U.S. Army Corps
of Engineers
Seattle District

Flow Plan Implementation Protocol Technical Team

SUMMARY
of
2023 VarQ and Temperature Operations at Libby Dam

and

Recommended Next Steps

March 31, 2024

U.S. Army Corps of Engineers
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Introduction

This is the eighteenth annual Flow Plan Implementation Protocol (FPIP) report required by both the 2006 and 2020 U.S. Fish and Wildlife Service (Service) Biological Opinions (BiOp) on the effects of the operation and maintenance of Libby Dam on the Kootenai River white sturgeon (sturgeon), the sturgeon's designated critical habitat, and bull trout. The FPIP Team, composed of biologists and water managers from the Corps and Bonneville Power Administration (BPA; together, the Action Agencies), the Service, Kootenai Tribe of Idaho (KTOI), Idaho Department of Fish and Game (IDFG), Montana Fish, Wildlife & Parks (FWP), and British Columbia Ministry of Water, Land and Resource Stewardship (BCWLRS) was established in the 2006 BiOp and required the Action Agencies to convene sturgeon biologists and water managers in the Kootenai River basin to implement the experimental Kootenai River Ecosystem Function Restoration Flow Plan (2005), which was part of the Action Agencies' Proposed Action for the 2006 BiOp. The 2006 BiOp created the FPIP Technical Team and framework for flow planning. The FPIP and process was carried forward from the 2006 BiOp to the 2020 BiOp due to its effectiveness, and has allowed testing of various flow strategies and scenarios at Libby Dam to execute the discharge of prescribed "sturgeon volumes" during the spring spawning season based on reservoir inflow forecasting. The annual operations have led to adaptive management of flows towards ecological objectives that support sturgeon spawning and rearing while also supporting research needs that have informed habitat modifications in the upriver spawning reach and the downriver rearing reach, as well as informing the research needs of KTOI's conservation aquaculture program.

This year's report is also adaptive, in that in addition to summarizing the 2023 spring operation, it summarizes the potential to expand flow planning for sturgeon spawning and rearing to a flow planning process that considers additional ecological objectives both upstream and downstream of Libby Dam, including objectives for listed bull trout. Water Year 2023 was the first since 2001 that the final May Koocanusa Water Supply Forecast (WSF) was lower than the threshold for delivery of a dedicated sturgeon volume (4.8 Million Acre-Feet; MAF; Tier 1) from Libby Dam. In the absence of a dedicated sturgeon volume, the Action Agencies continued implantation of the Variable Flow (VarQ) reservoir refill strategy through May and June, and controlled reservoir refill with shaped discharge, described below. This ability to shape discharge in the absence of a sturgeon volume generated discussion regarding the ability to model an entire season (April through September) - using multiple ecological objectives up and downstream of the dam - rather than focusing on the discharge of an exact volume of water based on inflow forecasting. These concepts are presented in this report.

In addition, this report includes an attachment entitled "Comparing Alternative Accounting Method for Sturgeon Flow Volume Tiers", which is the Action Agencies submittal to the Service in response to Term and Condition 17.1.3 of the 2020 BiOp. The report evaluates the impacts of an alternative accounting method for sturgeon flow volume tiers at Libby Dam for the benefit of Kootenai River white sturgeon, and compares the "current" method to an "alternative" method during a recent representative dry (Tier 2; 2019) and a wet year (Tier 3; 2022). The report analyzes the differences in operations within existing local and system Flood Risk Management (FRM) procedures. The alternative method resulted in delayed and decreased Koocanusa Reservoir refill in both the dry and wet years. The results of this analysis lend further support to modeling expanded ecological flow planning.

1. <u>Water Year 2023 Libby Dam VarQ Operations</u>

Monthly precipitation in the Kootenai basin through the fall, winter, and spring (October – June) of Water Year (WY) 2023 trended from normal to well-below normal through the winter. As a result, the monthly April-through-August WSF for Koocanusa Reservoir steadily declined through May (**Figure 1**).

The initial controlled flow (ICF) for the Dalles, Oregon, was calculated as 261,000 cubic feet per second (cfs) in the Declaration of Initiation of System Refill report issued by the Corps' Northwest Division Office on 27 April, which set the start of refill of Koocanusa Reservoir for 01 May. The final May WSF for Koocanusa Reservoir was 4.41 million acre-feet (MAF), or **72% of average**, with a corresponding initial Variable Flow (VarQ) Flood Risk Management (FRM) flow of 4,000 cfs.

Prior to issuance of the May WSF - in preparation for a potential Tier 2 sturgeon operation - the FPIP Technical Team reviewed and discussed operational scenarios to achieve the now-routine ecological objectives for sturgeon spawning and recruitment of **1) providing river stage at Bonners Ferry of ≥ 1,760.00-ft**+ Mean Sea Level (MSL; flood stage at Bonners Ferry is 1,764.0-ft MSL) for as many days as possible during the peak of the local tributary discharge downstream of Libby Dam, and **2) providing flows at Bonners Ferry of ≥30,000 cfs** for a duration concurrent with maximizing the duration of Kootenai River stage.

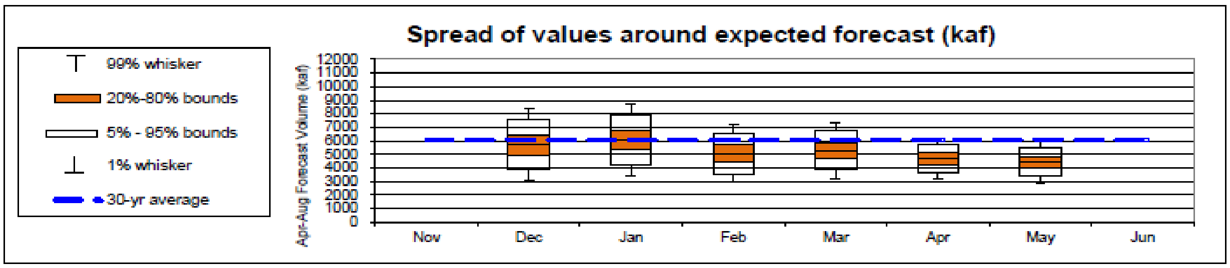
However, as indicated previously, the final May WSF - which dictates sturgeon tier volume, bull trout minimum flow, and end-of-September Koocanusa Reservoir target elevation - was 4.41 MAF, a **Tier 1** Sturgeon Tier with <u>**no**</u> associated sturgeon volume (**Figure 2**). With no sturgeon volume to execute, the Action Agencies (USACE and BPA) operated Libby Dam to control and achieve refill of Koocanusa Reservoir while targeting the required end-of-September reservoir elevation for the corresponding WSF. Given the lower-than-normal end-of-September drawdown elevation of 2,439.00-ft MSL, the resulting **Libby Dam outflows were able to be shaped to provide stable summer river flows that exceeded the minimum bull trout flow requirement of 6,000 cfs for a Tier 1 year, while avoiding a "double peak" operation** (i.e., increasing flows to achieve exact reservoir elevation, followed by a flow reduction once it is achieved). Flow and stage objectives in the lower Kootenai River were partially met as described above. Kootenai River flow at Bonners Ferry was ≥**30,000 cfs for 7 days**, and river stage was **≥ 1,760.00-ft MSL for 0 days** (**Figure 3**). River stage during the spring freshet is strongly influenced by local tributary discharge downstream of Libby Dam, as well as the elevation of Kootenay Lake (**Figure 4**), which is managed for flood risk reduction in compliance with the 1938 International Joint Commission (IJC) Rule Curve (**Figure 4, inset**).

Libby : May Runoff Forecast & Flood Risk Management Calculation **WY 2023**

Runoff Forecast	May	1991-2020 Average	1991 - 2020 Percent of Average	1929-2020 Average	1929 - 2020 Percent of Average
Most Probable Runoff Volume: Apr-Aug (kaf)	4408	6080	72%	6259	70%
Most Probable Runoff Volume: Apr-Jul (kaf)	4028	5570	72%	5708	71%
Most Probable Runoff Volume: May-Jul (kaf)	3732	5014	74%	5183	72%

Forecast/Reservoir Data	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Apr-Aug Runoff Forecast (kaf)		5692	6063	5075	5302	4698	4408	
First-of-Month Elev (ft)	2448.0	2435.9	2419.3	2409.0	2405.7	2402.4	2403.8	

Seasonal FRM Requirements	30-Nov	31-Dec	31-Jan	28-Feb	31-Mar	30-Apr		
Flood Risk Management Space (kaf)	500	1689	2054	1680	1823	1422		
Flood Risk Management Elevation (ft)	2448.0	2419.3	2409.5	2419.6	2415.8	2426.1		



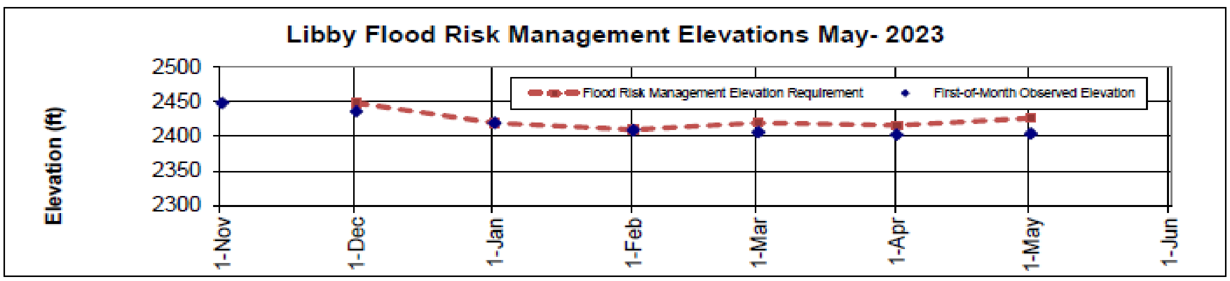


Figure 1. Final May 2023 WSF for Koocanusa Reservoir.

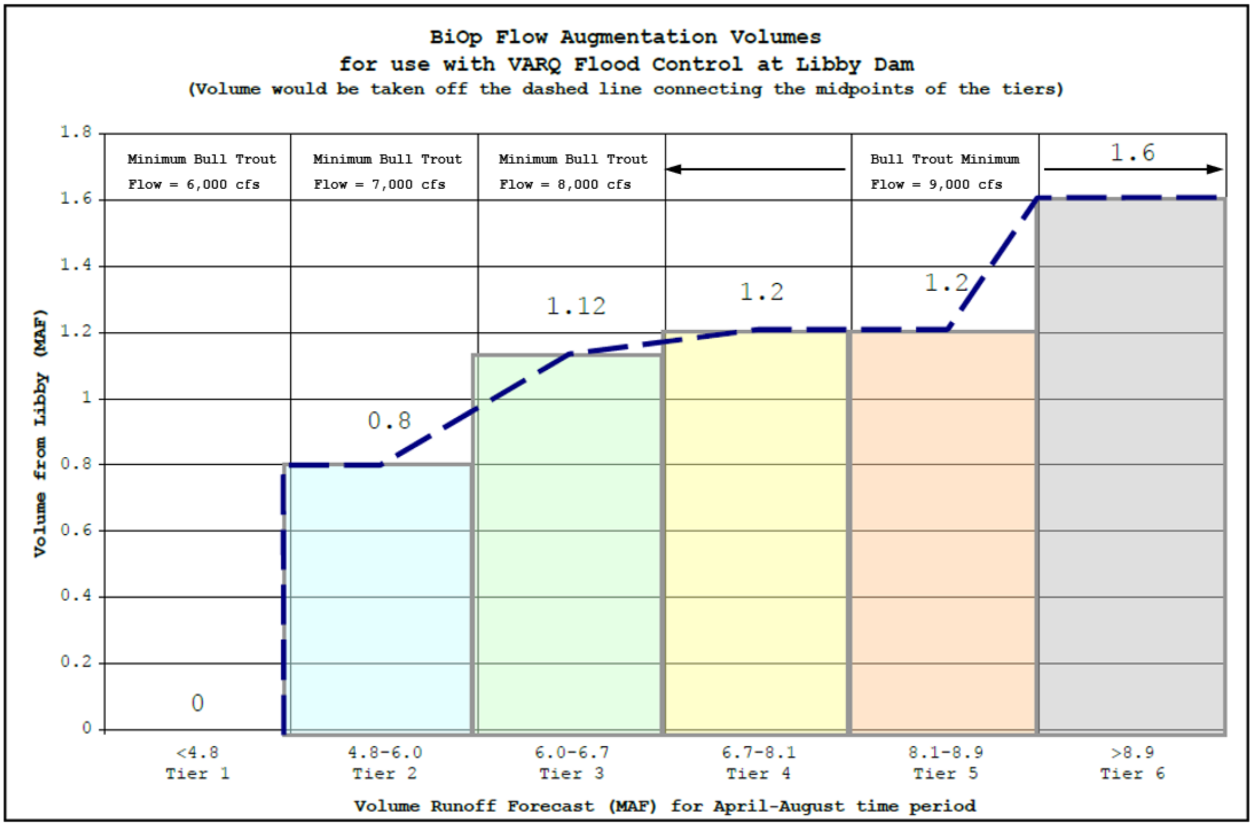


Figure 2. Kootenai River white sturgeon tiered volumes and minimum bull trout flows, as determined by the Corps' May WSF forecast. The sturgeon volume is released on a sliding scale and is interpolated within ranges, as shown, based on the actual volume of the WSF.

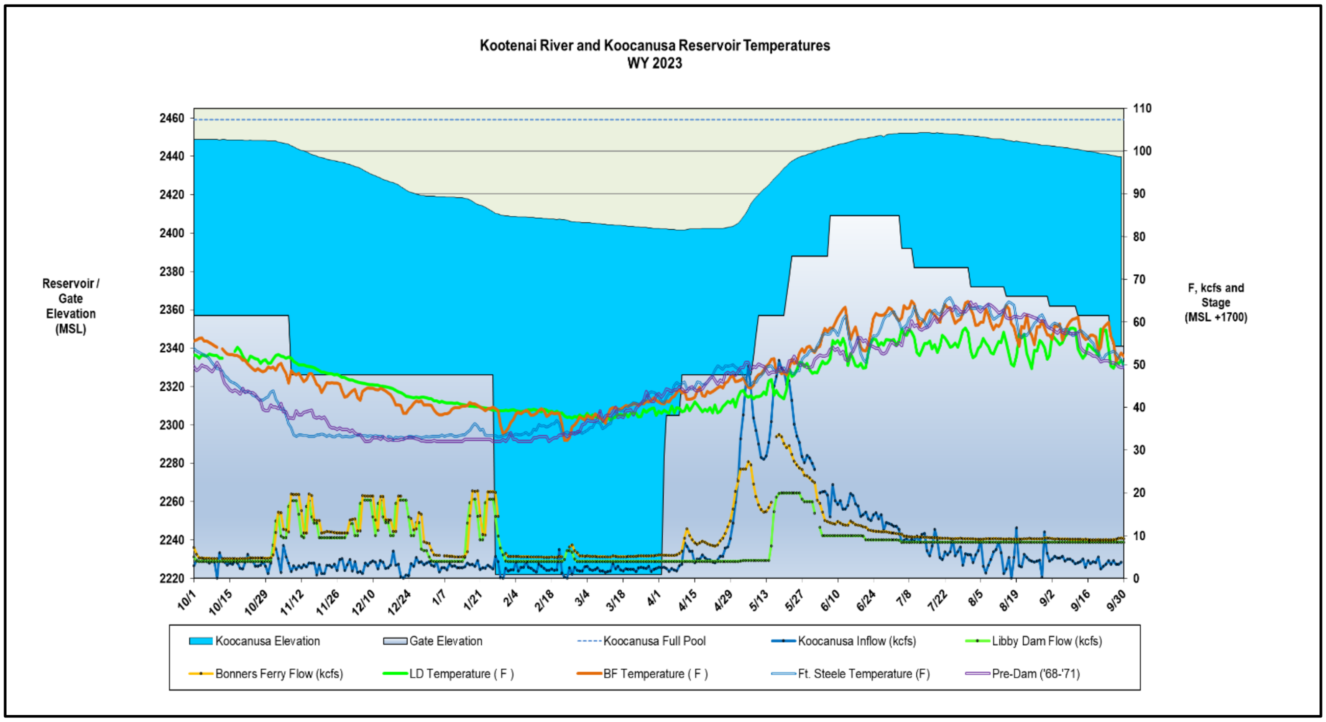


Figure 3. WY2023 Koocanusa Reservoir forebay elevation, selective withdrawal gate placement, Kootenai River flow and temperature at Libby Dam and Bonners Ferry, and stage and flood stage at Bonners Ferry.

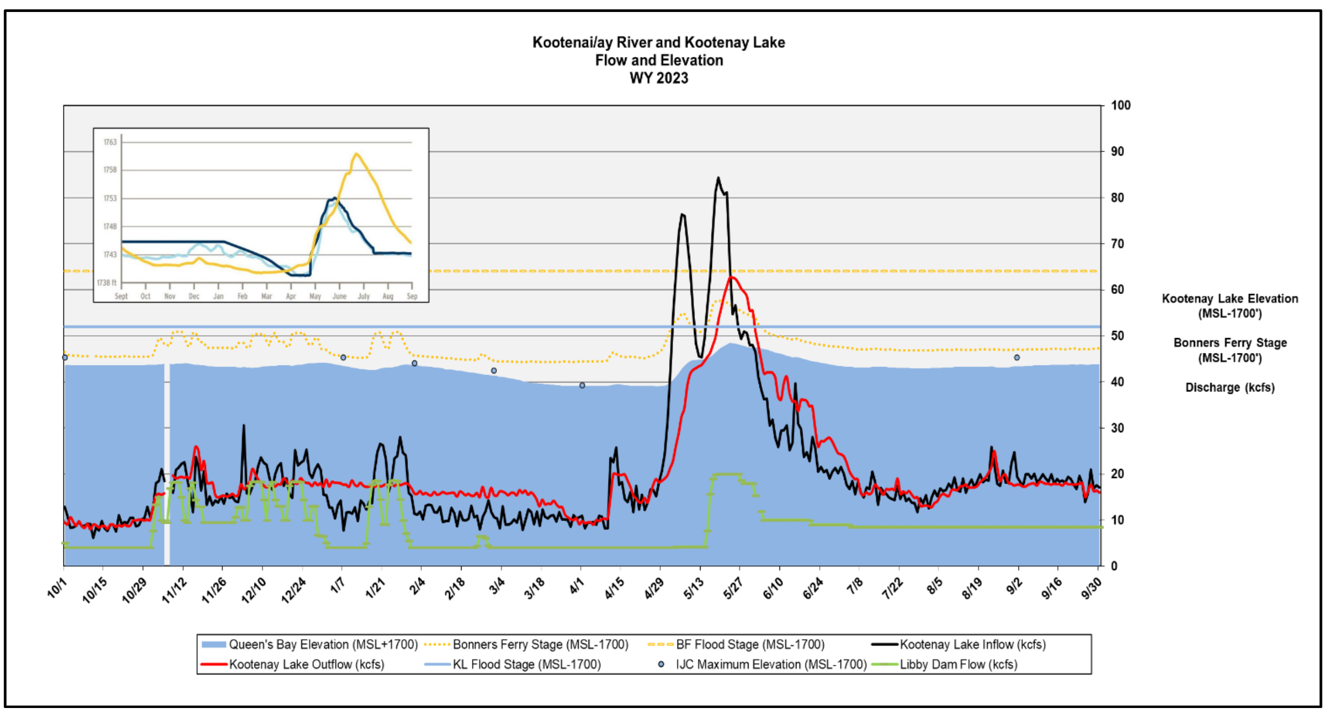


Figure 4. WY2023 Kootenay Lake elevation and discharge relative to Libby Dam discharge and 1938 International Joint Commission (IJC) Rule Curve.

2. Water Year 2023 Libby Dam Temperature Operations

Though Koocanusa Reservoir remains largely isothermic during late winter and early spring, warming surface water in the forebay in late spring and early summer can be discharged via the Libby Dam's Selective Withdrawal System (SWS) to provide more normative discharge temperatures within the operational constraints of the system. The SWS is also utilized to cool discharge temperature through the warmer summer months, and to minimize discharge temperature during the winter months.

The elevation the SWS gates during mid- to late-winter is typically set to 2,222.00-ft MSL - the deepest water that can be drafted through the dam – enabling withdraw of the coldest water available in the forebay of the reservoir to minimize river temperature during the burbot spawning season in the lower river (**Figure 3**). The reservoir becomes isothermic mid-winter, and slowly begins to stratify by late April in most years (**Figure 5**). Prior to the spring freshet, the SWS gates at Libby Dam are stacked to elevation 2,326.00-ft MSL to allow for more responsive and efficient placement of SWS gates as inflow and surface temperatures begin to increase. Incremental installation of additional SWS gates - towards a minimum of ~30-40-ft from the water surface - occurs as inflows increase and then decrease, allowing for discharge of the warmest available surface water as flows are reduced. The intent of the timing of SWS gate installations is to allow for river warming between Libby Dam and Bonners Ferry commensurate with increasing reservoir surface temperature and decreasing dam discharge. The overall intent of this strategy is to provide a stable-to-warming thermograph throughout the operation, including optimal spawning (~50° F at Bonners Ferry) and post-spawn egg incubation and larval development temperatures; sturgeon spawning activity peaks as flow is receding and temperature is increasing. Following the sturgeon spawning season, SWS gates are stacked progressively higher through the early summer as the reservoir refills to target increasing "normative" river temperature via withdrawal of warmer surface water. In most recent years SWS gates have been removed during mid- to late-summer to maintain discharge temperatures in the target range of 55-58°F.

In WY23, temperature at Bonners Ferry from May 1 through June 30 ranged from ~ 44.5 to 63.5° F (~7.0 to 17.5°C), with consistent temperature of 50°F/10°C observed after mid-May. Discharge temperature was near the pre-dam mean from late May through early July, at which time SWS gates began to be removed incrementally through the remainder of the summer to avoid high temperatures in the lower river due to high air temperature and low flow (**Figure 3**).

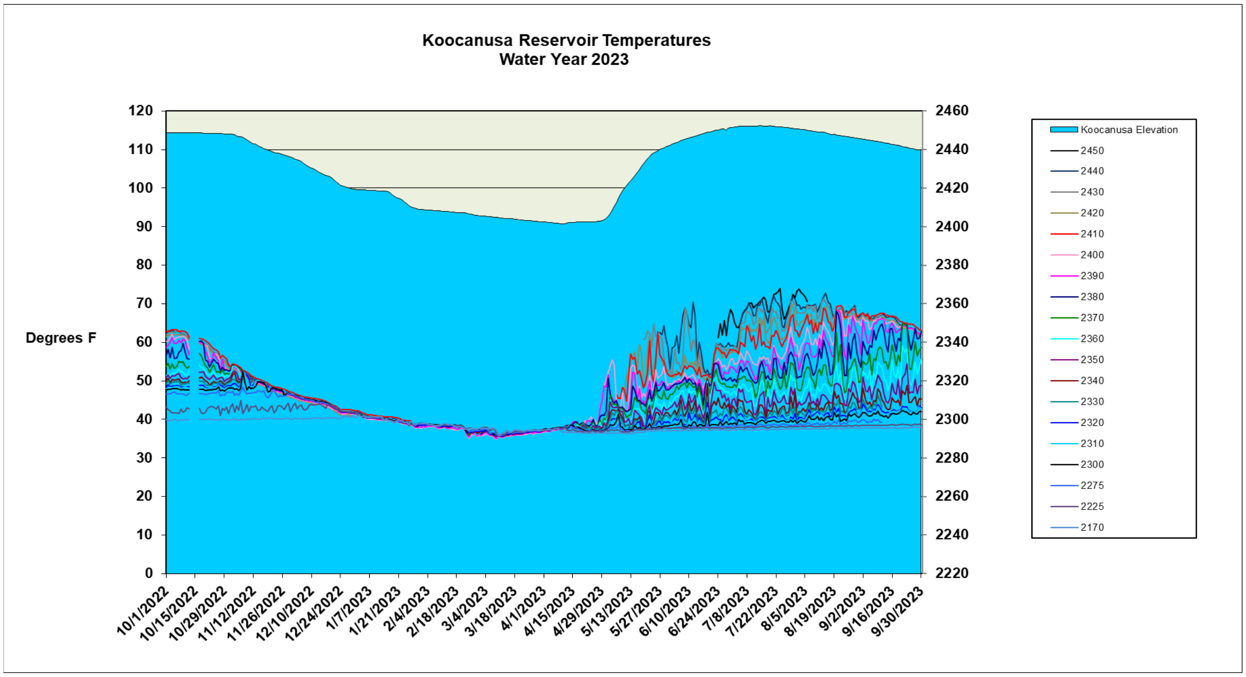


Figure 5. WY2023 Koocanusa Reservoir forebay elevation (MSL) and temperatures at elevation (MSL).

3. <u>2023 Flow Plan Implementation Protocol Assessment</u>

The final May WSF in 2023 was the lowest since 2001, and given the prescriptive nature of the sturgeon tiers, resulted in **no** sturgeon volume (**Figure 2; Tier 1**) and the lowest possible end-of-September draft target elevation for the reservoir (Columbia River salmon and steelhead flow augmentation water). However, during FPIP pre-planning **it became evident that the Action Agencies could use the flexibility inherent in VarQ protocols in the absence of dedicated sturgeon volume to shape the spring freshet and subsequent summer flows for ecological benefit in the river (including sturgeon objectives) and also meet the Koocanusa Reservoir end-of-September elevation target while providing more desirable spring and summer reservoir elevations that support ecological objectives upstream and downstream of Libby Dam**. The 2023 operation supported the notion that a more adaptive operational framework should be modeled and examined over a wide range of WSF's and reservoir management strategies within the overall VarQ FRM strategy (see **Section 5**, below). As was evidenced in 2023, this approach could be more responsive to ecological objectives (for multiple species) over a more extensive temporal scale (spring through fall), upstream and downstream of Libby Dam.

Despite the low WSF and lack of dedicated sturgeon volume in WY2023, FPIP ecological objectives for Kootenai River white sturgeon were attained to a certain degree, as previously described. Without a dedicated sturgeon volume to execute, and through ecologically shaping VarQ flows while controlling refill through spring and early summer, a steady/flat flow of 8,500 cfs was provided from Libby Dam through the end of September, in alignment with the Northwest Power and Conservation Council's "Montana Plan", which endorses normative summer flow shaping, including avoidance of flow variation. In addition to providing **more varial zone habitat for bull trout than would have been provided at the minimum bull trout flow of 6,000 cfs,** along with optimized conditions for river productivity for nearly the entire growing season (see below), this discharge in 2023 **provided connectivity at most bull trout spawning tributary deltas downstream of Libby Dam through the end of September**, when flows were reduced to the minimum 4,000 cfs, as occurs each fall. The ability to maintain flows higher than the minimum bull trout flow of 6,000 cfs for the 2023 WSF was due to the lower-than-normal end-of-September draft requirement, along with the availability of volume that was not discharged as dedicated sturgeon volume earlier in the summer. In most years, Koocanusa Reservoir is drafted to an end-of-September elevation of 2,449.00-ft MSL, but in 2023, due to the low WSF, the reservoir was only drafted to 2,439.00-ft MSL. The purpose of the end-of-September draft target is to augment mainstem Columbia River flows for salmon and steelhead, and dam discharge is adjusted accordingly, usually to the bull trout minimum flow for the corresponding WSF/Tier (**Figure 2**).

The current sturgeon volume accounting method notwithstanding, Koocanusa Reservoir has failed to refill in most years since the BiOp-required (2006) spill testing for sturgeon occurred in 2010-2012 (**Figure 6**, *courtesy of K. Homel, NPCC;* note that reservoir full pool was redefined to be 2,454.00-ft MSL after the reservoir was surcharged in 2012), though new VarQ FRM procedures in the 2020 CRS EIS appear to have increased the reliability of refill attainment in recent years, as intended. Not unrelated, the final May WSF's have not been consistently accurate for several years (**Figure 7**, *courtesy of K. Homel, NPCC*), and have led to an **"over-execution" of tiered sturgeon volumes** relative to actual April-through-August inflow, and in part explains refill failure in several years. In years such as these, **the combined impact of inaccurate forecasting and over-execution of sturgeon volumes can result in less water availability during the critical summer and fall growing season in the Kootenai River (for meeting minimum bull trout flows), as well as reduced reservoir volume in the lower Columbia River for salmon and steelhead**; the reservoir is drafted to an end-of-September target elevation to benefit these other species downriver, regardless of the maximum reservoir elevation attained during the summer.

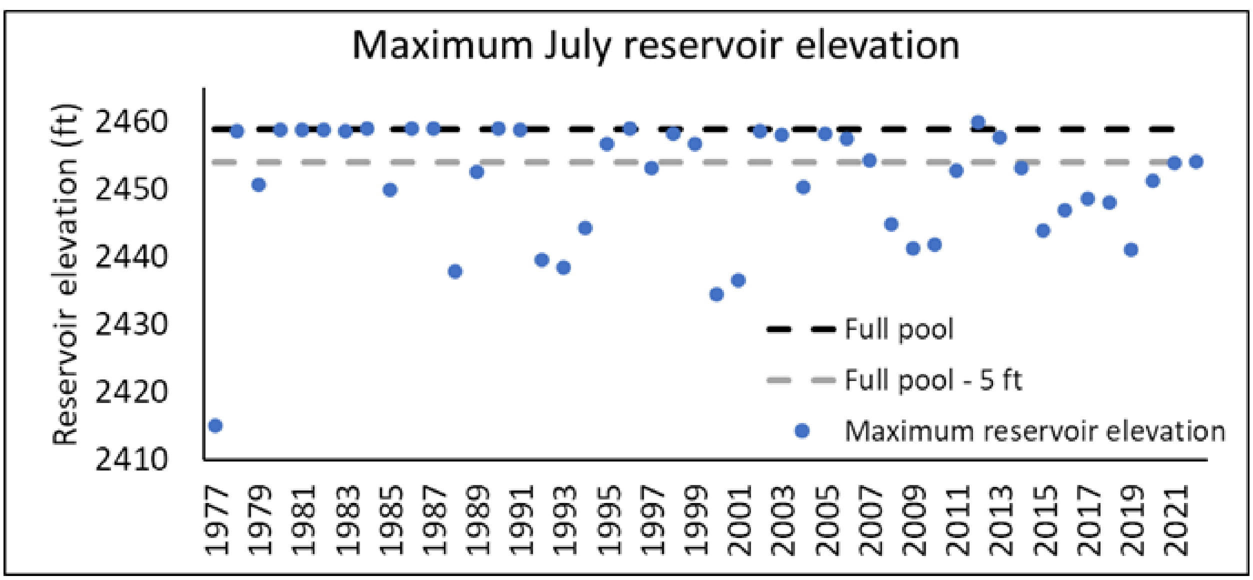


Figure 6. Maximum July Koocanusa Reservoir elevation 1977 through 2022. Physical Full Pool is elevation 2,459.00-ft MSL; management objective Full Pool is elevation 2,454.00-ft MSL post-2012.

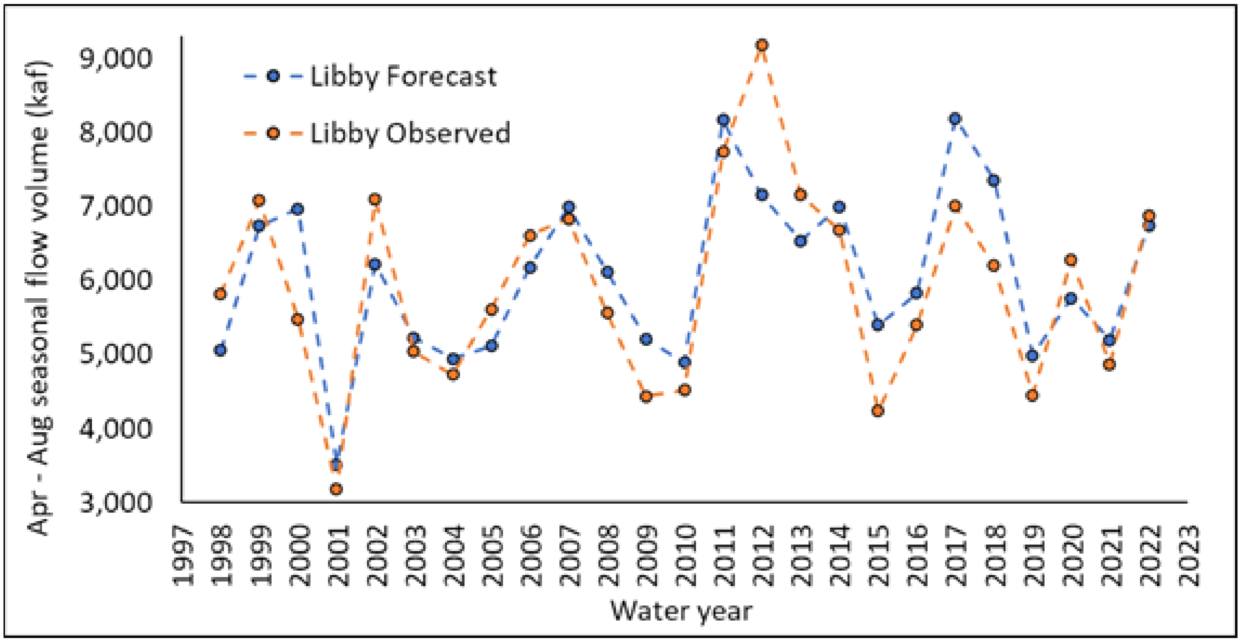


Figure 7. Forecasted (May) April-through-August Koocanusa Reservoir inflow vs. Observed inflow – 1997 through 2022.

4. 2020 U.S. Fish and Wildlife Service Biological Opinion Term and Condition 17.1.3

The Action Agencies **evaluated the impacts of an alternative accounting method for sturgeon flow volume tiers at Libby Dam**, per Term and Condition 17.1.3 of the Service's 2020 BiOp for the Columbia River System (CRS) Operations and Maintenance of 14 Federal Dams and Reservoirs in Washington, Oregon, Idaho and Montana (**Attachment A - Comparing Alternative Accounting Method for Sturgeon Flow Volume Tiers**). The report compared the "**current"** method to an "**alternative**" method during a recent representative dry (Tier 2; 2019) and a wet year (Tier 3; 2022); and then analyzed the differences in operations within existing local and system FRM procedures. The alternative method resulted in delayed and decreased Koocanusa Reservoir refill in both the dry and wet years. The Action Agencies will continue to employ the **current** methodology of accounting for sturgeon volume tiers (i.e., volume calculated from base flow of 4,000 cfs vs. the VarQ refill flow) to best meet ecological objectives under the FPIP flow-shaping framework – this approach is consistent with the 2020 CRS Biological Assessment - while retaining current FRM protocols and hydropower objectives.

5. Recommended Next Steps

Based on the lack of measurable sturgeon recruitment over a wide range of water years and experimental FPIP flow shaping and timing approaches, along with the limitations provided by downstream (Kootenay Lake) FRM protocols, **the Action Agencies do not recommend further examination of methodologies to increase the volume of dedicated water for sturgeon spawning and recruitment, as per above (Section 4) and attached (Attachment A). Rather, the Action Agencies propose to perform multi-objective modeling using seasonal ecological, FRM, hydropower and recreational objectives in a sequential, priorities-based fashion over a wide range of hydrologic conditions under the FPIP flow-shaping framework. The intent of the modeling would be to attempt to achieve/optimize flows considering multiple objectives without the encumbrance of a static sturgeon volume, while retaining current VarQ protocols and hydropower objectives. The objectives-based modeling priorities would be developed within the FPIP Technical Team and led by the Corps, considering current ecological targets for sturgeon along with the following:**

1. **VARQ Procedures.** The Action Agencies' VarQ reservoir refill management strategy was developed - and has been implemented - to balance the original authorized purposes of FRM and hydropower generation at Libby Dam while also meeting operational requirements for threatened and endangered species**. VarQ procedures were modified in the 2020 Columbia River System Operation (CRSO) Environmental Impact Statement (EIS) Record of Decision (ROD)**, described below in **Section 5.1**, to provide for greater assuredness of reservoir refill **while incorporating sturgeon volumes** (including zero volume Tier 1 years) while also utilizing a sliding scale end-of-September reservoir draft for Columbia River salmon and steelhead. As described above, these procedures in WY2023 – without sturgeon volume - allowed for the shaping of reservoir refill timing, elevation, and duration along with shaping an ecologically normative river flow downstream of the dam, to the extent practicable, through the spring and into fall. In WYs with higher WSF's – and thus more water to achieve early-season ecological objectives - summer discharge would likely not have exceeded bull trout minimum flow as it did in 2023. **The proposed modeling would inform operational scenarios for a wide range of WY's and water management objectives**, as per below.

2. **Minimum Bull Trout Flows**. The Action Agencies believe there is potential to model modifications to the **tiered minimum Bull Trout flow** requirement that may be more ecologically and climatologically responsive at a broader geospatial and temporal scale than a river flow based on WSF, as summarized in **Section 5.2** below.

3. **Sturgeon Volume Flows. Avoiding "over-execution" of sturgeon volume**, described above, may result in more assured reservoir refill for multiple purposes, including increased minimum bull trout flows in the Kootenai River and enhanced reservoir riparian development and maintenance conditions. Modeling more towards refill levels and timing after the **objectives-based sturgeon operation** (timed to occur on the forecasted peak of the local freshet) than towards extension and execution of **specific tiered volume flows** may more consistently result in favorable refill dates, levels, and durations in the interests of upper reservoir ecological function.

4. **End-of-September Koocanusa Reservoir Elevations**. The Action Agencies may propose to model changes to the **end-of-September Koocanusa Reservoir elevation targets** that provide reservoir volume for flow augmentation to benefit Columbia River salmon and steelhead draft. Modeling may indicate that prioritization of shaping a normative river flow pattern between the end of the sturgeon operation/refill and the end of September - rather than operating to exact end-of-September elevation targets - as the baseline "drafting" flow target, may result in similar reservoir elevations as the current hard target(s) of 2,439.00-2,449.00-ft MSL. In any case, the Action Agencies' proposed **modeling could allow for calculation of total volume discharged for Columbia River salmon and steelhead after attainment of peak reservoir elevation**.

5.1 Columbia River salmon and steelhead

The 2020 CRSO EIS ROD includes measures to improve refill reliability for Koocanusa Reservoir that are based on local conditions rather than conditions at The Dalles, both of which have potential benefits for resident listed and non-listed species and their habitats, as well as for listed Columbia River salmon and steelhead. ***Operational Measure 7.6.3.1*** allows a variable draft ("Sliding Scale") of the reservoir (2,439.00 to 2,454.00-ft MSL) to provide seasonal volume for Columbia River salmon and steelhead migration, depending on WSF (**Figure 7**). ***Operational Measure 7.6.3.2*** (Modified Draft) provides a greater probability of reservoir refill by incorporating local hydrologic conditions while also accounting for sturgeon tier volumes. These two operational measures are summarized below:

> ***CRSO EIS Operational Measure 7.6.3.1 - Sliding Scale at Libby and Hungry Horse***
>
> The Corps and BoR determine the summer draft from Koocanusa Reservoir and Hungry Horse Reservoirs for delivery of flow augmentation for downstream fish based on a local water supply forecast. The elevation objective is incrementally adjusted over a range of water supply conditions and enables water managers to balance local resident fish priorities in the upper basin with downstream flow augmentation for the Columbia River downstream of Chief Joseph Dams. This measure allows the Action Agencies to balance the needs of Koocanusa and Kootenai River species while also providing volume for Columbia River salmon and steelhead.
>
> ***CRSO EIS Operational Measure 7.6.3.2 - Modified Draft at Libby***
>
> The Modified Draft at Libby Dam provides water managers more flexibility to incorporate local conditions in the upper basin by changing flow management so that local flood durations and start of refill operations are tied to Kootenai Basin runoff. To provide flexibility to respond to local conditions, years with a WSF of less than 6.9 MAF for Koocanusa Reservoir are drafted lower than previously after December. Draft targets are the same as previously in December and for all months with a WSF greater than 6.9 MAF. The Modified Draft procedure improves water management flexibility to respond to local FRM conditions in the upper basin.

5.2 Minimum Bull Trout Flows

In the Kootenai River downstream of Libby Dam, the greatest amount of varial zone gain and loss in the spring through fall (productive months) range of flow operations occurs at 9,000 cfs and lower (**Figure 8**). Minimum bull trout flows range from 6,000 to 9,000 cfs (**Figure 2**), though flows between 9,000 and 12,000 cfs are considered ecologically optimal in terms of wetted perimeter, usable area, and biomass productivity (*see FWP IFIM study*).

In addition to varial zone productivity and habitat availability, maintaining flows of 9,000+ cfs (higher than current bull trout minimum flows in most years) through September would allow for **improved Kootenai River tributary access** conditions for bull trout during their critical spawning period. Additionally, there are **beneficial thermal effects** to the river with increased discharge volume during warm/hot periods.

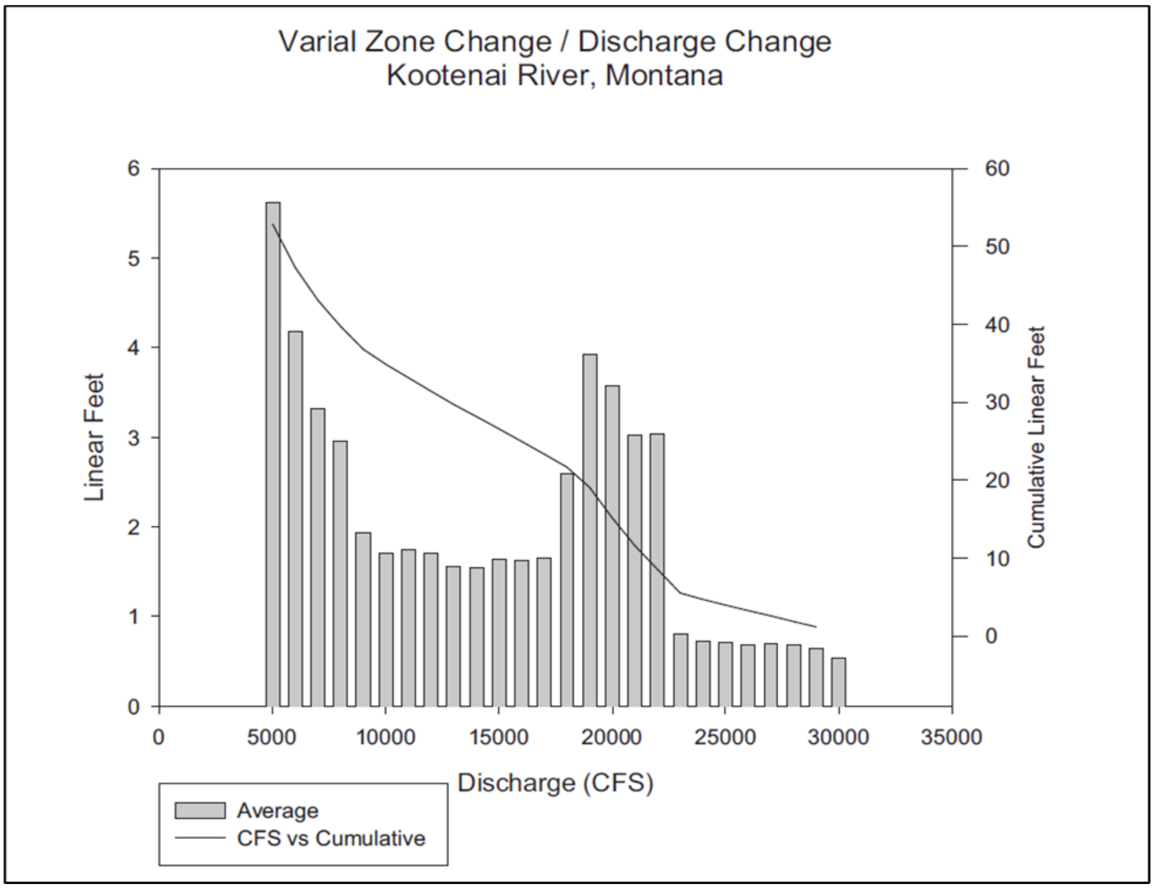


Figure 8. Cumulative gain/loss of linear varial zone habitat in the Kootenai River downstream of Libby Dam in Montana. Varial zone productivity and habitat availability is optimized at 9,000 to 12,000 cfs; decreasing discharge below 9,000 cfs decreases the wetted perimeter and reduces habitat availability at increasing rates, as well as seasonal access to mainstem bull trout spawning tributaries.

Attachment A

Comparing Alternative Accounting Method for Sturgeon Flow Volume Tiers

Comparing Alternative Accounting Method for Sturgeon Flow Volume Tiers

Prepared by

Greg Hoffman and Leon Basdekas USACE, Seattle District

For USFWS, Region 1

In response to Term & Condition 17.1.3, Endangered Species Act - Section 7 Consultation Biological Opinion U.S. Fish and Wildlife Service Columbia River System Operations and Maintenance of 14 Federal Dams and Reservoirs Washington, Oregon, Idaho, and Montana

December 19, 2023

1.0 Executive Summary

The U.S. Army Corps of Engineers (USACE) and Bonneville Power Administration (BPA) – collectively, with the Bureau of Reclamation, the Action Agencies – **evaluated the impacts of an alternative accounting method for sturgeon flow volume tiers at Libby Dam for the benefit of Kootenai River white sturgeon** (sturgeon), per Term and Condition 17.1.3 of the 2020 United States Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) for the Columbia River System (CRS) Operations and Maintenance of 14 Federal Dams and Reservoirs in Washington, Oregon, Idaho and Montana. This report satisfies this commitment by comparing the "**current"** method to an "**alternative**" method during a recent representative dry (Tier 2; 2019) and a wet year (Tier 3; 2022); and then analyzes the differences in operations within existing local and system Flood Risk Management (FRM) procedures.

The alternative method resulted in delayed and decreased Koocanusa Reservoir refill in both the dry and wet years. The evaluation considered the effects of the alternative accounting method on Koocanusa Reservoir refill extent and timing, and inferred effects on FRM and hydropower potential.

2.0 Purpose of Evaluation

The 2020 USFWS CRS BiOp requires the Action Agencies to assess the implications of calculating sturgeon tier volumes as volumes above the calculated Variable Flow (VarQ) FRM flow (alternative method), rather than from the prescribed Libby Dam minimum flow requirement of 4,000 cfs, the **current** method. Specifically, the 2020 USFWS CRS BiOp states:

Reasonable and Prudent Measure (RPM) 16.1(c): "*By December 31, 2023, the Action Agencies shall provide a report to the Service addressing sturgeon flow volume tiers, specifically focusing on the implications of accounting for the volumes as outflows above VarQ operations, rather than the current approach of accounting for the volumes as outflows above minimum flows (4,000 cfs)*".

Term and Condition (T&C) 17.1.3 requires the Action Agencies to "*ensure the report on reevaluation of how sturgeon volume tiers are accounted for, including alternatives for how sturgeon flow volume could be released under the* ***alternative*** *accounting, a description of the effects to flood risk management (FRM) and hydropower operations, and a decision by the Action Agencies as to how they will proceed on the possible reevaluation of the sturgeon volume tiers*".

This report summarizes current operational authorities and requirements, including FRM and hydropower strategies, as well as the annual **Flow Plan Implementation Protocol (FPIP)** for sturgeon flow operations. It then describes the Action Agencies' evaluation of the alternative accounting method and concludes with possible next steps based on a more broadly-based ecosystem flow strategy that considers temporospatial needs of sturgeon and bull trout in the Kootenai River. The Action Agencies also considered Columbia River salmon and steelhead flows as described in the Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species, January 2020 (2020 CRS BA).

3.0 Libby Dam Operational Background

Libby Dam is operated to meet multiple authorized purposes, including FRM and hydropower generation, as well as providing flow for Endangered Species Act threatened and endangered species in the Kootenai River and downstream in the mainstem Columbia River. Strategies to maximize the potential for successful sturgeon spawning and recruitment have been developed via the FPIP since 2006, including flow and elevation targets at Bonners Ferry, both described below *(3.3)*.

3.1 Flood Risk Management

Flood Risk Management at Libby Dam follows the VarQ Flood Control procedure *(see 7.05.b in the Libby Dam Water Control Manual)* to meet Columbia River System and local FRM objectives. The required flood storage space is based on monthly Water Supply Forecasts (WSF) for April through August inflow totals into Koocanusa Reservoir. The forecasts are completed each month from December through June. Springtime minimum flows are calculated using the VarQ procedure and are followed prior to FPIP sturgeon flow operations.

3.2 Hydropower

Hydropower operations are coordinated with BPA. Hydropower generation is produced during operations that provide flows for sturgeon and bull trout (2020 CRS BA).[1] During Koocanusa Reservoir fall draw down period, generation may be shaped to follow power demand and provide increased hydropower. When there is operational flexibility (such as soft end of month targets in October and November), some water may be stored as carryover in a given month, to provide greater generation benefit for the following weeks.

3.3 Kootenai River White Sturgeon Flow Plan Implementation Protocol

The Action Agencies began implementing tiered sturgeon flow operations at Libby Dam in 2001 in response to the 2000 U.S. Fish and Wildlife Service (USFWS) BiOp for operation and maintenance of the Columbia River System. The Action Agencies provided and accounted for the minimum flow volumes as per **Figure 1** since implementation of the tiered volume flow operations began, consistent with Reasonable and Prudent Measure (RPM) 6 of the 2000 USFWS BiOp, continuing through Reasonable and Prudent Alternative (RPA) Component 1 of the 2006 USFWS BiOp (when FPIP was created), and through Term and Condition 17.1.3 of the current 2020 USFWS BiOp. **Since the tiered volume construct was implemented, volume calculations have been based on the 4,000 cfs minimum flow at Libby Dam** (2000 USFWS BiOp).

[1] See Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species, January 2020 (2020 CRS BA) and Section 2.3.1.2 Libby Dam Flood Risk Management (pages 2-11 through 2-16) and Section 2.3.2.1 S*torage Project Operations for Fish and Wildlife Conservation* for *Operations for Kootenai River White Sturgeon Conservation* and S*torage Project Operations for Fish and Wildlife Conservation* and *Operations for Bull Trout Conservation* (pages 2-31 through 2-40).

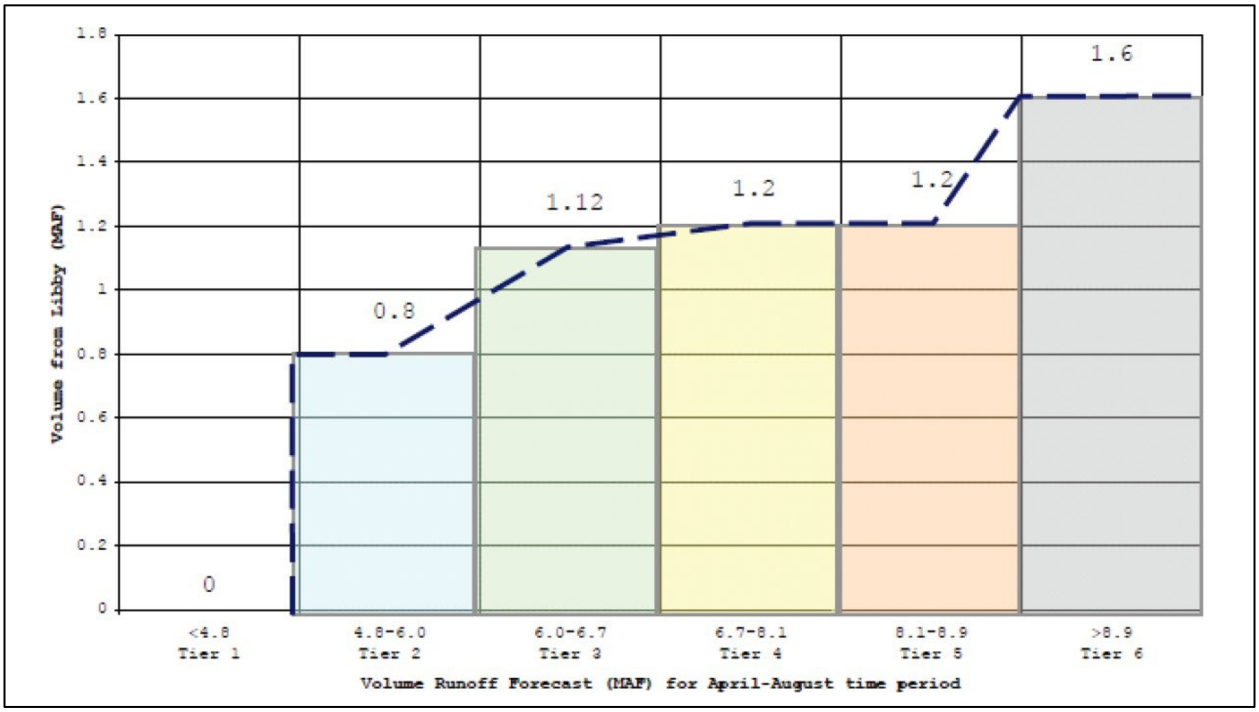


Figure 1. Sturgeon volume tiers based on final May, April through August inflow forecast for Koocanusa Reservoir. The 30-year (1991-2020) seasonal average inflow is 6.080 Million Acre Feet (MAF). Actual volumes are linearly interpolated between values as necessary.

The 2006 USFWS BiOp's Reasonable and Prudent Alternative (RPA) 1, Action 1.1, formed the **FPIP** team (comprised of USFWS, USACE, BPA, US Geological Survey, Montana Fish, Wildlife & Parks (FWP), Idaho Department of Fish and Game (IDFG), Kootenai Tribe of Idaho, and Confederated Salish and Kootenai Tribes representation at both technical and policy levels) to collaboratively and experimentally develop annual adaptive sturgeon flow plans based on "tiered" volumes of water allocated by the final May, April through August inflow forecast for Koocanusa Reservoir (**Figure 1**). Under FPIP, different approaches have been executed to vary timing, shape, and duration of the spring freshet downstream of Libby Dam near Bonners Ferry, Idaho, in designated critical habitat for sturgeon. To date, there have been limited observations of successful natural spawning occurring despite multiple years of adaptive flow management via FPIP and multiple large-scale habitat improvement projects.

In general, the annual ecological and biological objectives have evolved via adaptive management into: 1) providing flows of 30,000 cfs or greater in designated critical habitat at, and upstream of, Bonners Ferry to provide conditions for Kootenai River sturgeon to migrate to appropriate spawning habitat at and upstream of Bonners Ferry (**Table 2,** *courtesy of IDFG*), and; 2) reaching and maintaining river stage of 1,762.00' above Median Sea Level (MSL) at Bonners Ferry to connect and inundate rearing habitats, among other ecological functions (National Weather Service Flood Stage at Bonners Ferry is 1,764.00' MSL).

Table 2. Extent of movement of tagged adult sturgeon since 2005 by river kilometer (RKM). RKM 229 is at Shorty's Island in the Meander Reach downstream of Bonners Ferry. RKM 264 is upstream of the Moyie River. Blue shaded area represents the Straight Reach (RKM 240-246) through Bonners Ferry; light green shaded area represents Braided Reach upstream of Bonners Ferry (RKM 246-258.5); green shaded area represents the Canyon Reach upstream of the Moyie River (RKM > 258.5). Fish movement is depicted as the percentage of fish observed at receivers located at or above a particular RKM, with the number of tagged fish (n) observed migrating to Shorty's Island or above. Blank cells indicate no tags detected at or above that RKM for a given year. Preferred/improved spawning habitat exists upstream of RKM 240 (*courtesy of IDFG*).

RKM	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
days >30 Kcfs	2	41	33	39	10	17	52	75*	50	65	8	15	73	34	4	28	15	33
n	16	31	28	29	24	36	35	34	43	45	49	49	55	55	47	47	26	47
230.1	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
232.0	100%	94%	100%	97%	92%	100%	100%	100%	100%	100%	98%	98%	100%	100%	100%	100%	96%	98%
235.0	94%	87%	100%	86%	88%	100%	100%	94%	98%	78%	98%	73%	80%	80%	98%	98%	85%	98%
239.0	75%	74%	79%	86%	67%	89%	71%	79%	79%	78%	96%	73%	80%	80%	89%	85%	81%	91%
240.0	44%	48%	79%	86%	67%	89%	71%	79%	79%	78%	96%	73%	80%	80%	89%	85%	81%	91%
240.7	44%	48%	75%	79%	29%	86%	71%	74%	79%	76%	78%	73%	80%	80%	89%	70%	81%	89%
243.5	44%	48%	50%	66%	29%	67%	54%	56%	51%	51%	59%	59%	69%	62%	49%	53%	65%	62%
244.5	44%	39%	50%	62%	29%	56%	46%	47%	47%	47%	53%	59%	65%	55%	43%	49%	50%	53%
244.7	44%	29%	50%	62%	29%	56%	46%	47%	47%	47%	53%	59%	65%	55%	43%	49%	50%	53%
245.0	44%	29%	46%	52%	29%	36%	37%	41%	37%	44%	47%	51%	51%	47%	28%	43%	35%	43%
245.5	44%	29%	46%	52%	29%	36%	37%	41%	37%	44%	47%	51%	51%	47%	28%	43%	35%	43%
245.7	0%	29%	25%	45%	13%	42%	37%	41%	35%	44%	47%	51%	53%	47%	28%	40%	27%	40%
246.0	0%	16%	25%	45%	13%	25%	37%	38%	28%	29%	29%	37%	45%	36%	15%	36%	15%	34%
246.6		16%	25%	45%	13%	19%	17%	29%	28%	24%	22%	37%	45%	35%	15%	32%	12%	34%
246.8		6%	4%	14%	4%	6%	11%	21%	14%	22%	18%	33%	45%	35%	11%	32%	12%	32%
247.3		6%	4%	14%	4%	6%	11%	15%	14%	7%	2%	6%	24%	13%	11%	11%	12%	2%
248.0		6%	4%	14%	4%	6%	11%	15%	14%	7%	2%	6%	24%	13%	11%	11%	4%	2%
248.1		6%	4%	14%	4%	6%	11%	15%	14%	7%	2%	6%	5%	13%	11%	11%	4%	2%
248.5		6%	4%	14%	4%	6%	11%	12%	14%	7%	2%	6%	5%	13%	11%	11%	4%	2%
249.5			4%	14%	4%	3%	3%	6%	5%		2%	4%	5%	13%	4%	11%	4%	2%
250.0				14%	4%	3%	3%		2%		2%	4%	4%	9%	4%	11%	4%	2%
250.4				14%	4%	3%	3%		2%		2%	4%	4%	9%	4%	11%		2%
250.7				14%	4%	3%	3%		2%		2%	4%	4%	9%	4%	11%		2%
250.9				7%	4%	3%	3%		2%		2%	4%	4%	9%	4%	11%		2%
253.4				7%	4%	3%	3%		2%		2%	4%	4%	9%	4%	11%		2%
254.5				3%	4%	3%	3%		2%		2%		4%	7%	4%	4%		
255.1				3%	4%	3%	3%		2%		2%		4%	7%	4%	4%		
257.5				3%	4%	3%	3%		2%		2%		2%	7%	4%	4%		
264.0				3%	4%		3%		2%		2%		2%	7%	4%	4%		

Each of these objectives, in addition to previous experimental and adaptive FPIP objectives, have been met seasonally as real-time conditions have allowed since FPIP commenced. The FPIP process has been based on implementation of experimental and adaptive ecosystem flow strategies and has informed the adaptive needs for not only spawning sturgeon, but also of habitat improvement and conservation aquaculture strategies, riparian recruitment and survival, and nutrient and temperature limitations.

4.0 Evaluation Methods

Both the current and alternative methods for evaluating sturgeon volume tiers (within existing local and system FRM procedures at Libby Dam) were evaluated considering spring and summer flow shaping capability for sturgeon, minimum seasonal flows for threatened bull trout, and end-of-September reservoir targets for Columbia River salmon and steelhead flow augmentation. Effects on hydropower were not quantified but were inferred based on end-of-September reservoir elevations.

Water Years (WY) 2019 (dry year) and 2022 (wet year) were chosen for this analysis since they represent two different (water volume and tier) year types and are also from the recent past and thus represent contemporary conditions.

A mass balance daily spreadsheet model was used with historic inflows for both water years. Outflows were either kept historical (for the status quo, **current** method calculation) or adjusted as described below to calculate the accumulated sturgeon volume and reservoir elevations using the **alternative** method in the two water years.

The **current** accounting method was used for both WY 2019 and WY 2022 **using 4,000 cfs as the base flow for calculating sturgeon volume.** Actual daily average inflows and outflows from Libby Dam were used, as were actual starting reservoir elevation and sturgeon flow start date. The mass balance daily spreadsheet model was then used to calculate the accumulated sturgeon flow volume and reservoir elevations. An **alternative** accounting method was used for both WY 2019 and WY 2022 **using the calculated VarQ flow immediately preceding sturgeon flow as the base flow for calculating sturgeon volume.** Actual daily average inflow, starting reservoir elevation, and sturgeon flow start date were used. Actual outflows prior to the sturgeon flow were used and the sturgeon operation was extended as needed to release the required volume. After the sturgeon volume was exhausted, flows were reduced as needed to meet the end-of-September target reservoir elevation as closely as possible. Bull trout minimum flows were provided after the sturgeon volume was exhausted.

It should be noted that for Water Year 2019, the actual VarQ flow was based on the previous flow calculation method and storage reserve diagram, prior to its update in the **2020 Columbia River System Operations (CRSO) Environmental Impact Statement (EIS) and the 2020 CRS BA.** This analysis, therefore, provides an example of what 2019 operations might have looked like if the accounting were different. Had the current flow calculation method and storage reservation diagram for VarQ been in place in 2019, the reservoir likely would have filled to a somewhat higher level and the spring VarQ flow might have been a bit lower.

For modeling purposes, discharging additional volume prior to the commencement of each years' operation was not considered. Kootenay Lake in British Columbia, Canada, is drafted to or below a prescribed elevation through April to comply with the 1938 International Joint Commission Rule Curve. The desired early season lake-backwater effects for floodplain connectivity and inundation in the lower river are not achievable via increased flow from Libby Dam during this time.

The following data were used:

- **WY 2019** was a dry, Tier 2 year (**Table 3** and **Table 5**) with a sturgeon volume of 0.8 MAF, and VarQ flow of 18,000 cfs immediately preceding the sturgeon flow start date of May 29.

September end-of-month (EOM) target reservoir elevation was 2,449.00’ above median sea level (MSL).

- **WY 2022** was a wet, Tier 3 (**Table 4** and **Table 6**) year with a sturgeon volume of 1.15 MAF, and VarQ flow of 12,300 cfs immediately preceding the sturgeon flow start date of May 16. September EOM target reservoir elevation was 2,449.00’ above MSL.

The spreadsheet model was first validation-tested for both water years using historic data and current sturgeon pulse accounting methods. Modeled results for elevations, peak reservoir elevations and date were compared to observed values (**Table 3** and **Table 4**). WY 2019 September modeled and observed end-of-September reservoir elevations were within 0.30 feet, peak elevation date differed by 3 days, and peak elevations differed by 0.28 feet. WY 2022 September modeled and observed end-of- September reservoir elevations were within 0.20 feet, peak elevation date differed by 0 days, and peak elevations differed by 0.05 feet. Given these closely agreeing results, the model was considered acceptable for this comparative analysis.

Table 3. WY 2019 (dry year), model validation test results compared to observations.

WY 2019 (Dry)	Observed	Model Results	Difference
September EOM Elevation (MSL)	2,442.14’	2,441.84’	-0.30’
Peak Elevation (MSL)	2,442.42’	2,442.14’	-0.28’
Peak Date	8/20/19	8/23/19	3 Days

Table 4. WY 2022 (wet year), model validation test results compared to observations.

WY 2022 (Wet)	Observed	Model Results	Difference
September EOM Elevation (MSL)	2448.88’	2448.68’	-0.20’
Peak Elevation (MSL)	2454.28’	2454.23’	-0.05’
Peak Date	8/5/22	8/5/22	0 Days

5.0 Evaluation Results

WY 2019 (dry year) comparison results for the current and the alternative accounting methods are shown in Table 5 and Figure 2. WY 2022 (wet year) comparison results for each method are shown in Table 6 and Figure 3.

In the **dry year** comparison (WY 2019), results suggested that if the alternative method had been used based on the previous approach to calculating VarQ, discharging additional volumes to extend the sturgeon flow operation **delayed reservoir refill, reduced the extent and duration of summer reservoir elevation, and lowered end-of-September reservoir elevation with greater change in end-of-September elevations**. Lower reservoir elevations would decrease head for hydropower production, with the largest impacts in the fall and winter at Libby Dam, while also greatly reducing the volume available for mainstem Columbia River salmon and steelhead flow augmentation during late summer.

In the **wet year** comparison (WY 2022), results suggested that had the Alternative Method (revised per the 2020 CRS EIS) would have followed a similar pattern as seen for the WY 2019 comparison, but not to the extent seen in WY 2019 results. **Reservoir refill would have been delayed, a lower summer**

reservoir elevation would have been observed, as would a lower end-of-September reservoir elevation. Lower reservoir elevations would decrease head for hydropower production, with the largest impacts in the fall and winter at Libby Dam. There would also have been reduced volumes available for mainstem Columbia River salmon and steelhead flow augmentation during late summer.

Table 5. WY 2019 (**dry year**) modeling results.

	Calculation Method	
WY 2019	**Current (4,000 cfs)**	**Alternative (18,000 cfs)**
Starting Reservoir Elevation (MSL)	2,409.65’	2,409.65’
Sturgeon Volume Start Date	5/29/2019	5/29/2019
Sturgeon Volume End Date	6/25/2019	7/27/2019
Peak Reservoir Elevation Date	8/23/2019	8/23/2019[2]
Peak Reservoir Elevation (MSL)	2,442.14’	2,402.09’
September 30 Elevation (MSL)	2,441.84’	2,401.64’
September 30 Storage (MAF)	5.10	3.54

Table 6. WY 2022 (**wet year**) modeling results.

	Calculation Method	
WY 2022	**Current (4,000 cfs)**	**Alternative (12,300 cfs)**
Starting Reservoir Elevation (MSL)	2,374.60’	2,374.60’
Sturgeon Volume Start Date	5/16/2022	5/16/2022
Sturgeon Volume End Date	6/16/2022	8/1/2022
Peak Reservoir Elevation Date	8/5/2022	7/22/2022
Peak Reservoir Elevation (MSL)	2,454.23’	2,443.17’
September 30 Elevation (MSL)	2,448.68’	2,440.79’
September 30 Storage (MAF)	5.40	5.05

[2] This is the date of peak reservoir elevation following the sturgeon pulse. Maximum reservoir elevation 2421.19’ MSL occurred on June 8.

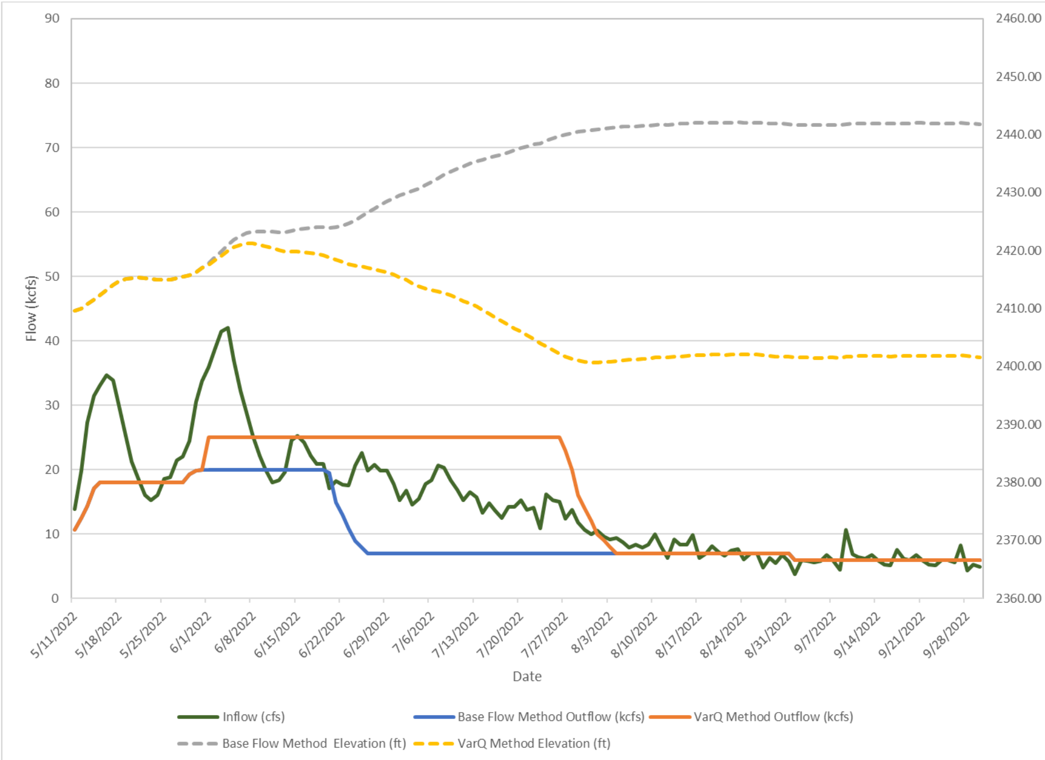


Figure 2. WY 2019 (dry year) modeling results.

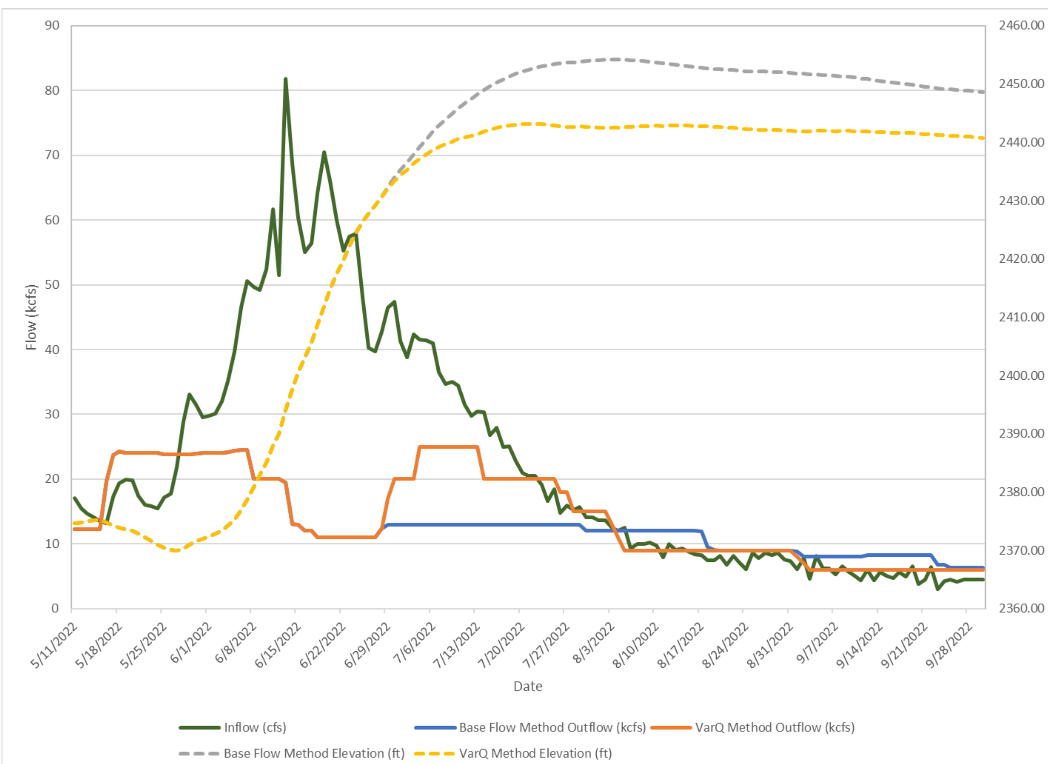


Figure 3. WY 2022 (wet year) modeling results.

7.0 Conclusions

This report satisfies the Action Agencies commitment (per T&C 17.1.3) to compare the current accounting method using sturgeon volumes tiers to an alternative accounting method using the calculated VarQ flow immediately preceding sturgeon flow**,** within existing local and system FRM procedures at Libby Dam. The evaluation considered the effects of an alternative accounting method on Koocanusa Reservoir refill extent and timing, and inferred effects on FRM and hydropower potential.
The **alternative** method resulted in delayed and decreased Koocanusa Reservoir refill in both the dry and wet years.

The Action Agencies will continue to implement FPIP using the **current** methodology of accounting for sturgeon volume tiers to best meet ecological objectives under the FPIP flow-shaping framework - consistent with the 2020 CRS BA - while retaining current FRM (VarQ) protocols and hydropower objectives.