White Paper on

COLUMBIA RIVER POST-2024
FLOOD RISK MANAGEMENT PROCEDURE

U.S. Army Corps of Engineers

Northwestern Division

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PREFACE

The Columbia River, the fourth largest river on the continent as measured by average annual flow, provides more hydropower than any other river in North America. While its headwaters originate in British Columbia, only about 15 percent of the 259,500 square miles of the river's basin is located in Canada. Yet the Canadian water accounts for about 38 percent of the average annual flow volume, and up to 50 percent of the peak flood waters, that flow on the lower Columbia River between Oregon and Washington.

In the 1940s, officials from the United States and Canada began a long process to seek a collaborative solution to reduce the risks of flooding caused by the Columbia River and to meet the postwar demand for energy. That effort resulted in the implementation of the Columbia River Treaty in 1964. This agreement between Canada and the United States called for the cooperative development of water resource regulation in the upper Columbia River Basin. The Columbia River Treaty has provided significant flood control (also termed flood risk management) and hydropower generation benefiting both countries.

The Treaty, and subsequent Protocol, include provisions that both expire on September 16, 2024, 60 years after the Treaty's ratification, and continue throughout the life of the associated facilities whether the Treaty continues or is terminated by either country. This white paper focuses on the flood risk management changes that will occur on that milestone date and satisfies the following purposes:

1. Describe key provisions of the Columbia River Treaty and Protocol pertaining to flood risk management operations after 2024 (post-2024).
2. Define the flood control authorizations of the major Columbia Basin reservoir projects.
3. Present a proposed procedure on how post-2024 flood risk management operations could be implemented.
4. Discusses the differences between the proposed post-2024 Treaty Continues procedure and a Treaty Terminated scenario.
5. Describe how the proposed post-2024 procedure will be integrated into the ongoing comprehensive flood risk management studies in the Columbia River Treaty (CRT) Review.

One notable change in the Treaty post-2024 is Canada's obligation to provide flood storage for the U.S. This obligation shifts from the current assured amount of annual flood storage in Canada to a process that allows the U.S. to call upon Canada for flood storage. What is described as "Called Upon" within this paper can simply be described as the U.S. calling upon Canada to provide a flood storage operation to meet the forecast flood needs in the U.S. The request for Called Upon flood storage in Canada may only be requested when the forecast flood needs cannot be adequately controlled by all related U.S. flood control storage facilities. Along with the request for Called Upon, the U.S. must compensate Canada for the operating costs and economic losses related to the request.

Other provisions in the Treaty describe what happens post-2024 in relation to how Canada and U.S. could continue to operate the system for flood risk management and hydropower generation. Some of the key provisions and how they influence post-2024 operations are contained in Section 2.

While the Treaty and Protocol includes specific provisions for implementing Called Upon requests, neither the Treaty nor the Protocol provides detailed guidance concerning the technical methods and/or procedures to be used to make such a request. Section 3 presents an evaluation of available U.S. flood control facilities, an analysis of total storage required for historical flood events, and a proposed procedure for determining the amount of Called Upon storage.

To provide a gateway to the flood risk management (FRM) studies now being conducted, Section 4 presents an overview of how the Called Upon procedure will be integrated into future FRM studies.

TABLE OF CONTENTS

List of Tables

List of Figures

1.0 INTRODUCTION

1.1 Overview

The Treaty between Canada and the United States of America Relating to Cooperative Development of the Water Resources of the Columbia River Basin (Treaty), executed in 1964, was a significant and far-reaching development in Pacific Northwest hydropower history that also provided flood risk reduction within the United States (U.S.). The Treaty's provisions for coordination between Canada and the U.S. on hydropower and flood risk management impart significant mutual benefits across the Columbia River Basin.

Under the provisions of the Columbia River Treaty (CRT or Treaty), Canada's obligation to provide storage to help manage flood events within the Columbia River Basin of the U.S. changes on September 16, 2024 (post-2024). This date correlates to 60 years after the Treaty's ratification on September 16, 1964. In addition, either Canada or the U.S. may terminate the Treaty on or after this same date provided 10 years advance notice is given. However, even if the Treaty is terminated, there are certain provisions of the Treaty that continue to be in effect, such as the provisions relating to Canada's obligation to provide post-2024 flood storage as long as the projects are operational.

This paper was prepared by staff of the U.S. Army Corps of Engineers (USACE or Corps) Northwestern Division, including representatives of the Columbia Basin Water Management Division and Portland, Seattle, and Walla Walla District offices involved in the Columbia River Basin Treaty 2014/2024 Review (CRT Review). The intent of this document is to describe a proposed procedure for post-2024 flood risk management operations. The document has been coordinated with the U.S. Entity and the U.S. Section of the Treaty Permanent Engineering Board (PEB). Input was also provided by the U.S. Bureau of Reclamation.

1.2 Purpose and Objectives

The purpose of this paper is to present a revised flood risk management strategy that was developed subsequent to the completion of the CRT 2014/2024 Phase 1 Report. Thus, this paper provides updated flood risk management procedures over those that were initially developed and documented in Phase 1. This paper has five objectives:

1. Describe the key provisions of the Columbia River Treaty and Protocol pertaining to flood risk management operations after 2024.
2. Define the flood control authorizations of the major Columbia Basin reservoir projects.
3. Present a proposed procedure on how post-2024 flood risk management operations could be implemented.
4. Discusses the differences between the proposed post-2024 Treaty Continues procedure and a Treaty Terminated scenario.
5. Describe how the proposed post-2024 procedure will be integrated into the ongoing comprehensive flood risk management studies in the Columbia River Treaty (CRT) Review.

Comment [mtr1]: Refer to Table 1

***(1) Describe the key provisions of the Columbia River Treaty and Protocol pertaining to flood control[1] operations after 2024 and describe how those flood control provisions could be implemented*.**

Comment [mtr2]: And provide Corps interpretation of…

The Treaty's provisions for coordination between Canada and the U.S. on power and flood control impart significant mutual benefit across the Columbia River Basin. When the current Treaty flood control obligations change in 2024, the Canadian and U.S. flood control operations may change. Unless otherwise agreed, the U.S. will no longer have a dedicated amount of flood storage to be used as defined by the U.S. Entity in the current Columbia River Treaty Flood Control Operating Plan (FCOP 2003).

Instead, the Treaty describes a process, termed "Called Upon," by which Canadian reservoir storage can still be utilized for flood control in the U.S. A Protocol to the Treaty, dated January 22, 1964, also provides further specificity concerning the implementation of post-2024 flood storage.

Comment [mtr3]: Very important to look at both the Treaty Provisions and Treaty Protocol to understand the intent of the Treaty framers

> "Called Upon" is the formal process by which the U.S. Entity may request additional flood storage drafts or delayed refill operations in Canada to supplement U.S. operations and reservoir storage required to meet flood risk management needs for the duration of a flood period. In this paper, the convention is to use "Called Upon" to refer to the post-2024 process as opposed to the term "On Call," which is used in other documents in reference to pre-2024 operations.

(2) Define the flood control authorizations of the major Columbia Basin reservoir projects.

Project authorizations were reviewed and summarized to show how the major U.S. Columbia Basin dams and reservoirs could be effectively used to minimize the need for Called Upon storage. The results of that review identify which projects provide system flood storage, local flood control storage and other incidental storage. This information is also used to develop a proposed post-2024 procedure for the U.S. to formally request flood risk management assistance from Canada.

(3) Present a proposed procedure on how post-2024 flood risk operations could be implemented.

The proposed procedure represents a starting point for further evaluation on how post-2024 flood risk management operations could be implemented. A key consideration is determining how Called Upon storage of Canadian reservoirs could be utilized for future flood risk management in the U.S. These operations are generally described by the provisions in the Treaty and Protocol.

[1] Current Corps of Engineers national policies and procedures emphasize the use of risk-based approaches to flood management as opposed to the deterministic approaches inherent in the historic application of "flood control" operations. Wherever possible in conducting the CRT 2014 Review, the Corps will follow risk-based approaches and will generally refer to those approaches as "flood risk management." However, the Treaty and Treaty Protocols refer to "flood control." Whenever specific reference is made to the Treaty and Protocol language, we use the term "flood control" to maintain consistency.

Utilizing those provisions, this paper then provides details of an implementation procedure that could be utilized.

Under a situation in which the Treaty continues after 2024, pre-coordinated power planning under Assured and Detailed Operating Plans continues. This would provide the U.S. detailed forecasts on available Canadian reservoir space from power drafts, reservoir releases, and flows at the border, thereby enabling the U.S. to develop a fairly specific annual plan for flood operations. It is anticipated these same basic procedures and concepts, with some adjustments, would be used if either the U.S. or Canada opts to terminate the Treaty after 2024. An implementation procedure is provided for this eventuality. However, additional analysis is needed to determine the specific applicability of the Called Upon procedure to the Treaty Terminated scenario due to the uncertainty of future Canadian power operations. Full evaluation of the Treaty Terminated scenario will necessitate that the U.S. Entity make assumptions about the likely Canadian operation or at least define an expected range of operations.

(4) Describe how the proposed post-2024 procedure described in this paper will be integrated into the ongoing comprehensive flood risk management studies that the Corps is undertaking in support of the U.S. Entity in the CRT Review process.

The proposed post-2024 procedure described under item (2) above is based on the flood control provisions of the Treaty and current FCOP. This deterministic procedure must be evaluated within the probability-based approach that current Corps of Engineers' policy requires for risk-based flood management studies. In 2009, the Corps initiated comprehensive flood risk management (FRM) studies in support of the U.S. Entity CRT Review. The first phase of that effort, called Flood Risk Assessment (FRA), will be completed in 2011 and will result in the collection of data and development of tools that will allow the characterization of factors that influence flood risk within the basin under the base conditions. Baseline conditions include pre- and post-2024 operations under a Treaty Continues scenario with coordinated power operations. In future phases of study, the U.S. Entity will use the tools developed in the flood risk assessment phase to evaluate and quantify the impacts associated with alternatives to the base conditions.

(5) Compare the proposed post-2024 Treaty Continues procedure with a Treaty Terminated scenario.

As a start to understanding the different impacts regarding continuation, modification or termination of the Treaty, information is provided on a few of the differences between the post-2024 procedure defined for the Treaty Continues scenario and a possible Treaty Terminated scenario. This is provided for discussion purposes and will be further developed under future phases of the Treaty review program.

2.0 TREATY PROVISIONS FOR POST-2024 OPERATIONS

Under the terms of the Treaty, the U.S. agreed to pay Canada $64.4 million for the assured use on an annual basis of 8.45 Maf of Canadian Treaty project space for U.S flood risk management needs for the first 60 years of the Treaty. Use of this guaranteed annual space has been implemented in the Treaty Flood Control Operating Plans (FCOP). Under the terms of the Treaty, the right to utilize this prepaid storage ends on September 16, 2024. However, the Treaty also provides important post-2024 flood control benefits to the U.S. by providing for a process by which Canadian reservoir drafts can be utilized on a reimbursable basis for U.S. flood risk management after 2024. A Protocol to the Treaty, dated January 22, 1964, provides further specificity concerning the implementation of post-2024 flood control storage. It is important to note that, regardless of whether or not the Treaty is terminated, the post-2024 Called Upon Treaty flood control provisions remain in place as long as storage capacity exists in the applicable Canadian projects and the U.S. has flood control needs. Key Treaty and Protocol provisions for post-2024 flood control follow:

1. Post-2024, Canada can be Called Upon to operate any Canadian storage in the Columbia River Basin, within the limits of then-existing facilities, during a flood control period.

This first key provision for post-2024 flood control is set forth in Article IV(3) of the CRT. In this provision Canada agreed that:

> *3. For the purpose of flood control after the expiration of sixty years from the ratification date, and for so long as the flows in the Columbia River in Canada continue to contribute to potential flood hazard in the United States of America, Canada shall, when called upon by an entity designated by the United States of America for that purpose, operate within the limits of existing facilities any storage in the Columbia River basin in Canada as the entity requires to meet flood control needs for the duration of the flood period for which the call is made.*

Under this provision, calls can include any of the Canadian reservoirs in the Columbia Basin within the then-existing limits of those projects. However, it is important to note that if the Treaty is terminated, there is no provision in the Treaty that obligates Canada to maintain the current dams or prevent them from reducing or eliminating storage capability.

Implementation provisions of the very broad Treaty provisions of Article IV(3) were detailed in Article VI of the Treaty and in the provisions of a Protocol attached to the Treaty. Article VI provides for the reimbursement to Canada for operating costs and economic losses due to Called Upon post-2024 flood control operations. Paragraph 4 of Article VI, which applies to the post-2024 period, states as follows:

> *4. For each flood period for which flood control is provided by Canada under Article IV(3), the United States of America shall pay Canada in United States funds:*

(a) the operating costs incurred by Canada in providing the flood control, and
(b) compensation for the economic loss to Canada arising directly from Canada foregoing alternative uses of the storage used to provide the flood control.

The Protocol provisions described below provide further limited conditions under which calls for post-2024 flood control can be made by the U.S.

2. Under Sections I and I (2) of the Protocol, calls by the United States for post-2024 flood control are limited only to the extent necessary to meet forecast flood control needs or control potential floods in the territory of the United States of America that cannot adequately be met or controlled by all the related flood control facilities in the United States.

Comment [mtr4]: Neither the Treaty nor the Protocol use the term "Effective Use"

Section I (1) and (2) of the Protocol states:

> *I. If the United States entity should call upon Canada to operate storage in the Columbia River Basin to meet flood control needs of the United States of America pursuant to Article IV(2)(b) or Article IV(3) of the Treaty, such call shall be made only to the extent necessary to meet forecast flood control needs in the territory of the United States of America that cannot adequately be met by flood control facilities in the United States of America in accordance with the following conditions:*
>
> *(1) Unless otherwise agreed by the Permanent Engineering Board, the need to use Canadian flood control facilities under Article IV(2)(b) of the Treaty shall be considered to have arisen only in the case of potential floods which could result in a peak discharge in excess of 600,000 cubic feet per second at The Dalles, Oregon, assuming the use of all related storage in the United States of America existing and under construction in January 1961, storage provided by any dam constructed pursuant to Article XII of the Treaty and the Canadian storage described in Article IV(2)(a) of the Treaty.*
>
> *(2) The United States entity will call upon Canada to operate storage under Article IV(3) of the Treaty only to control potential floods in the United States of America that could not be adequately controlled by all the related storage facilities in the United States of America existing at the expiration of 60 years from the ratification date but in no event shall Canada be required to provide any greater degree of flood control under Article IV(3) of the Treaty than that provided for under Article IV(2) of the Treaty.*

Comment [mtr5]: Note that Article IV(2)(b) deals specifically with the section of the Treaty addressing the first 60 years of operation (pre-2024)

Comment [mtr6]: Article IV(3) deals specifically with operations after the first 60 years of operation (after 2024)

Section I applies to calls on Canada for flood control both prior to and after the expiration of 60 years from the Treaty ratification date. This provision states that calls shall be made "only to the extent necessary to meet forecast flood control needs in the territory of the United States of America that cannot adequately be met by flood control facilities" in the U.S. The next two subsections of the Protocol then deal with the two periods in separate provisions. Subsection I (1) of the Protocol describes requirements for calls on Canadian storage during the first 60 years after Treaty ratification. Subsection I (2) of the Protocol describes the requirements for flood control calls after 60 years from the ratification date. Section I(2) provides that post-2024 flood control calls shall be made "only to control potential floods in the United States of America that could not be adequately controlled by all the related storage facilities in the United States of America existing at the expiration of 60 years from the ratification date ..."

Use of Forecasts in Developing Called Upon Requests

Sections I and I (2) of the Protocol make it clear that U.S. calls for flood control are based on "forecast flood control needs" to "control potential floods" in the United States, and do not require the imminent or actual occurrence of a flooding event prior to a U.S. call for flood control assistance.

The use of forecasts in developing calls for Canadian storage conveys the importance of a flood control plan that sets forth a methodology for developing these forecasts and takes into account available flood control space, forecast seasonal volume, the uncertainty of runoff volume and shape, real-time runoff conditions, and U.S. flood control objectives. The flood control plan will define the conditions under which the U.S. can be expected to make a request to Canada for the use of Called Upon storage. This condition will occur if forecasted Canadian and U.S. drafts for power and other purposes, including plans for reservoir refill, together with the use of U.S. flood control facilities, do not provide adequate flood control in the U.S.

Comment [mtr7]: This is the Basis for the CU methodology set forth in the iteration 1 alternatives for post-2024 operations.

Use of U.S. Storage

The use in the Protocol of the words "could not be adequately met by flood control facilities" in the U.S. in Section I (1) and "adequately controlled by all the related storage facilities" in the U.S. in Section I (2) of the Protocol, make it clear that the flood control storage in the U.S. that would be assumed to be used prior to a call on Canada would be that storage in related U.S. flood control facilities which has an ability or is effective in controlling flooding on the Columbia River in the U.S. Together, these two provisions require the identification of (1) the U.S. projects that are projected to be used in forecasting the need for Canadian flood control storage, and (2) the volume of space in the respective U.S. projects that needs to be taken into account for flood control use in forecasting the need for Canadian flood control storage

Related Storage Facilities

The related storage facilities in the U.S., referred to in Subsection I (2) of the Protocol, are considered to be U.S. flood control facilities with authorized flood storage space that exist in 2024, with the further limiting criteria that they need to be effective in controlling flooding on the Columbia River. The term "related storage facilities" in Subsection I(2) also adds the condition that the flood control facilities to be used are related to each other and to the Columbia River system in providing flood control, i.e., those U.S. flood control projects that can be or are operated as a system to provide flood control on the Columbia River in the U.S. This categorization is consistent with the listing of projects by the U.S. and Canadian Entities in the current Treaty FCOP, and is consistent with Corps studies that identify significant system flood control projects as those that have official flood control guidance that requires storage space to be reserved for flood control regulation and that have enough flood control storage capacity to be effective in reducing downstream flooding during the occurrence of a typical flood in the basin.[2]

[2] See for example "Review of Flood Control Columbia River Basin, Columbia River and Tributaries Study, CRT-63' June 1991 at 4."

In the U.S., projects that are utilized for flood control protection for the Columbia River consist of both Federal projects and non-Federal projects that have been authorized to operate storage or a part of their available storage for system flood control. Federal projects that have authorized flood control and space that has been reserved for flood control purposes are generally identified as such in their authorizing language or agency studies which Congress relied on in providing the authorization. Non-Federal projects are generally identified for flood control use under the terms of an applicable FERC license, which also identifies a volume of space the project operator must provide for flood control. Conditions imposed on Federal projects through authorizing conditions and non-Federal dams through the terms of FERC licenses generally act as both legal obligations and constraints that the operators must follow in the use, release, and refill of project storage. Both Federal and non-Federal projects with this type of defined system storage are considered to be "all the related storage facilities" in the U.S. referred to in Subsection I(2) of the Protocol. For FERC regulated projects, the terms of the FERC license generally provide that space allocated for flood control will be subject to regulations provided by the Corps. The regulation of flood control space in projects owned by other federal agencies is also a usual responsibility of USACE.

Comment [mtr8]: This translates into the 8 systems reservoirs available for "Effective Use":
-Grand Coulee
- Libby
- Hungry Horse
- Albeni Falls
- Kerr
- Dworshak
- Brownlee
- John Day

In the Phase 1 study, "effective use" was defined as drafting five U.S. flood control projects equivalent to the forecast runoff in the contributing basin, yet still enabling an agreed probability of refill when the project is on minimum flow through the refill season. This operation was assumed to be effective in managing flood risk because it provided the maximum flow reduction from the project and still refilled the project (an overall goal and assumption of the Phase 1 studies as well as in real-time operations where a water management criterion is to refill the projects each year). While the five projects were commensurate with the level of detail and analysis completed in the Phase 1 study, future phases of the Treaty review will include an analysis of the use of all Columbia River projects used for system flood control, with incidental system flood control provided by non-system projects.

Comment [mtr9]: The Term "Effective Use" came out of the Phase 1 studies with Canada as a way of describing U.S. operations prior making a call on Canadian storage after 2024.

For the Called Upon procedures described in this paper, the two considerations described above are critical: (1) the "effective use" of a given U.S. reservoir is limited by the authorized amount of system flood control storage space in that project; and (2) use of the project reservoir storage space also has to be shown to be effective (i.e., have an impact) in reducing the flood stages at The Dalles on the Columbia River. The Treaty and Protocol do not provide any further provisions indicating that the term adequately met/controlled used in Section I or Subsection I (2) or the effective use of authorized flood control space for purposes of forecasting and making Called Upon storage requests could be further limited by other project purposes, e.g. power, fish, irrigation, or recreation constraints and objectives.

Flood Regulation Objective

The objective for flood regulation in the current Treaty FCOP is to operate reservoirs to reduce to non-damaging levels the stages at all potential flood damage areas insofar as possible, and to regulate larger floods that cannot be controlled to non-damaging levels to the lowest possible level with available reservoir storage. The limits to which the flows/stage elevations should be reduced under the current Treaty provisions have been established in the Treaty FCOP. If needed, post-2024 Canadian storage will be requested in accordance with the Treaty provisions and utilized together with U.S. storage projects operating to the same degree of flood protection provided in the FCOP to control floods to non-damaging levels whenever possible. The Treaty FCOP provides that flooding in the Columbia River downstream from the mouth of the Snake River begins when the river reaches elevation 17.8 feet, NGVD (1959 USGS adjustment) at Vancouver, Washington (16 feet, Columbia River Datum). The corresponding flow measured at The Dalles, Oregon, is approximately 450 kcfs. As indicated in paragraph 4-2, Treaty FCOP, significant damage begins at elevation 24 feet NGVD (22.2 feet, Columbia River Datum). The corresponding flow at The Dalles, Oregon, is approximately 600 kcfs.

Because larger floods cannot be regulated to 450 kcfs at The Dalles, the desired goal of the current FCOP is to control major floods to 600 kcfs in the lower Columbia River at The Dalles. While these stage-damage thresholds and the flood control objective could be modified as a result of information collected as part of the FRM studies currently in progress, post-2024 Called Upon requests will be limited to the criteria set forth in the Treaty and associated Protocol. As discussed below, regardless of the flood control objective, in the post-2024 period, calls for Canadian flood control storage beyond the initial 8.45 Maf will be limited to those situations where flows are forecasted to exceed 600 kcfs at The Dalles, assuming the effective use of all related U.S. flood control projects in accordance with the preceding discussion. As described further in this document, these flows would be forecasted based on the April through August unregulated water supply volume forecasts at The Dalles. This forecasting process is similar to the procedure set forth in the Treaty FCOP for on call requests made during the first 60 years after ratification of the Treaty.[3]

In real-time operations during higher runoff years, when Called Upon may be required, effective use most likely will not require a change in current operations, because the U.S. projects are usually at their full authorized flood storage draft during these years (including Grand Coulee). However, this assumption will be further reviewed in future studies.

3. Canada is not required to provide any greater degree of flood control for the post-2024 period than it was obligated to provide during the first 60 years of the Treaty.

Under Section I(2) of the Protocol, Canada is not obligated to provide any greater degree of flood control after 2024 than it was required to provide prior to 2024. The relevant language of this section states, "… but in no event shall Canada be required to provide any greater degree of flood control under Article IV(3) of the Treaty [after 60 years from the ratification date] than that provided for under Article IV(2) [prior to 60 years from the ratification date] of the Treaty." Under Article IV (2) of the Treaty, during the first 60 years after ratification, the U.S. is entitled to 8.45 Maf of primary flood storage on an annual basis, and additional "on-call" storage when agreed to by the Permanent Engineering Board, or, in the case of potential floods which could result in a peak discharge in excess of 600 kcfs at The Dalles, Oregon, that cannot be adequately controlled by all related U.S. flood control facilities that existed in 1961.[4] The 8.45 Maf of

[3] See Treaty FCOP (May 2003) at pp. 39-42 and Appendix A. Generally, forecasts of unregulated volume runoff in excess of 105,000,000 to 111,000,000 acre-feet on various dates indicate the potential to exceed 900 kcfs unregulated and 600 kcfs regulated. As described elsewhere in this paper a similar forecasting method is to predict post-2024 Called Upon requests.

[4] In applying Section 1(2) of the Protocol for the post 2024 period the U.S. must use projects that are in place 60 years after the ratification date are used.

primary flood storage is to be distributed as set forth in Article IV of the Treaty, or alternative equivalents that would provide the same protection as measured at The Dalles, Oregon. In 1995, the original 8.45 Maf was augmented by 0.5 Maf to 8.95 Maf as part of a re-allocation of Arrow and Mica flood control space requested by the Canadian Entity.

Canada's obligation to provide for flood control prior to 60 years from the ratification date is reflected in the current Flood Control Operating Plan (FCOP May 2003). Canada is obligated under that plan to provide primary flood storage of up to 8.95 Maf, the Canadian power draft set forth in the Assured Operating Plan (AOP)/Detailed Operation Plan (DOP), plus additional storage when a call is made by the U.S. for flows forecasted to exceed 600 kcfs at The Dalles. The current Treaty FCOP describes procedures that are based on the assumption there is the potential to exceed 600 kcfs at The Dalles if the April-August water supply forecast (WSF) at The Dalles exceeds 120 Maf. As described in subsequent sections, post-2024 Called Upon requests would be based on a similar assumption.

Refill of Canadian Storage

In addition to drawdown of Canadian storage for flood control, for the post-2024 period the U.S. will also be able to control refill of the primary flood storage of 8.45 Maf, because under Annex A of the Treaty this was a right that was provided prior to the expiration of 60 years from the ratification date, i.e., "… refill will be as requested by the United States entity after consultation with the Canadian entity." See paragraph 5, Annex A, CRT. The ability of the U.S. to direct drawdown and/or refill storage outside of the primary zone will be limited to those situations where forecasts show flows exceeding 600 kcfs at The Dalles with the effective use of U.S. storage. Regardless of whether the drawdown or refill is for primary or secondary storage, the U.S. is obligated to compensate Canada for any calls associated with either types of storage.

Summary of Post-2024 Called Upon Obligations

To summarize the U.S. post-2024 flood control benefits in light of the Treaty and Protocol provisions, the U.S. is entitled to call upon Canada to provide storage operations for forecasted U.S. flood control needs that cannot be adequately controlled by all related U.S. flood control facilities existing in 2024, limited to no greater degree of flood control protection provided for under Article IV(2) of the Treaty. This degree of protection is reflected in the pre-2024 FCOPs. This storage consists of 8.45 Maf of Canadian primary flood storage, U.S. flood control storage, U.S. and Canadian power drafts, additional on-call storage if agreed to by the PEB, and all other related Canadian storage for flows forecasted to exceed 600 kcfs at The Dalles. The Protocol also provides that every effort will be made to minimize flood damage in both Canada and the U.S.

One method to plan implementation of the Treaty post-2024 Called Upon flood control storage right is to utilize the same 8.45 Maf of primary flood storage, and additional storage for flows exceeding 600 kcfs, at The Dalles that are provided in the current FCOP with modifications for U.S. projects existing in 2024. This allocation of flood storage space ensures that the U.S. is able to call upon storage in Canada should both the U.S. and Canadian power drafts and effective use of U.S. projects for flood control not provide the same degree of protection as the original 8.45 Maf of primary flood storage during the first 60 years. In addition to the primary flood storage, in practice, the U.S. has had a flood control benefit from Canadian power draft that ranges from

10 to 14 Maf – more than the current primary flood storage allocation of 8.95 Maf. Section 4-2 of the Treaty FCOP indicates that flooding downstream of the mouth of the Snake River begins at a flow of approximately 450 kcfs at The Dalles, and significant damage begins at flows of approximately 600 kcfs. Thus, the desired goal is to control major floods to no higher than 600 kcfs at The Dalles. This goal is consistent with the post-2024 requirements for Called Upon flood control.

4. Post-2024 flood control calls are to be made only if the Canadian Entity has been consulted whether the need for flood control is, or is likely to be, such that it cannot be met by the use of flood control facilities in the United States. If the Entities do not agree, the matter is submitted to the Permanent Engineering Board. If the PEB cannot agree, Canada must operate in accordance with the U.S. request.

Section I(3) of the Protocol presents a detailed process to be followed for implementing Called Upon storage.

> *(3) A call shall be made only if the Canadian entity has been consulted whether the need for flood control is, or is likely to be, such that it cannot be met by the use of flood control facilities in the United States of America in accordance with subparagraphs (1) or (2) of this paragraph. Within ten days of receipt of a call, the Canadian entity will communicate its acceptance, or its rejection or proposals for modification of the call, together with supporting considerations. When the communication indicates rejection or modification of the call the United States entity will review the situation in the light of the communication and subsequent developments and will then withdraw or modify the call if practicable. In the absence of agreement on the call or its terms the United States entity will submit the matter to the Permanent Engineering Board provided for under Article XV of the Treaty for assistance as contemplated in Article XV(2)(c) of the Treaty. The entities will be guided by any instructions issued by the Permanent Engineering Board. If the Permanent Engineering Board does not issue instructions within ten days of receipt of a submission the United States entity may renew the call for any part or all of the storage covered in the original call and the Canadian entity shall forthwith honor the request.*

This subsection provides that a call shall only be made if the Canadian Entity "has been consulted whether the need for flood control is, or is likely to be such that it cannot be met by the use of flood control facilities in the United States of America."

After a call is made, the Canadian Entity has 10 days to provide its acceptance, rejection, or proposal for modification. After reviewing the Canadian Entity response, and in the absence of an agreement on the call or its terms, the U.S. Entity will submit the matter to the PEB. The PEB may reject or modify the Called Upon request. The Entities will be guided by any instructions issued by the PEB; but, if the PEB does not issue instructions within 10 days of a request for assistance, the U.S. may renew the call and the Canadian Entity shall honor the request. Thus, in the absence of agreement by the Canadian Entity, or instructions from the PEB, Section I (3) of the Protocol provides that the Canadian Entity must honor a U.S. request for Called Upon storage.

Based on the foregoing, it is apparent that there must be a consultation or coordination process completed by the Entities prior to initiating an actual call for flood control storage. An overall agreement setting forth the hydrologic and operational metrics could constitute the consultation process and outline the general conditions when a call for storage may be made. Thus, assuming such a consultation/coordination process is in place, the U.S. and Canada would have a basic agreed upon approach for the consultation obligation requirement, and possibly for describing the runoff conditions when a call for storage would be made.

5. Section II of the Protocol requires that Called Upon storage be operated so that "every effort will be make to minimize flood damage in both Canada and the U.S.A." That section states:

> *II. In preparing the flood control operating plans in accordance with paragraph 5 of Annex A of the Treaty, and in making calls to operate for flood control pursuant to Articles IV(2)(b) and IV(3) of the Treaty, every effort will be made to minimize flood damage in both Canada and the United States of America.*

While this provision makes it clear that Canadian flood control needs will be taken into account in developing called upon flood control requests, it should not be considered as a substantive change to paragraph 5 of Annex A of the Treaty, wherein the flood control plans for the Canadian storage projects are developed to prevent flooding in the U.S.

6. Article VI, Sections 4 and 5 of the Treaty provides that for the use of Called Upon flood control operations, Canada will be compensated for their operating costs and economic losses. Article VI, Section 4 provides that:

> *4. For each flood period for which flood control is provided by Canada under Article IV(3), the United States shall pay Canada in United States funds:*
> *a. The operating cost incurred by Canada in providing the flood control, and*
> *b. Compensation for the economic loss to Canada arising directly from Canada foregoing alternative uses of the storage used to provide the flood control.*

Article VI, Section 5 provides that Canada may elect to receive, in electric power, the whole or any portion of the compensation, under paragraph (4)(b), representing loss of hydroelectric power to Canada.

7. If the Treaty is not terminated, the Entities will continue to develop AOPs that provide reliable information on power drafts for the Canadian projects and resulting flows at the Canada-U.S. border. The U.S. Entity will be able to use this information in developing forecasts of flood control needs for Called Upon requests.

Under the terms of the Treaty, Canada agreed to provide in the Columbia River Basin in Canada 15,500,000 acre-feet of storage for the purpose of increasing hydroelectric power generation in

Canada and the U.S. This Canadian storage was to be provided by the construction of three dams in British Columbia. These projects were Mica, Arrow, and Duncan. This Canadian storage was to be operated in accordance with operating plans made pursuant to guidance provided in Annex A of the Treaty. In consideration for Canada's agreement for providing this storage for increasing hydroelectric power generation, the U.S. agreed to provide Canada one-half of the estimated increase in downstream power benefits for the 1961 U.S. Base System.

Pursuant to Article III, paragraph 1, the U.S. is required to operate projects in the U.S. to make the most effective use of the Canadian storage for hydroelectric power generation. Under Section 2, this obligation can be discharged, by reflecting in the calculation of the downstream power benefits to which Canada was entitled, the assumption that the projects were operated to make the most effective use of the Canadian storage for power generation. The methodology for the calculation of Canada's downstream power benefit was set forth in Annexes A and B of the Treaty.

Under paragraph 9, Annex A of the Treaty, the U.S. and Canada agree annually on operating plans and the resulting downstream power benefits for the 6th succeeding year of operations. This procedure continues during the life of the Treaty, providing to both the U.S. and Canada, in advance, an assured plan of operation of the Canadian storage and a determination of the resulting downstream power benefits for the next succeeding 5 years. Canada is required to operate its projects pursuant to these operating plans, thus providing for reliable flows at the border for hydroelectric power generation.

3.0 PROPOSED PROCEDURE FOR POST-2024 OPERATIONS

While the Treaty and Protocol include specific provisions for Called Upon storage, neither provides detailed descriptions of technical methods and/or procedures needed to make such a request. This section outlines a strategy and proposed procedure for flood risk management operations after the expiration date of primary flood storage in September 2024. The proposed procedure represents an initial approach that will be further evaluated and modified as the CRT Review progresses.

3.1 Recommendations from Phase 1

The results of the Phase 1 modeling studies revealed that the initial method used for evaluating the Called Upon process needed to be re-evaluated. A number of recommendations for further analysis were included in the Phase 1 report. Those recommendations were incorporated into the development of this revised Called Upon procedure. The recommendations are listed below:

a) Canadian Called Upon Draft Volume: The Called Upon procedure used in Phase 1 frequently drafted Canadian reservoirs deeper than needed. The proposed post-2024 procedure should limit Called Upon drafts of the Canadian projects to the amount needed to operate the system to a regulated peak flow at The Dalles to avoid significant damage and to be consistent with Treaty and Protocol requirements.

b) Water Supply Forecast Changes in Called Upon Years: In the Phase 1 studies, the water supply forecasts at The Dalles occasionally fluctuated from month to month above and below the forecast value used to trigger Called Upon operations. The proposed procedure uses a gradual implementation of Called Upon storage in parallel with Canadian power drafts that results in a reduced frequency of Called Upon storage. This new procedure will continue to be tested with the newly developed models, evaluated and refined as necessary.

c) Drafting of all Effective Use Storage at Related U.S. Flood Control Projects: In the Phase 1 studies, only the U.S. headwater projects (Libby, Dworshak, Hungry Horse) that currently have defined storage reservation diagrams (SRD) were operated to the effective use procedure. Grand Coulee and Brownlee reservoirs were drafted toward empty in years when Called Upon storage was triggered. Current Flood Risk Management (FRM) studies will use all headwater projects and other facilities that have federally authorized system flood storage and are effective at reducing the flow at The Dalles. Also, incidental system flood risk management provided by non-system storage projects is taken into account in modified flow inputs used in Called Upon procedure. .

3.2 Assumptions

In order to develop the post-2024 strategy and Called Upon procedure, the following general assumptions were made.

- Canadian power drafts will be available for flood storage.
- Called Upon storage would be considered only if Canadian power drafts do not provide sufficient flood storage in conjunction with the use of U.S. system flood storage.

- Projects will be drafted according to their current SRDs, although future FRM studies may evaluate alternative SRDs.
- Both Canadian and U.S. projects are first operated to their expected power objectives and other project purposes, including Canadian local flood control, prior to making a Called Upon request
- U.S. system flood storage projects must continue to operate according to the plan for effective flood risk management as long as the flood storage need exists.
- Refill of all projects is based on current procedures.

If the above operations do not provide adequate storage for potential floods, the U.S. may:

- Call upon Canadian storage (up to 8.95 Maf) as needed (if not already drafted for power) for potential forecasted floods.
- Call upon Canada for U.S. flood protection when needed for potential or forecast floods with the agreement of the Permanent Engineering Board.
- Call upon all remaining related Canadian storage, within the existing project limits, as needed for potential floods forecasted to exceed 600 kcfs at The Dalles, the designated downstream system control point.

3.3 Goals of the Procedure

Based on the assumptions listed in the previous section, the following goals were established to develop the procedure presented herein:

- Identify the related U.S. flood storage projects that could effectively be used to manage forecasted Columbia River Basin water volumes and flow at The Dalles assuming incidental use of non-system storage projects.
- Describe the relationship between forecast water supply volumes at The Dalles and the associated required flood storage.
- Determine the approximate frequency or number of occurrences that a Called Upon request is triggered when applying the developed procedure to the same 70-year period of record used in the Phase 1 studies.

3.4 Columbia River Basin Management System

The Columbia River system is comprised of both run-of-river and storage reservoirs that are authorized or licensed for multiple purposes, including power generation, flood control, navigation, irrigation, recreation, and fish operations. Run-of-river reservoirs have very limited storage and therefore simply pass inflows through the hydroelectric project by generating power or by spilling. Storage reservoirs can accommodate significant changes in inflow volume, which can be utilized to modify the timing and quantity of runoff through the river system.

There are hundreds of dams within the Columbia River Basin. The majority of these dams are not authorized for flood control. **Figure 1** shows the major dams of the basin that are authorized for system flood control or that provide storage for other purposes, such as local flood control, navigation, irrigation, hydropower, recreation, and fish and wildlife benefits.

Figure 1 – Major Dams Relative to Flood Risk Management

To determine which of the U.S. projects should be considered as part of the system that could effectively be used to manage forecasted basin water volumes or manage flow at The Dalles, the functions and authorizations of major dams were examined.

3.5 Dam Authorizations and Flood Control Capacities

Appendix A presents a detailed examination of the authorizations for major dams in the U.S. shown in **Figure 1**. Dams listed in the Treaty as "base system" projects and dams listed in Chart 1A of the FCOP are included as part of the examination. These dams and reservoirs have been grouped according to their institutional authorizations and operations. The complete results of the examination are summarized in **Table 1.** The table is organized into the following groups:

- Projects authorized and currently operated for system flood control.
- Projects authorized for conditional system flood control.
- Projects authorized and operated for local flood control.
- Projects not authorized for flood control, but at times may provide incidental flood risk management.
- Irrigation projects not authorized for local flood control, with no flood control operations.
- Projects with minimal or no storage capacity (not effective at reducing flow at The Dalles).
- Run-of-river projects with minimal or no storage capacity.

These grouping reflects how the projects relate to the overall system flood risk management.

Table 1 – Summary of U.S. Project Authorizations

<table>
<tr><th rowspan="2" colspan="2">Project</th><th rowspan="2">River</th><th rowspan="2">Owner</th><th rowspan="2">Active Storage (Maf)</th><th colspan="2">Authorized</th><th rowspan="2">Not Authorized Incidental Storage (Maf)</th><th rowspan="2">Authorization
(see Appendix D for additional information)</th></tr>
<tr><th>System Flood Control (Maf)</th><th>Local Flood Storage (including Section 7) (Maf)</th></tr>
<tr><td colspan="4">Projects Authorized and Currently Operated for System Flood Control</td><td>19.738</td><td>18.282</td><td>---</td><td>0.000</td><td></td></tr>
<tr><td colspan="2">Libby</td><td>Kootenai</td><td>USACE</td><td>4.980</td><td>4.980</td><td>Included with System</td><td>---</td><td>Rivers and Harbors Act of 1950, PL 81-516; Columbia River Treaty</td></tr>
<tr><td colspan="2">Hungry Horse</td><td>South Fork Flathead</td><td>USBR</td><td>2.980</td><td>2.980</td><td>Included with System</td><td>---</td><td>Act of June 5, 1944, 58 Stat. 270; PL 78-329</td></tr>
<tr><td colspan="2">Dworshak</td><td>Clearwater</td><td>USACE</td><td>2.016</td><td>2.016</td><td>Included with System</td><td>---</td><td>Rivers and Harbors Act of 1962, PL 87-874</td></tr>
<tr><td rowspan="3">Brownlee</td><td>Brownlee</td><td>Middle Snake</td><td>Idaho Power Co.</td><td>1.426</td><td rowspan="3">0.990</td><td rowspan="3">---</td><td>---</td><td>FERC License No. 1971</td></tr>
<tr><td>Hells Canyon</td><td>Middle Snake</td><td>Idaho Power Co.</td><td>0.188</td><td>---</td><td>FERC License No. 1971</td></tr>
<tr><td>Oxbow</td><td>Middle Snake</td><td>Idaho Power Co.</td><td>0.058</td><td>---</td><td>FERC License No. 1971</td></tr>
<tr><td colspan="2">Kerr Dam [*1]</td><td>Flathead</td><td>PPL Montana & Salish Kootenai Tribe</td><td>1.219</td><td>1.000</td><td>---</td><td>---</td><td>FERC License No. 5</td></tr>
<tr><td colspan="2">Albeni Falls Dam [*1]</td><td>Pend Oreille</td><td>USACE</td><td>1.155</td><td>0.600</td><td>---</td><td>---</td><td>River and Harbors Act of 1950, PL 81-516</td></tr>
<tr><td colspan="2">Grand Coulee</td><td>Columbia</td><td>USBR</td><td>5.186</td><td>5.186</td><td>---</td><td>---</td><td>Section 2, River and Harbors Act of 1935, PL 74-409; The Columbia Basin Project Act of March 10, 1943; PL 89-448 (Third Powerhouse)</td></tr>
<tr><td colspan="2">John Day</td><td>Columbia</td><td>USACE</td><td>0.530</td><td>0.530</td><td>---</td><td>---</td><td>Rivers and Harbors Act of 1950, PL 81-516</td></tr>
<tr><td colspan="4">Projects Authorized for Conditional System Flood Control</td><td>1.275</td><td>0.745</td><td>---</td><td>---</td><td></td></tr>
</table>

	Project	River	Owner	Active Storage (Maf)	Authorized System Flood Control (Maf)	Authorized Local Flood Storage (including Section 7) (Maf)	Not Authorized Incidental Storage (Maf)	Authorization (see Appendix D for additional information)
Mid Columbia PUD	Wells	Columbia	Douglas County PUD No 1	0.125	0.125	---	---	FERC License No. 2149
Mid Columbia PUD	Rocky Reach	Columbia	Chelan County PUD No 1	0.360	0.120	---	---	FERC License No. 2145
Mid Columbia PUD	Rock Island	Columbia	Chelan County PUD No 1	0.009	---	---	---	FERC License No. 943
Mid Columbia PUD	Wanapum	Columbia	Grant County PUD No 2	0.590	0.500	---	---	FERC License No. 2114, Amendment No. 4
Mid Columbia PUD	Priest Rapids	Columbia	Grant County PUD No 2	0.191				FERC License No. 2114, Amendment No. 4
Projects Authorized and Operated for Local Flood Control *3				**2.149**	**---**	**2.149**	**0.000**	
	Palisades	Upper Snake	USBR	1.200	---	1.200	---	PL 81-864, 64 Stat. 1083 Palisades is authorized for flood control and as a Section 7 project. Palisades and Jackson are operated together in coordination with the Corps of Engineers to supply up to 1.6 Maf of combined flood control space as described in the Water Control Manual for Palisades Dam.
Boise	Anderson Ranch	Boise	USBR	0.413	---	0.949	---	Part of Boise Project-Arrowrock Division. Authorized by Secretary of the Interior in 1940 under 1902/1939 Reclamation Acts. The Act of Aug.24, 1954 authorizes the Secretary of the Interior to coordinate the facilities on the Boise River. 1953 MOA with Corps for flood control. Sept 25, 1985 MOA with Corps for flood control

	Project	River	Owner	Active Storage (Maf)	Authorized: System Flood Control (Maf)	Authorized: Local Flood Storage (including Section 7) (Maf)	Not Authorized Incidental Storage (Maf)	**Authorization** (see Appendix D for additional information)
	Arrowrock	Boise	USBR	0.272				Part of Boise Project-Arrowrock Division. Authorized in 1911 by Secretary of the Interior. The Act of Aug 24, 1954 authorizes the Secretary of the Interior to coordinate the facilities on the Boise River. 1953 MOA with Corps for flood control. Sept 25, 1985 MOU with Corps for flood control. PUDs operate power house under FERC License No. 4656.
	Lucky Peak	Boise	USACE	0.264				PL 79-526; Power operations under FERC License No. 2832.
	Willamette Projects*2	Willamette	USACE	*2	---	---	---	*2
Projects Not Authorized for Local Flood Control but at times may provide incidental system flood protection *3				**2.938**	**---**	**0.231**	**1.960**	
	Jackson Lake	Upper Snake	USBR	0.847	---	---	0.400	Part of the Minidoka Project authorized in 1904 by the Secretary of the Interior under the 1902 Reclamation Act. Palisades and Jackson are operated together in coordination with the Corps of Engineers to supply up to 1.6 Maf of combined flood control space as described in the Water Control Manual for Palisades Dam.
Payette	Deadwood	Payette	USBR	0.154	---	---	0.104	Boise Project-Payette Division. Secretary of the Interior, on Oct. 18, 1928 approved by the President on Dec. 19, 1935.

	Project	River	Owner	Active Storage (Maf)	Authorized: System Flood Control (Maf)	Authorized: Local Flood Storage (including Section 7) (Maf)	Not Authorized Incidental Storage (Maf)	**Authorization** (see Appendix D for additional information)
	Cascade	Payette	USBR	0.646	---	---	0.396	Boise Project-Payette Division. Secretary of the Interior, Nov. 30, 1935 approved by the President on Dec. 19, 1935
Yakima Projects	Cle Elum	Yakima	USBR	0.440	---	---	0.440	Yakima Project-Storage Division, Secretary of the Interior December 12, 1905
Yakima Projects	Kachess	Yakima	USBR	0.240	---	---	0.240	Yakima Project-Storage Division, Secretary of the Interior December 12, 1905
Yakima Projects	Keechelus	Yakima	USBR	0.160	---	---	0.160	Yakima Project-Storage Division, Secretary of the Interior December 12, 1905
Yakima Projects	Bumping Lake	Naches	USBR	0.030	---	---	0.030	Yakima Project-Storage Division, Secretary of the Interior December 12, 1905
Yakima Projects	Tieton	Naches	USBR	0.190	---	---	0.190	Yakima Project-Storage Division, Secretary of the Interior December 12, 1905
Clark Fork	Thompson Falls	Clark Fork	PPL Montana					FERC License No. 1869
Clark Fork	Noxon Rapids	Clark Fork	Avista Corporation	0.231	---	0.231	---	FERC License No. 2075
Clark Fork	Cabinet Gorge	Clark Fork	Avista Corporation					FERC License No. 2058
Irrigation Projects Not Authorized for Local Flood Control with No Flood Control Operations				**1.766**	**---**		**---**	
	American Falls	Upper Snake	USBR	1.671	---	---	---	Part of the Minidoka Project, The original American Falls Dam was Authorized by Secretary of Interior April 23, 1904; American Falls Replacement dam was authorized by PL 93-206.

Project	River	Owner	Active Storage (Maf)	Authorized: System Flood Control (Maf)	Authorized: Local Flood Storage (including Section 7) (Maf)	Not Authorized Incidental Storage (Maf)	Authorization (see Appendix D for additional information)
Minidoka	Upper Snake	USBR	0.095	---	---	---	Authorized in 1904 by the Secretary of the Interior under 1902 Reclamation Act.
Projects with Minimal or No Storage Capacity *3 (not effective at reducing flow at the Dalles)			**0.875**	**---**	**---**	**---**	
Chelan	Columbia	Chelan County PUD No 1	0.650	---	---	---	FERC License No. 637
Post Falls - Coeur d'Alene Lake	Spokane	Avista Corporation	0.225	---	---	---	FERC License No. 2545
Run of River Projects with Minimal or No Storage Capacity *3			**0.607**	**---**	**---**	**0.345**	
Box Canyon	Pend Oreille	SFG HCK Timber Partnership LP	---	---	---	---	FERC License No. 2024
Boundary	Pend Oreille	Seattle City Light	---	---	---	---	FERC License No. 2144
Chief Joseph	Columbia	USACE	0.115	---	---	---	PL 79-525
Lower Granite	Lower Snake	USACE	0.053	---	---	---	PL 79-14 (Section 2 of the River and Harbor Act of 1945), House Document 704, 75th Congress, 3d Session
Little Goose	Lower Snake	USACE	0.049	---	---	---	PL 79-14 (Section 2 of the River and Harbor Act of 1945), House Document 704, 75th Congress, 3d Session
Lower Monumental	Lower Snake	USACE	0.020	---	---	---	PL 79-14 (Section 2 of the River and Harbor Act of 1945)
Ice Harbor	Lower Snake	USACE	0.025	---	---	---	PL 79-14 (Section 2 of the River and Harbor Act of 1945)
McNary	Columbia	USACE	0.205	---	---	0.205	PL 79-14 (Section 2 of the River and Harbor Act of 1945)
The Dalles	Columbia	USACE	0.053	---	---	0.053	PL 81-516

Project	River	Owner	Active Storage (Maf)	Authorized		Not Authorized Incidental Storage (Maf)	**Authorization** (see Appendix D for additional information)
				System Flood Control (Maf)	Local Flood Storage (including Section 7) (Maf)		
Bonneville	Columbia	USACE	0.087	---	---	0.087	PL 74-409

Notes:

*1 Guide curves for these projects use the entire active capacity, however, natural channel restriction may prevent evacuation to full storage capacities in some years

*2 While the Willamette projects are authorized and operated for local flood control, the current FCOP was developed for regulation of the Columbia River basin-wide spring snowmelt events. For the purposes of the Phase 2 studies the assumption was made that the Willamette system contributes a minor amount to the overall Columbia system flood peak and these reservoirs were not included in the model.

*3 Run of river projects or tributary projects that have been not been authorized for system flood control but have been authorized for local flood control, irrigation, power, or other purposes may at times provide incidental main stem system flood control based on these other operational requirements. The use of such reservoirs for storing water for major floods is unreliable because the Corps does not have authority to exercise control of these projects for system flood control. Further, the uncertainty is compounded by the lack of appreciable storage capacity, limited outlet facilities, the non-coincident timing of flood flows at tributary reservoirs with those on the main stem, the reluctance of owners to delay filling reservoirs or changing project operations because of impact on authorized users, or for other reasons. Thus, while these projects may at times provide flood control incident to their normal operations for other purposes they are not considered effective in determining or forecasting main stem system flood control requirements.

3.6 Projects Authorized and Currently Operated for System Flood Control

While many dams and reservoirs in the system provide some contribution, the core of the system flood risk management in the Columbia River Basin is formed by seven U.S. storage reservoirs (Libby, Hungry Horse, Dworshak, Brownlee, Kerr, Albeni Falls, and Grand Coulee) and the three Canadian Treaty projects (Arrow, Mica, and Duncan). All but two of the projects are located on the Columbia River or its tributaries north of the conjunction with the Snake River. Dworshak and Brownlee are located in the Snake River system.

The primary focus of the U.S. flood risk management efforts is directed at regulating the spring runoff, or freshet, from the western side of the northern U.S. and Canadian Rocky Mountain area in the upper Columbia sub-basin, of which approximately 25 percent originates in Canada. The following sections present descriptions of how the dams and reservoirs are operated with the U.S. flood risk management strategy.

3.6.1 Reservoirs Operated Under Fixed Releases Primarily for Flood Storage of the Lower Columbia.

Project authorized for system flood control and operated under fixed releases primarily for flood risk management are two of the Canadian projects (Mica and Duncan) and four U.S. projects (Libby, Hungary Horse, Brownlee and Dworshak). These reservoirs typically are not operated on a day-to-day basis to aid in flood management of the lower Columbia due to the relatively long time that it takes for a change in the outflow at these reservoirs to have a significant effect upon streamflow in the lower Columbia River as measured at The Dalles, Oregon.

For these reservoirs, Storage Reservation Diagrams (SRD) define the amount of space, based on volumetric water supply forecasts, that is needed at each project for system flood storage. These reservoirs are drafted to their respective SRD target by a set date and operated to refill with a specified release based on the volume of runoff forecast for the reservoirs. This release will be maintained until the reservoir is filled or it becomes necessary to adjust the specified release because of the runoff pattern, a modified forecast, or because the reservoir is nearly full and the inflows are forecast to continue at a high rate.

Downstream from most of the reservoirs in this group are local areas that have flood risk. Therefore fixed release patterns for system flood storage may occasionally be altered to provide better flood risk management in these areas. Typically the storage operation required at these reservoirs for protection of major damage areas downstream (“system flood control”) results in the necessary local flood risk management with little to no modification. Additionally, it may be necessary to refill some space during local flood operations before the Initial Control Flow (ICF) at The Dalles is met. Basically initiation of refill at these projects is guided by both the ICF and streamflow forecasts at The Dalles.

3.6.2 Major Lakes with Projects Operated to Control Lake Elevations During Non-Flood Period.

There are two major natural lakes in the upper Columbia Basin that have been used to off-set system flood risk within the basin, Kerr (Flathead) and Albeni Falls (Pend Oreille Lake). These lakes are controlled by dams during low flow periods to maintain the integrity and purposes of the lakes. During high-flow periods the operation of the lakes may shift to provide storage space for flood risk management but the dependability of the natural lake is preserved to the maximum extent possible. Therefore while these lakes may be utilized to off-set flood risk, there are limiting factors that must be considered so that the local interests are preserved.

3.6.3 Reservoirs Operated With Variable Releases Primarily for Flood Control of the Lower Columbia River.

Reservoirs in this group are those in which outflows have a relatively brief time of travel (2 days or less) to the lower Columbia River, and which have sufficient flexibility to permit variable releases on a day-to-day forecast basis. These projects, John Day and Grand Coulee in the U.S. and Arrow in Canada, provide the final major storage regulation of the system and are used primarily to maintain the desired controlled flow in the lower Columbia in addition to providing local flood risk reduction.

Because of its size and location, Grand Coulee dam serves a key role in the U.S. flood risk management strategy. With an active storage capacity of approximately 5.2 Maf and as the closest storage reservoir to The Dalles, it offers the greatest opportunity to relatively quickly influence the flow in the lower Columbia. The hydraulic travel time from Grand Coulee to The Dalles is approximately 1 day. Therefore, modifications to the dam’s rate of release are quickly apparent downstream.

Arrow serves a similar function on the Canadian side of the border. It is the most downstream storage reservoir on the Columbia River in Canada and can quickly regulate the flows into the U.S. Since both projects serve as key control points in the system, they are operated in conjunction with each other, both in real time and in the flood model.

Although John Day is essentially a run-of-river dam, it has approximately 0.5 Maf of storage capacity that can be used for flow regulation. Because it is immediately upstream of The Dalles, it provides some value in reducing the peak flows for last-chance shaping of the flow.

3.7 Projects Authorized For Conditional System Flood Control

Projects that are authorized for condition system flood control require additional arrangements or compensations to be made prior to invoking the system flood storage. These projects correspond to run-of the river projects on the mainstem Columbia owned and operated by the mid-Columbia PUDs. While the primary purpose of these projects is power generation, four of the five mid-Columbia PUD projects, Wells, Rocky Reach, Wanapum, and Priest Rapids, are also authorized for conditional flood control.

3.8 Projects Authorized and Operated For Local Flood Control

Projects that are specifically authorized to operate for local flood management conditions rather than system flood management include Palisades (Upper Snake River), Anderson Ranch, Arrowrock and Lucky Peak (Boise River), and the Willamette Projects. In some cases, the local flood operations may be a secondary operation. These projects are usually operated to control the flow or elevation at a nearby control point. While the system may benefit from the local flood operations, these projects are not directly operated to control the flow at the designated system control point. The flood storage benefit provided by these projects is accounted for by the use of modified regulated flows as input to the Corps' flood model.

3.9 Projects Not Authorized For Local Flood Control, But At Times May Provide Incidental System Flood Risk Management

The majority of the reservoirs in this group are mainly used to provide irrigation. For these irrigation reservoirs, storage used to reduce flood risk is available under formal operating agreements. For the remaining reservoirs, flood risk management benefits are obtained through informal arrangements (such as calling for delayed filling). The projects under this group include Jackson Lake (Upper Snake), Deadwood and Cascade (Payette), the Clark Fork Dams (Thompson Falls, Noxon Rapids, Cabinet Gorge) and the Yakima River Dams (Cle Elum, Kachess, Keechelus, Bumping Lake, Tieton). The flood storage provided by these projects is accounted for by the use of modified regulated flows as input to the Corps' flood model.

3.10 Irrigation Projects Not Authorized For Local Flood Control with No Flood Control Operations

American Falls and Minidoka are authorized for irrigation purposes. Under current authorizations, they have no flood storage capacity and are not operated for local or system flood risk management.

3.11 Projects with Minimal or No Storage Capacity (not effective at reducing flow at The Dalles)

Chelan and Coeur D'Alene Lake (Post Falls) fall into this group. Chelan is owned by a private utility company and has no significant storage capacity that can be effectively used for system flood risk management. Coeur d'Alene Lake is not operated nor has the storage capacity to effectively offset system flood risk.

3.12 Run-of-River Projects with Minimal or No Storage Capacity

Run-of-river projects have only limited reservoir storage capacity, which is used primarily for power pondage. The effect of the run-of-river projects on the total regulation of the Columbia River flood flows is minor, but the operating requirements for these projects contribute to system flows and are considered when determining the day-to-day regulation of the lower Columbia River projects. The projects under this group include Box Canyon, Boundary, Chief Joseph, Lower Granite, Little Goose, Lower Monumental, Ice Harbor, McNary, The Dalles, Bonneville, and Corra Linn (Kootenay).

3.13 Canadian Projects

Article II of the Treaty requires Canada to provide 15.5 Maf of storage for improving the flow in the Columbia River. Canada built three projects in British Columbia to satisfy that Treaty requirement.

Table 2 includes a breakdown of the primary flood storage provided by the Treaty for the first 60 years after ratification. The 8.45 Maf storage stipulated in Article IV of the Treaty was later increased to 8.95 Maf as the result of a mutually agreed-upon shift of equivalent storage from Arrow (Keenleyside) to Mica.

Table 2 –Canadian Projects that Provide System Flood Control

Project	River	Owner	Active Storage (Maf)	Capacity Authorized by Treaty (Maf)	Primary Flood Control (Maf)	Authorization
Canadian Storage Projects			**20.500**	**15.500**	**8.950**	
Mica	Columbia	BC Hydro	12.000	7.000	4.080	Columbia River Treaty
Duncan	Duncan	BC Hydro	1.400	1.400	1.270	Columbia River Treaty
Arrow	Columbia	BC Hydro	7.100	7.100	3.600	Columbia River Treaty
TOTAL CANADIAN STORAGE			**20.500**	**15.500**	**8.950**	

3.14 Total Columbia River Basin Storage

Table 3 provides a summary of the information provided in sections 3.7 through 3.13. The summary includes the U.S. and Canadian projects within the Columbia River Basin. The information on the U.S. projects is organized in the same groups as included in **Table 1.**

Table 3 – Total Columbia Basin Storage

Project Groups	Active Storage (Maf)	Authorized		Not Authorized Incidental Storage (Maf)	Total Storage (Maf)
		System Flood Control (Maf)	Local Flood Storage (Maf)		
Projects Authorized and Currently Operated for System Flood Control	19.738	18.282	---	0.000	18.282
Projects Authorized for Conditional System Flood Control	1.275	0.745	---	---	0.745
Projects Authorized and Operated for Local Flood Control	2.149	---	2.149	0.000	2.149
Projects Not Authorized for Local Flood Control but at times may provide incidental system flood protection	2.938	---	0.231	1.960	2.191
Irrigation Projects Not Authorized for Local Flood Control with No Flood Control Operations	1.766	---	---	---	0.000
Projects with Minimal or No Storage Capacity(not effective at reducing flow at the Dalles)	0.875	---	---	---	0.000
Run of River Projects with Minimal or No Storage Capacity	0.607	---	---	0.345	0.345
TOTAL U.S. STORAGE	29.348	19.027	2.380	2.305	23.712
Canadian Storage Projects	20.500	15.500			20.500
TOTAL COLUMBIA BASIN STORAGE	**49.848**	**34.527**	**2.380**	**2.305**	**44.212**

* Per Article II of the Treaty

3.15 Use of U.S. Reservoirs

Section 2 of this document sets out Treaty and Protocol provisions that require U.S. projects be taken into account in determining flood risk management needs prior to calls on Canadian storage. These provisions obligate the U.S. to consider its own related reservoirs' ability or effectiveness to manage flooding within the Columbia River Basin prior to making a call to Canada for Called Upon storage. To define the appropriate procedure for implementing Canadian flood storage within the Treaty context, the related provisional assumptions are restated here:

- To be considered as a related flood control facility, a project or reservoir must be authorized by the U.S. government for system flood control in the Columbia River Basin.
- The project or reservoir must be effective at reducing the flow at the system control point (The Dalles) during a flood event.

For the current CRT flood risk studies, a project must meet both of these criteria to be included in the forecasts of U.S. flood risk management needs. This analysis is applied only to the U.S. projects currently authorized and operated for system or conditional system flood control as indicated in **Table 1,** and is consistent with the categorization of projects within the Treaty FCOP.

The reservoirs of the Willamette Basin and other lower Columbia tributaries (Cowlitz and Lewis Rivers) are further excluded from these calculations. While these projects provide flood risk reduction during winter flood events, they are downstream of the system control point (The Dalles) and therefore cannot be regulated to significantly offset flows at The Dalles. Additionally, these projects do not significantly reduce flows on the mainstem of the Columbia River during typical spring snowmelt flood events, which makes them less effective in reducing flood risk at the system control point.

As part of the overall CRT Review program, alternative operations to those set forth in this document may be considered. These will be developed and described on a regional or sub-basin level, employing synthetic reservoirs to evaluate the overall ability of the U.S. to manage flood risk within the basin. Presently, such analyses are beyond the scope of this document.

3.16 Basin Hydrology and Flood Management

System flood risk management in the Columbia River Basin is driven by its hydrology. There are two important runoff patterns in the basin – the snow melt runoff in the region east of the Cascade Mountain range and the rainfall runoff in the region west of the Cascades. Most of the precipitation occurs during the winter months in both regions. However, the precipitation in the eastern region falls as snow that accumulates in the mountains and does not melt until temperatures rise in spring. Rainfall in the western region of the basin, particularly the Willamette sub-basin, produces runoff in the winter when the rainfall occurs. While this runoff may contribute to flooding in the lower Columbia River, it occurs downstream of The Dalles and does not enter the system-operated reservoirs.

The regulation of the system reservoirs upstream of The Dalles is primarily snow driven and depends upon long-term forecasts associated with the snow accumulation. System flood risk management involves two seasonal periods for reservoir regulation: 1) the reservoir drawdown period, which normally occurs during the low flow times from October to March; and 2) the reservoir refill period, the high flow times during snow melt and runoff, normally from May through July. The post-2024 procedures could impact either or both periods.

The overall goals of system flood risk management include:

- Achieving the maximum reduction of peak discharge in the lower Columbia River.
- Maintaining flows within bank full levels at upstream potential flood damage areas on tributary streams.
- Assuring refill of reservoirs to meet all project needs.

Only projects that are authorized for the overall system flood control of the Columbia River Basin are regulated under the current FCOP and this post-2024 procedure. Those projects are operated to control the flow at a designated downstream system control point, The Dalles. The management of the system projects is accomplished by the application of a collection of SRDs. These curves establish how a reservoir is operated to evacuate storage space based on either a local or system water supply forecasts (runoff). Each SRD curve sets the draft (amount to be evacuated) for a range or particular forecast value. The evacuation is then accomplished by the manipulation of the downstream releases through discharge outlets, power generation or spillways. The SRDs must be flexible enough to handle a wide range of flows resulting from hydrological events and still ensure a high probability of achieving refill of the reservoirs. Efficient management of the Columbia River reservoirs during the hydrologically active period of April through August is important for all the system interests including flood control, power generation, irrigation, navigation, ecosystem, and recreation.

The initial Main Water Control Plan for the Columbia River was prepared by USACE for the Columbia River Review Report of 1948, House Document 531, 81st Congress, 2nd Session. About 23 Maf of upstream reservoir storage in the U.S. was proposed for flood regulation for the lower Columbia River. The principle objective was to reduce the 1894 flood of record (natural flow of 1,240 kcfs) to a regulated flow of 800 kcfs as measured at The Dalles, Oregon. A secondary objective was to control flows to below 600 kcfs whenever possible. At that time, it was determined that major flood damage would occur at about 600 kcfs in the lower Columbia River. However, several of the reservoir storage projects proposed in the Water Control Plan proved to be infeasible to construct. This led to a re-examination of the projects proposed in the 1948 Review Report, in the mid-to-late 1950s. During this same time, negotiations were conducted between the U.S. and Canada on development of storage projects within the Canadian portion of the Columbia River Basin, and technical studies were performed that supported the Treaty negotiations. The technical work is documented in Special Inter-Agency Study, United States and Canadian Storage Projects, Columbia River and Tributaries, January 1955. Canadian storage was eventually adopted into the Water Control Plan, replacing planned storage projects in the U.S. that were no longer possible to build. This is described in the Corps of Engineers' Columbia River Review Report of 1958 (with Supplement Report on Canadian Storage), House Document 403, 87th Congress, 2nd Session. The design principles of reducing the 1894 flood to 800 kcfs and regulating flows to below 600 kcfs whenever possible were used in the development and allocation of flood storage space in Canada.

To achieve the objectives of regulating major flood flows to below 600 kcfs at The Dalles, SRDs for the system reservoirs needed to be developed that could evacuate sufficient storage space to reshape a flood's hydrograph and reduce the peak flow to below 600 kcfs whenever possible. Due to the high degree of uncertainty associated with hydrologic events and the subsequent impact on downstream flows, it is desirable to maintain a buffer in the system operations to allow for errors in forecasts, the shape of runoff hydrographs, and the timing of the runoff events. Because the evacuation operations can be a lengthy process, such a buffer is essential for regulating flows, recovering from uncertainties, and minimizing the risk of flood damage. While this operation generally regulates flows to less than 600 kcfs, during unusually high runoff years regulated peak flows may still exceed 600 kcfs at The Dalles.

3.17 Required Flood Storage to Water Supply Forecast Relationship

The foundation for the proposed post-2024 procedure is the relationship between the required system-wide flood storage and the seasonal water supply volume forecast at The Dalles as shown in **Figure 2**. This relationship was developed using historical peak flow and runoff volume data similar to that found in the Treaty FCOP.

This relationship is used in the post-2024 procedure and the flood model to obtain an estimate of the amount of flood storage that will be required to manage the anticipated system runoff at The Dalles based on the April-August WSF. An example of the application of the relationship is included in **Figure 2** as follows: For a year with a water supply forecast at The Dalles (x-axis) of 120 Maf, a total of 29 Maf of system flood storage (y-axis) would be required. While this relationship provides an estimate of the total flood storage space needed, the actual reservoir drafts are determined by each project's operating curves and how it is managed.

The relationship shown in **Figure 2** was prepared to refine the method used in the Phase 1 studies to determine when a Called Upon request would be triggered. The relationship was developed for the current level of U.S. flood risk management provided by the Treaty FCOP. It is the initial effort of this study to refine the post-2024 procedure. Both the relationship and the procedure will be tested, evaluated, and adjusted until validated.

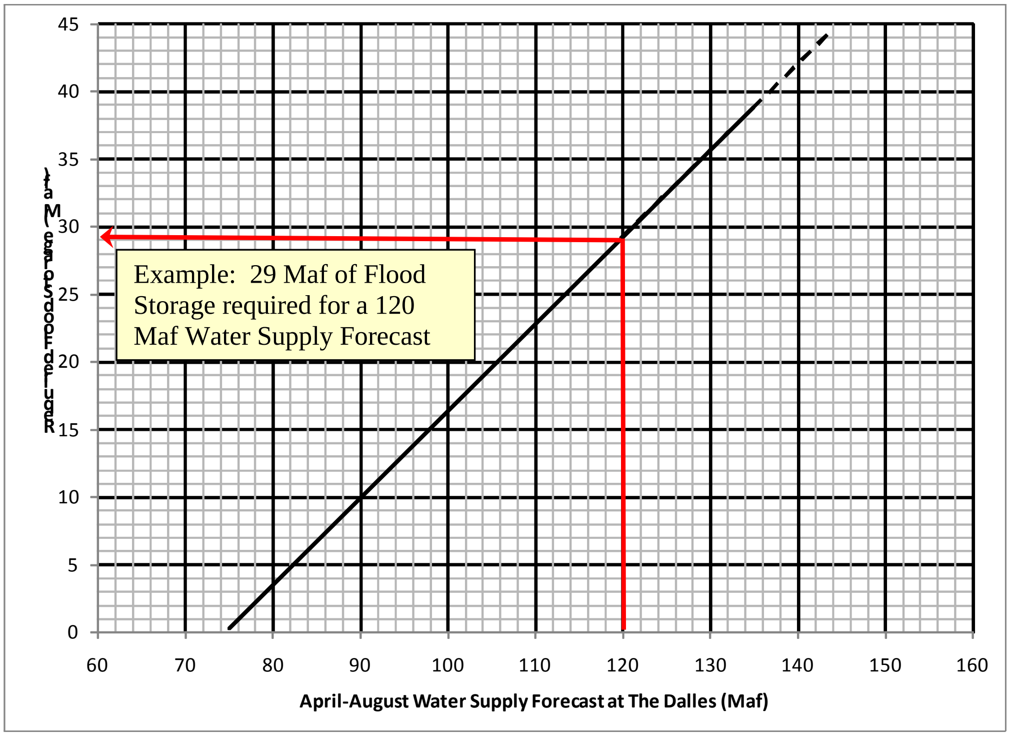

Figure 2 - Chart for Determining Flood Storage Requirement (Proposed)

3.18 Tiered Approach to Achieve Required Flood Storage

There are seven types of reservoir space that may contribute to flood storage requirements:

- U.S. projects authorized for system flood control (other than Grand Coulee)
- Projects authorized for local flood control
- Canadian power drafts
- Grand Coulee Operations
- Effective use storage at U.S. reservoirs
- Incidental storage (uncertain)
- Called Upon storage in Canadian reservoirs

A tiered approach is used in this procedure to determine how different types of flood storage spaces are utilized and when a Called Upon request may be required. Three tiers are presented in sequential order to provide sufficient storage space to satisfy the anticipated required flood storage as determined from the relationship in **Figure 2**. **Figure 3** illustrates this tiered approach.

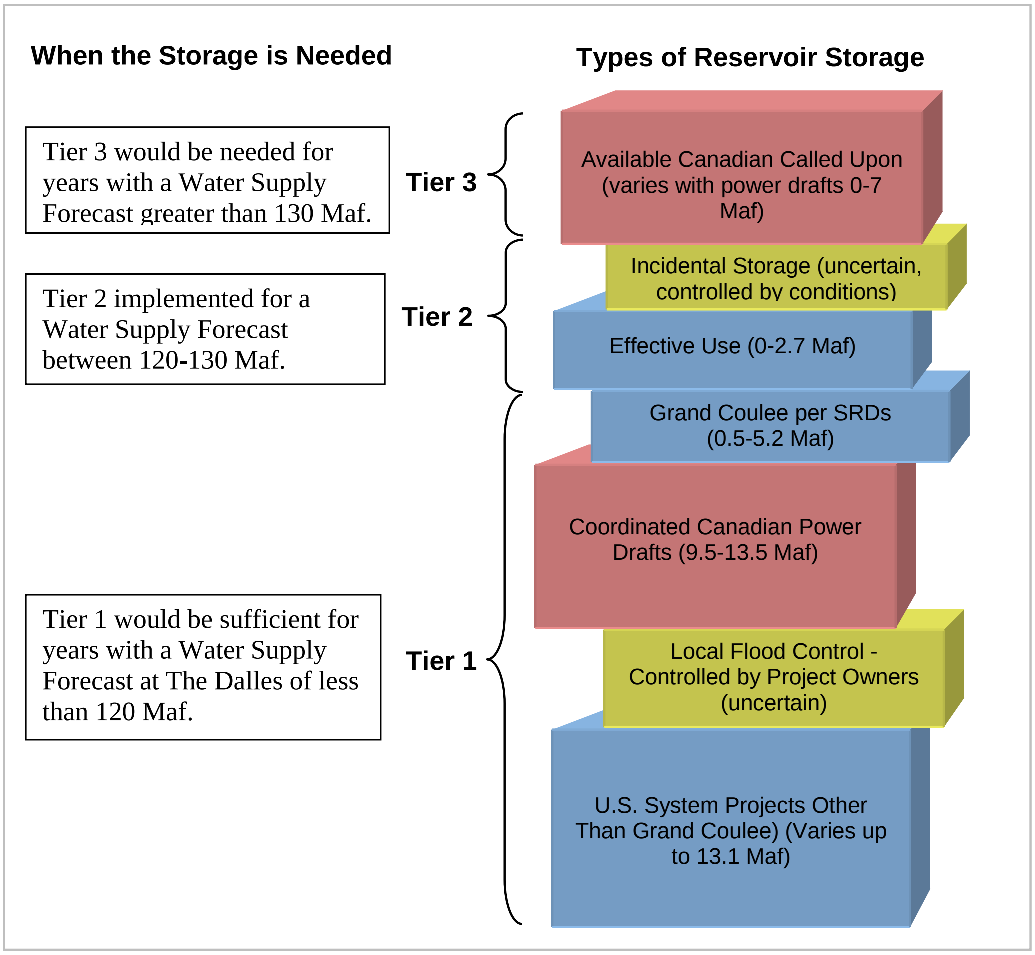

Figure 3 – Tiered Storage Diagram under Treaty Continues

Tier 1. *This tier is the initial grouping of flood storage space. It is expected that this tier would satisfy flood storage space requirements for years with a water supply forecast of less than 120 Maf at The Dalles.*

U.S. System Projects Other Than Grand Coulee (Varies up to 13.1 Maf)

The first step is to determine the available system flood storage of the core U.S. projects, with the exception of Grand Coulee. The required flood storage at each project is calculated based on its specified flood control operating rules. The flood storage for the four tributary projects Libby, Hungry Horse, Brownlee, and Dworshak are determined from their SRDs based on the water supply forecast at The Dalles, and the total storage capacity for the four projects is calculated. The average storage for the two major lake reservoirs, Kerr and Albeni Falls, is added to that total. While Kerr and

Albeni Falls are not headwater projects, these reservoirs are each drawn down for flood storage by approximately 0.5 Maf depending on the local lake conditions. The total amount of available flood space in these six U.S. reservoirs varies up to a maximum of 13.1 Maf. This data, along with a projected Grand Coulee draft, is used as input for the power model to calculate power drafts.

Local Flood Control – Controlled by Project Owners (Uncertain)

As shown in **Table 1,** some projects provide local flood control storage that also adds benefits to the system. While this storage is real, these projects are not operated as part of the system, and the amount of storage that may be available is uncertain. This is problematic when trying to determine the need for Called Upon storage. These projects are located in the Upper Snake and Boise basins. The model does not presently include any storage reservoirs upstream of Brownlee. However, the benefit provided by these projects is accounted for by the use of modified regulated flows as upstream input for Brownlee.

Coordinated Canadian Power Drafts (9.5 - 13.5 Maf)

The Canadian power drafts are determined from the Treaty Storage Regulation (TSR) methodology or other means which would continue to be prepared as part of the Treaty post-2024 planning process. Under the Treaty Continues scenario, there will continue to be an agreed-upon schedule for the release of the Canadian reservoir storage volume providing known operations of the Canadian projects which can be used for flood risk management or the U.S. will use assumptions of the power draft in the request.

Grand Coulee per SRDs (0.5 - 5.2 Maf)

After the determination of the power drafts at reservoirs in Canada, Grand Coulee's draft is determined from its SRD. The SRD uses an adjusted volume forecast, which is the unregulated seasonal runoff volume at The Dalles that is anticipated to be available on 30 April, minus the upstream storage corrections from Mica, Libby, Duncan, Hungry Horse, Dworshak, Arrow, Kerr, Albeni Falls, Brownlee, and John Day.[5]

This normal adjustment accounts for any deviations in upstream storage and allows Grand Coulee to be drafted less when Canadian power drafts provide sufficient flood storage. During infrequent events, when additional U.S. flood storage is required (>115 Maf WSF) or Called Upon storage may be required, Grand Coulee is drafted to its maximum flood storage volume (5.186 Maf) in accordance with its SRDs.

Tier 2. *This tier would provide additional drafts in the U.S. to maximize available U.S. flood storage space. Tier 2 would only be used in forecast runoff years in the Columbia Basin with WSF between120-130 Maf at The Dalles.*

Effective Use (0 - 2.7 Maf)

If Tier 1 does not provide sufficient reservoir space to meet the required flood storage determined from the graph provided in **Figure 2**, the next increment of storage space would

[5] See Chart 2, Treaty Flood Control Operating Plan, 2003.

be additional drafts from the U.S. projects, i.e., more than has already been drafted under their storage reservation diagrams. Libby and Hungry Horse would be drafted to the full extent of their authorized flood control space, or by a volume equal to the forecasted May-June runoff minus the volume associated with releasing project minimum flows over the same period (*in most years, the result will be drafting to the full authorized flood storage)*. This would supersede real time variable flow (VarQ) operations.

For years with forecasts greater than 120 Maf, Grand Coulee, Dworshak, and Brownlee should already be drafted to their full authorized flood storage, based on their SRDs. In addition, John Day would be operated on a short-term basis to gain an additional 0.5 Maf of storage, and arrangements would be implemented to use the conditional flood storage provided by the Mid-Columbia PUDs (0.75 Maf).

The use of these reservoirs and the other flood control reservoirs shown in **Table 1** could potentially provide sufficient storage to satisfy the required storage determined from the April-August WSF at The Dalles. The "effective use" of these reservoirs should satisfy the provision of the Treaty regarding "adequately controlled by U.S. related flood control facilities." Effective use would not be implemented if Tier 1 storage space is sufficient to meet the system flood storage requirement.

Incidental Storage (Uncertain, controlled by conditions)

Also included in Tier 2 is the storage that may at times be provided by projects that are not operated for either system or local flood control, such as the Payette and Yakima projects. However, since this storage is uncertain, it is not directly used in the calculation of available flood control storage. Similarly to the local flood control storage, the effect of these projects will reflected in the regulated flow inputs to the model.

Tier 3. *Tier 3 would be requested if Tier 1 and 2 drafts were not sufficient to control the forecasted runoff volume. In only the very highest runoff years (years with WSF greater than 130 Maf at The Dalles), would U.S. flood risk management operations call upon Canada for additional flood storage.*

Available Canadian Called Upon (varies with power drafts 0 - 7 Maf)

In the highest runoff years, generally above 130 Maf, the flood storage needed will be greater than the combined Canadian power drafts and the authorized flood storage drafts of the U.S. projects can provide. In these years, there is a potential that the U.S. will need to request additional space in Canada. As described in Section 2, the conditions under which the U.S. may call upon Canada to provide post-2024 operations are as follows:

1. Such call shall be made only to the extent necessary to meet ***forecasted*** flood control needs in the territory of the United States of America, **i.e., the U.S. cannot call for more space than needed based on the forecast.**

2. The forecasted flood control need cannot adequately be met by flood storage facilities in the United States of America and Canadian primary flood storage.

3. In no event shall Canada be required to provide any greater degree of flood control for the post-2024 period than it was obligated to provide during the first 60 years of the Treaty, i.e., primary flood storage of 8.45 Maf based on 7.1 Maf at Arrow, 0.08 Maf at Mica, and 1.27 Maf at Duncan reservoirs as originally scoped in the Treaty (Table 2) or equivalent. Canada would also provide additional storage when agreed to by the Permanent Engineering Board. In addition, should flows be forecasted to reach 600 kcfs at The Dalles, the U.S. would be entitled to Call Upon additional space.

4. Post-2024 flood operation calls for storage in Canada are to be made only if the Canadian Entity has been consulted about whether the need for additional Canadian storage is, or is likely to be, such that it cannot be met by the use of flood storage facilities in the United States.

One precedent for consultation with Canada on flood control operations is the On-Call storage provision that is in the current Treaty FCOP. It establishes 120 Maf minus the seasonal standard error as the threshold for making the On-Call request.

If, based on the required flood storage to WSF relationship in **Figure 2**, the combined Tier 1 and Tier 2 space is not sufficient to meet the system flood space requirement, then a call on Canadian reservoir space will be necessary to require Canadian projects to draft to a reservoir level lower than what was already drafted for power. The amount of Called Upon space requested would be only that which is necessary to meet the last increment of additional system flood space.

Table 4 presents a summary of how the U.S. and Canada storage will be drafted using the tiered approach described in this section.

Table 4 – Summary of Tiered Approach Drafts

Project		Active Storage (Maf)	Authorized for System Flood Control (Maf)	Tier 1 (U.S. and Canada) WSF < 120 Maf			Tier 2 (U.S. Only) WSF = 120 -130 Maf		
				Draft Type	Operating Storage Range (Maf)		Draft Type	Typical Value (Maf)	
					Min	Max		Min	Max
U.S. Projects Authorized and Operated for System Flood Control		**19.738**	**18.282**		**0.637**	**18.252**		**0.000**	**1.990**
	Libby	4.980	4.980	SRD-VarQ	0.100	4.980	Effective Use	0.000	0.980
	Hungry Horse	2.980	2.980	SRD-VarQ	0.000	2.980	Effective Use	0.000	0.480
	Dworshak	2.016	2.016	SRD	0.000	2.016	---		
Brownlee	Brownlee	1.426	0.990	SRD	0.000	0.990	---		
	Hells Canyon	0.188							
	Oxbow	0.058							
	Kerr Dam	1.219	1.000	URC	0.000	1.000[2]			
	Albeni Falls Dam	1.155	0.600	URC	0.000	0.600[2]	---		
	Grand Coulee (w/o adjustment)	5.186	5.186	SRD	0.537	5.186	---		
	John Day	0.530	0.530	- -	0.000	0.500	Effective Use	0.000	0.530
U.S. Projects Authorized for Conditional System Flood Control		**1.275**	**0.745**		**0.000**	**0.000**		**0.000**	**0.745**
Mid Columbia PUDs	Wells	0.125	0.125	No Sys FC	0.000	0.000	Conditional	0.000	0.125
	Rocky Reach	0.360	0.120	No Sys FC	0.000	0.000	Conditional	0.000	0.120
	Rock Island	0.009	---	No Sys FC	0.000	0.000	---		
	Wanapum	0.590	0.500	No Sys FC	0.000	0.000	Conditional	0.000	0.500
	Priest Rapids	0.191							
Totals - U.S. Projects Authorized for Flood Control		**21.013**	**19.027**		**0.637**	**18.252**		**0.000**	**2.735**

Project	Active Storage (Maf)	Authorized Treaty Flood Control (Maf)	Tier 1 (U.S. and Canada) WSF < 120 Maf			Tier 3 (Canada Only) WSF =>130 Maf		
			Draft Type	Storage (Maf)		Draft Type	Available CU (Maf)	
				Min (Flood)	Max [3] (Power)		Min	Max
Mica [2]	12.00	7.00	FC & Power	4.080	10.130	Called Upon	0.000	7.920
Duncan	1.40	1.40	FC	1.270	1.270	Called Upon	0.000	0.130
Arrow (Keenleyside) [2]	7.10	7.10	FC & Power	3.600	3.600	Called Upon	0.000	3.500
Totals - Canadian Storage	**20.50**	**15.50**		**8.950**	**15.000**		**0.000**	**11.550[4]**

NOTES:

1 May not be available due to local reservoir and channel restrictions

2 Canada can shift drafts between Mica and Arrow as long as the operation provides the same level of protection at The Dalles

3 Power drafts provided by BC Hydro for Phase 1 study

4 Maximum available if only drafted to primary flood storage of 8.95 Maf

3.19 Description of Post-2024 Called Upon Procedure

Figure 4 introduces a flow chart for the modeled Post-2024 Called Upon Procedure. The chart demonstrates the logic that was used to refine the Called Upon procedure that was initially developed in the Phase 1 studies. The tasks and decision points are identified with letters that are points of reference for the descriptive text. The procedure included in **Figure 4** represents the process that, in real time, will be initiated at the beginning of each month, January through May, during the reservoir evacuation period. Likewise, in modeling, the procedure is initiated on the first of each month beginning in January and ending on May 1, with a mid-month calculation in April.

3.19.1 Data Collection Steps

In real time operations, Tasks A, B, and C represent data collection steps. Under modeling efforts, these tasks are predetermined based on study analyses. The processes for predetermining data for Tasks A, B, and C are described in the hydrology and hydraulic (H&H) appendices of the Corps Flood Risk Assessment reports.

Task A - Obtain Water Supply Forecasts from the River Forecast Center: In real time operations, the water supply forecasts are prepared by the NOAA River Forecast Center. For modeling, these forecast volumes will be predefined time series inputs based on historical data or simulated events.

Task B - Obtain Local Runoff Forecast at Reservoirs: In real time operations, local runoff volumes are calculated based on readings from local snow and river monitoring stations. For modeling purposes, these values will be included as input with the historical and simulated data sets.

Task C- Determine Canadian Drafts: This includes determining the power and/or flood control drafts at the three Canadian Treaty reservoirs. During actual pre-2024 operations, the coordinated power drafts would be obtained for the DOP/TSR procedures. For modeling, the power drafts will be calculated for each power generation reservoir and produced as an output from the reservoir simulation (ResSim) power model. The power drafts at Arrow and Mica usually exceed the 8.95 Maf primary flood storage volume. Duncan has no power generation capacity and it is drafted to its normal SRDs. The Canadian drafts for the individual reservoirs are then added to get the total Canadian storage space. Under the Treaty Continues scenario, it is assumed that procedures similar to current DOP/TSR will remain in place. If, however, the Treaty is terminated, Canadian power drafts will be uncertain, and a procedure will need to be implemented for estimating the values.

3.19.2 Decision Making Steps

The decision making steps include calculations, comparisons, and decision points based on the information obtained from Tasks A, B, and C. The following tasks are performed to determine which reservoir operation tier is to be initiated (see section 3.18.3).

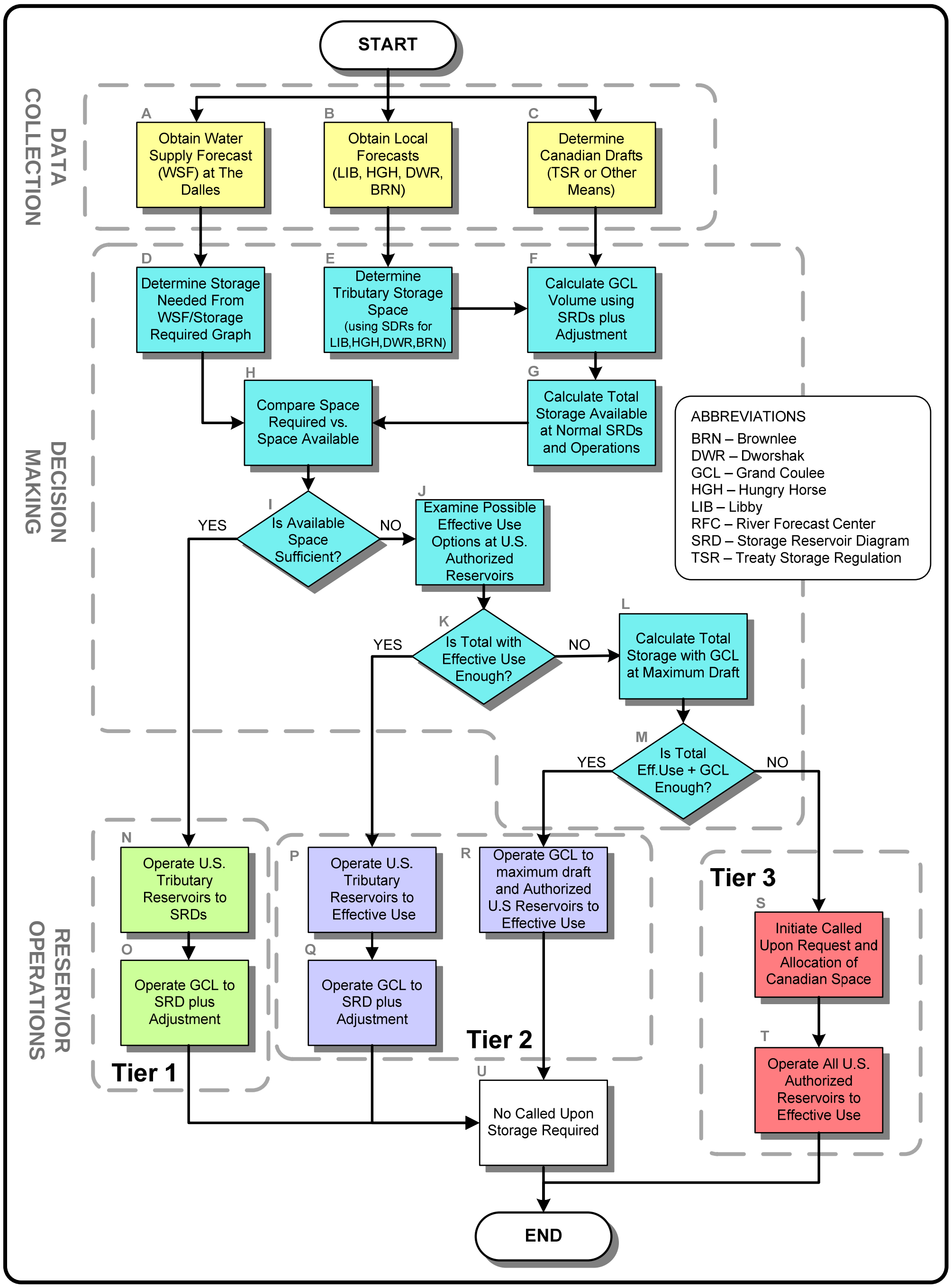

Figure 4 – Post-2024 Called Upon Procedure

Task D - Determine Storage Space Needed From Water Supply Forecast: Using the water supply forecast obtained from Task A and the relationship presented in **Figure 2**, the total amount of required storage space is calculated. The relationship is only used to calculate the storage space needed for a specified water supply forecast. The relationship is not used in the determination of flood control drafts at the storage reservoirs.

Task E - Determine Tributary Space: Using the local forecast values obtained from Task B, the available flood storage amounts for the six individual tributary reservoirs (Hungry Horse, Libby, Dworshak, Brownlee, Kerr and Albeni Falls) are calculated. The actual storage provided by these reservoirs fluctuates depending on the volume of runoff and the effects of the channel restrictions. Once calculated, the individual storage amounts from these six U.S. tributary reservoirs are added to determine the total amount of storage provided. That total, along with the Canadian power drafts (Task C), is used to calculate the Grand Coulee adjustment (Task F).

Task F - Determine Grand Coulee Volume with Adjustment: The flood control draft at Grand Coulee is usually adjusted for upstream deviations in the tributary storage and Canadian power drafts to reduce the impacts on the Coulee system. The Canadian power drafts obtained in Task C, which are usually greater than the primary flood control drafts, and the tributary storage values calculated in Task E are used together to adjust the draft and minimize the amount of drawdown at Grand Coulee. This provides the amount of storage at Grand Coulee under normal operating conditions (for water supply forecasts of less than 115 Maf).

Task G - Calculate Total Storage Available at Normal SRDs and Operations: Once the amount of storage provided by Grand Coulee is determined from Task F, the total amount of storage available at the eight U.S. reservoirs authorized for system flood control can be totaled. The authorized reservoirs include Libby, Hungry Horse, Dworshak, Brownlee, Kerr, Albeni Falls, Grand Coulee, and John Day. John Day is a run-of-river reservoir with limited storage capacity. The volumes from John Day, the six tributaries (Task E), Grand Coulee (Task F), Canadian drafts (Task C), are added to obtain the total available storage space.

Task H - Compare Space Required vs. Total Space Available: The total system storage space provided (Task G) is compared to the amount of storage required (Task D).

Decision Point I - Is Available Space Sufficient? If the amount of calculated available storage from Task G is equal to or greater than the calculated required storage from Task D, no Called Upon storage is needed and the Tier 1 operations are implemented. As a result, the authorized U.S. tributary reservoirs are operated to their normal SRDs (Task N) and Grand Coulee is operated with adjustment (Task O). If, to the contrary, the amount of available storage is less than the required storage, the option for operating the U.S. headwater projects to effective use (Task J) is examined.

Task J - Examine Possible Effective Use Options at U.S. Authorized Reservoirs: This task includes taking another look at the U.S. projects (except Grand Coulee) authorized for system flood storage to determine if other measures could be initiated to obtain additional storage space. Because of the current design of the SRDs, the core U.S. projects (Libby, Hungry Horse, Dworshak, and Brownlee) should already be operating at optimum storage capacity. This task may include implementing conditional storage at the Mid-Columbia PUD facilities, changing operations at Kerr, Albeni Falls, and possibly John Day to optimize storage.

In real time, operations at all U.S. projects authorized for system flood risk management are implemented to draft the reservoirs to maximum flood storage capacity possible at the time of the forecast. Depending on the time of the forecast, it may be too late to fully evacuate some of the reservoirs. This condition can result from large snow accumulations in the latter part of March or later, as was the case in 2011.

In the model, an Effective Use calculation is made for each reservoir to verify that it is drafted to the maximum storage capacity achievable. This generally equals the active flood storage capacity, but may be less at some reservoirs due to local conditions (local controls, channel constrictions, etc.).

Decision Point K - Is Effective Use Sufficient? In Task J, the total amount of storage space available was recalculated with the U.S. reservoirs operating to Effective Use. If enough storage is provided, no Called Upon request is needed. As a result, Tier 2 operations are implemented, with the U.S. authorized reservoirs operating to their Effective Use (Task P) and Grand Coulee operating with adjustment (Task Q). If, however, the amount of available storage is less than the required storage, the option for operating Grand Coulee to maximum draft (Task L) is examined.

Task L - Calculate Total Storage with Grand Coulee at Maximum Draft: If more storage space is required, then, similar to Task F, the total available U.S. storage is calculated with the U.S. reservoirs at Effective Use and Grand Coulee at maximum draft. That total is added to the Canadian power drafts to determine the total available storage.

Decision Point M - Is Total Effective Use Plus Grand Coulee Sufficient? This is the final check to determine if total space available, including Effective Use storage capacities of the U.S. reservoirs (Task L) together with the Canadian power drafts (Task C), provides the required amount of storage from Task D. If enough storage is provided, Tier 2 operations are implemented, with Grand Coulee operating to the pool level that will just meet the storage space required and the other U.S. reservoirs operating at Effective Use. In this case, no Called Upon request is needed. If the available storage is less than the required storage, Tier 3 is initiated and a Called Upon request is triggered (Task S).

3.19.3 Reservoir Operations

The following tasks represent the sequential tier structure in which the system reservoirs are operated to achieve the required flood storage determined in Task D.

Tier 1 Operations. *These operations are implemented when U.S. reservoirs operating to normal SRDs (with exception of Grand Coulee) and Canadian power drafts provide sufficient flood storage. Tier 1 operations will be sufficient in years with a water supply forecast less than 120 Maf.*

> **Task N - Operate Authorized U.S. Tributary Reservoirs to Normal SRDs:** The local runoff forecasts obtained in Task B are used to operate all authorized U.S. tributary reservoirs to their normal post-2024 SRDs or fixed releases.
>
> **Task O - Operate Grand Coulee with Adjustmen**t: Grand Coulee is operated to normal conditions using the adjustment for tributary and Canadian power drafts. This only occurs in a year when a Called Upon request is not needed.
>
> **Task U - No Called Upon Storage Required:** This task represents a year when no Called Upon request is needed. Likewise, the U.S. does not need to designate the allocation of flood storage space in the Canadian reservoirs.

Tier 2 Operations. *Tier 2 represents the effective use operations that are initiated when U.S. reservoirs operating to normal SRDs and Canadian power drafts do not provide sufficient flood storage. Tier 2 operations will be triggered in years with a water supply forecast between 120-130 Maf.*

> **Task P -** Operate Authorized U.S. Reservoirs to Effective Use: All U.S. projects authorized for system flood storage are drafted to their maximum flood storage capacity. In the model, an Effective Use calculation is made for each reservoir to verify that it is drafted to the maximum storage capacity achievable. This generally equals the active flood storage capacity, but may be less at some reservoirs due to local conditions (i.e. local controls, channel constrictions, etc.).
>
> **Task Q – Operate Grand Coulee with Adjustment:** Grand Coulee is operated to normal conditions using the adjustment for tributary and Canadian power drafts. This only occurs in a year when a Called Upon request is not needed.
>
> **Task R - Operate Grand Coulee As Needed Up To Maximum Draft and Authorized U.S. Reservoirs to Effective Use:** Under this task, the draft at Grand Coulee will be increased up to its maximum flood storage capacity. If the amount of additional storage space required is less than the amount that Grand Coulee can provide, then Grand Coulee is only drafted to the pool level that will satisfy the storage space required. If additional storage space required is beyond what Grand Coulee can provide, it drafts to minimum pool. Concurrently, all U.S. projects authorized for system flood storage are operated to Effective Use.

Task U - No Called Upon Storage Required: This task represents a year when no Called Upon request is needed. Likewise, the U.S. does not need to designate the allocation of flood storage space in the Canadian reservoirs.

Tier 3 Operations. *A formal request to Canada will begin if Tier 1 and 2 operations are not sufficient to control the forecasted runoff volume. Tier 3 operations will only occur in the highest runoff years with a water supply forecast greater than 130 Maf at The Dalles.*

Task S - Initiate Called Upon Request and Allocation of Canadian Space: This task includes formal notification to Canada that a Called Upon request may be needed. When a Called Upon request to Canada is initiated, the U.S. will consult with Canada and use the SRDs and charts included in a post-2024 procedure equivalent to the FCOP to calculate the amount of space needed. The Canadian reservoirs, primarily Mica and Arrow, will be evacuated to provide sufficient storage to manage the forecast runoff volume. In real time, this consultation will likely be implemented over a period of 10-20 days and will be initiated in advance of the actual need to compensate for this time delay.

In the model, the requested storage is assumed to be immediately available. The total storage space requested is the storage space required (Task D), less the total storage space provided (Task L). This amount of storage space must be divided up among the Canadian reservoirs. Storage is taken first from Arrow, then from Mica. Mica is constrained to a maximum drawdown based on an Effective Use calculation, analogous to the U.S. tributary reservoirs.

Task T - Operate Grand Coulee to Maximum Draft and Authorized U.S. Reservoirs to Effective Use: The draft at Grand Coulee will be increased to its maximum flood storage capacity, and all authorized U.S. reservoirs will operate to Effective Use.

3.20 Frequency of Called Upon Occurrences

One of the objectives of this study was to determine the approximate frequency that the U.S. might need to initiate a call Canada for flood storage after 2024. The Called Upon procedure used in the Phase I studies resulted in a frequency of Called Upon occurrences of 52 out of 70 years of record, using current SRDs. Since no request for Called Upon storage has ever been made by the U.S. Entity, the project team recognized that procedure for determining the need for Called Upon storage needed to be refined. Thus, the procedure presented in this document was developed.

This procedure, using volume water supply forecasts, is presently scripted in the reservoir simulation models developed for the CRT 2014 review Program. Preliminary testing indicates the frequency of Called Upon over the 70-year study period is between 4 and 6 times. While this result is considerably closer to actual operations, testing of the procedure has not been completed. The procedure will continue to be tested, evaluated, and refined as the Phase 2 studies progress.

3.21 Reshaping Canadian Refill

In addition to making a Called Upon request to Canada for flood storage, a request may be made to change Canadian reservoir releases from those planned under an AOP to aid in flood risk management. In this situation, the planned refill of the Canadian reservoirs would be modified by a call from the U.S. during the refill period to reshape the refill operations in Canada. This operation would typically occur in larger water years (110 **-** 130 Maf) when the U.S. has not requested additional drafts, but due to changes in runoff shape or volume, the U.S. requests that Canada modify the planned rate of refill.

Compensation to Canada may be necessary for this type of Called Upon request, since it requires a modification to the planned power operation. To quantify the impacts of the refill Called Upon request in real time operations, the operations for power and flood risk management would have to be optimized and the difference between the two determined to assess compensation requirements. In the modeling studies, reservoir refill procedures will be automated, which may limit the ability to discern differences between the two operations. Additionally, information on Canadian operations will need to be further refined to quantify the impacts of a reshaping procedure.

3.22 Treaty Terminated Scenario

The amount of system reservoir space for flood risk management is independent of the future of the Treaty because the U.S. flood storage space requirements are the same under either Treaty scenario. The same required flood storage to water supply forecast relationship described in Section 3.17 and shown in **Figure 2** will be used regardless of whether or not the Treaty continues.

In the Treaty Continues scenario, a predetermined and known amount of Canadian power draft will be available for flood risk management use as provided for in the AOPs. Hence, planning and acquisition of an annual base amount of Canadian draft under the Treaty Continues scenario decreases the amount of time required to secure the use of that space for flood risk management purposes compared to what would be needed for the Treaty Terminated scenario. It is not likely that Canada will cease to draft its reservoirs for power in the event that the Treaty is terminated. So, due to the fact that reservoir drafting will occur largely at Canada's discretion, some element of flood risk will occur via the reservoir drafting and refill process, although there would be some uncertainty of how much storage would be drafted.

Also, the way in which Canada drafts its projects for power may be different for the Treaty Terminated scenario. The total volume of power draft in Canada may be the same whether the or not, but the timing and distribution of the power draft may change. For flood risk management, the location of reservoir space is as important as the volume of that same space. If the Treaty is terminated, the certainty of having the necessary amount of reservoir storage space in the right reservoirs and at the right time to effectively manage flood risk may decrease.

In the Treaty Terminated scenario, the primary change in the proposed procedure described for the Treaty Continues scenario involves the Tier 1 reservoir space (see section 3.18). In the Treaty Terminated scenario, Canadian power drafts may change from a well defined quantity and operation to more of an estimated quantity and operation. For example, this document presents a strategy and procedure for the ordered application of reservoir space to meet the overall system need. In Tier 1,first U.S. space is applied as needed to meet the system storage space requirement then, the Canadian power draft space requirement is determined from consultation with Canada or based on a U.S. estimate of their future power drafts. This information is then utilized to adjust Grand Coulee storage drafts. If more space is needed, then the U.S. projects would draft up to their effective use space. If more space is still required, then the U.S. can call upon additional storage in Canada. The storage space that has been available in the past and was assumed to be available in the future is 8.45 Maf of primary flood space, which was later adjusted to 8.95 Maf through a reallocation of storage space at Mica and Arrow. If more Canadian space is required, then an additional call for Canadian space is needed. Such a call would need to be agreed to by the PEB or there exists a potential of peak flows in the U.S. at The Dalles, Oregon, reaching 600 kcfs.

The foundation for the proposed strategy for post-2024 operations without the Treaty is still the relationship between the seasonal (April-August) water supply volume forecast and required system-wide flood space previously shown in **Figure 2**. The same seven types of reservoir space available to meet the flood storage requirement under the Treaty Continues scenario would likewise be available for flood risk management under the Treaty Terminated scenario. Due to the uncertainty associated with the Canadian power under the Treaty Terminated scenario, the information presented below reflects the range of Canadian power drafts identified in the Phase 1 study. This scenario does not consider other uses for Canadian storage other than power (i.e. fisheries, recreation, local interests, etc). Therefore, the amounts of storage under this Treaty Terminated scenario are:

Tier 1. *This tier would satisfy years with a WSF less than 120 Maf at The Dalles*

U.S. System Projects Other Than Grand Coulee (Varies – up to 13.1 Maf)

U.S. flood storage space based on current SRDs for Libby, Hungry Horse, Dworshak, and Brownlee flood storage space and associated minor drafts at other projects. The total amount of available flood space in the U.S. headwater reservoirs can range from near 0 to 13.1 Maf.

Local Flood Control – Controlled by Project Owners (Uncertain)

Similar to the Treaty Continues scenario, some projects not currently included in the flood model, provide local flood storage that also provide benefits to the system. While this storage is real, these projects are not operated as part of the system and the resulting storage is uncertain with regard to trying to determine the need for Called Upon storage. These projects are located on the in the Upper Snake and Boise basins. As in the Treaty Continues scenario, the benefit provided by these projects is accounted for by the use of modified regulated flows as input flow to Brownlee.

Uncoordinated Canadian Power Drafts (Uncertain)

This includes power drafts of Arrow, Mica, and Duncan in Canada. With the Treaty terminated, this would have to be projected either based on power modeling, historical trends, or some other method. For the current discussion, it is assumed 11.4-12.6 Maf of space available based on estimates provided by BC Hydro during the Phase 1 study. Above a certain runoff volume, say 90 Maf or 100 Maf, Arrow Reservoir would be called upon for a portion of the estimated total and compensate Canada under the terms of the Treaty.

Grand Coulee per SRDs (0.5 – 5.2 Maf)

After the drafts upstream of Grand Coulee are calculated, the Grand Coulee required draft is re-tabulated, adjusting for the upstream deviations per the current operating procedure.

Tier 2. *U.S. flood risk management operations would utilize this space only in forecast runoff years on the Columbia Basin with WSF greater than 120 Maf at The Dalles. This is addition to the space described in Tier 1.*

Effective Use (Uncertain)

Similar to the previous Treaty Continues scenario, this space is acquired through additional draft of any U.S. projects to an elevation lower than required by its SRD, but only as far as that extra draft is within the authorized flood storage space and provides additional downstream stage reduction while refilling.

Incidental Storage (Uncertain, controlled by conditions)

Also included in Tier 2 is the incidental storage that may at times be provided by projects that are not operated for either system or local flood risk management. This type of storage can be provided by the Payette projects and Yakima projects. Similarly to the Treaty Continues scenario, this storage is uncertain and is not directly used in the calculation of available flood storage. The effect of these projects is reflected in the regulated flow inputs to the model.

Tier 3. *In only the very highest runoff years (years with WSF greater than 130 Maf at The Dalles), would U.S. flood risk management operations call upon Canada for additional flood storage drafts. This is additional Canadian draft after all the space in Tier 1 and Tier 2 projects is planned to be drafted.*

Available Canadian Called Upon (varies with power drafts)

If total flood storage space (U.S. reservoirs drafted to effective use space and Canadian power drafts) does not meet the total flood storage space required, then the U.S. would call upon Canada to draft their projects deeper (if needed).

The procedure for the Treaty Terminated scenario allocates space differently than in the Treaty Continues scenario. A comparison of these two post-2024 procedures with the current pre-2024 operations is presented in **Figure 5**.

The major difference between the two post-2024 scenarios is the change from coordinated Canadian power drafts to uncoordinated Canadian power drafts. In the Treaty Continues scenario, the amount of Canadian power draft is known in advance from the Assured Operating Plan (AOP) based on a coordinated effort between Canada and the U.S. Under the Treaty Terminated scenario, there would be no coordinated U.S. and Canadian power drafts. However, there will continue to be a need to estimate the Canadian power drafts. This estimated storage would be added to the Grand Coulee adjustment and the total basin storage available for flood storage (without this inclusion of Canadian drafts, Grand Coulee would be drafting empty for WSF of roughly 100 Maf or higher). In addition, at some point, part of this estimated space would need to be included in Arrow Reservoir to ensure the same level of flood protection that we currently have at The Dalles.

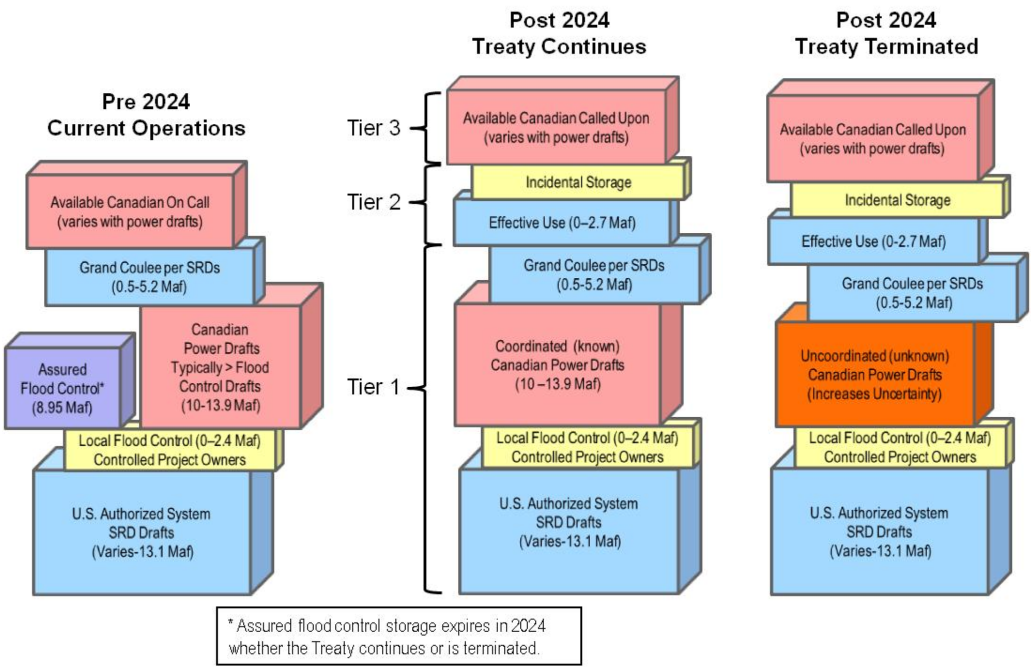

Figure 5 - Flood Storage Space Allocation With and Without the Treaty

Additional work is needed to finalize a process for system-wide flood storage acquisition in the event that the Treaty is terminated. Regardless of whether the Treaty continues or is terminated, the basic need and amount of flood storage required are independent of the future of the Treaty. However, the degree of uncertainty will increase under the "Treaty Terminated" scenario. Decisions regarding how the space is acquired, the uncertainty of how it is distributed, and how Canada would be compensated for the flood risk management operations they provide will be different because Canadian operations will be unknown.

4.0 CRT REVIEW FLOOD RISK MANAGEMENT (FRM) STUDIES

The flood risk management (FRM) studies for the CRT Review are designed to analyze flood risk within the Columbia River Basin. The flood risk analysis is one of the key U.S. determining factors on the future recommendation of the Treaty (continue, modify, or terminate).

4.1 Flood Risk Management Studies

The Corps is in the process of transforming into a risk managing organization. As outlined by Moser et al. in the White Paper *Transforming the Corps into a Risk Managing Organization*, the Corps and the public realized there are limits to prediction (uncertainty) of floods and in those limits to what protection the Corps can provide. Following hurricanes Katrina and Rita, the Corps initiated the Actions for Change and began shifting to a flood risk analysis approach to decision making. Risk analysis comprises three related and iterative tasks:

1. Risk assessment, to include the data and analytical activities that define the likelihood and future consequences of different alternatives having different costs.
2. Risk management, to include what hazards and opportunities will receive agency attention and what risk vs. benefit, vs. cost choices will be made and by whom and what would be the impact of current decisions on future options.
3. Risk communication among policy makers, budget authorities, and the public who must collectively make investment or regulatory decisions (risk management) with the knowledge provided by the risk assessment.

The Columbia River Treaty, Protocols, and current operating guidelines were written before these concepts were well understood or adopted by Corps. Terms such as “flood control” and “level of protection” will be replaced with the terms “flood risk management” and “annual exceedance probability.” Quantifying the risks is one of the first steps; subsequent steps will be communication of current and residual risks, and use risk in the decision making process.

The CRT Review FRM studies will fundamentally redefine the measure of flood risk on the Columbia River by integrating new flood risk metrics, like expected annual damages (EAD), annual exceedance probability (AEP), conditional non-exceedance probability (CNP), long-term risk, and residual risk, rather than using target flows translating to assumed degree of damages. Some of the key concepts are as follows:

- The EAD can be interpreted as the average annual damages realized over a long period of time. These damages reflect the full range of potential flood events and uncertainties.
- The AEP is the probability that flooding will occur at a given location (such as a consequence area index point, a specific grid cell, or a fragility curve location) in any given year, considering the full range of possible annual floods and project performance.
- The CNP, also known as “Assurance,” is the probability that a target stage (elevation) will not be exceeded during the occurrence of a specified flood.

- Long-term risk, also referred to commonly as natural, or inherent, hydrologic risk, characterizes the likelihood of one or more exceedances of a selected target or capacity in a specified duration.
- Residual risk, typically captured as residual EADs, is risk that emerges or increases as a result of mitigating another risk, or when the reduction of risk in one region of a system transfers the risk burden to another region in the system.

This re-characterization of flood risk within the Columbia River Basin is being analyzed in accordance with the Corps' flood risk management policy and guidance for conducting flood risk management studies.

In addition to measuring the benefits of flood risk management operations, these studies will also provide measurement of power and other flow or reservoir elevation impacts that can be translated to costs and benefits.

4.2 Flood Risk Analysis Modeling

The Corps is currently developing the next generation model for evaluating flood risk management projects, called HEC-WAT (Hydrologic Engineering Center - Watershed Analysis Tool) with the FRA Option. This model will incorporate a systems approach and use of event-based parameter sampling. It will provide scenario analysis and identify expected flood damages, including structural damages (on a structure-by-structure basis), non-structural damages, loss of life, and agricultural damages. The main benefit of HEC-WAT with the FRA Option will be its ability to evaluate a complex river system in an integrated way, rather than as a collection of independent models and projects.

As illustrated in **Figure 6**, HEC-WAT will provide the organizational structure for a collection of individual models and uncertainty parameter samplers that will operate as "plug-ins" to generate specific inputs needed to drive the overall risk analysis. Each event will run deterministically within HEC-WAT. The key input parameters will be sampled, the reservoir model will calculate regulated flows, the hydraulic model will calculate water surface elevations, the flood boundaries and depths will be generated, the consequences will be calculated, and then the flood risk metrics will be computed.

The HEC-WAT with the FRA option will allow the various flood risk metrics of the pre-2024 operations to be compared to the post-2024 operations. While some flood characteristics between the two conditions may not change, verifying that the flood risk under the post-2024 Treaty Continues scenario remains unchanged from current conditions is still yet to be determined.

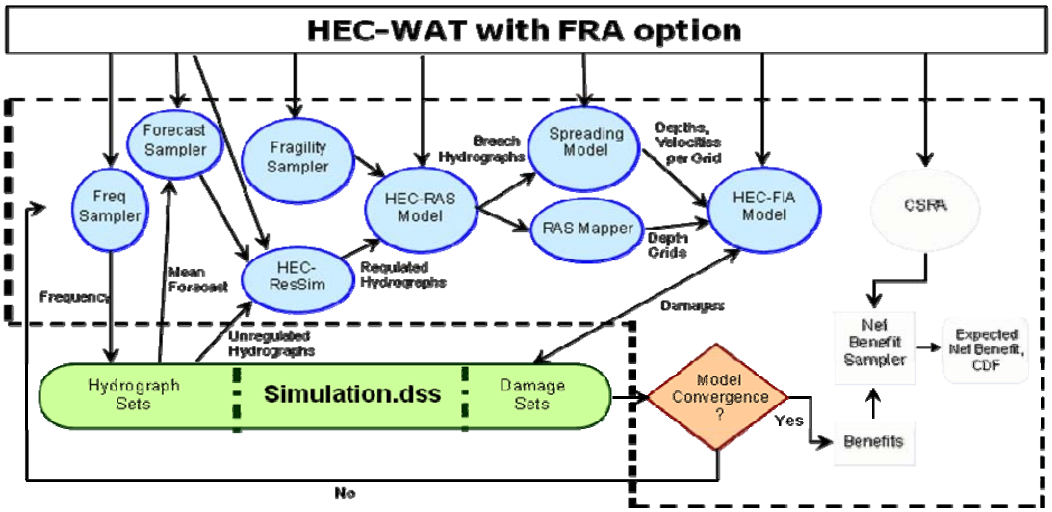

Figure 6 - HEC-WAT with FRA Option

Four general types of uncertainty will be considered in evaluating flood risk and impacts of the reservoir flood risk management procedure: 1) hydrologic uncertainty, 2) hydraulic uncertainty, 3) operational uncertainty, and 4) economic uncertainty.

1. Hydrologic inputs and uncertainties will be based on historic streamflow data. Unregulated stream flow data throughout the basin will be analyzed, and the frequencies of spatial and temporal patterns will be calculated for the system and individual sub-basins. The FRM analyses will also utilize volume runoff forecasts that vary monthly and are randomly generated based on the error of the current forecast procedure.
2. Hydraulic uncertainty will be defined based on an assessment of the quality of involved topographic data and the sensitivity analysis of flood stage to the estimated hydraulic roughness. Although it is recognized that hydraulic uncertainty is typically similar for with- and without-project conditions, the effect of hydraulic uncertainty cannot be ignored and will be evaluated.
3. Operational uncertainty reflects potential variation in levee system performance and reservoir operations. Levee system performance will be directly evaluated based on criteria developed by the Corps' Levee Team. The uncertainties in reservoir operations will be embedded within the flood and hydro-regulation ResSim models and captured in the FRM analysis.
4. Economic uncertainties incorporate the statistical variation of parameters such as first floor elevation, structure value, structure content value, and other economic inputs to the flood consequence calculations.

4.3 Post-2024 Flood Risk Management Procedure Revision and Refinement

4.3.1 Key Recommendations From Phase 1 Studies

A number of key recommendations for further analysis were posed in the Phase 1 report. Those that were addressed in the initial development of Called Upon procedures were identified in Section 3. The following recommendations will be addressed in the next steps of Called Upon revisions in the context of the flood risk management studies.

a) Called Upon Trigger: The Phase 1 report recommended that the approach of using a predetermined maximum flow objective to calculate Called Upon storage requirements will need to be reevaluated. The proposed Called Upon procedure should be predicated on the availability of Canadian and U.S. power drafts. This storage would be used along with the storage provided by U.S. flood storage projects.

b) Priority of Drafting Canadian Projects: For purposes of meeting flood risk management objectives at The Dalles, Arrow is the most effective Canadian reservoir for reducing flows, because the response time from Arrow to The Dalles is shorter than from Mica and Duncan to The Dalles, and because Arrow controls a much larger basin. Flood risk management and other tradeoffs associated with allocation of storage between different Canadian reservoirs could be incorporated into evaluation of alternatives in future study phases.

c) Return of Canadian Projects to Planned Operation After Called Upon: Because of the cost implications for post-2024 flood risk management operations, a critical element of Called Upon implementation will be clearly defining when that action is initiated, when it has been concluded, when the Canadian reservoirs have been returned to their planned operations, and tracking these operations. The U.S. will have to compensate Canada for the economic losses and operating costs associated with Called Upon operations after 2024.

d) Called Upon Operations and Flex Operations Impacts: In scenarios where the Treaty continues after 2024, Canada may flex operations between Arrow and Mica (shift storage of water between reservoirs), subject to maintaining the same border flow rates. Further investigation is required on how much these flex operations can impact the Called Upon operation.

e) Knowledge and Assurance of Canadian Operations: In the Treaty Terminated case, and without other agreements for coordination of the Columbia River operations, the U.S. may have greater uncertainties in planning for Called Upon flood risk management requests because there may not be a Canadian power operating plan. Regardless of whether the Treaty remains in place or is terminated, the U.S. is entitled to the same degree of Called Upon storage space after 2024. However, the greater the degree of assured future Canadian power drafts, the greater the ability the U.S. will have to estimate the amount of Canadian Called Upon storage space needed to manage flood risk, especially the ability to reduce the risk of flooding even in moderate runoff volume years. For effective flood risk management, the U.S. needs a forecast throughout the year of the planned Canadian reservoir operations, or the ability to develop provisional flood storage requests that estimate the extent of the Canadian power draft and Called Upon space needed for flood risk management needs. In future FRM studies, and under the assumption the Treaty Terminated after 2024, the U.S. will need to make estimates of likely Canadian operations, assess risks and consequences of various scenarios, and develop operating criteria based on those assessments. These varying Canadian operations will be investigated in future analyses.

f) Economic Loss and Canadian Operating Costs of Called Upon: Phase 1 did not attempt to develop methods or procedures for calculating Canadian operating costs and economic loss associated with Called Upon operations after 2024 or to estimate those costs under the Phase 1 scenarios. Future studies will develop a methodology for calculating these costs.

g) Winter Flood Events: During the flood of February 1996, the U.S. coordinated with Canada to modify releases from Canadian reservoirs for a few days to help mitigate flooding in Portland, Oregon. The flooding was caused by winter rains in the lower Columbia and its tributaries, primarily the Willamette River and the Snake River. The Called Upon procedure presented in this document is not relevant to this type of Canadian operation due to the short forecast window; however, it should be noted that modified operation of Canadian reservoirs could result in Canadian operating costs and economic losses. A procedure to calculate these costs for Called Upon operations could also be applied or modified for winter flood operations.

4.3.2 Flood Risk Management Integration

The basic concepts for post-2024 operations developed herein will also be further evaluated in future phases of the CRT Review. To integrate these concepts and procedures into the FRM process, they will have to be integrated into the new ResSim model being developed for this effort. The technical details of the proposed procedure and the consequences of implementing the procedure will be evaluated, and may be further refined through future CRT Review studies and will likely evolve when accounting for risk and uncertainty.

The first step will occur when new ResSim reservoir models are complete and the results of the proposed procedure is compared to the historical data set to ensure that the procedure is providing the same peak flood flows based on the historical record as the current operating plan. Once this is done, both the current and the proposed post-2024 procedure will be run in the HEC-WAT using updated frequency based flood hydrographs (synthetic hydrology). This will allow the study team to analyze the post-2024 procedure with hydrologic conditions that have not been observed in the past. This stage will also allow for the evaluation of a variety of flow targets and Called Upon triggers.

The second major evaluation of the proposed procedure will occur when the FRM models are complete. These models will enable the study team to link uncertainties and the Treaty Continues scenario to flood consequences throughout the basin. The Called Upon thresholds will then be linked to the probability of flood consequences and, if necessary, there will be new flow objectives developed for sub-basins in addition to The Dalles and other existing control points.

Hydrologic stationarity is the assumption that hydrologic events follow trends – in other words, using what happened in the past to predict the future. Traditionally, it has been the basis for hydrologic analyses. The awareness of global climate change has caused hydrologists and engineers to re-evaluate how accurately hydrologic stationarity can be applied to develop long-term forecasts and design criteria. Therefore, evaluating the proposed post-2024 procedure with hydrologic conditions that have not been experienced in the past is an important component of an FRM analysis. This is the only way to quantify the risks of future hydrologic uncertainty. Initial studies will assume hydrologic stationarity; however, the procedure will be in place to quantify the risks of potential future climate scenarios as well. Incorporating additional hydrologic uncertainty into the evaluation will also allow for a thorough evaluation of the Called Upon refill frequency and Canadian draft distribution.

4.4 Plan Formulation

The CRT Review studies will redefine CRT flood management in flood risk terms. The results will be used to formulate flood risk alternatives and evaluate the alternatives to inform a Treaty decision. The definition of the base condition is significant because assumptions made in the scenario will define the need for Called Upon storage, set the foundation for development of additional alternatives, and provide information on the level of flood risk under this condition. The base condition analyzed in FRM studies will characterize the starting point for formulation of alternatives. Alternatives will be compared on the basis of flood risk metrics (such as estimated annual damages and frequency of occurrence) and costs (levee improvements, power impacts, compensation costs for Canadian storage), and then compared to the base condition. From a flood risk management planning perspective, the base condition, with flood risk resulting from post-2024 operations, represents the most-likely future without taking an action to modify the Treaty or seek additional authorities and is the baseline for comparison of other flood risk reduction measures.

5.0 GLOSSARY

Annual Exceedance Probability – This is the probability that flooding will occur at a given location in any given year, considering the full range of possible annual floods and project performance.

Assured Flood Control Storage – Storage space in Canada that is committed for the first 60 years of the Columbia River Treaty for the purpose of helping with flood risk management of the Columbia River. The volumes are defined in the Columbia River Treaty as being 1,270,000 acre-feet at Duncan, 7,100,000 acre-feet at Arrow, and 80,000 acre-feet at Mica.

Called Upon – Called Upon is the formal process by which the U.S. Entity may request additional flood storage drafts or delayed refill operations in Canada to supplement U.S. operations and reservoir storage required to meet flood storage needs for the duration of a flood period. In this paper, the convention is to use "Called Upon" to refer to the post-2024 process, as opposed to the term "On Call," which is used in other documents to reference pre-2024 operations.

Conditional Non-exceedance Probability – This is the probability that a specified target stage will not be exceeded, given the occurrence of a specified flood event, also known as assurance.

Controlled Flow – The target flow for lower Columbia River for flood risk management as measured at The Dalles, Oregon. Storage in reservoirs to meet the controlled flow will generally result in aiding flood risk management for other flood damage areas (local needs) in Canada and the United States.

Effective Use – A term that is generally used to describe operation of U.S. flood control reservoirs that are operated as a system to effectively control flows at The Dalles in order to minimize flood risk.

Expected Annual Damage –The expected annual damage is the average or mean of all possible values of damage determined by an exhaustive Monte Carlo execution of hydrologic, hydraulic, and economic sampling, including their associated uncertainties. Expected annual damages are calculated by computing the area under the damage-frequency curve using a life-cycle approach. Expected annual damages are calculated for the with- and without-project conditions. The difference between the with- and without-project expected annual damages represents the benefit associated with the project.

Flood Control Draft – Libby, Duncan (Canada), Hungry Horse, and Dworshak use seasonal runoff volumes at site because they have a local flood risk management objective. Mica (Canada), Arrow (Canada), and Grand Coulee are mainly operated for system flood risk management and therefore use seasonal runoff volumes at The Dalles. Brownlee uses a seasonal regulated runoff volume at site and at The Dalles.

Flood Control Draft – The operation of a reservoir by the control of releases resulting in drawdown of the reservoir level to provide flood storage space.

Flood Control Refill Curve (FCRC) – Curves used to help guide the refill of reservoirs and ensure the flood control regulation does not adversely affect the reservoir refill insofar as possible.

Flood Risk Analysis – Risk analysis is a decision-making framework that explicitly evaluates the level of risk if no action is taken, and that recognizes the monetary and non-monetary costs and benefits of reducing risks when making decisions. Risk analysis includes three tasks: risk assessment, risk management, and risk communication. Risk analysis organizations pursue their missions by managing risks. Risk analysis is being adopted by a growing number of organizations nationally and globally.

Flood Risk Management – Risk management is the process of problem finding and initiating action to identify, evaluate, select, implement, monitor and modify actions taken to alter levels of risk, as compared to taking no action. The purpose of risk management is to choose those technically sound integrated actions to reduce risks after consideration of the costs of each increment of risk reduction. Environmental, social, cultural, ethical, political and legal considerations all factor into the decision made on how much cost will be incurred for each increment of risk reduction (how safe is safe enough?).

Flow Target – In the Phase 1 study, a flow objective was used, and the operation worked to stay below that flow objective in all circumstances. The flow target, much like the target on a firing range, is the flow to be in the vicinity of, but not necessarily to stay below. If the target is 550 kcfs, then a peak flow of 560 kcfs is a relative success at meeting the flow target.

Incrementally Acquired – When Called Upon is utilized, the quantity of Called Upon storage would be limited to the amount needed, not the amount that is available.

Initial Controlled Flow (ICF) – The first, or initial, controlled flow of the runoff season to which control will be attempted for the Columbia River as measured at The Dalles, Oregon. The Initial Controlled Flow is used in conjunction with unregulated stream flow forecasts to guide the determination of when to begin refill of reservoirs.

Local Flood Control Operation – Regulation of reservoir storage to control flooding in damage areas immediately downstream of the reservoir. Releases specified for the system flood risk management operation may be temporarily suspended insofar as possible to provide better flood protection in these areas.

Long-Term Exceedance Probability – The probability of one or more exceedances of a selected target or capacity in a specified duration that communicates the inherent, natural, or hydrologic risk.

Primary Flood Storage – 8.45 Maf of flood storage that was originally provided for in Article IV, Section 2 of the Columbia River Treaty.

Residual Risk – This is the flood risk that would remain if a proposed flood risk reduction project were implemented. Residual risk includes the consequence of capacity exceedance as well as consideration of project performance.

Risk – The probability an area will be flooded, resulting in undesirable consequences. Risk is often measured as potential or mean loss-of-life, property damage, and/or ecosystem losses, and may also include uncertainty over the benefits to be gained from a proposed or actual action taken. Usually, both the likelihood and the consequence are to some degree uncertain.

Storage Reservation Diagram (SRD) – A family of curves of Required Storage Space vs. Month, commonly abbreviated as SRD. Each curve on the SRD corresponds to a given seasonal runoff volume. Seasonal runoff volume is defined as the volume of water to pass a certain point over a period of months. For example, the period of months could be April through August or April through July, depending on the project.

Uncertainty – A measure of imprecision of knowledge of parameters and functions used to describe the hydraulic, hydrologic, geotechnical, and economic aspects of a project plan, in terms of both natural variability and knowledge uncertainty.

Water Control Manual – A manual for any storage or run-of-river project that describes the contributing basin and its hydrologic characteristics and the criteria and guidance for the project's operation.

6.0 BIBLIOGRAPHY

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APPENDIX A – U.S. PROJECT AUTHORIZATIONS

There are hundreds of dams within the Columbia River Basin. The majority have no flood risk management responsibility. As part of the preparation of the Columbia River Treaty (Treaty) post-2024 procedure, the major dams relative to flood risk management were reviewed. These dams are owned and operated by Federal agencies, public utilities, and private interests. The dams and associated reservoirs are authorized or licensed for multiple purposes, including power generation, flood control, navigation, irrigation, recreation, and fish operations. These dams are of interest because they either provide some form of storage, are impacted by flood control operations, or their operation is interrelated with flood risk management.

The U.S. projects have been grouped according to their institutional authorizations. This grouping reflects how the projects pertain to or contribute to the overall system flood risk management effort. The groups include:

- Projects authorized and currently operated for system flood control.
- Projects authorized for conditional system flood control.
- Projects authorized and operated for local flood control.
- Projects not authorized for flood control but at times may provide incidental system flood protection.
- Irrigation projects not authorized for local flood control, with no flood control operations.
- Projects with minimal or no storage capacity (not effective at reducing flow at The Dalles).
- Run-of-river projects with minimal or no storage capacity.

Projects Authorized and Currently Operated for System Flood Control

The following projects are authorized and operated for system flood control. These projects comprise the core of the U.S. flood risk management operations in the Columbia River system. These projects are operated to storage reservation diagrams (SRD) that set the evacuation.

Libby

Libby Dam was authorized as part of the River and Harbors Act of 1950, Public Law (PL) 81-516, and the Columbia River Treaty (1964). As part of the Columbia River Treaty with Canada (Treaty), the U.S. Government was granted approval to build Libby Dam on the Kootenay River in Montana. Libby Dam is a Treaty project, as it backs water 42 miles upstream of the Canadian border. This hydro project, along with another Treaty project in Canada (Duncan Reservoir), provide over 6 million acre-feet (Maf) of storage for flood control on the Kootenay River. Prior to the construction of these flood control projects, another project, Corra Linn, was built in 1932 on the Kootenay River near Nelson, British Columbia (B.C.), just downstream of the outlet of Kootenay Lake. Before and after construction of Corra Linn, the applicant, West Kootenay Power and Light Company (WKPL), applied for permission to operate Kootenay Lake at higher elevations to increase both head and water volume available for power production from the project. This required the consent of the International Joint Commission (IJC), as the water storage in the lake would affect areas on both sides of the border.

This request was continually denied due to resistance of the affected farmers in Idaho, until major flooding that occurred upstream in 1938 convinced them of the importance of flood control. The IJC established operating rules to provide flood storage upstream, and increased power production from Corra Linn Dam. With the construction of Libby Dam, the Treaty states, under Article XII, Paragraph (6), "The operation of the storage by the United States of America shall be consistent with any order of approval which may be in force from time to time relating to the levels of Kootenay Lake made by the International Joint Commission under the Boundary Waters Treaty, 1909."

Hungry Horse

Hungry Horse Dam and Reservoir was authorized by the Flood Control Act of June 5, 1944, "for the purpose of irrigation and reclamation of arid lands, for controlling floods, improving navigation, regulating the flow of the South Fork of the Flathead River, for the generation of electric energy, and for other beneficial uses primarily in the State of Montana…" The project is located in western Montana on the South Fork of the Flathead River, about 5 miles above the confluence with the main stem. The dam was constructed by the U.S. Bureau of Reclamation in 1950, and is operated for both local and system flood control in coordination with the Corps under Section 7 of the Flood Control Act of 1944.

Hungry Horse provides local flood protection from Columbia Falls to Flathead Lake, located 40 river miles further downstream. It is operated for system flood control by delaying the start of refill until 10 days before the ICF is forecasted to be exceeded at The Dalles. At that time, Hungry Horse releases are guided by the VARQ flood control procedure until final refill is possible. After refill in late June or early July, Hungry Horse begins gradually drafting for flow augmentation for endangered species.

Dworshak

Dworshak is located in northern Idaho on the North Fork of the Clearwater River, near the town of Orofino. The project includes Dworshak Dam, Dworshak Reservoir lands, powerhouse, recreation facilities, wildlife mitigation, and Dworshak National Fish Hatchery. This project was authorized by PL 87-874, 87th Congress, dated October 23, 1962, in accordance with House Document 403. The original name, Bruces Eddy, was changed to Dworshak Dam and Reservoir (PL 88-96, 88th Congress), in honor of the late Senator from Idaho. PL 87-874 authorized generator units 4, 5, and 6 for the powerhouse. Units 5 and 6 were deauthorized in 1990, with unit 4 deauthorized in 1995.

Brownlee Project

The Brownlee project consists of three facilities – Brownlee, Hells Canyon, and Oxbow dams. All three are owned by and operated in coordination with the Idaho Power Company. The utility was granted authority by FERC license No. 1971, with the primary purpose of providing power, but is it also used for flood management operations and to benefit fish, wildlife, and recreation. This license was to expire on July 31, 2005, and Idaho Power filed the final license application for the Hells Canyon complex on July 21, 2003. However, this application is still listed as pending by FERC. The Brownlee project is the most upstream project on the Snake River with authorized system flood control.

Kerr

Kerr Dam is owned and operated by PPL Montana and the Confederated Salish Kootenai Tribes (CSKT) under authority of FERC license No. 5. System flood control operations are coordinated with the Corps of Engineers in accordance with a Memorandum of Agreement between the Corps of Engineers and Montana Power Company, amended in October of 1965.

For system flood control, the project is operated to a set space requirement (1Maf); however, maximum discharge is limited by a natural lake outlet restriction. For this reason, full evacuation for flood storage space may not be achieved in sufficient time to offset spring runoff. This results in some storage capacity that may not be fully used, and has been listed as incidental storage in **Table 1.**

Albeni Falls

Albeni Falls is owned and operated by the Corps of Engineers as authorized under PL 81-16, Rivers and Harbors Act of 1950, 8lst Congress, Second Session, in accordance with Senate Document 9, 81st Congress, First Session. The project is authorized for the purposes of flood control, power generation, and navigation.

Albeni Falls Dam is constructed downstream of Lake Pend Oreille. The dam creates a backwater effect that can raise the lake level. However, a natural channel constriction located between the lake and the dam limits the amount of discharge that can be released from the dam. If the volume of runoff exceeds the maximum flow through the constriction and subsequent release from the dam, natural lake storage occurs and the reservoir cannot be fully evacuated, thus the incidental 0.5 Maf of storage is often not available for additional flood control.

Grand Coulee

Construction began on Grand Coulee Dam in 1933 as a low dam for power production only under the National Industrial Recovery Act. On June 5, 1935, Secretary Ickes authorized completion of Grand Coulee as a high dam. The high dam project was formally authorized by Section 2 of the Rivers and Harbors Act, August 30, 1935. It was reauthorized under the Columbia Basin Project Act of March 10, 1943, bringing it under the provisions of the Reclamation Project Act of 1939. The authorized purposes are controlling floods, improving navigation, regulating stream flow, storage and delivery of stored water for reclamation lands, and power generation.

The Franklin D. Roosevelt reservoir (Lake Roosevelt) formed by Grand Coulee Dam is perhaps the most important of all flood control reservoirs in the Columbia River Basin. With almost 5.2 million acre-feet of storage space located relatively close to the lower Columbia River damage centers, this project provides the capability of a fined-tuned regulation at The Dalles control point, taking into account storage operations at other projects in the system, volume forecasts, streamflow forecasts, and runoff emanating from the Snake River and other tributaries. In the Columbia River Treaty Flood Control Operating Plan, Grand Coulee project is classified as a Category IV project, along with Arrow and John Day reservoirs. This classification is defined as a reservoir operated with variable releases primarily for the control of the lower Columbia. In addition to its flood control capability, the Grand Coulee project has the largest installed power generation capacity of any reservoir in the system and provides irrigation water to over 670,000 acres of farmland in eastern Washington by pumping from the reservoir into Banks Lake.

There are impacts to drafting Lake Roosevelt deeply for flood control. When the lake is drafted below elevation 1240 feet, half of the pumping capacity is lost, and it is difficult for the remaining pumps to meet irrigation demand at the Columbia Basin project, especially when pumps are down for repair. In addition, cultural resources are exposed by deep reservoir drafts and are subject to vandalism. Contaminated sediments are exposed as the reservoir elevation drops, which may present a health risk. Ferry service between Inchelium and Gifford is lost when the reservoir drafts below elevation 1228 feet. This extends the commute by approximately 50 miles, which impacts emergency services and school bus schedules. During large runoff events, deep reservoir drafts result in high total dissolved gas levels downstream if flow exceeds turbine. There are further negative impacts to fish and wildlife, recreation, and commercial usage of the lake during the summer period. All of these project functions result in pressure to keep the reservoir as high as possible, and thus tend to be in conflict with flood control operating objectives. The current flood control storage reservation diagram for Grand Coulee was formally agreed upon by the Bureau of Reclamation and Corps of Engineers in March of 1997.

John Day

While the John Day project provides some system storage capacity (0.5 Maf), it primarily functions as a run-of-river project for power generation. Storage at John Day is not large enough to be used for regulating flows to meet the controlled flow at The Dalles for a significant period of time. Rather, use of storage at John Day is a final attempt to control peak runoff during large floods.

Projects Authorized for Conditional System Flood Control

The following projects are authorized for system flood control, but have institutional or organizational conditions that must be met before flood control operations may be implemented.

Mid-Columbia PUDs

The Mid-Columbia PUD projects consist of five facilities: Wells, Rocky Reach, Rock Island, Wanapum and Priest Rapids. All five projects are authorized under FERC licenses issued to the public utilities as indicated in **Table 1**.

Priest Rapids and Wanapum are currently being reviewed for a new license (as of April 17, 2008). Article 34 of the original license required Grant PUD, as directed by the District Engineer of the U.S. Army Corps of Engineers (Corps), to make available in the Priest Rapids and Wanapum reservoirs, storage space necessary to compensate for valley storage that may be lost when refilling the reservoirs' storage space during the flood season (between May 15 and June 30). Article 35 of the original license required Grant PUD, as might be requested by the Corps, to provide for flood control storage space up to 500,000 acre-feet in addition to the compensation for valley storage required by Article 34.

In the articles that follow, the Corps states that this storage is intended for very large floods, and that although extensive upstream storage development has reduced the frequency of such floods, they may still occur. It therefore recommended that the requirements of Articles 34 and 35 be included in the new license.

> Article 301. Flood Control-refill. The licensee shall, each year before May 15, by direction of the U.S. Army Corps of Engineers' District Engineer in charge of the locality, make available in the Priest Rapids and Wanapum reservoirs, storage space in an amount necessary to compensate approximately for valley storage that may be expected to be lost during the ensuing flood season: Provided, That said required storage space may be provided in either or both of the reservoirs in such manner as to least affect the interests of power generation: Provided, Further, That refill of this storage space shall be as directed by the District Engineer on a basis of forecasts of time and magnitude of flood flows and may be allowed any time between May 15 and June 30.
>
> Article 302. Flood Control-storage. The licensee shall provide for flood control storage space in addition to that required to compensate for valley storage, as provided for in Article 301 up to a total of 500,000 acre-feet by additional drawdown as may be requested by the U.S. Army Corps of Engineers, such drawdown to be based on forecasts of peak flow and time of occurrence: Provided, That suitable arrangements have been made to compensate the licensee for the use of the additional storage space, and Provided further, That such compensation shall be determined by the Commission, based upon the value of the additional storage space for other uses or upon payment in kind for power loss, at the discretion of the Commission.

While these projects are included as the system flood control, they are considered as conditional contributors. Agreements must be made with the operators for how the flood control storage will be achieved. In addition, the licenses stipulate that the Corps reimburse the operators of the used storage. These projects and the conditions associated with the flood control storage should be further evaluated as part of the CRT Review.

Projects Authorized and Operated for Local Flood Control

The following are Federal projects that are specifically authorized and operated for local flood control rather than system flood control. At times, they may provide incidental system flood control, based on their other operational requirements. The Bureau of Reclamation usually operates these reservoirs in coordination with the Corps. Since the Corps does not have authority to exercise direct control of these projects, the availability of this storage can be uncertain, depending upon other operational requirements.

Upper Snake (Palisades)

In the Upper Snake basin, two dams provide local flood protection. Palisades is authorized for flood control and is a Section 7 project. Jackson Dam is not authorized for flood control, but operates in conjunction with Palisades for local flood protection as described in the Water Control Manual for Palisades Reservoir. Jackson Dam will be discussed more in the following section, Projects Not Authorized For Flood Control.

Flood control space is held in Jackson Lake and Palisades Reservoir on a forecast basis to control the Snake River near Heise, about 48 miles below Palisades Dam, to no more than 20 kcfs. The Heise forecast is used to prescribe the combined space to be provided up to 1.6 Maf. No less than 75 percent of the required flood control space must be held in Palisades (up to 1.2 Maf).

The Secretary of the Interior initially authorized the Palisades Project on December 9, 1941, under the provisions of Section 9 of the Reclamation Project Act of 1939 (53 Stat. 1187). Congress reauthorized the Palisades Project in the Act of September 30, 1950 (64 Stat. 1083), for the purposes of irrigation, power, flood control, recreation, and fish and wildlife conservation, in accordance with a supplemental report approved by the Secretary of the Interior in 1949. Palisades provides up to 1.2 million acre-feet of flood space, depending on forecasted runoff. In combination with Jackson Lake, up to 1.6 million acre-feet can be provided for local flood protection.

There is little potential for providing additional effective flood control space from Palisades beyond what it currently provides without impacting the primary authorized purpose of providing irrigation water. Palisades reservoir does not always fill with current irrigation releases. Therefore, drafting it deeper will have minimal effect on further reducing downstream flooding. Operating to the current local flood control plan, Palisades fills in 7 out of 10 years. Of the 1,200,000 acre-feet of active storage in Palisades, less than 10,000 acre-feet (< 1 percent) is not contracted. The remaining 99 percent of space is contracted to water users who have expectations of reliable year-to-year supplies. Any shortfall to refill impacts the space holder’s ability to use, rent, or hold over the shortfall.

Boise River

The Boise River dams include Anderson Ranch, Arrowrock, and Lucky Peak. Reclamation’s Boise Project consists of two divisions, the Arrowrock Division on the Boise River and the Payette Division on the Payette River. The Payette Division reservoirs are described later in this report in the section Projects Not Authorized For Flood Control. Anderson Ranch and Arrowrock dams are Section 7 projects, owned and operated by Reclamation and authorized for local flood control. Lucky Peak Dam is a Corps of Engineers facility. The flood control operation of these three dams is coordinated between the two agencies to protect Boise, Idaho.

Construction of the original Boise Project was authorized on March 27, 1905, by the Secretary of the Interior. Arrowrock Dam was authorized on January 6, 1911, by the Secretary of the Interior under provisions of the Reclamation Act of June 17, 1902 (32 Stat. 388). The Secretary of the Interior authorized Anderson Ranch Dam and Reservoir on August 12, 1940, under the Reclamation Project Act of 1939 (53 Stat. 1187).

Lucky Peak is a Corps of Engineers structure and was authorized in accordance with the recommendation of the Chief of Engineers in his report dated May 13, 1946, stating that the dam and reservoir shall be so constructed as not substantially to damage the structure of the Arrowrock Dam, and shall be operated in such manner as not materially to interfere with the operation of said Arrowrock Reservoir (60 Stat. 642, U.S. Code, page 650).

Lucky Peak Reservoir is operated in conjunction with Arrowrock and Anderson Ranch Reservoirs pursuant to the Act of August 24, 1954 (68 Stat. 794), which authorized the Secretary of the Interior to coordinate the facilities on the Boise River on the basis of the September 21, 1953 revised Allocation and Replacement Report for the Boise Project.

The November 20, 1953, MOA between the Corps and Interior was submitted to Congress and served as a basis for the Act of August 24, 1954. This MOA was updated by the Sept.25, 1985 MOU, which approved the *Water Control Manual for the Boise River Reservoirs* dated April 1985.

The Water Control Manual provides for regulating the reservoirs for flood protection for the Boise River valley, in conjunction with delivering irrigation water and power generation. Incidental downstream flood control benefits also result from this operation. The formal flood control operating agreement signed by the Corps and Reclamation provides that sufficient space be maintained in Anderson Ranch, Arrowrock, and Lucky Peak Reservoirs to regulate the forecast river flow through Boise to no more 6,500 cubic feet per second (6,500 cfs is bank full. 7,000 cfs is flood stage).

In most years, irrigation demand causes the reservoirs to draft into the fall such that they are significantly below SRDs going into the winter. Minimum flows are provided from November through April unless additional flood control releases are required. In about half of the water years, there is no additional space required in the reservoirs beyond what was available due to normal irrigation operations. The SRDs for flood control operations on the Boise system balances flood control with refill for irrigation. The SRDs were designed based on operating the river to bankfull during refill. Minor nuisance flooding occurs at this level.

There is very little potential for providing additional effective flood control space from the Boise system without impacting the primary authorized purposes of providing irrigation water and providing local flood control. Further drafting of the reservoirs in late spring during years of large runoff would require reservoir releases beyond flood stage, causing flood damages in the Boise valley. If the reservoirs do not fill with current irrigation releases, then drafting them deeper will have no further effect on reducing downstream flooding. Operating to the current local flood control plan, Anderson Ranch fills in 7 out of 10 years. Arrowrock fills in roughly 6 of 10 years. Lucky Peak fills every year. Of the approximately 950,000 acre-feet of active storage in Anderson Ranch, Arrowrock, and Lucky Peak, only 194,000 acre-feet (~22 percent) is not contracted for water supply. However, all of the uncontracted water is earmarked for salmon flow augmentation (42,000 acre-feet) or winter instream flows (152,000 acre-feet). If the reservoir system does not fill due to flood control procedures, then the first 60,000 acre-feet of shortfall is taken from Reclamation's uncontracted account. Shortfalls greater than 60,000 acre-feet are divided between the spaceholders. Private spaceholders have expectations of reliable year-to-year supplies. Refill shortfalls impact spaceholders' ability to use, rent, or "hold over" the lost water.

Willamette Projects

Willamette River is a major contributor to winter floods in the Portland/Vancouver area. Willamette River runoff during this period is from rainfall or rain on snow. Spring runoff on the Columbia River is primarily from melting of the winter snow pack, augmented at times by rainfall. While the Willamette projects are authorized and operated for local flood control, the current FCOP was developed for regulation of the Columbia River basin-wide spring snowmelt events.

For the purposes of the Phase 2 studies and preparation of the reservoir model, the assumption was made that the Willamette system contributes a minor amount to the overall Columbia system flood peak, and these reservoirs were not included in the model. However, while the Willamette storage reservoirs will not be modeled, input flow hydrographs will be used that reflect the impact of the Willamette system on the Columbia system.

Projects Not Authorized for Flood Control, but at Times May Provide Incidental System Flood Protection

This group includes Federal and non-Federal projects that are not authorized for flood control but perform voluntary "informal" flood control for local areas downstream of the projects. The Bureau of Reclamation operates several of these dams and has created SRDs that allow some space to be reserved for flood control while still meeting the projects primary purpose of storing irrigation water. These SRDs rarely interfere with reservoir refill.

While at times these reservoirs may provide incidental system flood control based on their other operational requirements, the use of such reservoirs for storing water for major floods is unreliable. The Corps does not have authority to exercise control of these projects for system flood control.

Upper Snake (Jackson Lake)

Jackson Dam is not authorized for flood control, but operates in conjunction with Palisades Dam for local flood protection. Jackson Dam on the Snake River in Grand Teton National Park (880 river miles above Portland, OR) is operated to minimize damage in the Jackson, Wyoming area, and in combination with Palisades for protection at Heise, Idaho 135.3 miles downstream. It is not a Section 7 project, but is operated in combination with Palisades (which is a Section 7 project) through mutual agreement between Reclamation and the Corps as described in the Water Control Manual for Palisades Reservoir. By October 1 of each year, at least 200,000 acre-feet of space is made in Jackson Lake. Under the water control plan, no more than 25 percent of combined flood space (up to 0.4 Maf) is held in Jackson Lake. Flood control space is held in Jackson Lake and Palisades Reservoir on a forecast basis to control the Snake River near Heise, about 48 miles below Palisades Dam, to no more than 20 kcfs.

There is very little potential for providing additional effective flood control space from Jackson Dam without impacting the primary authorized purpose of providing irrigation water. Winter flows from Jackson Dam are usually set at the onset of cold weather and held until April when daytime temperatures exceed freezing. Dramatic flow changes are problematic during winter and early spring months due to snow and ice buildup in the Snake River channel downstream of the dam. The reservoir does not always fill due to current irrigation releases. Therefore, drafting deeper will have little effect on reducing downstream flooding. Operating to the current local flood control plan, Jackson Lake fills in roughly 6 of 10 years. Of the 847,000 acre-feet of active storage in Jackson, less than 4,000 acre-feet (less than 0.5 percent) is uncontracted. The remaining space is contracted to water users who have expectations of reliable year-to-year supplies. Any shortfall to refill impacts the spaceholder’s ability to use, rent, or “hold over” the shortfall.

Payette River

Deadwood and Cascade Dams are Reclamation owned and operated facilities on the Payette River in Idaho. The Dams are part of the Payette Division of the Boise Project. Both are authorized by the Secretary of Interior under provisions of the Act of June 25, 1910, which required approval of the President for new projects. Deadwood Dam was authorized by the Secretary on October 18, 1928, and approved by the President on October 9, 1928. Cascade Dam was authorized as part of the Payette Division of the Boise Project by the Secretary on November 20, 1935, and approved on December 19, 1935, by the President.

Flood control is not an authorized purpose for these projects. Lake Cascade and Deadwood Reservoir are primarily irrigation reservoirs operated on an informal forecast basis to control the flow of the Payette River through Horseshoe Bend so as not to exceed 12 kcfs. Maximum flood space in Cascade is limited to 396 kaf to maintain minimum pool of 250 kaf for water quality; space at Deadwood is limited to 104 kaf to maintain minimum pool of 50 kaf for threatened bull trout.

Yakima Storage Dams

The Yakima Project was authorized by the Secretary of the Interior on December 12, 1905, under the Reclamation Act of 1902. Storage dams and reservoirs on the project are Keechelus, Kachess, Cle Elum, Bumping Lake, and Tieton. Title XII of the Act of October 31, 1994, authorized fish, wildlife, and recreation as additional purposes of the Yakima Project. These purposes, however, shall not impair the operation of the Yakima Project to provide water for irrigation purposes nor impact existing contracts.

The Yakima reservoirs provide irrigation water for a comparatively narrow strip of fertile land that extends for 175 miles on both sides of the Yakima River in south-central Washington. The irrigable lands presently being served total approximately 464,000 acres. The reservoirs have a combined active capacity of 1,065,400 acre-feet with an average annual runoff of about 1,700,000 acre-feet.

Flood control is not a Congressionally authorized purpose of the Yakima Project. However, the project is operated on an informal basis to control runoff to below damaging levels to the extent possible without jeopardizing supply for irrigation. Flood levels are designated by the National Weather Service at control points on the Naches and Yakima Rivers. Controlling flows to below flood levels is not always possible due to large unregulated tributary inflows.

Current operations are guided by a five-reservoir flood control and refill SRD created by Reclamation and dated February 25, 1974. The winter (November 1 to February 1) flood space requirement is a fixed 300 KAF, while in the spring (February 1 to June 30) flood control space varies with the runoff forecast from a maximum of 847 KAF to a minimum of zero AF. Irrigation and instream flow demands typically draft the five reservoirs well below the winter flood control guideline. There is little to no potential to increase flood control without jeopardizing refill and the irrigation water supply.

Clark Fork Projects

The Clark Fork projects consist of Thompson Falls, Noxon Rapids, and Cabinet Gorge. All three are authorized by FERC licenses to Avista Corporation and Washington Water and Power as indicated in **Table 1**. These projects are operated voluntarily for local flood control by the owners.

Irrigation Projects Not Authorized for Local Flood Control, with No Flood Control Operations

The Bureau of Reclamation owns and operates dozens of dams which store irrigation water and have no flood control responsibility. They are not authorized for flood control and do not provide "informal" flood control space. These include American Falls and Minidoka reservoirs, among others. Irrigation reservoirs may, as a result of being drawn down to meet water supply needs the previous year, provide minor incidental downstream flood control by default. The intentional use of such reservoirs for storing water during major floods, however, is unauthorized and unreliable. The timing of flood flows to these reservoirs often does not match up with peaks on the main stem of the Columbia. Accordingly, no specific reduction in overall storage requirements is possible.

Projects With Minimal or No Storage Capacity (not effective at reducing flows at The Dalles)

Chelan and Post Falls are public utility owned reservoirs authorized by FERC licenses. Although they may have some have minimal storage capacity, for system flood control purposes they are not effective at reducing the flow at The Dalles. While these projects may at times provide flood control incident to their normal operations for other purposes, they are not considered effective in determining or forecasting main stem system flood control requirements.

Run-of-River Projects With Minimal or No Storage Capacity

The projects listed on Table 1 as run-of-river projects are operated primarily for power generation and have only minimal pondage capacity that cannot provide any significant long-term storage capacity unless drafted below spillway gates. The projects located on the lower reach of the Columbia River can provide some limited capacity that may be used to reduce short-term peak flows with careful operation. The use of such reservoirs for storing water for major floods is generally unreliable.

APPENDIX B – U.S. PROJECTS DATA SHEETS

These data sheets are included for the U.S. projects that are authorized for system flood control.

Project:	**Libby**	Owner:	U.S. Army Corps of Engineers		
River:	Kootenai	Reservoir:	Koocanusa		
Dates of Construction:		Height:	422 ft	Length:	3,055 ft

Primary Uses:	Flood control, power generation				
Secondary Uses:	Fishery, recreation		Drainage Area:	8,958	sq mi
Power Generation Capacity:	525	MW	Irrigation Area:	?	ac

Project Storage Capacities (Maf):			**Flood Control Capacities:**		
Total Capacity:	6.027	Maf	System Flood Control:	4.980	Maf
Active Storage:	4.980	Maf	Local/Informal:	(in system)	Maf
Minimun Elevation:	2,287.0	ft	Incidental:	0.000	Maf
Maximum Elevation:	2,459.0	ft			

Authorizations:

1) Rivers and Harbors Act of 1950

2) PL 81-516

3) Columbia River Treaty, 1964

Operational Notes:

1) VarQ operations - 1994 Kootenai River was listed in under the Endangered Species for protection of white sturgeon and enforced minium release rules for Libby. VarQ reduces the reservoir storage space during spring runoff and can cause a trapped storage condition.

Project:	**Hungry Horse**		Owner:	U.S. Bureau of Reclamation			
River:Hun	South Fork Flathead		Reservoir:	Hungry Horse			
Dates of Construction:	1952		Height:	564	Length:	2115	
Primary Uses:	Flood Control, Power						
Secondary Uses:	Irrigation			Drainage Area:		1,640	sq mi
Power Generation Capacity:	408	MW		Irrigation Area:		0	ac
Project Storage Capacities (Maf):				**Flood Control Capacities:**			
Total Capacity:	3.588	Maf		System Flood Control:		2.980	Maf
Active Storage:	2.980	Maf		Local/Informal:		0.000	Maf
Minimun Elevation:	3,336.0	ft		Incidental:		0.000	Maf
Maximum Elevation:	3,565.0	ft					

Authorizations:

1) Act of June 5, 1944, 58 Stat. 270; PL 78-329, authorized for irrigation, flood control and improved navigation

Operational Notes:

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Dworshak** (Bruces Eddy)		Owner:	U.S. Army Corps of Engineers		
River:	North Fork Clearwater River		Reservoir:	Dworshak Reservoir		
Dates of Construction:	1966-1972		Height:	717 ft	Length:	3287 ft
Primary Uses:	Flood control, power, navigation					
Secondary Uses:	Fishery, recreation		Drainage Area:		8,958	sq mi
Power Generation Capacity:	400	MW	Irrigation Area:			ac
Project Storage Capacities (Maf):			**Flood Control Capacities:**			
Total Capacity:	3.470	Maf	System Flood Control:		2.016	Maf
Active Storage:	2.016	Maf	Local/Informal:		0.000	Maf
Minimun Elevation:	1,445.0	ft	Incidental:		0.000	Maf
Maximum Elevation:	1,604.7	ft				

Authorizations:

1) Public Law 85-500, 85th Congress

Operational Notes:

1) Operated for system flood control

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Brownlee**		Owner:	Idaho Power Co.		
River:	Snake River		Reservoir:			
Dates of Construction:	1958		Height:	395	Length:	1380
Primary Uses:	Power, Flood Control					
Secondary Uses:	Recreation, Navigation			Drainage Area:	72,800	sq mi
Power Generation Capacity:	728	MW		Irrigation Area:		ac
Project Storage Capacities (Maf):				**Flood Control Capacities:**		
Total Capacity:	1.426	Maf		System Flood Control:	0.990	Maf
Active Storage:	0.990	Maf		Local/Informal:	0.000	Maf
Minimun Elevation:	1,976.0	ft		Incidental:	0.000	Maf
Maximum Elevation:	2,077.0	ft				

Authorizations:

1) FERC License No. 1971

Operational Notes:

1) Operated by Idaho Power Co, Primarily for power genration and for system flood control by FERC license and agreement
2) FERC license authorizes Brownlee, Hells Canyon and Oxbow for a combined 0.990 Maf of flood control storage

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Kerr**		Owner:	PPL Montana & Salish Kootenai Tribe	
River:	Flathead		Reservoir:	Flathead Lake	
Dates of Construction:	1930-1938		Height:	200	Length: 675
Primary Uses:	Power				
Secondary Uses:	Flood Control, Recreation		Drainage Area:	72,800	sq mi
Power Generation Capacity:	194	MW	Irrigation Area:		ac
Project Storage Capacities (Maf):			**Flood Control Capacities:**		
Total Capacity:		Maf	System Flood Control:	1.000	Maf
Active Storage:	1.219	Maf	Local/Informal:	0.000	Maf
Minimun Elevation:	2,883.0	ft	Incidental:	0.219	Maf
Maximum Elevation:	2,893.0	ft			

Authorizations:

1) FERC License No. 5

2) Memorandum of Agreement between the Corps of Engineers and Montana Power Company, amended Oct. 1965.

Operational Notes:

1) If a moderate to major flood year is forecast by NPD when the lake reaches elevation 2,886 ft, the spillway gates will be opened to maintain free flow condition until the danger of exceeding elevation 2,893 ft has passed.

2) The lake may be raised to reach elevation 2,893 ft. by 15 June if a flood potential does not exist in the river basin above the lake as determined by NPD

3) The settlement agreement arrived at during the relicensing procedure contains a provision that would increase the minimum daily release from 1,500 cfs to 3,200 cfs.

4) Project operated so that maximum discharge limited by natural lake outlet restriction.

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Albeni Falls**			Owner:	U.S. Army Corps of Engineers		
River:	Pend Oreille			Reservoir:	Pend Oreille Lake		
Dates of Construction:	1951-1955			Height:	90	Length:	775

Primary Uses: Flood control, power generation, navigation

Secondary Uses: Recreation — Drainage Area: 8,958 sq mi

Power Generation Capacity: 42 MW — Irrigation Area: ac

Project Storage Capacities (Maf):			**Flood Control Capacities:**		
Total Capacity:	1.155	Maf	System Flood Control:	0.600	Maf
Active Storage:	0.600	Maf	Local/Informal:	0.000	Maf
Minimun Elevation:	2,049.7	ft	Incidental:	0.550	Maf
Maximum Elevation:	2,062.5	ft			

Authorizations:

1) PL 81-516, Rivers and Harbors Act of 1950 , 8lst Congress, Second Session in accordance with Senate Document 9, 81st Congress, First Session. Flood Control Act of 1950.

Operational Notes:

1) Albeni Falls Dam is constructed downstream of Lake Pend Oreille. The dam creates a backwater effect that can raise the lake level. However, a natural channel constriction located between the lake and the dam limits the amount of discharge that can be released from the dam. If the volume of runoff exceeds the maximum flow through the constriction and susequent release from the dam, natural storage occurs and the reservoir cannot be fully evaculated, thus the incidental 0.550 Maf of storage is often not available for additional flood control .

2) Maximum rate of change established to prevent sloughing of downstream banks and limit tailwater fluctuation. Albeni Falls Dam Reservoir Regulation Manual, April 1960.

3) Lake level is maintained at or near the observed 20 November elevation through 31 December to protect beach-spawning Kokanee. During the incubation season (1 January- 1 April), the lake is not to be significantly drafted below the 20 November elevation.

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Grand Coulee**	Owner:	U.S. Bureau of Reclamation
River:	Columbia	Reservoir:	Franklin Delano Roosevelt Lake
Dates of Construction:	1933 - 1941	Height:	550 ft Length: 5223 ft

Primary Uses:	Power generation, flood control, river regulation, irrigation				
Secondary Uses:	Recreation		Drainage Area:	74,700	sq mi
Power Generation Capacity:	6,809	MW	Irrigation Area:	671,000	ac

Project Storage Capacities (Maf):			**Flood Control Capacities:**		
Total Capacity:	9.386	Maf	System Flood Control:	5.186	Maf
Active Storage:	5.186	Maf	Local/Informal:	0.000	Maf
Minimun Elevation:	1,208.4	ft	Incidental:	0.000	Maf
Maximum Elevation:	1,290.0	ft			

Authorizations:

1) Construction began in 1933 as a low dam for power only under the National Industrial Recovery Act
2) On 5 Jun 1935 Sec. Ickes authorized completion as high dam. Project was formally authorized by Section 2 of the 1935 Rivers and Harbors Act, August 30, 1935. The dam was authorized for the purpose of controlling floods, improving navigation, regulating the flow of the streams of the United States, providing for storage and for the delivery of the stored waters and power generation
3) Columbia Basin Project Act March 10, 1943 renamed the project and allows construction of irrigation components to begin following WWII
4) PL 74-409; PL 89-448 (Third Powerhouse)

Operational Notes:

1) August 27, 1976 Master Water Service Contract between USBR and irrigation districts
2) Minimum pool elevation of 1,240.0 on 31 May is needed for irrigation pumping operations.
3) Maximum daily draft limit established, based on reservoir elevation, to reduce risk of landslides within the reservoir.

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**John Day**		Owner:	U.S. Army Corps of Engineers		
River:	Columbia		Reservoir:	Lake Umatilla		
Dates of Construction:	1958-1971		Height:	184	Length:	7635
Primary Uses:	Power, navigation, flood control					
Secondary Uses:	Recreation, irrigation, fish		Drainage Area:		226,000	sq mi
Power Generation Capacity:	2,160	MW	Irrigation Area:			ac
Project Storage Capacities (Maf):			**Flood Control Capacities:**			
Total Capacity:	2.530	Maf	System Flood Control:		0.530	Maf
Active Storage:	0.530	Maf	Local/Informal:		0.000	Maf
Minimun Elevation:	257.0	ft	Incidental:		0.000	Maf
Maximum Elevation:	276.5	ft				

Authorizations:

1) Rivers and Harbors Act of 1950, PL 81-516

Operational Notes:

1) Normal minimum elevation in spring is 262.0 for protection of geese during nesting period 1 March - 15 May (land bridges form below this elevation).

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Wells** (Mid Columbia PUD)			Owner:	Douglas County PUD No 1		
River:	Columbia			Reservoir:			
Dates of Construction:		1968		Height:	160	Length:	4300
Primary Uses:	Power, flood control , recreation						
Secondary Uses:				Drainage Area:		85,300	sq mi
Power Generation Capacity:		851	MW	Irrigation Area:			ac
Project Storage Capacities (Maf):				**Flood Control Capacities:**			
Total Capacity:		0.500	Maf	System Flood Control:		0.125	Maf
Active Storage:		0.125	Maf	Local/Informal:		0.000	Maf
Minimun Elevation:		771.0	ft	Incidental:		0.000	Maf
Maximum Elevation:		781.0	ft				

Authorizations:

1) FERC License No. 2149

Operational Notes:

1) Flood control storage space required for replacement of Lost Valley storage vary by year

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Rocky Reach** (Mid Col. PUD)		Owner:	Chelan County PUD No 1		
River:	Columbia		Reservoir:	Lake Entiat		
Dates of Construction:	1956-1969		Height:	118	Length:	3820
Primary Uses:	Power, recreation					
Secondary Uses:			Drainage Area:		87,800	sq mi
Power Generation Capacity:	1,300	MW	Irrigation Area:			ac
Project Storage Capacities (Maf):			**Flood Control Capacities:**			
Total Capacity:	0.390	Maf	System Flood Control:		0.120	Maf
Active Storage:	0.360	Maf	Local/Informal:		0.000	Maf
Minimun Elevation:	703.0	ft	Incidental:		0.000	Maf
Maximum Elevation:	707.0	ft				

Authorizations:

1) FERC License No. 2145, granted 1957

2) Although authorized for system flood control, the FERC requires an agreement the the USACE and payment for use of flood control space

Operational Notes:

1) Flood control storage space required for replacement of Lost Valley storage vary by year

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Rock Island** (Mid Col. PUD)		Owner:	Chelan County PUD No 1			
River:	Columbia		Reservoir:	Rock Island Pool			
Dates of Construction:	1930-1933		Height:	71	Length:	3148	
Primary Uses:	Power						
Secondary Uses:				Drainage Area:		89,400	sq mi
Power Generation Capacity:	624	MW		Irrigation Area:			ac
Project Storage Capacities (Maf):				**Flood Control Capacities:**			
Total Capacity:	0.131	Maf		System Flood Control:		0.000	Maf
Active Storage:	0.009	Maf		Local/Informal:		0.000	Maf
Minimun Elevation:	609.0	ft		Incidental:		0.000	Maf
Maximum Elevation:	613.0	ft					

Authorizations:

1) FERC License, Project No. 943, granted amendment No. 17, License reissued Jan 1989

Operational Notes:

1) Required to pass probable maximum flood

Project:	**Wanapum** (Mid Col. PUD)		Owner:	Grant County PUD No 2			
River:	Columbia		Reservoir:	Lake Wanapum			
Dates of Construction:	1959-1965		Height:	93	Length:	8639	
Primary Uses:	Power, flood control						
Secondary Uses:	Rrecreation			Drainage Area:		95,000	sq mi
Power Generation Capacity:	1,038	MW		Irrigation Area:			ac
Project Storage Capacities (Maf):				**Flood Control Capacities:**			
Total Capacity:	0.796	Maf		System Flood Control:		0.5 *2	Maf
Active Storage:	0.590	Maf		Local/Informal:		0.000	Maf
Minimun Elevation:	539.0	ft		Incidental:		0.000	Maf
Maximum Elevation:	571.5	ft					

Authorizations:

1) FERC License No. 2114, Amendment No. 4

2) Article 35 of the original license required Grant PUD, as might be requested by the Corps, to provide for flood control storage space up to 500,000 acre-feet (Wanapum and Priest Rapids) in addition to the compensation for valley storage required by Article 34.

Operational Notes:

Appendix B - Post 2024 Flood Risk Management Procedure

Project:	**Priest Rapids** (Mid Col. PUD)		Owner:	Grant County PUD No 2		
River:	Columbia		Reservoir:	Priest Rapids Lake		
Dates of Construction:	1956-1961		Height:	93	Length:	8639
Primary Uses:	Power, recreation					
Secondary Uses:	Flood control		Drainage Area:		95,500	sq mi
Power Generation Capacity:	956	MW	Irrigation Area:			ac
Project Storage Capacities (Maf):			**Flood Control Capacities:**			
Total Capacity:	0.191	Maf	System Flood Control:		0.5 *2	Maf
Active Storage:	0.191	Maf	Local/Informal:		0.000	Maf
Minimun Elevation:	465.0	ft	Incidental:		0.000	Maf
Maximum Elevation:	488.0	ft				

Authorizations:

1) FERC License No. 2114, Amendment No. 4

2) Article 35 of the original license required Grant PUD, as might be requested by the Corps, to provide for flood control storage space up to 500,000 acre-feet (Wanapum and Priest Rapids) in addition to the compensation for valley storage required by Article 34.

Operational Notes:

Appendix B - Post 2024 Flood Risk Management Procedure

APPENDIX C – REQUIRED SYSTEM FLOOD CONTROL STORAGE

Introduction

The need to develop a procedure to determine Called Upon Canadian space requirements post-2024 are necessitated by the flood risk management studies under Phase 2a of the overall Treaty 2014 effort. The Treaty does not provide the specific technical detail specifying how post-2024 Called Upon space would be calculated and used to reduce flood impacts in the U.S. This paper presents a technical approach on how the space requirements would be calculated.

Proposed Procedure for Development of Called Upon Space Requirements

Figure 1 was developed to determine the amount of Canadian Called Upon storage space that would be required for flood risk management studies. The need for Called Upon was assumed to occur only in years that the April-August runoff volume at The Dalles would exceed 120 Maf. Information required to determine that amount of space required on April 30 are: volume forecast at The Dalles for the current month, projected power drafts for Canadian projects on April 30, and projected flood storage drafts for the U.S. projects on April 30. To determine the Called Upon space required, determine the total amount of space required using Figure 1 and the current volume forecast (see Table C-1). Subtract from this number the total U.S. flood storage drafts and Canadian power drafts. If the number is negative, no additional drafts are need. If the number is positive, this is the amount of Canadian Called Upon that is required.

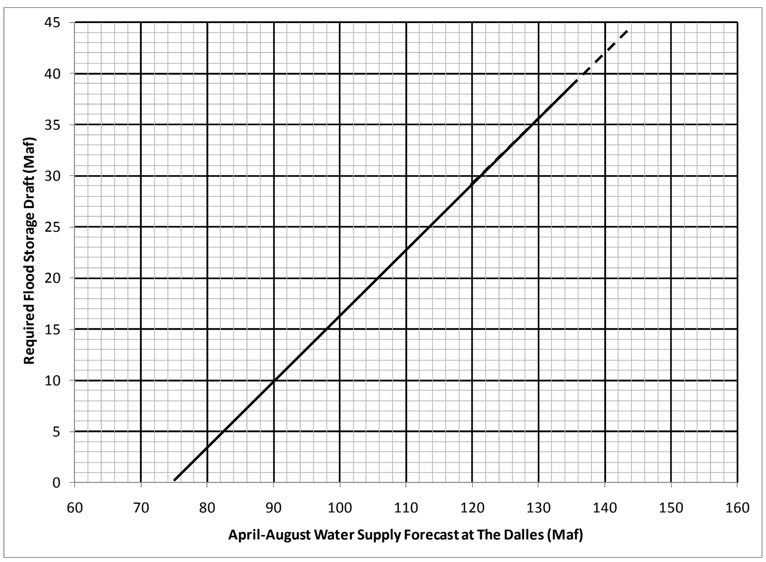

Figure 1 – Chart for Determining Flood Storage Space Requirement (Proposed)

Testing of Proposed Procedure

The procedure was tested to determine resultant flows at The Dalles. There are only 5 years in the historical period of record that the procedure could be tested. Utilizing existing assumed power drafts for Canadian projects and SRDs for U.S. projects resulted in additional Called Upon drafts of 3-7 Maf. Resulting flows at The Dalles are shown in Table 1. The 1948 flood was one of the largest of record. The volume forecast for this event would not have triggered the need for Called Upon. The April 1 forecast was 98.1 Maf, well below the 120 Maf needed to make a Call for additional storage. The resulting flow at The Dalles without Called Upon space was 607 kcfs.

Year	April 30 Volume Forecast, Maf	Flow at The Dalles, kcfs
1956	129.8	533
1971	120.6	484
1972	126.5	565
1974	138.0	583
1997	125.3	518

Table1 – Called Upon and Resultant flows