Appendix D

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

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

D.1 Introduction

The Supply Driven Alternative described in **Chapter 2** of this DEIS assumes 65% of the preceding 3-year Lees Ferry natural flow is released from Lake Powell, with annual releases constrained between 4.72 and 12 million acre-feet (maf). This sensitivity analysis explores the impacts of adjusting the assumed natural flow release percentage, specifically comparing 60%, 65%, and 70%, 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%, 65%, and 70%). The Colorado River Simulation System (CRSS) model was used to simulate operations under the Supply Driven Alternative with these three different natural flow release percentages, while holding all other modeling assumptions under the Supply Driven Alternative 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 (priority and pro rata). 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 percent[1] 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 (WY) 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 gap water volume is zero across all scenarios. The 70% natural flow release percentage has an upper quartile that extends to 0.9 maf, while other natural flow release percentages' upper quartile remains at zero. As the hydrologic conditions become drier, the gap water volume increases across all scenarios. In the Critically Dry Flow Category (less than 10.0 maf), the median for the 70% natural flow release scenario is 0.8 maf but is zero for 60% and 65%. 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 3,635 feet, 3,579 feet, and 3,534 feet in the 60%, 65%, and 70% natural flow release scenarios, respectively, and the bottom quartile of the 70% extends below 3,500 feet. In the Critically Dry Flow Category, the median elevation of the 65% and 70% natural flow release scenarios are at or below 3,500 feet, while the median of the 60% scenario is at 3,562 feet. The bottom quartile of the 65% and 70% scenarios are similar at 3,468 and 3,460 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 1,105 feet, 1,153 feet, and 1,176 feet in the 60%, 65%, and 70% scenarios for the priority shortage distribution, and 1,121 feet, 1,163 feet, and 1,183 feet in the 60%, 65%, and 70% scenarios for the pro rata shortage distribution. The elevation statistics are higher with pro rata than 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% with the priority shortage distribution is below 975 feet, while the other scenarios have medians above 1,000 feet. The bottom quartile extends below 1,000 feet in all but the 70% natural flow release scenario with 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 79.3, 83.0 and 87.4 maf in the 60%, 65%, and 70% natural flow release percentage scenarios, respectively. The bottom quartile of the 60% scenario extends below 75 maf and the 65% and 70% scenario extend below

[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 U.S. and Mexico (9.0 maf).

82.5 maf. In the Critically Dry Flow Category, the median 10-year releases are 69.1, 73.4 and 76.5 maf in the 60%, 65%, and 70% scenarios, with the 60% and 65% scenario medians below the 75 maf volume. All interquartile ranges are below the 82.5 maf threshold. The results do not vary by shortage distribution method.

D.2.4 Lower Basin Policy Shortage and Depletion

The Lower Basin policy shortage and depletion[2] by hydrologic condition are shown in the fifth and sixth columns of **Figure D-1**. The Lower Basin policy shortage decreases with increasing natural flow release percentage. The shortage distribution approach has only minor impacts on the policy shortage because the conservation mechanism is operationally neutral and therefore not visible to policy shortage determination. In the Average Flow Category, the median Lower Basin policy shortage is 1.5 maf in the 60% and 65% scenarios and 1.0 maf in the 70% scenarios. The interquartile range for the 60% scenario is smaller, extending from 1.5 maf to approximately 2 maf, compared to the 65% and 70% scenarios that have interquartile ranges that extend from around zero to 1.5 maf. In the Critically Dry Flow Category, the median Lower Basin policy shortages are all greater than 1.5 maf at 2.1, 1.95, and 1.6 maf in the 60%, 65%, and 70% 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 pro rata and priority methods shown in **Figure D-1** is the result of conservation activity modeling in the pro rata method. Though the Lower Basin policy shortages are similar between the shortage distribution methods, conservation activity modeling assumptions cause different depletions. In the Average Flow Category, the median depletions are 7.28, 7.47, and 7.83 maf in the 60%, 65%, and 70% scenarios, respectively, for the priority shortage distribution, and 7.15, 7.36, and 7.68 maf in the 60%, 65%, and 70% scenarios, respectively, for the pro rata shortage distribution. In the Critically Dry Flow Category, the median depletions are 6.80, 7.02 and 7.14 maf in the 60%, 65%, and 70% scenarios, respectively, for the priority shortage distribution, and 6.72, 6.91 and 7.01 maf in the 60%, 65%, and 70% scenarios, respectively, for the 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 Alternative. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Water Treaty or to represent current United States policy or a determination of future United States policy regarding deliveries to Mexico.

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