COLUMBIA RIVER TREATY

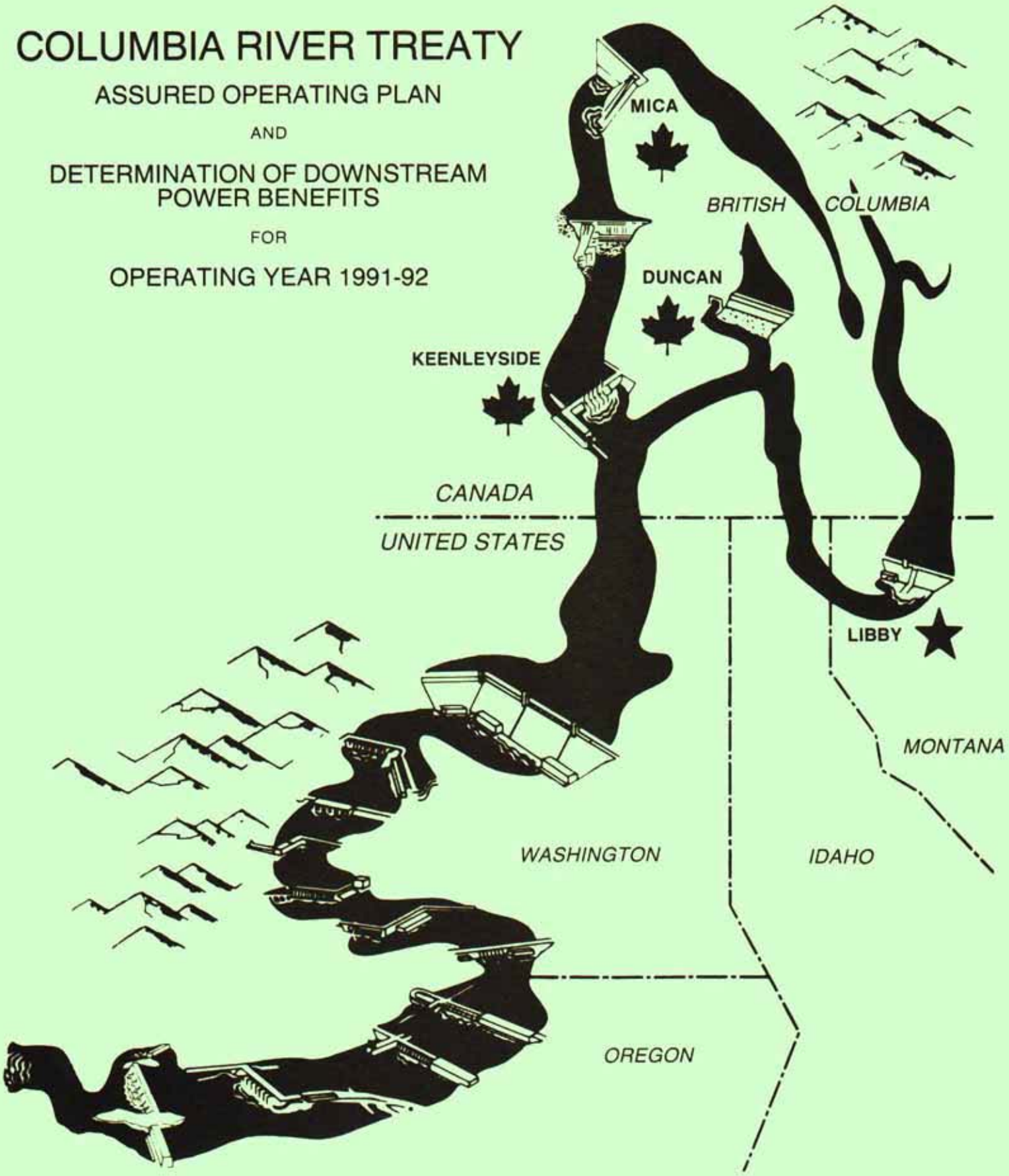
ASSURED OPERATING PLAN

AND

DETERMINATION OF DOWNSTREAM POWER BENEFITS

FOR

OPERATING YEAR 1991-92



COLUMBIA RIVER TREATY OPERATING COMMITTEE

NOVEMBER 1986

COLUMBIA RIVER TREATY
HYDROELECTRIC OPERATING PLAN

ASSURED OPERATING PLAN
FOR OPERATING YEAR 1991-92

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Assured Operating Plan for
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INTRODUCTION

The treaty between Canada and the United States of America relating to the cooperative development of the water resources of the Columbia River Basin requires that each year an Assured Operating Plan be agreed to by the Entities for the operation of the Columbia River Treaty storage in Canada during the sixth succeeding year. This plan will provide to the Entities information for the sixth succeeding year for planning the power systems in their respective countries which are dependent on or coordinated with the operation of the Canadian storage projects. The data assumed for this Assured Operating Plan will undergo review by the Entities immediately prior to the 1991-92 operating year and such data may be revised to reflect data and criteria current at that time. Should the Entities fail to agree on such revisions, then this Assured Operating Plan will form the basis for the Detailed Operating Plan for 1991-92.

This Assured Operating Plan was prepared in accordance with the principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans.[1] It is based on criteria contained in Annex A and Annex B of the Columbia River Treaty,[2] Protocol,[3] Terms of Sale,[4] and the Columbia River Treaty Flood Control Operating Plan.[5]

The Assured Operating Plan consists of:

(a) The Operating Rule Curve for the whole of the Canadian storage, computed from the individual project Critical Rule Curves, Assured Refill Curves and Variable Refill Curves, and the individual project Upper Rule Curves.

(b) Operating Rules which specifically designate criteria for operation of the Canadian storage in accordance with the principles contained in the above references.

A 30-year System Regulation Study[6] was utilized to develop and test the operating rules and rule curves. It contains the agreed-upon operating constraints such as maximum and minimum project elevations and discharges.

SYSTEM REGULATION STUDIES

In accordance with Annex A, Paragraph 7, of the Treaty, the Columbia River Treaty Operating Committee conducted system regulation studies reflecting Canadian storage operation for optimum generation in both Canada and the United States. Downstream power benefits were computed with the Canadian storage operation based on the operating rules specified herein. There is a reduction of 3.5 average megawatts of annual usable energy in the Canadian Entitlement to downstream power benefits. This is within the limits specified by the Treaty.

System Regulation Studies for the Assured Operating Plan were based on 1991-92 estimated loads and resources in British Columbia and in the United States Pacific Northwest System. The Entities have agreed that the 1991-92 Assured Operating Plan would be based on a 30-year streamflow period and an operating year of 1 August to 31 July. Historical flows for the period August 1928 through July 1958, modified to estimated 1991-92 conditions, were used. The steamflows were

derived from the 1970 Level Modified Streamflows[7] with an update in irrigation depletion estimates from the 1980 Level Modified Streamflows[8]

The Critical Rule Curve for these studies was determined from Bonneville Power Administration Study 92-41. The study indicated a 42-month critical period for the United States system resulting from the low flows during the period from 1 September 1928 through February 1932. It was assumed that all reservoirs, both in the United States and Canada, were full at the beginning of the critical period except where minimum release requirements made this impossible.

In the studies, individual project flood control criteria were followed. Flood Control and Variable Refill Criteria are based on historical inflow volumes. Although only 7.0 million acre-feet of usable storage at Mica is committed for power operation purposes under the Treaty, the Columbia River Treaty Flood Control Operating Plan provides for the full draft of the total 12 million acre-feet of storage at Mica in an on-call flood control situation.

DETERMINATION OF OPTIMUM GENERATION IN CANADA AND THE UNITED STATES

In order to determine whether optimum generation in both Canada and the United States was achieved in the system regulation studies, the following three quantities were computed for both the Canadian and United States systems:

(a) firm energy capability,

(b) dependable peaking capability,

(c) average annual usable secondary energy.

In the studies for the 1991-92 Assured Operating Plan, the Canadian storage operation was operated to achieve a weighted sum of the three quantities that was

greater than the weighted sum achieved under an operation of Canadian storage for optimum generation in the United States alone.

The table on page 5 shows the results from the studies adopted for the 1991-92 Assured Operating Plan and from studies designed to achieve optimum generation in the United States.

The Columbia River Treaty Operating Committee agreed that for the 1991-92 Assured Operating Plan the three quantities would be assigned the following relative values:

Quantity	Relative Value
firm energy capability (Avg. MW)	3
dependable peaking capability (MW)	1
average annual usable secondary energy (Avg. MW)	2

The three quantities were added after weighting on this basis and there was a net gain to the combined Canadian and United States systems with the study designed for optimum generation in Canada and the United States.

OPERATING RULE CURVES

The operation of Canadian storage during the 1991-92 Operating Year shall be guided by an Operating Rule Curve for the whole of Canadian storage, Flood Control Storage Reservation Curves for the individual projects, and operating rules for specific projects. The Operating Rule Curve is derived from the various curves described below. These curves are first determined for the individual Canadian projects, which in turn are used to determine Operating Rules Curves for the individual projects which are then summed to yield the Composite Operating Rule

COMPARISON OF ASSURED OPERATING PLAN STUDY RESULTS

	Optimum Generation in Canada and the United States	Optimum Generation in the United States			
	Study No. 92-41	Study No. 92-11	Net Gain	Weight	Value
1. Firm Energy Capability (Avg. MW)					
U.S. System1/	12,284.1	12,284.3	-0.2		
Canada (Mica + Rev.)2/	1,631.6	1,619.5	+12.1		
Total (Avg. MW)	13,915.7	13,903.8	+11.9	3	+35.7
2. Dependable Peaking Capacity (MW)					
U.S. System3/	31,392	31,392	0		
Canada (Mica + Rev.)4/	3,531	3,534	-3		
Total (MW)	34,923	34,926	-3	1	-3
3. Average Annual Usable Secondary Energy (Avg. MW)					
U.S. System5/	3,078.9	3,068.4	+10.5		
Canada (Mica + Rev.)6/	141.8	144.6	-2.8		
Total (Avg. MW)	3,220.7	3,213.0	+7.7	2	+15.4
				Total Value =	+48.1

1/ U.S. System firm energy capability was determined over the U.S. system critical period beginning 1 September 1928 and ending 29 February 1932.

2/ Canadian (Mica + Revelstoke) system firm energy capability was determined over the Canadian system critical period beginning 1 October 1940 and ending 30 April 1946.

3/ U.S. system dependable peaking capability was determined from January 1937.

4/ Canadian (Mica + Revelstoke) system dependable peaking capability was determined from December 1944.

5/ U.S. system 30-year average secondary energy limited to secondary market.

6/ Canadian (Mica and Revelstoke) 30-year average generation for the 92-11 and 92-41 were 1764.1 and 1773.4 respectively.

Curve for the whole of Canadian storage. This is in accordance with the provision of Article VII(2) of the Protocol.

(a) Critical Rule Curve. The Critical Rule Curve indicates the end-of-month storage content of Canadian storage during the critical period. It is designed to protect the ability of the United States system to serve firm load with the occurrence of flows no worse than those during the most adverse historical streamflow period. A tabulation of the Critical Rule Curves for Mica, Arrow and Duncan and the Composite Critical Rule Curve for the whole of Canadian storage is included in Table 1.

(b) Refill Curve. The Refill Curve is a guide to operation of Canadian storage which defines the normal limit of storage draft for secondary energy in order to provide a high probability of refilling the storage. In general, the Operating Plan does not permit serving secondary loads at the risk of failing to refill storages and thereby jeopardizing the firm load carrying capability of the United States system or the Mica and Revelstoke generating plants during subsequent years. The end of the refill period is considered to be 31 July.

The Refill Curve is, in turn, defined by two curves as discussed below. In each case, adjustment should be made for water required for refill of upstream reservoirs when applicable.

(1) Assured Refill Curve. The Assured Refill Curve indicates the end-of-month storage content required to assure refill of Canadian storage based on the 1930-31 water year, the system's second lowest historical volume of inflow during the 30-year record for the period January through July as measured at The Dalles, Oregon. A tabulation of the Assured Refill Curves for Mica, Arrow and Duncan is included as Table 2.

The schedule of outflows used in developing these Assured Refill Curves is the same as the Power Discharge Requirements used in computing the Variable

Refill Curve discussed in (2) below when The Dalles volume runoff is at 80 million acre-feet.

(2) Variable Refill Curve. The Variable Refill Curve gives end-of-month storage contents for the period January through July required to refill Canadian storage during the refill period. They were based on historical inflow volumes and Power Discharge Requirements determined in accordance with the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans.[1] In the system regulation studies the Power Discharge Requirement was made a function of the natural January - July runoff volume at The Dalles, Oregon. In those years when this volume was lower than 80 million acre-feet, the discharge used was that required to meet firm loads while refilling at 80 million acre-feet. In years when the runoff volume at The Dalles exceeded 95 million acre-feet, the Power Discharge Requirement was the project minimum outflow. For intermediate volumes, the Power Discharge Requirement used in computing the Variable Refill Curves was interpolated linearly between the values shown in Tables 3 - 5.

Variable Refill Curves for Mica, Arrow and Duncan for the 30 years of historical record are recorded in Tables 3 - 5. These illustrate the probable range of these curves based on historical conditions. In actual operation in 1991-92, the Power Discharge Requirements will be based on the forecast of unregulated runoff at The Dalles.

(c) Limiting Rule Curve. The Limiting Rule Curves indicate month-end storage contents which must be maintained to guarantee the system meeting its firm load during the period January 1 - March 31 in the event that the Variable Refill Curves permit storage to be emptied and sufficient natural flow is not available to carry the load prior to the start of the freshet. Such rule curves shall limit the Variable Refill Curve to be no lower than the Limiting Rule Curve. The

Limiting Rule Curve is developed for 1936-37 water conditions. Limiting Rule Curves for Mica, Arrow and Duncan are shown in Tables 3 - 5.

(d) Upper Rule Curve. The Upper Rule Curves[9] indicate the end-of-month storage content to which each individual Canadian storage project shall be evacuated for flood control and other requirements. The Upper Rule Curves used in the studies were based upon Flood Control Storage Reservation Diagrams contained in the Columbia River Treaty Flood Control Operating Plan and analysis of system flood control simulations. Each Upper Rule Curve is constrained to be not lower than the Variable Refill Curve, except in those years in which the April-August unregulated volume of runoff for the Columbia River at The Dalles exceeds 120 million acre-feet, and Canadian storage is subject to on-call request. Flood control curves for Mica, Arrow and Duncan for the 30 year study period are shown on Tables 6 - 8; however, the tables do not reflect the constraint that the Upper Rule Curve not be lower than the Variable Refill Curve. Tables 7 and 8 reflect an assumed transfer of 2 million acre-feet of flood control storage space from Arrow to Mica. In actual operation, the Flood Control Storage Reservation Curves will be computed as outlined in the Flood Control Operating Plan, using the latest forecast of runoff available at that time.

(e) Definition of Operating Rule Curve. During the period 1 August through 31 December, the Operating Rule Curve is defined by the Critical Rule Curve or the Assured Refill Curve, whichever is higher. The Critical Rule Curve for the first year of the critical period is used in the foregoing determination. During the period 1 January through 31 July, the Operating Rule Curve is defined by the higher of the Critical Rule Curve and the Assured Refill Curve; unless the Variable Refill Curve is lower than this value, then it is defined by the Variable Refill Curve. During the period 1 January through 31 March, it will not be lower

than the Limiting Rule Curve. The Operating Rule Curve meets all requirements for flood control operation. Composite Operating Rule Curves for the whole of Canadian storage for all 30 years of historical record are included as Table 9 to illustrate the probable future range of these curves based on historical conditions.

OPERATING RULES

The following rules, used in the 92-41 System Regulation Study, will apply to the operation of Canadian storage in the 1991-92 Operating Year.

(a) The whole of the Canadian storage may be drafted to its Operating Rule Curve as required to produce optimum generation in Canada and the United States in accordance with Annex A, Paragraph 7, of the Treaty, subject to project physical characteristics, operating constraints, and the criteria for the Mica project listed in (d) below.

(b) The whole of Canadian storage will not be drafted below its Operating Rule Curve unless:

(1) Reservoir storage in the United States system has been drafted to its Energy Content Curve.

(2) Deliveries of secondary energy in the United States are discontinued.

(3) Committed firm thermal and miscellaneous resources not displaced by surplus firm hydro resources are in operation or other replacement energy has been secured from sources other than those committed.

(c) When the conditions of (b) above are met, and it is necessary to draft additional storage to produce optimum generation as determined by the Critical

Period System Regulation study, the whole of the Canadian storage and reservoir storage in the United States system will be drafted proportionately between its Operating Rule Curve or Energy Content Curve, respectively, and its Composite Critical Rule Curve. The proportionate draft will be made, if necessary, first to the first year Composite Critical Rule Curve, then between the first and second year Composite Critical Rule Curve, the second and third year Composite Critical Rule Curve, etc. When it is necessary to operate the whole of the Canadian storage and the United States reservoir storage below their lowest Composite Critical Rule Curves, each shall be operated proportionately between its lowest Composite Critical Rule Curve and its normal minimum content. However, Mica Reservoir will continue to be operated in accordance with (d) below, so as to optimize generation at site and at Revelstoke as well as downstream in the United States. In the event the Mica operation results in more or less than the project's proportional share of draft from the whole of Canadian storage, compensating drafts will be made from Arrow to the extent possible.

(d) Mica project operation will be determined by the end of previous period Arrow storage content as shown in the table on page 12. Mica monthly outflows will be increased above the values shown in the table in the months from October to June if required to avoid violation of the Upper Rule Curve.

Under this Assured Operating Plan, Mica storage releases in excess of 7 million acre-feet that are required to maintain the Mica outflows specified under this plan will be retained in the Arrow reservoir, subject to flood control criteria at Arrow. The total combined storage draft from Mica and Arrow will not exceed 14.1 million acre-feet unless flood control criteria will not permit the additional Mica storage releases to be retained at Arrow. Should storage releases

in excess of 14.1 million acre-feet be made, the target Mica operation will remain as specified in the table on page 12.

Revelstoke has been included in the 1991-92 Assured Operating Plan and has been operated as a run-of-river project.

MICA PROJECT OPERATING CRITERIA

Month	End of Previous Period Arrow Storage Content (KSFD)	Target Operation Period Average Outflow (CFS)	End-of-Period[1] Storage Content (KSFD)	Minimum Outflow (CFS)	Minimum[2] Target Treaty Content (KSFD)
August 1-15	3 200 - FULL	-	3 529.2	10 000	2 543.8
	2 200 - 3 200	27 000			
	0 - 2 200	32 000			
August 16-31	3 200 - FULL	-	3 529.2	10 000	2 543.8
	2 400 - 3 200	27 000			
	0 - 2 400	32 000			
September	3 200 - FULL	-	3 529.2	10 000	2 543.8
	2 400 - 3 200	27 000			
	0 - 2 400	32 000			
October	3 200 - FULL	-	3 529.2	10 000	2 543.8
	2 400 - 3 200	28 000			
	0 - 2 400	32 000			
November	3 100 - FULL	-	3 122.2	10 000	2 543.8
	2 500 - 3 100	28 000			
	0 - 2 500	32 000			
December	2 700 - FULL	23 000	-	20 000	2 543.8
	0 - 2 700	32 000			
January	1 800 - FULL	23 000	-	20 000	3 900.0
	0 - 1 800	32 000			
February	700 - FULL	23 000	-	15 000	3 300.0
	0 - 700	27 000			
March	700 - FULL	18 000	-	15 000	2 700.0
	0 - 700	23 000			
April 1-15	0 - FULL	18 000	-	15 000	2 543.8
April 16-30	0 - FULL	18 000	-	10 000	2 543.8
May	0 - FULL	10 000	-	10 000	2 543.8
June	500 - FULL	10 000	-	10 000	2 543.8
	0 - 500	25 000			
July	1 500 - FULL	-	3 456.2	10 000	2 543.8
	0 - 1 500	32 000			

Note: (1) A maximum outflow of 34000 cfs will apply if the target end of period storage content is less than 3529.2 KSFD.

(2) Mica outflows will be reduced to minimum to maintain the reservoir above the indicated target minimum storage content.

ERRATA: VALUES IN THE LAST COLUMN OF THE ABOVE TABLE INCLUDE MICA NON-TREATY LIVE STORAGE.
TO CONVERT TO TREATY CONTENT THEY MUST BE REDUCED BY 2543.8 KSFD.

IMPLEMENTATION

The Entities have agreed that each year a Detailed Operating Plan will be prepared for the immediately succeeding operating year. Such Detailed Operating Plans are made under authority of Article XIV 2.(k) of the Columbia River Treaty which states:

"...the powers and the duties of the entities include:

(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."

The Detailed Operating Plan for 1991-92 will reflect the latest available load, resource, and other pertinent data to the extent the Entities agreed these data should be included in the plan. Beginning on 1 January 1991, the Assured Operating Plan contained herein will be reviewed and the data and criteria updated, as agreed by the Entities, to form the basis for a Detailed Operating Plan for the 1991-92 Operating Year. Failing agreement on updating the Assured Operating Plan, the Detailed Operating Plan will include all data and criteria given in this Assured Operating Plan. Actual operation during the 1991-92 Operating Year shall be guided by the Detailed Operating Plan.

The operating rules to be used in implementation of the Detailed Operating Plan are generally the same as the operating rules described in this document.

The values used in the Assured Operating Plan studies to define the various rule curves were month-end values only. In actual day-to-day operation, it is necessary to operate in such a manner during the course of each month that these month-end values can be observed in accordance with the operating rules. Because

of the normal variation of power load and streamflow during any month, straight line interpolation between the month-end points should not be assumed.

During the storage drawdown season, Canadian storage should not be drafted below its month-end point at any time during the month unless it can be conservatively demonstrated that sufficient inflow is available, in excess of the minimum outflow required to serve power demand, to refill the reservoir to its end-of-month value as required. During the storage evacuation and refill season, operation will be consistent with the Flood Control Operating Plan. When refill of Canadian storage is being guided by Flood Control Refill Curves,[5] such curves will be computed on a day-by-day basis using the residual volume-of-inflow forecasts depleted by the volume required for minimum outflow from each day through the end of the refill season.

REFERENCES

1 Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans dated May 1983.

2 Treaty between Canada and the United States of America relating to Cooperative Development of the Water Resources of the Columbia River Basin dated 17 January 1961.

3 Protocol - Annex to Exchange of Notes dated 22 January 1964.

4 Terms of Sale - Attachment to Exchange of Notes dated 22 January 1964.

5 Columbia River Treaty Flood Control Operating Plan dated October 1972.

6 BPA Hydroelectric Power Planning Program, Assured Operating Plan 30-year System Regulation Study 92-41, dated 14 November 1986.

7 Provisional Report on Modified Flows at Selected Sites, 1928 to 1968 for the 1970 and 2020 Level of Development, Columbia River and Coastal Basins, Columbia River Water Management Group, Revision 2, dated April 1974 and May 1974, respectively.

8 The 1980 Level Modified Streamflow, 1928 to 1978, Columbia River and Coastal Basins, dated July 1983.

9 Summary of End-of-Month Reservoir Storage Requirement from Columbia River Flood Regulation Studies dated April 1973 and as updated March 1975.

COLUMBIA RIVER TREATY
CRITICAL RULE CURVES
END OF MONTH CONTENTS IN KSFD
1991-92 OPERATING YEAR

TABLE 1

MICA

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	3529.2	3529.2	3529.2	3428.4	3122.2	2547.5	1953.1	1399.6	939.9	703.2	489.9	731.4	2163.8	3242.3
2ND YR	3529.2	3529.2	3529.2	3428.4	2710.5	2109.5	1477.1	910.5	477.3	342.4	338.5	770.0	2204.6	3456.2
3RD YR	3529.2	3529.2	3529.2	3428.4	2745.3	2143.3	1519.4	949.0	336.7	137.4	0.0	558.0	2058.3	2809.1
4TH YR	2949.3	3028.2	2836.3	2190.7	1475.7	631.7	112.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

ARROW

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	3579.6	3579.6	3577.7	3402.0	3453.6	3075.4	2320.8	1311.4	593.2	144.1	273.5	1307.8	3042.3	3345.4
2ND YR	3439.3	3476.0	3343.5	3079.6	3107.0	2777.3	1596.4	1053.8	246.8	297.4	408.5	879.9	2198.5	3003.2
3RD YR	3357.7	3485.7	3415.3	3055.0	3160.1	2489.0	1668.1	612.4	0.0	140.0	6.0	597.4	1349.5	2095.9
4TH YR	2334.8	2269.6	2314.5	2425.9	2150.0	759.4	514.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DUNCAN

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	705.8	705.8	705.6	683.9	705.8	471.1	232.4	113.7	63.6	45.1	1.9	119.3	365.8	519.8
2ND YR	572.8	626.3	596.2	469.7	247.3	60.9	0.0	0.1	2.5	0.8	22.9	115.8	255.2	463.9
3RD YR	499.8	506.1	542.1	443.5	258.7	59.9	22.0	2.9	0.0	4.0	2.5	159.7	100.8	18.6
4TH YR	8.9	0.2	58.9	58.4	40.7	29.6	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0

COMPOSITE

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	7814.6	7814.6	7812.5	7514.3	7281.6	6094.0	4506.3	2824.7	1596.7	892.4	765.3	2158.5	5571.9	7107.5
2ND YR	7541.3	7631.5	7468.9	6977.7	6064.8	4947.7	3073.5	1964.4	726.6	640.6	769.9	1765.7	4658.3	6923.3
3RD YR	7386.7	7521.0	7486.6	6926.9	6164.1	4692.2	3209.5	1564.3	336.7	281.4	8.5	1315.1	3508.6	4923.6
4TH YR	5293.0	5298.0	5209.7	4675.0	3666.4	1420.7	640.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

COLUMBIA RIVER TREATY
ASSURED REFILL CURVES
END OF MONTH CONTENTS IN KSFD
1991-92 OPERATING YEAR

TABLE 2

MICA

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
0.0	0.0	187.6	368.3	435.2	453.2	449.3	438.9	446.6	343.3	278.3	786.7	2238.9	3529.2

ARROW

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
0.0	0.0	0.0	0.0	0.0	0.0	294.7	873.9	1418.2	1485.8	1677.1	2525.8	3579.6	3579.6

DUNCAN

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
25.6	96.5	162.8	193.5	211.0	222.2	232.4	241.6	255.7	244.9	234.1	341.7	531.6	705.8

DUNCAN VARIABLE REFILL CURVE (KSFD) TABLE 3
1991-92 OPERATING YEAR

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							444.5	416.3	419.0	413.7	439.2	427.9	584.7	705.8
1929-30							442.5	414.3	416.7	411.2	449.6	448.8	596.1	,,
1930-31							387.1	360.1	366.0	367.2	401.0	397.2	584.7	,,
1931-32							2.0	0.0	0.0	0.0	35.6	112.3	447.9	,,
1932-33							,,	,,	,,	,,	0.0	0.0	314.3	,,
1933-34							,,	,,	,,	,,	45.9	144.5	488.3	,,
1934-35							113.1	90.1	106.3	124.1	178.8	216.7	473.3	,,
1935-36							88.8	66.7	72.6	87.7	146.0	207.0	517.1	,,
1936-37							390.6	363.6	368.1	364.5	393.4	389.3	566.9	,,
1937-38							2.0	0.0	0.0	16.2	91.5	168.0	471.8	,,
1938-39							242.0	218.0	225.9	231.3	281.5	308.4	567.7	,,
1939-40							230.3	206.5	221.7	236.7	287.9	310.5	556.4	,,
1940-41							310.3	284.9	296.3	309.8	364.0	388.4	579.8	,,
1941-42							229.2	203.9	215.3	229.9	279.5	315.1	540.0	,,
1942-43							122.0	96.5	105.7	131.9	199.9	280.8	505.0	,,
1943-44							466.5	437.8	445.3	441.0	466.6	461.3	614.7	,,
1944-45							387.8	360.8	369.2	367.9	396.1	389.7	573.1	,,
1945-46							2.0	0.0	0.0	0.0	0.0	56.8	440.9	,,
1946-47							,,	,,	,,	,,	9.3	100.4	453.6	,,
1947-48							,,	,,	,,	,,	43.8	118.7	464.5	,,
1948-49							174.4	147.8	153.6	175.7	233.2	294.2	565.4	,,
1949-50							2.0	0.0	0.0	0.0	61.4	126.9	408.6	,,
1950-51							,,	,,	,,	,,	11.1	92.4	439.6	,,
1951-52							6.1	,,	,,	24.4	95.7	178.3	484.5	,,
1952-53							5.5	,,	,,	23.7	93.2	156.5	450.9	,,
1953-54							2.0	,,	,,	0.0	0.0	18.9	381.9	,,
1954-55							,,	,,	,,	,,	59.5	118.2	392.2	,,
1955-56							,,	,,	,,	,,	0.0	66.8	437.5	,,
1956-57							,,	,,	,,	,,	48.2	119.6	501.4	,,
1957-58							,,	,,	,,	,,	0.0	57.2	453.6	,,
ECC LOWER LIMIT							2.0	0.0	0.0					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	100	100	100	1700	1700	1700	1700	1700
FOR JANUARY THROUGH JULY						90 MAF--	100	100	100	900	900	900	900	900
VOLUME RUNOFF AT THE DALLES						95 MAF--	100	100	100	100	100	100	100	100

ARROW VARIABLE REFILL CURVE (KSFD)
1991-92 OPERATING YEAR

TABLE 4

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							3088.1	3100.0	3449.3	3579.6	3579.6	3579.6	3579.6	3579.6
1929-30							2531.9	2205.4	2234.7	2354.8	3314.5	3333.0	,,	,,
1930-31							2663.0	2330.9	2304.0	2660.7	3467.7	3152.1	,,	,,
1931-32							394.8	103.6	0.0	0.0	63.9	1021.1	2580.8	,,
1932-33							,,	,,	,,	,,	325.8	1203.8	2533.5	,,
1933-34							,,	,,	,,	,,	0.0	1476.5	3007.0	,,
1934-35							850.6	714.3	970.0	1334.2	1944.5	2348.9	3173.2	,,
1935-36							990.7	856.7	946.3	1215.3	1827.5	2358.9	3537.3	,,
1936-37							3382.5	3381.7	3579.6	3579.6	3579.6	3579.6	3579.6	,,
1937-38							394.8	103.6	0.0	223.3	1025.4	1666.2	2847.2	,,
1938-39							2604.3	2274.7	2242.9	2495.0	3389.3	3251.4	3579.6	,,
1939-40							2385.4	2061.9	2086.4	2291.7	3197.1	3048.4	,,	,,
1940-41							3161.7	2814.2	3025.8	3452.9	3579.6	3579.6	,,	,,
1941-42							2589.2	2243.7	2234.8	2340.8	2950.5	3114.0	,,	,,
1942-43							1551.7	1209.2	1172.1	1321.6	2055.2	2620.4	3159.1	,,
1943-44							3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	3579.6	,,
1944-45							3345.2	3349.9	,,	,,	,,	,,	,,	,,
1945-46							394.8	103.6	0.0	0.0	56.5	1129.5	2751.0	,,
1946-47							,,	,,	,,	,,	647.1	1574.1	2834.0	,,
1947-48							,,	,,	,,	,,	271.7	1247.6	2747.9	,,
1948-49							641.5	310.0	314.6	741.2	1772.7	2330.5	3573.0	,,
1949-50							394.8	103.6	0.0	0.0	523.0	1206.5	2405.7	,,
1950-51							,,	,,	,,	,,	911.9	1540.1	2912.1	,,
1951-52							,,	,,	,,	239.0	851.5	1580.8	2897.1	,,
1952-53							616.6	409.6	409.4	629.4	1232.1	1700.0	2869.5	,,
1953-54							394.8	103.6	0.0	0.0	0.0	798.2	2398.8	,,
1954-55							,,	,,	,,	315.6	935.1	1458.9	2496.7	,,
1955-56							,,	,,	,,	0.0	276.7	1253.1	2735.9	,,
1956-57							,,	,,	,,	,,	429.1	1086.6	2988.8	,,
1957-58							,,	,,	,,	,,	362.9	1138.0	2771.6	,,
ECC LOWER LIMIT							394.8	103.6	0.0					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	5000	5000	5000	22000	22000	31000	31000	48000
FOR JANUARY THROUGH JULY						90 MAF--	5000	5000	5000	9600	9600	9600	26500	29000
VOLUME RUNOFF AT THE DALLES						95 MAF--	5000	5000	5000	5000	5000	5000	14000	14000

MICA VARIABLE REFILL CURVE (KSFD)
1991-92 OPERATING YEAR

TABLE 5

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							1981.4	1788.7	1752.2	1743.8	1831.9	1726.0	2672.5	3529.2
1929-30							893.1	723.2	676.1	720.4	974.5	1107.3	2391.3	,,
1930-31							1167.6	991.9	940.7	955.3	1135.0	1127.7	2465.6	,,
1931-32							516.5	172.6	0.0	0.0	0.0	210.3	1987.7	,,
1932-33							,,	,,	,,	,,	,,	105.5	1826.1	,,
1933-34							,,	,,	,,	,,	,,	0.0	2076.0	,,
1934-35							,,	,,	,,	,,	195.0	413.0	1960.6	,,
1935-36							,,	,,	,,	,,	187.7	495.3	2298.1	,,
1936-37							1948.6	1756.5	1705.3	1687.9	1823.2	1740.0	2704.5	,,
1937-38							516.5	172.6	0.0	0.0	131.4	437.7	2078.3	,,
1938-39							1038.0	865.1	827.6	871.1	1074.8	1151.7	2696.1	,,
1939-40							777.9	607.5	587.1	632.3	866.9	942.5	2458.4	,,
1940-41							1376.3	1196.3	1164.7	1190.9	1435.8	1511.8	2686.3	,,
1941-42							516.5	335.0	295.2	395.2	650.6	864.5	2300.7	,,
1942-43							,,	319.9	277.5	401.5	739.8	1077.1	2314.4	,,
1943-44							2045.1	1848.1	1810.7	1792.9	1903.4	1848.2	2841.6	,,
1944-45							2001.0	1807.9	1784.3	1783.5	1877.1	1774.2	2761.7	,,
1945-46							516.5	172.6	0.0	0.0	0.0	0.0	1982.3	,,
1946-47							,,	,,	,,	,,	,,	171.0	2052.1	,,
1947-48							,,	,,	,,	,,	,,	0.0	1939.1	,,
1948-49							1065.5	868.0	809.5	915.8	1155.2	1363.8	2703.8	,,
1949-50							516.5	172.6	0.0	0.0	0.0	185.9	1752.7	,,
1950-51							,,	,,	,,	,,	28.8	308.6	2111.0	,,
1951-52							,,	,,	,,	,,	284.0	606.5	2256.3	,,
1952-53							,,	210.6	170.7	298.0	557.8	765.0	2223.0	,,
1953-54							,,	172.6	0.0	0.0	0.0	0.0	1725.1	,,
1954-55							,,	,,	,,	1.8	303.5	533.3	1917.3	,,
1955-56							,,	,,	,,	0.0	0.0	204.6	2026.8	,,
1956-57							,,	,,	,,	,,	16.3	292.6	2353.5	,,
1957-58							,,	,,	,,	,,	0.0	189.5	2119.4	,,
ECC LOWER LIMIT							516.5	172.6	0.0					
POWER DISCHARGE REQUIREMENTS IN CFS						80 MAF--	3000	3000	3000	11600	11600	11600	11600	14600
FOR JANUARY THROUGH JULY						90 MAF--	3000	3000	3000	3000	3000	3000	3000	3000
VOLUME RUNOFF AT THE DALLES						95 MAF--	3000	3000	3000	3000	3000	3000	3000	3000

DUNCAN

FLOOD CONTROL STORAGE RESERVATION CURVES

1991-92 OPERATING YEAR

KSFD

TABLE 6

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	705.8	705.8	705.8	705.8	705.8	504.1	397.3	303.0	303.0	311.0	324.7	416.4	560.6	705.8
1929-30	,,	,,	,,	,,	,,	,,	385.7	281.3	281.3	289.9	304.0	400.8	553.0	,,
1930-31	,,	,,	,,	,,	,,	,,	368.5	248.0	248.0	257.1	272.7	377.1	540.9	,,
1931-32	,,	,,	,,	,,	,,	,,	272.2	65.5	65.5	80.6	108.9	281.3	609.5	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	75.1	94.2	191.6	573.2	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	65.5	127.0	339.8	605.5	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	83.7	187.0	488.0	,,
1935-36	,,	,,	,,	,,	,,	,,	,,	,,	,,	71.1	119.5	351.9	705.8	,,
1936-37	,,	,,	,,	,,	,,	,,	353.9	219.8	219.8	229.4	246.0	356.9	530.9	,,
1937-38	,,	,,	,,	,,	,,	,,	272.2	65.5	65.5	77.1	83.7	217.3	542.4	,,
1938-39	,,	,,	,,	,,	,,	,,	,,	,,	,,	82.7	107.4	385.7	705.8	,,
1939-40	,,	,,	,,	,,	,,	,,	,,	,,	,,	78.1	103.8	,,	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	321.1	156.3	156.3	167.4	186.0	311.0	508.2	,,
1941-42	,,	,,	,,	,,	,,	,,	302.0	121.0	121.0	131.1	155.3	291.9	483.0	,,
1942-43	,,	,,	,,	,,	,,	,,	305.0	126.0	126.0	141.1	172.9	248.0	647.8	,,
1943-44	,,	,,	,,	,,	,,	,,	392.7	294.4	294.4	302.5	316.6	410.4	557.6	,,
1944-45	,,	,,	,,	,,	,,	,,	361.5	234.4	234.4	235.9	236.9	349.9	567.7	,,
1945-46	,,	,,	,,	,,	,,	,,	272.2	65.5	65.5	75.6	95.8	322.1	647.3	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	77.1	101.8	314.1	629.7	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	65.5	65.5	300.5	705.8	,,
1948-49	,,	,,	,,	,,	,,	,,	348.3	208.7	208.7	215.2	236.9	408.8	,,	,,
1949-50	,,	,,	,,	,,	,,	,,	272.2	65.5	65.5	72.1	84.7	184.0	525.3	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	79.6	103.3	285.3	534.4	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	65.5	67.5	92.2	255.1	,,
1952-53	,,	,,	,,	,,	,,	,,	,,	,,	,,	72.1	84.7	234.4	522.8	,,
1953-54	,,	,,	,,	,,	,,	,,	,,	,,	,,	73.1	84.2	236.9	547.5	,,
1954-55	,,	,,	,,	,,	,,	,,	,,	,,	,,	72.1	80.6	154.7	488.5	,,
1955-56	,,	,,	,,	,,	,,	,,	,,	26.7	26.7	26.7	26.7	240.0	578.2	,,
1956-57	,,	,,	,,	,,	,,	,,	,,	65.5	65.5	74.6	89.7	376.1	655.9	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	77.1	96.3	359.4	705.8	,,

ARROW

TABLE 7

FLOOD CONTROL STORAGE RESERVATION CURVES
1991-92 OPERATING YEAR
KSFD

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	3579.6	3579.6	3579.6	3453.6	3453.6	3075.4	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	3579.6	3579.6
1929-30	,,	,,	,,	,,	,,	,,	3060.8	3047.7	3033.1	3047.2	3071.9	3207.0	,,	,,
1930-31	,,	,,	,,	,,	,,	,,	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	,,	,,
1931-32	,,	,,	,,	,,	,,	,,	2364.6	1719.2	1008.4	1015.9	1126.8	2224.4	,,	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	1008.4	1036.6	1761.6	3034.6	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1784.8	2327.2	3579.6	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1008.4	1725.8	3034.6	,,
1935-36	,,	,,	,,	,,	,,	,,	,,	,,	,,	1069.9	1373.4	2134.7	3579.6	,,
1936-37	,,	,,	,,	,,	,,	,,	2998.3	2927.7	2850.6	2869.7	2902.5	3082.5	,,	,,
1937-38	,,	,,	,,	,,	,,	,,	2364.6	1719.2	1008.4	1083.0	1278.1	1831.2	3147.5	,,
1938-39	,,	,,	,,	,,	,,	,,	2637.8	2243.6	1805.9	1869.5	1983.4	2735.1	3579.6	,,
1939-40	,,	,,	,,	,,	,,	,,	2849.6	2645.4	2420.0	2454.8	2536.0	2999.8	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	,,	,,
1941-42	,,	,,	,,	,,	,,	,,	2364.6	1719.2	1008.4	1064.8	1149.5	1934.0	,,	,,
1942-43	,,	,,	,,	,,	,,	,,	,,	,,	,,	1111.2	1321.9	1440.4	2389.3	,,
1943-44	,,	,,	,,	,,	,,	,,	3075.4	3075.4	3075.4	3088.5	3111.2	3235.8	3579.6	,,
1944-45	,,	,,	,,	,,	,,	,,	2641.9	2251.6	1818.0	1842.7	1908.3	2477.0	3368.4	,,
1945-46	,,	,,	,,	,,	,,	,,	2364.6	1719.2	1008.4	1072.4	1242.3	2201.2	3579.6	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	1075.4	1360.8	2147.3	,,	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	1036.6	1183.3	2216.8	,,	,,
1948-49	,,	,,	,,	,,	,,	,,	,,	,,	,,	1144.5	1375.9	2494.6	,,	,,
1949-50	,,	,,	,,	,,	,,	,,	,,	,,	,,	1103.6	1113.7	1113.7	2232.5	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	1052.2	1101.1	1355.2	3338.1	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	1069.9	1345.1	1792.3	3013.9	,,
1952-53	,,	,,	,,	,,	,,	,,	,,	,,	,,	1057.3	1172.7	1476.2	,,	,,
1953-54	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	1134.4	1628.0	1898.2	,,
1954-55	,,	,,	,,	,,	,,	,,	,,	,,	,,	1075.4	1090.5	1653.7	3224.7	,,
1955-56	,,	,,	,,	,,	,,	,,	,,	857.1	0.0	0.0	289.9	1367.3	2763.4	,,
1956-57	,,	,,	,,	,,	,,	,,	,,	1719.2	1008.4	1077.9	1224.1	2651.4	3579.6	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	1046.7	1190.9	2242.6	,,	,,

TABLE 8

MICA
FLOOD CONTROL STORAGE RESERVATION CURVES
1991-92 OPERATING YEAR
KSFD

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	3529.2	3529.2	3529.2	3428.4	3428.4	3428.4	3406.7	3387.0	3365.3	3369.9	3380.5	3412.2	3469.7	3529.2
1929-30	,,	,,	,,	,,	,,	,,	3378.5	3332.6	3282.7	3290.2	3305.9	3353.2	3440.0	,,
1930-31	,,	,,	,,	,,	,,	,,	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	,,
1931-32	,,	,,	,,	,,	,,	,,	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1934-35	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1935-36	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1936-37	,,	,,	,,	,,	,,	,,	3353.2	3283.7	3208.5	3218.1	3238.3	3300.8	3413.2	,,
1937-38	,,	,,	,,	,,	,,	,,	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	,,
1938-39	,,	,,	,,	,,	,,	,,	3213.1	3018.5	2806.7	2828.4	2873.8	3013.9	3267.5	,,
1939-40	,,	,,	,,	,,	,,	,,	3296.8	3174.3	3042.7	3057.3	3088.1	3182.3	3353.2	,,
1940-41	,,	,,	,,	,,	,,	,,	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	,,
1941-42	,,	,,	,,	,,	,,	,,	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	,,
1942-43	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1943-44	,,	,,	,,	,,	,,	,,	3428.4	3428.4	3428.4	3431.4	3437.9	3457.1	3492.9	,,
1944-45	,,	,,	,,	,,	,,	,,	3214.6	3021.5	2811.3	2832.9	2878.3	3017.5	3269.6	,,
1945-46	,,	,,	,,	,,	,,	,,	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1948-49	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1949-50	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1951-52	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1952-53	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1953-54	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1954-55	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1955-56	,,	,,	,,	,,	,,	3025.0	2067.1	1058.8	100.9	100.9	100.9	803.7	2363.6	,,
1956-57	,,	,,	,,	,,	,,	3428.4	3100.7	2808.2	2480.5	2511.8	2577.8	2781.5	3149.6	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,

COLUMBIA RIVER TREATY
COMPOSITE OPERATING RULE CURVES
FOR THE WHOLE OF CANADIAN STORAGE
END OF MONTH CONTENTS IN KSFD
1991-92 OPERATING YEAR

TABLE 9

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	7814.6	7814.6	7812.5	7514.3	7281.6	6094.0	4506.3	2952.6	2613.8	2433.9	2401.1	3654.2	6350.1	7814.6
1929-30	,,	,,	,,	,,	,,	,,	3446.3	2276.2	2350.0	,,	,,	,,	,,	,,
1930-31	,,	,,	,,	,,	,,	,,	3720.8	2544.9	2613.8	,,	,,	,,	,,	,,
1931-32	,,	,,	,,	,,	,,	,,	913.3	276.2	0.0	0.0	99.5	1343.7	5016.4	,,
1932-33	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	325.8	1309.3	4673.9	,,
1933-34	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	45.9	1621.0	5571.3	,,
1934-35	,,	,,	,,	,,	,,	,,	1480.2	977.0	1076.3	1458.3	2050.9	2978.6	5607.1	,,
1935-36	,,	,,	,,	,,	,,	,,	1596.0	1096.0	1018.9	1303.0	2010.8	3061.2	6293.3	,,
1936-37	,,	,,	,,	,,	,,	,,	4501.8	2952.6	2613.8	2433.9	2401.1	3654.2	6350.1	,,
1937-38	,,	,,	,,	,,	,,	,,	913.3	276.2	0.0	239.5	1248.3	2271.9	5397.3	,,
1938-39	,,	,,	,,	,,	,,	,,	3591.2	2394.5	2471.7	2420.3	2401.1	3620.9	6350.1	,,
1939-40	,,	,,	,,	,,	,,	,,	3329.0	2125.4	2227.0	2354.8	,,	3623.0	,,	,,
1940-41	,,	,,	,,	,,	,,	,,	3929.5	2749.3	2613.8	2433.9	,,	3654.2	,,	,,
1941-42	,,	,,	,,	,,	,,	,,	3066.5	1850.3	1928.7	2110.9	,,	3627.6	,,	,,
1942-43	,,	,,	,,	,,	,,	,,	2190.2	1625.6	1555.3	1855.0	2366.9	3593.3	5903.0	,,
1943-44	,,	,,	,,	,,	,,	,,	4506.3	2952.6	2613.8	2433.9	2401.1	3654.2	6350.1	,,
1944-45	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,
1945-46	,,	,,	,,	,,	,,	,,	913.3	276.2	0.0	0.0	56.5	1186.3	5174.2	,,
1946-47	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	656.4	1845.5	5339.7	,,
1947-48	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	315.5	1366.3	5151.5	,,
1948-49	,,	,,	,,	,,	,,	,,	1881.4	1325.8	1277.7	1620.1	2400.2	3411.4	6343.5	,,
1949-50	,,	,,	,,	,,	,,	,,	913.3	276.2	0.0	0.0	584.4	1519.3	4567.0	,,
1950-51	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	951.8	1941.1	5462.7	,,
1951-52	,,	,,	,,	,,	,,	,,	917.4	,,	,,	263.4	1231.2	2365.6	5620.5	,,
1952-53	,,	,,	,,	,,	,,	,,	1138.6	620.2	580.1	951.1	1815.2	2621.5	5543.4	,,
1953-54	,,	,,	,,	,,	,,	,,	913.3	276.2	0.0	0.0	0.0	817.1	4505.8	,,
1954-55	,,	,,	,,	,,	,,	,,	,,	,,	,,	317.4	1298.1	2110.4	4806.2	,,
1955-56	,,	,,	,,	,,	,,	,,	,,	,,	,,	0.0	276.7	1524.5	5200.2	,,
1956-57	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	493.6	1498.8	5729.1	,,
1957-58	,,	,,	,,	,,	,,	,,	,,	,,	,,	,,	362.9	1384.7	5344.6	,,

DETERMINATION OF DOWNSTREAM POWER BENEFITS RESULTING FROM CANADIAN STORAGE FOR OPERATING YEAR 1991-92

DETERMINATION OF DOWNSTREAM POWER BENEFITS

RESULTING FROM OPERATION OF CANADIAN TREATY STORAGE

FOR OPERATING YEAR 1991-92

November 1986

Introduction

The Columbia River Treaty between Canada and the United States of America and related documents relating to the cooperative development of the water resources of the Columbia River Basin require that downstream power benefits from the operation of Canadian Treaty storage be determined in advance by the two Entities. The purpose of this report is to describe the results of those downstream power benefit computations developed from the 1991-92 Assured Operating Plan.

The procedures followed in the benefit studies are those provided in Annex A, Paragraph 7, and Annex B of the Treaty; in Articles VIII, IX, and X of the Protocol; and in the document, "Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans" (POP), dated May 1983.

The Canadian Entitlement to downstream power benefits was computed from the following studies:

Step I - based on the total United States of America planned hydro and thermal system with 15-1/2 million acre feet (maf) of Canadian Treaty storage operated for optimum power generation in both countries.

Step II - based on the United States base hydro and thermal system with 15-1/2 maf of Canadian Treaty storage operated for optimum power generation in both countries.

Step III - based on the United States base hydro and thermal system operated for optimum power generation in the United States.

As part of the determination of downstream power benefits for the operating year 1991-92, separate determinations were carried out relating to:

1. the limit of year-to-year change in benefits attributable to the operation of Canadian Treaty storage in operating plans designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States of America, and

2. the decrease in downstream power benefits due to the operation of Canadian Treaty storage for optimum power generation at-site in Canada and downstream in Canada and the United States of America, instead of operation of Canadian Treaty storage for optimum power generation in the United States of America only.

Results of Canadian Entitlement Computations

The Canadian Entitlement to the downstream power benefits in the United States of America attributable to operation in accordance with Treaty Annex A, Paragraph 7, for optimum power generation in the Canada and the United States of America, which is one-half the total computed downstream power benefits, was computed to be:

Dependable Capacity = 1,428.9 MW
Average Annual Energy = 587.3 MW

Computation of Minimum Permitted Canadian Entitlement

In accordance with Part III, Paragraph 15c(2) of POP, the computation for the minimum permitted Canadian Entitlement to downstream power benefits for the 1991-92 operating year are based on the formula X - (Y - Z), where the quantities X, Y, and Z are defined in POP. The quantities X and Y were obtained from the downstream power benefit computations set out in the 1990-91 agreement 1/. The quantity Z, which is computed from one-half of the downstream power benefits determined for 15 maf of Canadian Treaty storage operated for optimum generation in the United States of America, was computed to be:

Dependable Capacity = 1,404.4 MW
Average Annual Energy = 578.7 MW

The computation of the formula X - (Y - Z) is as follows:

Dependable Capacity lower limit = 1,447.5 - (1,447.5-1,404.4) = 1,404.4 MW
Average Annual Energy Lower Limit = 580.6 - (583.3- 578.7) = 576.0 MW

The computed Canadian Entitlement to downstream power benefits exceeds these amounts.

Effect on Sale of Canadian Entitlement

The Canadian Entitlement to downstream power benefits for operating year 1991-92 was sold to the United States of America under the Canadian Entitlement Purchase Agreement dated 13 August 1964. The studies developed for this sale included the assumption of operation of Treaty storage for optimum power generation downstream in the United States of America only. The Canadian Entitlement determined from the 1991-92 Assured Operating Plan for this condition would have been:

Dependable Capacity = 1,428.9 MW
Average Annual Energy = 590.8 MW

Since the 1991-92 Assured Operating Plan was in fact designed to achieve optimum power generation at-site in Canada and downstream in Canada and the United States of America, Section 7 of the Agreement requires that "any reduction in the Canadian Entitlement resulting from action taken pursuant to Paragraph 7 of Annex A of the Treaty shall be determined in accordance with Subsection (3) of Section 6 of this Agreement." A comparison with the Canadian Entitlement to downstream power benefits shown above indicates a reduction in Canadian Entitlement of 3.5 average megawatts of average annual usable energy, but no reduction in dependable capacity.

The Entities are agreed that the United States Entity is entitled to receive during the period 1 April 1991 through 31 March 1992, from B.C. Hydro & Power Authority, 3.5 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement dated 13 August 1964.

Summaries of Canadian Entitlement Computations

The following Tables and Chart summarize the study results:

Table 1. Computation of Canadian Entitlement From 1991-92 Assured Operating Plan For:

A. Optimum Generation in Canada and the U.S.
B. Optimum Generation in the U.S. Only
C. Optimum Generation in the U.S. and a 1/2 Million Acre-Feet Reduction in Total Canadian Treaty Storage

The essential elements used in the computation of the Canadian Entitlement to downstream power benefits, the minimum permitted downstream power benefits, and the reduction in downstream power benefits attributable to operation of Treaty storage for optimum power generation in the United States only, are shown in this table.

Table 2. Summary of Power Regulations from 1991-92 Assured Operating Plan for the Computation of Canadian Entitlement to Downstream Power Benefits

This table summarizes the results of the Step I, II, and III power regulation studies for each project and the total power system.

Table 3. Determination of Load Shape for Steps II and III, 1991-92 Canadian Entitlement Computation

This table shows the computation of the Step II and III loads. The load shape for Step II and III studies carry the same ratio between each month and the annual average as does the Pacific Northwest area load used in the Step I study. The Northwest area firm loads on this table were based on the current forecast data. The Grand Coulee pumping load is also included in this estimate.

The firm load for Step II and III studies was computed as follows:

(1) Estimate the hydro nominal prime power for the critical period;

(2) Add the thermal from Step I less reserve;

(3) Multiply (2) by the ratio of the area annual average firm load to the area critical period firm load to obtain the annual average firm load for Steps II and III;

(4) Pro rate the average annual Step II and III load determined in (3) by months in the ratio that each monthly area load bears to the annual average area load; and

(5) Subtract the thermal in each month to obtain the monthly firm hydro load. The average annual hydro loads for Steps II and III also become the firm energy considered usable according to Annex B, Paragraph 3(a).

Chart 1. Secondary Energy Duration Curve, Steps II and III

This chart shows duration curves of the secondary energy for the Step II and III studies and graphically illustrates the portion of secondary energy that is usable for thermal displacement. Secondary energy is the energy capability each month which exceeds the firm hydro loads shown in Table 3. The usable secondary energy in average megawatts for the Step II and III studies is computed in accordance with Annex B, Paragraphs 3(b) and 3(c), as the portion of secondary energy which can displace Pacific Northwest area thermal resources plus the other usable secondary generation. The Entities have agreed that the "other usable secondary" is computed on the basis of 40 percent of the remainder after thermal displacement. The potential thermal displacement market was limited to the existing and scheduled thermal energy capability after allowance for reserves and minimum thermal generation, and was computed as follows:

Thermal Resource Energy Capability	= 5800 MW 2/
Less Minimum Thermal Generation	= 1862 MW
Potential Thermal Displacement Market	= 3938 MW

1/ X = Difference between last year's AOP studies 91-42 and 91-13.
Y = Difference between last year's AOP studies 91-12 and 91-13.

2/ Thermal energy capabilities are based on an annual plant factor of 60 percent the first full year of operation and 75 percent thereafter, unless specified differently by project owner. The annual plant factors include deductions for energy reserves and scheduled maintenance.

TABLE 1

COMPUTATION OF CANADIAN ENTITLEMENT FROM 1991-92 ASSURED OPERATING PLAN FOR:

A. Optimum Generation in Canada and the U.S.
B. Optimum Generation in the U.S. Only
C. Optimum Generation in the U.S. and a 1/2 Million Acre-Feet Reduction in Total Canadian Treaty Storage

Determination of Dependable Capacity Credited to Canadian Storage (MW)

	A	B	C
Step II - Critical Period Avg. Generation 1/	8,903.8	8,903.8	8,869.7
Step III - Critical Period Avg. Generation 2/	6,919.6	6,919.6	6,919.6
Gain Due to Canadian Storage	1,984.2	1,984.2	1,950.1
Average Critical Period Load Factor in % 3/	69.43	69.43	69.43
Dependable Capacity Gain 4/	2,857.8	2,857.8	2,808.7
Canadian Share of Dependable Capacity 5/	1,428.9	1,428.9	1,404.4

Determination of Increase in Average Annual Usable Energy (Average MW)

Step II (with Canadian Storage) 1/	A	B	C
Annual Firm Hydro Energy 3/	8,735.3	8,735.3	8,702.4
Thermal Replacement Energy 6/	1,732.1	1,742.4	1,748.0
Other Usable Secondary Energy 7/	396.8	393.4	396.6
System Annual Average Usable Energy	10,864.2	10,871.2	10,846.9
Step III (without Canadian Storage) 2/	**A**	**B**	**C**
Annual Firm Hydro Energy 3/	6,417.0	6,417.0	6,417.0
Thermal Replacement Energy 6/	2,408.9	2,408.9	2,408.9
Other Usable Secondary Energy 7/	863.7	863.7	863.7
System Annual Average Usable Energy	9,689.6	9,689.6	9,689.6
Average Annual Usable Energy Gain 8/	1,174.6	1,181.6	1,157.3
Canadian Share of Average Annual Energy Gain 5/	587.3	590.8	578.7

1/ Step II values were obtained from the AOP 92-42, 92-12, and 92-22 studies, respectively.
2/ Step III values were obtained from the AOP 92-13 study.
3/ Average 30-year firm load.
4/ Dependable capacity gain credited to Canadian storage equals gain in critical period average generation divided by the estimated average critical period load factor.
5/ One-half of Total Gain.
6/ Average secondary generation limited to Potential Thermal Displacement market.
7/ Forty percent (40%) of the remaining secondary energy.
8/ Difference between Step II and Step III System Average Annual Usable Energy.

SUMMARY OF POWER REGULATIONS FROM 1991-92 ASSURED OPERATING PLAN
FOR THE COMPUTATION OF CANADIAN ENTITLEMENT TO DOWNSTREAM POWER BENEFITS

TABLE 2

PROJECTS	BASIC DATA: NUMBER OF UNITS	BASIC DATA: NOMINAL INSTALLED PEAKING CAPACITY MW	BASIC DATA: USABLE STORAGE 1000 AF	STEP I: JANUARY PEAKING CAPABILITY MW	STEP I: CRITICAL PERIOD AVERAGE GENERATION MW	STEP II: USABLE STORAGE 1000 AF	STEP II: JANUARY PEAKING CAPABILITY MW	STEP II: CRITICAL PERIOD AVERAGE GENERATION MW	STEP II: AVERAGE ANNUAL GENERATION MW	STEP III: USABLE STORAGE 1000 AF	STEP III: JANUARY PEAKING CAPABILITY MW	STEP III: CRITICAL PERIOD AVERAGE GENERATION MW	STEP III: AVERAGE ANNUAL GENERATION MW
CANADIAN													
Mica			7,000			7,000							
Arrow			7,100			7,100							
Duncan			1,400			1,400							
Subtotal			15,500			15,500							
BASE FEDERAL SYSTEM													
Hungry Horse	4	328	3,161	317	97	3,008	202	115	102	3,008	254	198	102
Albeni Falls	3	49	1,155	25	25	1,155	23	24	24	1,155	23	26	25
Grand Coulee	24	6,684	5,185	6,382	2,018	5,072	6,349	1,753	2,351	5,072	5,948	1,216	2,265
Chief Joseph	27	2,687		2,687	1,124		2,687	1,024	1,366		2,687	724	1,305
Ice Harbor	6	693		693	219		693	217	297		693	169	297
McNary	14	1,127		1,127	630		1,124	578	745		1,124	421	701
John Day	16	2,484	535	2,484	930		2,484	922	1,255		2,484	691	1,224
The Dalles	22+2F	2,076		2,076	751		2,076	721	975		2,076	563	959
Bonneville	18+2F	1,147		1,147	630		1,147	607	753		1,147	478	722
Subtotal		17,275	10,036	16,938	6,424	9,235	16,785	5,961	7,868	9,235	16,436	4,486	7,600
BASE SYSTEM NON-FEDERAL													
Kootenay Lake			649			427				427			
Kerr	3	160	1,219	148	113	1,219	148	100	115	1,219	151	132	115
Thompson Falls	6	40		40	38		40	39	38		40	39	37
Noxon Rapids	5	554	231	536	149		553	138	208		553	155	208
Cabinet Gorge	4	227		227	104		227	91	119		227	100	119
Box Canyon	4	74		71	46		71	44	48		71	50	47
Coeur d'Alene			223	0	0	223	0	0	0	223	0	0	0
Wells	10	820		820	394		820	369	450		820	262	420
Chelan	2	54	677	51	39	676	51	38	45	676	51	49	45
Rocky Reach	11	1,267		1,267	565		1,267	531	677		1,267	380	638
Rock Island	18	544		544	275		544	258	322		544	181	296
Wanapum	10	986		986	521		986	490	605		986	345	550
Priest Rapids	10	912		912	513		912	484	578		912	334	523
Brownlee	5	675	975	675	215	974	675	255	274	974	675	273	275
Oxbow	4	220		220	88		220	106	112		220	114	112
Subtotal		6,533	3,974	6,497	3,060	3,519	6,514	2,943	3,591	3,519	6,517	2,434	3,385
Total Base System Hydro		23,808	29,510	23,435	9,484	28,254	23,299	8,904	11,459	12,754	22,953	6,920	10,985
ADDITIONAL STEP I PROJECTS													
Libby	5	555	4,980	417	181								
Boundary	6	1,055		655	369								
Spokane River Plants	24	157	104	155	91								
Hells Canyon	3	450		425	171								
Dworshak	3	460	2,015	460	179								
Lower Granite	6	930		930	216								
Little Goose	6	930		930	216								
Lower Monumental	6	930		930	218								
R. Butte, Pelton, & Rereg	7	413	274	408	127								
Subtotal		5,880	7,373	5,310	1,768								
Other Coordinated Hydro		3,186	5,486	2,648	1,032								
Total Coordinated Hydro		32,874	42,369	31,393	12,284								
Independent Hydro Resources		1,710	4,400	1,084	758								
Estimated Hydro Maintenance				(1,356)	(32)								
Total Hydro Resources		34,584	46,769	31,121	13,010								
TOTAL IMPORTS				187	43								
MISCELLANEOUS CONTRACTS				400	313								
THERMAL RESOURCES 1/													
Small Existing Thermal Plants				1,721	260								
Centralia #1 & #2				1,280	981								
Jim Bridger #1, #2, #3, & #4				1,986	1,388								
Colstrip #1, #2, #3, & #4				1,310	1,003								
Trojan				1,080	787								
Boardman				530	406								
Valley				242	183								
WNP #2				1,100	792								
Total Thermal Resources				9,249	5,800		9,249	5,800			9,249	5,800	
TOTAL RESOURCES				40,957	19,166		32,548	14,704			32,202	12,720	
RESERVES 2/				(2,509)	0		(1,937)	0			(1,628)	0	
RESOURCES AVAILABLE FOR LOAD				38,448	19,166		30,611	14,704			30,574	12,720	
ESTIMATED LOAD PACIFIC NORTHWEST AREA				31,362	18,927		24,215	14,704			20,352	12,720	
SURPLUS				7,086	239		6,396	0			10,221	0	
CRITICAL PERIOD													
Start				September 1, 1928			September 1, 1943				September 16, 1936		
End				February 29, 1932			April 30, 1945				April 15, 1937		
Length (Months)				42 Months			20 Months				7 Months		
Study Identification				92-41			92-42				92-13		

1/ Thermal energy capabilities are based on an annual plant factor of 60 percent the first full year of operation and 75 percent thereafter unless specified differently by project owner. These annual plant factors include deductions for energy resources and scheduled maintenance.
2/ Peak reserves are 8 percent of peak load from Table 3; energy reserve deductions have been included in thermal plant energy capability.

TABLE 3

DETERMINATION OF LOAD SHAPE FOR STEP II AND III STUDIES
1991-92 CANADIAN ENTITLEMENT COMPUTATIONS

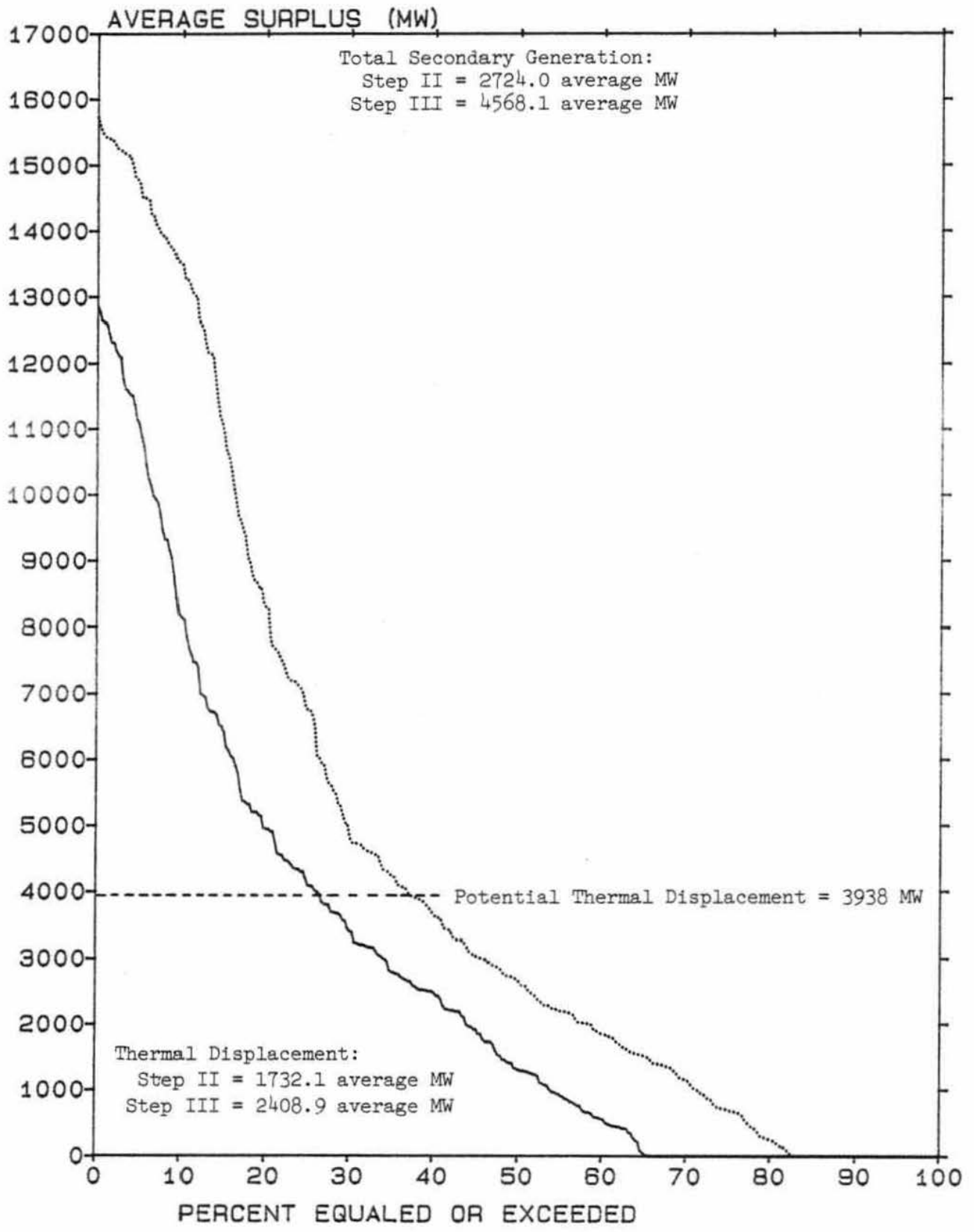
Pacific Northwest Area Load (MW)					Step II			Step III		
	Peak 1/	Load Factor Percent	Energy	% Annual Average Energy	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load
August 1-15	23843	73.29	17474	92.82	13492	5800	7692	11340	5800	5540
August 16-31	23843	73.09	17428	92.58	13456	5800	7656	11310	5800	5510
Sept. 1-15	24267	70.14	17022	90.42	13143	5800	7343	11046	5800	5246
Sept. 16-31	24267	70.02	16992	90.26	13119	5800	7319	11027	5800	5227
October	26525	67.24	17836	94.75	13771	5800	7971	11575	5800	5775
November	28613	68.19	19512	103.65	15065	5800	9265	12662	5800	6862
December	30232	68.75	20785	110.41	16048	5800	10248	13488	5800	7688
January	31362	68.77	21569	114.58	16653	5800	10853	13997	5800	8197
February	29945	68.54	20524	109.02	15847	5800	10047	13319	5800	7519
March	28255	68.30	19298	102.51	14900	5800	9100	12523	5800	6723
April 1-15	27002	68.19	18414	97.82	14217	5800	8417	11950	5800	6150
April 16-31	26888	68.55	18431	97.91	14231	5800	8431	11961	5800	6161
May	25751	69.45	17883	95.00	13807	5800	8007	11605	5800	5805
June	24796	71.86	17819	94.66	13758	5800	7958	11564	5800	5764
July	24816	72.04	17878	94.97	13804	5800	8004	11602	5800	5802
Annual Average		69.57	18825.1	100.00	14534.8	5800	8734.8	12216.6	5800	6416.6
Critical Period Avg.		69.43	18927.3	100.54	14703.8	5800	8903.8	12719.6	5800	6919.6
Critical Period = 42 Months 9/1/28 - 2/29/32 Study 92-41					Critical Period = 20 Months 9/1/43 - 4/30/45 Study 92-42			Critical Period = 7 Months 9/16/36 - 4/15/37 Study 92-13		

1/ Figures in this column are peak megawatts. All other figures are monthly or half-monthly energy in average megawatts

2/ Total firm load of Step II and Step III systems, computed for each system to have an average energy load equivalent to the average energy capability within the critical period and to bear a constant ratio, month by month, to the Pacific Northwest Area Load

Chart 1

1991-92 AOP SECONDARY ENERGY



1. ——— STEP II
2. ····· STEP III

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