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Claims of Sustained Peaking, Ramping, Reserve, Flexibility and Balancing Power from the lower Snake River Dams; What Is Feasible?

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Abstract

This paper examines the claim that "*the four lower Snake River Dams (LSRDs) can generate 2,650 MW of sustained peaking power for 10 hours per day for five consecutive days.*" This claim has been published in fact sheets by the Public Power Council (PPC), Bonneville Power Administration (BPA), Northwest River Partners, and appears in the recently released Columbia River Systems Operations Environmental Impact Statement (EIS). Based on this claim, the federal agencies have derived cost estimates for a full replacement of LSRD power with a zero-carbon portfolio, and used these values in further analysis to choose a preferred alternative for salmon recovery. Despite wide use of this claim to justify the flexibility and high value of the LSRDs, the origin and supporting calculations remain unknown. In this paper, we evaluate Army Corps of Engineers documents for feasibility of the scenario, and model two peaking scenarios and their potential effect on the projects. The paper also addresses further claims made in the EIS concerning ramping, reserves and the assigned dollar values. We find that the limitations of dam operation on the Snake River along with the negative effects of reservoir drawdown, demonstrate the ***infeasibility*** of a peaking power scenario. The analysis concludes that the noted documents should be immediately corrected in order to facilitate accurate decision making by all stakeholders and the effected public, specifically BPA rate payers.

Background

The claim that "*the LSRDs can generate 2,650 MW of peaking power for 10 hours per day for five consecutive days in an extended cold snap or other power emergency*" was made by the Public Power Council on a 2020 fact sheet. The citation appears in a BPA Fact Sheet from 2016 that has the same claim but does not include a citation. Northwest River Partners also uses this claim widely. A similar claim about peaking power is made in the 2020 EIS where it is stated that, in addition to the average normal 1,000 MW of generation, the projects provide "more than 2,000 MW of sustained peaking capabilities during the winter."[1] The EIS places total zero-carbon portfolio value (with increased solar) of $801 million per year for replacing LSRD power[2], composed of roughly $400 million to replace normal generation[3], plus the expense of replacing ramping (also called peaking power), reserve, and balancing services etc., usually referred to as Ancillary Services. Source(s) of these claims are unclear. The Corps of Engineers (COE's) 1947 report outlining the predicted benefits of dam construction and hydropower on the Snake do not mention ramping or peaking power. While the origin of the peaking power claim remains unknown, the 2002 EIS does provide a "peaking value" to the LSRDs as a small

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*Jim Waddell is not representing his public utility district nor any organization as an author of this report.

[1] Chapter 3 page 944, Chapter 7 pg 10, pg 30 executive summary 2020 USACE EIS, https://www.nwd.usace.army.mil/CRSO/Complete-DEIS/#top

[2] Chapter 3 page 848 2020 USACE EIS, https://www.nwd.usace.army.mil/CRSO/Complete-DEIS/#top

[3] Chapter 3 page 944 2020 USACE EIS, https://www.nwd.usace.army.mil/CRSO/Complete-DEIS/#top

percentage of total federal hydro generation (Table 3.1-1 Appendix I). This statement, based on the *overload capacity* of the LSRDs, is close to the amount in megawatts of the peaking power claim. Thus, one possible explanation for its appearance is that authors of the 2020 EIS may have erroneously turned this percentage ($15^{\%}$) into a claim about the potential for additional power generation. Regardless, generation data from the Corps of Engineers (COE) show the claimed ramping/peaking power scenario has not occurred in the history of LSRD power generation, nor has been discussed in any additional technical reports known to us. The economics section of the 2002 EIS gives a total annual value for Ancillary Services, (but does mention ramping power) of $8 million (Tables 3.1-20 and 20 on page I3-43).[4] In current year dollars this is approximately **$16 million.** When compared to values of $714 and $801 million predicted for replacing Ancillary Services in the 2020 EIS, there appears to be a massive error. Indeed, generation data reflects a pattern that rises and falls throughout the day, following demand, (Chart 1.2), but does not include a peaking scenario. Contradictory information about LSRD flexibility and capabilities beyond normal generation calls into question the value assumptions for the LSRDs. In the present analysis, we aim to understand if the peaking claim is feasible based on the physics and design of the system.

Introduction

The four dams on the lower Snake River, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor, have an average annual output of 930 aMW[5], and operate under a run-of-river configuration. In addition to hydropower, all four dams function as a means for barge/cruise and juvenile fish transportation to/from various ports between Ice Harbor and Lewiston ID, and contain fish passage facilities through a juvenile bypass system and adult fish ladders. All four dams contain an upstream reservoir and the Ice Harbor reservoir allows for irrigation by commercial farmers. None of the LSRDs are authorized or operated as flood control projects. Typical of run-of-river federal hydro projects, the four dams release water nearly at the same rate water enters the reservoir. While the reservoirs behind the dams are 100ft deep, they operate within a three to five foot reservoir level range. For instance, the minimum operating pool for Lower Granite Dam and reservoir is 733 fmsl (feet above mean sea level), and the maximum is 738 fmsl. Reservoir levels are referred to as being above or below minimum operating pool or MOP. Unlike storage reservoirs like Grand Coulee, run-of-river dams must maintain MOP to allow inland waterway navigation (barging) and fish passage. Because these four dams were authorized, built, and operated to provide navigation and hydro power generation, one authorized purpose cannot impair another authorized purpose through a change in operations. It is important to note that changing the purpose of a project requires congressional authorization, whereas placing a project into a non-operational status does not. Terms such as decommissioning, mothballing and caretaker status are similarly used to denote non-operational status. Willamette Lock and Dam in Portland, Oregon, for example, was placed into a caretaker status around 2005 by the Portland District Commander. The four LSRDs have generally maintained MOP and their authorized purposes since construction, except for navigation lock outages (repairs) and the 1992 drawdown test, which we will discuss later in this paper.

The nature of the hydraulics/flows in the lower Snake River further compromise the flexibility and capacity of the LSRD's. Normal generation on the LSRDs is governed by seasonal flow conditions, high in the spring and relatively low in summer, fall and winter. Generation often follows load (demand), and price declines during the early morning hours reflect no generation at all at these projects, (see Chart 1.2) allowing the reservoirs to fill 1-3 feet above minimum operating pool. They then are able release at a higher flow rate for a few hours and generate more power when demand and prices are

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[4] Page I3-3 USACE 2002 EIS, https://www.nww.usace.army.mil/Library/2002-LSR-Study/

[5] USACE Walla Walla District. www.nww.usace.army.mil Supporting Documents: Snake River Production to Northwest Residential Use Negating Aug Sep 2015.

higher. This pattern of load following is often mistakenly called "peaking capability" but it is more accurately a description of standard daily operations. Most peaking capability comes from storage dams, where a spike in load increases generation above average, and the large reservoir supports the discharge of more water.

As we will later model, initiating sustained peaking power cannot occur without drawing the reservoir down below MOP with noted consequences. According to the 1992 drawdown test "Once the reservoir level drops below MOP, most project facilities, such as the navigation lock, and juvenile and adult fish passage facilities, become inoperable[6]." Additional analysis of this scenario will show the potential for damage to the dams, reservoirs, adjacent roads, railroads, bridge abutments, stranding of towboats/barges and other vessels, cutting off of fish passage completely and potentially affecting Native American cultural resource sites. Effects of peaking would persist until the reservoir was restored to MOP levels.

The remainder of this paper will model two peaking power scenarios and use data collected from the 1992 Reservoir Drawdown Test to verify corresponding effects of drawdown on facilities and structure, water, biological, and cultural resources.

Assumptions and Modeling

For simplicity of the model, various assumptions are used for river flow and output of turbines. At the time of peaking, it is assumed the four Lower Snake River Dams (LSRDs) have been maintaining base generation of 700-800MWs based on average river flow November through February. It is in this time period that we assume the highest probability of a cold snap or power load spike, requiring peaking. At this time of year, 25 kfcs is the average flow in the river, which is constant throughout the model. Power output differs slightly between turbines and an average output of 133 MW per unit is used (Table 2.4). Flow per turbine differs slightly between turbines and an average flow per turbine of 18,500 ft^3/sec is used throughout (Chart 2.4). We started our modeling exercise at the Lower Granite maximum operating pool level of 738 fmsl. However, a peaking event could start at any elevation between MOP and maximum pool. In the model, changes in reservoir volume correspond to changes in forebay elevation, (Table 2.3) or level of the pool in fmsl. Lower Granite draws down while the three lower reservoirs stay the same level. We assume **no spill** during the five-day peaking event.

Based on the claim, it is unclear whether the 2650 MW of peaking power was meant to be in addition to base generation or peaking and base generation are mutually exclusive. Therefore, we model both scenarios.

Scenario 1 involves ramping up from normal generation to max generation, running all six turbines at all four dams. Running 24 turbines at this capacity yields 3,192 MW, close to desired output of base generation plus peaking power. Power generation in the model is consistent with regularly scheduled generation and refill, where power generation occurs throughout the day to meet demand, and refill occurs from midnight to five AM.

Scenario 2 assumes base generation ceases during peaking (mutually exclusive events). Therefore, running five turbines at each of the four dams would be sufficient to meet the peaking claim of 2650 MW in a winter demand spike. Refill occurs from midnight to five AM.

Both scenario 1 and 2 reduced pool elevation below MOP. To account for this, we retrospectively modeled refilling of Lower Granite dam in two ways. One by maintaining base generation and five-hour refill and the second modeled by ceasing generation until refill to 733 fmsl or MOP is reached.

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[6] USACE Walla Walla District, 1992 Reservoir Drawdown Test, page 27

However, the second refill model would mean that all four dams could not generate base load until MOP was reached.

Calculations:

Peaking Scenario 1 -- 6 turbines running at each dam, drawdown occurs at Lower Granite dam only.

From 0500 to 1500 hours, peaking discharge = (6 Turbines)(18,500 ft^3/sec/turbine) = 111,000 ft^3/sec

Peaking discharge, Hourly Flow = (111,000 ft^3/sec)(60 sec/min)(60 min/hour) = 399,600,000 ft^3/hr

$\frac{399{,}600{,}000\ ft^3/hr}{43{,}560\ ft^2/acre}$ = 9,174 AF/hr *(AF equals acre ft)*

Peaking continues for 10 hours a day = (9,174 AF/hr)(10 hours) = 91,740 AF/10hr

Inflow occurring simultaneously: (25,000 ft^3/sec)(60 sec/min)(60 min/hr) = 90,000,000 ft^3/hr

$\frac{90{,}000{,}000\ ft^3/hr}{43{,}560\ ft^2/acre}$ = 2,066 AF/hr

(2,066 AF/hr)(10 hours) = 20,660 AF/ 10 hrs

Total ***drawdown*** in first 10 hrs of peaking = (91,740 AF/10 hr) - (20,660 acre ft/ 10 hrs)= 71,080 AF

From 1500 to 0000 hours, maintenance of base power production based on inflow of 25,000 ft^3/sec, where inflow equals discharge, ***no drawdown.***

$\frac{25{,}000\ ft^3/sec}{18{,}500\ ft^3/sec}$ = 1.35 turbines, one or two turbines in operation over the nine hours to generate base load of 702 MW.

From 0000 hour – 0500 hours turbines are idle on all four dams, inflow partially refills Lower Granite Reservoir.

Hourly Flow (25,000 ft^3/sec)(60 sec/min)(60min/hour)= 90,000,000 ft^3/hr

$\frac{90{,}000{,}000\ ft^3/hr}{43{,}560\ ft^2/acre}$ = 2,066 AF/hr

Refill = (2,066 AF/hr)(5 hours) = 10,330 AF for the 5 hours of refill

After 5 days pool elevation is down 47 feet to pool elevation 691ft msl (table 2.1)

Peaking Scenario 2 -- 5 turbines at each dam, drawdown at Lower Granite Dam only.

From 0500 to 1500 hours, Peaking discharge per hour =
(5 turbines)(18,500 ft^3/sec)(60 sec/min)(60 min/hr) = 333,000,000 ft^3/hr

$\frac{333{,}000{,}000\ ft^3/hr}{43{,}560\ ft^2/acre}$ = 7,645 AF/hour of drawdown.

Inflow occurring simultaneously is still 2,066 acre ft/hr, same as Scenario 1

((7,645 AF/hour)(10))-((2,066 AF/hr)(10)) = 55,790 acres/10 hours of drawdown with refill

From 1500 to 0000 hours = maintenance of base power production based on inflow of 25,000 ft^3/sec, inflow equals discharge, ***no drawdown*** (same as scenario 1).

From 0000 hour – 0500 hours, turbines are idle, ***refill*** (same as scenario 1).

Hourly Flow (25,000 ft^3/sec)(60 sec/min)(60min/hour)= 90,000,000 ft^3/hr

$$\frac{90{,}000{,}000\ ft^3/hr}{43{,}560\ ft^2/acre} = 2{,}066\ \text{Acre ft/hr}$$

Refill = (2,066 AF/hr)(5 hours) = 10,330 AF for the 5 hours of refill

After 5 days pool elevation is down 33 feet to 705 ft msl (table 2.2).

Lower Granite Refill to MOP -- Scenario 1, model 1

From 0000-0500 hours is daily refill period

Inflow for five hours (5)(2,066 acre ft) = 10,330 AF for 5 hours or per day

From 0500-2400 hours, Base power production (at all four dams) inflows equal outflows at all 4 dams, no refill at Lower Granite.

Starting refill at elevation 691 ft msl equates to a reservoir volume of about 180,050 AF.
Thus it takes 268,580 AF to reach MOP or a reservoir volume of 448,600 AF

(180,050 AF) + (268,580 AF) = 448,630 AF

$$\frac{268{,}580\ AF}{10{,}330\ AF/day} =$$ **26 days to refill Lower Granite reservoir**

Scenario 1, model 2 - refill to MOP with *no* generation at all four dams.

(24 hrs)(2,066 acre ft) = 49,584 acre ft/day

$$\frac{268{,}580\ \text{acre ft}}{49{,}584\ \text{acre ft/day}} =$$ **5.5 days to refill Lower Granite Reservoir**

Scenario 2, model 1, refill to MOP

From 0000-0500 hours is daily refill period

Inflow for five hours (5)(2,066 AF) = 10,330 AF for 5 hours or per day

0500-2400 hours, Base power production (at all four dams) inflows equal outflows at all 4 dams, so no refill at Lower Granite

Starting refill at elevation 705 feet equates to a reservoir volume of 256,530 AF.
Thus it takes 192,100 AF to reach MOP or a reservoir volume of 448,630 AF

(256,530 AF) + (192,100 AF) = 448,630 AF

$\frac{192{,}100\ \text{AF}}{10{,}330\ \text{AF/day}}$ = **18.5 days to refill Lower Granite reservoir**

Scenario 2, model 2 - refill to MOP with *no* generation at all four dams.

(24 hrs)(2,066 AF) = 49,584 AF/day

$\frac{192{,}100\ \text{AF}}{49{,}584\ \text{AF/day}}$ = **3.8 days to refill Lower Granite Reservoir**

Modeling Results

Results of the both peaking scenarios are displayed in chart 1.1. During the first day of peaking, both scenarios would drain Lower Granite reservoir below MOP. At the start of peaking the next day, the reservoir in Scenario 2 would have refilled to MOP once again, only to drop below MOP that day. It is unlikely that functions lost from drawdown on day one would be reestablished before peaking began again on day two. For both scenarios, the reservoirs continue to drop significantly despite five hours of refill per day. After five days of sustained peaking for ten hours a day, Scenario 1 results in a total drawdown of 49 feet, Scenario 2 a total of 33 feet.

The average rate of drawdown is 9.4 feet/day for Scenario 1 and 6.6 feet per day for Scenario 2. The volume of water drained from the reservoir is the same each day. However, pool elevation decreases at an increasing rate due to the reservoir bathymetry. After peaking on the fifth day, Lower Granite reservoir drops to 689 fmsl for Scenario 1 and 703 fmsl for Scenario 2. This equates to 44 and 30 feet below MOP, respectively. The modeled peaking event ends after normal refill from midnight to five AM. Additional refill must begin the next day to restore MOP.

Refill for Scenario 1 would take 26 days if base generation was ongoing. If generation ceased and refill took its place, it would take 5.5 days to refill Lower Granite, but this scenario is unlikely since **there could be no generation at the lower three dams without their reservoirs dropping below MOP.**

Refill for Scenario 2 would take 18.5 days if base generation was ongoing. If generation ceased and refill took its place, it would take 3.8 days to refill Lower Granite**, but again there could be no generation at the lower three dams without their reservoirs dropping below MOP.**

1992 Draw Down Test

The 1992 Drawdown test was designed to gather information about the effects of lowering reservoirs substantially. The intended purpose was to provide evidence to improve survival of downstream migrating juvenile salmon. Results were observed as Lower Granite (LGR) Reservoir levels fell two feet per day for 14 days. Drawdown at LGR was 36 feet below MOP and Little Goose (LGO) Reservoir was lowered 12.5 feet below MOP (Figure 27). We will focus on results at Lower Granite as this is the same reservoir we use to model the peaking claim. The low point of Lower Granite pool was 697 fsml before refill. Once the pool elevation was substantially reduced a series of spill tests were conducted to monitor flow pattern and dissolved gas conditions under a variety of tailwater elevations. Here we will discuss relevant results related to drawdown only.

The results of the drawdown had varying effects on turbines, reservoirs, adjacent roads, railroads, bridge abutments, wildlife, fish passage, and native American cultural resource sites. Turbines were at risk of cavitation from either low head (feet of water above turbine intakes) or low tailwater conditions. Cavitation causes the dynamic energy from water flow to be transferred to shafts and draft tubes that are outside the design parameters. Resulting damage to the turbine and surrounding structure can be costly and in some instances beyond repair. The concern of turbine cavitation was an important conversation point of the test[7] and is an important consideration today, given the same turbines have now aged (45 to 55 years old) and have decreased in reliability ratings.

Numerous effects related to embankment stability we expressed as a result of the 1992 drawdown test. Fully saturated embankments, once exposed to atmospheric conditions following the movement of water out, causes soil instability. This was the explanation behind choosing a safe drawdown limit of two feet per day[7]. As the reservoir was drawn down, embankment material that was previously saturated lost the stabilizing effect of the weight of the reservoir. The water seeped out, but at a slower rate than the drawdown. This lack of pore pressure on the bank face indeed caused stress and instability[8]. As a result of the test, 33 areas experienced embankment movement. This was evidenced by cracking, depressed and raised areas in the road, guardrail movement and numerous minor slides. Railroads experienced misalignment that caused speed restrictions until the tracks could be realigned. Piezometers used to detect movement at the Lewiston Levees reported slight affects. There were related damages reported to port and private structures totaling 1.3 million dollars.

Biological effects of the test occurred due to exposed sediment as the pool level was decreased. Fish kills from stranding were estimated at 15 – 35,000 fish. The report stated, "predation by birds, raccoons, and other opportunistic scavengers will tend to make estimates somewhat conservative."[9] Effect on benthic organisms was evidenced by exposed amphipods. The report concluded the "effects on food webs, resident and anadromous fish were unknown but probably significant."[10] Salmonids were affected in two ways. Stranding caused 22 Salmonid mortalities. More significant was the change in flow pattern at adult fish passage entrances. The report states that "flow patterns observed at main adult fishway entrances appeared to be undesirable for adult fish passage."[11] Fish ladders became non-functional below an elevation of 710 fmsl and the juvenile passage system became non-functional below 729fsml.

The drawdown affected turbidity due to water velocity changes. USACE scientists observed that coarser sediments resuspended but settled quickly. Low pool elevations increased turbidity and resuspension of finer materials that did not settle quickly and persisted downstream. Various Native American cultural resource sites were inspected for effects of drawdown. Change to landforms where artifacts remained exposed or covered by silt were observed. Terracing and slumpage of sandier slopes was common, however, USACE archeologists concluded many inspected sites still contained cultural deposits eligible for inclusion in the National Register of historic places.

Drawdown Comparative Analysis

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[7] USACE Walla Walla District, 1992 Reservoir Drawdown Test, page 74

[8] USACE Walla Walla District, 1992 Reservoir Drawdown Test, page 28

[9] USACE Walla Walla District, 1992 Reservoir Drawdown Test

[10] USACE Walla Walla District, 1992 Reservoir Drawdown Test

[11] USACE Walla Walla District, 1992 Reservoir Drawdown Test

The modeled peaking power event and 1992 drawdown test had different intended purposes. However, both resulted in significant reservoir drawdown well below MOP. We compared the 1992 drawdown to the two scenarios modeled to predict unavoidable effects of drawdown during a peaking event. In the 2020 EIS, the calculations and origin behind the peaking claim remains unknown. This study is the first analysis conducted to understand achievability of the claim using available data.

The 1992 LGR drawdown value falls in-between the drawdown values in the two modeled scenarios. Scenario 1's minimum pool elevation of 689 fmsl is 8 feet lower than the minimum pool level in the 1992 test. Scenario 2's minimum pool elevation of 703 fmsl is six feet above the minimum pool level in the 1992 test. Because of this outcome, we can assume implementation of a LSRD peaking event could result in outcomes similar to those recorded during the 1992 test.

The rate of drawdown modeled in peaking can be also be compared prospectively to the 1992 drawdown. In the 1992 test, a rate of two feet a day was chosen as one that would invoke minimal embankment movement in saturated conditions. However, as the rate of drawdown increases, embankment instability is magnified. Both modeled scenarios have a significantly higher rate of drawdown per day than the 1992 test. Therefore, predicted embankment failures are more severe and widespread in our model. Drawdown followed by refill and further drawdown helps loosen the bank material and can lead to increased instability of banks. An increased rate of drawdown also increases the risk of turbine cavitation from reduced head.

Given the many contingencies in predicting events in nature, we cannot specifically describe the severity of various possible effects in a peaking event, but will discuss them hypothetically in order of importance. In our analysis, embankment failure is predicted to be more prevalent and more severe due to a faster drawdown rate. This alone should call into question the veracity of peaking claims made in both the most recent federal EIS and attendant claims made by pro-hydropower interests. As stated on page 42 of the 1992 Drawdown Test, "maintaining embankment stability is critical to the integrity and safety of the lower Snake River projects." We predict effects of drawdown from "peaking" will similarly affect rail lines, ports and private facilities and structures as it did in the 1992 test.

Biological damage with a peaking drawdown would be unreasonably high. We expect a failure of the juvenile fish passage system and adult fish ladders, as happened at similar elevation pool levels in the 1992 test. However, a newly installed pump may be used to continue operating adult fish ladders. Other biological effects are predicted to be similar to the 1992 drawdown, depending on how much sediment is exposed. Peaking would likely to occur in the winter, and would affect anadromous fish returns. The 1992 test occurred in March. Our model, with flows of 25 kfcs, is average for November through February. 25 kfcs is also possible in March. We expect densities of resident fish and benthic organisms to be similar and thus biological effects to be similar to what was documented in the 1992 drawdown.

We expect exposed archaeological sites to be similarly if not more affected by a peaking event due to increased soil instability and soil pumping. We also are concerned that looting of these sites could take place if not properly protected or guarded.

Conclusions

This is the first known analysis done of a theoretical sustained peaking event, or at least the first time it is acknowledged that the claimed event would cause drawdown below MOP. To put it simply, we found that because claimed peaking would draw a reservoir down below minimum operating pool, the ability to generate power over the ~1,000 aMW or the average output of the LSRDs, can only safely occur when high flows allow it in the spring. The long recovery time it would take to get back to MOP further explains the infeasibility of the claim. We affirm the limitation of the LSRDs, based on river flows and spill requirements in summer, fall, and especially winter. In the spring, peaks in flow can potentially generate over 3,000 MW and is the only time the peaking claim is plausible. However, since load is relatively low during this time, if this much power *is* generated it cannot be deemed essential or peaking, because it contributes to the surplus and is sold on different markets.

The modeling results showed that under two claimed peaking scenarios, pool elevations drop significantly below MOP, 44 and 30 feet, respectively. This was confirmed even though modeling was started at maximum pool elevation, 5 feet above MOP. These low pool levels are similar to those tested for in the 1992 drawdown test, the impacts being:

Navigation becomes non-functional
- Below MOP barge traffic cannot safely pass.
- Smaller craft affected since they would begin to be stranded in marinas or unable to use boat ramps within the first day in the Lewiston/Clarkston area.
- Navigation impaired until refill which could take up 31 days depending on process.

Inability to spill
- Although court ordered spill for salmon mitigation would not be implemented in winter months, it cannot safely occur below MOP. Spill would result in loss of generation and increased drawdown.

Juvenile passage system becomes non-functional
- Below pool elevation of 729 fmsl juvenile fish passage orifice is no longer submerged.

Embankment failure
- Damages to reservoir banks, adjacent roads, railroads, bridge abutments, ports, private facilities, structures, & levees will occur, especially given the high drawdown rate.

Turbine Cavitation Risk
- Predicted turbine vibration as a precursor to cavitation.
- Cavitation can damage draft tubes, turbines, and concrete structure.

Damage to biological and cultural resources
- Adverse effects to anadromous fish, resident fish, and benthic organisms.
- Predicted damage to exposed Native American archeological sites from erosion and theft.

Overall, these impacts show peaking at the claimed level is ***infeasible*** and is a clear demonstration of why the four LSRDs and reservoirs were never designed, or operated in a manner, to allow for anything more than the variance within the minimum and maximum operating pool levels. As such, these unsupported sustained peaking claims are invalid, and should be removed from Federal Agency and Non-Government Organization Fact Sheets. Likewise, where this claim is assigned a dollar value, calculations must be corrected to omit this feature. For example, the Final CRSO Review and EIS assigns $801 Million as a total zero-carbon replacement cost for these peaking or ramping capabilities in the dam breaching alternative. In the discussion, additional contradictory claims about LSRD value and ancillary services (named as peaking, ramping, reserve and balancing reserves) will be examined.

Discussion

The Lower Snake River dams are designed and operated as "run of river" projects, and have an established base generation that varies daily and seasonally. For almost fifty years, this yearly average output exemplifies both the value and limitation of the dams. Claims about peaking power seem to appear on the heels of discourse around breaching the dams, which was extensively discussed in the USACE 2002 EIS. In addition to peaking power, ramping, reserves, balancing power, and flexibility have been features singled out to add value to the Snake River Dams in the case against breaching. Too often, these features are not described in comparison to other hydro projects and sources of energy.

Ramping & Peaking

Ramping capability is discussed in the 2020 EIS where it states, "The Lower Snake River projects have the *unique* ability during certain times of the year to back down their generation to very low levels at night and then increase (ramp) the generation during the day to meet daytime peaks." (*chapter 3- page 945*). When examining generation data, distinctions between ramping, peaking, and base generation must be made. Ramping capabilities are defined as the amount of generation that the resource is able to increase or decrease over a defined time,[12] but should be included in base generation if it refers to the daily scheduled pattern of generation following load. For hydropower, this occurs by engaging or disengaging available turbines. Other energy sources may have variations of this capability as well if multiple units are manipulated to balance power. Renewables such as wind and solar are viewed as having little flexibility but could still be capable of ramping. While there are times they are constrained by lack of wind and sun, wind turbine units can be feathered quickly to adjust output up or down, and solar can be cut back if it is not needed. Hence, like a run-of-river dam, these renewables have ramping flexibility if the source of energy is available and as long as they are idled in a standby mode ready to ramp up. Because ramping in this capacity occurs at most federal hydro projects everyday, (chart 1.2) ramping should not be considered unique to the LSRDs.

In the 2020 EIS replacement resource analysis for the LSRDs, a sustained peak *value* is "derived" from generation data. Then revenue values are further "derived" using rate case and 2030 LT forecast models. Totals of $2.8 million/yr. and $27 million/yr. for sustained ramping capability are the concluded values (respectively), yet it is unclear how this was included in the prediction of $801 million in in total zero-carbon power replacement annual costs. (*See table 3-166)*. This should be as concerning to the public as the false peaking claims, because standard ramping is inherent in daily hydropower operations and has the potential to be double counted when cost breakdown is not clearly shown.

Reserve & Balancing Reserve

Also noted in the 2020 EIS (*chapter 3- page 945)* is *reserve value*. It states, "250 MW of operating reserves are assigned to the Lower Snake River Projects," as part of the "big ten projects." This assumption is likely based on BPA's requirement to hold 10% of generation capacity in reserve. However, this requirement can be fulfilled using any energy resource in the "big ten" system, not necessarily the LSRDs, and it is highly unlikely this designated reserve capability would fall on the LSRD projects, given their flow constraints. The EIS did not show further analysis of this capability, though it clearly influenced the acceptable profile for replacement power sources, and thus replacement costs. The 2002 EIS's $8 million for ancillary services included reserve is dramatically lower than the 2020 EIS estimations of $714 and $801 million.

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[12] 2020 EIS Chapter 3 page 828.

The *balancing reserves* noted in the EIS (*page 3-945)* and assigned replacement value, depend on the ability of "the LSR projects to respond quickly to requested changes." The reasoning is that they "are connected to a rapid response system called automatic generation control" (AGC). While all four LSR projects may be "connected" to AGC, it does not mean they are first priority in AGC system reserves. Limited in its use due to fish passage and spill requirements, those familiar with LSR dam operations know that operators are constantly having to monitor eddy patterns that can increase salmon mortality or erosion of dam structures. The highly complex and reactive decision process has many variables, such as river flow, temperatures, dissolved gas, passage timing, fish arrivals, avian predation, mandatory spill, etc., that cannot be incorporated into AGC responses. Indeed, the 2002 EIS recognized this problem and used "expert opinion" to derive a value of $465,000 for replacing the value of AGC. Even adjusting for inflation, replacing ACG reserves lost to LSRD removal would most certainly not result in the hundreds of millions of dollars the 2020 EIS claims as a value. Manual operations are not quick enough to meet contingency or balancing reserves, which happens on dams under full control of AGC within seconds or minutes. The 2020 EIS claim about response capabilities has been contradicted in the 2020 biological assessment, where it states (*page 2-63*) "at run-of-river projects (e.g., lower Snake River dams) there is minimal ability to control the timing of electricity generation, some generation can be adjusted from one hour to the next, and perhaps to the subsequent day." By comparing generation data with known events, we have more information to support the inflexible nature of LSRD projects responding to changes. For example, the unscheduled outage at Columbia Generating Station in the summer of 2018 instantly dropped 1200 MW of power in the Tri-Cities area of Washington for about two weeks. USACE generation data shows LSR projects played virtually no role in covering this event. The LSRDs were also not used to responded to cold snaps in 2017 and 2019.

Opposing rhetoric

Even when capabilities of the LSRDs are overstated or embellished, limitations are elsewhere discussed that contradict flexibility claims. For example, after discussing "unique" capabilities in chapter 3 of the 2020 draft EIS, it states in appendix J. "These (LSR) projects…. do not have any flexibility." In the final EIS this statement was removed. In the 2020 EIS (appendix I page 14) it states, "no reserves are carried by lower Snake projects when operating in MOP," The 1992 drawdown test shows us the reasons why these projects were not designed to operate outside of minimum to maximum operating pool range, yet reserves were still an input value in the report. This contradiction is again expressed in the 2020 Biological Assessment when it says on page 2-65, **"there is little capacity to hold reserves at the lower Snake River dams when the forebays are maintained within *a narrow operating range at MOP*."**[13]

The analysis in the 2020 EIS dam breach alternative identified what is called a potential zero-carbon replacement portfolio, consisting of 2,550 MW of solar resources and 600 MW of demand response.[14] However, the EIS only identifies the loss of 730 MW of "firm power" with a dam breach alternative.[15] This is another example of the difference between actual vs. theorized generation on the LSRDs. Their base load/assured generation is much lower than capacity, overload capacity, and ancillary benefits, of which are called into question by this paper. When it comes to the LSRDs, their value should be based on the value they've shown in the last fifty years, without exaggerating the potential of additional

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[13] 2020 USACE EIS Appendix V CRS Biological Assessment Chapter 2 pp 65. file:///Users/jimwaddell/Downloads/p16021coll7_14968.pdf

[14] 2020 USACE EIS Chapter 7 page 11 https://www.nwd.usace.army.mil/CRSO/Complete-DEIS/#top

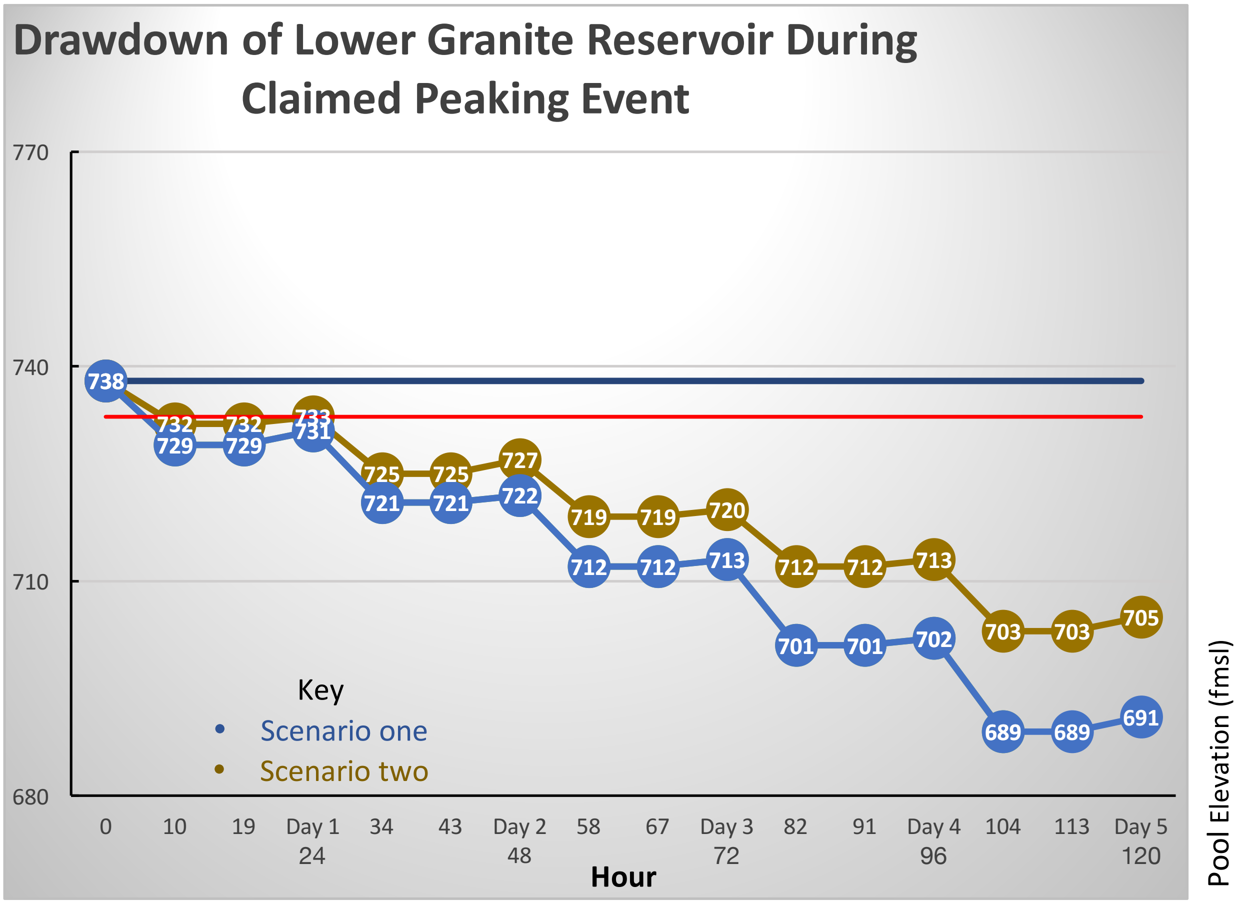
[15] 2020 USACE EIS Table 6-26 https://www.nwd.usace.army.mil/CRSO/Complete-DEIS/#top

capabilities. A chart from BPAs 2020 Strategic Asset Management Plan shows the four LSRDs have an average annual plant generation value of approx. $227 million[16]. This number, which is based on realistic market prices, might more accurately describe their value. It is also further representation of the overstatement of replacement power for the dams in the 2020 EIS.

A realistic evaluation of the value of the four LSRDs is missing from breach discussions. This is a serious breach of the BPA's duty to serve the public interest. Inaccurate peaking and ancillary service values undermines the analysis of a preferred alternative and may result in economic impacts for ratepayers and the environment.

Charts and Tables

Chart 1.1



Minimum operating pool 733 Maximum pool 738

Chart 1.1.
In Scenario 1 the reservoir was drawn down 49 feet in five days, or 44 feet below MOP.
In Scenario 2 the total drawdown was 35 feet or 30 feet below MOP. Both scenarios drew down the reservoir below MOP during first ten hours of peaking event.

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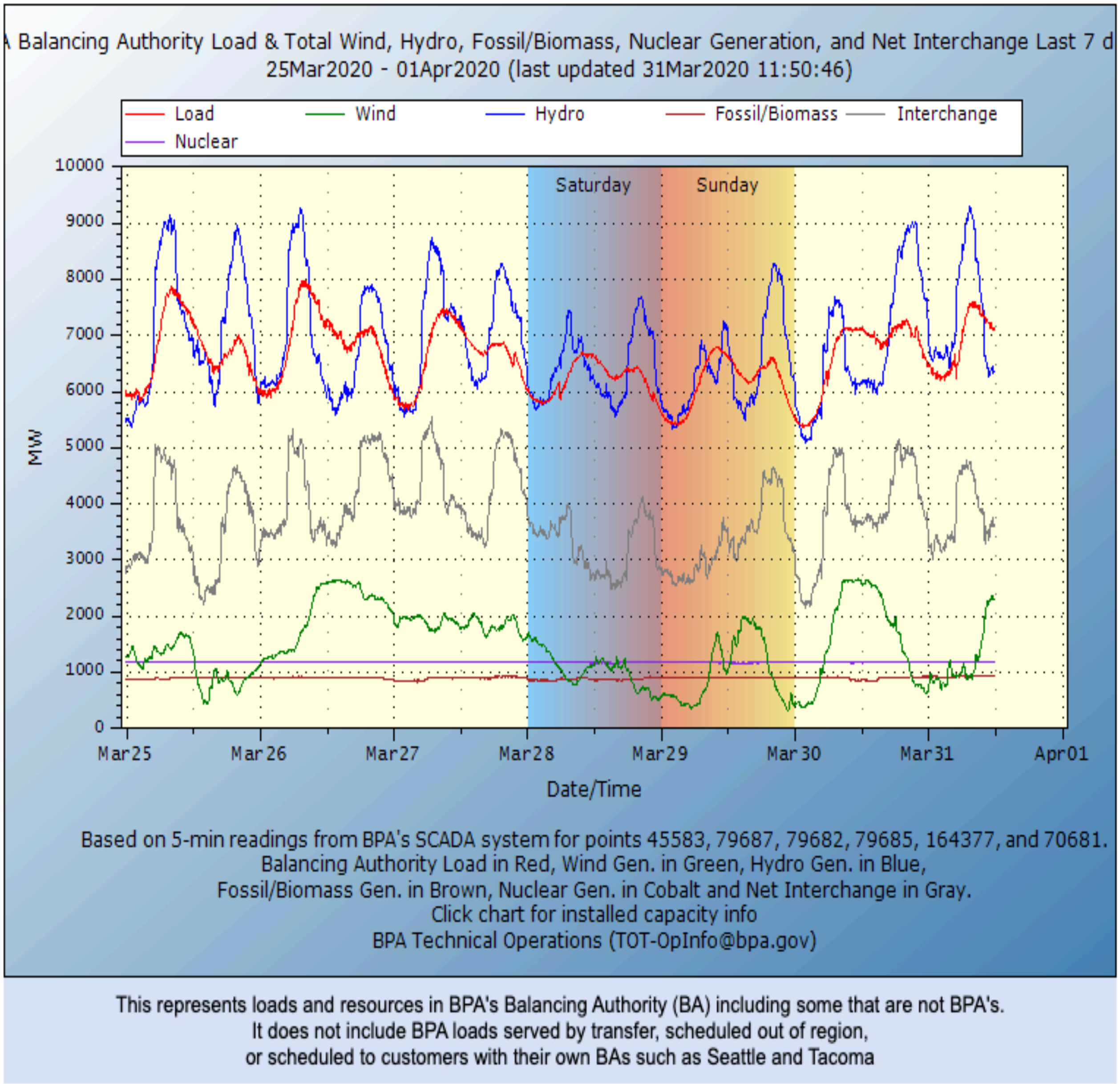
[16]

Chart 1.2


Balancing Authority Load & Total Wind, Hydro, Fossil/Biomass, Nuclear Generation, and Net Interchange Last 7 d
25Mar2020 - 01Apr2020 (last updated 31Mar2020 11:50:46)

Based on 5-min readings from BPA's SCADA system for points 45583, 79687, 79682, 79685, 164377, and 70681.
Balancing Authority Load in Red, Wind Gen. in Green, Hydro Gen. in Blue,
Fossil/Biomass Gen. in Brown, Nuclear Gen. in Cobalt and Net Interchange in Gray.
Click chart for installed capacity info
BPA Technical Operations (TOT-OpInfo@bpa.gov)

This represents loads and resources in BPA's Balancing Authority (BA) including some that are not BPA's.
It does not include BPA loads served by transfer, scheduled out of region,
or scheduled to customers with their own BAs such as Seattle and Tacoma

Chart 1.2. The blue plot is overall hydro generation which follows load and price in most cases. The LSRDs are not unique by being able to ramp up in the early hours, most of the dams do. The 4LSRDs often shut down all generation for a few hours between midnight and 5am to store a few feet of water above MOP, that is then discharged to meet the morning increase in load. Numerous public relations statements by BPA and their supporters often call this "peaking Power" and now ramping "capability". The grey plot is surplus power, sold on various interchange markets. The latest real-time chart is from: https://transmission.bpa.gov/Business/Operations/Wind/baltwg3.aspx

Reference Charts

Scenario 1 Drawdown

Table 2.1

Hour	Pool Elevation (fmsl)	ol Volume (AF)
0	738	483,800
10	729	412,720
19	729	412,720
Day 1 24	731	423,050
34	721	351,970
43	721	351,970
Day 2 48	722	362,300
58	712	291,220
67	712	291,220
Day 3 72	713	301,550
82	701	230,470
91	701	230,470
Day 4 96	702	240,800
104	689	169,720
113	689	169,720
Day 5 120	691	180,050

Table 2.2

Scenario 2 Drawdown

Hour	Pool Elevation (fmsl)	Pool Volume (AF)
0	738	483,800
10	732	428,010
19	732	428,010
Day 1 24	733	438,340
34	725	382,550
43	725	382,550
Day 2 48	727	392,880

		58	719	337,090
		67	719	337,090
Day 3	72		720	347,420
		82	712	291,630
		91	712	291,630
Day 4	96		713	301,960
		104	703	246,170
		113	703	246,170
Day 5	120		705	256,500

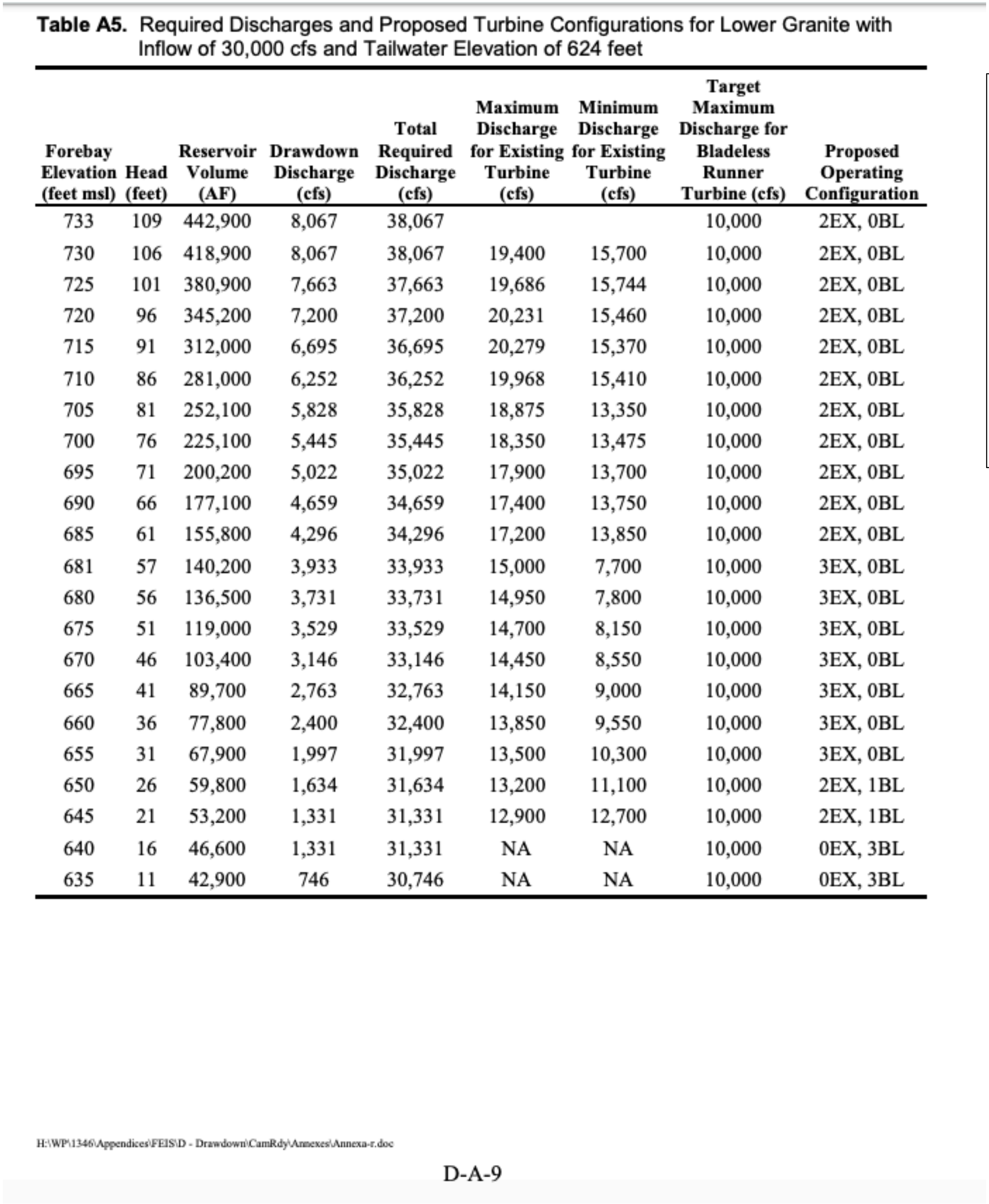


Table A5. Required Discharges and Proposed Turbine Configurations for Lower Granite with Inflow of 30,000 cfs and Tailwater Elevation of 624 feet

Forebay Elevation (feet msl)	Head (feet)	Reservoir Volume (AF)	Drawdown Discharge (cfs)	Total Required Discharge (cfs)	Maximum Discharge for Existing Turbine (cfs)	Minimum Discharge for Existing Turbine (cfs)	Target Maximum Discharge for Bladeless Runner Turbine (cfs)	Proposed Operating Configuration
733	109	442,900	8,067	38,067			10,000	2EX, 0BL
730	106	418,900	8,067	38,067	19,400	15,700	10,000	2EX, 0BL
725	101	380,900	7,663	37,663	19,686	15,744	10,000	2EX, 0BL
720	96	345,200	7,200	37,200	20,231	15,460	10,000	2EX, 0BL
715	91	312,000	6,695	36,695	20,279	15,370	10,000	2EX, 0BL
710	86	281,000	6,252	36,252	19,968	15,410	10,000	2EX, 0BL
705	81	252,100	5,828	35,828	18,875	13,350	10,000	2EX, 0BL
700	76	225,100	5,445	35,445	18,350	13,475	10,000	2EX, 0BL
695	71	200,200	5,022	35,022	17,900	13,700	10,000	2EX, 0BL
690	66	177,100	4,659	34,659	17,400	13,750	10,000	2EX, 0BL
685	61	155,800	4,296	34,296	17,200	13,850	10,000	2EX, 0BL
681	57	140,200	3,933	33,933	15,000	7,700	10,000	3EX, 0BL
680	56	136,500	3,731	33,731	14,950	7,800	10,000	3EX, 0BL
675	51	119,000	3,529	33,529	14,700	8,150	10,000	3EX, 0BL
670	46	103,400	3,146	33,146	14,450	8,550	10,000	3EX, 0BL
665	41	89,700	2,763	32,763	14,150	9,000	10,000	3EX, 0BL
660	36	77,800	2,400	32,400	13,850	9,550	10,000	3EX, 0BL
655	31	67,900	1,997	31,997	13,500	10,300	10,000	3EX, 0BL
650	26	59,800	1,634	31,634	13,200	11,100	10,000	2EX, 1BL
645	21	53,200	1,331	31,331	12,900	12,700	10,000	2EX, 1BL
640	16	46,600	1,331	31,331	NA	NA	10,000	0EX, 3BL
635	11	42,900	746	30,746	NA	NA	10,000	0EX, 3BL

H:\WP\1346\Appendices\FEIS\D - Drawdown\CamRdy\Annexes\Annexa-r.doc

D-A-9

Table 2.3
The 1st and 3rd columns of this chart from the UASCE 2002 EIS is used to establish forebay elevations based on reservoir volume as a result of discharges.

The link to the source document is:
https://www.nww.usace.army.mil/Portals/28/docs/library/2002%20LSR%20study/Appendix_D-AnnexA.pdf?ver=2019-05-03-135521-310

Project	LWG Units 1 and 3 – with ESBS						LWG Units 1 and 3 – No ESBS					
Head	1% Lower Limit		1% Upper Limit		Operating Limit		1% Lower Limit		1% Upper Limit		Operating Limit	
(feet)	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs	MW	cfs
85	69.9	11,938	116.2	19,863	140.9	25,477	65.7	10,897	120.6	20,010	140.9	24,226
86	70.6	11,922	118.5	20,007	142.8	25,484	66.4	10,882	123.0	20,155	142.8	24,243
87	71.4	11,906	120.8	20,146	144.6	25,489	67.2	10,868	125.4	20,296	144.6	24,258
88	72.2	11,890	123.1	20,282	146.5	25,493	67.9	10,853	127.8	20,434	146.5	24,272
89	73.0	11,875	125.4	20,415	148.3	25,494	68.6	10,839	130.2	20,568	148.3	24,283
90	73.7	11,859	127.7	20,544	150.2	25,493	69.3	10,826	132.6	20,698	150.2	24,292
91	74.6	11,849	128.1	20,346	151.5	25,400	70.2	10,817	133.0	20,500	151.5	24,217
92	75.5	11,839	128.5	20,152	152.8	25,305	71.0	10,808	133.3	20,305	152.8	24,139
93	76.3	11,829	128.8	19,963	154.0	25,207	71.8	10,799	133.7	20,115	154.0	24,059
94	77.2	11,818	129.2	19,777	155.2	25,135	72.6	10,790	134.1	19,929	155.2	23,973
95	78.1	11,808	129.5	19,596	155.2	24,808	73.4	10,781	134.4	19,747	155.2	23,646
96	79.1	11,825	129.7	19,385	155.2	24,463	74.4	10,797	134.6	19,536	155.2	23,322
97	80.2	11,841	129.8	19,179	155.2	24,126	75.4	10,813	134.7	19,329	155.2	23,004
98	81.2	11,857	130.0	18,978	155.2	23,797	76.4	10,827	134.9	19,126	155.2	22,694
99	82.3	11,872	130.1	18,780	155.2	23,474	77.4	10,842	135.0	18,928	155.2	22,390
100	83.3	11,887	130.3	18,586	155.2	23,159	78.3	10,855	135.2	18,734	155.2	22,093
101	84.2	11,890	132.0	18,637	155.2	22,836	79.2	10,858	137.0	18,785	155.2	21,784
102	85.1	11,892	133.7	18,687	155.2	22,521	80.0	10,860	138.8	18,836	155.2	21,482
103	86.0	11,895	135.4	18,736	155.2	22,212	80.9	10,863	140.6	18,885	155.2	21,186
104	86.9	11,897	137.2	18,784	155.2	21,910	81.7	10,865	142.4	18,934	155.2	20,897
105	87.8	11,899	138.9	18,830	155.2	21,615	82.5	10,867	144.2	18,981	155.2	20,615
	LWG Units 4, 5, 6 – with ESBS						LWG Units 4, 5, 6 – No ESBS					
85	83.9	13,761	107.2	17,586	142.5	24,793	85.1	13,602	116.0	18,546	142.5	23,969
86	85.0	13,769	108.9	17,652	144.3	24,810	86.1	13,600	117.9	18,616	144.3	23,986
87	86.1	13,777	110.7	17,717	146.1	24,825	87.2	13,597	119.8	18,685	146.1	24,001
88	87.1	13,784	112.4	17,780	147.9	24,838	88.2	13,595	121.7	18,751	147.9	24,013
89	88.2	13,791	114.2	17,841	149.7	24,849	89.2	13,592	123.5	18,816	149.7	24,024

90	89.3	13,798	115.9	17,900	151.4	24,857	90.3	13,589	125.4	18,879	151.4	24,032
91	90.3	13,778	117.1	17,878	152.8	24,721	91.4	13,598	126.8	18,856	152.8	23,946
92	91.2	13,759	118.4	17,857	154.1	24,583	92.5	13,607	128.1	18,834	154.1	23,857
93	92.1	13,740	119.6	17,836	155.2	24,425	93.7	13,615	129.4	18,812	155.2	23,747
94	93.1	13,722	120.8	17,815	155.2	24,112	94.8	13,623	130.8	18,791	155.2	23,676
95	94.0	13,703	122.0	17,795	155.2	23,675	95.9	13,630	132.1	18,769	155.2	23,011
96	95.1	13,707	122.6	17,676	155.2	23,372	96.9	13,620	132.7	18,645	155.2	21,828
97	96.1	13,711	123.1	17,560	155.2	23,076	97.9	13,609	133.3	18,523	155.2	21,557
98	97.2	13,714	123.7	17,446	155.2	22,786	98.9	13,599	133.9	18,403	155.2	21,292
99	98.3	13,717	124.2	17,335	155.2	22,502	99.9	13,589	134.5	18,285	155.2	21,032
100	99.4	13,720	124.8	17,225	155.2	22,224	100.9	13,579	135.0	18,170	155.2	21,620
101	100.4	13,724	126.0	17,227	155.2	21,941	101.9	13,579	136.4	18,172	155.2	21,325
102	101.4	13,728	127.3	17,229	155.2	21,665	102.9	13,580	137.8	18,174	155.2	21,036
103	102.5	13,731	128.6	17,230	155.2	21,394	104.0	13,580	139.1	18,175	155.2	20,753
104	103.5	13,735	129.8	17,232	155.2	21,128	105.0	13,581	140.5	18,177	155.2	20,477
105	104.5	13,739	131.1	17,233	155.2	20,868	106.0	13,581	141.9	18,179	155.2	20,206

Table 2.4 LWG-6 & LWG-7 table, 2020 Fish Passage Plan
3rd and 4th rows under “No ESBS” heading used to establish 133 MW average and discharge.

Figures from the USACE Walla Walla District, 1992 Reservoir Drawdown Test

Figure 27

Summary of the March, 1992, drawdown test phases showing reservoir elevation changes at Lower Granite and Little Goose Dams.

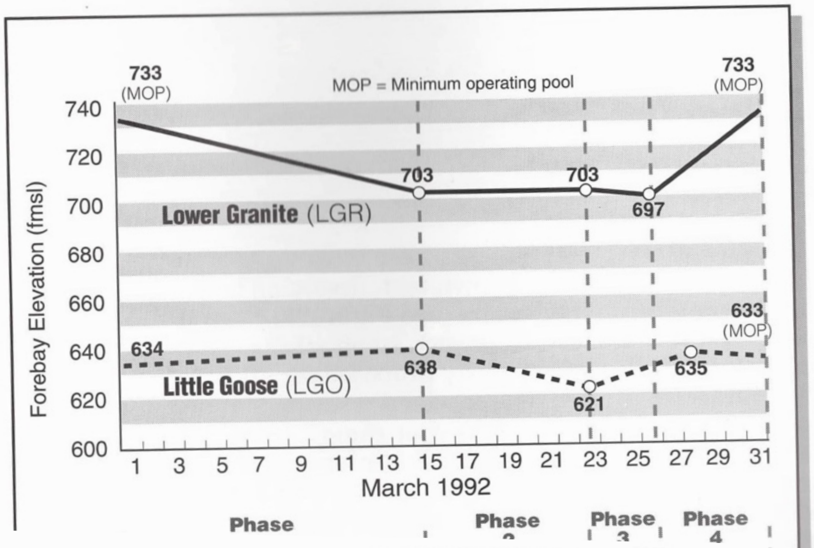


Figure 8

Cross-section of Lower Granite Dam showing elevations of project features. Elevations shown are feet above mean sea level (fmsl).

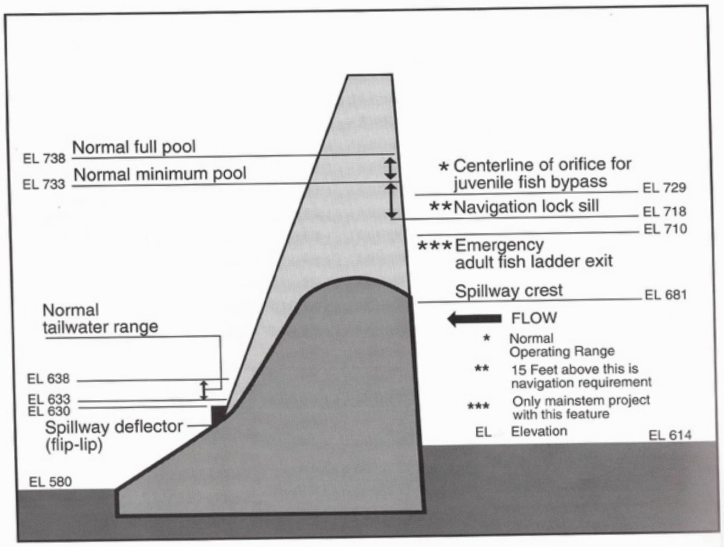


Figure 37
Illustration of extent of embankment protection against wind and wave erosion.