
Appendix D

Sensitivity Analysis – Effects of Natural Flow
Percentage Used for the Supply Driven Alternative

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Contents

APPENDIX D. SENSITIVITY ANALYSIS – EFFECTS OF NATURAL FLOW PERCENTAGE	
	USED FOR THE SUPPLY DRIVEN ALTERNATIVE..... D-1
D.1	IntroductionD-1
D.2	Modeling ResultsD-1
D.2.1	Water Year Gap Water Volume.....D-1
D.2.2	Lake Powell and Lake Mead Water Surface Elevations.....D-2
D.2.3	Glen Canyon 10-Year Release VolumeD-3
D.2.4	Lower Basin Shortage and DepletionD-3

Figure

D-1	Response of Key Variables to Different Natural Flow Release Percentages for Lower Basin Priority (dark color) and Lower Basin Pro Rata (light color) Shortage Distribution MethodsD-4
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Acronym or Abbreviation	Full Phrase
CRSS	Colorado River Simulation System
EIS	environmental impact statement
EOWY	end-of-water year
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
maf	million acre-feet
Mexico	United Mexican States
U.S.	United States

Appendix D. Sensitivity Analysis – Effects of Natural Flow Percentage Used for the Supply Driven Alternative

D.1 Introduction

The Supply Driven Alternative (both Lower Basin Priority [LB Priority] and Lower Basin Pro Rata [LB Pro Rata] approaches) described in **Appendix S** of this Final Environmental Impact Statement (EIS) assumes 65 percent of the preceding 3-year Lees Ferry natural flow is released from Lake Powell, with annual releases constrained between 4.7 and 12.0 million acre-feet (maf). This sensitivity analysis explores the impacts of adjusting the assumed natural flow release percentage, specifically comparing 60 percent, 65 percent, and 70 percent, on key hydrologic and water delivery resources.

D.2 Modeling Results

An analysis was performed to test the sensitivity of the hydrologic and water delivery resources to three different natural flow release percentages (60 percent, 65 percent, and 70 percent). The Colorado River Simulation System (CRSS) model was used to simulate operations under the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) with these three different natural flow release percentages, while holding all other modeling assumptions under the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) constant. See **Appendix A**, CRSS Model Documentation, for detailed modeling assumptions.

Figure D-1 compares the response of key variables to different hydrologic conditions for the different scenarios that vary the natural flow release percentages and Lower Basin shortage distribution methods (both LB Priority and LB Pro Rata approaches). Results are presented using conditional boxplots, which separate results based on five flow categories (see **Chapter 3.2.6** for additional details on conditional boxplots). Each boxplot in the figure illustrates the distribution of modeled results, where the bold center line represents the median value, the top and bottom of each box shows the interquartile range which captures the 25th to 75th percentile, the lines extend to the 10th and 90th percentiles, and the outliers are represented as dots beyond these lines. The following sections compare the responses of key variables to different natural flow release percentages by hydrologic conditions.

D.2.1 Water Year Gap Water Volume

In years when Lake Powell cannot meet its required water year release because of low elevation infrastructure constraints (i.e., Lake Powell is less than 3,490 feet), additional water is introduced

into the system to (partially) make up the shortfall. For modeling purposes, this supplemental volume is termed “gap water.” Gap water is injected into Lake Powell and released when conditions allow, subject to the same low-elevation release constraints. Any portion not released in a given water year is tracked as carryover and released in subsequent years. The annual amount of gap water is limited to no more than 23 percent¹ of the Upper Basin’s modeled depletion for that year, minus any Upper Basin conservation that occurs. Additional detail is provided in **Appendix A**.

Water year gap water volume is shown in the first column of **Figure D-1**. In the Average Flow Category (12.0-14.0 maf), the median and upper quartile gap water volume is zero at the 60 and 65 percent natural flow release percentages. For the 70 percent natural flow release scenario, the median and upper quartile are slightly over 0.1 maf and 0.9 maf, respectively. As the hydrologic conditions become drier, the gap water volume increases across all scenarios. In the Critically Dry Flow Category (4.5-10.0 maf), the median for the 70 percent natural flow release scenario is 0.8 maf but is zero for 60 percent and 65 percent. With higher natural flow release percentages, the gap water volumes increase and are required more frequently, especially in drier flow conditions, since more Lake Powell releases are infrastructure constrained. Results do not vary with Lower Basin shortage distribution method.

D.2.2 Lake Powell and Lake Mead Water Surface Elevations

Lake Powell and Lake Mead end-of-water year (EOWY) elevation by hydrologic condition are shown in the second and third columns of **Figure D-1**, respectively. Across all flow categories, as the natural flow release percentage increases, the elevation of Lake Powell declines due to higher releases, while Lake Mead elevations increase due to higher inflows.

In the Average Flow Category, median Lake Powell EOWY elevation is 3,633 feet, 3,573 feet, and 3,528 feet in the 60 percent, 65 percent, and 70 percent natural flow release scenarios, respectively, and the bottom quartile of the 70 percent extends below 3,500 feet. In the Critically Dry Flow Category, the median elevation of the 65 percent and 70 percent natural flow release scenarios are nearly at or below 3,500 feet, while the median of the 60 percent scenario is at 3,550 feet. The bottom quartile of the 65 percent and 70 percent scenarios are similar at 3,470 and 3,464 feet, respectively, since releases are limited by infrastructure. The results do not vary by Lower Basin shortage distribution method.

In the Average Flow Category for Lake Mead, the median EOWY elevations are 1,088 feet, 1,146 feet, and 1,173 feet in the 60 percent, 65 percent, and 70 percent scenarios for the LB Priority shortage distribution, and 1,111 feet, 1,158 feet, and 1,181 feet in the 60 percent, 65 percent, and 70 percent scenarios for the LB Pro Rata shortage distribution. The elevation statistics are higher with LB Pro Rata than LB Priority because user-level conservation activity modeling assumptions cause higher volumes of conserved water to be stored in Lake Mead. In the Critically Dry Flow Category, the median elevation of the 60 percent with the LB Priority shortage distribution is below 975 feet, while the 65 and 75 percent scenarios have medians above 1,000 feet. The bottom quartile extends

¹ The 23 percent limit is based on the ratio of the maximum Lower Basin shortage (2.1 maf) to the total Lower Basin apportionment to the United States (U.S.) and the United Mexican States (Mexico) (9.0 maf).

below 1,011 feet in all but the 70 percent scenario, with a median value of 1,025 feet, natural flow release scenario with LB Pro Rata shortage distribution.

D.2.3 Glen Canyon 10-Year Release Volume

Glen Canyon 10-year release volume by hydrologic condition is shown in the fourth column of **Figure D-1**. In the Average Flow Category, the median 10-year releases are 76.7, 81.7 and 86.9 maf in the 60 percent, 65 percent, and 70 percent natural flow release percent scenarios, respectively. The bottom quartile of the 60 percent scenario extends below 75.0 maf and the 65 percent and 70 percent scenario extends below 82.5 maf. In the Critically Dry Flow Category, the median 10-year releases are 69.8, 73.5 and 76.3 maf in the 60 percent, 65 percent, and 70 percent scenarios, with the 60 percent and 65 percent scenario medians below the 75.0 maf volume. All upper quartiles are below the 82.5 maf threshold. The results do not vary by shortage distribution method.

D.2.4 Lower Basin Shortage and Depletion

The Lower Basin shortage and depletion² by hydrologic condition are shown in the fifth and sixth columns of **Figure D-1**. The Lower Basin shortage decreases with increasing natural flow release percentage. The shortage distribution approach has only minor impacts on the shortage because the conservation mechanism is operationally neutral and therefore not visible to shortage determination. In the Average Flow Category, the median Lower Basin shortage is 1.6 maf and 1.5 maf in the 60 percent and 65 percent scenarios, respectively, and between 1.1 maf to 1.2 maf for the 70 percent scenarios. The interquartile range (0.6 maf) for the 60 percent scenario is smaller, extending from 1.5 maf to 2.1 maf, compared to the 65 percent and 70 percent scenarios that have interquartile ranges around 1.5 maf. In the Critically Dry Flow Category, the median Lower Basin shortages are all greater than 1.5 maf at 2.1, 2.0, and 1.8 maf in the 60 percent, 65 percent, and 70 percent scenarios, respectively.

As shown in **Figure D-1**, the Lower Basin depletions increase with increasing natural flow release percentage in both shortage distribution methods. The variations in Lower Basin depletions between the LB Pro Rata and LB Priority methods shown in **Figure D-1** is the result of conservation activity modeling in the LB Pro Rata method. Though the Lower Basin shortages are similar between the shortage distribution methods, conservation activity modeling assumptions cause different depletions. In the Average Flow Category, the median depletions are 7.2, 7.4, and 7.8 maf in the 60 percent, 65 percent, and 70 percent scenarios, respectively, for the LB Priority shortage distribution, and 7.1, 7.3, and 7.7 maf in the 60 percent, 65 percent, and 70 percent scenarios, respectively, for the LB Pro Rata shortage distribution. In the Critically Dry Flow Category, the median depletions are 6.7, 6.9 and 7.1 maf in the 60 percent, 65 percent, and 70 percent scenarios, respectively, for the LB Priority shortage distribution, and 6.7, 6.8 and 6.9 maf in the 60 percent, 65 percent, and 70 percent scenarios, respectively, for the LB Pro Rata shortage distribution.

² The total Lower Basin policy shortage and Lower Basin depletions include shortages to U.S. Lower Division States and water delivery reductions to Mexico based on the modeling assumptions for the distribution of shortages in the Supply Driven (both LB Priority and LB Pro Rata approaches) Alternative. The Bureau of Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Water Treaty or to represent current U.S. policy or a determination of future U.S. policy regarding deliveries to Mexico.

Figure D-1
Response of Key Variables to Different Natural Flow Release Percentages for Lower Basin Priority (dark color) and Lower Basin Pro Rata (light color) Shortage Distribution Methods

