Appendix J

Sensitivity Analysis – Effects of Assumed Parameter Values on 602(a) Storage

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Appendix J. Sensitivity Analysis – Effects of Assumed Parameter Values on 602(a) Storage

J.1 Introduction

The No Action and Basic Coordination Alternatives both incorporate storage equalization operations, which include modeling assumptions regarding the 602(a) storage requirement in Lake Powell. Pursuant to the LROC, annual releases from Lake Powell greater than the minimum objective release occur when Upper Basin storage is greater than the storage required by 602(a) storage, and the storage in Lake Powell is forecast to be greater than the storage in Lake Mead by the end of that water year. Under these conditions, additional releases are made from Lake Powell to equalize the storage in Lake Mead with the storage in Lake Powell by the end of the water year.

The 602(a) storage requirement specifies the amount of storage in Upper Basin reservoirs necessary to assure deliveries to the Lower Basin without impairment to the annual consumptive use in the Upper Basin. If the 602(a) storage requirement is not met, equalization does not occur. The LROC specifies that all relevant factors including historic stream flows, the most critical period of record, the probabilities of water supply, and estimated future depletions be considered when determining the 602(a) storage amount. Calculating the 602(a) storage based on these factors depends on values for several parameters including assumed future Upper Basin water demands, historical natural flow, the magnitude and duration of a critical period flow, and the percent shortage in the Upper Basin during the critical period.

This appendix provides a brief overview of the 602(a) storage requirement and the numerical equation used to calculate the required storage volume. It also provides updated data on Upper Basin water demands and the historical natural flow record, reflecting changes since the 2007 Interim Guidelines. Finally, it analyzes how the 602(a) storage determination varies based on different variables such as ranges of critical period flow, lengths of critical period, and a range of assumed Upper Basin shortage percent during the critical period.

J.2 Description of 602(a) Storage Requirement

Appendix A, CRSS Model Documentation describes the implementation of the 602(a) storage requirement used in this Draft EIS. Since 2004, the Interim 602(a) Storage Guideline (69 Fed. Reg. 28945) has been included in the Colorado River Simulation System (CRSS), and relies on parameter values from the 1994 FORTRAN-based CRSS. The algorithm estimates the amount of storage needed in the Upper Basin to ensure that both the minimum objective release and Upper Basin depletions can be met over a future period of n years, assuming inflows during that period match those observed during the most critical historical period.

The previously identified critical period for the Colorado River Basin occurred from 1953 to 1964, spanning 12 years. Inflows from this period are used in the 602(a) storage calculation.

At the start of each calendar year, the 602(a) storage requirement is calculated using the following formula (**Table J-1** describes each parameter):

$$602(a) = \{(UBDepletion + UBEvap) * (1 - percentShort / 100) + minObjRel - criticalPeriodInflow\} * criticalPeriodLength + minPowerPoolStorage$$

Table J-1
Description of Parameters included in the 2007 Interim Guidelines 602(a) Storage Requirement Formula

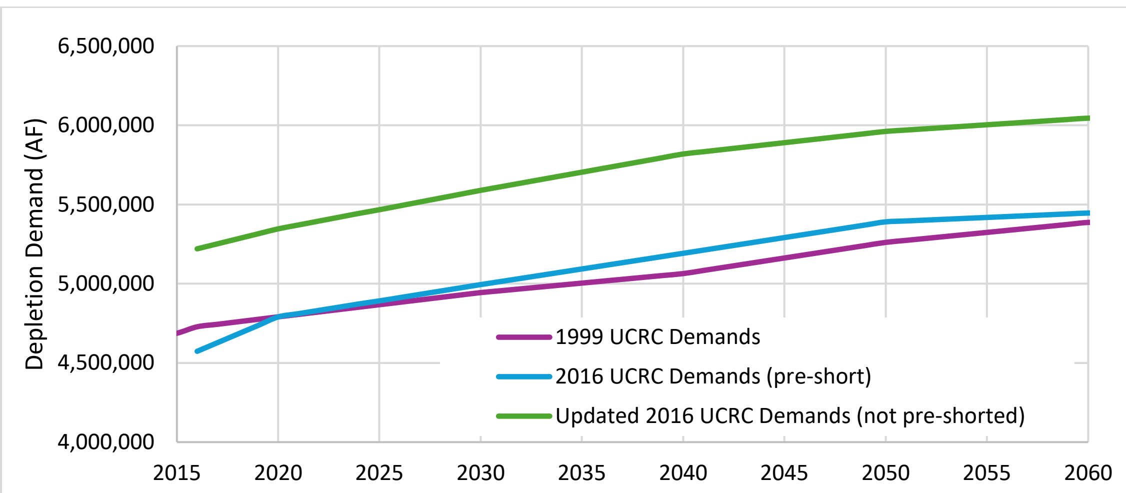
602(a) Storage Parameters	Definition	Value from 2007 FEIS	Source Data
602(a)	the 602(a) storage requirement		
UBDepletion	the average over the next 12 years of the Upper Basin scheduled depletions	Depends on simulation start year	2007 Interim Guidelines, Appendix C – 1999 Upper Colorado River Commission Depletion Demand Schedule
UBEvap	the average annual evaporation loss in the Upper Basin	560 kaf	Value from CRSS Cyber mainframe
percentShort	the percent shortage applied to Upper Basin depletions during the critical period	0%	Value from CRSS Cyber mainframe
minObjRel	the minimum objective release to the Lower Basin	8.23 maf	1970 Long-range Operating Criteria
criticalPeriodInflow	average annual natural inflow into the Upper Basin during the critical period (1953–1964)	12.18 maf	From WY 1953-1964 Natural Flow dated 6.22.07
criticalPeriodLength	number of years of the critical period (1953-1964)	12	Based on above period
minPowerPoolStorage	the cumulative amount of minimum power pool storage to be preserved in Upper Initial Unit reservoirs	5.179 maf	Value from CRSS Cyber mainframe

To facilitate further exploration of 602(a) storage requirement sensitivity, an extension of the current equalization line in CRSS was based on the same source data (shown above) originally used for 2007 Interim Guidelines equalization line estimation. To better understand the equalization line sensitivity to variations in specific parameters the following parameters were updated to use the latest available version of that parameter, Upper Basin depletion schedule and annual natural flow; or varied across a range of potential values, critical period inflow and length, and percent shortage, to understand the impact on the computed 602(a) storage.

J.3 Upper Basin Depletion Schedule

The Upper Basin depletion schedule titled the Updated 2016 Upper Colorado River Commission (UCRC) depletion demand schedule, further described in **Appendix L**, Upper Division States Depletion Schedules, replaces the 1999 UCRC depletion demand schedule used during the 2007 Interim Guidelines. The 1999 UCRC schedule pre-shorted depletions because a portion of depletion demands could not be met in the high Upper Basin tributaries that were not represented in the previous version of CRSS. The latest CRSS (version 6) now incorporates methods to apply high tributary shortage directly in CRSS and uses the Updated 2016 UCRC depletion demand schedule. **Figure J-1** compares the Updated 2016 UCRC demands, the 2016 UCRC demands that include pre-shorted values, and the 1999 UCRC demands used in the 2007 Interim Guidelines.

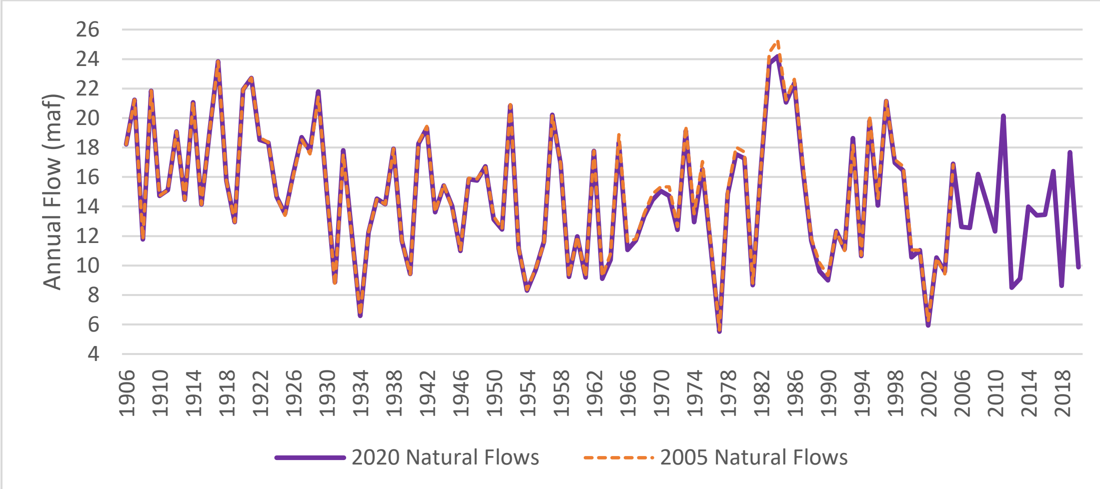
Figure J-1
Comparison of UCRC Depletion Demand Schedules (excludes CRSP Evaporation)



J.4 Annual Natural Flow

The latest official natural flow dataset, released December 15, 2022, spans 1906-2020 and replaces the June 22, 2007 natural flow record used during the 2007 Interim Guidelines that spanned 1906-2005. Many incremental changes have been applied since that release, but these only resulted in minor changes (see **Figure J-2**) to the overlapping record.

Figure J-2
WY Colorado River at Lees Ferry Natural Flow Comparison



J.5 Critical Period Inflow and Length

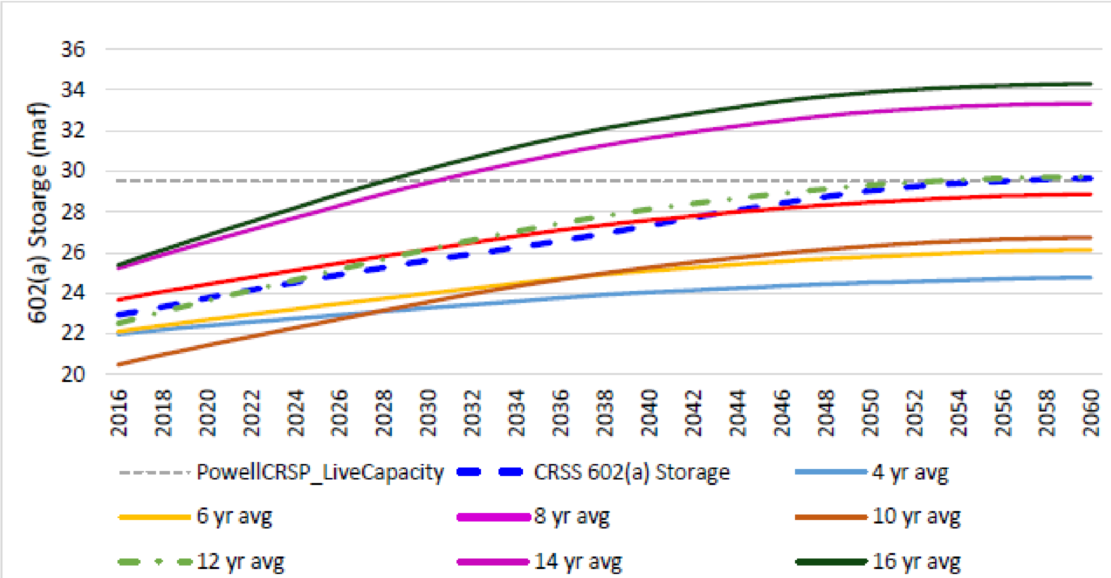
The critical period inflow and length parameters are determined from an analysis of the available natural flow record. Using the 1906-2020 natural flow record the critical period average inflow was computed for different critical period lengths, ranging from four to 20 years (**Table J-2)**[1]. The 12-year critical period is still the 1953-1964 period, though the average inflow decreased by 0.05 maf due to the minor, incremental changes that have been applied to the natural flow record since 2005.

Figure J-3 shows the 602(a) storage given critical period lengths of 4, 6, 8, 10, 12, 14, and 16 years based on the 1906-2020 natural flow record and the Updated 2016 UCRC demand schedule with an assumed 10 percent shortage compared to the 602(a) storage requirement computed for the 2007 Interim Guidelines ("CRSS 602a Storage" long dashed royal blue line). The 602(a) storage for the 2007 Interim Guidelines used the 1906-2005 natural flow 12-year critical period (1953-1964) inflow of 12.18 maf from the CRSS Cyber mainframe values and the 1999 UCRC pre-shorted demand schedule. Except where otherwise noted, all other parameter values are consistent for all of the computed 602(a) storage requirements in **Figure J-3** and listed in **Table J-1.**

Figure J-3 shows that both the inflow volume and the duration of the critical period have a significant impact on the 602(a) storage requirement. However, it is important to note that the selection of the critical period is not straightforward, and there are no clearly defined or objective criteria available to guide this choice.

[1] The critical period average inflow is the minimum average inflow over a specified critical period length using the updated natural flow record (1906-2020).

Figure J-3
602(a) Storage Values across Various Critical Periods based on Updated Natural Flow and Upper Basin Demands with 10 Percent Shortage



Note: CRSS 602(a) Storage line continues to use the 12-year 1953-1964 period with a 12.18 maf critical period inflow from the original CRSS Cyber mainframe values.

Table J-2
Critical Period Lengths, Inflow, and Years Spanned

Critical Period Length (years)	Critical Period Inflow (maf)	Years in Record- 2020 NF
4	9.27	2001-2004
5	9.53	2000-2004
6	10.68	1999-2004
7	11.02	2000-2006
8	11.22	2000-2007
9	11.77	2000-2008
10	12.02	2000-2009
11	12.05	2000-2010
12	12.13	1953-1964

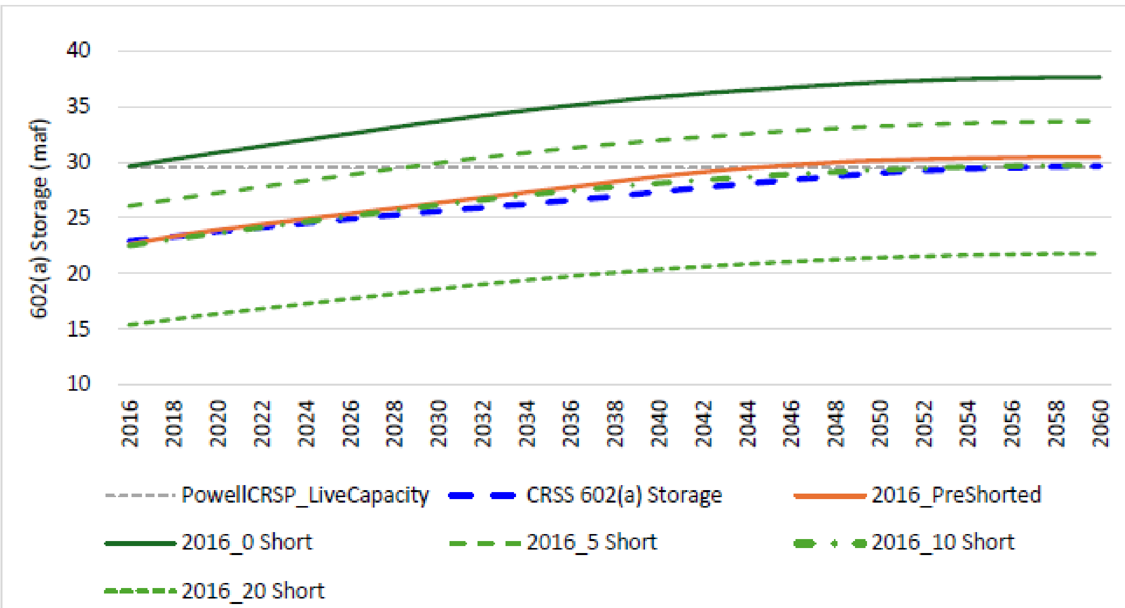
Critical Period Length (years)	Critical Period Inflow (maf)	Years in Record- 2020 NF
13	12.28	2001-2013
14	12.16	2000-2013
15	12.29	2000-2014
16	12.36	2000-2015
17	12.43	2000-2016
18	12.54	2001-2018
19	12.44	2000-2018
20	12.64	1999-2018

J.6 Critical Period Percent Shortage

To isolate the effect of the percent shortage parameter on 602(a) storage the Upper Basin depletion percent shortage varied between 0, 5, 10, and 20 percent. The 12-year critical period calculated from the updated natural flow, highlighted green in **Table J-2**, was held the same.

Figure J-4 compares the 602(a) storage computed using these different percent shortage parameter values and the Updated 2016 UCRC demands to the 602(a) storage computed using 0 percent shortage with the 2016 UCRC pre-shorted demands and the 602(a) storage requirement computed for the 2007 Interim Guidelines ("CRSS 602(a) Storage" long dashed royal blue line)[2]. As with the choice of critical period inflow and length the assumed percent shortage during the critical period also exhibits significant impact on the calculated 602(a) storage volume. The Updated 2016 UCRC depletion demand schedule with a 10 percent Upper Basin shortage results in a similar 602(a) storage value to both the 2016 UCRC pre-shorted demand schedule and the 602(a) storage requirement computed for the 2007 Interim Guidelines.

Figure J-4
602(a) Storage Values across Various Upper Basin Depletion Percent Shortages



Note: CRSS 602(a) Storage lines continues to use the 12-year 1953-1964 period with a 12.18 maf critical period inflow from the original CRSS Cyber mainframe values.

J.7 Discussion

The 602(a) storage refers to the quantity of water required to be in storage in the Upper Basin so as to assure future deliveries to the Lower Basin without impairing annual consumptive uses in the Upper Basin. Its calculation depends on several inputs—most notably the assumed future Upper Basin demands, the selected "critical period," and the assumed level of Upper Basin shortage during that period.

Updating these inputs with the most recent information is sensible, but it also highlights how the time period affects the calculation. For example, using the full 1906–2020 natural flow record only

[2] The 602(a) storage for the 2007 Interim Guidelines uses the 1906-2005 natural flow 12-year critical period (1953-1964) inflow of 12.18 maf from the CRSS Cyber mainframe values and the 1999 UCRC pre-shorted demand schedule.

slightly changes the 12-year critical-period average inflow (12.13 maf vs. 12.18 maf using the 1906–2005 record). But the *choice of the critical period itself* has a much larger effect, and there is no objective standard for selecting it. A 12-year period with 12.13 maf average inflow is not necessarily more or less "critical" than a 10-year period averaging 12.02 maf or a 14-year period averaging 12.16 maf, yet each produces a different 602(a) requirement.

Assumptions about future Upper Basin demands introduce similar sensitivities. The 2007 calculation assumed zero Upper Basin shortage during the critical period because it relied on pre-shorted demand schedules. Because the Updated 2016 UCRC demand schedules no longer include pre-shorting, the zero-shortage assumption may no longer be appropriate—and it meaningfully affects the storage requirement.

Overall, this analysis shows that the 602(a) storage requirement varies substantially depending on the choices made for these key parameters. The 602(a) storage used in the 2007 Interim Guidelines generally falls near the middle of the range produced by the different tested assumptions.

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