ANNUAL REPORT

to the

GOVERNMENTS

of

THE UNITED STATES and CANADA

COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. **Ottawa, Ontario**

30 September 2015

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COLUMBIA RIVER TREATY PERMANENT ENGINEERING BOARD

CANADA • UNITED STATES

CANADIAN SECTION
N. O'DEA, Chair
T. Newton, Member

UNITED STATES SECTION
J. DALTON, Chair
E. Sienkiewicz, Member

3 February 2016

The Honorable John Kerry
Secretary of State
Washington, D.C.

The Honourable James Carr
Minister of Natural Resources
Ottawa, Ontario

Dear Secretary Kerry and Minister Carr:

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 51st Annual Report of the Permanent Engineering Board, dated 30 September 2015. The report documents the results achieved under the Treaty for the period from 1 October 2014 to 30 September 2015.

The Board is pleased to report that, for this reporting period, the objectives of the Treaty were met.

Respectfully submitted:

For the United States

James Dalton, Chair

Ed Sienkiewicz

For Canada

Niall O'Dea, Chair

Tim Newton

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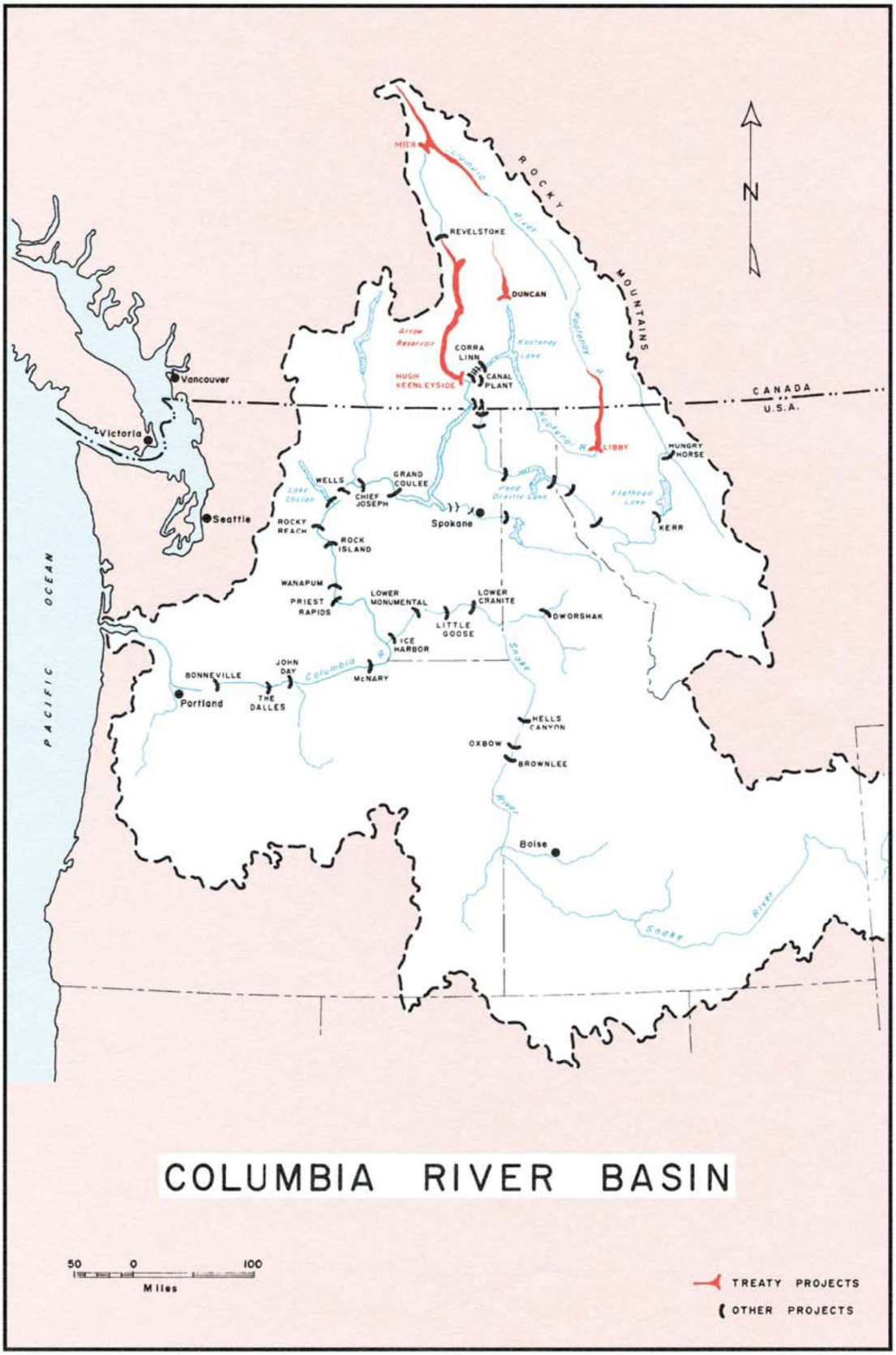
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ANNUAL REPORT

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COLUMBIA RIVER TREATY

PERMANENT ENGINEERING BOARD

Washington, D.C. Ottawa, Ontario

30 September 2015

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EXECUTIVE SUMMARY

The fifty-first 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 (CRT) 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 2014 to 30 September 2015.

During the reporting period, the Canadian Treaty projects – Mica, Duncan, and Arrow – were operated according to the 2014-2015 and 2015-2016 DOPs, the 2003 FCOP, and several supplemental operating agreements. The Libby project was operated consistently with the LCA, including the LOP, US requirements for power, and the USFWS 2006 BiOp, as clarified, and NOAA Fisheries' 2010 and 2014 Supplemental BiOp for operation and maintenance of the FCRPS.

Canadian Treaty storage began the Operating Year on 1 August 2014 at 97.6 percent full, and ended the year on 31 July 2015 at 76.8 percent full. The actual runoff for the overall Columbia Basin (US and Canada combined) measured at The Dalles for January through July 2015 was 83% of normal. The 2015 WY ranks third driest out of 55 years of record in total April-August runoff as measured at The Dalles. Water Year 2015 was a quiet flood risk management season due to the low seasonal volumes. There was less snow pack across the basin and less late season rainfall than in previous years resulting in no local flood risk issues.

The Canadian Entitlement to the downstream power benefits for the reporting period was determined according to the procedures set out in the Treaty and Protocol. From 1 August 2014 through 31 July 2015, the US Entity delivery of the Canadian Entitlement to downstream power benefits, before deducting transmission losses, was 479.9 megawatts of average energy at rates up to 1,369 megawatts of capacity. From 1 August 2015 to 30 September 2015, the US Entity delivery of the Canadian Entitlement to downstream power benefits, before deducting transmission losses, was 488.7 megawatts of average energy at rates up to 1,332 megawatts of capacity. The Canadian Entitlement obligation was determined by the 2013-2014 and 2014-2015 AOP and Determination of Downstream Power Benefits.

The Canadian Entitlement was delivered on schedule 100% of the time. During the course of the 2014-2015 Operating Year, there were no curtailment events for Canadian Entitlement deliveries.

The CRTHMC implemented a new Libby seasonal inflow volume forecast procedure for WY2015. The CRTHC also laid out a schedule of dates for official seasonal volume forecasts using ESP with 5 days of short-term forecast produced by the Northwest River Forecast Center. BC Hydro completed their transition to secure FTP and all agencies are now receiving Canadian CROHMS data through this more secure channel. The four new snow pillows added under agreement with BPA /BCH worked well over their first snow season. Fernie, BC climate station is being automated to improve data reliability. These new stations will provide much needed high elevation snowpack information in real time for water supply forecasting. The CRTHMC finds the basin gaging network to be adequate for Treaty purposes at this time. The Committee's 2015 Annual Report was completed in December 2015.

The Long Term NTSA, executed in April 2012, was utilized by BPA and BC Hydro for power purposes through fall and winter of 2014-15. The NTSA includes a dry year release provision that guarantees to BPA the release of 0.5 Maf (252 ksfd) from Canadian storage projects during the driest 20% of runoff years as measured at The Dalles Dam in the US These dry conditions were met based on the May 2015 volume forecast and BPA requested release of 0.5 Maf of water in May and June per the NTSA. In accordance with the Entity agreement that approved the 2012 NTSA contract between BPA and BC Hydro, the CRTOC monitored the storage and release operations under the Agreement throughout the operating year to ensure they did not adversely impact the operation of CRT storage required by the DOPs.

During the period of this Annual Report, the CRTOC completed two supplemental operating agreements. As in past years, the CRTOC negotiated the 2015 Non-power Uses Agreement, for the period 1 December 2014 through 31 July 2015 signed 6 November 2014 to manage Keenleyside outflows and to improve conditions for fish in both countries. Under provisions of that agreement, the US Entity stored 1.23 km^3 (504 ksfd) of flow augmentation water during January 2015. Operation under the agreement helped to manage flows downstream of Keenleyside for Canadian whitefish and trout spawning protection during the January through June period. The flow augmentation water was subsequently released during July 2015 to help meet US salmon flow objectives. The CRTOC also negotiated the Arrow Summer Storage Agreement for the Period 1 July 2015 through 30 September 2015 signed on 17 July 2015 to help mitigate local concerns and operational issues at Arrow.

Regarding the review of the Columbia River Treaty, it was noted that final recommendations were transmitted to the US Department of State on 13 December 2013 by the US Entity. The US Entity's Final Recommendation and the three-year process leading up to it also marked the successful conclusion of the regional recommendation chapter of the US Treaty Review, and the beginning of a formal review by the US Government. The final recommendation was that "…both countries develop a modernized Treaty framework that reflects the actual value of coordinated power operations with Canada, maintains an acceptable level of flood risk and supports a resilient and healthy ecosystem-based function throughout the Columbia River Basin." The US Government initiated a formal national interest review in 2014 that is still ongoing at this time.

Led by the BC Treaty Review team, the Canadian Entity released the Government of British Columbia's decision to continue the Columbia River Treaty and seek improvements within its existing framework on 13 March 2014. BC's decision includes 14 principles that will guide BC in any future discussions with Canada and the US on the future of the Treaty. The decision and principles follow more than two years of technical, social, economic and legal studies and an extensive consultation process with various levels of government, stakeholder groups, First Nations and the public. The principles include considerations around flood risk management, hydropower generation, ecosystems and climate change, while allowing for flexibility moving forward to adapt to evolving economic, social and environmental circumstances in each country. BC recently initiated the Columbia R. Basin Advisory Committee to facilitate advice from regional stakeholders into the CRT 2014 review and ongoing reservoir operations planning.

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ABBREVIATIONS AND ACRONYMS

AER ……Actual Energy Regulation
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
CRTHMC ……Columbia River Treaty Hydrometeorological Committee
CRTOC ……Columbia River Treaty Operating Committee
cfs ……Cubic feet per second
DDPB ……Determination of Downstream Power Benefits
DOP ……Detailed Operating Plan (from 1 August to 31 July)
ESA ……Endangered Species Act
ESP ……Ensemble Streamflow Prediction
FCOP ……Flood Control Operating Plan
FCRPS ……Federal Columbia River Power System
ft ……Feet
hm^3 ……Cubic hectometres
IJC ……International Joint Commission
kaf ……Thousand acre-feet
kcfs ……Thousand cubic feet per second
km ……Kilometres
km^3 ……Cubic kilometres
kV ……Kilovolts
LCA ……Libby Coordination Agreement
m ……Meters
m^3/s ……Cubic meters per second
Maf ……Million acre-feet
mi ……Miles
MW ……Megawatts
MWh ……Megawatt hour
NMFS ……National Marine Fisheries Service
NOAA ……National Oceanic and Atmospheric Administration
NTSA ……Non-Treaty Storage Agreement
PEBCOM ……Permanent Engineering Board Engineering Committee
PNCA ……Pacific Northwest Coordination Agreement
PSANI ……Puget Sound Area / Northern Intertie
SRT ……Sovereign Review Team
TSR ……Treaty Storage Regulation
USACE ……US Army Corps of Engineers
USFWS ……US Fish and Wildlife Service
VarQ ……Variable discharge flood control

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 from 1 October 2014 through 30 September 2015, 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 – Kootenai River, Montana

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 Canadian 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^3 (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 totalling 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. All sales under the Sales Agreement have now expired.

Termination Provisions

Article XIX describes the period of the Treaty and provisions for its termination. While the Treaty has no official termination date, Canada or the United States may issue notice to terminate most of the provisions of the Treaty 60 years (at the earliest) from its date of ratification (that is, on September 16, 2024), provided they have given at least ten years' written notice. Certain provisions of Treaty change automatically in 2024, while others continue for the useful life of the Treaty facilities.

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 (PEBCOM).

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 locks and earthfill dam.
The new 185-MW power plant is on the north abutment (right-hand side).

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 (moved by a later Executive Order to the Department of Energy), and the Division Engineer, North Pacific (now Northwestern) 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 OF THE BOARD

Meetings

The Board held its 82nd meeting on 4 February 2015 in Vancouver, BC. In conjunction with this meeting, the Board also held its 63rd joint meeting with the Entities.

The following topics were discussed at the meeting: the current status of the 2015 CRT Review, the preparation and implementation of operating plans, the Short Term Libby Agreement and the delivery of the Canadian Entitlement as well as other Treaty implementation issues.

Reports Received

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

- Detailed Operating Plan for Columbia River Storage for 1 August 2015 through 31 July 2016, dated June 2015

  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 2015 through 31 July 2016.

- Columbia River Treaty Entity Agreement on the Detailed Operating Plan (DOP) for Canadian Storage signed 26 June 2015.

  This document is the agreement between the Entities to implement the DOP for Columbia River storage during the period 1 August 2015 through 31 July 2016.

- Annual Report of the Columbia River Treaty, Canadian and United States Entities, for the period 1 August 2014 through 30 September 2015.

  This report summarizes the operation of Treaty projects and other activities of the Entities for the period 1 August 2014 through 30 September 2015.

Report to the Governments

In accordance with Article XV, paragraph 2(e) of the Treaty, the fiftieth Annual Report of the Board, dated 30 September 2014, was submitted to the governments of Canada and the United States.

Duncan Dam – Duncan River, British Columbia
The earthfill 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, preparation of flood control operating plan, and annual preparation of operating plans for power and calculation of downstream power benefits. The three Treaty storage projects in British Columbia (Duncan, Arrow, and Mica) and the Libby storage project in the United States have been operated accordingly to produce flood control and power benefits in both Canada and the United States. The locations of the Treaty projects are shown in Plate No.1 in Appendix D.

In the United States, the 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 four turbines at Mica Dam by 1977 and a fifth in 2014, completion of the Revelstoke dam including four turbines in 1984 (and a fifth turbine installed in 2010), and installation of two turbines adjacent to the Keenleyside Dam in Arrow Lakes in 2002, have resulted in 5573 MW of generation capacity in British Columbia that might not have been installed without the Treaty. A sixth turbine with a capacity of 520 MW is being installed in the Mica Dam. An additional generation unit at Revelstoke is also being planned.

The Treaty provides Canada with an option to divert the Kootenay River at Canal Flats into the headwater of the Columbia River starting 1984. BC Hydro undertook engineering feasibility and environmental studies but no further work has been done in recent years.

Further to the expiration of the Sales Agreements 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 US resource agencies' biological opinions (BiOps) on Treaty operations.

Treaty Projects

Duncan Project

Duncan Dam, the smallest Treaty project, was scheduled to begin operation by 1 April 1968. It was the first of the Treaty projects to be completed and became fully operational on 31 July 1967, well in advance of Treaty requirement. The Sales Agreement for Duncan expired 31 March 1998.

The earthfill dam is situated 9.7 km (6 mi) north of Kootenay Lake and rises 39.6 m (130 ft) above its foundation. The reservoir behind the dam extends for as much as 43.5 km (27 mi) and provides 1.73 km^3 (1.40 Maf) of usable storage, which is all committed under the Treaty. No power generation facilities have been installed.

The project is shown on page 11, 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 the starting date of 1 April 1969 for the 30-year Sales Agreement.

The dam consists of two main components: a concrete gravity structure that extends 366 m (1200 ft) 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 ft) above the riverbed and extends 503 m (1650 ft) from the navigation lock to the south bank of the river. The reservoir extends 233 km (145 mi) upstream when full, including both the Upper and Lower Arrow lakes, and provides 8.8 km^3 (7.1 Maf) of Treaty storage.

A 185-MW power plant located on the north abutment (left bank) of the Arrow Project was completed in 2002. It is licensed to Arrow Lakes Power Corporation which is owned by Columbia Basin Trust and Columbia Power Corporation, both Crown Corporations in British Columbia. A 1493 m (4900 ft) intake approach channel runs along the north end of the concrete dam and diverts the water of the Arrow Lakes through a powerhouse located in a rock outcrop 396 m (1300 ft) 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 integrate into BC Hydro's existing power grid. The power production at this generating facility is incidental to releases for Treaty purposes. This new power plant reduces spill at Keenleyside Dam and provides environmental benefits by reducing the total gas pressure in the releases, which could be harmful to fish.

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 to begin operation on 1 April 1973. The project was declared operational and commenced to store water on 29 March 1973. The dam is located on the Columbia River 137 km (85 mi) north of the town of Revelstoke in British Columbia. The earthfill dam rises more than 244 m (800 ft) above its foundation and extends 793 m (2600 ft) across the Columbia River valley. It is one of the tallest dams in North America. It creates a reservoir, the Kinbasket Lake, that is up to 217 km (135 mi) long with a storage capacity of 24.7 km^3 (20 Maf). The project is operated within 14.8 km^3 (12 Maf) of live storage, of which 8.6 km^3 (7 Maf) are committed under the Treaty.

The powerhouse in Mica Dam was designed for six generating units. Five Francis turbines and generators have been installed with a total capacity of around 2325 MW. Installation of the sixth generating unit, with a capacity of 520 MW, is in progress and is scheduled for completion by 2016. However, the authorized diversion in its water licence would limit the maximum generation at the plant to around 2750 MW after all six units become operational.

The project is shown on page 19, 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 mi) 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 ft) long, rises 113 m (370 ft) above the riverbed, and creates Lake Koocanusa, which is up to 145 km (90 mi) long and extends 67.6 km (42 mi) into Canada. Lake Koocanusa has a gross storage of 7.2 km^3 (5. 9 Maf), of which 6.1 km^3 (5.0 Maf) is 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 600 MW. Recent US legislation (*Public Law 104-303*, 12 Oct. 1996) authorizes the US Army Corps of Engineers (USACE) to complete generating units six through eight. 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 68 km (42 mi) 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 to establish and operate, in consultation with the Permanent Engineering Board, of a hydrometeorological system to obtain data for the planning of flood control and power operations. This system includes snow courses, meteorological stations, and reservoir level and streamflow gauges. The CRTHMC, formed by the Entities in 1968, makes recommendations on further development of the Treaty Hydrometeorological System. The Committee's 2015 Annual Report was completed in December 2015.

Four new snow pillow stations were installed in 2013 and 2014 in the Upper Columbia drainage area and have provided much needed high elevation snowpack information in real time for water supply forecasting in 2015, the first year of operation of these stations. One new hydrometric station was added in the Nordic headwater basin above Mica in 2015. A BC climate station at Fernie is being automated to improve data reliability. The reliability of Porthill and Bonners Ferry stations in Idaho is under review and alternative data source is under consideration.

The Committee reviews the adequacy of the hydrometeorological network every year based on the status of the stations and data quality, and if the data meet model input requirements. The Committee believes the basin gauging network is adequate for Treaty purposes at this time.

The Committee regularly assesses the role and appropriateness of data used in water supply forecasts. In 2015, it determined that the high early season precipitation at one station (Blue River) in an anomalously warm winter would contribute less to volume forecast for the Revelstoke local runoff than is attributed in the water supply model algorithm. Model input for that station was adjusted accordingly.

Methodology for the April to August Libby seasonal inflow volume forecast has been updated in 2015 to include the above-average rainfall in the springs of 2011-2013 in the statistics of historical data. POP Appendix 8 was updated to incorporate details of the changes accordingly.

An updated water supply forecast procedure incorporates 5-day weather forecasts (extended from 3-day forecasts), consistent with the methodologies used in other River Forecast Centers in the west. These changes were adopted at the 22 September 2015 CRTOC meeting.

As an improvement to data maintenance and exchange, BC Hydro completed transition to a secure FTP and all agencies are now receiving Canadian data through this more secure channel.

Power Operating Plans and Calculation of Downstream Power Benefits

The Treaty and related documents require the Entities to develop and agree on an AOP annually for the sixth succeeding year from the current year. This AOP, prepared five years in advance, represents the 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. The calculation of downstream power benefits accrued to each country under the Treaty is also prepared five years in advance based on the Treaty operation criteria in the AOP. At the beginning of each operating year, a DOP for the three Treaty projects in Canada is prepared. This plan accounts for projected resources and demands to determine operations that are more advantageous to both countries than those in accordance with the AOP. To supplement the DOP, the Entities may enter into agreements throughout the year regarding the operation of Treaty storage that provide mutual benefits to both Entities. The operating plan for the Libby project in the United States has been prepared separately since 2000 and has not been included in the DOP thereafter. Details on Libby operations are discussed further below.

During the reporting year, operation of Treaty storage in Canada was regulated under the rule curves set out in the Entities' *Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2014 through 31 July 2015*, signed on 16 June 2014, and the *Detailed Operating Plan for Columbia River Treaty Storage, 1 August 2015 through 31 July 2016*, signed on 26 June 2015, as well as in accordance with extension of the STLA, signed 15 April 2015 and CRTOC Agreements on Operation of Canadian Storage for Non-power Uses for 1 December 2014 through 31 July 2015, signed on 6 November 2014, and Arrow Summer Storage Agreement for the period 1 July 2015 through 30 September 2015 signed on 17 July 2015. These documents were based on the operating criteria and studies contained in the corresponding AOPs, together with any changes agreed to by the Entities.

The Libby operating criteria and expected operation of the Libby project are no longer included in the annual DOP beginning in the 2000-2001 operating year. Information on Libby operations is provided separately in the Libby Operating Plan prepared by the US Entity. Operation at Libby takes non-power considerations into account as required in the BiOps of the USFWS and the NOAA Fisheries Service. Compared to operations prior to 2000–2001, the BiOps requires higher releases from Libby Dam in the spring and summer and lower releases in the fall and winter. In January 2003, USACE adopted, on an interim basis, a new approach to determine operations at Libby. This approach, referred to as VarQ, applies only when dry-to-moderate hydrologic runoff conditions are forecasted. It uses (encroaches) flood control storage space to store water to increase flows for fisheries during the spring period. In June 2008, USACE issued a Record of Decision for Libby Dam Flood Control and Fish Operations and incorporated the VarQ Flood Control Procedures into the Libby Dam Water Control Manual. USACE will continue to coordinate with Canada on the operation of Libby Dam pursuant to provisions in the Columbia River Treaty.

The LCA, signed on 16 February 2000, addressed some of the issues concerning salmon and white sturgeon fisheries operations of the Libby Project, and allowed the Entities to coordinate reservoir releases and agree to AOPs and DDPBs without having to fully resolve outstanding issues of disagreement. The LCA could be terminated by either Entity on 30 days' notice. Details of the LCA are presented later in this report under "Operations under the Treaty." The Entities have successfully implemented the LCA since signing.

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 circumstances so require in the future, the Board will re-examine the matter by using its earlier recommendations as guidelines for appropriate Treaty interpretations, 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 referenced 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 US 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

During the reporting period the Canadian Entitlement was delivered as scheduled 100 percent of the time. The Board will continue to keep the governments informed of transmission developments that may impact Treaty implementation.

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, 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-US 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

The Long Term Non-Treaty Storage agreement (NTSA), executed in April 2012, was utilized by BPA and BC Hydro for power purposes through fall and winter of 2014-15. The NTSA includes a dry year release provision that guarantees to BPA the release of 0.5 Maf (252 ksfd) from Canadian storage projects during the driest 20% of runoff years as measured at The Dalles Dam in the US. These dry conditions were met based on the May 2015 volume forecast and BPA requested release of 0.5 Maf of water in May and June per the NTSA. In accordance with the Entity agreement that approved the 2012 NTSA contract between BPA and BC Hydro, the CRTOC monitored the storage and release operations under the Agreement throughout the operating year to ensure they did not adversely impact the operation of CRT storage required by the DOPs.

Fisheries Operations

Many US reservoirs are presently operated in accordance with BiOps issued by the USFWS 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 Treaty permits the Entities to develop DOPs to address fisheries' needs, to the extent that these actions do not conflict with Treaty objectives.

Biological Opinion on the Federal Columbia River Power System

The 2008/2010 FCRPS Biological Opinion contained a "reasonable and prudent alternative" which identified specific actions to ensure the survival of ESA listed salmon and steelhead in the United States. The actions required BPA and the Corps pursue negotiations with Canada for annual agreements to provide 1 Maf of Treaty storage and negotiate a new long-term agreement on use of non-Treaty space in Canada so long as such an agreement provides both power and non-power benefits for BC Hydro, BPA, and Canadian and US interests. The Entities did provide 1 Maf of Treaty storage for fish needs in 2015 through the Non-Power Uses Agreement (1 December 2014 through 31 July 2015). A new NTSA was signed by BPA and the BC Hydro on 12 April 2012 which reserves an additional 0.5 Maf for fish in the spring of qualifying dry years. These dry conditions were met based on the May 2015 volume forecast and 0.5 Maf was released for fish in May and June of 2015

NOAA Fisheries issued a supplemental BiOp in January 2014. The supplemental BiOp analyzed research and monitoring results from the first five years of work under the original biological opinions, as well as the biological status of the species. The FCRPS Supplemental 2014 BiOp addresses FCRPS project operations through 2018:

- FCRPS project operations generally are continuing as before

- FCRPS storage project operations unchanged
    - Libby Dam continues implementation of VarQ Flood Risk Management
    - Continue Libby and Hungry Horse Dam summer operations as per Northwest Power & Conservation Council
    - Continue to pursue agreements with Canadian Entity for 1 Maf of Treaty space
    - Continue to implement Non-Treaty Storage agreement with BC Hydro
    - Continue to improve forecasting effectiveness and participation in developing information on climate change

- Actions are being implemented as intended and are on track

Mica Dam and Lake Kinbasket – Columbia River, British Columbia
The spillway is on the right of the earthfill dam, and the underground powerhouse 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 Operating Year from August to July of the following year. Although the Permanent Engineering Board reporting period is 1 October 2014 to 30 September 2015, Treaty operations are based on the Treaty Operating Year of 1 August 2014 to 31 July 2015. Additional information for 1 August 2015 to 30 September 2016 is based on the Treaty Operating Year 1 August 2015 to 31 July 2016.

For the 1 August 2014 through 30 September 2015 reporting period, the Canadian Treaty Projects were operated according to the 2014-2015 and the 2015-2016 DOPs, the 2003 FCOP, and supplemental operating agreements as described below. The Libby project was operated consistently with the LCA, including the LOP, US requirements for power, and US Fish and Wildlife Service's 2006 BiOp, as clarified, and NOAA Fisheries' 2010 and 2014 Supplemental BiOp for operation and maintenance of the FCRPS.

Treaty storage in Canada was operated by the Canadian Entity in accordance with the documents listed below. The Libby project was operated by the US Entity according to the 2003 FCOP, the 2000 LCA, including the 13 January 2010 and 12 October 2010 updates to the LOP, US requirements for power, guidelines set forth in the USFWS 2008 Biological Opinion, and the US NMFS BiOps and Action Agency Plans, as approved by Court order, and strict application of the eight-step VarQ operating procedures.

- *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, stream flows 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 for1 April 1998 through 15 September 2024 between the Bonneville Power Administration, Acting on Behalf of the US Entity, and the Province of British Columbia*, signed 29 March 1999

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

- *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 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.

- *US 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.

- *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.

- *Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2018–2019*, dated December 2013

  This document provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2018 through 31 July 2019.

- *Columbia River Treaty Operating Committee Agreement on Changes to Attachment B to 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 29 March 1999*, signed 19 December 2007

  This agreement amends the scheduling guidelines for delivery of the Canadian Entitlement contained in Attachment B in the Aspects of Delivery Agreement.

- *Columbia River Treaty Assured Operating Plan and Determination of Downstream Power Benefits for Operating Year 2014–2015*, dated September 2010

  This document provides information on the operating plan for Columbia River Treaty storage and the resulting downstream power benefits for the period 1 August 2014 through 31 July 2015.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2014 through 31 July 2015*, dated June 2014

  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 2014 through 31 July 2015.

- *Detailed Operating Plan for Columbia River Storage for 1 August 2015 through 31 July 2016*, signed 26 June 2015

  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 2015 through 31 July 2016.

- *Columbia River Treaty Short-Term Libby Agreement on Coordination of Project Operations (STLA)*, signed 27 September 2013

  This document address, until 31 August 2015, issues raised by the Canadian entity regarding VarQ operations at Libby. The STLA provides the Canadian Entity additional flexibility to draft and store at Arrow reservoir. During the term that the STLA is in effect, Section 10 and Attachment C of the LCA are suspended. Other portions of the LCA shall remain in effect.

The CRTOC completed two supplemental operating agreements during the reporting period:

- *Columbia River Treaty Operating Committee Agreement on Operation of Canadian Storage for Nonpower Uses for 1 December 2014 through 31 July 2015*, signed 6 November 2014

- *Columbia River Treaty Operating Committee Arrow Summer Storage Agreement for the Period 1 July 2015 through 30 September 2015*, signed 17 July 2015

These agreements are similar to previous agreements implemented to utilize Treaty storage for non-power uses. These uses include: (1) providing flows for Canadian whitefish and trout spawning for the January through June period; (2) enhancing the capability in the US 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; and, (4) improving the US capability to meet flow objectives for salmon at Vernita Bar below Priest Rapids Dam.

In addition to the agreements listed above, the Bonneville Power Administration and/or USACE and B.C Hydro developed the following bilateral agreements:

Agreement between BPA and BC Hydro that covered the storage, and subsequent release, of Non-Treaty Storage Agreement (NTSA) water during the period 28 February through 31 October 2015, providing mutual power and nonpower benefits during the period.

System Storage

The 2014-2015 operating year began on 1 August 2014 with the Canadian Treaty storage at 18.6 km^3 (15.1 Maf), or 97.6 percent full. Canadian Treaty storage drafted to a minimum of 5.4 km3 (4.4 Maf), or 28.4 percent full on 27 March 2015, and refilled to 14.7 km^3 (11.9 Maf), or 76.8 percent full, on 31 July 2015. Canadian Treaty reservoirs operated in proportional draft mode during the second half of August through October 2014 and again during May 2015 through the end of this reporting period to meet Treaty firm loads. Throughout the operating year, composite Canadian Treaty storage targeted the TSR study composite storage plus any operations implemented under mutually agreed upon Supplemental Operating Agreements including the STLA, Arrow Summer Shaping Agreement and the NPU. Exceptions occurred in all periods due to inadvertent draft or storage which occurs routinely due to updated inflow forecasts or differences between forecast and actual inflows as well as after-the-fact changes in proportional draft points. Canadian Treaty storage began the operating year close to the DOP storage levels specified by the TSR study but ended the operating year above TSR specified storage levels under the provisions of the Arrow Summer Shaping Agreement.

Under terms of the STLA, BC Hydro exercised 291.1 cubic hectometers (hm^3) (119 ksfd) of provisional draft from Keenleyside in August – September 2014. In October - November 2014, BC Hydro exercised 0.51 km3 (210 ksfd) of STLA provisional storage followed by a draft of 102.8 hm^3 (42 ksfd) for one week in November.

As in past years, the CRTOC negotiated a NPU in order to manage Keenleyside outflows and to improve conditions for fish in both countries. Under provisions of that agreement, the US Entity stored 1.23 km^3 (504 thousand second-foot-days (ksfd), 1 Maf) of flow augmentation water during January 2015. Operation under the agreement helped to manage flows downstream of Keenleyside for Canadian whitefish and trout spawning protection during the January through June period. The flow augmentation water was subsequently released during July 2015 to help meet US salmon flow objectives. From January until the end of July 2015, Canadian storage remained above TSR-specified levels.

The January 2015 water supply forecast for the Columbia River above The Dalles for January through July was 126.6 km^3 (102.6 Maf), or 101 percent of the 1981–2010 average. After the water supply forecast increased to 128.0 km^3 (103.8 Maf) in February, or 102 percent of the 1981-2010 average, the spring water supply forecasts at The Dalles decreased as the water year developed. By the June 2015 forecast, the (January-July) runoff forecast had decreased to 106.1 km3 (86. 0 Maf), or 85 percent of the 1981-2010 average. The actual January through July runoff for the Columbia River above The Dalles was 103.2 km^3 (83.7 Maf), or 83 percent of the 1981-2010 average.

Operations of the three Canadian projects— Mica, Keenleyside, and Duncan — and Libby in the United States are illustrated in Section VIII as Charts 5 through 8 for the 14-month period from 1 August 2014 to 30 September 2015. The hydrographs show actual reservoir levels (Storage Curve) and key rule curves that govern the operations of Treaty storage. The Flood Risk Management Rule Curve specifies maximum month-end reservoir levels which will permit timely evacuation of the reservoir to mitigate potentially high inflows from precipitation and snowmelt events. The First Critical Rule Curve (CRC1) shows the start of the proportional draft that ensures firm power demands can be met under adverse (low) 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. The Assured Refill Curve indicates the end-of-month storage content required to assure refill of the reservoir based on the 1931 historical volume of inflow during the refill period.

Mica (Kinbasket Reservoir)

Kinbasket reached a maximum elevation in 2014 of 753.98 m (2473.7 ft), 0.4 m (1.3 ft) below normal full pool on 6 November 2014, setting a new record high since 1976 for this date. Due to warmer than normal winter temperatures and lack of loads, the reservoir continued to remain at record level highs for most of November through December 2014 and again in late March through mid-June. The reservoir reached a minimum level of 736.98 m (2417.9 ft) on 15 May 2015, 12.19 m (40.0 ft) higher than the 2014 minimum level.

Mica generation also set record levels on several days across the spring and summer. Generation was increased to help support Arrow reservoir levels and for system requirements. From 1 April through 22 August, Mica discharges have been approximately 230 percent above average. Despite near normal freshet inflows during the 2014/15 operating year, the significant amount of discharge resulted in Kinbasket not filling to full pool. The reservoir filled to a maximum level of 750.97 m (2463.8 ft) on 15 July 2015, 3.41 m (11.2 ft) below normal full pool. The reservoir continued drafting since reaching below average levels by mid-August.

Keenleyside (Arrow Lakes Reservoir)

Arrow reached a maximum level of 436.69 m (1432.7 ft), or 3.44 m (11.3 ft) below full pool, on 1 August 2014. Arrow reached a minimum level of 423.82 m (1390.5 ft) on 30 March 2015. By comparison, in the previous year, Arrow reached a minimum level of 427.06 m (1401.1 ft) on 31 January 2014. The berm work was completed at Keenleyside in May 2015, allowing the reservoir to surcharge 0.61 m (2 ft) if necessary upon approval from Dam Safety (to elevation 440.74 m [1446 ft]). Due to low snowpack and unseasonably low forecast runoff at The Dalles (67% of normal April - August runoff at The Dalles), the third driest year since 1960, the Columbia reservoir system has been operating in proportional draft since the beginning of May 2015. This operation resulted in high discharges from Keenleyside across the spring /summer and corresponding low summer Arrow levels. The reservoir filled to a maximum level of 435.47 m (1428.7 ft), or 4.66 m (15.3 ft) below full pool, on 13 June 2015. Arrow drafted across July, August and September due to continuing proportional draft reaching 428.95 m and 429.12 m (1407.3 ft and 1407.9 ft) by 31 August and 30 September 2015, respectively.

Duncan (Duncan Reservoir)

Duncan refilled to 576.53 m (1891.5 ft), or 0.15 m (0.5 ft) below normal full pool, on 13 August 2014. During the remainder of that month, Duncan was operated to target a reservoir level of 575.46 m (1888.0 ft) for Labour Day 2014. From September 2014 through April 2015, Duncan was operated to supplement inflows into Kootenay Lake, to provide spawning and incubation flows for fish downstream in the Duncan River, and to meet Treaty Flood Risk Management requirements. As in most years, the reservoir was drafted to near empty in late April. Duncan reached its licensed minimum level, 546.90 m (1794.3 ft) on 21 April 2015. By comparison, the reservoir reached a similar minimum level of 546.87 m (1794.2 ft) the year before on 25 April 2014. The reservoir discharge was reduced to its minimum of 3.0 m3/s (0.1 kcfs) in mid-May to initiate reservoir refill. Releases from Duncan were held at minimum until mid-July, when discharges were gradually increased to manage the rate of reservoir refill. Due to low inflows, Duncan also did not fully refill.

By 31 July 2015, the Duncan level reached 574.70 m (1885.5 ft) and the reservoir level peaked at 575.04 m (1886.6 ft), or 1.65 m (5.4 ft) below full, on 3 August 2015. Duncan discharges were increased during August to support Arrow levels during proportional draft operations. To enable this operation, British Columbia Hydro and Power Authority (BC Hydro) requested and was granted a variance from the Water Comptroller. The variance allowed Duncan to deviate from the summer recreation target of 575.46 m (1888.0 ft) between 10 August and Labour Day as per the Duncan Water Use Plan Order.

Libby (Koocanusa Reservoir)

Libby ended July 2014 at elevation 747.64 m (2452.9 ft). The project was drafted to elevation 747.10 m (2451.1 ft) at the end of August 2014, with outflows held constant at 255 m^3/s (9.0 kcfs), the bull trout minimum through the end of August 2014. There was no request from the Kootenai Tribe of Idaho (KTOI) for low flows in the fall of 2014 to assist with the continuing habitat restoration work in the Kootenai River, as had been the case in previous years. For the month of September, releases were maintained above the 170 m^3/s (6.0 kcfs), September bull trout minimum, until elevation 746.46 m (2449.0 ft) was achieved and then releases continued near 255 m^3/s (9.0 kcfs) for most of the month at Bonneville Power Administration's (BPA's) request. The reservoir elevation at the end of September 2014 was 745.97 m (2447.4 ft). The final April – August 2014 inflow volume to the project was 8.3 km3 (6.7 Maf), or 113 percent of normal (1981 – 2010, 30 year normal).

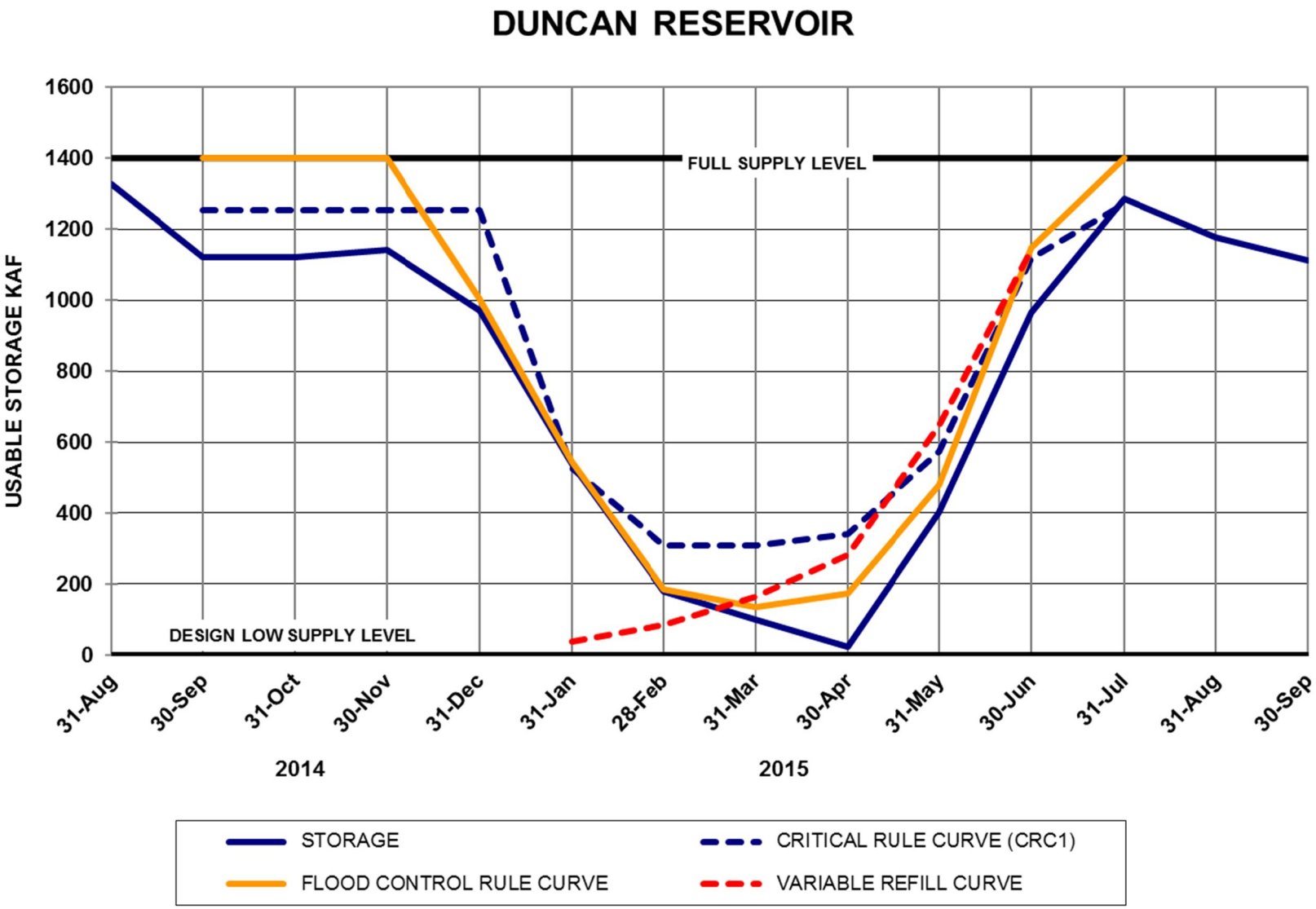
Releases were reduced to 113 m^3/s (4.0 kcfs) for the month of October and then increased in November to target end of year flood risk management (FRM) goals. The December 2014 water supply forecast for April-August 2015 runoff was 8.5 km^3 (6.9 Maf), or 117 percent of average, requiring the end of December FRM elevation to be 734.87 m (2411.0 ft). The December FRM elevation was reached at the end of the month and releases were set to the 113 m^3/s (4.0 kcfs), the default minimum flow, for the balance of the winter.

Libby's seasonal volume forecasts decreased for the rest of the forecast season and were not sufficiently large to require a Koocanusa draft below the elevation set at the end of December 2014. The water supply forecast for May 2015 was 6.7 km^3 (5.4 Maf), or 92 percent of average. Libby outflow was managed to try to pass inflows for the first part of May since inflows were less than the Variable Flow flood risk management (VarQ) outflow of 513 m3/s (18.1 kcfs). On 22 May 2015, Libby began to release the sturgeon volume 1.0 km^3 (0.8 Maf) set by the May water supply forecasts and releases were increased to the powerhouse capacity of 750 m^3/s (26.5 kcfs) for 7 days. In 2015, this was a single pulse operation followed by a gradual ramp-down (instead of the double pulse utilized in 2014). Releases were ramped down to 326 m^3/s (11.5 kcfs) on 17 June once the sturgeon volume was expended. The elevation at Libby ended the month of June at 744.57 m (2442.8 ft).

The operation for the rest of the summer, July through August, was to try to refill Libby as best as possible and still meet the 743.41 m (2439.0 ft) target by the end of September, as required in the NOAA BiOp, with The Dalles water supply forecast being below the 20th percentile. Libby reached its peak elevation for the summer on 15 July, 744.96 m (2444.1 ft), which was 4.54 m (14.9 ft) below full pool. Due to low inflow conditions, the project reduced outflow in August to the minimum bull trout flow of 198 m^3/s (7.0 kcfs) and then ramped down to 170 m^3/s (6.0 kcfs), the minimum bull trout flow for September. Libby elevations were 743.93 m (2440.7 ft) and 743.77 m (2440.2 ft) at the end of August and September respectively. The 170 m^3/s (6.0 kcfs) in September was also the requested release from Libby to help with the in-stream habitat work for the KTOI.

Flood Control Operations

Columbia River Basin projects were operated according to the May 2003 Flood Control Operating Plan. The 2015 water supply forecasts were below normal across the Columbia River Basin. The regulated peak flow during the freshet at The Dalles, Oregon, was 6,300 m^3/s (223 kcfs) on 2 April 2015, and the unregulated peak flow was estimated at 10,025 m^3/s (354 kcfs) on 4 June 2015. The peak stage observed during the freshet at Vancouver, Washington, was 2.23 m (7.3 ft) on 4 April 2015, and the estimated peak unregulated stage was 3.12 m (10.3 ft) on 4 June 2015 while the flood stage is 4.88 m (16 ft).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30-Sep
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28-Feb
31-Mar
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30-Jun
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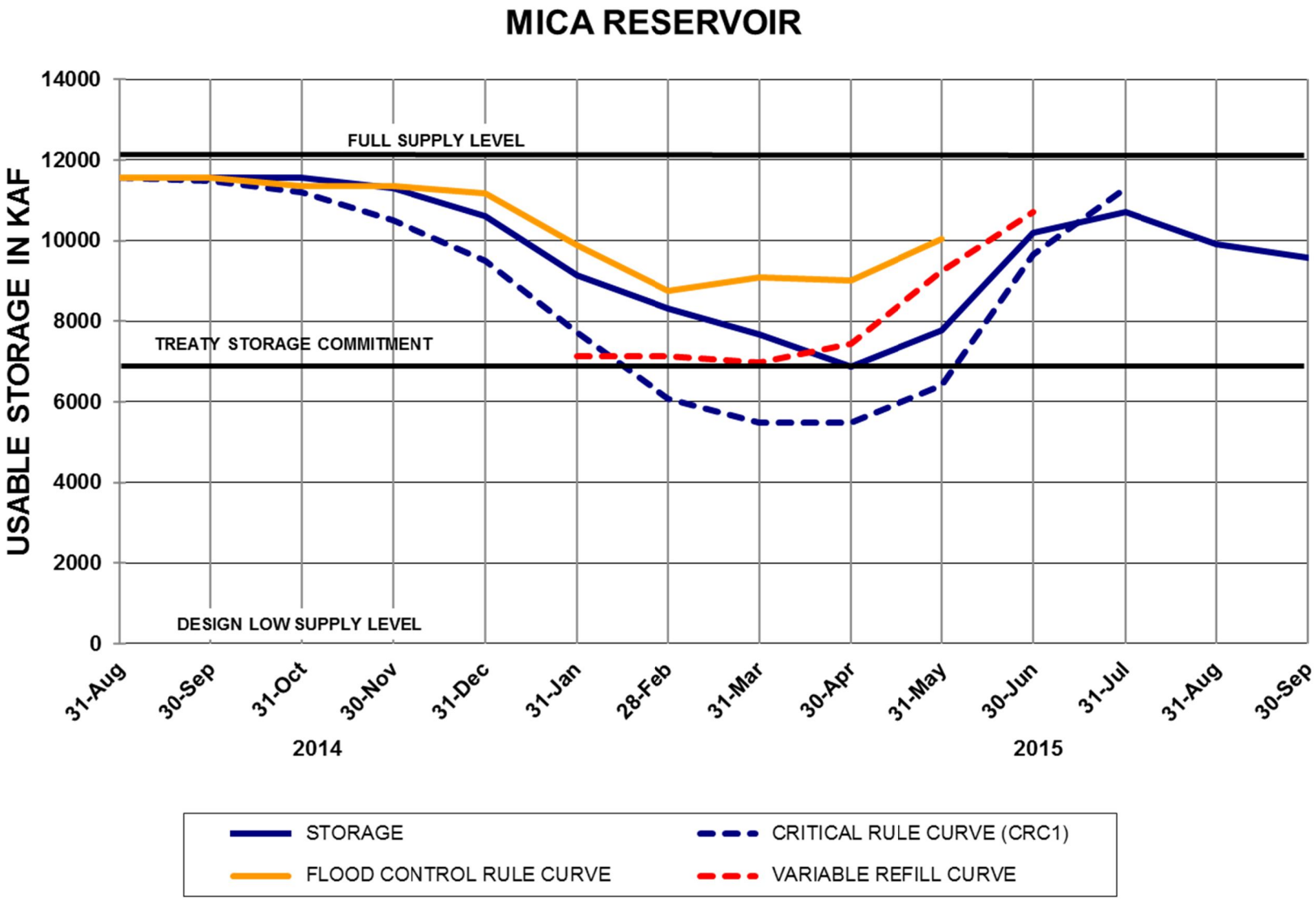
2014
2015
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE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USABLE STORAGE IN KAF
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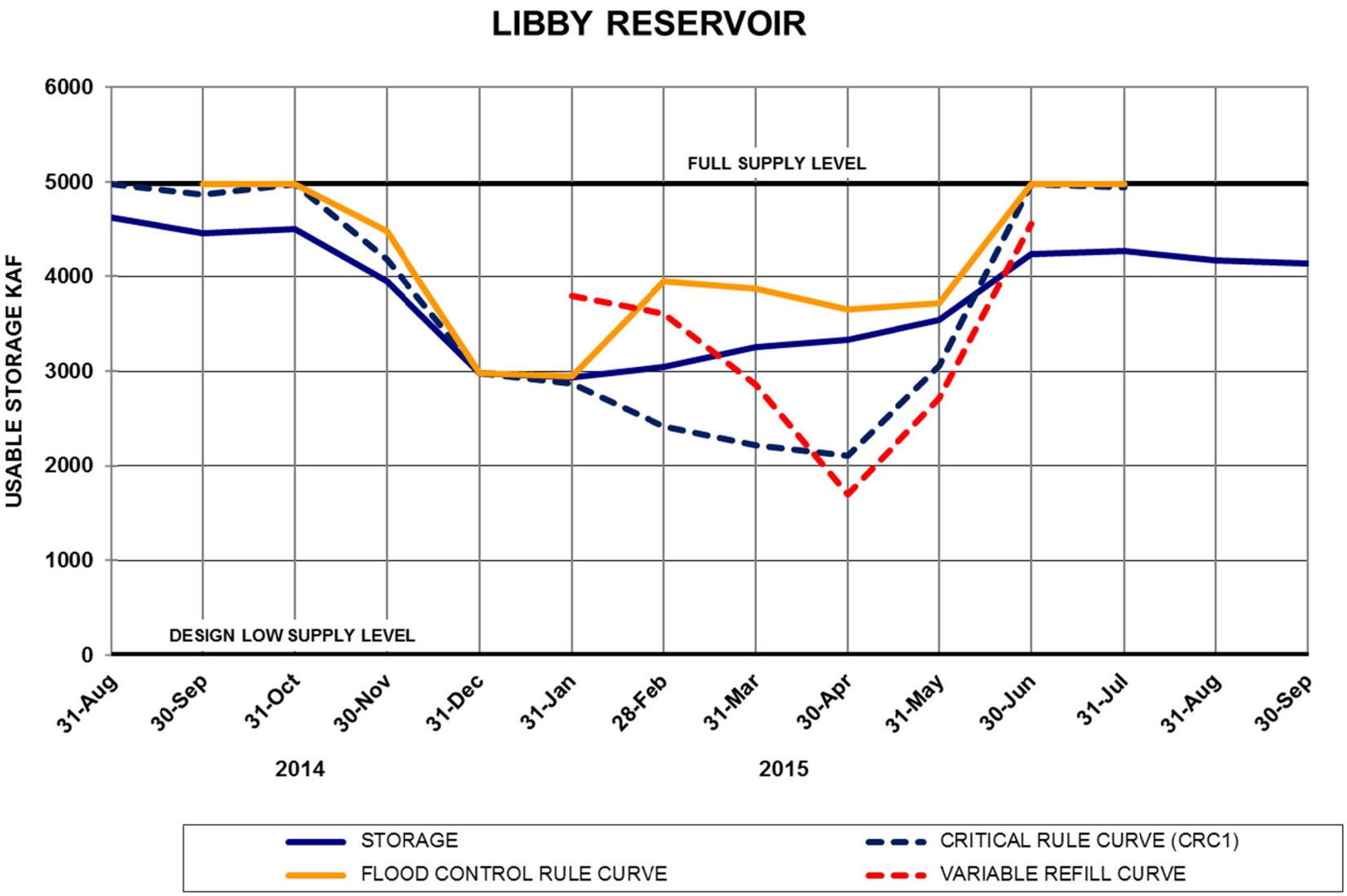
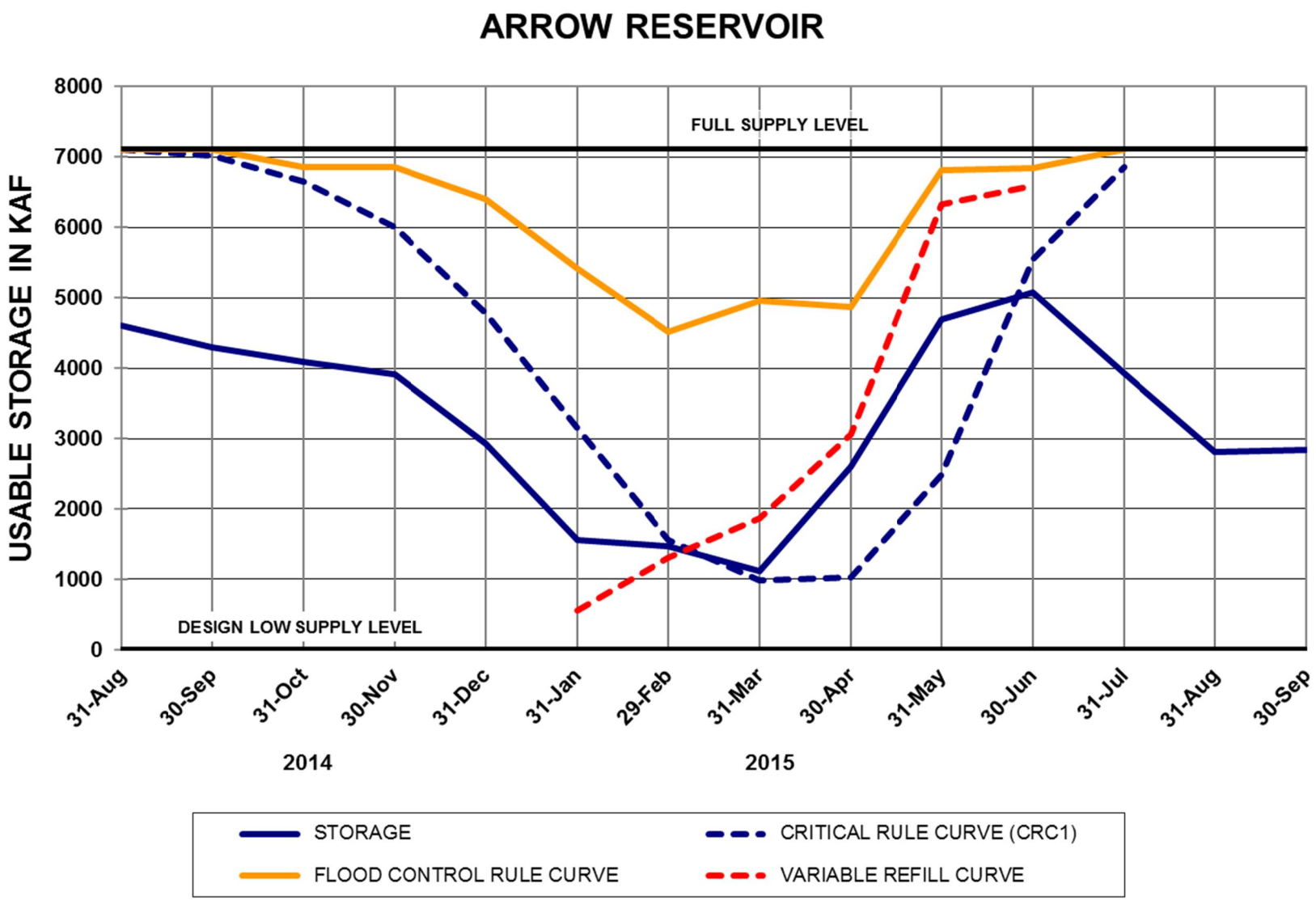
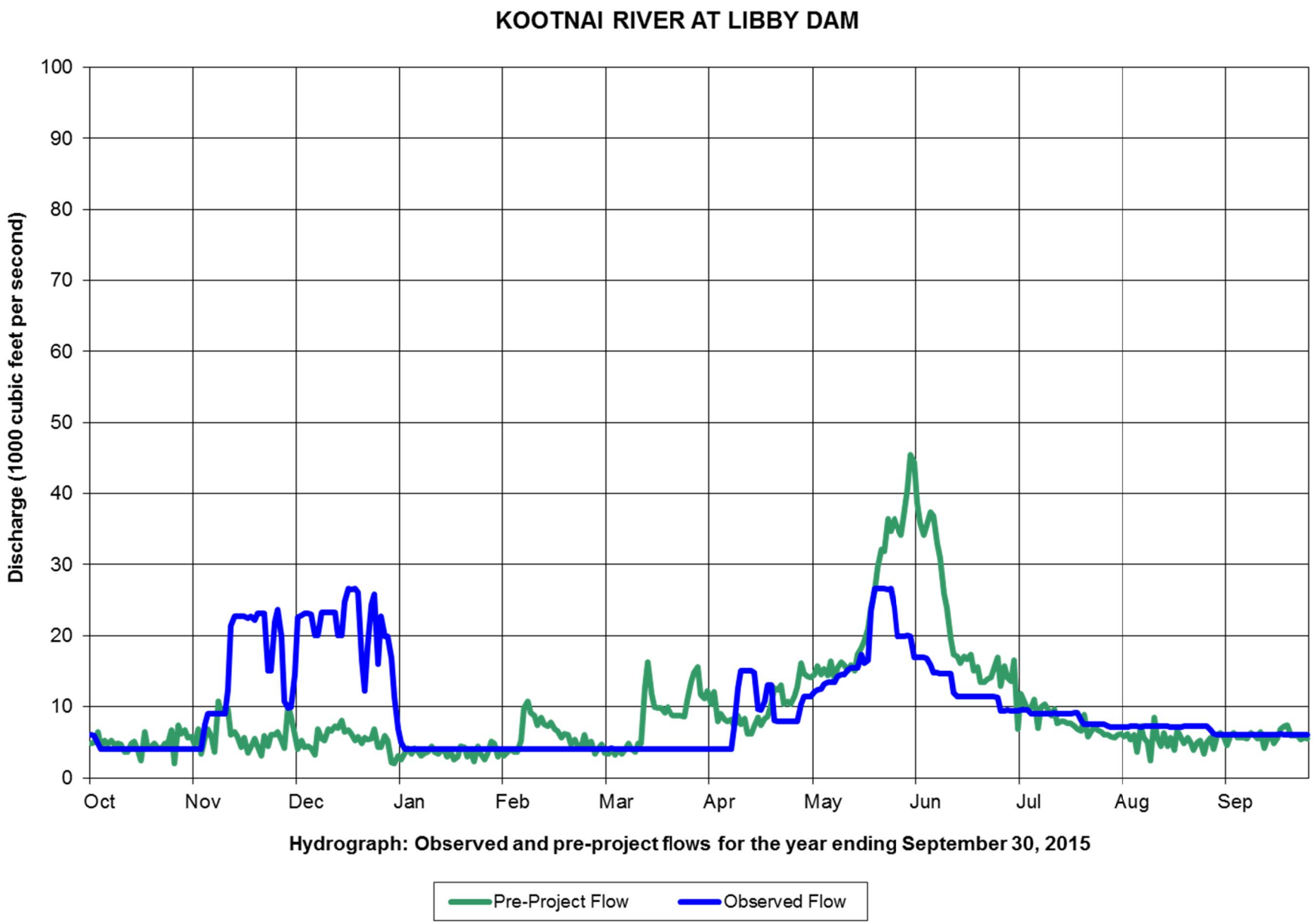
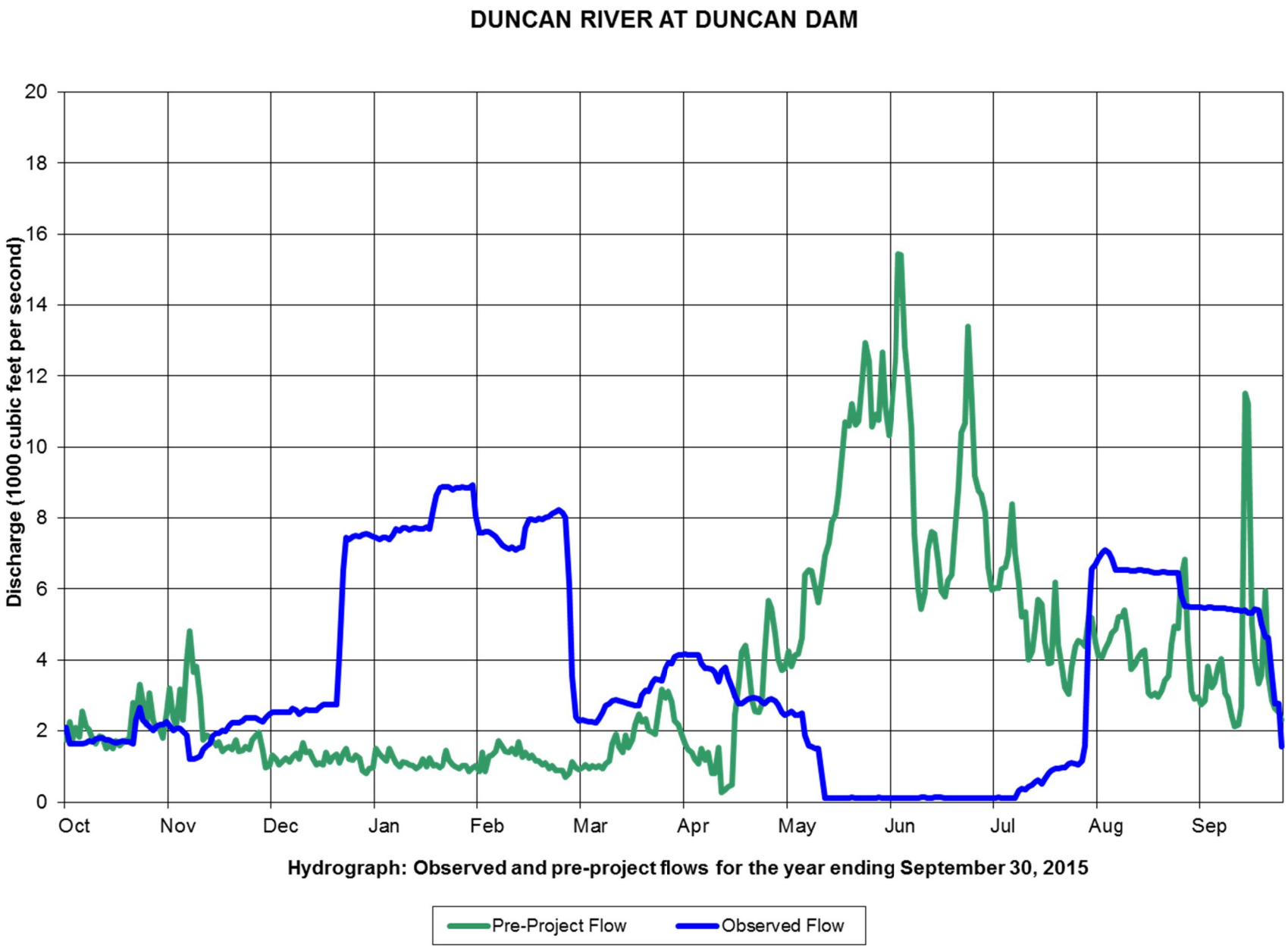
FULL SUPPLY LEVEL
TREATY STORAGE COMMITMENT
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
28-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2014
2015
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

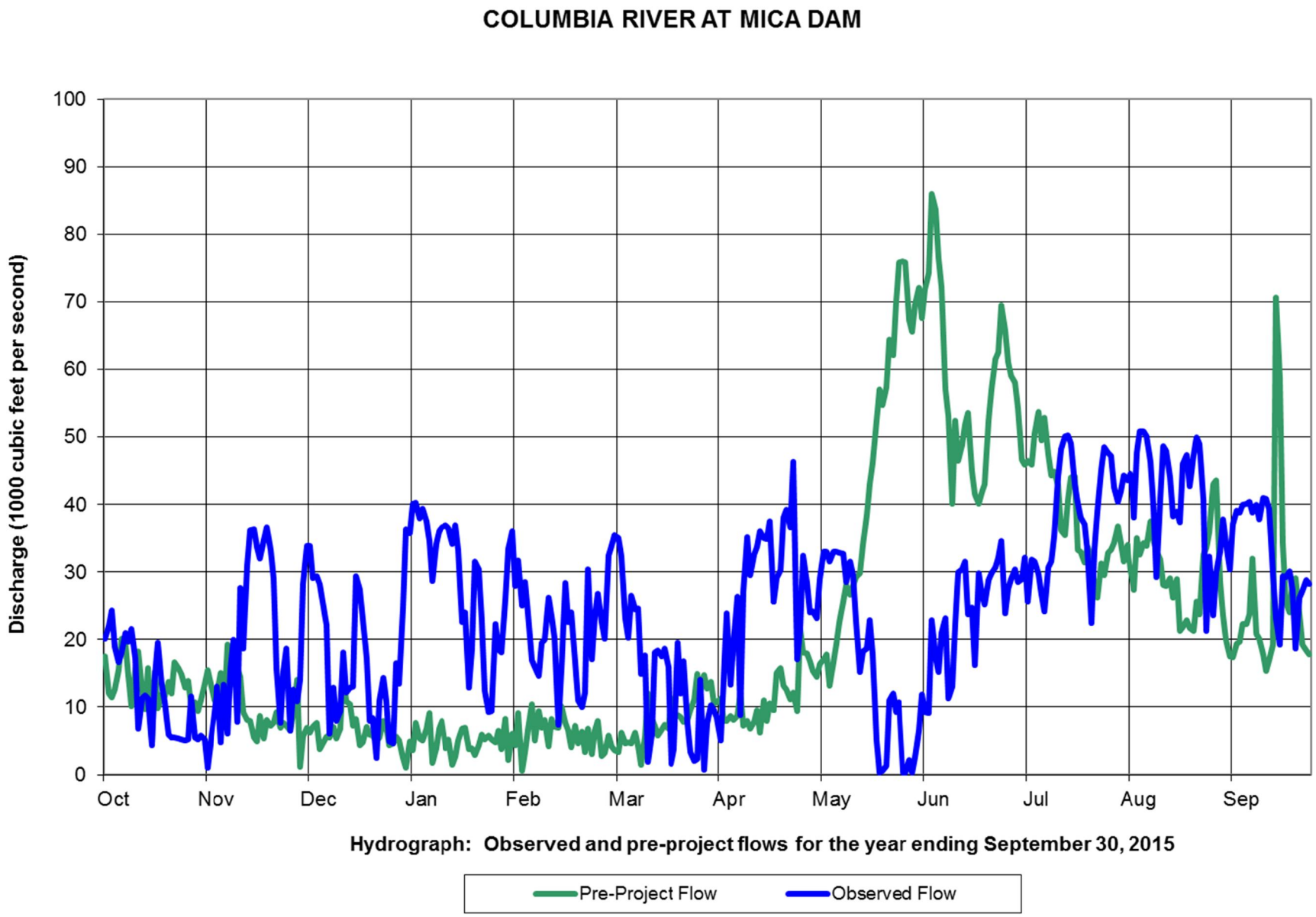

LIBBY RESERVOIR
USABLE STORAGE KAF
6000
5000
4000
3000
2000
1000
0
FULL SUPPLY LEVEL
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
28-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2014
2015
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

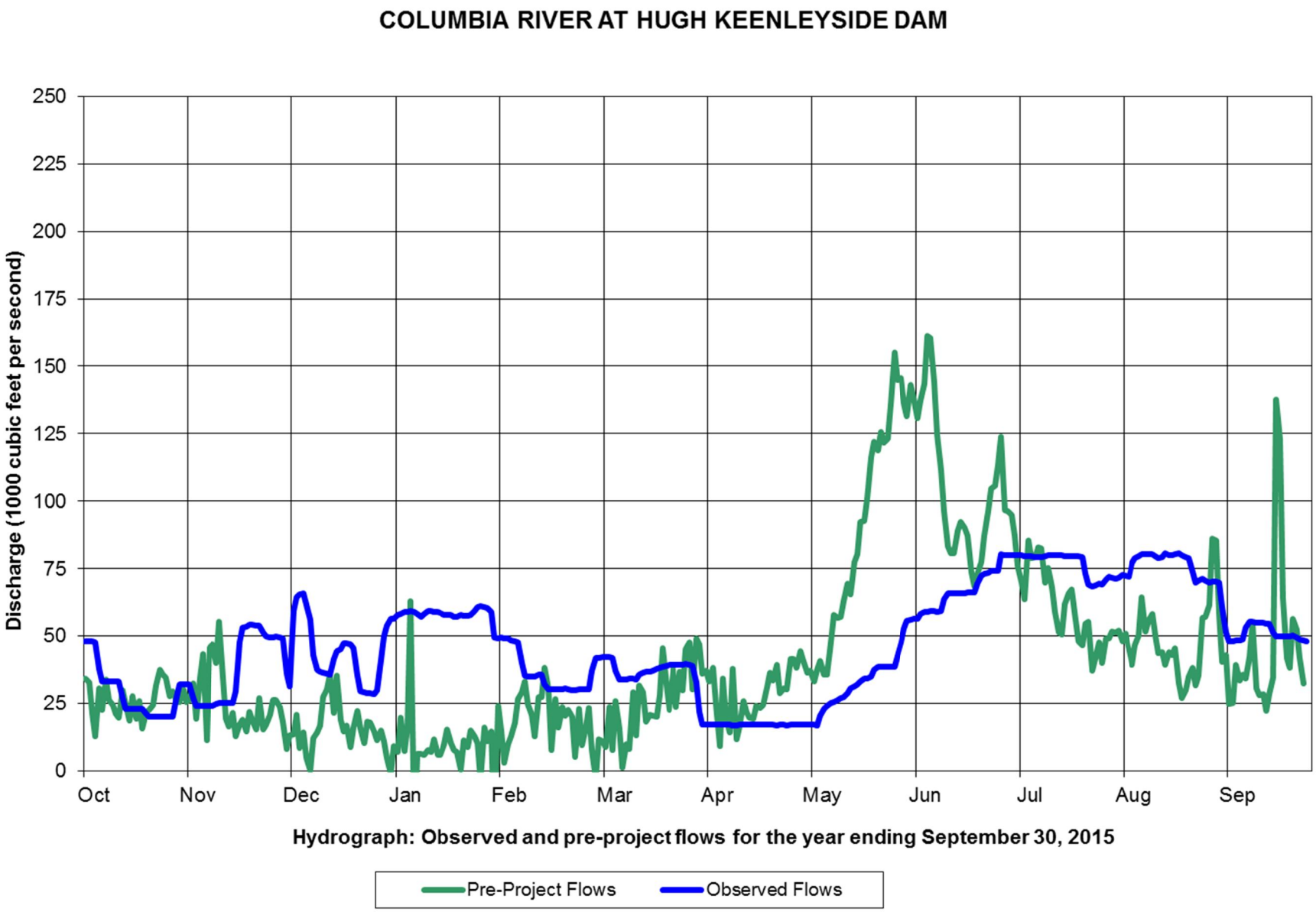

ARROW RESERVOIR
USABLE STORAGE IN KAF
8000
7000
6000
5000
4000
3000
2000
1000
0
FULL SUPPLY LEVEL
DESIGN LOW SUPPLY LEVEL
31-Aug
30-Sep
31-Oct
30-Nov
31-Dec
31-Jan
29-Feb
31-Mar
30-Apr
31-May
30-Jun
31-Jul
31-Aug
30-Sep
2014
2015
STORAGE
CRITICAL RULE CURVE (CRC1)
FLOOD CONTROL RULE CURVE
VARIABLE REFILL CURVE

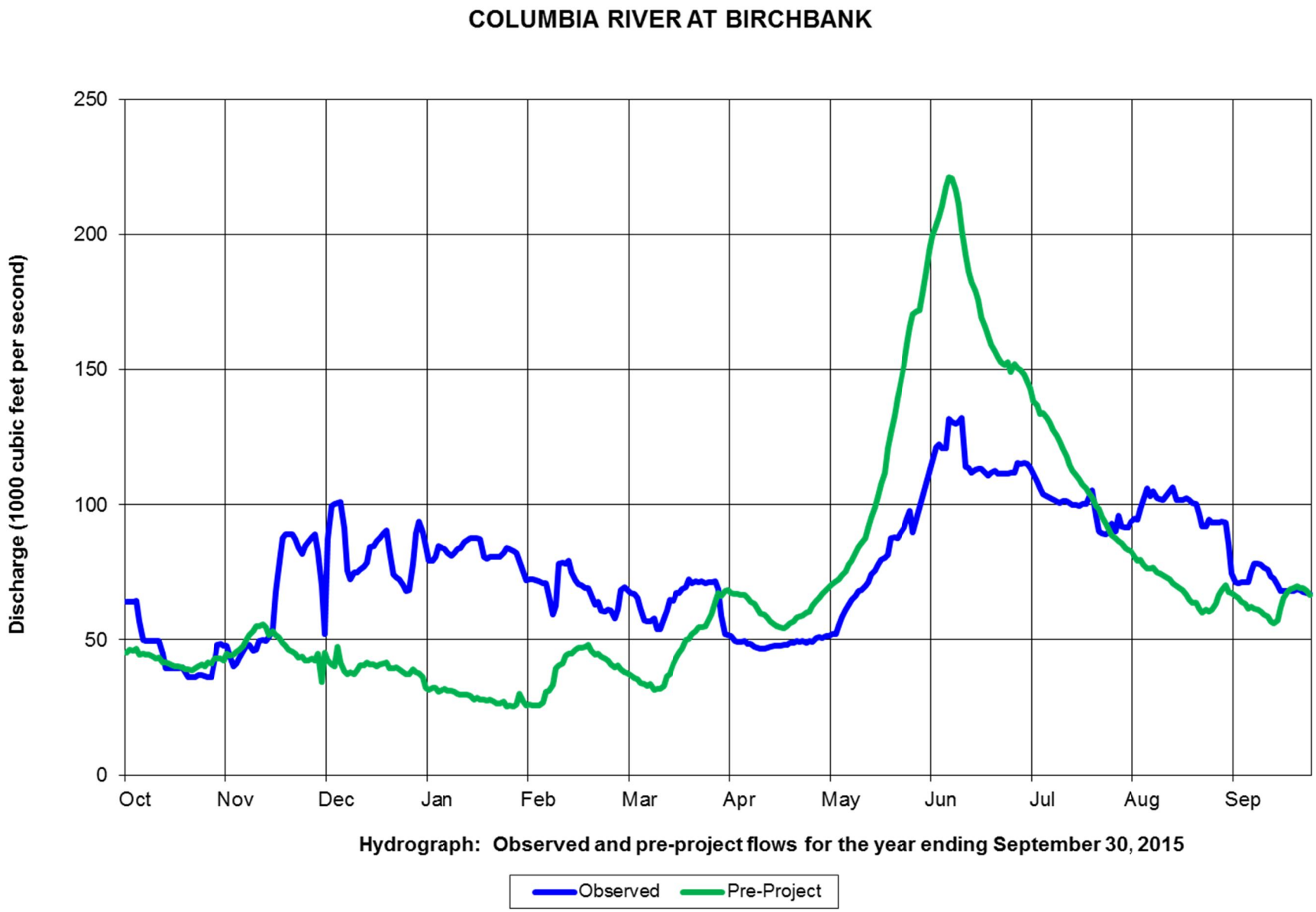

KOOTNAI RIVER AT LIBBY DAM
Discharge (1000 cubic feet per second)
100
90
80
70
60
50
40
30
20
10
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2015
Pre-Project Flow
Observed Flow



Hydrograph: Observed and pre-project flows for the year ending September 30, 2015


COLUMBIA RIVER AT MICA DAM
Discharge (1000 cubic feet per second)
100
90
80
70
60
50
40
30
20
10
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2015
Pre-Project Flow
Observed Flow


COLUMBIA RIVER AT HUGH KEENLEYSIDE DAM
Discharge (1000 cubic feet per second)
250
225
200
175
150
125
100
75
50
25
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2015
Pre-Project Flows
Observed Flows


COLUMBIA RIVER AT BIRCHBANK
Discharge (1000 cubic feet per second)
250
200
150
100
50
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Hydrograph: Observed and pre-project flows for the year ending September 30, 2015
Observed
Pre-Project

TREATY BENEFITS

Flood Risk Management Benefits

Water Year 2015 was a quiet flood risk management season due to the low seasonal volumes. There was less snow pack across the basin and less late season rainfall than in previous years resulting in no local flood risk issues. Reservoirs throughout the Columbia River basin, including the Treaty projects, were drafted during the winter and spring in preparation for flood season. The actual runoff for the overall Columbia basin (US and Canada combined) measured at The Dalles for January through July 2015 was 103.2 km^3 (83.7 Maf), 83 percent of normal. The peak regulated and estimated unregulated flows, and river stages are shown in the following tables:

Columbia River Steam flow at The Dalles, Oregon

Date	Peak Unregulated Flow m^3/s (cfs)	Date	Peak Regulated Flow m^3/s (cfs)
4 June 2015	10,025 m^3/s (354 kcfs)	2 April 2015	6,300 m3/s (223 kcfs)[1]

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

Date	Peak Unregulated **Stage** meters (feet)	Date	Peak Regulated Stage meters (feet)
4 June 2015	3.12 m (10.3 ft)	4 Apr 2015	2.23 m (7.3 ft)[2]

Hydroregulation by Duncan and Libby projects limited the peak level of Kootenay Lake to 532.55 m (1747.2 ft) on 9 June 2015. Without regulation from those Treaty dams, the peak level would have been approximately 533.7 m (1751.0 ft). As documented in the 2003 Flood Control Operating Plan, flood damages commence at Nelson when Kootenay Lake elevation reaches 534.92 m (1755.0 ft). Duncan, Keenleyside, Mica and Libby projects limited the peak flow of the Columbia River at Trail, just upstream of Birchbank, British Columbia, to 3,737 m^3/s (132 kcfs) on 14 June 2015. Absent the dams but with natural lake effects at Kootenay Lake, the flow would have been approximately 6,258 m^3/s (~221 kcfs). For reference, the bankfull flow at Birchbank is estimated to be 6,371 m^3/s (225 kcfs).

[1] The peak regulated flow at The Dalles during the reporting period was 7,000 m^3/s (247.2 kcfs) that occurred on 13 February 2015.

[2] The peak observed regulated stage at the Vancouver gage during the reporting period was 3.3 m (10.81 ft) occurred on 11 February 2015.

Power Benefits

A DDPB is computed in conjunction with the AOP. This computation represents the optimized generation from downstream US projects that could have been produced by an optimized Canadian/US system. The DDPB is prepared in accordance with the Treaty and Protocol, and other Entity Agreements. The Canadian Entitlement represents one-half of the DDPB. For the period 1 August 2014 through 31 July 2015, the Canadian Entitlement amount, before deducting transmission losses, was 479.9 aMW of energy, scheduled at rates up to 1369 MW. From 1 August 2015 through 30 September 2015, the amount, before deducting transmission losses, was 488.7 aMW of energy, scheduled at rates up to 1332 MW. During the course of the 2014-2015 Operating Year, the Canadian Entitlement deliveries were completed exactly as scheduled with no curtailment events.

Actual US power benefits from the operation of CRT storage are unknown and can only be roughly estimated. Treaty storage has such a large impact on the US system operation that its absence would significantly affect operating procedures, non-power requirements, loads and resources, and market conditions, thus making any benefit analysis highly speculative. A rough estimate of the impact on downstream US power generation during the 2014-2015 operating year, with and without the regulation of Canadian storage, based on the PNCA AER that includes minimum flow and spill requirements for US fishery objectives, is 597 aMW. In addition to the increase in average annual US power generation, the Treaty regulation also shifted the timing of generation from the freshet period into the winter months. No quantification of this benefit was reported by the Entities.

Other Benefits

While flood risk management and hydroelectric power generation interests remain the primary factors driving the operation of Treaty storage, the Canadian reservoir draft to provide firm energy during low runoff conditions can be beneficial for other purposes including fisheries benefits. During the near record low flows over the summer months, Canadian CRT reservoirs drafted below their normal refill curves providing higher flows than would have occurred had they been operated to the typical non-drought reservoir levels. Flows from Canadian projects into the US were driven by the following three factors:

- Proportional Draft: During particularly dry periods, the Treaty storage provided in Mica, Keenleyside and Duncan is drafted much more deeply than under normal inflow conditions, to ensure that the US power system is able to produce the agreed firm energy for each month. While these additional Canadian reservoir storage releases, referred to as Proportional Draft, are motivated by the CRT's firm power provisions, they also can provide flows useful for addressing other interests in the US and Canada.

- Nonpower Uses (Flow Augmentation) Agreement and Arrow Summer Storage Agreement: The provisions within the annual CRT Non-power Uses Agreement provide fisheries benefits in both Canada and the US Under the agreement, 1.23 km^3 (504 ksfd, 1 Maf) of water was stored in Canadian Treaty reservoirs by reducing the Treaty-specified releases in January 2015, outflows from Canadian Storage were shaped through the February – July period to meet multiple needs of both entities, and the stored water was later released during July 2015. Water above the TSR storage level at the end of July was managed through the Arrow Summer Storage Agreement to manage flows into September.

- NTSA Dry Year Provisions: The Non-Treaty Storage Agreement (NTSA) includes a dry year release provision that guarantees to BPA the release of 0.62 km^3(252 ksfd, 0.5 Maf) from Canadian storage projects during the driest 20 percent of runoff years as measured at The Dalles Dam in the US These dry conditions were met based on the May 2015 volume forecast and BPA requested release of 0.62 km^3 (252 ksfd, 0.5 Maf) of water in May and June per the NTSA.

Revelstoke Dam, Columbia River, BC

Cora Linn Dam (FortisBC) at the outflow of Kootenay Lake, British Columbia

APPENDIX A

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD

United States

Members

Mr. James C. Dalton, P.E., Chair
Chief
Engineering and Construction
US Army Corps of Engineers
Washington, DC

Mr. Ed Sienkiewicz
Consultant
Newberg, Oregon

Alternates

Mr. Robert A. Pietrowsky
Director
Institute for Water Resources
US Army Corps of Engineers
Alexandria, Virginia

Mr. Stephen R. Oliver
Consultant
Lake Oswego, Oregon

Secretaries

Mr. Jerry W. Webb, P.E., D.WRE
Principal Hydrologic & Hydraulic Engineer
Engineering & Construction CoP
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

Canada

Dr. Niall O'Dea, Chair
Director General
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

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

Mr. Glen Davidson, P.Eng.
Comptroller of Water Rights
Water Management Division
BC Ministry of Natural Resource Operations
Victoria, British Columbia

Mr. Les MacLaren
Assistant Deputy Minister
Electricity and Alternative Energy Branch
BC Ministry of Energy and Mines
Victoria, British Columbia

Mr. Darcy Blais
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

Members
Mr. Wendell Johnson* 1964–1970
Mr. Morgan Dubrow 1964–1970
Mr. John Neuberger 1970–1973
Mr. Joseph Caldwell* 1971–1973
Mr. Homer Willis* 1973–1979
Mr. King Mallory 1973–1975
Mr. Raymond Peck, Jr. 1976–1977
Mr. Emerson Harper 1978–1988
Mr. Lloyd Duscha* 1979–1990
Mr. Ronald Wilkerson 1988–2005
Mr. Herbert Kennon* 1990–1994
Mr. John Elmore* 1994–1996
Mr. Steven Stockton* 1996–2014
Mr. Ed Sienkiewicz 2005-
Mr. James Dalton* 2014-

Alternates
Mr. Fred Thrall 1964–1974
Mr. Emerson Harper 1964–1978
Mr. Alex Shwaiko 1974–1987
Mr. Herbert Kennon 1987–1990
Mr. Thomas Weaver 1979–1997
Mr. John Elmore 1990–1994
Mr. Paul Barber 1994–1995
Mr. Daniel Burns 1995–1997
Mr. George Bell 1997–2014
Mr. Earl Eiker 2000–2004
Mr. Robert Pietrowsky 2004-
Mr. Stephen Oliver 2015-

Secretaries
Mr. John Roche 1965–1969
Mr. Verle Farrow 1969–1972
Mr. Walter Duncan 1972–1978
Mr. Shapur Zanganeh 1978–1995
Mr. Richard DiBuono 1995–2000
Mr. Robert Bank 2000–2004
Mr. Jerry Webb 2004-

*Chair

Canada

Mr. Gordon McNabb* 1964–1991
Mr. Arthur Paget 1964–1973
Mr. Valter Raudsepp 1973–1974
Mr. Ben Marr 1974–1987
Mr. Tom Johnson 1987–1988
Mr. Douglas Horswill 1989–1991
Mr. John Allan 1991–1999
Mr. David Oulton* 1991–1996
Mr. Daniel Whelan* 1996–2002
Mr. Charles Kang 1999–2001
Mr. Jack Ebbels 2001–2003
Mr. Tim Newton 2003-
Mr. Tom Wallace* 2004–2012
Mr. Jonathan Will* 2012–2015
Dr. Niall O'Dea* 2015-

Mr. Mac Clark 1964–1992
Mr. Jim Rothwell 1964–1965
Mr. Hugh Hunt 1966–1988
Dr. Donald Kasianchuk 1988–1996
Mr. Vic Niemela 1992–1994
Mr. David Burpee 1994–2007
Mr. Jack Farrell 1996–1997
Mr. Prad Kharé 1997–1999
Mr. James Mattison 1999–2009
Mr. Ivan Harvie 2007–2015
Mr. Glen Davidson 2009-
Mr. Les MacLaren 2015-

Mr. Mac Clark 1964–1992
Mr. David Burpee 1992–2003
Ms. Eve Jasmin 2003–2007
Mr. Darcy Blais 2007-

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
ENGINEERING COMMITTEE

CURRENT MEMBERSHIP

United States

Members

Mr. Jerry W. Webb, P.E., D.WRE, Chair
Principal Hydrologic & Hydraulic Engineer
Engineering & Construction CoP
Directorate of Civil Works
US Army Corps of Engineers
Washington, DC

Mr. Kamau Sadiki
Manager
National Hydropower Program Business Line
Operations Community of Practice
US Army Corps of Engineers
Washington, DC

Mr. Thomas K. Patton, P.E.
Energy Management & Marketing Specialist
Power Marketing Division
Western Area Power Administration
Folsom, California

Mr. John Roache
Manager
River and Reservoir Operations Group
Pacific Northwest Regional Office
Bureau of Reclamation
Boise, Idaho

Canada

Mr. Darcy Blais, Chair
Senior Policy Advisor
Renewable and Electrical Energy Division
Electricity Resources Branch
Natural Resources Canada
Ottawa, Ontario

Mr. Chris Trumpy
Director
Generation and Regulatory
BC. Ministry of Energy and Mines
Victoria, British Columbia

Mr. KT Shum
Head, Licensing & Allocation
Water Management Division
BC Ministry of Natural Resource Operations
Victoria, British Columbia

COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
ENGINEERING COMMITTEE

RECORD OF MEMBERSHIP

United States

Members

Mr. Shapur Zanganeh* 1990-1995
Mr. Gary Fuqua 1990-1996
Mr. Earl Eiker 1990-2000
Mr. Steve Wright 1990-1996
Mr. Larry Eilts 1991-1995
Mr. Richard Mittelstadt 1991-1996
Mr. Richard DiBuono* 1995-2000
Mr. James Barton 1996-2001
Mr. Robert Johnson 1996-1998
Mr. James Fodrea 1997-2009
Mr. Michael Cowan 1998-2014
Mr. Robert Bank* 2000-2004
Mr. Kamau Sadiki 2001-
Mr. Jerry Webb* 2003-
Mr. Patrick McGrane 2009-2014
Mr. Thomas Patton 2014-
Mr. John Roache 2014-

*Chair

Canada

Mr. Neill Lyons* 1990-1996
Mr. Dave McCauley 1990-1992
Mr. B. Stipdonk 1990-1991
Mr. Roger McLaughlin* 1991-2009
Mr. Robin Round 1991-1993
Mr. David Burpee* 1992-2000
Dr. Bala Balachandran 1993-2008
Mr. Bruno Gobeil 1995-1997
Mr. Larry Adamache 1996-2001
Ms. Myriam Boudreault 1997-2001
Ms. Donna Clarke 2001-2003
Mr. Ivan Harvie* 2002-2015
Ms. Eve Jasmin 2003-2007
Mr. Darcy Blais* 2007-
Mr. KT Shum 2008-
Mr. Chris Trumpy 2015-

APPENDIX B

COLUMBIA RIVER TREATY ENTITIES

COLUMBIA RIVER TREATY ENTITIES

United States

Members

Mr. Elliot E. Mainzer, Acting Chair
Acting Administrator and CEO
Bonneville Power Administration
Department of Energy
Portland, Oregon

BG Scott Spellmon, Member
Division Engineer
US Army Engineer Division
Northwestern
Portland, Oregon

Coordinators

Mr. Richard Pendergrass, BPA Coordinator
Acting Vice President
Generation Supply
Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. David Ponganis, USACE Coordinator
Regional Director of Programs
Programs Directorate
US Army Engineer Division
Northwestern
Portland, Oregon

Secretaries

Ms. Birgit Koehler, Secretary
Regional Coordination
Power Operations and Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Canada

Mr. Christopher K. O'Riley, Chair
Deputy CEO
Generation
British Columbia Hydro and Power Authority
Vancouver, British Columbia

Ms. Renata Kurschner, Coordinator
Director
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Douglas A. Robinson, Secretary
Principal Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

COLUMBIA RIVER TREATY ENTITIES OPERATING COMMITTEE

CURRENT MEMBERSHIP

United States

Members

Ms. Pamela A. Kingsbury, Alternating Chair
Manager
Power and Operations Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Ms. Birgit Koehler, Member
Regional Coordination
Power and Operations Planning
Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. Steven B. Barton, Alternating Chair
Chief
Columbia Basin Water Management Division
US Army Engineer Division
Northwestern
Portland, Oregon

Ms. Julie H. Amman, Member
Chief, Reservoir Control Center
US Army Engineer Division
Northwestern
Portland, Oregon

Canada

Mr. Darren Sherbot, Chair
Manager
System Optimization
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Doug Robinson, Member
Principal Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Ms. Gillian Kong, Member
Specialist Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Herbert Louie, Member
Specialist Engineer
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

COLUMBIA RIVER TREATY ENTITIES HYDROMETEOROLOGICAL COMMITTEE

CURRENT MEMBERSHIP

United States

Members

Ms. Ann McManamon, Co-chair
Hydrologist
Bonneville Power Administration
Department of Energy
Portland, Oregon

Mr. William Proctor, Co-chair
Chief
Hydrologic Engineering and Power Branch
US Army Engineer Division
Northwestern
Portland, Oregon

Canada

Ms. Stephanie Smith, Chair
Manager
Hydrologic and Technical Services
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, British Columbia

Mr. Georg Jost, Member
Senior Engineer
Hydrology and Technical Services
Generation Resource Management
British Columbia Hydro and Power Authority
Burnaby, 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 2015

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7.21	5.60	21.80	9.37	7.38	8.47	16.40	15.50	25.60	11.60	8.95	8.37
2	6.78	5.81	26.40	7.58	7.35	8.50	15.60	17.90	26.10	11.90	8.89	7.64
3	6.10	5.70	26.50	7.01	7.28	8.37	14.60	19.30	27.00	12.10	8.44	7.29
4	5.14	10.20	26.10	7.22	7.24	8.16	13.90	19.50	25.70	11.80	8.85	6.99
5	5.30	12.30	25.90	7.00	7.32	8.18	13.30	19.20	23.00	11.70	8.16	7.50
6	5.59	12.40	25.80	6.94	9.40	8.14	12.80	19.70	22.20	11.80	8.63	7.32
7	5.41	12.20	23.40	7.14	16.50	8.00	12.40	19.80	22.00	11.70	8.25	7.21
8	5.08	12.00	23.30	7.01	23.60	7.88	12.10	19.80	21.70	11.40	8.65	7.10
9	5.20	11.60	25.40	6.91	23.80	7.83	11.70	20.20	21.10	11.30	8.57	7.21
10	5.18	11.60	26.50	6.75	21.30	7.85	11.50	20.30	19.90	10.60	8.30	7.30
11	5.20	14.90	27.20	6.70	19.50	7.96	11.20	20.40	19.00	11.20	8.26	7.44
12	5.50	22.70	28.00	6.73	17.80	7.72	13.80	20.60	18.20	11.10	8.43	7.22
13	5.43	24.00	27.80	6.71	16.50	8.07	19.10	21.30	18.20	10.60	8.14	7.01
14	5.42	24.00	25.10	6.72	15.60	8.77	21.40	21.60	18.10	10.50	8.82	7.18
15	5.22	24.10	24.90	6.67	15.10	13.10	21.50	21.60	18.10	10.80	8.43	7.11
16	5.27	23.80	28.70	6.64	14.30	26.10	21.30	22.00	17.60	10.40	8.12	7.29
17	5.39	23.90	29.70	6.77	13.50	29.40	21.10	22.70	15.20	10.70	7.99	7.27
18	5.22	24.30	30.10	6.82	12.90	24.00	20.30	22.70	14.70	10.60	7.93	7.04
19	5.33	23.70	30.00	6.67	12.30	20.10	16.90	22.50	14.70	10.60	8.28	6.74
20	5.28	24.50	27.80	6.67	11.60	18.10	16.10	22.30	14.30	10.40	8.70	6.82
21	5.38	24.60	20.90	6.60	11.10	17.10	17.80	23.00	14.10	10.60	7.91	6.75
22	5.14	23.60	17.30	6.46	10.50	17.10	20.20	23.60	14.30	10.70	8.29	7.27
23	5.67	17.70	22.60	6.51	10.10	16.70	19.90	30.20	14.00	10.50	8.24	7.21
24	5.95	17.40	27.40	6.44	9.80	16.20	16.00	32.70	13.90	10.40	7.97	7.28
25	6.22	23.40	26.90	6.76	9.60	15.60	15.20	33.10	14.10	9.30	7.99	7.07
26	5.68	24.80	20.90	7.30	9.30	14.70	14.90	32.90	14.00	8.85	7.92	6.64
27	5.79	21.10	24.80	7.49	9.07	14.60	14.80	32.70	13.80	9.02	8.44	6.99
28	5.42	15.50	23.30	7.70	8.87	15.80	14.70	32.20	13.80	8.91	8.30	7.00
29	5.44	20.00	22.60	7.69		18.80	15.10	32.00	13.60	9.09	8.69	7.20
30	5.94	20.00	18.80	7.68		18.40	15.50	28.60	13.00	9.10	8.20	7.18
31	5.83		13.40	7.48		17.30		26.30		8.75	8.33	
Mean	**5.57**	**17.91**	**24.82**	**7.04**	**12.81**	**13.77**	**16.04**	**23.75**	**18.03**	**10.58**	**8.36**	**7.19**

KOOTENAI RIVER AT BIRCHBANK, BRITISH COLUMBIA

Daily discharges in thousands of cubic feet per second for the year ending 30 September 2015

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	64.00	47.90	52.27	84.71	71.98	61.15	68.64	50.66	91.20	112.02	90.19	93.40
2	64.09	44.19	87.22	79.27	72.27	68.44	59.02	50.92	93.00	115.40	95.91	93.56
3	64.03	40.22	99.45	79.18	72.27	69.46	52.11	50.83	98.50	115.05	91.87	93.91
4	64.31	41.11	100.42	80.80	72.04	68.43	51.80	51.23	104.20	115.57	91.41	93.25
5	56.76	43.36	100.69	84.82	71.66	67.33	51.47	51.57	112.60	115.02	91.53	85.53
6	49.80	45.91	100.93	83.85	71.03	66.85	49.73	52.17	118.70	113.56	93.76	74.42
7	49.65	47.65	91.07	83.75	71.12	65.37	49.27	52.25	121.42	111.32	94.69	71.30
8	49.56	48.10	75.81	82.29	66.36	61.57	49.27	55.31	122.50	108.55	94.47	70.83
9	49.62	46.09	72.23	81.18	59.27	57.12	49.55	58.43	120.84	105.95	98.31	71.46
10	49.62	46.18	75.05	82.15	62.53	56.87	48.51	61.02	121.02	103.86	101.89	71.48
11	49.47	49.58	74.91	83.71	78.11	57.00	48.65	62.90	131.59	103.10	106.05	71.49
12	44.74	49.79	76.04	83.93	78.64	57.84	47.34	64.97	130.52	102.50	103.03	75.26
13	39.49	49.63	77.00	86.15	78.17	53.81	46.95	66.11	129.80	101.90	104.86	78.12
14	39.39	50.90	78.43	87.01	79.19	53.89	46.77	67.92	130.51	101.10	102.50	78.10
15	39.47	53.84	84.52	87.48	75.10	57.79	46.68	68.52	132.07	100.64	102.12	77.96
16	39.50	67.68	84.60	87.68	71.95	60.89	47.00	69.69	113.97	101.43	101.54	76.90
17	39.50	76.52	86.53	87.70	70.42	64.87	47.56	71.16	113.67	101.35	103.50	76.11
18	39.66	87.66	87.47	87.10	70.34	64.34	47.77	74.17	111.85	100.71	104.80	73.54
19	37.88	89.01	89.32	80.55	69.03	67.19	47.77	75.79	113.03	99.78	106.28	72.66
20	36.35	88.95	90.54	79.96	69.18	67.37	47.90	77.69	113.19	99.90	101.72	70.22
21	36.22	89.07	82.89	80.88	65.00	68.60	48.30	79.46	113.34	99.66	101.70	67.99
22	36.16	87.09	74.25	80.86	62.94	69.54	48.00	80.39	111.82	100.10	101.73	68.06
23	36.81	84.19	73.08	80.77	64.18	72.22	48.70	81.38	110.77	100.20	102.38	68.01
24	36.90	81.71	72.40	80.68	60.64	70.95	48.94	87.46	111.77	103.00	101.67	68.18
25	36.64	84.85	70.15	82.20	60.53	71.62	49.70	87.85	112.59	105.47	100.60	68.05
26	36.11	86.27	68.09	83.94	61.20	71.18	49.32	87.74	111.50	95.76	100.23	68.71
27	36.31	88.14	68.39	83.46	60.81	71.52	49.49	89.54	111.46	90.20	96.65	68.54
28	41.75	89.03	78.28	82.92	57.97	71.09	48.78	91.51	111.61	89.25	92.06	67.73
29	48.19	82.69	89.55	82.34		71.23	49.57	94.99	111.52	88.89	92.08	67.28
30	48.38	69.79	93.67	81.00		71.48	49.25	97.72	111.83	89.63	94.54	66.94
31	47.78		89.78	79.80		71.57		89.72		93.01	93.48	
Mean	**45.42**	**65.24**	**82.10**	**82.97**	**68.71**	**65.44**	**49.79**	**71.00**	**114.75**	**102.71**	**98.63**	**74.97**

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

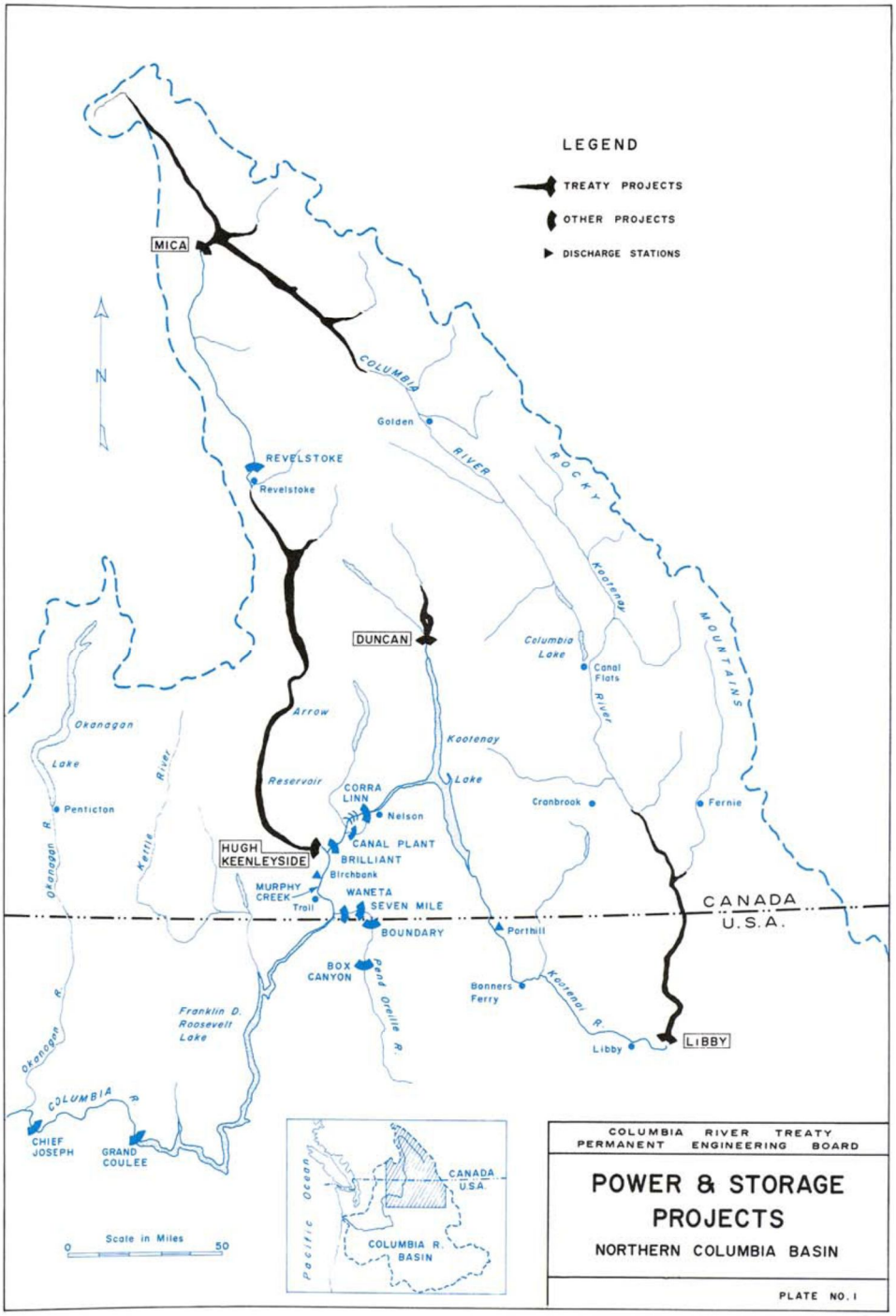

LEGEND
TREATY PROJECTS
OTHER PROJECTS
DISCHARGE STATIONS
MICA
N
COLUMBIA
RIVER
ROCKY
MOUNTAINS
Golden
REVELSTOKE
Revelstoke
DUNCAN
Columbia Lake
Canal Flats
Kootenay
River
Arrow
Reservoir
Okanagan
Lake
Penticton
Okanagan R.
Kettle
River
Kootenay
Lake
CORRA LINN
Nelson
CANAL PLANT
BRILLIANT
HUGH KEENLEYSIDE
Birchbank
MURPHY CREEK
Trail
WANETA
SEVEN MILE
BOUNDARY
Cranbrook
Fernie
CANADA
U.S.A.
Porthill
BOX CANYON
Pend Oreille R.
Bonners Ferry
Kootenai R.
Libby
LIBBY
Franklin D. Roosevelt Lake
Okanagan R.
COLUMBIA
CHIEF JOSEPH
GRAND COULEE
Scale in Miles
0
50
Pacific Ocean
CANADA
U.S.A.
COLUMBIA R. BASIN
COLUMBIA RIVER TREATY
PERMANENT ENGINEERING BOARD
POWER & STORAGE PROJECTS
NORTHERN COLUMBIA BASIN
PLATE NO. 1

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 ft)
Normal minimum pool elevation	547 m (1794 ft)
Surface area at full pool	7290 hectares (18,000 acres)
Total storage capacity	1.77 km^3 (1.43 Maf)
Usable storage capacity	1.73 km^3 (1.40 Maf)
Treaty storage commitment	1.73 km^3 (1.40 Maf)

Dam, Earthfill

Crest elevation	581 m (1907 ft)
Length	792 m (2600 ft)
Approximate height above riverbed	39.6 m (130 ft)
Spillway – Maximum capacity	1350 m^3/sec (47.7 kcfs)
Discharge tunnels – Maximum capacity	570 m^3/sec (20.0 kcfs)

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 ft)
Normal minimum pool elevation	420 m (1378 ft)
Surface area at full pool	52,610 hectares (130,000 acres)
Total storage capacity	10.3 km^3 (8.34 Maf)
Usable storage capacity	8.8 km^3 (7.10 Maf)
Treaty storage commitment	8.8 km^3 (7.10 Maf)

Dam, Concrete Gravity and Earthfill

Crest elevation	445 m (1459 ft)
Length	869 m (2850 ft)
Approximate height above riverbed	52 m (170 ft)
Spillway – Maximum capacity	6800 m^3/sec (240 kcfs)
Low-level outlets – Maximum capacity	3740 m^3/sec (132 kcfs)

Power Facilities

Currently installed:

2 units at 92.5 MW	185 MW
Power commercially available	2002
Head at full pool (Gross maximum head)	23.5 m (77 ft)
Maximum turbine discharge	1200 m^3/sec (42.4 kcfs)

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 ft)
Normal minimum pool elevation	707.1 m (2320 ft)
Surface area at full pool	42,900 hectares (106,000 acres)
Total storage capacity	24.7 km^3 (20 Maf)
Usable storage capacity	14.8 km^3 (12 Maf)
Treaty storage commitment	8.6 km^3 (7 Maf)

Dam, Earthfill

Crest elevation	762.0 m (2500 ft)
Length	792.5 m (2600 ft)
Approximate height above foundation	244 m (800 ft)
Spillway – Maximum capacity	4250 m^3/sec (150 kcfs)
Outlet works – Maximum capacity	1060 m^3/sec (37.4 kcfs)

Power Facilities

Designed ultimate installation:

6 units at 450 MW	2700 MW

Currently installed:

4 units at 451 MW	1805 MW
Power commercially available	1976
Head at full pool	183 m (600 ft)
Maximum turbine discharge of 4 units at full pool	1080 m^3/sec (38.2 kcfs)

Currently under-construction (expected completion by 2016):

2 units at 520 MW	1040 MW

TABLE 4

LIBBY PROJECT

Libby Dam and Lake Koocanusa

Storage Project

Construction began	June 1966
Storage became fully operational	17 April 1973

Reservoir

Normal full pool elevation	749.5 m (2459 ft)
Normal minimum pool elevation	697.1 m (2287 ft)
Surface area at full pool	18,820 hectares (46,500 acres)
Total storage capacity	7.2 km^3 (5.87 Maf)
Usable storage capacity	6.1 km^3 (4.98 Maf)

Dam, Concrete Gravity

Deck elevation	753.5 m (2472 ft)
Length	931.2 m (3055 ft)
Approximate height above riverbed	112.8 m (370 ft.)
Spillway – Maximum capacity	4110 m^3/sec (145 kcfs)
Low-level outlets – Maximum capacity	1730 m^3/sec (61 kcfs)

Power Facilities

Designed ultimate installation:

8 units at 105 MW	840 MW

Currently installed:

5 units at 120 MW	600 MW
Power commercially available	1975
Head at full pool	107 m (352 ft)
Maximum turbine discharge of 5 units at full pool	750 m^3/sec (26.5 kcfs)