Columbia River Treaty

2014/2024 Review

United States Entity Supplemental Report

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United States Entity

United State Entity Supplemental Report
Columbia River Treaty 2014/2024 Review

Executive Summary

The United States Entity Supplemental Report is a companion report to the Columbia River Treaty Phase 1 Report. Unlike the Phase 1 Report, which was prepared jointly by the Canadian and United States Treaty Entities[1], the Supplemental Report was produced by the Bonneville Power Administration (BPA) and the U.S. Army Corps of Engineers (Corps) on behalf of the U.S. Entity. It builds on the information compiled in the joint Phase 1 studies and is intended to be read in conjunction with the Phase 1 Report. The purpose of the Supplemental Report is to provide the results of additional studies (Supplemental studies) conducted by the U.S. Entity in which Endangered Species Act (ESA) Biological Opinions (BiOp) and other fish operations were added to the Phase 1 studies. These are important drivers of U.S. reservoir operations and including them in discussions of post-2024 Treaty scenarios represents a more realistic picture of the operation of U.S. projects. The information in the Supplemental Report will inform regional discussions to help develop additional studies for looking at potential post-2024 Treaty scenarios.

The Columbia River Treaty

The "Treaty between the United States and Canada Relating to Cooperative Development of the Water Resources of the Columbia River Basin," otherwise known as the Columbia River Treaty, has brought significant benefits to both the United States and Canada.

The Treaty, which the two countries signed in 1961 and which became effective in 1964, doubled the water storage capacity on the Columbia River system with the construction of three large storage projects (Duncan, Keenleyside and Mica) in Canada, and Libby Dam in the United States. These projects increased flood control and firm power generation in both Canada and the U.S. The increased firm power generation led to many related agreements including Congressional approval for construction of the Pacific Northwest-Pacific Southwest Intertie to carry surplus power to the Southwest.

Under the terms of the Treaty, the U.S. purchase of a dedicated amount of annual flood control storage for the first 60 years of the Treaty will automatically expire on September 16, 2024, and be replaced by a provision where the U.S. may "Call Upon" Canadian storage as needed to meet U.S. flood control needs that cannot be adequately met by all related flood control facilities in the U.S. The U.S. must then pay Canada for its operating expenses and economic losses due to the Called Upon operation.

[1] The Treaty established Canadian and U.S. Entities as implementing agents for each government. The Bonneville Power Administration (BPA) Administrator and the U.S. Army Corps of Engineers (Corps) Division Engineer, Northwestern Division, were designated as the U.S. Entity. British Columbia Hydro and Power Authority (BC Hydro) was designated as the Canadian Entity.

In addition, although the Treaty has no specified termination date, September 16, 2024 is the earliest date that either Canada or the U.S. has the option to terminate most of the provisions of the Treaty, once a minimum 10 years' advance written notice is given. The Treaty provisions regarding post-2024 flood control remain in effect regardless of whether Canada or the U.S. provides notice of termination.

Initial Phase 1 Studies

Given the significance of these provisions, it was important for the Canadian and U.S. Entities to work toward an understanding of the implications for post-2024 Treaty planning and Columbia River operations. The joint effort by the Entities to conduct initial post-2024 modeling and analysis is referred to as Phase 1 of the 2014/2024 Columbia River Treaty Review. The Phase 1 studies were intended to provide fundamental information about post-2024 conditions both with and without the Treaty and only from the limited perspective of power and flood control, the two purposes recognized in the Treaty.

The Entities designed the Phase 1 studies to model post-2024 river operations with three basic scenarios:

Treaty Continues: The Treaty was assumed to continue post-2024 with its current provisions. Canadian flood control obligations would change from the current prescribed annual operation of a dedicated amount of storage to an assumed Called Upon operation. Treaty planning for power benefits and Canadian Entitlement provisions would continue, but modifications to current procedures would be required to reflect the revised Canadian flood control obligations.

Treaty is Terminated: The Treaty was assumed to be terminated in 2024 with no replacement agreement. The U.S. payment of the Canadian Entitlement would end, as would the requirement for Canada to regulate flows for U.S. power interests. Canadian flood control obligations would change to an assumed Called Upon operation. Two Canadian operational scenarios were developed to depict a range of possible flows across the border into the U.S. One scenario represented a Canadian operation with minimal Canadian reservoir storage draft, for local flood control only, and one scenario represented a Canadian reservoir draft primarily for power production in Canada.

Continuation of Pre-2024 Conditions: The Treaty was assumed to continue post-2024 with the pre-2024 Flood Control Operating Plan (FCOP), Treaty planning, and Canadian Entitlement procedures. This study is not consistent with the existing Treaty language in that it assumed the current coordinated FCOP operation would continue post-2024. To actually continue the current FCOP, new arrangements (e.g., an extension or replacement of the current flood control purchase) would be required. This study was conducted to provide a basis for comparison with current operations.

In order to model the implementation of Called Upon flood control in the Phase 1 studies, a maximum flow objective at The Dalles, Oregon, was needed. For these studies, the maximum flood control flow objective is the level to which significant flood damages are assumed to begin to occur in the lower Columbia and it also defines at what level the U.S. may call upon storage in Canada under post-2024 conditions. Given the uncertainty of future flood control needs, the Phase 1 and Supplemental studies looked at two potential scenarios of U.S. flood control

objectives. For studies implementing Called Upon, the analyses used both 450 and 600 thousand cubic feet per second (kcfs) as the maximum flow objective.

Additional information and the results of the joint Phase 1 studies can be found in the Phase 1 Report at: http://www.crt2014-2024review.gov/

Supplemental Studies

The Phase 1 studies were primarily concerned with the operation of Canadian projects and, consistent with current Treaty planning procedures requirements, did not include fish operations at U.S. projects. Therefore, the Phase 1 studies did not depict realistic reservoir operations and generation at U.S. projects. The Supplemental studies included additional operations at U.S. projects that are intended to improve fish passage and survival of various fish species in the U.S. portion of the Columbia River and its tributaries. These additional operations have been implemented in the last 15 to 20 years, largely as the result of BiOps related to consultations for the Federal Columbia River Power System (FCRPS) under the ESA. The operations referred to as BiOp operations in the Supplemental studies do not include all ESA BiOp operations, however, they do include the majority of FCRPS reservoir and mainstem Columbia River flow objectives in a manner similar to Treaty and regional planning studies conducted by BPA and the Corps.

The Supplemental studies used the Canadian and U.S. end-of-month flood control elevations and Canadian reservoir operations from the Phase 1 studies. The U.S. projects were then modeled using this information for flows across the border into the U.S., combined with the Phase 1 U.S. project flood control operation, and the U.S. fish operations.

Study Assumptions and Limitations

It is important to understand where assumptions and methodologies may have been the primary influence in the results in order to make the best use of the study data and conclusions. While the U.S. Entity believes that the assumptions it made in the studies are reasonable, there is a high degree of uncertainty around some of the assumptions, and the use of different assumptions could produce different results than contained in the Phase 1 Report and this Supplemental Report. The Supplemental Report identified five areas that warrant particular attention in further studies and analyses:

- Methodologies and Requirements of Called Upon Flood Control
- Power Load and Resource Forecasts
- Modeling and Procedures
- Modeling Time-step
- Future Canadian Operating Scenarios

Because of these and other study assumptions and limitations, it is important to use caution when interpreting the study data and making any firm conclusions about future river operations at this stage of analysis. The Phase 1 and Supplemental studies were only intended to provide base information from a very limited perspective and scope and were never intended to provide the sole basis for any recommendation on the Treaty future. The studies themselves and their results

will be used as a tool for opening up broader discussions and for scoping and designing future work.

Supplemental Study Results

Flood Control

- The Supplemental studies indicated that Called Upon flood control operations limited the ability to meet fish objectives in the U.S. Two specific examples include Libby and Arrow projects. These issues will be more fully evaluated in future studies.
- In the Supplemental studies, assumptions about Called Upon operations were a stronger influence on the ability of U.S. reservoirs to meet fish operating criteria than other variables relating to Treaty continuation versus termination.

U.S. Reservoir Levels

- On average, the addition of fish operations to the Phase 1 scenarios resulted in higher reservoir levels during the January through April period due to the BiOp criteria to operate U.S. projects to their upper flood control rule curves by mid-April.
- Comparing across all Supplemental studies, there were significant differences in average elevation which were primarily driven by the flood control maximum flow objective at The Dalles, not by continuing or terminating the Treaty. The 450 kcfs studies generally produced deeper drafts during the January through April period, on a 70-year average basis, than the 600 kcfs studies because the projects drafted deeper for flood control more often in the 450 kcfs studies than the 600 kcfs studies.

U.S. Hydropower Generation

- Comparing the Supplemental studies to the Phase 1 studies showed the inclusion of fish operations reduced the U.S. system generation by about 1520 to 1665 annual average megawatts (aMW). This loss of generation occurred with or without the Treaty continuing and was the largest difference when comparing the Phase 1 studies to the Supplemental studies.
- Comparing terminating the Treaty to continuing the Treaty, the Supplemental studies showed that terminating the Treaty resulted in a relatively small decrease in annual average generation of 90-94 aMW (less than 1 percent of the total system generation), however, the amount varied by month and across different water conditions. In the 20 lowest runoff years, this decrease was close to 200 annual aMW. In general, generation was higher in the winter and spring, lower in the summer and fall, and much lower in the summer during low water years (by more than 1000 aMW).
- Comparing a 450 kcfs flow objective to the 600 kcfs flow objective, the Supplemental studies showed that the 450 kcfs flood control objective increased the January – April average generation and decreased the average May - July generation compared to the 600 kcfs objective. Regardless of Treaty continuation or termination, the net result was a 50 to 54 aMW increase in average annual generation.
- The Supplemental studies show that the net effect of terminating the Treaty, when including both generation impacts and the end of the Canadian Entitlement, is a large gain in available

U.S. hydropower generation in the fall, winter, and spring during almost all water conditions, and in the summer during high water conditions. However, there are many uncertainties in future operating policies, markets, renewable resources, peaking operations, wind integration, etc., that were not considered in the Phase 1 and Supplemental studies, that could significantly change this result.

Fish Objectives

- Looking across all scenarios (on a 70-year average), the largest impact on the ability to meet the fish flow objectives was due to the maximum flood control objective at The Dalles, not whether the Treaty terminated or continued.
- The ability to meet fish flow objectives in the spring at Priest Rapids was primarily impacted by the maximum flood control objective at The Dalles. Managing for flood control objective of 450 kcfs, compared to 600 kcfs, reduced the ability to meet the fish flow objective for Priest Rapids by 5 more years out of 70 and reduced the average spring (Apr 16-Jun) flow by 12 kcfs with the Treaty and 17 kcfs without the Treaty.
- The ability to meet fish flow objectives at McNary was primarily impacted by the maximum flood control objective at The Dalles, mainly in the spring and slightly in the summer. For continuing the Treaty, the effect of changing the flood control objective from 600 kcfs to 450 kcfs reduced the ability to meet the spring fish flow objective at McNary by 8 years out of 70 and reduced the spring average flow by 15 kcfs, but only 1 year and 3 kcfs in the summer. The results are similar for Treaty termination, with spring fish flow objective missed in 9 more years and average flows reduced by 22 kcfs, and summer fish flow objectives were missed in 3 more years and average flows reduced by 6 kcfs.
- In general, none of the scenarios had much of an impact on the flows at Lower Granite in either the spring or summer.

Next Steps

This Supplemental Report was intended to provide additional follow-on information to the initial Phase 1 studies. It is important to understand that there are significant limitations on the scope and depth of this information, given that the U.S. Entity is only at the beginning of this process. It is recognized that additional collaborative work within the region will need to be done to further understand the implications of post-2024 Treaty scenarios on fish and related operations.

It is also recognized that other regional concerns such as ecosystem health, water supply and quality, climate change, cultural resources, recreation, navigation, irrigation, and other needs of river, that were not looked at in either the Phase 1 or Supplemental studies will need to be considered. The Corps of Engineers has also initiated a comprehensive Flood Risk Management (FRM) study to understand the potential implication of post-2024 Treaty changes on system flood control operations. All these factors will need to be considered in future work.

Moving forward, the U.S. Entity is fully committed to an open, collaborative, and region-wide engagement process, so that all voices in the Pacific Northwest that wish to be heard can inform and identify the best possible policy options in the 2014/2024 Columbia River Treaty Review. The Phase 1 and U.S. Entity Supplemental reports will provide valuable information moving forward, but are only the beginning of this important process.

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Disclaimer

The scenarios included in the United States Entity Supplemental Report (Supplemental Report) were identified for analysis purposes only and do not represent a determination, decision, or commitment by the U.S. Entity or U.S. government concerning any particular position, operation, or other course of action. Report results are non-binding on the U.S. Entity and U.S. government and do not prejudice any future position on, or interpretation of, Treaty rights and obligations. Furthermore, notwithstanding anything contained in the Supplemental Report, assumptions used in developing the Supplemental Report scenarios do not represent the future expected position, interpretation, or perspective on any matter of the U.S. Entity or the U.S. government.

Nothing in the report (including the studies undertaken) sets a precedent or implies agreement by the U.S. Entity concerning interpretation of Treaty rights and obligations. In addition, nothing in this report, or actions taken by the U.S. Entity and their representatives in preparing this report, represents a past practice or procedure or constitutes a Treaty modification or interpretation that prejudices, changes, or waives in any way Treaty rights and obligations. Finally:

- Preparation by the U.S. Entity of this report shall not be considered to be an acknowledgment or admission by the U.S. Entity of any facts, rights, or obligations related to the Treaty or Treaty operations.
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- No assumption or result identified in this report shall be considered to be an acknowledgment or admission by the U.S. Entity of any facts, rights, or obligations that may be implied by any such assumption or result, and the U.S. Entity reserves the right to revise or entirely change any assumption or result, notwithstanding its presence in this report.
- The absence of any scenario, alternative, curve, or similar output in this report is not to be considered an acknowledgment that such scenario, alternative, curve, or output is not valid or relevant to the 2014/2024 Columbia River Treaty Review.

1.0 INTRODUCTION

The Columbia River Treaty is an international agreement between Canada and the United States (U.S.) through which the two nations jointly regulate and manage the Columbia River for power and flood control as it flows from British Columbia into the U.S. The Treaty established the Canadian and U.S. Entities as the implementing agents for each government. The Administrator of Bonneville Power Administration (BPA) and the Division Engineer of the U.S. Army Corps of Engineers (Corps), Northwestern Division, serve as the U.S. Entity. The U.S. Entity collaborated with the Canadian Entity to jointly conduct the Columbia River Treaty 2014/2024 Review Phase 1 studies. The Phase 1 studies were an initial modeling and analysis effort designed to establish a preliminary baseline of information related to power generation and flood control for potential future river operations after 2024 under a limited set of future Treaty scenarios that both entities could use to support further discussion regarding the future of the Treaty. The Phase 1 Report[2] presenting the results of the joint Phase 1 studies was released for public information in July 2010.

This document is the U.S. Entity Supplemental Report (Supplemental Report), and is a U.S. Entity developed companion report to the jointly developed Columbia River Treaty Phase 1 Report. The Supplemental Report was produced by BPA and the Corps on behalf of the U.S. Entity. It builds on the information compiled in the joint Phase 1 studies and is intended to be read in conjunction with the Phase 1 Report. In addition, since this report is a companion to the Phase 1 Report, it often refers to acronyms and terms used and defined in the Phase 1 Report. If the term is not defined within this report, please refer to the Phase 1 Report, Appendix C "List of Acronyms and Glossary of Terms".

Many of the factors affecting the Treaty have a wide degree of uncertainty. The narrow range of assumptions used in the Phase 1 and Supplemental studies directly influenced the study results. Therefore, it is important to use caution when interpreting the study data or making any firm conclusions about future river operations. The Phase 1 and Supplemental studies were only intended to provide base information from a very limited perspective and scope and were never intended to provide conclusions or recommendations with regard to the Treaty future. Considerable more work needs to be done to understand the risks and uncertainty associated with evaluating and interpreting various post-2024 Treaty scenarios.

The Supplemental and Phase 1 reports did not fully evaluate all possible power and flood control implications, nor did they consider other regional concerns such as fish and wildlife, ecosystem health, water supply and quality, climate change, cultural resources, recreation, navigation, irrigation, and other needs of the Columbia River system. Instead the studies themselves and their results were intended to be used as tools for opening up broader discussions and for scoping and designing future work. With completion of these two reports, the U.S. Entity is fully committed to taking the next steps toward engaging the region in an open, collaborative process to listen to and understand the concerns and ideas of the Pacific Northwest with regards to the post-2024 future of the Columbia River Treaty.

[2] The Phase 1 Report and its appendices can be found at http://www.crt2014-2024review.gov/

1.1 PURPOSE

The purpose of the U.S. Entity Supplemental Report is to provide additional information beyond the Phase 1 studies. The Phase 1 studies and report were conducted and prepared jointly with the Canadian Entity and present the findings and results of those studies mutually agreed to by both Entities. In comparison, this Supplemental Report was prepared independently by the U.S. Entity. Nothing in this report is intended to contradict the Phase 1 study results and findings as presented in the Phase 1 Report. However, the Supplemental Report does present additional preliminary analysis and information that, from a U.S. Entity perspective, are important in order to inform discussions on potential Treaty futures.

In general, the planning and operation of the Canadian Treaty projects does not consider operations not defined in the actual Treaty or Treaty Protocol. Since the Phase 1 studies were primarily focused on looking at the two fundamental river purposes defined under the Treaty, power and flood control, the studies did not include additional operations not considered under the Treaty. By approaching the Phase 1 studies from this Treaty standpoint, both the U.S. and Canadian Entities believed they created a baseline of information for comparison to build from for future studies and for engagement with the sovereigns and stakeholders within their respective countries. However, the U.S. Entity is fully aware that a number of other river uses and needs significantly influence the U.S. operations. In particular, the U.S.'s obligations to carry out its Endangered Species Act (ESA) responsibilities for listed fish species affected by the Federal Columbia River Power System (FCRPS) have resulted in a profound and substantial change in the way the FCRPS is operated. The U.S. Entity felt it was important to look at the Phase 1 study results with the Biological Opinion (BiOp) operations included to provide a more realistic view of the operation of U.S. projects (refer to section 3.2.3 and Appendix A for additional information on the operations used in the Supplemental studies). Therefore, this report describes and provides study results from the additional modeling that was done to assess the impacts to the U.S. system and fish operations when the Called Upon operations and Canadian project operations from the Phase 1 studies were used in reservoir regulation studies which also operated U.S. projects for Biological Opinion fish requirements. (See Section 3.0)

1.2 REPORT DESCRIPTION

The Supplemental Report contains the following sections and Appendices:

Section 1 - Introduction: Includes a brief introduction to the Columbia River Treaty 2014/2024 Review, an explanation of what the Supplemental studies and report are and why they were done, and then provides general background on what critical provisions take effect September 16, 2024 as well as important background information on the Phase 1 studies and various key topics discussed in the report.

Section 2 - Phase 1 Studies: Includes an overview and description of the studies done in Phase 1 as well as listing a subset of the key findings from the Phase 1 studies that are pertinent to the Supplemental studies and report.

Section 3 - Supplemental Studies: Includes an overview and description of the Supplemental studies and the key findings from these additional studies.

Section 4 - Moving Forward: Includes a brief description of the next steps or actions are for the U.S. Entity beyond Phase 1.

Appendix A - U.S. Entity Supplemental Studies Methodology: Describes the methodology and modeling assumptions used in developing the Supplemental Studies.

Appendix B - Phase 1 Study Results Compared to the Supplemental Study Results: Compares the Phase 1 results with the Supplemental results on a 70-year average basis as well as by Called Upon subsets. The purpose of this Appendix is to highlight the changes to the Phase 1 studies related directly to the application of the fish operations and requirements.

Appendix C - Supplemental Study Results - 70-year Comparisons: Compares only Supplemental scenarios to Supplemental scenarios in order to evaluate the impact to fish operations from changes in various future conditions such as with and without the Treaty and for different flood control operations (FCOP, 450 kcfs maximum flow objective, and 600 kcfs maximum flow objective) on a 70-year average basis.

Appendix D - Supplemental Study Results - Called Upon Years: Compares only Supplemental scenarios to Supplemental scenarios in order to evaluate the impact to fish operations from changes in various future conditions such as with and without the Treaty and for different flood control operations (FCOP, 450 kcfs maximum flow objective, and 600 kcfs maximum flow objective) on a Called Upon-year average basis.

1.3 BACKGROUND

The “Treaty between the United States and Canada Relating to Cooperative Development of the Water Resources of the Columbia River Basin,” otherwise known as the Columbia River Treaty, has brought significant benefits to both the United States and Canada. It remains the standard against which other international water coordination agreements around the world are compared. When the Treaty was negotiated, its goals were to provide significant flood control and power generation benefits to both countries.

The Treaty contains two important provisions that take effect on September 16, 2024, that could impact the current power and flood control benefits:

1. Canadian flood control obligations automatically change from a pre-determined annual operation to a “Called Upon” operation.
2. The year 2024 is the earliest date that either Canada or the U.S. can terminate most of the provisions of the Treaty, with a minimum 10-years advance written notice.

Given the significance of these provisions, it is important for the Canadian and U.S. Entities to work toward an understanding of the implications for post-2024 Treaty planning and Columbia River operations. The joint effort by the Entities to conduct initial post-2024 modeling and analysis is referred to as Phase 1 of the 2014/2024 Columbia River Treaty Review.

1.3.1 PHASE 1 STUDIES

Phase 1 was intended to be the initial modeling and analysis phase of the 2014/2024 Columbia River Treaty Review and was a joint effort between the U.S. and Canadian Entities. Its purpose was to provide fundamental information about post-2024 conditions both with and without the Treaty and only from the limited perspective of power and flood control, the two uses of the river recognized in the Treaty.

The Entities designed the Phase 1 studies to model post-2024 river operations with three basic approaches:

1. Treaty Continues post-2024 and Called Upon flood control is implemented (Study A);
2. Treaty is Terminated in 2024 and Called Upon flood control is implemented (Study B); and
3. Treaty Continues post-2024 with largely the same Treaty operations as today (Study C).

Additional information on the Phase 1 studies can be found in Section 2.0 of this report or in the Phase 1 Report. The Phase 1 studies provided the base information on flood control (Called Upon) and Canadian operations used in the development of the Supplemental studies. A broader description of the Supplemental studies can be found in Section 3.0.

1.3.2 PHASE 1 FLOOD CONTROL

Flood control will play a major role in future studies to evaluate potential Treaty scenarios. The Treaty provides the basic outline for Called Upon flood control but contains little detail with respect to procedures and methodologies for actual implementation. The Phase 1 studies were a starting point to understand Called Upon by examining one set of assumed procedures and methodologies. Those details remain to be resolved. The Phase 1 studies did help to clarify that there are four key issues that may directly impact the operation of U.S. reservoirs under both the Treaty continues and Treaty terminates scenarios, which are: 1) the level of flood control protection needed by the U.S., 2) the clarification and implementation of effective use of U.S. reservoirs for flood control, 3) the clarification of the limit on Called Upon use to no greater degree of flood control than prior to 2024, and 4) how will Canada be compensated. The Phase 1 studies helped to understand these issues, but the methodologies and application were by no means intended to be the answer on how to deal with these issues in the future. Perhaps one of the important findings from the Phase 1 studies was that considerable work and further studies are absolutely necessary to better understand these issues. The following describes some of the background information on these issues as well as how they were modeled in the Phase 1 studies:

Current flood control procedures for Treaty projects are described in the Columbia River Treaty Flood Control Operating Plan (FCOP) and provide the U.S. with assured flood control operations

for Canadian projects. These procedures are in effect through September 16, 2024. After this date, regardless of whether the Treaty is terminated or continues, flood control will change from the current procedures for dedicated annual storage space in Canadian reservoirs to a system in which the U.S. will need to call upon flood space from Canada when there is a potential that the U.S. cannot adequately control flood flows in the U.S. Called Upon is the term used when the U.S. requests this flood control space from Canada. Flood control studies were prepared under Phase 1 to develop potential Called Upon procedures for Canadian Treaty projects, to develop flood control operations for U.S. projects when Canada is Called Upon, and to evaluate the ability to meet the system flood objectives for a range of maximum flow objectives.

In the Phase 1 studies two different maximum flood control flow objectives were simulated: 450 kcfs and 600 kcfs as measured at The Dalles, Oregon. The 450 kcfs objective was selected because it is the current standard for flood control operations as cited in the FCOP. The 600 kcfs objective was selected because it is cited in the Treaty and Protocol as the threshold at which the U.S. can request additional space from Canada prior to 2024. According to the FCOP, flooding begins around 450 kcfs as measured at The Dalles, Oregon, while major damages begin around 600 kcfs in the lower Columbia. There are different views between the Canadian and U.S. Entities with regard to interpretation of Called Upon rights and obligations. However, the Phase 1 studies were conducted without prejudice to provide information regarding a potential range of future operations for both the Treaty Continues and Treaty is Terminated studies.

In Phase 1, flood control procedures for U.S. headwater projects (Libby, Hungry Horse and Dworshak) were developed for use during Called Upon years. Called “effective use”, these procedures followed the Treaty requirement that after 2024 the U.S. will use or plan for the use of all related storage in the U.S. before calling upon Canada to provide Called Upon storage. For the Phase 1 studies, this meant the projects were drafted to the extent needed to ensure minimum flow could be released during the spring runoff period to aid in reducing flows at The Dalles to below the flood flow objective. In addition, Grand Coulee and Brownlee reservoirs were drafted toward empty during Called Upon, and were regulated to reduce flows at The Dalles during the peak flow.

When Canada provides Called Upon flood control storage after 2024, the U.S. will be required to compensate Canada for any operating costs they incur and economic losses arising directly from Canada forgoing alternative uses of the storage used to provide the flood control in the U.S. How this compensation would be calculated and assessed is still yet to be understood and resolved was not analyzed in the Phase 1 studies.

1.3.3 CANADIAN ENTITLEMENT

Under the Treaty, the estimated increase in power generated at downstream U.S. dams as a result of the operation of Canadian Treaty storage is called the Downstream Power Benefits, and the Treaty requires the U.S. and Canada to share those benefits equally. The Canadian half of the calculated benefit is called the Canadian Entitlement and is delivered to the Province of British Columbia.

Calculation of potential changes in the Canadian Entitlement over time was an important issue that the Phase 1 studies attempted to look at. Although incorporation of BiOp requirements in the U.S. system operations does not directly impact the calculation of the Canadian Entitlement, it does play a role in the achievement of the overall downstream benefits realized through the coordination of the Canadian storage operation under the Treaty. The following background information is provided in order to better understand some of the issues surrounding the Canadian Entitlement when they are discussed later in Section 4.0.

The Treaty requires the Canadian Entitlement to be determined six years in advance, through a series of studies that create an Assured Operating Plan[3] (AOP) for Canadian Treaty storage and determine the resulting downstream power benefits. The downstream power benefits are the expected increase in dependable capacity and average annual usable energy generated at U.S. hydropower dams that existed or were under construction in 1961, using AOP operating criteria for only power and flood control objectives and today's thermal power resources to meet today's load shape. Once calculated and agreed to by the U.S. and Canadian Entities, the Canadian Entitlement must be delivered regardless of the actual power benefits which may occur. The actual benefits may be substantially different due to actual precipitation, U.S. reservoir and river operating requirements, power loads and markets, and other factors.

The Treaty requires delivery of the Canadian Entitlement to a point on the U.S.-Canada border near Oliver, British Columbia, or at such other points as mutually agreed. The Treaty also provides for disposals of the Canadian Entitlement within the United States. Canada initially sold the Canadian Entitlement for $254 million to a consortium of U.S. utilities for a period of 30 years. The agreement for this sale expired completely in 2003. Since then, the Canadian Entitlement power is delivered on a daily schedule to the Province of British Columbia at two points on the U.S.-Canada border – one near Blaine, Washington, and the other near Nelway, British Columbia – for Canada's use or resale.

The U.S. Government is obligated to ensure that sufficient generating and transmission resources are available to deliver the Canadian Entitlement to the border. In the 1990's, the Entities reached agreement on the points of delivery to Canada for the Canadian Entitlement, as well as the methods for delivery. Under this agreement, the Entitlement power is pre-scheduled each workday for the following day, except holidays and weekends are scheduled through the next workday. The Canadian Entity may schedule delivery of any amount on any hour up to a maximum of the Capacity Entitlement, but must take delivery each month of an amount of energy equal to a constant annual rate of delivery. B.C. Hydro uses the Entitlement power either to meet load in B.C. or merge the power with their hydro system flexibility to sell a variable power product into U.S. markets. The arrangements agreed to by the Entities for Canadian Entitlement delivery expire at midnight on September 15, 2024 (the same date as the earliest termination date of the Treaty).

The U.S. Entity has separate agreements with the owners of the five mid-Columbia nonfederal dams, which are downstream and benefit from the operation of Treaty storage, to deliver to BPA

[3] The Assured Operating Plan can be found at http://www.crt2014-2024review.gov/Planning.aspx

27.5 percent of a calculated estimate of the Entitlement. The power is delivered on a fixed annual schedule on heavy load hours only. BPA is responsible for delivering all of the Canadian Entitlement to British Columbia.

1.4 KEY ASSUMPTIONS AND LIMITATIONS IN THE PHASE 1 AND SUPPLEMENTAL STUDIES

Careful attention and thought went into modeling and projecting what the future may hold in 2024-25 and as far out as 2044-45 in the Phase 1 studies, including important assumptions that were made throughout the process. Many of these assumptions had significant influence on the outcome of the Phase 1 studies and consequently the Supplemental studies. While the U.S. Entity believes that the assumptions it made in the studies are reasonable, the U.S. Entity also fully acknowledges that the use of different assumptions could produce vastly different results than contained in the Phase 1 Report and this Supplemental Report.

In addition, like all future modeling exercises, there are certain limitations of the Phase 1 and Supplemental studies that must be recognized. Some of these limitations relate to methods that were used to attempt to keep the studies manageable, while others are the result of key assumptions that were made.

In order to make the best use of the study results, it is important to understand where assumptions and methodologies may have been the primary influence in the results and where limitations in the modeling and analysis exist. The following discusses where some, but not all, of the key areas for study assumptions and limitations can be found:

- **Methodologies and Requirements of Called Upon**. While the Treaty includes provisions for requesting Called Upon flood control after 2024, neither the Treaty nor the Protocol provide a concise description of operational procedures that will be needed to implement Called Upon flood control on a planning or real-time basis. For the purposes of these studies, the preliminary assumptions represent a single way the procedure could be implemented and therefore do not evaluate the many uncertainties associated with Called Upon implementation. As an example, the results of the Phase 1 studies indicated many more Called Upon years than historically observed because the assumed procedure simply triggered the need for Called Upon flood storage based upon unregulated runoff volume. Subsequently, the Phase 1 Report emphasizes the need for further evaluation of future operations to refine the procedure and identify an approach that meets the requirements of both the U.S. and Canada.
- **Power Load and Resource Assumptions**. For these studies, assumptions on future loads and resources from updates to BPA's "2007 Pacific Northwest Loads and Resources Study", combined with assumptions about requirements for Renewable Portfolio Standards, were used to forecast future loads and resources in the region. There is, however, a wide range of uncertainty associated with forecasting future growth of loads, thermal generating plants, renewable generating resources, and extra-regional imports and exports – which are among the most important factors affecting Treaty

planning and the calculation of the Canadian Entitlement for the scenarios where the Treaty continues. These factors also have potentially similar impacts on Canadian and U.S. reservoir operations and power benefits for the scenarios without the Treaty.

- **Modeling and Procedural Assumptions**. By design, the Phase 1 and Supplemental studies have a limited number of assumptions on future operating strategies and policies for Columbia basin reservoirs that can affect the study results. Except for Called Upon flood control, current planning policies and procedures were used to guide the operation of the Columbia River basin dams (e.g. critical and operating rule curves and Biological Opinion requirements). Future studies need to consider changes to planning procedures and requirements that more directly meet or balance the competing operating objectives.
- **Modeling Time-step**. The Phase 1 studies and Supplemental studies used monthly or daily time steps in computer models that simulate the operation of Columbia River basin dams. Daily time-steps were only used for flood control studies. Monthly time-steps were used to simulate actual Treaty planning modeling and to simplify the analysis and allow a wider range of flow years and scenarios to be studied. However, there are some types of impacts that cannot be seen with these time-steps. Therefore, more detailed studies, using the appropriate time-steps, are needed to fully understand the impact on various operating objectives.
- **Future Canadian Operating Scenarios**. The range of possible flows across the border from Canada under the Treaty is Terminated study was purposely limited to only two scenarios developed by the Canadian Entity. The first scenario represented a Canadian reservoir operation with minimal Canadian draft to meet only local flood control needs (B1), and the second scenario represented a Canadian reservoir operation for power production in Canada (B2). In many respects the B1 scenarios were not considered plausible future scenarios since they did not include any power operation for Canadian projects. It is unlikely that Canada would not use their projects for some degree of power production in the future. Therefore, B1 was not considered realistic and most of the results shown in the Supplemental Report focus on only the B2 power scenarios. However, by limiting the Treaty is Terminated scenarios to only B2, the Supplemental studies did not assess the uncertainty of the assumptions that affect the flows across the border. To really understand this uncertainty, alternative study assumptions will need to be evaluated in the future.

Because of these and other assumptions and limitations, it is important to use caution when interpreting the study data and making any firm conclusions about future river operations. The Phase 1 and Supplemental studies were only intended to provide base information from a very limited perspective and scope and were never intended to provide the answer with regard to the Treaty future. Therefore, although both the Phase 1 and the Supplemental study results have been completed and shared, no firm conclusions about future river impacts have been or should be based on the Phase 1 or Supplemental studies. Instead, the studies themselves and their results should be used as a tool for opening up broader discussions and for scoping and designing future work.

2.0 PHASE 1 STUDIES

2.1 OVERVIEW OF PHASE 1 STUDIES

This section provides a brief overview and review of the Phase 1 studies as a prelude to the subsequent work and discussions that follow in this Supplemental Report. The summary of the studies and the results under this section are directly from the Phase 1 Report. Since these studies were done jointly by the U.S. and Canadian Entities, the wording in this section is as close as possible to the way the information appears in the Phase 1 Report, respecting the joint nature of the Phase 1 effort. For additional information and a more thorough discussion of the Phase 1 studies, please refer to the Phase 1 Report.

For these Phase 1 technical studies, the Entities agreed to limit the scope of the analyses to the three studies described below:

2.2 DESCRIPTION OF PHASE 1 STUDIES

Study A - Treaty Continues: The Treaty was assumed to continue post-2024 with its current provisions. Under this study, Canadian flood control obligations changed from the current prescribed annual operation of a dedicated amount of storage to an assumed Called Upon operation. Treaty planning and modeling for power benefits and Canadian Entitlement provisions were assumed to continue, but modifications to current procedures would be required to reflect revised Canadian flood control obligations.

Study B - Treaty is Terminated: The Treaty was assumed to be terminated in 2024 with no replacement agreement. The U.S. payment of the Canadian Entitlement would end, as would the requirement for Canada to regulate flows for U.S. power interests. Canadian flood control obligations would change to an assumed Called Upon operation. Two Canadian operational scenarios were developed to depict a range of possible flows across the border into the U.S. One scenario represented a Canadian operation with minimal Canadian reservoir storage draft, for local flood control only (B1), and one scenario represented a Canadian reservoir draft primarily for power production in Canada (B2).

Study C - Continuation of Pre-2024 Conditions: The Treaty was assumed to continue post-2024 with the pre-2024 Flood Control Operating Plan (FCOP), Treaty planning, and Canadian Entitlement procedures. This study is not consistent with the existing Treaty language in that it assumed the current coordinated FCOP operation would continue post-2024. To actually continue the current FCOP, new arrangements (e.g., an extension or replacement of the current flood control purchase) would be required. This study was conducted to provide a basis for comparison with current operations.

The following table is directly from the Phase 1 Report and provides additional information about each study in Phase 1. The table frequently refers to acronyms and terms that were defined in the Phase 1 Report. For definitions, please refer to either the Phase 1 Report itself or the Phase 1 Report, Appendix C “List of Acronyms and Glossary of Terms.”

Table 1 - Comparison of Phase 1 Studies

	Study A: Treaty Continues	Study B: Treaty is Terminated	Study C: Continuation of Pre-2024 Conditions
Overview	Treaty continues post-2024 with its current provisions. Canadian flood control obligations change from the current assured annual operation to a Called Upon operation. This study forecast what the AOP, Canadian and U.S. power and flood control operations, and Canadian Entitlement, might look like under these conditions post-2024.	The Treaty is Terminated in 2024 and Called Upon flood control is implemented. This study assessed two potential Canadian operational scenarios—one with minimal Canadian draft, for local flood control only; and one with reservoir draft specifically for power production in Canada.	Treaty continues with the current AOP, FCOP, and Canadian Entitlement procedures. This study forecast the AOP operating criteria and resulting Canadian and U.S. power and flood control operations, and the Canadian Entitlement, assuming the CRT continues with the existing pre-2024 provisions.
Flood Control	➢ Called Upon flood control based on regulating flows at The Dalles to a maximum flood control objective (450 kcfs or 600 kcfs). ➢ Libby standard flood control draft. ➢ Hungry Horse VarQ flood control draft. ➢ A1 Study: Grand Coulee flood control includes adjustment for Canadian upstream power draft. ➢ A2 Study: Grand Coulee flood control includes adjustment for upstream flood control draft only.	➢ Called Upon flood control based on regulating flows at The Dalles to a maximum flood control objective (450 kcfs or 600 kcfs). ➢ Libby VarQ flood control draft. ➢ Hungry Horse VarQ flood control draft. ➢ B1 Study: Grand Coulee flood control includes adjustment for Canadian flood control draft ➢ B2 Study: Grand Coulee flood control includes adjustment for Canadian power draft	➢ Mimics the current Annual FCOP procedures. ➢ Libby standard flood control draft. ➢ Hungry Horse VarQ flood control draft. ➢ Grand Coulee flood control includes adjustment for upstream flood control draft.
Loads and Resources	➢ Projected loads and resources for 2024-25.	➢ Projected loads and resources for 2024-25.	➢ Projected loads and resources for both 2024-25 and 2044-45.
Assured Operating Plan (AOP)	➢ Performed using current methodology, without the Canadian primary flood control obligation. ➢ Based on 2024-25 operating year. ➢ Performed critical period and 70-year hydroregulation studies using current methodology.	➢ No AOP. Instead, Canadian operation for power and flood control in Canada only, and U.S. operation modeled with an AOP-like study using assured fixed Canadian operation. ➢ Performed critical period and 70-year hydroregulation studies using current methodology. ➢ Based on 2024-25 operating year.	➢ Performed using current methodology. ➢ Based on 2024-25 and 2044-45 operating years. ➢ Critical period and 70-year hydroregulation studies performed for 2024-25 only. ➢ 2044-45 AOP study streamlined based on 2024-25 study work.

	Study A: Treaty Continues	Study B: Treaty is Terminated	Study C: Continuation of Pre-2024 Conditions
Canadian Entitlement (DDPB)	➢ Performed critical period and 30-year studies for determining Canadian Entitlement for 2024-25 operating year.	➢ Canadian Entitlement discontinued.	➢ Performed critical period and 30-year studies for determining Canadian Entitlement for 2024-25 and 2044-45 operating years.
Called Upon Power Impact Study	➢ TSR-like studies were performed to assess power impacts due to Called Upon operation	➢ TSR-like studies were performed to assess power impacts due to Called Upon operation	➢ No power impact assessments were done for this study.
Simulation Mode	➢ A1: Both observed and forecast. ➢ A2: Observed only	➢ B1: Observed and forecast. ➢ B2: Forecast only.	➢ Observed mode only.
Key Assumptions and Factors	➢ AOPs and Canadian Entitlement provisions continue, but modifications to current procedures would be required to reflect the different Canadian flood control obligations. ➢ Called Upon is considered a real-time operation and is not modeled in the planning studies but instead occurs in power studies and real-time modeling.	➢ U.S. flood control operation treats Canadian power draft as assured, even though it is not assured with Treaty termination. ➢ Called Upon is considered a real-time operation and is not modeled in the planning studies but instead occurs in power studies and real-time modeling.	➢ The current FCOP remains in place; however, new arrangements (e.g., an extension or replacement of the current flood control purchase) would be required to implement these study conditions. ➢ This study was conducted to provide a basis for comparison with current operations and to model the potential change in Canadian Entitlement over time.

2.3 KEY RESULTS FROM THE PHASE 1 STUDIES

The results shown below are directly from the Phase 1 Report. The key points listed are only a subset of those Phase 1 findings that are relevant to the issues and modeling done in this Supplemental Report. For a complete listing of the Phase 1 summary and key findings please refer to the Phase 1 Report.

2.3.1 CANADIAN ENTITLEMENT

- Based on the assumptions used, the Phase 1 studies indicated that Canadian Entitlement energy decreased from 470 aMW in 2025 to a minimum value of approximately 290 aMW by about 2040. The Entitlement capacity increased from 1340 MW to 1524 MW, primarily due to a change in the length of the critical period.

- The primary factors affecting the Canadian Entitlement Energy are the amount of load growth and type of new resources, especially the mix of thermal and renewable resources. There is a high level of uncertainty associated with these parameters. Less load growth and more renewable resources would reduce the need for thermal installations, and having less thermal generation would actually increase the Canadian Entitlement Energy.

2.3.2 FLOOD CONTROL

- Implementation of procedures to make effective use of U.S. storage caused the U.S. projects to draft substantially deeper during Called Upon years compared to current flood control operations.

- Implementation of effective use of U.S. projects with the maximum flow objective at 450 kcfs caused Grand Coulee to draft empty 28 to 30 times out of 70 years. Under the Treaty Continues with pre-2024 flood control (FCOP), only 4 years out of 70 required Grand Coulee to draft empty.

- Implementation of effective use of U.S. projects caused occasional refill failures (3 years at Libby, 6 at Hungry Horse, and 7 at Dworshak, but Grand Coulee refilled in all 70 years). While power draft of Canadian composite storage provided flood control benefits to the U.S., the Canadian reservoir elevations under either a Flex operation (A1) or a power operation (B2) often did not provide enough draft at Arrow for U.S. flood control.

- The Phase 1 studies examined Treaty planning and modeling as they pertain to power and flood control; however, impacts and results for many U.S. reservoirs were not necessarily representative of how the projects are actually operated because most U.S. reservoirs also include operations for fish and other non-power uses. Similarly, the Canadian Flex operation for the Phase 1 studies was developed based on the current load-resource balance, market conditions, and other factors without any consideration of non-power and other environmental needs. If additional evaluations of the Treaty future and the impacts

to U.S. reservoirs are undertaken, it is recommended that these evaluations consider applying non-power requirements to the results of the Phase 1 studies.

2.3.3 ARROW PLUS DUNCAN OUTFLOWS

- The Treaty is Terminated (B2) scenarios were intended to simulate a possible Canadian power operation. In this operation, Arrow plus Duncan outflows (without Called Upon implementation) were relatively constant across the year compared to the A1 Treaty power operations in order to minimize spill and maximize generation at Arrow. In comparison to Treaty Continues (A1), there was less flow in the winter and summer and more flow in spring.

- For the Treaty is Terminated studies (B2), the Arrow plus Duncan outflows mimicked the outflow shape of the Treaty Continues studies (A1) only when Called Upon was implemented, which required additional draft in the winter and less outflows during the refill period in the spring.

- In the Treaty is Terminated scenarios (B2), the reduction of Arrow plus Duncan outflows in August caused Grand Coulee to draft during the month and never recover toward full during the fall and early winter in most years. In the Treaty Continues scenarios (A1 and C), draft of Canadian projects for power maintained flows from Arrow during this period and allowed Grand Coulee to remain fuller.

2.3.4 GENERATION

- In the Treaty Continues scenarios (A1), the coordinated U.S./Canada assured power drafts provided substantial flood control benefits to the U.S., including more certainty and less additional volume of Canadian storage required as a direct result of a Called Upon flood control request.

- Overall, in the Treaty is Terminated scenarios (B2) the average annual energy production in Canada and the U.S. remained essentially unchanged in comparison to the A1 studies; however, the monthly shape differed dramatically from the coordinated operation found in the Treaty Continues scenarios.

- On average, the B2 scenarios shifted generation from high-value winter months to low-value spring freshet months, with the exception of Called Upon years where the flood control Called Upon operation reshaped the generation into the winter and out of the spring.

- Under the Treaty is Terminated scenarios (B2), the ability of the U.S. hydro system to meet firm loads in the critical water year diminished by approximately 225 aMW. In addition, the Critical Period was shortened from 4 years to 1 year, which may be of concern during prolonged low inflow conditions.

3.0 U.S. ENTITY SUPPLEMENTAL STUDIES

3.1 INTRODUCTION

To further investigate possible impacts to U.S. operations due to the changes in flood control and Canadian operations developed in the various scenarios in the Phase 1 studies, additional studies were run using the Phase 1 study results as the base starting point for Canadian operation and flood control.

Beyond flood control and power generation, most of the additional operations at U.S. projects involve operations intended to improve fish passage and survival of various fish species in the Columbia River and its tributaries. These additional operations have been implemented in the last 15 to 20 years, largely as the result of Biological Opinions (BiOps) related to consultations for the FCRPS under the Endangered Species Act (ESA). These operations are defined in the following Biological Opinions:

1. NOAA Fisheries FCRPS BiOp regarding salmon and steelhead, issued May 5, 2008 (Consistent with the 2010 Supplemental BiOp);
2. USFWS FCRPS BiOp regarding bull trout and Kootenai River white sturgeon, issued December 20, 2000;
3. USFWS Libby BiOp regarding bull trout and Kootenai River white sturgeon, issued February 18, 2006;
4. NOAA Fisheries Upper Snake BiOp, issued May 5, 2008; and
5. NOAA Fisheries Willamette BiOp, issued July 11, 2008.

The operations referred to as BiOp operations in the Supplemental studies do not include all ESA and BiOp requirements, however, they do include the majority of FCRPS reservoir and mainstem flow requirements. The major operations for fish used in these Supplemental studies are:

- Provide 1 Maf (1 million acre-feet) of Flow Augmentation storage/release in Canada through a Supplemental Operating Agreement (SOA) between the U.S. and Canada. This agreement includes whitefish and trout spawning flows below Arrow.
- Libby white sturgeon and bull trout flows
- Libby variable flow (VarQ) and variable December flood control elevation
- Vernita Bar protection flows for salmon and steelhead
- Lower Granite and McNary fish flow objectives for salmon
- Operate in fall and winter to provide flows below Bonneville Dam for chum salmon
- Spill for fish and spill caps to limit total dissolved gas (TDG) levels
- Limit project drafts to flood control or minimum flow
- Draft projects during the summer to enhance flows for fish
- Operate certain projects at minimum operating pool (MOP)

The various scenarios incorporating these operations are named with +BiOp to distinguish them from their respective Phase 1 studies. It should be noted that these Supplemental studies do not make any assumptions or decisions about how project operational requirements might change due to Called Upon flood control or flow changes from Canada. Data, requirements, and procedures were not modified from those used for the Rate Case study (refer to section 3.2.1).

Appendix A provides a more complete description of the required project operations for fish.

3.2 DESCRIPTION OF SUPPLEMENTAL STUDIES

3.2.1 KEY ASSUMPTIONS

1. The Treaty is Terminated studies (B) were based on two different Canadian operations provided by B.C. Hydro. The B1, or Canadian local flood control only scenarios, were initially intended to test the magnitude of the Canadian storage draft required for flood control without a power operation, but not intended to reflect a likely future scenario. The B2 scenarios reflected a possible Canadian power operation absent the Treaty, and were assumed to be a more likely Canadian operation than B1. Therefore, for comparison and evaluation of the Treaty is Terminated scenarios, the B2 scenarios are primarily shown in the Supplemental Report results, rather than the B1 scenarios. The exception to this is under the section which looks at the Arrow plus Duncan outflows (Section 3.3.1), where a comparison of B1 and B2 is provided to compare cross-border flows given the two different objectives, power and flood control, for the Canadian projects. Even though the B2 scenarios were the focus of the results in this report, it is very important to remember that B2 is just one Canadian reservoir operation and therefore not representative of the range of possible future operations.

2. In addition to the Phase 1 scenarios listed above, the Phase 1 studies were also done in both observed mode (reservoir regulation decisions are based on perfect knowledge of future runoff volumes and streamflow shape) and forecast mode (reservoir regulation decisions are based on water supply forecasts). As a result of the Phase 1 studies, the forecast mode scenarios were recognized as being more relevant in depicting the uncertainty and risk involved in actual implementation of Called Upon operations. Therefore, the results evaluated in the Supplemental Report are based entirely on forecast mode scenarios.

3. Also of note, the Phase 1 studies and consequently the Supplemental scenarios were run in 14 period (monthly except April and August are split) time-steps. While this provides a general understanding of various aspects of the system, it does not allow for specific evaluation of many important parameters, such as peak load, dissolved gas, water temperature, etc., that require smaller time-steps such as daily and hourly. Analysis of parameters requiring shorter time-steps may be considered in future studies and evaluation.

4. A recent BPA 2010 Rate Case study[4] was the basis for the Supplemental studies. This rate case study included system operations under the May 5, 2008 final BiOp RPA[5]. Data used from the BPA Rate Case reflected 2010 levels and criteria for:

    - U.S. projects' operating requirements
    - Loads
    - Outages
    - Hydro Independent data

5. The B1 and B2 scenarios did not include flow augmentation storage operations similar to those included in the A and C studies. Flow Augmentation is part of a Supplemental Operating Agreement under the current Detailed Operating Plans that helps meets both Canadian and U.S. fishery needs. For the Treaty is Terminated scenarios, the studies assumed Canada will operate to meet their fishery objectives without the need to provide flow augmentation for the U.S.

3.2.2 GENERAL METHODOLOGY

For each scenario with fish requirements included (+BiOp), the flood control curves (reflecting a Called Upon operation where appropriate) and the operations of the Canadian Treaty projects (Mica, Arrow, and Duncan) developed in the respective Phase 1 studies replaced the flood control and Canadian operation in the Rate Case study.

For the Supplemental studies there were three possible Canadian operations from the Phase 1 studies. In the Treaty Continues scenarios, or the A1 studies, Canada provided a possible Flex[6] power operation of Mica, Arrow, and Duncan. In the studies where the Treaty is Terminated there were two possible scenarios. The B1 scenarios operated Mica, Arrow, and Duncan for local Canadian flood control only and for the B2 scenarios Canada provided a possible power operation for Mica, Arrow, and Duncan. The B1 scenarios were not focused on for comparison with the Treaty continues scenarios in this report as the B1 scenarios were considered unlikely future Canadian operations. See the Phase 1 Report for further information about the B1 operations from Canada.

All of the Supplemental studies except C+BiOp used the flood control end of month elevations from their respective Phase 1 studies which were based on forecast volumes and included Called Upon and Libby VarQ flood control. The C+BiOp study used flood control elevations provided by the Corps for the BPA Rate Case study. These flood control elevations were also based on forecast volumes and included Libby VarQ, but used the current Flood Control Operating Plan which does not reflect a Called Upon flood control operation.

In the +BiOp studies where the Treaty Continues (studies A and C), a Supplemental Operating Agreement (SOA) between Canada and the U.S. was assumed. The SOA allowed Canadian

[4] Specifically, the Rate Case base was from the "08_RateCase10_final" from the final 2010 study
[5] Reasonable and Prudent Action
[6] Canada has the flexibility (Flex) to operate their individual projects for maximum Canadian benefits, so long as the sum of Arrow plus Duncan outflows is the same as that specified in Treaty planning.

operations to be modified to provide, when possible, storage of 1 Maf at Arrow in January for release in May through July to improve flows in the U.S. for fish migration. The SOA also contained provisions to improve outflows downstream of Arrow for whitefish and trout spawning. For studies without the Treaty (B studies) Mica, Arrow, and Duncan were fixed to their Phase 1 operations. No agreements were assumed with Canada for either Flow Augmentation or whitefish and trout spawning flows.

3.2.3 BIOP OPERATING REQUIREMENTS FOR U.S. PROJECTS

The specific BiOp operations used in the Supplemental studies reflected the operations used in the BPA Rate Case study referenced in Section 3.2.1 item 4. Most of the operations listed below were not included in the original Phase 1 studies, unless otherwise noted under each operation. For more detailed information about the operations included in the Supplemental studies, refer to Appendix A. In general, the BiOp operating requirements for U.S. projects included:

Libby:

- Variable end of December flood control and VarQ flood control *(also included in B scenarios of the Phase 1 studies)*
- Operate at minimum flow or flood control during the drawdown period
- Maximize storage by June 30th for release during the summer
- Operate May - June for sturgeon and May 15th - September 30th for Bull Trout

Hungry Horse:

- Operate to VarQ flood control or minimum flows at site and at Columbia Falls
- January - March, operate to the computed Variable Draft Limits (VDL)[7]
- Target flood control elevation on April 10th
- Maximize storage by June 30th for release during the summer

Grand Coulee:

- Operate to elevation 1283 feet on September 30th for Kokanee spawning
- Operate to meet FELCC October – December, subject to draft limits
- January - March, operate to the higher of winter draft limits or the VDLs
- Target flood control elevation on April 10th and April 15th
- Draft to the lower of flood control or draft limits to support Priest Rapids and McNary flow augmentation objectives

Priest Rapids Flow:

- Meet Vernita Bar minimum flows December – May
- Minimum flow objective of 135 kcfs for steelhead and salmon April - June

[7] Variable Draft Limits (VDLs) are defined by the Bureau of Reclamation for Hungry Horse and Grand Coulee. These are draft limits to protect the ability to refill at Hungry Horse and Grand Coulee to each project's April 10th flood control elevation objective with 75% and 85% confidence, respectively.

Dworshak: *(the following operations were also included in the Phase 1 A studies)*

- October - June, operate on minimum flow of 1300 cfs or flood control
- July - August, end of August target elevation of 1535 feet with smooth draft
- September, draft to elevation 1520 feet by September 15th and then minimum flow

Lower Snake projects: *(also included in the Phase 1 A studies, except for Ice Harbor)*

- Operate at MOP (minimum operating pool) during fish migration season
- Operate turbines within 1% of peak efficiency during March - November

Lower Columbia River projects:

- Operate turbines within 1% of peak efficiency during March – November

McNary Flow:

- Grand Coulee, Hungry Horse, and Libby (in that order) contribute to spring and summer flow objectives of 200 - 260 kcfs
- Juvenile passage spill and dissolved gas caps from the Pacific Northwest Coordination Agreement (PNCA) planning for Operating Year 2008
- Spill for fish passage at federal and nonfederal projects

Bonneville chum spawning:

- Flows for chum for November - March based on Bonneville tailwater elevation, modeled as a minimum flow at Bonneville of 125 kcfs from Nov – Mar

Under current operations, all flood control rule curves and requirements are limits to implementing the BiOp objectives. For the post-2024 studies, it is assumed that the changes to the flood control rule curves needed to implement Called Upon may also impact implementation of current BiOp objectives[8].

3.3 SUMMARY OF KEY FINDINGS FROM THE SUPPLEMENTAL STUDIES

The following sections provide a summary of the key findings from the additional modeling that was done to look at the impacts to generation, reservoirs, and fish objectives when the Phase 1 studies had the current fish operations and requirements incorporated. There are really two ways to look at these results. One is comparing the results from the Phase 1 studies to the Supplemental studies to see what the resulting reservoir levels, flows, and generations would be if the Phase 1 scenarios were actually implemented in real operations. The second way to look at the results is to compare Supplemental studies to Supplemental studies. From this perspective the impacts of Called Upon and continuing the Treaty or terminating the Treaty on fish operations can be compared. In general, each section below is divided into these two perspectives for clarity and comparison.

[8] It is anticipated that ESA consultation will occur if there is a significant change in operations that may affect listed species.

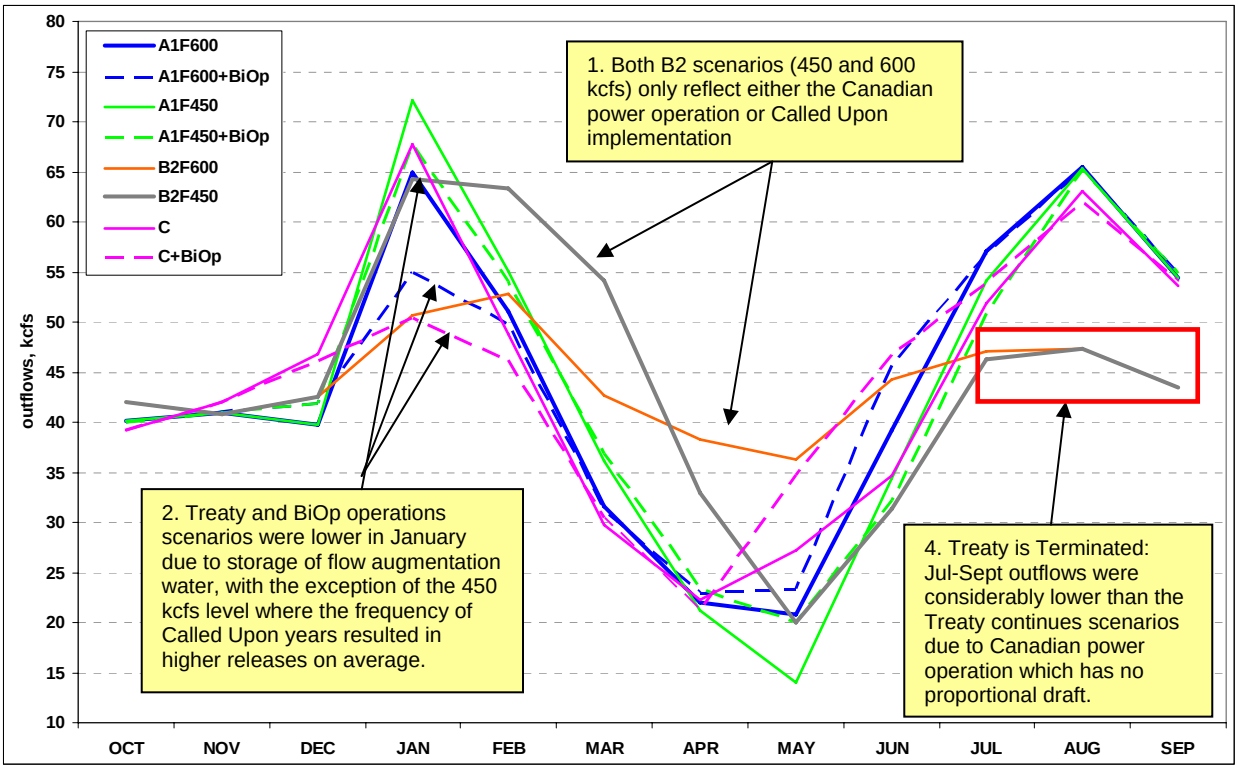
The study groups that are referred to in this section are:

1. Treaty Continues post-2024 and Called Upon flood control is implemented (Study A);
2. Treaty is Terminated in 2024 and Called Upon flood control is implemented (Study B); and
3. Treaty Continues post-2024 with largely the same Treaty operations as today (Study C).

3.3.1 ARROW PLUS DUNCAN OUTFLOWS

Figure 1 - Arrow plus Duncan Outflows - Phase 1 and Supplemental Studies 70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	40	41	40	65	51	32	22	21	39	57	65	54
A1F600+BiOp	40	41	42	55	50	31	23	23	46	57	65	55
A1F450	40	41	40	72	55	36	21	14	34	54	65	54
A1F450+BiOp	40	41	42	68	54	37	23	20	32	51	65	55
B2F600	42	41	43	51	53	43	38	36	44	47	47	44
B2F450	42	41	43	64	63	54	33	20	31	46	47	44
C	39	42	47	68	49	30	22	27	35	52	63	54
C+BiOp	39	42	46	50	46	30	21	35	47	54	62	54



<u>Phase 1 to Supplemental Studies Comparison</u>

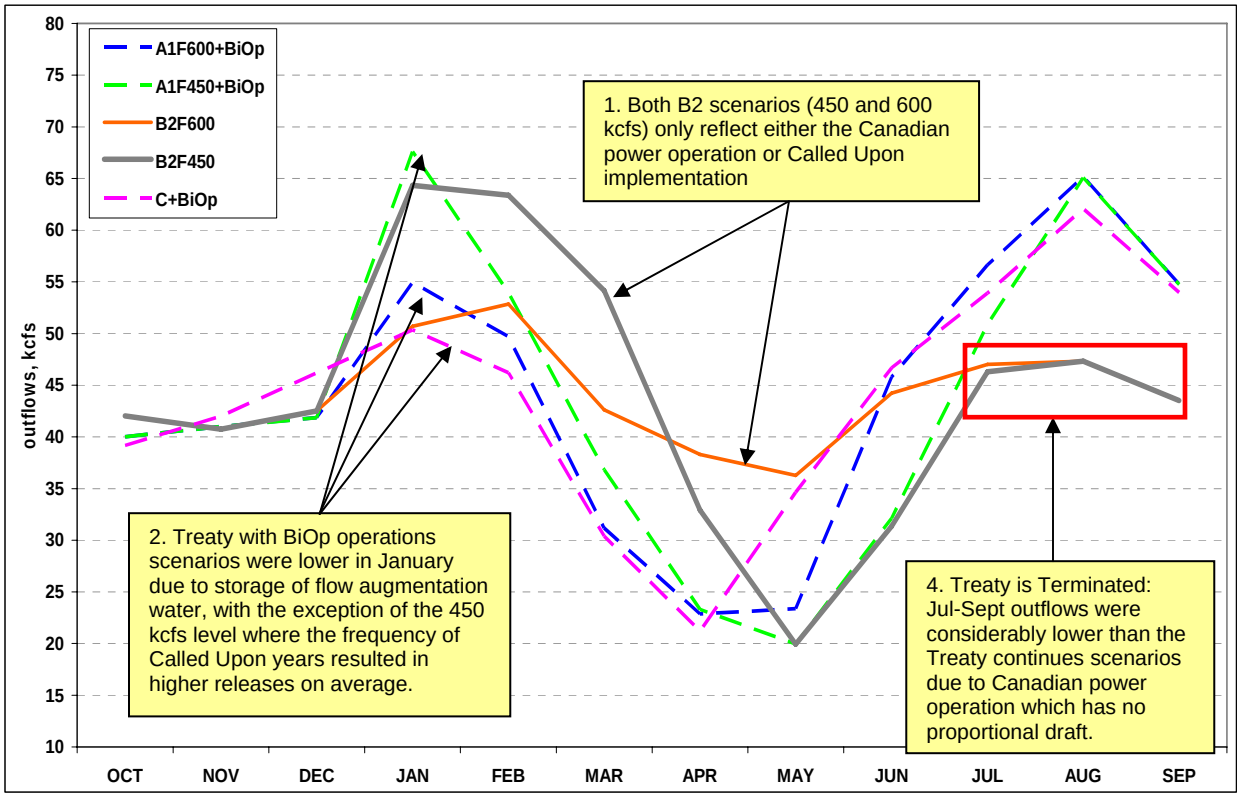
1. For the Treaty is Terminated scenarios, it was assumed for the Phase 1 and Supplemental studies that Canada would not agree to implement the storage of 1 Maf of BiOp flow augmentation water for the U.S. under a supplemental operating agreement. Therefore, the

Phase 1 and the Supplemental study results shown in Figure 1 only reflect the Canadian power operation (B2) with Called Upon implementation.

2. In the Supplemental studies with the Treaty Continues (A1F600 +BiOp and C+BiOp), Arrow plus Duncan outflows were lower in January than the corresponding Phase 1 scenarios due to the storage of flow augmentation water during this time. The 450 kcfs maximum flow objective (A1F450+BiOp) showed less difference due to the Called Upon need to draft the Canadian projects limited the ability to store flow augmentation water.
3. The release of the flow augmentation water in the spring caused the Supplemental studies with Treaty Continues (A1F600+BiOp and C+BiOp) to provide higher outflows, on average, for flow augmentation than their corresponding Phase 1 scenarios. The 450 kcfs maximum flow objective scenario (A1F450+BiOp) showed less of a difference due to Called Upon limiting the amount of flow augmentation and reservoir refill.
4. Outflows during the July- September period were considerably lower for the Phase 1 Treaty is Terminated scenarios (B2) compared to any of the Phase 1 Treaty Continues (A1 and C) or Supplemental scenarios with Treaty Continues (A1+BiOp and C+BiOp) due to the Canadian power operation significantly reducing outflows from Arrow and the loss of Treaty proportional draft from Canada during this period.
5. The Treaty is Terminated scenarios (B2) reflected either the Canadian power operation or Called Upon flood control. Terminating the Treaty resulted in higher Arrow plus Duncan outflows during the February to April period as the Canadian power operation or Called Upon requirements were the key drivers during this period.
6. With the 450 kcfs scenarios (B2450), the higher frequency of Called Upon years (52 years) resulted in higher flows during the drawdown period and lower flows during the refill period compared to the 600 kcfs level. The 600 kcfs level (B2600) had fewer Called Upon years and therefore reflected a shape closer to the actual Canadian power operation. Under any Treaty is Terminated scenarios the results are highly dependent on the Canadian power operation provided and the number of times Called Upon is required.

Figure 2 - Arrow plus Duncan Outflows - Supplemental Studies
70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600+BiOp	40	41	42	55	50	31	23	23	46	57	65	55
A1F450+BiOp	40	41	42	68	54	37	23	20	32	51	65	55
B2F600	42	41	43	51	53	43	38	36	44	47	47	44
B2F450	42	41	43	64	63	54	33	20	31	46	47	44
C+BiOp	39	42	46	50	46	30	21	35	47	54	62	54

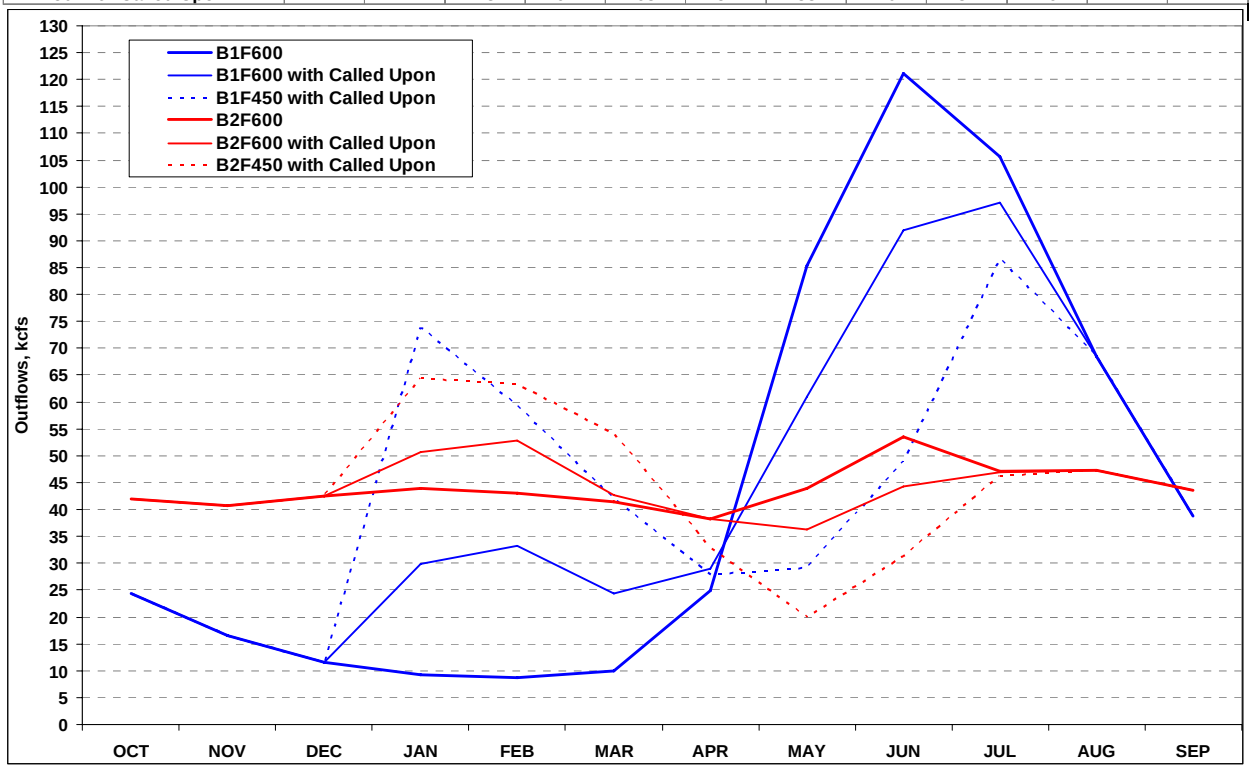


Comparison Across Supplemental Studies

1. For the BiOp studies, Arrow plus Duncan outflows were similar during October to December whether or not the Treaty is terminated due to the power operation being the driving factor during this period.
2. Differences in January outflows were mainly caused by the flood control maximum flow objective, not by whether or not the Treaty was terminated.
3. Terminating the Treaty resulted in higher outflows during February to April, and lower outflows during July to September.
4. Average monthly outflows during the August - September period were considerably lower (11 kcfs – 18 kcfs) under Treaty Termination compared to the Treaty Continues due to the Canadian power operation significantly reducing outflows from Arrow.

Figure 3 - Arrow plus Duncan Outflows – B1 vs. B2 Scenarios
70-Year Averages

Outflows - kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
B1F600	24	17	12	9	9	10	25	85	121	106	68	39
B1F600 with Called Upon	24	17	12	30	33	24	29	61	92	97	68	39
B1F450 with Called Upon	24	17	12	74	59	42	28	29	49	87	68	39
B2F600	42	41	43	44	43	41	38	44	53	47	47	44
B2F600 with Called Upon	42	41	43	51	53	43	38	36	44	47	47	44
B2F450 with Called Upon	42	41	43	64	63	54	33	20	31	46	47	44



Under the Treaty is Terminated study, two scenarios (B1 and B2) were provided by B.C. Hydro to represent a possible range of Arrow plus Duncan outflows. Figure 3 shows the 70-year average flows for each of the original scenarios provided by B.C. Hydro and then with Called Upon applied in those years which required Called Upon storage from Canada.

<u>B1 Scenarios:</u>

1. The original B1 scenario reflected a Canadian operation for local flood control in Canada, not the U.S. It had no operation specifically for power, only the local flood control operation. The bold blue line in the graph above represents the 70-year average of the B1 data set. The shape is very similar to an unregulated streamflow with the exception of the small amount of regulation for local flood control.
2. The original B1 scenario (in bold blue) provided by B.C. Hydro was intended to be one bookend of the range of possible cross-boundary flows if no coordination between the U.S. and Canada existed. It was also intended to be used to look at the amount of Canadian storage that would be required based solely on the U.S. flood control need, regardless of any Canadian or Treaty power draft.

3. The procedure used to determine the Called Upon need drafted the Canadian projects (and therefore influenced the Arrow plus Duncan outflow) to about the same level regardless of whether the maximum flow objective at The Dalles was 450 kcfs or 600 kcfs. The only difference between the two objectives was the frequency of Called Upon years (600 kcfs was triggered in 29 years and 450 kcfs was triggered in 52 years), not the amount of total draft required for each objective. Therefore, the total amount of Canadian storage required for varying runoff scenarios was not determined in the Phase 1 studies and will need to be evaluated in future studies.
4. Starting with the base data set provided by B.C. Hydro (bold blue line), as each Called Upon scenario was applied, the flood control requirements progressively altered the shape of the Arrow plus Duncan outflows. In Figure 3, the B1 scenarios show progressively more frequent draft in the January through April period and a slower refill in the May through July period as a result of Called Upon. At the 600 kcfs objective (thin blue line), 29 out of the 70 years were Called Upon years causing a slight increase in the average outflows in the winter and a decrease in the spring and early summer. The 450 kcfs flow objective (dashed blue line) increased the number of Called Upon years to 52 and therefore increased the average even more in the winter and decreased the outflows again in the spring. The lower the flood control maximum flow objective the more dramatic the shift in outflows from the spring into the winter.
5. Because B1 reflected almost an unregulated flow and not an operation to fully utilize Canadian power production, it was considered unrealistic in terms of relative likelihood of occurrence in the future. Therefore, the B2 scenario was the focus of the Supplemental Report and analysis.

<u>B2 Scenarios:</u>

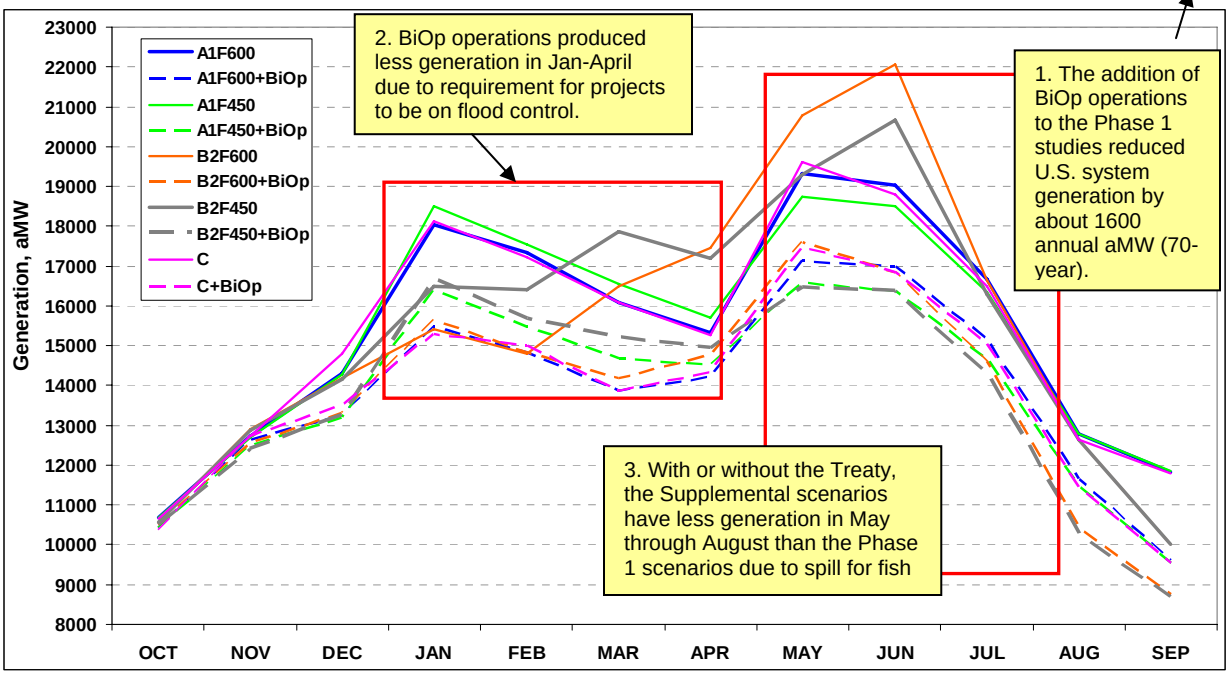
1. The original B2 scenario reflected a Canadian operation with power production as the primary objective. The bold red line in Figure 3 shows the 70-year average for this original data set. In this scenario, B.C. Hydro attempted to keep Arrow as full as possible and to sustain outflows at maximum powerhouse capability of about 39 kcfs to maximize generation (approximately 185 MW) at the project. The result is an Arrow plus Duncan outflow that is held relatively constant throughout the year except for a slight increase during the peak of the runoff.
2. As with the B1 scenarios, as Called Upon is implemented, the shape of the Arrow plus Duncan outflows change to reflect more frequent draft of the Canadian projects in the January through April period and a slower refill in the May through July period. With the 600 kcfs maximum flow objective (29 years out of 70 years), the Arrow plus Duncan average outflows begin to shift to higher outflows in the winter and lower in the spring and early summer. At the 450 kcfs maximum flow objective (52 out 70 years, dashed red line), the increase in the number of Called Upon years caused even more shift in the 70-year average to higher outflows in the winter and early spring during the drawdown season and lower outflows in the spring and summer during refill.
3. While the B2 scenarios represent only one Canadian power operation strategy, it is a more likely scenario than the B1 scenarios which reflect a nearly unregulated outflow. Therefore,

the focus of the Supplemental report is in comparing the B2, or Treaty is Terminated scenario, to the Treaty Continues scenarios (A1 and C). However, it is very important to recognize that this provides only a narrow look at one possible outcome, not nearly enough to understand the uncertainty and variability associated with termination of the Treaty. Future studies will need to provide a wider range of scenarios for evaluation.

3.3.2 U.S. System Generation

Figure 4 - U.S. System Generation - Phase 1 and Supplemental Studies 70-Year Averages

generation, aMW	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN AVE
A1F600	10672	12720	14294	18040	17350	16088	15314	19336	19024	16671	12791	11831	15334
A1F600+BiOp	10437	12635	13247	15480	14825	13858	14206	17133	16979	15156	11646	9606	13763
A1F450	10674	12708	14276	18491	17551	16565	15698	18727	18494	16344	12789	11846	15336
A1F450+BiOp	10426	12504	13195	16415	15462	14690	14510	16579	16382	14667	11465	9543	13813
B2F600	10576	12890	14199	15420	14805	16487	17449	20782	22060	16644	12650	10017	15333
B2F600+BiOp	10522	12549	13325	15639	14843	14177	14780	17611	16840	14606	10429	8770	13669
B2F450	10570	12871	14166	16481	16391	17853	17197	19305	20657	16294	12648	10014	15364
B2F450+BiOp	10506	12409	13256	16675	15681	15219	14936	16464	16367	14297	10267	8707	13723
C	10668	12738	14787	18114	17227	16075	15271	19628	18794	16486	12639	11803	15345
C+BiOp	10363	12727	13511	15283	14989	13854	14339	17494	16846	15036	11446	9538	13780

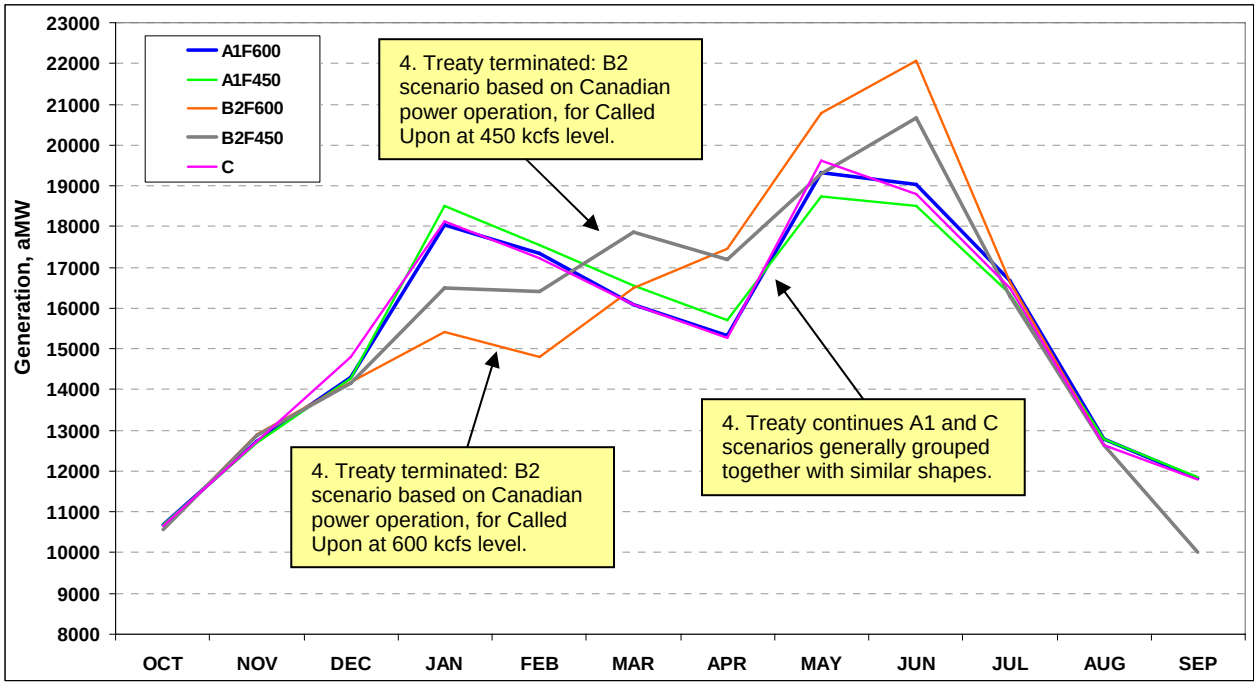


<u>Phase 1 to Supplemental Studies Comparison</u>

1. With or without the Treaty, looking across all of the scenarios, the addition of BiOp operations to the Phase 1 studies reduced U.S. system generation by about 1520 to 1665 annual aMW (70-year).
2. With or without the Treaty, the BiOp operations produced less generation in December through April because of the attempt to keep the U.S. reservoirs as high as possible on their flood control rule curves, or upper rule curves, during this period. Without the BiOp, the U.S. projects usually drafted deeper than their flood control curves for power during this period resulting in higher generation.
3. With or without the Treaty, the BiOp operations produced less generation in May through August than the Phase 1 scenarios due to spill for fish during this period.

Figure 5 - U.S. System Generation - Phase 1 Studies
70-Year Averages

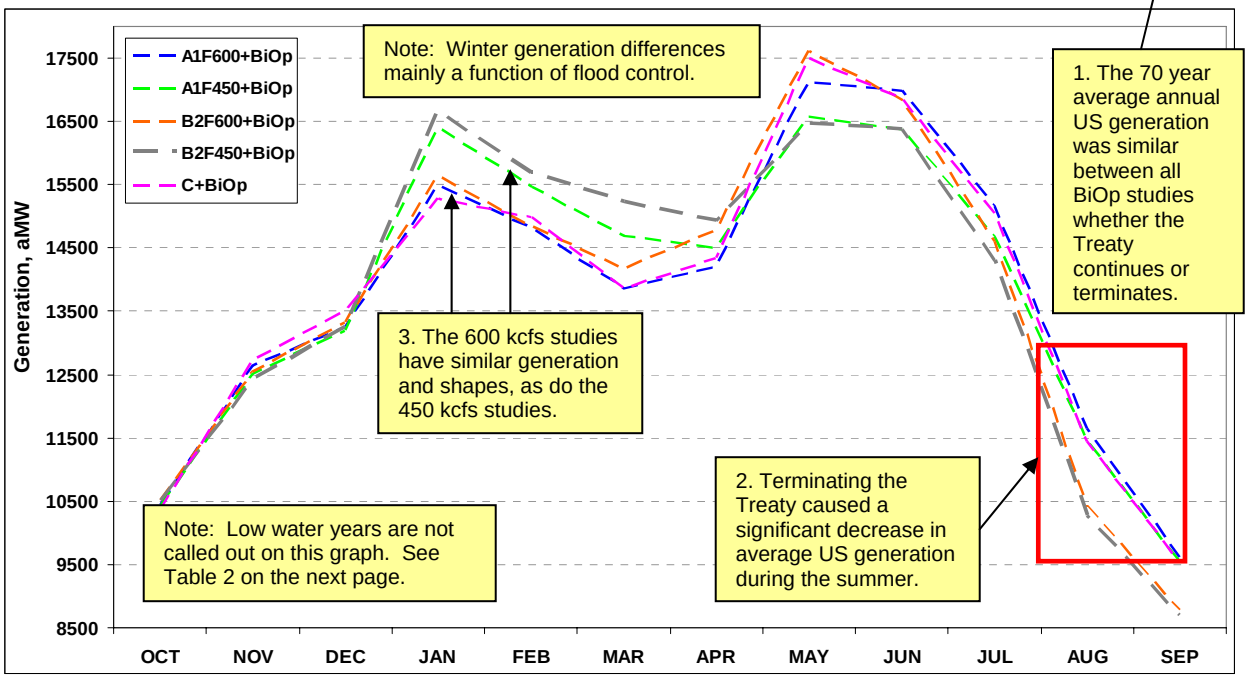
generation, aMW	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN AVE
A1F600	10672	12720	14294	18040	17350	16088	15314	19336	19024	16671	12791	11831	15334
A1F450	10674	12708	14276	18491	17551	16565	15698	18727	18494	16344	12789	11846	15336
B2F600	10576	12890	14199	15420	14805	16487	17449	20782	22060	16644	12650	10017	15333
B2F450	10570	12871	14166	16481	16391	17853	17197	19305	20657	16294	12648	10014	15364
C	10668	12738	14787	18114	17227	16075	15271	19628	18794	16486	12639	11803	15345



4. In the Phase 1 studies, the monthly shape of system generation is dramatically different between the Treaty Continues (A and C) and Treaty is Terminated (B2) scenarios. The addition of the BiOp operations (shown in Figure 6 below) greatly reduces these differences in generation shape.

Figure 6 - U.S. System Generation - Supplemental Studies
70-Year Averages

generation, aMW	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN AVE
A1F600+BiOp	10437	12635	13247	15480	14825	13858	14206	17133	16979	15156	11646	9606	13763
A1F450+BiOp	10426	12504	13195	16415	15462	14690	14510	16579	16382	14667	11465	9543	13813
B2F600+BiOp	10522	12549	13325	15639	14843	14177	14780	17611	16840	14606	10429	8770	13669
B2F450+BiOp	10506	12409	13256	16675	15681	15219	14936	16464	16367	14297	10267	8707	13723
C+BiOp	10363	12727	13511	15283	14989	13854	14339	17494	16846	15036	11446	9538	13780
B2F600-A1F600	85	(86)	78	159	18	319	574	478	(139)	(550)	(1217)	(836)	(94)
B2F450-A1F450	81	(94)	61	260	218	530	427	(115)	(15)	(371)	(1198)	(835)	(90)



Comparison Across Supplemental Studies

1. Terminating the Treaty causes the 70-year average annual U.S. generation to decrease by 90-94 aMW; this is less than 1% of total system generation. However, the differences vary greatly by month and water year (see Table 2 below).
2. Per the Phase 1 study results, the estimated 2024 Canadian Entitlement (CE) was 470 aMW. In the Treaty is Terminated scenarios (B2), the U.S. would no longer be obligated to deliver the CE to Canada and that power would be retained in the U.S. When the CE is added back in the annual average generation change, the net effect is a gain of approximately 380 aMW.
3. In general, Terminating the Treaty caused average U.S. generation to increase in the winter and decrease in the summer due to the Canadian power operation and the loss of proportional draft.
4. At the 450 kcfs maximum flow objective, both the Treaty and no Treaty scenarios produce more generation during the January through April period and less generation during the May into July period than the 600 kcfs objective. This is due to a higher frequency of Called Upon years at the 450 kcfs level resulting in more generation during the drafting of projects for flood control in the winter and less generation during the spring refill.

The following table provides additional detail regarding seasonal and high, medium, and low water year differences.

Table 2 - U.S. System Generation - Supplemental Studies
Seasonal and Annual Differences (B2 minus A1 scenarios)

Generation Differences (MW)	B2 minus A1 F450	w/CE 470 included	B2 minus A1 F600	w/CE 470 included
High 20 Years				
Fall, Sep-Dec	(103)	367	(84)	386
Winter, Jan-Apr15	67	537	(172)	298
Spring, Apr16-Jun	(136)	334	35	505
Summer, Jul-Aug	(282)	188	(337)	133
Annual	(91)	379	(128)	342
Middle 30 Years				
Fall, Sep-Dec	(93)	377	(94)	376
Winter, Jan-Apr15	429	899	548	1018
Spring, Apr16-Jun	378	848	(47)	423
Summer, Jul-Aug	(852)	(382)	(677)	(207)
Annual	27	497	2	472
Lowest 20 Years				
Fall, Sep-Oct.	(425)	45	(430)	40
Winter, Jan-Apr15	279	749	288	758
Spring, Apr16-Jun	352	822	392	862
Summer, Jul-Aug	(1478)	(1008)	(1448)	(978)
Annual	(240)	230	(225)	245

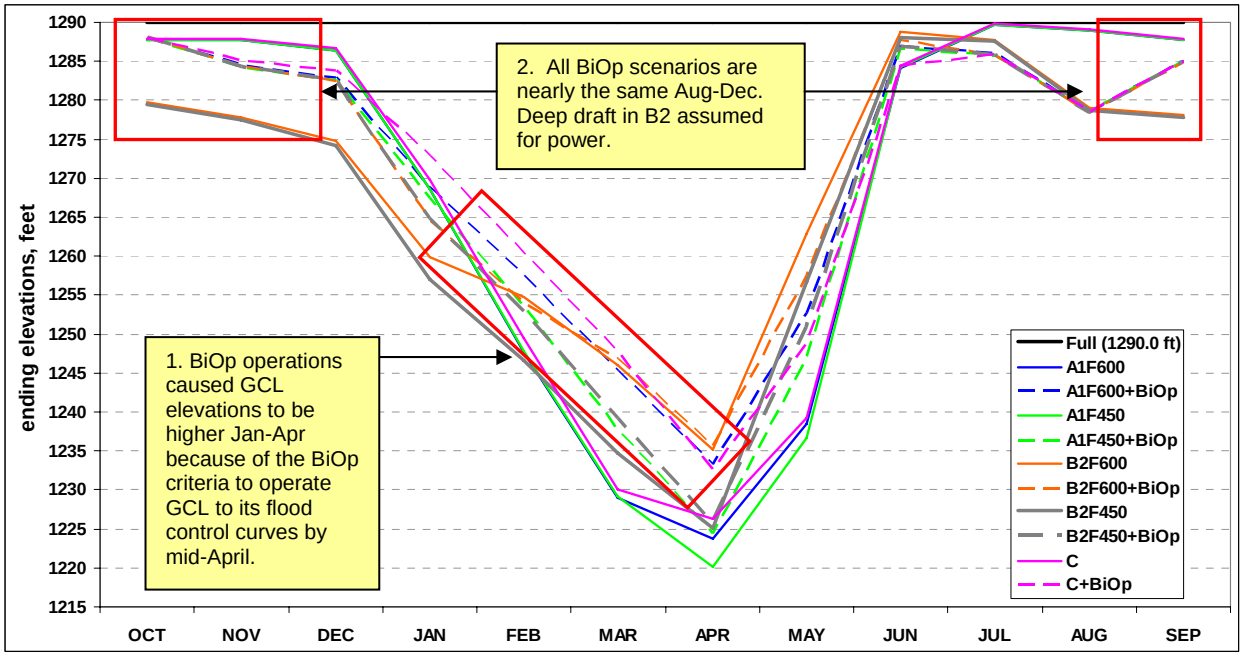
5. Terminating the Treaty caused a significant decrease in average U.S. System generation during the summer by 282-337 aMW in the high water years and 1448-1478 aMW in the low water years.
6. Prior to adding back the CE, terminating the Treaty resulted in generally less generation in the fall, spring, and summer. However, when the CE is added back, only the middle and low water year summer seasons are diminished.
7. During the <u>20 driest</u> water years, terminating the Treaty caused:
   - The decrease in summer generation to grow much larger, and
   - The average annual generation decreased approximately 225-240 aMW

3.3.3 RESERVOIRS

3.3.3.1 Grand Coulee

Figure 7 - Grand Coulee Elevations - Phase 1 and Supplemental Studies
70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (1290.0 ft)	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290
A1F600	1288	1288	1286	1269	1248	1229	1224	1238	1284	1290	1289	1288
A1F600+BiOp	1288	1285	1283	1269	1257	1245	1233	1253	1287	1286	1278	1285
A1F450	1288	1288	1286	1269	1248	1229	1220	1237	1284	1290	1289	1288
A1F450+BiOp	1288	1284	1283	1267	1254	1238	1224	1247	1287	1286	1279	1285
B2F600	1280	1278	1275	1260	1255	1246	1235	1263	1289	1288	1279	1278
B2F600+BiOp	1288	1284	1283	1265	1254	1247	1236	1258	1288	1286	1278	1285
B2F450	1279	1277	1274	1257	1247	1235	1225	1257	1288	1288	1279	1278
B2F450+BiOp	1288	1284	1282	1265	1253	1239	1226	1251	1287	1286	1278	1285
C	1288	1288	1287	1270	1249	1230	1226	1239	1284	1290	1289	1288
C+BiOp	1288	1285	1284	1273	1260	1248	1233	1249	1284	1286	1279	1285



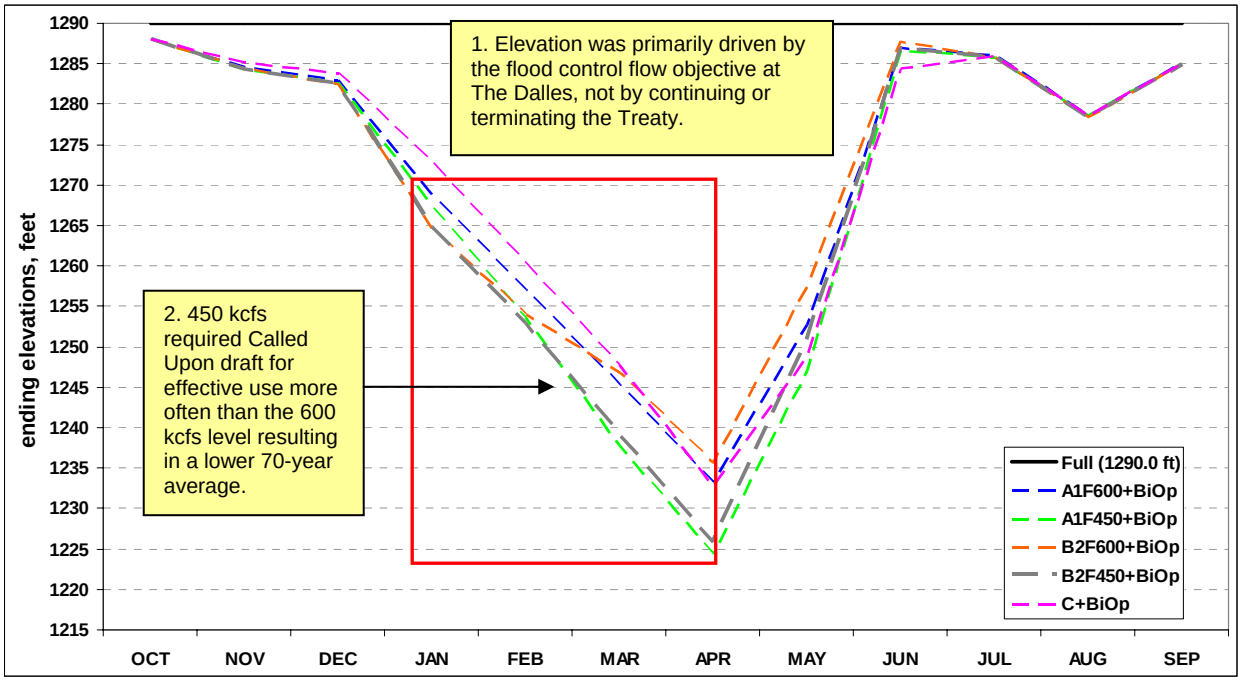
<u>Phase 1 to Supplemental Comparison</u>

1. On average, BiOp operations caused Grand Coulee reservoir elevations to be higher in the January through April period than in the Phase 1 studies because of the BiOp criteria to operate Grand Coulee to its flood control curves by mid-April.
2. All Supplemental studies attempted to reach the elevation of 1285 feet on September 30th per the kokanee spawning objective and then 1288 feet by October 31st. For the Treaty terminates scenarios (B2) the modeling assumption continued to draft to meet load during the late summer through December and therefore ended lower than the Supplemental studies during this period.

Figure 8 - Grand Coulee Elevations - Supplemental Studies
70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (1290.0 ft)	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290	1290
A1F600+BiOp	1288	1285	1283	1269	1257	1245	1233	1253	1287	1286	1278	1285
A1F450+BiOp	1288	1284	1283	1267	1254	1238	1224	1247	1287	1286	1279	1285
B2F600+BiOp	1288	1284	1283	1265	1254	1247	1236	1258	1288	1286	1278	1285
B2F450+BiOp	1288	1284	1282	1265	1253	1239	1226	1251	1287	1286	1278	1285
C+BiOp	1288	1285	1284	1273	1260	1248	1233	1249	1284	1286	1279	1285

B2F600-A1F600	0	0	0	(4)	(3)	2	2	5	1	0	0	0
B2F450-A1F450	0	0	0	(3)	(1)	2	2	4	0	0	0	0



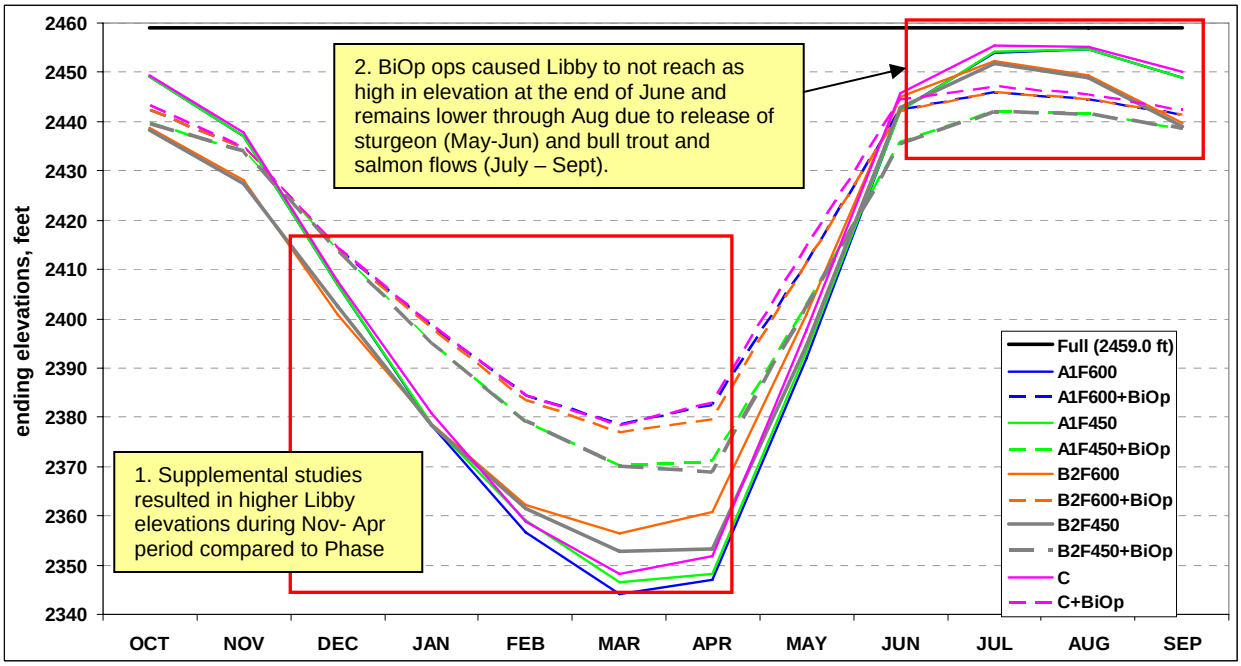
Comparison Across Supplemental Studies

1. The difference in average elevation for the Supplemental studies was driven by the flood control flow objective at The Dalles, not by continuing or terminating the Treaty.
2. Across all Supplemental studies, the 450 kcfs maximum flow objective scenarios required Called Upon draft for effective use more often than the 600 kcfs level scenarios resulting in a lower 70-year average elevation during the January through April period.

3.3.3.2 Libby

Figure 9 - Libby Elevations - Phase 1 and Supplemental Studies
70-year Average

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (2459.0 ft)	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459
A1F600	2449	2437	2407	2378	2357	2344	2347	2392	2442	2454	2455	2449
A1F600+BiOp	2442	2435	2414	2398	2384	2379	2382	2411	2442	2446	2445	2441
A1F450	2449	2437	2407	2379	2359	2347	2348	2393	2442	2454	2455	2449
A1F450+BiOp	2440	2434	2414	2395	2379	2370	2371	2403	2436	2442	2442	2439
B2F600	2439	2428	2401	2379	2362	2356	2361	2401	2445	2452	2449	2440
B2F600+BiOp	2442	2435	2414	2398	2383	2377	2379	2411	2442	2446	2445	2441
B2F450	2438	2428	2402	2378	2361	2353	2353	2395	2443	2452	2449	2439
B2F450+BiOp	2439	2434	2414	2395	2379	2370	2369	2402	2435	2442	2441	2438
C	2449	2438	2408	2381	2359	2348	2352	2398	2446	2455	2455	2450
C+BiOp	2443	2435	2414	2399	2384	2378	2383	2415	2445	2447	2446	2442



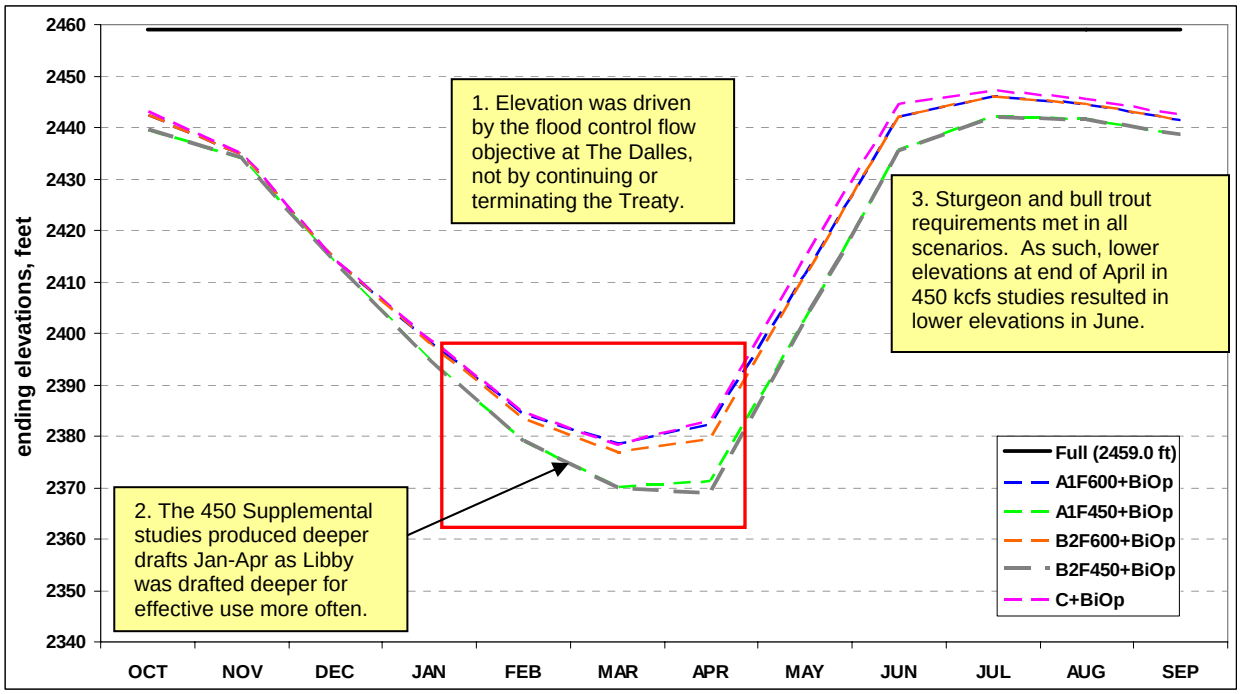
<u>Phase 1 to Supplemental Comparison</u>

1. The Supplemental studies drafted Libby less during the November through April 10th period when compared to their respective Phase 1 studies which were drafting for power.
2. Supplemental study operations generally caused Libby's elevation to not reach as high at the end of June and remain lower through August because of the release of sturgeon (May-Jun) and Bull Trout and salmon flows (July – Sept).
3. By December all Supplemental studies showed a higher elevation than the Phase 1 studies. The Supplemental studies operated to the Variable December flood control elevation as required by the BiOp, while the Phase 1 studies drafted deeper for power.

Figure 10 - Libby Elevations - Supplemental Studies Only
70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (2459.0 ft)	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459	2459
A1F600+BiOp	2442	2435	2414	2398	2384	2379	2382	2411	2442	2446	2445	2441
A1F450+BiOp	2440	2434	2414	2395	2379	2370	2371	2403	2436	2442	2442	2439
B2F600+BiOp	2442	2435	2414	2398	2383	2377	2379	2411	2442	2446	2445	2441
B2F450+BiOp	2439	2434	2414	2395	2379	2370	2369	2402	2435	2442	2441	2438
C+BiOp	2443	2435	2414	2399	2384	2378	2383	2415	2445	2447	2446	2442

B2F600-A1F600	0	0	0	0	(1)	(2)	(3)	0	0	0	0	0
B2F450-A1F450	0	0	0	0	0	0	(2)	0	0	0	0	0



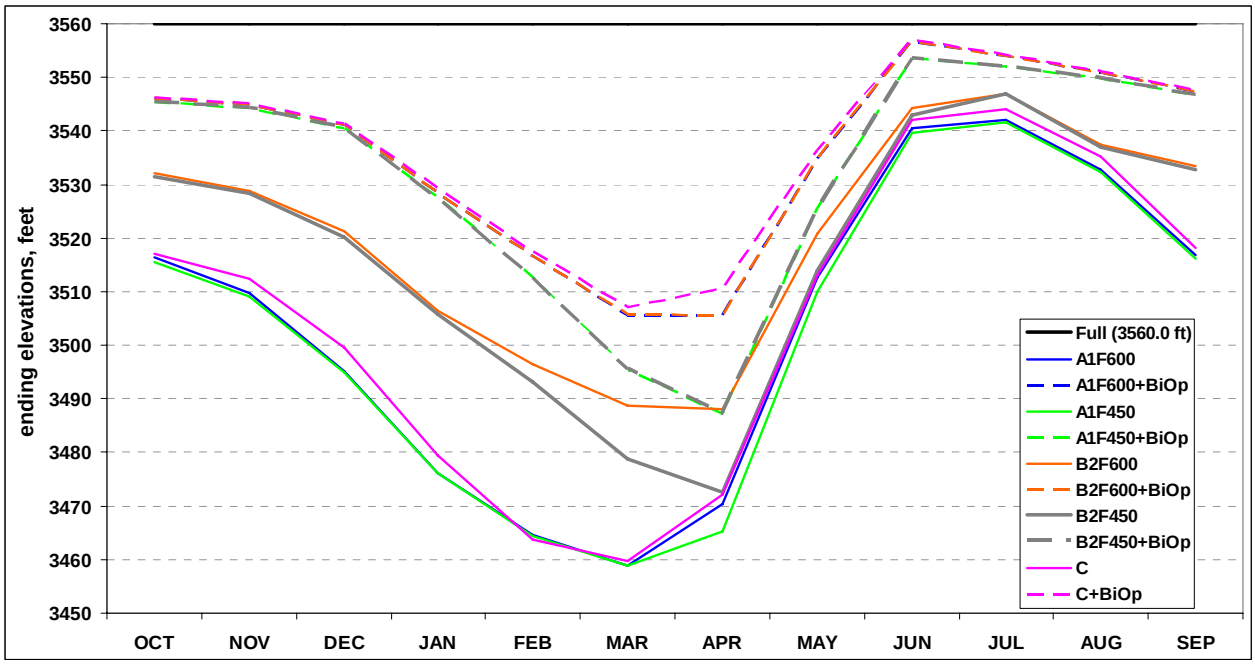
Comparison Across Supplemental Studies

1. The difference in average elevation for the Supplemental studies was driven primarily by the flood control flow objective at The Dalles, not by continuing or terminating the Treaty.
2. Because the Supplemental studies required Libby to be on its flood control rule curve during the January through April period, the 450 kcfs studies drafted for effective use more often in the January – April 10th period than in the 600 kcfs studies resulting in lower average elevations by April.
3. Sturgeon and bull trout requirements were met in all scenarios. As such, the lower elevations at the end of April in the 450 kcfs studies resulted in lower elevations at the end of June.

3.3.3.3 Hungry Horse

Figure 11 - Hungry Horse Elevations – Phase 1 and Supplemental Studies 70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (3560.0 ft)	3560	3560	3560	3560	3560	3560	3560	3560	3560	3560	3560	3560
A1F600	3516	3510	3495	3476	3465	3459	3470	3513	3541	3542	3533	3517
A1F600+BiOp	3546	3545	3541	3528	3517	3506	3506	3535	3557	3554	3551	3547
A1F450	3515	3509	3495	3476	3464	3459	3465	3510	3540	3542	3532	3516
A1F450+BiOp	3545	3544	3541	3527	3513	3495	3487	3526	3554	3552	3550	3547
B2F600	3532	3529	3521	3506	3496	3489	3488	3521	3544	3547	3537	3533
B2F600+BiOp	3546	3545	3541	3528	3517	3506	3506	3535	3557	3554	3551	3547
B2F450	3532	3528	3520	3506	3493	3479	3473	3514	3543	3547	3537	3533
B2F450+BiOp	3545	3544	3541	3527	3513	3496	3487	3526	3554	3552	3550	3547
C	3517	3512	3500	3479	3464	3460	3472	3513	3542	3544	3535	3518
C+BiOp	3546	3545	3541	3529	3518	3507	3511	3536	3557	3554	3551	3548



<u>Phase 1 to Supplemental Comparison</u>

1. On average the Supplemental scenarios kept Hungry Horse fuller throughout the year due to the BiOp requirement to operate to VarQ flood control criteria or variable draft limits in non-Called Upon years and effective use in Called Upon years. The project drafted only for flood control and minimum flow requirements at site, at Columbia Falls, and downstream minimum flows in the summer.
2. Without BiOp requirements, the Phase 1 studies drafted for effective use flood control or power which usually drafted the project deeper than the Supplemental study.
3. BiOp operations improved June refill over Phase 1 studies due to the BiOp requirement to refill by June 30th of each year.
4. All Phase 1 scenarios had lower reservoir elevations during the September period due to a lower probability of refill at the start of the period and various levels of power drafts through December. Although both the Treaty is Terminated scenarios (B2) and the Treaty Continues

scenarios (A1 and C) operated Hungry Horse to similar criteria, the difference between these scenarios was the switch from a 4 year critical period (A1 and C) to a one year critical period (B2). The one year critical period produced less generation, therefore the B2 scenarios required less draft to meet FELCC.

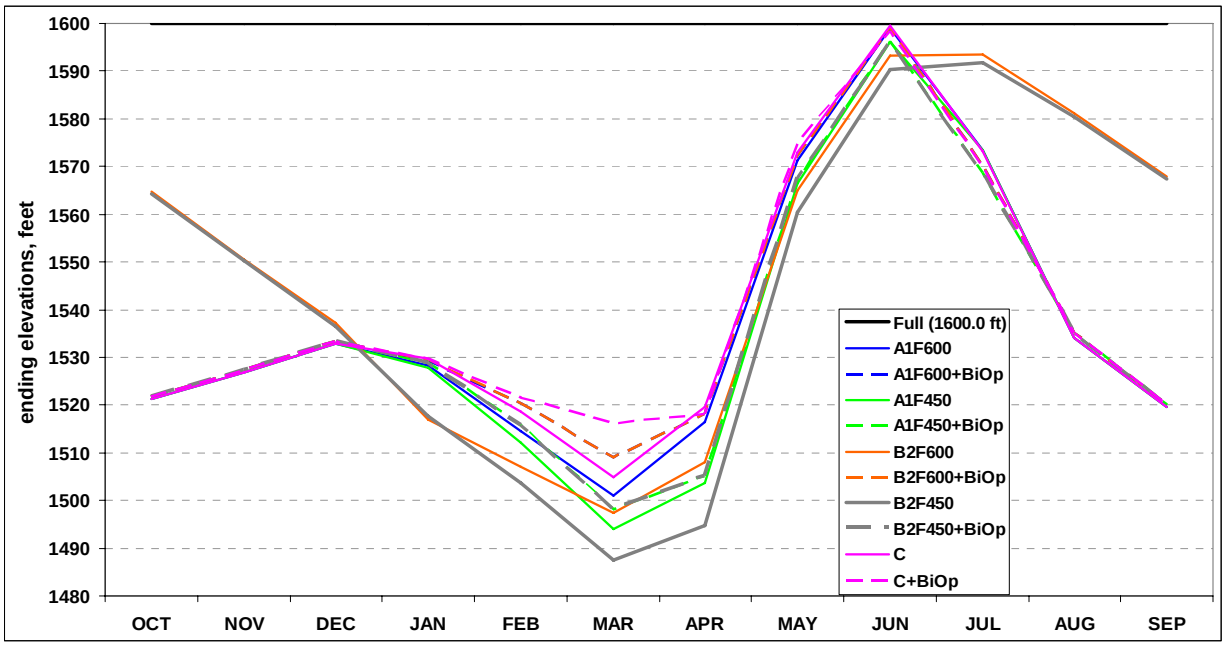
Comparison Across Supplemental Studies

1. The difference in average elevation for the Supplemental studies was driven by the flow objective at The Dalles, not by continuing or terminating the Treaty.
2. The average elevation was impacted by whether the flow objective was 450 kcfs or 600 kcfs. The 450 kcfs studies produced deeper drafts in all periods compared to the 600 kcfs studies because Hungry Horse drafted for effective use more often in the 450 kcfs studies.

3.3.3.4 Dworshak

Figure 12 - Dworshak Elevations – Phase 1 and Supplemental Studies
70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (1600.0 ft)	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600
A1F600	1521	1527	1533	1528	1515	1501	1517	1571	1599	1573	1534	1520
A1F600+BiOp	1522	1527	1533	1529	1520	1509	1518	1572	1599	1570	1535	1520
A1F450	1521	1527	1533	1528	1512	1494	1504	1566	1596	1573	1534	1520
A1F450+BiOp	1522	1527	1533	1529	1516	1498	1505	1567	1596	1569	1535	1520
B2F600	1565	1551	1537	1517	1507	1497	1508	1565	1593	1593	1581	1568
B2F600+BiOp	1522	1527	1533	1529	1520	1509	1518	1572	1599	1570	1535	1520
B2F450	1564	1550	1536	1518	1504	1487	1495	1560	1590	1592	1580	1567
B2F450+BiOp	1522	1527	1533	1529	1516	1498	1505	1568	1596	1569	1535	1520
C	1521	1527	1533	1530	1519	1505	1520	1573	1599	1573	1534	1520
C+BiOp	1522	1527	1533	1530	1521	1516	1518	1575	1598	1570	1535	1520



<u>Phase 1 to Supplemental Comparison</u>

1. Since Dworshak is not considered part of the Treaty Base System[9], and the BiOp requirements are normally applied to Treaty planning studies, the BiOp requirements were included in the Treaty Continues scenarios (A1 and C). However, for the B2 scenarios the studies assumed that since the overall objective for the B studies was only for power and flood control, the Dworshak BiOp constraints would be excluded. The U.S. Entity recognizes the inconsistency and need for more analysis in the future.
2. Therefore, the July through November period varied dramatically between the B2 Phase 1 studies and all of the other studies which included BiOp operations, as the project drafted for BiOp objectives in July to September and recovered in October and November.

[9] The 24 projects listed in the Treaty, plus post-1961 projects added on the mainstem of the Columbia.

Comparison Across Supplemental Studies

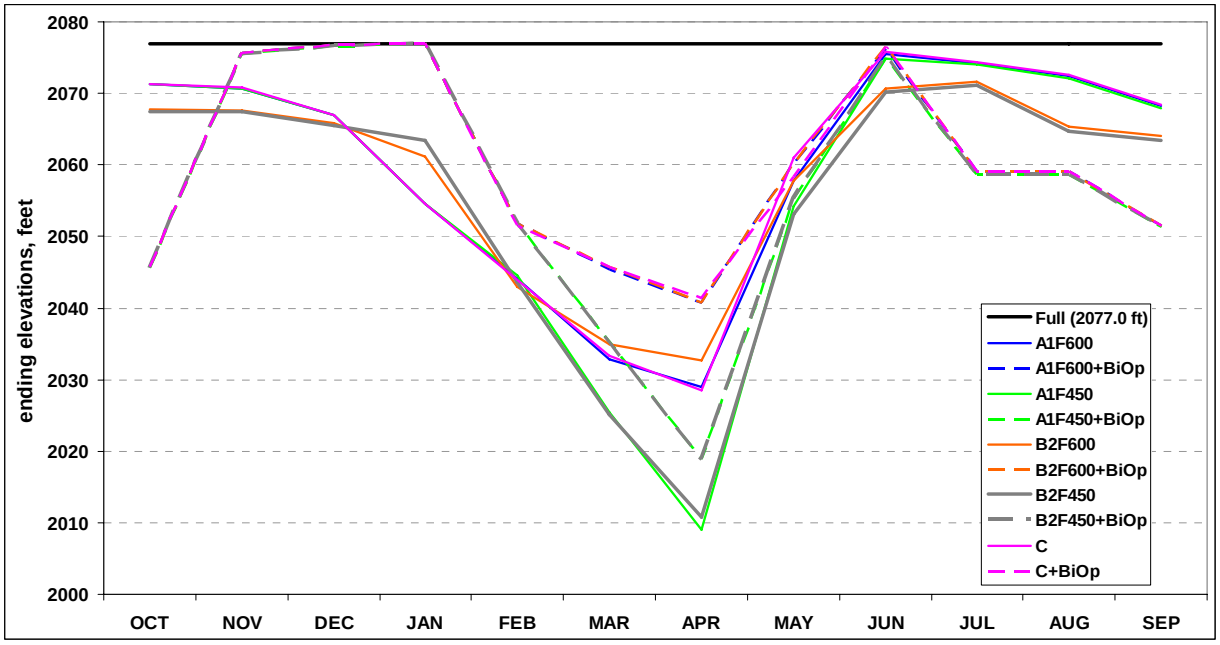
1. All of the Supplemental studies have similar operations August through December. The difference in average elevation during January through July was driven by the flood control maximum peak flow objective at The Dalles, not by continuing or terminating the Treaty.The difference in average elevation for the Supplemental studies was driven by the flow objective at The Dalles, not by continuing or terminating the Treaty.
2. The 450 kcfs studies produce deeper drafts in January through July because it drafts for effective use more often and doesn't recover to the same elevations until August. The 450 kcfs flood control objective, compared to 600 kcfs, lowered the 70 average elevation on April 30th by 13 feet.
3. The average elevations are impacted by whether the flow objective is 450 kcfs or 600 kcfs. The 450 kcfs studies produce deeper drafts in January through July because it drafts for effective use more often and doesn't recover to the same elevations until August.

3.3.3.5 Brownlee

Note: The operations listed below for Brownlee were from the Idaho Power Company's FERC license requirements and are not part of the Federal BiOp operations.

Figure 13 - Brownlee Elevations – Phase 1 and Supplemental Studies
70-Year Averages

end of period elevations, ft	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Full (2077.0 ft)	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077	2077
A1F600	2071	2071	2067	2055	2044	2033	2029	2058	2075	2074	2072	2068
A1F600+BiOp	2046	2076	2077	2077	2052	2045	2041	2060	2076	2059	2059	2052
A1F450	2071	2071	2067	2055	2045	2025	2009	2054	2075	2074	2072	2068
A1F450+BiOp	2046	2075	2077	2077	2052	2035	2019	2055	2075	2059	2059	2051
B2F600	2068	2068	2066	2061	2043	2035	2033	2058	2071	2072	2065	2064
B2F600+BiOp	2046	2076	2077	2077	2052	2046	2041	2060	2076	2059	2059	2052
B2F450	2067	2067	2066	2063	2044	2025	2011	2053	2070	2071	2065	2063
B2F450+BiOp	2046	2075	2077	2077	2052	2035	2019	2055	2075	2059	2059	2051
C	2071	2071	2067	2055	2044	2033	2028	2061	2076	2074	2073	2068
C+BiOp	2046	2076	2077	2077	2051	2046	2041	2058	2077	2059	2059	2052



Phase 1 to Supplemental Comparison

1. Local fish operations (fall Chinook salmon) caused Brownlee to refill in October and November, whereas, in Phase 1 studies Brownlee drafted for power operations during this period.
2. The Phase 1 studies operated for power and flood control during the December through April period, however, the Supplemental studies filled Brownlee in November and remained full through January before drafting again for flood control and power.
3. Brownlee drafted deeper in July through September in the Supplemental studies while the Phase 1 studies generally draft for power during this period.

Comparison Across Supplemental Studies

1. The difference in average elevation for the Supplemental studies was driven by the flow objective at The Dalles, not by continuing or terminating the Treaty.
2. The average elevations are impacted by whether the flow objective is 450 kcfs or 600 kcfs. The 450 kcfs studies produced deeper drafts in the March through April period due to effective use and a slower refill in through June. The 70 year average elevation on April 30th was 22 feet lower for the 450 kcfs flood control objective.
3. Whether terminating or continuing the Treaty, Brownlee BiOp operations were generally the same July through February.

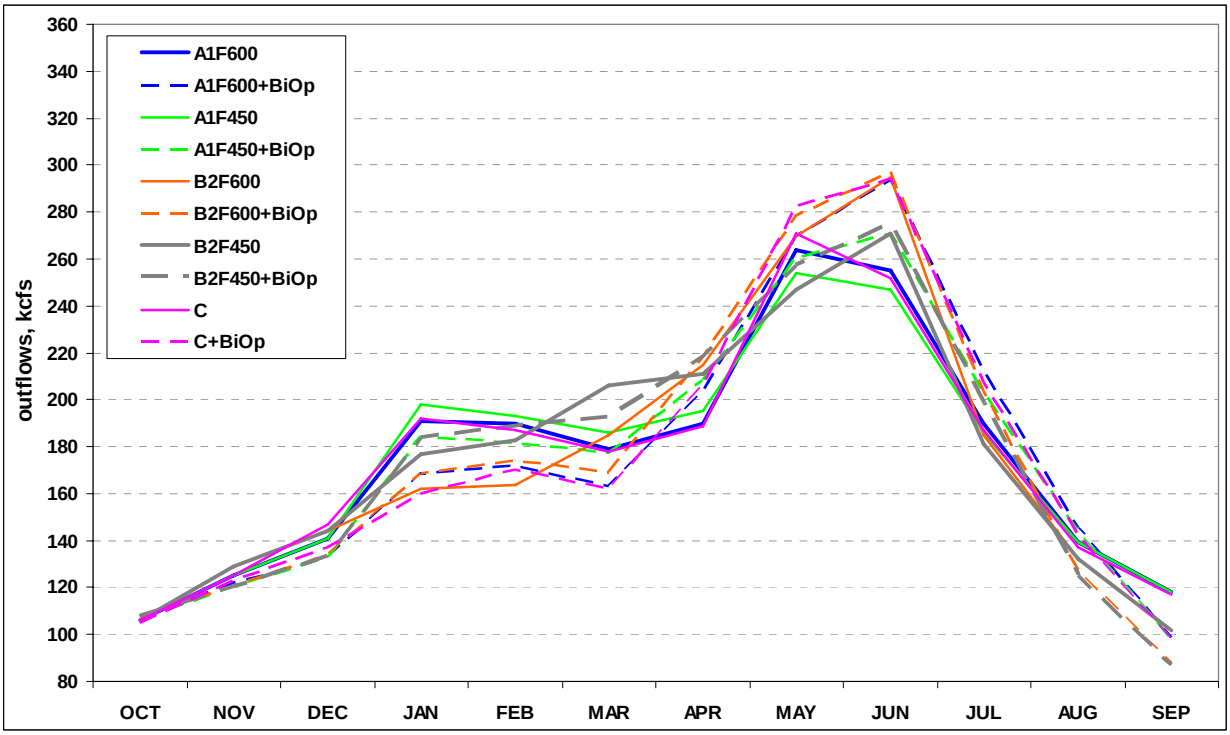
3.3.4 FISH FLOW OBJECTIVES

3.3.4.1 McNary

The salmon flow objective from mid-April through June is between 220 and 260 kcfs depending on The Dalles runoff volume forecast. The salmon flow objective from July through August is 200 kcfs.

Figure 14 - McNary Flows – Phase 1 and Supplemental Studies
70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	106	125	141	191	190	179	190	264	255	190	139	118
A1F600+BiOp	106	122	133	168	172	163	203	270	294	212	145	99
A1F450	106	125	141	198	193	186	195	254	247	186	139	118
A1F450+BiOp	106	121	132	184	182	177	208	260	271	203	143	98
B2F600	106	129	144	162	164	185	215	270	295	185	132	102
B2F600+BiOp	108	121	134	169	174	169	218	279	297	203	127	88
B2F450	106	129	144	177	183	206	211	247	271	181	132	102
B2F450+BiOp	107	120	133	184	189	192	218	257	274	199	125	87
C	106	125	147	192	187	178	189	271	252	187	137	117
C+BiOp	105	123	137	160	170	162	206	282	294	207	142	98



<u>Phase 1 to Supplemental Comparison</u>

1. In general, the BiOp operations provided higher flows during the late spring and summer than the Phase 1 studies due to flow augmentation releases and various reservoir operations.
2. The only exception was the B2 studies where the Supplemental scenarios resulted in lower flows in August than the Phase 1 studies. Since August outflows from Canada were not

changed by the BiOp operations, the cause was in the U.S. due to a change in the operation of Grand Coulee. The Phase 1 A1 studies held Grand Coulee near full in August and the B2 studies assumed a power draft. So adding the BiOp operation increased August flows in A1, but had little impact in B2 where the BiOp operation was nearly the same as the Phase 1 power operation.

Comparison Across Supplemental Studies

Table 3 - Comparison of McNary Average Seasonal Flows

Outflows are in kcfs	A1 F450	B2 F450	Diff	% Diff	A1 F600	B2 F600	Diff	% Diff	A1F450 minus A1F600	% Diff	B2F450 minus B2F600	% Diff
Average of Lowest 20 Years												
Spring, Apr16-Jun	190	196	6	3%	195	201	6	3%	(5)	-3%	(5)	-2%
Summer, Jul-Aug	135	114	(21)	-16%	137	115	(22)	-16%	(2)	-1%	(1)	-1%
Average of Middle 30 Years												
Spring, Apr16-Jun	258	261	3	1%	279	292	13	5%	(21)	-8%	(31)	-11%
Summer, Jul-Aug	173	161	(12)	-7%	181	167	(14)	-8%	(8)	-4%	(6)	-4%
Average of High 20 Years												
Spring, Apr16-Jun	328	327	(1)	0%	338	341	3	1%	(10)	-3%	(14)	-4%
Summer, Jul-Aug	212	210	(2)	-1%	216	213	(3)	-1%	(4)	-2%	(3)	-1%
Number of years McNary Target Flow met												
Spring, Apr16-Jun	44	46	2	5%	52	55	3	6%	(8)	-15%	(9)	-16%
Summer, Jul-Aug	20	18	(2)	-10%	23	19	(4)	-17%	(3)	-13%	(1)	-5%

1. The ability to meet the spring flow objectives at McNary was largely driven by the maximum flow objective at The Dalles, not by continuing or terminating the Treaty. Table 3 above shows the effect on McNary outflows from lowering the peak flow objective at The Dalles from 600 kcfs to 450 kcfs is very similar with or without the Treaty: Specifically, lowering the peak flow objective:
   - Reduced average spring flows by 5 kcfs, and summer flows by 1 to 2 kcfs, in the 20 lowest water years,
   - Reduced average spring flows by 21 to 31 kcfs, and summer flows by 6-8 kcfs, in the 30 middle water years,
   - Reduced average spring flows by 8 to 9 kcfs, and summer flows by 1 to 3 kcfs, in the 20 high water years, and
   - Reduced number of years out of 70 to meet target minimum flows by 8 to 9 in the spring and 1 to 3 in the summer.

2. Terminating the Treaty does have the general effect of increasing spring flows and decreasing summer flows at McNary, and the summer decease is much larger in low water years. Table 3 shows that:
   - In low water years, terminating the Treaty caused spring flows to increase by an average of three percent, but decreased summer flows by an average of 16 percent,

- In middle water years, terminating the Treaty caused the spring flows to increase by an average of 1 to 5 percent, but summer flows decreased by an average of 7 to 8 percent, and
- In high water years, continuing or terminating the Treaty had minimal effect on the ability to meet the McNary flow objectives.

3. When comparing the Treaty Continues with BiOp (A1+BiOp) and current flood control operations (C+BiOp), the 600 kcfs level scenarios performed similarly at meeting the spring and summer objectives.
4. When comparing the Treaty Continues with BiOp and current flood control operations (C+BiOp), the 450 kcfs level scenarios reduced the ability to meet the spring objectives by about 9 years but performed similarly in meeting the summer objective. The reduction in meeting spring objectives was due to more frequent and deeper drafts for effective use, resulting in less water available after April.

Table 4 - McNary Number of Years Target Met
70-year Studies

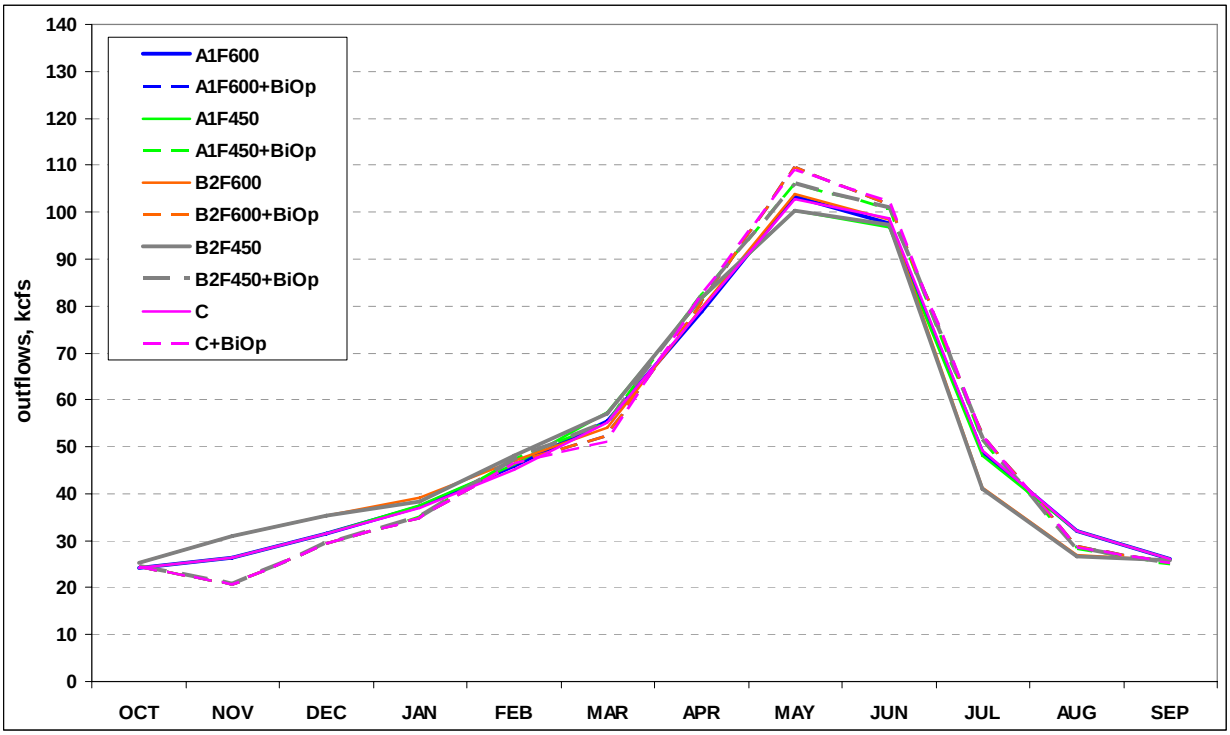
	(220-260 kcfs) Apr16-30	(220-260 kcfs) May	(220-260 kcfs) June	(220-260 kcfs) Apr16-Jun30	(200 kcfs) July	(200 kcfs) August	(200 kcfs) Jul1-Aug31
C	29	51	48	54	37	3	19
A1F600	29	45	54	52	38	3	23
B1F600	31	56	60	61	52	3	34
B2F600	38	53	53	55	34	3	19
A1F450	25	41	46	44	32	3	20
B1F450	31	38	50	49	48	3	28
B2F450	34	38	45	46	31	3	18

Differences = C minus "study"							
C - A1F600	0	6	(6)	2	(1)	0	(4)
C - B1F600	(2)	(5)	(12)	(7)	(15)	0	(15)
C - B2F600	(9)	(2)	(5)	(1)	3	0	0
C - A1F450	4	10	2	10	5	0	(1)
C - B1F450	(2)	13	(2)	5	(11)	0	(9)
C - B2F450	(5)	13	3	8	6	0	1

3.3.4.2 Lower Granite

Figure 15 - Lower Granite Flows – Phase 1 and Supplemental Studies
70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	24	26	32	37	46	55	79	103	98	49	32	26
A1F600+BiOp	25	21	29	35	46	52	81	109	102	52	29	25
A1F450	24	26	32	38	46	57	82	100	97	48	32	26
A1F450+BiOp	25	21	29	35	47	55	82	106	101	51	28	25
B2F600	25	31	35	39	47	54	80	104	99	41	27	26
B2F600+BiOp	25	21	29	35	46	52	81	109	102	52	29	25
B2F450	25	31	35	38	48	57	82	100	97	41	27	26
B2F450+BiOp	25	21	29	35	47	55	82	106	101	52	28	25
C	24	26	32	37	45	55	79	103	99	49	32	26
C+BiOp	25	21	29	35	46	51	82	109	102	52	29	25



Phase 1 to Supplemental Comparison

1. In general, the BiOp operations provided slightly higher flows during the spring and summer than the Phase 1 studies. However, due to the limited storage to augment flows during this period there really was very little variation across all scenarios.

Comparison Across Supplemental Studies

1. Continuing or terminating the Treaty had no impact on the ability to meet the flow objectives.
2. There was very little difference in meeting both the spring and summer flow objectives across all the Supplemental studies.

3. Even the difference in flood control objective had very little impact on meeting the spring and summer flow objectives. Using the lower flow objective of 450 only decreased meeting the flow targets by 1-2 years.
4. As compared to current operations (C+BiOp), the ability to meet the Lower Granite flow objectives was similar whether the Treaty continues or terminates.

Table 5 - Lower Granite Number of Years Target Met
70-year Studies

	(85-100 kcfs) Apr1-15	(85-100 kcfs) Apr16-30	(85-100 kcfs) May	(85-100 kcfs) June	(85-100 kcfs) Apr16-Jun 30	(50-55 kcfs) July	(50-55 kcfs) August	(50-55 kcfs) Jul1-Aug31
C	23	30	45	49	48	32	0	9
A1F600	23	29	45	49	47	32	0	10
B1F600	23	29	45	49	47	32	0	10
B2F600	23	29	45	49	47	32	0	10
A1F450	25	29	42	48	46	32	0	9
B1F450	25	29	42	48	46	32	0	9
B2F450	25	29	42	48	46	32	0	9

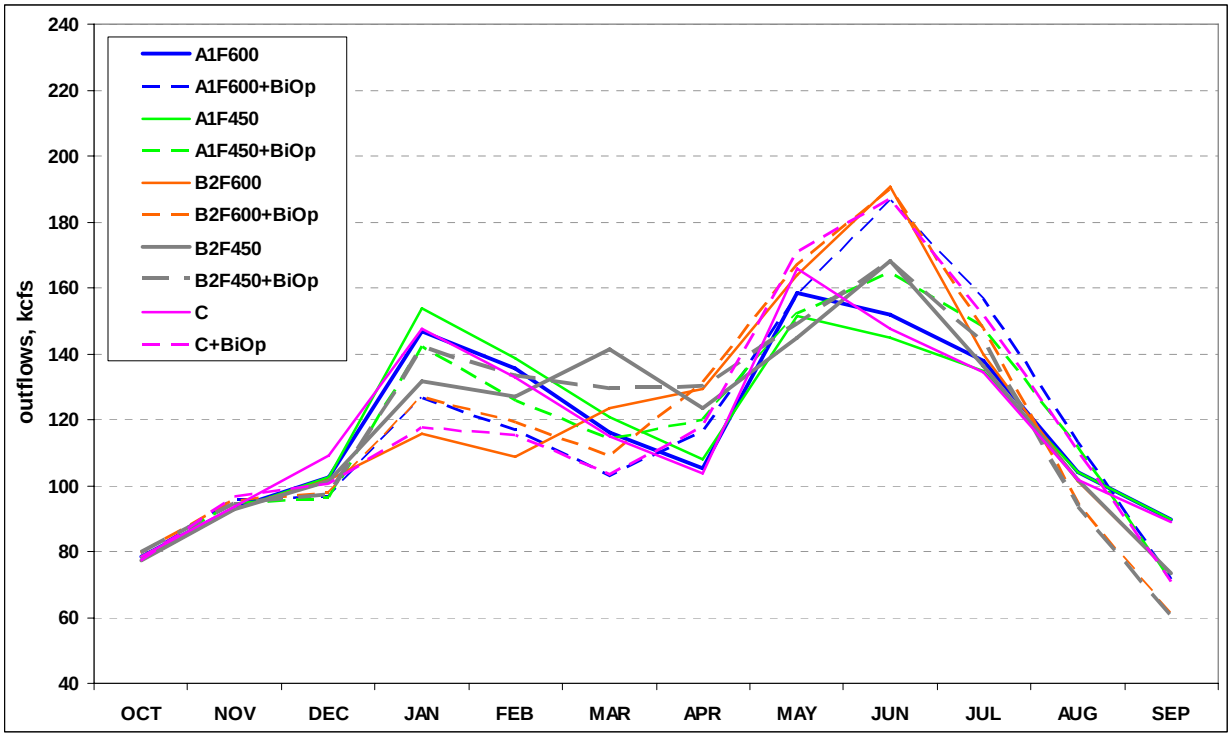
Differences = C minus "study"								
C - A1F600	0	1	0	0	1	0	0	(1)
C - B1F600	0	1	0	0	1	0	0	(1)
C - B2F600	0	1	0	0	1	0	0	(1)
C - A1F450	(2)	1	3	1	2	0	0	0
C - B1F450	(2)	1	3	1	2	0	0	0
C - B2F450	(2)	1	3	1	2	0	0	0

3.3.4.3 Priest Rapids

The minimum steelhead flow objective at Priest Rapids is 135 kcfs during April through June.

Figure 16 - Priest Rapids Flows – Phase 1 and Supplemental Studies
70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	79	93	102	147	136	116	105	158	152	138	104	90
A1F600+BiOp	78	96	97	126	117	103	117	158	186	156	113	71
A1F450	79	93	102	154	138	121	108	151	145	135	104	90
A1F450+BiOp	78	95	96	142	126	114	120	152	165	148	112	71
B2F600	77	93	102	116	109	123	129	164	191	140	101	74
B2F600+BiOp	80	96	98	127	119	109	131	167	190	148	95	60
B2F450	77	93	101	132	127	141	124	145	168	136	102	74
B2F450+BiOp	80	94	97	142	133	129	130	149	168	143	93	60
C	78	94	109	147	133	115	104	166	148	134	102	89
C+BiOp	77	97	101	118	115	103	118	171	187	152	110	71



<u>Phase 1 to Supplemental Comparison</u>

1. In general, the BiOp operations provided higher flows during the April through June period than the Phase 1 studies due to flow augmentation releases and various reservoir operations.

<u>Comparison Across Supplemental Studies</u>

1. Compared to the Treaty Continues with the current FCOP (C+BiOp) operations, the 600 kcfs studies (A1F600+BiOp and B2F600+BiOp) performed the same or slightly increased the number of years the flow objective was met.

2. Compared to the Treaty Continues with the current FCOP (C+BiOp) operations, the 450 kcfs studies (A1F450+BiOp and B2F450+BiOp) slightly decreased the number of years the flow objective was met. The 450 kcfs studies decreased the ability to meet the flow objectives over current operations because upstream projects drafted deeper for effective use by the end of April, having less water available through June, while Grand Coulee's operation was limited by its flow augmentation draft limit.
3. The main impact to the ability to meet the flow target at Priest was the Called Upon maximum flow objective. Regardless, the impact to the number of times the target was met was small across all scenarios.

Table 6 - Priest Rapids Number of Years Target Met
70-year Studies

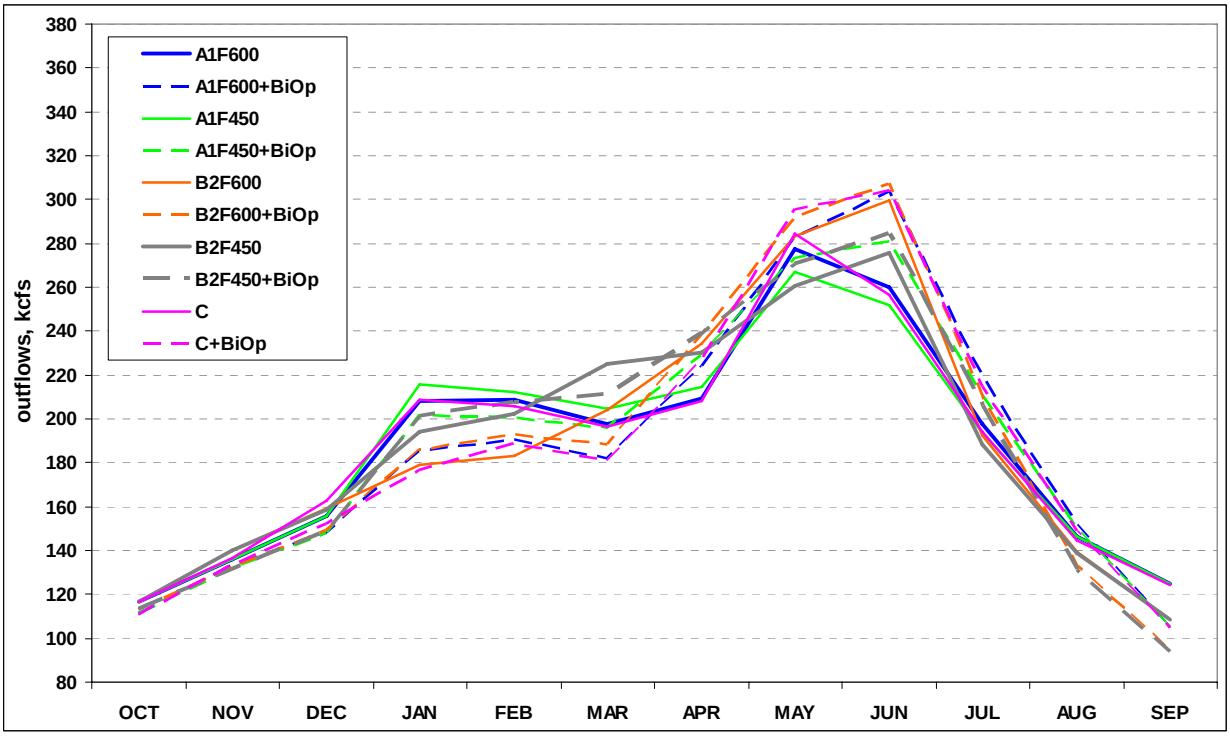
	(135 kcfs) Apr1-15	(135 kcfs) Apr16-30	(135 kcfs) May	(135 kcfs) June	(135 kcfs) Apr1-Jun 30
C	37	36	60	59	58
A1F600	33	37	58	61	58
B1F600	43	42	65	67	64
B2F600	41	46	60	60	61
A1F450	45	36	52	55	53
B1F450	47	40	50	59	60
B2F450	47	47	50	54	56

Differences = C minus "study"					
C - A1F600	4	(1)	2	(2)	0
C - B1F600	(6)	(6)	(5)	(8)	(6)
C - B2F600	(4)	(10)	0	(1)	(3)
C - A1F450	(8)	0	8	4	5
C - B1F450	(10)	(4)	10	0	(2)
C - B2F450	(10)	(11)	10	5	2

3.3.4.4 Bonneville

Figure 17 - Bonneville Flows – Phase 1 and Supplemental Studies
70-Year Averages

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	117	136	156	208	209	198	209	278	260	198	147	125
A1F600+BiOp	112	133	148	186	191	182	224	283	304	219	152	105
A1F450	117	136	156	215	212	204	215	267	252	194	146	125
A1F450+BiOp	112	132	148	202	201	196	229	274	281	210	150	105
B2F600	117	140	159	179	183	204	234	284	299	192	139	108
B2F600+BiOp	113	133	149	186	193	188	239	292	307	211	133	94
B2F450	117	140	159	194	202	225	230	261	276	188	139	108
B2F450+BiOp	113	131	149	201	208	211	239	271	285	206	131	94
C	117	137	163	209	206	197	208	284	257	194	144	124
C+BiOp	111	134	152	177	189	181	227	296	304	214	149	105



Flows for chum for November - March are based on Bonneville tailwater elevation, modeled as a minimum flow at Bonneville dam of the 125 kcfs from Nov – Mar.

<u>Comparison Across Supplemental Studies</u>

1. All Supplemental studies, whether continuing or terminating the Treaty (A1 and B2), performed similarly across studies and to current operations (C+BiOp) in the ability to meet flow objectives.

Table 7 - Bonneville Number of Years Target Met
70-year Studies

	(125 kcfs) Nov	(125 kcfs) December	(125 kcfs) January	(125 kcfs) February	(125 kcfs) March	(125 kcfs) Oct1-Mar31	(125 kcfs) Nov1-Mar31
C	37	59	55	54	55	56	60
A1F600	32	57	54	53	55	56	59
B1F600	12	16	39	42	48	40	43
B2F600	37	50	62	55	56	58	58
A1F450	32	53	56	56	54	57	59
B1F450	13	16	54	51	51	52	53
B2F450	35	51	62	57	57	59	59

Differences = C minus "study"							
C - A1F600	5	2	1	1	0	0	1
C - B1F600	25	43	16	12	7	16	17
C - B2F600	0	9	(7)	(1)	(1)	(2)	2
C - A1F450	5	6	(1)	(2)	1	(1)	1
C - B1F450	24	43	1	3	4	4	7

3.3.4.5 Fish Operations Summary

Table 8 - Number of Years Flow Objective Was Met - Supplemental Studies
70-year Studies

	Lower Granite		Priest Rapids	McNary		Bonneville	
	(85-100 kcfs) Apr16-Jun 30	(50-55 kcfs) Jul1-Aug31	(135 kcfs) Apr1-Jun 30	(220-260 kcfs) Apr16-Jun30	(200 kcfs) Jul1-Aug31	(125 kcfs) Oct1-Mar31	(125 kcfs) Nov1-Mar31
C+BiOp	48	9	58	54	19	56	60
A1F600+BiOp	47	10	58	52	23	56	59
B2F600+BiOp	47	10	61	55	19	58	58
A1F450+BiOp	46	9	53	44	20	57	59
B2F450+BiOp	46	9	56	46	18	59	59

Table 9 - Average Flow - Supplemental Studies
70-year Studies

	Lower Granite		Priest Rapids	McNary		Bonneville	
	(85-100 kcfs) Apr16-Jun 30	(50-55 kcfs) Jul1-Aug31	(135 kcfs) Apr1-Jun 30	(220-260 kcfs) Apr16-Jun30	(200 kcfs) Jul1-Aug31	(125 kcfs) Oct1-Mar31	(125 kcfs) Nov1-Mar31
C+BiOp	103	40	171	288	175	157	166
A1F600+BiOp	102	40	166	281	179	158	168
B2F600+BiOp	102	40	174	288	165	160	170
A1F450+BiOp	101	40	154	266	173	165	175
B2F450+BiOp	100	40	157	266	162	168	180

- Looking across all scenarios (on a 70-year average), the largest impact on the ability to meet the fish flow objectives was due to the maximum flood control objective at The Dalles, not whether the Treaty terminated or continued.
- The ability to meet flow objectives in the spring at Priest Rapids was primarily impacted by the maximum flood control objective at The Dalles. Going from a flood control objective of 600 kcfs to 450 kcfs, reduced the ability to meet the flow objective for Priest Rapids by 5 years and reduced the average flow by 12-17 kcfs.
- The ability to meet flow objectives at McNary was primarily impacted by the maximum flood control objective at The Dalles, mainly in the spring and slightly in the summer. Going from a flood control objective of 600 kcfs to 450 kcfs, reduced the ability to meet the flow objective for McNary by 8-9 years and reduced the average flow by 15-22 kcfs in the spring but only 1-3 years and 3-6 kcfs in the summer.
- In general, none of the scenarios had much of an impact on the flows at Lower Granite in both the spring and summer.

4.0 MOVING FORWARD

This Supplemental Report was intended to provide additional follow-on information and thoughts on questions and issues that arose from the initial Phase 1 studies, recognizing that the scope of the Phase 1 studies did not encompass all the many facets of the river and its uses that are part of today's concerns and needs. However, it is important to understand that there are significant limitations on the scope and depth of the additional information that the Supplemental studies provide, given that the U.S. Entity is only at the beginning of this process. For example, even with the extensive effort that went into applying fish operations to the Phase 1 studies, it is clear that the resulting additional information included in this Supplemental Report only provided a glimpse of how the Phase 1 results were impacted when current fish operations were applied. It is recognized that additional collaborative work within the region will need to be done to understand the implications of the post-2024 Treaty scenarios on fish and fish operations.

Recognizing that flood control is a major driver in all reservoir modeling for the Columbia Basin, the Corps of Engineers (in support of the U.S. Entity and Treaty Review) has also initiated a comprehensive Flood Risk Management (FRM) study to understand the potential implication of post-2024 Treaty changes on flood control operations and to further develop procedures for implementing Called Upon flood control in a manner consistent with the Treaty. The Flood Risk Assessment (FRA) is the first phase of the study with the objective to collect and update data and develop models and tools needed to evaluate flood risk under existing and base case conditions. The models and tools will be used in future FRM studies to produce quantifiable estimates of flood control benefits and costs associated with various post-2024 Treaty scenarios. The Corps initiated work on the Flood Risk Assessment portion of FRM in 2009 and is scheduled for completion in 2011.

It is also recognized that other regional concerns such as ecosystem health, water supply and quality, climate change, cultural resources, recreation, navigation, irrigation, and other needs of river, that were not looked at in either the Phase 1 or Supplemental studies will need to be considered. Moving forward, the U.S. Entity is fully committed to an open, collaborative, and region-wide engagement process, so that all voices in the Pacific Northwest that wish to be heard can inform and identify the best possible policy options in the 2014/2024 Columbia River Treaty Review. The Phase 1 and the U.S. Entity Supplemental Reports will hopefully provide valuable information moving forward, but are only the beginning of this important process.