APPENDIX J

Power Generation Report

Hydropower Impacts Analysis of Upper Columbia VARQ Flood Control and Fish Operations for Environmental Impact Statement

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1 Introduction.

The Seattle District (NWS) of the US Army Corps of Engineers (Corps), and the US Bureau of Reclamation (Reclamation) are preparing an Environmental Impact Statement (EIS), called the Upper Columbia Alternative Flood Control (VARQ) and Fish Operations EIS, or UCEIS. VARQ stands for variable discharge, with Q being engineering shorthand for discharge. The proposed operational changes would take place at Libby and Hungry Horse dams in Montana. This operational proposal is in response to the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) Biological Opinions of December 2000. Both Biological Opinions recommended VARQ as a flood control operations strategy for Libby and Hungry Horse. These operational changes would also result in changes in operations at Grand Coulee Dam on the Columbia River in Washington. The UCEIS will be used to help determine whether to implement VARQ at Libby and Hungry Horse on a permanent basis beginning in January 2006. In addition, the UCEIS documents the effects of providing flow augmentation for Kootenai River white sturgeon, bull trout in the Kootenai and Flathead rivers, and salmon and steelhead in the lower Columbia River. As part of that, the USFWS Biological Opinion calls for increasing flow capacity from Libby by 10,000 cubic feet per second (cfs) above current powerhouse capacity, within Montana's dissolved gas standard of 110% saturation. Although the mechanism for achieving that has not been worked out, the UCEIS evaluates the effects of the flow capacity increase itself.

This hydropower study was prepared by the Corps of Engineers, North Pacific Division, Water Management Division, Power Branch and will be used for input to the UCEIS. This study includes the regulation of projects in the Columbia River coordinated hydropower system that consist of federal, private, and public utility projects in the Columbia and Snake River basins.

1.1 Purpose and Scope

The purpose of this study is to assess the monthly hydropower impacts to the Columbia River system due to the implementation of VARQ flood control as compared to standard flood control for each, with and without fish flows. Data from this study will be input into the UCEIS. Four alternative combinations and two benchmark combinations were modeled:

Benchmark Combination LS+HS- Standard Flood Control without Libby fish flows

Benchmark Combination LV+HV- VARQ Flood Control without Libby fish flows

Alternative Combination LS1+HS- Standard Flood Control, with fish flows at Libby including sturgeon flows up to current powerhouse capacity (QPHC)

Alternative Combination LV1+HV- VARQ Flood Control, with fish flows at Libby including sturgeon flows up to QPHC

Alternative Combination LS2+HS- Standard Flood Control, with fish flows at Libby including sturgeon flows up to powerhouse capacity + 10 thousand cubic feet per second (kcfs) (QPHC+10)

Alternative Combination LV2+HV- VARQ Flood Control, with fish flows at Libby including sturgeon flows up to QPHC+10

Studies were prepared using the Corps' Hydro System Seasonal Regulation (HYSSR) monthly model. Hungry Horse operations provided fish flows under all of the alternative combinations, but depended on VARQ or Standard Flood Control. All studies included a power operation.

To compare the effects of VARQ to Standard Flood Control, alternative/benchmark combinations LV+HV vs. LS+HS, LV1+HV vs. LS1+HS, and LV2+HV vs. LS2+HS were compared. To assess the effects of 2 fish flow alternative combinations for Standard Flood Control from Libby, alternative/benchmark combinations LS1+HS vs. LS+HS, and LS2+HS vs. LS+HS were compared. To assess the effects of the 2 fish flow alternative combinations for VARQ flood control, alternative/benchmark combinations LV1+HV vs. LV+HV and LV2+HV vs. LV2+HV were compared. Detailed descriptions of alternative/benchmark combinations are provided in Section 2. Tables and figures are provided to display the results of the modeling.

Metrics for comparisons include:

- Differences in Columbia River coordinated hydropower system generation
- Differences in generation at select federal and non-federal projects
- Differences in spill at select federal and non-federal projects
- Libby discharge and flow exceedance curves in September, October, December, and January.
- Grand Coulee elevation non-exceedance curves for the end of April
- Ability to meet McNary and Priest Rapids fish flow objectives

1.2 Prior Related Hydropower Studies.

The Power Branch prepared a study entitled, "Hydropower Impacts Analysis of Upper Columbia Alternative Flood Control and Fish Operations and Detailed Operating Plan Alternative Combinations including Hydropower Considerations and VARQ on the Columbia River System, dated October 28, 2002." This hydropower study was used in the Environmental Assessment (EA) that was prepared by the Seattle District entitled, "Upper Columbia Alternative Flood Control and Fish Operations Interim Implementation, Libby and Hungry Horse Dams, Montana, Idaho, and Washington, Final Environmental Assessment", dated December, 2002.

1.3 Major Hydropower Study Changes from the EA.

The following are major changes from the hydropower study prepared for the EA.

- Mica/Arrow flood control allocation changed from 2.08 million-acre-ft (Maf)/5.1 Maf to 4.08Maf/3.6Maf for Standard and VARQ flood control curves to reflect the allocation now used in actual operations.
- VARQ and Standard Flood Control curves were updated with the Wortman-Morrow forecast procedure for Libby, and with Reclamation's forecast for Hungry Horse, for system flood control in the drawdown period, and used Seattle District's (NWS) and Reclamation's refill curves.
- VARQ refill dates were determined by the initial controlled flow. They were set at May 1st for the EA.
- Historic natural flows were updated from the 1990 level to the 2000 level.
- The study period was changed from 1928-1987 to 1947-1999. The study period is defined by the availability of the Wortman-Morrow water supply forecasts for Libby, which have been developed back to 1948.
- Canadian operation was updated from the operating year (OY) 2002-03 to 2007-08 to reflect an operation resulting in flows at the US/Canadian border that is planned for the future.
- U.S. system critical rule curves and project operating criteria was updated from OY 2002-03 to OY 2003-04, which is the most current data available.
- Loads were updated to use 52 years of different Pacific Northwest Coordination Agreement (PNCA) coordinated system loads instead of one set of federal loads used for each year. This will allow the total coordinated system to draft for load as needed depending on water year. In the EA, federal projects served the same federal firm energy load carrying capability (FELCC) in every year, regardless of water availability. In the UCEIS, the Pacific Northwest Coordination Agreement (PNCA) coordinated system serves the coordinated system load to better simulate the system operation for each alternative combination.
- Updated operations for Libby and Hungry Horse from NWS and Reclamation, respectively, for all alternative combinations as detailed in Section 2.

1.4 General Hydroregulation Assumptions.

The Pacific Northwest reservoir system was modeled using the Corps' HYSSR model. HYSSR is a FORTRAN model with a monthly time step. There are 14 periods, one period for each month except April and August, which are split in half months (AP1 and APR are the first and second halves of April, and AG1, and AUG are the first and second halves of August). Model runs cover a 52-year period from August 1, 1947 through July 31, 1999, (August through July is the operating year for hydropower planning studies). All alternative combinations are "continuous" type studies where the July end-of-month elevations are the start elevations for the following August. All reservoirs started full on July 31st of 1947, except for Grand Coulee, Hungry Horse, and Dworshak in all alternative combinations and Libby in the fish flow alternative combinations, which started at their draft limits for McNary flow objectives. Libby started full in the alternative combinations without fish flows.

All alternative combinations modeled the system using power operations for all projects as submitted in accordance with the PNCA except for Libby and Hungry Horse which were modeled to target elevations specific for this study. The PNCA was ratified in 1964, and the owners of the projects in the Columbia River coordinated hydropower system have agreed to plan, coordinate, and operate their systems for flood control and to optimize power production taking into consideration non-power uses. Operating criteria for non-federal projects are as submitted by project owners for the operating year 2003-2004, or as otherwise stated in this report. Project operation for federal projects are as described in this report.

The model operates so that projects run to their operating rule curve (ORC) or draft as necessary to meet the load. The ORC is a combination of curves made up of flood control curves, refill curves, and power critical rule curves. The projects that operate for power first run to their ORCs, and if the energy produced is greater than the load, then the model run is complete. If the energy produced by running to the ORC is less than the load, then the projects draft until the load is just met. Projects that operate specifically for fish flows do not operate to ORCs, but still produce generation, which contributes toward meeting the load.

2 Description of Alternative Combinations

2.1 Benchmark Combination: LS+HS Standard Flood Control without Libby Fish Flows.

This alternative combination used Standard Flood Control as the maximum reservoir elevations. Hungry Horse was operated to target simulated elevations with fish flows for Standard Flood Control year around, and Libby was operated to target system flood control in January through April and simulated Standard Flood Control elevations in May through August. All other projects used PNCA 2003-2004 operating criteria or as described below. Grand Coulee flood control curves and Variable Draft Limits (VDLs) were adjusted for upstream power drafts.

<u>Flood control.</u> The data sources for the Standard Flood Control Curves were provided by the Corps' Hydrologic Engineering Branch (HEB) Northwestern Division, Reclamation, and NWS. The following are the file names, the source, and periods in which they were used.

- "Hyssrst.txt" from HEB—Used for all projects and periods except as stated below
- "ForPwrBr.DSS, EIS2FCBA, LIB ELEV" from NWS—for Libby in May and June
- "Varq_nepa_analysis_alf3up1down_toACOE_021004.xls, Standard FC Simulation Data, Hungry Horse Rule Curves," from Reclamation-- for Hungry Horse in May and June (flood control was at full pool in all years). Flood control for April 30 was set equal to the target elevations from the Hungry Horse Pool Elevations from the same file to facilitate the project to meet elevation targets by spilling.

Flood control curves are upper limits for project forebay elevations. Flood control curves take precedence over any targeted elevations that may have been above these flood control curves. Exceptions to regulate above flood control curves may occur for local flood protection, approach channel capacity, and Libby may be above system flood control elevations due to the Kootenay Lake IJC operation.

Grand Coulee Flood Control Adjustments. An initial model run was made and the resulting drafts at projects upstream of Grand Coulee were used to determine the flood control adjustment at Grand Coulee. The adjustment was made such that when the drafts at upstream projects at the end of April are below their flood control curves, Grand Coulee's flood control curves are adjusted upwards. After the Grand Coulee curves were adjusted, a final model run was made to incorporate the adjustment.

Critical Rule Curves. Critical Rule Curves are the projects' ending elevations from the PNCA 2003-2004 critical period Final Regulation. For the PNCA 2004 operating year, the critical period regulation is from August 1936 through July 1937. The ending elevations reflect the Firm Energy Load Carrying Capability (FELCC) produced by the system, which is the generation the system can be expected to produce in a critical water year. The Critical Rule Curves were developed with Hungry Horse and Libby VARQ flood control, however for purposes of computing differences between alternative combinations, these critical rule curves were used for all alternative combinations.

Loads. PNCA coordinated system loads were computed for each year of the 52-year model run. The loads were based on the Firm Energy Load Carrying Capability (FELCC) from the PNCA 2003-2004 operating year. The PNCA critical year is not within the period of record of this study, but is considered to be applicable for the purposes of this study. The FELCC was adjusted for each year due to the generation capability of the hydro-independent projects, which are projects that serve load in the northwest, but are not in the PNCA coordinated system. Table 1 shows the month average load over the 52-year period and was developed with Libby and Hungry Horse VARQ Flood Control.

Table 1. 52-Year Average Pacific Northwest Coordinated System Loads (aMW)

52-Year Average Pacific Northwest Coordinated System Loads (aMW).													
AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
10564	9075	6601	8463	8968	10613	9089	8843	7510	7883	8313	10359	12870	11539

Fish Spill. Fish spill for federal projects are as shown in Table 2, and are based on the Corps of Engineers' PNCAOY04 Data Submittal, which is based on the 2000 NMFS Biological Opinion. The spill caps and percentages are developed based on meeting total dissolved gas standards and fish passage criteria.

Table 2. Project Period Average Spill Cap (cfs) and Percent Spill

Project	Apr 1-15	Apr 15-30	May	June	July	Aug 1-15	Aug 16-31
Wells	0%	6.5%	6.5%	0%	6.5%	2.5%	0%
Rocky Reach	0%	15%	21.8%	15%	15%	15%	0%
Rock Island	0%	20%	20%	20%	20%	20%	0%
Wanapum	0%	43%	43%	46%	49%	49%	49%
Priest Rapids	0%	61%	61%	50%	39%	39%	39%
L. Granite	16,467	19,000	19,000	12,667			
Little Goose	13,000	15,000	15,000	10,000			
L.Monumental	34,667	40,000	40,000	26,667			
Ice Harbor	62,833	72,500	72,500	72,500	72,500	72,500	72,500
McNary	34,000	85,000	85,000	85,000			
John Day	28,000	70,000	66,801	64,167	64,167	70,000	70,000
John Day %	12%	30%	29%	28%	28%	30%	30%
The Dalles	42,800	107,000	107,000	107,000	107,000	107,000	107,000
The Dalles%	40%	40%	40%	40%	40%	40%	40%
Bonneville	38,483	95,292	95,474	93,906	93,750	95,375	95,938

Note: 1) Spill caps and percentages are prorated for the number of spill days in the period.
2) The spill is as developed for the Feb 1 2004 PNCA Data Submittal. Federal projects' spill is based on instantaneous gas caps and maximum spill for day-time and night-time hours provided by the Corps' Reservoir Control Center, Northwestern Division. Day-time and night-time hours are from the Corps' Fish Passage Plan. Spill for non-federal projects are as submitted by project owners in the Feb 2004 Data Submittal

Canadian Treaty Projects Operation. The Canadian Treaty projects, Mica, Duncan and Arrow, are on their 2008 Assured Operation Plan (AOP08) operations including a few changes agreed to by the Canadian Entity for this study. These changes include Brilliant expansion data, and a January maximum outflow of 80 kcfs at Arrow. The AOP was developed in accordance with the Columbia River Treaty, an agreement between the United States and Canadian governments to coordinate the operation of the Columbia River. The Canadian Treaty projects were modeled to target the operation resulting from the 52-year Treaty Storage Regulation and determined the flow across the United States and Canadian border. The flood control used to develop the Canadian operation includes Standard Flood Control for Libby and VARQ for Hungry Horse, as this was used in the AOP08.

Libby. For January through April, Libby was operated to target flood control elevations based on the system flood control curves from HEB. For May-August, Libby was modeled to target the simulated Standard Flood Control elevations provided by NWS. For September through November, Libby operated for power to the operating rule curves as needed to meet load. In December, Libby operated to target the flood control elevation 2411 feet. Modeling includes following the IJC rules for Kootenay Lake. At times the target elevations were not achieved because of minimum flow requirements or the operation of Kootenay Lake to meet the IJC rule curve may have controlled. Data sources for target elevations for January through August are as follows:

- “Hyssrst.txt” from HEB, for January through April
- “ForPwrBr.DSS, EIS2FCBA, LIB ELEV” from NWS, for May through August

Hungry Horse. Hungry Horse was modeled year around to target the simulated elevations from the fish flow regulations for standard flood control provided by Reclamation. The data source for the target elevations is “Varq_neap_analysis_alf3up1down_toACOE_021004.xls, Standard FC Simulation Data, Hungry Horse Pool Elevation,” from Reclamation. These simulations include VDLs, which provide draft limits for winter power operations.

Albeni Falls. Albeni Falls was modeled to operate on a four-year cycle winter cycle. Albeni Falls operated to target elevation 2051 in the winter of 1948-49, and every 4 years thereafter. The project targeted elevation 2055 in the winter in all other years. Albeni Falls fills in April through June to elevation 2062.5 and drafts in September through November to the winter elevation.

Grand Coulee. Data on pumping from Lake Roosevelt to Banks Lake was modeled based on Reclamation’s PNCA OY04 Data Submittal. In January through March, the project operated for power to the draft limits of the higher of the VDLs and the resident fish limits of elevation 1260, 1250, and 1240 ft in January, February, and March, respectively. The VDLs were adjusted for upstream power drafts after the initial model run and incorporated into the final run. In December through May, Grand Coulee drafted as needed to meet the Vernita Bar requirement. Grand Coulee augmented for McNary and Priest Rapids flows in April 15, April 30, May, June, July, August 15, and August 31 to draft limits of elevation 1280, 1280, 1280, 1288, 1285, 1280, and 1280/1278 feet, respectively. The project drafted for power in September, October, November and December, with draft limits of Els.1283, 1283, 1275, and 1270 feet, respectively. Chum flow objectives of 125 kcfs at Bonneville were met by drafting Grand Coulee, but were subject to draft limits of elevation 1275, 1270, in November and December, and VDLs in January through March.

McNary. McNary flow objectives for salmon are those recommended from the NMFS Biological Opinion. The flow objective for April 10th through June 30th varies between 220 kcfs and 260 kcfs. If the April runoff volume forecast at The Dalles Dam for April through August is less than 80 Maf, the flow objective is 220 kcfs. If the volume forecast is greater than 92 Maf, the flow objective is 260 kcfs. If the forecasted volume is between 80 and 92 Maf, the flow objective is linearly interpolated between 220 kcfs and 260 kcfs. The flow objective for July and August is 200 kcfs.

Priest Rapids. Priest Rapids flow objectives to meet needs for steelhead, are for the period April 10 through June 30. The flow objectives are 90 kcfs for the first half of April, and 135 kcfs for the second half of April, May and June. The Vernita Bar requirement is dependant on the October and November flows at Wanapum Dam and is between 50 kcfs and 70 kcfs in December through May.

Brownlee. Brownlee was operated to the fixed elevation operation used in the PNCA studies.

Dworshak. In January through June the project operated to target flood control. Dworshak drafted to meet Lower Granite flow objectives in July through August. In September through December, the project operated on minimum flow of 1300 cfs or flood control. Although the NMFS Biological Opinion discusses flow objectives at Lower Granite in the spring that would be met by drafting of Dworshak, the Biological Opinion places priority on June refill rather than meeting spring flow objectives, therefore Dworshak was modeled to refill in June.

Lower Granite. Lower Granite flow objectives in July and August range from 50 kcfs to 55 kcfs and are based on the April through July volume forecast (determined in June) at Lower Granite. Flow objectives are based on recommendations contained in the NMFS Biological Opinion.

Lower Snake Projects Minimum Operating Pool (MOP). The Lower Snake River projects operated as run-of-river projects, and run to MOP in April-August, except for Lower Granite that runs to MOP in April-October. The projects run to full pool in all other periods.

2.2 Benchmark Combination LV+HV: VARQ Flood Control without Libby Fish Flows.

This Alternative Combination LV+HV is similar to Benchmark Combination LS+HS, except VARQ Flood Control is used as the upper rule curve, Hungry Horse was operated to target simulated elevations with fish flows for VARQ Flood Control, and Libby was operated to target VARQ system flood control elevations in January through April and simulated VARQ Flood Control elevations in May through August. Grand Coulee flood control curves and VDLs were adjusted for upstream power drafts determined for this alternative combination.

Flood Control. The VARQ flood control curves were provided by the HEB, Reclamation, and NWS. The following are the file names, the source, and periods in which they were used.

- "Hyssrvq.txt" from HEB—For all projects and periods except as stated below
- "ForPwrBr.DSS, EIS2FCVQ, LIB ELEV" from NWS—for Libby May and June
- "Varq_nepa_analysis_alf3up1down_toACOE_021004.xls, VARQ Simulation Data, Hungry Horse Rule Curves", for Hungry Horse in May through June (flood control was at full pool in all years). Flood control for April 30 was set to the target elevations from the Hungry Horse Pool Elevation data from the same file.

Libby. For January through April, Libby was operated to target flood control elevations based on the system VARQ flood control curves from HEB. For May-August, Libby was modeled to target the simulated VARQ flood control elevations provided by NWS. The data sources are as follows:

- "Hyssrvq.txt" from HEB, for January through April
- "ForPwrBr.DSS, EIS2FCVQ, LIB ELEV" from NWS, for May through August

Hungry Horse. Hungry Horse was modeled year around to target the simulated elevations from the fish flow regulations for VARQ flood control provided by Reclamation. The data source is "Varq_nepa_analysis_alf3up1down_toACOE_021004.xls, VARQ Simulation Data, Hungry Horse Pool Elevations," from Reclamation.

2.3 Alternative Combination LS1+HS: Standard Flood Control with Libby Fish Flows at QPHC

This Alternative Combination LS1+HS is similar to Benchmark Combination LS+HS except that Libby's May through August target elevations are based on a regulation using fish flows with a maximum flow during the sturgeon pulse of powerhouse capacity for Standard Flood Control (the average powerhouse capacity is approximately 25 kcfs). The data source for these target elevations is "ForPwrBr.DSS, EIS2F1BA, LIB ELEV" from NWS. The model run incorporated Grand Coulee flood control curves and VDLs adjusted for upstream power drafts determined for this alternative combination.

2.4 Alternative Combination LV1+HV: VARQ Flood Control with Libby Fish Flows at QPHC

Same as Alternative Combination LV+HV, except that Libby's May through August target elevations were based on a regulation using fish flows with a maximum flow during the sturgeon pulse of powerhouse capacity for VARQ flood control. The data source for these target elevations is "ForPwrBr.DSS, EIS2F1VQ, LIB ELEV" from NWS. Grand Coulee flood control curves and Variable Draft Limits were adjusted for upstream power drafts determined for this alternative combination.

2.5 Alternative Combination LS2+HS: Standard Flood Control with Libby Fish Flows at QPHC+10

Same as Benchmark Combination LS+HS, except Libby's May through August target elevations were based on a regulation using fish flows with a maximum flow during the sturgeon pulse of powerhouse capacity plus 10 kcfs for Standard Flood Control. The data source for these target elevations is "ForPwrBr.DSS, EIS2F2BA, LIB ELEV" from NWS. Grand Coulee flood control curves and Variable Draft Limits were adjusted for upstream power drafts determined for this alternative combination.

2.6 Alternative Combination LV2+HV: VARQ Flood Control with Libby Fish Flows at QPHC+10

Same as Alternative Combination LV+HV, except Libby's May through August target elevations was based on a regulation using fish flows with a maximum flow during the sturgeon pulse of powerhouse capacity plus 10 kcfs for VARQ flood control. The data source for these target elevations is "ForPwrBr.DSS, EIS2F2VQ, LIB ELEV" from NWS. Grand Coulee flood control curves and VDLs were adjusted for upstream power drafts determined for this alternative combination.

3 Comparison of Alternative/Benchmark Combinations

System, federal, and non-federal generation are compared. Spill for federal and non-federal projects are compared. Libby elevation and flow exceedance curves in September, October, and flow exceedance curves in December and January are provided for each alternative combination. Grand Coulee elevation non-exceedance curves and elevation difference (VARQ minus Standard) exceedance curves for April are provided. Priest Rapids, and McNary flow objective and exceedance curves during fish flow periods are provided.

3.1 System Generation

Table 3 shows the 52-year average system generation for each alternative combination. It should be noted that the generation values are approximations of system generation based on operating year 2003-04, PNCA coordinated projects, stated operating criteria specific to this report, and limitations of the monthly HYSSR model. This data is appropriate for comparison of alternative combinations for this report and other related evaluations, and should not be used for any other purpose.

Values shown in May, June and July for Alternative Combinations LS2+HS and LV2+HV were adjusted from the HYSSR model output to reflect the lost generation due to spilling 10,000 cfs over powerhouse capacity that show up in the daily regulations, but would not show in a monthly model. This is explained in Section 3.2, in the discussion relating to Table 6.

Table 3. 52-Year Average System Generation for Alternative/Benchmark Combinations LS+HS through LV2+HV (aMW)

Alternative Combination	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL
LS1+HS	13743	11600	8712	10557	12566	14166	19849	15831	14716	15290	16366	19337	19279	16683
LV1+HV	13965	11846	8755	10586	12631	14229	19025	15394	14711	15390	16106	19698	19521	16885
LS2+HS	13703	11551	8705	10549	12558	14159	19847	15831	14715	15290	16366	19365	19259	16655
LV2+HV	13927	11808	8743	10583	12626	14227	19024	15393	14710	15391	16106	19717	19497	16858
Benchmark Combination														
LS+HS	13627	11244	10061	10603	12570	14217	19882	15833	14715	15299	16365	19155	18769	16503
LV+HV	13655	11246	10068	10610	12611	14263	19053	15410	14704	15362	16110	19594	19264	16662

3.2 System Generation Differences

Differences in generation for the PNCA Coordinated System are provided in Tables 3 through 9.

Table 4 shows the generation differences for Benchmark Combination LV+HV minus LS+HS, VARQ without Libby fish flows minus Standard Flood Control without Libby fish flows. Both alternative combinations included power operations and fish operations for all projects except for Libby, which was modeled to target VARQ or Standard Flood Control elevations. In Table 4, a negative number means there is less generation in the VARQ alternative combination. There is less system generation with VARQ in January through March and the second half of April because there is less water released from Hungry Horse in Jan, Feb, and the second half of April, and from Libby in January through March in order to achieve the higher flood control elevations by the end of April with VARQ flood control. There was slightly more flow from Libby and Hungry Horse in the first half of April because in some years, they had to draft more to meet flood control with VARQ than with Standard (at Libby, there were 6 years where there was more outflow in the first half of April and 5 years where there was less flow). In May and June, more water is released, therefore more generation. In August, Libby targeted elevation 2459 in both alternative combinations. The pool was higher at the end of July in 7 years under VARQ, which caused slightly more outflow in August in those years, and therefore more system generation. The largest impact by month was in January, which had 828 MW less generation with VARQ, which is a 4.2 % reduction of generation from the Standard flood control alternative combination. The average annual loss in generation due to VARQ under flood control only alternative combinations is 12 MW.

Table 5 shows generation differences for Alternative Combination LV1+HV minus LS1+HS, VARQ Flood Control with Libby fish flows at QPHC minus Standard Flood Control with Libby fish flows at QPHC. In January through April, differences between Table 5 and 4 are similar because Hungry Horse's resulting operation is the same in the standard alternative combinations and the same in the VARQ alternative combinations, and Libby's resulting operation is nearly the same. In May through August, Libby and Hungry Horse pass more flow under VARQ resulting in more generation. For September through December, more water was released and more generation was produced with VARQ because Libby's ending elevation in August was higher under VARQ, and Libby ended at the December target elevation of elevation 2411 in both VARQ and Standard. Also, since Libby produced more flow in August, this allowed other projects in the system to draft less when the system was drafting to just meet load. This produced higher elevations in August at these projects (for example, Kerr), which provided more water in the fall that passes through the run of river projects, resulting in more generation. The average annual loss in generation due to VARQ under fish flows at QPHC is 8 MW.

Table 6 shows generation differences between Alternative Combination LV2+HV minus LS2+HS, VARQ Flood Control with QPHC+10 minus Standard Flood Control with QPHC+10. Results are similar to that explained for Table 4. The generation differences that are italicized in May, June, and July were adjusted from the HYSSR model output to reflect the lost generation due to spill as shown in the daily regulations, and as explained below.

The USFWS Biological Opinion calls for increasing flow capacity from Libby by 10,000 cubic feet per second (cfs) above current powerhouse capacity, within Montana's dissolved gas standard of 110% saturation. Although the mechanism for achieving that has not been determined, the UCEIS evaluates the effects of the flow capacity increase itself. Considering that spill may in fact be the method used to achieve the additional 10,000 cfs, the potential generation lost due to voluntary spill was evaluated.[1]

Adjustments were made to the generation computed by the HYSSR model to account for loss of generation due to spill shown in daily regulations that would not be evident in a monthly model. The generation computed by the HYSSR model uses the average flow and other factors. If the month average flow is less than the powerhouse capacity computed by HYSSR, then HYSSR will show the project not spilling. The QPHC + 10 kcfs daily simulations provided by NWS show that spill occurred in part of the months in May in 24 years and in June in 34 years, with the month average being less than powerhouse capacity. To estimate the May and June generation that includes the loss due to spill, daily spill in MW was computed, then averaged over each of the months and subtracted from the corresponding month generation from the HYSSR model. To compute spill in MW on a daily basis, first the spill flow was computed to be the total regulated flow minus the powerhouse capacity. The powerhouse capacity was computed based on powerhouse capacity vs. forebay table provided by NWS. The spill flow was converted to MW by a conversion factor, MW/Kcfs. The conversion factor varies with

[1] Installation of additional generating units at Libby would also be considered to achieve the additional flow capacity for 10,000 cfs, in which case generation would not be lost to provide the additional 10,000 cfs. Both spill and installation of additional units present logistical and funding challenges. Any decisions on the method used to pass the additional water would include further studies on design, benefits, and impacts, and subsequent documentation under the National Environmental Policy Act, including a public comment period.

head and the head was computed to be the daily forebay elevation minus an assumed tailwater elevation 2124 feet. The MW/Kcfs conversion factor vs. head table used was that submitted for use for the PNCA. This method is intended only to provide an estimate. The average annual loss in generation due to VARQ under fish flows at QPHC + 10 is 7 MW.

Table 7 shows differences in generation for Alternative/Benchmark Combination LS1+HS minus LS+HS, Standard Flood control with Libby fish flows at QPHC minus Standard Flood Control without Libby fish flows. For May and June, there was more flow and generation in the fish flow alternative combination because the targeted elevations produced more flow than in the flood control only alternative combination, which was trying to fill to the flood control elevation. In July, 58% of the time Libby's fish flow targeted elevations produced less flow than that flow needed to fill from the June flood control elevation to full in July in the flood control only alternative combination. This resulted in less overall flow at Libby, however, Kootenay Lake still attempted to operate to meet its IJC rule curves, and drafted as it could within the channel capacity limitations. This resulted in more flow released from Kootenay Lake in July, which carried through the system and resulted in higher system generation in July. In both halves of August, Libby released more flows from the fish flow alternative combination than the flood control only alternative combination because the flood control only alternative combination operated to maintain elevation 2459 from the end of July through the end of August just passing natural flows. For September, in the fish flow alternative combination, Libby drafted 1.1 feet from elevation 2439 at the end of August to elevation 2437.9 (the power operating rule curve) at the end of September in most years. In the fish flow alternative combination, Libby drafted 21.1 feet from elevation 2459 at the end of August to elevation 2437.9 at the end of September. This resulted in less flow and generation in the fish flow alternative combination in September. For October through December, on average, small generation differences occurred when the system drafted to just meet load. The average annual loss in generation due to fish flows at QPHC with Standard Flood Control is 31 MW with most of the loss occurring in September. In a few years in January through April, some residual effects of the prior year show up, but for the most part, the projects operated the same in both alternative combinations.

Table 8 shows differences in generation for Alternative/Benchmark Combination LS2+HS minus LS+HS, Libby with fish flows at QPHC+10 and Standard Flood Control minus Standard Flood Control without Libby fish flows. The explanation of the results is similar to that for Table 7. The average annual loss in generation due to fish flows up to QPHC + 10 under Standard Flood Control is 38 MW.

Tables 9 and 10 show differences in generation for Libby with fish flows at QPHC, and at QPHC+10, respectively, minus Libby on VARQ Flood Control. The explanation of the results is similar to that for Table 6. The average annual loss in generation due to fish flows up QPHC under VARQ Flood Control is 27 MW. The average annual generation lost due to fish flows up to QPHC+10 under VARQ flood control is 33 MW.

Table 4. System Generation Differences (aMW), Benchmark Combination LV+HV minus LS+HS

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	100	0	0	0	0	0	-489	-1452	7	244	115	588	20	131	-84
48-49	0	0	0	0	0	0	-1285	-60	-794	675	-650	878	956	58	-19
49-50	0	0	95	23	35	45	-758	120	-303	160	-62	306	409	82	8
50-51	-1	-34	0	0	0	17	162	-532	-66	353	-154	65	173	-67	-13
51-52	-7	14	0	0	0	0	-10	-994	-384	103	-163	245	495	664	0
52-53	182	0	0	0	0	0	0	-861	-281	17	-500	403	631	178	-6
53-54	-59	0	0	0	0	0	-1149	63	341	484	-251	154	313	45	-12
54-55	62	-1	5	0	0	0	-1899	-118	11	-155	230	-421	835	573	-78
55-56	-4	-209	0	0	0	0	69	-569	267	206	-83	22	-5	-27	-23
56-57	115	0	0	0	0	0	-1422	-1033	-23	-99	-596	530	1394	244	-50
57-58	0	0	0	0	0	0	-1156	-741	396	-46	-293	418	1153	12	-7
58-59	0	0	0	0	0	0	-392	-443	-179	341	145	546	379	-84	5
59-60	38	0	0	0	0	401	-1473	-512	1	-201	27	839	816	-7	0
60-61	0	0	0	0	0	0	-993	-962	-144	-355	-540	502	781	240	-85
61-62	0	0	0	0	0	0	-1774	-252	32	-46	-291	626	790	644	-8
62-63	0	0	0	0	0	0	-1644	-325	-15	-197	-347	752	911	274	-26
63-64	315	0	0	0	0	0	-1035	-448	9	-84	-834	516	621	503	-11
64-65	2	-28	0	0	0	0	-157	-617	355	442	-16	251	248	-125	12
65-66	142	0	0	0	0	0	-1276	12	19	-325	-456	526	676	319	-3
66-67	2	0	0	0	0	0	-630	192	667	634	-323	-63	108	-178	21
67-68	-120	0	0	0	0	0	-1153	-1004	-368	469	-540	698	932	505	-40
68-69	56	0	0	0	0	241	-466	-119	-232	-259	191	323	242	181	13
69-70	272	0	0	0	0	0	-68	-300	-31	-557	-539	351	163	107	-15
70-71	0	0	0	0	0	0	-1280	57	-6	544	190	309	446	73	-2
71-72	2	1	0	0	0	0	-742	343	182	253	-322	373	-59	-333	-22
72-73	146	39	0	0	87	-89	-1383	-470	-180	0	-1	411	210	162	-96
73-74	0	-1	1	151	810	202	8	-164	252	520	-83	45	70	-102	124
74-75	-147	-30	0	0	0	0	-1154	-864	108	164	-465	627	615	510	-33
75-76	291	0	0	0	0	35	-249	-2027	628	477	230	238	446	330	-8
76-77	114	15	2	0	0	4	-226	1	1	0	1	54	45	-42	-8
77-78	3	1	-32	-1	11	139	-768	-1242	18	385	-470	158	694	1241	14
78-79	0	0	0	0	-796	504	-529	-196	-662	-28	-8	614	73	0	-84
79-80	0	-1	114	0	220	430	-1469	57	303	367	-601	668	581	-43	62
80-81	0	0	0	0	0	0	-360	-1563	408	-56	-745	488	612	139	-56
81-82	-11	-66	0	0	0	0	-1274	-620	-336	478	-119	538	918	330	-25
82-83	-6	-41	0	0	0	0	-1167	-1080	22	-150	-656	545	1446	632	-2
83-84	0	0	0	0	0	0	-1342	-652	199	315	-611	393	1176	-1	-31
84-85	0	0	0	0	0	0	-1197	-125	-157	511	-421	184	402	0	-70
85-86	0	0	82	108	370	574	-1956	-60	-215	200	-768	308	1244	751	76
86-87	0	1	-1	0	0	0	-1375	-247	-130	17	-650	1097	1	0	-80
87-88	0	0	-1	-1	-1	0	-1	1099	121	-1543	211	624	-86	-1	90
88-89	0	0	-3	-9	497	-57	-2122	-538	11	-746	-119	1046	630	-15	-82
89-90	116	173	69	96	348	277	-1195	122	-130	-177	206	577	747	-117	79
90-91	-16	0	0	0	0	5	178	64	-83	-106	-176	-3	135	-113	2
91-92	-118	-22	0	0	0	0	-1007	-989	13	-7	-288	1024	0	423	-62
92-93	365	265	0	1	1	-1	-418	-1	31	21	4	425	37	21	35
93-94	0	0	0	0	0	0	-328	2	2	-164	-942	673	133	-1	-6
94-95	0	0	0	0	22	-5	-801	-456	-386	448	-586	858	605	-11	-20
95-96	0	0	0	0	0	184	41	-49	-54	-268	-115	119	14	-79	-1
96-97	10	36	0	0	0	0	-434	22	-6	259	-79	49	343	331	34
97-98	-304	0	0	0	0	0	-483	-720	167	-202	-25	716	521	-421	-40
98-99	0	0	0	0	540	-545	-1065	-736	-3	-42	48	661	712	353	-6
Ave MW	27	2	6	7	41	45	-828	-422	-11	62	-255	439	495	159	-12
% Diff	0.2%	0.0%	0.1%	0.1%	0.3%	0.3%	-4.2%	-2.7%	-0.1%	0.4%	-1.6%	2.3%	2.6%	1.0%	-0.1%

Table 5. System Generation Differences (aMW), Alternative Combination LV1+HV minus LS1+HS

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	0	0	0	0	0	0	-489	-1452	7	244	115	588	5	147	-84
48-49	17	78	-7	0	0	0	-1285	-60	-794	675	-650	633	483	391	-48
49-50	221	1	0	0	150	388	-775	119	-303	165	-63	306	260	57	30
50-51	32	134	30	0	0	17	162	-532	-66	353	-154	65	177	-62	-2
51-52	4	18	-7	0	0	0	-10	-994	-384	81	-163	246	476	103	-50
52-53	84	67	265	65	94	233	0	-861	-281	17	-499	269	174	260	4
53-54	792	516	-15	0	0	0	-1149	63	341	484	-251	154	247	37	37
54-55	164	66	7	0	0	0	-1899	-118	11	-155	230	-556	502	639	-105
55-56	165	1031	0	0	0	0	56	-569	267	206	-83	22	127	-62	41
56-57	-56	-143	7	0	0	0	-1422	-1033	-23	-99	-596	452	572	572	-110
57-58	690	1	385	127	0	0	-1156	-741	396	-46	-293	297	207	516	17
58-59	604	521	22	0	0	0	-342	-443	-179	341	145	540	294	-97	50
59-60	263	104	-14	0	0	401	-1473	-512	1	-214	27	839	395	72	-16
60-61	125	130	282	0	0	0	-993	-962	-144	-355	-540	502	614	343	-56
61-62	211	95	30	0	0	0	-1774	-252	32	-46	-291	560	157	438	-68
62-63	493	457	263	223	78	0	-1644	-325	-15	-197	-347	596	431	316	10
63-64	1347	301	0	0	0	0	-1035	-448	9	-84	-834	443	58	555	-4
64-65	228	1452	-7	0	0	0	-157	-617	355	442	-16	247	151	-242	65
65-66	9	-12	31	313	0	0	-1276	12	19	-325	-456	526	416	320	-2
66-67	312	251	0	0	0	0	-630	192	667	634	-323	-75	58	-112	44
67-68	-77	-64	15	0	0	0	-1153	-1004	-368	469	-540	583	130	563	-111
68-69	1144	878	7	0	0	241	-470	-119	-232	-259	191	309	128	284	93
69-70	207	116	15	0	0	0	-68	-300	-31	-557	-539	278	33	121	-28
70-71	239	190	-8	0	0	0	-1275	57	-6	544	190	303	228	63	-4
71-72	290	294	-30	0	0	0	-742	343	185	253	-322	361	115	-305	15
72-73	-203	-62	-211	0	87	-89	-1383	-470	-180	0	-1	285	0	170	-160
73-74	0	0	0	56	1055	498	1	-185	235	513	-113	-31	23	-29	151
74-75	-80	-67	-10	0	0	0	-1154	-864	108	164	-465	627	358	186	-81
75-76	265	256	454	173	0	35	-249	-2027	628	477	230	202	195	267	24
76-77	342	276	139	0	0	4	-226	1	1	0	1	54	45	30	29
77-78	56	81	0	0	0	2	-857	-1242	18	385	-470	27	287	1147	-49
78-79	735	605	22	0	-796	504	-529	-196	-662	-28	-8	428	0	0	-48
79-80	-2	1	0	-1	446	634	-1465	19	302	366	-603	807	394	-93	77
80-81	71	62	-15	0	0	0	-360	-1563	408	-56	-745	393	325	88	-88
81-82	30	359	270	0	0	0	-1274	-637	-336	478	-119	538	561	318	-15
82-83	112	682	-22	0	0	0	-1167	-1080	13	-150	-656	545	754	560	-33
83-84	142	917	306	11	0	0	-1342	-652	199	315	-611	197	472	417	0
84-85	628	532	-7	0	0	0	-1197	-125	-157	511	-421	108	0	0	-62
85-86	-1	1	0	508	954	357	-2007	-203	-261	190	-767	69	596	1163	74
86-87	725	516	-30	0	0	0	-1375	-247	-130	17	-650	781	-1	0	-58
87-88	0	0	1	-1	-1	-1	165	527	304	347	1	438	13	-87	127
88-89	-1	-1	1	-1	575	-59	-2216	-631	97	-746	-119	916	0	577	-97
89-90	654	482	50	43	123	243	-1207	122	-130	-177	206	584	175	239	68
90-91	253	207	-15	0	0	5	178	64	-83	-106	-176	-3	57	-46	20
91-92	-41	-86	7	0	0	0	-1136	-841	13	-7	-288	727	0	134	-108
92-93	194	955	0	0	-1	0	138	0	29	35	-5	212	165	63	99
93-94	-69	-26	-1	1	8	0	-328	2	2	-164	-942	453	1	0	-38
94-95	-31	0	-1	0	78	236	-938	-449	-257	535	-586	577	597	293	8
95-96	25	47	7	0	0	184	41	-49	-54	-268	-115	103	117	-88	8
96-97	-21	-116	7	0	0	0	-434	22	-6	259	-79	49	19	232	-7
97-98	284	678	22	0	0	0	-483	-720	167	-202	-25	509	553	-241	14
98-99	-12	50	-8	0	540	-545	-1065	-736	-3	-42	48	661	424	276	-36
Ave MW	222	246	43	29	65	63	-824	-436	-5	100	-260	360	241	201	-8
% Diff	1.6%	2.1%	0.5%	0.3%	0.5%	0.4%	-4.2%	-2.8%	0.0%	0.7%	-1.6%	1.9%	1.3%	1.2%	-0.1%

Table 6. System Generation Differences (aMW), Alternative Combination LV2+HV minus LS2+HS

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	0	1	0	0	0	0	-489	-1452	7	244	115	588	***11***	213	***-72***
48-49	36	228	-207	0	0	0	-1285	-60	-794	675	-650	***597***	531	391	***-58***
49-50	220	0	-1	-2	149	396	-775	119	-303	164	-63	306	***248***	21	***25***
50-51	44	252	7	0	0	17	162	-532	-66	353	-154	65	***178***	-72	***4***
51-52	5	-1	0	0	0	0	-10	-994	-384	103	-163	245	***483***	78	***-47***
52-53	33	43	258	63	95	299	0	-861	-281	17	-499	***291***	***181***	211	***11***
53-54	826	523	-45	0	0	0	-1149	63	341	484	-251	154	***253***	23	***35***
54-55	166	105	34	0	0	0	-1899	-118	11	-155	230	***-556***	***503***	656	***-102***
55-56	170	1072	7	0	0	0	56	-569	267	206	-83	22	***120***	-60	***48***
56-57	-69	-80	-15	0	0	0	-1422	-1033	-23	-99	-596	***459***	***557***	534	***-108***
57-58	635	1	383	195	0	0	-1156	-741	396	-46	-293	***297***	***212***	502	***24***
58-59	604	521	22	0	0	0	-346	-443	-179	341	145	540	***303***	-68	***56***
59-60	158	130	-7	0	0	401	-1473	-512	1	-205	27	839	***390***	30	***-21***
60-61	89	79	312	79	0	0	-993	-962	-144	-355	-540	502	***466***	377	***-55***
61-62	312	183	-15	0	0	0	-1774	-252	32	-46	-291	***566***	***164***	388	***-67***
62-63	457	417	248	224	179	0	-1644	-325	-15	-197	-347	***590***	404	326	***14***
63-64	1258	497	-37	0	0	0	-1035	-448	9	-84	-834	***458***	***93***	520	***1***
64-65	222	1399	0	0	0	0	-157	-617	355	442	-16	247	***138***	-239	***69***
65-66	5	14	1	309	34	0	-1276	12	19	-325	-456	526	***440***	296	***-2***
66-67	271	261	7	0	0	0	-630	192	667	634	-323	-75	***56***	-111	***43***
67-68	-65	-53	-7	0	0	0	-1153	-1004	-368	469	-540	***575***	120	598	***-108***
68-69	1187	897	0	0	0	241	-506	-119	-232	-259	191	309	***151***	263	***95***
69-70	171	129	15	0	0	0	-68	-300	-31	-557	-539	***259***	40	131	***-26***
70-71	212	192	15	0	0	0	-1275	57	-6	544	190	303	***249***	90	***-2***
71-72	149	272	-7	0	0	0	-742	343	185	253	-322	361	***106***	-305	***8***
72-73	-147	-72	-179	0	87	-89	-1383	-470	-180	0	-1	***236***	0	167	***-159***
73-74	0	1	0	37	1098	499	5	-182	239	516	-110	3	***19***	***-32***	***158***
74-75	-36	-75	6	0	0	0	-1154	-864	108	164	-465	627	***371***	163	***-74***
75-76	238	231	461	247	0	35	-249	-2027	628	477	230	202	***208***	252	***38***
76-77	350	290	126	0	0	4	-226	1	1	0	1	54	45	23	29
77-78	42	70	-1	1	0	6	-847	-1242	18	385	-470	***49***	***86***	1104	***-59***
78-79	1108	759	0	0	-796	504	-529	-196	-662	-28	-8	***375***	0	0	***-30***
79-80	0	0	1	0	426	704	-1456	19	301	366	-603	***813***	***354***	-66	***81***
80-81	28	26	7	0	0	0	-360	-1563	408	-56	-745	***327***	281	150	***-82***
81-82	39	389	313	0	0	0	-1274	-633	-336	478	-119	538	***578***	314	***-6***
82-83	110	656	-15	0	0	0	-1167	-1080	13	-150	-656	545	***809***	520	***-25***
83-84	129	809	276	104	0	0	-1342	-652	199	315	-611	***94***	491	540	***5***
84-85	573	504	-15	0	0	0	-1197	-125	-157	511	-421	***80***	0	1	***-70***
85-86	0	0	0	492	964	387	-2006	-201	-233	190	-767	***56***	550	1239	***80***
86-87	736	561	-75	0	0	0	-1375	-247	-130	17	-650	***749***	0	-1	***-61***
87-88	0	0	0	-1	0	0	278	466	250	348	1	426	21	-52	129
88-89	2	0	1	0	571	-65	-2236	-631	97	-746	-119	***928***	***13***	533	***-99***
89-90	644	462	80	41	117	243	-1207	122	-130	-177	206	584	***193***	230	***69***
90-91	220	209	0	0	0	5	178	64	-83	-106	-176	-3	***54***	-51	***20***
91-92	-11	-57	-7	0	0	0	-1136	-841	13	-7	-288	***675***	0	176	***-105***
92-93	200	955	0	1	1	0	126	-1	28	23	-5	211	151	79	101
93-94	-69	-51	1	-1	16	7	-328	2	2	-164	-942	***444***	-1	0	***-39***
94-95	-50	0	1	0	31	289	-938	-446	-257	535	-586	***516***	537	281	***-1***
95-96	204	124	37	0	0	184	41	-49	-54	-268	-115	103	***101***	-74	***22***
96-97	-13	-92	0	0	0	0	-434	22	-6	259	-79	49	***30***	270	***-3***
97-98	313	581	-44	0	0	0	-483	-720	167	-202	-25	***494***	593	-263	***12***
98-99	-70	14	8	0	540	-545	-1065	-736	-3	-42	48	661	***440***	289	***-34***
Ave MW	223	257	37	34	67	67	-823	-437	-5	100	-260	***351***	***236***	***203***	***-7***
% Diff	1.6%	2.2%	0.4%	0.3%	0.5%	0.5%	-4.3%	-2.8%	0.0%	0.6%	-1.6%	***1.8%***	***1.2%***	***1.2%***	***0.0%***

Table 7. System Generation Differences (aMW), Alternative/Benchmark Combination LS1+HS minus LS+HS

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	-19	1	-1596	0	0	0	0	0	0	0	0	0	63	259	-106
48-49	158	1363	-1581	0	0	0	0	0	0	0	0	447	908	0	44
49-50	-1	0	-686	-208	-267	-552	12	2	-1	-12	2	0	592	357	-63
50-51	-5	-163	-1601	0	0	0	0	0	0	0	0	0	731	125	-69
51-52	76	544	-1575	0	0	0	0	0	0	0	0	0	867	1061	55
52-53	-78	14	-1880	-65	-94	-233	0	0	0	0	0	271	661	-76	-120
53-54	-76	565	-1585	0	0	0	0	0	0	0	0	0	461	263	-51
54-55	-161	433	-1238	-12	0	0	0	0	0	0	0	206	365	-72	-51
55-56	140	839	-1571	0	0	0	0	0	0	0	0	0	473	162	-37
56-57	233	776	-1592	0	0	0	0	0	0	0	0	230	1011	-166	-1
57-58	-17	0	-1717	0	0	0	0	0	0	0	0	260	1166	-307	-50
58-59	40	69	-1536	1	0	0	-27	0	0	0	0	6	480	154	-72
59-60	249	667	-958	-537	0	0	0	0	0	13	0	0	1020	510	41
60-61	-281	115	-1862	0	0	0	0	0	0	0	0	0	164	280	-125
61-62	738	822	-1613	0	0	0	0	0	0	0	0	245	920	679	84
62-63	-294	5	-1855	-223	-78	0	0	0	0	0	0	537	629	-162	-108
63-64	-205	621	-1577	0	0	0	0	0	0	0	0	239	678	-81	-44
64-65	1	244	-1558	0	0	0	0	0	0	0	0	5	918	603	7
65-66	313	309	-2048	-313	0	0	0	0	0	0	0	0	953	44	-87
66-67	74	366	-1597	0	0	0	0	0	0	0	0	11	598	70	-58
67-68	3	539	-1587	0	0	0	0	0	0	0	0	446	719	-144	-24
68-69	47	235	-1554	0	0	0	0	0	0	0	0	14	610	-106	-74
69-70	660	293	-1312	0	0	0	0	0	0	0	0	569	478	-153	4
70-71	157	180	-1428	0	2	1	-4	0	0	0	0	6	633	213	-34
71-72	-204	743	-1572	0	0	0	0	0	-3	0	0	12	59	285	-79
72-73	349	479	-1144	0	0	0	0	0	0	0	0	545	210	1	2
73-74	0	-1	0	-266	-104	-670	7	21	17	7	30	88	143	133	-51
74-75	296	1248	-1532	0	0	0	0	0	0	0	0	0	885	834	79
75-76	-8	-216	-2045	-173	0	0	0	0	0	0	0	46	1128	658	-41
76-77	-550	-524	-1635	-19	0	0	0	0	0	0	0	0	0	518	-139
77-78	608	550	-32	-1	1	-632	-331	-11	-8	-1	-1	177	571	351	55
78-79	34	121	-1556	0	0	0	0	0	0	0	0	493	74	0	-76
79-80	1	-1	-1089	1	273	19	22	36	-6	1	3	14	300	381	-3
80-81	674	654	-1583	0	0	0	0	0	0	0	0	457	348	-299	-34
81-82	147	1157	-1526	0	0	0	0	0	0	0	0	0	940	265	27
82-83	-61	-95	-1543	0	0	0	0	0	0	0	0	0	1009	626	1
83-84	-110	-307	-1861	-11	0	0	0	0	0	0	0	509	603	-97	-88
84-85	-5	299	-1580	0	0	0	0	0	0	0	0	474	402	0	-46
85-86	0	-1	-1220	-538	133	225	55	148	115	10	0	498	593	-181	-13
86-87	148	99	-1391	2	0	0	0	0	0	0	0	555	1	0	-59
87-88	1	1	-1	0	1	1	-165	-217	-31	-347	-7	-145	-83	87	-60
88-89	0	1	-176	-65	261	-38	-200	0	0	0	0	257	631	224	74
89-90	-119	-139	-1574	76	260	34	12	0	0	0	0	0	993	177	-12
90-91	-197	186	-1587	0	0	0	0	0	0	0	0	6	734	259	-49
91-92	-321	591	-1592	0	0	0	0	0	0	0	0	568	0	593	-24
92-93	278	190	1	0	0	0	-1071	-1	-25	-139	-4	-70	-437	125	-109
93-94	1180	1193	-705	-38	-569	-202	0	-77	-19	0	0	494	-2	0	5
94-95	228	-1	0	0	-43	-617	0	-4	9	-1	-1	509	-46	-87	-13
95-96	765	917	-1582	0	0	0	0	0	0	0	0	50	309	102	-23
96-97	172	1287	-1571	0	0	0	0	0	0	0	0	2	421	194	-18
97-98	76	667	-1564	0	0	0	0	0	0	0	0	455	-311	157	-74
98-99	887	550	-1380	9	0	0	0	0	0	0	0	0	946	541	69
Ave MW	115	355	-1348	-45	-4	-51	-32	-1	0	-9	0	182	509	180	-31
% Diff	0.8%	3.2%	-13.4%	-0.4%	0.0%	-0.4%	-0.2%	0.0%	0.0%	-0.1%	0.0%	1.0%	2.7%	1.1%	-0.2%

Table 8. System Generation Differences (aMW), Alternative/Benchmark Combination LS2+HS minus LS+HS

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	-19	1	-1596	0	0	0	0	0	0	0	0	0	***26***	237	***-109***
48-49	138	1195	-1567	0	0	0	0	0	0	0	0	***523***	775	0	***37***
49-50	0	0	-687	-207	-275	-578	12	2	-1	-12	2	0	***580***	367	***-66***
50-51	-16	-281	-1587	0	0	0	0	0	0	0	0	0	***757***	143	***-69***
51-52	35	233	-1583	0	0	0	0	0	0	0	0	0	***808***	1076	***39***
52-53	-67	14	-1880	-63	-95	-299	0	0	0	0	0	***315***	***629***	-137	***-128***
53-54	-123	539	-1577	0	0	0	0	0	0	0	0	0	***442***	305	***-49***
54-55	-315	338	-1290	-12	0	0	0	0	0	0	0	***291***	***314***	-169	***-69***
55-56	136	786	-1578	0	0	0	0	0	0	0	0	0	***476***	137	***-39***
56-57	164	711	-1585	0	0	0	0	0	0	0	0	***265***	***969***	-215	***-8***
57-58	-4	0	-1722	-68	0	0	0	0	0	0	0	***306***	***1112***	-383	***-63***
58-59	13	43	-1536	1	0	0	-23	0	0	0	0	6	***489***	123	***-75***
59-60	181	600	-972	-537	0	0	0	0	0	4	0	0	***983***	544	***35***
60-61	-282	114	-1906	-79	0	0	0	0	0	0	0	0	***162***	252	***-135***
61-62	650	746	-1590	0	0	0	0	0	0	0	0	***304***	***888***	635	***81***
62-63	-285	5	-1855	-224	-179	0	0	0	0	0	0	***642***	611	-216	***-111***
63-64	-464	595	-1577	0	0	0	0	0	0	0	0	***289***	***618***	-136	***-59***
64-65	14	268	-1580	0	0	0	0	0	0	0	0	5	***881***	627	***9***
65-66	312	297	-2049	-394	-34	0	0	0	0	0	0	0	***929***	21	***-101***
66-67	7	292	-1582	0	0	0	0	0	0	0	0	11	***605***	13	***-65***
67-68	-61	476	-1564	0	0	0	0	0	0	0	0	***552***	708	-293	***-30***
68-69	20	183	-1561	0	0	0	0	0	0	0	0	14	***613***	-131	***-79***
69-70	562	204	-1312	0	0	0	0	0	0	0	0	***620***	465	-238	***-5***
70-71	157	166	-1443	0	2	1	-4	0	0	0	0	6	***632***	173	***-38***
71-72	-249	617	-1572	0	0	0	0	0	-3	0	0	12	***37***	290	***-84***
72-73	141	443	-1270	0	0	0	0	0	0	0	0	***628***	210	1	***-8***
73-74	-1	-2	1	-266	-203	-711	7	19	14	5	27	52	***144***	***152***	***-66***
74-75	218	1119	-1580	0	0	0	0	0	0	0	0	0	***852***	845	***70***
75-76	-21	-215	-2046	-247	0	0	0	0	0	0	0	46	***1105***	664	***-48***
76-77	-639	-598	-1645	-19	0	0	0	0	0	0	0	0	0	525	-145
77-78	622	560	-32	-2	1	-637	-342	-11	-8	-1	-1	***228***	***546***	265	***49***
78-79	-19	83	-1549	0	0	0	0	0	0	0	0	***568***	74	0	***-70***
79-80	0	1	-1090	0	215	-85	14	36	-5	1	3	***49***	***242***	309	***-25***
80-81	660	641	-1583	0	0	0	0	0	0	0	0	***566***	314	-451	***-39***
81-82	143	1158	-1545	0	0	0	0	0	0	0	0	0	***906***	247	***25***
82-83	-72	-159	-1536	0	0	0	0	0	0	0	0	0	***957***	653	***-2***
83-84	-111	-308	-1861	-104	0	0	0	0	0	0	0	***549***	583	-175	***-100***
84-85	-19	274	-1565	0	0	0	0	0	0	0	0	***543***	402	-1	***-38***
85-86	0	-1	-1220	-558	41	194	54	146	87	10	0	***604***	566	-346	***-36***
86-87	134	85	-1406	2	0	0	0	0	0	0	0	***609***	0	1	***-54***
87-88	0	0	0	0	0	1	-278	-217	-31	-348	-7	-146	-95	51	-74
88-89	-1	1	-176	-66	266	-31	-178	0	0	0	0	***306***	***594***	170	***73***
89-90	-111	-134	-1649	82	265	34	12	0	0	0	0	0	***961***	157	***-21***
90-91	-259	134	-1587	0	0	0	0	0	0	0	0	6	***754***	281	***-49***
91-92	-452	358	-1577	0	0	0	0	0	0	0	0	***617***	1	552	***-33***
92-93	272	188	1	0	0	0	-1091	-1	-37	-144	-4	-77	-437	109	-116
93-94	1180	1218	-706	-37	-578	-209	0	-78	-19	0	0	***523***	-1	-1	***12***
94-95	222	-1	-1	1	-43	-704	0	-7	9	-1	-1	***602***	1	-156	***-16***
95-96	577	833	-1619	0	0	0	0	0	0	0	0	50	***362***	108	***-30***
96-97	134	990	-1579	0	0	0	0	0	0	0	0	2	***408***	199	***-30***
97-98	-38	607	-1557	0	0	0	0	0	0	0	0	***471***	-382	157	***-81***
98-99	887	550	-1380	9	0	0	0	0	0	0	0	0	***941***	541	***71***
Ave MW	75	307	-1355	-53	-11	-58	-34	-2	0	-9	0	***210***	***490***	***151***	***-38***
% Diff	0.6%	2.7%	-13.5%	-0.5%	-0.1%	-0.4%	-0.2%	0.0%	0.0%	-0.1%	0.0%	***1.1%***	***2.6%***	***0.9%***	***-0.3%***

Table 9. System Generation Differences (aMW), Alternative/Benchmark Combination LV1+HV minus LV+HV

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	-19	0	-1596	0	0	0	0	0	0	0	0	0	48	274	-106
48-49	175	1441	-1589	0	0	0	0	0	0	0	0	201	434	333	15
49-50	220	1	-781	-231	-151	-209	-5	1	0	-7	2	0	443	332	-41
50-51	28	6	-1572	0	0	0	0	0	0	0	0	0	735	130	-57
51-52	87	547	-1583	0	0	0	0	0	0	-23	0	0	848	500	5
52-53	-177	81	-1615	0	0	0	0	0	0	0	0	137	204	6	-109
53-54	774	1081	-1600	0	0	0	0	0	0	0	0	0	396	254	-1
54-55	-60	500	-1236	-12	0	0	0	0	0	0	0	71	32	-6	-77
55-56	309	2078	-1571	0	0	0	-13	0	0	0	0	0	606	127	28
56-57	62	633	-1585	0	0	0	0	0	0	0	0	153	190	162	-61
57-58	673	1	-1332	127	0	0	0	0	0	0	0	139	220	196	-26
58-59	645	590	-1514	1	0	0	22	0	0	0	0	0	396	141	-28
59-60	473	771	-972	-537	0	0	0	0	0	0	0	0	599	589	25
60-61	-156	245	-1580	0	0	0	0	0	0	0	0	0	-3	383	-96
61-62	949	918	-1582	0	0	0	0	0	0	0	0	179	286	473	24
62-63	199	463	-1592	0	0	0	0	0	0	0	0	382	149	-119	-70
63-64	827	923	-1577	0	0	0	0	0	0	0	0	166	115	-29	-37
64-65	228	1724	-1566	0	0	0	0	0	0	0	0	0	820	486	59
65-66	181	298	-2017	0	0	0	0	0	0	0	0	0	693	44	-86
66-67	385	617	-1597	0	0	0	0	0	0	0	0	0	547	136	-34
67-68	46	475	-1572	0	0	0	0	0	0	0	0	332	-84	-86	-95
68-69	1135	1113	-1547	0	0	0	-4	0	0	0	0	0	496	-2	5
69-70	595	409	-1297	0	0	0	0	0	0	0	0	497	349	-138	-7
70-71	396	370	-1435	0	2	1	0	0	0	0	0	0	415	204	-35
71-72	83	1037	-1601	0	0	0	0	0	0	0	0	0	233	313	-41
72-73	0	377	-1354	0	0	0	0	0	0	0	0	419	0	8	-61
73-74	0	0	-1	-361	141	-374	1	0	0	0	0	13	96	205	-23
74-75	362	1212	-1542	0	0	0	0	0	0	0	0	0	628	511	32
75-76	-35	41	-1592	0	0	0	0	0	0	0	0	10	877	595	-8
76-77	-322	-263	-1498	-19	0	0	0	0	0	0	0	0	0	590	-101
77-78	661	629	0	0	-10	-769	-420	-11	-8	-1	-1	47	165	257	-8
78-79	770	726	-1535	0	0	0	0	0	0	0	0	306	1	0	-40
79-80	-1	1	-1203	0	498	222	26	-1	-7	0	0	153	114	330	11
80-81	745	716	-1598	0	0	0	0	0	0	0	0	361	62	-351	-66
81-82	187	1582	-1256	0	0	0	0	-17	0	0	0	0	583	254	37
82-83	57	629	-1565	0	0	0	0	0	-9	0	0	0	317	554	-30
83-84	32	610	-1555	0	0	0	0	0	0	0	0	313	-101	320	-58
84-85	622	831	-1587	0	0	0	0	0	0	0	0	398	0	0	-38
85-86	0	1	-1302	-138	718	8	4	5	69	0	0	260	-55	231	-16
86-87	874	614	-1420	2	0	0	0	0	0	0	0	239	-1	0	-36
87-88	1	0	1	0	0	1	1	-788	152	1543	-217	-330	17	1	-23
88-89	-1	1	-172	-58	339	-39	-294	-93	85	0	0	127	1	816	59
89-90	419	170	-1592	22	34	0	0	0	0	0	0	8	421	533	-23
90-91	72	393	-1603	0	0	0	0	0	0	0	0	6	655	326	-32
91-92	-244	527	-1584	0	0	0	-129	148	0	0	0	270	0	304	-70
92-93	107	879	1	-1	-2	1	-515	0	-26	-125	-12	-283	-309	167	-45
93-94	1112	1167	-706	-37	-561	-202	0	-77	-19	0	0	275	-134	0	-26
94-95	197	0	0	0	13	-376	-137	2	138	87	0	228	-54	217	14
95-96	789	965	-1574	0	0	0	0	0	0	0	0	34	412	93	-13
96-97	140	1136	-1564	0	0	0	0	0	0	0	0	3	97	95	-60
97-98	664	1345	-1542	0	0	0	0	0	0	0	0	249	-280	337	-19
98-99	875	600	-1387	9	0	0	0	0	0	0	0	0	657	463	39
Ave MW	310	600	-1312	-23	19	-33	-28	-15	7	28	-4	103	256	222	-27
% Diff	2.3%	5.3%	-13.0%	-0.2%	0.2%	-0.2%	-0.1%	-0.1%	0.0%	0.2%	0.0%	0.5%	1.3%	1.3%	-0.2%

Table 10. System Generation Differences (aMW), Alternative/Benchmark Combination LV2+HV minus LV+HV

YEAR	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
47-48	-19	1	-1596	0	0	0	0	0	0	0	0	0	***17***	318	***-103***
48-49	175	1423	-1773	0	0	0	0	0	0	0	0	***242***	350	333	***1***
49-50	220	1	-782	-231	-161	-226	-6	1	0	-7	2	0	***421***	306	***-47***
50-51	29	5	-1579	0	0	0	0	0	0	0	0	0	***763***	138	***-54***
51-52	46	218	-1583	0	0	0	0	0	0	0	0	0	***796***	489	***-12***
52-53	-217	57	-1622	0	0	0	0	0	0	0	0	***204***	***180***	-103	***-116***
53-54	761	1063	-1622	0	0	0	0	0	0	0	0	0	***382***	283	***0***
54-55	-212	444	-1261	-12	0	0	0	0	0	0	0	***157***	***-17***	-87	***-89***
55-56	309	2067	-1571	0	0	0	-13	0	0	0	0	0	***602***	104	***31***
56-57	-20	631	-1599	0	0	0	0	0	0	0	0	***194***	***133***	75	***-71***
57-58	631	0	-1339	127	0	0	0	0	0	0	0	***185***	***171***	106	***-35***
58-59	617	565	-1514	1	0	0	22	0	0	0	0	0	***412***	138	***-27***
59-60	300	730	-980	-537	0	0	0	0	0	0	0	0	***557***	581	***13***
60-61	-193	193	-1594	0	0	0	0	0	0	0	0	0	***-154***	389	***-110***
61-62	962	929	-1605	0	0	0	0	0	0	0	0	***245***	***260***	379	***23***
62-63	171	422	-1607	0	0	0	0	0	0	0	0	***480***	103	-163	***-71***
63-64	478	1092	-1614	0	0	0	0	0	0	0	0	***230***	***90***	-119	***-48***
64-65	235	1695	-1580	0	0	0	0	0	0	0	0	0	***770***	513	***61***
65-66	175	311	-2047	-85	0	0	0	0	0	0	0	0	***694***	-3	***-98***
66-67	276	553	-1575	0	0	0	0	0	0	0	0	0	***553***	80	***-42***
67-68	-6	423	-1572	0	0	0	0	0	0	0	0	***428***	-104	-199	***-100***
68-69	1151	1080	-1561	0	0	0	-41	0	0	0	0	0	***522***	-48	***2***
69-70	461	333	-1297	0	0	0	0	0	0	0	0	***528***	343	-213	***-18***
70-71	368	358	-1428	0	2	1	0	0	0	0	0	0	***437***	191	***-34***
71-72	-103	888	-1579	0	0	0	0	0	0	0	0	0	***202***	318	***-51***
72-73	-151	331	-1450	0	0	0	0	0	0	0	0	***453***	-1	7	***-72***
73-74	0	0	0	-381	85	-415	4	0	0	0	0	11	***94***	***221***	***-33***
74-75	329	1074	-1574	0	0	0	0	0	0	0	0	0	***607***	498	***23***
75-76	-74	16	-1584	0	0	0	0	0	0	0	0	10	***869***	586	***-10***
76-77	-403	-324	-1520	-19	0	0	0	0	0	0	0	0	0	590	***-107***
77-78	661	629	0	0	-10	-769	-420	-11	-8	-1	-1	***120***	***-62***	128	***-33***
78-79	1089	842	-1549	0	0	0	0	0	0	0	0	***329***	1	0	***-18***
79-80	1	1	-1203	0	422	189	26	-1	-7	0	0	***195***	***15***	285	***-4***
80-81	688	668	-1576	0	0	0	0	0	0	0	0	***405***	-16	-440	***-76***
81-82	193	1612	-1232	0	0	0	0	-13	0	0	0	0	***566***	231	***42***
82-83	44	538	-1551	0	0	0	0	0	-9	0	0	0	***319***	541	***-31***
83-84	18	501	-1585	0	0	0	0	0	0	0	0	***250***	-101	366	***-63***
84-85	554	779	-1580	0	0	0	0	0	0	0	0	***440***	0	1	***-36***
85-86	0	0	-1302	-175	635	8	4	5	69	0	0	***352***	-129	141	***-31***
86-87	870	645	-1481	2	0	0	0	0	0	0	0	***261***	-1	0	***-35***
87-88	0	0	1	0	1	1	1	-850	97	1543	-217	-344	12	0	-33
88-89	1	1	-172	-58	340	-39	-292	-93	85	0	0	***187***	***-24***	718	***56***
89-90	417	154	-1637	26	34	0	0	0	0	0	0	8	***406***	503	***-29***
90-91	-23	343	-1587	0	0	0	0	0	0	0	0	6	***671***	343	***-32***
91-92	-345	323	-1584	0	0	0	-129	148	0	0	0	***268***	0	304	***-81***
92-93	107	878	0	-1	0	1	-547	-1	-41	-142	-12	-290	-324	167	-51
93-94	1112	1167	-705	-38	-562	-202	0	-77	-19	0	0	***295***	-135	0	***-21***
94-95	172	-1	0	1	-34	-410	-137	2	138	87	0	***261***	-67	136	***1***
95-96	781	957	-1582	0	0	0	0	0	0	0	0	34	***449***	112	***-7***
96-97	110	863	-1579	0	0	0	0	0	0	0	0	3	***95***	138	***-68***
97-98	578	1188	-1600	0	0	0	0	0	0	0	0	***249***	-310	315	***-33***
98-99	816	563	-1372	9	0	0	0	0	0	0	0	0	***667***	476	***41***
Ave MW	271	562	-1324	-26	14	-35	-29	-17	5	28	-4	***122***	***232***	***195***	***-33***
% Diff	2.0%	5.0%	-13.2%	-0.2%	0.1%	-0.2%	-0.2%	-0.1%	0.0%	0.2%	0.0%	**0.6%**	**1.2%**	**1.2%**	***-0.2%***

3.3 Federal Generation Differences

Differences in generation for individual federal projects are as shown in Tables 11 through 17. Abbreviations for projects are as follows:

LIB—Libby
HGH—Hungry Horse
GCL—Grand Coulee
CHJ—Chief Joseph
MCN—McNary
JDA – John Day
TDA—The Dalles
BON – Bonneville

LIB, HGH, and GCL are reservoir projects that store and release water by allowing the forebay to draft and fill for flood control, fish flows and power. The rest of these projects are run-of- river projects (JDA has some storage for flood control, but for the most part is treated as a run-of-river project). These run-of-river projects pass the flow that comes into their forebay and maintains a steady forebay elevation. They do not draft to meet power loads or for fish flows. The generation differences in Tables 10-16 for these run-of-river projects are a result of the difference in flow passing through their projects.

Table 11 shows the 52-year average difference in generation for Benchmark Combination LV+HV minus LS+HS, VARQ flood control without Libby fish flows minus Standard flood control without Libby fish flows. For Libby, in January and February, on an average annual basis, Libby produced less energy in VARQ than in Standard Flood Control because it was filling to a higher flood control elevation. In March, Libby's average outflow is less in VARQ but the generation is more because of the higher head. In April through July, Libby released more flow in VARQ because the VARQ flood control curves start higher, requiring less volume to fill in these months than with standard flood control, which, along with the higher head, produced more generation. In August through December, Libby operated similarly between alternative combinations however there were some effects in August due to a difference in July ending elevations between alternative combinations.

There is less generation at Hungry Horse in January and February in the VARQ alternative combination because the VARQ Flood Control Curves and simulated elevations are typically higher than the Standard Flood Control Curves and simulated elevations. In March, on average there was slightly more flow in the VARQ alternative combination, thus more generation. In the first half of April, on average, Hungry Horse released slightly more flow with VARQ than with Standard (the target elevations received by Reclamation were overridden by the system flood control which caused the project to draft), but there was less generation because of head effects. In the second half of April, less flow was released in VARQ, therefore less generation. In May, June and July, on average, there was more water available in the VARQ alternative combination so there was more generation. In August through November, there was no difference in the project's operation because the target elevations were the same. In December, there are 8 years where the VARQ alternative combination produced more flow than the standard alternative combination. In December, the target elevation for VARQ is lower than the target elevation for Standard (the VARQ and Standard Flood Control elevations are elevation 3449.4 and 3555.7, respectively), therefore, the project drafted more in the VARQ alternative combination which accounted for more flow and generation in this month. Differences in generation at CHJ, MCN, JDA, TDA, and BON are a result of the differences of flows from LIB, HGH, GCL, and other reservoir projects upstream of them.

For Grand Coulee, in most years in January, the project ended at the higher of elevation 1260 or the VDL in both alternative combinations. With less incoming flow due to VARQ at Libby and Hungry Horse, Grand Coulee produced less generation in VARQ in January. In February and March the VDLs in the VARQ alternative combination are lower than in the Standard Flood Control alternative combination, which would produce more generation, but with less inflow from Libby in February and March and from Hungry Horse in February, the net effect is that less generation is produced at Grand Coulee. The VDLs are lower with VARQ because the Grand Coulee upper rule curve adjustment lowers Grand Coulee's flood control curve at the end of April to compensate for Libby and Hungry Horse's VARQ operation that raises their flood control curves at the end of April. Grand Coulee's VDLs are based on Grand Coulee's April 10th flood control curve, which is interpolated between the March 31st and April 15th curves.

Tables 12 and 13 show differences in generation for VARQ minus Standard Flood Control for Libby fish flows at QPHC and QPHC+10, respectively. These tables are similar to Table 11 except in May through August at Libby when the project releases fish flows. In May through August, there is more generation due to VARQ.

Table 14 shows differences in generation for Libby with fish flows at QPHC and Standard Flood Control minus Libby on Standard Flood Control without fish flows. There are no differences for Libby in February through April because the elevation targets are the same. Differences in May through December and January are as addressed in the explanation for Table 7.

There are no differences at Hungry Horse because the target elevations are from the fish flow regulations for standard flood control in both alternative combinations.

For Grand Coulee in February through April, Grand Coulee's VDLs are the same so its operation is nearly the same in both alternative combinations. In both alternative combinations in May through August 15th, the project generally operated to its draft limits of elevation 1280, and elevation1280 or elevation 1278 on August 31st. In both alternative combinations, Grand Coulee just passes the additional flow from Libby and Hungry Horse under VARQ, producing more generation in these months. In September, Grand Coulee operated to nearly the same elevations in both alternative combinations, but the reduced inflow from Libby in September as described in the section for Table 7 reduced the generation at Grand Coulee in this month. The project recovered by operating to its operating rule curve in October. In November and December, the project drafted when needed to the draft limits of elevation 1275 and 1270 respectively, to attempt to meet chum flows at Bonneville. This occurred in 9 years in November and 7 years in December.

Table 15 shows differences in generation for Libby with fish flows at QPHC+10 and Standard Flood Control minus Libby on Standard Flood Control. This table has similar explanations as for Table 14 but indicates in bold italics, the generation that is affected by the loss in generation due to spill at Libby with fish flows up to QPHC + 10.

Tables 16 and 17 show differences in generation for Libby with fish flows at QPHC, and at QPHC+10, respectively, minus Libby on VARQ Flood Control. The explanation of the results is similar to that for Table 14.

Table 11. 52-Year Average Difference in Generation for Federal Projects (aMW), Alternative/Benchmark Combination LV+HV minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	4	2	0	0	0	1	-137	-45	4	15	20	139	108	15	9
HGH	0	0	0	0	0	7	-31	-37	6	-6	-132	81	45	4	1
GCL	7	-1	0	0	3	3	-184	-81	-11	3	-39	50	137	41	-5
CHJ	3	0	0	0	2	2	-96	-45	-3	9	-12	38	67	19	-1
MCN	1	0	0	0	0	0	-30	-16	0	2	-5	11	20	3	-1
JDA	1	0	0	0	0	1	-64	-27	-1	5	-6	22	41	11	-1
TDA	1	0	0	0	0	1	-47	-20	-1	4	-4	15	29	7	-1
BON	1	0	0	0	0	0	-26	-10	0	2	-3	9	16	6	0

Table 12. 52-Year Difference in Generation for Federal Projects (aMW), Alternative Combination LV1+HV minus LS1+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	66	54	9	4	2	5	-135	-45	4	15	20	115	27	70	11
HGH	0	0	0	0	0	7	-31	-37	6	-6	-132	81	45	4	1
GCL	54	66	6	5	10	9	-184	-86	-7	15	-39	34	71	43	-4
CHJ	28	35	3	2	5	5	-96	-49	-1	15	-13	30	31	20	-1
MCN	12	14	1	0	2	2	-30	-18	0	5	-5	8	9	5	0
JDA	12	15	2	1	3	3	-64	-29	0	9	-6	18	20	11	-2
TDA	8	10	1	1	2	2	-47	-22	0	7	-4	12	16	7	-1
BON	10	9	1	0	1	1	-26	-11	0	4	-3	7	6	7	0

Table 13. 52-Year Avg. Difference in Generation for Federal Projects (aMW), Alternative Combination LV2+HV minus LS2+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	65	55	8	5	2	6	-135	-45	4	15	20	***111***	***28***	70	***12***
HGH	0	0	0	0	0	7	-31	-37	6	-6	-132	81	45	4	1
GCL	54	67	5	6	10	10	-183	-86	-7	15	-39	33	70	43	-4
CHJ	28	36	3	3	5	5	-96	-49	-1	15	-13	29	31	20	-1
MCN	11	14	1	1	2	2	-30	-18	0	5	-5	8	9	5	0
JDA	12	15	1	1	3	3	-64	-29	-1	9	-6	17	20	12	-2
TDA	8	10	1	1	2	2	-47	-22	0	7	-4	12	16	7	-1
BON	10	10	0	0	1	1	-26	-11	0	4	-3	6	6	7	0

Table 14. 52-Year Avg. Difference in Generation for Federal Projects (aMW), Alternative/Benchmark Combination LS1+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	55	96	-338	-13	-7	-18	-3	0	0	0	0	64	164	-37	-9
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	28	98	-296	-14	-8	-18	-7	0	0	-1	0	37	137	77	-3
CHJ	15	52	-161	-7	-4	-9	-3	0	0	-1	0	20	70	38	-2
MCN	6	23	-67	-2	-1	-4	-1	0	0	0	0	6	19	6	-3
JDA	5	22	-94	-4	-2	-6	-2	0	0	0	0	11	41	22	-2
TDA	4	15	-74	-3	-2	-4	-2	0	0	0	0	8	28	14	-2
BON	5	14	-48	-1	-1	-2	-1	0	0	0	0	5	16	11	-1

Table 15. 52-Year Avg. Difference in Generation for Federal Projects (aMW), Alternative/Benchmark Combination LS2+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	44	86	-338	-14	-7	-19	-3	0	0	0	0	***58***	***113***	***-49***	***-16***
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	18	86	-298	-16	-9	-19	-7	0	0	-1	0	47	145	72	-3
CHJ	10	46	-162	-8	-4	-10	-3	0	0	-1	0	26	73	36	-2
MCN	5	20	-67	-3	-2	-4	-1	0	0	0	0	8	20	5	-3
JDA	3	19	-95	-4	-3	-6	-2	0	0	0	0	15	43	20	-2
TDA	2	13	-74	-3	-2	-4	-2	0	0	0	0	10	30	14	-2
BON	3	11	-48	-2	-1	-2	-1	0	0	0	0	7	17	10	-1

Table 16. 52-Year Avg. Difference in Generation for Federal Projects (aMW), Alternative/Benchmark Combination LV1+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	116	148	-329	-9	-4	-14	-1	0	0	0	0	40	82	17	-7
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	75	165	-290	-9	-1	-12	-6	-5	3	10	0	21	71	79	-2
CHJ	40	88	-158	-4	0	-6	-3	-3	1	5	0	11	34	39	-2
MCN	17	38	-66	-1	0	-2	-1	-1	0	2	0	3	8	8	-2
JDA	16	37	-92	-2	0	-4	-2	-2	0	2	0	7	20	22	-2
TDA	11	25	-73	-2	0	-3	-1	-2	0	2	0	4	15	14	-2
BON	14	24	-47	-1	0	-1	-1	-1	0	1	0	3	7	12	-1

Table 17. 52-Year Avg. Difference in Generation for Federal Projects (aMW), Alternative/Benchmark Combination LV2+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	105	140	-330	-9	-4	-15	-1	0	0	0	0	***30***	***33***	***5***	***-13***
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	65	154	-292	-9	-2	-12	-6	-5	3	10	0	30	79	73	-2
CHJ	35	82	-159	-4	-1	-6	-3	-3	1	5	0	17	37	36	-2
MCN	16	35	-66	-1	0	-2	-1	-1	0	2	0	5	9	7	-2
JDA	14	35	-93	-2	0	-4	-2	-2	0	2	0	10	22	21	-2
TDA	10	24	-73	-2	0	-3	-2	-2	0	2	0	7	17	14	-2
BON	12	22	-47	-1	0	-1	-1	-1	0	1	0	4	7	11	-1

3.4 Non-Federal Generation Differences

Generation differences for Non-Federal Projects are provided in Tables 18 through 24. Abbreviations for these projects are as follows:

KER—Kerr
TOM—Thompson Falls
NOX—Noxon
CAB—Cabinet Gorge
BOX—Box Canyon
BND—Boundary
PRD—Priest Rapids
WAN—Wanapum
RIS—Rock Island
RRH—Rocky Reach
WEL—Wells

KER and NOX are the only reservoirs in this set of projects that draft for power, so they are affected by the system power needs. The rest of the projects are run-of-river type projects and the increase or decrease of incoming flow between alternative combinations shows up as an increase or decrease in generation. KER is directly affected by flows from Hungry Horse, and TOM, NOX, CAB, are directly affected by flows from KER, which include operation for flood control. BOX and BND are directly affected by Albeni Falls, which is indirectly affected by flows from Hungry Horse. PRD, WAN, RIS, RRH, and WEL projects are directly affected by flows released from Grand Coulee. Section 5 discusses detailed results of Grand Coulee's operation.

Table 18 shows the difference in generation for VARQ minus Standard Flood Control without Libby fish flows. The table shows that for all of the projects, there is less generation in January through March and the second half of April because of reduced flows from Hungry Horse and Libby with VARQ. There is more generation in May through July due to VARQ because of the higher elevations at the end of April for VARQ resulting in more water being released through the end of July. For KER in March, different years show that there is higher or lower generation in VARQ**,** but the average difference in generation is zero. There is no difference in generation at KER, TOM, CAB, and BOX in May and June because these projects are at powerhouse capacity in both cases and spill to pass additional flow.

Tables 19 and 20 show the generation differences between VARQ and Standard Flood Control with Libby fish flows at QPHC and QPHC+10, respectively. Results are similar to that for Table 18 except in August where there is more flow released from Libby and Hungry Horse under VARQ, therefore, there is more generation.

Tables 21 and 22 show the difference in generation for Libby with fish flows at QPHC and at QPHC+10 with Standard Flood Control, respectively, minus Libby on Standard Flood Control. There are basically no differences in January through April because Libby and Hungry Horse each target the same elevations in both alternative combinations. There are no differences in May through July for projects upstream of BND because Hungry Horse targets the same elevations in both alternative combinations so that the flow releases and generation are the same. In May through August for PRD and projects downstream, fish flows are released from Libby in the fish flow alternative combination rather than filling to the flood control elevations, producing more generation in the fish flow alternative combination. In August at KER, there is slightly less flow and generation with VARQ in years where the load is just met. Due to increased flow and generation at Libby and projects downstream, under VARQ, KER can reduce generation in August in some years.

Tables 23 and 24 show the difference in generation for Libby with fish flows at QPHC and QPHC+10, respectively, with VARQ Flood Control minus Libby on VARQ Flood Control. The explanation is similar to that for Tables 21 and 22.

Table 18. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Benchmark Combination LV+HV minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	1	1	-11	-9	0	-1	-13	-1	0	0	-2
TOM	0	0	0	0	0	0	-3	-3	0	0	-2	0	0	0	-1
NOX	0	0	0	0	1	1	-10	-11	0	3	-12	5	7	0	-1
CAB	0	0	0	0	0	1	-6	-7	0	2	-7	0	0	0	-1
BOX	0	0	0	0	0	0	-2	-2	0	0	-1	0	0	0	-1
BND	0	0	0	0	1	2	-16	-20	-1	5	-19	7	7	1	-2
PRD	0	0	0	0	0	0	-27	-18	-1	3	-2	7	17	5	-1
WAN	0	0	0	0	0	1	-34	-20	-1	3	-3	11	20	5	-1
RIS	0	0	0	0	0	0	-18	-9	0	1	-2	6	10	3	-1
RRH	1	0	0	0	0	1	-47	-22	-1	4	-5	15	26	8	-2
WEL	1	0	0	0	0	0	-29	-16	-1	3	-4	11	18	6	-1

Table 19. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative Combination LV1+HV minus LS1+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-1	-1	0	0	2	1	-11	-8	-1	-1	-13	-1	0	-1	-2
TOM	0	0	0	0	0	0	-3	-3	0	0	-2	0	0	0	-1
NOX	-1	-1	0	0	2	2	-10	-11	0	2	-12	5	7	0	-1
CAB	-1	0	0	0	1	1	-6	-6	0	1	-7	0	0	0	-1
BOX	0	0	0	0	0	0	-2	-2	0	0	-1	0	0	0	-1
BND	-3	-2	0	0	4	3	-17	-18	-1	4	-19	7	7	0	-2
PRD	7	9	1	1	2	2	-28	-20	0	5	-2	5	9	5	-1
WAN	7	8	1	1	2	2	-35	-21	0	6	-3	8	11	5	-1
RIS	4	7	0	0	1	1	-18	-10	0	3	-2	4	5	3	0
RRH	12	17	1	1	2	2	-47	-24	0	7	-5	11	12	8	-1
WEL	9	12	1	1	2	1	-29	-17	0	5	-4	8	8	6	-1

Table 20. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative Combination LV2+HV minus LS2+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-1	-1	0	0	2	1	-11	-8	-1	-1	-13	-1	0	-1	-2
TOM	0	0	0	0	0	0	-3	-3	0	0	-2	0	0	0	-1
NOX	-1	-1	0	0	2	2	-10	-11	0	2	-12	5	7	0	-1
CAB	-1	0	0	0	1	1	-6	-6	0	1	-7	0	0	0	-1
BOX	0	0	0	0	0	0	-2	-2	0	0	-1	0	0	0	-1
BND	-2	-2	0	0	4	3	-16	-18	-1	4	-19	7	7	0	-2
PRD	7	9	1	1	2	2	-28	-20	0	5	-2	5	9	5	-1
WAN	7	8	1	1	2	2	-34	-21	0	6	-3	8	10	5	-1
RIS	5	7	0	0	1	1	-18	-10	0	3	-2	4	4	3	0
RRH	12	17	1	1	2	2	-47	-24	0	7	-5	11	12	8	-1
WEL	9	12	1	1	2	2	-29	-17	0	5	-4	7	8	6	-1

Table 21. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative/Benchmark Combination LS1+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-1	-5	1	0	1	0	0	0	0	0	0	0	0	0	0
TOM	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
NOX	-1	-5	1	0	1	0	0	0	0	0	0	0	0	0	0
CAB	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0
BOX	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
BND	-2	-8	2	0	2	0	1	0	0	0	0	0	0	0	0
PRD	3	14	-66	-2	-1	-4	-1	0	0	0	0	3	16	10	-3
WAN	3	12	-72	-3	-2	-4	-1	0	0	0	0	5	19	10	-3
RIS	2	10	-35	-1	-1	-2	0	0	0	0	0	3	10	6	-1
RRH	6	25	-81	-3	-2	-4	-1	0	0	0	0	8	26	16	-2
WEL	5	19	-60	-2	-1	-3	-1	0	0	0	0	6	19	11	-2

Table 22. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative/Benchmark Combination LS2+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-1	-5	1	0	1	0	0	0	0	0	0	0	0	0	0
TOM	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
NOX	-1	-4	1	0	1	0	0	0	0	0	0	0	0	0	0
CAB	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0
BOX	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
BND	-2	-8	2	0	1	0	1	0	0	0	0	0	0	0	0
PRD	2	12	-66	-3	-2	-4	-1	0	0	0	0	4	17	9	-3
WAN	2	11	-72	-3	-2	-4	-1	0	0	0	0	7	20	9	-3
RIS	1	9	-35	-1	-1	-2	0	0	0	0	0	4	11	6	-1
RRH	4	22	-82	-3	-2	-5	-1	0	0	0	0	10	27	15	-2
WEL	3	16	-61	-3	-1	-3	-1	0	0	0	0	8	19	10	-2

Table 23. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative/Benchmark Combination LV1+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-3	-6	1	0	3	0	0	0	0	0	0	0	0	-1	0
TOM	-1	-2	0	0	1	0	0	0	0	0	0	0	0	0	0
NOX	-3	-6	1	0	2	0	0	0	0	0	0	0	0	-1	0
CAB	-2	-3	1	0	1	0	0	0	0	0	0	0	0	0	0
BOX	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
BND	-6	-10	2	0	4	1	0	1	0	-1	0	0	0	-1	0
PRD	10	23	-65	-1	0	-2	-1	-1	0	2	0	2	8	10	-3
WAN	9	21	-70	-1	0	-3	-1	-1	0	2	0	3	10	10	-3
RIS	6	18	-34	0	0	-1	0	0	0	1	0	1	5	6	-1
RRH	16	42	-80	-2	0	-3	-1	-2	0	2	0	4	12	16	-2
WEL	13	31	-59	-1	0	-2	-1	-1	0	2	0	3	9	11	-2

Table 24. 52-Year Avg. Difference in Generation for Non-Federal Projects (aMW), Alternative/Benchmark Combination LV2+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	-3	-6	1	0	3	0	0	0	0	0	0	0	0	0	0
TOM	-1	-2	0	0	0	0	0	0	0	0	0	0	0	0	0
NOX	-3	-5	1	0	2	0	0	0	0	0	0	0	0	0	0
CAB	-2	-3	1	0	1	0	0	0	0	0	0	0	0	0	0
BOX	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0
BND	-5	-9	2	0	4	1	0	0	0	-1	0	0	0	-1	0
PRD	9	22	-65	-1	0	-2	-1	-1	0	2	0	3	9	10	-3
WAN	8	20	-71	-2	0	-3	-1	-1	0	2	0	4	11	9	-3
RIS	6	16	-34	-1	0	-1	0	0	0	1	0	2	5	6	-1
RRH	14	40	-80	-2	0	-3	-1	-2	0	2	0	6	13	15	-2
WEL	11	29	-60	-1	0	-2	-1	-1	0	2	0	4	9	10	-2

3.5 Spill for Federal Projects

Table 25 shows the 52-year average spill flow at federal projects from Grand Coulee through Bonneville. Differences in spill between various alternative combinations are provided in Section 3.6. This data will be used to aid in the water quality evaluation for the UCEIS study.

Table 25. Spill at Federal Projects for Alternative/Benchmark Combinations LS+HS through LV2+HV (cfs)

Grand Coulee														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	0	0	0	0	0	0	0	0	0	0	0	316	553	0
LV+HV	0	0	0	0	0	0	0	0	0	0	0	322	700	0
LS1+HS	0	0	0	0	0	0	0	0	0	0	0	317	597	0
LV1+HV	0	0	0	0	0	0	0	0	0	0	0	324	735	0
LS2+HS	0	0	0	0	0	0	0	0	0	0	0	317	615	0
LV2+HV	0	0	0	0	0	0	0	0	0	0	0	324	753	0

Chief Joseph														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	0	0	0	0	0	0	199	0	0	0	0	743	2480	0
LV+HV	0	0	0	0	0	0	197	0	0	0	0	738	3460	94
LS1+HS	0	0	0	0	0	0	199	0	0	0	0	744	2885	0
LV1+HV	0	0	0	0	0	0	197	0	0	0	0	740	3891	91
LS2+HS	0	0	0	0	0	0	199	0	0	0	0	744	2994	0
LV2+HV	0	0	0	0	0	0	197	0	0	0	0	740	3978	56

McNary														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	840	392	0	0	0	838	11971	3923	3688	36119	87067	107379	112903	17627
LV+HV	892	397	0	0	0	857	10066	3501	3594	36370	87037	108444	115703	18615
LS1+HS	672	282	0	0	0	838	11875	3923	3688	36119	87067	107745	115479	19615
LV1+HV	759	343	0	0	0	857	10003	3468	3594	36345	87037	108711	117312	20328
LS2+HS	595	265	0	0	0	838	11864	3923	3688	36119	87067	107907	115704	19582
LV2+HV	708	329	0	0	0	857	9943	3473	3594	36370	87041	108797	117553	20375

John Day														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	51251	40362	0	0	0	0	55	0	0	22458	63033	67384	66463	54963
LV+HV	51313	40348	0	0	0	0	78	0	0	22507	62795	67592	67297	55230
LS1+HS	51653	41708	0	0	0	0	84	0	0	22443	63032	67474	67022	55371
LV1+HV	52347	42562	0	0	0	0	73	0	0	22555	62789	67650	67722	55729
LS2+HS	51551	41547	0	0	0	0	69	0	0	22443	63032	67506	67082	55307
LV2+HV	52252	42423	0	0	0	0	54	0	0	22554	62790	67674	67786	55668

The Dalles														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	70394	55742	0	0	0	0	361	235	178	42615	91994	103621	103121	85068
LV+HV	70501	55725	0	0	0	0	389	244	211	42615	91668	104227	104631	85623
LS1+HS	70847	57488	0	0	0	0	396	235	178	42615	91993	103945	104412	85941
LV1+HV	71821	58655	0	0	0	0	383	244	211	42615	91659	104414	105203	86585
LS2+HS	70687	57267	0	0	0	0	378	235	178	42615	91993	104033	104501	85805
LV2+HV	71672	58463	0	0	0	0	360	244	211	42615	91661	104485	105274	86498

Bonneville														
Alternative/Benchmark Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS+HS	95375	89984	0	0	0	140	5158	1923	2014	38651	95754	102082	106875	93585
LV+HV	95375	90029	0	0	0	140	4801	1926	1877	38578	95751	102579	108491	93575
LS1+HS	95375	91143	0	0	0	140	5162	1923	2052	38438	95754	102139	108228	93695
LV1+HV	95375	91803	0	0	0	140	4766	1785	2005	38578	95751	102643	109521	93700
LS2+HS	95375	91109	0	0	0	140	5142	1923	2052	38578	95754	102140	108358	93696
LV2+HV	95375	91721	0	0	0	140	4742	1785	2005	38578	95755	102656	109727	93700

3.6 Spill Differences for Federal Projects

Differences in month average spill for federal projects are provided in Tables 26 through 32. For the alternative combinations with Libby fish flows up to QPHC +10, it is assumed that the additional 10 kcfs above existing powerhouse capacity is passed as spill at Libby.

For Tables 26 through 28, spill differences in January through March for all the projects reflect differences in forced spill (if inflow is greater than powerhouse capacity, the project will be forced to spill, and this is called "forced spill"). Differences for April through July for LIB, HGH, GCL, and CHJ, reflect forced spill differences. There was forced spill in only a few years in these months and this occurs after relatively big water years. Generally there is less spill flow in January through April, and more spill in May through July with VARQ. Voluntary spill for fish occurs at MCN in the first half of April through June, and at JDA, TDA, and BON in the first half of April through August. The differences in the voluntary spill periods reflect the differences in forced spill for MCN and BON, as these projects operate to a fixed spill discharge shown in Table 2. For JDA and TDA, spill is based on percent of regulated flow up to the spill cap. The spill differences are due to a percent of the difference of the regulated flow, or due to forced spill. There was only 3 or 4 years in each May and June where there was forced spill at TDA and JDA in both alternative combinations.

Table 26 shows the difference in spill for VARQ minus Standard Flood Control without Libby fish flows. On average, VARQ reduces spill at Libby in January and February. There is spill in 4 years with VARQ and 10 years with Standard Flood Control in January, and no spill in February with VARQ and 1 year with Standard flood control. In the years where there are differences, the differences range from approximately 500 to 2700 cfs. In June and July, there were only a few years where there were differences in spill, where differences were about 800 to 4000 cfs. For Hungry Horse there was more spill in the first half of April in 9 years with VARQ. The increased spill under VARQ was caused by the project needing to draft for system flood control, more so than it needed to for Standard Flood control. In the second half of April, there was less spill as HGH was targeting their respective elevations for VARQ or Standard flood control with fish flows.

Tables 27 and 28 show differences in spill for VARQ minus Standard Flood Control for Libby with fish flows at QPHC and at QPHC+10, respectively. The explanations are similar to Table 26 except for August where there is more fish flow released from Libby with VARQ, and therefore, more spill flow occurs.

Tables 29 and 30 show differences in spill for Libby with fish flows at QPHC and QPHC+10, respectively, with Standard Flood Control minus Libby on Standard Flood Control. There are little or no differences in spill in February through April. In May through August, there is more spill flow with the fish flow alternative combinations for projects downstream of MCN due to higher fish flows from Libby. Table 30 shows an adjustment for spill based on the daily regulations provided by NWS. The adjustments are shown italicized and bolded.

Tables 31 and 32 show difference in spill for Libby with fish flows at QPHC and QPHC+10, respectively, with VARQ Flood Control minus Libby on VARQ Flood Control. The explanation of results is similar to that for Tables 29 and 30.

Table 26. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Benchmark Combination LV+HV minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	-178	-14	0	0	0	0	20	32	-12
HGH	0	0	0	0	0	0	2	-9	0	283	-216	0	0	0	2
GCL	0	0	0	0	0	0	0	0	0	0	0	6	147	0	13
CHJ	0	0	0	0	0	0	-2	0	0	0	0	-4	979	94	89
MCN	52	4	0	0	0	19	-1904	-421	-94	250	-30	1064	2800	988	216
JDA	62	-14	0	0	0	0	23	0	0	49	-237	208	833	266	105
TDA	106	-17	0	0	0	0	27	9	32	0	-326	606	1510	555	219
BON	0	44	0	0	0	0	-357	3	-137	-73	-3	496	1616	-9	133

Table 27. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative Combination LV1+HV minus LS1+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	-178	-14	0	0	0	0	20	0	-14
HGH	0	0	0	0	0	0	2	-9	0	283	-216	0	0	0	2
GCL	0	0	0	0	0	0	0	0	0	0	0	6	137	0	12
CHJ	0	0	0	0	0	0	-2	0	0	0	0	-4	1005	91	91
MCN	87	60	0	0	0	19	-1871	-455	-94	225	-30	966	1833	713	107
JDA	694	854	0	0	0	0	-10	0	0	111	-243	176	700	357	161
TDA	974	1166	0	0	0	0	-13	9	32	0	-334	468	791	643	236
BON	0	659	0	0	0	0	-395	-137	-47	140	-3	504	1293	5	135

Table 28. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative Combination LV2+HV minus LS2+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	-178	-14	0	0	0	***72***	***-146***	***1***	***-22***
HGH	0	0	0	0	0	0	2	-9	0	283	-216	0	0	0	2
GCL	0	0	0	0	0	0	0	0	0	0	0	6	138	0	12
CHJ	0	0	0	0	0	0	-2	0	0	0	0	-4	984	56	86
MCN	113	63	0	0	0	19	-1920	-450	-94	250	-25	890	1849	792	107
JDA	700	875	0	0	0	0	-14	0	0	110	-241	168	704	361	162
TDA	985	1196	0	0	0	0	-17	9	32	0	-332	452	773	693	239
BON	0	611	0	0	0	0	-400	-137	-47	0	1	515	1368	3	134

Table 29. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative/Benchmark Combination LS1+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	0	0	0	0	0	0	0	-86	-7
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	0	0	0	0	0	0	0	0	0	0	0	1	44	0	4
CHJ	0	0	0	0	0	0	0	0	0	0	0	1	405	0	34
MCN	-168	-109	0	0	0	0	-96	0	0	0	0	365	2576	1988	391
JDA	401	1345	0	0	0	0	29	0	0	-14	0	89	559	408	163
TDA	452	1745	0	0	0	0	35	0	0	0	0	324	1290	872	302
BON	0	1159	0	0	0	0	4	0	38	-213	0	56	1352	110	170

Table 30. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative/Benchmark Combination LS2+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	0	0	0	0	0	***1239***	***2187***	***-43***	***281***
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	0	0	0	0	0	0	0	0	0	0	0	1	61	0	5
CHJ	0	0	0	0	0	0	0	0	0	0	0	1	513	0	43
MCN	-244	-126	0	0	0	0	-107	0	0	0	0	527	2801	1955	416
JDA	300	1185	0	0	0	0	14	0	0	-14	0	122	618	343	153
TDA	292	1524	0	0	0	0	16	0	0	0	0	412	1379	737	288
BON	0	1124	0	0	0	0	-15	0	38	-73	0	57	1483	111	183

Table 31. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative/Benchmark Combination LV1+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	0	0	0	0	0	0	0	-118	-10
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	0	0	0	0	0	0	0	0	0	0	0	1	34	0	3
CHJ	0	0	0	0	0	0	0	0	0	0	0	1	431	-3	36
MCN	-133	-53	0	0	0	0	-63	-33	0	-25	0	267	1609	1713	282
JDA	1034	2214	0	0	0	0	-4	0	0	47	-6	58	425	499	219
TDA	1320	2929	0	0	0	0	-5	0	0	0	-8	186	571	961	320
BON	0	1774	0	0	0	0	-34	-140	128	0	0	64	1029	125	172

Table 32. 52-Year Avg. Difference in Spill for Federal Projects (cfs), Alternative/Benchmark Combination LV2+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
LIB	0	0	0	0	0	0	0	0	0	0	0	*1311*	*2021*	*-74*	*271*
HGH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GCL	0	0	0	0	0	0	0	0	0	0	0	1	52	0	5
CHJ	0	0	0	0	0	0	0	0	0	0	0	1	518	-37	40
MCN	-183	-67	0	0	0	0	-123	-28	0	0	4	352	1850	1759	307
JDA	939	2075	0	0	0	0	-23	0	0	46	-5	82	490	438	210
TDA	1171	2737	0	0	0	0	-28	0	0	0	-7	258	642	875	308
BON	0	1692	0	0	0	0	-58	-140	128	0	4	76	1236	125	185

3.7 Spill for Non-Federal Projects

Table 33 shows the 52-year average spill flow at non-federal projects in the mid-Columbia. Differences in spill between various alternative combinations are provided in Section 3.8. This data will be used to aid in the water quality evaluation for the UCEIS study.

Table 33. Spill for Non-Federal Projects (cfs)

Wells														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	3173	0	0	0	0	0	1665	0	0	0	8792	13508	10967	10006
LV1+HV	3233	0	0	0	0	0	1288	0	0	0	8741	13919	12235	10136
LS2+HS	3162	0	0	0	0	0	1665	0	0	0	8792	13558	11144	10022
LV2+HV	3223	0	0	0	0	0	1288	0	0	0	8741	13978	12392	10158
Benchmark Combination														
LS+HS	3142	0	0	0	0	0	1665	0	0	0	8792	13379	9686	9551
LV+HV	3150	0	0	0	0	0	1288	0	0	0	8742	13782	11386	9685
Chelan														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	240	28	0	5	42	15	0	0	0	0	15	916	3707	1757
LV1+HV	240	28	0	5	42	15	0	0	0	0	15	957	3736	1757
LS2+HS	240	28	0	5	42	15	0	0	0	0	15	915	3705	1757
LV2+HV	240	28	0	5	42	15	0	0	0	0	15	955	3736	1757
Benchmark Combination														
LS+HS	240	28	0	5	42	15	0	0	0	0	15	962	3765	1757
LV+HV	240	28	0	5	42	15	0	0	0	0	15	975	3797	1757

Table 33. Continued

Rocky Reach														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	19338	0	0	0	0	0	646	0	0	0	21406	39168	30764	23323
LV1+HV	19700	0	0	0	0	0	683	0	0	0	21239	39807	32223	23683
LS2+HS	19273	0	0	0	0	0	646	0	0	0	21406	39287	30955	23289
LV2+HV	19638	0	0	0	0	0	683	0	0	0	21240	39913	32386	23620
Benchmark Combination														
LS+HS	19159	0	0	0	0	0	646	0	0	0	21407	38770	29070	22779
LV+HV	19207	0	0	0	0	0	683	0	0	0	21243	39574	31180	23134
Rock Island														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	26285	0	0	0	0	0	311	0	0	0	29402	37490	39247	32117
LV1+HV	26768	0	0	0	0	0	308	0	0	0	29178	38078	40650	32514
LS2+HS	26198	0	0	0	0	0	311	0	0	0	29402	37599	39407	32071
LV2+HV	26685	0	0	0	0	0	308	0	0	0	29179	38175	40797	32467
Benchmark Combination														
LS+HS	26046	0	0	0	0	0	311	0	0	0	29402	37124	37807	31391
LV+HV	26110	0	0	0	0	0	308	0	0	0	29183	37863	39788	31779
Wanapum														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	64477	51615	0	0	0	0	7180	0	0	492	63100	80003	85059	78802
LV1+HV	65660	53044	0	0	0	0	5448	0	0	574	62620	81256	86934	79774
LS2+HS	64264	51344	0	0	0	0	7177	0	0	492	63100	80238	85276	78690
LV2+HV	65456	52809	0	0	0	0	5448	0	0	574	62622	81465	87129	79661
Benchmark Combination														
LS+HS	63890	49476	0	0	0	0	7268	0	0	492	63101	79219	81981	77025
LV+HV	64048	49456	0	0	0	0	5448	0	0	574	62629	80797	85303	77974
Priest Rapids														
Alternative Combination	**AG1**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**AP1**	**APR**	**MAY**	**JUN**	**JUL**
LS1+HS	51753	41296	0	0	0	0	7058	87	0	377	90366	114322	93240	63247
LV1+HV	52694	42433	0	0	0	0	5534	96	0	461	89685	116100	95268	64020
LS2+HS	51583	41080	0	0	0	0	7055	87	0	377	90366	114655	93475	63158
LV2+HV	52531	42246	0	0	0	0	5534	96	0	461	89688	116397	95480	63930
Benchmark Combination														
LS+HS	51285	39594	0	0	0	0	7148	87	0	377	90368	113211	89898	61832
LV+HV	51411	39577	0	0	0	0	5534	96	0	461	89699	115449	93498	62588

3.8 Spill Differences for Non-federal Projects

Table 34 shows spill differences for Standard minus VARQ for Libby without fish flows. The table shows generally less spill flow in January through April and more spill in May through August 15th due to VARQ.

Tables 35 and 36 show spill differences for VARQ minus Standard for Libby with fish flows at QPHC and QPHC + 10, respectively. Hungry Horse was operated to the same Standard simulated target elevations in all Standard Flood Control alternative combinations and the same simulated VARQ target elevations in the VARQ alternative combinations, therefore data in Tables 34, 35, and 36 for KER, TOM, NOX, CAB, BOX, and BND are nearly the same. The tables show similar patterns as Table 34 except in August where there is more flow released from Libby, and more spill at Priest Rapids and projects downstream because spill at these projects is based on a percent of regulated flow.

Tables 37 and 38 show spill differences for Libby with fish flows at QPHC, and at QPHC+10, respectively, with Standard Flood Control minus Libby on Standard Flood Control. More spill flow occurs with VARQ in May through August due to higher flows with VARQ and because spill is based on a percentage of regulated flow.

Tables 39 and 40 show spill differences for Libby with fish flows at QPHC, and at QPHC+10 respectively, with VARQ Flood Control minus Libby on VARQ Flood Control. The explanation for these tables is the same as that for Tables 37 and 38.

Table 34. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Benchmark Combinations LV+HV minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	0	59	-16	-233	28	411	0	354	1743	101	187
TOM	0	0	0	0	0	54	9	-124	10	283	-319	284	1793	75	174
NOX	0	0	0	0	0	0	0	0	0	0	0	-183	877	0	58
CAB	0	0	0	0	0	8	0	0	0	-33	-1	220	1748	-16	162
BOX	0	0	0	0	0	21	2	-118	11	320	-348	272	1768	83	169
BND	0	0	0	0	0	0	0	0	0	0	0	-126	1165	-13	85
PRD	125	-16	0	0	0	0	-1614	8	0	83	-669	2238	3600	755	396
WAN	158	-20	0	0	0	0	-1819	0	0	81	-471	1577	3322	949	325
RIS	64	0	0	0	0	0	-2	0	0	0	-219	739	1980	387	252
RRH	48	0	0	0	0	0	36	0	0	0	-164	804	2110	355	271
WEL	8	0	0	0	0	0	-377	0	0	0	-49	402	1699	134	153

Table 35. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative Combinations LV1+HV minus LS1+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	3	59	-16	-233	28	411	0	354	1743	101	187
TOM	0	0	0	0	0	54	9	-124	10	283	-322	284	1793	75	174
NOX	0	0	0	0	0	0	0	0	0	0	0	-183	877	0	58
CAB	0	0	0	0	0	8	0	0	0	-33	-1	220	1759	-16	163
BOX	0	0	0	0	0	21	2	-118	11	320	-400	272	1779	83	168
BND	0	0	0	0	0	0	0	0	0	0	0	-126	1165	-13	85
PRD	941	1137	0	0	0	0	-1524	8	0	83	-681	1777	2028	773	317
WAN	1182	1429	0	0	0	0	-1732	0	0	81	-480	1253	1875	972	290
RIS	482	0	0	0	0	0	-2	0	0	0	-223	588	1403	396	210
RRH	361	0	0	0	0	0	36	0	0	0	-167	639	1458	359	216
WEL	60	0	0	0	0	0	-377	0	0	0	-50	410	1268	130	120

Table 36. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative Combinations LV2+HV minus LS2+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	0	59	-16	-233	28	411	0	354	1743	101	187
TOM	0	0	0	0	0	54	9	-124	10	283	-322	284	1793	75	174
NOX	0	0	0	0	0	0	0	0	0	0	0	-183	877	0	58
CAB	0	0	0	0	0	8	0	0	0	-33	-1	220	1759	-16	163
BOX	0	0	0	0	0	21	2	-118	11	320	-400	272	1779	83	168
BND	0	0	0	0	0	0	0	0	0	0	0	-126	1165	-13	85
PRD	948	1166	0	0	0	0	-1521	8	0	83	-678	1741	2004	772	314
WAN	1191	1465	0	0	0	0	-1729	0	0	81	-478	1227	1853	970	288
RIS	486	0	0	0	0	0	-2	0	0	0	-222	576	1389	396	208
RRH	364	0	0	0	0	0	36	0	0	0	-166	626	1431	330	210
WEL	60	0	0	0	0	0	-377	0	0	0	-50	420	1248	136	119

Table 37. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative/Benchmark Combinations LS1+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAB	0	0	0	0	0	0	0	0	0	0	0	0	-16	0	-1
BOX	0	0	0	0	0	0	0	0	0	0	0	0	-16	0	-1
BND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRD	467	1702	0	0	0	0	-89	0	0	0	-1	1111	3342	1414	572
WAN	587	2139	0	0	0	0	-87	0	0	0	0	783	3077	1777	576
RIS	239	0	0	0	0	0	0	0	0	0	0	365	1439	725	221
RRH	179	0	0	0	0	0	0	0	0	0	0	397	1694	544	227
WEL	30	0	0	0	0	0	0	0	0	0	0	128	1280	455	157

Table 38. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative/Benchmark Combinations LS2+HS minus LS+HS

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAB	0	0	0	0	0	0	0	0	0	0	0	0	-15	0	-1
BOX	0	0	0	0	0	0	0	0	0	0	0	0	-15	0	-1
BND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRD	297	1486	0	0	0	0	-92	0	0	0	-1	1444	3577	1325	596
WAN	374	1867	0	0	0	0	-90	0	0	0	0	1018	3295	1665	584
RIS	152	0	0	0	0	0	0	0	0	0	0	474	1599	679	236
RRH	114	0	0	0	0	0	0	0	0	0	0	516	1885	509	247
WEL	19	0	0	0	0	0	0	0	0	0	0	178	1458	470	176

Table 39. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative/Benchmark Combinations LV1+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
TOM	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0
NOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAB	0	0	0	0	0	0	0	0	0	0	0	0	-4	0	0
BOX	0	0	0	0	0	0	0	0	0	0	-51	0	-5	0	-3
BND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRD	1282	2856	0	0	0	0	0	0	0	0	-13	650	1770	1432	493
WAN	1611	3588	0	0	0	0	0	0	0	0	-9	458	1630	1799	540
RIS	657	0	0	0	0	0	0	0	0	0	-4	214	862	734	178
RRH	493	0	0	0	0	0	0	0	0	0	-3	233	1042	548	172
WEL	83	0	0	0	0	0	0	0	0	0	0	137	849	451	123

Table 40. 52-Year Avg. Difference in Spill for Non-Federal Projects (cfs), Alternative/Benchmark Combinations LV2+HV minus LV+HV

	AG1	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	AP1	APR	MAY	JUN	JUL	AVE
KER	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TOM	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0
NOX	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CAB	0	0	0	0	0	0	0	0	0	0	0	0	-4	0	0
BOX	0	0	0	0	0	0	0	0	0	0	-51	0	-4	0	-3
BND	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PRD	1120	2669	0	0	0	0	0	0	0	0	-10	947	1981	1342	513
WAN	1407	3353	0	0	0	0	0	0	0	0	-7	667	1826	1686	546
RIS	574	0	0	0	0	0	0	0	0	0	-3	312	1008	688	191
RRH	430	0	0	0	0	0	0	0	0	0	-2	339	1205	485	187
WEL	72	0	0	0	0	0	0	0	0	0	0	196	1006	472	143

4 Results of Libby Operation

4.1 Results of Libby Operation in September and October

For recreational interests, Libby's operation for September and October is addressed.

Figure 1 shows Libby's elevation percent exceedance curves for September. Libby operates for power in September. As shown in Figure 1, Libby operates to its normal operating rule curve of elevation 2437.9, about 70% to 90% of the time over all alternatives. The remainder of the time, the system does not meet load when drafting to its ORC, so projects that operate for power draft below their ORC. Figure 1 shows that the alternatives without fish flows are able to meet the system load for a higher percentage of time. This is because Libby starts at elevation 2459 instead of elevation 2439 at the end of August and has more water available for September. The figure also shows that the VARQ alternatives also provide more water for September. The data points for VQ FC and St. FC at 0% shows Libby at elevation 2445.7, and that is due to Libby reaching powerhouse capacity.

Figure 2 shows Libby's elevation percent exceedance curves for October. Libby operates for power to the ORC for October at elevation 2436.5 at least 76% of the time for all alternatives. The explanation for this figure is similar to that for Figure 1.

Figure 3 shows Libby flow percent exceedance curves for September. Flows are higher in September without Libby fish flows because of the higher starting elevation at the end of August as described for Figure 1. The average flows in September for alternatives without fish flows at Libby, is about 22,000 cfs and alternatives with fish flows is about 8,600 cfs. All fish flow alternatives produce similar results for September, except there are about 8 years where the flows are higher with VARQ.

Figure 4 shows Libby flow percent exceedance curves for October. The curves for all alternatives are similar to each other because the October and November end of month elevations are similar.

The average flow for October is about 7,000 cfs for all alternatives.

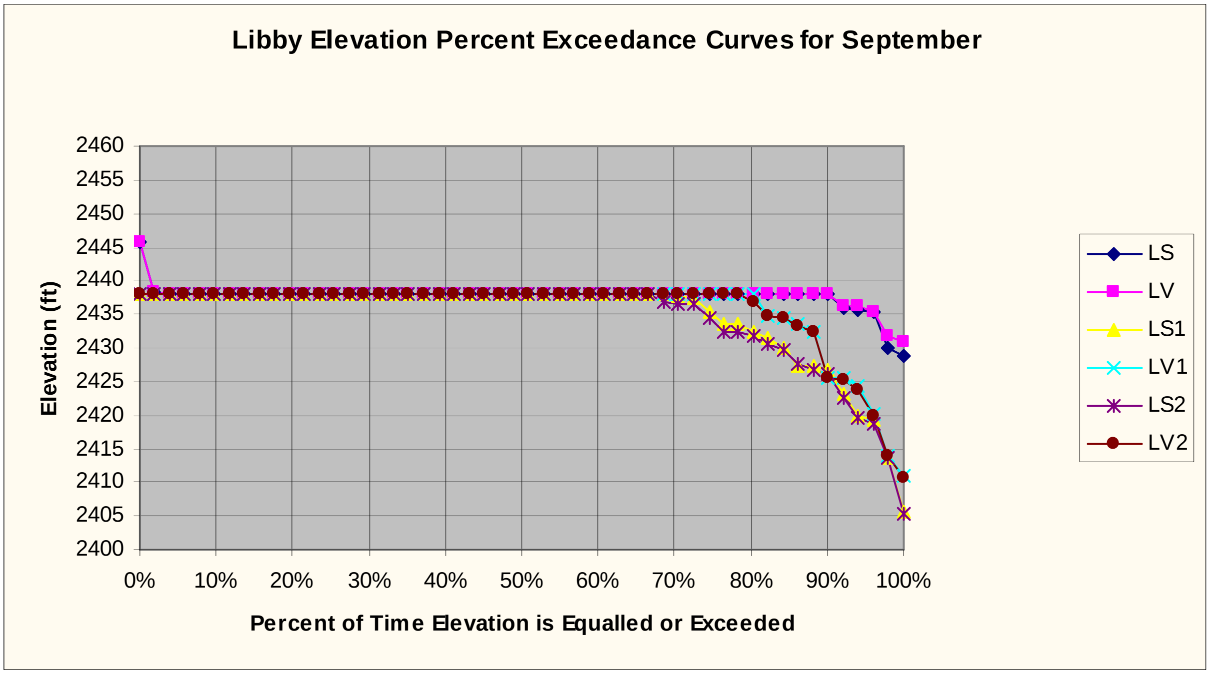

Figure 1. Libby Elevation Percent Exceedance Curves for September

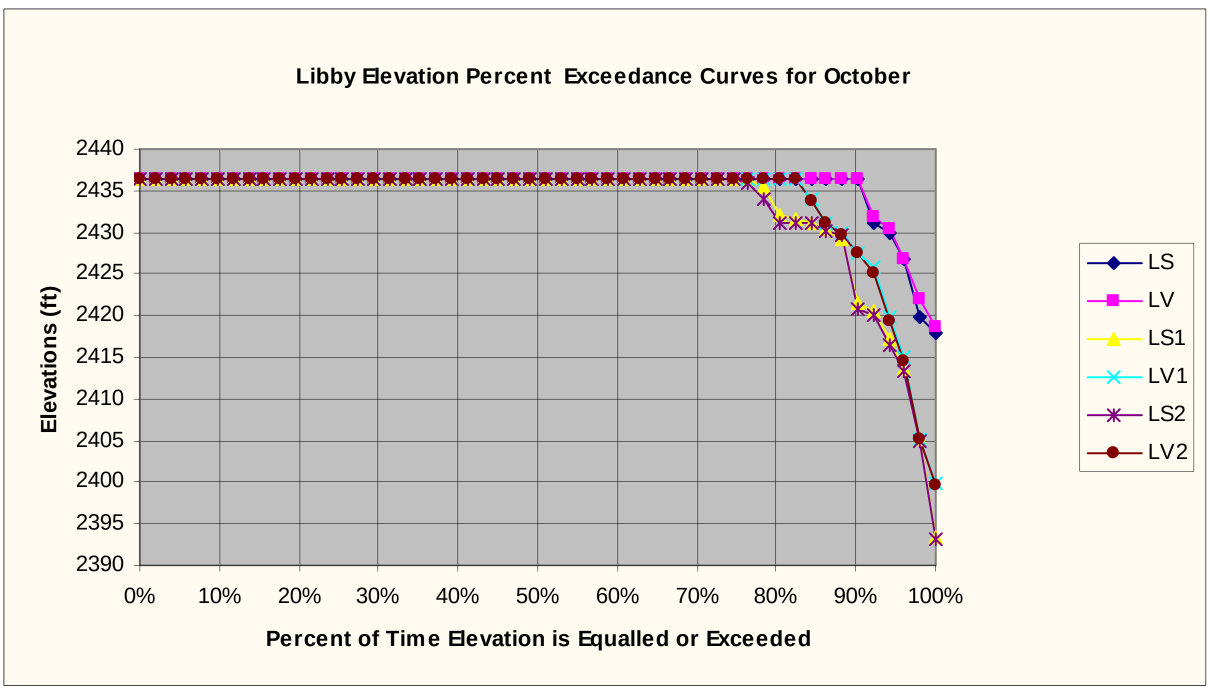

Figure 2. Libby Elevation Percent Exceedance Curves for October

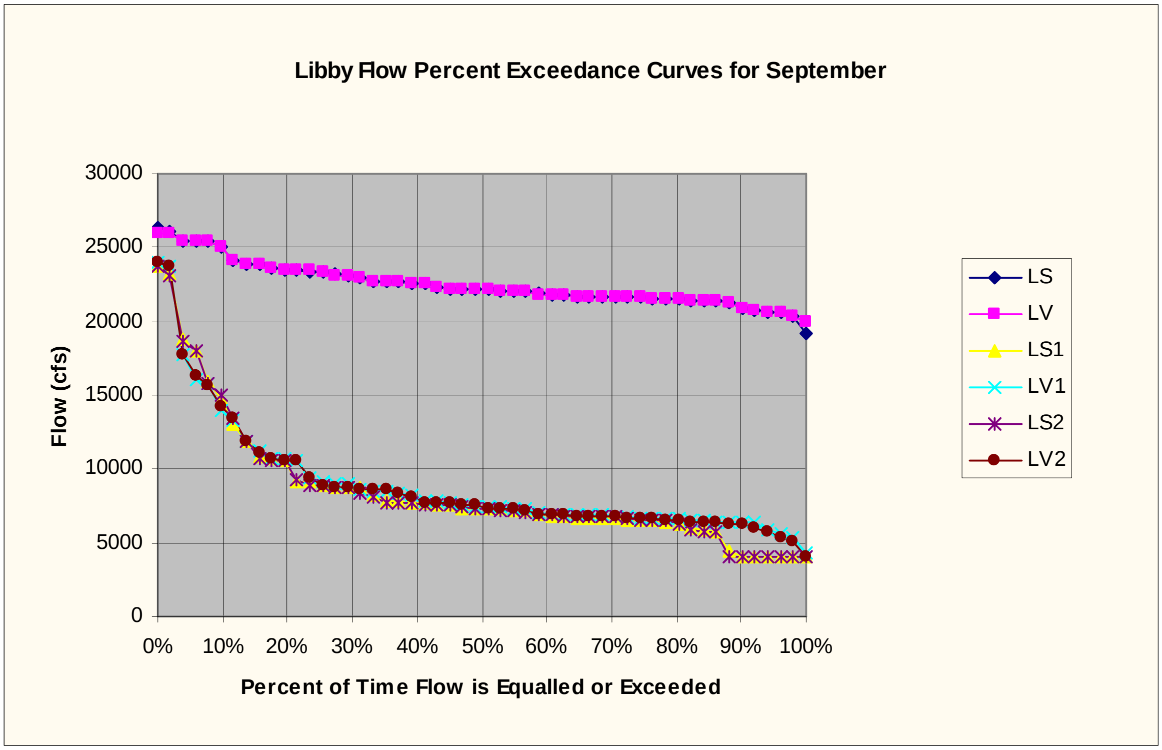

Figure 3. Libby Flow Percent Exceedance Curves for September

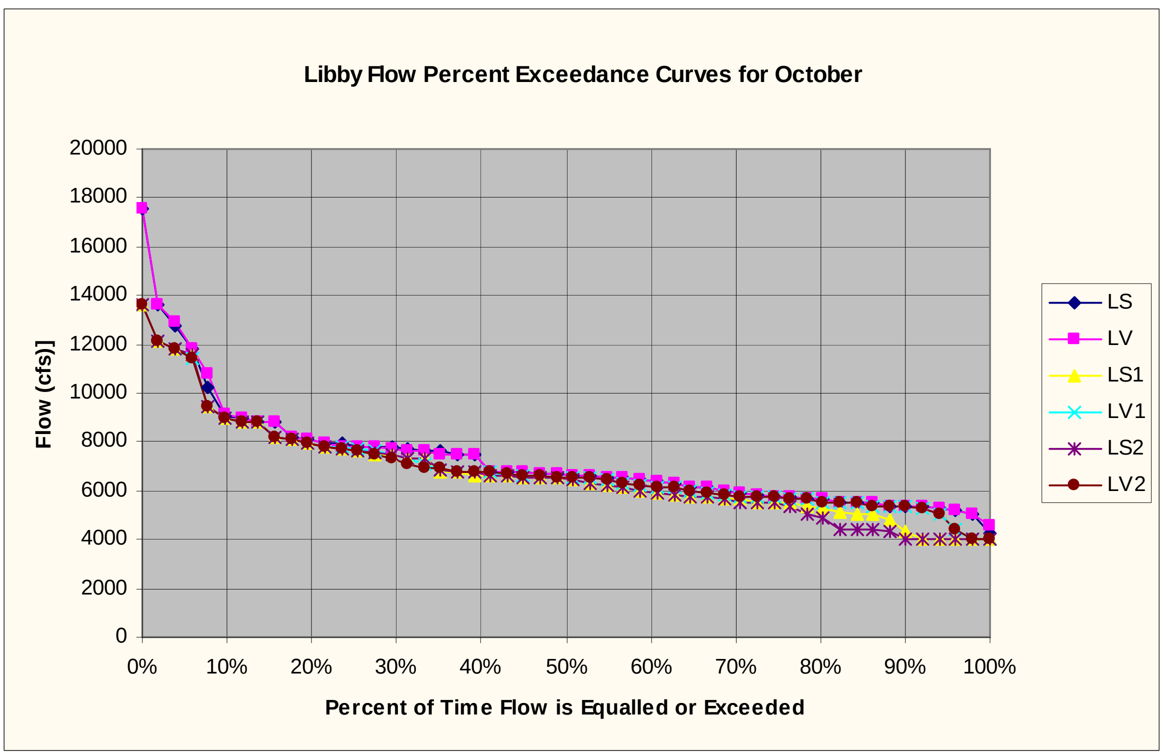

Figure 4. Libby Flow Percent Exceedance Curves for October

4.2 Results of Libby Operation in December and January

For burbot interests, flow exceedance curves for December and January are shown in figures 5 and 6.

Figure 5 shows Libby flow percent exceedance curves for December. Libby operates for power in November to its operating rule curve of elevation 2434.0, or drafts additionally as needed to meet firm load (this occurs in 5 to 11 years depending on alternative). In December, Libby targets elevation 2411 and meets the target in every year in the alternatives without fish flows. The project is below the elevation 2411 target in 3 years in the Standard Flood Control with fish flow alternatives and in 2 years in the VARQ with fish flows alternatives. Figure 5 shows less flow available in December in the fish flow alternatives as a result of a lower starting elevations at the end of August.

Figure 6 shows the Libby flow percent exceedance curves for January. The curves for alternatives with standard flood control are nearly the same as each other because they are all targeting the same flood control curves. Small differences occur because of elevation differences in December between alternatives. This explanation is the same for the VARQ Flood Control alternatives.

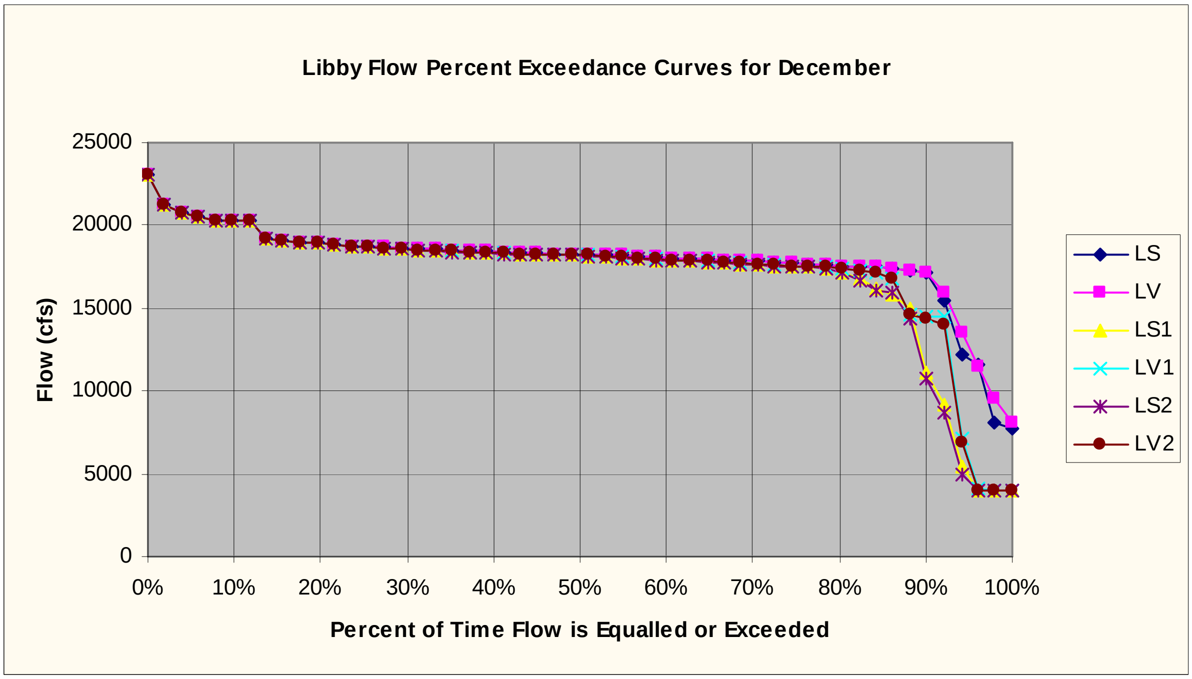

Figure 5. Libby Flow Percent Exceedance Curves for December

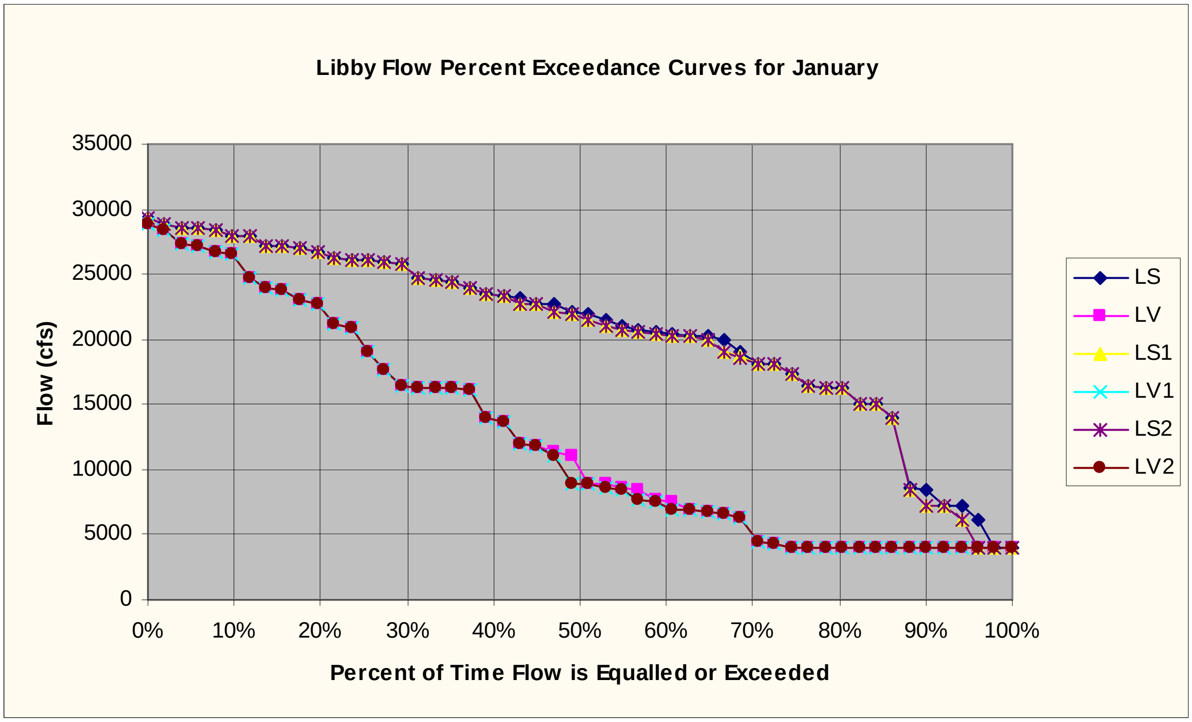

Figure 6. Libby Flow Percent Exceedance Curves for January

5 Results of Grand Coulee Operation

5.1 Grand Coulee Elevation Differences, January – May

The differences in the minimum, maximum and average forebay elevations at Grand Coulee for all alternative combinations are provided in Table 38. The values in the tables are very similar between standard flood control alternative combinations and between VARQ alternative combinations because January through April operations at Libby and Hungry Horse are the same. For January, the minimum elevation is elevation 1260 in all alternative combinations, which is the draft limits for resident fish. For February, the minimum elevation is the draft needed to meet the Vernita Bar flow requirement. For March through May, the minimum elevation are flood control elevations. In January through the first half of April, the maximum elevations are flood control elevations. In the second half of April, Grand Coulee needed to draft to elevation 1280 to meet McNary flow objectives in 7 to 9 years depending on alternative combination, and this became the maximum elevation in that period. In all other years, in the second half of April the project was on flood control except in a few years when it drafted for Vernita Bar. For May, the maximum elevation was a flood control elevation.

Table 41. Grand Coulee Min., Max., and Avg. Elevations for All Alternative/Benchmark Combinations

Alternative Combination	Jan	Feb	Mar	Ap1	Apr	May
LS1+HS						
Min	1260.0	1246.3	1220.4	1212.2	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.0	1288.6
Avg	1268.3	1264.1	1260.8	1253.5	1244.0	1254.0
LV1+HV						
Min	1260.0	1245.0	1220.3	1212.3	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.0	1288.5
Avg	1268.4	1263.6	1259.6	1251.9	1242.4	1252.8
LS2+HS						
Min	1260.0	1246.3	1220.4	1212.2	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.0	1288.6
Avg	1268.3	1264.1	1260.8	1253.5	1244.0	1254.0
LV2+HV						
Min	1260.0	1245.0	1220.3	1212.3	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.0	1288.5
Avg	1268.4	1263.5	1259.6	1251.9	1242.4	1252.8
Benchmark Combination						
LS+HS						
Min	1260.0	1246.3	1220.4	1212.2	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.0	1288.6
Avg	1268.3	1264.1	1260.9	1253.5	1244.0	1254.0
LV+HV						
Min	1260.0	1245.0	1220.3	1212.3	1208.0	1208.0
Max	1290.0	1290.0	1283.1	1283.1	1280.7	1288.5
Avg	1268.4	1263.2	1259.4	1251.9	1242.4	1252.8

5.2 Results of Grand Coulee End of April Operation

The April, end of month elevations are of interest because of bank exposure issues. Table 42 and Figure 7 show the Grand Coulee Elevation Percent Non-Exceedance Curves for the end of April for each alternative combination. All Standard Flood Control alternative combinations are similar to each other and all VARQ alternative combinations are similar to each other because operation of the projects upstream of Grand Coulee are nearly the same for each type of flood control. Generally, Grand Coulee operated on flood control curves about 85% of the time, drafted for McNary flows in 7 to 9 years, and drafted for Vernita Bar 1 to 3 years, depending on alternative combination. Grand

Coulee flood control operations are dependent on upstream space available. As VARQ rule curves are higher in both Libby and Hungry Horse than standard rule curves (meaning less space is available), more flood control space is necessary in Grand Coulee's pool. The flood control curves are adjusted based on the April 30 ending elevations for upstream projects. There was little variation of power drafts between each of the VARQ alternative combinations and the Standard FC alternative combinations because projects operated nearly the same for each set of alternative combinations. There were only 2 years, 1988 and 1993, where there were differences in Libby's April 30 Elevation, between fish flow alternative combinations and flood control only alternative combinations. Grand Coulee drafted to elevation 1280 for McNary flows in those years in all alternative combinations except alternative combination LV+HV where it drafted to 1280.7.

Figure 8 shows the difference in elevations (VARQ minus Standard) for the flood control only, Libby fish flows at QPHC, and Libby fish flows at QPHC+10. Again, the differences are the same because operation of upstream projects is nearly the same for VARQ and for Standard.

Table 42. Grand Coulee End of April Elevation Percent Non-Exceedance, All Alternative/Benchmark Combinations

	Benchmark Combination		Alternative Combination			
Elevation (ft)	**LS+HS**	**LV+HV**	**LS1+HS**	**LV1+HV**	**LS2+HS**	**LV2+HV**
1280	85%	88%	85%	88%	85%	88%
1270	81%	83%	81%	83%	81%	83%
1260	73%	77%	73%	77%	73%	77%
1250	62%	71%	62%	71%	62%	71%
1240	52%	54%	52%	54%	52%	54%
1230	33%	35%	33%	35%	33%	35%
1220	10%	10%	10%	10%	10%	10%
1210	4%	4%	4%	4%	4%	4%

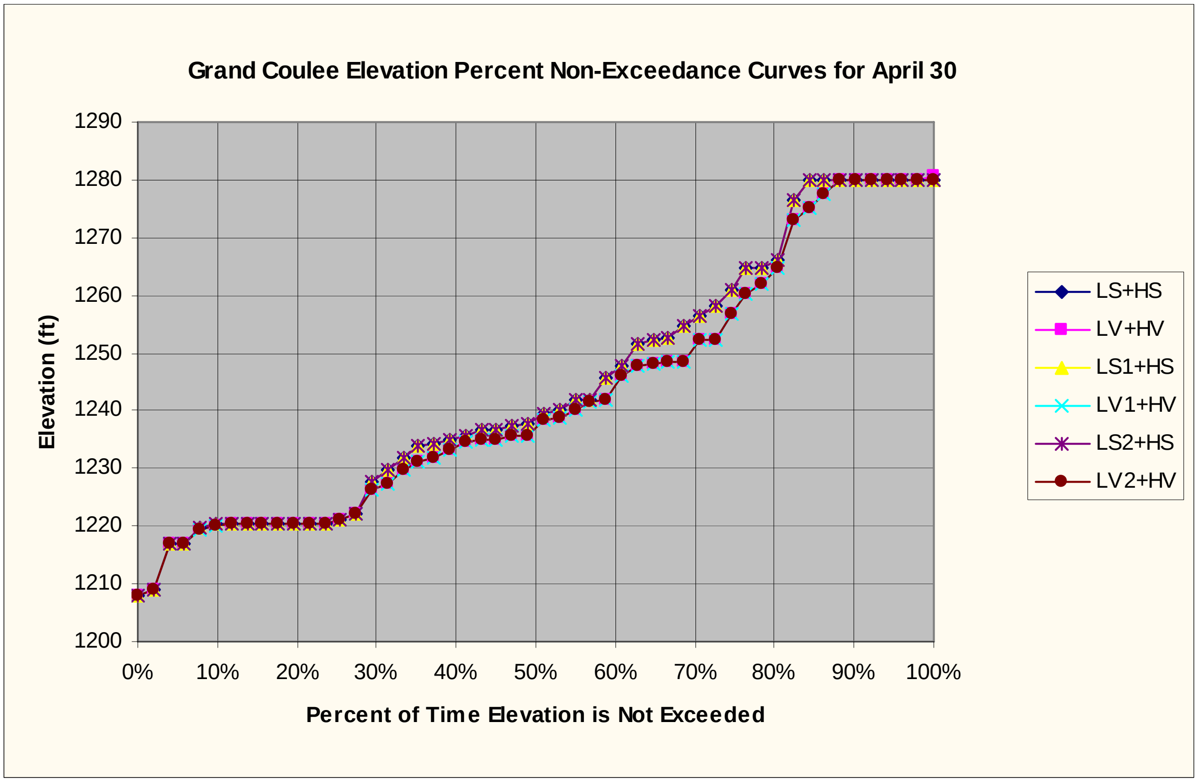

Figure 7. Grand Coulee Elevation Percent Non-Exceedance Curves for April 30

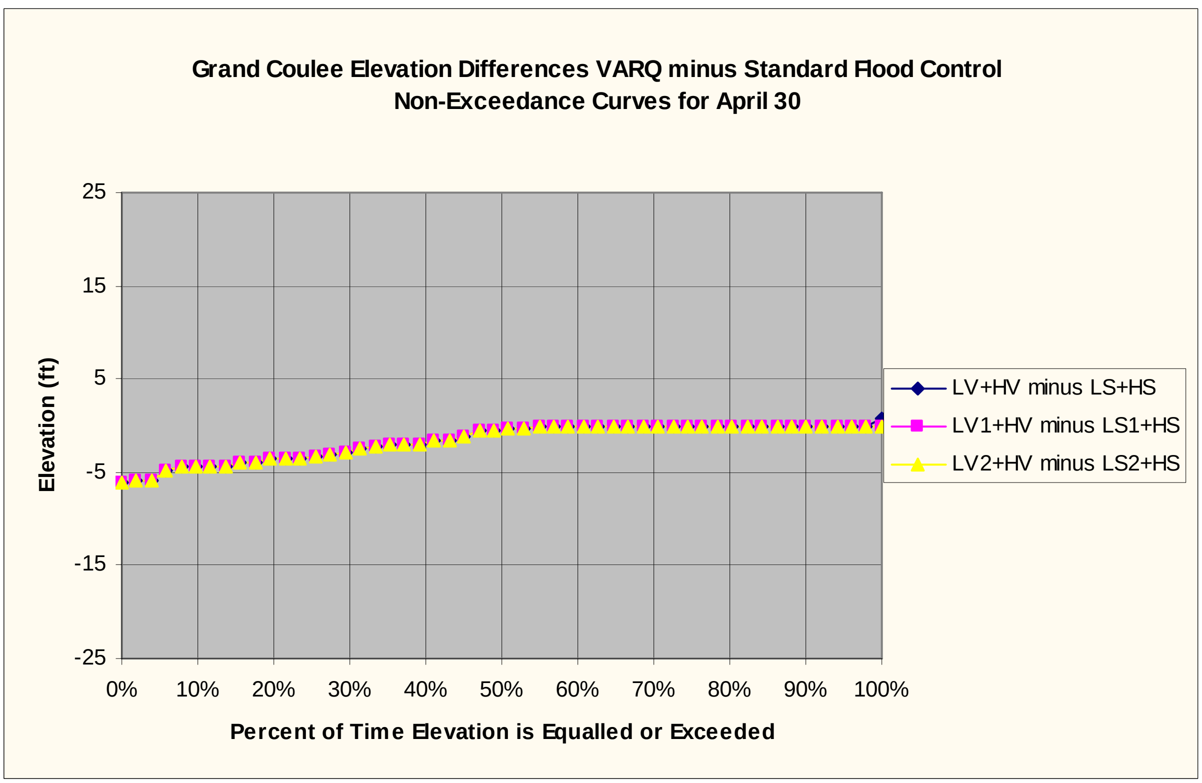

Figure 8. Grand Coulee Elevation Differences Standard minus VARQ Flood Control Exceedance Curves for April 30

6 Priest Rapids Flow Objectives

Tables 43 and 44 show the number of years of 52 that Priest Rapids flow objectives (90 kcfs in the first half of April and 135 kcfs for the second half of April through June) were missed and the average amount in cfs that the flow objectives were missed.

For the alternative combinations with no fish flow at Libby, VARQ increased the flow miss in the first and second halves of April by about 500 cfs (2%) and 1800 cfs (7%), respectively, while the number of years the objectives were missed stayed the same. In May, VARQ increased the flow amount missed by about 11,000 cfs (64%) but decreased the number of years missed by 2. In June, VARQ reduced the flow amount miss by 2800 cfs (14%) and decreased the number of years missed by 3.

In the alternative combinations with fish flows at Libby, VARQ did not change the number of years the flow objectives were missed in the first half of April through June. For the first half of April, VARQ decreased the average amount of flow miss by about 1000 cfs (5%). In the second half of April, VARQ increased the flow amount missed by about 1800 cfs (7%). For May, VARQ reduced the flow miss by about 1300 cfs (5%), with no change in the number of years missed (about 90% of the time Grand Coulee was operated for flood control, with the remainder of the time drafting to elevation1280 for McNary flow objectives). In June, VARQ reduced the flow miss by 3600 cfs (19%).

Figures 9 through 12 show the flow exceedance curves for each month that flow objectives occur. The curves are similar for all alternative combinations.

Table 43. Number of Years of 52 that Priest Rapids Flow Objective was Missed

Alternative Combination	Ap1	Apr	May	Jun
LS1+HS	17	20	3	10
LV1+HV	17	20	3	10
LS2+HV	17	20	3	10
LV2+HV	17	20	3	10
Benchmark Combination				
LS+HS	17	20	5	13
LV+HV	17	20	3	10

Table 44. Average Flow By Which Priest Rapid Flow Objective was Missed (cfs)

Alternative Combination	Ap1	Apr	May	Jun
LS1+HS	18498	26118	25584	19719
LV1+HV	17499	27932	26922	16033
LS2+HV	18501	26118	24614	19734
LV2+HV	17512	27930	26174	16083
Benchmark Combination				
LS+HS	18131	26118	17304	20312
LV+HV	18640	27925	28486	17515

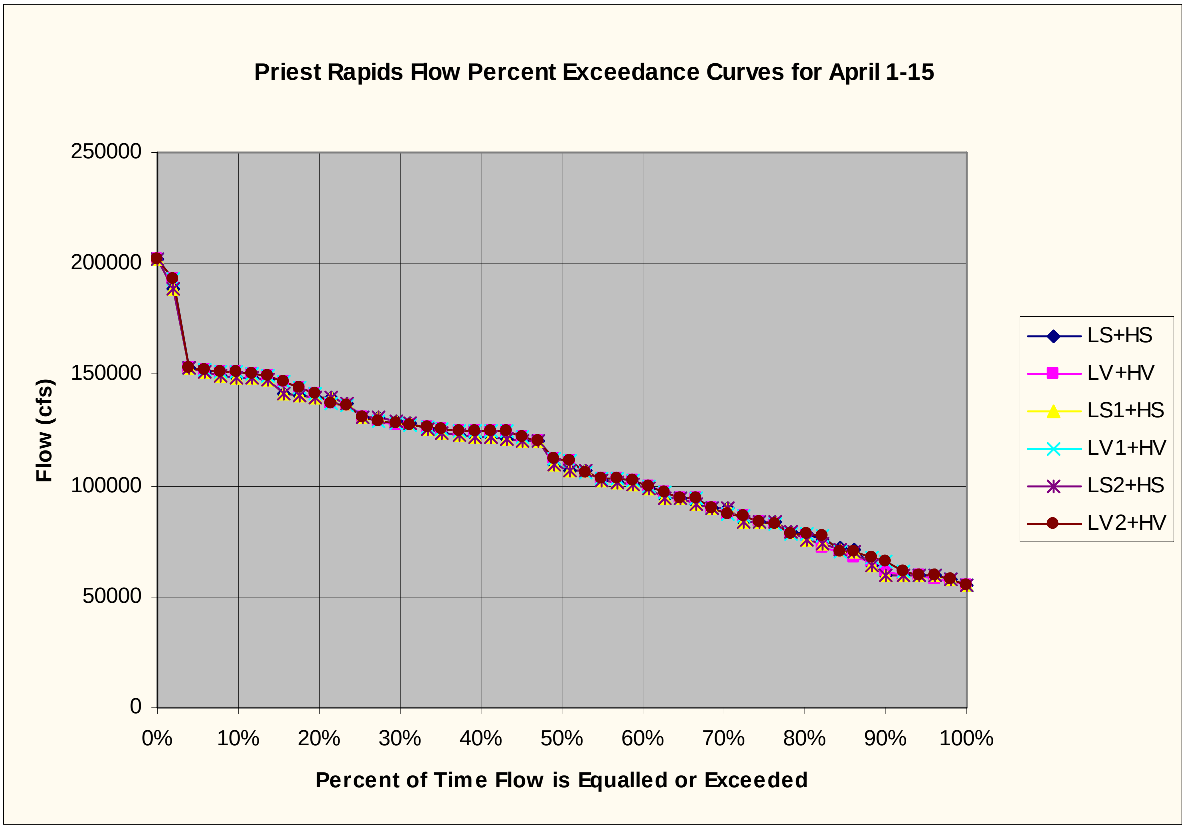

Figure 9. Priest Rapids Flow Percent Exceedance Curves for April 1-15

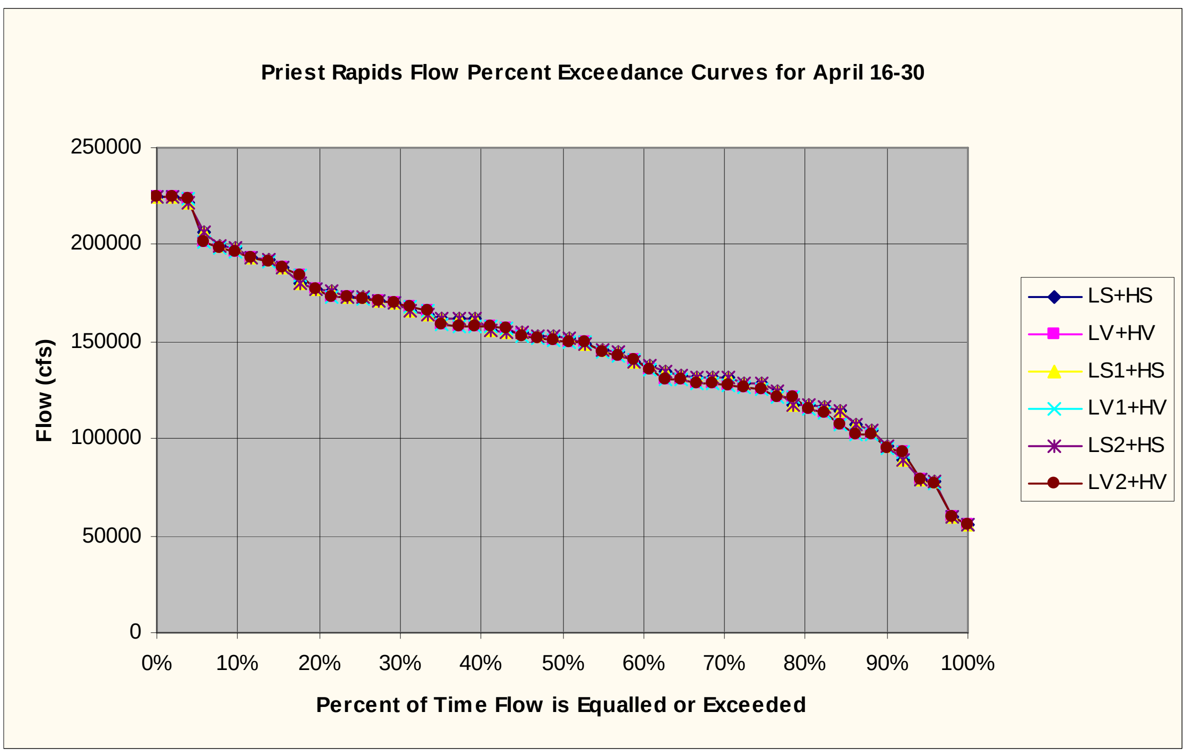

Figure 10. Priest Rapids Flow Percent Exceedance Curves for April 16-30

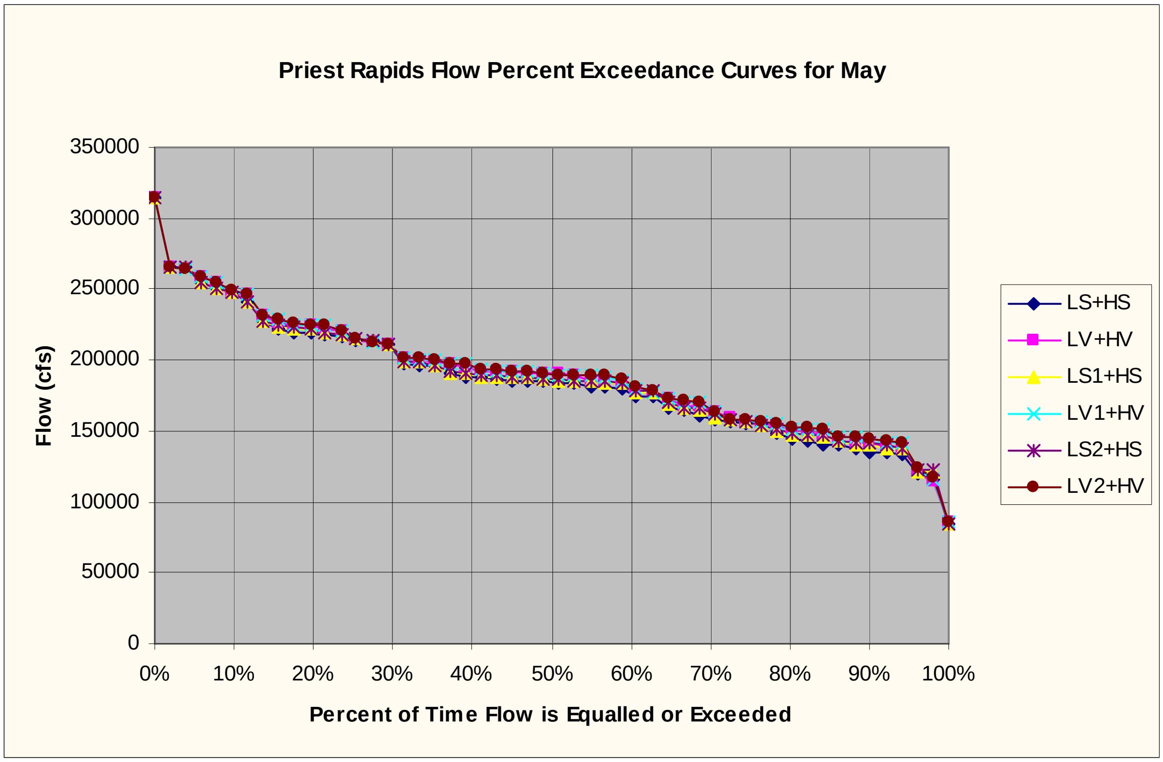

Figure 11. Priest Rapids Flow Percent Exceedance Curves for May

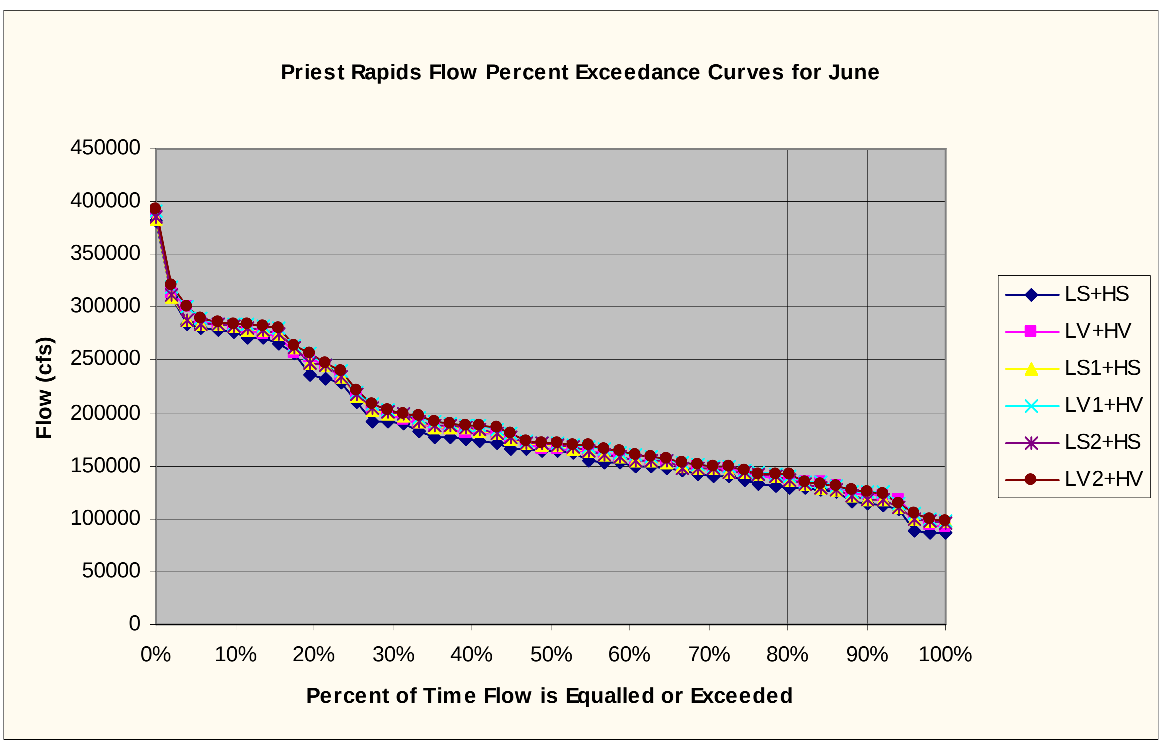

Figure 12. Priest Rapids Flow Percent Exceedance Curves for June

7 McNary Flow Objectives

Tables 45 and 46 show the number of years that the McNary flow objectives were missed and the average flow that the flow objective were missed by in the years that the flow objectives were not met. VARQ does not change the number of years the flow objectives were missed in the first and second halves of April. In May through the first half of August, VARQ reduces the number of years the flow objectives missed by zero to 3 years. In the second half of August, VARQ increases the number of years missed by zero to 2. The difference in the average amount the flow objectives were missed between VARQ and Standard alternative combinations only varied by a few percent.

Figures 13-19 show McNary flow exceedance curves for each month that flow objectives occur. All curves are very similar, however there is a slight improvement in the ability to meet the McNary flow objectives with VARQ and fish flow alternative combinations in July and August.

Table 45. Number of Years out of 52 that McNary Flow Objective was Missed

Alternative Combination	Ap1	Apr	May	Jun	Jul	AG1	Aug
LS1+HS	10	30	16	19	21	40	48
LV1+HV	10	30	15	18	21	38	48
LS2+HV	10	30	16	19	22	39	48
LV2+HV	10	30	15	18	20	36	49
Benchmark Combination							
LS+HS	10	30	16	23	23	40	49
LV+HV	10	30	15	21	21	42	50

Table 46. Average Flow by Which McNary Flow Objective was Missed (cfs)

Alternative Combination	Ap1	Apr	May	Jun	Jul	AG1	Aug
LS1+HS	23008	71598	35193	51386	40896	37384	64012
LV1+HV	22217	73125	34368	50775	38931	36270	60944
LS2+HV	23008	71598	34412	51307	39463	38667	64570
LV2+HV	22217	73124	33704	50780	41268	38639	60177
Benchmark Combination							
LS+HS	22584	71594	37826	48555	39683	39301	67373
LV+HV	24335	73087	35972	45998	42383	36965	66075

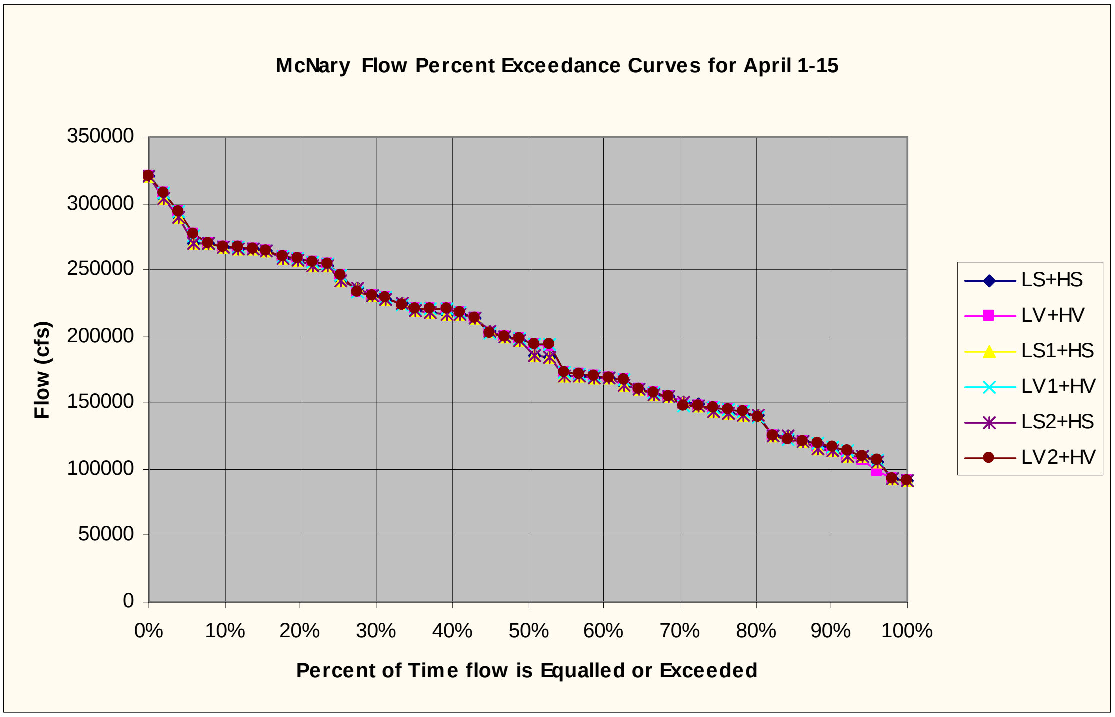

Figure 13. McNary Flow Percent Exceedance Curves for April 1-15

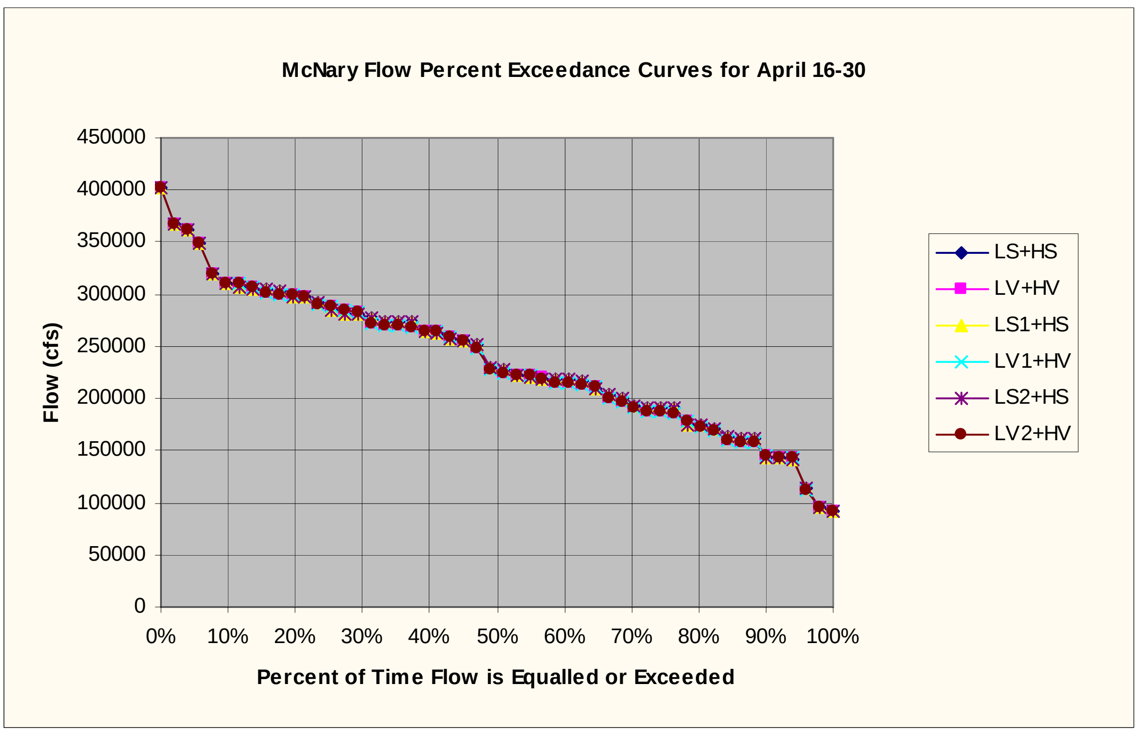

Figure 14. McNary Flow Percent Exceedance Curves for April 16-30

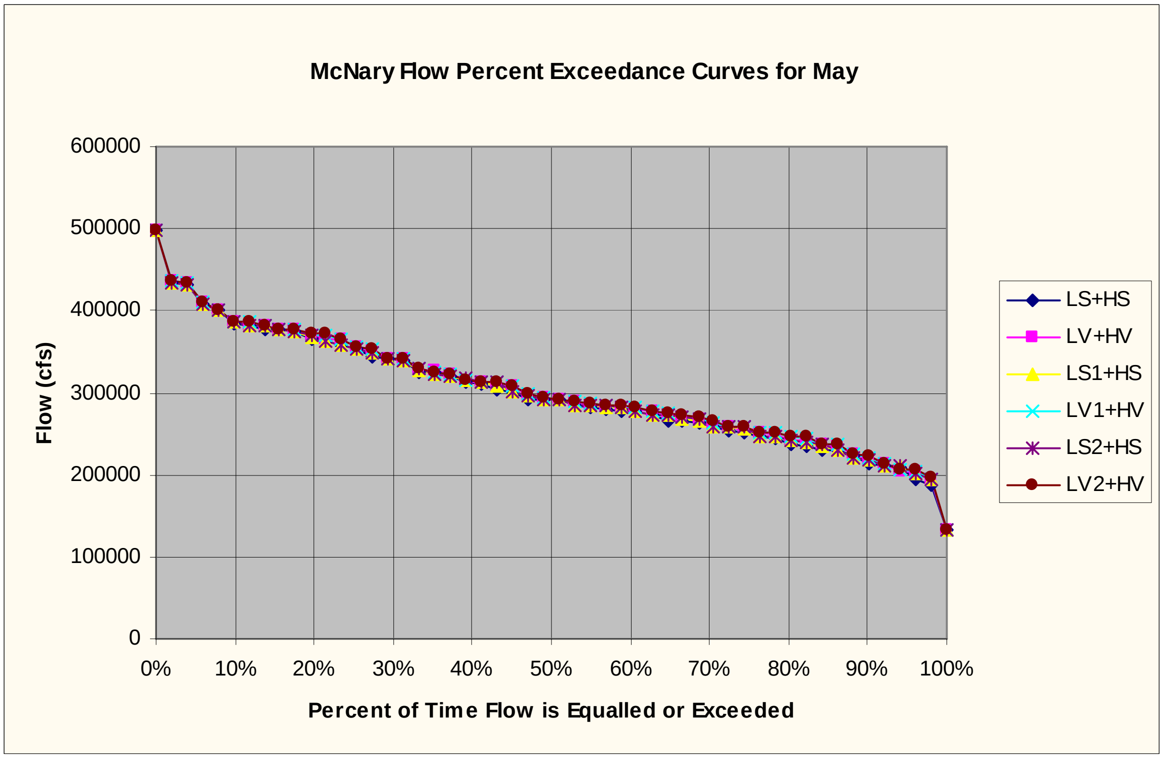

Figure 15. McNary Flow Percent Exceedance Curves for May

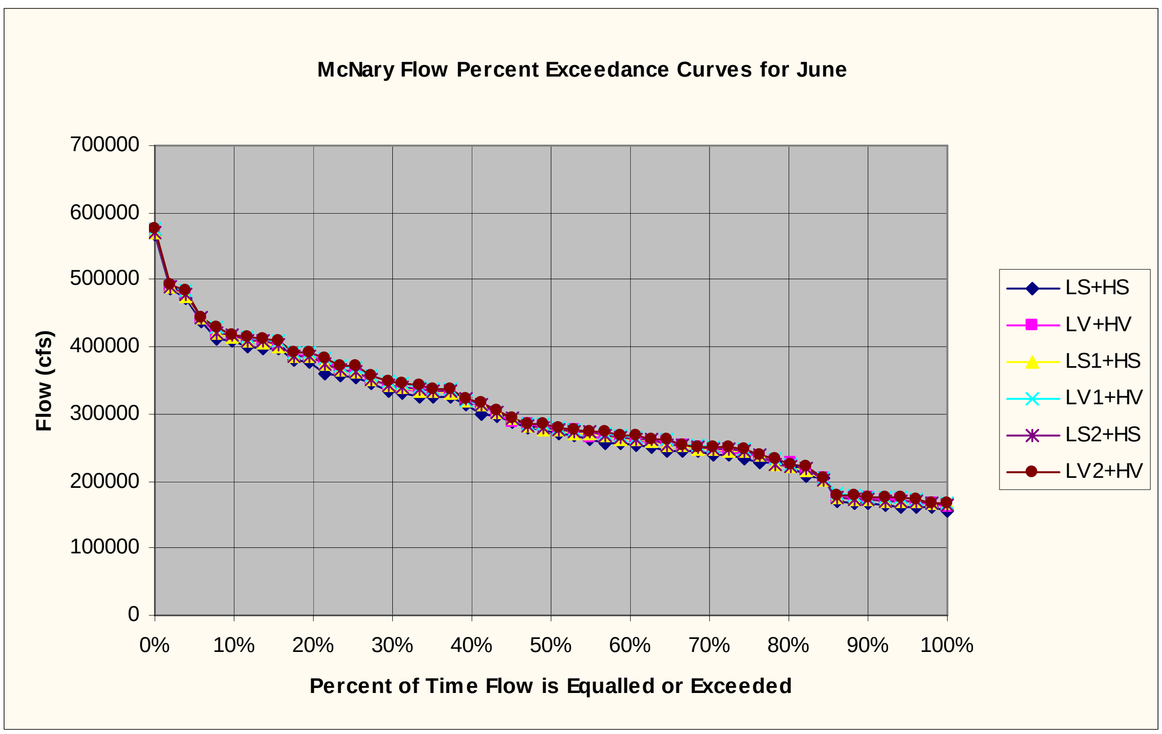

Figure 16. McNary Flow Percent Exceedance Curves for June

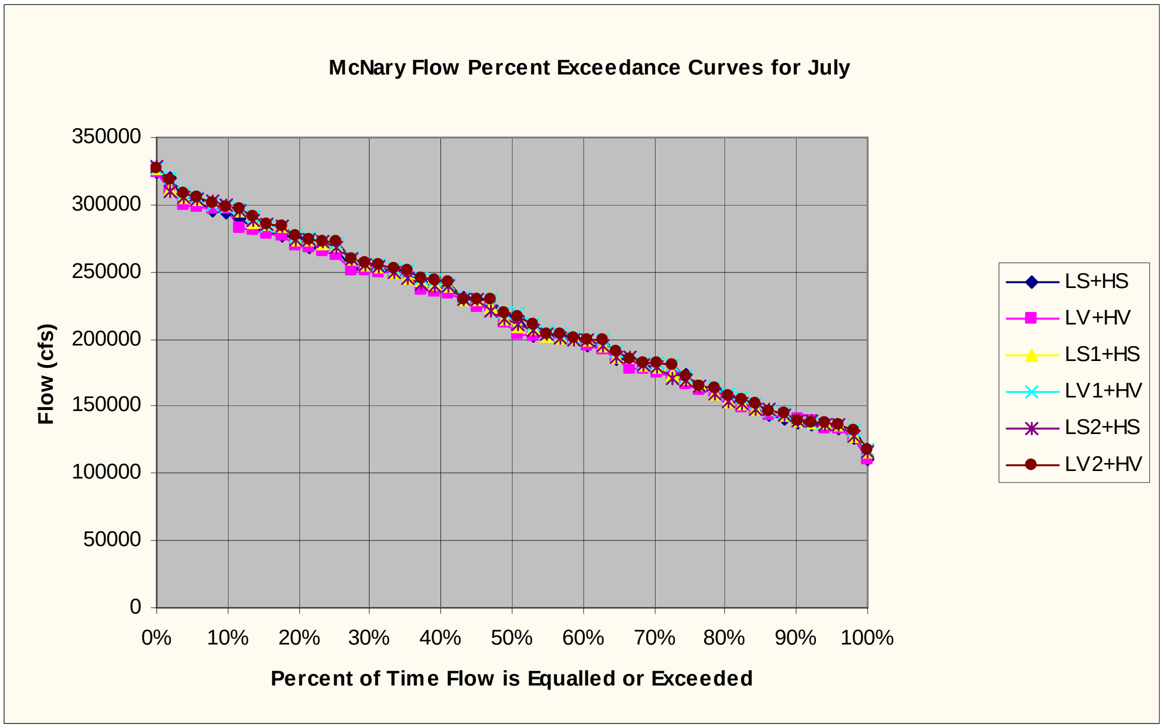

Figure 17. McNary Flow Percent Exceedance Curves for July

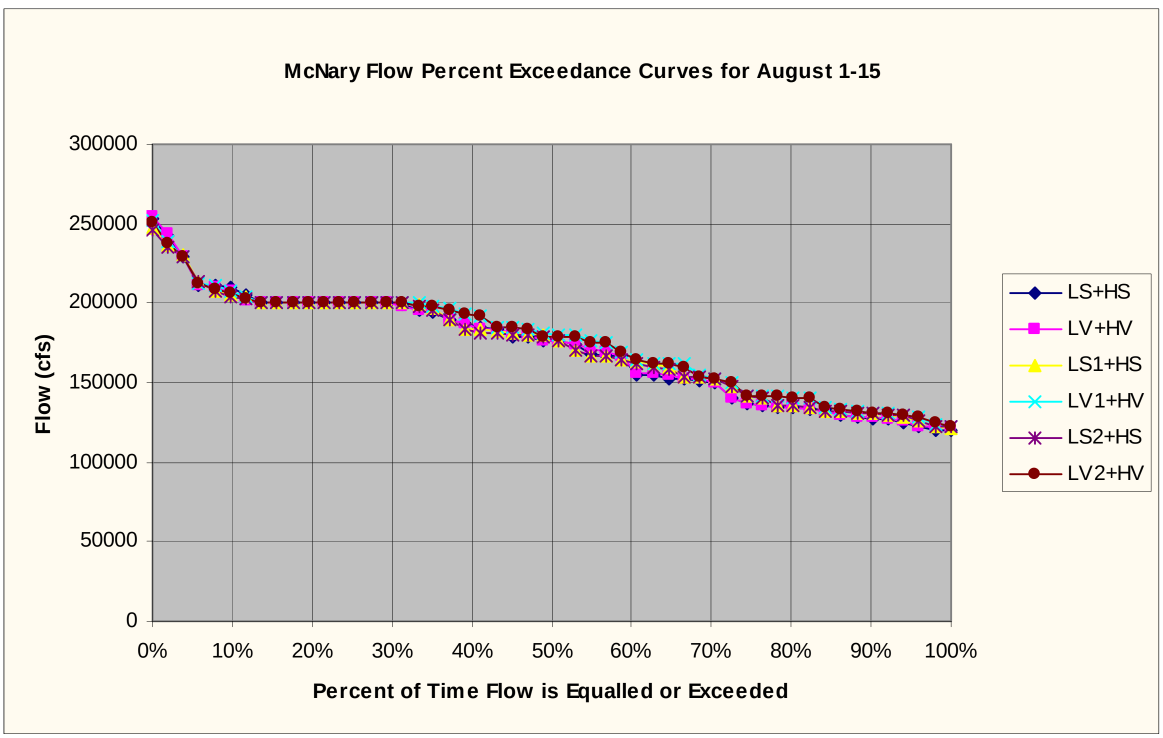

Figure 18. McNary Flow Percent Exceedance Curves for August 1-15

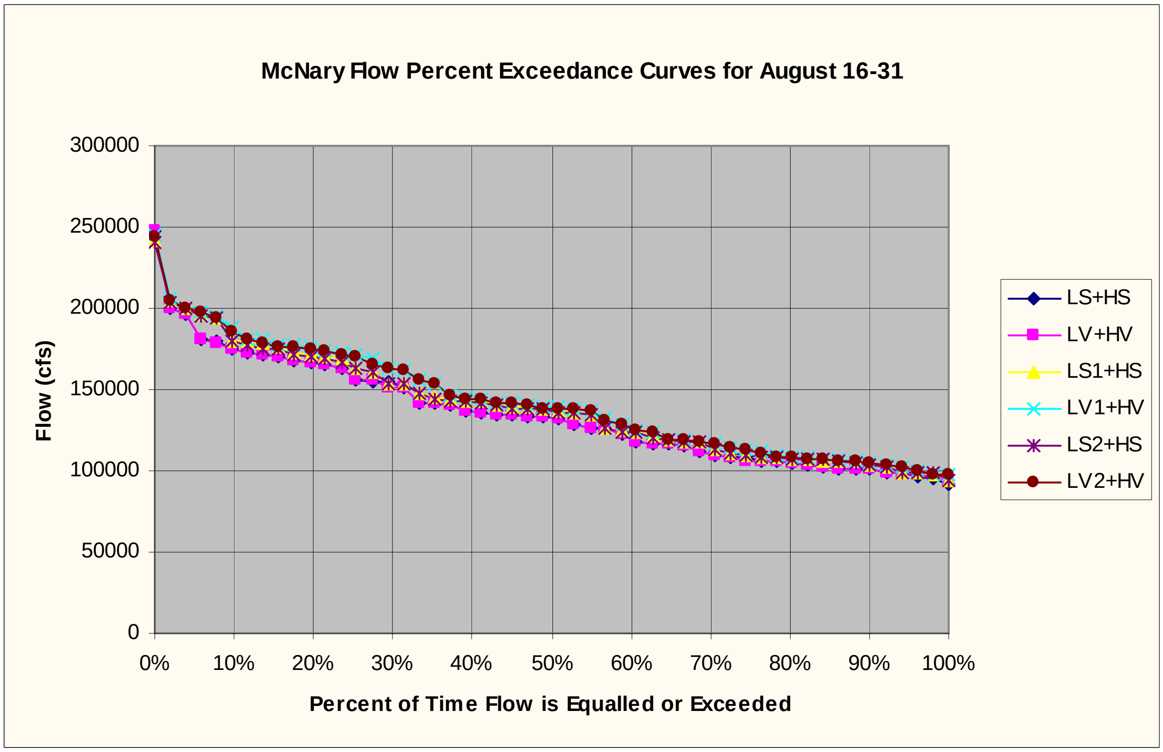

Figure 19. McNary Flow Percent Exceedance Curves for August 16-31

8 Summary of Results

For system generation, in comparing all VARQ to Standard Flood Control with and without fish flows at Libby, VARQ reduces average annual system generation by 7 to 12 MW. Comparing alternative combinations with Libby fish flows at QPHC to alternative combinations with no fish flows, fish flows reduce average annual generation by 27 to 31 MW. Comparing alternative combinations with Libby fish flows at QPHC+10 to alternative combinations with no fish flows, the fish flow alternative combinations reduce system generation by 33 to 38 MW. By these comparisons, Libby with fish flows at QPHC+10 has a greater impact on generation than Libby fish flows at QPHC, and the effects of VARQ on system generation are about one-third the impacts of the fish flows.

For all alternative combinations that compare VARQ to Standard, the largest impact to system generation occurred in January, with a reduction of 825 MW, which is about a 4.2% reduction. The largest increase occurs in May of 351-439 MW, which is about a 2 % increase.

For Standard Flood Control alternative combinations that compare Libby fish flows at QPHC and QPHC+10 to Libby without fish flows, the largest system generation impact occurs in September with a reduction of about 1350 MW, which is about a 13.5% reduction and the largest increase in generation occurs in June for 500 MW at about a 2.7% increase.

For VARQ Flood Control alternative combinations that compare Libby fish flows at QPHC and QPHC+10 to Libby without fish flows, the largest system generation impact occurs in September with a reduction of about 1320 MW, which is about a 13.1% reduction and the largest increase in generation occurs in the second half of August of 562-600 MW at about a 5.2% increase.

For VARQ compared to Standard, comparisons of generation for federal and non-federal projects generally follow the same patterns as for system generation with less generation in January through March and more generation in May through August, however, generation for projects on the Pend Oreille and Flathead Rivers were minimally affected in May through October. Additional flow was passed through these projects in May through July but had to spill due to reaching powerhouse capacity.

For spill at the federal and non-federal projects, in general, comparing the VARQ to Standard alternative combinations, VARQ reduced forced spill in January through March, and increased voluntary spill for fish in May through August. Voluntary spill increased because many projects spill based on a percent of regulated flow, which increased with VARQ. Differences between alternative combinations were relatively small (generally a 2% difference) in the comparison of alternative combinations.

Libby discharge and flow exceedance curves for September and October were provided. Libby operated to its normal operating rule curves of elevation 2437.9 at least 70% of the time and at elevation 2436.5 in October at least 76% of the time for all alternative combinations. The remainder of the time, Libby drafted to meet the system load. The average flows in September for alternative combinations without fish flows at Libby, is about 22,000 cfs and alternative combinations with fish flows is about 7300 cfs. The average flows for October is about 7,600 cfs for all alternative combinations.

Libby flow exceedance curves for December and January were provided. For all alternative combinations in December, at least 80% of the time the flow was greater than about 17,200 cfs. For January, the average flow for the Standard and VARQ alternative combinations is about 22,000 cfs, and 9,000 cfs respectively, however, the median flow for January with VARQ is about 8,900 cfs.

Grand Coulee elevation non-exceedance curves for the end of April were provided to evaluate bank exposure issues. About 85% of the time Grand Coulee operated to its flood control elevation. The remainder of the time, Grand Coulee had operated to elevation 1280 for McNary flow objectives or drafted to meet the Vernita Bar requirement. The average end of April elevation for VARQ and Standard Flood Control alternative combinations is elevation 1242.4 and 1244.0 ft respectively.

For Priest Rapids fish flow objectives in April through June, VARQ very slightly improved the ability to meet the flow objectives.

For McNary fish flow objectives in April through August, VARQ slightly improved the ability to meet the flow objectives. In the first and second halves of April, there is basically no difference. The flow amount misses were reduced only a few percent, and the number of years missed was reduced by 1 to 3 years.