

# Columbia River Treaty

## 2014/2024 Review

### United States Entity Supplemental Report Appendix B

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United States Entity



**APPENDIX B  
PHASE 1 STUDY RESULTS COMPARED TO  
SUPPLEMENTAL STUDY RESULTS**

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## **B.1 INTRODUCTION**

In general, the planning and operation of the Canadian Treaty projects does not include operating objectives and procedures other than those for power and flood control, the two purposes recognized in the Treaty and Protocol. Since the Phase 1 studies were focused on looking only at these two fundamental river purposes defined under the Treaty, 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 expected to create a baseline of information for comparison and to build from for future studies and for engagement with the sovereigns and stakeholders within their respective countries. However, since the Biological Opinions (BiOp) have such a strong influence on the U.S. operations, the U.S. Entity felt it was important to also look at the Phase 1 study results with the fish operations included. The purpose of this appendix is to describe the modeling, methodology and criteria used in the U.S. Entity Phase 1 Supplemental studies that were done to assess the impacts to the U.S. system and fish operations when BiOp requirements were overlaid on the Phase 1 studies. The Phase 1 studies referred to in this appendix 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).

The purpose of this Appendix is to compare the Phase 1 study results to the Phase 1 Supplemental results on a 70-year basis as well as by Called Upon subsets. By comparing the Phase 1 results to the Phase 1 Supplemental studies results, the effects and changes to river flow, reservoir levels, and generation resulting from the fish operations under possible future Treaty scenarios can be assessed and evaluated. Appendices C and D compare across Phase 1 with Supplemental studies to see the impacts of the three flood control scenarios used in the Phase 1 studies as well as the Called Upon operations at 450 kcfs and 600 kcfs maximum flow objective at The Dalles.

## **B.2 GENERAL STUDY COMPARISONS**

The following are comparisons of study results between the Phase 1 studies and the Supplemental studies. The Phase 1 power studies were developed to test the Columbia River System's ability to meet projected load after 2024 when operating to one potential Called Upon flood control operation. The results compare how the system performed across all seventy historic water years as well as the 21 Called Upon years in the Phase 1 studies where the maximum flood control flow objective at The Dalles was 600 kcfs and the 52 Called Upon years in the Phase 1 studies where the maximum flood control flow objective at The Dalles was 450 kcfs.

The data showing the 70-year study results yields less pronounced variation because the dataset is an average of both Called Upon and non-Called Upon years under the entire 70-year record of streamflow conditions. The data showing results for the 21 years that Called Upon was triggered in the Phase 1 studies may show pronounced variation between the Phase 1 and Supplemental

study results. These 21 years are generally larger water years and they are more similar in nature than the 70-year dataset.

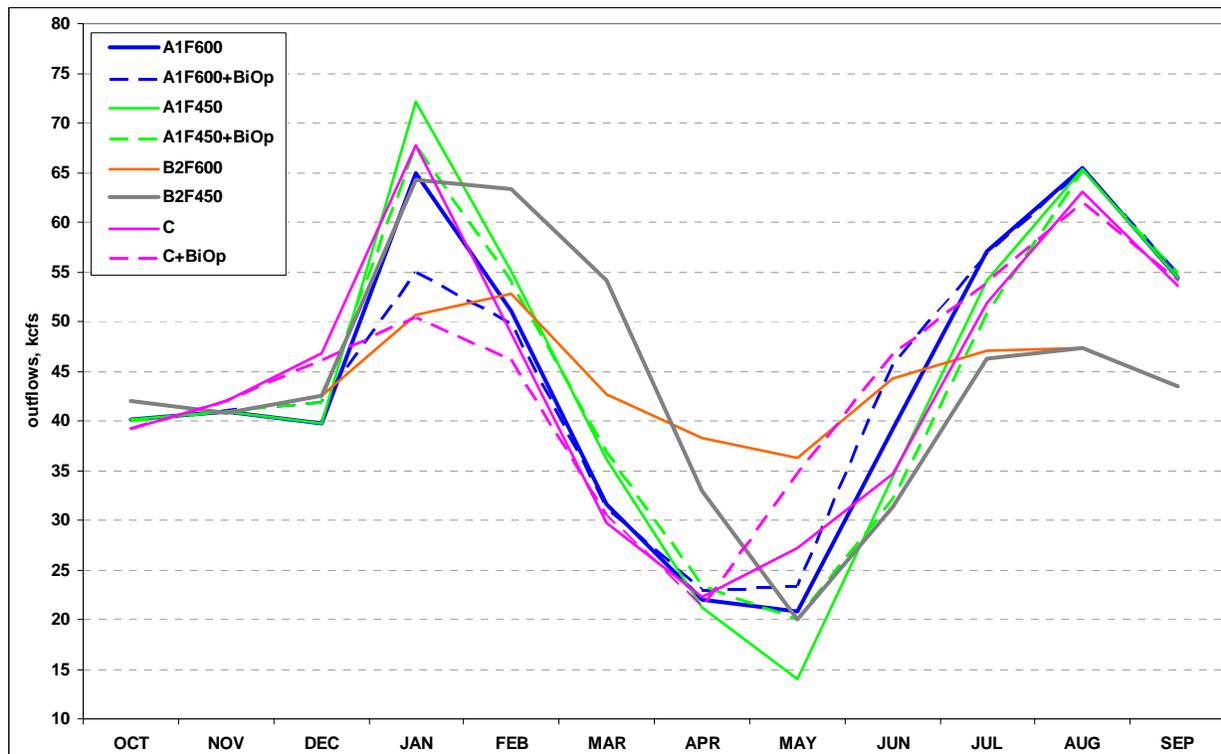
### **B.3 ARROW PLUS DUNCAN OUTFLOWS**

For Canadian outflows, the only difference between the Phase I studies and the Supplemental Studies is the addition of a 1 Maf flow augmentation storage operation at Arrow reservoir for the A and C studies. This operation is similar to current Supplemental Operating Agreements authorized by the Treaty Detailed Operating Plans (DOP), where 1 Maf is typically stored in January above reservoir levels defined in the DOP, and the water is released in May through July to aid downstream migrating salmon in the U.S. The operation is requested in the current Biological Opinion, but is available only by agreement with the Canadian Entity such that it also meets Canadian trout spawning and other objectives.

**Figure B-1 Arrow plus Duncan Outflows - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



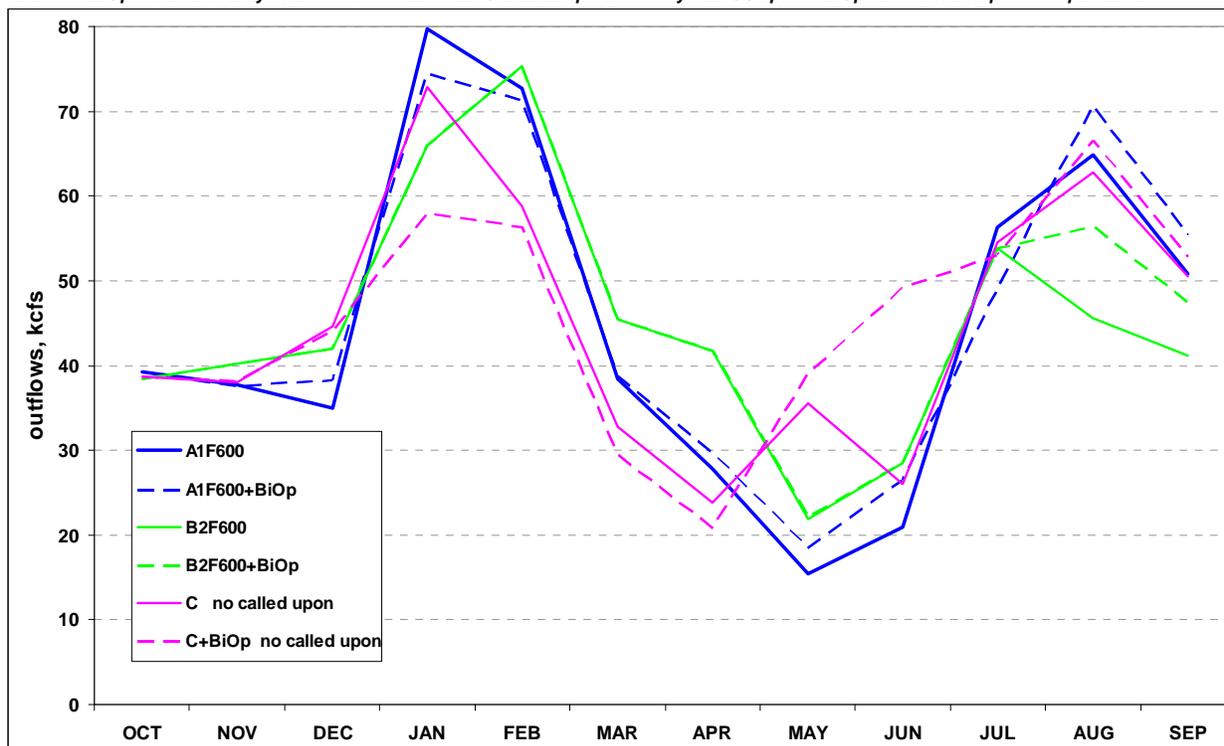
The B studies, where the Treaty is terminated, do not include the 1 Maf flow augmentation storage operation because it was assumed that Canadian reservoirs would be operated to meet their own fish objectives without the need for a mutually beneficial agreement with the U.S. Therefore, in the above graph, the B2F Phase 1 studies and the B2F+BiOp Supplemental studies have the same Canadian operation. Generally the B2F power studies shape more flow from Arrow and Duncan in the February and March period and less in the June through August period than the A and C studies where the Treaty continues.

In the A and C studies, Arrow + Duncan outflows in January were less in the Supplemental studies compared to the Phase 1 studies due to the storing 1 Maf, and flows were higher in May and June for U.S. flow augmentation. In the A1F450+Supplemental studies, these higher spring flows resulted in the flow augmentation storage of 1 Maf being used by the end of June which resulted in lower July outflows than the Phase 1 study. Called Upon flood control often forced out the 1 Maf flow augmentation water during the drawdown period. That combined with the 15 kcfs trout spawning minimum outflow in April and May left very little flow in July.

**Figure B-2 Arrow plus Duncan Outflows - 21 Called Upon Years @ 600 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	39	38	35	80	73	38	28	15	21	56	65	51
A1F600+BiOp	39	38	38	74	71	39	30	19	26	49	71	55
B2F600	38	40	42	66	75	45	42	22	29	54	46	41
B2F600+BiOp	38	40	42	66	75	45	42	22	29	54	56	47
C no called upon	39	38	45	73	59	33	24	36	26	54	63	50
C+BiOp no called upon	39	38	44	58	56	30	21	39	49	53	67	53

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

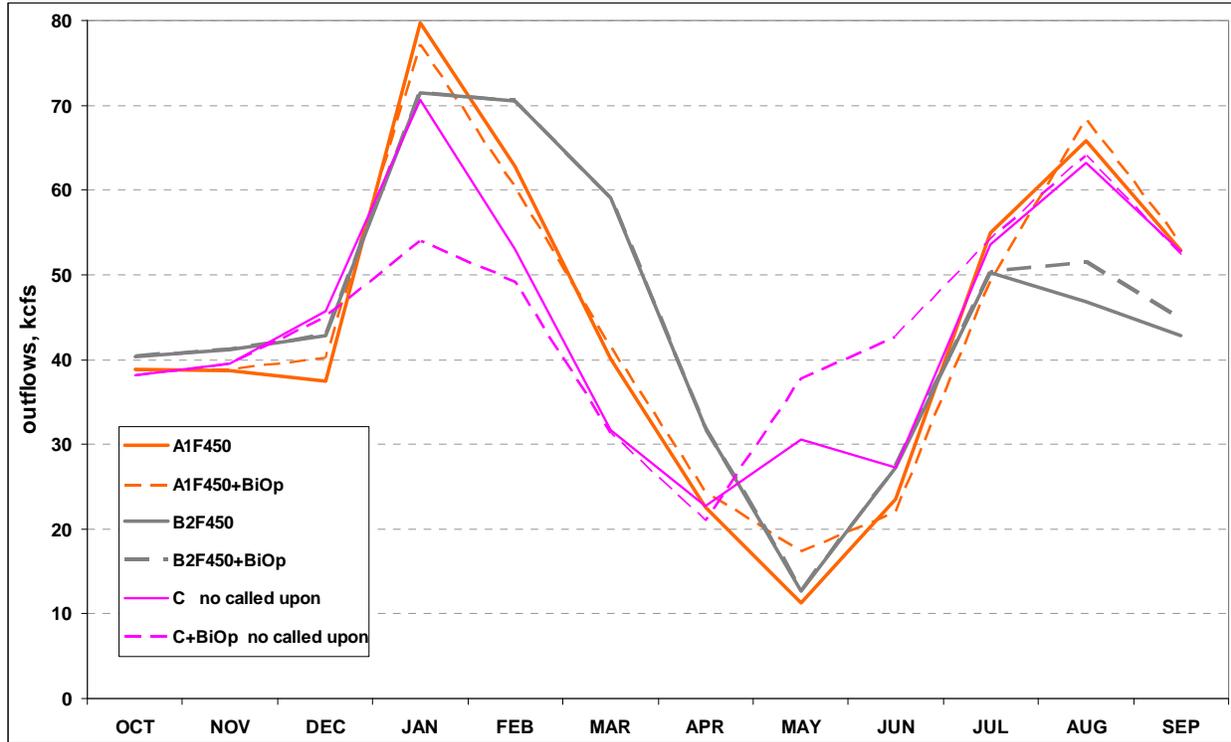


During the 21 years with Called Upon flood control operations at the 600 kcfs objective, out of the 70 water years studied, the ability to store the 1 Maf for flow augmentation is sometimes limited by the flood control rule curves. Therefore, differences between the Phase 1 and Supplemental studies average Canadian outflows shown in Figure B2 are less than the 70 year averages shown in Figure B1.

**Figure B-3 Arrow plus Duncan Outflows - 52 Called Upon Years @ 450 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F450	39	39	37	80	63	40	23	11	24	55	66	53
A1F450+BiOp	39	39	40	77	60	41	24	17	22	49	68	54
B2F450	40	41	43	71	70	59	32	13	27	50	47	43
B2F450+BiOp	40	41	43	71	70	59	32	13	27	50	52	45
C no called upon	38	40	46	71	53	32	23	31	27	54	63	53
C+BiOp no called upon	38	39	45	54	49	31	21	38	43	54	64	52

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



During the 52 years with Called Upon flood control operations at the 450 kcfs objective, out of the 70 water years studied, the ability to store the 1 Maf for flow augmentation is limited by the flood control rule curves more often than it was at the 600 kcfs objective.

## **B.4 U.S. SYSTEM POWER GENERATION**

Fish operations reduce U.S. average annual generation because of the additional spill on the U.S. system in May through August as required in the Biological Opinions. This amount of reduction is similar whether or not the Treaty is terminated. .

Figure B-4 demonstrates that with or without the Treaty, looking across all of the scenarios, the addition of fish operations to the Phase 1 studies reduced U.S. system generation by about 1520 to 1665 annual aMW. This is due to the U.S. reservoirs operating to higher elevations during the winter months as they operate up to the flood control rule curve elevations, resulting in higher outflows during the spring and summer when many projects are required to bypass powerhouse turbines (spill) for fish passage. The chart and graph show the greatest generation reduction because of the BiOp is in the May – June period because of fish spill at U.S. projects. Even though the Treaty is Terminated scenarios (B2) Phase 1 shape is dramatically different than the Treaty Continues (A and C) Phase 1 shapes, the addition of the fish operations reshapes generation such that all +BiOp shapes are similar. With the Treaty continues, the fish operations produced less generation in January 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.

**Figure B-4 U.S. System Generation - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

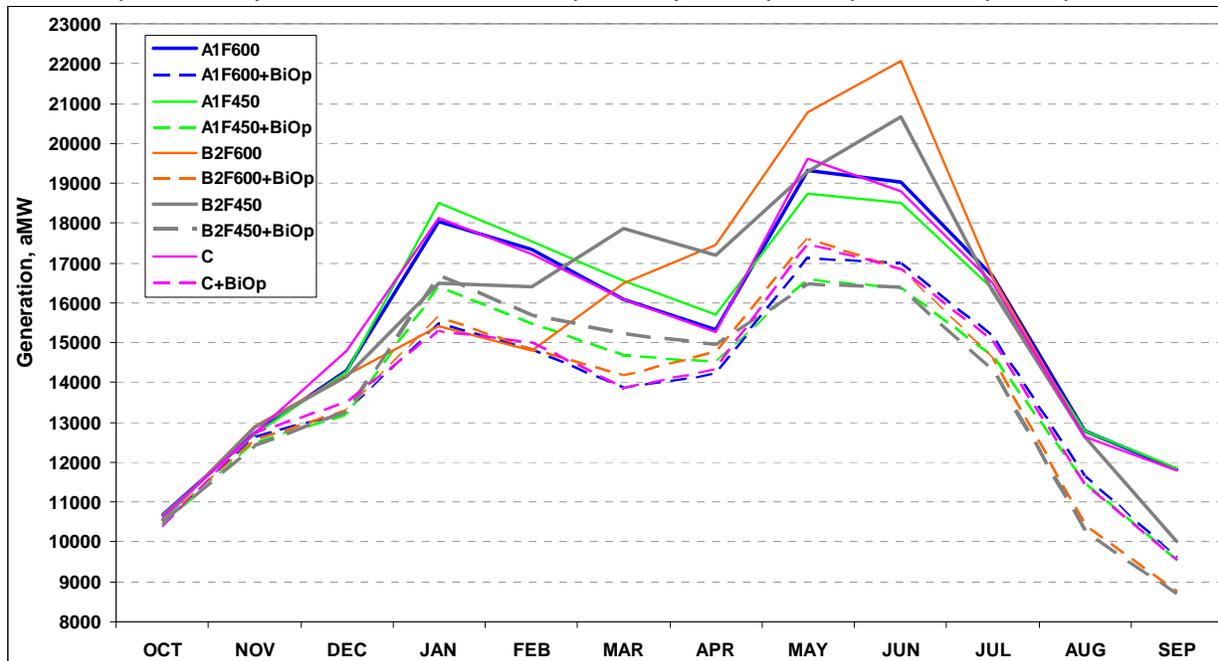


Figure B-5 shows the difference in generation between the 21 years that Called Upon was triggered in the Phase 1 studies when 600 kcfs was the maximum flow at The Dalles. The fish operations reduced average annual generation approximately 1900 aMW in the 21 Called Upon years.

In general, the overall annual generation across all Phase 1 studies was similar, however, the month-to-month shape showed variation between studies throughout the year, as A1 and C were similar, but B2 had less generation in winter and more in the spring and summer. If the system were operated with the Treaty as shown in the A1F600 and C studies, or without the Treaty as shown in the B2F600 study, the fish operations overlaid on any of these studies produced similar U.S. power generation with the BiOp.

**Figure B-5 U.S. System Generation - 21 Called Upon Years @ 600 kcfs objective**

generation, aMW	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN AVE
A1F600	10918	13274	15582	21965	21147	19271	19172	21876	21097	18883	12976	11813	17309
A1F600+BiOp	10750	12971	14844	18869	17905	16341	17107	18730	18005	16441	12542	10339	15418
B2F600	10831	13310	15724	18515	19965	20067	21220	22957	23331	19322	12532	9846	17364
B2F600+BiOp	10581	13094	15144	18941	17858	16310	17245	18844	17933	16444	11654	9677	15354
C no called upon	10912	13262	16351	21643	20323	18821	18589	22594	21414	19136	12811	11786	17290
C+BiOp no called upon	10702	13105	15200	18286	17711	16270	16841	19492	17882	16602	12361	10159	15375

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

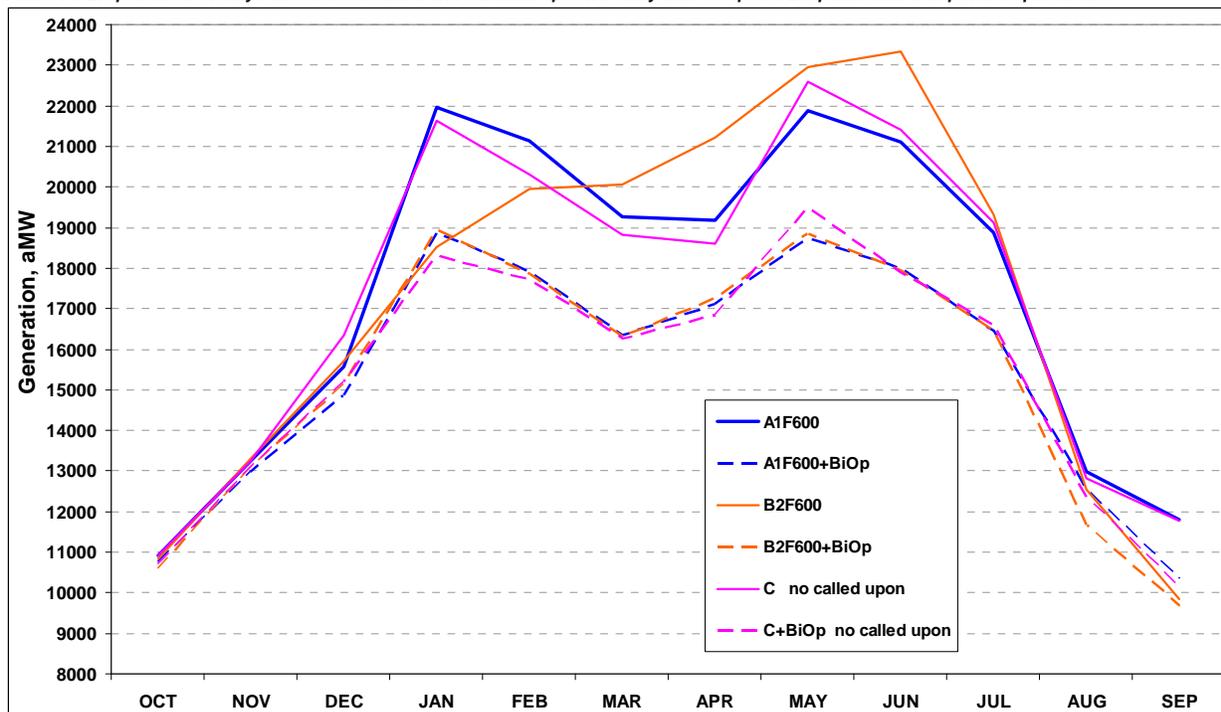


Figure B-6 shows the difference in generation between the 52 years that Called Upon was triggered in the Phase 1 studies when 450 kcfs was the maximum flow at The Dalles. The fish operations reduce average annual generation approximately 1600 aMW in the 52 Called Upon years.

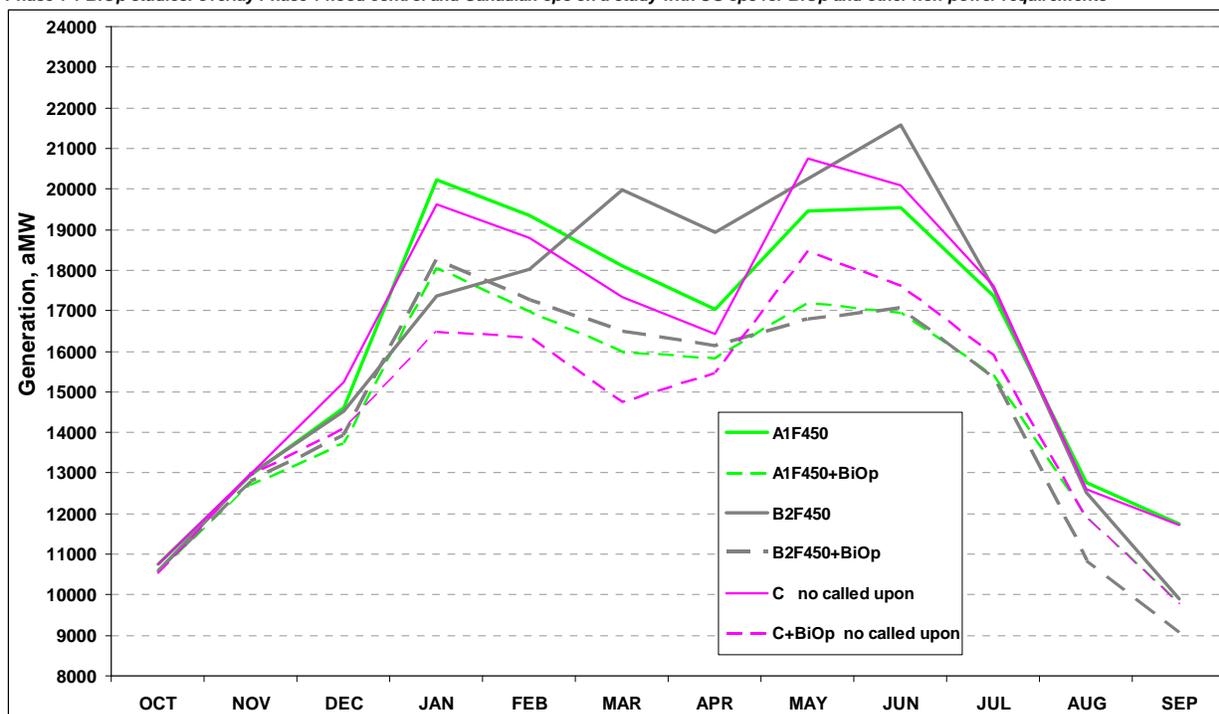
The overall annual generation across all Phase 1 studies was similar; however, the month-to-month shape showed variation between studies throughout the year due to differences in power generation needs. The B2F450 power study has slightly more power generation than any other study in March and June. However when the BiOp is included in the study, the A1 and C studies that are a continuation of the Treaty, have more power generation in the spring than the power study where the Treaty is terminated.

**Figure B-6 U.S. System Generation - 52 Called Upon Years @ 450 kcfs objective**

generation, aMW	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANN AVE
A1F450	10749	12955	14619	20220	19339	18097	17028	19446	19551	17350	12771	11748	16139
A1F450+BiOp	10544	12700	13719	18063	16986	15980	15817	17193	16937	15405	11915	9784	14576
B2F450	10592	12986	14533	17361	18037	19972	18922	20258	21586	17566	12524	9901	16175
B2F450+BiOp	10585	12786	13932	18246	17249	16473	16136	16779	17074	15352	10846	9065	14530
C no called upon	10746	12994	15233	19610	18806	17332	16422	20756	20095	17600	12602	11729	16148
C+BiOp no called upon	10506	12962	14074	16494	16350	14760	15475	18475	17597	15906	11889	9750	14511

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



## B.5 RESERVOIR OPERATIONS

As expected, the federal projects’ reservoirs operated higher in January through April in the studies with the Biological Opinion. This is because of the BiOp requirement for the federal reservoirs to operate to flood control upper limits by April 10. In the Phase 1 studies, the reservoirs operated no higher than their effective use draft in years when Called Upon was triggered. In non-Called Upon years project operated to no higher than their current flood control curves determined by their current Storage Reservation Diagrams. The U.S. reservoirs then operated to near full by June 30 for summer flow augmentation. On average, Libby reservoir did not refill in any of the scenarios with the BiOp due to the release of sturgeon and bull trout flow objectives.

### B.5.1 GRAND COULEE

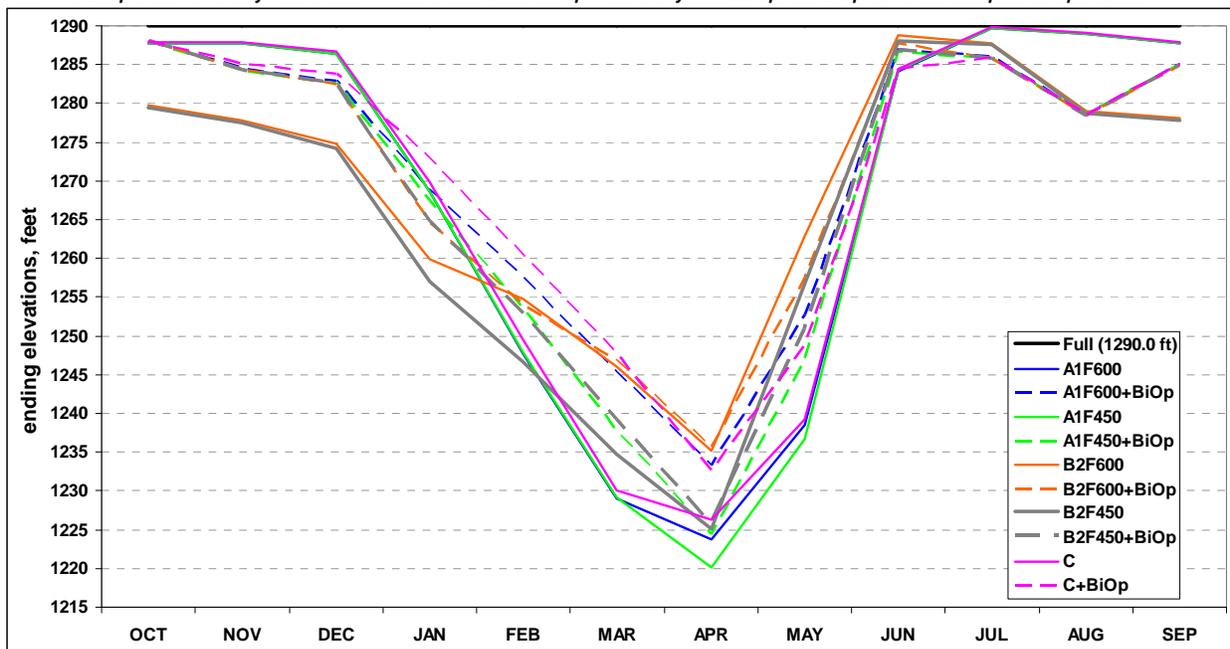
As expected Grand Coulee reservoir is generally operated higher in January through May in the Supplemental studies because Grand Coulee reservoir is attempting to fill up to the April 10<sup>th</sup> flood control elevation. All Supplemental studies were lower than the corresponding Phase 1 studies on September 30 due to the Kokanee spawning objective of 1285 feet on September 30, with the exception of the Treaty terminates scenarios (B2) where the reduction in Arrow plus

Duncan outflows resulted in a larger draft for power. This impact on Grand Coulee’s elevation continued through January.

**Figure B-7 Grand Coulee Elevations, feet - 70-Year Studies - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



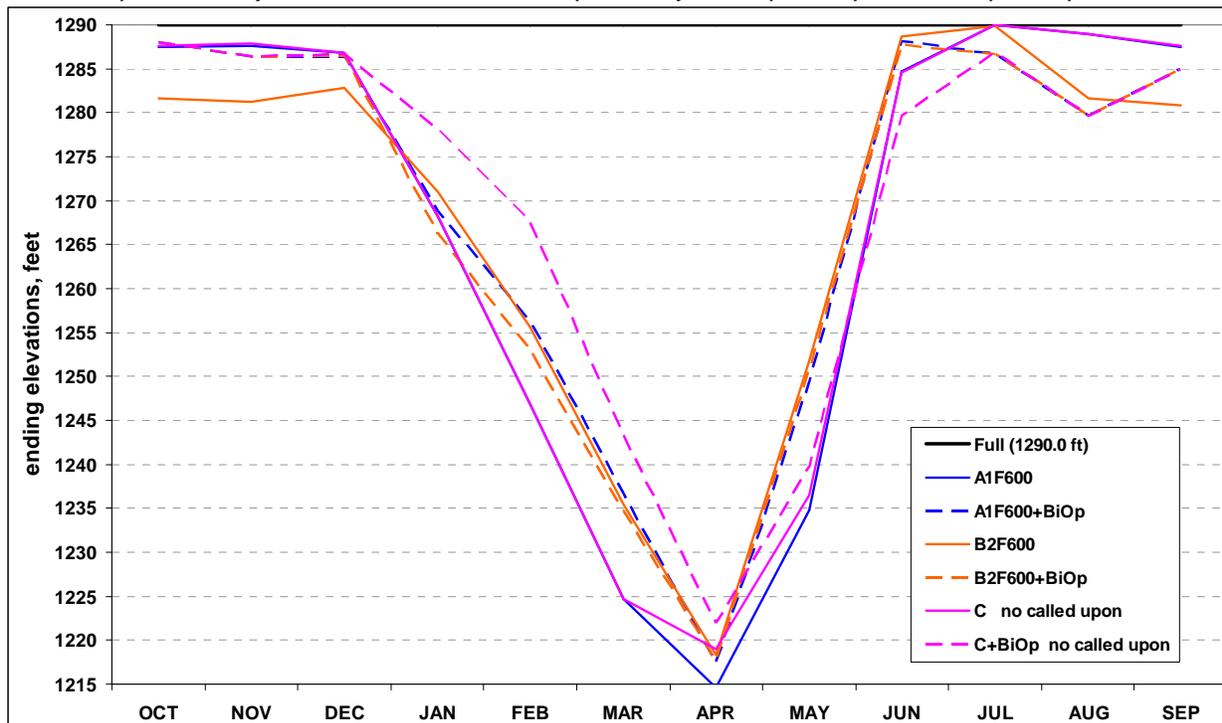
In the 21 years where Called Upon was triggered in the 600 kcfs studies, Grand Coulee drafted toward empty. The reservoir drafted deeper at the end of April in the Phase 1 studies than it did in the Supplemental studies. The Phase 1 studies allowed Grand Coulee to draft below flood control or its effective use for power generation needs, while the Supplemental studies kept Grand Coulee more full during the drawdown period so the reservoir could be at its April 10<sup>th</sup> effective use elevation.

**Figure B-8 Grand Coulee Elevations, feet - 21 Called Upon Years @ 600 kcfs objective**

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	1287	1288	1287	1268	1247	1225	1215	1235	1285	1290	1289	1287
A1F600+BiOp	1288	1286	1286	1269	1256	1237	1217	1249	1288	1287	1280	1285
B2F600	1282	1281	1283	1271	1256	1235	1218	1252	1289	1290	1282	1281
B2F600+BiOp	1288	1286	1287	1266	1253	1235	1218	1251	1288	1287	1280	1285
C no called upon	1288	1288	1287	1268	1247	1225	1219	1237	1285	1290	1289	1288
C+BiOp no called upon	1288	1286	1287	1278	1268	1243	1222	1240	1280	1287	1280	1285

Phase 1 studies: A1F600 includes called upon and Flex, B2F600 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



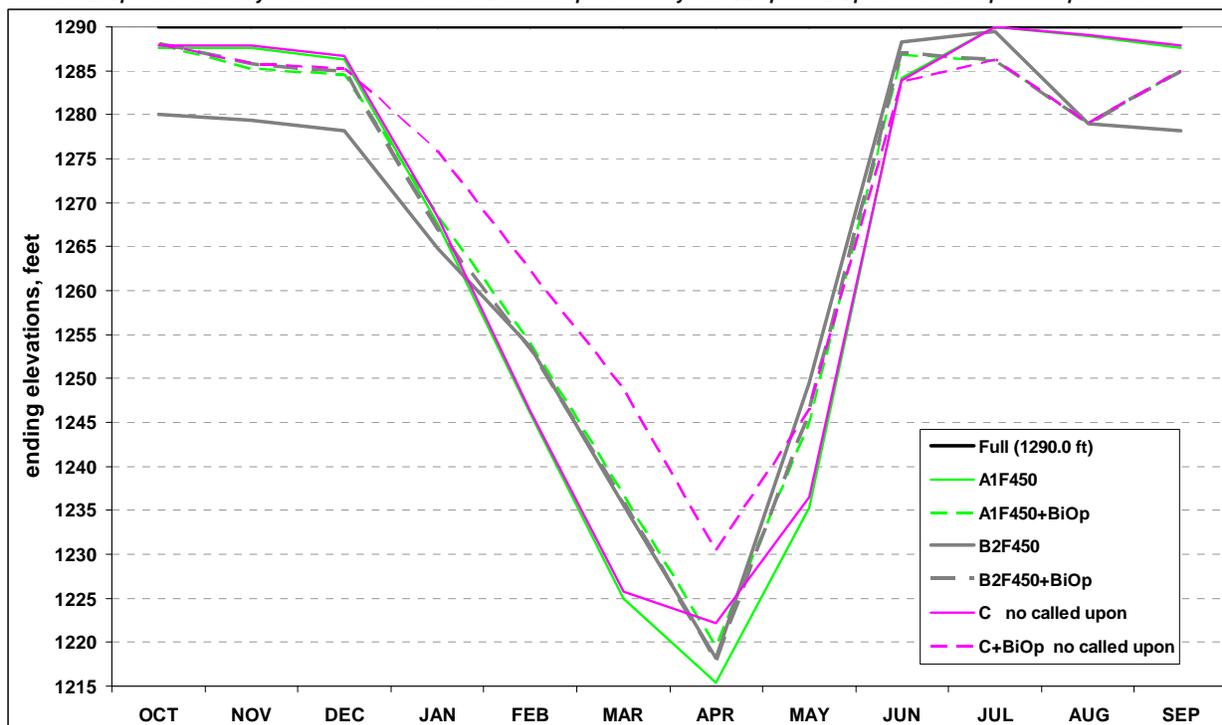
In the 52 Called Upon years in the 450 kcfs studies, Grand Coulee drafted more deeply in the Phase 1 studies for power generation than it did in the +BiOp scenarios where Grand Coulee operates up to its April 10<sup>th</sup> flood control elevation, in this case the flood control elevation in a Called Upon year. The highest end of April elevations in the Supplemental studies were in the 52 Called Upon years in the C studies where the Treaty continues and Called Upon was not used. The elevation at the end of April is higher than it was in the studies where the maximum flow at The Dalles was 600 kcfs because there are more data points in this sample and a wider variety of end of April elevations in the dataset that makes up this average sample.

**Figure B-9 Grand Coulee Elevations, feet - 52 Called Upon Years @ 450 kcfs objective**

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
A1F450	1288	1288	1286	1268	1246	1225	1215	1235	1284	1290	1289	1288
A1F450+BiOp	1288	1285	1285	1269	1254	1237	1219	1245	1287	1286	1279	1285
B2F450	1280	1279	1278	1265	1254	1236	1218	1249	1288	1289	1279	1278
B2F450+BiOp	1288	1286	1285	1267	1253	1236	1218	1246	1287	1286	1279	1285
C no called upon	1288	1288	1287	1268	1246	1226	1222	1237	1284	1290	1289	1288
C+BiOp no called upon	1288	1286	1285	1276	1262	1249	1230	1247	1284	1286	1279	1285

Phase 1 studies: A1F450 includes called upon and Flex, B2F450 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



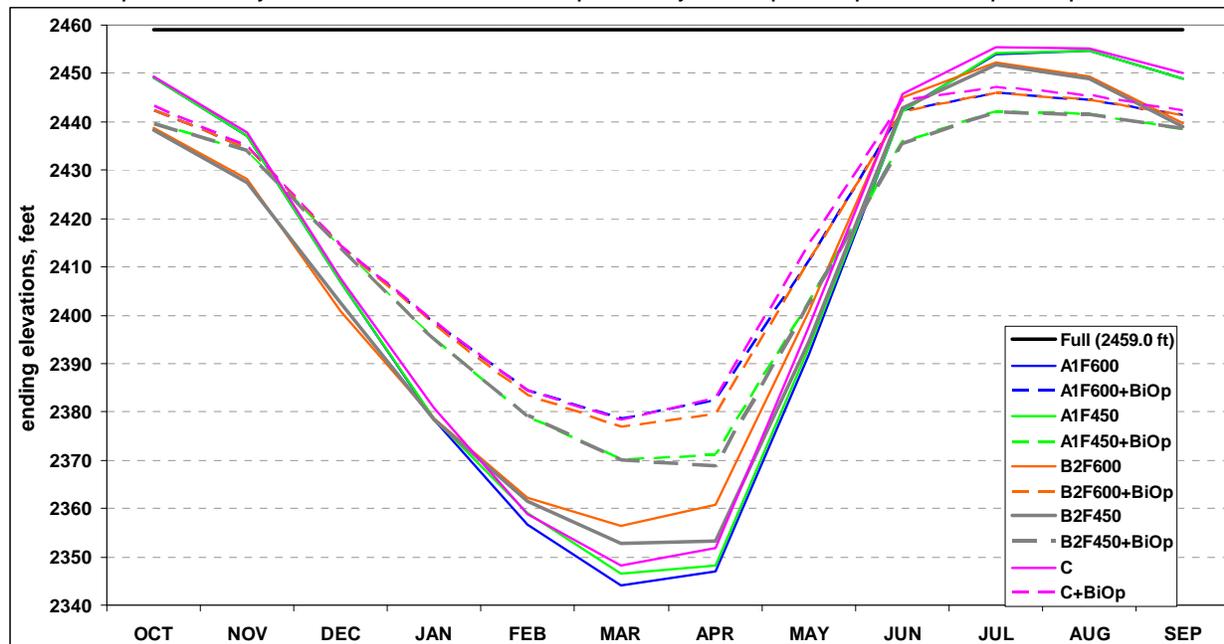
### B.5.2 LIBBY DAM

The Phase 1 scenarios drafted Libby deeper during the November through April 10 period when compared to their respective Supplemental studies due to power operations. fish operations caused Libby to operate to a lower elevation 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). By December all Supplemental studies showed a higher elevation than the Phase 1 studies. The Supplemental studies operated to the Variable End of December flood control elevation as required by the BiOp, while the Phase 1 studies drafted deeper for power.

**Figure B-10 Libby Elevations, feet - 70-Year Studies - 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	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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



In these 21 years when Called Upon was triggered, Libby reservoir is higher at the end of April in all the Supplemental studies than the comparable Phase 1 studies because the reservoir was filling up to its effective use elevation rather than drafting for power. The B2 study had the least difference at the end of April between the Phase 1 and Supplemental studies as Canadian reservoirs operated for power and U.S. reservoirs did not draft as deeply for power.

The A1F600 and C Study had lower elevations in January through April because the project was operating to Standard flood control. The B2F600 study operated to VarQ flood control. All the studies with the BiOp operated to VarQ food control.

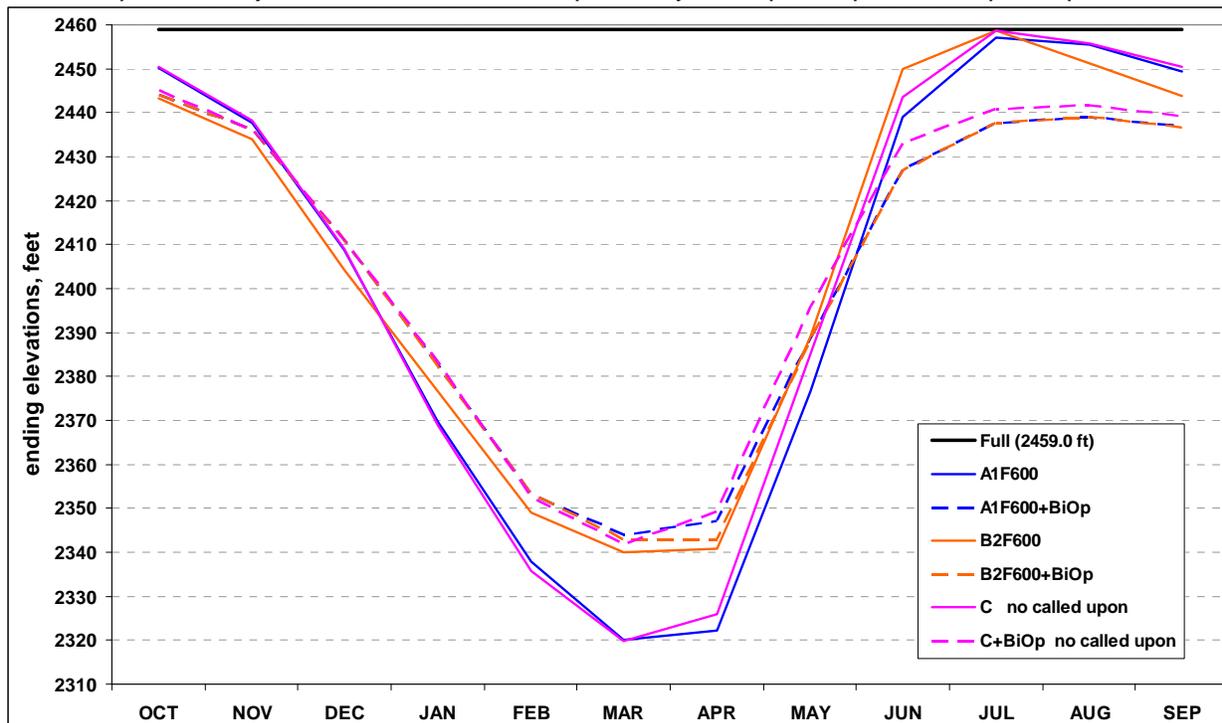
In this subset of the 70-years of data, Libby reservoir is approximately 30 to 40 feet lower than the 70-year average elevation in March and April in the Supplemental studies because Libby is operating to effective use in all the years in this data subset. Rather than operating up to the VarQ flood control elevation, the reservoir is operating to its effective use elevation at the end of April when the dam would release minimum outflow in May and June. But since the Supplemental studies had Libby Dam release flow greater than minimum in May and June for bull trout and sturgeon flow, the reservoir failed to refill to within 20 feet from full in June.

**Figure B-11 Libby Elevations, feet - 21 Called Upon Years @ 600 kcfs objective**

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	2450	2438	2409	2370	2338	2320	2322	2377	2439	2457	2456	2449
A1F600+BiOp	2444	2436	2411	2382	2353	2344	2347	2389	2427	2438	2439	2437
B2F600	2443	2434	2404	2377	2349	2340	2341	2389	2450	2459	2451	2444
B2F600+BiOp	2444	2436	2411	2382	2353	2343	2343	2388	2427	2438	2439	2437
C no called upon	2450	2438	2409	2369	2336	2320	2326	2385	2444	2459	2456	2450
C+BiOp no called upon	2445	2436	2411	2383	2353	2342	2349	2396	2433	2441	2442	2439

Phase 1 studies: A1F600 includes called upon and Flex, B2F600 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



As with the 21 Called Upon years, in the 52 Called Upon years, when the maximum flow at The Dalles was 450 kcfs, Libby operated to a higher end of April elevation in all the Supplemental studies. The B2 study had the least variation between the Phase 1 and Supplemental studies because Libby did not draft for power as much as it did in the A and C Phase 1 studies. In the Phase 1 power studies, Libby fills because the project is operating to its Energy Content Curve (ECC) which tries to refill the reservoir in July for future power generation. In the Supplemental studies Libby does not refill because the dam was releasing bull trout and sturgeon outflows in excess of minimum.

In this subset of the 70-years of data, Libby reservoir is approximately 10 to 25 feet lower than the 70-year average elevation in March and April in the Supplemental studies because Libby is operating to effective use in all of the years in this data subset except in the C+BiOp study where it operated for VarQ flood control. Rather than operating up to the VarQ flood control elevation in the A +BiOp and BiOP studies, the reservoir is operating to its effective use elevation at the end of April when the dam would release minimum outflow in May and June. But since the Supplemental studies had Libby Dam release flow greater than minimum in May and June for bull trout and sturgeon flow, the reservoir failed to refill to within 20 feet from full in June. These elevations are slightly higher than the 21 years where the maximum flow at The Dalles

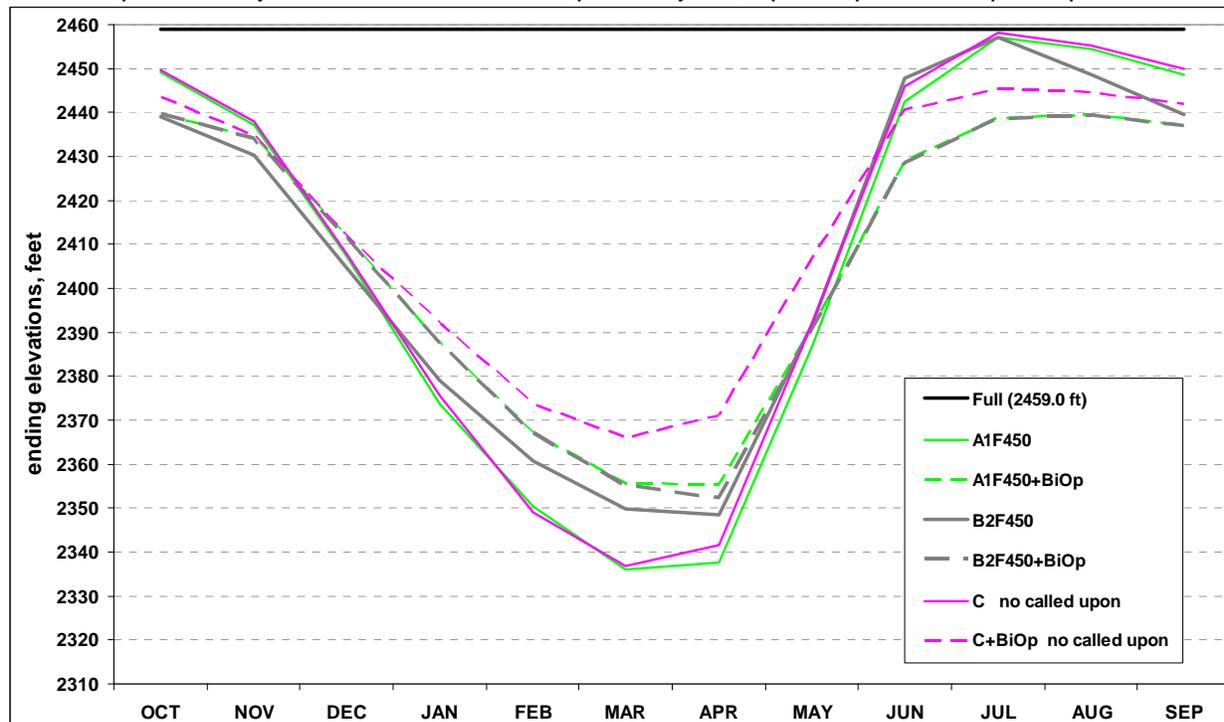
was 600 kcfs because there are more data points in the dataset and more diverse water years represented in the data.

**Figure B-12 Libby Elevations, feet - 52 Called Upon Years @ 450 kcfs objective**

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
A1F450	2449	2437	2407	2374	2350	2336	2338	2387	2443	2457	2454	2449
A1F450+BiOp	2440	2434	2412	2388	2367	2356	2355	2391	2429	2439	2440	2437
B2F450	2439	2430	2405	2379	2361	2350	2350	2348	2392	2448	2457	2449
B2F450+BiOp	2440	2434	2412	2387	2367	2355	2352	2391	2428	2439	2439	2437
C no called upon	2450	2438	2408	2376	2349	2337	2342	2392	2446	2458	2455	2450
C+BiOp no called upon	2444	2435	2412	2392	2374	2366	2371	2407	2441	2445	2445	2442

Phase 1 studies: A1F450 includes called upon and Flex, B2F450 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



### B.5.3 HUNGRY HORSE DAM

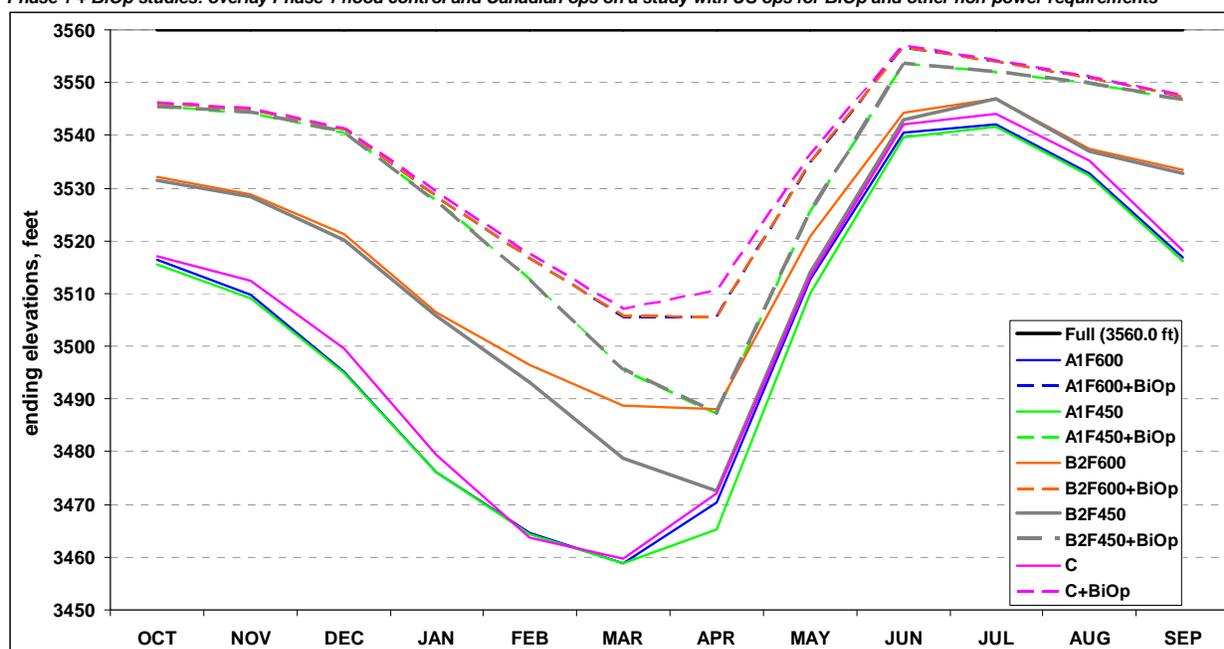
In general, the +BiOp scenarios did not draft Hungry Horse as deep as the Phase 1 scenarios alone because the Supplemental studies start Hungry Horse at a higher elevation in December and January. On average the +BiOp scenarios kept Hungry Horse fuller throughout the year due to the criteria to operate to VarQ flood control procedures in non-Called Upon years and effective use in Called Upon years, and only drafted to meet minimum flow requirements at site and at Columbia Falls. The Phase 1 studies operated for effective use flood control or power which usually drafted the project deeper. Fish operations improved June refill over Phase 1 studies due to the BiOp requirement to operate Hungry Horse reservoir on its Integrated Rule Curve (IRC) which allows refill by June 30<sup>th</sup> of each year. All Phase 1 scenarios had lower reservoir elevations during September through December due to drafting for power in Phase 1 and operating not lower than the BiOp draft limits in the Supplemental studies. 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.

**Figure B-13 Hungry Horse Elevations, feet - 70-Year Studies - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



Generally Hungry Horse drafted more deeply during the spring in the Phase 1 studies as it was used for power generation. Since less generation was needed in the B2 studies, Hungry Horse operated to higher elevations in spring in the B2 study where the Treaty is terminated. In the B2 Study there is not much difference in the Phase 1 elevation and the +BiOp elevation in these 21 Called Upon years because Hungry Horse was not needed for power generation.

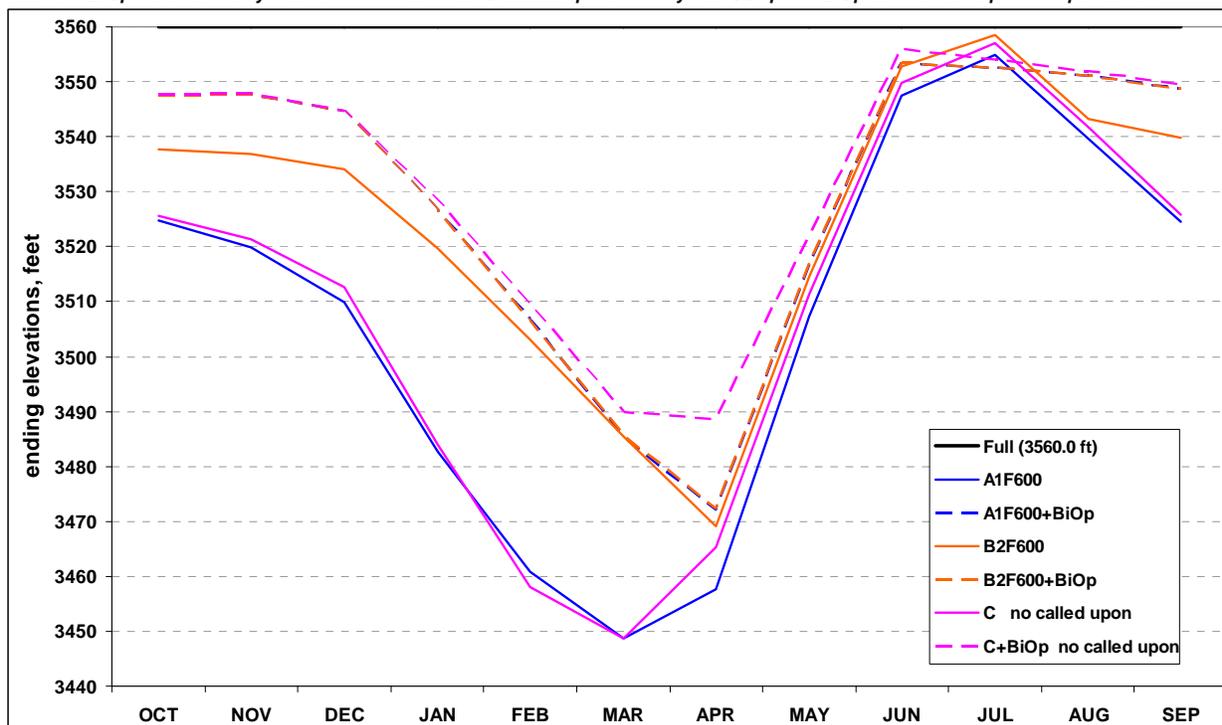
At the end of April the average elevation in the 21 Called Upon years with the BiOp are about 30 feet lower than the 70-year average elevations with the BiOp because this is a smaller dataset with large water years that would have drafted for effective use, not VarQ. This is also demonstrated at the end of March in the Phase 1 study results. The end of March elevation in this dataset is about 10 feet lower in the A and C Studies where the Treaty continues than the end of March elevation in the Phase 1 70-year average elevation dataset.

**Figure B-14 Hungry Horse Elevations, feet - 21 Called Upon Years @ 600 kcfs objective**

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	3525	3520	3510	3483	3461	3449	3458	3507	3547	3555	3540	3525
A1F600+BiOp	3547	3548	3545	3527	3507	3485	3472	3517	3553	3553	3551	3549
B2F600	3538	3537	3534	3520	3503	3486	3469	3515	3553	3558	3543	3540
B2F600+BiOp	3547	3548	3545	3527	3506	3486	3472	3517	3553	3553	3551	3549
C no called upon	3526	3521	3513	3484	3458	3449	3465	3511	3550	3557	3542	3526
C+BiOp no called upon	3548	3548	3545	3528	3509	3490	3489	3522	3556	3554	3552	3550

Phase 1 studies: A1F600 includes called upon and Flex, B2F600 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



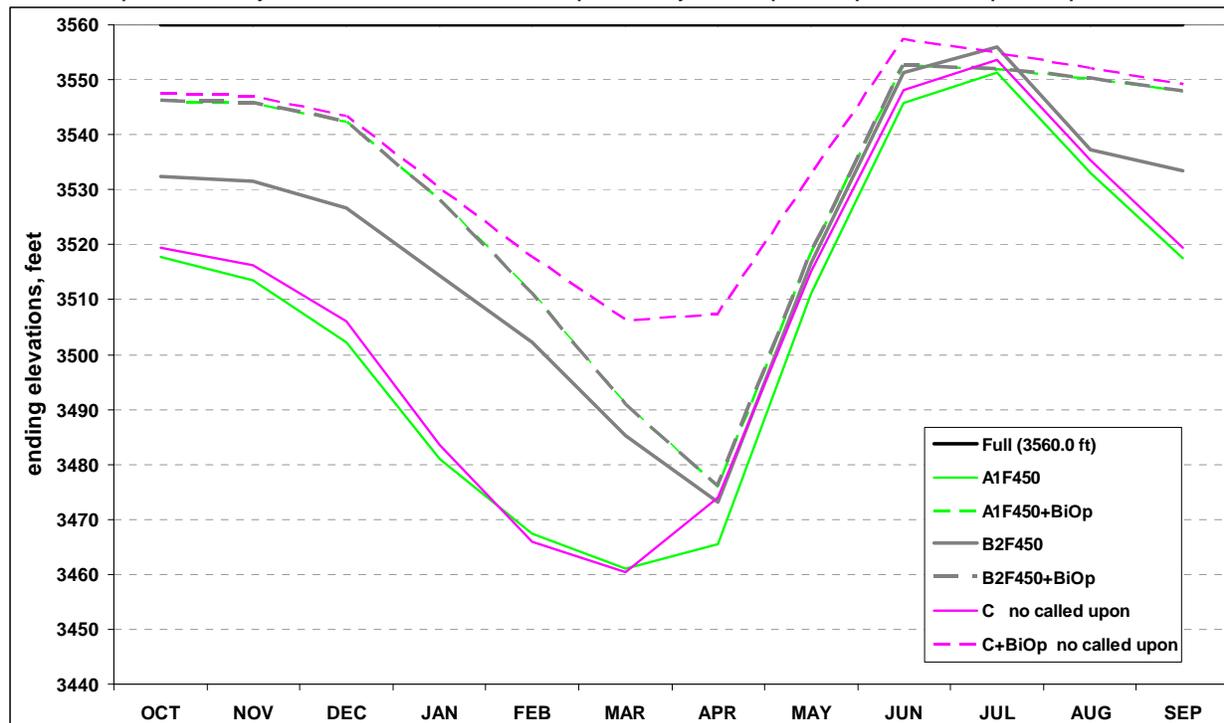
In Figure B-15, the C+BiOp average elevation was by far the highest Hungry Horse reservoir elevations as compared all other Phase 1 or Supplemental studies. Comparing the C, A1, and B2 scenarios to their respective Supplemental studies, the Supplemental studies resulted in higher elevations throughout the year due to the requirement to operate to near flood control and to not draft below the BiOp draft limits, while the Phase 1 studies operated for power, drafting deeper. Comparing C+BiOp to the other +BiOp scenarios, C+BiOp elevations are higher because Hungry Horse operated to the VarQ flood control elevations in the C+BiOp study, and the A1F+BiOp and B2F Supplemental studies, operated to effective use draft for flood control in January through April. ..

**Figure B-15 Hungry Horse Elevations, feet - 52 Called Upon Years @ 450 kcfs objective**

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
A1F450	3518	3514	3502	3481	3467	3461	3466	3511	3546	3551	3533	3517
A1F450+BiOp	3546	3546	3542	3528	3511	3491	3476	3518	3553	3552	3550	3548
B2F450	3532	3532	3527	3514	3502	3485	3473	3517	3551	3556	3537	3533
B2F450+BiOp	3546	3546	3542	3528	3511	3491	3476	3519	3553	3552	3550	3548
C no called upon	3520	3516	3506	3484	3466	3460	3474	3515	3548	3554	3535	3519
C+BiOp no called upon	3547	3547	3543	3530	3518	3506	3507	3533	3557	3555	3552	3549

Phase 1 studies: A1F450 includes called upon and Flex, B2F450 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



### B.5.4 DWORSHAK DAM

Dworshak operated to higher elevations in the Supplemental studies in January through April as it operated up to its April 10<sup>th</sup> flood control elevation each year rather than drafting for power generation as it did in the Phase 1 studies. Dworshak drafted to elevation 1520 feet at the end of September in the Supplemental studies.

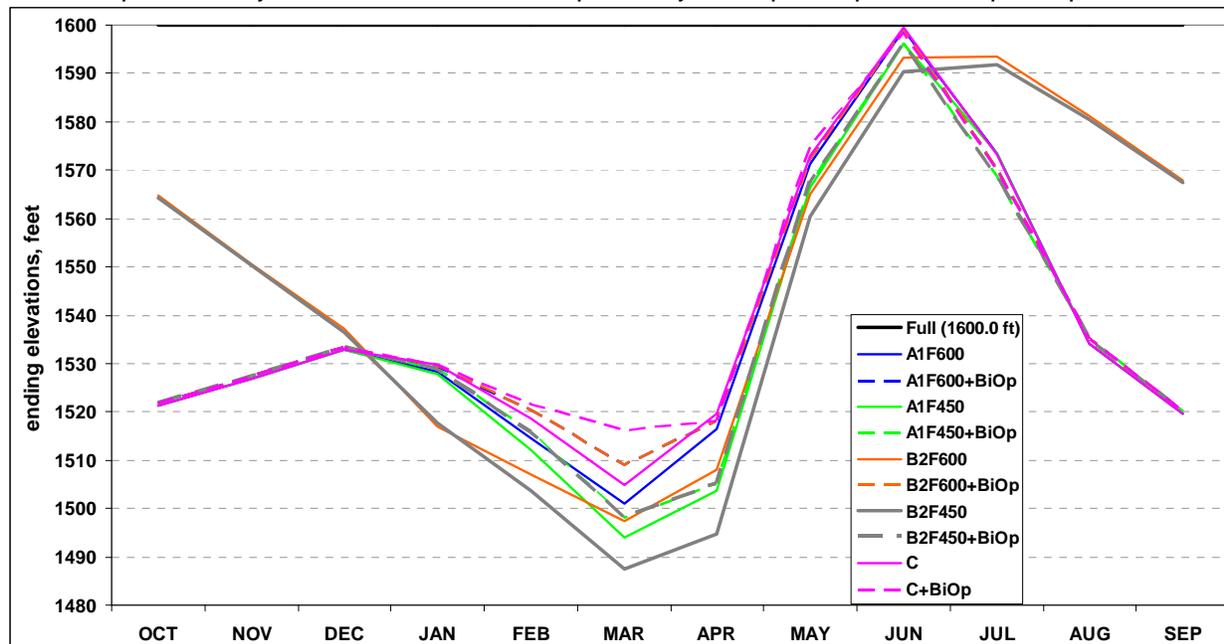
Since Dworshak is not considered part of the Treaty base system<sup>1</sup>, the BiOp requirements were applied in the Treaty continues scenarios (A1 and C); however, the B2 scenarios did not include fish operations to be able to see the effects of implementing the BiOp. The Phase 1 B2 scenarios operated Dworshak for power and flood control only. The reservoir elevation was higher in July through December in the Phase 1 B2 studies because Dworshak operated only for power, while it drafted deeper for the fish operations in the Phase 1 and BiOp, A and C studies. The July through November period varied dramatically between the B2 Phase 1 studies and all of the other studies which included fish operations, as the project drafted for BiOp objectives at the end of August and September and recovering in October through December.

<sup>1</sup> The 24 projects listed in the Treaty, plus post-1961 projects added on the mainstem of the Columbia.

**Figure B-16 Dworshak Elevations, feet - 70-Year Studies - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



In the A1 and C studies where the Treaty continues, Dworshak operated nearly the same in the Phase 1 studies and the Supplemental studies because Dworshak was allowed to operate for the Biological Opinion in Treaty studies as it is a non-base system plant. The B2F600 study drafted Dworshak slightly below the Supplemental studies in some periods for power generation in that study.

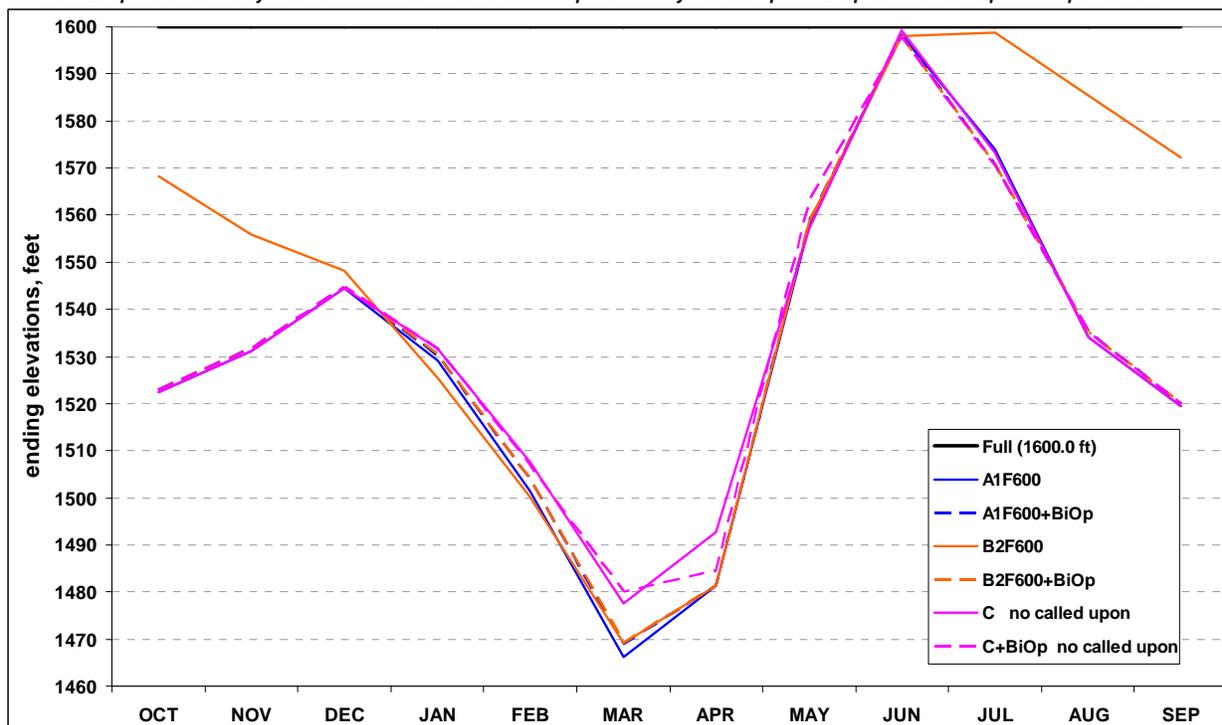
The B2F600 Study does not draft Dworshak for flow augmentation July through September. In this data subset of 21 years when Called Upon was triggered and Dworshak operated to effective use, the end of March reservoir elevation is about 20 to 40 feet lower than the 70-year average because Dworshak would have drafted deeply for effective use. The 70-year dataset includes many low water years where the end of March flood control elevation would have been quite full.

**Figure B-17 Dworshak Elevations, feet - 21 Called Upon Years @ 600 kcfs objective**

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	1522	1531	1545	1529	1501	1466	1481	1558	1598	1574	1534	1520
A1F600+BiOp	1523	1532	1545	1530	1504	1469	1481	1559	1598	1571	1535	1520
B2F600	1568	1556	1548	1525	1500	1469	1481	1559	1598	1599	1585	1572
B2F600+BiOp	1523	1532	1545	1530	1504	1469	1481	1559	1598	1571	1535	1520
C no called upon	1522	1531	1545	1532	1508	1478	1493	1557	1599	1573	1534	1520
C+BiOp no called upon	1523	1532	1545	1532	1507	1480	1485	1563	1598	1570	1535	1520

Phase 1 studies: A1F600 includes called upon and Flex, B2F600 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



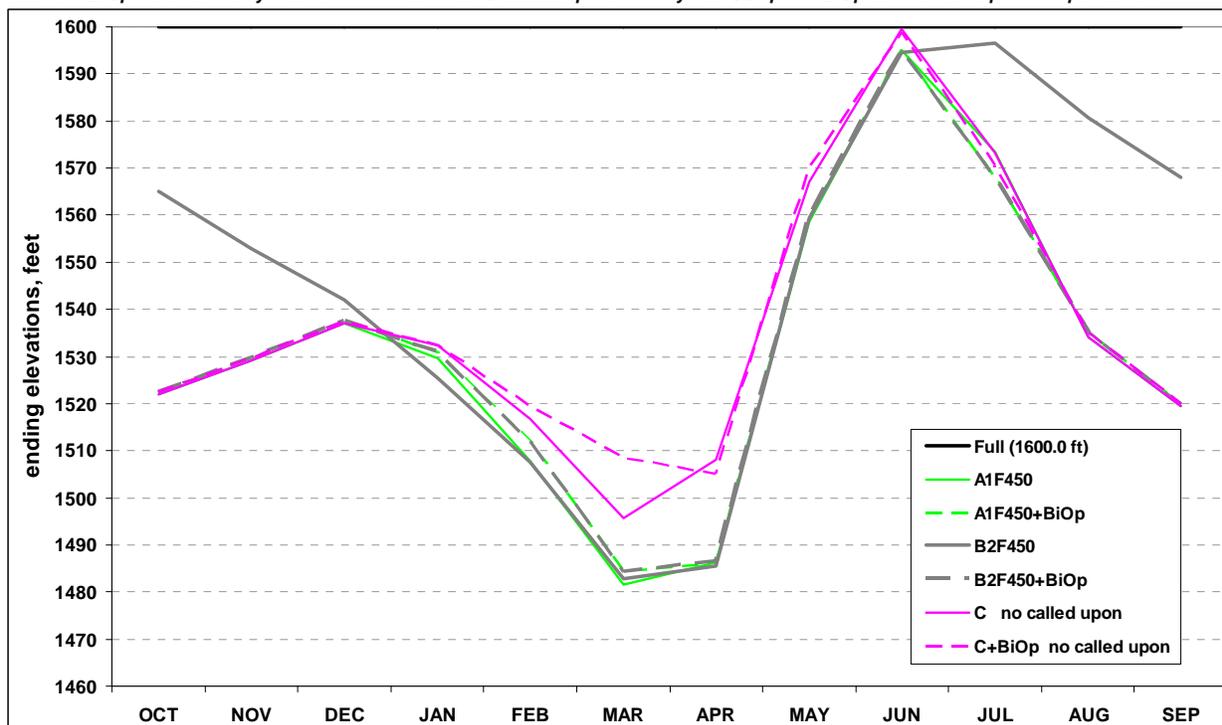
In the A1 and C studies where the Treaty continues, Dworshak operates nearly the same in the Phase 1 studies and the Supplemental studies because Dworshak is allowed to operate for the Biological Opinion in Treaty studies as it is a non-base system plant. The B2F450 study drafted Dworshak slightly below the Supplemental studies in some periods for power generation in that study since the B2 study did not include fish operations. The B2F450 Study does not draft Dworshak for flow augmentation July through September.

**Figure B-18 Dworshak Elevations, feet - 52 Called Upon Years @ 450 kcfs objective**

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
A1F450	1522	1529	1537	1530	1508	1482	1486	1559	1595	1573	1534	1520
A1F450+BiOp	1522	1530	1538	1531	1512	1484	1486	1559	1595	1568	1535	1520
B2F450	1565	1553	1542	1525	1508	1483	1486	1559	1595	1596	1581	1568
B2F450+BiOp	1522	1530	1538	1531	1512	1484	1486	1560	1595	1568	1535	1520
C no called upon	1522	1529	1537	1532	1517	1496	1508	1567	1600	1573	1534	1520
C+BiOp no called upon	1522	1530	1538	1532	1520	1509	1505	1570	1599	1570	1535	1520

Phase 1 studies: A1F450 includes called upon and Flex, B2F450 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



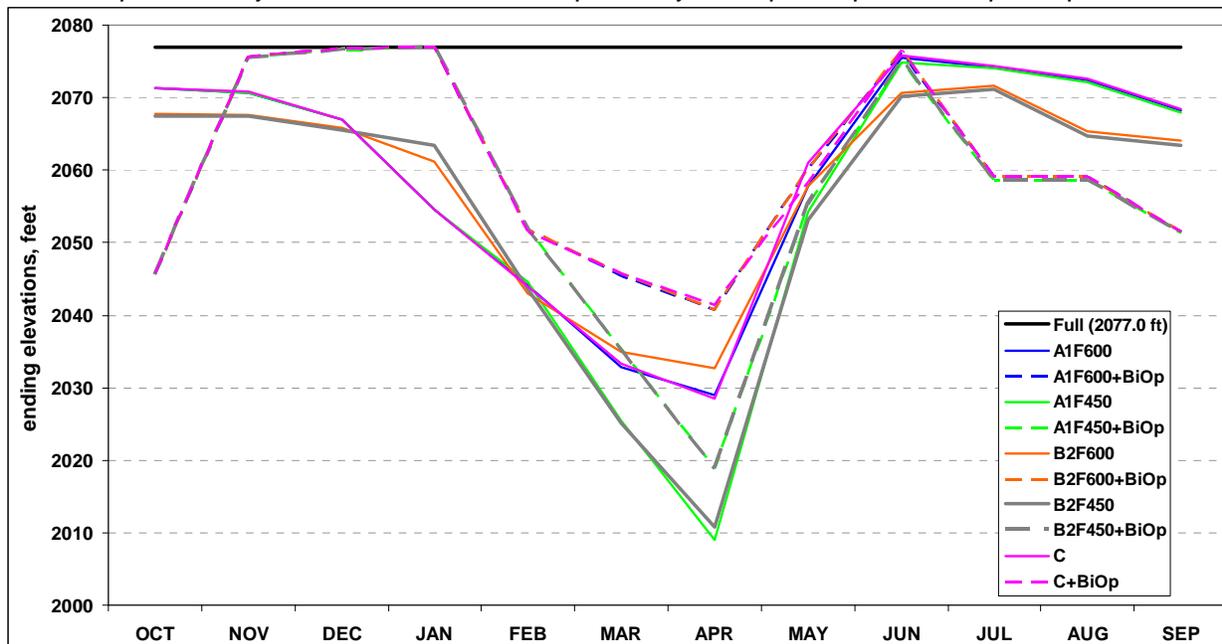
### B.5.5 BROWNLEE DAM

In the Phase 1 Studies Brownlee drafts heavily by the end of April in the A1 and B2 Studies for power needs. The reservoir generally does not refill in the Phase 1 power studies. In the Supplemental studies Brownlee refills by the end of June so that it may draft for flow augmentation in July. The A1F450+BiOp and the B2F450 Supplemental studies are the same at Brownlee because these studies both began with the 2010 rate case assumptions. In that 2010 rate cast study Brownlee was fixed to an operation that was submitted by Idaho Power Company, the BiOp operation overlaid on the rate case study was also a fixed operation, so Brownlee is the same in both these studies. Similarly the A1F600+BiOp and B2F600 Supplemental studies are the same at Brownlee. The Phase 1 studies at Brownlee are different from each other because Brownlee operated for power in the Phase 1 studies and the generation requirements were different from each other.

**Figure B-19 Brownlee Elevations, feet - 70-Year Studies - 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 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



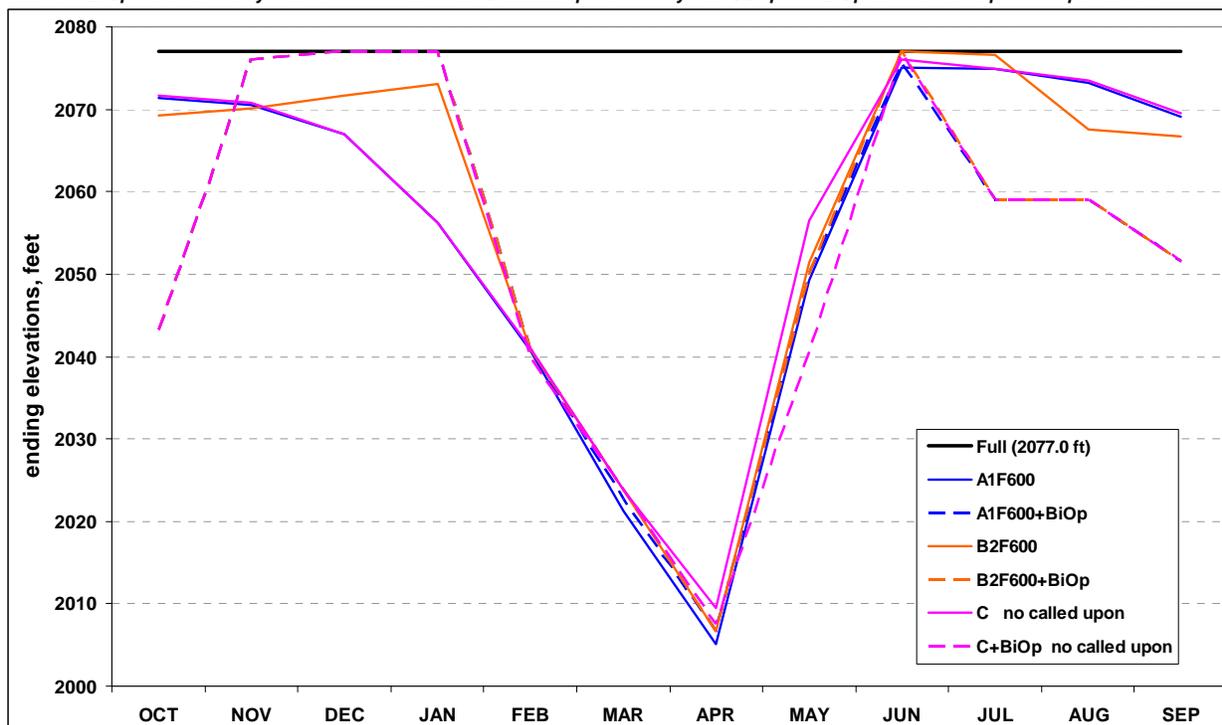
In the 21 Called Upon years when the maximum flow at The Dalles is 600 kcfs, the operation at Brownlee was not significantly different in comparing the Phase 1 studies and the Supplemental studies during the February through June periods because drafting for effective use and power in the Phase 1 studies produced similar results as the fish operations. In July, the Supplemental studies draft the reservoir about 18 feet deeper for flow augmentation.

**Figure B-20 Brownlee Elevations, feet - 21 Called Upon Years @ 600 kcfs objective**

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	2056	2041	2021	2005	2049	2075	2075	2073	2069
A1F600+BiOp	2043	2076	2077	2077	2041	2023	2007	2050	2076	2059	2059	2052
B2F600	2069	2070	2072	2073	2041	2024	2007	2051	2077	2077	2068	2067
B2F600+BiOp	2043	2076	2077	2077	2041	2024	2007	2050	2077	2059	2059	2052
C no called upon	2072	2071	2067	2056	2041	2024	2009	2057	2076	2075	2074	2070
C+BiOp no called upon	2043	2076	2077	2077	2040	2024	2008	2041	2077	2059	2059	2052

Phase 1 studies: A1F600 includes called upon and Flex, B2F600 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



In this 52 year data subset Brownlee reservoir was higher at the end of April in the C and C+BiOp studies as compared to the A and B studies. The C studies have the Treaty continuing with no Called Upon operation and the reservoir would operate to its current Storage Reservation Diagram. In the A1 and B2 studies, Brownlee’s flood control curve during Called Upon years drafted empty by April 30<sup>th</sup> unless refill began before April 30<sup>th</sup>.

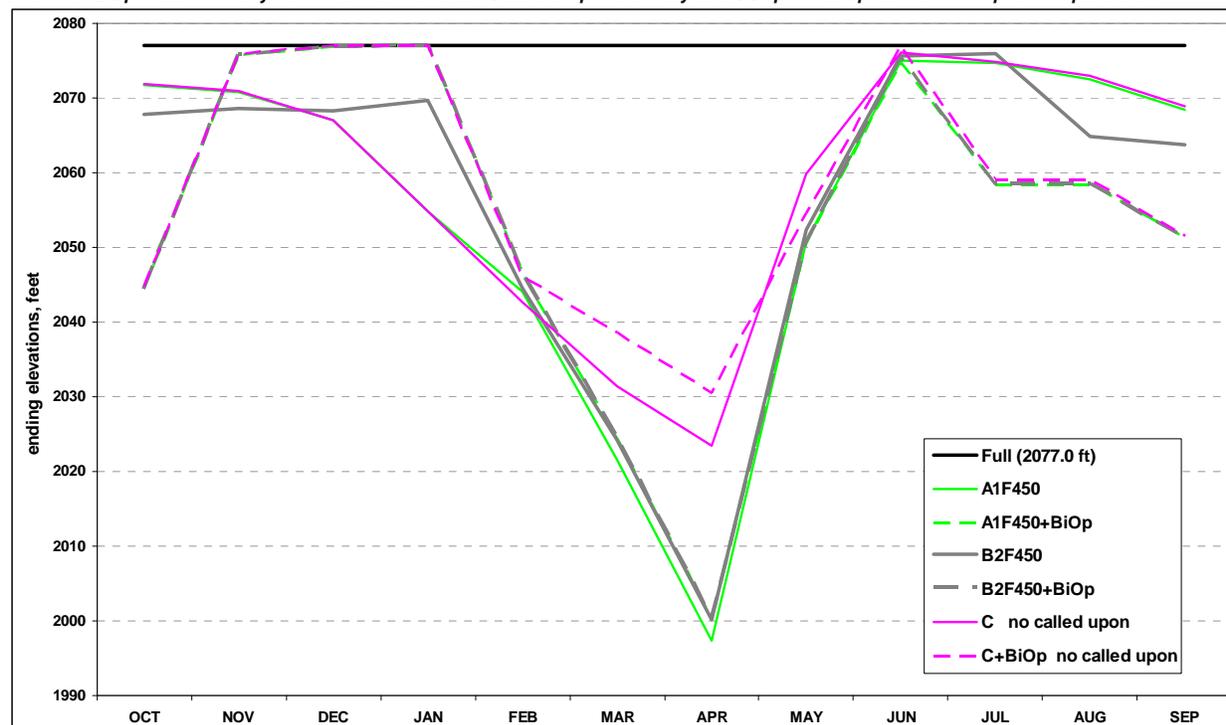
For the A and B studies, Brownlee reservoir elevations are higher with the fish operations November through February, about the same in March through June, and lower in July through October.

**Figure B-21 Brownlee Elevations, feet - 52 Called Upon Years @ 450 kcfs objective**

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
A1F450	2072	2071	2067	2055	2044	2022	1997	2051	2075	2075	2072	2068
A1F450+BiOp	2044	2076	2077	2077	2047	2024	2000	2050	2075	2058	2058	2051
B2F450	2068	2069	2068	2070	2045	2024	2000	2052	2076	2076	2065	2064
B2F450+BiOp	2044	2076	2077	2077	2047	2024	2000	2051	2075	2058	2058	2051
C no called upon	2072	2071	2067	2055	2043	2031	2023	2060	2076	2075	2073	2069
C+BiOp no called upon	2045	2076	2077	2077	2046	2039	2030	2055	2077	2059	2059	2052

Phase 1 studies: A1F450 includes called upon and Flex, B2F450 includes called upon, and C is current Treaty and FCOP

Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



## B.6 FISH FLOW OBJECTIVES

The ability to meet the flow objectives is driven by the flood flow objective at The Dalles, not by continuing or terminating the Treaty. The flow objectives are met slightly less often when the flood flow objectives is 450 kcfs because there are more years when the federal reservoirs draft for effective use for Called Upon operations and therefore have somewhat less outflow during the refill period.

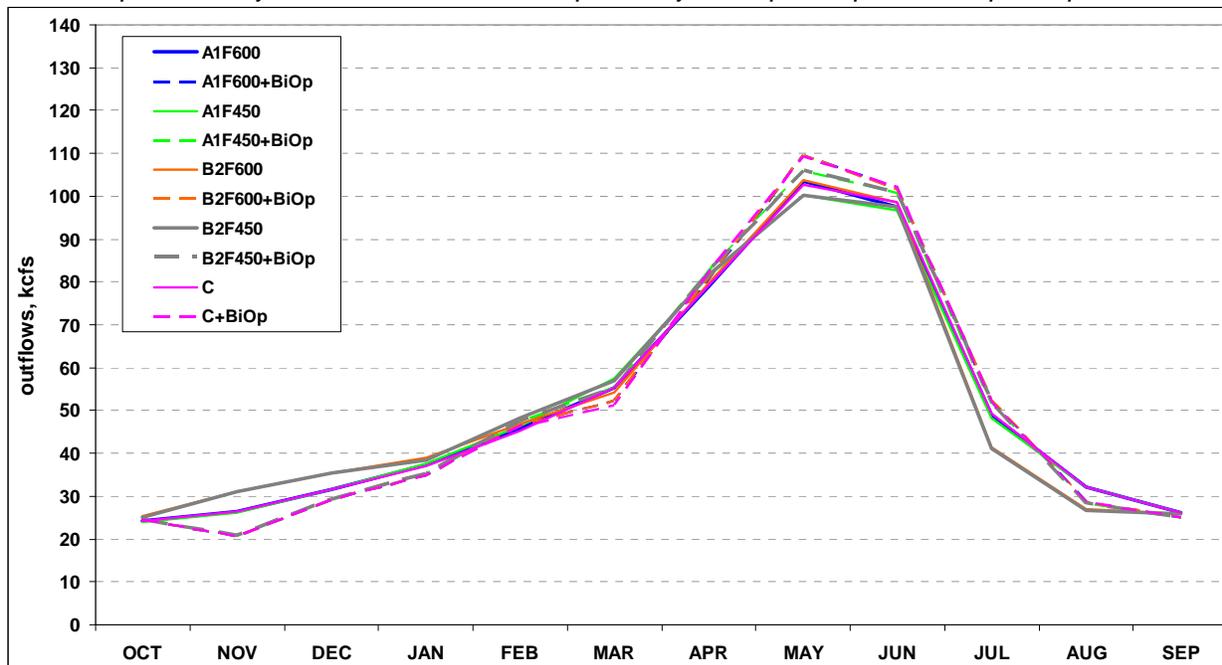
### B.6.1 LOWER GRANITE DAM

Because Lower Granite is not downstream of Canadian storage it is not directly influenced by Canadian operation, therefore, comparison of the Phase 1 studies to Supplemental studies show only slight differences at Lower Granite. The flow at Lower Granite is slightly greater in all the Supplemental studies in the April through July periods because it was an operating criterion. Although Dworshak operated somewhat differently in the Supplemental studies, Brownlee had more significant operational changes that contributed to the Lower Granite flow in the Supplemental studies.

**Figure B-22 Lower Granite Outflows, kcfs - 70-Year Studies - 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 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

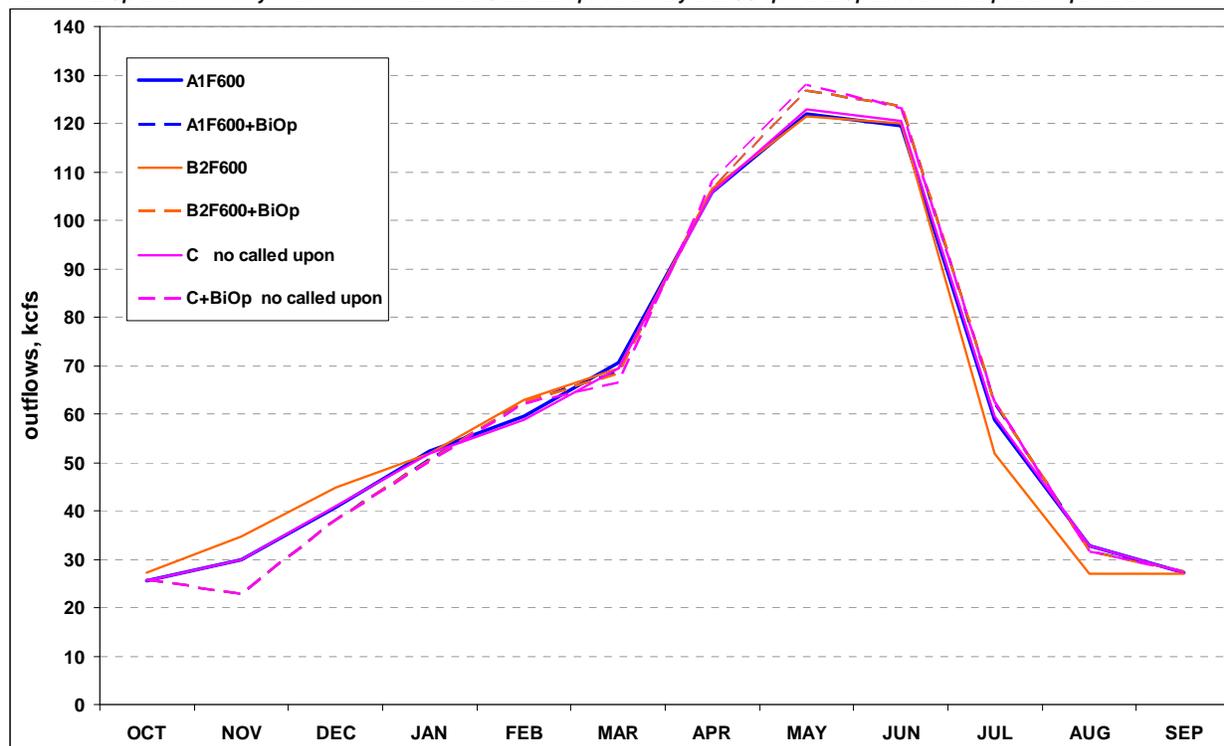


In the 21 Called Upon years from the 600 kcfs study, the Lower Granite flow did not change in most periods between the Phase 1 and the Supplemental studies. The slight difference in flow in May and June between the Phase 1 Studies and the Phase 1 Supplemental studies is because of the Brownlee operation. In the Phase 1 Studies, Brownlee operated to fixed annual power operations submitted by Idaho Power Company. The studies with the BiOp include some operation for fish during the flow augmentation season.

**Figure B-23 Lower Granite Outflows, kcfs - 21 Called Upon Years @ 600 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	25	30	41	52	60	71	106	122	120	59	33	27
A1F600+BiOp	26	23	38	51	62	69	106	127	124	62	32	27
B2F600	27	35	45	52	63	69	106	121	120	52	27	27
B2F600+BiOp	26	23	38	50	62	68	106	127	124	62	32	27
C no called upon	26	30	41	52	59	69	106	123	121	60	33	27
C+BiOp no called upon	26	23	38	50	62	67	108	128	123	62	32	27

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

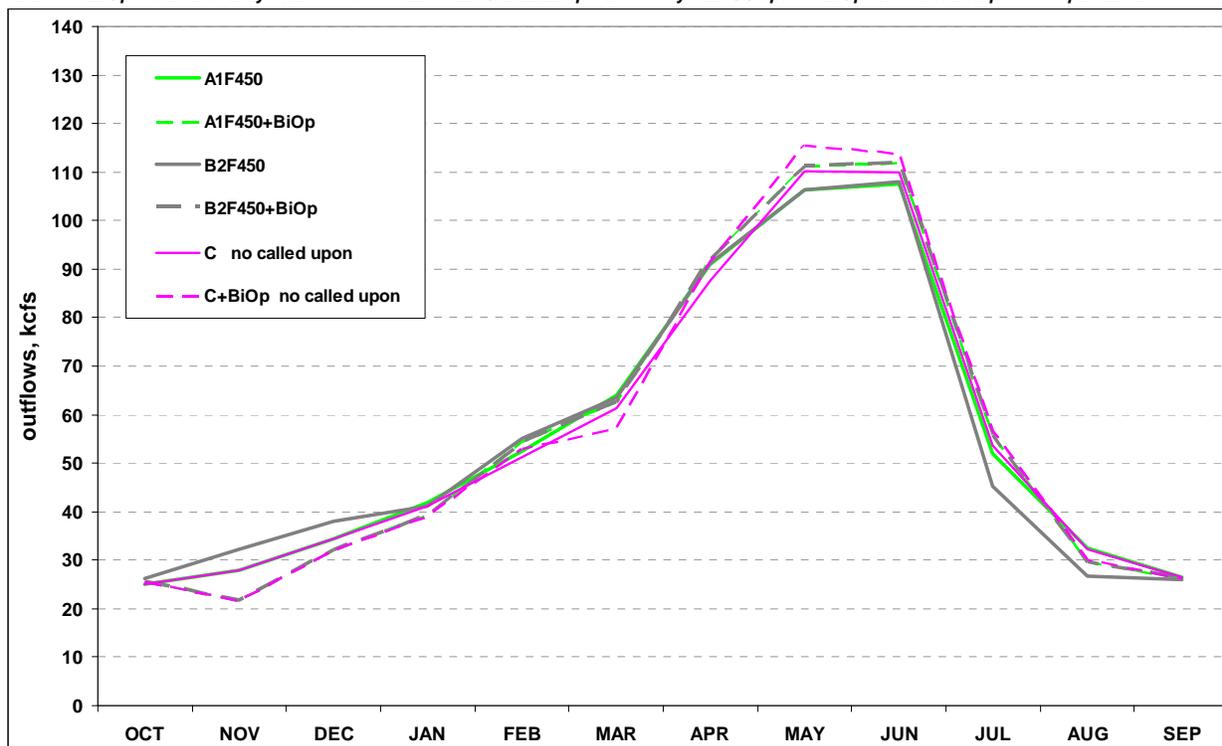


In the 52 Called Upon years from the 450 kcfs studies, the Lower Granite flow did not change in most periods between the Phase 1 and the Supplemental studies. The slight difference in flow in May and June between the Phase 1 Studies and the Phase 1 Supplemental studies is because of the Brownlee operation. In the Phase 1 Studies, Brownlee operated to fixed annual power operations submitted by Idaho Power Company. The studies with the BiOp include some operation for fish during the flow augmentation season.

**Figure B-24 Lower Granite Outflows, kcfs - 52 Called Upon Years @ 450 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F450	25	28	34	42	52	64	91	106	108	52	32	26
A1F450+BiOp	26	22	32	39	54	63	92	111	112	56	29	26
B2F450	26	32	38	41	55	64	91	106	108	45	27	26
B2F450+BiOp	26	22	32	39	54	63	92	111	112	56	29	26
C no called upon	25	28	34	41	51	61	87	110	110	54	32	26
C+BiOp no called upon	26	22	32	39	53	57	91	115	114	56	30	26

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



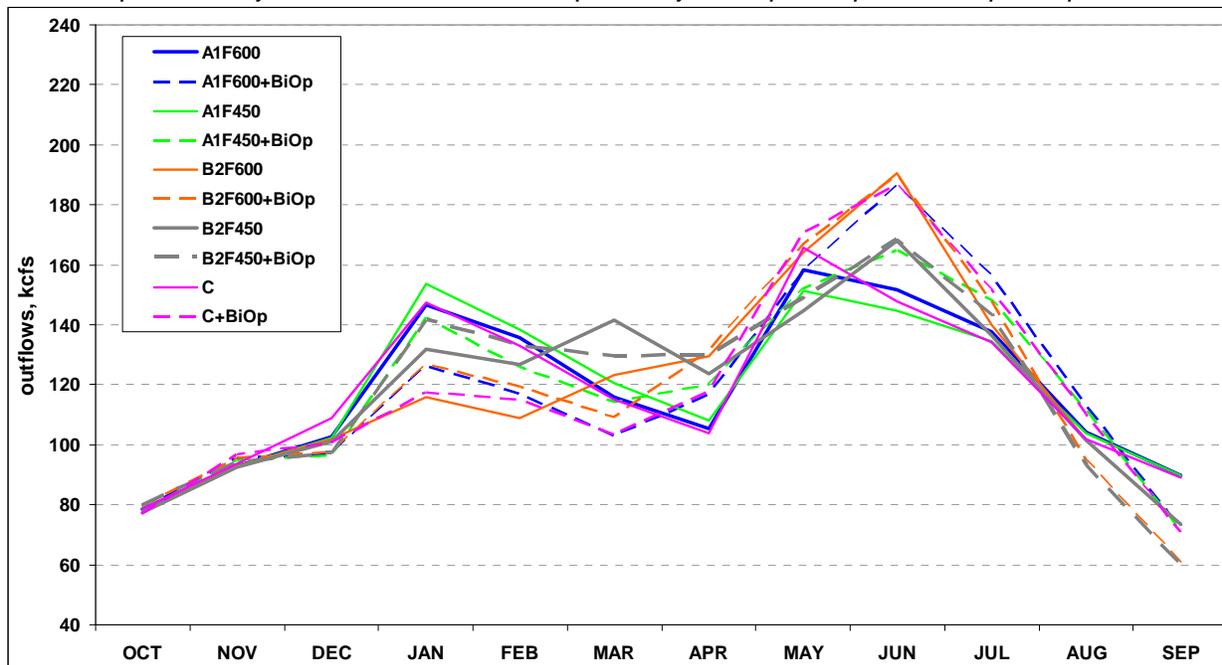
### B.6.2 PRIEST RAPIDS

In general, the fish operations provided higher flows during the late spring and summer than the Phase 1 studies due to flow augmentation releases and various reservoir operations. The only exception was the Phase 1 Treaty terminates scenarios (B2) where higher Arrow plus Duncan outflows assisted in increasing flows to the level of the Supplemental studies.

**Figure B-25 Priest Rapids Outflows, kcfs - 70-Year Studies - 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	147	115	103	118	171	187	152	110	71

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



In the C Study where the Treaty continues and there is no Called Upon operation, the flow at Priest Rapids is lowest in April, but the greatest in May and June in the Supplemental studies. The A1+BiOp Study where the Treaty continues with Called Upon is not significantly different than the B2+BiOp Study where the Treaty is terminated and there is a Called Upon operation. This is because upstream reservoirs would be operating to their effective use or Called Upon operations in these 21 Called Upon years.

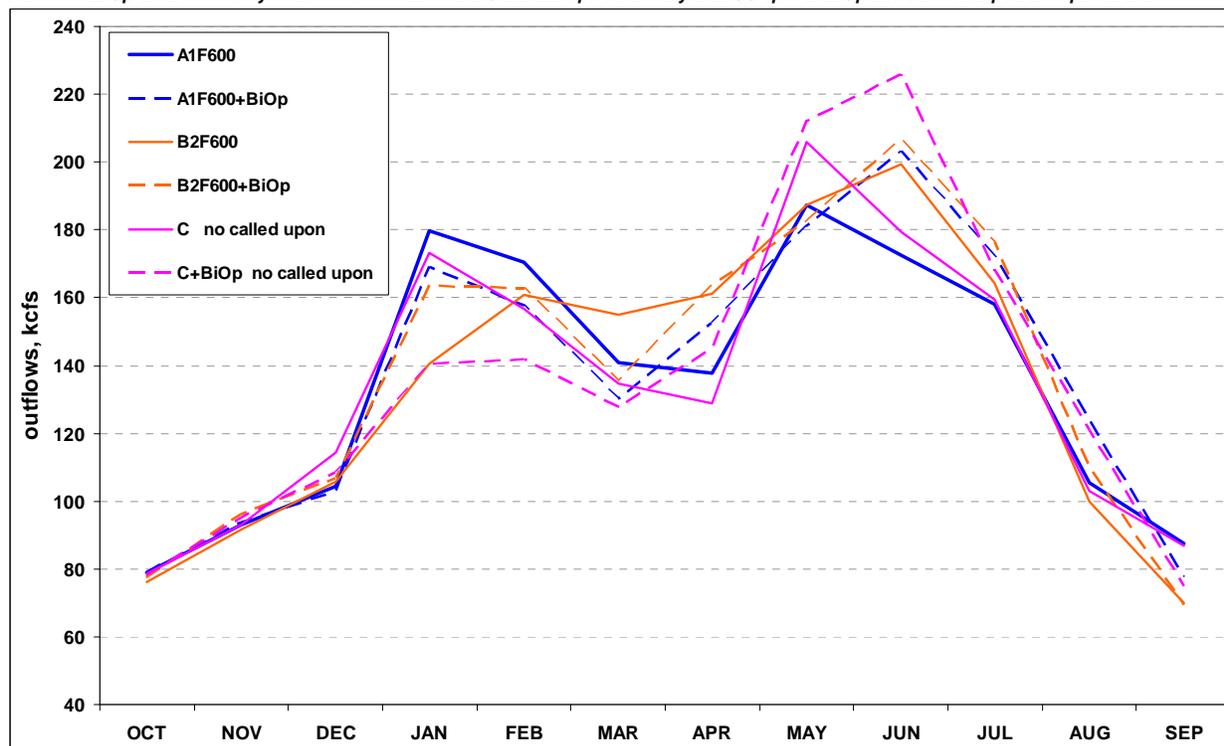
In the A and C studies, fish operations cause lower flows at Priest Rapids in January through March because of reduced flows from upstream projects while they operate to flood control and Phase 1 studies operate for power. Fish operations generally cause higher flows in April through August due to meeting fish flow objectives.

In the B studies, fish operations cause higher flows at Priest Rapids in January, February, April, and June through August, and less flows in March and May. This pattern is different than the comparison of the A and C studies with and without BiOp, because the B2 Phase 1 outflows from upstream projects are influenced by the generation requirement that is different from the A1 and C study generation requirements.

**Figure B-26 Priest Rapids Outflows, kcfs - 21 Called Upon Years @ 600 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	79	93	104	180	171	141	138	187	172	158	105	87
A1F600+BiOp	79	94	103	169	158	130	152	181	203	172	124	77
B2F600	76	92	106	140	161	155	161	187	199	164	100	70
B2F600+BiOp	77	96	107	164	163	135	163	183	207	176	110	69
C no called upon	79	93	114	173	157	135	129	206	179	160	103	87
C+BiOp no called upon	78	95	108	140	142	128	145	212	226	168	121	75

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



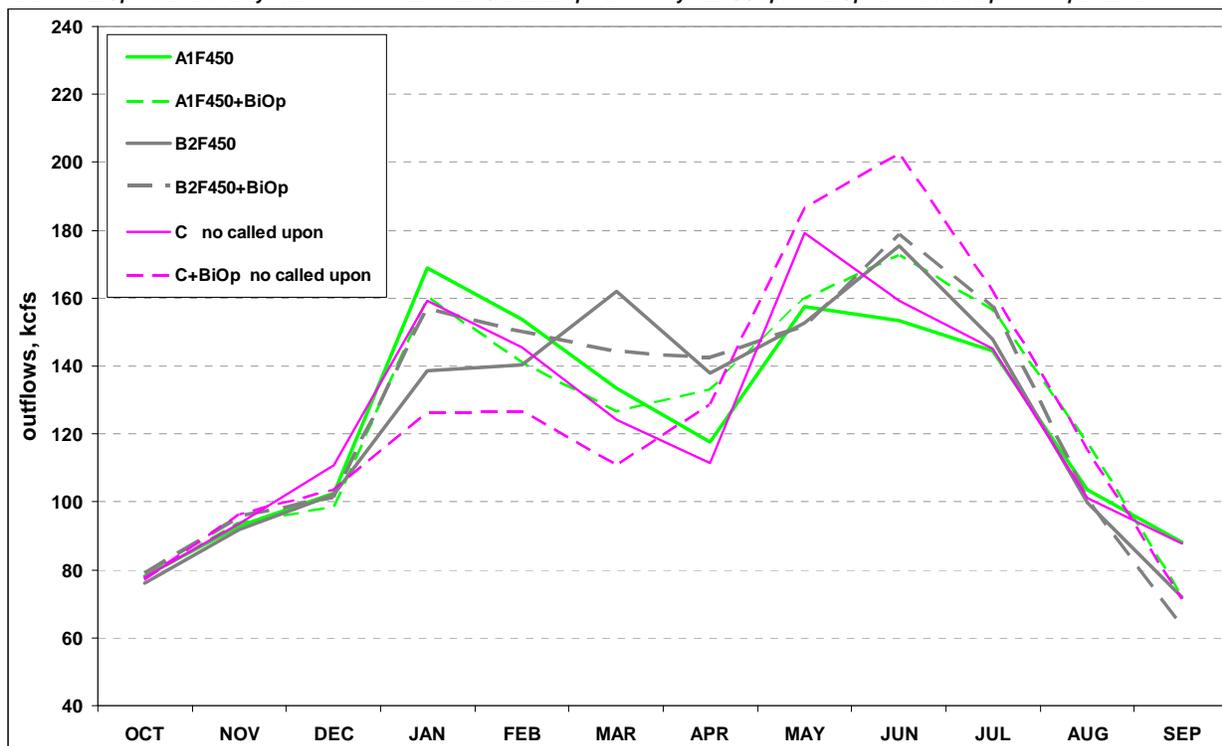
In the C Study where the Treaty continues and there is no Called Upon operation, the flow at Priest Rapids is lowest in April, but the greatest in May and June in the Supplemental studies. The A1+BiOp Study where the Treaty continues with Called Upon is not significantly different than the B2+BiOp Study where the Treaty is terminated and there is a Called Upon operation. This is because all upstream reservoirs would be operating to their effective use or Called Upon operations in these 52 Called Upon years.

The pattern of differences in the Phase 1 and Supplemental studies for these 52 Called Upon years in the 450 studies are similar to that of the 21 Called Upon years for the 600 kcfs studies.

**Figure B-27 Priest Rapids Outflows, kcfs - 52 Called Upon Years @ 450 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F450	78	93	103	169	154	133	118	158	153	144	103	88
A1F450+BiOp	78	94	99	160	141	126	133	160	173	157	117	72
B2F450	76	92	102	139	140	162	138	153	176	148	100	72
B2F450+BiOp	79	96	101	157	150	144	142	152	179	157	101	63
C no called upon	78	94	111	159	145	124	112	179	159	145	101	88
C+BiOp no called upon	77	96	103	126	127	111	129	186	202	162	115	71

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



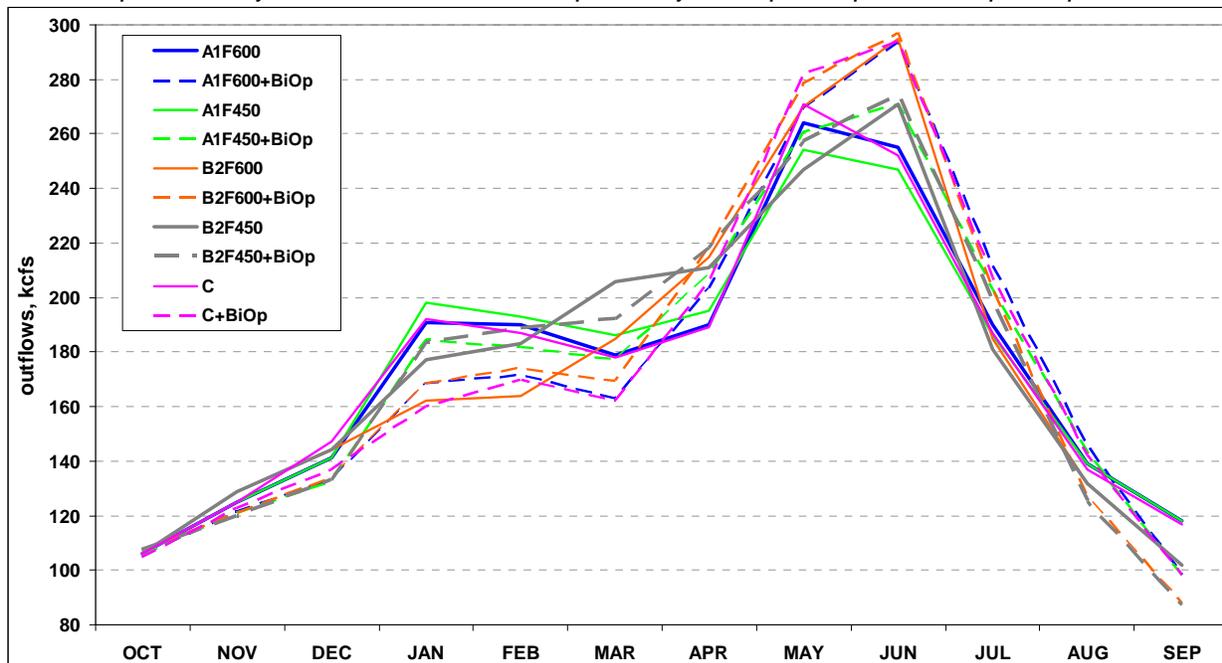
### B.6.3 McNary Outflows

In general, the fish operations provided higher flows during the late spring and summer than the Phase 1 studies due to flow augmentation releases and various reservoir operations. The only exception was the Phase 1 Treaty terminates scenarios (B2) where Canadian operation of higher Arrow plus Duncan outflows in the spring increased flows to the level of the Supplemental studies.

**Figure B-28 McNary Outflows, kcfs - 70-Year Studies - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

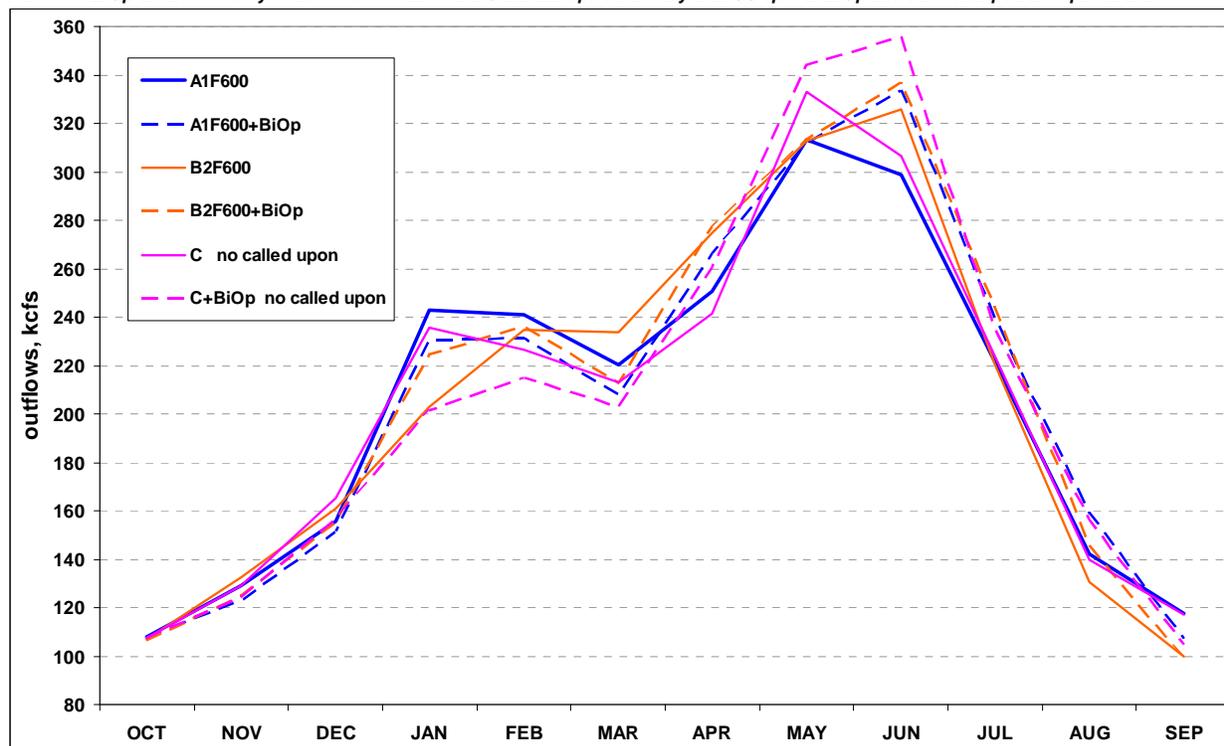


As expected, the Supplemental studies have generally more flow in the May through August period than the Phase 1 studies since the system is operating to meet BiOp flow objectives at McNary. In these 21 years when Called Upon was triggered in the Phase 1 studies the C Study where the Treaty continues had the highest flow at McNary in May. The A1+BiOp and the B2+BiOp had similar flow in May and June because the upstream reservoirs were operating to Called Upon or effective us which are the same in this small subset of years.

**Figure B-29 McNary Outflows, kcfs - 21 Called Upon Years @ 600 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	108	129	156	243	241	220	251	313	299	222	142	118
A1F600+BiOp	108	123	151	230	231	208	266	312	333	239	159	107
B2F600	107	132	161	203	235	234	275	313	326	221	130	100
B2F600+BiOp	107	125	155	225	236	213	277	313	337	244	145	99
C no called upon	108	129	165	236	226	213	241	333	307	224	140	117
C+BiOp no called upon	108	124	157	201	215	203	260	344	356	235	156	104

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements

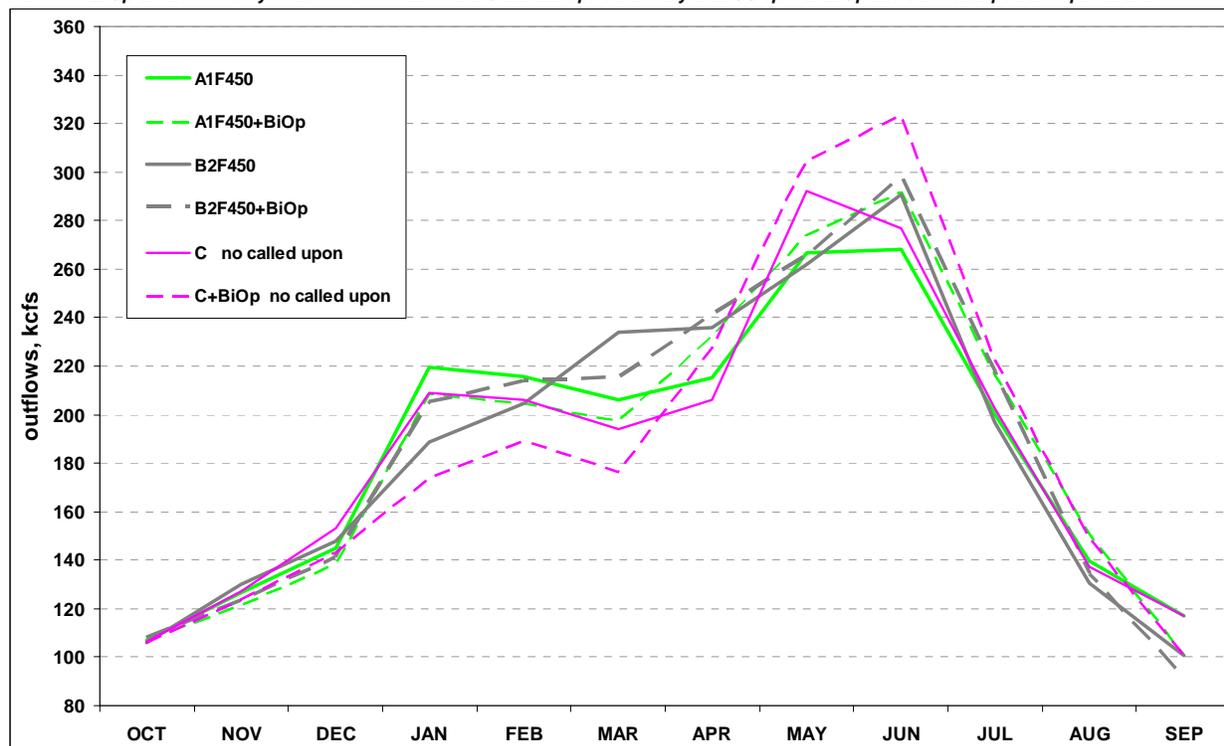


In the 52 years Called Upon years from the 450 kcfs studies, the fish operations increased the average flow in each month, April through August over their respective Phase 1 studies. In the 52 years when Called Upon was triggered in the 450 kcfs studies the flow at McNary was greatest in May and June in the +BiOp study where the Treaty continued and there was no Called Upon. The A1+BiOp and B2+BiOp Studies had similar average flow in April through July in these 52 years when Called Upon was triggered.

**Figure B-30 McNary Outflows, kcfs - 52 Called Upon Years @ 450 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F450	107	127	145	219	216	206	215	267	268	201	139	117
A1F450+BiOp	107	121	138	208	205	197	232	274	292	216	151	101
B2F450	106	130	148	189	205	234	236	262	291	197	130	101
B2F450+BiOp	108	123	141	205	214	215	241	266	298	217	134	92
C no called upon	107	127	153	209	206	194	206	292	277	203	137	117
C+BiOp no called upon	106	124	143	174	189	176	227	304	323	222	149	100

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



### B.6.4 BONNEVILLE DAM

The minimum flow for chum spawning and emergence downstream of Bonneville Dam is modeled as a tailwater elevation at Bonneville Dam of approximately 11.5 feet beginning the first week of November (or when chum arrive) and ending by December 31, if reservoir elevations and climate forecasts indicate this operation can be maintained through incubation and emergence. The model uses a flow-vs.-tailwater elevation rating curve, which also factors in tributary flows, and maintains this tailwater elevation through March to reflect likely in-season management decisions.

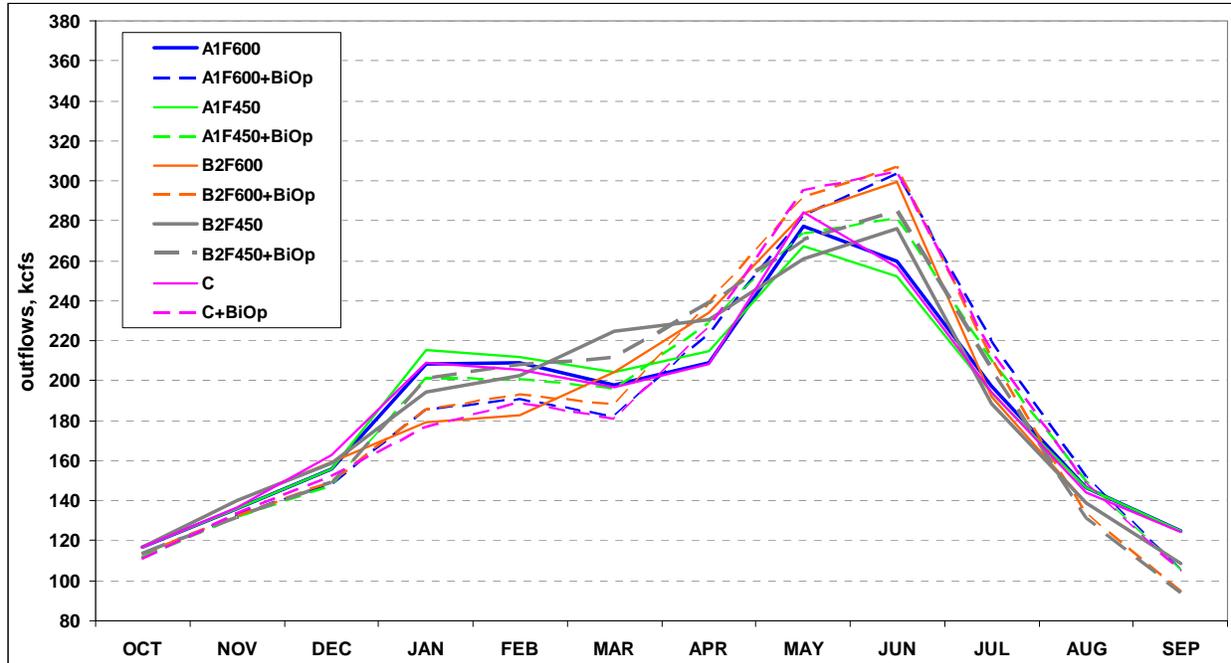
Fish operations cause the 70-year average flows in November and December flows to be less than that of the Phase 1 studies in the A and C study comparisons, however, the average flows are still greater than the 125 kcfs flow objective.

The Fish operations cause average flows in November and December to be lower than Phase 1 in the B studies, higher in January and February, and then lower in March, however, the average monthly flows are greater than the 125 kcfs flow objective.

**Figure B-31 Bonneville Outflows, kcfs - 70-Year Studies - 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

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



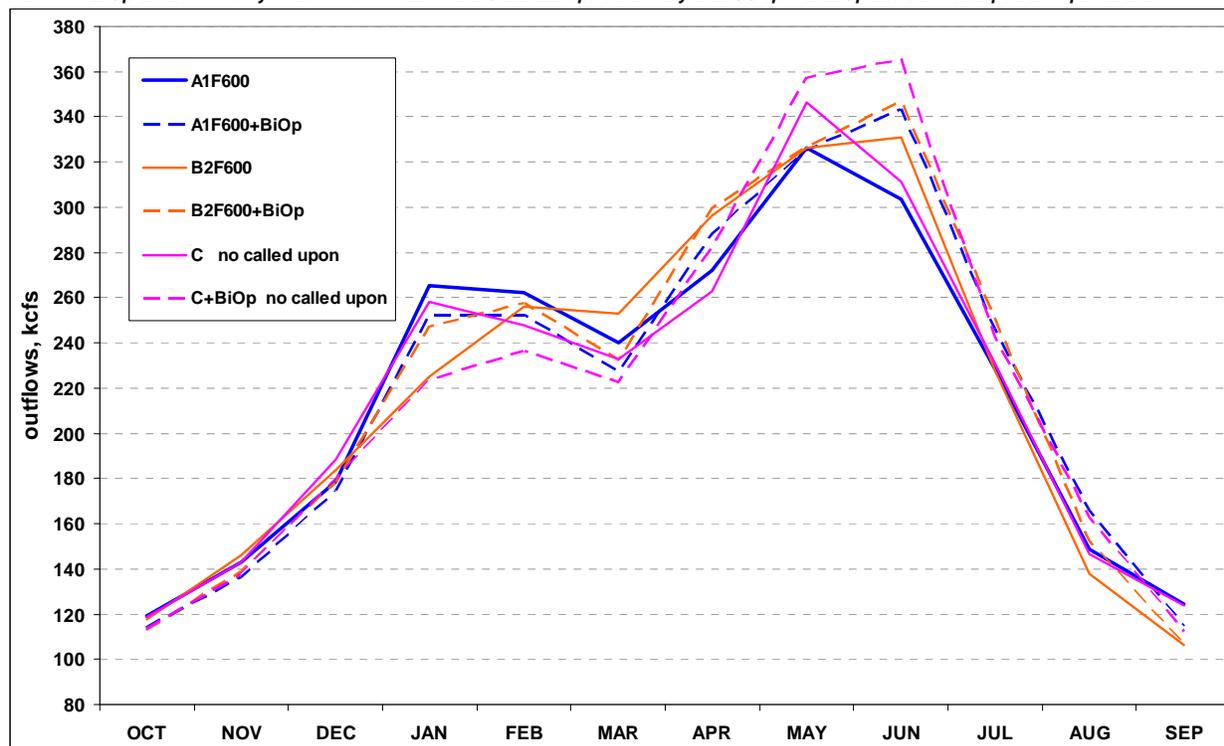
In the 21 Called Upon years the flow at Bonneville increases from October through February in the Supplemental studies and decreases in March in all the studies.

The pattern of the comparison of the Supplemental studies to the Phase 1 studies are the same as for the 70-year averages.

**Figure B-32 Bonneville Outflows, kcfs - 21 Called Upon Years @ 600 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F600	119	143	178	265	262	240	272	327	304	229	149	124
A1F600+BiOp	114	137	174	253	253	227	288	325	343	247	166	114
B2F600	118	146	184	225	256	253	296	326	331	228	138	106
B2F600+BiOp	113	139	178	247	258	232	299	327	347	251	152	106
C no called upon	119	143	188	258	248	233	263	346	311	231	146	124
C+BiOp no called upon	114	138	180	224	236	223	282	357	366	242	163	112

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



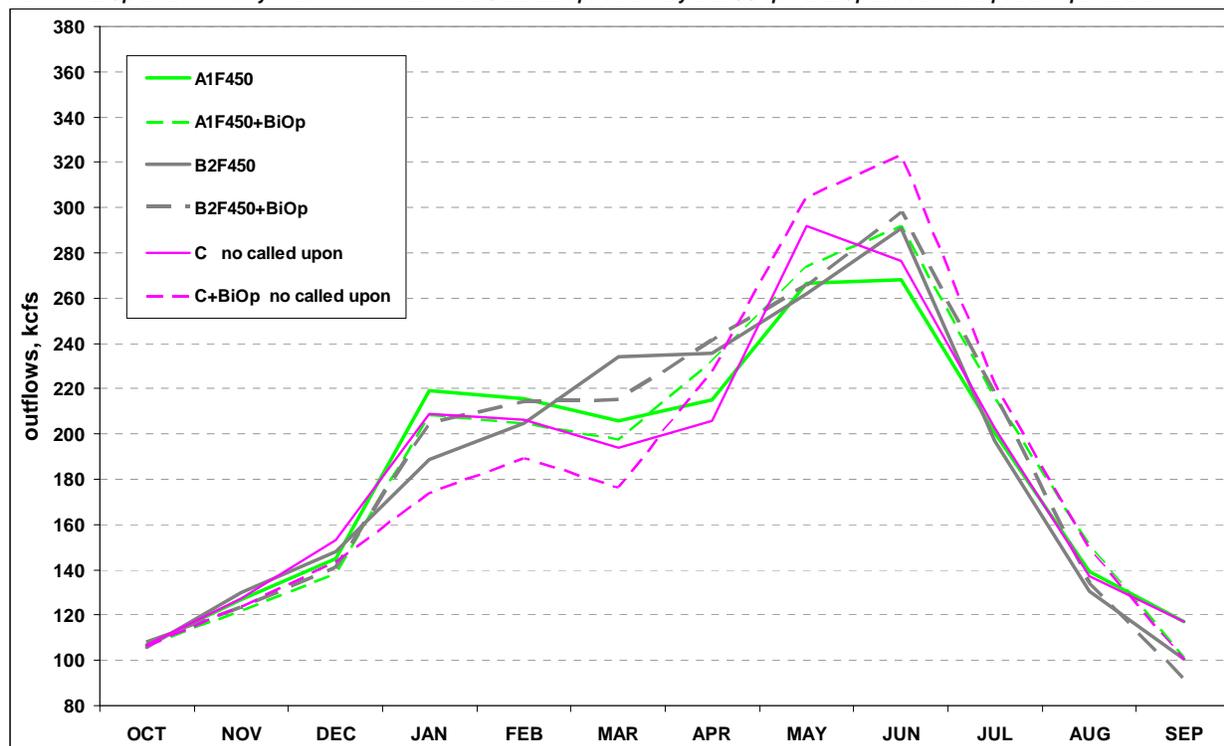
In the 52 Called Upon years with the BiOp the flow at Bonneville increases from October through March in the B2F450+BiOp study; this is a study where the Treaty terminates and Canada operates its reservoirs for power generation. In the A1 and C Studies where the Treaty continues, the flow increases through February in the A1 Study with Called Upon and increases through March in the C study where the Treaty continues and there is no Called Upon.

The pattern of the comparison of the BiOp studies to the Phase 1 studies are the same as for the 70-year averages.

**Figure B-33 Bonneville Outflows, kcfs - 52 Called Upon Years @ 450 kcfs objective**

outflows, kcfs	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
A1F450	107	127	145	219	216	206	215	267	268	201	139	117
A1F450+BiOp	107	121	138	208	205	197	232	274	292	216	151	101
B2F450	106	130	148	189	205	234	236	262	291	197	130	101
B2F450+BiOp	108	123	141	205	214	215	241	266	298	217	134	92
C no called upon	107	127	153	209	206	194	206	292	277	203	137	117
C+BiOp no called upon	106	124	143	174	189	176	227	304	323	222	149	100

Phase 1 studies: A1F600 and A1F450 include called upon and Flex, B2F600 and B2F450 include called upon, and C is current Treaty and FCOP  
 Phase 1 + BiOp studies: overlay Phase 1 flood control and Canadian ops on a study with US ops for BiOp and other non-power requirements



The table on the next page is a summary of the data in the charts and graphs from this Appendix comparing Phase 1 Study results to Phase 1 + BiOp Study results. The chart shows seasonal average flow at a few locations in the system. The spring and summer seasons represent the fish passage season when flow objectives are trying to be met. The chart also includes the end of April elevation comparisons at U.S. reservoirs. Finally the chart includes a comparison of U.S. System Generation between studies.

**Preliminary Draft - For Discussion Purposes Only**

**Table B-1 Summary of Phase 1 Results vs. Supplemental Results**

	<b>Treaty Continues</b>															<b>Treaty Terminates</b>					
	Water Year*	Season**	Current	Continue A1F600			Difference	Continue A1F450			Difference	Terminate B2F600			Difference	Terminate B2F450			Difference		
			C+BiOp	Phase1+BiOp	Phase1	+BiOp-Phase1	Phase1+BiOp	Phase1	+BiOp-Phase1	Phase1+BiOp	Phase1	+BiOp-Phase1	Phase1+BiOp	Phase1	+BiOp-Phase1	Phase1+BiOp	Phase1	+BiOp-Phase1			
<b>Flows - Canadian (Arrow+Duncan)</b> Average Seasonal Outflows in kcfs	Low 20yrs	winter	34	32	34	-2	35	36	-1	40	40	0	42	40	2	42	51	-9			
		spring	40	39	39	0	37	37	0	42	42	0	39	30	9	34	42	-8			
		summer	55	56	58	-2	55	57	-2	34	42	-8	34	42	-8	34	42	-8			
	Middle 30yrs	winter	38	37	42	-5	47	48	-1	43	43	0	58	62	-4	27	22	5			
		spring	34	33	27	6	23	21	2	48	48	0	47	53	-6	47	53	-6			
		summer	57	63	63	0	59	61	-2	47	48	-1	67	52	15	18	34	-16			
	High 20yrs	winter	45	58	60	-2	64	65	-1	58	58	0	67	52	15	18	34	-16			
		spring	40	25	20	5	19	16	3	30	30	0	58	42	16	58	42	16			
		summer	62	63	62	1	59	60	-1	59	52	7	58	42	16	58	42	16			
<b>Flows - McNary</b> Average Seasonal Outflows in kcfs	Low 20yrs	spring	197	195	178	17	190	176	14	201	185	16	196	180	16	115	129	-14			
		summer	136	137	137	0	135	136	-1	115	129	-14	114	128	-14	114	128	-14			
	Middle 30yrs	spring	279	279	249	30	258	241	17	292	287	5	261	255	6	167	158	9			
		summer	176	181	163	18	173	161	12	167	158	9	161	155	6	167	158	9			
	High 20yrs	spring	357	338	321	17	328	315	13	341	338	3	327	322	5	213	189	24			
		summer	212	216	195	21	212	193	19	213	189	24	210	186	24	213	189	24			
<b>Elevation - Grand Coulee</b> average April 30 elevation, feet	Low		1238	1239	1232	7	1235	1232	3	1247	1242	5	1243	1238	5	1247	1242	5			
	Middle		1237	1240	1225	15	1224	1217	7	1240	1243	-3	1222	1224	-2	1240	1243	-3			
	High		1221	1217	1214	3	1214	1213	1	1217	1218	-1	1214	1214	0	1217	1218	-1			
<b>Elevation - Libby</b> average April 30 elevation, feet	Low		2416	2415	2376	39	2408	2374	34	2415	2368	47	2408	2363	45	2383	2370	13			
	Middle		2386	2385	2343	42	2369	2345	24	2383	2370	13	2366	2360	6	2339	2340	-1			
	High		2346	2346	2324	22	2338	2327	11	2339	2340	-1	2333	2334	-1	2339	2340	-1			
<b>Elevation - Hungry Horse</b> average April 30 elevation, feet	Low		3522	3522	3467	55	3516	3465	51	3522	3477	45	3516	3471	45	3489	3484	5			
	Middle		3520	3519	3480	39	3489	3472	17	3519	3506	13	3489	3484	5	3469	3472	-3			
	High		3485	3469	3460	9	3456	3455	1	3469	3472	-3	3456	3457	-1	3469	3472	-3			
<b>Elevation - Dworshak</b> average April 30 elevation, feet	Low		1555	1559	1556	3	1556	1553	3	1559	1524	35	1556	1520	36	1523	1523	0			
	Middle		1522	1523	1521	2	1497	1496	1	1523	1523	0	1497	1497	0	1470	1470	0			
	High		1555	1470	1470	0	1467	1467	0	1470	1470	0	1467	1467	0	2071	2042	29			
<b>Elevation - Brownlee</b> average April 30 elevation, feet	Low		2071	2071	2042	29	2066	2038	28	2071	2042	29	2066	2038	28	2047	2047	0			
	Middle		2047	2047	2038	9	2008	2004	4	2047	2047	0	2008	2009	-1	2002	2002	0			
	High		2004	2002	2002	0	1987	1987	0	2002	2002	0	1987	1987	0	11,210	11,119	12,686			
<b>US System Generation</b> Average Seasonal Generation in amw	Low 20yrs	winter	11,210	11,119	12,686	-1,567	11,504	12,869	-1,365	11,398	12,477	-1,079	11,792	12,771	-979	9,621	12,385	-2,764			
		summer	11,026	11,090	12,808	-1,718	10,933	12,732	-1,799	9,621	12,385	-2,764	9,485	12,345	-2,860	11,258	12,801	-1,543			
		annual	11,544	11,498	12,808	-1,310	11,496	12,810	-1,314	11,258	12,801	-1,543	11,271	12,796	-1,525	14,589	14,497	16,582			
	Middle 30yrs	winter	14,589	14,497	16,582	-2,085	15,751	17,056	-1,305	14,926	14,782	144	16,299	16,509	-210	13,372	13,657	14,599			
		summer	13,372	13,657	14,599	-942	13,087	14,373	-1,286	12,805	14,681	-1,876	12,410	14,422	-2,012	13,926	13,930	15,274			
		annual	13,926	13,930	15,274	-1,344	14,015	15,269	-1,254	13,957	15,298	-1,341	14,017	15,313	-1,296	17,754	17,945	21,130			
	High 20yrs	winter	17,754	17,945	21,130	-3,185	18,415	21,480	-3,065	17,773	20,410	-2,637	18,482	21,423	-2,941	15,260	15,328	16,854			
		summer	15,260	15,328	16,854	-1,526	15,168	16,690	-1,522	14,991	16,858	-1,867	14,886	16,672	-1,786	15,798	15,777	17,952			
		annual	15,798	15,777	17,952	-2,175	15,825	17,962	-2,137	15,649	17,917	-2,268	15,734	18,010	-2,276	15,798	15,777	17,952			

Water Year\* based on Jan-Jul runoff volumes measured at The Dalles Results averaged for the various volume ranges.

Season\*\* winter Jan1- Apr15  
 spring Apr16-Jun30  
 summer Jul1- Aug31

Note: Difference = Phase 1+BiOp study minus Phase 1 study

Continue Treaty studies - A1F studies include Canadian flex operations and called upon flood control

Terminate Treaty studies - B2F studies include Canadian power draft and called upon flood control