Columbia River Treaty Principles and Procedures for Preparation and Use of Hydroelectric Operating Plans

Columbia River Treaty Operating Committee

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COLUMBIA RIVER TREATY

PRINCIPLES AND PROCEDURES

FOR PREPARATION AND USE OF HYDROELECTRIC

OPERATING PLANS

Prepared by the Columbia River

Treaty Operating Committee

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PART I - INTRODUCTION

1. AUTHORITY AND PURPOSE

This document has been authorized by the United States and Canadian Entities as a guide for the preparation and use of hydroelectric operating plans for Canadian storage. It replaces the document, "Principles and Procedures for the Preparation and Use of Hydroelectric Operating Plans for Canadian Treaty Storage", dated May 1979, which was agreed to by the Entities on 31 May 1979. This revision includes only the following changes:

a. the use of 30 years of streamflows in the hydroelectric operation plans;

b. update charts and tables;

c. the name change of McNaughton Lake to Kinbasket Lake; and

d. correction of typographical errors.

2. SCOPE

The Columbia River Treaty provides that the operating arrangements necessary to implement the Treaty will be formulated and carried out by the Entities designated by the United States and Canada. Article XIV2 of the Treaty specifies that the powers and duties of the Entities include, among other things:

"(h) preparation of the hydroelectric operating plans and the flood control operating plans for the Canadian storage together with determination of the downstream power benefits to which Canada is entitled;"

"(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."

Guidance for flood control planning and operations is provided in the Columbia River Treaty Flood Control Operating Plan submitted by the United States Entity in accordance with Annex A, paragraph 5 of the Treaty.

Guidance for the preparation of hydroelectric operating plans and for the calculation of downstream benefits is provided in this document. In addition, the Principles and Procedures, together with the Flood Control Operating Plan, detail the steps necessary to prepare and implement the detailed operating plans. This document will be reviewed periodically and revised as necessary to take advantage of actual operating experience and to deal with any problems resulting from the need to operate towards the optimization of generation in Canada, in the United States, or in both countries.

Each year two operating plans shall be prepared. An Assured Operating Plan will be prepared for the sixth succeeding year which, with previous plans, will assure both Entities of the manner of operation of Canadian storage in advance for the next succeeding 5 years and will also be the basis for computing downstream power benefits for the corresponding year. Once adopted, the Assured Operating Plan shall not be changed even though the data on which it was developed may change. Immediately prior to each operating year, a Detailed Operating Plan will be developed from the Assured Operating Plan for that operating year. The Detailed Operating

Plan will reflect the latest load, resource, flood control, and other pertinent data if mutually agreed by the Entities. The Detailed Operating Plan will serve as a guide and provide criteria for actual operation of the Canadian storage during the immediately ensuing operating year. An operating year shall mean the period 1 August through 31 July.

3. REFERENCES

a. Columbia River Treaty dated 17 January, 1961, and its allied documents, pertaining to the preparation and use of operating plans.

(1) Article IV - Operation by Canada; paragraphs 1 and 2.

(2) Article V - Entitlement to Downstream Power Benefits; paragraph 1.

(3) Article VI - Payment for Flood Control; paragraphs 3, 4 and 5.

(4) Article VII - Determination of Downstream Power Benefits; paragraphs 1 and 2.

(5) Article XII - Kootenai River Development; paragraphs 5 and 6.

(6) Article XIV - Arrangements for Implementation; paragraph 2.

(7) Annex A - Principles of Operation.

(8) Annex B - Determination of Downstream Power Benefits.

(9) Terms of Sale - Attachment to Exchange of Notes dated 22 January, 1964; Section B.1.

(10) Protocol - Annex to Exchange of Notes dated 22 January, 1964; paragraphs V, VII, VIII, IX and X.

(11) Canadian Entitlement Purchase Agreement - Sections 6 and 7.

b. Columbia River Treaty Flood Control Operating Plan dated October 1972, as amended.

4. DEFINITIONS

Terms defined in Article I of the Columbia River Treaty dated 17 January, 1961, have the same meanings in this document except "storage" which refers to water content rather than space; other terms have the meanings given in the Glossary of Electric Power Terms, Appendix XV, Columbia-North Pacific Region Comprehensive Framework Study, Pacific Northwest River Basins Commission dated October 1970.

"Month" shall mean a calendar month except in April and August when it will mean each of the following periods:

1 April to 15 April

16 April to 30 April

1 August to 15 August

16 August to 31 August

5. TREATY ORGANIZATION

Implementation of the Columbia River Treaty is carried out by the United States and Canadian Entities, which were appointed by the two Governments for this purpose. The Canadian Entity is the British Columbia Hydro and Power Authority. The United States Entity is composed of the Administrator of the Bonneville Power Administration and the Division

Engineer of the North Pacific Division, Corps of Engineers. The Administrator is designated as Chairman of the United States Entity.

The United States Entity has appointed a Secretary and two Coordinators, one from the Corps of Engineers and one from the Bonneville Power Administration, to coordinate the activities of the Entity. The Canadian Section has established the position of Manager, Canadian Entity Services to manage the activities of its Entity.

The Entities have, in turn, established two committees: the Columbia River Treaty Operating Committee and the Columbia River Treaty Hydrometeorological Committee. Each committee has a United States Section and a Canadian Section. The United States Sections of these committees have equal representation by the Corps of Engineers and the Bonneville Power Administration. The chairmanship of the United States Section of the Operating Committee rotates between the Corps of Engineers and the Bonneville Power Administration. From 1 March through 31 August a representative of the Corps of Engineers is chairman. From 1 September through the end of February, a representative of the Bonneville Power Administration is chairman.

The Operating Committee membership is limited to four members from each country. The Committee is responsible for making the system regulation studies, preparing the operating plans, insuring that the plans are carried out, and performing other duties as required by the Entities.

Each Entity shall evidence appointment of representatives by written notice to the other Entity, and by similar notice either Entity may at any time change its representatives.

6. THE POWER AND RESERVOIR SYSTEM

The operation of the Canadian storage at Duncan, Arrow, and Mica reservoirs is designed to increase power generation downstream in the United States and downstream in Canada, as soon as the latter can be effected. In the plans, storage at the three Canadian projects is considered an element in the Columbia Basin power system, within which individual storage operation may be varied by the Canadian Entity.

In the United States the system consists of all the hydroelectric projects on the main stem of the Columbia River, including large-capacity multipurpose storage reservoirs and run-of-the-river projects with storage capacity sufficient for weekly load factoring only. In addition, the system includes numerous reservoirs of both types on tributary streams of the Columbia River and coastal streams in the States of Washington, Oregon, Montana and Idaho. The combined power output is supplied to the regional electrical transmission network.

In Canada, the system included in the hydroelectric operating plans consists of Duncan, Keenleyside, Mica, and any future projects that may be constructed below Mica projects. If agreed to, other projects in Canada may be included.

Libby project, which is located in the United States, and whose reservoir extends into Canada is assumed to be a normal United States

tributary reservoir although the Treaty provides that its regulation may be planned to improve the inflows to those projects immediately downstream of Kootenay Lake, provided that there is no disadvantage to the United States.

The seasonal pattern of operation of storage projects depends on their location in the basin. Reservoirs on the main stem of the Columbia River, and those tributary streams whose headwaters are in the interior ranges, attain their maximum pool elevations in July or August from streamflow runoff caused primarily by snowmelt. Streamflows gradually fall after the summer snowmelt is complete. These reservoirs are lowered by withdrawals required to augment winter streamflows to sustain the region's winter electric power demand, which is at a maximum during this period. Additional storage withdrawals may be made for the purpose of controlling floods, should the potential runoff be great enough. Regulation of these reservoirs during the spring season is for power or flood control, or both purposes coincidentally.

Coastal reservoirs in the United States are subject to high winter season inflows, hence they are normally drafted a significant amount in advance to provide enough reservoir space to minimize the possibility of spilling winter freshets and to prevent flood damage.

Most coastal reservoirs, operate to predetermined elevations for power and flood control except during the time that such floods are being controlled. Normally, coastal reservoirs fill by late May or June, and water thus stored is retained until power demands require drafts in late summer or early fall.

The entire hydroelectric system is integrated with the thermal generating facilities of the region.

The seasonal operation of storage reservoirs is guided by project rule curves, variable and assured refill curves, upper rule curves, flood control refill curves, and other operating criteria which are developed from systemwide power and flood control studies as well as operating experience. These operating guidelines are incorporated into the Assured Operating Plans and Detailed Operating Plans, and their development is described in detail in Parts II, III and IV of this document. These operating guidelines are also used for guiding storage use during the course of actual operations.

PART II - GENERAL OPERATING GUIDELINES & RULES USED IN SYSTEM REGULATION STUDIES

7. PURPOSE OF GUIDELINES AND OPERATING RULES

Seasonal operation of storage reservoirs in both the United States and Canada is governed by operating criteria generally known as "rule curves." Such curves delineate a schedule of reservoir drafts which, together with other criteria, assure the system of meeting electric power loads efficiently and of utilizing storage and natural flow in such a manner as to produce the optimum amount of usable energy under any pattern of streamflow. They also provide guidance to assure adequate flood control on the Columbia River and its tributaries and insure refill of the system reservoirs with a high degree of probability.

Special operating criteria and operating rules supplement rule curves and also guide the use of system storage. Some examples are: Mica project target outflows, system draft below rule curves to meet load, and physical project operating constraints.

These parameters are derived from systemwide power regulation studies and previous operating experience, as well as hydrologic analyses of flood control problems in the basin. Both are usually developed in part by simulation techniques using mathematical models. Unless otherwise agreed, the regulation studies will be based on a 30-year sequence of historical streamflows, August 1928 to July 1958, adjusted for irrigation depletions,

the effects of natural lake storage regulation, and losses due to evaporation.

The rule curves, special operating criteria, and operating rules so developed by the mathematical simulations are intended for use in guiding the actual system operation. They prescribe a coordinated use of storage so that optimum power generation in the combined systems will be achieved in accordance with the provisions of Annex A, paragraphs 7 or 8 of the Treaty, whichever apply.

8. OPERATING GUIDELINES

a. Critical Rule Curves. A Critical Rule Curve provides a guide to reservoir storage drafts and fills with respect to time so as to provide optimum energy to meet system firm loads during the critical period (see Chart 1). The end-of-month storage contents attained by the storage reservoirs in the Critical Period Regulation Study will form the Critical Rule Curve for each project. Refer to paragraph 13c(1). In multiple year critical periods there will be a Critical Rule Curve for each corresponding year of the critical period. Time sequence will determine which curve will be first, second, etc. Usually the first curve will be highest in indicated storage energy, the second being next highest, etc.

b. Refill Curves. A Refill Curve is a guide to operation of a reservoir which allows the production of the greatest amount of usable energy consistent with an agreed probability of refill. A reservoir will not normally be drafted below its Refill Curve to serve any secondary energy loads.

Unless otherwise agreed, Refill Curves, as described in subsection (1) and (2), below, will be prepared for use as simulated operating guides in the 30-Year System Regulation Studies made for the Assured Operating Plan and Detailed Operating Plan. In actual system operation, Refill Curves are usually based on actual forecasts and are supplemented by the Flood Control Refill Curve, from 1 April through 31 July of each year, as defined in the Implementation of the Detailed Operating Plan, paragraph 23.

The end of the refill period for each Canadian reservoir will be that which provides generation in accordance with Annex A, paragraphs 7 or 8 of the Treaty, whichever applies.

(1) Assured Refill Curves. The Assured Refill Curve indicates the end-of-month storage content required to assure refill of the reservoir based on 1931 historical volume of inflow during the refill period. The year 1931 represents the second lowest historical January through July volume inflow for the Columbia River for the period 1928 to 1958 measured near The Dalles, Oregon. In computing water available for refill of the reservoir, the following shall be deducted to obtain the net inflow volume: the power discharge requirement, as described in paragraph (2)(iv) below; consumptive requirements for water at-site and upstream; and water required for refill of upstream reservoirs.

If necessary, the Assured Refill Curve shall be adjusted to prevent the Variable Refill Curves from failing the refill test described in paragraph (2)(iii), below.

(2) Variable Refill Curves. The Variable Refill Curve indicates the end-of-month storage content required during the refill period to refill

each cyclic reservoir consistent with at-site volume inflow forecasts and consistent with upstream reservoir refill requirements.

In the simulated system regulations, the Variable Refill Curve shall be developed as shown in Table 1 and detailed below:

(i) Forecast volumes of inflow used in the 30-Year System Regulation Studies will be the historical inflow volume experienced during each of the 30 years included in the studies. Each forecast volume will be reduced by a forecast error such that there is a 95 percent probability that the reduced forecast volume will be equaled or exceeded. The inflow volume will be determined for each of the periods from the first day of January, February, March, etc., to the end of the refill period using appropriate adjustments for forecast error. In computing water available for refill of the reservoir, the following shall be deducted to obtain the net inflow volume: power discharge requirement, as described in paragraph (2)(iv); requirements for water at-site and upstream; and water required for refill of upstream reservoirs.

(ii) Using the net volumes of inflow determined in (i) above, Variable Refill Curves will be determined for each of the periods of (i) above, giving the month-end storage content required to assure refilling the reservoir (see Table 1).

(iii) The Variable Refill Curves determined in (ii) above will be tested by making 30 separate 1-year System Regulation Studies wherein the cyclic reservoirs are drafted each year on a rule curve as defined below, or below this rule curve if required, as defined by the applicable Critical Period System Regulation. The rule curve used in the test shall be the

Critical Rule Curve or the Assured Refill Curve, whichever is higher; except that in the period 1 January through 31 July, if the Variable Refill Curve is lower than the rule curve defined above, the Variable Refill Curve shall be used as the rule curve. The Critical Rule Curve for the first year of the critical period will be used in the foregoing determination of the rule curve.

The storage content of each reservoir at the start of each of the 30 years of historical record will be its normal full pool content. If, in more than 5 percent of the years in the historical period the storage energy in the reservoirs fails to fill to 98 percent of the total system storage energy in the years in which secondary energy was produced in the January through July period, the net volumes available for refill determined in (i) above shall be reduced until the Variable Refill Curves of these reservoirs will meet this test. These become the Variable Refill Curves that will be used in the studies and shall serve to guide the computation of Variable Refill Curves based on forecast volume inflow in actual system operation as described in paragraph 23b(2). Failure of any reservoir to refill when secondary energy is produced by the system, January through July, due to uncontrollable natural flow in the main stem of the Columbia River, shall not constitute a violation.

(iv) In executing the test of (iii), the net volumes available for refill will be reduced, if required, by increasing the power discharge requirement. The increase will be to an extent necessary that each project will have its pro rata share of storage draft decreased to allow a greater portion of its natural inflow to be utilized for generation purposes during

the refill period. The power discharge requirement for each project will be a function of project outflow allocation during the refill period, the January through July natural volume runoff at The Dalles, Oregon (inversely proportional), and magnitude and shape of firm hydro load. The power discharge requirement will be not less than the project minimum discharge requirement nor greater than that required to support the firm energy load demand of the system for a low natural runoff at The Dalles, Oregon, during the period January through July.

(v) In practice, the refill test in (iii) is performed by 1 September, for next year's Detailed Operating Plan using rule curves and operating criteria developed from the Final Critical Period Regulation. If any reservoir does not refill at the end of the current operating year, the refill test will be initialized with storage contents actually attained by 31 July. The levels of power discharge requirements so defined are carried forward 5 years and applied to the next subsequent Assured Operating Plan. In those test cases where the system regulation is initialized under extreme draft conditions, special refill studies for the Assured Operating Plan may be necessary.

c. Limiting Rule Curves. The Limiting Rule Curves shall consist of month-end storage contents which must be maintained to guarantee the system meeting its firm load during the period 1 January through 31 March 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 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.

d. Upper Rule Curves. The Upper Rule Curves shall consist of the following:

(1) During the Flood Control Evacuation Period the Upper Rule Curve shall be derived from Flood Control Storage Reservation Diagrams which provide the required storage space. Required drawdown for headwater projects are based on at-site inflow forecasts. Drawdown for major lakes controlled by dams is designed to achieve the maximum natural storage effect of the lakes during the refill period. Grand Coulee and Keenleyside project Storage Reservation Diagrams reflect the unregulated runoff forecasts for the Columbia River at The Dalles, Oregon, for the period April through August.

(2) During the refill period the Upper Rule Curve shall be the storage content necessary to control the flood runoff to nondamaging levels if possible, and to regulate larger floods that cannot be controlled to nondamaging levels to the lowest possible level with the available storage space. This regulation is accomplished by establishing a flood control objective at The Dalles and adjusting outflows from Keenleyside, Grand Coulee, and John Day projects to meet the controlled flow. The initial objective, the "Initial Controlled Flow for the Columbia River at The Dalles", is determined as described in the "Columbia River Treaty Flood Control Operating Plan", dated October 1972. Adjustments to the controlled flow objective can be made, if necessary, as the refill period proceeds. During this period the headwater project outflows are normally reduced to

their minimums unless greater flows are required to meet power demands. Higher outflows may also be maintained if they are determined not to be detrimental to flood control, or are required to control storage space during exceedingly large floods.

(3) During both the evacuation and refill periods, the Upper Rule Curve may be established by project construction or other contingency requirements. It shall not be lower than the Variable Refill Curve, except in those years in which the April through 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, the Upper Rule Curve may be lower.

(4) In the studies, Upper Rule Curves define the maximum allowable storage content of each reservoir. Such data is determined from independent simulated flood control regulations for the historical period 1928 to 1958, in accordance with the concepts of the Flood Control Operating Plan.

e. Operating Rule Curves. The Operating Rule Curve for each reservoir for use in the 30-Year System Regulation Studies is a synthesis of all of the preceding operating guidelines. It will be developed from the Critical Rule Curve, Assured Refill Curve, Variable Refill Curve, and the Upper Rule Curve as follows: During the period 1 August through 31 December, the Operating Rule Curve shall be defined by the first Critical Rule Curve or the Assured Refill Curve, whichever is higher. During the period 1 January through 31 July the Operating Rule Curve shall be defined by the higher of the first Critical Rule Curve or the Assured

Refill Curve, unless the Variable Refill Curve is below the higher of the two above curves, then it shall be defined by the Variable Refill Curve. In no case shall the Operating Rule Curve be higher than the Upper Rule Curve; it shall not be lower than the Limiting Rule Curve developed for such year (see Charts 2 and 3) during the period 1 January through 31 March. The Operating Rule Curve for the whole of Canadian storage is the summation, by months, of the usable storage corresponding to the Operating Rule Curve indicated for each individual project.

f. Special Mica Operating Criteria.

(1) In accordance with paragraph VII (3) of the Protocol, Canadian storage is operated to provide optimum generation in Canada and the United States. To accomplish this, the Mica project is operated to criteria developed annually in the Hydroelectric Operating Plans and Detailed Operating Plans. The operating criteria for Mica project typically consist of target end-of-month storage content, target outflows and modifications as a function of Arrow reservoir storage content, maximum outflows and minimum outflows.

The Mica operating criteria are designed to accomplish the following:

(i) Increase the firm energy, secondary energy, and/or dependable capacity of the Mica and Canadian downstream projects.

(ii) Improve the monthly distribution of energy production on the Canadian system.

(iii) Maintain sufficient outflow to allow peaking at all times; and

(iv) Provide for reservoir drawdown, including drawdown into non-Treaty storage, at times required by the Canadian system.

A sample set of Mica operating criteria is shown in Table 2.

(2) Mica operating criteria may require non-Treaty storage releases from Kinbasket Lake. When possible these releases will be held in Arrow reservoir and transferred back to Kinbasket Lake. This operation may cause additional losses to the United States if the Mica minimum release requirements prevent water from being transferred back to Mica prior to the time Arrow fills or reaches the Upper Rule Curve. Allowance for this possible loss is included as a reduction in Canadian Entitlement.

9. OPERATING RULES

Operating Rules, as outlined below, shall be developed and applied jointly by the Canadian and United States Entities to describe the operation of the system, including the Canadian storages, for optimum generation in accordance with Annex A, paragraph 7 or 8 of the Treaty, whichever applies. (Optimum generation is defined by a series of system regulation studies and downstream benefit determinations, see paragraph 13b.) These Operating Rules shall be observed in conducting the System Regulation Studies in Part III and Part IV and in actual operation.

The Operating Rules will include the following:

a. The whole of the Canadian storage shall be drafted to its Operating Rule Curve as required to produce optimum generation in accordance with Annex A, paragraph 7 or 8 of the Treaty, whichever applies, subject to the following:

b. The whole of the Canadian storage will not be drafted below its Operating Rule Curve until: (1) all reservoirs in the United States system

have been drafted to their Energy Content Curves; (2) all deliveries of secondary energy in the United States are curtailed; and (3) all 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. In actual operation, secondary energy refers to markets exceeding the developed firm energy load carrying capability of the United States system. Energy Content Curves for United States reservoirs are equivalent to Operating Rule Curves.

c. When the conditions of paragraph 9b above are met, and it is necessary to draft additional storage to produce optimum generation, as determined by the applicable Critical Period System Regulation Study, the whole of the Canadian storage and all reservoirs in the United States system will be drafted proportionately between their respective Operating Rule Curves or Energy Content Curves and their first Critical Rule Curves. If it is necessary to draft additional storage after system reservoirs reach their first Critical Rule Curves the proportionate draft will be made between their first and second Critical Rule Curves, their second and third Critical Rule Curves, etc. When it is necessary to operate the whole of the Canadian storage and the United States reservoirs below their lowest Critical Rule Curves, they shall be operated proportionately between their lowest Critical Rule Curves and their normal minimum contents. If the storage content for any reservoir is equal to or lower than the Critical Rule Curve to which the system is being proportionately drafted, such reservoir shall not participate in proportionate draft until the system proportionate draft exceeds such Operating Rule Curve or Energy Content

Curve for such reservoir. It shall then participate in the additional system draft.

d. Constraints to be considered include:

(1) Maximum rate of storage draft and refill.

(2) Maximum and minimum outflows.

(3) Upper and lower reservoir elevations.

(4) Flood control criteria.

(5) Nonpower requirements.

e. In the studies, proportionality between rule curves shall be computed in terms of storage.

f. In operation, proportionate draft between Critical Rule Curves for the whole of Canadian storage and major United States Federal reservoirs will be determined as set out in Part IV, paragraph 23c and in general accordance with the following description:

(1) Establish the amount of energy to be produced by proportionate draft for the remaining balance of the current month. (Refer to Table 7.)

(2) Calculate the system energy content between the appropriate rule curves by assuming release of the total storage content therein through the estimated total water to power conversion factors applicable at the time for all at-site and downstream power projects in the United States. Constraints and other operating limitations shall be recognized in this calculation.

(3) The amount of system energy to be produced by proportionate draft in (1) above divided by the total amount of system energy calculated in (2) above is the ratio which is multiplied by each reservoir's storage

content between rule curves determined in (2) above, to indicate its proportionate share of the required draft. The whole Canadian storage is considered one reservoir.

(4) The indicated proportionate draft will be adjusted to minimize project discharge in excess of turbine capacity for energy conservation. The adjusted storage draft shall be the proportionate draft.

(5) Proportionate draft will be recalculated if the energy requirement or system conditions change but not more often than once each week.

Notwithstanding the operating guidelines as stated above, exchanges of capacity and energy may be substituted for releases from Canadian storage, if mutually agreed by the Entities as to quantities, timing and method, and energy acquired by United States Systems from sources outside the Pacific Northwest Coordinated System may be used in lieu of energy otherwise produced by proportionate draft of such system reservoirs.

PART III - ASSURED OPERATING PLAN AND DOWNSTREAM BENEFIT COMPUTATION

10. OBJECTIVES AND USE OF ASSURED OPERATING PLANS

An Assured Operating Plan will be prepared each year for the sixth succeeding year of operation. This requirement will provide that an Assured Operating Plan will always be available for five complete operating years. An operating year, as used herein, shall mean the period 1 August through 31 July. The plan will establish the generation potential of both systems, prescribe operating criteria and procedures to insure that the potential will be realized, and will serve as a basis for the Detailed Operating Plan. It is intended that the Assured Operating Plan will also provide the Entities with essential information for effective operational planning of their respective power systems which are dependent on or coordinated with the operation of Canadian storage.

The Assured Operating Plan shall reflect the requirements included in the Treaty, its annexes, and related documents. The studies necessary to develop the plan will be undertaken by the Entities jointly.

11. OBJECTIVES AND USE OF THE DOWNSTREAM BENEFIT COMPUTATIONS

Downstream Benefit Computations will be prepared annually in accordance with Annex A, paragraph 7 and Annex B of the Treaty, paragraphs VIII, IX and X of the Protocol; and as detailed in paragraph 17 below. They shall be prepared in conjunction with the Assured Operating Plan, as outlined in paragraph 13 below, and shall define the downstream

power benefits in the United States from Canadian storage 5 years in advance for each year in which the Treaty is in force. As indicated in paragraph 13 below, they shall also serve to define the limit to which Canadian storage may be reregulated to Canadian advantage so as to develop optimum power generation in Canada and the United States.

12. DATA REQUIREMENTS

Prior to March of each year the Entities shall exchange information and data for the systems in the two countries not previously exchanged and which are necessary for development of the Assured Operating Plan. The information and data to be exchanged shall include: schedules for initial operation of power generating and storage facilities, peak and energy load data, project modified flows for the period in use beginning with 1 August 1928, reservoir capacity, conversion factors and peaking capacities throughout the operating range, constraints, minimum flow limitations, limitations including flood control criteria, maintenance or construction schedules, and any other data necessary to establish the required operating plans.

13. GENERAL PROCEDURE FOR DEVELOPING THE ASSURED OPERATING PLAN AND DOWNSTREAM BENEFIT STUDIES

a. Because the Assured Operating Plan and the Downstream Benefit Computation are mutually dependent, their development is accomplished concurrently. Each step of the procedure, as outlined below, evolved from experience for ease and efficiency of deriving the operating plan. It

assumes that generating facilities exist at Mica Dam or downstream thereof, and that the plans must be designed "to achieve optimum power generation at - site in Canada and downstream in Canada and the United States of America, including consideration of any agreed electrical coordination between the two countries". (Reference: Annex A, paragraph 7 of the Treaty.)

b. In accordance with Annex A, paragraph 7 of the Treaty and paragraph VII (3) of the Protocol to the Treaty, optimum power generation in both Canada and the United States is achieved in the Assured Operating Plan through analysis of the following modes of Canadian storage operation:

(1) Canadian storage in the Annex B, Step I system is initially operated for optimum generation in the United States which maximizes the firm energy capability in the United States system. Three quantities are then computed for both the Canadian and United States systems:

(i) firm energy capability;

(ii) dependable peak capability; and

(iii) average annual usable secondary energy capability.

(2) The Canadian storage operation in (1) is then modified to achieve a weighted sum for Canada and the United States of the three quantities listed in (1) that is greater than the weighted sum achieved under operation for optimum generation in the United States alone.

(3) When an operation in (2) is achieved such that the weighted firm energy, dependable peak, and average annual usable secondary energy capabilities are maximized, the mode of Canadian storage operation is entered into a Downstream Benefit Computation (Annex B of the Treaty, Step II and Step III systems) to determine:

(i) the resulting downstream benefits; and

(ii) whether the loss of downstream benefits to the United States are within the allowable limits.

If the loss in downstream benefits exceeds the allowable limits described in paragraph 15c, the modified operation of Canadian storage in (2) above must be revised so that the downstream benefits are within the limits. In order to select the optimum system operation from the studies in (1) and (2) above, the sum of the gains or losses in firm energy, dependable peak and average annual secondary energy capability that is usable in each system must be defined by the respective Entities. A relative value of each of the three quantities will be assigned for the purpose of establishing a common measure of the gains or losses.

c. In order to assess the quantities defined in paragraph 13b(1) above, a number of simulated system regulation studies are required. These studies are described in the following sections.

(1) Critical Period System Regulation Studies. The Critical Period Regulation Study shall be adopted to form a basis for the Critical Rule Curves, which are developed from a hindsight evaluation of the critical period. The Critical Period Study is normally incorporated into a 30-year study which operates the system identically during the water years applicable to the Critical Period; the Rule Curves developed also guide storage use in other periods when they govern the Operating Rule Curve. The critical period itself is the most adverse flow sequence of the historical period of streamflows and the one which produces the least amount of firm energy load-carrying capability for the system. The

critical period can be of varying length depending on the number of storage reservoirs in the system, the schedule of incoming resources, and the shape of the system load.

The study is a simulated system regulation and shall be prepared in accordance with established utility practice. The regulation shall assume:

(i). Except reservoirs operating for non-power purposes, each reservoir will be at its normal top elevation at the beginning of the critical period, and will be drafted to its normal bottom elevation by the end of the critical period.

(ii). The system shall be regulated with the intent to maximize critical period energy, consistent with the de-maximization limits provided for in the downstream benefit computations.

(iii). When other authorized reservoir uses limit release of storage water in the critical period, such regulation shall be based on the maximum storage use consistent with the limitations.

(iv). The output at any project shall not exceed an 85 percent plant factor in any period, unless a higher plant factor is necessary to make all storage water usable during the critical period.

(v). In multiple-year critical periods, no reservoir shall be drafted by any 1 April below the elevations determined by its Assured Refill Curve, unless all reservoirs have been drafted to such elevations and additional draft is required to meet the firm load of the system.

(vi). The estimated loads and scheduled hydro and thermal resources for the operating year of the study shall be used. As appropriate, scheduled maintenance outages, reserves, and firm import/export loads shall also be

considered. The load shall include power required for pumping water into Banks Lake from Grand Coulee reservoir, but shall be reduced by miscellaneous regional resources which are not included in the study.

(vii). If the residual calculated load is not balanced with the included system resources, the energy surplus will be shaped uniformly by month. If the load resource balance indicates a system deficit, unscheduled resources will be added uniformly for each period so that the deficit is eliminated.

(2) 30-Year System Regulation Studies. 30-Year System Regulation Studies shall be made for each operating year using the appropriate Operating Rule Curve and Operating Rules described in Part II. It is intended, in particular, that the Operating Rule Curve and associated operating criteria, including the Critical Rule Curves, be designed to regulate the system for the entire 30 years without the benefit of historical hindsight. Failure of the system to operate in accordance with the refill principle set forth in paragraph 8b(2)(iii) of this document will require that the Operating Rules or the Operating Rule Curve, including its component parts, be modified to eliminate such failures.

The studies shall be made sequentially for the prescribed 30 years, using the estimated load shape and resources for the operating year for which the Assured Operating Plan is being developed.

14. DEVELOPMENT OF THE ASSURED OPERATING PLAN

a. A total of nine studies are required to complete the Assured Operating Plan and downstream benefit studies. The basic assumptions for these studies and their basic purpose is shown in the accompanying table.

ASSURED OPERATING PLAN SYSTEM REGULATION STUDIES

Study No.	Study*1 Designation	Annex B Step No.	Generation Optimized in	Period*2			
1	YR-11	I	U.S.	Critical	15 1/2 maf All Columbia Hydro Projects	Total Hydro + Thermal	Used to establish operation of real system operated for optimum generation in U.S. and to determine whether total generation capabilities increase due to optimization in both countries.
2	YR-12	II	U.S.	30-year	15 1/2 maf	U.S. Base*3 + Thermal	Computation of DSB; system operated for optimum generation in the U.S. Used to establish allowable annual DSB reduction.
3	YR-13	III	-	30-year	-	U.S. Base + Thermal	Base run for all DSB computations.
4	YR-22	II	U.S.	30-year	15 maf	U.S. Base + Thermal	Computation of DSB; system operated for optimum generation in the U.S. with 1/2 maf withdrawn. Used to establish allowable annual DSB reduction.
5	YR-32	II	U.S.	30-year	12 1/2 maf	U.S. Base + Thermal	Computation of maximum total permitted reduction in DSB, operated for optimum generation in the U.S.
6	YR-11	I	U.S.	30-year	15 1/2 maf All Columbia Hydro Projects	Total Hydro + Thermal	Same as Study 1.
7	YR-41	I	U.S. & Can.	Critical	15 1/2 maf All Columbia Hydro Projects	Total Hydro + Thermal	Final adopted regulation of real system. Optimization of real system in both countries.
8	YR-42	II	U.S. & Can.	30-year	15 1/2 maf	U.S. Base + Thermal	Computation of DSB, optimized for both countries.
9	YR-41	I	U.S. & Can.	30-year	15 1/2 maf All Columbia Hydro Projects	Total Hydro + Thermal	Same as Study 7.

*1 YR denotes study year, e.g. 82-11, is study for year August 81 to July 82.

*2 Studies 2, 3, 4, 5, and 8 (DSB computations) use flows as indicated in paragraph VIII of the Protocol. Studies 1, 6, 7, and 9 use modified flows from Columbia River Water Management Group Report titled "Provisional Report on Modified Flows at Selected Sites 1928 to 1968 for the 1970 Level of Development," dated April 1974 and, "Provisional Report on Modified Flows at Selected Sites 1928 to 1968 for the 2020 Level of Development," dated May 1974.

*3 U.S. Base System is defined in Annex B, Base System Table.

This table assumes that the Assured Operating Plan is being developed in accordance with Annex A, paragraph 7 of the Treaty. In the event that the plan is to be developed for optimum generation in either country, a similar schedule of studies to be performed will be developed to insure compliance with the provisions of Annex A, paragraph 8 of the Treaty.

b. Studies 1 and 6

These are detailed simulated system regulations of the total United States power system less minor resources with the Canadian storage operated to provide optimum power generation in the United States. Optimum generation is achieved if the firm energy capability of the United States system is maximized.

Study 1 optimizes United States system critical period energy capability and the rules, operating criteria, etc., are then applied to Study 6. Study 6 simulates system operation for the 30-year period. In practice the two studies are developed concurrently.

Both the United States and Canadian systems' firm energy, secondary energy and dependable capacity are then summed per paragraph 13b.

c. Studies 7 and 9

In Studies 7 and 9 the objective is to modify the operation of Canadian storage in Studies 1 and 6 in such a manner as to achieve optimum generation in both countries as indicated in paragraph 13b. The Mica project is operated to fixed rules similar to those outlined in paragraph 8f. Duncan and Arrow storage operation are modified when possible to compensate for the changes in flows at the international boundary caused by the change in Mica operation. Because Duncan and Arrow

storage cannot fully mitigate these changes there may be a net loss in the United States system relative to the United States optimum Study 6.

Generally, losses to the United States system result from the following conditions:

(1) Water is trapped in Mica, Arrow is empty or at maximum discharge capability, resulting in a decrease of water being released from Canadian storage in a given period compared to that indicated in the United States optimum study. The deficit must then be compensated by United States reservoirs.

(2) Additional water is released from Mica in a given period, Arrow storage is full or governed by flood control requirements and, therefore, unable to hold the additional water. Water is thus released at a time not required in the United States.

(3) Minimum release requirements at Mica project prevent Kinbasket Lake from refilling when all other projects in the basin refill. This may result in increased spill at downstream projects in the United States, reduction in usable surplus or reduction in firm energy capability for the next operating year. These expected real losses to the United States system must be at least equaled by increases in the Canadian system in order for the modified Canadian system operation to be allowable. If this condition is satisfied, Studies 7 (critical period) and 9 (30-year average) will form the basis of the Assured Operating Plan.

15. DEVELOPMENT OF THE DOWNSTREAM BENEFIT STUDIES

a. Five downstream power benefit studies are required coincidentally with the Step I studies prepared for the Assured Operating Plan. The downstream benefit studies contain the United States base system as defined in Annex B, Base System Table, and where applicable, Canadian storage. All Step II and III studies are performed with 30-year flows identified in paragraph VIII of the Protocol to the Treaty. Use of these flows assures that the downstream benefit computations performed currently will be based on the same fundamental water supply assumptions as those computed for earlier Assured Operating Plans. Thermal energy capability used in Step II and III studies is equal to the Step I thermal energy capability.

b. Study 3 (Step III) includes the United States base system only, generation optimized for the United States. Step II Studies 2, 4, 5, and 8 (reference Table paragraph 14a) include Canadian storage in the first-added position to the base system. Generation is optimized for the United States in Studies 2, 4, and 5, and in both countries in Study 8. The differences in capacity and energy derived from the Step II and Step III studies provide the computed downstream benefits for the year and serve the purpose of defining the limits to which Canadian storage may be reregulated to achieve optimum generation in both countries. These studies are based on the same regulation criteria used in the applicable Step I study. Special operating rules for Mica project which are developed for the Assured Operating Plan are recognized in Study 8 and are identical to those used in Study 9. The differences in capacity and energy derived from Study 8 and Study 3 provide the computed downstream power benefits for the year.

c. From the studies listed above, the minimum permitted downstream power benefits shall be the higher of the two following conditions:

(1) The downstream power benefits associated with 12.5 million acre-feet (maf) of Canadian storage in any year, which is derived from Study 5 and Study 3 for the year under study; or

(2) The downstream power benefits associated with the preceding year's benefits reduced by the effect of withdrawing 0.5 maf of Canadian storage in addition to natural reductions caused by irrigation depletions and system growth.

Condition 1 defines the benefits of 12.5 maf of Canadian storage operated for optimum generation in the United States compared to the United States base system operating alone. Condition 1 has not controlled the minimum permitted benefits through 1978, hence Study 5 has not been performed each year. Condition 2 is defined by the following:

$$\begin{aligned} \underset{\text{min}}{Dsb} &= X + (Yp - Y) - (Yp - Z) \\ &= X - Y + Z \\ &= X - (Y - Z) \end{aligned}$$

where

X is the previous year's downstream power benefits derived from Study 8 and Study 3, operated for optimum generation in both countries

Y is derived from the previous year's Study 2 and previous year's Study 3, operated for optimum generation in the United States

Yp is derived from the current year's Study 2 and Study 3, operated for optimum generation in the United States

Z is derived from the present year's Study 4 (15 maf) and Study 3 operated for optimum generation in the United States.

The computation above is based on the fact that in addition to the allowable decrease due to withholding of 0.5 maf of Canadian storage, there is a normal decrease (or increase) from year-to-year due to irrigation depletions and resource changes in the United States base system. Such increase/decrease is the difference between the benefits derived from the previous year's Studies 2 and 3, and the present year's Studies 2 and 3 (Yp - Y).

The differences in capacity and energy derived from Study 8 and Study 3 will provide the computed downstream power benefits for the year. The resulting benefits shall not be less than the greater of the two minimum permitted benefits calculated above. If this requirement is met, then Study 9 will be the basis for the Assured Operating Plan for the year under study.

d. The compensation due to Columbia Storage Power Exchange with respect to reduction of the Canadian Entitlement, in accordance with Section 7 of the Canadian Entitlement Purchase Agreement, is half the differences between the computed downstream power benefits derived from Study 2 and Study 3, i.e. Yp, and the computed downstream power benefits derived from Study 8 and Study 3.

16. CONTENT OF THE ASSURED OPERATING PLAN

The following items used in or developed from the 30-Year System Regulation Study adopted in paragraphs 13 and 14, for each of the operating

years, shall form the Assured Operating Plan for the Canadian storages for the particular operating year concerned. It shall be compiled by the Entities by 1 September of each year and shall contain the following:

a. The Critical Rule Curves and the Assured Refill Curves in terms of end-of-month storage content for the whole of the Canadian storage. The Critical Rule Curves shall be composed of the tabulated storage contents for the water years which are included in the critical period for the particular operating year concerned. In multi-year critical periods, the Critical Rule Curve (tabulated for all water years within which the critical period falls) shall be designated as first, second, third, etc., on the basis of their time sequence, in Canadian storage as a whole at the beginning of the operating year. The end-of-month storage contents tabulated to form such a Critical Rule Curve will be determined from the Critical Period System Regulation Study.

b. Variable Refill Curves in terms of end-of-month storage content for the whole of Canadian storage for the period 1928 to 1958.

c. Upper Rule Curves for Duncan, Keenleyside and Mica projects, in terms of end-of-month storage content for the period 1928 to 1958.

d. The Operating Rule Curve, in terms of end-of-month storage content for the whole of Canadian storage for the period 1928 to 1958.

e. The procedures for development of Variable Refill Curves.

f. Operating Rules, including special Mica Project Operating Criteria, such as target end-of-month storage contents, outflows, maximum/minimum outflows by months as a function of Arrow reservoir storage contents.

g. Text, as required to supplement the tables in a through d above, including amplifying comments regarding operating rules, constraints, loads, resources, construction requirements, or other pertinent data unique to the operating year.

An implementation section consistent with Article XIV2(k) of the Treaty shall also be included.

17. METHOD OF DETERMINING DOWNSTREAM BENEFITS

The following procedure for determining the downstream benefits and Canadian Entitlement supersedes the "Agreement on Procedures for the Determination of Downstream Power Benefits Resulting From Canadian Storage", dated 19 September 1968. In determining, for each year, the increase in dependable hydroelectric capacity and the increase in average annual hydroelectric energy, system regulation studies will be made as follows:

Step I

This study will establish the plant installation of the United States base systems and the energy capability during the critical period of the thermal installation, in accordance with paragraph 17b.

Step II

A system regulation study will be made to determine the critical period energy capability and the average annual energy capability of the system using the thermal energy capability defined in paragraph 17c; the United States base system, with the same hydro plant installation as in Step I; and Canadian storage.

Step III

A system regulation study will be made to determine the critical period energy capability and the average annual energy capability of the system using the thermal energy capability defined in paragraph 17c. and the United States base system, with the same hydro plant installation as in Step I.

a. For the Step I system regulation studies, the monthly forecast firm load of the Pacific Northwest Area, defined in Annex B, paragraph 7 of the Treaty, will be reduced by the monthly capacity and energy capabilities of all Pacific Northwest resources not included in the study to obtain the residual area load to be met in the Step I study. In accordance with paragraph X of the Protocol, the area load used will include the power required for pumping water into Banks Lake from Grand Coulee reservoir. The estimated Canadian Entitlement to be returned to Canada will also be included in the area load. The annual load used in making the determinations required by Step II and Step III systems shall have the same month-by-month shape as the load of the Pacific Northwest area. The loads for Step II and Step III will be taken as equal to the energy capabilities of the systems and will be determined in accordance with the following procedures:

(1) Estimate the average hydro energy capabilities for the critical periods of the Step II and Step III systems;

(2) Add the thermal energy capability as determined in paragraph 17c below to each of the capabilities of (1) above to obtain a total average critical period energy capability for the Step II and Step III systems;

(3) Multiply the totals obtained in (2) above by the ratio of the area average annual firm load to the area average critical period firm load to obtain the average annual firm loads for Step II and Step III systems;

(4) Prorate the average annual firm loads determined in (3) in the ratio that each Step I monthly area firm load bears to the Step I area average annual firm load to obtain an Area monthly firm load for Step II and Step III systems; and

(5) Subtract the thermal energy capability to determine the monthly firm hydro loads of Step II and Step III systems.

The average annual hydro loads for Step II and Step III systems also become the firm energy considered usable according to Annex B, paragraph 3(a) of the Treaty.

b. The thermal energy capability of the thermal installation to be used in the Step I system will be the sum of:

(1) the average thermal energy forecast to be required during the critical period to carry firm load of the Pacific Northwest area; and

(2) the average over the critical period of any surplus energy capability of the thermal installation that is agreed by the Entities to be usable in meeting secondary loads.

c. The thermal energy capability shall be based on project owner's recommended annual capacity factors that reflect scheduled maintenance and energy reserves. Capacity reserves shall be 8 percent of the total system peak load. The thermal energy capability to be used in the Step II and III studies shall be the same as determined for Step I in paragraph 17b. The potential thermal energy displacement to be used in the determination of

the usable energy described in paragraph 17f(2)(ii) shall be the thermal energy capability less the minimum thermal operation.

d. The flows used in the system regulation for the benefit determination will be the same as those indicated in paragraph 15a.

e. As long as the International Joint Commission Order of Approval of 11 November 1938, is in effect, the operation of Kootenay Lake in the Step II and Step III system regulation studies will be limited to the usable storage content below El. 1743.32 feet. If, in the future, this order is amended, the Entities may agree to modifying this criterion for Kootenay Lake usable storage operation. The Kootenay Lake usable storage content, not exceeding 673,000 acre-feet, will be operated in the Step II and Step III studies for system prime power, within the limits of the International Joint Commission Order then in force.

f. The Canadian Entitlement to downstream power benefits for any operating year, in accordance with paragraph 1 of Article V of the Treaty, shall be one-half of the dependable hydroelectric capacity benefit and one-half the average annual usable hydroelectric energy determined, in accordance with (1) and (2) below:

(1) Dependable Hydroelectric Capacity Benefit - The capacity benefit from Canadian storage will be the difference between the average rates of generation during the critical periods of the Step II and Step III hydro systems divided by the average of the monthly load factors during the critical period of the Pacific Northwest area, as determined from the Step I study.

(2) Average Annual Usable Hydroelectric Energy Benefits - The energy benefit from Canadian storage will be the difference in the average annual usable energy of the Step II and Step III systems computed for the system of each step as the sum of:

(i) The firm energy, which is the firm hydro energy capability shaped to the area load shape, plus

(ii) The energy which can be used for thermal energy displacement in the Pacific Northwest area, plus

(iii) Forty (40) percent of the energy remaining.

g. The operating year, 1 August through 31 July, is the period for which downstream power benefits will be determined. The Canadian Entitlement to downstream power benefits shall begin on 1 April prior to the 1 August commencement of the operating year for which the determination has been made and shall end on the following 31 March.

18. CONTENT OF THE DOWNSTREAM POWER BENEFIT DOCUMENT

The Downstream Power Benefit Document shall note the following:

a. The Canadian Entitlement, which is one-half the total computed downstream power benefits for the Assured Operating Plan studies adopted.

b. One-half the minimum permitted downstream power benefits, as indicated by paragraph 15c above.

c. Effect on the Canadian Entitlement Purchase Agreement which is the difference between paragraph a above, and one-half the downstream power benefits which would have been computed if the Assured Operating Plan had

been designed to achieve optimum generation downstream in the United States alone.

The document shall also contain tables and charts as follows:

(1) Computation of Canadian Entitlement;

(2) Summary of Power Regulations;

(3) Determination of Steps II and III loads; and

(4) Secondary Energy Duration Curves for Steps II and III (refer to Tables 3, 4, and 5, and Charts 4 and 5).

PART IV - DETAILED OPERATING PLAN

19. GENERAL

For each year's actual operation, a Detailed Operating Plan shall be developed for Libby reservoir, each of the Canadian storage reservoirs and for the whole of the Canadian storage. The Detailed Operating Plan shall be developed, as described below, from the Assured Operating Plan previously agreed to for that operating year. Planning of the Detailed Operating Plan will begin in January for the August through July operating year immediately following, and the plan will be completed by September as indicated below. In general, all system regulation studies necessary for the formulation of the Detailed Operating Plan will be done either jointly by the Entities, or by one of the two Entities in consultation with the other.

20. REVIEW OF ASSURED OPERATING PLAN

a. The Canadian and United States Entities will review the Assured Operating Plan applicable to the immediately ensuing operating year. Changes in system load estimates, resources, duration of the critical period, flood control criteria, and any other pertinent data will be considered in this review using the latest available data in comparison with that used in the original computation. If the Entities agree that these changes warrant further investigation, a revised Critical Period System Regulation Study will be made using these latest data. The regulation studies will be made in accordance with Annex A, paragraphs 7 or

8 of the Treaty, whichever may be in force. In addition, 30-Year System Regulation Studies will be made as desired by the Entities to evaluate all effects of the changes in the operating plan.

b. The Entities will agree prior to 1 February on the need for either a revised Critical Period System Regulation or to use the Critical Period System Regulation from the Assured Operating Plan as the basis for the Detailed Operating Plan. If the necessity for a revised Critical Period System Regulation cannot be agreed upon, or if a revision cannot be agreed upon, the Critical Period System Regulation from the Assured Operating Plan shall be retained in the Detailed Operating Plan and shall be set forth in the same detail as provided in paragraph 22 below.

21. SYSTEM REGULATION STUDIES

a. Modifications to Critical Period System Regulation. If the Assured Operating Plan regulation of Canadian storage is to be revised, each Entity may make an optimum Critical Period System Regulation Study and may make such other System Regulation Studies of its own coordinated system as it deems necessary. Copies of the optimum regulation studies will be exchanged by the Entities. Following completion of these studies, and in any case not later than 1 April, the Entities will meet and review the foregoing studies to agree on any modifications to the regulation of Canadian storage which may be mutually desirable, or which may be desirable to one Entity and is acceptable to the other Entity.

If new Operating Rule Curves or operating rules are to be developed for the Detailed Operating Plan, they shall be developed from a load growth

type regulation study. In this case, the estimated loads and scheduled resources will be accounted for during the entire length of the Critical Period. If the load is not balanced with the resources during the critical period, the system energy surplus will be shaped in a manner such that no month is deficit. If the system is deficit during the critical period no surplus may be shaped into any month. The extent of such shaping will be governed by a simulated system regulation which is acceptable to both Entities.

Further changes to the Critical Period System Regulation may be made by either Entity prior to 15 May, provided that (1) such changes are made pursuant to existing contracts in the United States, and (2) both Entities are in agreement.

b. Final Critical Period System Regulation. Using the regulation of Canadian storage, as agreed to or as modified within limits agreed in paragraph a above, a final Critical Period System Regulation Study will be made jointly by the Entities, or by the United States Entity in consultation with the Canadian Entity by 1 July. The Critical Rule Curves and related operating criteria developed from the final study will then provide the operating guides for Canadian storage until the completion of the term of the Detailed Operating Plan.

c. Historical 1-Year System Regulation. Using the Critical Rule Curves developed in the final Critical Period Study, 30 separate 1-Year System Regulation Studies, beginning with August 1928 flows, will be made by the Entities to insure the adequacy of the operating guidelines and criteria, in accordance with the principles set forth in Part II. Starting

reservoir contents in each of the 30 years will be that actually reached by 31 July preceding the new operating year. The regulation will be made to meet the estimated firm and secondary loads, in accordance with Annex A, paragraphs 7 or 8 of the Treaty, whichever applies. The Operating Rule Curve and its components will be changed, if necessary, to comply with the principles set forth in Part II. These studies shall be completed by 1 September.

22. CONTENT OF DETAILED OPERATING PLAN

The Detailed Operating Plan shall consist of the data and criteria listed below. It shall be compiled by the Entities by 1 October.

a. Distribution of usable Canadian storage space available for power and flood control purposes.

b. Definition of the Operating Rule Curve.

c. Guidelines for the anticipated means of implementing the Detailed Operating Plan.

d. Definition of operating rules and project operating limits.

e. Critical Rule Curves for each of the Canadian reservoirs and for the whole of the Canadian storage tabulated in terms of end-of-month storage contents. The first Critical Rule Curve data shall be taken from the final Critical Period System Regulation Study described in paragraph 21b above. In addition, Critical Rule Curves tabulated in previous Detailed Operating Plans applicable to the immediately ensuing operating year shall be tabulated herein and identified as second, third, etc., on the basis of their time sequence (see Chart 6).

f. Assured Refill Curves for each of the Canadian reservoirs and for the whole of the Canadian storage tabulated in terms of month-end storage contents. These data are to be those finally agreed upon, as described in paragraph 21c above.

g. Procedure for determining the Variable Refill Curves for each of the Canadian reservoirs.

h. Procedure for determining the Flood Control Refill Curves for each of the Canadian reservoirs, if required.

i. Storage-elevation tables for Keenleyside, Mica, Duncan and Libby projects.

j. Critical Rule Curves for succeeding operating years.

k. Any additional supplementary text or tables required to limit or clarify the intended operation of the system which would be unique to the operating year for which the plan is devised.

l. Special Mica project rules and operating criteria.

m. Critical Rule Curves, Energy Content Curves and pertinent operating criteria for Libby project.

23. IMPLEMENTATION

Actual operation of the Canadian storage shall be guided by the Detailed Operating Plan and by any more detailed operating arrangements that may be worked out by the operating or scheduling personnel. These detailed operating arrangements will be made in accordance with established utility and water management practices. The Entities will exchange all

current operating data necessary for continuing review of system operations.

a. Scheduling Operation of Canadian Storage. Requests by the United States Entity for storage operation shall be directed to the whole of the Canadian storage consistent with the Operating Rule Curve and other operating criteria designed to provide optimum generation in accordance with Annex A, paragraphs 7 or 8 of the Treaty, whichever applies. Requests will be made on a regular weekly basis, or as otherwise mutually agreed and shall be in terms of storage water delivered at the Canadian-United States border. In honoring such requests, the Canadian Entity shall operate Canadian storage consistent with optimum storage use. The Operating Rule Curves and or special operating criteria prepared for the individual Canadian reservoirs shall be used as a measure of any deviation from the optimum operation.

b. Operating Rule Curves.

(1) During the period 1 August through 31 December the Operating Rule Curve for each Canadian reservoir will be that indicated in paragraph 8e.

(2) During the period 1 January through 31 March, the Operating Rule Curve will be that indicated for the period beginning 1 January in paragraph 8e, except that Variable Refill Curves shall be based on the actual 95 percent confidence volume inflow forecasts at-site and the most probable inflow forecast at The Dalles, Oregon, utilizing the same principles indicated in paragraph 8b. The Upper Rule Curve shall be based on the most probable forecasts.

(3) During the period 1 April through 31 July, the Operating Rule Curve shall be defined as the higher of the first Critical Rule Curve or the Assured Refill Curve unless the Flood Control Refill curve is below the higher of the above two curves. Then it is defined as the Flood Control Refill Curve. In addition, the Operating Rule Curve for this period shall not be higher than the Upper Rule Curve, which is developed from day-by-day computer simulations of the system during the refill period consistent with flood control objectives and the most current forecasts of volume and distribution of flow. The Upper Rule Curve shall not be lower than the Flood Control Refill Curve.

(4) In the period 1 January through the end of the drawdown period, the Operating Rule Curve shall not be lower than the Limiting Rule Curve developed for such year.

(5) Flood Control Refill Curves are computed on a similar basis to the Variable Refill Curves, except that daily inflows into the reservoir are accounted for and deducted from the first of the month 95 percent confidence inflow forecast to determine the residual volume inflow. They represent the lower limit to which the project should normally be operated during the refill period to serve a secondary energy market. The power discharge requirements will be the same as those computed for Variable Refill Curves. A sample form for making this computation is shown on Table 6.

(6) During the course of an operating year, the Operating Rule Curve for the whole of the Canadian storage will be continuously available as a guide to actual operations. Operation of the individual Canadian

reservoirs to fulfill the United States Entity's requests will be the responsibility of the Canadian Entity. Actual operation shall be guided by the Operating Rule Curve, as follows:

Operation When the Whole of Canadian Storage is Above Operating Rule Curve.

The whole of the Canadian storage shall be drafted to its Operating Rule Curve as required to produce optimum generation in accordance with Annex A, paragraphs 7 or 8 of the Treaty, whichever applies, subject to the stated operating rules and constraints in the Detailed Operating Plan.

Operation When the Whole of Canadian Storage is On or Below Operating Rule Curve.

Draft of the whole of Canadian storage below its Operating Rule Curve will be in accordance with paragraph 9c and 23c.

Operation of the Whole of Canadian Storage Provisionally Below Operating Rule Curve.

While an arrangement has not been completed for provisional draft of Canadian Storage, procedures are being prepared by the Operating Committee in accordance with the 13 January 1977 agreement among the coordinators to satisfy the following basic accepted principles:

(i) The arrangement would produce advantages to each country compared to operating to the Assured Operating Plan Operating Rule Curve or to the modified Assured Operating Plan Operating Rule Curve agreed by the Entities in the Detailed Operating Plan.

(ii) The arrangement would provide both Entities with the same assurance as provided by the Assured Operating Plan.

(iii) The arrangement would specify limits on the provisional drafting of Canadian Treaty Storage.

(iv) Either Entity could request a provisional draft of Canadian Treaty storage, however, the other Entity would have the option of accepting up to 50 percent of the additional energy generated downstream in the United States. The liabilities incurred by provisional drafting including the provision of replacement energy or its equivalent, would be shared by the Entities in proportion to the energy actually received by each.

c. System Proportionate Draft Between Critical Rule Curves. The system proportionate draft point shall be calculated each month, as required, by regulating the whole of Canadian storage and major United States Federal reservoirs with a simulation model to meet the system load in accordance with the following conditions:

(1) The whole of Canadian storage shall be regulated as one reservoir with special cognizance of paragraph 8e, Special Mica Operating Criteria.

(2) The simulation model shall recognize all agreed planned operating constraints from the Detailed Operating Plan and shall be similar in design or contain operating logic similar to the seasonal model that was used to develop the Detailed Operating Plan.

(3) Flows used in the simulated regulation shall be based on most probable volume inflow forecasts for each project for the months to be simulated. The operation of the reservoirs shall be constrained by actual current operating limitations to reduce spill or other losses.

(4) The simulation model will simulate operation of the system successively between critical period rule curves until sufficient water is drafted to meet the estimated load. That point between critical rule curves where all reservoirs have reached their proportionate share of draft and where the load is satisfied shall be the proportionate draft point.

Calculation of the proportionate draft point is described in Paragraph 9f and illustrated in Table 7.

Notwithstanding the operating rules as stated above, exchanges of capacity and energy may be substituted for releases from Canadian storage, if mutually agreed by the Entities as to quantities, timing and method, and energy acquired by United States systems from sources outside the Pacific Northwest Coordinated System may be used in lieu of energy otherwise produced by proportionate draft of such systems reservoirs.

d. Operation for Flood Control. The regulation of Canadian storage for system flood control requires that outflows be specified from individual projects on a daily basis during the spring runoff period. Such regulation shall be in effect during the Flood Control Refill Period. The Columbia River Treaty Flood Control Operating Plan defines the Flood Control Refill Period and provides charts which are to be used for guidance of operation during this period. Project release shall be based on these charts, on volumetric runoff forecasts, and on daily computer simulations of streamflow and reservoir regulation to provide effective flood stage reduction at the Columbia River at The Dalles, Oregon, and at tributary control points. Occasionally, flood control regulation of Arrow project will be required during the winter period, as defined in the Flood Control

Operating Plan. The regulation for system flood control shall be the responsibility of the North Pacific Division, Corps of Engineers.

e. Computation of Operating Parameters and Exchange of Pertinent Operating Data. From 1 January to the end of the refill period, computations related to the operating parameters of each Canadian reservoir shall be performed as follows:

(1) By the second working day of each month the Corps of Engineers will issue a January through July natural volume runoff forecast for the Columbia River at The Dalles, Oregon. Such forecasts will be issued only for the purpose of defining the power discharge requirement in computing Variable Refill Curves and Flood Control Refill Curves.

(2) By the tenth day of each month, through 10 June, the Canadian Section of the Operating Committee will issue the volume forecasts for each Canadian reservoir, its computed end-of-month Variable Refill Curve, and corresponding Operating Rule Curve storage content. Variable Refill Curves shall be computed according to paragraph 8b(2).

(3) By the tenth day of each month, through 10 June, the Corps of Engineers will issue the volume forecasts, Variable Refill Curve, and Operating Rule Curve end-of-month storage contents for Libby reservoir.

(4) Computation of Flood Control Refill Curves, Upper Rule Curves, and exchange of pertinent data for flood control purposes shall be accomplished in accordance with Section X of the Flood Control Operating Plan.

PART V - PROCEDURE FOR CALCULATING HYDROELECTRIC POWER LOSSES BY CANADA AS A RESULT OF OPERATING ON-CALL STORAGE

24. CONSIDERATION FOR ON-CALL STORAGE

Consideration for the need for On-Call storage will be initiated by the United States Section in consultation with the Canadian Section as soon after 1 January as conditions indicate that a call may be necessary. Results of these considerations will be reported to the respective Entities, together with the assessment of the effects of the drawdown on the production of power. A formal call for On-Call storage space may be made by the United States Entity following the above consultation.

25. STUDIES REQUIRED UPON INITIATION OF ON-CALL REQUEST

Upon acceptance of a request for On-Call storage use by the Canadian Entity, the Operating Committee will make a set of 7-month system studies for the period 1 January to 31 July of the current operating year in the following manner:

a. The studies will be based on a selected set of streamflow conditions from the available hydrologic record in which the January through July volume at The Dalles, Oregon, was greater than or equal to the most probable January through July runoff volume forecast at The Dalles, Oregon, for the current operating year. If the forecast indicates a probable flood of unprecedented size, reasonable estimates of the natural flows that could be expected will be used.

b. The system studies will incorporate the rule curves, operating rules, etc., for Canadian storage contained in the current Detailed Operating Plan adjusted for current conditions. The purpose of the studies is to estimate Mica and downstream Canadian projects' monthly outflows revised from those indicated in the Detailed Operating Plan for the remainder of the current operating year if On-Call storage were not requested.

c. The outflows used in the studies in b above, shall not be less than those indicated in the Detailed Operating Plan.

d. If the On-Call storage request is accepted after 1 January, system studies will be performed utilizing the most current conditions relating to initial reservoir elevations and outflows; the study period may then be shortened to less than 7 months.

e. The studies above will be completed in a timely manner so that United States liabilities for capacity and energy may be computed as indicated in paragraph 26.

26. PROCEDURE FOR ESTIMATING LOSSES

The Canadian Section of the Operating Committee will perform the following daily calculations from the time that On-Call storage evacuation of Canadian storage is initiated to the end of the current operating year:

a. The energy and capacity at Mica and downstream projects in Canada will be calculated based on actual recorded inflows and the monthly outflows computed in paragraph 25 above.

b. The actual daily energy and capacity at Mica and downstream projects in Canada will be tabulated.

Energy and capacity computations will take into account the actual availability of generating units throughout the January through July period.

The capacity loss (or gain) in Canada at Mica and at downstream projects will be computed on a daily basis by subtracting the capacity in b above from that in a above.

The energy loss (or gain) will be accumulated on a daily basis by adding the daily energy difference obtained by subtracting the energy capability in b above from that in a above.

If the volume runoff forecast at The Dalles changes significantly after initiation of the daily calculations in a and b above, target and actual monthly outflows may be adjusted accordingly at the request of either Entity. Such adjustment shall consider Mica project at-site volume forecasts as well as Canadian system energy/capacity requirements.

27. DELIVERY OF CAPACITY AND ENERGY TO CANADA

a. Capacity Deliveries

If a capacity loss occurs based on the computations of Paragraph 26 above, then daily capacity deliveries up to the daily loss will be scheduled by the United States Entity based on the need as stated by the Canadian Entity. If agreed to by both Entities, loss in capacity can be offset by gains in energy if energy is usable in the Canadian system.

b. Energy Deliveries

It will normally not be possible to determine whether a net loss of energy has occurred until the end of the operating year. Nevertheless, energy deliveries will be scheduled by the Entities, based on the need as stated by the Canadian Entity, to compensate for any reduction in energy in Canada in the interim period.

c. Resources

The United Stated Entity will provide sufficient resources to cover actual Canadian energy and capacity losses.

28. LIABILITY OF UNITED STATES ENTITY

The procedure established in paragraphs 24, 25, 26, and 27 above is designed as a practical means of estimating, measuring, and offsetting power losses in Canada which could reasonably be considered as a result of On-Call operation.

However, there remains the remote possibility that some combination of unforeseen circumstances, coupled with an operation of On-Call storage, could prevent the Canadian storage from refilling during the current operating year. In that unlikely event, special procedures based on the particular circumstances may have to be instituted by the Entities to cover any losses not covered by the procedures above.

The period of potential liability of the United States Entity to offset capacity or energy losses in Canada will begin when On-Call storage evacuation begins, and will end when each of the Canadian storages reaches its normal Operating Rule Curve computed for the current or succeeding year, unless the Entities otherwise agree.

CHART 1

ILLUSTRATION OF

CRITICAL RULE CURVES FOR A RESERVOIR

IN A MULTI-YEAR CRITICAL PERIOD

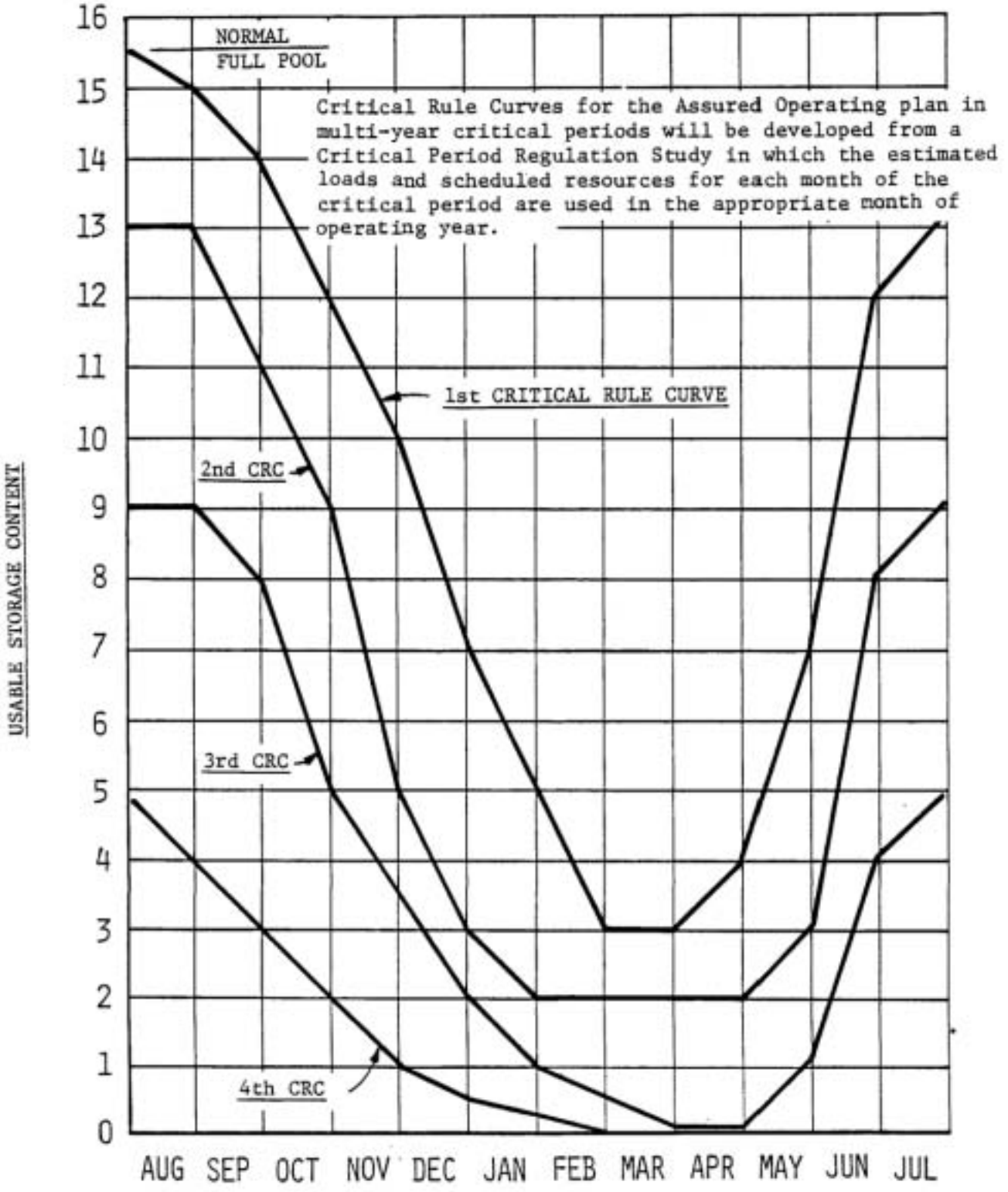
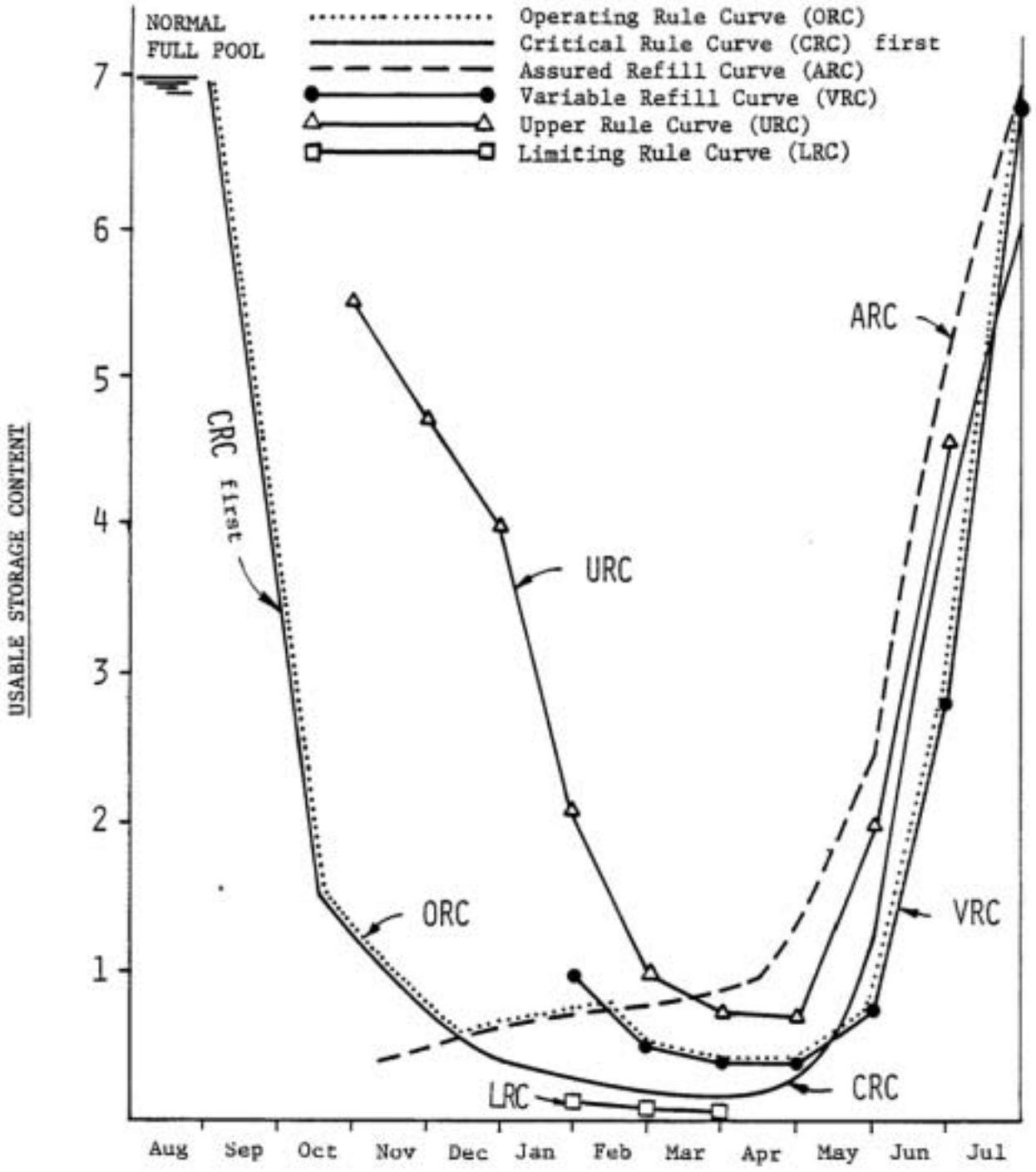


Chart 2

ILLUSTRATION OF

OPERATING RULE CURVE FOR A RESERVOIR



Note: 1. In the studies the Operating Rule Curve (ORC) is defined by the higher of the first Critical Rule Curve (CRC) and Assured Refill Curve (ARC) through December 31. After January 1, it is defined by the higher of the CRC or ARC unless the Variable Refill Curve is below the higher of the CRC or ARC. Then it is defined by the VRC. In no case shall it be higher than the Upper Rule Curve (URC) nor lower than the Limiting Rule Curve.

2. In the studies the URC defines the maximum allowable elevations and is determined from independent simulated flood control regulations.

CHAR. 3

ILLUSTRATION OF STEPS IN DEVELOPMENT OF OPERATING RULE CURVE FOR 30-YEAR SYSTEM REGULATION STUDIES

		A S O N D J F M A M J J	
1.	Critical Rule Curve	C C C C C C C C C C C C	This curve is developed for each reservoir by the Critical Period Regulation Study and will be used as an operating guide in the 30-Year System Regulation Studies.
2.	Assured Refill Curve	A A A A A A A A A A A A	This curve is the same for each water condition in the 30-Year System Regulation Studies. The values may be the same as the CRC in the first 4 or 5 months.
3.	Variable Refill Curve	V V V V V V V	This curve is defined in paragraph 8(b) and will vary with the water condition. There will be 30 different curves used in the 30-Year System Regulation Studies.
4.	Upper Rule Curves	U U U U U U U U U U U U	This curve is a function of requirements such as flood control, bank protection, etc., and will generally vary with each of the 30 water conditions.
5.	Limiting Rule Curve	L L L	This curve serves as a limit on the potential total system and project draft to protect the system's capability to meet loads until the start of the spring freshet.
6.	Operating Rule Curve	0 0 0 0 0 0 0 0 0 0 0 0	The monthly values for this curve are derived from the first five curves based on the following criteria: C or A whichever is higher, except that after 1 January, V will be used if it is below the higher of C or A. In all cases, if U is lower than the value thus determined, U will be used. In no case shall it be lower than the Limiting Rule Curve (L).

The Operating Rule Curve for each of the 30 water conditions will limit reservoir operation in respect to secondary generation. Reservoirs will be drafted below Operating Rule Curves if necessary for firm load requirements in accordance with paragraph 9c.

NOTE: The same steps as above for 30-Year System Regulation Studies are used in actual operation except that the Variable Refill Curve beginning January is developed each month from actual inflow volume forecasts.

CHART 3

CHART 4

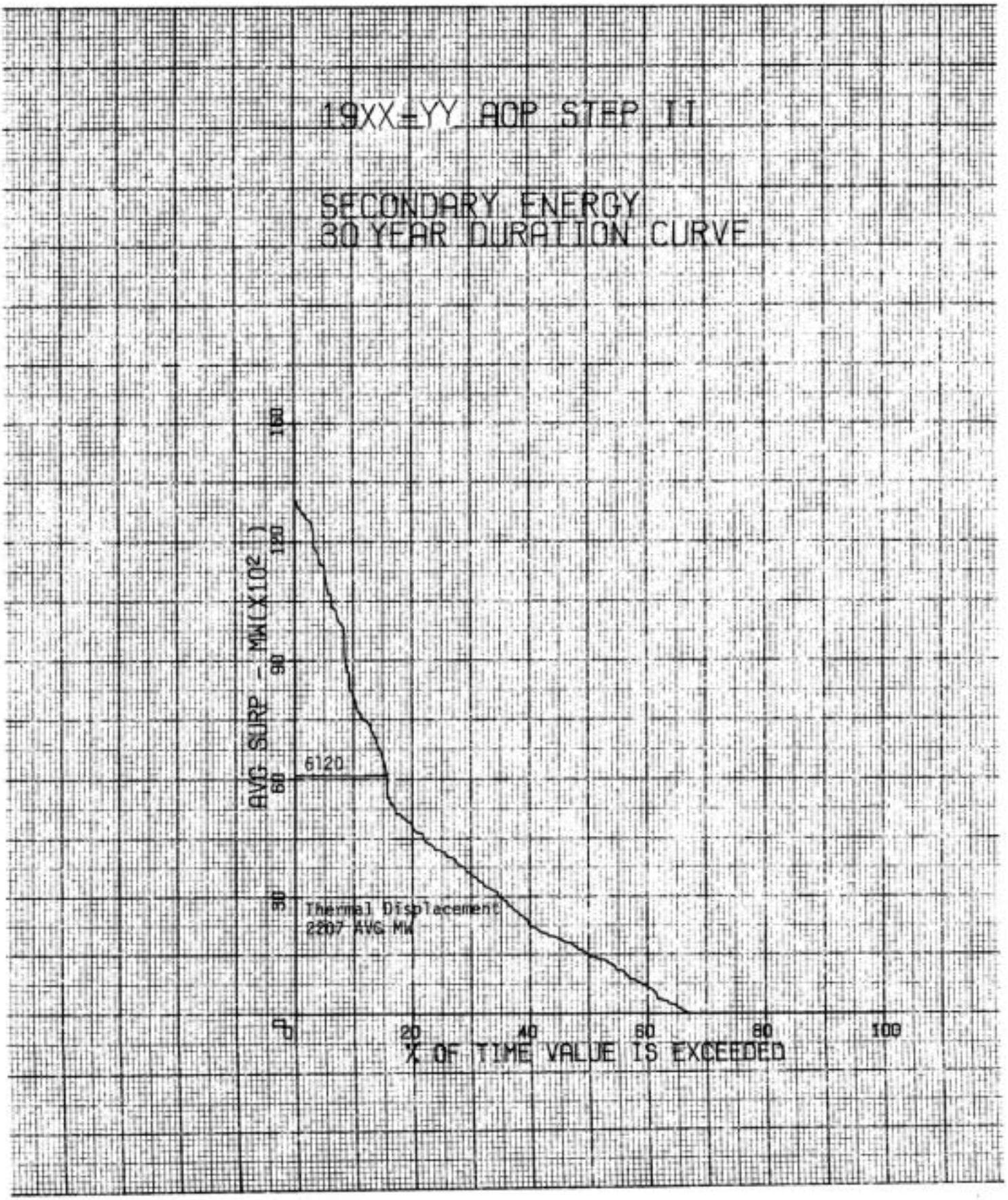
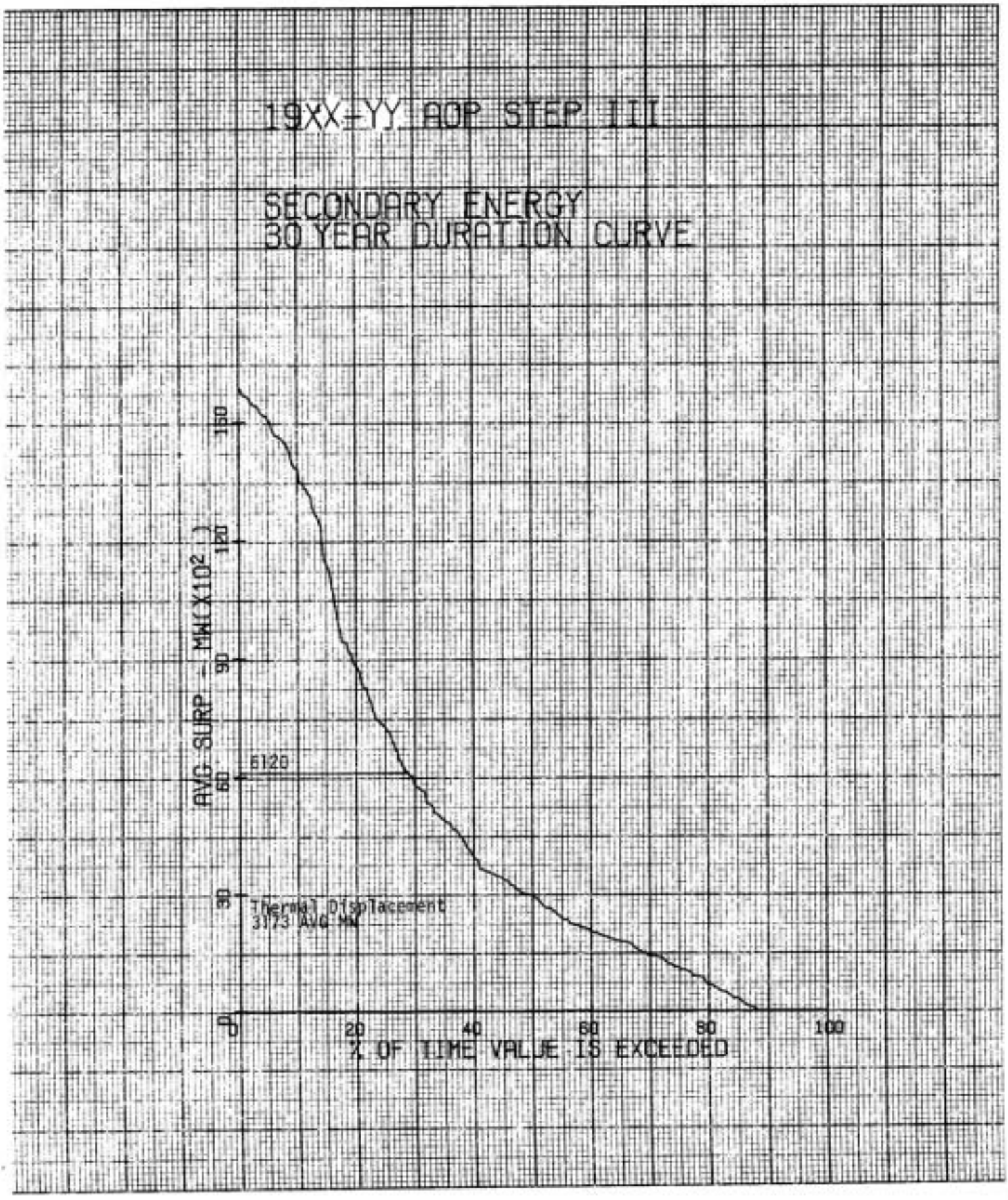
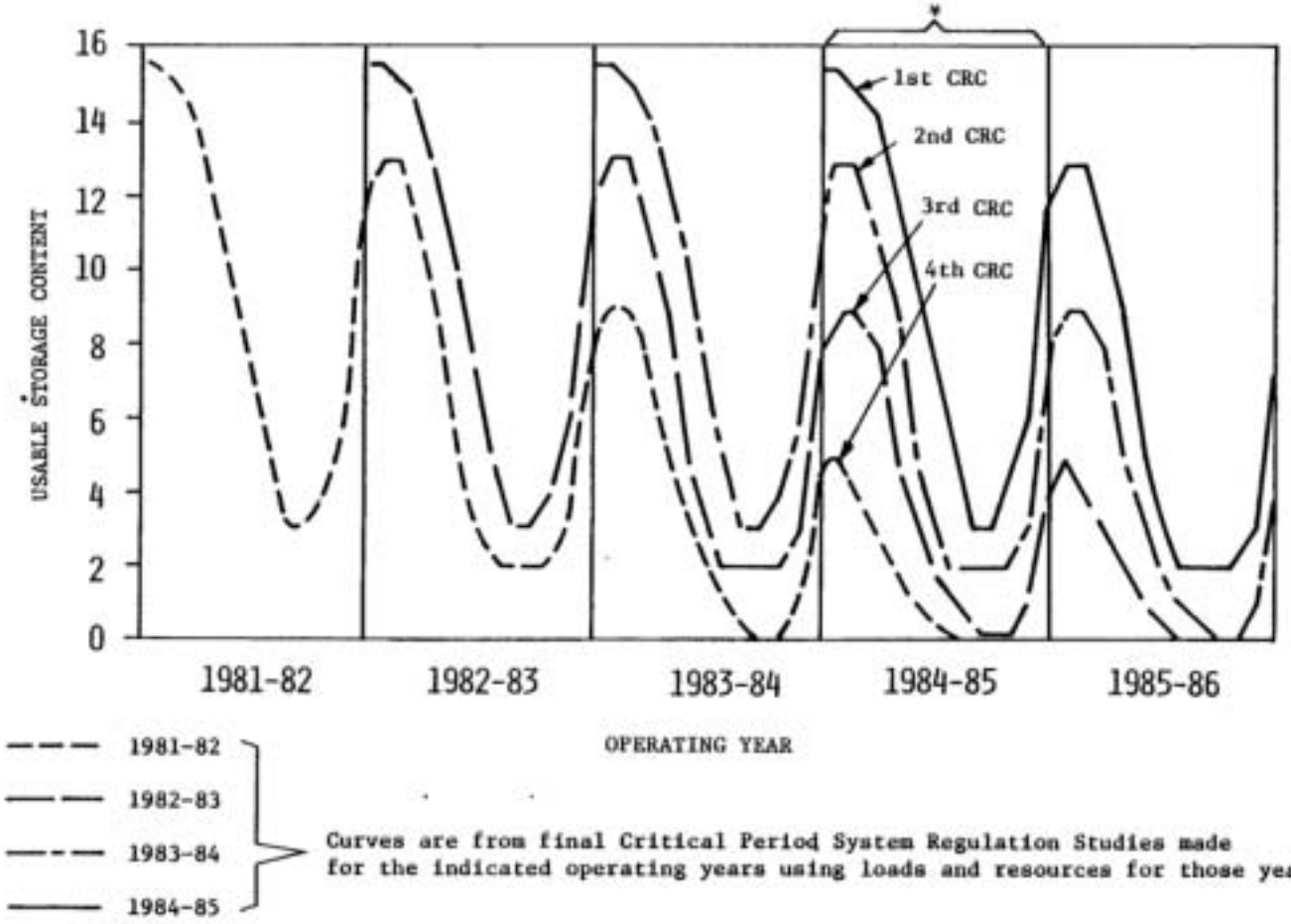

19XX-YY AOP STEP II
SECONDARY ENERGY
80 YEAR DURATION CURVE
AVG SURP - MW(X10²)
160
120
90
60
30
0
6120
Thermal Displacement
2207 AVG MW
20
40
60
80
100
% OF TIME VALUE IS EXCEEDED

CHART 5


19XX-YY AOP STEP III
SECONDARY ENERGY
30 YEAR DURATION CURVE
AVG SURP = MW(X10²)
150
120
90
60
30
0
6120
Thermal Displacement
3173 AVG MW
0
20
40
60
80
100
% OF TIME VALUE IS EXCEEDED

COLUMBIA RIVER TREATY HYDROELECTRIC OPERATING PLANS

ILLUSTRATION OF SELECTION OF CRITICAL RULE CURVES FOR THE DETAILED OPERATING PLAN FOR A RESERVOIR IN A MULTI-YEAR CRITICAL PERIOD



* The Detailed Operating Plan, Critical Rule Curves for 1984-85 Operating Year are from studies made in the current and past years.

CHART 6

SAMPLE C(UTATION
VARIABLE REFILL CURVES (VRC)
DUNCAN

Water Year 1929 PDR Level 3*3 Depletion Year 1978		Forecast Date 1 Jan	1 Feb	1 Mar	1 Apr	16 Apr	1 May	1 Jun
Prob. Forecast Inflow (Date to 31 July)*1	KAF	1267.	1243.	1226.	1202.	1189.	1162.	924.
Forecast Error at 95% Prob.*2	KAF	306.	240.	221.	209.	200.	191.	188.
95% Prob. Forecast Date to 31 July	KAF	961.	1003.	1005.	993.	989.	971.	736.
Inflow Period		1 Feb- 31 Jul	1 Mar- 31 Jul	1 Apr- 31 Jul	16 Apr- 31 Jul	1 May- 31 Jul	1 Jun- 31 Jul	1 Jul- 31 Jul
Normal Inflow Percentage of 95% Prob. Forecast		98.1	98.6	98.0	98.9	97.8	79.5	40.5
Forecast Inflow	KAF	943.	989.	985.	982.	967.	772.	298.
Power Discharge Requirement	KAF	423.	418.	411.	361.	310.	206.	105.
Upstream Storage Refill	KAF	0.	0.	0.	0.	0.	0.	0.
Net Inflow	KAF	520.	571.	574.	622.	657.	566.	193.
Variable Refill Curve	KAF	905.	854.	851.	803.	768.	859.	1232.

Maximum Storage Content: 1425 KAF
Minimum Storage Content: 25 KAF

Upstream storage was computed from operating rule curve for upstream projects.

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*1 Prob. forecast inflow is the actual historical natural volume.

*2 95% forecast error = 1.65 x Std. Error.

*3 PDR Level 3 corresponds to a January through July runoff volume of 80 MAF or less at The Dalles.

TABLE 1

TABLE 2

SAMPLE MICA OPERATING CRITERIA*1

Period	Target Operation*2 Storage (ksfd)	Target Operation*2 Outflow (cfs)	Arrow End of Previous Period Storage Content (ksfd)	Revised Target Outflow (cfs)	Minimum Release (cfs)
15 Aug	-	10000	-	-	10000
31 Aug	3529.2	-	0-2000	20000	10000
Sept	3529.2	-	0-2000	20000	10000
Oct	-	14000	0-2000	30000	10000
Nov	-	19000	3400-FULL	12000	10000
			0-2000	34000	
Dec	-	23000	0-1500	34000	15000
Jan	-	23000	0-2500	30000	15000
Feb	-	23000	0-1400	30000	15000
Mar	-	20000	1-100	25000	15000
15 Apr	-	18000	-	-	15000
30 Apr	-	15000	-	-	15000
May	-	10000	0-600	16000	10000
Jun	-	10000	0-1400	20000	10000
Jul	-	10000	-	-	10000

*1 Values indicated in this table will serve as an example.

Example

The typical Mica operation for November of this operating year sets an average project outflow of 19000 cfs. If the Arrow storage at the end of October was above 3400 ksfd, the target Mica outflow will be 12000 cfs; and if the Arrow storage at the end of October was below 2000 ksfd, the Mica target outflow will be 34000 cfs. If Mica storage content falls below the usable Treaty storage, Mica outflows will be reduced to minimum.

*2 Mica releases will be determined by its target operation unless:

1. End of previous period Arrow storage content is within the above specified limits, then it shall be the revised target outflow.

2. Mica indicated release is less than the specified minimum release, then it shall be minimum release.

3. Kinbasket Lake storage withdrawal exceeds 7 million acre-feet of Treaty storage, then the release will be the specified minimum release.

TABLE 3

COMPUTATION OF CANADIAN ENTITLEMENT
19XX-19YY

Generation Figures are in Average Megawatts; Load Factors, in Percent

Determination of Dependable Capacity Credited to Canadian Storage

Critical Period Average Rate of Generation with Canadian Storage, Step II	9,075
Critical Period Average Rate of Generation without Canadian Storage, Step III	7,054
Gain Due to Canadian Storage	2,021
Estimated Average Critical Period Load Factor -- Percent	70.253
Dependable Capacity Gain 1/	2,877
Canadian Share of Dependable Capacity	1,438.5

Determination of Increase in Average Annual Usable Energy

Step II (with Canadian Storage)

Annual Firm Hydro Energy	8,841
Thermal Replacement Energy	2,275
Other Usable Secondary Energy	209
System Annual Average Usable Energy	11,325

Step III (without Canadian Storage)

Annual Firm Hydro Energy	6,341
Thermal Replacement Energy	3,330
Other Usable Secondary Energy	565
System Annual Average Usable Energy	10,236
Average Annual Usable Energy Gain	1,089
Canadian Share of Average Annual Energy Gain	544.5

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

SUMMARY OF POWER REGULATIONS FOR 19XX-YY
FOR THE
COMPUTATION OF CANADIAN ENTITLEMENT
TO DOWNSTREAM BENEFITS

TABLE 4

PROJECTS	BASIC DATA: Number of Units	BASIC DATA: Nominal Installed Peaking Capacity MW	STEP I: 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	233	94	3,008	241	115	182	3,008	280	112	181
Albeni Falls	3	49	1,155	24	25	1,155	23	22	22	1,155	24	25	25
Grand Coulee	24 + 3	6,415	5,189	6,389	2,901	3,072	6,380	1,770	3,172	5,072	5,951	1,227	2,178
Chief Joseph	27	2,613		2,613	1,086		2,613	1,900	1,323		2,612	732	1,259
Ice Harbor	6	693		693	213		693	222	302		693	170	302
McNary	14	1,127		1,127	538		1,124	590	755		1,124	430	711
John Day	16	2,484	535	2,484	921		2,484	922	1,258		2,484	684	1,225
The Dalles	22	2,058		2,058	816		2,058	794	1,035		2,058	633	1,015
Bonneville	18	1,114		1,114	608		1,114	590	736		1,114	446	706
Subtotal		16,640	10,036	18,496	8,406	9,235	18,489	8,025	7,903	9,235	18,250	4,559	7,611
BASE SYSTEM NON-FEDERAL													
Kootenay Lake (Canadian)			649			427				427			
Kerr	3	160	1,319	131	113	1,219	131	101	114	1,219	150	139	116
Thompson Falls	4	48		48	34		48	28	32		60	37	32
Noxon Rapids	5	534	131	546	148		534	138	111		554	138	111
Cabinet Gorge	4	230		230	106		230	93	121		230	106	124
Ace Canyon	4	74		71	44		71	45	48		71	51	48
Coeur d'Alene & Long Lake			527			223				223			
Wells	10	820		820	436		820	408	510		820	289	471
Chelan	2	54	677	51	38	676	51	38	44	676	51	49	44
Rocky Reach	11	1,267		1,267	589		1,267	552	711		1,267	394	668
Rock Island	18	544		544	278		544	241	329		544	183	303
Wanapum	10	986		986	514		986	523	655		986	367	599
Priest Rapids	10	912		912	529		912	497	617		912	358	566
Brownlee	4	675	900	675	200	674	675	248	289	674	675	210	269
Oxbow	4	220		220	67		220	108	133		220	114	126
Subtotal		6,536	4,083	6,573	3,184	3,319	6,521	3,050	3,788	3,319	6,533	2,493	3,558
TOTAL BASE SYSTEM HYDRO		23,176	29,619	23,069	9,572	28,234	23,010	9,075	11,683	12,754	22,619	7,054	11,169
ADDITIONAL STEP I PROJECTS													
Libby	8	984	4,934	466	187								
Libby Rereg.	3	88		88	35								
Boundary	4	635		635	360								
Spokane River Plants		153		151	89								
Wells Canyon	2	450		438	170								
Dworshak	3	460	2,213	429	163								
Lower Granite	6	930		930	213								
Little Goose	6	930		930	213								
Lower Monumental	6	930		930	214								
Felcon and Round Butte		434	274	417	124								
Subtotal		6,516	7,423	5,654	1,772								
Independent Resources		4,857	8,352	4,107	1,754								
TOTAL HYDRO RESOURCES		34,549	45,194	32,778	13,098								
MISCELLANEOUS CONTRACTS				23	9								
THERMAL RESOURCES 1/													
Small Existing Thermal Plants				1,444	176								
Centralia #1 & #2				1,313	962								
Jim Bridger #1, #2, #3, & #4				2,000	1,431								
Colstrip #1 & #2				330	259								
Trojan				1,130	824								
Boardman				330	405								
WNP #2				1,180	794								
Colstrip #3 & #4				660	391								
WNP #1				1,120	821								
WNP #3				0	284								
WNP #4				0	113								
Added Thermal Requirement				2,773	1,664								
TOTAL THERMAL RESOURCES				12,680	8,324								
TOTAL IMPORTS				100	484								
ESTIMATED HYDRO MAINTENANCE				-478	-30								
TOTAL RESOURCES (HYDRO AND THERMAL)				44,895	21,865								
RESERVES 2/				-2,806	0								
RESOURCES AVAILABLE FOR LOAD				42,089	21,865								
ESTIMATED LOAD													
Pacific Northwest Area				35,077	21,865								
SURPLUS OR (DEFICIT)				7,012	0								
CRITICAL PERIOD													
Starts:				August 16, 1928			September 1943				September 16, 1936		
Ends:				February 1931			April 1945				April 15, 1937		
Length (Months):				43½ Months			20 Months				7 Months		
Study Identification				85-41			85-42				85-13		

1/ Thermal energy capabilities are based on an annual plant factor of 60 percent the first full year of operation and 75 percent thereafter. 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.

DETERMINATION OF LOAD SHAPE FOR STEPS II AND III
19XX-YY CANADIAN ENTITLEMENT COMPUTATIONS

	Pacific Northwest Area Load			Step II			Step III		
	Peak	Avg.	Load Factor %	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load	Total Firm Load 1/	Thermal Firm Load	Hydro Firm Load
Aug. 1-15	28,142*	19,759	70.21	15,584	8,324	7,260	13,315	8,324	4,991
Aug. 16-31	28,064*	19,579	69.77	15,442	8,324	7,118	13,193	8,324	4,869
Sept. 1-15	28,390*	19,135	67.40	15,092	8,324	6,768	12,894	8,324	4,570
Sept. 16-30	28,345*	19,097	67.37	15,062	8,324	6,738	12,868	8,324	4,544
October	30,049*	20,251	67.39	15,972	8,324	7,648	13,646	8,324	5,322
November	32,067*	22,722	70.86	17,921	8,324	9,597	15,311	8,324	6,987
December	34,587*	24,628	71.21	19,424	8,324	11,100	16,595	8,324	8,271
January	35,077*	25,339	72.24	19,985	8,324	11,661	17,075	8,324	8,751
February	33,201*	23,984	72.24	18,916	8,324	10,592	16,162	8,324	7,838
March	31,494*	22,691	72.05	17,896	8,324	9,572	15,290	8,324	6,966
Apr. 1-15	29,694*	21,216	71.45	16,733	8,324	8,409	14,296	8,324	5,972
Apr. 16-30	30,036*	21,336	71.03	16,828	8,324	8,504	14,377	8,324	6,053
May	29,868*	20,383	68.24	16,076	8,324	7,752	13,735	8,324	5,411
June	29,628*	20,681	69.80	16,311	8,324	7,987	13,936	8,324	5,612
July	29,050*	20,537	70.70	16,197	8,324	7,873	13,839	8,324	5,515
Critical Period Avg.		21,865	70.253	17,399	8,324	9,075	15,378	8,324	7,054
Annual Average		21,764		17,165	8,324	8,841	14,665	8,324	6,341
January Peak	35,077*								
Step I Critical Period Aug. 16, 1928 - Feb. 29, 1932 42½ Months				Critical Period Sept 1943- Apr. 1945 20 Months			Critical Period Sept. 16, 1936 - Apr. 15, 1937 7 Months		

1/ 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.

* Figures so marked are peak megawatts. All other figures are monthly or semi-monthly energy in average megawatts.

TABLE 5

LIBBY RESERVOIR

TABLE 6

FLOOD CONTROL REFILL CURVE

Sample Computation Through May 6

BY	DATE		CHECKED			PART		PAGE	OF
Date	95% Inflow Fcst	Mean Daily Inflow	Accum. Inflow	Resid. Volume Inflow	Min. Outflow thru Jul	Avail. for Refill	FCRC Full= 1386.0	FCRC Full= 2405.0	Actual Elev.
May	KSFD	KSFD	KSFD	KSFD	KSFD	KSFD	KSFD	FT	FT
1	1800.0	3.0	3.0	1797.0	368.0	1429.0	-43.0	2280.0	
2	↑	3.0	6.0	1794.0	364.0	1430.0	-44.0	2280.0	
3		10.0	14.0	1786.0	360.0	1426.0	-40.0	2280.5	
4		15.0	29.0	1771.0	356.0	1415.0	-29.0	2282.3	
5		18.0	47.0	1753.0	352.0	1401.0	-15.0	2284.5	
6		28.0	75.0	1725.0	348.0	1377.0	9.0	2288.2	
7					344.0				
8					340.0				
9					336.0				
10					332.0				
11					328.0				
12					324.0				
13					320.0				
14					316.0				
15					312.0				
16					308.0				
17					304.0				
18					300.0				
19					296.0				
20					292.0				
21					288.0				
22					284.0				
23					280.0				
24					276.0				
25					272.0				
26					268.0				
27					264.0				
28					260.0				
29					256.0				
30	↓				252.0				
31	1800.0				248.0				

EXAMPLE OF PROPORTIONATE DRAFT COMPUTATION BASED ON STORAGE CONTENT

Required 500 MW-Mo

Reservoir	Storage Between 1st & 2nd CRC (ksfd)	Water to Power Conversion (kW/cfs)	Estimated Generation 1st & 2nd CRC (MW-Mo)	*Proportional Draft (4.1%) x Storage (ksfd) (ksfd)	(MW-Mo)
Canadian Storage	2,000	90	6,000	82.0	246.0
Grand Coulee	100	90	300	4.1	12.3
Libby	500	100	1,670	20.5	68.8
Hungry Horse	600	160	3,200	24.6	131.0
Dworshak	310	100	1,030	12.7	42.2
Total	3,510		12,200	143.9	500.0

Estimated System Storage to Energy Conversion

$$\frac{12{,}200 \text{ MW-Mo}}{3{,}510 \text{ ksfd}} = 3.475 \text{ MW-Mo/ksfd}$$

Estimated Storage Draft

$$500 \text{ MW-Mo} \times \frac{\text{ksfd}}{3.475 \text{ MW-Mo}} = 143.9 \text{ ksfd}$$

Estimated Proportional Draft based on Storage Content

$$\frac{143.9 \text{ (ksfd Estimated)}}{3{,}510 \text{ (ksfd Available)}} = 4.1\%$$

*Objective was achieved in one iteration of the calculation because estimates were perfect and no constraints were encountered.

TABLE 7