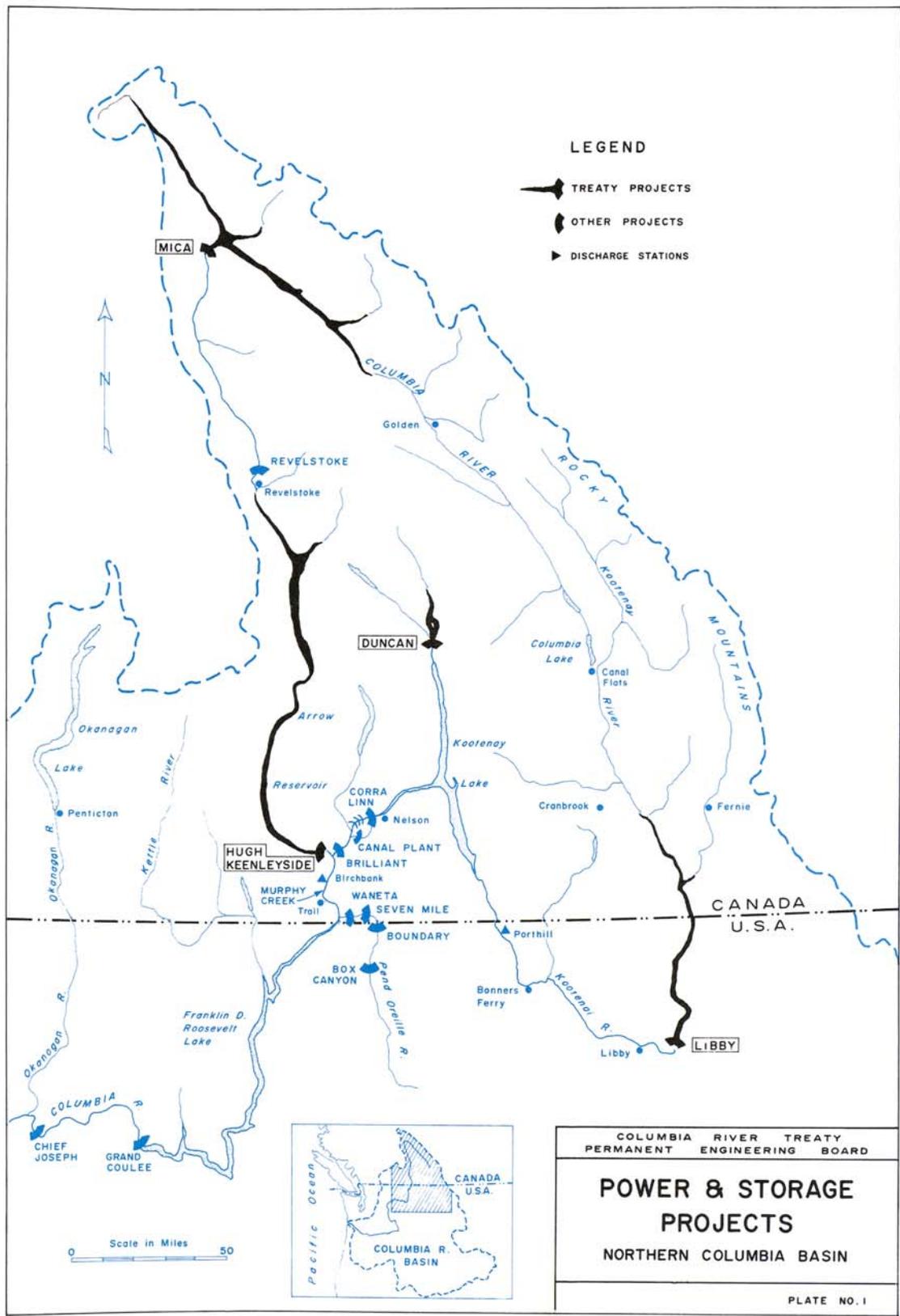
Table No. 2

Mica Project

Table No. 3

Libby Project

Table No. 4



**TABLE 1****DUNCAN PROJECT****Duncan Dam and Duncan Lake****Storage Project**

Construction began	17 September 1964
Storage became fully operational	31 July 1967

**Reservoir**

Normal full pool elevation	577 m (1892 feet)
Normal minimum pool elevation	547 m (1794.2 feet)
Surface area at full pool	7290 hectares (18 000 acres)
Total storage capacity	1.77 km <sup>3</sup> (1 432 400 acre-feet)
Usable storage capacity	1.73 km <sup>3</sup> (1 400 000 acre-feet)
Treaty storage commitment	1.73 km <sup>3</sup> (1 400 000 acre-feet)

**Dam, Earthfill**

Crest elevation	581 m (1907 feet)
Length	792.5 m (2600 feet)
Approximate height above riverbed	39.6 m (130 feet)
Spillway—Maximum capacity	1350 m <sup>3</sup> /sec (47 700 cfs)
Discharge tunnels—Maximum capacity	570 m <sup>3</sup> /sec (20 000 cfs)

**Power Facilities**

None

**TABLE 2**

**ARROW PROJECT**

**Hugh Keenleyside Dam and Arrow Lakes**

**Storage Project**

Construction began	March 1965
Storage became fully operational	10 October 1968

**Reservoir**

Normal full pool elevation	440 m (1444 feet)
Normal minimum pool elevation	420 m (1377.9 feet)
Surface area at full pool	52 650 hectares (130 000 acres)
Total storage capacity	10.3 km <sup>3</sup> (8 337 000 acre-feet)
Usable storage capacity	8.8 km <sup>3</sup> (7 100 000 acre-feet)
Treaty storage commitment	8.8 km <sup>3</sup> (7 100 000 acre-feet)

**Dam, Concrete Gravity and Earthfill**

Crest elevation	445 m (1459 feet)
Length	869 m (2850 feet)
Approximate height above riverbed	52 m (170 feet)
Spillway—Maximum capacity	6700 m <sup>3</sup> /sec (240 000 cfs)
Low-level outlets—Maximum capacity	3740 m <sup>3</sup> /sec (132 000 cfs)

**Power Facilities**

Currently installed	
2 units at 92.5 MW	185 MW
Power commercially available	2002
Head at full pool (Gross maximum head)	23.6 m (77 feet)
Maximum turbine discharge	1200 m <sup>3</sup> /sec (42 400 cfs)

**TABLE 3****MICA PROJECT****Mica Dam and Kinbasket Lake****Storage Project**

Construction began	September 1965
Storage became fully operational	29 March 1973

**Reservoir**

Normal full pool elevation	754.4 m (2475 feet)
Normal minimum pool elevation	707.1 m (2320 feet)
Surface area at full pool	42 930 hectares (106 000 acres)
Total storage capacity	24.7 km <sup>3</sup> (20 000 000 acre-feet)
Usable storage capacity	14.8 km <sup>3</sup> (12 000 000 acre-feet)
Treaty storage commitment	8.6 km <sup>3</sup> (7 000 000 acre-feet)

**Dam, Earthfill**

Crest elevation	762.0 m (2500 feet)
Length	792.5 m (2600 feet)
Approximate height above foundation	244 m (800 feet)
Spillway—Maximum capacity	2250 m <sup>3</sup> /sec (150 000 cfs)
Outlet works—Maximum capacity	1060 m <sup>3</sup> /sec (37 400 cfs)

**Power Facilities**

Designed ultimate installation	
6 units at 450 MW	2700 MW
Power commercially available	1976
Currently installed	
4 units at 451 MW	1805 MW
Head at full pool	183 m (600 feet)
Maximum turbine discharge	
of 4 units at full pool	1080 m <sup>3</sup> /sec (38 140 cfs)

**TABLE 4**

**LIBBY PROJECT**

**Libby Dam and Lake Koochanusa**

**Storage Project**

Construction began	June 1966
Storage became fully operational	17 April 1973

**Reservoir**

Normal full pool elevation	749.5 m (2459 feet)
Normal minimum pool elevation	697.0 m (2287 feet)
Surface area at full pool	18 830 hectares (46 500 acres)
Total storage capacity	7.2 km <sup>3</sup> (5 869 000 acre-feet)
Usable storage capacity	6.1 km <sup>3</sup> (4 980 000 acre-feet)

**Dam, Concrete Gravity**

Deck elevation	753.5 m (2472 feet)
Length	916.0 m (3055 feet)
Approximate height above riverbed	112.8 m (370 feet)
Spillway—Maximum capacity	4106 m <sup>3</sup> /sec (145 000 cfs)
Low-level outlets—Maximum capacity	1730 m <sup>3</sup> /sec (61 000 cfs)

**Power Facilities**

Designed ultimate installation	
8 units at 105 MW	840 MW
Power commercially available	1975
Currently installed	
5 units at 105 MW	525 MW
Head at full pool	107.0 m (352 feet)
Maximum turbine discharge	
of 5 units at full pool	745.6 m <sup>3</sup> /sec (26 500 cfs)