Report on Libby Dam Water Management Operations in 2006

Introduction

The following describes the U.S. Army Corps of Engineers (Corps) real-time operational decision-making for Libby Dam relative to the 2006 flood event. Libby Dam is one of 14 federal projects operated as a system for multiple uses in the Columbia Basin - commonly referred to as the Federal Columbia River Power System (FCRPS). The Corps real-time management of its FCRPS projects is multi-faceted and takes into account many factors to provide for these multiple uses. Decisions for real-time water management operations for the Corps FCRPS projects are the responsibility of the Corps' Northwestern Division (NWD) and implemented primarily by the Columbia Basin Water Management Reservoir Control Center (RCC).

Libby Dam is one of several storage projects in the Columbia Basin and is authorized by Congress to provide for multiple uses including system and local flood control, fish and wildlife, hydropower, navigation, and recreation. In order to provide for the multiple uses, the Corps is obligated to comply with various statutes, regulations, and treaties. The Corps must integrate the requirements associated with meeting these responsibilities with information that is available in real-time to make water management decisions to effectuate these multiple purposes. The following discussion provides a detailed description of how real-time water management decisions were made in 2006.

Overview of Factors Influencing Real-Time Operational Decisions in 2006

To set the stage for describing how water management decisions are made, the following identifies some of the factors that the Corps takes into account in real-time. One of the Corps' primary functions is to operate Libby Dam to reduce flood damages both system-wide[1] in the Columbia Basin, and locally for the Kootenai River Basin. Libby Dam operations are coordinated with Canada, pursuant to the Columbia River Treaty (Treaty), to provide hydro-power and flood control benefits in Canada and the U.S. Coordination with Canada is ongoing and updated weekly, factoring into the Corps' water management decisions. The International Joint Commission Order of 1938 establishes daily upper limits on lake elevation at Kootenay Lake. During January through March, maintaining Kootenay Lake below these upper limits may cause a limit to the outflows from Libby Dam, which the Corps incorporates into its operational regime.

[1] System-wide flood control, often called "system flood control," refers to the operation of all Columbia Basin reservoirs with authorized flood control space in a coordinated manner to effect flood damage reduction primarily in the densely populated Portland-Vancouver metropolitan areas, but also includes the entire river reach from Bonneville Dam to the mouth. All system damages are indexed to the flow at The Dalles, OR.

The hydropower operations at Libby Dam are routinely coordinated with Bonneville Power Administration (BPA) and other federal and non-federal power producers to optimize power generation. Powerhouse maintenance and appurtenant transmission system are also factors affecting real time decision making. Optimization of other benefits provided by Libby Dam is the result of input and requests for operational adjustments routinely made by Northwest States and Tribes throughout the year[2].

Another significant factor in real-time decision making is a consequence of the effects of the operation of the FCRPS projects, including Libby Dam, on several species listed under the Endangered Species Act (ESA). The Corps, Bureau of Reclamation, and BPA are obligated to consult with both the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS or NOAA Fisheries) to ensure the operation of these projects does not jeopardize the continued existence of these species or their designated critical habitat.

In making operational decisions to support the various objectives and factors described above, the Corps utilizes a variety of tools to inform its water management decisions. These tools include: long range, or seasonal water supply forecasts[3], and streamflow forecasts; short-term precipitation/weather, and streamflow forecasts; operational guidance that is provided in various planning documents;[4] and, other guidance that is prepared annually for that particular water year, such as the System Flood Control Guidance, which includes VARQ Guidance.

Information Obtained to Assist in Real-Time Decision Making

Flood control guidance is provided by the NWD Hydrologic Engineering Branch (HEB) to the RCC for use in planning for real-time operational decisions for both system and local flood control requirements. System Flood Control Guidance includes potential operational strategies at all storage projects in the Columbia River Basin to meet the regional system flood control objectives as measured at The Dalles, Oregon. The action of evacuating water from reservoir storage projects for system flood control also provides flood protection for local damage centers downstream of those storage projects. During the refill period, the effects of reservoir regulation on system and local flood control are evaluated concurrently and in a balanced manner to provide maximum protection throughout the basin. The guidance provides the minimum flood control space requirement to be held prior to the start of refill, i.e. "drawdown guidance," and the forecast date at which time projects may begin to refill into the flood control space, i.e. "refill guidance."

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[2] Examples include operations for burbot in mid-winter, and extending summer draft from Libby Dam for salmon flow augmentation into September.

[3] Water supply forecasts (WSF) are the expected total quantity or volume of run-off for a given time, generally April through August. These forecasts do not inform the timing or the shape of the run-off. They are based on snowpack and assume average precipitation over the course of the season.

[4] Examples include the Water Control Manuals, the annual Water Management Plan, the annual Fish Passage Plan, annual operating plans under the Columbia River Treaty such as the Detailed Operating Plan, and hydropower plans prepared in accordance with the Pacific Northwest Coordination Agreement.

Beginning in January, and monthly thereafter through June, a water supply forecast (WSF) [5] is developed for the April through August period. During the flood control drawdown period, January through April (or until the forecast refill date is met, in the case of projects operated according to VARQ flood control), HEB prepares guidance for each flood control project based on the current WSF. Storage Reservation Diagrams (SRDs) are then used to develop end-of-month minimum flood control space requirements (or upper flood control elevation). These are updated once a month when the new WSF is issued. One of the Corps' objectives for ESA listed salmon is to target the upper flood control elevation at the end of each month from January into April,[6] unless refill begins before the end of April for projects operated in accordance with VARQ flood control.

For the refill period, usually April/May through July, guidance is prepared based on the most recent WSF, residual run-off[7] volumes, and streamflow forecasts. The guidance includes the observed inflow that occurred in April and May, respectively.[8] Average project outflows for the refill period are identified to meet local and system flood control objectives, and to refill by late June or early July. In 2006, the guidance was revised every two weeks to reflect changing conditions, although weekly meetings between HEB and RCC staff took place to review the status of system conditions and discuss system operations.

Chronology of 2006 Libby Dam Operations

The following chronology describes the Corps' decision points and reservoir operations, including the application of the tools described above, as events unfolded in 2006. A short summary of WSFs and reservoir elevations is provided for the months of January through March. For the months of April into July, a more detailed discussion is provided.

January through March

Technical Data Highlights for Real-time Operational Decisions

- April through August final WSF issued in:

[5] The Corps develops WSF for its headwater storage projects, i.e. Libby and Dworshak dams. The National Weather Service's River Forecast Center (RFC) also prepares WSF through July, which the Corps uses for comparison purposes. The WSF for Libby Dam is the expected volume of runoff into the Libby reservoir during this period.

[6] The 2004 UPA as considered in the 2004 NOAA BiOp concluding no jeopardy, targets storage reservoir elevations at the upper flood control limit to maximize the water available in the spring for listed salmonids. The storage reservoirs are to be at upper rule curve elevations on certain dates in April - Libby, Hungry Horse and Grand Coulee dams on April 10, and April 3 at Dworshak Dam.

[7] Residual runoff is the expected remaining water supply volume yet to runoff. The residual runoff is the current WSF less the inflow that has occurred from the start of the forecast period to date. It is a combination of snow pack remaining and forecasted precipitation.

[8] VARQ Refill Guidance provides for updating the guidance as the runoff season progresses to include the observed inflow that occurred in previous months.

  - January - 5.5 Million Acre Feet (MAF) - 88% of normal
  - February - 6.2 MAF - 99% of normal
  - March - 6.35 MAF - 102% of normal
- Based on the WSF issued in March, the calculated end-of-March upper flood control limit was elevation 2404.1 feet.
- Following the VARQ SRD draft regime for January through March, the actual end-of-March elevation at Libby Dam was 2404.2 feet.

Objectives and Factors Influencing Real-time Operational Decisions

Throughout the January through March drawdown period, Libby Dam was operated such that the system flood control objectives were met and the end-of- month upper flood control elevations were not exceeded. As described below, ESA consultation was continuing with the USFWS on the effects of the operation of Libby Dam on listed sturgeon and bull trout - with the expectation that the BiOp would be completed prior to initiation of 2006 sturgeon operations.

On January 11, 2006, policy representatives from the Corps, BPA, USFWS, Montana, Idaho, Kootenai Tribe, and Salish-Kootenai Tribe met to discuss the status of the Libby Dam consultation. Specifically, they discussed the flow component for sturgeon in the forthcoming USFWS BiOp. The regional policy representatives tasked a collaborative technical team with developing an approach to provide and evaluate a range of flows from Libby to assist sturgeon recruitment. The plan was to include the following considerations: operations were not to voluntarily cause the Kootenai River to exceed elevation 1764 feet as measured at Bonners Ferry; criteria for determining when to implement and under what conditions an operation would be suspended (e.g. if exceeding the total dissolved gas (TDG) standard below Libby Dam with monitoring for adverse downstream biological effects); a description of the hypothesis(ses) being tested and a detailed research plan; and, how the results would apply to adaptive management decisions regarding future operations/conservation actions. Completion of this plan was anticipated for April 2006.

On February 18, 2006, the USFWS issued the 2006 BiOp concerning the effects of Libby Dam operations on listed sturgeon and bull trout. Included in the 2006 BiOp was a Reasonable and Prudent Alternative (RPA), which called for the completion of the flow plan implementation protocol (Protocol) collaboratively developed by the regional technical team described above. The Protocol was to identify operational actions to test biological responses to temperatures, depth, and velocity and was to be completed by April 14, 2006 with consideration of the following:

- address flow releases for all sturgeon tiers and flow releases up to 35,000 cfs out of Libby Dam.
- include provisions for the real-time implementation of operations considering distribution of the tiered volumes for sturgeon. These releases will be planned

to coincide with the optimum temperatures to provide a more normative hydrograph.
- provision of an assessment of the probability of having appropriate conditions necessary to provide for total test releases up to 35,000 over the course of the of the next ten years (2006-2016) with implementation of VARQ flood control procedures and fish flows.

Summary

During January through March, Libby Dam was operated such that the system-wide flood control objectives were met, including the VARQ Drawdown Procedures. The actual end-of month upper flood control elevation for March at Libby Dam was 2404.2 feet, well within flood control limits. Libby Dam 2006 operations for sturgeon were under consideration by regional policy and technical representatives.

April

Technical Data Highlights for Real-time Operational Decisions

- April final WSF issued on April 6: 6.076 MAF - 97.2% of normal [9]
- Based on the VARQ SRD and the updated April WSF, the calculated end of April upper flood control limit was elevation 2417 feet. This was calculated for April 15 and April 30 [10]
- The actual end of April elevation at Libby Dam was 2413.2 feet. (3.8 feet below the calculated upper flood control limit of elevation 2417 feet)
- VARQ Refill Guidance was for project releases of 16.4 kcfs to begin on April 20.
- The project operated at minimum flows of 4.0 kcfs for most of the month
- Anticipated residual volume (based on the April WSF):
    - April 18, approximately 5833 KAF (96% remaining)
    - April 26, approximately 5590 KAF (92%)
    - April 30, approximately 5408 KAF (89%)

Flood Control Guidance Provided During the Month of April

***April 19 System Flood Control Guidance**:*

The system guidance was based on the April 18, 2006 Single Trace Process (STP) unregulated deterministic model.[11] The April 19 guidance provided potential operational

[9] Based on the April final water supply forecast prepared by the Corps, the 95% non-exceedance limit was 6.987 MAF (111.8% of average). This means that statistically there was a 95% confidence that April though August runoff would be less than 6.987 MAF.
[10] Summary of Columbia River Flood Control Data 1 Apr 2006 http://www.nwd-wc.usace.army.mil/cafe/forecast/sum2006/sum200604.pdf

scenarios as recommended in the Treaty Flood Control Operating Plan.[12] Included in the April 19 guidance was system and VARQ guidance for Libby Dam as follows:

> "Based on April 2006 final forecasts.
> Initial Controlled Flow (ICF)[13] at The Dalles – 359 kcfs
> Date ICF Reached – April 30 – based on 18 April 2006 Single Trace Process (STP) unregulated deterministic model that denotes intersection date on 25 April plus 5 day timing delay due to effects of major lakes."

> "System flood control space should be gradually filled through the end of June. Filling of US and Canadian projects in the upper Columbia may need to be extended into July. Once the residual runoff reaches 30 to 35 percent, projected to occur in late June, then the potential for flooding in the lower Columbia is negligible."

The flood control guidance specifically for Libby Dam guidance stated:

> "4. LIB – Guidance can be divided into two components: (1) the theoretical VARQ guidance and (2) hedge refill guidance for the final 20-ft.
>
> (a) VARQ Guidance. For VARQ, hold pool at or below 2417.0 ft until 20 April (10 days before ICF date) when VARQ refill operations begin. Schedule project releases of 16.4 kcfs from 20 April to 08 May, and then tentatively plan to revise the estimated release to 21.0 kcfs from 09 May to 30 June. When the 01 May forecast is completed on 08 May, however, a revised VARQ project release should then be available for the same period 09 May to 30 June.
>
> (b) Final Refill. Final refill is at the discretion of RCC. Refill of the final 20-ft (2439 to 2459 ft) should be hedged by RCC regulators using available short-term RFS models. Please note that this is flood control guidance only. For final refill

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[11] The STP is a systemwide streamflow forecast model prepared in cooperation with the River Forecast Center. The Corps regulates reservoir operations from Brownlee and Dworshak and all other headwater basins in the Columbia River. The Corps does not prepare reservoir regulation of dams upstream of Brownlee. The unregulated streamflow would somewhat mimic the flow at The Dalles if no dams were in place. The Initial Controlled Flow (ICF) is an unregulated flow at The Dalles. The STP is developed based on ten days of expected precipitation and air temperature overlaid on the existing snowpack and soil moisture. The RFC forecast procedure assumes the first ten days are error-free, i.e., a perfect forecast. After the first ten days, the long term forecast is developed based on mean areal temperature and mean areal precipitation.

[12] The purpose of the Flood Control Operating Plan for Canadian storage is to prescribe criteria and procedures by which the Canadian Entity will operate Mica, Duncan and Arrow Reservoirs to achieve desired flood control objectives in the United States and Canada. The purpose of including Libby Reservoir in the Flood Control Operating Plan is to meet the Treaty requirement to coordinate its operation for flood protection in Canada.

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

operations, flood control refill curves - including sturgeon most probable and sturgeon 95% confidence - should be used to meet assured refill criteria. *(For reference purposes, AER refill target elevations for 30 April, 31 May, and 30 June are respectively 2417.0 ft, 2434.4 ft, and 2459.0 ft.)*[14]

When residual runoff recedes to about 30 to 35 percent, then the project may be completely filled. As of 0000 hours on 18 April, residual runoff for the April-August runoff period for the Libby catchment is estimated to be 96 percent. The pool elevation at said time is 2407.2 ft. The 01 April 2006 forecast for Libby for April-August is estimated at 6076 KAF, or 97.2 % of normal."

***April 28 System Flood Control Guidance**:*

The system flood control guidance was similar to the April 19 guidance.

"Based on April 2006 final forecasts.
Initial Controlled Flow (ICF) at The Dalles – 359 kcfs
Date ICF Reached – April 30 – based on 25 April 2006 Single Trace Process (STP) unregulated deterministic model."

The guidance for Libby Dam was identical to the April 19 guidance except for the additional language that provided:

"As of 0000 hours on 26 April, residual runoff for the April-August runoff period for the Libby catchment is estimated to be 92 percent. The pool elevation at said time is 2410.1 ft. The 01 April 2006 forecast for Libby for April-August is estimated at 6076 KAF, or 97.2 % or normal."

In summary, the Flood Control Guidance for April indicated that the WSF at Libby Dam was 97% of normal, approximately 92 % of the run-off was still to occur, the calculated end-of-April target elevation was elevation 2417.0 feet, and project releases identified under the VARQ Refill Guidance were 16.4 kcfs to begin April 20.

Application of Guidance and Additional Factors Pertaining to April System Flood Control Operations

- In late April the Columbia River was operated for system flood control as a result of high flows in the lower Snake River. The month average unregulated flow for the lower Snake River at Lower Granite Dam in April was 151% of average. The flood control guidance reported the ICF for the system was 359 kcfs, indicating that when

[14] The Actual Energy Regulation (AER) is developed by the Northwest Power Pool to determine energy rights and obligations for Pacific Northwest Utilities who are signatories of the Pacific Northwest Coordination Agreement (PNCA). From January through July the Corps submits end of month upper limits for northwest reservoirs as input to the monthly hydropower models.

the calculated unregulated flow at The Dalles was forecasted to reach this threshold, the system should be operated in a coordinated manner far enough in advance to approximate a regulated flow of no higher than 359 kcfs at The Dalles.

- Based on the April 19 and 28 guidance for Grand Coulee, the recommended operation was to maintain the reservoir at or below the end of April flood control upper limit of elevation 1229.0 feet, which had been modified to 1233.4 feet.[15]

- Specifically for system flood control purposes, Grand Coulee was to operate to a regulated flow at The Dalles of 359 kcfs. On April 20, RCC requested Reclamation operate Grand Coulee, in accordance with Reclamation's deviation request to target elevation 1233.4 feet by April 30 followed by reaching elevation 1229.0 feet by May 5. This Grand Coulee draft combined with the flow on the lower Snake River was expected not to exceed a regulated flow at The Dalles of 359 kcfs. The operation was coordinated with Reclamation and BPA so that the daily draft of Grand Coulee reservoir was a consideration in meeting the operating objective of flow at The Dalles of 359 kcfs. The coordination discussions between the agencies was limited to the Grand Coulee outflow and daily draft limits, and did not address operations at other headwater dams.

    - Additional inflow to the Grand Coulee reservoir from upstream projects such as Libby, was not advisable because of the likelihood that Grand Coulee would not meet its May 5 flood control target elevation of 1229.0 feet, and because of the increased likelihood this would result in releasing water out of the low level outlets causing high levels of total dissolved gas.[16]

    - Although the system operating strategy was to achieve daily flow at The Dalles of 359 kcfs by appropriate releases from Grand Coulee on a daily basis, actually accomplishing this every day is not realistic. From April 20 to April 30, the regulated flow at The Dalles fluctuated from as low as 282 kcfs on April 23 to as high as 350 kcfs on April 21. The outflow from Grand Coulee fluctuated from a low of 135 kcfs on April 27 to a high of 168 kcfs on April 23. These variations are the result of changing conditions downstream of Grand Coulee and changing conditions on the Snake River. With variable inflow on the lower Snake River and daily maximum draft limitations at Grand Coulee Dam, combined with varying streamflow forecasts, predictably achieving a regulated flow of 359 kcfs is not practicable.

[15] Reclamation made a request on April 14, 2006 to the Corps to operate Grand Coulee reservoir as high as elevation 1233.4 feet at the end of April and draft to elevation 1229.0 feet by May 7. The Corps' Columbia Basin Water Management Division agreed to Reclamation's request to operated Grand Coulee to the higher elevation on April 17, 2006.

[16] When Grand Coulee reservoir elevations are low, a draft of no more than 1.5 feet per day on a rolling daily average is recommended to avoid bank sloughing. During this period in April, Grand Coulee was drafting at a rate that was approaching the daily draft limit, with discharges at or near powerhouse capacity.

- The intended operational strategy for Grand Coulee Dam from April 20 through the end of the month was to draft to elevation 1233.4 feet. However, when Grand Coulee Dam shifted to an operation to meet the ICF at The Dalles, this resulted in Grand Coulee reservoir drafting to elevation 1231.7 feet by April 30. As the system flood control operation continued into early May to control regulated flow at The Dalles, the Grand Coulee reservoir drafted only to elevation 1231.6 feet (2.6 feet above target flood control elevation) by May 7.

Objectives and Factors Influencing Real-time Operational Decisions in April

The upper flood control elevation for Libby Dam at the beginning of April was 2404.2 feet with the expectation that the drawdown period would transition into the refill period sometime in April or early May. The Protocol for the implementation of flow for sturgeon was to be completed by April 14, 2006, which would provide information for regional policy makers to make a recommendation for 2006 sturgeon operations.

Corps policy decision-makers were continuing discussions with the USFWS, BPA, the states of Montana and Idaho, the Kootenai Tribe of Idaho, and the Salish-Kootenai Tribe on the operational strategy for Libby Dam pursuant to the 2006 BiOp and RPA for sturgeon and bull trout. In early April, representatives from the two states and two Tribes collectively indicated they did not support implementation of the powerhouse plus 10,000 cfs operation because this flow would exceed the TDG standard of 110% below Libby Dam. These entities supported flow releases from Libby "stacked" with downstream local tributary inflow to see if successful sturgeon spawning and recruitment could be achieved.

On April 14, the "Kootenai River Ecosystem Function Restoration Flow Plan Implementation Protocol" was completed. The "Purpose" statement of the Protocol included the following:

> The 2006 USFWS BiOp RPA recommends that when environmental conditions are favorable, test releases of powerhouse capacity plus 10,000 cfs be provided during three of the next ten years (2006-2016), and within three of the next four years, if possible. Currently, the means available to provide flows above powerhouse capacity is by using the spillway. However, it is recognized that adequate water supply conditions must be available to provide spill. During the years after three flow treatments have been implemented using spill, or when spill is not achievable, depth may be maximized by "stacking" powerhouse releases with local inflow below Libby Dam.
>
> In order to test depth, two approaches will be considered:
>
> 1. Maximizing depth by providing powerhouse releases in conjunction with peak(s) in low elevation runoff below Libby Dam (low elevation runoff below Libby Dam has generally receded by the last week in

May since sturgeon spawning augmentation operations began in 1991); and

2. Maximizing depth by providing spill from Libby Dam based on the ability to maintain a consistent river temperature of approximately 9°C while radio-tagged female sturgeon expected to spawn during the test period are near or within the braided reach (described in detail below). On average, temperature at Bonners Ferry approaches 9°C in mid-May (Figure 2), but Libby Dam releases have the potential to reduce river temperature by unacceptable increments early in the season.

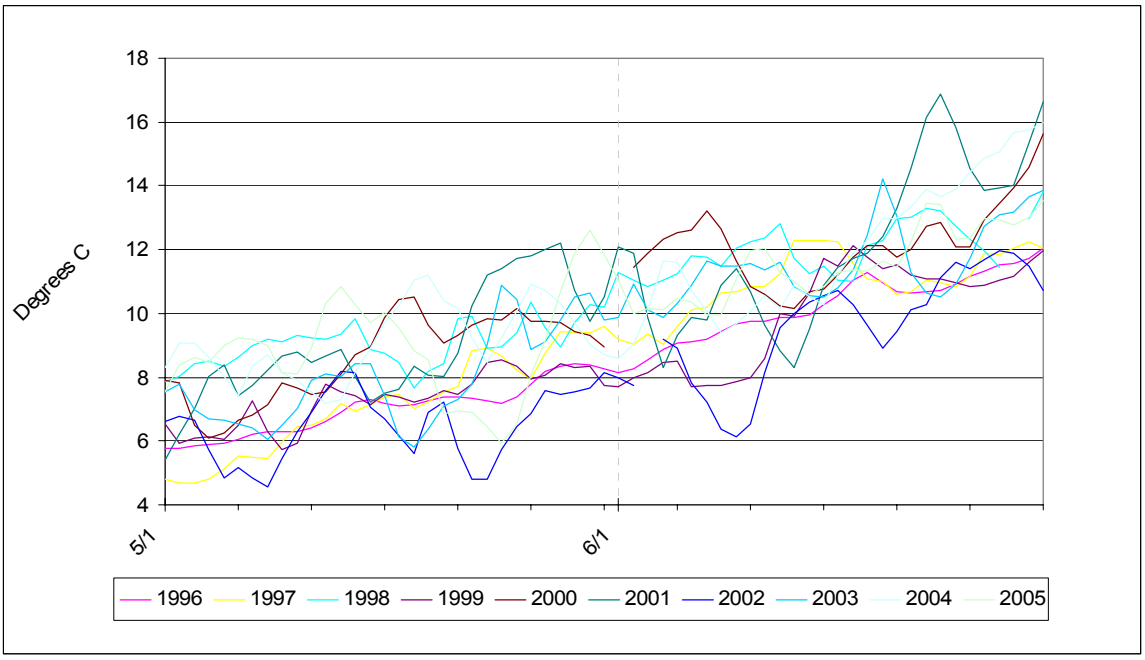


Figure 2. Daily water temperature in the Kootenai River at Bonners Ferry, Idaho, during May and June (1996-2005).

See Protocol, pages 7-8.

As indicated in the Protocol, an important objective for the two sturgeon operations described above: the "stacked flow" operation, and the "powerhouse plus 10,000 cfs" operation, are to attain the habitat attributes of depth, temperature, velocity, where suitable substrate currently exists, i.e. in the braided reach above Bonners Ferry as described in the 2006 USFWS BiOp.

The powerhouse plus 10,000 cfs operation is recommended in Tier III, IV, and V water years, which are near average or normal water years. Based on the April final WSF, 2006 was a Tier III water year, i.e. sturgeon releases of 1.029 MAF from Libby Dam. This was a suitable water year for the powerhouse plus 10,000 cfs operation, which

is typically requested by the USFWS to be in mid-May to mid-June when temperatures are most suitable.

The expected volume releases for sturgeon would be either to shape the flow to full powerhouse for as long as possible, or to release powerhouse plus 10,000 cfs for up to 14 days. At full powerhouse outflow, 1 MAF of sturgeon volume would be exhausted in about 24 days. With the powerhouse plus 10,000 cfs operation in 2006, the 1 MAF sturgeon volume would be exhausted in about 16 days. The powerhouse plus 10,000 cfs operation was intended to begin when flows could be sustained for several days and the water temperature at Bonners Ferry could be sustained near 10 degrees Celsius during the high flow. Historically this occurs between June 1 and 15 and often later.[17]

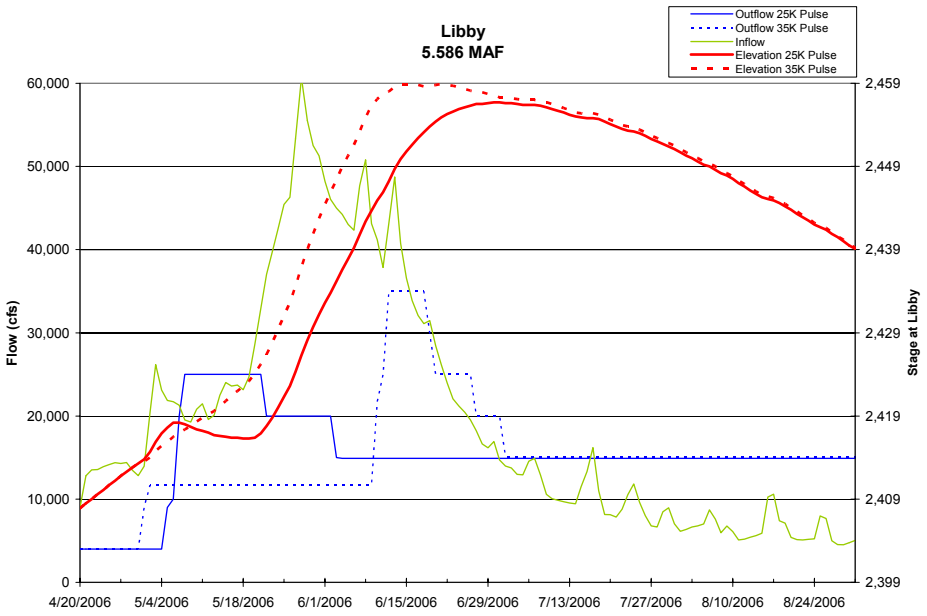
Taking into account the information contained in the April 14 Protocol and the stated positions of the regional States and Tribes, the Corps, BPA and the USFWS discussed options for 2006 Libby Dam operations in late April and early May to ensure compliance with the 2006 BiOp RPA and the Incidental Take Statement. The USFWS position, as described in the 2006 BiOp, was that the powerhouse plus 10,000 cfs operation would provide for the desired habitat attributes; however, taking into account the regional concerns, in mid-April the federal agencies conducted an analysis to assess the viability and likelihood for attaining the habitat attributes with the powerhouse plus 10,000 cfs operation and the alternative stacked flow operation.

For a comparative analysis of the potential stacked flow or powerhouse plus 10,000 cfs operation, on April 20, RCC prepared scenarios as shown below in Figures A, B, and C.[18] RCC used three water supply forecasts: 5.6 MAF, 6.0 MAF, and 6.5 MAF, which represented reasonable error bounds for the forecast. The inflow hydrograph for the larger water year scenario included an early inflow peak.[19]

[17] This late start for sturgeon flow operations and accounting for sturgeon volumes adds to the complexity of planning and operating Libby Dam. The USFWS position is that accounting for the designated "sturgeon volume" begins once a request is made by the USFWS. According to the USFWS, any flow released before the requested sturgeon volume is not considered to be for the benefit of sturgeon, and therefore is not attributed to the designated sturgeon volume. This accounting methodology and the associated uncertainty as to when the USFWS will request the sturgeon volume makes it more difficult to plan Libby Dam operations to meet other objectives, in particular refilling the project by about June 30 (2004 UPA, page 46). An added concern with this approach to accounting is when supplying the sturgeon volume in early to mid-June, the objective of refilling the reservoir while also avoiding a "double peak" difficult. A double peak is the result of a large outflow from Libby Dam for sturgeon (generally ranging up to full powerhouse outflows of approximately 25 kcfs) in late May or June (first peak), followed by a reduced flow (ranging from10 kcfs to 15 kcfs) to refill the reservoir by the end of June or early July, followed by an increased outflow again in July and August for salmon flow augmentation (second peak) drafting to approximately elevation 2439 feet by the end of August.

[18] Inflow information was added to Figures A, B, and C, subsequent to providing to the USFWS on May 4, 2006 for discussion of the sturgeon operation for 2006.

[19] None of these forecast hydrographs included an inflow scenario comparable to what occurred in May and June 2006.


Libby
5.586 MAF
Outflow 25K Pulse
Outflow 35K Pulse
Inflow
Elevation 25K Pulse
Elevation 35K Pulse
Flow (cfs)
Stage at Libby
60,000
50,000
40,000
30,000
20,000
10,000
0
2,459
2,449
2,439
2,429
2,419
2,409
2,399
4/20/2006
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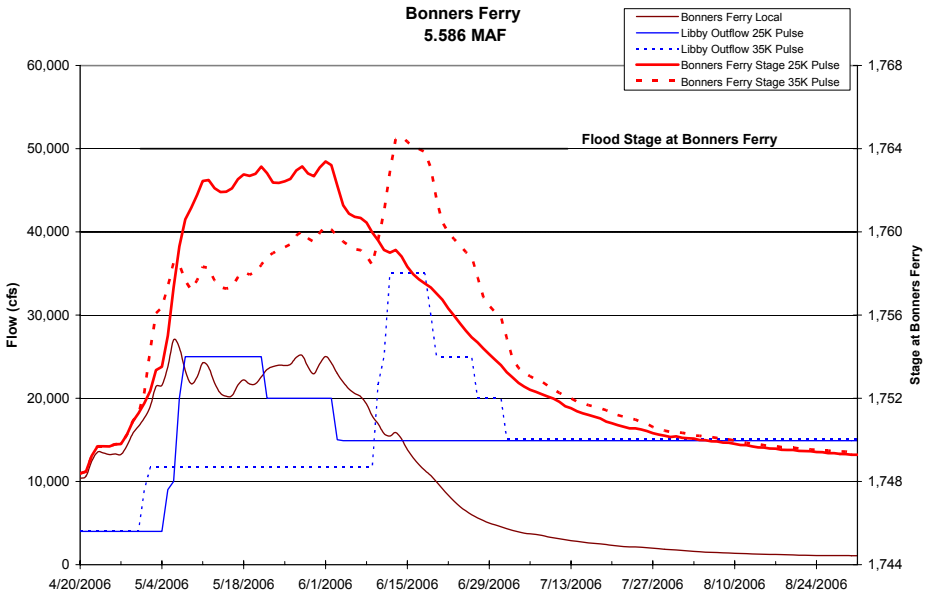
Bonners Ferry
5.586 MAF
Bonners Ferry Local
Libby Outflow 25K Pulse
Libby Outflow 35K Pulse
Bonners Ferry Stage 25K Pulse
Bonners Ferry Stage 35K Pulse
Flood Stage at Bonners Ferry
Flow (cfs)
Stage at Bonners Ferry
60,000
50,000
40,000
30,000
20,000
10,000
0
1,768
1,764
1,760
1,756
1,752
1,748
1,744
4/20/2006
5/4/2006
5/18/2006
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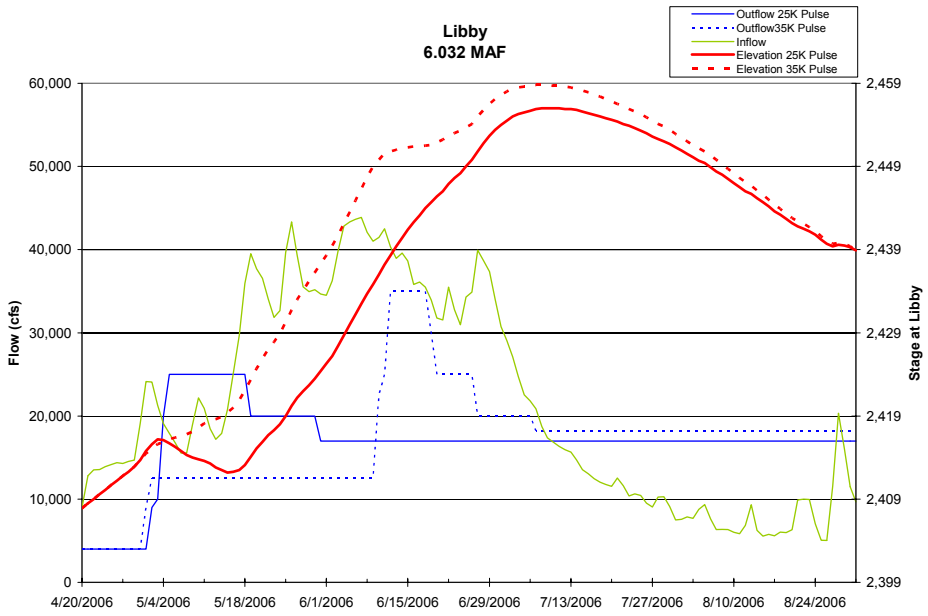
7/27/2006
8/10/2006
8/24/2006

Figure A


Libby
6.032 MAF
Outflow 25K Pulse
Outflow35K Pulse
Inflow
Elevation 25K Pulse
Elevation 35K Pulse
Flow (cfs)
Stage at Libby
60,000
50,000
40,000
30,000
20,000
10,000
0
2,459
2,449
2,439
2,429
2,419
2,409
2,399
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5/4/2006
5/18/2006
6/1/2006
6/15/2006
6/29/2006
7/13/2006
7/27/2006
8/10/2006
8/24/2006

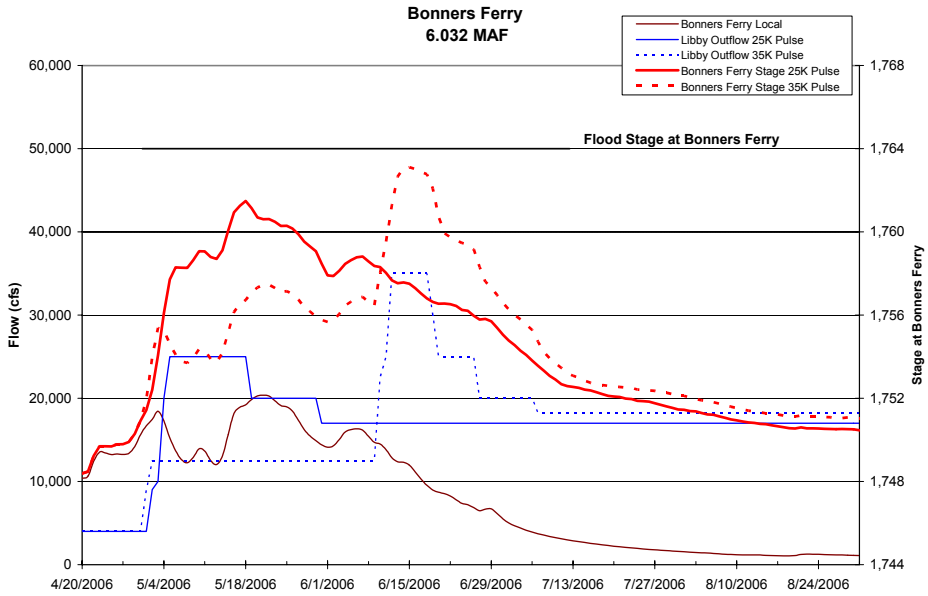
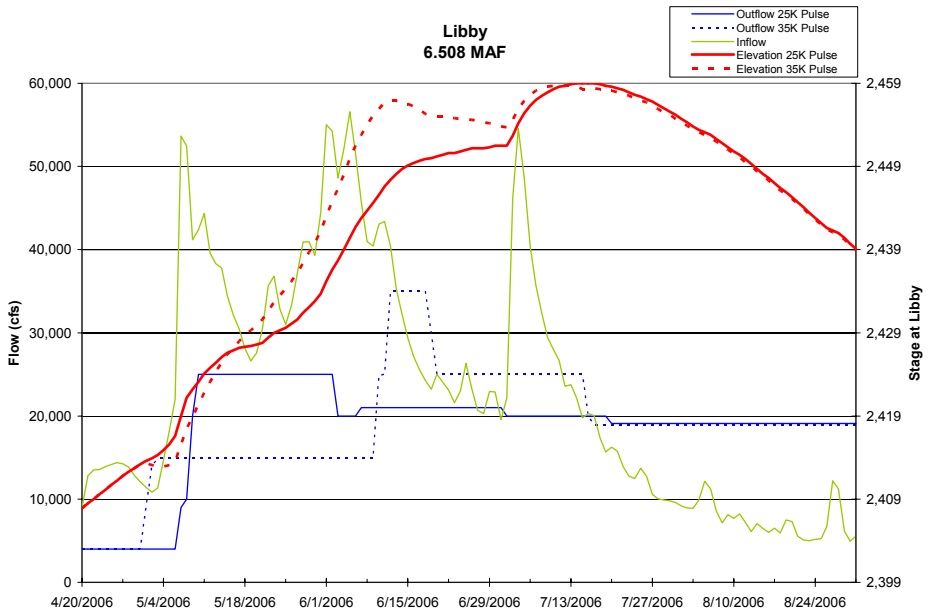

Bonners Ferry
6.032 MAF
Bonners Ferry Local
Libby Outflow 25K Pulse
Libby Outflow 35K Pulse
Bonners Ferry Stage 25K Pulse
Bonners Ferry Stage 35K Pulse
Flood Stage at Bonners Ferry
Flow (cfs)
Stage at Bonners Ferry
60,000
50,000
40,000
30,000
20,000
10,000
0
1,768
1,764
1,760
1,756
1,752
1,748
1,744
4/20/2006
5/4/2006
5/18/2006
6/1/2006
6/15/2006
6/29/2006
7/13/2006
7/27/2006
8/10/2006
8/24/2006

Figure B


Libby
6.508 MAF
Outflow 25K Pulse
Outflow 35K Pulse
Inflow
Elevation 25K Pulse
Elevation 35K Pulse
Flow (cfs)
Stage at Libby
60,000
50,000
40,000
30,000
20,000
10,000
0
2,459
2,449
2,439
2,429
2,419
2,409
2,399
4/20/2006
5/4/2006
5/18/2006
6/1/2006
6/15/2006
6/29/2006
7/13/2006
7/27/2006
8/10/2006
8/24/2006

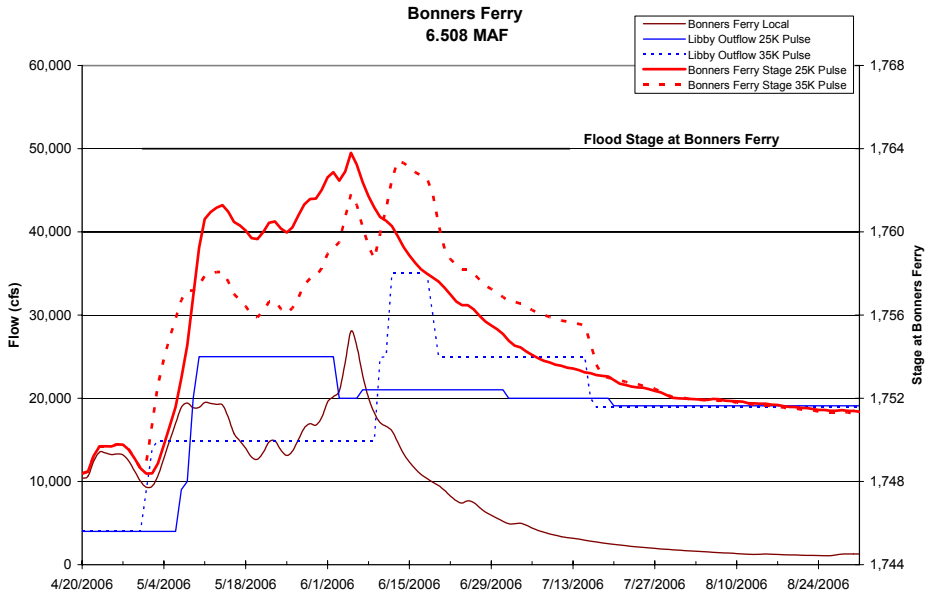

Bonners Ferry
6.508 MAF
Bonners Ferry Local
Libby Outflow 25K Pulse
Libby Outflow 35K Pulse
Bonners Ferry Stage 25K Pulse
Bonners Ferry Stage 35K Pulse
Flood Stage at Bonners Ferry
Flow (cfs)
Stage at Bonners Ferry
60,000
50,000
40,000
30,000
20,000
10,000
0
1,768
1,764
1,760
1,756
1,752
1,748
1,744
4/20/2006
5/4/2006
5/18/2006
6/1/2006
6/15/2006
6/29/2006
7/13/2006
7/27/2006
8/10/2006
8/24/2006

Figure C

This information was used to assist discussions between the Corps, BPA, and the USFWS in determining the efficacy of the stacked flow and powerhouse plus 10,000 cfs operations. Additional analysis was performed in late April (and throughout the refill season).

The RCC uses a variety of tools throughout the season to make assessments on water management operations for the Columbia Basin system and the Kootenai Valley. A tool that is used for the Technical Management Team (TMT)[20] forum is the Ensemble Streamflow Predictor (ESP)[21] inflow for the entire Columbia Basin, which converts the inflow into a monthly time-step. The monthly time-step inflow is applied in the HYSSR[22] model. Using the system-wide ESP HYSSR scenarios allows for a level of analysis of varying water supply volumes and shapes in the monthly time-step. This is used to test the system's ability to meet a variety of objectives for listed species, including streamflow objectives, spill quantity, and reservoir refill.

An ESP HYSSR model output summary was prepared on April 3 for presentation to TMT on April 5.[23] This showed that Libby filled in about three fourths of the years studied, and the projected average outflow from Libby in May and June was less than 20,000 cfs. The output showed little risk of spill from Libby Dam.

Summary of April Operations

The calculated end of April flood control upper limit for Libby Dam, as shown in the Summary of Columbia River Flood Control Data, was 2417 feet. This elevation was targeted for the end of April with the actual elevation on April 30, at elevation 2413.2 feet. At the end of April the residual runoff was approximately 89%. This is derived from the April final WSF of 6076 KAF for the April through August period, minus the 621 KAF runoff in April.

Libby Dam outflows remained at approximately 4,000 cfs during the month. In its evaluation of potential operational outcomes and risk associated with shaping the flows identified in the VARQ Refill Guidance, the Corps used ESP inflow forecasts for

[20] The TMT is a Regional Forum team that is comprised of sovereign representatives invited from Northwest States, Tribes and federal agencies to make recommendations on real-time operations to meet the BiOp objectives.

[21] Ensemble Streamflow Prediction (ESP) forecasts prepared by the RFC are used by RCC as an additional WSF indicator and are used as tool in decision-making for Libby operations. ESP forecasts are developed once each week for the entire Columbia River Basin. The forecast begins with a 10-day single trace deterministic streamflow forecast that includes expected precipitation and temperature on the current snow states and soil moisture content. Beginning on day eleven, 44 historic temperature and precipitation sequences are used to develop 44 potential inflow sequences for the basin. These 44 hydrographs may be averaged to develop a WSF, and individual water sequences may be singled out for use as a potential operational hydrograph for use in decision-making.

[22] HYSSR is a monthly time-step model that is used for system hydropower modeling and can be used as a tool to test outcomes of other system operations. ESP HYSSR differs from other uses of HYSSR in that ESP HYSSR uses unique calculated inflow as developed using ESP rather than using observed historic inflow sequences. As the ESP inflow is updated, ESP HYSSR can be updated.

[23] Additional ESP HYSSR model runs were performed during this period for internal decision-making.

Libby Dam, as shown in Figures A – C, and other tools including the ESP HYSSR model. Given the uncertainty of the timing and magnitude of flows for the 2006 sturgeon operation, and the reservoir refill objective in late June or early July, the Corps determined risk to flood damage reduction to be small in light of the 97.2% of normal WSF and the Libby reservoir elevation was expected to be below the end of the month target elevation.

May

Technical Data Highlights for Real-time Operational Decisions for May

- May final WSF issued on May 4: 6.179 MAF - 98.9% of normal.[24] The ESP forecasts prepared by the RFC on May 10 showed median April - August volume of 6.04 MAF.
- Libby reservoir was at elevation 2413.2 feet on May 1 and continued to release minimum outflow of 4,000 cfs.
- Approximately 82% of anticipated runoff remained at Libby as of May 11.

Flood Control Guidance Provided During the Month of May

May 11 Flood Control Guidance:

The Libby Dam flood control guidance issued by HEB to RCC on May 11 was:

"4. LIB – Guidance can be divided into two components: (1) VARQ and (2) final refill.

(a) VARQ. Release 19.7 kcfs from 09 May to 30 June. The high project release of 19.7 kcfs is needed to maintain space in the reservoir for an extended period of time to address both the volume and time constraints of a snowmelt flood event that may occur during the later portion of the refill season.

(b) Final Refill. RCC regulators should refill the final 20-ft (2439 to 2459 ft) using available tools – including short-term RFS model runs, residual runoff information, FTC curves, etc. General guidance is that when LIB residual runoff recedes to about 30 percent, the project may then be completely filled.

Refill target elevations for 31 May and 30 June based on AER are respectively 2431.8 and 2459.0 ft. Residual runoff through 11 May at 0000 hours is estimated at 81.6% for the period April through August."

[24] Based on the May final water supply forecast prepared by the Corps, the 95% Non-exceedance limit was 7.024 MAF (112.4% of average). This means that statistically there was a 95% confidence that April though August runoff would be less than 7.024 MAF. The May water supply calculation also showed the look-back flood control upper limit for April 30 was elevation 2412.3 feet.

Objectives and Factors Influencing Real-time Operational Decisions in May

In May, operations transition from flood control elevation targets to balancing project refill and flood control.[25] Discussions continued between the USFWS, the Corps, and BPA including analysis of the options for sturgeon flow operations for 2006. On May 4, 2006, the Corps and BPA sent a letter to the USFWS identifying the stacked flow operation as the planned operation. The letter indicated the stacked flow operation was designed to be consistent with the RPA and was more effective in attaining desired depths in the braided reach for longer duration than the powerhouse plus 10,000 cfs operation. The plan was to provide 25,000 cfs for up to two weeks with the objective of timing the start of these releases to coincide with a peak in local run-off freshet below Libby Dam. The Corps indicated it would coordinate with the USFWS and the biologists on the sturgeon recovery team for the recommended start time. The Corps also stated that it would not intentionally exceed elevation 1764 feet at Bonners Ferry.[26] The USFWS responded on May 5, 2006 concurring that the planned stacked flow operation was consistent with the 2006 BiOp RPA and the Incidental Take Statement.

During the late-April and early May period, RCC was monitoring Bonners Ferry stage and water temperatures, and weather and streamflow forecasts. RCC observed an early rise in the stage and water temperatures at Bonners Ferry between April 30 and May 2 - from a low of 1748 feet on April 27 to higher than 1752 feet on May 1. RCC was concerned the peak freshet may have occurred prior to a decision on the sturgeon operation, thus the stacked flow operation would no longer be an effective option. However, the water temperature at Bonners Ferry during this time was only about 41 degrees (5 degrees Celsius), which biologists indicate is too cold for sturgeon spawning. The recommended water temperature for the stacked flow operation was 48 – 50 degrees (9 - 10 degrees Celsius). RCC also examined historic data that represented the local hydrograph from Libby Dam to Bonners Ferry and found that the peak freshet often occurs in early May and generally no later than mid-May.

RCC also used the ESP forecast hydrographs prepared for Libby Dam by the RFC to inform decision-making. The ESP graph shown in Figure D was prepared on May 1. The first ten days included the 10-day temperature and precipitation forecast for sites throughout the Columbia Basin. Figure D shows the forecasts that were prepared for the Kootenai Basin. This forecast tool includes 44 historic temperature and precipitation sequences overlaid on the snow and soil moisture conditions expected on May 11. Note that this forecast did not include an inflow of 77,000 cfs in May, the actual peak inflow in 2006.[27]

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[25] For projects that are operated in accordance with VARQ flood control, the refill period begins 10 days prior to the ICF.

[26] Included in the May 4, 2006 letter was the analyses provided by RCC with 5.6 MAF, 6.0 MAF and 6.5 MAF ESP traces prepared by the RFC. (Figures A, B, and C)

[27] Also note a major event represented in Figure D was a thunderstorm event that occurred around June 25th (1969) with an ESP produced inflow peak as high as 88,000 cfs. This 88,000 cfs peak inflow is not meant to simulate the inflow that was experienced in 1969. This demonstrates that if a thunderstorm event occurred in 2006 with similar magnitude and intensity as occurred in 1969, there may be potential for

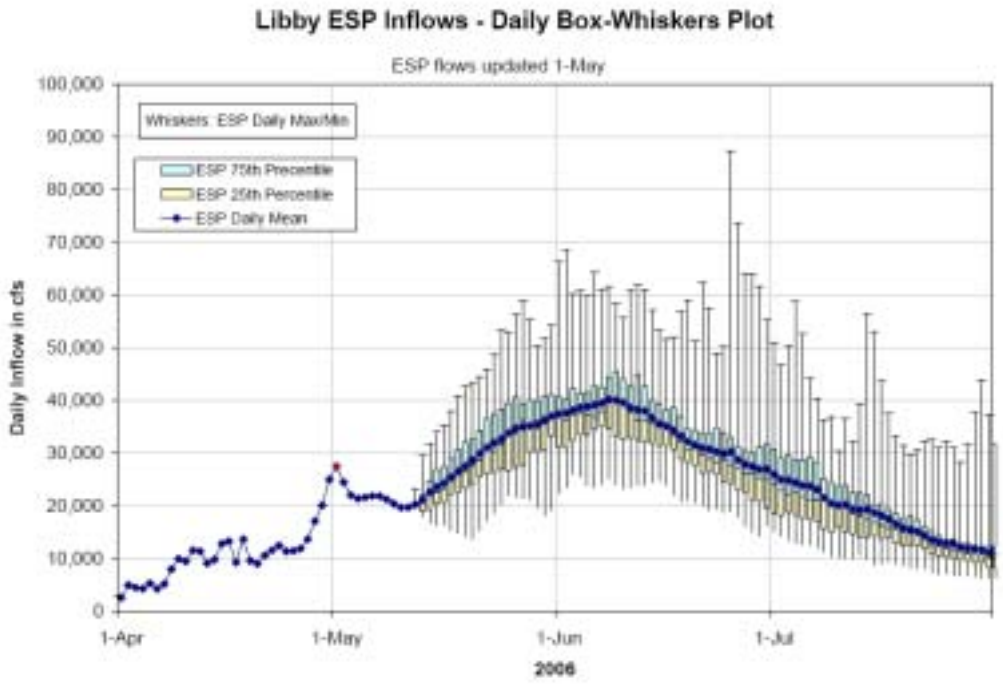

Figure D

For each day in the ESP Box-Whiskers plots:

- 11 days (25%) fall in the whisker above the blue box
- 11 days (25%) fall in the blue box
- 11 days (25%) fall in the yellow box
- 11 days (25%) fall in the whisker below the yellow box
- The tips of the upper and lower whiskers correspond to the value of the highest and lowest flows of the 44 ESP flows for that date.

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inflow of 88,000 cfs in late June. The 1969 weather sequence that simulated a late June inflow of 88,000 cfs also simulated an April through August inflow volume of 7.1 MAF, the third highest volume of the 44 years simulated. In the ESP graph shown, the maximum outflow shown for each day is not necessarily from the same historic weather sequence. The daily maximum flow may be from one year's historic weather sequence one day and from another year's historic weather sequence the next day. There is not necessarily any day-to-day continuity in the maximum, or minimum flows, although there can be (a large event can cause the largest flows to occur on several consecutive days).

- 50% of the flows (22 years) fall within the range represented by the blue and yellow boxes.
- 75% of the flows (33 years) fall within or below the ranges represented in the blue box, yellow box, and the lower whisker.
- 25% of the flows (11 years) fall within the range above the blue box

RCC used the ESP whisker plots for Libby Dam and the ESP HYSSR system analysis in its assessment that continuing with minimum outflows was low risk while the discussions concerning 2006 sturgeon operations were concluding. Information such as the three individual ESP traces shown in Figures A – C and the ESP HYSSR data prepared for presentation to the TMT on May 3[28] indicated a potential that the Libby reservoir may not refill and continuing a minimum outflow operation was considered appropriate to meet all the operating goals for Libby Dam. http://www.nwd-wc.usace.army.mil/tmt/agendas/2006/0503_ESP_HYSSR_003.pdf

Implementation Actions Taken in May

The Corps signed a Record of Consultation and Statement of Decision (ROCASOD) adopting the 2006 USFWS BiOp and RPA on May 8, 2006. This formalized the Corps' decision to implement the 2006 BiOp and specifically the 2006 stacked flow operation for sturgeon. During early May, the RFC short-term streamflow forecasts were updated daily, and long term streamflow forecasts were prepared weekly. RCC monitored the Bonners Ferry water temperatures and local inflows daily to determine the appropriate time to initiate the stacked flow operation, and based on available information, considered increasing to full powerhouse flow beginning on May 8. This start date was posed to the biologists, and they indicated this was too early for a successful test of the stacked flow operation because water temperatures continued to be below the desired range of 48 – 50 degrees. They viewed starting on this date would have been an operation to attain depth only, and would not have achieved all the desired habitat attributes.

Consequently, the RCC conducted additional analysis and monitored conditions to inform the decision for initiating the stacked flow operation. In analyzing the ESP forecast on May 8 (Figure E), RCC expected another slight rise in flow into Libby and the Bonners Ferry area in mid-May, which would be a viable start time for the stacked flow operation because river temperatures would be slightly warmer.

The inflow hydrographs for Libby showed projected inflow of about 25,000 by May 18, which represents a statistical 75% confidence that inflow would be less than 50,000 cfs through June. Based on the May 8th information, RCC's assessment was that it was reasonable to wait for the next expected freshet to initiate the stacked flow operation. Note that neither the May 1 nor the May 8 forecast (Figures D and E) indicated the magnitude of the inflows that actually occurred in May. The actual inflows, 63,000

[28] The ESP HYSSR model output summary prepared for the May 3 presentation to TMT showed that Libby filled in about three fourths of the years studied, and the projected average outflow from Libby in May and June was less than 20,000 cfs. The output showed little risk of spill from Libby Dam.

cfs on May 18 and 77,000 on May 21, were the result of record high temperatures set May 16 through 18, with nighttime temperatures remaining above freezing. This resulted in a rapid and effective melt of the snowpack.[29]

In addition, the May 8 ESP HYSSR results showed Libby reservoir refilled in even fewer years than indicated in the May 3 ESP HYSSR results. RCC was concerned that Libby would meet the Libby summer refill objective for salmon flow augmentation. Taking into account the analysis conducted and described above, RCC determined initiating the stacked flow operation on May 14 would be the most effective in providing for the multiple objectives, including flood control and fish operations.

On May 9, RCC participated in the SRT conference call and notified participants that initiating increased releases on May 14 for the stacked flow operation would be the most advantageous operation to achieve the desired habitat attributes for sturgeon. The participants on the call concurred with the timing of the increased outflow.

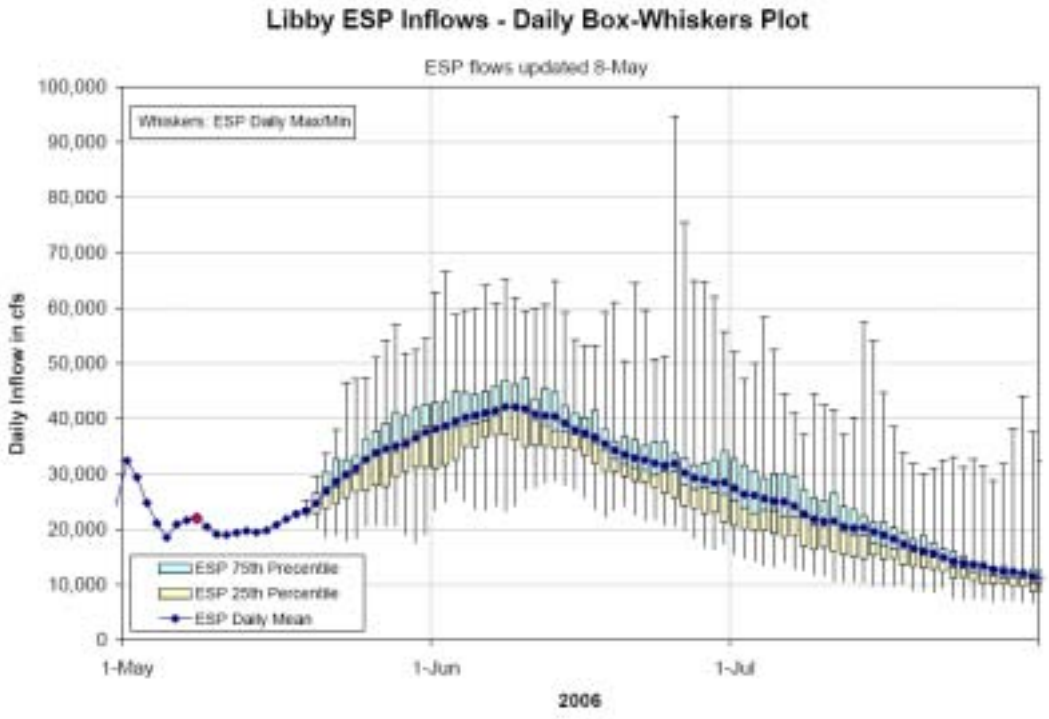

Figure E

On May 10, the Corps, BPA, and the USFWS held a public meeting in Libby, Montana, describing the stacked flow operation scheduled to begin on May 14. The Corps presented the information in Figure F, which was prepared Tuesday May 9, 2006.

[29] The ESP forecasts also did not point to the forthcoming significant June precipitation.

This graph represents forecasted inflow to Libby reservoir of 5.97 MAF from April through August, which updated information prepared earlier in the month (which was based on the Corps' 6.179 MAF WSF).[30] The RFC WSF for May was 6.06 MAF. The RCC looks at the various WSFs and the calculated inflows to Libby reservoir for comparative purposes. During this period they were comparable, indicating an acceptable range of level of forecast error. This graph (Figure F) shows a peak inflow to the Libby reservoir of about 38,000 cfs, whereas the observed peak inflow was 77,000 cfs.

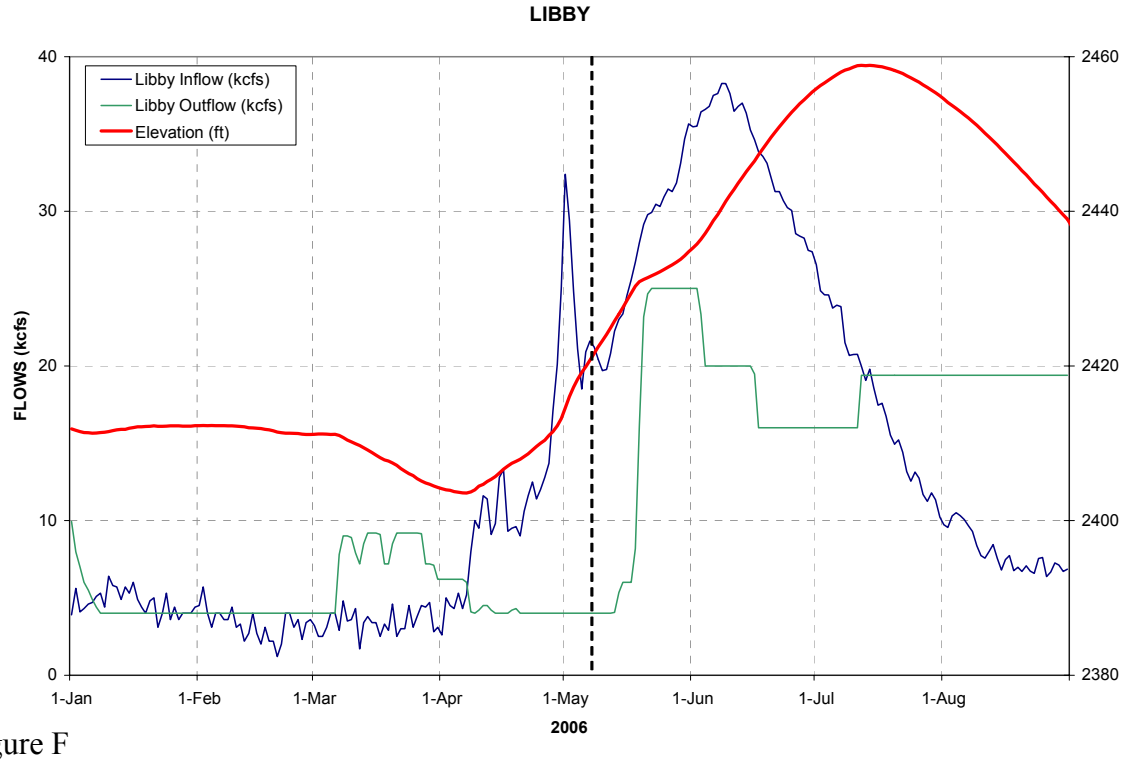

Figure F

The planned stacked flow operation began on May 14 with Libby Dam outflows increasing to full powerhouse capacity (25,000 cfs) by May 17. The VARQ Refill Guidance of 16.4 kcfs in late April, and 19.7 kcfs in early May, was shaped to provide the stacked flow operation to achieve the sturgeon habitat attributes described in the USFWS BiOp, and the summer refill objective for salmon flow augmentation. With full powerhouse flows, the Tier III sturgeon volume of approximately 1.06 MAF based on May's final WSF would have been exhausted by approximately June 10.

By May 18, the stage at Bonners Ferry was slightly above 1762 feet. The Corps initiated an Emergency Management action because of concerns about the condition of the levee in Bonners Ferry near the sewage treatment plant. Rock was placed on May 20-21 to stabilize the area and full powerhouse outflow continued from Libby Dam. On May 20, Corps senior management discussed the status of the emergency rock placement on the levees and reduction of the outflow from Libby Dam for the remainder of the refill season to maintain lower stages at Bonners Ferry. Outflow was not reduced because the

[30] Inflow volumes vary each week.

reservoir was too full to capture the expected residual runoff without significantly increasing the risk of spill.

By May 20, the inflow to Libby reservoir was in excess of 70,000 cfs, which was more than double what was forecasted earlier in the week. The reservoir was filling quickly and maintaining higher outflow was recommended to maintain storage space in the reservoir for the remainder of the runoff season. By May 21, the inflow to Libby had peaked at an unexpected high of 77,000 cfs, and the reservoir filled more than 10 feet to elevation 2437 feet (22 feet from full). The stage at Bonners Ferry on May 21 was as high as 1763.65 feet. Inflow into Libby reservoir during May averaged 38,660 cfs (141% of normal). This is the ninth highest May inflow since 1928.

Libby outflow remained at full powerhouse for the remainder of the month, except for a few days reduction to maintain the stage at Bonners Ferry near elevation 1764 feet. Inflows receded to nearly 30 kcfs as the reservoir continued to fill in May. After the initial flood fight in May, the stage at Bonners Ferry receded to 1759.2 feet on June 7.

Figure G below was developed in late May based on the information available at the time. The graph shows a very large daily peak inflow to Libby Reservoir. That information, combined with the fact that much of the snowpack had melted during the late May record high temperature sequence, indicated that much of the expected runoff had occurred and the inflows for the remainder of the season should be receding. Between 1948 and 1999, there were seven years that had a May inflow peak similar to or greater than the observed 2006 inflow. Of those years, six of them had April – August volumes greater than 7.8 MAF.

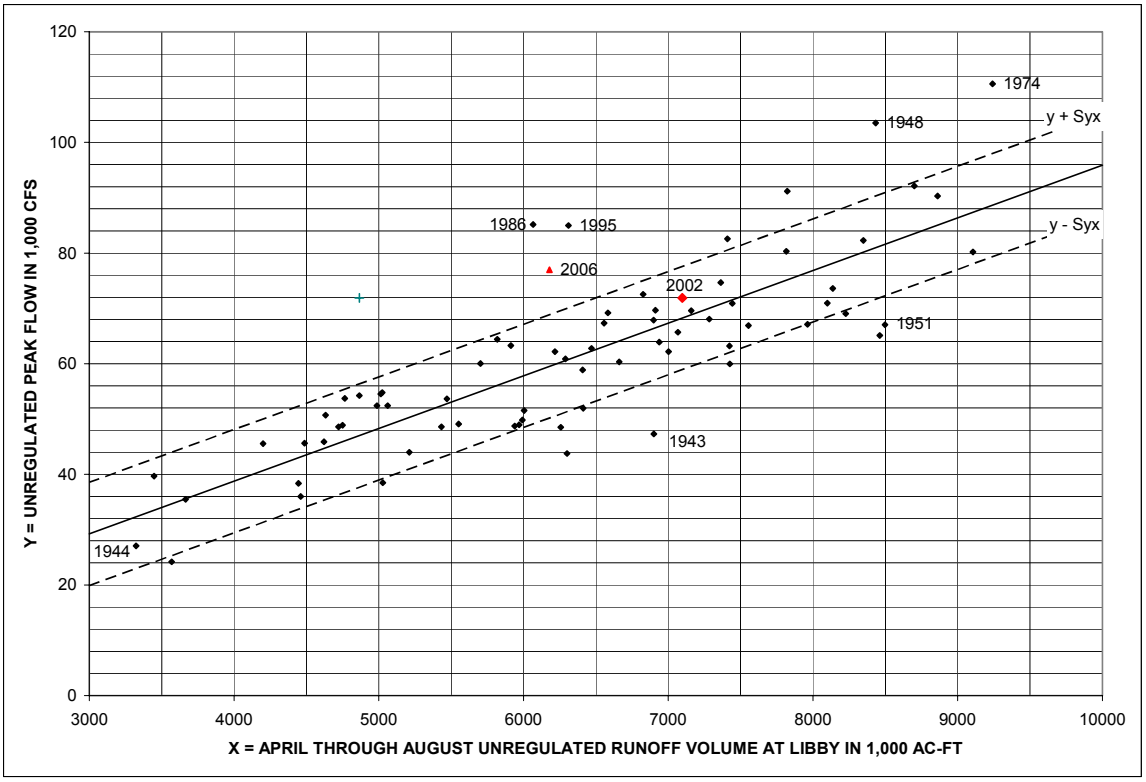

Figure G

In Figure G, the red triangle labeled 2006 is the 6.179 MAF WSF on the X-axis and the 77,000 cfs inflow in May on the Y-axis. This point on the graph demonstrates that the peak May inflow to Libby reservoir was well outside the statistically expected peak inflow based on the WSF. When compared to the historical peak-to-volume relationship for the period of record of 1929-1999 at Libby, the observed peak inflow of 77,000 cfs was high. The solid black line represents the peak inflows (as a function of volume) expected based on the historical record.[31] Thus, with a WSF of 6.18 MAF the expected peak inflow would be approximately 60,000 cfs. Because the observed peak inflow in May was 77,000 cfs, which is in excess of 67% of the peak inflows for a water supply volume of 6.18 MAF, it was assumed that the peak inflow had passed and the remainder of the season would experience lesser inflow.

[31] The dotted lines represent the expected range of peak inflows for a given runoff volume in 2/3 of the historical water years, or 67% confidence limit.

Columbia Basin Snowpack Information:

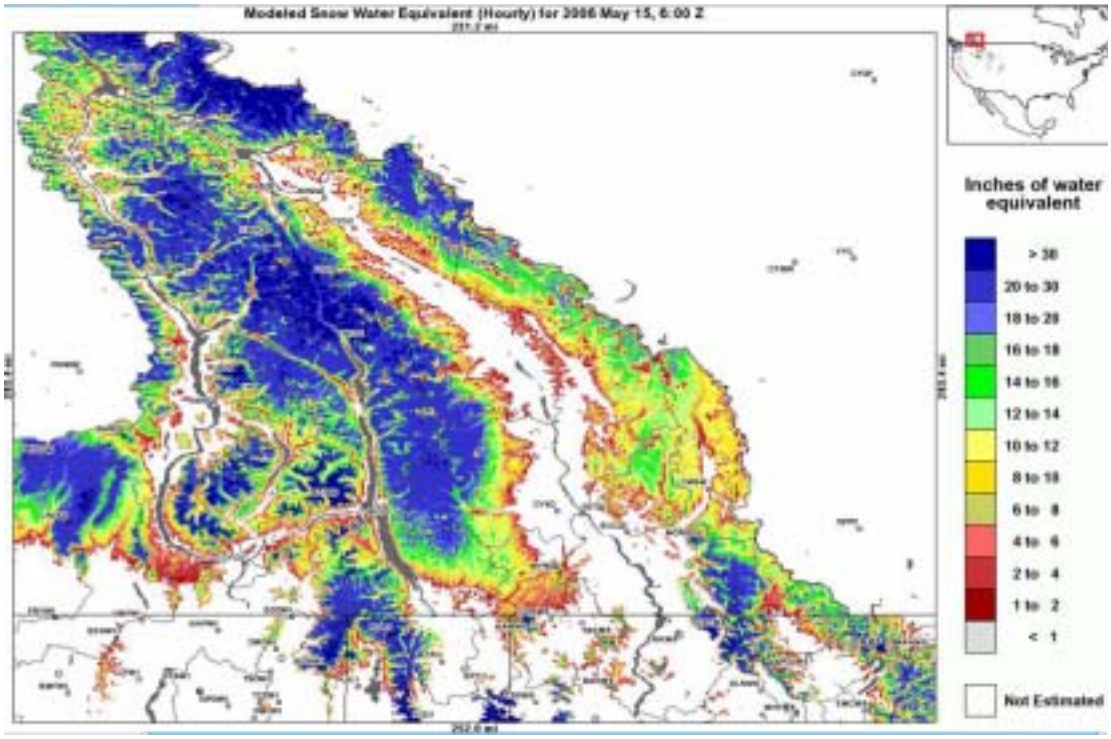

Figure H

Figure H depicts the estimated snow water equivalent in the upper Columbia Basin on May 15. The Kootenai River is shown near the center of the figure. The dark blue areas show snow water equivalent in excess of 30 inches. This figure is representative of the snowpack conditions prior to the record high temperatures in May.

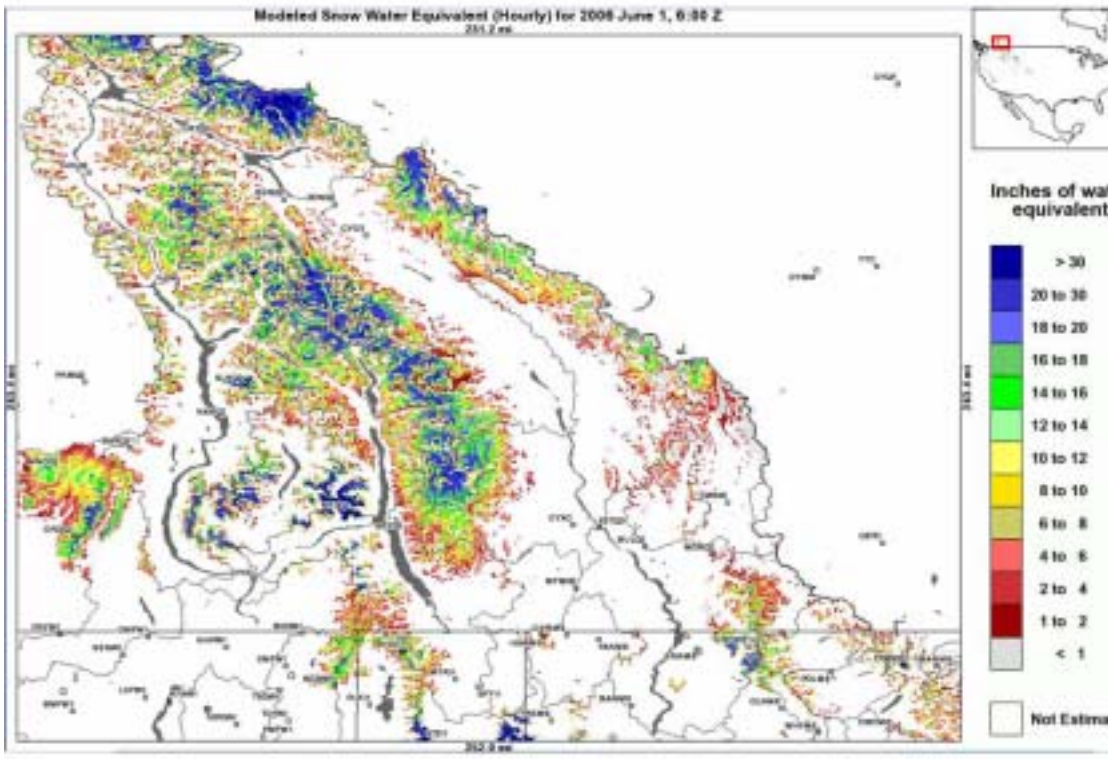

Figure I

Figure I is the estimated snow water equivalent in the upper Columbia Basin on June 1. The area of snow water equivalent in excess of 30 inches has diminished significantly. Most areas had far less than half the snow water equivalent remaining, or no snow because of the melt in late May.

Summary of May Operations

In early May, sturgeon operations were under discussion between the Corps, BPA, and the USFWS resulting in agreement on May 5, 2006 to implement the stacked flow operation. During this period, RCC was monitoring conditions and continued to conduct analyses of weather and streamflow forecasts, Bonners Ferry stage and river temperatures. Flood Control Guidance was issued on May 11, which identified Libby Dam outflows of 19.7 kcfs. As the May final WSF was 98.9% of normal, RCC planned to shape these outflows to meet multiple objectives.

In May, RCC continued assessing the possibility of achieving the various objectives: i.e. providing for flood damage reduction and timing the initiation of the stacked flow operation to achieve the desired habitat attributes for sturgeon, while not compromising the end of June or early July reservoir refill objective. RCC utilized a variety of tools to monitor and assess the risk to meeting the multiple objectives, including the WSF, the ESP forecast hydrographs for Libby Dam and ESP HYSSR system models. Concurrently, the Corps coordinated with regional biologists on sturgeon

and salmon operations. The planned sturgeon operation was presented to the public on May 10, with implementation of the stacked flow operation beginning on May 14.

By May 18, the inflows to the Libby reservoir were increasing to 63,000 cfs and the stage at Bonners Ferry was slightly above 1762 feet. Emergency management actions were initiated to stabilize levees in the Bonners Ferry area on May 20. On May 21, Libby reservoir inflows peaked at 77,000 cfs and the reservoir filled to elevation 2437 feet (22 feet from full). Inflow to the reservoir for the month of May was 38,660 cfs, 141% of average. Bonners Ferry stage on May 21 was as high as 1763.65 feet.

June

Technical Data Highlights for Real-time Operational Decisions

- June final WSF issued on June 5: 6.766 MAF - 108% of normal. This was an increase from the previous WSFs in 2006.[32] The June final WSF of 6.766 MAF was 587 KAF more than the May final WSF of 6.179 MAF. This increase is 132 KAF more than the expected forecast error of 455 KAF for June.
- With high inflows in May due to the loss of the snowpack in BC, the Libby reservoir began June at elevation 2449.8 feet, within nine feet of full leaving only 420 KAF of space available.
- June 2, approximately 54% of the anticipated runoff remained. This residual inflow to Libby Reservoir was updated with a June preliminary WSF of 6.7 MAF. Based on this, the residual inflow would be 3.624 MAF.
- BPA prepares year-round hydro-regulation models. The June 1 BPA model showed that there was no projected spill at Libby in June based on the estimated inflows. The Corps receives the BPA model summaries and uses them as another tool to cross reference for expected operational outcomes.

Objectives and Factors Influencing Real-time Operational Decisions in June

In early June, RCC was monitoring the shape of the inflow runoff into the Libby reservoir. Because of the high inflow to Libby in May and the significant diminishment of snowpack, the expectation was for less than average inflow to Libby in June; and, a recession trend in inflows - also because of the diminished snowpack.[33] The RFC forecast prepared in June was 6.28 MAF - 101% of normal. This forecast was greater than the RFC May forecast and lower than the Corps' June forecast, which was 6.766 MAF. This information indicated to the Corps that maintaining full powerhouse outflows from Libby Dam would soon result in draft of the reservoir. During the first few days of June, there was no indication that spill would be necessary.

[32] The forecast included snow states from May 1 and May 15 at several locations throughout Canada, but all indicators were that the snowpack had significantly depleted in late May as shown in Figures H and I.
[33] Note that in the "Technical Data Highlights," that on June 2, approximately 54% of the anticipated runoff remained. This residual runoff is the expected remaining water supply volume yet to runoff, which is a combination of both snow pack remaining *and* forecasted precipitation through August.

Included in the Corps' June WSF is information on the status of the snowpack. Figure J shows the status of the snow at Morrissey Ridge in B.C. The May 1 snow state for Morrissey Ridge is used in the June 1 WSF. The light blue line labeled current year, shows that the snowpack, which had been slightly above average in early May, was depleted in May during the hot weather. The Corps' WSF calculation uses the snow water equivalent data from this station as measured May 1 and May 15. The snow had depleted during May and would not contribute to the future water supply, indicating that the Corps' final June WSF forecast may be too high.[34] The other snow sites in B.C. also demonstrated that the snow had significantly depleted in May.[35]

Snow Pillow Data 2005-2006

Morrissey Ridge- 2C09QP

Drainage: East Kootenay **Yrs of Record:** 22 **Elevation:** 1 800 m

Latitude: 49° 27' **Longitude:** 114° 58' **Type:** Pillow

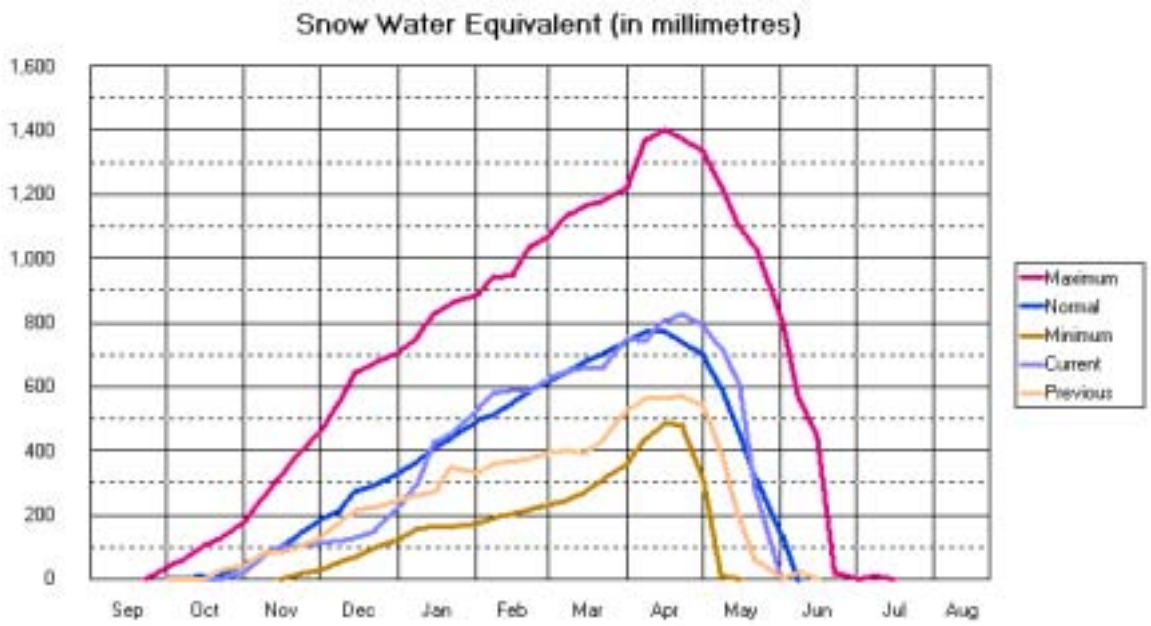

Figure J

Figure K below shows a basin-wide view of snow-water equivalent in early June. It is important to note that nearly all of the low elevation snowpack and much of the high

[34] The Morrissey Ridge snowpack had depleted dramatically and slightly earlier than average in May; using the May 1 and May 15 data in the June forecast seemed to skew the forecast too high.

[35] In addition to the Morrissey Ridge station, other snow stations that are used to calculate the Corps' WSF are East Creek, BC, Hawkins Lake, MT, and Stahl Peak, MT. The two stations within the Libby watershed that are used most often as indicators of snowpack status are Morrissey Ridge and Stahl Peak.

elevation snowpack rapidly melted off during the hot weather event that occurred in late May.

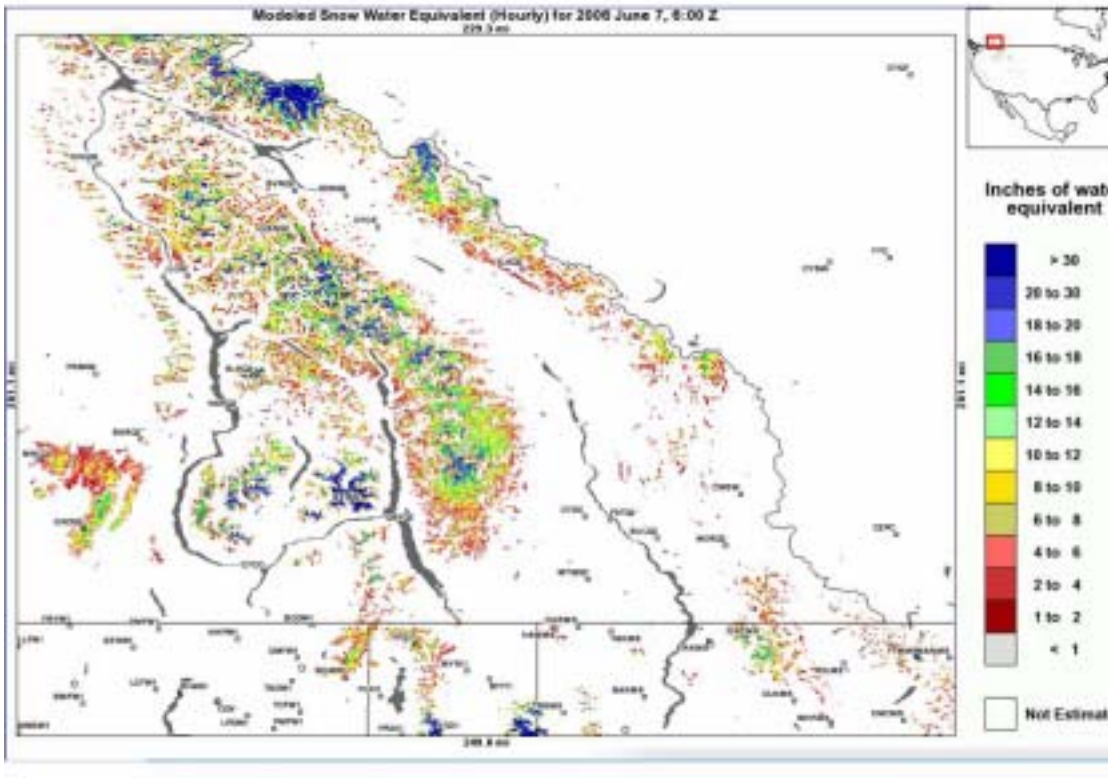

Figure K

By June 2 the residual inflow to Libby Reservoir was updated with a preliminary WSF of 6.7 MAF. Based on that WSF, the residual inflow would be 3.624 MAF (54% remaining). The ESP information prepared on May 30[36] (see Figure L) indicated that Libby reservoir should be able to draft somewhat in June while releasing full powerhouse outflow. The expectation was for a small rise in inflow in early June followed by a recession that would allow for a draft of the reservoir. Because Libby was within 9 feet from full, RCC planned to maintain full powerhouse outflow and draft the reservoir when inflow receded to below full powerhouse outflow. RCC continued to monitor the shape of the runoff, recognizing that if the inflow did not recede, or remain in the 30 kcfs range, spill later in June may become necessary.

[36] Figure L may be compared to Figure D and Figure E to understand the information available progressing through time.

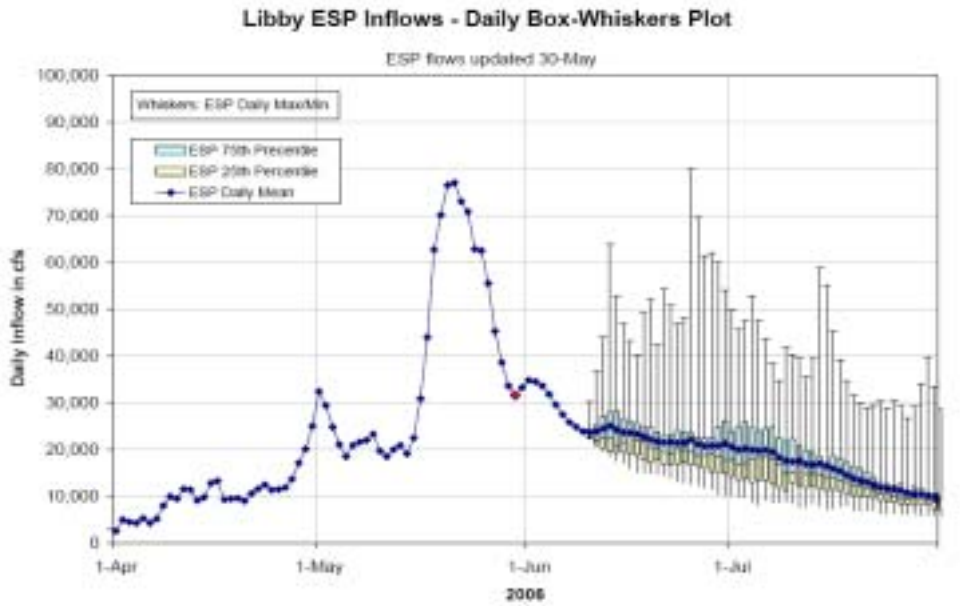

Figure L

By June 7, the inflow to Libby reservoir remained in excess of 40 kcfs and the reservoir had filled to elevation 2454 feet, five feet from full with only about 200 KAF of space available. Based on this information, Corps personnel contacted representatives from the State on Montana and local officials, e.g. the Libby County Commissioners, to coordinate plans to slow the refill by initiating a pre-emptive spill from Libby reservoir beginning on June 10.[37] Figure M shows the daily inflow forecasts (colored lines) provided by the RFC prior to the start of spill operations at Libby Dam, as well as the observed inflow (black line). Note that between June 4 (blue line) and June 7 (maroon line), the forecasts were showing a moderate rise in inflow about June 9 or 10 followed by a general recession.

[37] On June 7 representatives from the Corps discussed with Chris Levine and Bob Bucantis of Montana Department of Environmental Quality (MDEQ), Brian Marotz of Montana Fish Wildlife and Parks (MFW&P), and Bruce Measure, one of Montana's representatives on the Northwest Planning Conservation Council (NPCC) the Corps plan to begin a pre-emptive spill at Libby Dam on June 10.

Libby Inflow Forecasts for 4 - 8 June

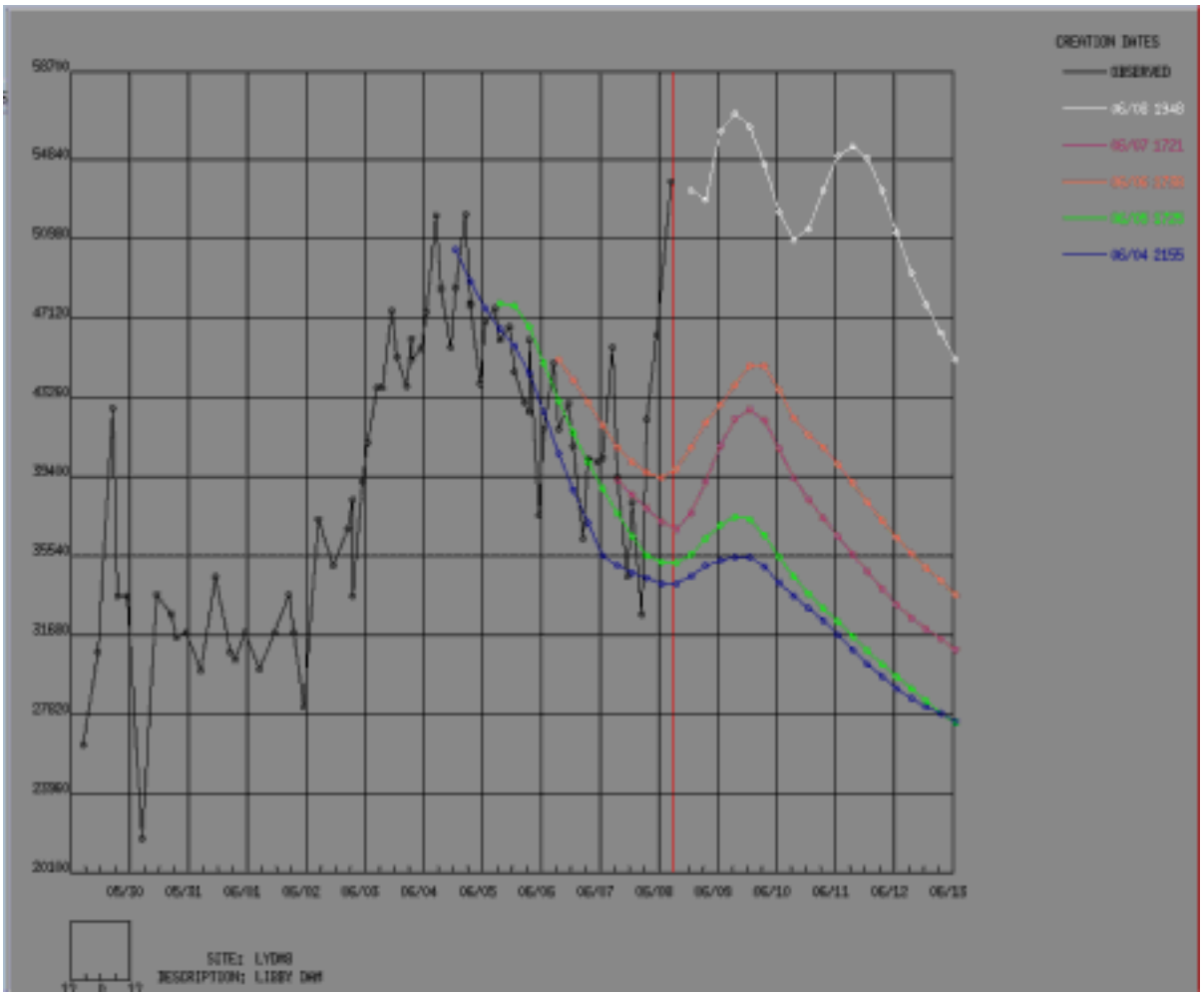

Figure M

On June 7, because of thunderstorm activity in the basin, inflow overnight increased to more than 10 kcfs greater than what was in the forecast prepared earlier in the day. The June 8 forecast (Figure M, white line) included the inflow overnight as a result of the rain activity. The inflow forecasts were now in excess of 50 kcfs. Based on the rain activity and the forecast prepared on June 8, RCC began a spill operation at Libby reaching 8,000 cfs on June 8 at 5:00 p.m.

On June 8, RCC and Libby project personnel contacted officials and the media to notify local citizens that spill of 8, 000 cfs was planned to start later in the day. The following is a list of contacts made by RCC:

- Bonners Ferry radio was contacted via voice mail.
- Mayor Kerby at Bonners Ferry City Hall was notified of the upcoming spill from Libby Dam.[38]
- The Mayor, MDEQ and MFW&P all agreed that notification of changed operation via e mail would meet their needs.[39]
- Mayor Kerby was notified by telephone of the expected increase to 14 kcfs spill on June 9. The spill was increased from 8 kcfs to 14 kcfs at 1:00 p.m. June 9.
- Bruce Measure was contacted on June 9 with a status report.
- Libby local radio and Bonners County officials were notified again on June 9 of expected operation.
- Montana DEQ was notified via e mail as at least daily beginning June 9 and ending June 22. On June 26, an update was sent outlining the final ramp down and end of spill.
- Corps representatives (Cindy Henriksen with Nola Leyde, Mick Shea, and Eric Winters) met with Bonners Ferry elected officials on June 14 in Bonners Ferry.

Spill was maintained at 14 kcfs from June 9 until 1:00 p.m. through June 16 when spill was increased again to 19 kcfs because of a change in the inflow forecast. Figure N shows the inflow projections provided by the RFC each day from June 13 through June 16, prior to increasing spill from 14,000 cfs to over 30,000 cfs. The colored lines show the forecast data while the black line shows the observed inflow. Projections from June 13 (blue line) through June 15 (orange line) showed a continual decrease in inflow. This expected recession started initial plans to begin ramping down spill.

[38] The Sheriff's dispatch at Bonners Ferry City Hall is set up to locate the Mayor and the Emergency Manager, Bob Graham.

[39] Mayor Kerby requested RCC provide information to him that was planned to be given to the radio stations. RCC agreed to send a daily e-mail (or as needed) that would likely be shared with radio stations. Although radio contact was minimal, daily reports were sent to Boundary County and Montana representatives.

Libby Inflow Forecasts for 13 – 16 June

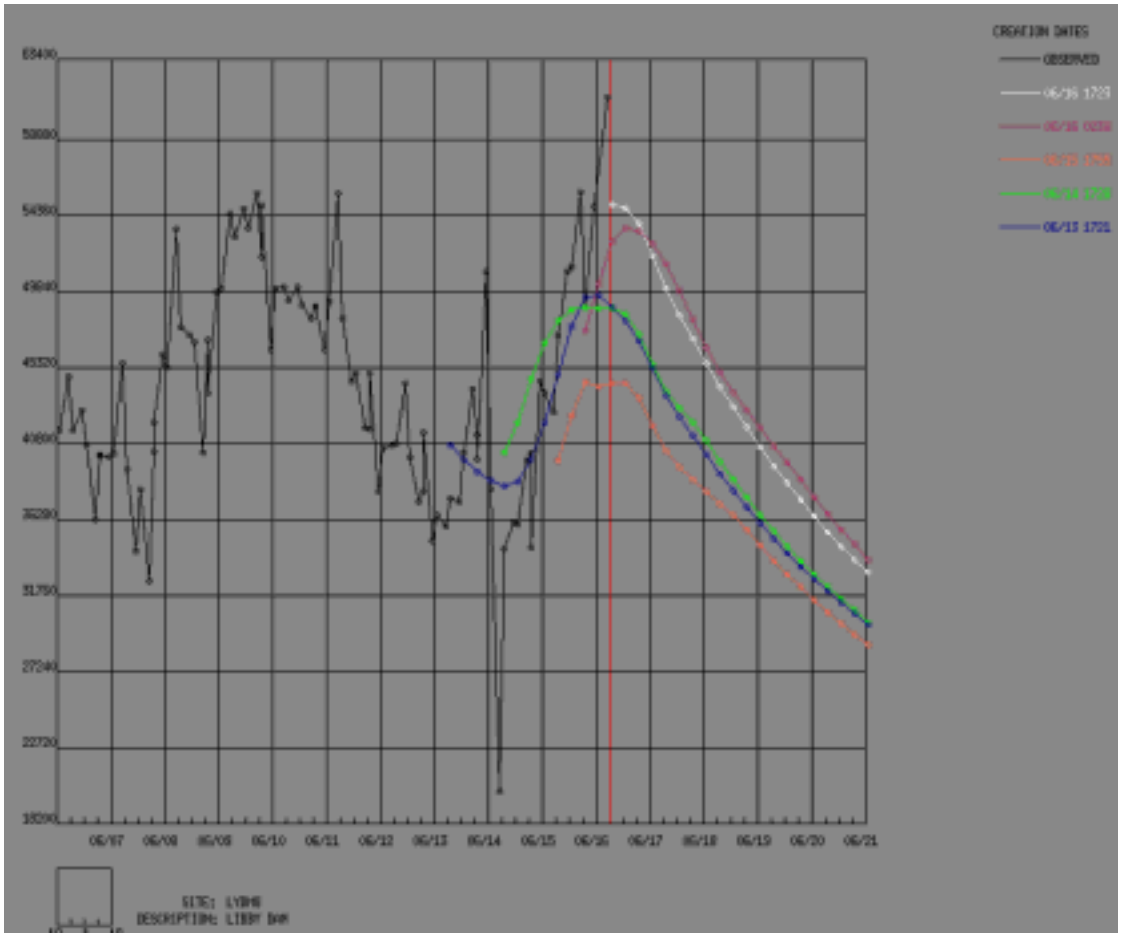

Figure N

During the day on June 15, the observed inflow continued to increase well beyond what was forecasted for that day. On June 16 the observed inflow was nearly 10,000 cfs higher than previously expected, prompting an additional increase in spill volume. During the night of June 16 through the morning of June 17, inflow to Libby reservoir was greater than expected because of thunderstorm activity in the basin upstream of Libby. During the night, the project worked with RCC to determine spill quantities to respond to the changing inflow. The reservoir was nearly full and inflow was being monitored hourly. By 10:00 a.m. the spill was increased to 31 kcfs for a total outflow from the dam of 55 kcfs. Libby elevation was above normal full reservoir elevation, or 2459 feet, for approximately 34 hours. The maximum elevation was about 0.13 feet above full.

The stage at Bonners Ferry ultimately peaked at 1766.6 feet on June 18 about 5:00 p.m. The stage returned to flood stage of 1764 at Bonners Ferry on June22, aroung 4:00 p.m. By noon on June 20 outflow from Libby was being reduced incrementally to avoid rapid dewatering of the levee embankments and minimize sloughing of levees

downstream. Spill quantities of 2 kcfs and 1.5 kcfs were released on June 27 to better measure TDG at lower levels. Spill stopped on June 27 at noon.

Summary of June Operations

In early June, RCC continued monitoring conditions such as Libby reservoir inflows using the ESP hydrographs, and releasing full powerhouse flows consistent with the "stacked flow" operation for sturgeon. Continuing high inflows and reservoir filling necessitated discussions on June 5 with local and state officials about initiating a pre-emptive spill with the objective of slowing refill to maintain adequate storage space in the reservoir. On June 7, significant thunderstorm activity resulted in inflows greater than 10 kcfs over levels projected earlier in the day. Consequently, on June 8, RCC contacted local officials to apprise them of current conditions, and that 8,000 cfs spill would start later in the day on June 8. Spill levels were increased as inflows and reservoir levels continued to rise from June 9 to June 17. Spill levels peaked at 31,000 cfs with a total release from Libby Dam of 55,000 cfs as the reservoir filled to above elevation 2459.0 feet for approximately 34 hours. Emergency management actions continued throughout this period. River stage at Bonners Ferry peaked at elevation 1766.6 feet on June 18th. By June 20th, inflows and river stage levels began to recede, and spill levels were reduced slowly to minimize sloughing of levee embankments downstream. Spill was stopped on June 27th. June observed inflow to Libby Dam was 39,612, 108% of normal for the 30 year period from 1971-2000.

July

Technical Data Highlights for Real-time Operational Decisions

- The RFC July WSF was 7.10 MAF, 114% of normal.
- Average July inflow was 14,141 cfs, 69% of average. The first half of July the average inflow was approximately 18 kcfs, and the last half of the month the inflow was about 10 kcfs.
- Salmon flows were initiated in early July after regional discussions.

Objectives and Factors Influencing Real-time Operational Decisions in July

Once spill ended on June 27, the next operational objective for Libby Dam was to release a somewhat steady outflow for the remainder of July and August so that the reservoir would draft to elevation 2439 feet by August 31, to contribute to the salmon flow augmentation objectives. The dam released full powerhouse outflow for the last few days of June and the reservoir ended June at elevation 2456.73 feet, 2.27 feet from full.

In July the outflow was set at 19,000 cfs to begin the twenty foot draft for summer flow augmentation for salmon. The inflow to the dam receded quickly and the outflow was adjusted several times in early July. By July 8, the outflow from Libby Dam was 17,000 cfs, which was intended to target the 20 foot reservoir draft by the end of August. Ultimately the inflow in July was only 69% of average and inflow receded quickly across the month. The Corps did not want to draft the reservoir too quickly in July and then have to reduce outflows in August to achieve the end of August elevation of 2439 feet. The strategy through early and mid-July was to provide a steady outflow through the summer period for salmon flow augmentation. By late July the outflow was reduced again as the region agreed to implement a steady outflow from Libby. The operation changed to releasing full load on three units, about 13,900 cfs outflow, from July 26 through the end of August, which would not draft the full twenty feet from the reservoir by the end of August. The observed inflow to Libby Dam in August was 68% of average and the reservoir ended August at elevation 2443.26 feet, 15.74 feet from full.

Overall Summary of 2006 Water Management Operations

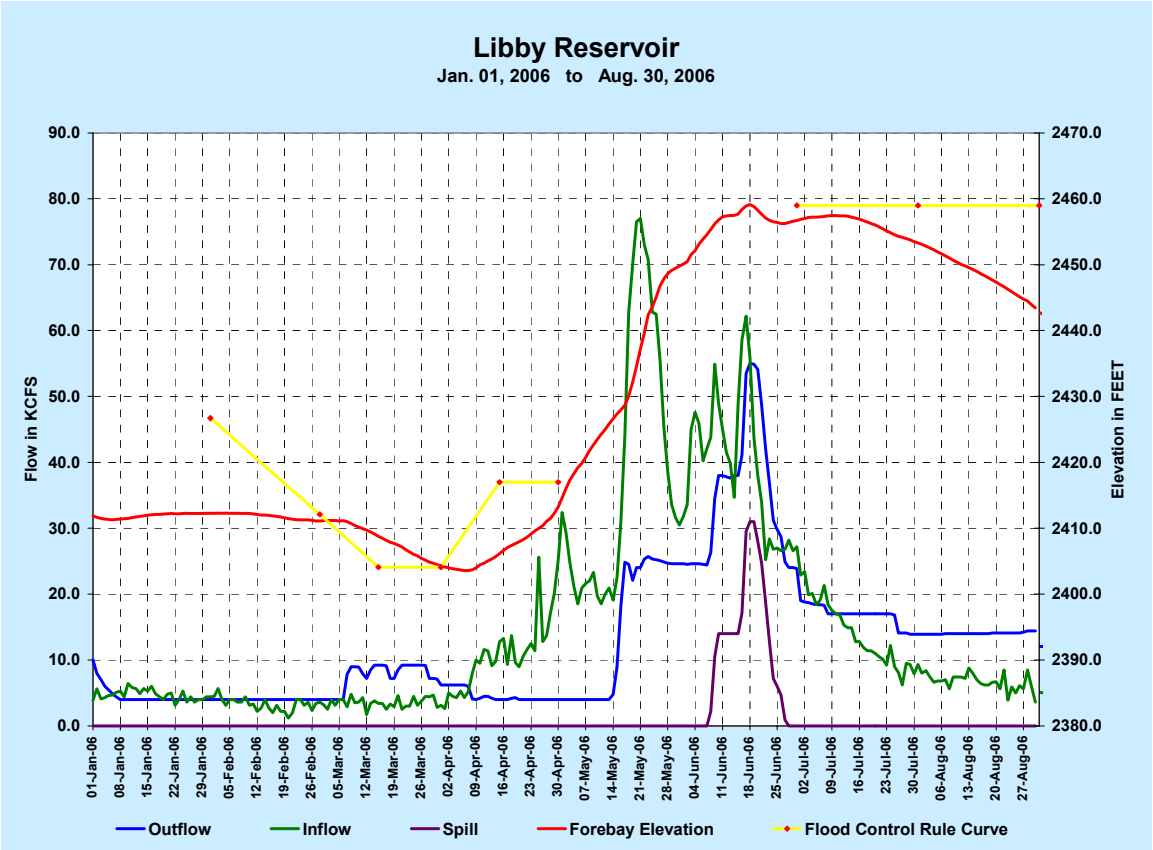

Figure O

Figure O shows the operation of Libby during the January through August period in 2006. The observed volume runoff for the April through August period was 6.62 MAF, 106% of average, but the shape of the inflow into Libby Dam was concentrated with a peak in mid-May followed by another peak in early June. The Figure shows Libby Dam releases at minimum flows from early April through mid-May and then Libby releases were increased to provide for the stacked flow operation. Once releases were increased to full powerhouse outflow in mid-May, high inflows resulted in the reservoir filling to within nine feet of full by the end of May. Figure O also shows the secondary peak inflow in mid-June associated with the rain events. This led to the initiation of spill as the reservoir filled resulting in peak outflows of 55 kcfs from Libby Dam on June 18. Spill levels were gradually reduced until spill ended on June 27. The figure shows the reductions in outflows that continued until salmon flow augmentation started in early July. A steady release of salmon flows in the July through August period resulted in Libby reservoir ending at elevation 2443 feet at the end of August.

Technical Data Highlights

- The observed runoff volume from April through July was 6.2 MAF, 110% of average. This volume is less than the highest volume chosen for Figure C, but the shape of the inflow was concentrated into May and June.
- The observed runoff volume from May 16 through June was 4 MAF, more than 60% of the observed April through August inflow.
- The observed runoff volume from for the April through August period was 6.628 MAF, 106% of average, slightly higher than the largest volume shown in Figure C.
- Between 1948 and 1999, there were seven years that had a May inflow peak similar or greater than the observed in 2006. Of those years, six of them had April – August volumes greater than 7.8 MAF.
- Between 1948 and 1999, the 2006 water year (April – August) had the highest May 16 – June 30 volume when compared to years of similar volume. During the above time period, those years averaged 3482 KAF while in 2006 the volume was 4055 KAF. Close to 570 KAF of water in excess of average entered Lake Koocanusa during late May and June when compared to years of similar April – August volume.
- Some information of note (but not available while the event was unfolding) is that the precipitation gauge at Libby Dam recorded 4.98 inches in June, or 266% of normal.
- Based on the Western Regional Climate Center data, mean June precipitation for Libby for 1986-2006, is 2.29 inches, with a standard deviation of 1.59. This means that 2006 June precipitation was 217% of average, and about 1.7 standard deviations from the mean. This represents about the 90th percentile for June precipitation.