

# COLUMBIA RIVER TREATY

ASSURED OPERATING PLAN

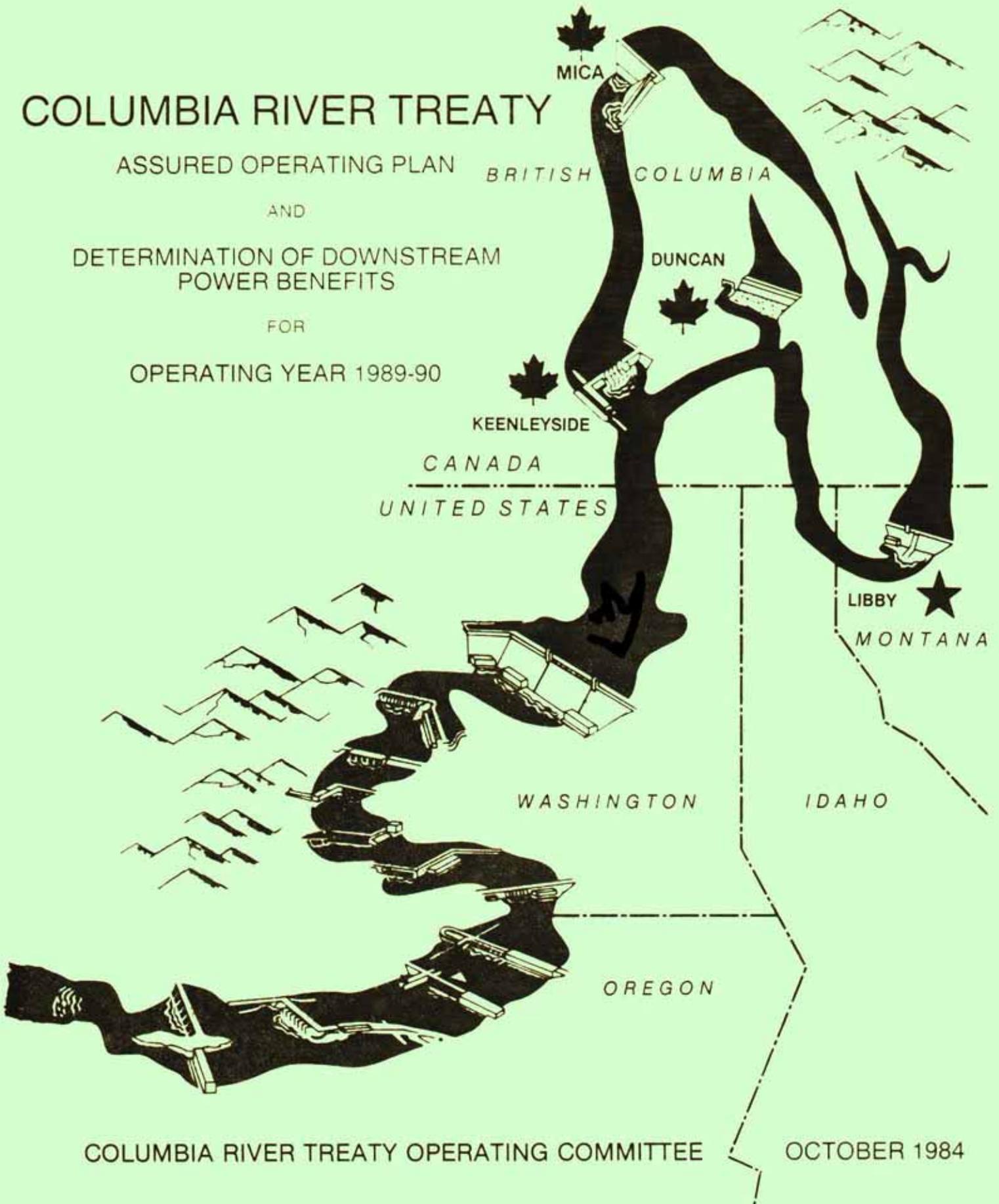
BRITISH COLUMBIA

AND

DETERMINATION OF DOWNSTREAM  
POWER BENEFITS

FOR

OPERATING YEAR 1989-90



COLUMBIA RIVER TREATY OPERATING COMMITTEE

OCTOBER 1984

**DETERMINATION OF DOWNSTREAM POWER BENEFITS  
RESULTING FROM CANADIAN STORAGE  
FOR OPERATING YEAR 1989-90**

DETERMINATION OF DOWNSTREAM POWER BENEFITS RESULTING FROM  
CANADIAN STORAGE FOR OPERATING YEAR 1989-90

October 1984

I. Introduction.

The 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 Canadian 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 1989-90 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," dated May 1983 (POP).

The Canadian Entitlement Benefits were computed from the following studies:

- Step I - based on the total U.S. planned hydro and thermal system with 15-1/2 maf of Canadian storage operated for optimum generation in both countries.
- Step II - based on the U.S. base hydro and thermal system with 15-1/2 maf of Canadian storage operated for optimum generation in both countries.
- Step III - based on the U.S. base hydro and thermal system operated for optimum generation in the U.S.

As part of the determination of downstream power benefits for the operating year 1989-90, separate determinations were carried out relating to the limit of year-to-year change in benefits attributable to the operation of Canadian storage in operating plans designed to achieve optimum generation at-site in Canada and downstream in Canada and the United States of America.

II. Results of Study.

- (a) The Canadian Entitlement for optimum generation in the U.S. and Canada, which is one-half the total computed downstream power benefits, was computed 1/ to be:

Dependable Capacity = 1,341.8 MW  
Average Annual Energy = 566.4 MW

- (b) In accordance with Part III, Paragraph 15c(2) of POP, the computation for the Canadian share of the minimum permitted downstream power benefits for the 1989-90 operating year are based on the formula  $X - (Y - Z)$ , where the quantities X, Y, and Z are defined in POP 2/. The quantities X and Y are derived from the downstream power benefit computations set out in the 1988-89 agreement. The quantity Z, which is computed from one-half of the downstream power benefits determined for 15 maf of Canadian storage operated for optimum generation in the United States, was computed 3/ to be :

Dependable Capacity = 1,319.3 MW  
Average Annual Energy = 567.1 MW

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

Dependable Capacity =  $1,321.6 - (1,321.6 - 1,319.3) = 1,319.3$  MW  
Average Annual Energy =  $544.9 - (547.7 - 567.1) = 564.3$  MW

The computed downstream power benefits exceed these amounts.

### III. Effect on Canadian Entitlement.

The Canadian Entitlement to downstream power benefits for operating year 1989-90 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 optimum generation downstream in the United States alone. The Canadian Entitlement determined from the 1989-90 Assured Operating Plan for this condition would have been 4/:

Dependable Capacity = 1,341.8 MW  
Average Annual Energy = 569.8 MW

Since the 1989-90 Assured Operating Plan was in fact designed to achieve optimum generation at-site in Canada and downstream in 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 computed in Section II(a) indicates a reduction in Canadian Entitlement of 3.4 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 1989 through 31 March 1990, from B.C. Hydro & Power Authority, 3.4 average megawatts of energy in accordance with Sections 7 and 10 of the Canadian Entitlement Purchase Agreement dated 13 August 1964.

#### IV. Computation of Entitlement.

The following Tables and Charts summarize the study results:

Table 1.           Computation of Canadian Entitlement

The essential elements used in the computation of the Canadian Entitlement as provided in Paragraphs 2 and 3 of Annex B are shown in this table.

Table 2.           Summary of Power Regulations for the Computation of Canadian Entitlement to Downstream Benefits

This table summarizes the Step I, II, and III regulations by projects.

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

The load shape for Steps II and III carry the same ratio between each month and the annual average as does the Pacific Northwest area load. 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 Steps II and III is 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 (the ratios used in this study were 0.98528 and 0.95079, respectively);
- (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).

Charts 1 & 2. Secondary Energy Duration Curve, Steps II and III

These charts are duration curves of the secondary energy for Steps II and III studies 5/. The secondary energy is the capability each month which exceeds the firm hydro loads shown in Table 3. The usable secondary energy in average megawatts for each step is computed in accordance with Annex B, Paragraphs 3(b) and 3(c). The "other usable secondary" was computed on the basis of 40 percent of the remainder after thermal displacement. The thermal displacement was limited to the existing and scheduled thermal energy capability after allowance for reserve and minimum thermal generation.

Thermal Energy Capability - MW	7229 <u>6/</u>
Less Minimum Thermal Generation - MW	<u>1793</u>
Potential Thermal Displacement - MW	5436

- 
- 1/ Difference between studies 90-42 and 90-13.
  - 2/ X = Difference between studies 89-42 and 89-13.  
Y = Difference between studies 89-12 and 89-13.  
Z = Difference between studies 90-22 and 90-13.
  - 3/ Difference between studies 90-22 and 90-13.
  - 4/ Difference between studies 90-12 and 90-13.
  - 5/ Studies 90-42 and 90-13.
  - 6/ 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 reserves and scheduled maintenance. This value includes Added Thermal Requirement from the Step I Study. (See Table 2)

WP-PRC-0004G

COMPUTATION OF CANADIAN ENTITLEMENT  
1989-1990

Generation Figures are in Average Megawatts

Determination of Dependable Capacity Credited to Canadian Storage

Critical Period Average Generation with Canadian Storage, Step II <u>1/</u>	8,965.8
Critical Period Average Generation without Canadian Storage Step III <u>2/</u>	<u>6,951.0</u>
Gain Due to Canadian Storage . . . . .	2,014.8
 Estimated Average Critical Period Load Factor -- Percent . . . . .	 75.08
 Dependable Capacity Gain <u>3/</u> . . . . .	 2,683.5
Canadian Share of Dependable Capacity <u>4/</u> . . . . .	1,341.8

Determination of Increase in Average Annual Usable Energy

Step II (with Canadian Storage) 1/

Annual Firm Hydro Energy <u>5/</u> . . . . .	8,728.7
Thermal Replacement Energy <u>6/</u> . . . . .	2,057.6
Other Usable Secondary Energy <u>7/</u> . . . . .	<u>284.8</u>
System Annual Average Usable Energy . . . . .	11,071.1

Step III (without Canadian Storage) 2/

Annual Firm Hydro Energy <u>5/</u> . . . . .	6,254.2
Thermal Replacement Energy <u>8/</u> . . . . .	2,986.8
Other Usable Secondary Energy <u>7/</u> . . . . .	<u>697.3</u>
System Annual Average Usable Energy . . . . .	9,938.3
 Average Annual Usable Energy Gain <u>9/</u> . . . . .	 1,132.8
 Canadian Share of Average Annual Energy Gain <u>4/</u> . . . . .	 566.4

1/ Step II values were obtained from the 90-42 study.

2/ Step III values were obtained from the 90-13 study.

3/ Dependable capacity gain credited to Canadian storage equals gain in critical period average generation divided by the estimated average critical period load factor.

4/ One-half of Total Gain.

5/ From Table 3.

6/ From Chart 1.

7/ 40% of the remaining secondary energy

8/ From Chart 2.

9/ Difference between Step II and Step III System Annual Average Usable Energy.

SUMMARY OF POWER REGULATIONS FROM 1989-90  
ASSURED OPERATING PLAN FOR THE  
COMPUTATION OF CANADIAN ENTITLEMENT  
TO DOWNSTREAM BENEFITS

TABLE 2

BASIC DATA			STEP I			STEP II				STEP III			
PROJECTS	Number of Units	Nominal Installed Peaking Capacity MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Average Annual Generation MW	Usable Storage 1000 AF	January Peaking Capability MW	Critical Period Average Generation MW	Average Annual Generation MW
<b>CANADIAN</b>													
Mica			7,000			7,000							
Arrow			7,100			7,100							
Duncan			1,400			1,400							
Subtotal			15,500			15,500							
<b>BASE FEDERAL SYSTEM</b>													
Hungry Horse	4	328	3,161	281	98	3,008	210	115	102	3,008	258	201	102
Albeni Falls	3	49	1,155	24	25	1,155	23	23	23	1,155	23	25	25
Grand Coulee	24 + 2F	6,684	5,185	6,380	2,013	5,072	6,350	1,769	2,371	5,072	5,931	1,213	2,257
Chief Joseph	27	2,687		2,687	1,078		2,687	993	1,323		2,687	698	1,264
Ice Harbor	6	693		693	208		693	217	298		693	169	298
McNary	14	1,127		1,127	627		1,124	581	746		1,123	420	701
John Day	16	2,484	535	2,484	914		2,484	918	1,249		2,484	682	1,213
The Dalles	22 + 2F	2,076		2,076	811		2,076	791	1,033		2,076	631	1,014
Bonneville	18 + 2F	1,147		1,147	625		1,147	608	754		1,147	478	722
Subtotal		17,275	10,036	16,899	6,399	9,235	16,794	6,015	7,899	9,235	16,422	4,517	7,596
<b>BASE SYSTEM NON-FEDERAL</b>													
Kootenay Lake (Canadian)			649			427				427			
Kerr	3	160	1,219	152	112	1,219	151	101	115	1,219	151	135	116
Thompson Falls	6	40		40	38		40	39	37		40	39	37
Noxon Rapids	5	554	231	536	146		553	139	209		553	156	209
Cabinet Gorge	4	227		227	103		227	91	120		227	101	120
Box Canyon	4	74		71	47		71	44	48		71	50	48
Coeur d'Alene			223			223				223			
Wells	10	820		820	393		820	369	451		820	262	419
Chelan	2	54	677	51	38	676	51	38	45	676	51	49	44
Rocky Reach	11	1,267		1,267	566		1,267	534	679		1,267	379	637
Rock Island	18	544		544	274		544	259	323		544	181	296
Wanapum	10	986		986	521		986	492	606		986	344	550
Priest Rapids	10	912		912	513		912	485	577		912	353	523
Brownlee	5	675	975	675	202	974	675	253	276	974	675	271	276
Oxbow	4	220		220	82		220	107	113		220	114	113
Subtotal		6,533	3,974	6,501	3,035	3,519	6,517	2,951	3,599	3,519	6,517	2,434	3,388
TOTAL BASE SYSTEM HYDRO		23,808	29,510	23,377	9,434	28,254	23,311	8,966	11,498	12,754	22,939	6,951	10,984
<b>ADDITIONAL STEP I PROJECTS</b>													
Libby	4	483	4,980	408	191								
Boundary	6	1,055		655	367								
Spokane River Plants	24	157	104	155	90								
Hells Canyon	3	450		394	161								
Dworshak	3	460	2,015	460	182								
Lower Granite	6	930		930	211								
Little Goose	6	930		930	211								
Lower Monumental	6	930		930	207								
Pelton, Rereg., & Round Butte		413	274	409	127								
Subtotal		5,808	7,373	5,271	1,747								
OTHER COORD. HYDRO RESOURCES		3,262	5,693	2,611	1,027								
INDEPENDENT RESOURCES		1,700	4,400	1,368	730								
ESTIMATED HYDRO MAINTENANCE				-1,081	-61								
TOTAL HYDRO RESOURCES		34,578	46,976	31,569	12,877								
TOTAL IMPORTS				464	99								
MISCELLANEOUS CONTRACTS				139	125								
<b>THERMAL RESOURCES<sup>1/</sup></b>													
Small Existing Thermal Plants				1,721	227								
NPR				0	425								
Centralia #1 & #2				1,280	945								
Jim Bridger #1, #2, #3, & #4				1,991	1,304								
Colstrip #1 & #2				330	230								
Trojan				1,080	788								
Boardman				530	406								
Valley				242	193								
WNP #2				1,100	826								
Colstrip #3 & #4				980	745								
WNP #3				1,240	508								
Added Thermal Requirement				1,053	632								
TOTAL THERMAL RESOURCES				11,547	7,229		11,547	7,229			11,547	7,229	
TOTAL HYDRO AND THERMAL RESOURCES				43,719	20,330		34,858	16,195			34,486	14,180	
RESERVES <sup>2/</sup>				-2,594	0		-2,048	0			-1,730	0	
RESOURCES AVAILABLE FOR LOAD				41,125	20,330		32,810	16,195			32,756	14,180	
ESTIMATED LOAD PACIFIC NORTHWEST AREA				32,423	20,330		25,596	16,195			21,626	14,180	
SURPLUS OR (DEFICIT)				8,702	0		7,214	0			11,130	0	
<b>CRITICAL PERIOD</b>													
Starts:			August 16, 1928			September 1943			September 16, 1936				
Ends:			February 1932			April 1945			April 15, 1937				
Length (Months):			42-1/2 Months			20 Months			7 Months				
Study Identification			90-41			90-42			90-13				

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 reserves and scheduled maintenance.

2/ Peak reserves are 8 percent of peak load; energy reserve deductions have been included in thermal plant energy capability.

TABLE 3

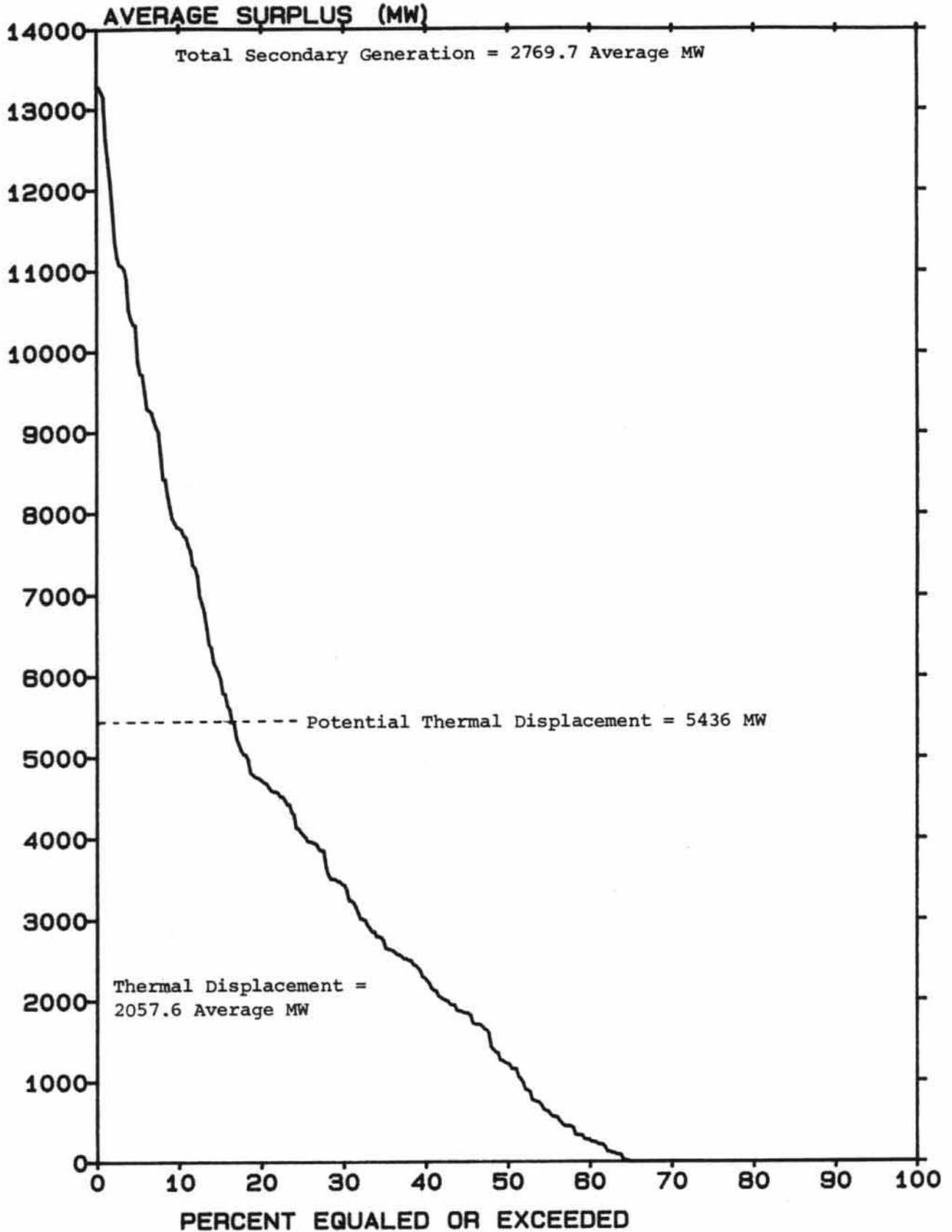
DETERMINATION OF LOAD SHAPE FOR STEPS II AND III  
1989-90 CANADIAN ENTITLEMENT COMPUTATIONS

Pacific Northwest Area Load				Step II			Step III		
	Peak 1/	Avg.	Load Factor %	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 2/	Thermal Firm Load	Hydro Firm Load
Aug. 1-15	23,055	18,660	80.94	14,731	7,229	7,502	12,447	7,229	5,218
Aug. 16-31	22,887	18,450	80.61	14,566	7,229	7,337	12,307	7,229	5,078
Sep. 1-15	23,303	18,133	77.81	14,315	7,229	7,086	12,096	7,229	4,867
Sep. 16-30	23,258	18,093	77.79	14,284	7,229	7,055	12,069	7,229	4,840
October	26,154	18,897	72.25	14,919	7,229	7,690	12,605	7,229	5,376
November	28,625	21,066	73.59	16,631	7,229	9,402	14,052	7,229	6,823
December	30,570	22,685	74.21	17,909	7,229	10,680	15,132	7,229	7,903
January	32,423	23,950	73.87	18,908	7,229	11,679	15,975	7,229	8,746
February	30,964	22,672	73.22	17,899	7,229	10,670	15,123	7,229	7,894
March	28,116	20,712	73.67	16,351	7,229	9,122	13,816	7,229	6,587
Apr. 1-15	26,673	19,656	73.69	15,517	7,229	8,288	13,112	7,229	5,883
Apr. 16-30	26,675	19,587	73.43	15,463	7,229	8,234	13,066	7,229	5,837
May	25,602	18,697	73.03	14,760	7,229	7,531	12,472	7,229	5,243
June	24,224	18,816	77.68	14,854	7,229	7,625	12,551	7,229	5,322
July	24,195	18,894	78.09	14,916	7,229	7,687	12,603	7,229	5,374
Annual Average		20,212	75.16	15,958	7,229	8,729	13,483	7,229	6,254
Critical Period Avg.		20,334	75.08	16,195	7,229	8,966	14,180	7,229	6,951
Step I Critical Per. 42 1/2 Months Aug 16, 1928 - Feb 1932 Study 90-41				Critical Per. 20 Months Sep 1943 - Apr 1945 Study 90-42			Critical Per. 7 months Sep 16, 1936 - Apr 15, 1937 Study 90-13		

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

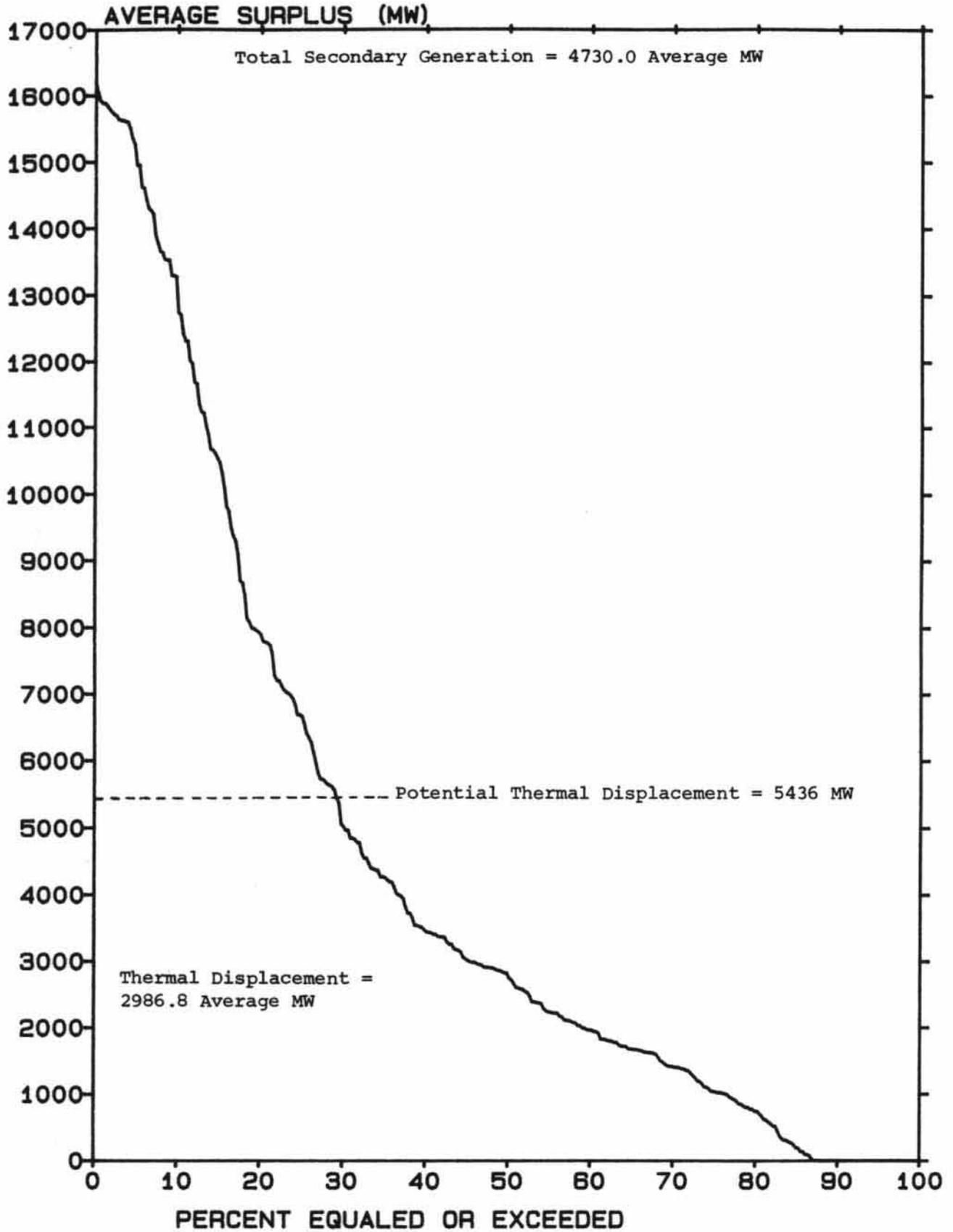
2/ Total firm load of Step II and Step III systems, computed for each system to have an average energy load equivalent to the average energy capability within the critical period and to bear a constant ratio, month by month, to the Pacific Northwest Area Load.

# 1989-90 AOP STEP II SECONDARY ENERGY



— 30-YEAR DURATION CURVE

# 1989-90 AOP STEP III SECONDARY ENERGY



— 30-YEAR DURATION CURVE

**COLUMBIA RIVER TREATY  
HYDROELECTRIC OPERATING PLAN**

**ASSURED OPERATING PLAN  
FOR OPERATING YEAR 1989-90**

COLUMBIA RIVER TREATY  
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for  
Operating Year 1989-90

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COLUMBIA RIVER TREATY  
HYDROELECTRIC OPERATING PLAN

Assured Operating Plan for  
Operating Year 1989-90

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 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 1989-90 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 1989-90.

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

The Assured Operating Plan consists of:

(a) The Operating Rule Curve for the whole of the Canadian storage, including the Critical Rule Curve, Assured Refill Curve, 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<sup>6</sup> 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 3.4 average megawatts of average annual usable energy in the Canadian Entitlement of downstream power benefits. This is within the limits specified by the Treaty.

System Regulation Studies for the Assured Operating Plan were based on 1989-90 estimated loads and resources in British Columbia and in the United States Pacific Northwest System. The Entities have agreed that the 1989-90 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 1989-90 conditions,<sup>7</sup> were used.

The Critical Rule Curve for these studies was determined from Bonneville Power Administration Study 90-41. The study indicated a 42-1/2 month critical period for the United States system resulting from the low flows during the period from 16 August 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 1989-90 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 1989-90 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 1989-90 Assured Operating Plan the three quantities would be assigned the following relative values:

<u>Quantity</u>	<u>Relative Value</u>
firm energy capability (Av. MW)	3
dependable peaking capability (MW)	1
average annual usable secondary energy (Av. 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 1989-90 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 Curve for the whole of Canadian storage. This is in accordance with the provision of Article VII(2) of the Protocol.

COMPARISON OF ASSURED OPERATING PLAN  
STUDY RESULTS

	Optimum Generation in Canada and the United States		Optimum Generation in the United States		Net Gain	Weight	Value
	Study No. 90-41	Study No. 90-11	Loss	Gain			
<b>1. Firm Energy Capability (Av. MW)</b>							
U.S. System <sup>1/</sup>	12,208	12,208	-	-			
Canada (Mica + Rev.) <sup>2/</sup>	<u>1,640</u>	<u>1,568</u>	<u>-</u>	<u>72</u>			
Total (Av. MW)	13,848	13,776	-	72	72	3	216
<b>2. Dependable Peaking Capacity (MW)</b>							
U.S. System <sup>3/</sup>	31,289	31,299	10	-			
Canada (Mica + Rev.) <sup>4/</sup>	<u>3,505</u>	<u>3,521</u>	<u>16</u>	<u>-</u>			
Total (MW)	34,794	34,820	26	-	(26)	1	(26)
<b>3. Average Annual Usable Secondary Energy (Av. MW)</b>							
U.S. System <sup>5/</sup>	3,068	3,077	9	-			
Canada (Mica + Rev.) <sup>6/</sup>	<u>87</u>	<u>157</u>	<u>70</u>	<u>-</u>			
Total (Av. MW)	3,155	3,234	79	-	(79)	2	(158)
<b>Total Value</b>						<b>32</b>	

- <sup>1/</sup> U.S. System firm energy capability was determined over the U.S. system critical period beginning 16 August 1928 and ending 29 February 1932.
- <sup>2/</sup> Canadian (Mica + Revelstoke) system firm energy capability was determined over the Canadian system critical period beginning 1 October 1940 and ending 30 April 1946.
- <sup>3/</sup> U.S. system dependable peaking capability was determined from January 1937.
- <sup>4/</sup> Canadian (Mica + Revelstoke) system dependable peaking capability was determined from December 1944.
- <sup>5/</sup> U.S. system 30-year average secondary energy limited to secondary market.
- <sup>6/</sup> Canadian (Mica and Revelstoke) 30-year average generation minus firm generation.

(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 stream-flow period. A tabulation of 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 for the period January through July as measured at The Dalles, Oregon. The tabulation of the composite Assured Refill Curve for the whole of Canadian storage is included as Table 2.

The schedule of outflows 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. It was based on historical inflow volume and Power Discharge Requirements determined in accordance with the Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans.<sup>1</sup> 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 the table on page 8.

Composite Variable Refill Curves for the whole of Canadian storage for the 30 years of historical record are recorded in Table 3; the effect of the Limiting Rule Curve, as described below, is included. These illustrate the probable range of these curves based on historical conditions. In the actual operation in 1989-90, 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 shall be developed for 1936-37 water conditions.

POWER DISCHARGE REQUIREMENTS IN CFS  
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

80 MAF

<u>Project</u>	<u>January</u> <u>February</u> <u>March</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>
Mica	3,000	11,600	11,600	11,600	14,600
Arrow	5,000	22,000	31,000	31,000	48,000
Duncan	100	1,700	1,700	1,700	1,700

POWER DISCHARGE REQUIREMENTS IN CFS  
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

90 MAF

<u>Project</u>	<u>January</u> <u>February</u> <u>March</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>
Mica	3,000	3,000	3,000	3,000	3,000
Arrow	5,000	9,600	9,600	26,500	29,000
Duncan	100	900	900	900	900

POWER DISCHARGE REQUIREMENTS IN CFS  
FOR JANUARY THROUGH JULY VOLUME AT THE DALLES

95 MAF

<u>Project</u>	<u>January</u> <u>February</u> <u>March</u>	<u>April</u>	<u>May</u>	<u>June</u>	<u>July</u>
Mica	3,000	3,000	3,000	3,000	3,000
Arrow	5,000	5,000	5,000	14,000	14,000
Duncan	100	100	100	100	100

(d) Upper Rule Curve. The Upper Rule Curves<sup>8</sup> indicate 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 each of the Canadian Treaty projects for the 30 year study period are shown on Tables 4, 5, and 6; however, the tables do not reflect the constraint that the Upper Rule Curve not be lower than the Variable Refill Curve. Table 5 and 6 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 7 to illustrate the probable future range of these curves based on historical conditions.

#### OPERATING RULES

The following rules, used in the 90-41 System Regulation Study, will apply to the operation of Canadian storage in the 1989-90 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 Critical Rule Curve. The proportionate draft will be made, if necessary, first to the first

year Critical Rule Curve, then between the first and second year Critical Rule Curve, the second and third year 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 Critical Rule Curves, each shall be operated proportionately between its lowest 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 as well as downstream in the United States. In the event the Mica operation results in 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 the 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 1989-90 Assured Operating Plan and has been operated as a run-of-river project.

MICA PROJECT OPERATING CRITERIA

<u>Month</u>	<u>End of Previous Period Arrow Storage Content (KSF)</u>	<u>Target Operation Period Average Outflow (CFS)</u>	<u>End-of-Period<sup>(1)</sup> Storage Content (KSF)</u>	<u>Minimum Outflow (CFS)</u>
August 1-15	1 900 - FULL 0 - 1 900	- 25 000	3 456.2	10 000
August 16-31	2 500 - FULL 0 - 2 500	- 30 000	3 529.2	10 000
September	2 300 - FULL 0 - 2 300	- 30 000	3 529.2	10 000
October	3 200 - FULL 0 - 3 200	10 000 27 000	-	10 000
November	3 200 - FULL 0 - 3 200	- 32 000	3 122.2	10 000
December	3 200 - FULL 0 - 3 200	26 000 34 000	-	15 000
January	2 200 - FULL 0 - 2 200	26 000 34 000	-	15 000
February	600 - FULL 0 - 600	23 000 28 000	-	15 000
March	100 - FULL 0 - 100	17 000 25 000	-	15 000
April 1-15	0 - FULL	15 000	-	15 000
April 16-30	0 - FULL	10 000	-	10 000
May	100 - FULL 0 - 100	10 000 20 000	-	10 000
June	500 - FULL 0 - 500	10 000 20 000	-	10 000
July	1 600 - FULL 0 - 1600	- 25 000	3 356.2	10 000

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

## 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 1989-90 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 1988, 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 1989-90 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 1989-90 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,<sup>5</sup> 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 90-41, dated 25 October 1984.
- 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 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  
 COMPOSITE CRITICAL RULE CURVES  
 FOR THE WHOLE OF CANADIAN STORAGE  
 END OF MONTH CONTENTS IN KSF  
 1989-90 OPERATING YEAR

TABLE 1

	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1ST YR	7814.6	7814.6	7803.0	7587.8	7281.6	6023.4	4744.6	2943.8	2004.5	1081.6	1046.7	2507.2	5937.1	7350.6
2ND YR	7741.6	7806.5	7518.7	6758.2	5527.5	4442.1	2620.2	1611.2	939.5	311.4	519.6	1705.0	4728.0	6780.7
3RD YR	7289.1	7512.4	7287.4	6539.3	5424.3	3985.0	2485.9	1022.7	358.5	34.7	0.0	684.9	3015.2	3980.3
4TH YR	4099.8	4216.1	3916.6	3094.2	1735.1	305.7	18.1	0.0	1.6	11.2	44.6	1037.3	4369.4	0.0

COLUMBIA RIVER TREATY  
 COMPOSITE ASSURED REFILL CURVE  
 FOR THE WHOLE OF CANADIAN STORAGE  
 END OF MONTH CONTENTS IN KSFU  
 1989-90 OPERATING YEAR

TABLE 2

AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
2637.4	3467.4	4329.6	4572.1	4654.5	4684.1	4687.9	4687.1	4707.1	4525.0	4349.3	4806.4	6586.0	7814.6

COLUMBIA RIVER TREATY  
COMPOSITE VARIABLE REFILL CURVES  
FOR THE WHOLE OF CANADIAN STORAGE  
END OF MONTH CONTENTS IN KSF  
1989-90 OPERATING YEAR

TABLE 3

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29							5129.0	5965.8	5920.7	5946.1	5971.6	5765.4	6692.5	7814.6
1929-30							4194.9	3603.0	3633.6	4175.2	4716.6	4574.0	6627.7	..
1930-31							4559.6	4299.1	4405.8	4792.6	5179.2	4535.2	6786.1	..
1931-32							1023.1	438.1	23.2	22.0	43.8	1155.1	5007.5	..
1932-33							..	..	..	131.8	263.5	1141.8	4666.3	..
1933-34							..	..	..	24.7	49.4	1472.4	5583.1	..
1934-35							1961.8	1365.2	1483.3	1930.4	2377.5	2881.8	5640.3	..
1935-36							2061.7	1463.5	1400.7	1811.7	2222.5	2951.7	6319.9	..
1936-37							5192.7	5880.1	5820.6	5878.2	5935.9	5842.3	6910.9	..
1937-38							1025.5	438.1	74.8	648.4	1224.3	2155.5	5396.4	..
1938-39							4219.0	3668.3	3791.9	4255.3	4718.7	4413.5	6896.6	..
1939-40							3735.0	3140.2	3266.7	3842.5	4418.5	4089.7	6719.3	..
1940-41							5154.8	5073.4	5228.2	5446.0	5663.7	5727.7	6967.4	..
1941-42							3666.4	3079.1	3068.1	3448.3	3828.5	4162.0	6438.7	..
1942-43							2471.6	1886.5	1843.4	2407.6	2972.0	3679.2	5893.1	..
1943-44							5457.0	6145.4	6101.0	6128.0	6154.9	6079.9	7126.6	..
1944-45							6290.1	5977.7	5937.2	5967.8	5998.3	5885.2	6974.2	..
1945-46							1023.1	438.1	23.2	78.1	156.3	1155.8	5224.8	..
1946-47							..	..	..	393.9	787.8	1881.4	5402.3	..
1947-48							..	..	..	211.2	422.4	1338.8	5208.3	..
1948-49							2292.6	1706.7	1696.5	2438.1	3179.5	3708.1	6650.5	..
1949-50							1023.1	438.1	23.2	360.9	721.7	1512.3	4635.3	..
1950-51							..	..	..	520.2	1040.3	1897.7	5497.6	..
1951-52							1039.0	..	274.9	790.5	1308.2	2329.9	5637.1	..
1952-53							1543.1	989.4	954.5	1422.4	1891.8	2589.9	5559.9	..
1953-54							1023.1	438.1	23.2	23.6	47.1	828.5	4585.0	..
1954-55							..	466.0	476.8	980.4	1486.1	2176.1	4913.0	..
1955-56							..	438.1	23.2	247.1	494.2	1593.7	5301.4	..
1956-57							..	..	..	278.7	557.4	1453.8	5772.6	..
1957-58							..	..	..	176.6	353.2	1270.4	5364.5	..

FLOOD CONTROL STORAGE RESERVATION CURVES  
DUNCAN  
KSF0  
1989-90 OPERATING YEAR

TABLE 4

	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	397.2	303.0	303.0	311.0	324.6	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	191.5	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	..	..	..	..	..	..	..	..	..	82.6	107.4	385.7	705.8	..
1939-40	..	..	..	..	..	..	..	..	..	78.1	103.8	..	..	..
1940-41	..	..	..	..	..	..	321.1	156.3	156.3	167.3	186.0	311.0	508.2	..
1941-42	..	..	..	..	..	..	302.0	121.0	121.0	131.0	155.2	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	305.4	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	239.9	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	..

FLOOD CONTROL STORAGE RESERVATION CURVES  
 ARROW  
 KSF0  
 1989-90 OPERATING YEAR

TABLE 5

	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	1008.3	1015.9	1126.8	2224.4	..	..
1932-33	..	..	..	..	..	..	..	..	..	1008.3	1036.6	1761.6	3034.6	..
1933-34	..	..	..	..	..	..	..	..	..	..	1784.8	2327.2	3579.6	..
1934-35	..	..	..	..	..	..	..	..	..	..	1008.3	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	1008.3	1083.0	1278.1	1831.1	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	1008.3	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	..	..	..	..	..	..	2641.8	2251.6	1818.0	1842.7	1908.3	2477.0	3368.4	..
1945-46	..	..	..	..	..	..	2364.6	1719.2	1008.3	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	1008.3	1077.9	1224.1	2651.4	3579.6	..
1957-58	..	..	..	..	..	..	..	..	..	1046.7	1190.9	2242.5	..	..



COLUMBIA RIVER TREATY  
COMPOSITE OPERATING RULE CURVES  
FOR THE WHOLE OF CANADIAN STORAGE  
END OF MONTH CONTENTS IN KSF  
1989-90 OPERATING YEAR

TABLE 7

FLOW YEAR	AUG15	AUG31	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUN	JUL
1928-29	7814.6	7814.6	7803.0	7587.8	7281.6	6023.4	5535.5	5028.2	4707.1	4525.0	4349.3	4806.4	6586.0	7814.6
1929-30	..	..	..	..	..	..	4072.7	3431.4	3451.4	3734.8	4056.3	4371.0	6574.6	..
1930-31	..	..	..	..	..	..	4491.1	3976.5	3808.9	3993.4	4216.0	4196.9	6586.0	..
1931-32	..	..	..	..	..	..	1023.1	438.1	23.2	22.0	43.8	1155.1	5007.5	..
1932-33	..	..	..	..	..	..	..	..	..	131.8	263.5	1141.8	4666.3	..
1933-34	..	..	..	..	..	..	..	..	..	24.7	49.4	1472.4	5583.1	..
1934-35	..	..	..	..	..	..	1961.8	1365.2	1483.3	1930.4	2377.5	2881.8	5640.3	..
1935-36	..	..	..	..	..	..	2061.7	1463.5	1400.7	1811.7	2222.5	2951.7	6319.9	..
1936-37	..	..	..	..	..	..	5684.5	5028.2	4707.1	4525.0	4349.3	4806.4	6586.0	..
1937-38	..	..	..	..	..	..	1025.5	438.1	74.8	648.4	1224.3	2155.5	5396.4	..
1938-39	..	..	..	..	..	..	4219.0	3668.3	3590.3	3839.6	4096.7	4251.9	6586.0	..
1939-40	..	..	..	..	..	..	3735.0	3140.2	3174.4	3523.0	3875.6	4027.6	..	..
1940-41	..	..	..	..	..	..	5067.4	4649.6	4521.4	4484.7	4349.3	4806.4	..	..
1941-42	..	..	..	..	..	..	3666.4	3079.1	3068.1	3445.3	3678.3	4162.0	6438.7	..
1942-43	..	..	..	..	..	..	2471.6	1886.5	1843.4	2407.6	2794.1	3646.3	5893.1	..
1943-44	..	..	..	..	..	..	5684.5	5028.2	4707.1	4525.0	4349.3	4806.4	6586.0	..
1944-45	..	..	..	..	..	..	..	..	..	..	..	..	..	..
1945-46	..	..	..	..	..	..	1023.1	438.1	23.2	78.1	156.3	1156.8	5224.8	..
1946-47	..	..	..	..	..	..	..	..	..	393.9	787.8	1881.4	5402.3	..
1947-48	..	..	..	..	..	..	..	..	..	211.2	422.4	1338.8	5208.3	..
1948-49	..	..	..	..	..	..	2292.6	1705.7	1686.0	2151.9	2650.4	3442.5	6375.9	..
1949-50	..	..	..	..	..	..	1023.1	438.1	23.2	360.9	721.7	1512.3	4635.3	..
1950-51	..	..	..	..	..	..	..	..	..	520.2	1040.3	1897.7	5497.6	..
1951-52	..	..	..	..	..	..	1039.0	..	274.9	790.5	1308.2	2329.9	5637.1	..
1952-53	..	..	..	..	..	..	1543.1	989.4	954.5	1422.4	1891.8	2589.9	5559.9	..
1953-54	..	..	..	..	..	..	1023.1	438.1	23.2	23.6	47.1	828.5	4585.0	..
1954-55	..	..	..	..	..	..	..	466.0	476.8	980.4	1486.1	2175.1	4913.0	..
1955-56	..	..	..	..	..	..	..	438.1	2.2	0.0	289.9	1593.7	5226.4	..
1956-57	..	..	..	..	..	..	..	..	23.2	278.7	557.4	1453.8	5772.6	..