Technical Appendix 3

Hydrologic Resources

This page intentionally left blank.

Contents

TA 3. HYDROLOGIC RESOURCES 3-1

TA 3.1 Affected Environment 3-1
- TA 3.1.1 Hydrologic Overview 3-2
- TA 3.1.2 Upper Basin 3-3
- TA 3.1.3 Lake Powell and Glen Canyon Dam 3-4
- TA 3.1.4 Lees Ferry Gaging Station 3-9
- TA 3.1.5 Glen Canyon Dam to Lake Mead 3-12
- TA 3.1.6 Lake Mead and Hoover Dam 3-13
- TA 3.1.7 Hoover Dam to Lake Mohave 3-15
- TA 3.1.8 Davis Dam to Lake Havasu 3-16
- TA 3.1.9 Parker Dam to Cibola Gage 3-16
- TA 3.1.10 Cibola Gage to Imperial Dam 3-17
- TA 3.1.11 Imperial Dam to NIB 3-17
- TA 3.1.12 NIB to SIB 3-18

TA 3.2 Environmental Consequences 3-19
- TA 3.2.1 Issue 1: Reservoir Elevations 3-20
- TA 3.2.2 Issue 2: System Storage 3-47
- TA 3.2.3 Issue 3: Reservoir Releases 3-57
- TA 3.2.4 Issue 4: River Flows 3-79
- TA 3.2.5 Issue 5: Groundwater 3-98
- TA 3.2.6 Summary Comparison of Alternatives 3-101

TA 3.3 References 3-105

Tables

TA 3-1 Summary of Lake Powell and Lake Mead Coordinated Operations 2008-2024 3-7
TA 3-2 Critical Elevations at Lake Powell 3-21
TA 3-3 EOWY Elevation (Feet) at Lake Powell 3-22
TA 3-4 Minimum Water Year Elevation (Feet) at Lake Powell 3-23
TA 3-5 Critical Elevations at Lake Mead 3-30
TA 3-6 End of Calendar Year Elevations (Feet) at Lake Mead 3-31
TA 3-7 Minimum Calendar Year Elevation (Feet) at Lake Mead 3-32
TA 3-8 Summary of Conservation Mechanisms by Alternative 3-39
TA 3-9 Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Powell 3-40
TA 3-10 Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Mead 3-44
TA 3-11 EOWY Powell and Mead Combined Storage (% Full) 3-49
TA 3-12 EOWY CRSP Combined Storage (% Full) 3-52
TA 3-13 EOWY Seven-Reservoir Combined Storage (% Full) 3-55
TA 3-14 WY Releases from Glen Canyon Dam (maf) 3-58
TA 3-15 10-Year Releases from Glen Canyon Dam 3-61
TA 3-16 Compact Point 10-Year Flow Volume (maf) 3-64
TA 3-17 Compact Point 10-Year Volume Relative to 75.0 maf 3-67
TA 3-18 Compact Point 10-Year Volume Relative to 82.5 maf 3-68
TA 3-19 EOCY Releases from Hoover Dam (maf) 3-71
TA 3-20 CY Releases from Davis Dam (maf) 3-74
TA 3-21 CY Releases from Parker Dam (maf) 3-77
TA 3-22 Annual Flow Volume Below Hoover Dam (maf) 3-81
TA 3-23 Annual Flow Volume Below Davis Dam (maf) 3-84
TA 3-24 Annual Flow Volume Below Parker Dam (maf) 3-87
TA 3-25 Annual Flow Volume at Imperial Dam (maf) 3-90
TA 3-26 Annual Flow Volume Below Imperial Dam (maf) 3-93
TA 3-27 Annual Flow Volume Below Morelos Diversion Dam (maf) 3-96

Figures

TA 3-1 Lake Powell Annual High and Low Elevations (1963-2024) 3-6
TA 3-2 Lees Ferry Gaging Station and Lee Ferry Compact Point 3-10
TA 3-3 WY Colorado River Natural Flow at Lees Ferry Gaging Station, Arizona (1906-2025) 3-11
TA 3-4 Colorado River Observed Flow at Lees Ferry Gaging Station, Arizona (1922-2024).... 3-12
TA 3-5 Lake Mead Annual High and Low Elevations (1935-2024) 3-14
TA 3-6 Water Year Minimum and End of Water Year (EOWY) Elevations and Storage Volumes of Lake Powell 3-24
TA 3-7 Lake Powell 3,500 Feet: Robustness. Percent of futures in which Lake Powell elevation stays above 3,500 feet in the percent of months specified by each row 3-26
TA 3-8 Lake Powell 3,500 Feet: Vulnerability. Conditions that could cause Lake Powell elevation to fall below 3,500 feet in one or more months 3-27
TA 3-9 Lake Powell 3,525 Feet: Robustness. Percent of futures in which Lake Powell stays above 3,525 feet in the percent of months specified by each row 3-28
TA 3-10 Lake Powell 3,525 Feet: Vulnerability. Conditions that could cause Lake Powell elevation to fall below 3,525 feet in more than 10% of months 3-29
TA 3-11 Calendar Year Minimum and End of Calendar Year Elevations and Storage Volumes of Lake Mead 3-33
TA 3-12 Lake Mead 975 Feet: Robustness. Percent of futures in which Lake Mead elevation stays above 975 feet in the percent of months specified by each row 3-35
TA 3-13 Lake Mead 975 Feet: Vulnerability. Conditions that could cause Lake Mead elevation to fall below 975 feet in one or more months 3-36
TA 3-14 Lake Mead 1,000 Feet: Robustness. Percent of futures in which Lake Mead elevation stays above 1,000 feet in the percent of months specified by each row 3-37
TA 3-15 Lake Mead 1,000 Feet: Vulnerability. Conditions that could cause Lake Mead elevation to fall below 1,000 feet in more than 10% of months 3-38
TA 3-16 Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Powell 3-43
TA 3-17 Impacts of Modeling Assumptions for Conservation Activity on EOWY Elevations and Storage Volumes for Lake Mead 3-46
TA 3-18 EOWY Powell and Mead Combined Storage 3-50
TA 3-19 EOWY CRSP Combined Storage 3-53
TA 3-20 EOWY Seven-Reservoir Combined Storage 3-56
TA 3-21 WY Releases from Glen Canyon Dam 3-59
TA 3-22 10-Year Releases from Glen Canyon Dam 3-62
TA 3-23 Compact Point 10-Year Volume 3-65
TA 3-24 Compact Point 10-Year Volume Relative to 75 maf and 82.5 maf 3-69
TA 3-25 CY Releases from Hoover Dam 3-72
TA 3-26 CY Releases from Davis Dam 3-75
TA 3-27 CY Releases from Parker Dam (Box Plot) 3-78
TA 3-28 Annual Flow Volume Below Hoover Dam 3-82
TA 3-29 Annual Flow Volume Below Davis Dam 3-85
TA 3-30 Annual Flow Volume Below Parker Dam 3-88
TA 3-31 Annual Flow Volume at Imperial Dam 3-91
TA 3-32 Annual Flow Volume Below Imperial Dam 3-94
TA 3-33 Annual Flow Volume Below Morelos Diversion Dam 3-97

This page intentionally left blank.

Acronyms and Abbreviations

Acronym or Abbreviation	Full Phrase
2007 Final EIS	2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement
2007 ROD	2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Record of Decision
2016 LTEMP ROD	2016 Glen Canyon Dam Long-Term Experimental and Management Plan Record of Decision
2024 Final SEIS	2024 Near-term Colorado River Operations Final Supplemental Environmental Impact Statement
2024 ROD	2024 Near-term Colorado River Operations Record of Decision
AAC	All-American Canal
af	acre-feet
CCS	Continued Current Strategies
CE	Current Era
cfs	cubic feet per second
CRSP	Colorado River Storage Project
CRSS	Colorado River Simulation System
CY	Calendar Year
DCP	Drought Contingency Plan
DROA	Drought Response Operations Agreement
EIS	Environmental Impact Statement
EOCY	End of Calendar Year
EOWY	End of Water Year
ICS	Intentionally Created Surplus
kaf	thousand acre-feet
kafy	thousand acre-feet per year
LB Priority	Lower Basin Priority
LB Pro Rata	Lower Basin Pro Rata
Lower Basin	Lower Colorado River Basin
LROC	Long-Range Operating Criteria
maf	million acre-feet
Mexico	United Mexican States
NIB	Northerly International Boundary
NOAA	National Oceanic and Atmospheric Administration
Reclamation	United States Bureau of Reclamation

SIB	Southerly International Boundary
UIU	Upper Initial Units
Upper Basin	Upper Colorado River Basin
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WY	Water Year

TA 3. Hydrologic Resources

TA 3.1 Affected Environment

This section presents an overview of the hydrology of the Colorado River Basin (Basin) beginning with the full pool elevation of Lake Powell and extending downstream along the Colorado River to the Southerly International Boundary (SIB) with the United Mexican States (Mexico). It also includes groundwater that is under the direct influence of the Colorado River and the Lower Basin reservoirs, starting with Lake Powell on the upstream end. The geography and connectivity of the hydrologic resources analysis area is the same as analyzed in the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement (2007 Final EIS; Reclamation 2007a).

The Colorado River has been divided into nine distinct reaches along the study area. These reaches include the full pool Lake Powell (downstream of Gypsum Canyon) to Glen Canyon Dam, from Glen Canyon Dam to Lake Mead at Separation Canyon (which includes the Grand Canyon National Park), the full pool Lake Mead (downstream of Separation Canyon) to Hoover Dam, from Hoover Dam to Davis Dam (including Lake Mohave), Davis Dam to Parker Dam (including Lake Havasu), from Parker Dam to Cibola Gage, from Cibola Gage to Imperial Dam, from Imperial Dam to the Northerly International Boundary (NIB), and from the NIB to the SIB. Refer to **Table 3-1**, Colorado River Reaches and Reach Limits, for a description of the nine Colorado River reaches and their associated river miles and **Map 3-1**, Colorado River Reaches and Reach Limits, for a map of the Colorado River reaches. Not included in the study area are reservoirs upstream of Lake Powell, the Salton Sea, and portions of northwestern Mexico that are operated independently.

Hydrologic resources within the study area that could potentially be affected by the implementation of any given alternative include:

- Reservoir storage, total system storage, reservoir releases, and corresponding changes in Colorado River flows downstream of the reservoirs
- Groundwater in areas adjacent to and connected to the Colorado River corridor

The overall characteristics and connectivity of the Basin remain unchanged from when the 2007 Final EIS was issued. However, since 2007, several factors have affected hydrologic resources in the Basin. These factors can be divided into two categories: operational changes in the Basin since 2007 and key environmental drivers. Refer to **Section 1.8.2.1 The Law of the River** for a summary of operational changes since 2007.

Worsening drought conditions have been a major driver for changes to hydrologic resources in the Basin. Since 2000, the Basin has experienced persistent drought conditions, exacerbated by a warming climate resulting in increased evapotranspiration, reduced soil moisture, and ultimately reduced runoff. Runoff conditions in the Basin are below what was contemplated in the Record of Decision for Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 ROD) resulting in altered reservoir storage, reservoir releases, and river flows and future drier conditions are anticipated.

TA 3.1.1 Hydrologic Overview

The Colorado River originates at the Continental Divide in Rocky Mountain National Park in Colorado and flows downstream through Utah, Nevada, Arizona, and California to Mexico, where it historically flowed into the Sea of Cortez. Major tributaries to the Colorado River include the Green, San Juan, Yampa, Gunnison, and Gila Rivers. While 85 percent of the Basin is desert and semi-arid rangelands, the remaining 15 percent of the watershed is comprised of mountainous areas in Wyoming, Colorado, Utah, and New Mexico. These mountainous areas receive snow throughout the winter months which makes up the majority, approximately 92 percent, of the streamflow of the Colorado River. Mountain snowmelt in the Upper Basin typically results in high river flows in the late spring that diminish quickly by mid-summer. The rest of the arid and semi-arid Basin historically receives fewer than 10 inches of precipitation per year. Flow in the Colorado River is highly variable from year to year because of variations in precipitation in the Basin. However, the Basin is currently experiencing a prolonged dry period resulting in extended periods of drought and record low runoff conditions.

The Colorado River Basin Climate and Hydrology: The *State of the Science* report provided a comprehensive assessment of Basin hydroclimate conditions and trends through 2019 (Lukas and Payton 2020). According to the report, the Basin has experienced persistent drought conditions since 2000, exacerbated by increasing temperatures. This drought has led to a 20 percent decrease in average annual Upper Basin (at Lee Ferry) natural flows (Reclamation 2025a). 2000 to 2024 was the driest 24-year period in more than a century. A paleo reconstruction of Colorado River streamflow at Lee Ferry, Arizona back to 762 current era (CE) indicates that this 24-year period is lower than any other period in the last 1,200 years (Meko et al. 2007).

These conditions have led to a cumulative streamflow deficit of about 70 million acre-feet (maf) relative to twentieth-century conditions (Reclamation 2025a). Historically, the primary driver for the hydrologic drought in the Basin has been below normal precipitation over the winter, resulting in reduced snowmelt in the spring, but warming temperatures are playing an increasing role as evaporative losses and soil moisture deficits increase.

Annual water use in the Basin has exceeded the annual inflows in most years since 2000. This resulted in a depletion of storage to a historic low of 24 percent of the total combined capacity of Lake Powell and Lake Mead (equivalent to approximately 12.68 maf) between March and April of 2023 (Reclamation 2025b). Since issuance of the 2007 Final EIS, changes in the Basin have included further increases in temperature, ongoing years of below-normal precipitation, declining snowpack water volume and annual streamflow, and earlier snowmelt runoff. Since 2000, the average temperature across the Lower Basin has been 2.2 degrees Fahrenheit warmer than the twentieth-century average. Since 2007, the average temperature of the Lower Basin has trended upward, with the warmest 10-year period on record occurring from 2012 to 2022 (NOAA 2025).

Due to the Basin precipitation's high interannual variability and the impacts of short-term trends associated with the El Niño-Southern Oscillation, multidecadal trends are most informative when describing Basin precipitation. For both the Upper Basin and Lower Basin, a declining (but statistically non-significant) trend was noted over the period from 1980 to 2019. During the 1980 to 2019 period, precipitation over the cold season (October through March), which typically falls as snow, showed a greater declining trend than precipitation over the warm-season months. Because of naturally colder temperatures, snowpack at higher elevations in the Upper Basin has not been affected as much as snowpack at lower elevations; however, studies summarized in the *State of the Science* report indicate that snowmelt runoff is occurring 1–3 weeks earlier than the average timing prior to 2000.

TA 3.1.2 Upper Basin

Congress passed the Colorado River Storage Project Act in 1956, which authorized the construction of the Colorado River Storage Project (CRSP) reservoirs "to initiate the comprehensive development of the water resources of the Upper Basin, for the purposes, among others, of regulating flow of the Colorado River, storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes…"

In addition to Lake Powell, the CRSP reservoirs include the Upper Basin reservoirs, known as CRSP Upper Initial Units (UIU). The CRSP UIU are Flaming Gorge in Utah, Navajo in New Mexico, and Blue Mesa in Colorado. These 4 CRSP reservoirs were constructed in the 1960s and took several years to begin filling. Excluding surcharge space, the total storage volume of the four CRSP reservoirs is 29.5 maf.

Flaming Gorge reservoir has a total storage capacity of 3.79 maf and from 1980 to the implementation of the 2007 ROD, the average storage capacity (as a percentage of the total capacity) of Flaming Gorge reservoir was approximately 82 percent. From 2007 through 2024, the average storage capacity of Flaming Gorge reservoir was 83 percent. Flaming Gorge reservoir experienced the two lowest storage capacities from 2002 to 2004 and spring 2023 of 68 percent and 65 percent of the total capacity, respectively.

Navajo reservoir has a total storage capacity of 1.71 maf and from 1980 to the implementation of the 2007 ROD, the average storage capacity (as a percentage of the total capacity) of Navajo reservoir was approximately 80 percent. From 2007 through 2024, the average storage capacity of Navajo reservoir was 71 percent. Navajo reservoir experienced the two lowest storage capacities from 2002 to 2004 and spring 2023 of 41 percent and 49 percent of the total capacity, respectively.

Blue Mesa reservoir is part of the Aspinall Unit in Colorado, which also includes Crystal Reservoir and Morrow Point Reservoir. Blue Mesa has the largest capacity of the Aspinall Unit reservoirs with a total capacity of 941.0 thousand acre-feet (kaf). Crystal Reservoir has a total capacity of 26.0 kaf and Morrow Point has a total capacity of 117.0 kaf. From 1980 to the implementation of the 2007

ROD, the average storage capacity (as a percentage of the total capacity) of Blue Mesa reservoir was approximately 61 percent. From 2007 through 2024, the average storage capacity of Blue Mesa reservoir was 56 percent. Blue Mesa reservoir experienced the two lowest storage capacities in the winters of 2018 and 2021 of 21 percent and 22 percent of the total capacity, respectively.

Release operations under the 2019 Drought Response Operations Agreement (DROA) began in 2021 and included releases from Flaming Gorge, Navajo, and Blue Mesa. In 2022, DROA operations included releases from Flaming Gorge. In 2023, DROA operations included recovery of storage at Flaming Gorge, Navajo, and Blue Mesa (Reclamation 2024b).

While the alternatives analyzed may include the operation of reservoirs upstream of Lake Powell (CRSP UIU), to protect Glen Canyon Dam infrastructure, these Operations are intended to remain within the scope of the existing Records of Decision (RODs) for the respective facilities. Accordingly, the Draft EIS does not expand the geographic scope of analysis upstream of Lake Powell.[1]

TA 3.1.3 Lake Powell and Glen Canyon Dam

Lake Powell is a reservoir that is located primarily in southern Utah with a portion extending into northern Arizona. Inflows into Lake Powell originate from the mainstream Colorado River which is dammed near Page, Arizona by Glen Canyon Dam. The concrete arch dam was constructed from 1956 to 1964, and it rises 710 feet above the bedrock of Glen Canyon. Lake Powell is relatively narrow and when it is full, stretches over 180 miles in length along the mainstream Colorado River in Glen Canyon. When full, it also includes approximately 25 miles of Cataract Canyon and 50 miles of the San Juan River. The water surface operating range of Lake Powell runs between 3,490 feet (corresponding to the minimum power pool) and 3,700 feet (corresponding to the top of Glen Canyon Dam spillway). The total live storage capacity of Lake Powell at the full pool elevation of 3,700 feet is 23.31 maf (excluding approximately 1.9 maf of flood control space).

The 2007 Final EIS and 2024 Final SEIS noted that groundwater adjacent to Lake Powell may increase or decrease in correlation with corresponding changes in pool elevations. This EIS will consider qualitative impacts to groundwater elevations adjacent to the reservoirs, including Lake Powell. The Arizona Department of Water Resources Groundwater Site Inventory website (ADWR 2025) tracks depth to water measurements for three active groundwater monitoring wells located adjacent to Lake Powell near Glen Canyon Dam. All three groundwater monitoring wells show a decreasing groundwater elevation trend beginning in the early 2000s, with the lowest groundwater elevations occurring in 2022.

Releases are typically made through the penstock intakes which are eight 15-foot diameter steel pipes that deliver water to the Glen Canyon Powerplant turbines. Releases can still be made from Glen Canyon Dam from 3,490 feet down to 3,370 feet (corresponding to dead pool) through the

[1] While the Secretary will consider and prioritize operations at these facilities that are consistent with existing RODs, the Secretary retains the authority to operate outside those RODs if necessary. The modeling assumptions regarding operation of the Upper Initial CRSP Units presented in this Draft EIS are not intended to, and do not, limit the Secretary's ability to operate these facilities as necessary to respond to hydrologic conditions in accordance with applicable federal law, including operations for the authorized purposes as stated in the 1956 Colorado River Storage Project Act.

four 8-foot diameter river outlet works, however, according to the 2024 Establishment of Interim Operating Guidance for Glen Canyon Dam during Low Reservoir Levels at Lake Powell Technical Memorandum, the river outlet works were not intended for long-term use at low reservoir levels (Reclamation 2024c). The cutoff elevation for routine operations of Glen Canyon Dam is considered 3,490 feet.

In 1968, the Colorado River Basin Project Act directed the Secretary to establish the Long-Range Operating Criteria (LROC) which was developed in 1970 to establish operating criteria for Colorado River reservoirs that were compliant with the Law of the River. According to the LROC "the objective shall be to maintain a minimum release of water from Lake Powell of 8.23 million acre-feet for that year." Releases above this amount only occurred if Upper Basin storage exceeded the requirements listed in Section 602(a) of the Colorado River Basin Project Act, storage in Lake Powell exceeded storage in Lake Mead, and if a spill was anticipated. Lake Powell and Glen Canyon Dam are operated consistent with the Colorado River Storage Project Act.

Lake Powell also services direct water delivery to the City of Page, Arizona.

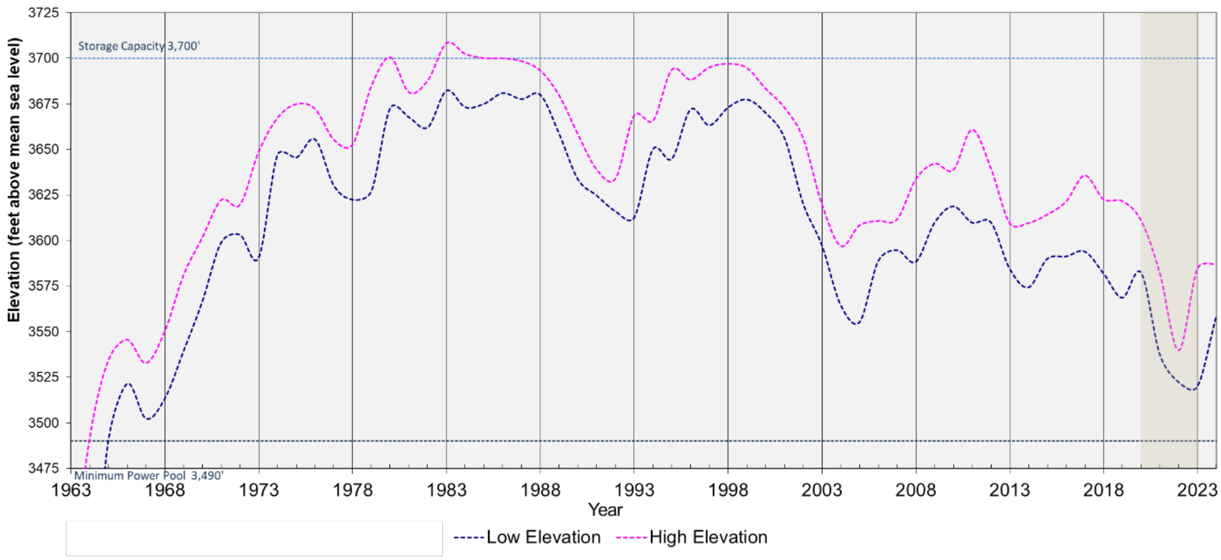
Unregulated inflows to Lake Powell from the Upper Basin vary year to year based on hydrologic conditions. According to a study that reconstructed historical conditions as far back as 600 CE, the current drought is the driest to occur since 800 CE (Wahl 2022). During the current 24-year drought period, unregulated water year (WY) inflows (the Colorado River WY refers to the period from October 1 to September 30 of the following calendar year [CY]) to Lake Powell ranged from 2.64 maf in 2002 to 15.97 maf in 2011 with an average of 8.29 maf (Reclamation 2025c). From 2020 to 2022, the Basin experienced three of the lowest consecutive inflow WYs on record, with inflows for those three years totaling around 15.5 maf (with 2021 having the lowest inflow of 3.5 maf). This continued period of drying and decrease in inflows in recent years has resulted in critically low elevations at Lake Powell.

Lake Powell began filling in 1963. The lake reached its highest elevation of 3,708.34 feet in 1983. Since Lake Powell is fed from inflows from the Upper Basin, water surface elevations are variable due to hydrologic conditions. To capture conditions since the implementation of the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines), water surface elevation data were analyzed for the years 2008 through 2022 from the Bureau of Reclamation's (Reclamation's) Upper Basin Hydrologic dataset (Reclamation 2025b). The operating range during this period was between a low of 3,519.92 feet (occurring in 2023) and a high of 3,660.9 feet (occurring in 2011). The average operating elevation was 3,602.3 feet, which is well below the average elevation throughout the 1980s and late 1990s, when the average operating elevations were closer to 3,683 feet and 3,679 feet, respectively. Since 2017, the annual average water surface elevation at Lake Powell has declined by approximately 87 feet, with the two largest year-over-year declines occurring in 2021 and 2022.

Lake Powell's annual high-water elevation and annual low-water elevation for 1963 through 2024 are shown in **Figure TA 3-1**. Note that these data include changes to elevations associated with operation of Lake Powell in accordance with the 2007 ROD, the Upper Basin Drought Contingency Plans (DCPs; Reclamation 2019; activated starting in 2020), and the Glen Canyon Dam Long-Term

Experimental and Management Plan Record of Decision (2016 LTEMP ROD; Reclamation 2016). The shaded box indicates the three lowest consecutive inflow years from 2020 to 2022.

Figure TA 3-1
Lake Powell Annual High and Low Elevations (1963-2024)



Source: Reclamation 2025b

As mentioned previously, 2000 to 2024 is the driest 24-year period in more than a century. The start of these drought conditions in the 2000s triggered the need to outline specific operations to provide a greater degree of certainty to Colorado River water users about timing and volumes of potential water delivery reductions during low reservoir elevations. The result was the 2007 ROD, which adopted the 2007 Interim Guidelines (in effect through 2026) for the operation of Lake Powell and Lake Mead to manage potential water delivery reductions and provide flexibility to conserve and store water in the system.

The 2007 Interim Guidelines governed annual releases from Glen Canyon Dam based on the end-of-water-year (EOWY) surface elevations of Lake Powell and Lake Mead. Different release volumes from Glen Canyon Dam were categorized by the following assigned Operational Tiers for Lake Powell[2]:

- Equalization Tier: releases are 8.23 maf or greater (to the extent necessary) to avoid spills or equalize storage in the two reservoirs. The "Equalization Volume" is the amount of water released above 8.23 maf in this Tier
- Upper Elevation Balancing Tier: releases depend on the elevation of Lake Powell and Lake Mead at the EOWY and are either 8.23 maf, or between 7.0 maf and 9.0 maf to balance contents

[2] The operational tiers are described in more detail in Sections 6.A through 6.D of the 2007 Interim Guidelines (Reclamation 2007b)

- Mid-Elevation Release Tier: releases depend on the elevation of Lake Powell and Lake Mead at the EOWY and are either 8.23 maf or 7.48 maf
- Lower Elevation Balancing Tier: releases between 7.0 maf and 9.5 maf as needed to balance contents

Since 2008, the most common Operational Tier has been the Upper Elevation Balancing Tier, which allowed releases from 7.0 maf to 9.0 maf (see **Table TA 3-1**). Glen Canyon Dam releases since 2007 have been between 7.00 maf to 12.52 maf (averaging 8.69 maf). This annual average of 8.69 maf is 1.06 maf lower than the average annual releases from 1996 to 2007 of 9.75 maf, which can be attributed to hydrologic conditions in the Basin and operations under the 2007 Interim Guidelines.

Table TA 3-1
Summary of Lake Powell and Lake Mead Coordinated Operations 2008-2024

Year	Lake Powell Operations					Lake Mead Operations
	Operational Tier	Adjustment	Operating Year Unregulated Inflow (% Average) [6]	Release Volume (maf)	Equalization Volume (maf)	Operating Condition
2008	Upper Elevation Balancing	Equalization	126	8.98	0.75	Normal/Intentionally Created Surplus (ICS) Surplus
2009	Upper Elevation Balancing	None	106	8.24 [1]		Normal/ICS Surplus
2010	Upper Elevation Balancing	None	88	8.23		Normal/ICS Surplus
2011	Upper Elevation Balancing	Equalization	166	12.52	4.29 [2]	Normal/ICS Surplus
2012	Equalization	N/A	51	9.47	1.23 [3]	Normal/ICS Surplus
2013	Upper Elevation Balancing	None	53	8.23		Normal/ICS Surplus
2014	Mid-Elevation Release	N/A	108	7.48		Normal/ICS Surplus
2015	Upper Elevation Balancing	Balancing	106	9.00		Normal/ICS Surplus
2016	Upper Elevation Balancing	Balancing	100	9.00		Normal/ICS Surplus
2017	Upper Elevation Balancing	Balancing	124	9.00		Normal/ICS Surplus
2018	Upper Elevation Balancing	Balancing	48	9.00		Normal/ICS Surplus
2019	Upper Elevation Balancing	Balancing	135	9.00		Normal/ICS Surplus
2020 [4]	Upper Elevation Balancing	None	61	8.23		Normal/ICS Surplus and DCP Contributions

Year	Lake Powell Operations					Lake Mead Operations
	Operational Tier	Adjustment	Operating Year Unregulated Inflow (% Average) [6]	Release Volume (maf)	Equalization Volume (maf)	Operating Condition
2021 [4]	Upper Elevation Balancing	None	36	8.23		Normal/ICS Surplus and DCP Contributions
2022 [4]	Mid-Elevation Release	Adjusted in May 2022	63	7.00 [5]		Level 1 Shortage and DCP Contributions
2023 [4]	Lower Elevation Balancing	Balancing	140	8.56		Level 2 Shortage and DCP Contributions
2024 [4]	Mid-Elevation Release	None	83	7.48		Level 1 Shortage and DCP Contributions
2025 [4]	Mid-Elevation Release	None	50	7.48		Level 1 Shortage and DCP Contributions

Source: Adapted from Reclamation 2024a

[1]In 2009, while the scheduled release volume was 8.23 maf, the actual release was 8.24 maf due to rounding and a release of 5,702 acre-feet (af) above 8.23. Balancing did not occur in 2009.

[2] The total 2011 equalization volume was 5.52 maf, with 4.29 maf released in operating year 2011. The remaining equalization volume was released as soon as practicable and was released fully by December 31, 2011.

[3] Although Lake Powell operated in the Equalization Tier in 2011, 8.23 maf was released in operating year 2012 due to dry conditions. The additional release of 1.23 maf was operating year 2011 equalization water released during operating year 2012. The difference between 9.47 maf and 8.23 maf is due to rounding.

[4] Supplemental data for 2020 - 2024 provided by Annual Operating Plan (Reclamation, 2020, 2021, 2022a, 2023, 2024d, 2025d, 2025e)

[5] Lake Powell's release was reduced by 480,000 af during WY 2022 in May 2022 (Reclamation 2022b)

[6] The unregulated inflow statistics (percent average) are based on a mean of the 30-year period 1991-2020 for all years (9.6 maf).

Drought conditions from 2020 to 2022 triggered the need to supplement the 2007 Interim Guidelines with near-term provisions for addressing extremely low reservoir levels. The result was the 2024 Near-term Colorado River Operations Record of Decision (2024 ROD; Reclamation 2024e), which adopted modified operations to stabilize the declining reservoir storage volumes and prevent system collapse. Beginning in 2024, releases from Lake Powell were based on the following modified Operational Tiers:

- Equalization Tier: remains the same as the 2007 ROD (Reclamation 2007b)
- Upper Elevation Balancing Tier: remains the same as the 2007 ROD (Reclamation 2007b)
- Mid-Elevation Release Tier: remains the same as the 2007 ROD (Reclamation 2007b) except that Reclamation may reduce releases to a minimum of 6.0 maf, if needed
- Lower Elevation Balancing Tier: remains the same as the 2007 ROD (Reclamation 2007b) except that Reclamation may reduce releases to a minimum of 6.0 maf, if needed
- If Lake Powell elevations drop below 3,500 feet, Reclamation facilities may be operated in a manner that protects the Colorado River system if hydrologic conditions require such action.

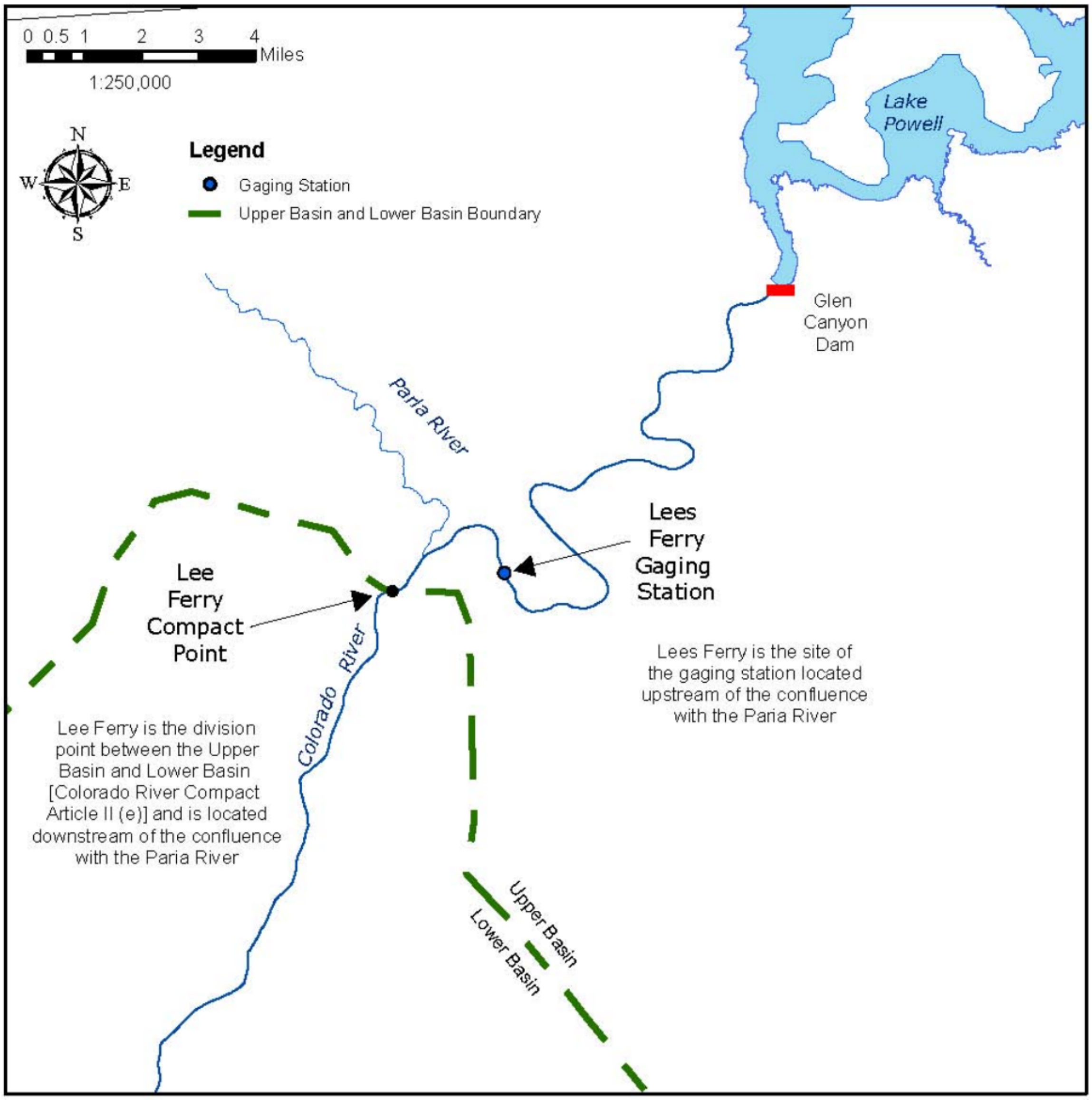
Releases from Glen Canyon Dam are scheduled on an annual, monthly, and hourly basis. Any sub annual releases comply with the 2016 LTEMP ROD and Supplemental Glen Canyon Dam Long-Term Experimental and Management Plan ROD (2024 LTEMP ROD) minimum daily and hourly flows of 5,000 cubic feet per second (cfs) at night and 8,000 cfs during the day through Glen Canyon Dam (Reclamation 2016).

TA 3.1.4 Lees Ferry Gaging Station

The Lees Ferry Gaging Station is located in Arizona, approximately 15.9 river miles downstream of Glen Canyon Dam, but still upstream of the confluence with the Paria River. The Lees Ferry Gaging Station differs from the Lee Ferry Compact Point, which is the division point between the Upper Basin and Lower Basin as established by the 1922 Colorado River Compact. The Lee Ferry Compact Point is located a few miles downstream of the Lees Ferry Gaging Station.

The Lee Ferry Compact Point is located downstream of the confluence with the Paria River. **Figure TA 3-2** shows the difference between the Lees Ferry Gaging Station location and the Lee Ferry Compact Point Location.

Figure TA 3-2
Lees Ferry Gaging Station and Lee Ferry Compact Point

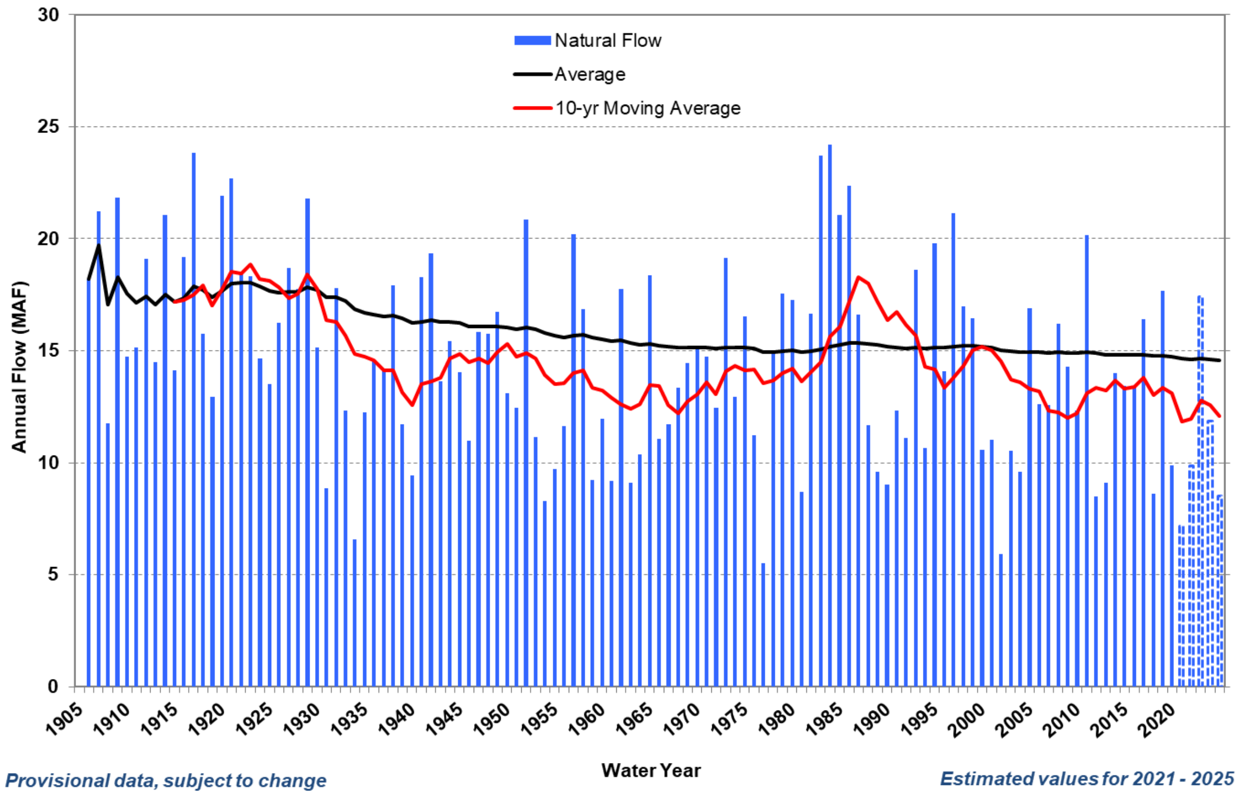


Source: Reclamation 2007a

Natural flows at Lees Ferry Gaging Station are calculated based on observed (gage) flow and corrected by Reclamation for upstream reservoir changes in storage and release, losses including evaporation, and depletions due to agriculture and domestic uses. The natural flow record for Lees Ferry Gaging Station exists from 1922.

From 1906 to 2007, the average annual natural flow at the Lees Ferry Gaging Station was calculated to be 14.9 maf and ranged from 5.4 maf to 24.4 maf. Since the implementation of the 2007 ROD (2008 to 2025), the annual natural flow at the Lees Ferry Gaging Station averaged 12.7 maf and has ranged from a low of 6.7 maf (2021) to 20.3 maf (2011). **Figure TA 3-3** shows the WY natural flows calculated at the Lees Ferry Gaging Station for 1922 through 2025.

Figure TA 3-3
WY Colorado River Natural Flow at Lees Ferry Gaging Station, Arizona (1906-2025)

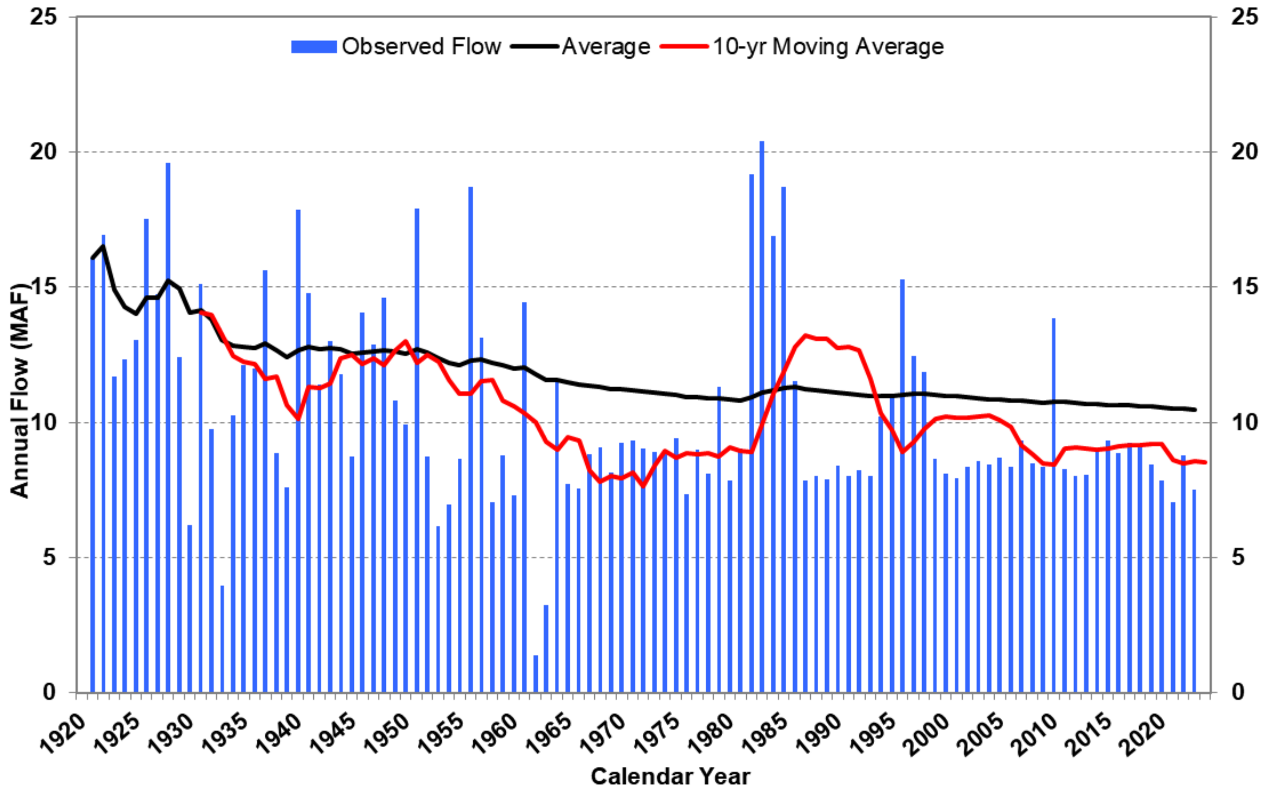


Source: Reclamation 2025f

According to the 2020 *State of the Science* report, a 2-year average flow of less than 15 maf at Lees Ferry is considered a streamflow deficit (Lukas and Payton, 2020). During the 1963–2007 period, the maximum 2-year average natural Lees Ferry flow that occurred was 24 maf in 1984. For comparison, since implementation of the 2007 ROD, the maximum 2-year average natural Lees Ferry flow was 16.27 maf in 2011. Other than the high flows in 2011, the 2-year average natural Lees Ferry flows since 2007 have been below 15 maf. Based on the 2020 *State of the Science* report's definition of a streamflow deficit, and the natural flow at Lees Ferry data, the system has been in a streamflow deficit since 2011 (Lukas and Payton 2020).

The annual observed flow at Lees Ferry Gaging Station differs from natural flow in that it does not account for the above-mentioned factors and is simply the recorded gage data with infrastructure in place. The annual observed flow at Lees Ferry since Glen Canyon Dam was built (1963) until the 2007 ROD was implemented ranged from 1.4 maf (following when the dam was built in 1963) to 20.4 maf (1984) with an average of 9.8 maf. Since the implementation of the 2007 ROD (2008 to 2024), the annual observed flows at the Lees Ferry Gaging Station have generally decreased, ranging from 7.0 maf (in 2022) to 13.9 maf (in 2011) and averaging 8.8 maf. This average annual observed flow is approximately 1.0 maf less than the average observed flow from 1962-2007. **Figure TA 3-4** shows the observed flows recorded at the Lees Ferry Gaging Station for 1922 through 2024.

Figure TA 3-4
Colorado River Observed Flow at Lees Ferry Gaging Station, Arizona (1922-2024)



Source: Reclamation 2025f

TA 3.1.5 Glen Canyon Dam to Lake Mead

The narrow 292-mile reach between Glen Canyon Dam and Lake Mead flows through Marble Canyon, Glen Canyon, and Grand Canyon National Park. The reach through Glen Canyon is 15 miles long and the reach through the Grand Canyon reach is 277 miles long. Flows within this reach primarily consist of flow from Glen Canyon Dam releases but include contributions from perennial tributaries located between Glen Canyon Dam and Lake Mead. The two largest tributaries are the Paria River and Little Colorado River. The 95-mile long Paria River starts in the Grand Staircase-Escalante National Monument and joins the Colorado River approximately five miles downstream from Glen Canyon Dam. The 340-mile long Little Colorado River drains a region of the Colorado River watershed to the southeast of Lake Powell, including the Painted Desert. The smaller creeks entering the Grand Canyon National Park from side canyons include Bright Angel Creek, Shinumo Creek, Tapeats Creek, Kanab Creek, Havasu Creek, and Diamond Creek.

Based on historical United States Geological Survey (USGS) gage data, inflows from the Paria River and Little Colorado River make up approximately three percent of the total flow in this reach of the Colorado River (USGS 2025a). From 1906 to 2005, the annual inflow of the Paria River averaged 21 thousand acre-feet per year (kafy) and the Little Colorado River averaged 180.0 kafy. Since 2007, the annual inflows from the Paria River averaged 17.0 kafy and the Little Colorado River averaged 274.0

kaf. Just below the confluence of the Little Colorado River (USGS gage 09402500), the flows in Colorado River ranged from 7.56 maf to 14.24 maf (averaging 9.31 maf; USGS 2024).

The Stream Flow and Losses of the Colorado River in the Southern Colorado Plateau White Paper 5 (White Paper 5; Wang et al. 2020) stated that there is approximately 150.0 kaf a year of seepage loss around Glen Canyon Dam and this volume has remained consistent.

Downstream of Glen Canyon Dam is the incised Grand Canyon, which limits hydraulic connection to groundwater to sandbars. Debris flow from side canyons result in deposits into the Grand Canyon of boulders and sand to replenish sandbars during elevated flows. Refer to **TA 5**, Geomorphology and Sediment, for more details regarding physical geotechnical characteristics of the Grand Canyon. Effects to groundwater elevations through the Grand Canyon were not considered in the 2007 Final EIS or the 2024 Final SEIS. While the flows in the Colorado River would not affect groundwater in the region, changes to the groundwater systems in the Grand Canyon due to climate change may be an additional environmental factor that affects flows in the Colorado River.

TA 3.1.6 Lake Mead and Hoover Dam

Lake Mead is a reservoir that is located on both sides of the Arizona-Nevada state line. Inflows into Lake Mead are from the Colorado River through Black Canyon, which is dammed by Hoover Dam and also from the Virgin River and Muddy River tributaries to the north of the reservoir. The concrete, thick arch dam was constructed from 1931 to 1936 and rises 726 feet as the highest concrete dam in the United States. When full, Lake Mead is 112 miles long.

The water surface elevation operating range of Lake Mead is set between 895 feet and 1,219.6 feet, with a maximum elevation of 1,229 feet. The total live storage capacity of Lake Mead at the full pool elevation of 1,219.6 feet is 26.12 maf (excluding 1.5 maf of flood control space)[3] storage available above the maximum operating elevation).

Groundwater basins adjacent to Lake Mead are generally small in size and are bound by zones of non-water bearing rock. Previous efforts in the 2007 Final EIS and 2024 Final SEIS noted that groundwater adjacent to Lake Mead may increase or decrease in correlation with changes in pool elevations. The Arizona Department of Water Resources Groundwater Site Inventory website (ADWR 2025) tracks depth to water measurements for one active groundwater monitoring well located to the south of Lake Mead, near the Detrital Wash. Groundwater elevations have remained steady since the groundwater monitoring well was installed in 1984 with the exception of two low groundwater elevation measurements in 2021 and 2022.

Beginning in 2011 and continuing for several years, Hoover Dam underwent improvements consisting of the installation of five new wide-head turbines to improve hydropower operations at lower water levels resulting in the lowering of the minimum power pool elevation from 1,050 feet to 950 feet. Low water level releases (below elevation 950 feet to elevation 895 feet) would continue

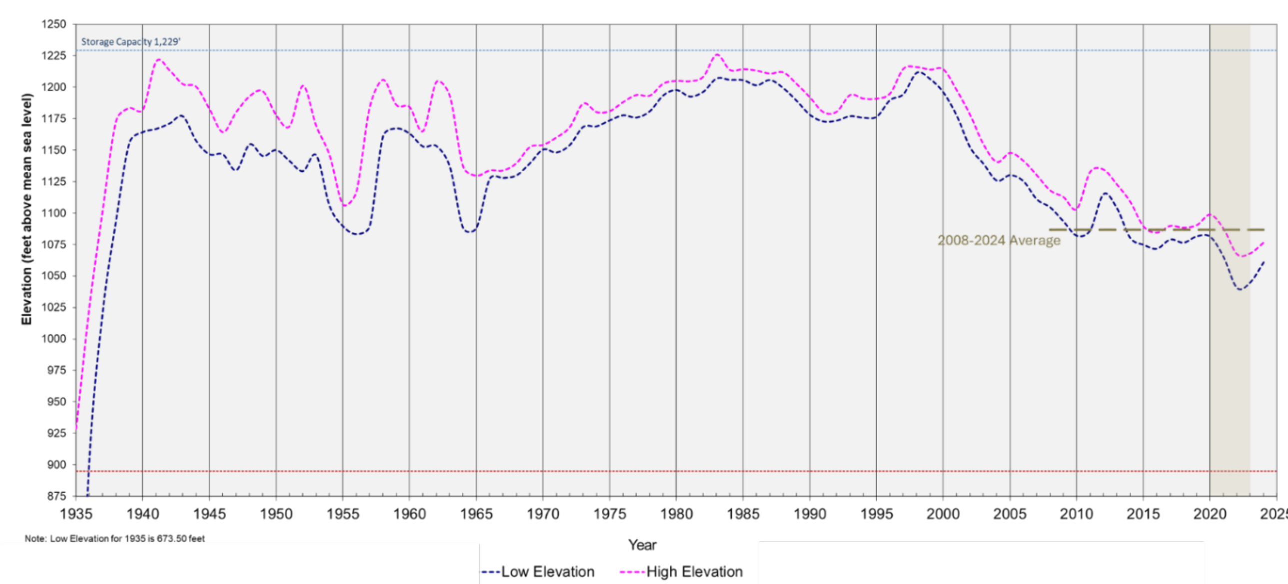
[3] Exclusive flood control space of 1.5 maf at elevation 1,219.6 feet as defined in the Field Working Agreement Between Department of the Interior, Bureau of Reclamation and Department of the Army, Corps of Engineers for Flood Control of Hoover Dam and Lake Mead, Colorado River, Nevada-Arizona, February 8, 1984.

through the four intake tours and penstocks but would no longer be able to be released through the hydropower turbines; instead, below 950 feet, water would only be released through the river outlet works. When elevations drop below 895 feet (referred to as dead pool), water is no longer able to be delivered downstream from Hoover Dam.

Lake Mead took approximately four years to fill to an average annual water surface elevation of 1,172 feet following the construction of Hoover Dam in 1936, but levels were highly variable. From 1939 to 1963, until Glen Canyon Dam and Lake Powell came online, the reservoir's water surface elevation fluctuated from 1,098 feet to 1,195 feet. Average annual peak elevation steadied in 1983 at 1,215 feet, then decreased through the late 1980s and early 1990s. In 1998, the average annual elevation peaked again at 1,214 feet before sharply declining to a new low of 1,118 feet in 2007. From 1939 to 2007, the average annual water surface elevation of Lake Mead was 1,170 feet.

Since 2007, water surface elevations at Lake Mead have generally declined. Reclamation's hydrologic geodatabase collected water surface elevation data from 2008 through 2024 which showed that the average annual operating range was between 1,040.6 feet (2022) and 1,134.5 feet (2011). Since the implementation of the 2007 Interim Guidelines, the water surface operating range of Lake Mead was between a low of 1,040.5 feet (occurring in 2022) and a high of 1,134.6 feet (occurring in 2012). The average annual operating elevation was 1,086.8 feet, approximately 83.2feet lower than the historical average annual from 1939 to 2007. **Figure TA 3-5** shows the annual high-water elevation and annual low-water elevation of Lake Mead from 1935 to 2024 with the average elevation of 1,086.8 feet from 2007 to 2024 shown as a dashed line, for reference.

Figure TA 3-5
Lake Mead Annual High and Low Elevations (1935-2024)



Source: Reclamation 2025b

The Compact apportioned 7.5 maf of water per year for beneficial consumptive use to the Lower Basin states. The LROC established operating criteria for Colorado River reservoirs that was compliant with the Law of the River including criteria for Normal, Surplus, and Shortage operating conditions at Lake Mead pursuant to Section II(B) of the Supreme Court Decree in *Arizona v. California* 1964 and the 2006 Consolidated Decree. Prior to the 2007 ROD, water availability in the Colorado River was sufficient that reductions to Lake Mead annual releases below 7.5 maf were not necessary.

The 2007 ROD also adopted criteria for storing and delivering conserved Colorado River system and non-system water in Lake Mead. Water conserved under this program is called ICS and it allowed for additional flexibility in meeting water needs during drought and bolstered Lake Mead during low reservoir conditions. The 2019 DCPs substantially expanded the ICS program. Since the 2007 ROD, Lake Mead has operated on a normal/ICS condition each year from 2008 through 2021 (refer to **Table TA 3-1**, Summary of Lake Powell and Lake Mead Coordinated Operations 2008-2024, above for Lake Mead's operating condition). In 2022, Reclamation declared the first ever Level 1 Shortage Condition for Lake Mead. Hydrologic conditions worsened and Lake Mead operated at a Level 2 Shortage Condition in 2023. In 2024 and 2025, Lake Mead operated in a Level 1 Shortage Condition. From 2020 through 2025, contributions from the Lower Basin DCP were required when the elevation of Lake Mead was below elevation 1,090 feet.

The ICS activity since the 2007 ROD has contributed to decreases in Hoover Dam releases. Annual Hoover Dam releases from Lake Mead ranged from 8.275 maf to 12.781 maf (averaging 10.199 maf) from 1996 through 2007 but have since ranged from 8.515 maf to 9.615 maf (averaging 9.185 maf) from 2008 through 2024.

Hoover Dam releases are managed on an hourly basis to maximize the value of generated power by providing peaks during high-demand periods. Releases from Hoover Dam are also based on Flood Control regulations are directed by the United States Army Corps of Engineers (USACE). Approximately 1.5 maf of space must be reserved within Lake Mead at all times exclusively for flood control purposes.

TA 3.1.7 Hoover Dam to Lake Mohave

The 67-mile reach from Hoover Dam (Lake Mead) to Davis Dam forms Lake Mohave. The upper part of this reach consists of Pyramid Canyon, El Dorado Canyon, and Black Canyon. The steep walls of these canyons bounds most of this reach. The narrow Lake Mohave is less than four miles across its widest point. The lake creates some minor side washes but flow within this reach is almost entirely comprised of releases from Hoover Dam (Reclamation 2007a).

Hoover Dam operations are consistent with operations prior to the 2007 Interim Guidelines. However, after 2007 ROD, the default operations of the dam to meet monthly elevation targets resulted in lower releases and decreased river flows. The 2007 Interim Guidelines have reduced average annual releases from Hoover Dam by approximately 1.014 maf (annually averaging 9.185 maf).

The target water surface elevation range of Lake Mohave and Davis Dam were not affected by the 2007 Interim Guidelines, with target water surface elevation levels between elevation 633 feet to 645 feet. Lower elevations are implemented in the fall to provide Flood Control capacity while higher elevations are introduced in the spring. The average storage in Lake Mohave has remained constant at approximately 1.6 maf over the past few decades, with an average annual water surface elevation of approximately 640.8 feet from 1996 to 2007 and 640.9 feet since 2008.

With Black Canyon located directly downstream of Hoover Dam, the bedrock canyon limits the connection to groundwater with a few small sandbars and the 2007 Final EIS identified no anticipated impacts on the groundwater basins from the 2007 Interim Guidelines.

TA 3.1.8 Davis Dam to Lake Havasu

The 84-mile reach from Davis Dam to Parker Dam forms Lake Havasu, which provides a forebay and desilting basin that pumps water for delivery to the Metropolitan Water District of Southern California and Central Arizona Project service areas. Minor tributaries are located above the reservoir, but flow in this reach primarily consists of releases from Davis Dam.

Bill Williams River, the largest of the tributaries in this reach, flows directly into Lake Havasu. The small inflows (on the order of 50 cfs) from this tributary flow into Lake Havasu and are regulated by the USACE operations of Alamo Dam. Based on historical USGS gage data, from 1906 to 2007, the annual inflow ranged from 1,300 af to 702,000 af and averaged 102,000 af (USGS 2025b). Flood Control operations at the Alamo Dam occasionally contribute to increased flows to Lake Havasu. The 2007 Interim Guidelines did not affect these operations, such that annual Alamo Dam releases from 2008 to 2022 have ranged from 15.4 af to 501,900 af and averaged 105,000 af. Bill Williams River flow contributions to the reach have remained unchanged.

Parker Dam is operated under the same rule curve that determines end-of-month target elevations as prior to the 2007 Interim Guidelines, maintaining Lake Havasu's water surface elevation between 445 and 450 feet. Seasonal adjustments to the reservoir's water surface elevation allow for Flood Control in the fall and higher water levels in the spring. The average annual elevation was 447.5 feet from 1996 to 2007, and approximately 447.7 feet from 2008 to 2022, remaining consistent for the last several decades.

This reach flows through two separate groundwater basins separated by the bedrock Topock Narrows: the Mohave Valley (north) and Chemehuevi Valley (south). Based on the 2007 Final EIS hydrologic and hydraulic models, the Mohave Valley aquifer, which is mostly alluvial fill, groundwater elevations were assumed to have decreased by approximately 0.25 feet since 2007. Water levels in the Chemehuevi Valley groundwater basin are assumed to have remained relatively consistent since 2007.

TA 3.1.9 Parker Dam to Cibola Gage

The 105-mile reach starting at Lake Havasu's Parker Dam is bounded by Reclamation's Cibola Gage, and this dam is used to regulate downstream water demands. This reach primarily consists of releases from Parker Dam, which is considered the last major storage facility on the Colorado River.

Parker Dam releases are scheduled on a daily and hourly basis to meet demand for power while supplementing water supply downstream. The 2007 Interim Guidelines did not explicitly target Parker Dam operations but have resulted in decreased annual release rates since implementation. Current minimum releases of the dam are 1,600 cfs daily, 1,400 cfs hourly, releasing 95,000 af during a 30-day month. The 2007 Final EIS stated Parker Dam releases from Lake Havasu ranged from 6.19 maf to 10.3 maf (averaged 7.4 maf) from 1996 to 2007. Since 2008, annual dam releases ranged from 6.2 maf to 6.7 maf (averaged 6.4 maf) through 2022. The average annual Parker Dam releases decreased by 1.0 maf post implementation of the2007 Interim Guidelines.

Two major diversion dams located in this reach are Headgate Rock Dam and Palo Verde Diversion Dam. The impoundments of these dams are used to facilitate the diversion of water for the Colorado River Indian Tribes and the Palo Verde Irrigation District. Current reservoir operations keep these reservoir levels at constant elevations.

The single large groundwater basin (mostly alluvial fill) within this reach is referred to by separate valley names: Parker Vally, Cibola Valley, and Palo Verde Valley. The 2007 Final EIS determined that groundwater elevations would decrease by approximately 0.15 feet to 0.30 feet in these areas based on hydrologic and hydraulic models and corresponding reductions in river flow. Therefore, groundwater levels have been assumed to have decreased since 2007 due to a decreasing trend in river flows.

TA 3.1.10 Cibola Gage to Imperial Dam

The 38-mile reach from Cibola Gage is bounded on the downstream end by Imperial Dam. Flows in this reach are primarily comprised of releases from Parker Dam. Imperial Dam is located approximately 18 miles northeast of Yuma, Arizona and provides enough increase in water surface elevation for gravity flow diversions to the All-American Canal (AAC) and the Gila Main Canal. The 2007 Interim Guidelines did not affect these diversions.

The Imperial Dam impoundment in this reach operates at a nearly constant elevation to meet water delivery requirements. The 2007 Interim Guidelines did not change operations of Parker Dam, but annual releases have decreased since 2008 due to decreased upstream releases from Lake Powell and Lake Mead, which translated to decreased inflows into Lake Havasu. Average flow rates in this reach ranged from 1,488 cfs to 18,168 cfs (averaged 8,931 cfs) from 1996 to 2007, and from 2,224 cfs to 18,751 cfs (averaged 7,632 cfs) since 2008. The reach has seen a decrease of 1,299 cfs.

This reach is located in a narrow alluvial fill valley without irrigated agriculture, and many backwaters are located in the southern half of the reach. Groundwater elevations are assumed to have decreased in this reach since 2007.

TA 3.1.11 Imperial Dam to NIB

The 26-mile reach extends from Imperial Dam to the NIB between the United States and Mexico. The channel of the Colorado River through this reach is bounded by a system of levees. Flow through this reach is comprised of water released from Imperial Dam to make deliveries, water leaked from the California sluiceway gates and return flow from Imperial Dam diversions.

Imperial Dam was constructed to raise the water surface elevation enough to provide gravity-controlled flow into the AAC on the California side and the Gila Gravity Main Canal on the Arizona side to meet water deliveries. The AAC diverts water for the Imperial Irrigation District, the Coachella Valley Water District, the Yuma Project, and the City of Yuma. The AAC also has a desilting works used to remove sediment from the Colorado River prior to diversion into the AAC. The Gila Gravity Main Canal diverts water for Gila Valley, Yuma Mesa, and the Wellton-Mohawk area. Imperial Dam also regulates deliveries to Mexico.

Downstream of Imperial Dam, in the upper portion of the reach, flows are typically around 250 cfs to 350 cfs. Laguna Dam is located approximately five miles downstream from Imperial Dam and was initially constructed to divert water to the Yuma Project area. However, since the AAC was built, Laguna Dam has been used as a regulating structure to manage sluicing flows from Imperial Dam and to protect the toe of Imperial Dam. Approximately 9 miles downstream from Laguna Dam is the confluence with Gila River, which is a major tributary to the Colorado River.

The 2007 ROD did not affect the operations and flows in the upper portion of this reach. The Yuma Valley groundwater basin and the South Gila Valley groundwater basin were also not anticipated to be affected from the 2007 Interim Guidelines. Reclamation assumed that groundwater levels have remained essentially the same since 2007.

TA 3.1.12 NIB to SIB

The Morelos Diversion Dam, located 1.1 miles downstream of the NIB, impounds the majority of the water supply that is diverted by Mexico into the Reforma Canal. The dam is owned, operated, and maintained by Mexico per the 1944 United States-Mexico Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande (1944 Water Treaty). The dam's flow in limitrophe to the SIB consists of water in excess of Mexico's scheduled delivery due to Flood Control operations at Hoover Dam, seepage from Morelos Diversion Dam, irrigation return flows, groundwater inflow, and any water released for environmental purposes in the Colorado River Delta.

To ensure the annual 1.5 maf water delivery under Normal Conditions per the 1944 Water Treaty, the Morelos Diversion Dam operations have not changed as a result of the 2007 ROD or the 2024 ROD. In Minute 323 to the 1944 Water Treaty, Mexico agreed to reductions and savings under low elevation reservoir conditions. Refer to **Appendix M**, International Border Region of the Colorado River, for more details related to an overview of previous binational coordination efforts.

The Flood Control releases from Lake Mead and Hoover Dam upstream are largely dependent on hydrologic conditions and therefore have potential impacts. The average flows to Mexico in excess of the required delivery volume were approximately 114,081 af from 1974 to 2012, until Warren H. Brock Reservoir was built to reduce excess flows at the NIB. Prior to completion, the 10-year annual average flow from 2003 to 2012 was 82,853 af. Since completion of the reservoir, flows in excess of the required delivery volume have decreased by approximately two thirds, or by 56,000 af, per year. Additionally, considerations for hydrologic conditions, rainfall events, and other operational variables are relevant to the volume of flows in excess of the required delivery volume.

This reach is in the Colorado River Delta groundwater basin and is referred to as the limitrophe. It's characterized as a dry or minimally flowing streambed with an annual rainfall of less than three inches. Flows in this reach can be from releases from the Morelos Diversion Dam, various wasteway discharges from the Yuma area irrigation system, or from nearby agricultural fields percolating into the hyporheic zone and subsurface alluvium.

Due to high groundwater levels in adjacent irrigated fields, the upper portion of the limitrophe is a gaining reach that receives perennial inflow from the groundwater basin. Depths to groundwater increase in the southern portions of the limitrophe reach, towards the SIB, which is considered a losing reach. Groundwater elevations in this reach dropped around 27 feet between 1960 and 2009 (refer to **Appendix M**, International Border Region of the Colorado River, for more details related to the affected environment description for the border region).

TA 3.2 Environmental Consequences

This section provides an analysis of the extent and magnitude of potential impacts on hydrologic resources for the No Action Alternative, four action alternatives, and Continued Current Strategies (CCS) Comparative Baseline (as described in **Section 3.1**). Potential impacts are considered for the following hydrologic resources: reservoir storage, reservoir releases, and corresponding changes in river flows downstream of the reservoirs.

Methodology

Reclamation uses the Colorado River Simulation System (CRSS) model for long-term planning studies. The CRSS model simulates Basin conditions decades into the future (the full analysis period is through 2060) and can be used to account for hydrological uncertainty. The CRSS model is a monthly time-step model that produces reservoir elevations, releases and river flows as outputs. Refer to **Appendix A**, CRSS Model Documentation, for more details related to model documentation.

The hydrologic analysis is modeled in CRSS using 5 flow condition categories for the preceding 3-year average natural flow at Lees Ferry. These flow categories help to visualize the different states of potential modeled futures and are used to frame the CRSS outputs shown in the conditional box plots presented in the analysis below. A sample conditional box plot figure with guidance on how to parse the information shown within it is provided in **Figure 3-2**.

The CRSS model results are further analyzed using robustness heat maps, which show the percentage of futures (across the full analysis period) that meet a specified level of performance. In the Hydrologic Resources section, the level of performance is related to maintaining certain critical water surface elevations in Lake Powell and Lake Mead, for a given frequency. A sample robustness heatmap with guidance on how to parse the information shown within it is provided in **Figure 3-3**.

Vulnerability bar plots are used to complement the robustness heat map analysis by relating the likelihood of a potential future being considered either successful or unsuccessful (for the specific level of performance identified in the robustness heat map) to the hydrologic conditions associated with that outcome. In the Hydrologic Resources section, a successful outcome is defined as the critical water surface elevation being maintained for a given frequency and it is related to the hydrologic conditions that are likely to cause vulnerability to achieving a successful outcome. A sample vulnerability bar plot with guidance on how to parse the information shown within it is provided in **Figure 3-4**.

Impact Analysis Area

The geographic scope of the hydrologic resources analysis is the Colorado River corridor from the upstream limits of full pool elevation of Lake Powell to the downstream limits of the SIB. Reservoirs upstream of Lake Powell are operated pursuant to their own Records of Decision, which are not altered by the proposed alternatives.

Assumptions

The hydrologic resources results are direct outputs from the CRSS model. Refer to **Appendix A**, CRSS Model Documentation, for more details related to model assumptions and documentation. All action alternatives except for the Basic Coordination Alternative incorporate mechanisms related to the storage and delivery of conserved water in Lake Powell and/or Lake Mead (refer to **Sections 2.6 through 2.8** for a description of alternatives). Unless otherwise specified, impacts reflect modeling assumptions about voluntary conservation behavior.

Impact Indicators

The following indicators were used to assess impacts on hydrologic resources:

- **Reservoir elevations**: impacts on reservoir elevations due to operational activities
- **System storage**: impacts on system storage due to operational activities
- **Reservoir releases:** impacts on reservoir releases due to operational activities
- **River flows:** impacts on river flows due to operational activities
- **Groundwater**: qualitative impacts on groundwater adjacent to reservoirs and river reaches due to operational activities

TA 3.2.1 Issue 1: Reservoir Elevations

Issue 1 addresses how operational activities for the various alternatives would affect reservoir elevations. This includes comparing the various action alternatives to the No Action Alternative and the CCS Comparative Baseline for the following metrics:

- Lake Powell pool elevations
- Lake Mead pool elevations
- Impacts of modeling assumptions for Upper Basin and Lower Basin conservation activity on Lake Powell and Lake Mead storage

Lake Powell

This section presents a comparison of the No Action Alternative, CCS Comparative Baseline, and action alternatives with respect to EOWY elevations at Lake Powell. Note that the performance of the Supply Driven (Lower Basin [LB] Priority approach) and Supply Driven (LB Pro Rata approach) will not differ in Lake Powell elevations because they use the same operation of Lake Powell. Critical Lake Powell elevations are listed in **Table TA 3-2** below. The total live storage capacity of Lake Powell at the full pool elevation of 3,700 feet is 23.31 maf (excluding approximately 1.9 maf of flood control space).

Table TA 3-2
Critical Elevations at Lake Powell

Critical Condition	Associated Elevation	Description of Critical Elevation
Spillway	3,700 feet	Top of Glen Canyon Dam spillway
Spill Avoidance	3,680 feet	At high elevations, releases deviate from the planned release for spill avoidance and infrastructure protection. Capacity between this elevation and the top of the spillway allows for 1.9 maf of Flood Control storage
Buffer Elevation	3,525 feet	Water supply buffer elevation; may trigger additional (within Record of Decision) releases from CRSP UIUs (Flaming Gorge, Navajo, and Blue Mesa reservoirs)
Buffer Elevation	3,500 feet	10-foot buffer elevation above minimum power pool (3,490 feet) for water supply and hydropower.
Minimum Power Pool	3,490 feet	No longer able to produce hydropower at Glen Canyon Dam; releases below this elevation are constrained and may damage release structures
Dead Pool	3,370 feet	No longer able to deliver water downstream through Glen Canyon Dam

Table TA 3-3 below shows the statistical breakdown of EOWY elevations (in feet) at Lake Powell for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOWY elevations. Similarly, **Table TA 3-4** shows the statistical breakdown of minimum WY elevations (in feet).

Table TA 3-3
EOWY Elevation (Feet) at Lake Powell

Alternative	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	> 16	3,696	3,692	3,690	3,680	3,663	3,631	3,499
CCS Comparative Baseline	14-16	3,697	3,690	3,677	3,643	3,596	3,557	3,462
CCS Comparative Baseline	12-14	3,695	3,672	3,633	3,584	3,541	3,500	3,414
CCS Comparative Baseline	10-12	3,694	3,623	3,575	3,527	3,498	3,471	3,404
CCS Comparative Baseline	< 10	3,691	3,564	3,525	3,498	3,454	3,422	3,398
No Action	> 16	3,696	3,693	3,690	3,685	3,672	3,646	3,503
No Action	14-16	3,697	3,691	3,684	3,659	3,613	3,565	3,433
No Action	12-14	3,697	3,682	3,649	3,598	3,536	3,483	3,411
No Action	10-12	3,695	3,638	3,585	3,513	3,476	3,449	3,407
No Action	< 10	3,691	3,578	3,519	3,475	3,440	3,420	3,400
Basic Coordination	> 16	3,696	3,692	3,689	3,679	3,661	3,635	3,534
Basic Coordination	14-16	3,696	3,688	3,670	3,641	3,607	3,577	3,476
Basic Coordination	12-14	3,696	3,659	3,629	3,593	3,556	3,524	3,413
Basic Coordination	10-12	3,695	3,616	3,581	3,540	3,501	3,467	3,404
Basic Coordination	< 10	3,678	3,572	3,532	3,486	3,449	3,420	3,398
Enhanced Coordination	> 16	3,696	3,692	3,690	3,680	3,662	3,644	3,585
Enhanced Coordination	14-16	3,696	3,689	3,671	3,648	3,630	3,615	3,527
Enhanced Coordination	12-14	3,697	3,669	3,651	3,630	3,606	3,580	3,483
Enhanced Coordination	10-12	3,694	3,653	3,631	3,602	3,569	3,541	3,464
Enhanced Coordination	< 10	3,690	3,626	3,601	3,565	3,528	3,497	3,399
Max. Operational Flexibility	> 16	3,697	3,692	3,691	3,682	3,665	3,649	3,591
Max. Operational Flexibility	14-16	3,696	3,691	3,679	3,654	3,632	3,615	3,528
Max. Operational Flexibility	12-14	3,697	3,671	3,650	3,624	3,598	3,576	3,508
Max. Operational Flexibility	10-12	3,695	3,642	3,619	3,585	3,560	3,539	3,494
Max. Operational Flexibility	< 10	3,692	3,617	3,583	3,549	3,522	3,508	3,425
Supply Driven (LB Priority)	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Priority)	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Priority)	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Priority)	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Priority)	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398
Supply Driven (LB Pro Rata)	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Pro Rata)	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Pro Rata)	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Pro Rata)	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Pro Rata)	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398

NOTE: Elevations colored blue are above the spill avoidance elevation of 3,680 feet, listed in the previous table. Elevations colored red are below the minimum power pool elevation of 3,490 feet, listed in the previous table.

Table TA 3-4
Minimum Water Year Elevation (Feet) at Lake Powell

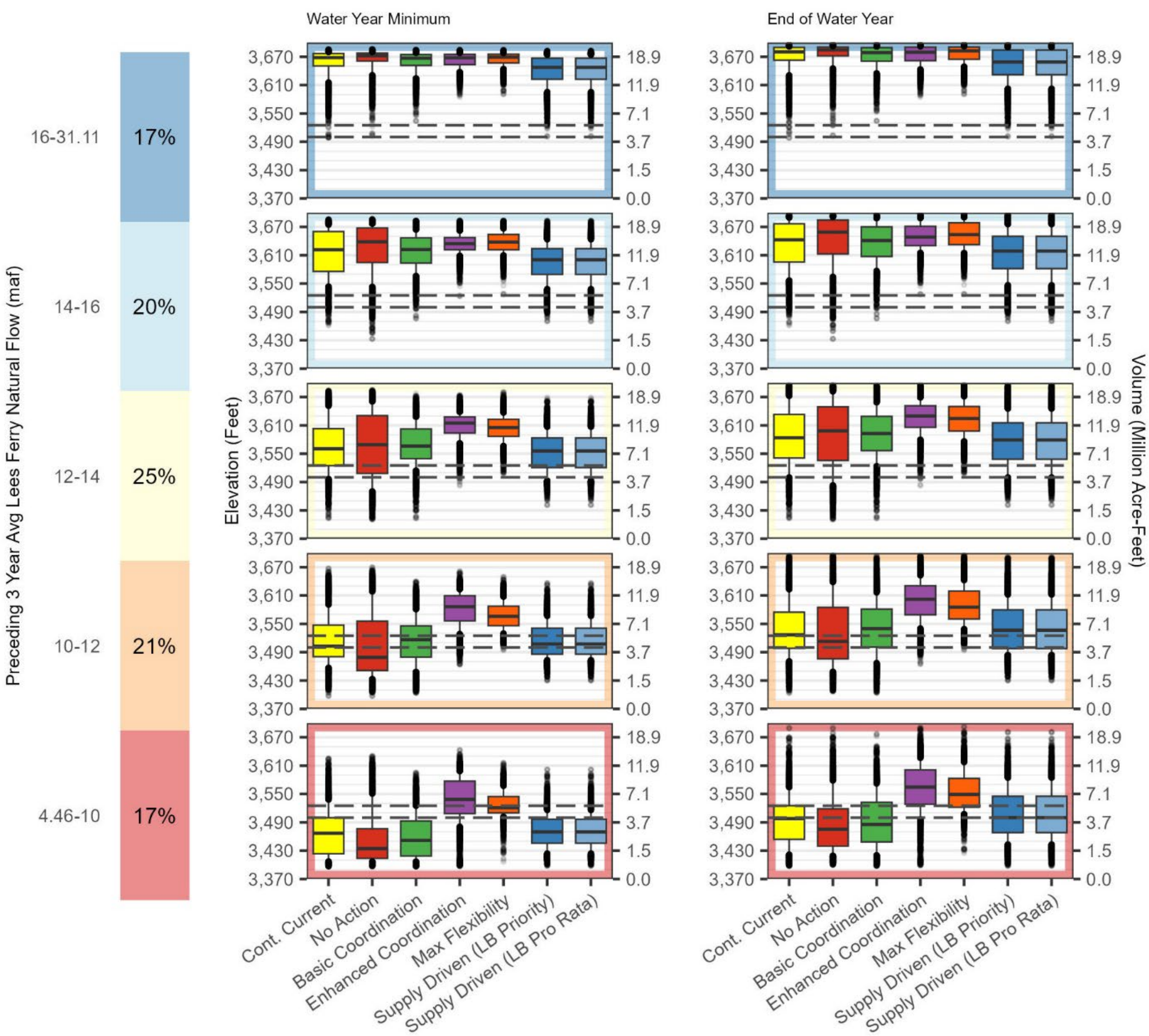
Alternative	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	> 16	3,696	3,692	3,690	3,680	3,663	3,631	3,499
CCS Comparative Baseline	14-16	3,697	3,690	3,677	3,643	3,596	3,557	3,462
CCS Comparative Baseline	12-14	3,695	3,672	3,633	3,584	3,541	3,500	3,414
CCS Comparative Baseline	10-12	3,694	3,623	3,575	3,527	3,498	3,471	3,404
CCS Comparative Baseline	< 10	3,691	3,564	3,525	3,498	3,454	3,422	3,398
No Action	> 16	3,696	3,693	3,690	3,685	3,672	3,646	3,503
No Action	14-16	3,697	3,691	3,684	3,659	3,613	3,565	3,433
No Action	12-14	3,697	3,682	3,649	3,598	3,536	3,483	3,411
No Action	10-12	3,695	3,638	3,585	3,513	3,476	3,449	3,407
No Action	< 10	3,691	3,578	3,519	3,475	3,440	3,420	3,400
Basic Coordination	> 16	3,696	3,692	3,689	3,679	3,661	3,635	3,534
Basic Coordination	14-16	3,696	3,688	3,670	3,641	3,607	3,577	3,476
Basic Coordination	12-14	3,696	3,659	3,629	3,593	3,556	3,524	3,413
Basic Coordination	10-12	3,695	3,616	3,581	3,540	3,501	3,467	3,404
Basic Coordination	< 10	3,678	3,572	3,532	3,486	3,449	3,420	3,398
Enhanced Coordination	> 16	3,696	3,692	3,690	3,680	3,662	3,644	3,585
Enhanced Coordination	14-16	3,696	3,689	3,671	3,648	3,630	3,615	3,527
Enhanced Coordination	12-14	3,697	3,669	3,651	3,630	3,606	3,580	3,483
Enhanced Coordination	10-12	3,694	3,653	3,631	3,602	3,569	3,541	3,464
Enhanced Coordination	< 10	3,690	3,626	3,601	3,565	3,528	3,497	3,399
Max. Operational Flexibility	> 16	3,697	3,692	3,691	3,682	3,665	3,649	3,591
Max. Operational Flexibility	14-16	3,696	3,691	3,679	3,654	3,632	3,615	3,528
Max. Operational Flexibility	12-14	3,697	3,671	3,650	3,624	3,598	3,576	3,508
Max. Operational Flexibility	10-12	3,695	3,642	3,619	3,585	3,560	3,539	3,494
Max. Operational Flexibility	< 10	3,692	3,617	3,583	3,549	3,522	3,508	3,425
Supply Driven (LB Priority)	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Priority)	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Priority)	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Priority)	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Priority)	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398
Supply Driven (LB Pro Rata)	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Pro Rata)	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Pro Rata)	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Pro Rata)	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Pro Rata)	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398

NOTE: Elevations colored blue are above the spill avoidance elevation of 3,680 feet, listed in the previous table. Elevations colored red are below the minimum power pool elevation of 3,490 feet, listed in the previous table.

Figure TA 3-6 below looks at the response of Lake Powell WY minimum and EOWY elevations and storage volumes to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-3** and **Table TA 3-4** in two side by side conditional box plot panels. The bold center line of each box represents the median value, the top and bottom of each box captures the 25th to 75th percentile of the modeled results, the lines extend to the 10th and 90th percentiles, and the outliers are represented as dots beyond these lines.

In each flow category shown in the box plots, the key elevations of 3,525 feet and 3,500 feet are identified with dashed lines.

Figure TA 3-6
Water Year Minimum and End of Water Year (EOWY) Elevations and Storage Volumes of Lake Powell



In the Average Flow Category (12.0–14.0 maf) for WY minimums, the medians and interquartile ranges for all alternatives are projected to remain above 3,500 feet. The Enhanced Coordination and Maximum Operational Flexibility Alternatives have higher, less variable results centered around 3,600 feet, while the Supply Driven (LB Priority approach), Supply Driven (LB Pro Rata approach), Basic Coordination, and No Action Alternatives, and the CCS Comparative Baseline have median elevations around 3,560 feet.

As flow categories get drier, the WY minimums for the CCS Comparative Baseline and the No Action, Basic Coordination, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives shift notably toward and below 3,500 feet and their full interquartile ranges fall below this key elevation in the Dry Flow Category (less than 10.0 maf). The Maximum Operational Flexibility and Enhanced Coordination Alternatives show less decline: even in the Dry Flow Category the interquartile ranges for both remain above 3,500 feet.

For the EOWY elevations panel, the comparisons across alternatives and flow categories are the same as in the WY minimum elevations panel, but the distributions of elevations shift higher since Lake Powell generally reaches its minimum elevation in March before spring runoff begins and elevations increase by EOWY.

The alternatives generally perform similarly under Wet and Moderately Wet Flow Categories, except for the two Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches), which have lower median reservoirs elevations compared to others. Performance deviations increase as conditions get drier because operations as elevations get lower vary widely across alternatives.

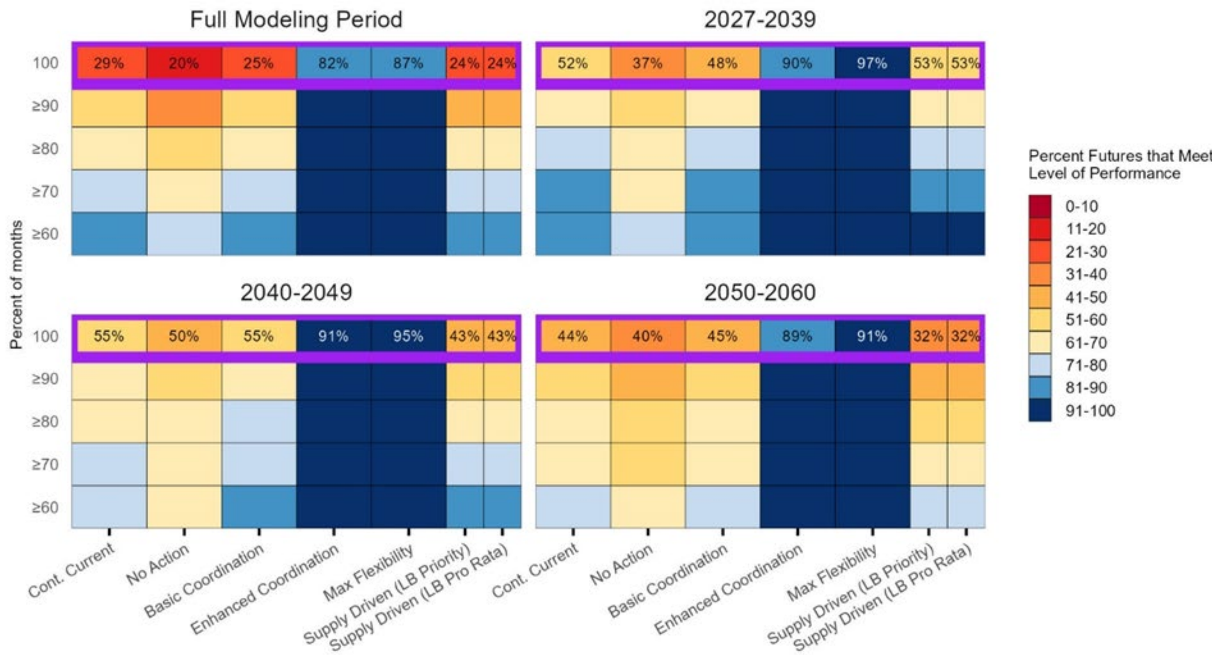
Lake Powell 3,500 Feet Robustness

Figure TA 3-7 below depicts the performance of each alternative with respect to keeping Lake Powell above an elevation of 3,500 feet. Elevation 3,500 feet is important because it provides a 10-foot buffer for water supply and hydropower, which are critically impacted at an elevation of 3,490 feet.

The figure is broken into four heat maps, each showing a different time period during the analysis; the top left heat map shows the full modeling period from 2027 through 2060 and the remaining three panels show sub periods. Rows of the heat map show different frequency ranges (percents of months) for keeping Lake Powell above 3,500 feet, with higher rows corresponding higher (more challenging) frequencies. The highlighted (top) row captures the percentage of futures that an alternative keeps Lake Powell above 3,500 feet in 100 percent of the months. The 100 percent row was chosen because of the importance of avoiding critical impacts on water deliveries and hydropower.

The Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying above elevation 3,500 feet in 100 percent of months over the full modeling period, doing so in 87 percent and 82 percent of the futures, respectively. The Basic Coordination, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives perform similarly to the CCS Comparative Baseline, succeeding in 25 percent, 24 percent, and 24 percent of futures, respectively, over the full analysis period. The No Action Alternative has the least robust with a 20 percent success rate over the full modeling period.

Figure TA 3-7
Lake Powell 3,500 Feet: Robustness.
Percent of futures in which Lake Powell elevation stays above 3,500 feet in the percent of months specified by each row



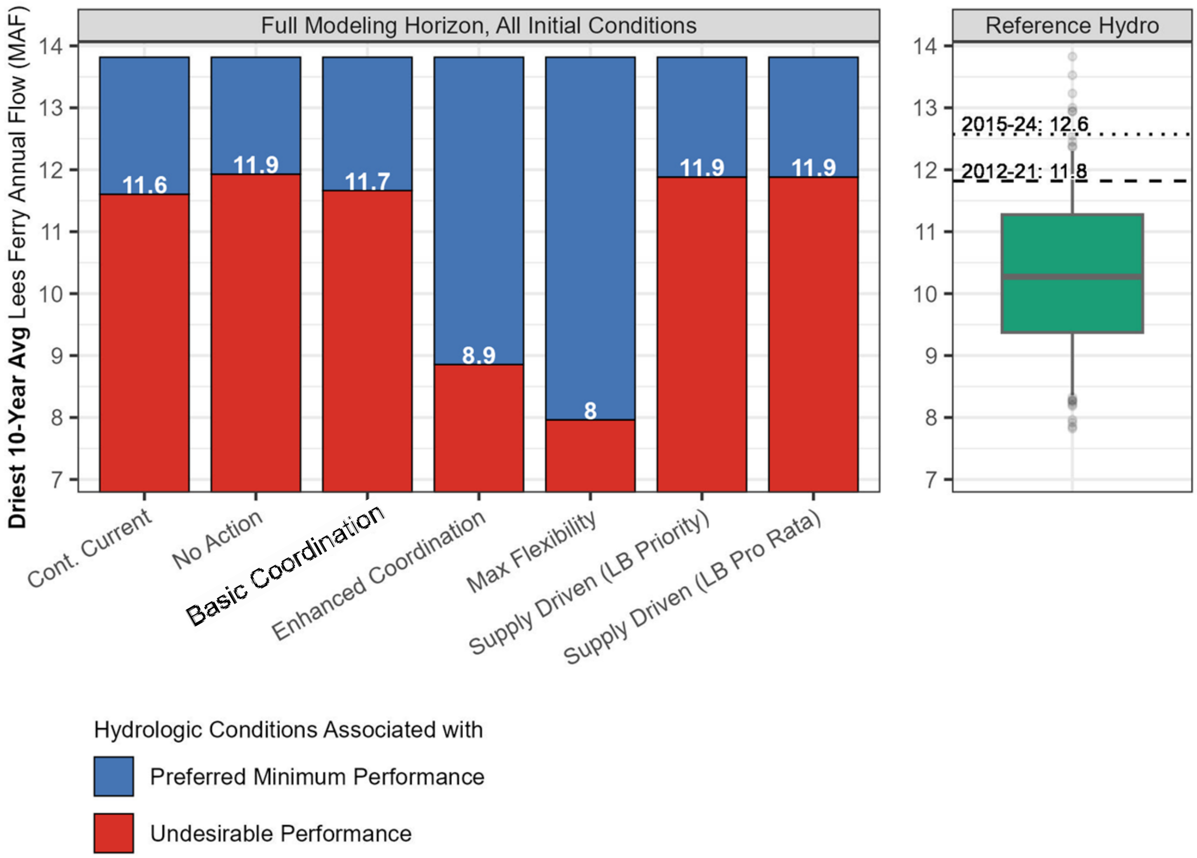
In lower rows of the heat maps, the Enhanced Coordination and Maximum Operational Flexibility Alternatives consistently achieve 91-100 percent robustness, while the other alternatives only reach a maximum of 80 percent robustness at even the lowest levels of performance (e.g., greater than or equal to 60 percent of months).

The robustness scores of Basic Coordination, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives improve when analyzing shorter modeling periods because it is easier to stay above 3,500 feet for shorter periods than the full 34-year simulation. However, none of these alternatives achieve a high level of robustness in these shorter periods, nor does the CCS Comparative Baseline.

Figure TA 3-8 below looks at flow conditions that could cause the Lake Powell elevation to fall below 3,500 feet during at least one month in any year across the 34-year simulation. This definition of undesirable performance is based on the highlighted row in the above **Figure TA 3-8,** which qualifies a future as successful in meeting the minimum preferred performance when an alternative would keep Lake Powell above this critical buffer elevation of 3,500 feet 100 percent of the time.

For this vulnerability analysis, the driest 10-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the range of driest 10-year averages in the reference hydrology ensemble using this summary streamflow statistic. The driest observed 10-year average flow from 2012-2021 (11.8 maf) and the average flow from 2015-2024 (12.6 maf) are also provided as dashed and dotted lines, respectively, for comparison.

Figure TA 3-8
Lake Powell 3,500 Feet: Vulnerability.
Conditions that could cause Lake Powell elevation to fall below 3,500 feet in one or more months

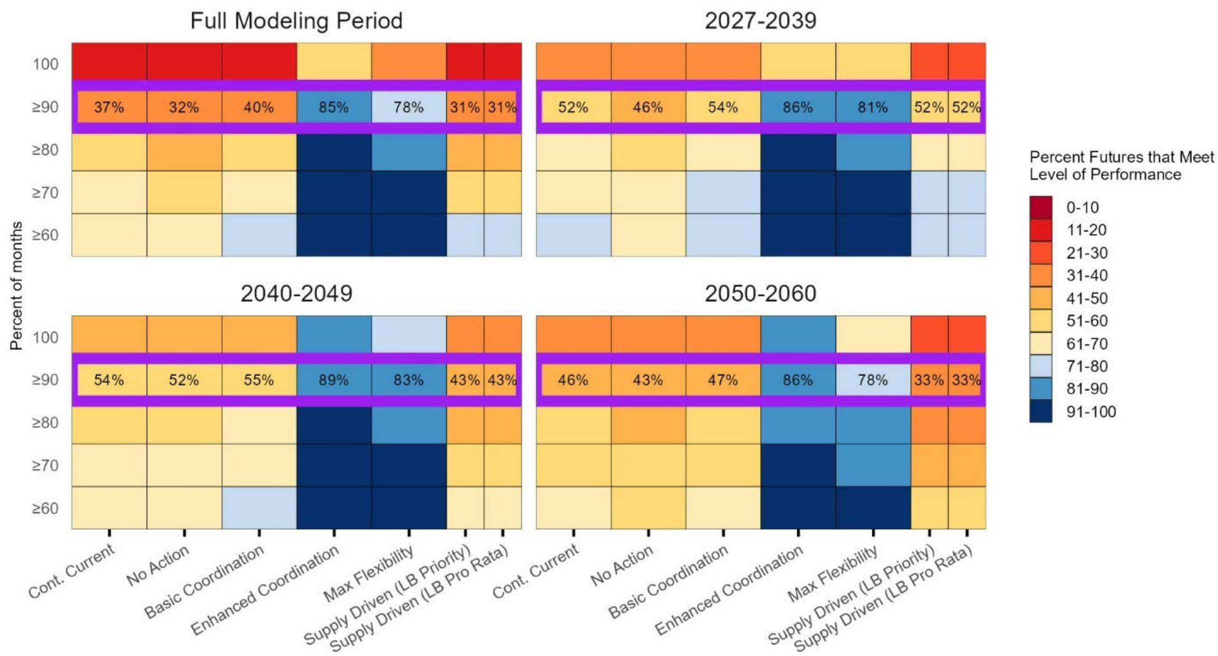


The Supply Driven (LB Priority approach), Supply Driven (LB Pro Rata approach), and No Action Alternatives result in undesirable performance (i.e., become vulnerable to falling below an elevation of 3,500 feet) when the driest 10-year average Lees Ferry flow is below 11.9 maf. This vulnerability is similar to the CCS Comparative Baseline and Basic Coordination Alternative, which are likely to be vulnerable when the driest 10-year average Lees Ferry flow is below 11.6 maf and 11.7 maf, respectively. These conditions are similar to the driest observed Lees Ferry 10-year average flow of 11.8 maf from 2012-2021, and above the 75th percentile of the reference hydrology ensemble, meaning more than 75 percent of the traces includes droughts this dry or drier. Vulnerabilities for the Enhanced Coordination and Maximum Operational Flexibility Alternatives are likely to occur if the driest 10-year average flow is 8.9 maf and 8.0 maf, respectively. The reference hydrology ensemble box plot shows the range of driest modeled 10-year averages, and fewer than 25 percent of these traces have 10-year droughts as low as 8.9 maf.

Lake Powell 3,525 Feet Robustness

Figure TA 3-9 below depicts the performance of each alternative with respect to keeping Lake Powell above elevation 3,525 feet.

Figure TA 3-9
Lake Powell 3,525 Feet: Robustness.
Percent of futures in which Lake Powell stays above 3,525 feet in the percent of months specified by each row



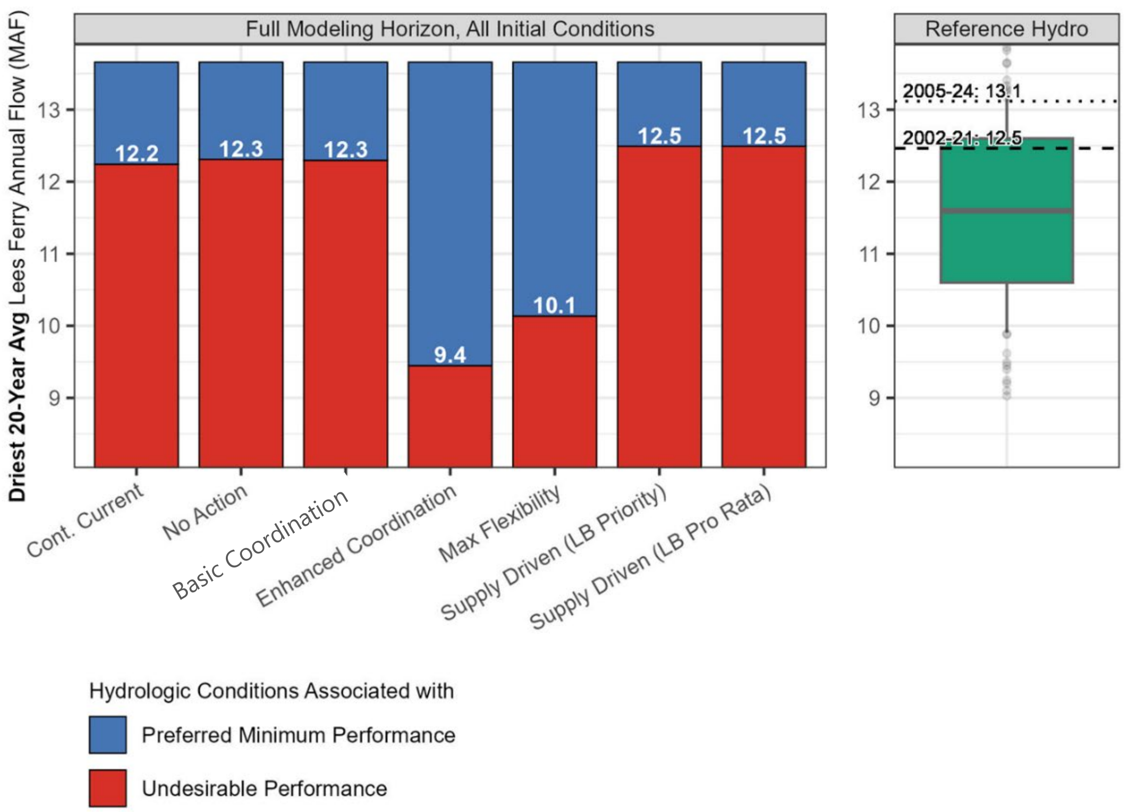
The figure is broken into four heat maps, each showing a different time period during the analysis; the top left heat map shows the full modeling period from 2027 through 2060 and the remaining three panels show sub periods. Rows of the heat map show different frequency ranges (percents of months) for keeping Lake Powell above 3,525 feet, with higher rows corresponding higher (more challenging) frequencies. The highlighted row (second from the top) captures the percentage of futures that an alternative keeps Lake Powell above 3,525 feet in at least 90 percent of months. The greater than or equal to 90 percent row was chosen because it provides a reasonable amount of flexibility to go below 3,525 feet occasionally in very dry hydrology.

The Maximum Operational Flexibility and Enhanced Coordination Alternatives are the most robust at staying above elevation 3,525 feet in 90 percent of months over the full modeling period (shown in second from the top row), doing so in 78 percent and 85 percent of the futures respectively. Over the full modeling period, the Basic Coordination Alternative performs similarly to the CCS Comparative Baseline, succeeding in 40 percent and 37 percent of futures, respectively. This is slightly more robust than the No Action and Supply Driven Alternatives (both Priority and Pro Rata approaches), which only meet the minimum preferred performance (staying above elevation 3,525 feet in 90 percent of months over the full modeling period) in 32 percent and 31 percent of futures, respectively. When looking at shorter periods of performance in the other heat maps, the robustness of the least-robust operations (the CCS Comparative Baseline and No Action, Basic Coordination, and both Supply Driven Alternatives) increases because it is easier to keep Lake Powell above an elevation of 3,525 feet at least 90 percent of the time over shorter timespans.

In the full modeling period heat map, all alternatives have poor levels of performance for the 100 percent of months row (top). Even the Enhanced Coordination Alternative, which is the most robust, only achieves this elevation in 51-60 percent of futures.

Figure TA 3-10 below looks at flow conditions that could cause the Lake Powell elevation to fall below 3,525 feet in more than 10 percent of months. This definition of undesirable performance is based on the highlighted row in the above **Figure TA 3-10,** which qualifies a future as successful in meeting the minimum preferred performance when an alternative keeps Lake Powell above elevation 3,525 feet in at least 90 percent of months.

Figure TA 3-10
Lake Powell 3,525 Feet: Vulnerability.
Conditions that could cause Lake Powell elevation to fall below 3,525 feet in more than 10% of months



For this vulnerability analysis, the driest 20-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the reference hydrology ensemble using this streamflow summary statistic. The driest observed 20-year average flow from 2002-2021 (12.5 maf) and the average flow from 2005-2024 (13.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

The Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) become vulnerable to undesirable performance at 12.5 maf. This vulnerability is similar to the CCS Comparative

Baseline, and the Basic Coordination and No Action Alternatives, which are likely to be vulnerable at 12.2 maf, 12.3 maf, and 12.3 maf, respectively. This is close to the 2002-2021 observed average flows (12.5 maf), and almost 75 percent of the traces in the reference hydrology ensemble have 20-year droughts this dry. Vulnerabilities for the Enhanced Coordination and Maximum Operational Flexibility Alternatives occur at much lower driest 20-year averages: 9.4 maf and 10.1 maf, respectively. Only about 5 percent to 10 percent of traces in the reference hydrology ensemble include 20-year droughts this low.

Lake Mead

This section presents a comparison of the No Action Alternative, CCS Comparative Baseline, and action alternatives with respect to end-of-calendar-year (EOCY) elevations at Lake Mead. Critical elevations at Lake Mead listed in **Table TA 3-5** below preserve infrastructure and ensure Hoover Dam continues to operate under its intended design for purposes of downstream water releases. The total live storage capacity of Lake Mead at the full pool elevation of 1,219.6 feet is 28.7 maf (excluding approximately 1.5 maf of Flood Control storage available above the maximum operating elevation).

Table TA 3-5
Critical Elevations at Lake Mead

Critical Condition	Associated Elevation	Description of Critical Elevation
Spillway	1,221 feet	Top of Hoover Dam spillway.
Maximum Operating Elevation	1,219.6 feet	Allows for 1.5 maf of exclusive Flood Control space between elevations 1,219.6 feet and 1,229 feet (full pool).
Hydropower Critical Elevation	1,035 feet	Elevation at which 12 of the 17 turbines are no longer able to be used
Buffer Elevation	1,000 feet	Elevation of historical water supply significance that provides analysis continuity
Buffer Elevation	975 feet	25-foot buffer elevation[4] above minimum power pool (950 feet) for critical infrastructure and hydropower
Minimum Power Pool	950 feet	No longer able to produce hydropower at Hoover Dam; releases below this elevation are constrained.
Dead Pool	895 feet	No longer able to deliver water downstream through Hoover Dam.

Table TA 3-6 below shows the statistical breakdown of EOCY elevations (in feet) at Lake Mead for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOCY elevations. Similarly, **Table TA 3-7** shows the statistical breakdown of minimum CY elevations (in feet).

[4] A larger buffer above the hydropower and critical infrastructure elevation is used at Lake Mead (25 feet) than at Lake Powell (10 feet) because Reclamation is required to deliver water orders that have already been approved and therefore does not have as much flexibility to adjust releases from Hoover Dam as from Glen Canyon Dam.

Table TA 3-6
End of Calendar Year Elevations (Feet) at Lake Mead

Alternative	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	> 16	1,229	1,220	1,203	1,165	1,087	1,056	985
CCS Comparative Baseline	14-16	1,220	1,187	1,126	1,077	1,048	1,028	913
CCS Comparative Baseline	12-14	1,220	1,126	1,076	1,046	1,020	993	899
CCS Comparative Baseline	10-12	1,220	1,081	1,046	1,015	957	909	897
CCS Comparative Baseline	< 10	1,186	1,054	1,021	960	903	900	897
No Action	> 16	1,229	1,220	1,201	1,158	1,054	981	937
No Action	14-16	1,220	1,188	1,115	1,040	975	951	917
No Action	12-14	1,220	1,127	1,047	993	954	945	898
No Action	10-12	1,220	1,062	1,012	958	923	903	897
No Action	< 10	1,188	1,032	981	923	902	901	897
Basic Coordination	> 16	1,229	1,220	1,209	1,189	1,138	1,084	955
Basic Coordination	14-16	1,220	1,204	1,168	1,121	1,072	1,022	934
Basic Coordination	12-14	1,220	1,175	1,128	1,085	1,034	961	900
Basic Coordination	10-12	1,220	1,137	1,106	1,045	949	918	897
Basic Coordination	< 10	1,203	1,118	1,063	989	907	900	896
Enhanced Coordination	> 16	1,229	1,220	1,218	1,209	1,177	1,138	1,029
Enhanced Coordination	14-16	1,220	1,219	1,204	1,149	1,116	1,092	981
Enhanced Coordination	12-14	1,220	1,199	1,144	1,112	1,080	1,054	924
Enhanced Coordination	10-12	1,220	1,140	1,108	1,073	1,036	997	897
Enhanced Coordination	< 10	1,196	1,108	1,065	1,017	964	901	897
Max. Operational Flexibility	> 16	1,229	1,220	1,219	1,213	1,194	1,139	1,031
Max. Operational Flexibility	14-16	1,229	1,219	1,211	1,175	1,110	1,077	957
Max. Operational Flexibility	12-14	1,229	1,212	1,184	1,135	1,067	1,036	930
Max. Operational Flexibility	10-12	1,229	1,191	1,156	1,079	1,022	992	898
Max. Operational Flexibility	< 10	1,215	1,164	1,099	1,021	978	919	896
Supply Driven (LB Priority)	> 16	1,229	1,220	1,220	1,219	1,202	1,160	992
Supply Driven (LB Priority)	14-16	1,220	1,219	1,212	1,186	1,137	1,092	967
Supply Driven (LB Priority)	12-14	1,220	1,204	1,185	1,153	1,089	1,039	924
Supply Driven (LB Priority)	10-12	1,220	1,180	1,159	1,102	1,018	947	898
Supply Driven (LB Priority)	< 10	1,196	1,153	1,110	1,023	931	902	897
Supply Driven (LB Pro Rata)	> 16	1,229	1,220	1,220	1,219	1,207	1,171	995
Supply Driven (LB Pro Rata)	14-16	1,220	1,219	1,213	1,193	1,151	1,106	972
Supply Driven (LB Pro Rata)	12-14	1,220	1,205	1,190	1,163	1,108	1,066	922
Supply Driven (LB Pro Rata)	10-12	1,220	1,183	1,166	1,117	1,052	980	898
Supply Driven (LB Pro Rata)	< 10	1,196	1,159	1,122	1,050	974	904	897

NOTE: Elevations colored blue are above the spillway elevation of 1,221 feet, listed in the previous table. Elevations colored red are below the minimum power pool elevation of 950 feet, listed in the previous table.

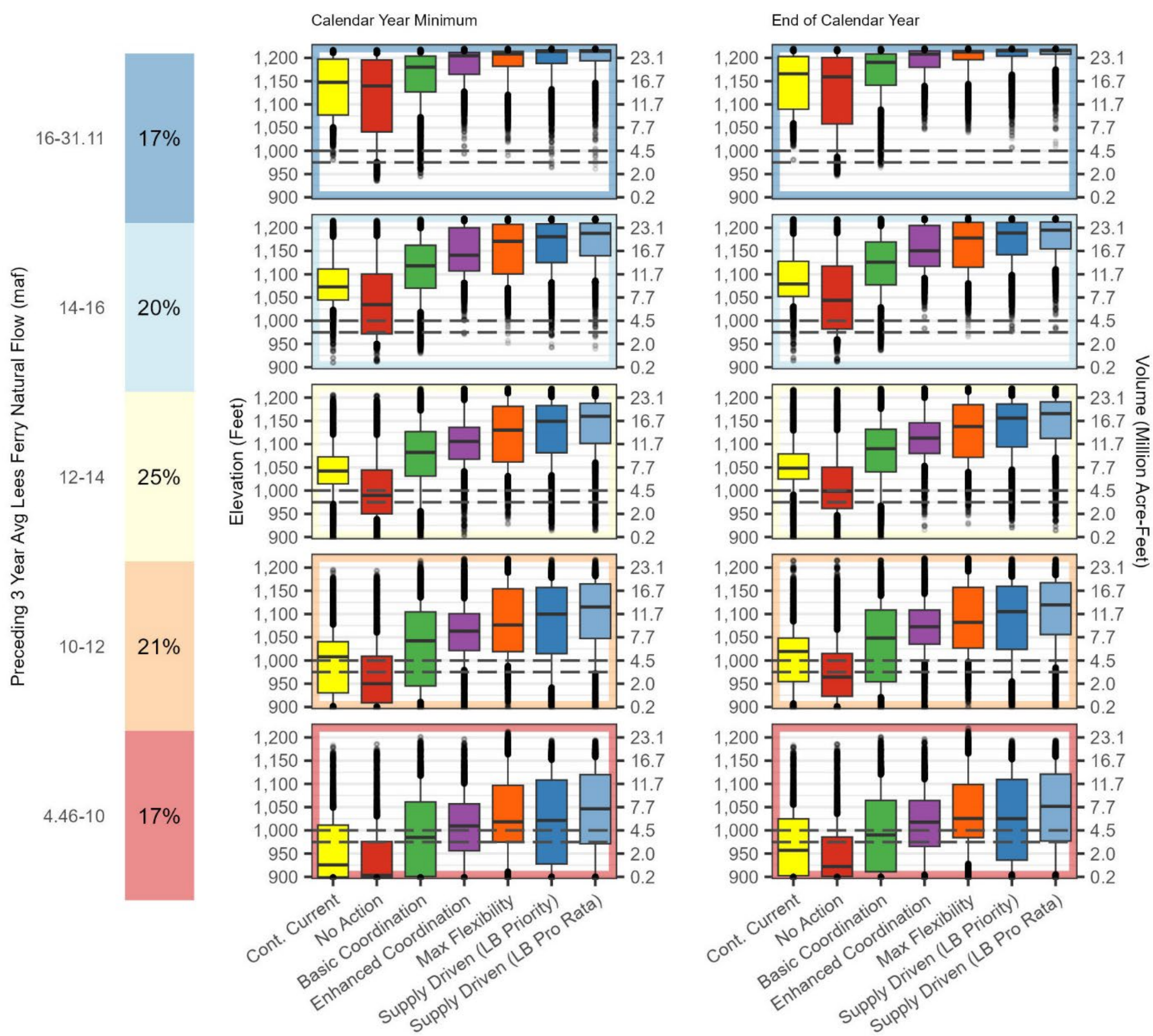
Table TA 3-7
Minimum Calendar Year Elevation (Feet) at Lake Mead

Alternative	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	> 16	1,217	1,211	1,198	1,147	1,076	1,049	981
CCS Comparative Baseline	14-16	1,216	1,180	1,110	1,072	1,043	1,021	910
CCS Comparative Baseline	12-14	1,206	1,120	1,072	1,042	1,013	972	899
CCS Comparative Baseline	10-12	1,195	1,077	1,040	1,008	932	902	897
CCS Comparative Baseline	< 10	1,186	1,048	1,012	929	900	898	896
No Action	> 16	1,217	1,209	1,196	1,138	1,038	974	936
No Action	14-16	1,215	1,182	1,099	1,034	970	950	915
No Action	12-14	1,204	1,119	1,044	988	950	940	898
No Action	10-12	1,193	1,058	1,009	950	910	901	897
No Action	< 10	1,188	1,029	974	904	900	899	897
Basic Coordination	> 16	1,217	1,212	1,205	1,179	1,122	1,066	945
Basic Coordination	14-16	1,219	1,199	1,162	1,117	1,069	1,018	922
Basic Coordination	12-14	1,219	1,171	1,126	1,080	1,030	954	900
Basic Coordination	10-12	1,214	1,135	1,104	1,041	945	911	897
Basic Coordination	< 10	1,203	1,117	1,061	986	901	899	896
Enhanced Coordination	> 16	1,219	1,214	1,212	1,205	1,161	1,123	981
Enhanced Coordination	14-16	1,220	1,214	1,199	1,139	1,104	1,074	955
Enhanced Coordination	12-14	1,220	1,195	1,136	1,105	1,067	1,041	902
Enhanced Coordination	10-12	1,219	1,133	1,101	1,063	1,021	980	897
Enhanced Coordination	< 10	1,196	1,101	1,058	1,011	956	899	896
Max. Operational Flexibility	> 16	1,220	1,216	1,214	1,208	1,177	1,113	980
Max. Operational Flexibility	14-16	1,229	1,215	1,207	1,169	1,094	1,066	952
Max. Operational Flexibility	12-14	1,220	1,209	1,181	1,128	1,059	1,028	929
Max. Operational Flexibility	10-12	1,219	1,189	1,154	1,076	1,018	986	897
Max. Operational Flexibility	< 10	1,213	1,163	1,098	1,018	974	910	896
Supply Driven (LB Priority)	> 16	1,220	1,218	1,216	1,213	1,182	1,124	943
Supply Driven (LB Priority)	14-16	1,220	1,216	1,208	1,178	1,118	1,074	923
Supply Driven (LB Priority)	12-14	1,219	1,203	1,183	1,147	1,077	1,029	902
Supply Driven (LB Priority)	10-12	1,218	1,178	1,157	1,099	1,014	940	898
Supply Driven (LB Priority)	< 10	1,196	1,153	1,110	1,022	927	900	896
Supply Driven (LB Pro Rata)	> 16	1,220	1,218	1,217	1,213	1,189	1,139	943
Supply Driven (LB Pro Rata)	14-16	1,220	1,216	1,210	1,185	1,133	1,077	922
Supply Driven (LB Pro Rata)	12-14	1,219	1,204	1,188	1,158	1,097	1,057	907
Supply Driven (LB Pro Rata)	10-12	1,218	1,182	1,165	1,115	1,046	970	898
Supply Driven (LB Pro Rata)	< 10	1,196	1,159	1,121	1,047	972	900	897

NOTE: Elevations colored red are below the minimum power pool elevation of 950 feet, listed in the previous table.

Figure TA 3-11 shows how Lake Mead CY minimum elevations and EOCY elevations respond to different hydrologic conditions under different alternatives. The figure visualizes the same data that is included in **Table TA 3-6** and **Table TA 3-7** in two side by side conditional box plot panels. In each flow category shown in the box plots, the key elevations of 1,000 feet and 975 feet are identified with dashed lines.

Figure TA 3-11
Calendar Year Minimum and End of Calendar Year Elevations and Storage Volumes of Lake Mead



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

In the Average Flow Category (12.0–14.0 maf), the alternatives demonstrate a range of behavior in terms of medians and variability of Lake Mead minimum CY elevations. The Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives have the highest medians, around 1,140 feet and similar 75th percentile elevations, but the Maximum Operational Flexibility Alternative is more variable with a lower 25th percentile elevation. The Enhanced Coordination Alternative has the next highest median in the Average Flow Category, around elevation 1,105 feet, and a smaller interquartile range indicating less variability. The Basic Coordination Alternative has a median elevation around 1,180 feet and moderate variability between 25th and 75th percentiles. The No Action Alternative has a median elevation around 990 feet, and a similar level of variability to the Basic Coordination Alternative. The CCS Comparative Baseline median and interquartile range sit between the No Action and Basic Coordination Alternatives in the Average Flow Category.

In the Dry Flow Category (less than 10.0 maf), the order of the alternatives with respect to median Lake Mead minimum CY elevations is the same as in the Average Flow Category, but the alternatives' medians shift downward by about 100 feet. The interquartile ranges for the Supply Driven (LB Priority approach), Supply Driven (LB Pro Rata approach), Enhanced Coordination, and Basic Coordination Alternatives, and the CCS Comparative Baseline are all wider in this flow category, indicating more variability than in the Average Flow Category, while the variability in the Maximum Operational Flexibility and No Action Alternatives is similar to the range in the Average Flow Category.

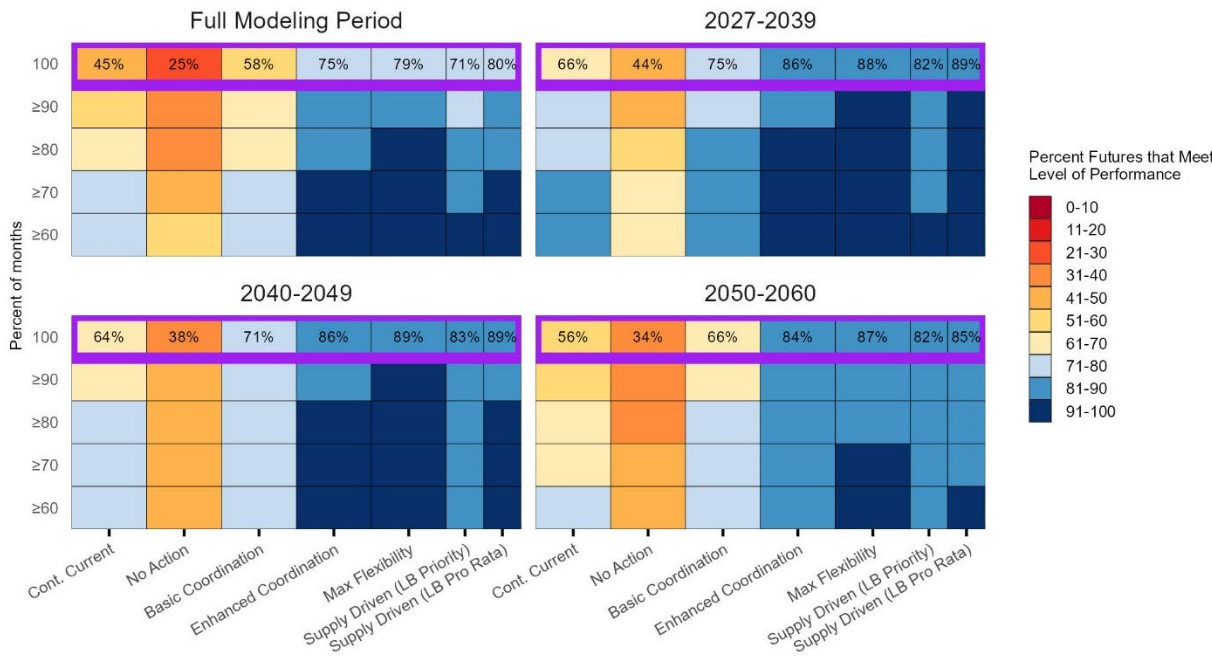
The findings for Lake Mead EOCY elevations are similar, with some median elevations being slightly higher than for the minimum CY elevations. With respect to the Lake Mead minimum CY elevation falling below elevation 975 feet, all action alternatives perform better than the No Action Alternative, in which Lake Mead falls below this elevation in 75 percent of years in the Dry Flow Category and almost 50 percent of years in the Average Flow Category. The action alternatives also outperform the CCS Comparative Baseline. The Maximum Operational Flexibility Alternative most reliably stays above 975 feet.

Lake Mead 975 Feet Robustness

Figure TA 3-12 below shows how each alternative performs with respect to keeping Lake Mead above elevation 975 feet. Elevation 975 feet is important because it provides a 25-foot buffer to protect critical infrastructure and hydropower, which can no longer be produced at elevation 950 feet.

The figure is broken into four heat maps, each showing a different time period during the analysis; the top left heat map shows the full modeling period from 2027 through 2060 and the remaining 3 panels show sub periods. Rows of the heat map show different frequency ranges (percents of months) for keeping Lake Mead above 975 feet, with higher rows corresponding higher (more challenging) frequencies. The highlighted (top) row represents the percentage of futures that an alternative keeps Lake Mead above 975 feet in 100 percent of the months. The 100 percent row was chosen because of the importance of avoiding critical impacts on water delivery and hydropower that would occur if elevations dropped to 950 feet.

Figure TA 3-12
Lake Mead 975 Feet: Robustness.
Percent of futures in which Lake Mead elevation stays above 975 feet in the percent of months specified by each row

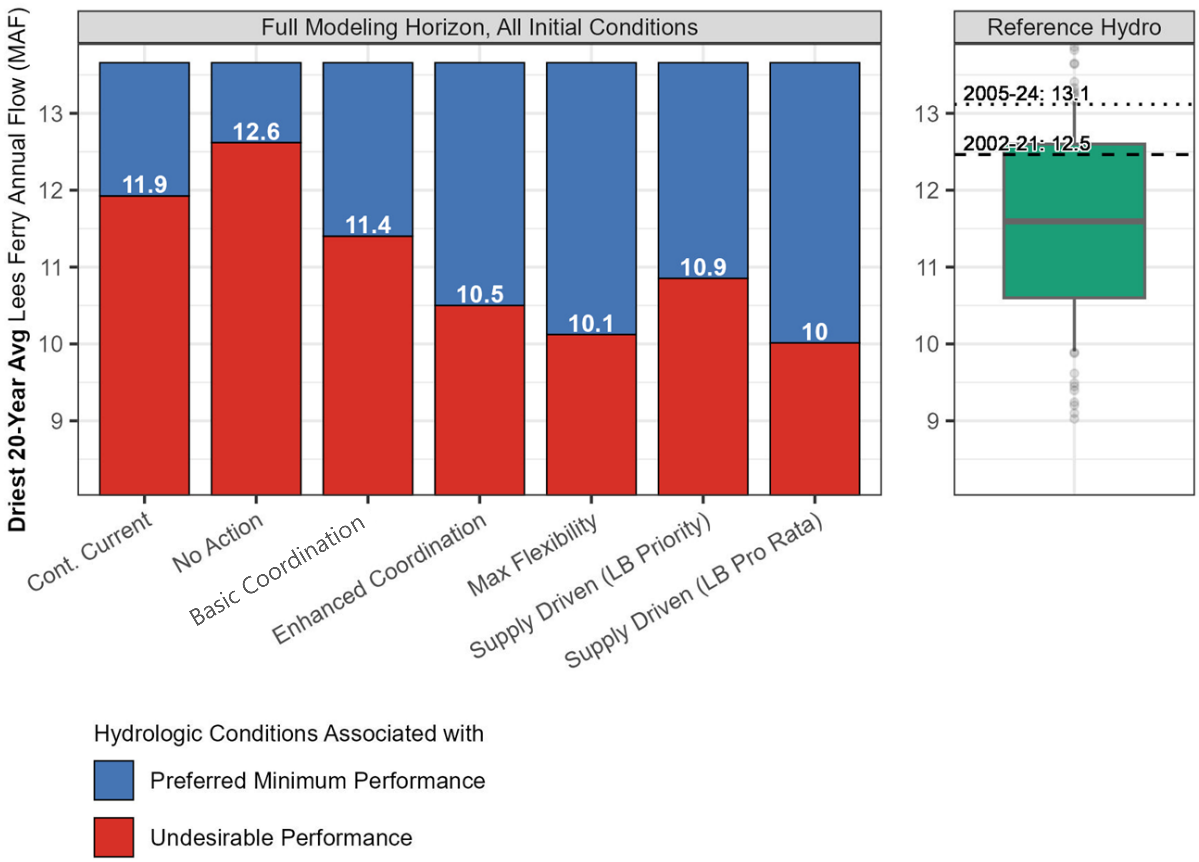


Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

Over the full modeling period, the CCS Comparative Baseline and No Action Alternative are successful at keeping Lake Mead above 975 feet 100 percent of months in 45 percent and 25 percent of futures, respectively. All action alternatives are more robust than the CCS Comparative Baseline and the No Action Alternative. The Basic Coordination Alternative succeeds in 58 percent of futures and the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives are similarly robust, succeeding in 75 percent, 79 percent, 71 percent, and 80 percent of futures, respectively. The action alternatives and the CCS Comparative Baseline show increasing robustness with darker shades of blue, as the specified frequency is relaxed in lower rows. The No Action Alternative does not achieve 50 percent robustness until the frequency is relaxed to keeping Lake Mead above 975 only 60 percent of the time.

Figure TA 3-13 below shows what flow conditions are likely to cause Lake Mead's monthly elevation to fall below elevation 975 feet during at least one month across a 34-year future. This definition of undesirable performance is based on the highlighted row in the above **Figure TA 3-13**, which qualifies a future as successful in meeting the minimum preferred performance when an alternative kept Lake Mead above this critical buffer elevation of 975 feet in 100 percent of months.

Figure TA 3-13
Lake Mead 975 Feet: Vulnerability.
Conditions that could cause Lake Mead elevation to fall below 975 feet in one or more months



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

For this vulnerability analysis, the driest 20-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the reference hydrology ensemble using this streamflow summary statistic. The driest observed 20-year average flow from 2002-2021 (12.5 maf) and the average flow from 2005-2024 (13.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

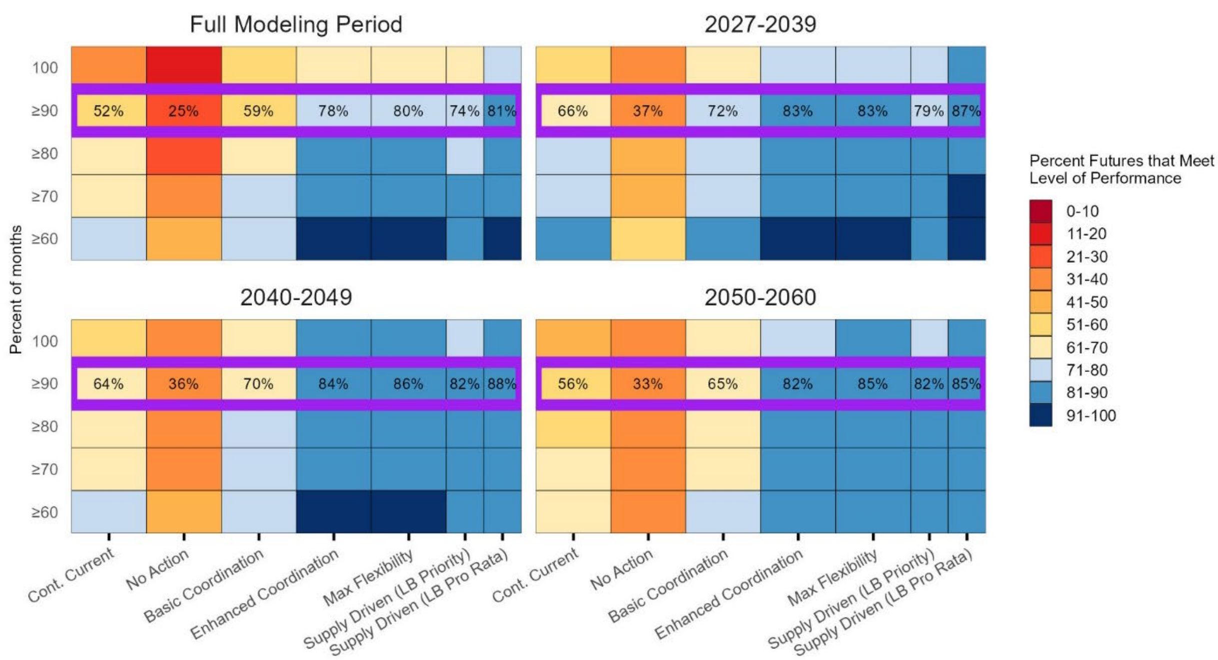
The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (LB Pro Rata approach) Alternatives result in undesirable performance (i.e., become vulnerable to falling below elevation 975 feet) under similar conditions: droughts when 20-year average Lees Ferry flows are below 10.5 maf, 10.1 maf, and 10.0 maf, respectively. These conditions are lower than the 25th percentile of the reference hydrology ensemble, meaning less than 25 percent of the traces include droughts this dry or drier. The Supply Driven (LB Priority approach) Alternative is vulnerable to 20-year droughts with an average flow of 10.9 maf, which is slightly above the 25th percentile of the reference hydrology ensemble. Basic Coordination is more vulnerable, with a 20-year drought of 11.4

maf likely to cause undesirable performance. The No Action Alternative is the most vulnerable; Lake Mead is likely to go below 975 feet in a 20-year drought averaging 12.6 maf. From 2002 to 2021, the 20-year average was 12.4 maf, so the No Action Alternative is vulnerable to conditions that have already occurred.

Lake Mead 1,000 Feet Robustness

Figure TA 3-14 below shows how each alternative performs with respect to keeping Lake Mead's elevation above 1,000 feet, which is an elevation of historical significance to water supply.

Figure TA 3-14
Lake Mead 1,000 Feet: Robustness.
Percent of futures in which Lake Mead elevation stays above 1,000 feet in the percent of months specified by each row



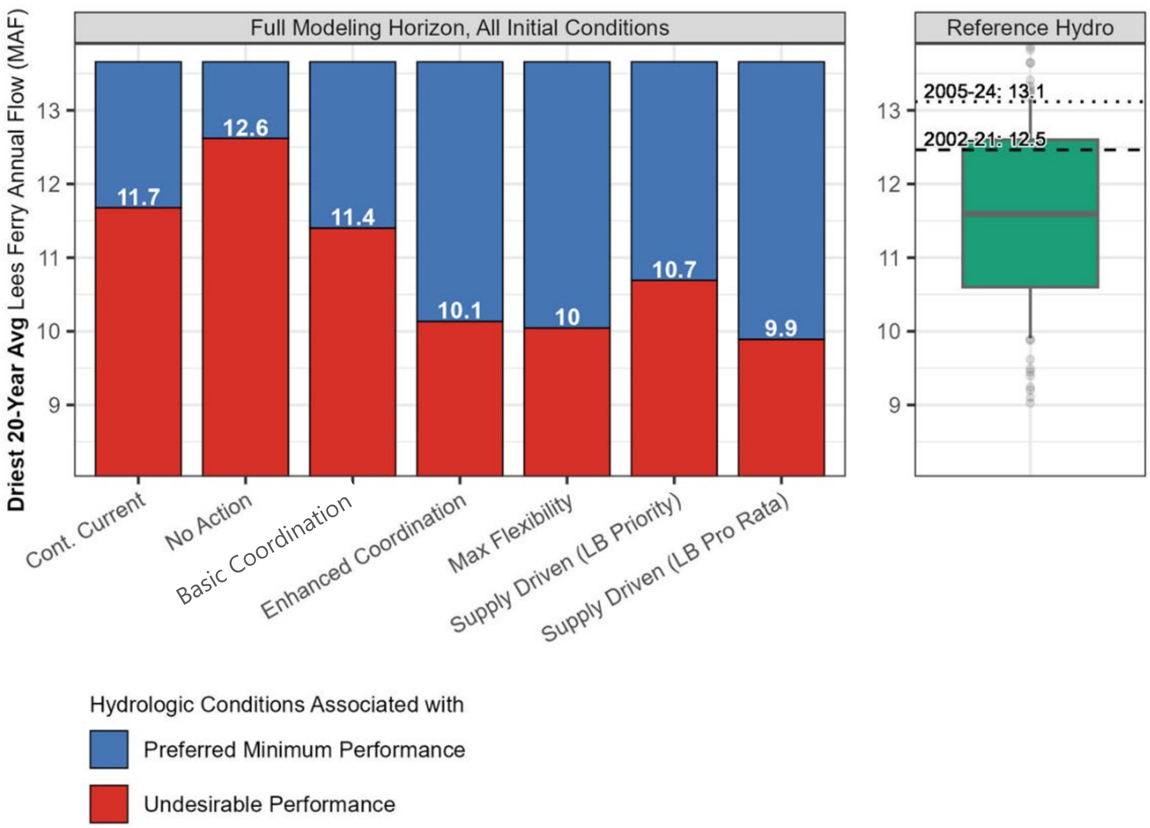
Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

The figure is broken into four heat maps, each showing a different time period during the analysis; the top left heat map shows the full modeling period from 2027 through 2060 and the remaining three panels show sub periods. Rows of the heat map show different frequency ranges (percents of months) for keeping Lake Mead above 1,000 feet, with higher rows corresponding higher (more challenging) frequencies. The highlighted row (second from the top) represents the percentage of futures that an alternative successfully achieves this result in 90 percent or more of the months. The greater than or equal to 90 percent row was chosen because it provides a reasonable amount of flexibility to go below 1,000 feet occasionally in very dry hydrology.

Over the full modeling period, the CCS Comparative Baseline and No Action Alternative are the least robust at keeping Lake Mead above 1,000 feet 90 percent of the time, doing so in 52 percent and 25 percent of futures, respectively. All action alternatives are more robust than the CCS Comparative Baseline and No Action Alternative. The Basic Coordination Alternative is slightly better than the CCS Comparative Baseline, succeeding in 59 percent of futures, and the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives are similarly robust, succeeding in 78 percent, 80 percent, 74 percent, and 81 percent of futures, respectively. The action alternatives and CCS Comparative Baseline show increasing robustness with darker shades of blue as the specified frequency is relaxed in lower rows. The No Action Alternative never succeeds in more than 50 percent of futures, even in the lowest row.

Figure TA 3-15 below shows what flow conditions are likely to cause Lake Mead's monthly elevation to fall below an elevation of 1,000 feet in more than 10 percent of months across a 34-year future. This definition of undesirable performance is based on the highlighted row in the above **Figure TA 3-15**, which qualifies a future as successful in meeting the minimum preferred performance when an alternative keeps the Lake Mead elevation above 1,000 feet in at least 90 percent of months.

Figure TA 3-15
Lake Mead 1,000 Feet: Vulnerability.
Conditions that could cause Lake Mead elevation to fall below 1,000 feet in more than 10% of months



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

For this vulnerability analysis, the driest 20-year average Lees Ferry annual flow was determined to be skillful at predicting undesirable performance. The vulnerability threshold for each alternative is described and compared to the reference hydrology ensemble using this streamflow summary statistic. The driest observed 20-year average flow from 2002-2021 (12.5 maf) and the average flow from 2005-2024 (13.1 maf) are also provided as dashed and dotted lines, respectively, for comparison.

The Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (LB Pro Rata approach) Alternatives are vulnerable to similar conditions: 20-year droughts of 10.1 maf, 10.0 maf, and 9.9 maf, respectively. These conditions are near the 10th percentile of the reference hydrology ensemble, so only about 10 percent of the traces include droughts this dry or drier. The Supply Driven (LB Priority approach) Alternative is vulnerable to 20-year droughts with an average flow of 10.7 maf, which is slightly above the 25th percentile of the reference hydrology ensemble. The Basic Coordination Alternative is more vulnerable, with a 20-year drought of 11.4 maf likely to cause undesirable performance. The No Action Alternative is the most vulnerable; Lake Mead is likely to go below 1,000 feet elevation more than 10 percent of the time in a 20-year drought averaging 12.6 maf. From 2002 to 2021, the 20-year average was 12.4 maf, so the No Action Alternative is vulnerable to conditions that have already occurred.

Impacts of Modeling Assumptions for Upper Basin and Lower Basin Conservation Activity on Lake Powell and Lake Mead Storage

The following section describes the impacts of modeling assumptions for conservation activities for the various alternatives by showing how removing all conservation activity results in differences to reservoir elevations at Lake Powell and Lake Mead.

All action alternatives except for the Basic Coordination Alternative incorporate mechanisms related to the storage and delivery of conserved water in Lake Powell and Lake Mead. **Table TA 3-8** below summarizes the various conservation mechanisms for each action alternative. Refer to **Sections 2.6-2.8** for specifics related to each alternative's policy on conservation.

Table TA 3-8
Summary of Conservation Mechanisms by Alternative

Alternative	Conservation Pool Volume	Conservation Pool Mechanism
Enhanced Coordination	2.0 maf	Upper Basin users in Lake Powell
	5.0 maf	Lower Basin users in Lake Mead
	2.0 maf	Federal Protection Pool in Lake Mead
Maximum Operational Flexibility	5.0 maf	Upper Basin users (distributed strategically across Lake Powell and Lake Mead)
	3.0 maf	Lower Basin users (distributed strategically across Lake Powell and Lake Mead)
Supply Driven	3.0 maf	Upper Basin users in Lake Powell
	8.0 maf	Lower Basin users in Lake Mead

For modeling purposes, assumptions about storage and delivery of previously conserved water were developed in order to show the maximum impacts of the conservation pools on reservoir elevations and downstream flows; they are not intended to represent specific activities or constrain individual users. Refer to **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water, for more details related to the assumptions for each alternative. While the No Action and Basic Coordination Alternatives do not include mechanisms to conserve and store water in Lake Powell or Lake Mead, the model does include assumptions for the delivery of existing ICS that was conserved prior to 2027. In the conservation-off results, activity related to pre-2027 conservation is turned off for all the alternatives and the CCS Comparative Baseline.

Table TA 3-9 below shows the statistical breakdown and comparison of the impacts of modeling assumptions for conservation activity on EOWY Lake Powell elevations for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum volumes of shortage and dead pool–related reductions.

Table TA 3-9
Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Powell

Alternative	Activity	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	On	> 16	3,696	3,692	3,690	3,680	3,663	3,631	3,499
CCS Comparative Baseline	Off	> 16	3,696	3,692	3,690	3,681	3,663	3,633	3,499
CCS Comparative Baseline	On	14-16	3,697	3,690	3,677	3,643	3,596	3,557	3,462
CCS Comparative Baseline	Off	14-16	3,697	3,690	3,677	3,643	3,597	3,559	3,464
CCS Comparative Baseline	On	12-14	3,695	3,672	3,633	3,584	3,541	3,500	3,414
CCS Comparative Baseline	Off	12-14	3,696	3,673	3,633	3,585	3,544	3,500	3,414
CCS Comparative Baseline	On	10-12	3,694	3,623	3,575	3,527	3,498	3,471	3,404
CCS Comparative Baseline	Off	10-12	3,694	3,624	3,577	3,531	3,499	3,472	3,404
CCS Comparative Baseline	On	< 10	3,691	3,564	3,525	3,498	3,454	3,422	3,398
CCS Comparative Baseline	Off	< 10	3,690	3,565	3,527	3,498	3,455	3,422	3,398
No Action	On	> 16	3,696	3,693	3,690	3,685	3,672	3,646	3,503
No Action	Off	> 16	3,696	3,693	3,691	3,685	3,672	3,646	3,503
No Action	On	14-16	3,697	3,691	3,684	3,659	3,613	3,565	3,433
No Action	Off	14-16	3,697	3,691	3,685	3,659	3,613	3,565	3,433
No Action	On	12-14	3,697	3,682	3,649	3,598	3,536	3,483	3,411
No Action	Off	12-14	3,697	3,682	3,649	3,598	3,536	3,483	3,411
No Action	On	10-12	3,695	3,638	3,585	3,513	3,476	3,449	3,407
No Action	Off	10-12	3,695	3,638	3,585	3,513	3,476	3,449	3,407
No Action	On	< 10	3,691	3,578	3,519	3,475	3,440	3,420	3,400
No Action	Off	< 10	3,691	3,578	3,519	3,475	3,440	3,420	3,400

Alternative	Activity	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
Basic Coordination	On	> 16	3,696	3,692	3,689	3,679	3,661	3,635	3,534
Basic Coordination	Off	> 16	3,696	3,692	3,690	3,679	3,661	3,635	3,534
Basic Coordination	On	14-16	3,696	3,688	3,670	3,641	3,607	3,577	3,476
Basic Coordination	Off	14-16	3,696	3,688	3,670	3,641	3,607	3,577	3,476
Basic Coordination	On	12-14	3,696	3,659	3,629	3,593	3,556	3,524	3,413
Basic Coordination	Off	12-14	3,696	3,659	3,629	3,593	3,556	3,524	3,413
Basic Coordination	On	10-12	3,695	3,616	3,581	3,540	3,501	3,467	3,404
Basic Coordination	Off	10-12	3,695	3,616	3,581	3,540	3,501	3,467	3,404
Basic Coordination	On	< 10	3,678	3,572	3,532	3,486	3,449	3,420	3,398
Basic Coordination	Off	< 10	3,678	3,572	3,533	3,486	3,449	3,420	3,398
Enhanced Coordination	On	> 16	3,696	3,692	3,690	3,680	3,662	3,644	3,585
Enhanced Coordination	Off	> 16	3,695	3,692	3,689	3,677	3,658	3,640	3,586
Enhanced Coordination	On	14-16	3,696	3,689	3,671	3,648	3,630	3,615	3,527
Enhanced Coordination	Off	14-16	3,695	3,686	3,667	3,644	3,626	3,612	3,534
Enhanced Coordination	On	12-14	3,697	3,669	3,651	3,630	3,606	3,580	3,483
Enhanced Coordination	Off	12-14	3,696	3,665	3,645	3,624	3,603	3,580	3,484
Enhanced Coordination	On	10-12	3,694	3,653	3,631	3,602	3,569	3,541	3,464
Enhanced Coordination	Off	10-12	3,694	3,646	3,624	3,598	3,569	3,539	3,464
Enhanced Coordination	On	< 10	3,690	3,626	3,601	3,565	3,528	3,497	3,399
Enhanced Coordination	Off	< 10	3,687	3,621	3,596	3,563	3,528	3,495	3,399
Max. Operational Flexibility	On	> 16	3,697	3,692	3,691	3,682	3,665	3,649	3,591
Max. Operational Flexibility	Off	> 16	3,696	3,692	3,690	3,680	3,662	3,647	3,596
Max. Operational Flexibility	On	14-16	3,696	3,691	3,679	3,654	3,632	3,615	3,528
Max. Operational Flexibility	Off	14-16	3,696	3,689	3,675	3,650	3,630	3,612	3,540
Max. Operational Flexibility	On	12-14	3,697	3,671	3,650	3,624	3,598	3,576	3,508
Max. Operational Flexibility	Off	12-14	3,696	3,668	3,646	3,620	3,595	3,575	3,507
Max. Operational Flexibility	On	10-12	3,695	3,642	3,619	3,585	3,560	3,539	3,494
Max. Operational Flexibility	Off	10-12	3,695	3,638	3,615	3,582	3,558	3,537	3,502
Max. Operational Flexibility	On	< 10	3,692	3,617	3,583	3,549	3,522	3,508	3,425
Max. Operational Flexibility	Off	< 10	3,689	3,613	3,580	3,545	3,519	3,507	3,429
Supply Driven (LB Priority)	On	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Priority)	Off	> 16	3,698	3,690	3,681	3,654	3,625	3,593	3,492
Supply Driven (LB Priority)	On	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Priority)	Off	14-16	3,696	3,669	3,643	3,611	3,572	3,534	3,470
Supply Driven (LB Priority)	On	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Priority)	Off	12-14	3,695	3,639	3,608	3,572	3,530	3,496	3,439
Supply Driven (LB Priority)	On	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Priority)	Off	10-12	3,691	3,606	3,573	3,531	3,494	3,482	3,429
Supply Driven (LB Priority)	On	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398
Supply Driven (LB Priority)	Off	< 10	3,679	3,579	3,541	3,497	3,467	3,443	3,398

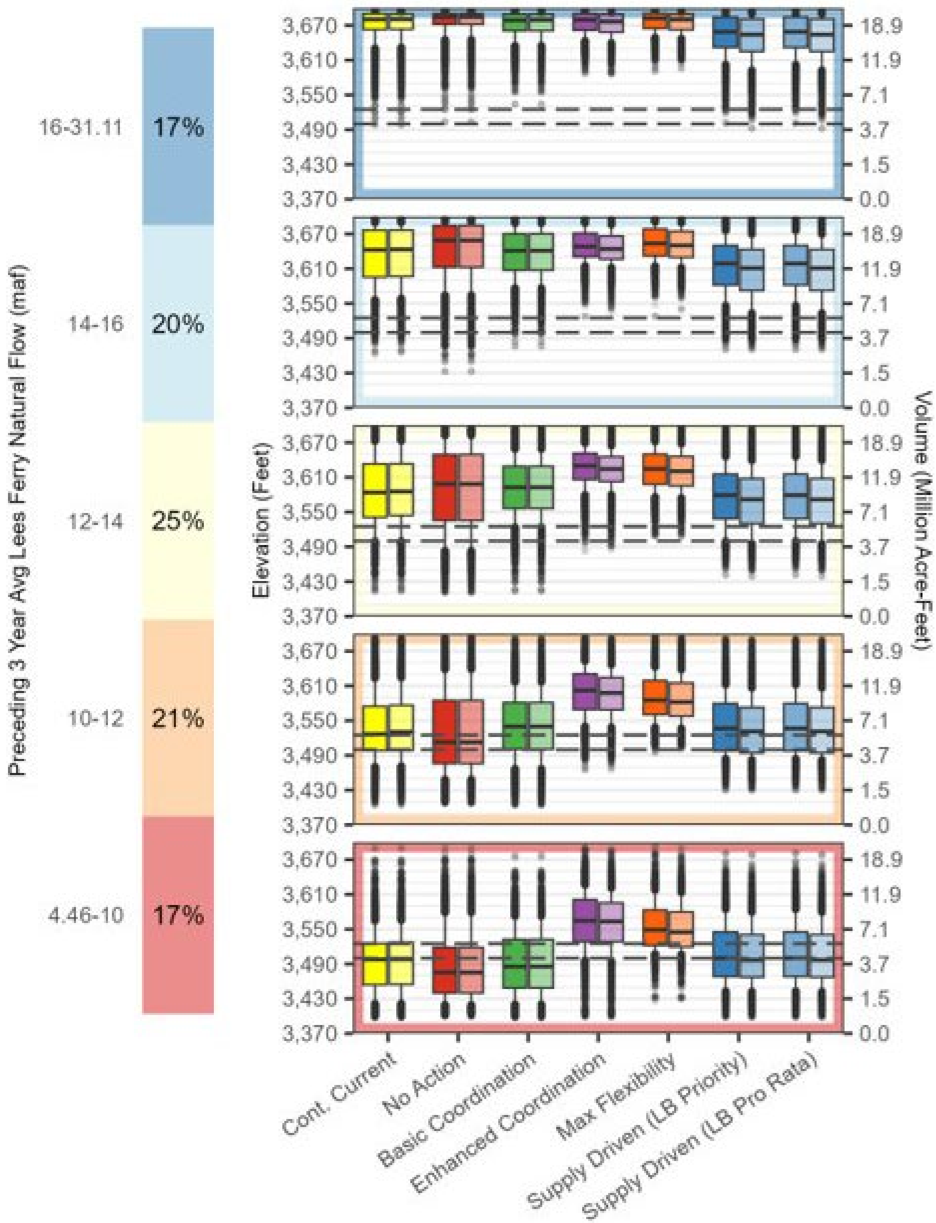
Alternative	Activity	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
Supply Driven (LB Pro Rata)	On	> 16	3,698	3,691	3,684	3,659	3,632	3,603	3,501
Supply Driven (LB Pro Rata)	Off	> 16	3,698	3,690	3,681	3,654	3,625	3,593	3,492
Supply Driven (LB Pro Rata)	On	14-16	3,697	3,676	3,650	3,619	3,582	3,547	3,470
Supply Driven (LB Pro Rata)	Off	14-16	3,696	3,669	3,643	3,611	3,572	3,534	3,470
Supply Driven (LB Pro Rata)	On	12-14	3,696	3,645	3,615	3,579	3,538	3,500	3,441
Supply Driven (LB Pro Rata)	Off	12-14	3,695	3,639	3,608	3,572	3,530	3,496	3,439
Supply Driven (LB Pro Rata)	On	10-12	3,694	3,612	3,580	3,537	3,498	3,484	3,430
Supply Driven (LB Pro Rata)	Off	10-12	3,691	3,606	3,573	3,531	3,494	3,482	3,429
Supply Driven (LB Pro Rata)	On	< 10	3,681	3,584	3,545	3,500	3,468	3,443	3,398
Supply Driven (LB Pro Rata)	Off	< 10	3,679	3,579	3,541	3,497	3,467	3,443	3,398

NOTE: Elevations colored blue are above the spill avoidance elevation of 3,680 feet, listed in the previous table. Elevations colored red are below the minimum power pool elevation of 3,490 feet, listed in the previous table

Figure TA 3-16 below compares the impacts of conservation activity on EOWY Lake Powell elevations. The reductions are broken out by different hydrologic conditions based on the modeled preceding three-year average of Lees Ferry natural flow. In each boxplot, conservation activity is turned on for the left of each pair (black outline) and conservation activity is turned off for the right of each pair (gray outline). The figure visualizes the same data that is included in **Table TA 3-9** in a conditional box plot.

Across all hydrologic conditions, the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative have higher median elevations in Lake Powell with conservation activity on than with conservation activity off (elevations differ between 1.2–5.6 feet). Additionally, the interquartile ranges for these two alternatives shift up with conservation activity on compared to conservation activity off across all flow categories. For all other alternatives, median elevations as well as the interquartile ranges are very similar when comparing conservation activity on and conservation activity off across all flow categories. In the Average Flow Category (12.0–14.0 maf) and the Moderately Dry Flow Category (10.0–12.0 maf), the CCS Comparative Baseline has lower median elevations in Lake Powell when conservation activity is on by 1.6 feet and 3.8 feet, respectively; for the other flow categories, the CCS Comparative Baseline has very similar medians for both conservation activity on and conservation activity off. For the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), Lake Powell elevations are completely independent of conservation activity. In other words, within each flow category, the results for this alternative are identical for conservation activity on and conservation activity off.

Figure TA 3-16
Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Powell



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

Table TA 3-10 below shows the statistical breakdown and comparison of the impacts of modeling assumptions for conservation activity on EOWY Lake Mead elevations for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum volumes of shortage and dead pool–related reductions.

Table TA 3-10
Impacts of Modeling Assumptions for Conservation Activity on End of Calendar Year Elevations (Feet) at Lake Mead

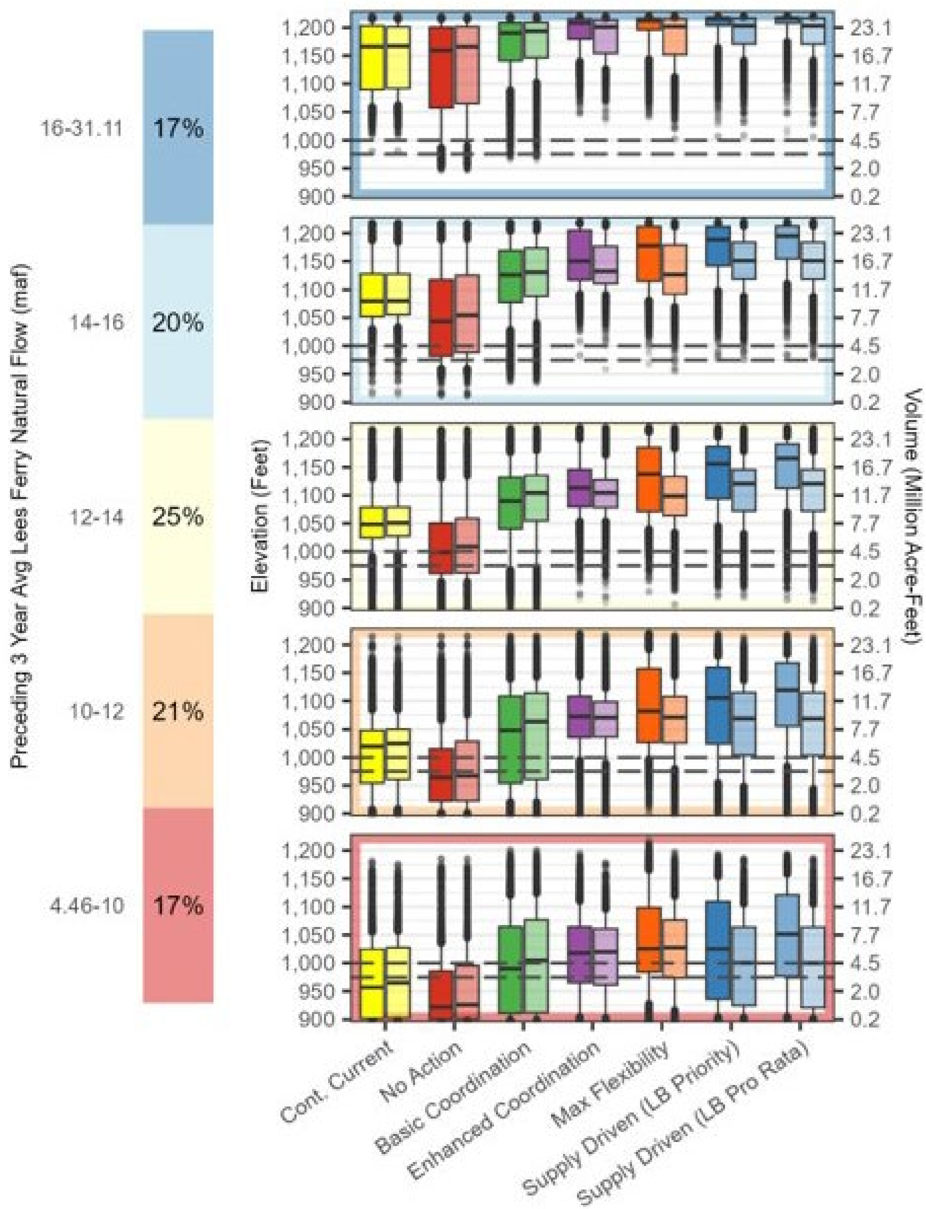
Alternative	Activity	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
CCS Comparative Baseline	On	> 16	1,226	1,215	1,203	1,166	1,090	1,060	980
CCS Comparative Baseline	Off	> 16	1,226	1,215	1,201	1,167	1,092	1,063	981
CCS Comparative Baseline	On	14-16	1,219	1,187	1,128	1,079	1,052	1,031	914
CCS Comparative Baseline	Off	14-16	1,219	1,184	1,128	1,080	1,056	1,034	914
CCS Comparative Baseline	On	12-14	1,217	1,129	1,079	1,048	1,025	992	898
CCS Comparative Baseline	Off	12-14	1,217	1,128	1,079	1,051	1,028	996	897
CCS Comparative Baseline	On	10-12	1,215	1,084	1,048	1,019	955	908	898
CCS Comparative Baseline	Off	10-12	1,215	1,084	1,051	1,024	961	909	898
CCS Comparative Baseline	On	< 10	1,184	1,055	1,025	957	902	899	896
CCS Comparative Baseline	Off	< 10	1,177	1,056	1,028	965	903	900	896
No Action	On	> 16	1,225	1,215	1,201	1,159	1,058	988	945
No Action	Off	> 16	1,225	1,215	1,202	1,166	1,065	992	945
No Action	On	14-16	1,219	1,188	1,118	1,044	982	960	912
No Action	Off	14-16	1,219	1,189	1,125	1,054	988	960	912
No Action	On	12-14	1,218	1,129	1,050	999	961	947	897
No Action	Off	12-14	1,217	1,133	1,059	1,009	962	948	897
No Action	On	10-12	1,215	1,066	1,015	964	923	901	897
No Action	Off	10-12	1,215	1,075	1,028	967	923	901	897
No Action	On	< 10	1,186	1,035	986	922	901	899	897
No Action	Off	< 10	1,185	1,045	995	926	901	900	897
Basic Coordination	On	> 16	1,226	1,215	1,209	1,190	1,141	1,089	964
Basic Coordination	Off	> 16	1,225	1,215	1,209	1,194	1,146	1,103	962
Basic Coordination	On	14-16	1,220	1,204	1,170	1,126	1,077	1,030	936
Basic Coordination	Off	14-16	1,220	1,204	1,174	1,131	1,088	1,042	935
Basic Coordination	On	12-14	1,219	1,176	1,132	1,090	1,040	968	898
Basic Coordination	Off	12-14	1,219	1,179	1,136	1,104	1,055	972	898
Basic Coordination	On	10-12	1,215	1,139	1,109	1,048	954	921	897
Basic Coordination	Off	10-12	1,215	1,142	1,115	1,064	961	921	897
Basic Coordination	On	< 10	1,201	1,120	1,065	990	911	900	897
Basic Coordination	Off	< 10	1,201	1,124	1,077	1,005	912	900	896

Alternative	Activity	Flow Category	Max (feet)	90% (feet)	75% (feet)	50% (feet)	25% (feet)	10% (feet)	Min (feet)
Enhanced Coordination	On	> 16	1,220	1,217	1,215	1,208	1,180	1,140	1,046
Enhanced Coordination	Off	> 16	1,220	1,216	1,213	1,201	1,154	1,127	1,033
Enhanced Coordination	On	14-16	1,220	1,217	1,205	1,150	1,117	1,092	983
Enhanced Coordination	Off	14-16	1,220	1,212	1,177	1,133	1,111	1,091	959
Enhanced Coordination	On	12-14	1,220	1,199	1,146	1,113	1,080	1,053	915
Enhanced Coordination	Off	12-14	1,220	1,171	1,128	1,105	1,079	1,054	908
Enhanced Coordination	On	10-12	1,220	1,143	1,109	1,073	1,035	996	897
Enhanced Coordination	Off	10-12	1,217	1,123	1,098	1,071	1,036	991	896
Enhanced Coordination	On	< 10	1,196	1,110	1,064	1,018	965	905	897
Enhanced Coordination	Off	< 10	1,179	1,096	1,061	1,020	962	903	897
Max. Operational Flexibility	On	> 16	1,226	1,218	1,216	1,213	1,196	1,145	1,040
Max. Operational Flexibility	Off	> 16	1,227	1,217	1,215	1,202	1,152	1,113	1,003
Max. Operational Flexibility	On	14-16	1,229	1,217	1,212	1,178	1,115	1,081	966
Max. Operational Flexibility	Off	14-16	1,220	1,211	1,179	1,127	1,092	1,069	955
Max. Operational Flexibility	On	12-14	1,229	1,213	1,185	1,138	1,072	1,040	927
Max. Operational Flexibility	Off	12-14	1,219	1,182	1,133	1,099	1,064	1,034	905
Max. Operational Flexibility	On	10-12	1,229	1,191	1,157	1,082	1,027	997	898
Max. Operational Flexibility	Off	10-12	1,217	1,144	1,108	1,071	1,026	980	897
Max. Operational Flexibility	On	< 10	1,220	1,165	1,099	1,026	984	928	897
Max. Operational Flexibility	Off	< 10	1,197	1,118	1,076	1,028	974	917	897
Supply Driven (LB Priority)	On	> 16	1,220	1,219	1,218	1,215	1,204	1,165	1,007
Supply Driven (LB Priority)	Off	> 16	1,220	1,218	1,216	1,203	1,170	1,142	1,008
Supply Driven (LB Priority)	On	14-16	1,220	1,217	1,211	1,189	1,142	1,099	977
Supply Driven (LB Priority)	Off	14-16	1,220	1,212	1,184	1,151	1,119	1,089	976
Supply Driven (LB Priority)	On	12-14	1,220	1,204	1,186	1,156	1,094	1,046	920
Supply Driven (LB Priority)	Off	12-14	1,219	1,178	1,146	1,120	1,073	1,032	919
Supply Driven (LB Priority)	On	10-12	1,220	1,180	1,160	1,105	1,024	956	899
Supply Driven (LB Priority)	Off	10-12	1,215	1,136	1,116	1,069	1,004	948	898
Supply Driven (LB Priority)	On	< 10	1,195	1,153	1,110	1,025	936	905	897
Supply Driven (LB Priority)	Off	< 10	1,186	1,105	1,064	1,000	925	903	897
Supply Driven (LB Pro Rata)	On	> 16	1,220	1,219	1,218	1,216	1,208	1,176	1,009
Supply Driven (LB Pro Rata)	Off	> 16	1,220	1,218	1,216	1,203	1,170	1,142	1,006
Supply Driven (LB Pro Rata)	On	14-16	1,220	1,218	1,213	1,195	1,155	1,111	981
Supply Driven (LB Pro Rata)	Off	14-16	1,220	1,212	1,184	1,151	1,119	1,088	979
Supply Driven (LB Pro Rata)	On	12-14	1,220	1,205	1,191	1,166	1,112	1,071	914
Supply Driven (LB Pro Rata)	Off	12-14	1,219	1,178	1,146	1,120	1,072	1,031	912
Supply Driven (LB Pro Rata)	On	10-12	1,219	1,184	1,167	1,120	1,056	986	898
Supply Driven (LB Pro Rata)	Off	10-12	1,215	1,136	1,115	1,069	1,004	944	897
Supply Driven (LB Pro Rata)	On	< 10	1,195	1,158	1,121	1,052	977	905	897
Supply Driven (LB Pro Rata)	Off	< 10	1,186	1,105	1,064	1,000	921	902	897

NOTE: Elevations colored blue are above the spillway elevation of 1,221 feet, listed in the previous table. Elevations colored red are below the minimum power pool elevation of 950 feet, listed in the previous table.

Figure TA 3-17 below compares the impacts of conservation activity on EOWY Lake Mead elevations. The reductions are broken out by different hydrologic conditions based on the modeled preceding 3-year average of Lees Ferry natural flow. In each boxplot, conservation activity is turned on for the left of each pair (black outline) and conservation activity is turned off for the right of each pair (gray outline). The figure visualizes the same data that is included in **Table TA 3-10** in a conditional box plot.

Figure TA 3-17
Impacts of Modeling Assumptions for Conservation Activity on EOWY Elevations and Storage Volumes for Lake Mead



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

For all action alternatives except for the Basic Coordination Alternative, median elevations in Lake Mead are higher when conservation activity is on across all flow categories except the Dry Flow Category (4.5–10.0 maf). In the Dry Flow Category, only the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) have higher medians with conservation on. Across all hydrologic conditions, the interquartile ranges are shifted up with conservation activity on for all alternatives except the No Action Alternative and the Basic Coordination Alternative. The CCS Comparative Baseline, the No Action Alternative and the Basic Coordination Alternative all have lower median elevations and interquartile ranges that shift down when conservation activity is on across all flow categories.

Lake Mohave and Lake Havasu

Lake Mohave and Lake Havasu are operated under an existing rule curve that determines specific target elevations at the end of each month (refer to **TA 6**, Water Quality). The existing rule curves were used in the CRSS model and applied to operations for all alternatives and the CCS Comparative Baseline.

Inflows into Lake Mohave from upstream operations (releases from Hoover Dam) vary across alternatives. However, because the range of target elevations at Lake Mohave are kept within the bounds of the rule curve, elevations at Lake Mohave are not affected by the alternatives or the CCS Comparative Baseline.

Similarly, inflows into Lake Havasu from upstream operations (releases from Davis Dam) vary across alternatives, however, because of the rule curve, elevations at Lake Havasu are not affected by the alternatives or the CCS Comparative Baseline.

TA 3.2.2 Issue 2: System Storage

Issue 2 addresses how operational activities would affect system storage. This was evaluated by comparing the various action alternatives to the No Action Alternative and the CCS Comparative Baseline for the following metrics:

- Combined System Storage at Lake Powell and Lake Mead
- Combined System Storage at CRSP Reservoirs
- Combined System Storage at Seven-Reservoirs

Combined System Storage at Lake Powell and Lake Mead

This section compares all alternatives and the CCS Comparative Baseline with respect to EOWY combined storage capacity of Lake Powell and Lake Mead. Analysis of the combined storage across Lake Powell and Lake Mead helps to understand the overall health of the Colorado River system. Based on this analysis, the primary drivers of Colorado River system conditions are related to assumptions for shortage operations and conservation activities. Not including space for Flood Control storage, the live storage capacity is 23.31 maf at Lake Powell, and 26.12 maf at Lake Mead, for a maximum combined live storage volume of 49.43 maf.

Table TA 3-11 below shows the statistical breakdown of the EOWY Lake Powell and Lake Mead combined storage (as a percentage of the total storage capacity) for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOWY combined storage percentages. **Figure TA 3-18** below shows EOWY Lake Powell and Lake Mead combined storage volumes to assess how the alternatives respond to different hydrologic conditions based on the preceding 3-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-11** in a conditional box plot. The vertical axis is defined on the lefthand side as combined percent full and on the righthand side as absolute volume in storage. A threshold reflecting the lowest observed EOWY combined storage (which occurred in September 2022) is shown at 26.55 percent full.

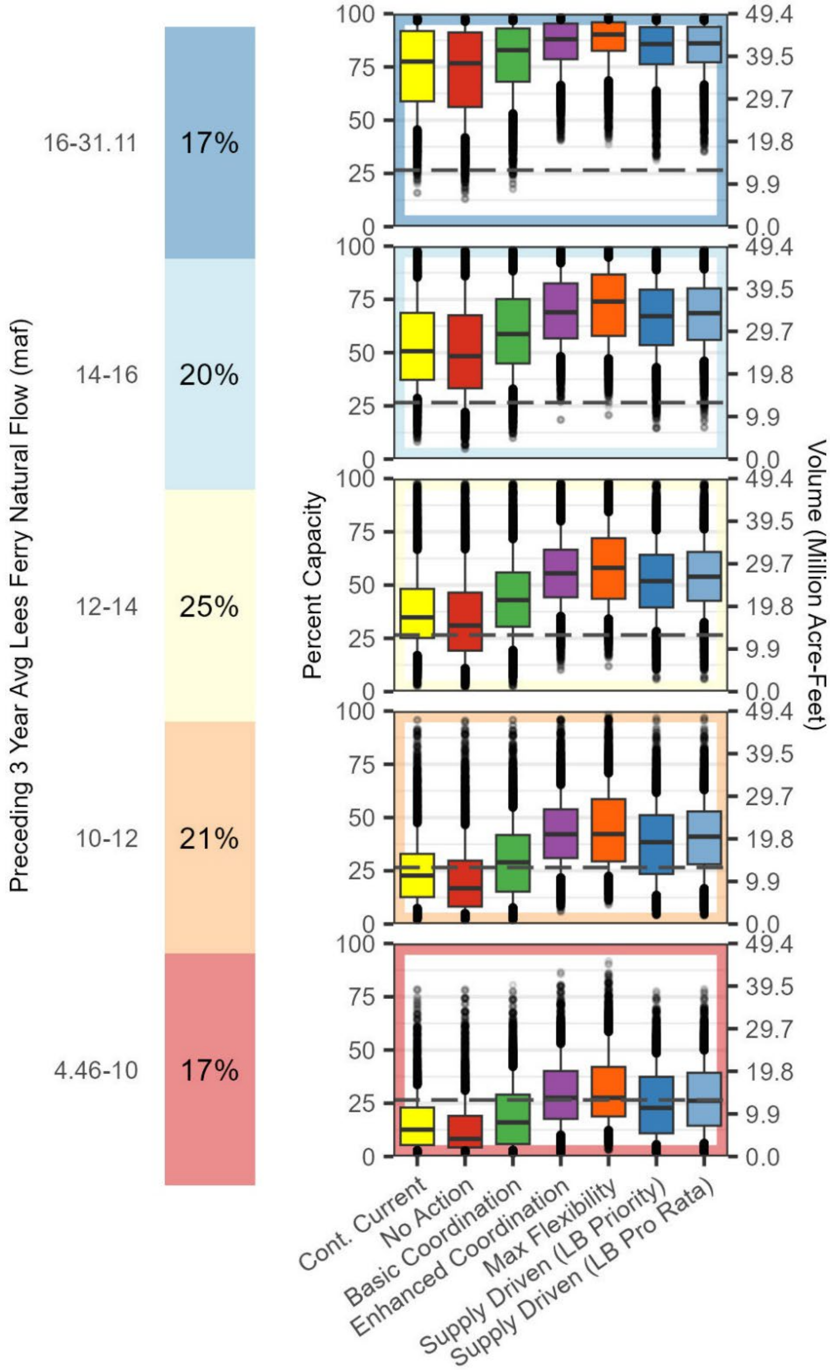
In the Average Flow Category (12.0–14.0 maf), the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives all have median Lake Powell and Lake Mead combined storage volumes above 50 percent of the total storage capacity. Fewer than 10 percent of years modeled (corresponding to the 10th percentile) fall below the lowest observed EOWY storage reference line of 26.55 percent. These four action alternatives also have similar interquartile ranges, but the Maximum Operational Flexibility Alternative has slightly 75th percentile storage volumes with the greatest variability, and the Supply Driven Alternative (LB Priority approach) has the lowest range of interquartile storage volumes. The CCS Comparative Baseline and Basic Coordination and No Action Alternatives have lower median storage percentages than the other alternatives, at 43 percent, 35 percent and 31 percent, respectively. Under the No Action Alternative and CCS Comparative Baseline, more than 25 percent of years (corresponding to the 25th percentile) fall below the lowest observed storage reference line.

In the Dry Flow Category (less than 10.0 maf), the order of combined storage volume medians and relationships across the alternatives and the CCS Comparative Baseline is similar to those in the Average Flow Category, but with notable reductions to storage volumes; for the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven (LB Priority approach) Alternatives almost 50 percent of years go below the lowest observed storage of 26.55 percent. For the Supply Driven Alternative (LB Pro Rata approach), slightly more than 50 percent of years go below the lowest observed storage and for the Basic Coordination and No Action Alternatives and the CCS Comparative Baseline, approximately 75 percent or more years go below. Maximum Operational Flexibility is the only alternative that does not reach 0 percent storage in any year.

Table TA 3-11
EOWY Powell and Mead Combined Storage (% Full)

Alternative	Flow Category	Max (% Full)	90% (% Full)	75% (% Full)	50% (% Full)	25% (% Full)	10% (% Full)	Min (% Full)
CCS Comparative Baseline	> 16	100.0	96.5	91.8	77.5	58.8	45.7	15.8
CCS Comparative Baseline	14-16	98.1	85.1	68.7	50.7	37.2	28.8	8.2
CCS Comparative Baseline	12-14	97.7	66.5	48.2	34.8	25.2	17.1	2.4
CCS Comparative Baseline	10-12	95.7	47.3	32.9	22.7	12.7	7.4	1.6
CCS Comparative Baseline	< 10	78.6	33.5	23.0	12.6	5.4	2.9	1.5
No Action	> 16	99.6	96.4	91.2	76.7	56.2	42.0	13.0
No Action	14-16	98.2	85.8	67.6	48.4	33.3	22.2	4.9
No Action	12-14	97.9	66.7	46.5	31.0	19.2	11.0	2.2
No Action	10-12	95.5	46.4	29.8	16.8	8.2	5.0	1.9
No Action	< 10	78.7	30.9	19.1	8.3	4.2	2.8	1.6
Basic Coordination	> 16	99.8	96.6	93.1	82.9	68.1	53.2	17.5
Basic Coordination	14-16	98.4	88.1	75.1	58.7	44.9	33.2	9.9
Basic Coordination	12-14	97.5	71.5	55.9	43.0	30.5	19.6	2.4
Basic Coordination	10-12	95.8	54.6	41.8	29.0	15.2	7.8	1.8
Basic Coordination	< 10	80.5	42.0	29.1	16.0	5.8	3.0	1.4
Enhanced Coordination	> 16	98.5	97.1	95.4	88.0	78.6	66.7	40.3
Enhanced Coordination	14-16	98.6	91.9	82.5	68.9	56.7	48.4	18.5
Enhanced Coordination	12-14	98.1	79.8	66.6	55.5	44.3	35.5	10.2
Enhanced Coordination	10-12	96.0	65.1	53.9	42.1	31.0	21.9	5.6
Enhanced Coordination	< 10	86.6	52.8	40.1	27.6	17.7	10.2	1.4
Max. Operational Flexibility	> 16	99.3	97.2	95.9	90.2	82.6	68.8	38.3
Max. Operational Flexibility	14-16	99.8	94.6	86.7	74.0	57.9	47.3	20.5
Max. Operational Flexibility	12-14	98.4	84.3	72.0	58.1	43.5	34.2	11.8
Max. Operational Flexibility	10-12	98.5	70.6	58.6	42.2	29.4	22.6	8.9
Max. Operational Flexibility	< 10	91.7	58.4	42.0	27.6	18.8	12.4	2.9
Supply Driven (LB Priority)	> 16	99.4	96.8	93.7	85.7	76.3	64.1	31.0
Supply Driven (LB Priority)	14-16	98.3	88.7	79.6	67.1	53.5	43.3	14.5
Supply Driven (LB Priority)	12-14	98.1	75.7	64.2	51.9	39.5	28.4	5.7
Supply Driven (LB Priority)	10-12	97.0	61.5	51.1	38.4	23.5	13.7	4.0
Supply Driven (LB Priority)	< 10	77.7	48.4	37.4	22.8	10.9	5.7	1.5
Supply Driven (LB Pro Rata)	> 16	99.4	96.8	93.8	86.1	77.2	66.9	35.1
Supply Driven (LB Pro Rata)	14-16	98.7	89.0	80.2	68.5	56.0	46.2	14.8
Supply Driven (LB Pro Rata)	12-14	98.1	76.2	65.6	53.9	42.6	32.7	5.7
Supply Driven (LB Pro Rata)	10-12	97.0	62.8	52.9	41.0	28.1	16.9	4.0
Supply Driven (LB Pro Rata)	< 10	78.7	49.8	39.3	26.1	14.4	6.3	1.4

Figure TA 3-18
EOWY Powell and Mead Combined Storage[5]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[5] Dashed reference line is historical EOWY minimum 26.55 percent in September 2022.

Combined System Storage at CRSP Reservoirs

This section compares all alternatives and the CCS Comparative Baseline with respect to EOWY combined storage capacity of CRSP reservoirs. Analysis of the combined storage across CRSP reservoirs helps to understand the overall status of Lake Powell and the CRSP UIUs (Flaming Gorge, Navajo, and Blue Mesa reservoirs). The CRSP UIU reservoirs can be operated in a way that releases flows to help bolster elevations in Lake Powell and protect Glen Canyon Dam infrastructure (within their Records of Decision). Excluding surcharge space, the total storage volume of the four CRSP reservoirs is 29.5 maf. Since Lake Powell storage capacity accounts for approximately 80 percent of CRSP capacity, and because storage at the CRSP UIUs varies minimally between alternatives (slight variations would result from the use of the UIUs to bolster Lake Powell elevations), the majority of the performance differences across alternatives result from Lake Powell operations.

Under the CCS Comparative Baseline and Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives, releases from CRSP UIUs can be increased to bolster Lake Powell's elevations. The Basic Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives state that CRSP UIU releases may be increased if Lake Powell's elevation is projected to drop below 3,525 feet. (The Enhanced Coordination Alternative broadly states that Reclamation may consider increases to CRSP UIU releases to address extreme low-reservoir conditions at Lake Powell.) Since the water is being moved internally within the same CRSP system (from the CRSP UIUs downstream to Lake Powell), the overall CRSP combined storage volumes do not change, and these intra-system balancing operations are not apparent in the box plots. Differences across alternatives are driven by Lake Powell's operations, described in Issue 1 above.

Table TA 3-12 below shows the statistical breakdown of the EOWY CRSP combined storage (as a percentage of the total storage capacity) for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOWY combined storage percentages.

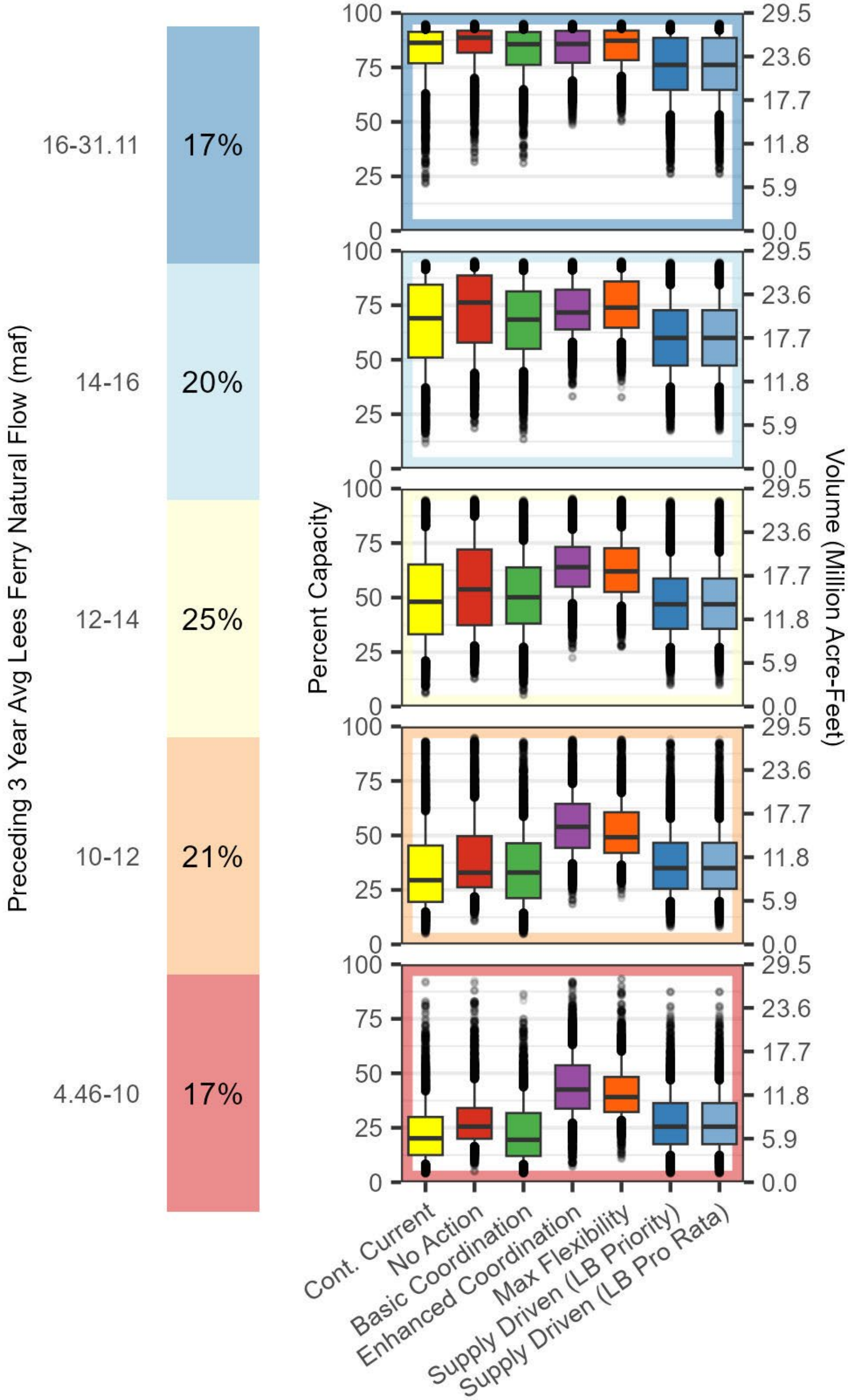
Figure TA 3-19 shows EOWY CRSP combined storage volumes to assess how the alternatives respond to different hydrologic conditions based on the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-12** in a conditional box plot. The CRSP combined storage box plots include storage at Lake Powell, as well as the three CRSP UIUs.

In the Wet Flow Category (greater than 16.0 maf), all alternatives have very high median storage volumes and similar ranges of interquartile CRSP combined storage volumes, except for the Supply Driven (LB Priority approach) and Supply Driven (LB Pro Rata approach) Alternatives, which have lower CRSP combined storage volume medians and lower ranges of interquartile storage volumes with the greatest variability.

Table TA 3-12
EOWY CRSP Combined Storage (% Full)

Alternative	Flow Category	Max (% Full)	90% (% Full)	75% (% Full)	50% (% Full)	25% (% Full)	10% (% Full)	Min (% Full)
CCS Comparative Baseline	> 16	94.9	92.4	91.3	86.3	76.9	63.1	21.7
CCS Comparative Baseline	14-16	94.7	91.4	84.4	69.0	51.0	37.3	11.4
CCS Comparative Baseline	12-14	94.9	82.3	65.2	48.1	33.2	21.0	6.0
CCS Comparative Baseline	10-12	93.1	61.0	45.4	29.5	19.5	15.0	4.9
CCS Comparative Baseline	< 10	92.3	41.7	29.9	20.2	12.5	8.3	4.0
No Action	> 16	95.1	92.8	91.8	88.6	81.8	70.3	31.6
No Action	14-16	95.2	92.3	88.7	76.3	57.9	44.0	18.6
No Action	12-14	95.5	87.2	72.1	53.7	37.3	27.9	12.7
No Action	10-12	94.8	67.2	49.7	32.9	26.2	22.0	10.7
No Action	< 10	92.5	47.3	34.0	25.5	20.0	16.5	5.0
Basic Coordination	> 16	95.4	92.4	91.2	85.6	76.2	65.0	31.0
Basic Coordination	14-16	95.0	90.8	81.4	68.4	55.0	44.8	13.5
Basic Coordination	12-14	94.7	76.1	63.8	50.1	38.1	27.4	5.2
Basic Coordination	10-12	93.1	58.5	46.4	33.0	21.2	14.4	4.8
Basic Coordination	< 10	86.5	43.6	31.8	19.5	12.0	8.2	4.0
Enhanced Coordination	> 16	94.9	92.8	91.8	85.7	77.1	69.0	48.5
Enhanced Coordination	14-16	95.1	91.1	82.1	71.7	63.9	58.1	33.1
Enhanced Coordination	12-14	95.5	81.2	73.2	64.0	55.0	47.5	22.2
Enhanced Coordination	10-12	94.2	73.7	64.5	53.9	44.3	37.1	18.4
Enhanced Coordination	< 10	92.2	62.9	53.7	42.5	33.8	27.3	7.2
Max. Operational Flexibility	> 16	95.3	92.9	91.9	87.2	78.3	71.1	50.2
Max. Operational Flexibility	14-16	95.2	92.0	85.9	73.9	64.7	58.2	32.7
Max. Operational Flexibility	12-14	95.3	82.2	72.7	62.0	52.6	46.2	27.3
Max. Operational Flexibility	10-12	93.9	69.4	60.6	49.2	42.0	36.4	21.3
Max. Operational Flexibility	< 10	93.2	60.0	48.3	39.1	32.2	28.5	10.8
Supply Driven (LB Priority)	> 16	95.2	92.0	88.6	76.2	64.7	53.3	26.0
Supply Driven (LB Priority)	14-16	95.0	84.3	72.7	60.0	47.3	37.6	17.0
Supply Driven (LB Priority)	12-14	94.3	70.7	58.8	46.9	35.7	27.2	9.9
Supply Driven (LB Priority)	10-12	94.1	57.7	46.6	35.0	25.5	19.8	7.9
Supply Driven (LB Priority)	< 10	87.5	46.8	36.3	25.5	17.5	12.4	4.1
Supply Driven (LB Pro Rata)	> 16	95.2	92.0	88.6	76.2	64.7	53.3	26.0
Supply Driven (LB Pro Rata)	14-16	95.0	84.3	72.7	60.0	47.3	37.6	17.0
Supply Driven (LB Pro Rata)	12-14	94.3	70.7	58.8	46.9	35.7	27.2	9.9
Supply Driven (LB Pro Rata)	10-12	94.1	57.7	46.6	35.0	25.5	19.8	7.9
Supply Driven (LB Pro Rata)	< 10	87.5	46.8	36.3	25.5	17.5	12.4	4.1

Figure TA 3-19
EOWY CRSP Combined Storage



In the Average Flow Category (12.0–14.0 maf), the CCS Comparative Baseline, No Action, Basic Coordination, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives all have median CRSP combined storage volumes near 50 percent of the total storage capacity, while the Enhanced Coordination and Maximum Operational Flexibility Alternatives have higher median CRSP combined storage volumes of 64 percent and 62 percent of the total storage capacity, respectively. The Enhanced Coordination and Maximum Operational Flexibility Alternatives also have higher ranges of interquartile storage volumes and less variability, with the Enhanced Coordination Alternative having the highest range of interquartile storage volumes and the least variability across all alternatives. The No Action Alternative has the greatest variability of interquartile storage volume ranges.

In the Dry Flow Category (less than 10.0 maf), the order of combined storage volumes medians and relationships across the alternatives and the CCS Comparative Baseline are similar to those in the Average Flow Category, but with notable reductions to storage volumes across all alternatives and narrower interquartile ranges (except for the Enhanced Coordination Alternative, which has slightly wider interquartile ranges in the Dry Flow Category). The CCS Comparative Baseline and No Action Alternative have the least variability in interquartile storage volume ranges. None of the alternatives nor the CCS Comparative Baseline reach 0 percent of the total storage capacity in any year.

Combined System Storage at Seven-Reservoirs

This section compares all alternatives and the CCS Comparative Baseline with respect to EOWY combined storage capacity of the seven-reservoir system. The seven-reservoir system storage (also referred to as total system storage) volumes over time can be used to better understand overall system conditions and is mainly driven by shortage operations. The seven-reservoirs include the CRSP UIUs of Flaming Gorge, Navajo, and Blue Mesa Reservoirs, as well as Lake Powell, Lake Mead, Lake Mohave, and Lake Havasu. Excluding surcharge space, the total storage volume of the seven-reservoir system reservoirs is 55.03 maf. Lake Powell and Lake Mead make up approximately 90 percent of the total seven-reservoir system storage capacity.

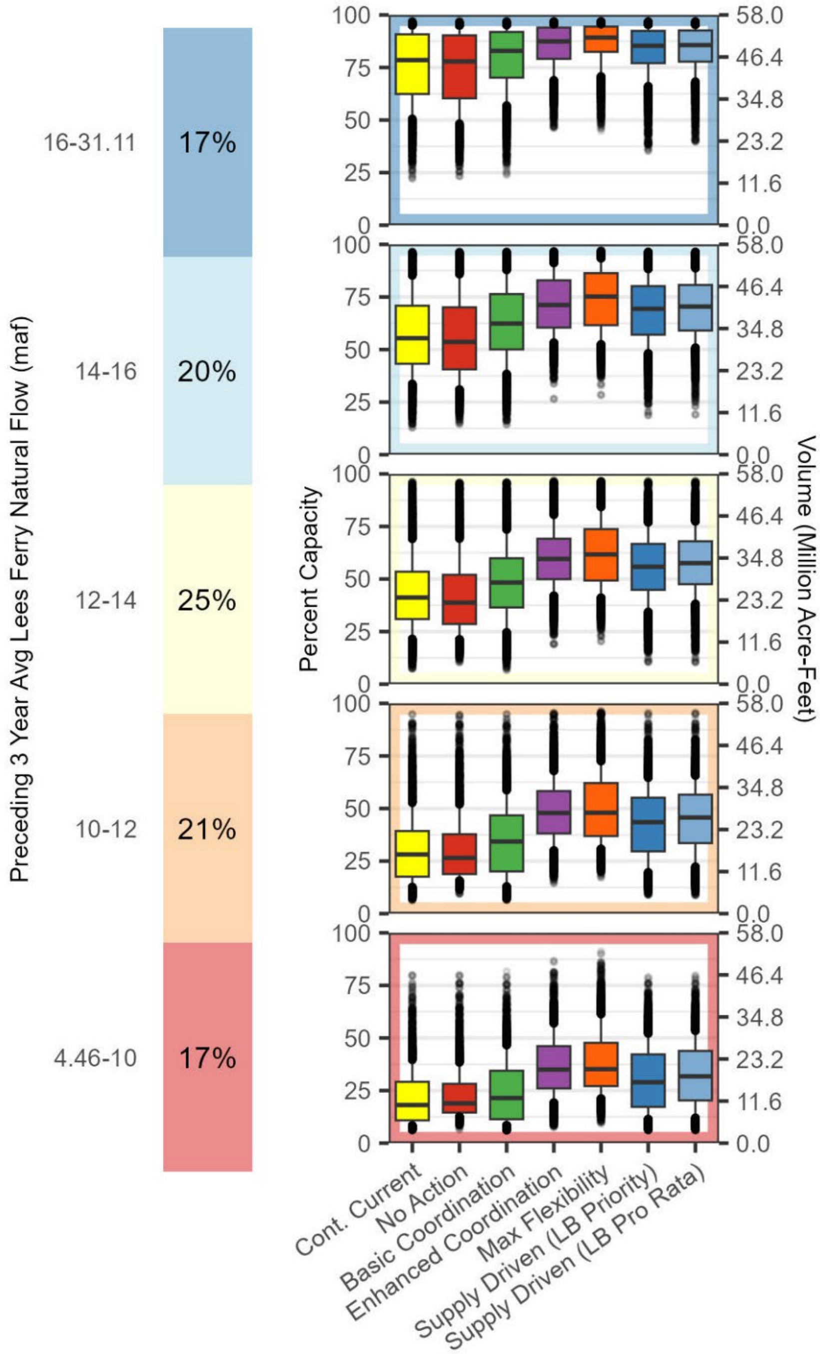
Table TA 3-13 below shows the statistical breakdown of the EOWY seven-reservoir combined storage (as a percentage of the total storage capacity) for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOWY combined storage percentages.

Figure TA 3-20 shows EOWY seven-reservoir combined storage volumes to assess how the alternatives respond to different hydrologic conditions based on the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-13** in a conditional box plot. The seven-reservoir combined storage box plots include storage at the following reservoirs: Flaming Gorge, Navajo, Blue Mesa, Powell, Mead, Mohave, and Havasu.

Table TA 3-13
EOWY Seven-Reservoir Combined Storage (% Full)

Alternative	Flow Category	Max (% Full)	90% (% Full)	75% (% Full)	50% (% Full)	25% (% Full)	10% (% Full)	Min (% Full)
CCS Comparative Baseline	> 16	98.0	95.1	90.8	78.5	62.4	50.7	22.3
CCS Comparative Baseline	14-16	96.6	85.0	70.8	55.4	43.2	33.7	12.9
CCS Comparative Baseline	12-14	96.2	69.0	53.5	41.2	31.0	21.6	7.4
CCS Comparative Baseline	10-12	94.8	52.5	39.3	28.2	17.6	12.7	6.4
CCS Comparative Baseline	< 10	80.0	39.5	29.2	18.1	10.8	8.4	6.2
No Action	> 16	97.8	95.0	90.3	77.9	60.3	48.4	23.4
No Action	14-16	96.6	85.7	70.1	53.6	40.6	31.1	14.6
No Action	12-14	96.0	69.0	52.0	38.8	28.6	21.3	10.4
No Action	10-12	94.6	51.9	37.8	26.5	18.8	15.7	9.5
No Action	< 10	80.2	38.2	28.2	18.9	14.5	12.5	6.7
Basic Coordination	> 16	97.9	95.2	91.9	82.9	70.2	57.0	23.9
Basic Coordination	14-16	96.7	87.6	76.4	62.4	50.1	38.6	14.4
Basic Coordination	12-14	96.0	73.4	59.9	48.3	36.5	24.7	6.8
Basic Coordination	10-12	94.8	58.5	46.7	34.3	20.1	13.0	6.5
Basic Coordination	< 10	81.6	46.5	34.4	21.4	11.4	8.5	6.0
Enhanced Coordination	> 16	96.9	95.6	94.0	87.4	79.1	69.1	46.1
Enhanced Coordination	14-16	96.8	91.0	82.9	71.2	60.4	53.4	26.5
Enhanced Coordination	12-14	96.9	80.4	69.2	59.6	49.9	42.1	18.8
Enhanced Coordination	10-12	95.4	67.7	58.3	47.9	38.1	30.2	14.4
Enhanced Coordination	< 10	86.8	56.8	46.1	35.0	26.0	19.4	7.6
Max. Operational Flexibility	> 16	96.9	95.7	94.5	89.2	82.4	70.9	44.9
Max. Operational Flexibility	14-16	97.4	93.3	86.3	75.2	61.6	52.5	28.3
Max. Operational Flexibility	12-14	96.8	84.2	73.7	61.7	49.3	41.2	20.3
Max. Operational Flexibility	10-12	96.3	72.3	62.1	48.0	36.9	30.9	17.0
Max. Operational Flexibility	< 10	91.2	61.3	47.7	35.2	27.1	21.3	9.5
Supply Driven (LB Priority)	> 16	96.9	95.4	92.4	85.3	77.0	66.2	35.2
Supply Driven (LB Priority)	14-16	96.6	88.3	80.2	69.4	57.1	48.3	18.8
Supply Driven (LB Priority)	12-14	96.6	76.9	66.7	55.8	44.9	34.5	10.6
Supply Driven (LB Priority)	10-12	95.6	64.5	55.1	43.5	29.6	19.7	8.9
Supply Driven (LB Priority)	< 10	79.0	52.0	42.2	28.9	17.2	11.4	6.1
Supply Driven (LB Pro Rata)	> 16	96.9	95.4	92.6	85.7	77.8	68.4	39.6
Supply Driven (LB Pro Rata)	14-16	96.6	88.6	80.7	70.4	59.0	51.0	19.0
Supply Driven (LB Pro Rata)	12-14	96.7	77.3	68.0	57.6	47.5	38.2	10.4
Supply Driven (LB Pro Rata)	10-12	95.6	65.6	56.6	45.7	33.6	22.4	8.7
Supply Driven (LB Pro Rata)	< 10	79.9	53.3	43.8	31.8	20.3	12.1	6.1

Figure TA 3-20
EOWY Seven-Reservoir Combined Storage



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

In the Wet Flow Category (greater than 16.0 maf), all alternatives have median seven-reservoir storage volumes higher than 75 percent of the total storage capacity. The Maximum Operational Flexibility Alternative has the highest median seven-reservoir storage volume and highest interquartile ranges and the least variability. The No Action Alternative and CCS Comparative Baseline have the lowest median seven-reservoir storage volumes and highest interquartile variability.

In the Average Flow Category (12.0–14.0 maf), the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives all have median seven-reservoir storage volumes above 50 percent of the total storage capacity. These four alternatives also have similar ranges of interquartile seven-reservoir storage volumes, but the Maximum Operational Flexibility Alternative has slightly higher interquartile ranges with the greatest variability, and the Supply Driven Alternative (LB Pro Rata approach) has the lowest interquartile range. The Basic Coordination and No Action Alternatives and the CCS Comparative Baseline have median storage percentages of 48 percent, 41 percent, and 39 percent of the total storage capacity, respectively.

In the Dry Flow Category (less than 10.0 maf), the order of medians and relationships across the alternatives and the CCS Comparative Baseline are similar to those in the Average Flow Category, with notable reductions to storage volumes. The CCS Comparative Baseline has a higher median storage volume than the No Action Alternative in all flow categories except for in the Dry Flow Category, where the CCS Comparative Baseline has a lower median storage volume and lower interquartile range. None of the alternatives nor the CCS Comparative Baseline reach 0 percent of the total storage capacity in any year.

TA 3.2.3 Issue 3: Reservoir Releases

Issue 3 addresses how operational activities would affect reservoir releases. This was evaluated by comparing the various action alternatives to the No Action Alternative and the CCS Comparative Baseline for the following metrics:

- WY Releases from Glen Canyon Dam
- 10-Year Releases from Glen Canyon Dam
- 10-Year Flows at Lee Ferry Compact Point
- CY Releases from Hoover Dam

Glen Canyon Dam

This section compares all alternatives and the CCS Comparative Baseline with respect to WY releases from Glen Canyon Dam at Lake Powell. Note that the performance of the Supply Driven (LB Priority approach) and Supply Driven (LB Pro Rata approach) Alternatives will not differ in Glen Canyon Dam releases because they use the same operation of Lake Powell.

Table TA 3-14 below shows the statistical breakdown of WY releases (in maf) from Glen Canyon Dam, at Lake Powell, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum WY releases (in maf).

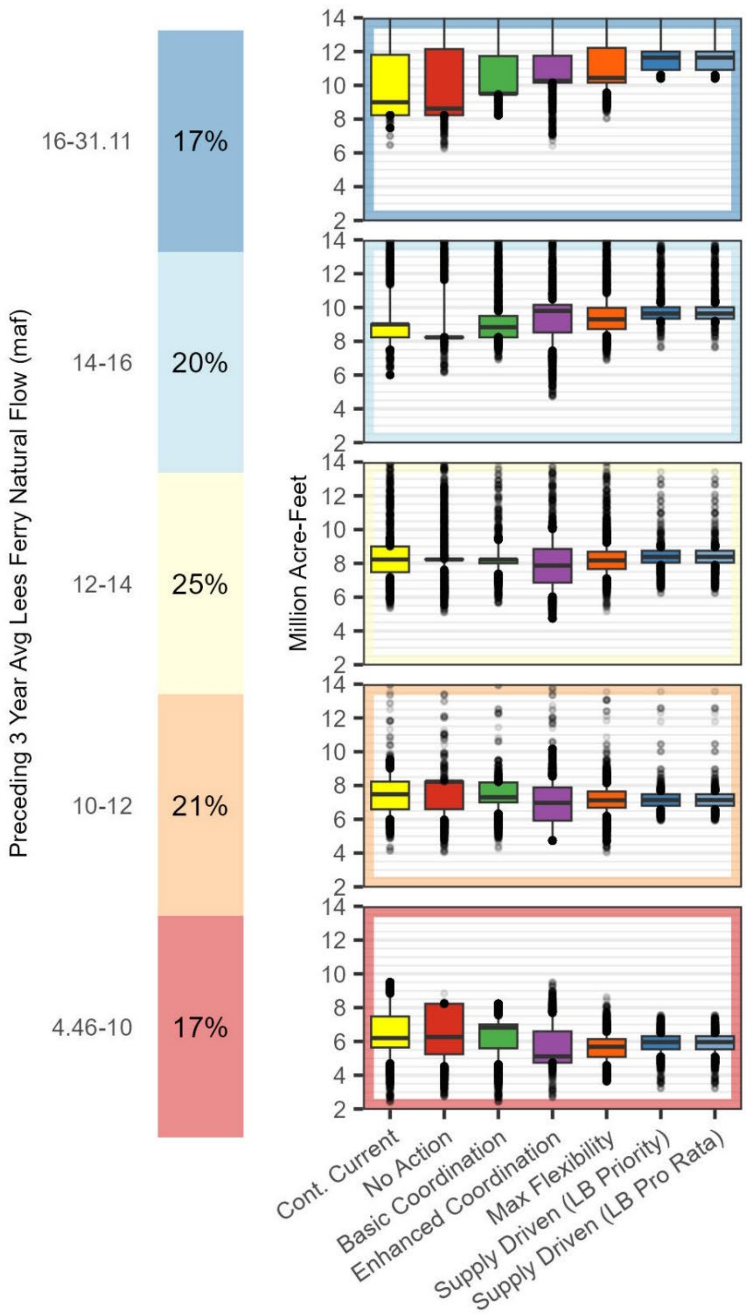
Table TA 3-14
WY Releases from Glen Canyon Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	38.09	14.97	11.81	9.00	8.23	8.23	6.45
CCS Comparative Baseline	14-16	26.61	11.35	9.00	9.00	8.23	7.48	6.00
CCS Comparative Baseline	12-14	28.14	9.00	9.00	8.23	7.48	7.20	5.35
CCS Comparative Baseline	10-12	17.22	9.00	8.23	7.48	6.59	6.00	4.15
CCS Comparative Baseline	< 10	9.50	8.81	7.48	6.20	5.64	4.71	2.42
No Action	> 16	38.13	15.43	12.15	8.63	8.23	8.23	6.26
No Action	14-16	27.36	11.60	8.23	8.23	8.23	8.23	6.15
No Action	12-14	28.49	8.23	8.23	8.23	8.23	7.63	5.09
No Action	10-12	18.89	8.23	8.23	8.23	6.60	5.97	4.06
No Action	< 10	8.83	8.23	8.23	6.26	5.24	4.54	2.76
Basic Coordination	> 16	38.09	15.09	11.74	9.50	9.50	9.50	8.23
Basic Coordination	14-16	27.06	9.76	9.50	8.83	8.23	8.23	6.92
Basic Coordination	12-14	26.99	9.38	8.23	8.23	8.01	7.40	5.67
Basic Coordination	10-12	17.59	8.23	8.18	7.31	7.00	6.35	4.26
Basic Coordination	< 10	8.23	7.53	7.00	6.82	5.59	4.66	2.42
Enhanced Coordination	> 16	38.44	15.46	11.75	10.26	10.16	10.16	6.42
Enhanced Coordination	14-16	27.35	10.47	10.16	9.79	8.52	7.45	4.74
Enhanced Coordination	12-14	29.33	10.03	8.85	7.87	6.86	6.04	4.74
Enhanced Coordination	10-12	19.84	8.53	7.89	6.97	5.92	4.74	4.74
Enhanced Coordination	< 10	9.49	7.67	6.59	5.11	4.74	4.74	2.70
Max. Operational Flexibility	> 16	38.59	15.83	12.21	10.44	10.16	9.57	8.04
Max. Operational Flexibility	14-16	27.65	10.84	9.98	9.30	8.72	8.33	6.89
Max. Operational Flexibility	12-14	28.85	9.22	8.69	8.17	7.67	7.11	5.14
Max. Operational Flexibility	10-12	19.31	8.14	7.65	7.13	6.69	6.20	4.01
Max. Operational Flexibility	< 10	8.65	6.58	6.14	5.68	5.08	4.60	3.62
Supply Driven (LB Priority)	> 16	38.29	14.44	12.00	11.64	10.91	10.61	10.40
Supply Driven (LB Priority)	14-16	26.53	10.28	10.02	9.64	9.33	9.20	7.63
Supply Driven (LB Priority)	12-14	27.98	8.97	8.75	8.39	8.04	7.90	6.22
Supply Driven (LB Priority)	10-12	18.53	7.67	7.48	7.14	6.80	6.57	5.93
Supply Driven (LB Priority)	< 10	7.56	6.49	6.31	5.96	5.54	5.10	3.23
Supply Driven (LB Pro Rata)	> 16	38.29	14.44	12.00	11.64	10.91	10.61	10.40
Supply Driven (LB Pro Rata)	14-16	26.53	10.28	10.02	9.64	9.33	9.20	7.63
Supply Driven (LB Pro Rata)	12-14	27.98	8.97	8.75	8.39	8.04	7.90	6.22
Supply Driven (LB Pro Rata)	10-12	18.53	7.67	7.48	7.14	6.80	6.57	5.93
Supply Driven (LB Pro Rata)	< 10	7.56	6.49	6.31	5.96	5.54	5.10	3.23

NOTE: Releases colored blue highlight Glen Canyon Dam's median release of 8.23 maf. Releases colored red are at or below the smallest releases allowable of 4.7 maf in accordance with LTEMP (Reclamation 2016).

Figure TA 3-21 below looks at the response of Glen Canyon Dam WY Releases to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-14** in a conditional box plot. In all categories except the Dry Flow Category, the high end of the results range is cut off to improve comparisons in the Average and Dry Flow Categories.

Figure TA 3-21
WY Releases from Glen Canyon Dam[6]



[6] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median annual Glen Canyon Dam releases for most alternatives are situated between 8.0 and 8.5 maf, with a higher variability in interquartile annual releases observed under the CCS Comparative Baseline and the Enhanced Coordination, Maximum Operational Flexibility Alternatives. The median annual Glen Canyon Dam releases are highest under the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) at 8.39 maf each. The Basic Coordination Alternative, the No Action Alternative, and the CCS Comparative Baseline all have median annual releases of 8.23 maf. The median annual release for the Maximum Operational Flexibility Alternative 8.17 maf, and for the Enhanced Coordination Alternative is the lowest, at 7.87 maf.

In the Moderately Dry Flow Category (10.0–12.0 maf), although there is similar variability in interquartile ranges for annual releases, the median annual release under all action alternatives is below the No Action Alternative median release (8.23 maf) and the CCS Comparative Baseline (7.48 maf). The Enhanced Coordination Alternative has the lowest median annual release of 6.97 maf, and the lowest interquartile range with the greatest variability.In the Dry Flow Category (less than 10.0 maf), the order of medians and relationships across the alternatives and the CCS Comparative Baseline is similar to those in the Average Flow Category, with notable reductions to Glen Canyon annual releases. In the Dry Flow Category, for 75 percent of traces all action alternatives have releases of less than 7.6 maf. The Enhanced Coordination Alternative has the lowest median release of 5.11 maf, closely followed by the Maximum Operational Flexibility Alternative, and the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) which have median releases of 5.68 maf, 5.96 maf, and 5.96 maf, respectively.

Interquartile variability for the CCS Comparative Baseline and No Action Alternative is largest in the Wet or Dry Flow Categories. Although the values shift depending on each flow category, the Enhanced Coordination, Maximum Operational Flexibility, and Supply Driven Alternatives (both the LB Priority and LB Pro Rata approaches) show relatively consistent size of interquartile ranges across both Wet and Dry Flow Categories.

Glen Canyon 10-Year Releases

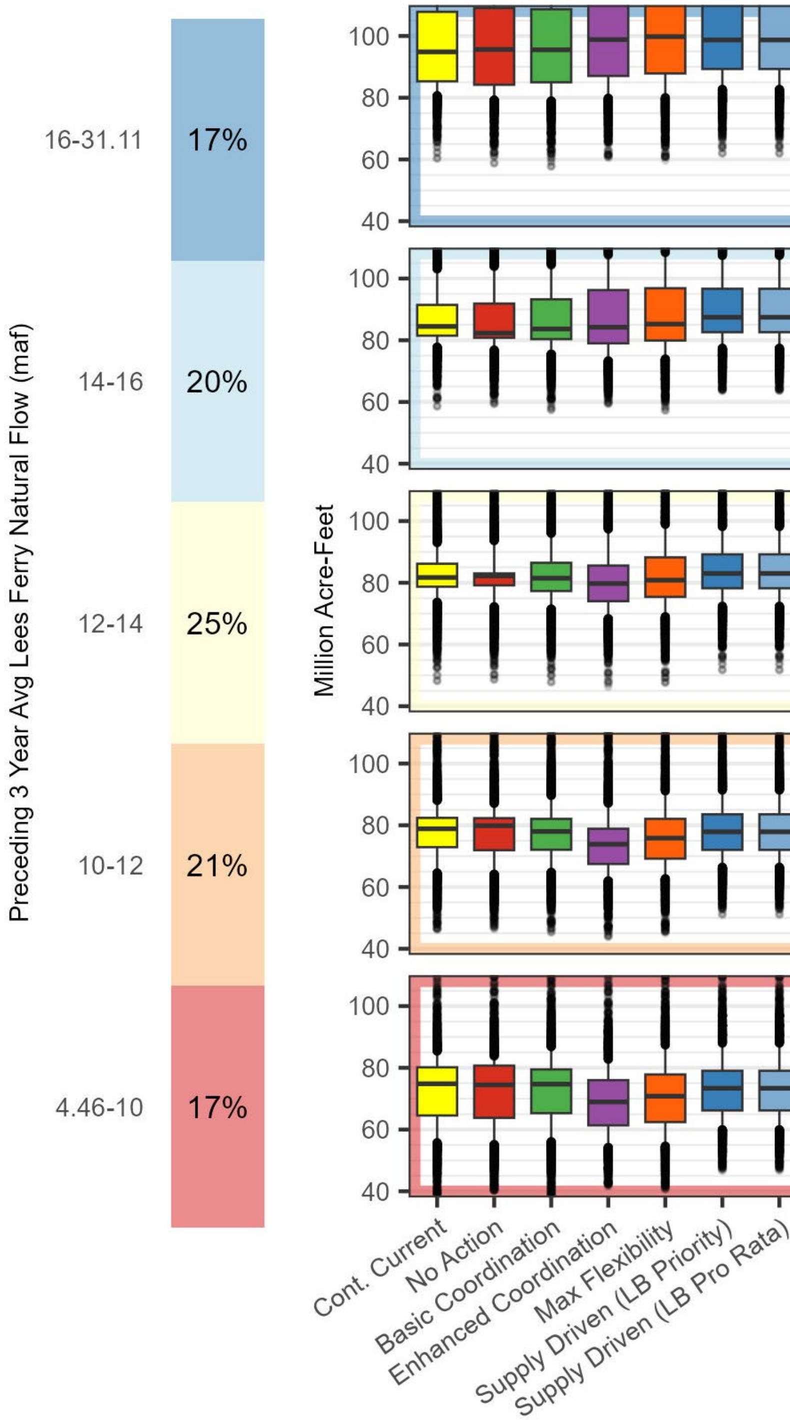
Table TA 3-15 below shows the statistical breakdown of 10-year cumulative WY releases (in maf) from Glen Canyon Dam for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum 10-year releases (in maf).

Figure TA 3-22 below looks at the response of 10-year cumulative WY Glen Canyon Dam releases to different hydrologic conditions under different alternatives by looking at the preceding 3-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-15** in a conditional box plot. In all categories except the Dry Flow Category, the high end of the results range is cut off to improve comparisons in the Average and Dry Flow Categories.

Table TA 3-15
10-Year Releases from Glen Canyon Dam

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	176.3	121.4	107.8	94.9	85.3	80.7	60.4
CCS Comparative Baseline	14-16	154.5	103.0	91.5	84.5	81.5	77.8	58.6
CCS Comparative Baseline	12-14	145.4	92.9	86.2	81.7	78.7	73.7	48.2
CCS Comparative Baseline	10-12	134.9	88.0	82.4	78.9	72.9	64.6	46.2
CCS Comparative Baseline	< 10	134.9	85.4	80.2	74.8	64.6	55.8	38.2
No Action	> 16	176.6	122.3	109.1	95.6	84.2	79.2	58.8
No Action	14-16	156.9	103.8	91.9	82.3	80.8	77.0	59.4
No Action	12-14	145.5	93.6	83.0	82.2	79.2	72.3	48.7
No Action	10-12	135.3	87.0	82.3	79.9	71.9	64.2	46.3
No Action	< 10	135.3	83.7	80.7	74.5	63.8	55.2	40.3
Basic Coordination	> 16	176.2	121.7	108.7	95.5	85.0	79.0	57.7
Basic Coordination	14-16	156.3	104.3	93.3	83.7	80.4	75.6	57.5
Basic Coordination	12-14	148.6	95.9	86.5	81.5	77.3	71.5	47.8
Basic Coordination	10-12	135.3	89.6	82.1	78.0	72.1	64.9	45.4
Basic Coordination	< 10	132.2	86.8	79.5	74.7	65.3	56.1	38.2
Enhanced Coordination	> 16	179.1	124.7	112.0	98.8	87.1	79.9	60.5
Enhanced Coordination	14-16	160.6	107.5	96.3	84.2	79.0	73.4	59.3
Enhanced Coordination	12-14	153.7	97.4	85.6	79.8	74.0	68.4	46.2
Enhanced Coordination	10-12	139.3	87.1	78.9	73.9	67.5	62.0	43.8
Enhanced Coordination	< 10	135.6	82.7	76.0	69.0	61.4	54.3	41.7
Max. Operational Flexibility	> 16	183.1	126.4	113.2	99.8	87.9	80.1	59.6
Max. Operational Flexibility	14-16	161.0	108.4	96.9	85.2	79.9	74.0	57.3
Max. Operational Flexibility	12-14	152.4	98.8	88.2	80.9	75.4	69.0	47.6
Max. Operational Flexibility	10-12	138.8	91.1	82.1	75.8	69.2	62.7	44.9
Max. Operational Flexibility	< 10	133.7	87.3	77.8	70.8	62.4	54.7	40.7
Supply Driven (LB Priority)	> 16	177.9	124.0	110.9	98.7	89.3	82.8	62.0
Supply Driven (LB Priority)	14-16	161.0	107.4	96.7	87.4	82.6	77.4	63.7
Supply Driven (LB Priority)	12-14	152.4	98.1	89.2	83.0	78.2	72.4	51.7
Supply Driven (LB Priority)	10-12	138.9	91.4	83.6	77.9	72.0	66.5	50.9
Supply Driven (LB Priority)	< 10	132.8	87.9	79.0	73.4	66.2	60.0	46.8
Supply Driven (LB Pro Rata)	> 16	177.9	124.0	110.9	98.7	89.3	82.8	62.0
Supply Driven (LB Pro Rata)	14-16	161.0	107.4	96.7	87.4	82.6	77.4	63.7
Supply Driven (LB Pro Rata)	12-14	152.4	98.1	89.2	83.0	78.2	72.4	51.7
Supply Driven (LB Pro Rata)	10-12	138.9	91.4	83.6	77.9	72.0	66.5	50.9
Supply Driven (LB Pro Rata)	< 10	132.8	87.9	79.0	73.4	66.2	60.0	46.8

Figure TA 3-22
10-Year Releases from Glen Canyon Dam[7]



[7] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median 10-year Glen Canyon Dam releases for all alternatives and the CCS Comparative Baseline are situated near 80.0 maf. There is a range of interquartile variability of at least 10.0 maf observed under all action alternatives, excluding the No Action Alternative and the CCS Comparative Baseline. The median 10-year Glen Canyon Dam releases are highest under both the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches; 83.0 maf each). The No Action Alternative (82.2 maf) has the second highest median releases followed by the Basic Coordination Alternatives (81.5 maf each), with the Maximum Operational Flexibility Alternative (80.9 maf) having the second lowest median releases.

The Enhanced Coordination Alternative has the lowest median 10-year release of 79.8 maf, and the lowest interquartile range with the greatest variability.

In the Moderately Dry Category (10.0–12.0 maf), the order of medians and relationships across the alternatives and the CCS Comparative Baseline is similar to those in the Average Flow Category, but with reductions to the 10-year median. The lowest 10-year median releases is 74.0 maf for the Enhanced Coordination Alternative and the highest 10-year median release is 80.0 maf for the No Action Alternative. The No Action, Basic Coordination, and Enhanced Coordination Alternatives and the CCS Comparative Baseline have interquartile variability of around 10.0 maf, while the Maximum Operational Flexibility Alternative has an interquartile range of 13.0 maf, and the Supply Driven Alternatives (both the LB Priority and LB Pro Rata approaches) have interquartile ranges of 11.5 maf.

In the Dry Flow Category (less than 10.0 maf), the CCS Comparative Baseline, No Action, Enhanced Coordination, and Maximum Operational Flexibility Alternatives have median volumes below 75.0 maf. The Basic Coordination and both Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) have median volumes above the Compact requirement of 75.0 maf. However, 75 percent of traces across all alternatives are below 80.0 maf.

Interquartile variability for the CCS Comparative Baseline and the No Action Alternative are largest in the Wet and Dry Flow Categories.

Lee Ferry Compact Point 10-Year Flows

The Lee Ferry Compact Point is the division point between the Upper Basin and the Lower Basin, as established by the 1922 Colorado River Compact. The Lee Ferry Compact point is located in Arizona, approximately 17 miles downstream of Glen Canyon Dam and approximately 1 mile downstream of the confluence with the Paria River. Refer to **Figure TA 3-2** in the Affected Environment Section for a map of the Lee Ferry Compact Point.

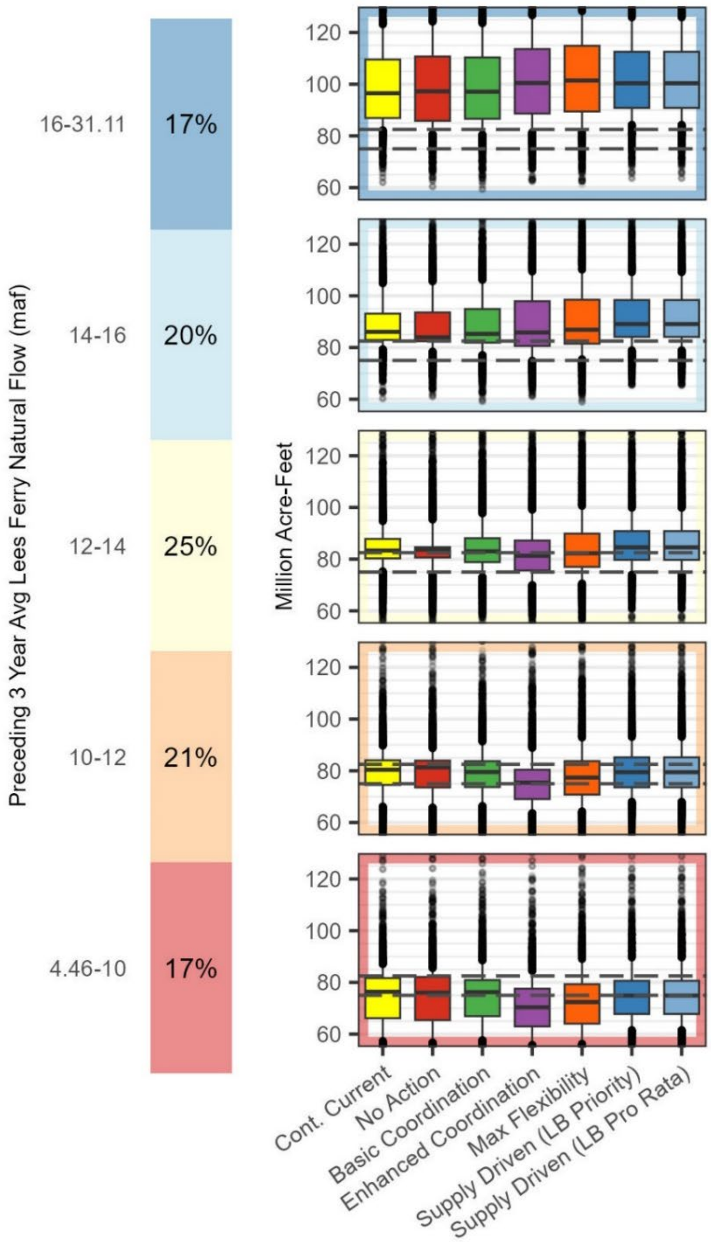
Table TA 3-16 below shows the statistical breakdown of 10-year cumulative flow volumes (in maf) at the Lee Ferry Compact Point for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum 10-year flow volumes (in maf).

Table TA 3-16
Compact Point 10-Year Flow Volume (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	177.9	123.0	109.5	96.5	86.9	82.2	62.0
CCS Comparative Baseline	14-16	156.2	104.7	93.1	86.1	82.9	79.3	60.3
CCS Comparative Baseline	12-14	147.0	94.6	87.8	83.3	80.3	75.3	49.8
CCS Comparative Baseline	10-12	136.6	89.6	84.0	80.4	74.5	66.2	47.8
CCS Comparative Baseline	< 10	136.6	87.1	81.7	76.4	66.2	57.4	39.8
No Action	> 16	178.2	124.0	110.7	97.2	85.8	80.8	60.4
No Action	14-16	158.5	105.5	93.6	84.0	82.4	78.5	61.1
No Action	12-14	147.2	95.2	84.6	83.6	80.6	73.9	50.3
No Action	10-12	137.0	88.7	83.9	81.3	73.6	65.8	47.9
No Action	< 10	137.0	85.4	82.1	76.0	65.4	56.8	41.9
Basic Coordination	> 16	177.9	123.4	110.3	97.1	86.6	80.5	59.4
Basic Coordination	14-16	157.9	106.0	94.9	85.3	81.9	77.1	59.2
Basic Coordination	12-14	150.3	97.6	88.1	83.0	78.9	73.2	49.4
Basic Coordination	10-12	136.9	91.2	83.7	79.5	73.7	66.5	47.0
Basic Coordination	< 10	133.9	88.4	80.9	76.2	66.9	57.7	39.8
Enhanced Coordination	> 16	180.8	126.4	113.6	100.5	88.7	81.4	62.2
Enhanced Coordination	14-16	162.2	109.2	97.9	85.8	80.6	75.0	61.0
Enhanced Coordination	12-14	155.3	99.0	87.2	81.3	75.6	70.0	47.8
Enhanced Coordination	10-12	140.9	88.7	80.4	75.4	69.1	63.7	45.4
Enhanced Coordination	< 10	137.3	84.3	77.6	70.4	63.0	55.8	43.3
Max. Operational Flexibility	> 16	184.8	128.1	114.9	101.4	89.4	81.7	61.2
Max. Operational Flexibility	14-16	162.6	110.0	98.5	86.9	81.5	75.6	59.0
Max. Operational Flexibility	12-14	154.1	100.5	89.9	82.3	77.0	70.6	49.2
Max. Operational Flexibility	10-12	140.4	92.8	83.7	77.4	70.8	64.4	46.5
Max. Operational Flexibility	< 10	135.4	88.9	79.3	72.4	64.0	56.3	42.3
Supply Driven (LB Priority)	> 16	179.6	125.7	112.5	100.4	90.8	84.4	63.6
Supply Driven (LB Priority)	14-16	162.7	109.0	98.4	89.1	84.1	79.0	65.3
Supply Driven (LB Priority)	12-14	154.1	99.8	90.9	84.6	79.7	74.0	53.3
Supply Driven (LB Priority)	10-12	140.6	93.0	85.2	79.5	73.6	68.1	52.5
Supply Driven (LB Priority)	< 10	134.4	89.5	80.6	74.9	67.8	61.6	48.4
Supply Driven (LB Pro Rata)	> 16	179.6	125.7	112.5	100.4	90.8	84.4	63.6
Supply Driven (LB Pro Rata)	14-16	162.7	109.0	98.4	89.1	84.1	79.0	65.3
Supply Driven (LB Pro Rata)	12-14	154.1	99.8	90.9	84.6	79.7	74.0	53.3
Supply Driven (LB Pro Rata)	10-12	140.6	93.0	85.2	79.5	73.6	68.1	52.5
Supply Driven (LB Pro Rata)	< 10	134.4	89.5	80.6	74.9	67.8	61.6	48.4

Figure TA 3-23 plots the results for the 10-Year flow volumes at the Lee Ferry Compact Point under each alternative to assess how they perform over a range of hydrologic conditions. The box plots are divided into five Flow Categories based on the preceding three-year average of Lees Ferry natural flow. In all categories except Dry Flow, the high end of the results range is cut off to improve comparisons in the Average and Dry Flow Categories. In each flow category the legally significant thresholds of 75.0 maf and 82.5 maf are shown as dashed lines.

Figure TA 3-23
Compact Point 10-Year Volume[8]



[8] High end of range is cut off to improve comparisons in Average and drier categories

In the Average Flow Category (12.0–14.0 maf), the Lee Ferry Compact Point 10-year median flows for all the alternatives are situated between 81.0 maf and 85.0 maf. The median 10-year Lee Ferry Compact Point flows are highest under both the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches); 84.6 maf each). The No Action Alternative (83.6 maf) has the second highest median flows followed by the Basic Coordination Alternatives (83.0 maf each), with the Maximum Operational Flexibility Alternative (82.3 maf) having the second lowest median flows and the Enhanced Coordination Alternative (81.3 maf) having the lowest flows.

The CCS Comparative Baseline has the largest variability of all the alternatives, with lower interquartile values dropping below 75.0 maf.

In the Moderately Dry Flow Category (10.0–12.0 maf), the median release under all action alternatives is below the No Action Alternative median release (82.3 maf).

In the Critically Dry Flow Category (less than 10.0 maf) the Lee Ferry Compact Point 10-year median flows range from approximately 75.0 maf in the Basic Coordination, Supply Driven (both the LB Priority and LB Pro Rata approaches), and No Action Alternatives to approximately 70.0 maf in the Enhanced Coordination and Maximum Operational Flexibility Alternatives and the CCS Comparative Baseline.

Table TA 3-17 below shows the statistical breakdown of Compact Point 10-year cumulative flow volumetric differences compared to 75.0 maf for each of the different hydrologic conditions under different alternatives. **Table TA 3-18** below shows the statistical breakdown of Compact Point 10-year cumulative flow volumetric differences compared to 82.5 maf for each of the different hydrologic conditions under different alternatives. Values greater than 0 (the dashed line) indicate years where the 10-year Compact Point volume exceeds 75.0 maf or 82.5 maf, respectively, whereas values less than 0 indicate years below 75.0 maf or 82.5 maf. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum 10-year flow volumes (in maf).

Figure TA 3-24 shows the volumetric difference between the 10-year Compact Point volume compared to 75.0 maf (left column) and 82.5 maf (right column). Values greater than 0 (the dashed line) indicate years where the 10-year Compact Point volume exceeds 75.0 maf or 82.5 maf, respectively, whereas values less than 0 indicate years below 75.0 maf or 82.5 maf. The y-axis is zoomed in to the lowest 10th percentile in the Critically Dry Flow Category (less than 10.0 maf) and the largest 90th percentile in the Average Flow Category (12.0–14.0 maf), to help compare alternatives. The figure visualizes the same data that is included in **Table TA 3-17** and **Table TA 3-18** in a conditional box plot.

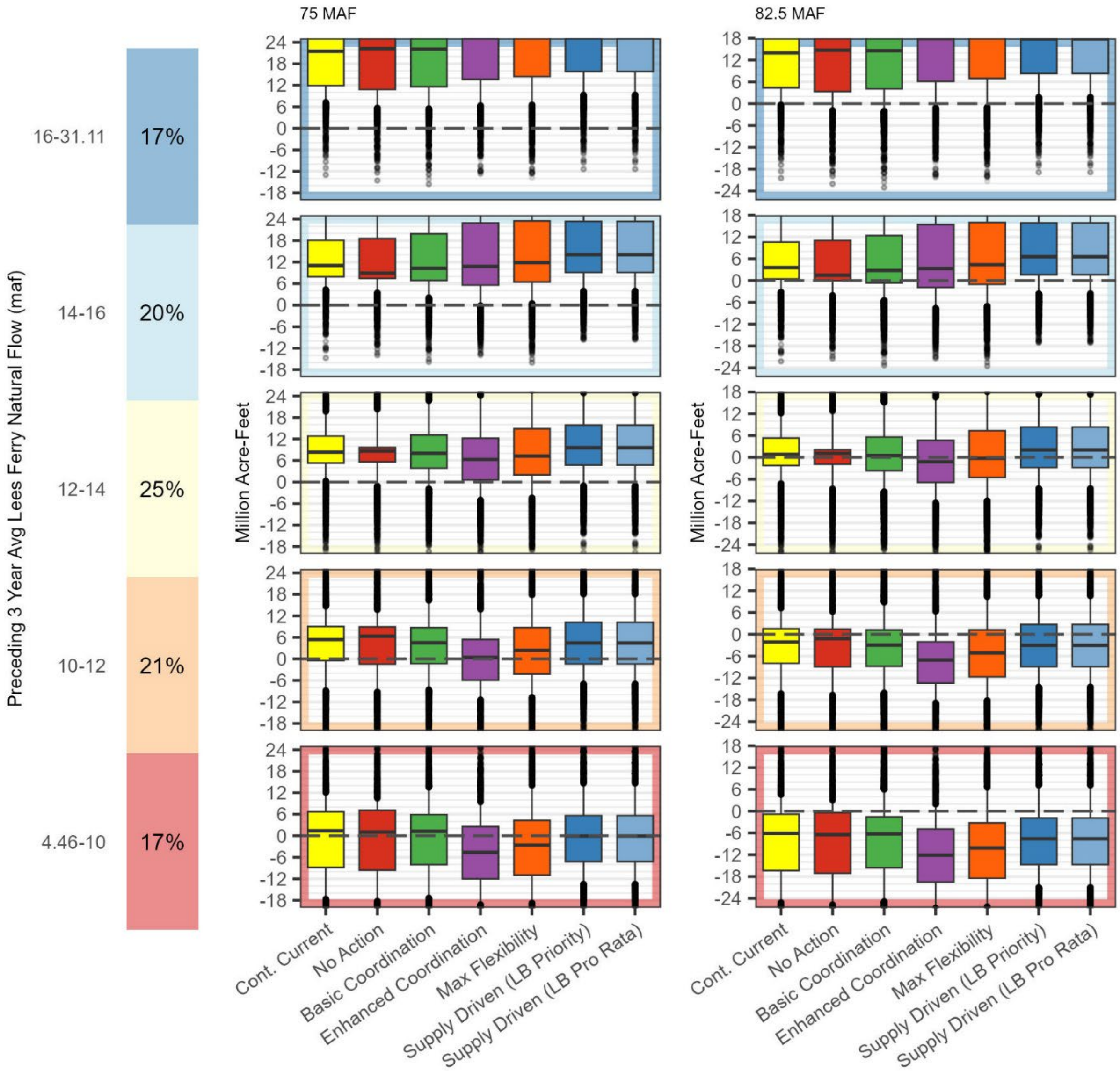
Table TA 3-17
Compact Point 10-Year Volume Relative to 75.0 maf

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	102.9	48.0	34.5	21.5	11.9	7.2	-13.0
CCS Comparative Baseline	14-16	81.2	29.7	18.1	11.1	7.9	4.3	-14.7
CCS Comparative Baseline	12-14	72.0	19.6	12.8	8.3	5.3	0.3	-25.2
CCS Comparative Baseline	10-12	61.6	14.6	9.0	5.4	-0.5	-8.8	-27.2
CCS Comparative Baseline	< 10	61.6	12.1	6.7	1.4	-8.8	-17.6	-35.2
No Action	> 16	103.2	49.0	35.7	22.2	10.8	5.8	-14.6
No Action	14-16	83.5	30.5	18.6	9.0	7.4	3.5	-13.9
No Action	12-14	72.2	20.2	9.6	8.6	5.6	-1.1	-24.7
No Action	10-12	62.0	13.7	8.9	6.3	-1.4	-9.2	-27.1
No Action	< 10	62.0	10.4	7.1	1.0	-9.6	-18.2	-33.1
Basic Coordination	> 16	102.9	48.4	35.3	22.1	11.6	5.5	-15.6
Basic Coordination	14-16	82.9	31.0	19.9	10.3	6.9	2.1	-15.8
Basic Coordination	12-14	75.3	22.6	13.1	8.0	3.9	-1.8	-25.6
Basic Coordination	10-12	61.9	16.2	8.7	4.5	-1.3	-8.5	-28.0
Basic Coordination	< 10	58.9	13.4	5.9	1.2	-8.1	-17.3	-35.2
Enhanced Coordination	> 16	105.8	51.4	38.6	25.5	13.7	6.4	-12.8
Enhanced Coordination	14-16	87.2	34.2	22.9	10.8	5.6	0.0	-14.0
Enhanced Coordination	12-14	80.3	24.0	12.2	6.3	0.6	-5.0	-27.2
Enhanced Coordination	10-12	65.9	13.7	5.4	0.4	-5.9	-11.3	-29.6
Enhanced Coordination	< 10	62.3	9.3	2.6	-4.6	-12.0	-19.2	-31.7
Max. Operational Flexibility	> 16	109.8	53.1	39.9	26.4	14.4	6.7	-13.8
Max. Operational Flexibility	14-16	87.6	35.0	23.5	11.9	6.5	0.6	-16.0
Max. Operational Flexibility	12-14	79.1	25.5	14.9	7.3	2.0	-4.4	-25.8
Max. Operational Flexibility	10-12	65.4	17.8	8.7	2.4	-4.2	-10.6	-28.5
Max. Operational Flexibility	< 10	60.4	13.9	4.3	-2.6	-11.0	-18.7	-32.7
Supply Driven (LB Priority)	> 16	104.6	50.7	37.5	25.4	15.8	9.4	-11.4
Supply Driven (LB Priority)	14-16	87.7	34.0	23.4	14.1	9.1	4.0	-9.7
Supply Driven (LB Priority)	12-14	79.1	24.8	15.9	9.6	4.7	-1.0	-21.7
Supply Driven (LB Priority)	10-12	65.6	18.0	10.2	4.5	-1.4	-6.9	-22.5
Supply Driven (LB Priority)	< 10	59.4	14.5	5.6	-0.1	-7.2	-13.4	-26.6
Supply Driven (LB Pro Rata)	> 16	104.6	50.7	37.5	25.4	15.8	9.4	-11.4
Supply Driven (LB Pro Rata)	14-16	87.7	34.0	23.4	14.1	9.1	4.0	-9.7
Supply Driven (LB Pro Rata)	12-14	79.1	24.8	15.9	9.6	4.7	-1.0	-21.7
Supply Driven (LB Pro Rata)	10-12	65.6	18.0	10.2	4.5	-1.4	-6.9	-22.5
Supply Driven (LB Pro Rata)	< 10	59.4	14.5	5.6	-0.1	-7.2	-13.4	-26.6

Table TA 3-18
Compact Point 10-Year Volume Relative to 82.5 maf

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	95.4	40.5	27.0	14.0	4.4	-0.3	-20.5
CCS Comparative Baseline	14-16	73.7	22.2	10.6	3.6	0.4	-3.2	-22.2
CCS Comparative Baseline	12-14	64.5	12.1	5.3	0.8	-2.2	-7.2	-32.7
CCS Comparative Baseline	10-12	54.1	7.1	1.5	-2.1	-8.0	-16.3	-34.7
CCS Comparative Baseline	< 10	54.1	4.6	-0.8	-6.1	-16.3	-25.1	-42.7
No Action	> 16	95.7	41.5	28.2	14.7	3.3	-1.7	-22.1
No Action	14-16	76.0	23.0	11.1	1.5	-0.1	-4.0	-21.4
No Action	12-14	64.7	12.7	2.1	1.1	-1.9	-8.6	-32.2
No Action	10-12	54.5	6.2	1.4	-1.2	-8.9	-16.7	-34.6
No Action	< 10	54.5	2.9	-0.4	-6.5	-17.1	-25.7	-40.6
Basic Coordination	> 16	95.4	40.9	27.8	14.6	4.1	-2.0	-23.1
Basic Coordination	14-16	75.4	23.5	12.4	2.8	-0.6	-5.4	-23.3
Basic Coordination	12-14	67.8	15.1	5.6	0.5	-3.6	-9.3	-33.1
Basic Coordination	10-12	54.4	8.7	1.2	-3.0	-8.8	-16.0	-35.5
Basic Coordination	< 10	51.4	5.9	-1.6	-6.3	-15.6	-24.8	-42.7
Enhanced Coordination	> 16	98.3	43.9	31.1	18.0	6.2	-1.1	-20.3
Enhanced Coordination	14-16	79.7	26.7	15.4	3.3	-1.9	-7.5	-21.5
Enhanced Coordination	12-14	72.8	16.5	4.7	-1.2	-6.9	-12.5	-34.7
Enhanced Coordination	10-12	58.4	6.2	-2.1	-7.1	-13.4	-18.8	-37.1
Enhanced Coordination	< 10	54.8	1.8	-4.9	-12.1	-19.5	-26.7	-39.2
Max. Operational Flexibility	> 16	102.3	45.6	32.4	18.9	6.9	-0.8	-21.3
Max. Operational Flexibility	14-16	80.1	27.5	16.0	4.4	-1.0	-6.9	-23.5
Max. Operational Flexibility	12-14	71.6	18.0	7.4	-0.2	-5.5	-11.9	-33.3
Max. Operational Flexibility	10-12	57.9	10.3	1.2	-5.1	-11.7	-18.1	-36.0
Max. Operational Flexibility	< 10	52.9	6.4	-3.2	-10.1	-18.5	-26.2	-40.2
Supply Driven (LB Priority)	> 16	97.1	43.2	30.0	17.9	8.3	1.9	-18.9
Supply Driven (LB Priority)	14-16	80.2	26.5	15.9	6.6	1.6	-3.5	-17.2
Supply Driven (LB Priority)	12-14	71.6	17.3	8.4	2.1	-2.8	-8.5	-29.2
Supply Driven (LB Priority)	10-12	58.1	10.5	2.7	-3.0	-8.9	-14.4	-30.0
Supply Driven (LB Priority)	< 10	51.9	7.0	-1.9	-7.6	-14.7	-20.9	-34.1
Supply Driven (LB Pro Rata)	> 16	97.1	43.2	30.0	17.9	8.3	1.9	-18.9
Supply Driven (LB Pro Rata)	14-16	80.2	26.5	15.9	6.6	1.6	-3.5	-17.2
Supply Driven (LB Pro Rata)	12-14	71.6	17.3	8.4	2.1	-2.8	-8.5	-29.2
Supply Driven (LB Pro Rata)	10-12	58.1	10.5	2.7	-3.0	-8.9	-14.4	-30.0
Supply Driven (LB Pro Rata)	< 10	51.9	7.0	-1.9	-7.6	-14.7	-20.9	-34.1

Figure TA 3-24
Compact Point 10-Year Volume Relative to 75 maf and 82.5 maf



Considering the Compact Point 10-year volume relative to 75.0 maf (left column), under the Average Flow Category (12.0–14.0 maf), all alternatives result in over 75 percent of years exceeding 75.0 maf. The Enhanced Coordination (6.3 maf) and Maximum Operational Flexibility (7.3 maf) Alternatives have the lowest medians. The Basic Coordination Alternative (8.0 maf), CCS Comparative Baseline (8.3 maf), and the No Action Alternative (8.6 maf) have similar medians while the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches; 9.6 maf) has the largest. Maximum Operational Flexibility (12.9 maf), Enhanced Coordination (11.6 maf), and Supply Driven (both LB Priority and LB Pro Rata approaches) have the largest interquartile ranges (11.1 maf), followed by Basic Coordination (9.2 maf), CCS Comparative Baseline (7.5 maf), and No Action (4.0 maf).

Under the Critically Dry Flow Category (less than 10.0 maf), median values for Enhanced Coordination (-4.6 maf) and Maximum Operational Flexibility (-2.6 maf) are negative, Supply Driven (both LB Priority and LB Pro Rata approaches) is near zero (-0.1 maf), and No Action (1.0 maf), Basic Coordination (1.2 maf), and CCS Comparative Baseline (1.4 maf) are greater than 0. The interquartile ranges increased for all alternatives relative to the Average Flow Category, but the largest increases occur for No Action (16.7 maf compared to 4.0 maf), CCS Comparative Baseline (15.5 maf compared to 7.5 maf) and Basic Coordination (14.0 maf compared to 9.2 maf).

Considering the Compact Point 10-year volume relative to 82.5 maf, under the Average Flow Category, the median values for Supply Driven (both LB Priority and LB Pro Rata approaches; 2.1 maf), No Action (1.1 maf), CCS Comparative Baseline (0.8 maf), and Basic Coordination (0.5 maf) are greater than zero, indicating that at least 50 percent of years result in Compact Point volumes above 82.5 maf. The median values for Maximum Operational Flexibility (-0.2 maf) and Enhanced Coordination (-1.2 maf) are below zero.

Under the Critically Dry Flow Category, all alternatives result in over 75 percent of years with a Compact Point 10-year volume less than 82.5 maf. The median values for Enhanced Coordination (-12.1 maf) and Maximum Operational Flexibility (-10.1 maf) are the most negative, followed by Supply Driven (both LB Priority and LB Pro Rata approaches; -7.6 maf), No Action (-6.5 maf), Basic Coordination (-6.3 maf), and CCS Comparative Baseline (-6.1 maf).

Interquartile ranges are the same as when using comparing the Compact Point 10-year volume to 75 maf.

Hoover Dam

This section compares all the alternatives and the CCS Comparative Baseline with respect to CY releases from Hoover Dam at Lake Mead.

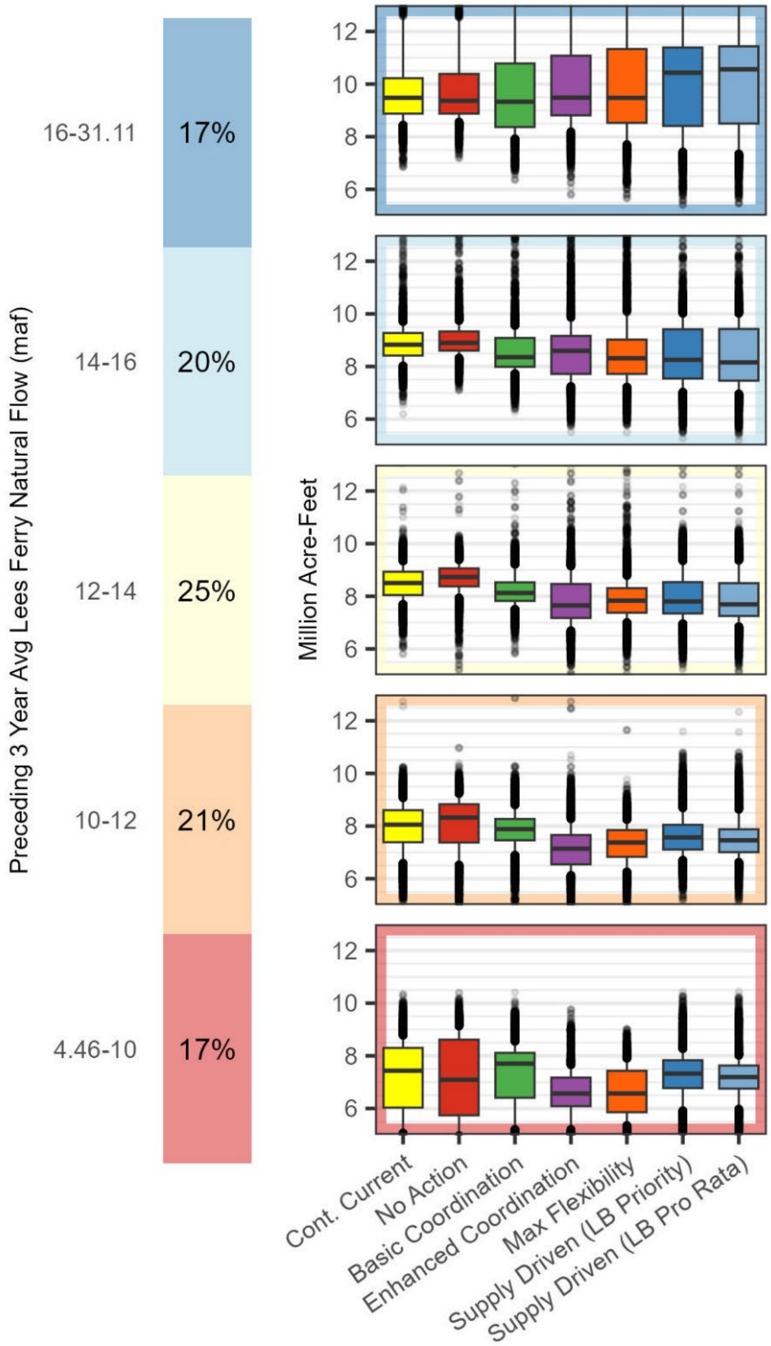
Table TA 3-19 below shows the statistical breakdown of CY releases (in maf) from Hoover Dam, at Lake Mead, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum CY releases.

Figure TA 3-25 below looks at the response of Hoover Dam CY releases to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-19** in a conditional box plot. Note that the range of releases has been truncated at the high end to facilitate comparisons in the Average, Moderately Dry, and Dry Flow Categories.

Table TA 3-19
EOCY Releases from Hoover Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	37.94	12.56	10.22	9.48	8.88	8.45	6.85
CCS Comparative Baseline	14-16	22.33	9.70	9.27	8.83	8.42	8.03	6.19
CCS Comparative Baseline	12-14	21.35	9.34	8.93	8.50	8.05	7.70	5.81
CCS Comparative Baseline	10-12	13.17	9.06	8.60	8.05	7.39	6.60	4.28
CCS Comparative Baseline	< 10	10.36	8.77	8.30	7.44	6.03	5.08	2.64
No Action	> 16	37.85	12.54	10.39	9.37	8.88	8.56	7.20
No Action	14-16	22.37	9.74	9.33	8.90	8.60	8.33	7.10
No Action	12-14	22.68	9.38	9.06	8.73	8.38	7.94	5.19
No Action	10-12	13.27	9.23	8.83	8.32	7.38	6.53	3.72
No Action	< 10	10.41	9.12	8.62	7.09	5.74	4.98	2.88
Basic Coordination	> 16	38.04	13.18	10.78	9.33	8.37	7.92	6.37
Basic Coordination	14-16	21.75	9.54	9.08	8.36	7.99	7.73	6.27
Basic Coordination	12-14	22.02	9.21	8.53	8.13	7.82	7.51	5.83
Basic Coordination	10-12	12.87	8.79	8.27	7.88	7.46	6.90	4.14
Basic Coordination	< 10	10.41	8.54	8.11	7.70	6.41	5.22	2.60
Enhanced Coordination	> 16	38.33	14.38	11.08	9.48	8.81	8.20	5.77
Enhanced Coordination	14-16	23.36	9.86	9.16	8.59	7.72	7.25	5.51
Enhanced Coordination	12-14	24.08	9.14	8.46	7.65	7.17	6.70	4.89
Enhanced Coordination	10-12	14.35	8.26	7.66	7.14	6.55	6.13	4.32
Enhanced Coordination	< 10	9.76	7.65	7.17	6.57	6.09	5.22	2.85
Max. Operational Flexibility	> 16	38.48	14.71	11.33	9.48	8.53	7.71	5.67
Max. Operational Flexibility	14-16	23.91	10.05	9.02	8.31	7.72	7.22	5.50
Max. Operational Flexibility	12-14	24.99	8.78	8.31	7.83	7.37	7.01	4.98
Max. Operational Flexibility	10-12	16.69	8.24	7.85	7.38	6.83	6.27	4.70
Max. Operational Flexibility	< 10	9.02	7.91	7.43	6.57	5.86	5.36	3.66
Supply Driven (LB Priority)	> 16	38.25	13.70	11.39	10.43	8.41	7.43	5.40
Supply Driven (LB Priority)	14-16	20.06	10.01	9.41	8.25	7.54	7.04	5.27
Supply Driven (LB Priority)	12-14	19.51	9.34	8.54	7.80	7.35	6.96	4.87
Supply Driven (LB Priority)	10-12	13.13	8.68	8.05	7.57	7.11	6.71	4.75
Supply Driven (LB Priority)	< 10	10.43	8.26	7.83	7.32	6.77	5.93	3.46
Supply Driven (LB Pro Rata)	> 16	38.25	13.74	11.43	10.56	8.50	7.35	5.45
Supply Driven (LB Pro Rata)	14-16	20.06	10.01	9.42	8.16	7.46	6.97	5.19
Supply Driven (LB Pro Rata)	12-14	19.51	9.36	8.50	7.69	7.25	6.85	4.79
Supply Driven (LB Pro Rata)	10-12	13.54	8.63	7.88	7.46	7.01	6.63	4.72
Supply Driven (LB Pro Rata)	< 10	10.43	8.00	7.63	7.19	6.76	5.99	3.48

Figure TA 3-25
CY Releases from Hoover Dam[9]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[9] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median CY releases from Hoover Dam range from 7.65 maf, under the Enhanced Coordination Alternative, to 8.73 maf, under the No Action Alternative. The median releases for the No Action and Basic Coordination Alternatives and the CCS Comparative Baseline are all above 8.0 maf, meanwhile, the median releases for the Enhanced Coordination, Maximum Operational Flexibility, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives are all less than 8.0 maf. The No Action and Basic Coordination Alternatives have the least interquartile variability, with interquartile ranges spanning around 700.0 kaf to 800.0 kaf. The Enhanced Coordination, Supply Driven (LB Priority approach), and Supply Driven (LB Pro Rata approach) Alternatives have the greatest interquartile variability, with interquartile ranges spanning between 1.2 maf to 1.3 maf.

In the Dry Flow Category (less than 10.0 maf), the median CY releases from Hoover Dam range from 6.57 maf under both the Enhanced Coordination and Maximum Operational Flexibility Alternatives, to 7.70 maf, under the Basic Coordination Alternative. The interquartile variability ranges increased notably for CCS Comparative Baseline and the No Action, Basic Coordination, and Maximum Operational Flexibility Alternatives. The No Action Alternative has the lowest interquartile range and greatest variability, spanning from 5.74 maf to 8.62 maf. The Maximum Operational Flexibility Alternative has the next lowest interquartile range, with the 25th percentile dropping to 5.86 maf.

Davis Dam

Releases from Davis Dam, at Lake Mohave, are based on target elevations defined by the existing rule curve (refer to **TA 6**, Water Quality). Inflows into Lake Mohave vary across alternatives, and because elevations are kept to the range determined by the rule curve, releases from Davis Dam subsequently vary across alternatives.

Table TA 3-20 below shows the statistical breakdown of CY releases (in maf) from Davis Dam, at Lake Mohave, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOCY releases.

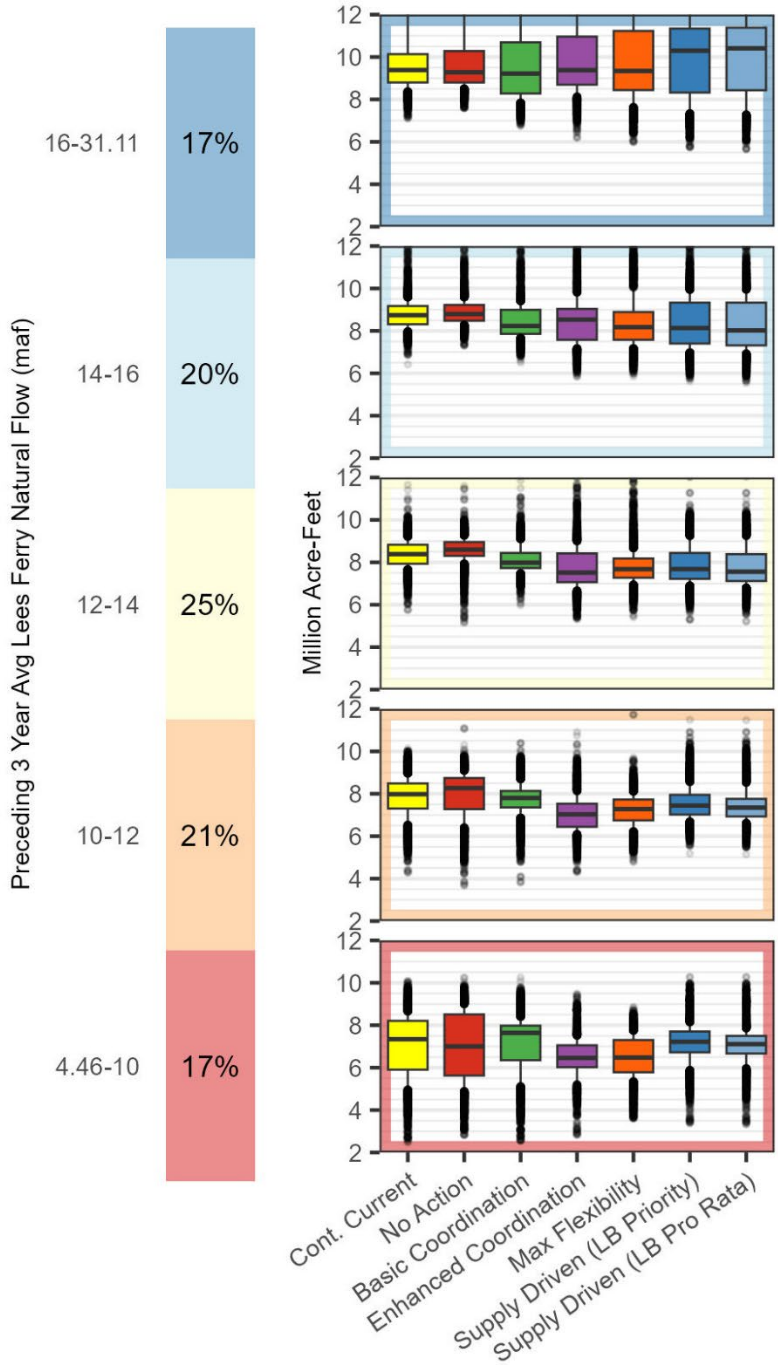
Figure TA 3-26 below looks at the response of Davis Dam CY releases to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-20** in a conditional box plot. Note that the range of releases has been truncated at the high end to facilitate comparisons in the Average, Moderately Dry, and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median CY releases from Davis Dam range from 7.5 maf, under the Enhanced Coordination Alternative, to 8.6 maf, under the No Action Alternative. The median release for the CCS Comparative Baseline is 8.4 maf and for the Basic Coordination Alternative is 8.0 maf. Meanwhile, the median releases for the Maximum Operational Flexibility and the two Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives are closer to the median release under Enhanced Coordination (at 7.6 maf, 7.7 maf, and 7.7 maf, respectively). The No Action and Basic Coordination Alternatives have the least interquartile variability, with interquartile ranges spanning around 600.0 kaf to 700.0 kaf.

Table TA 3-20
CY Releases from Davis Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	37.6	12.6	10.1	9.4	8.8	8.4	7.1
CCS Comparative Baseline	14-16	22.5	9.6	9.2	8.7	8.3	8.0	6.4
CCS Comparative Baseline	12-14	21.9	9.2	8.8	8.4	7.9	7.7	5.7
CCS Comparative Baseline	10-12	13.3	9.0	8.5	8.0	7.3	6.5	4.3
CCS Comparative Baseline	< 10	10.1	8.7	8.2	7.3	5.9	5.0	2.5
No Action	> 16	37.5	12.5	10.3	9.3	8.8	8.5	7.6
No Action	14-16	22.6	9.6	9.2	8.8	8.5	8.3	7.3
No Action	12-14	23.2	9.3	9.0	8.6	8.3	7.9	5.2
No Action	10-12	13.4	9.1	8.7	8.3	7.3	6.4	3.7
No Action	< 10	10.3	9.0	8.5	7.0	5.6	4.9	2.8
Basic Coordination	> 16	37.7	13.4	10.7	9.2	8.3	7.8	6.8
Basic Coordination	14-16	21.8	9.4	9.0	8.2	7.9	7.7	6.5
Basic Coordination	12-14	22.6	9.1	8.4	8.0	7.7	7.5	6.0
Basic Coordination	10-12	13.0	8.7	8.1	7.8	7.4	6.9	3.8
Basic Coordination	< 10	10.3	8.4	8.0	7.6	6.4	5.1	2.6
Enhanced Coordination	> 16	38.0	14.4	11.0	9.4	8.7	8.1	6.2
Enhanced Coordination	14-16	23.4	9.8	9.0	8.5	7.6	7.2	5.8
Enhanced Coordination	12-14	24.6	9.0	8.4	7.5	7.1	6.7	5.3
Enhanced Coordination	10-12	14.5	8.1	7.5	7.0	6.4	6.1	4.3
Enhanced Coordination	< 10	9.5	7.5	7.1	6.5	6.0	5.2	2.8
Max. Operational Flexibility	> 16	38.2	14.8	11.2	9.3	8.4	7.6	6.0
Max. Operational Flexibility	14-16	23.8	10.0	8.9	8.2	7.6	7.2	5.9
Max. Operational Flexibility	12-14	25.5	8.7	8.2	7.7	7.3	6.9	5.4
Max. Operational Flexibility	10-12	16.8	8.1	7.7	7.3	6.7	6.2	4.8
Max. Operational Flexibility	< 10	8.9	7.7	7.3	6.5	5.8	5.3	3.6
Supply Driven (LB Priority)	> 16	37.9	13.8	11.3	10.3	8.3	7.3	5.8
Supply Driven (LB Priority)	14-16	20.2	9.9	9.3	8.1	7.4	7.0	5.6
Supply Driven (LB Priority)	12-14	19.8	9.2	8.4	7.7	7.2	6.9	5.3
Supply Driven (LB Priority)	10-12	13.0	8.6	7.9	7.4	7.0	6.7	5.2
Supply Driven (LB Priority)	< 10	10.3	8.1	7.7	7.2	6.7	5.9	3.4
Supply Driven (LB Pro Rata)	> 16	37.9	13.9	11.4	10.4	8.4	7.3	5.7
Supply Driven (LB Pro Rata)	14-16	20.2	9.9	9.3	8.0	7.3	6.9	5.5
Supply Driven (LB Pro Rata)	12-14	19.8	9.3	8.4	7.6	7.1	6.8	5.2
Supply Driven (LB Pro Rata)	10-12	13.4	8.5	7.8	7.3	6.9	6.6	5.1
Supply Driven (LB Pro Rata)	< 10	10.3	7.9	7.5	7.1	6.7	6.0	3.3

Figure TA 3-26
CY Releases from Davis Dam[10]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[10] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

In the Dry Flow Category (less than 10.0 maf), the median CY releases from Davis Dam range from 6.5 maf under both the Enhanced Coordination and Maximum Operational Flexibility Alternatives, to 7.6 maf, under the Basic Coordination Alternative. The interquartile variability ranges increased notably for the CCS Comparative Baseline and the No Action, Basic Coordination, and Maximum Operational Flexibility Alternatives. The No Action Alternative has the lowest interquartile range and greatest variability, spanning from 5.6 maf to 8.5 maf. The Maximum Operational Flexibility Alternative has the next lowest interquartile range, with the 25th percentile dropping to 5.8 maf.

Parker Dam

Releases from Parker Dam, at Lake Havasu, are based on target elevations defined by the existing rule curve (refer to **TA 6**, Water Quality). Inflows into Lake Havasu vary across alternatives, and because elevations are kept to the range determined by the rule curve, releases from Parker Dam subsequently vary across alternatives.

Table TA 3-21 below shows the statistical breakdown of CY releases (in maf) from Parker Dam, at Lake Havasu, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum EOCY releases.

Figure TA 3-27 below looks at the response of Parker Dam CY releases to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that is included in **Table TA 3-21** in a conditional box plot Note that the range of releases has been truncated at the high end to facilitate comparisons in the Average, Moderately Dry, and Dry Flow Categories.

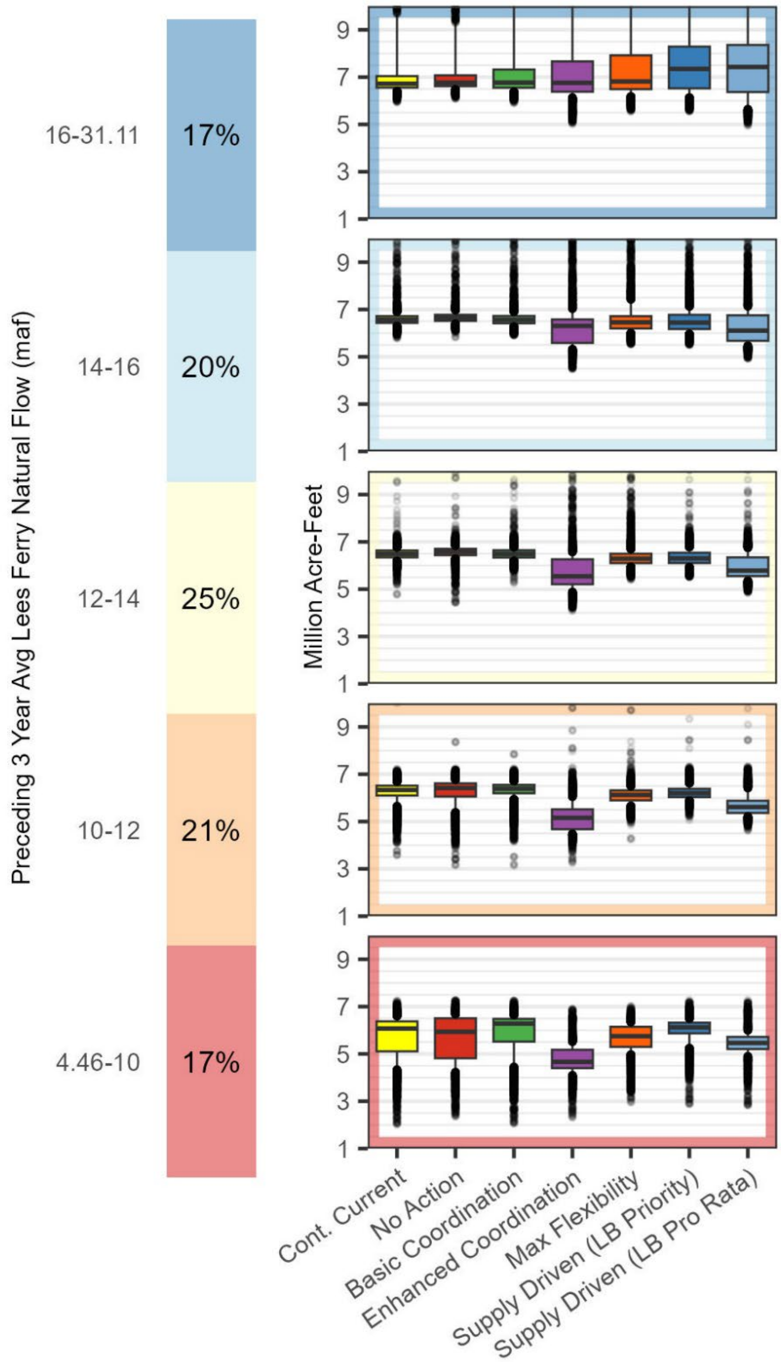
In the Average Flow Category (12.0–14.0 maf), the median CY releases from Parker Dam range from 5.5 maf, under the Enhanced Coordination Alternative, to 6.6 maf, under the No Action Alternative. The median release for both the CCS Comparative Baseline and for the Basic Coordination Alternative is 6.5 maf. The median release for the Supply Driven Alternative (LB Pro Rata approach) is 5.8 maf and for both the Maximum Operational Flexibility and the Supply Driven (LB Priority approach) Alternatives is 6.3 maf. The Enhanced Coordination Alternatives has the greatest interquartile variability, with interquartile ranges spanning 1.1 maf.

In the Dry Flow Category (less than 10.0 maf), the median CY releases from Davis Dam range from 4.7 maf under the Enhanced Coordination Alternative, to 6.3 maf, under the Basic Coordination Alternative. The interquartile variability ranges increased notably for the CCS Comparative Baseline and the No Action, Basic Coordination, and Maximum Operational Flexibility Alternatives. The Enhanced Coordination Alternative has the lowest interquartile range, with the 25th percentile dropping to 4.4 maf.

Table TA 3-21
CY Releases from Parker Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	34.8	9.7	7.0	6.7	6.6	6.4	5.9
CCS Comparative Baseline	14-16	19.9	6.9	6.7	6.6	6.4	6.3	5.8
CCS Comparative Baseline	12-14	18.7	6.8	6.6	6.5	6.3	6.2	4.8
CCS Comparative Baseline	10-12	10.6	6.7	6.5	6.3	6.1	5.7	3.6
CCS Comparative Baseline	< 10	7.2	6.6	6.4	6.1	5.1	4.3	2.0
No Action	> 16	34.4	9.3	7.1	6.8	6.6	6.5	6.1
No Action	14-16	19.6	7.0	6.8	6.6	6.5	6.4	5.8
No Action	12-14	19.7	6.8	6.7	6.6	6.4	6.3	4.4
No Action	10-12	10.6	6.8	6.6	6.4	6.1	5.4	3.2
No Action	< 10	7.3	6.7	6.5	5.9	4.8	4.2	2.4
Basic Coordination	> 16	34.6	10.3	7.3	6.8	6.6	6.4	5.9
Basic Coordination	14-16	19.2	6.9	6.7	6.6	6.4	6.3	5.9
Basic Coordination	12-14	19.1	6.8	6.6	6.5	6.3	6.2	5.2
Basic Coordination	10-12	10.2	6.7	6.6	6.4	6.2	5.9	3.1
Basic Coordination	< 10	7.2	6.7	6.5	6.3	5.5	4.5	2.1
Enhanced Coordination	> 16	34.9	11.3	7.7	6.8	6.4	6.1	5.0
Enhanced Coordination	14-16	20.1	7.0	6.6	6.3	5.6	5.3	4.5
Enhanced Coordination	12-14	21.1	6.6	6.3	5.5	5.2	4.9	4.1
Enhanced Coordination	10-12	12.0	6.0	5.5	5.2	4.7	4.5	3.2
Enhanced Coordination	< 10	6.9	5.5	5.2	4.7	4.4	4.1	2.3
Max. Operational Flexibility	> 16	35.0	11.7	7.9	6.8	6.5	6.2	5.5
Max. Operational Flexibility	14-16	20.6	7.4	6.7	6.5	6.2	6.0	5.5
Max. Operational Flexibility	12-14	21.7	6.7	6.5	6.3	6.1	5.9	5.4
Max. Operational Flexibility	10-12	14.5	6.5	6.3	6.1	5.9	5.7	4.3
Max. Operational Flexibility	< 10	7.0	6.3	6.1	5.8	5.3	5.0	2.9
Supply Driven (LB Priority)	> 16	34.8	10.9	8.3	7.3	6.5	6.1	5.5
Supply Driven (LB Priority)	14-16	17.7	7.1	6.8	6.4	6.2	6.0	5.5
Supply Driven (LB Priority)	12-14	16.4	6.8	6.5	6.3	6.1	5.9	5.5
Supply Driven (LB Priority)	10-12	10.7	6.6	6.4	6.2	6.0	5.9	5.1
Supply Driven (LB Priority)	< 10	7.3	6.5	6.3	6.1	5.9	5.3	2.9
Supply Driven (LB Pro Rata)	> 16	34.8	10.9	8.4	7.4	6.4	5.6	5.0
Supply Driven (LB Pro Rata)	14-16	17.7	7.1	6.8	6.1	5.7	5.5	4.9
Supply Driven (LB Pro Rata)	12-14	16.4	6.8	6.3	5.8	5.6	5.3	4.8
Supply Driven (LB Pro Rata)	10-12	10.9	6.4	5.9	5.6	5.4	5.2	4.6
Supply Driven (LB Pro Rata)	< 10	7.3	6.0	5.7	5.5	5.2	4.9	2.8

Figure TA 3-27
CY Releases from Parker Dam (Box Plot)[11]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[11] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

TA 3.2.4 Issue 4: River Flows

Issue 4 addresses how operational activities would affect river flows. This was evaluated by comparing the various action alternatives to the No Action Alternative and the CCS Comparative Baseline for the following metrics:

- Annual Colorado River flows below Hoover Dam
- Annual Colorado River flows below Davis Dam
- Annual Colorado River flows below Parker Dam
- Annual Colorado River flows at Imperial Dam
- Annual Colorado River flow below Imperial Dam
- Annual Colorado River flow below Morelos Diversion Dam

The conclusions in this section are drawn from three-year average natural flow model outputs and are framed using five flow categories. The conditional box plots show the distribution of river flows (y-axis) over the full analysis period relative to each alternative (x-axis).

Reach 1: Glen Canyon Dam to Lake Mead

This reach of the river (between Glen Canyon Dam and Lake Mead) extends for 292-miles through narrow canyons, including Grand Canyon National Park. River flows in this reach primarily consist of controlled releases from Glen Canyon Dam at Lake Powell. Refer to Issue 3 for the analysis of WY releases and the 10-year cumulative releases from Glen Canyon Dam for the No Action Alternative, CCS Comparative Baseline, and action alternatives. While the results of the CRSS analysis are on an annual basis, monthly releases from Lake Powell at Glen Canyon Dam meet the 2016 LTEMP ROD (Reclamation 2016) minimum flows. Reclamation has the option to conduct high flow experiment releases from Glan Canyon Dam under certain conditions to reduce sediment deposition, which usually occur in durations ranging from 60 hours to 10 days. Refer to **TA 5**, Geomorphology and Sediment, and **TA 8**, Biological Resources – Fish and Other Aquatic Species, for the analysis of high flow experiment flows from Glen Canyon Dam.

This reach also includes contributions from the Paria River and Little Colorado River, two perennial tributaries that discharge to the Colorado River between Glen Canyon Dam and Lake Mead. Based on historical USGS gage data, inflows from the Paria River and Little Colorado River make up approximately three percent of the total flow in this reach of the Colorado River (USGS 2025a). From 1906 to 2005, the annual inflow of the Paria River averaged 21.0 kafy and the Little Colorado River inflow averaged 180.0 kafy. Since 2007, the annual inflow from the Paria River averaged 17.0 kafy, and the Little Colorado River inflow averaged 274.0 kafy. Inflows from the Paria River and Little Colorado River were modeled in CRSS as the same across alternatives.

Relating back to the Issue 3 analysis for Glen Canyon Dam, in the Average Flow Category, the median WY releases from Glen Canyon Dam are: 8.39 maf under both Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches), 8.23 maf under the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives, 8.17 maf under the Maximum Operational Flexibility Alternative, and 7.87 maf under the Enhanced Coordination Alternative. The historic combined inflows from the Paria River and the Little Colorado River (291.0 kaf combined) are approximately 3.4 percent to 3.7 percent of these modeled Average Flow Category median Glen Canyon Dam releases.

Reach 2: Hoover Dam to Lake Mohave

This reach of the river (starting from the Hoover Dam at Lake Mead) is 67-miles long and flows through Pyramid Canyon, El Dorado Canyon, and Black Canyon. Lake Mohave is on the downstream end of the reach, and it acts hydraulically like a tailwater to Hoover Dam. River flows in this reach primarily consist of releases from Hoover Dam and tributary inflows. Refer to Issue 3 for the analysis of CY releases from Hoover Dam for all alternatives and the CCS Comparative Baseline. According to the 2007 Final EIS, the tributary inflows, mostly from side washes, comprise less than 1 percent of the total annual flow in this reach (Reclamation 2007a)

Table TA 3-22 below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River below Hoover Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes.

Figure TA 3-28 below looks at the response of annual Colorado River flow volumes below Hoover Dam to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-22** in a conditional box plot. Note that the range of volumes has been truncated at the high end to facilitate comparisons in the Average and Dry Flow Categories.

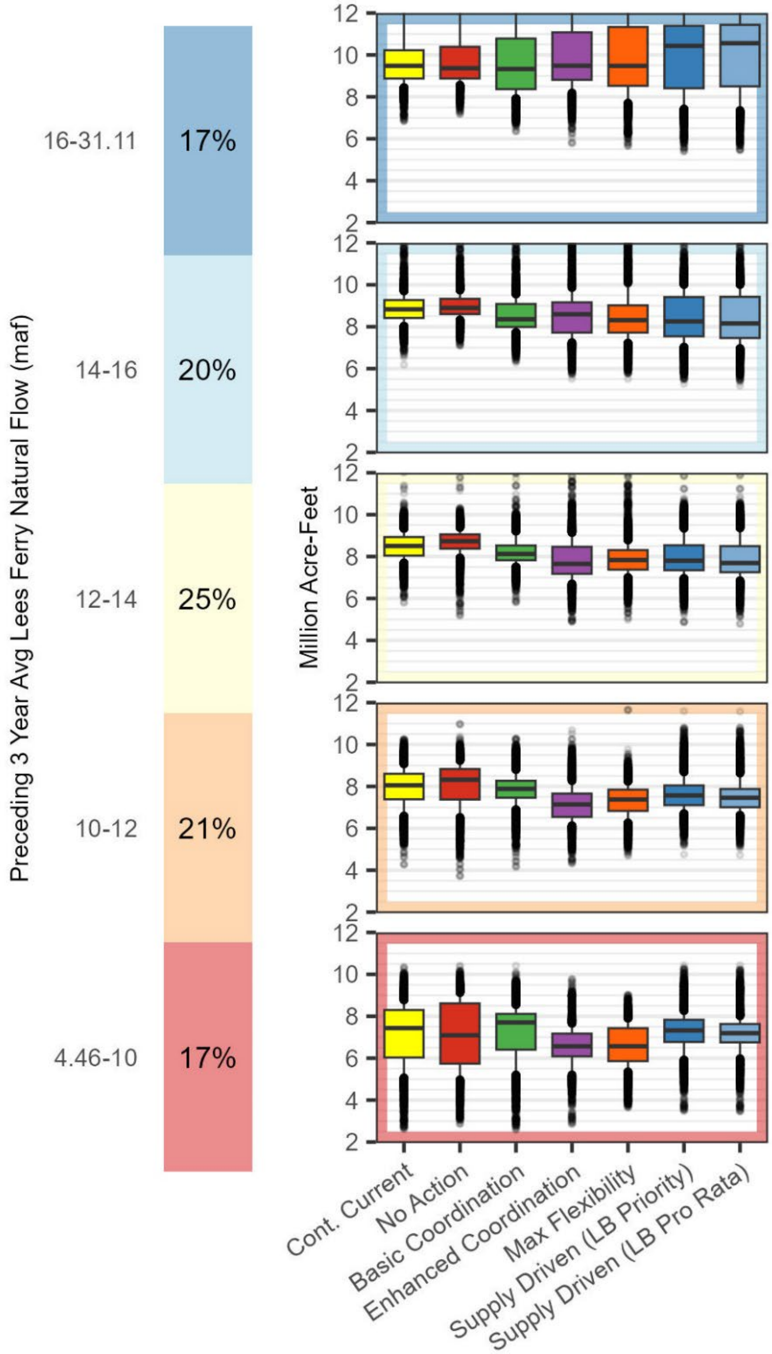
In the Average Flow Category (12.0–14.0 maf), the median annual flow volumes below Hoover Dam are 7.7 maf for the Enhanced Coordination and Supply Driven (LB Pro Rata approach) Alternatives, 7.8 maf for the Maximum Operational Flexibility and Supply Driven (LB Priority approach) Alternatives, 8.1 maf for the Basic Coordination Alternative, 8.5 maf for the CCS Comparative Baseline, and 8.7 maf for the No Action Alternative. The No Action and Basic Coordination Alternatives have the least interquartile variability, with interquartile annual flow volume ranges spanning about 700.0 kaf. The Enhanced Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives have the greatest interquartile variability, with interquartile annual flow volume ranges spanning around 1.2 to 1.3 maf.

In the Dry Flow Category (less than 10.0 maf), the median annual volumes range from 6.6 maf (Enhanced Coordination and the Maximum Operational Flexibility Alternatives) to 7.7 maf (Basic Coordination Alternative). The interquartile variability ranges grew notably for the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives. The No Action Alternative has the largest variability with an interquartile range spanning 5.7 to 8.6 maf.

Table TA 3-22
Annual Flow Volume Below Hoover Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	37.9	12.6	10.2	9.5	8.9	8.5	6.9
CCS Comparative Baseline	14-16	22.3	9.7	9.3	8.8	8.4	8.0	6.2
CCS Comparative Baseline	12-14	21.3	9.3	8.9	8.5	8.0	7.7	5.8
CCS Comparative Baseline	10-12	13.2	9.1	8.6	8.1	7.4	6.6	4.3
CCS Comparative Baseline	< 10	10.4	8.8	8.3	7.4	6.0	5.1	2.6
No Action	> 16	37.8	12.5	10.4	9.4	8.9	8.6	7.2
No Action	14-16	22.4	9.7	9.3	8.9	8.6	8.3	7.1
No Action	12-14	22.7	9.4	9.1	8.7	8.4	7.9	5.2
No Action	10-12	13.3	9.2	8.8	8.3	7.4	6.5	3.7
No Action	< 10	10.4	9.1	8.6	7.1	5.7	5.0	2.9
Basic Coordination	> 16	38.0	13.2	10.8	9.3	8.4	7.9	6.4
Basic Coordination	14-16	21.8	9.5	9.1	8.4	8.0	7.7	6.3
Basic Coordination	12-14	22.0	9.2	8.5	8.1	7.8	7.5	5.8
Basic Coordination	10-12	12.9	8.8	8.3	7.9	7.5	6.9	4.1
Basic Coordination	< 10	10.4	8.5	8.1	7.7	6.4	5.2	2.6
Enhanced Coordination	> 16	38.3	14.4	11.1	9.5	8.8	8.2	5.8
Enhanced Coordination	14-16	23.4	9.9	9.2	8.6	7.7	7.2	5.5
Enhanced Coordination	12-14	24.1	9.1	8.5	7.7	7.2	6.7	4.9
Enhanced Coordination	10-12	14.4	8.3	7.7	7.1	6.5	6.1	4.3
Enhanced Coordination	< 10	9.8	7.7	7.2	6.6	6.1	5.2	2.9
Max. Operational Flexibility	> 16	38.5	14.7	11.3	9.5	8.5	7.7	5.7
Max. Operational Flexibility	14-16	23.9	10.1	9.0	8.3	7.7	7.2	5.5
Max. Operational Flexibility	12-14	25.0	8.8	8.3	7.8	7.4	7.0	5.0
Max. Operational Flexibility	10-12	16.7	8.2	7.8	7.4	6.8	6.3	4.7
Max. Operational Flexibility	< 10	9.0	7.9	7.4	6.6	5.9	5.4	3.7
Supply Driven (LB Priority)	> 16	38.2	13.7	11.4	10.4	8.4	7.4	5.4
Supply Driven (LB Priority)	14-16	20.1	10.0	9.4	8.3	7.5	7.0	5.3
Supply Driven (LB Priority)	12-14	19.5	9.3	8.5	7.8	7.3	7.0	4.9
Supply Driven (LB Priority)	10-12	13.1	8.7	8.0	7.6	7.1	6.7	4.8
Supply Driven (LB Priority)	< 10	10.4	8.3	7.8	7.3	6.8	5.9	3.5
Supply Driven (LB Pro Rata)	> 16	38.2	13.7	11.4	10.6	8.5	7.4	5.5
Supply Driven (LB Pro Rata)	14-16	20.1	10.0	9.4	8.2	7.5	7.0	5.2
Supply Driven (LB Pro Rata)	12-14	19.5	9.4	8.5	7.7	7.3	6.9	4.8
Supply Driven (LB Pro Rata)	10-12	13.5	8.6	7.9	7.5	7.0	6.6	4.7
Supply Driven (LB Pro Rata)	< 10	10.4	8.0	7.6	7.2	6.8	6.0	3.5

Figure TA 3-28
Annual Flow Volume Below Hoover Dam[12]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

12 High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

Reach 3: Davis Dam to Lake Havasu

This reach of the Colorado River (starting from Davis Dam at Lake Mohave) is 84-miles long and forms Lake Havasu. River flows in this reach are mostly comprised of releases from Davis Dam and tributary inflow from the Bill Williams River.

Inflows from the Bill Williams River discharge directly into Lake Havasu and are regulated by the USACE operations of Alamo Dam. From 1906 to 2007, the annual inflow averaged 102,000 af. From 2008 to 2022 the annual inflow averaged 105,000 af (USGS, 2025b).

Releases from Davis Dam are the variable that would differ between alternatives, so they have been used for comparison. **Table TA 3-23** below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River below Davis Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes.

Figure TA 3-29 below looks at the response of annual Colorado River flow volumes below Davis Dam to different hydrologic conditions under different alternatives by looking at the preceding 3-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-23** in a conditional box plot. Note that the range of volumes has been truncated at the high end to facilitate comparisons in the average and drier flow categories.

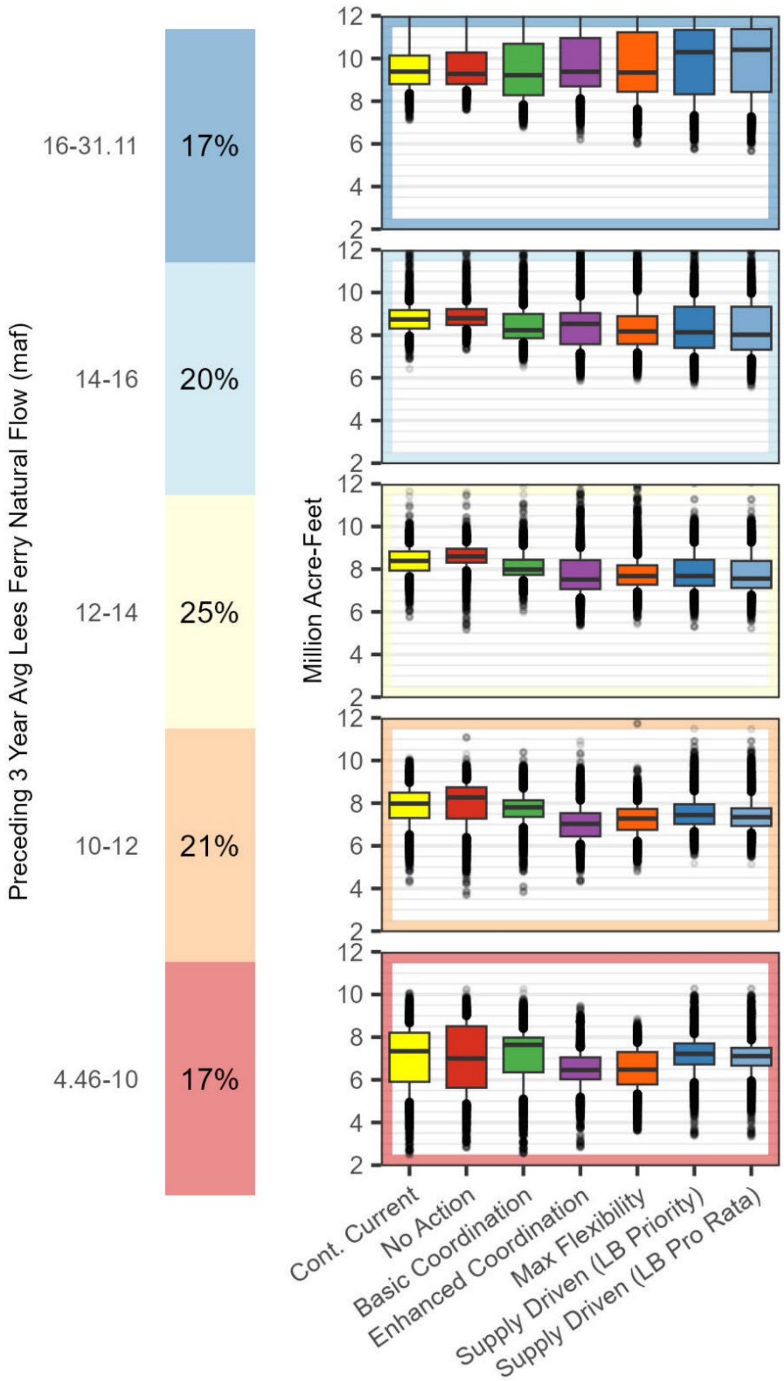
Median flows are most similar across different alternatives for the two wettest flow categories. In the Wet Flow Category (greater than 16.0 maf), the Supply Driven Alternative (LB Priority approach), and Supply Driven Alternative (LB Pro Rata approach) have the highest median annual flow volume below Davis Dam of 10.3 maf and 10.4 maf, respectively, and the greatest interquartile variability. The other alternatives and the CCS Comparative Baseline have median annual flow volumes around 9.2 to 9.4 maf. The No Action Alternative and CCS Comparative Baseline have the least interquartile variability.

In the Average Flow Category (12–14 maf), the median annual flow volumes below Davis Dam for the Enhanced Coordination, Supply Driven (LB Pro Rata approach), Maximum Operational Flexibility, and Supply Driven (LB Priority approach) Alternatives are 7.5 maf, 7.6 maf, 7.7 maf, and 7.7 maf, respectively. The median annual flow volumes for the Basic Coordination Alternative, No Action Alternative and CCS Comparative Baseline are 8.0 maf, 8.6 maf, and 8.4 maf, respectively. The No Action and Basic Coordination Alternatives have the least interquartile variability, with interquartile annual flow volume ranges spanning about 600.0-700.0 kaf. And both Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) have the greatest interquartile variability, with interquartile annual flow volume ranges spanning around 1.2 to 1.4 maf.

Table TA 3-23
Annual Flow Volume Below Davis Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	37.6	12.6	10.1	9.4	8.8	8.4	7.1
CCS Comparative Baseline	14-16	22.5	9.6	9.2	8.7	8.3	8.0	6.4
CCS Comparative Baseline	12-14	21.9	9.2	8.8	8.4	7.9	7.7	5.7
CCS Comparative Baseline	10-12	13.3	9.0	8.5	8.0	7.3	6.5	4.3
CCS Comparative Baseline	< 10	10.1	8.7	8.2	7.3	5.9	5.0	2.5
No Action	> 16	37.5	12.5	10.3	9.3	8.8	8.5	7.6
No Action	14-16	22.6	9.6	9.2	8.8	8.5	8.3	7.3
No Action	12-14	23.2	9.3	9.0	8.6	8.3	7.9	5.2
No Action	10-12	13.4	9.1	8.7	8.3	7.3	6.4	3.7
No Action	< 10	10.3	9.0	8.5	7.0	5.6	4.9	2.8
Basic Coordination	> 16	37.7	13.4	10.7	9.2	8.3	7.8	6.8
Basic Coordination	14-16	21.8	9.4	9.0	8.2	7.9	7.7	6.5
Basic Coordination	12-14	22.6	9.1	8.4	8.0	7.7	7.5	6.0
Basic Coordination	10-12	13.0	8.7	8.1	7.8	7.4	6.9	3.8
Basic Coordination	< 10	10.3	8.4	8.0	7.6	6.4	5.1	2.6
Enhanced Coordination	> 16	38.0	14.4	11.0	9.4	8.7	8.1	6.2
Enhanced Coordination	14-16	23.4	9.8	9.0	8.5	7.6	7.2	5.8
Enhanced Coordination	12-14	24.6	9.0	8.4	7.5	7.1	6.7	5.3
Enhanced Coordination	10-12	14.5	8.1	7.5	7.0	6.4	6.1	4.3
Enhanced Coordination	< 10	9.5	7.5	7.1	6.5	6.0	5.2	2.8
Max. Operational Flexibility	> 16	38.2	14.8	11.2	9.3	8.4	7.6	6.0
Max. Operational Flexibility	14-16	23.8	10.0	8.9	8.2	7.6	7.2	5.9
Max. Operational Flexibility	12-14	25.5	8.7	8.2	7.7	7.3	6.9	5.4
Max. Operational Flexibility	10-12	16.8	8.1	7.7	7.3	6.7	6.2	4.8
Max. Operational Flexibility	< 10	8.9	7.7	7.3	6.5	5.8	5.3	3.6
Supply Driven (LB Priority)	> 16	37.9	13.8	11.3	10.3	8.3	7.3	5.8
Supply Driven (LB Priority)	14-16	20.2	9.9	9.3	8.1	7.4	7.0	5.6
Supply Driven (LB Priority)	12-14	19.8	9.2	8.4	7.7	7.2	6.9	5.3
Supply Driven (LB Priority)	10-12	13.0	8.6	7.9	7.4	7.0	6.7	5.2
Supply Driven (LB Priority)	< 10	10.3	8.1	7.7	7.2	6.7	5.9	3.4
Supply Driven (LB Pro Rata)	> 16	37.9	13.9	11.4	10.4	8.4	7.3	5.7
Supply Driven (LB Pro Rata)	14-16	20.2	9.9	9.3	8.0	7.3	6.9	5.5
Supply Driven (LB Pro Rata)	12-14	19.8	9.3	8.4	7.6	7.1	6.8	5.2
Supply Driven (LB Pro Rata)	10-12	13.4	8.5	7.8	7.3	6.9	6.6	5.1
Supply Driven (LB Pro Rata)	< 10	10.3	7.9	7.5	7.1	6.7	6.0	3.3

Figure TA 3-29
Annual Flow Volume Below Davis Dam[13]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[13] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

In the Dry Flow Category (less than 10.0 maf), the lowest median annual flow volume is 6.5 maf for both the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative. The Basic Coordination Alternative has the highest median annual flow volume of 7.6 maf. The CCS Comparative Baseline and No Action Alternative have the greatest interquartile variability, with interquartile annual flow volume ranges spanning around 2.3 maf and 2.9 maf, respectively. The Enhanced Coordination and Supply Driven (both LB Priority and LB Pro Rata approaches) Alternatives show the smallest interquartile ranges with the least amount of variability.

Minor tributaries enter this reach above Lake Havasu, but flows are primarily controlled by Davis Dam releases from Lake Mohave, which is operated under a rule curve that targets specific monthly elevations. Therefore, when inflow to Lake Mohave is reduced due to lower preceding flow conditions and decreased Hoover Dam releases, releases from Davis Dam are decreased to achieve the designated target elevation. The differences in median flow within each flow category are caused by differences in upstream releases from Hoover Dam that enter Lake Mohave.

Reach 4: Parker Dam to Cibola Gage

This reach of the river (starting from Parker Dam at Lake Havasu) is 105-miles long and goes to Reclamation's Cibola Gage. Flows in this reach primarily consist of releases from Parker Dam. Two major diversion dams are located in this reach of the river: Headgate Rock Dam and Palo Verde Diversion Dam. The impoundments of these dams are used to facilitate the diversion of water for the Colorado River Indian Tribes and Palo Verde Irrigation District.

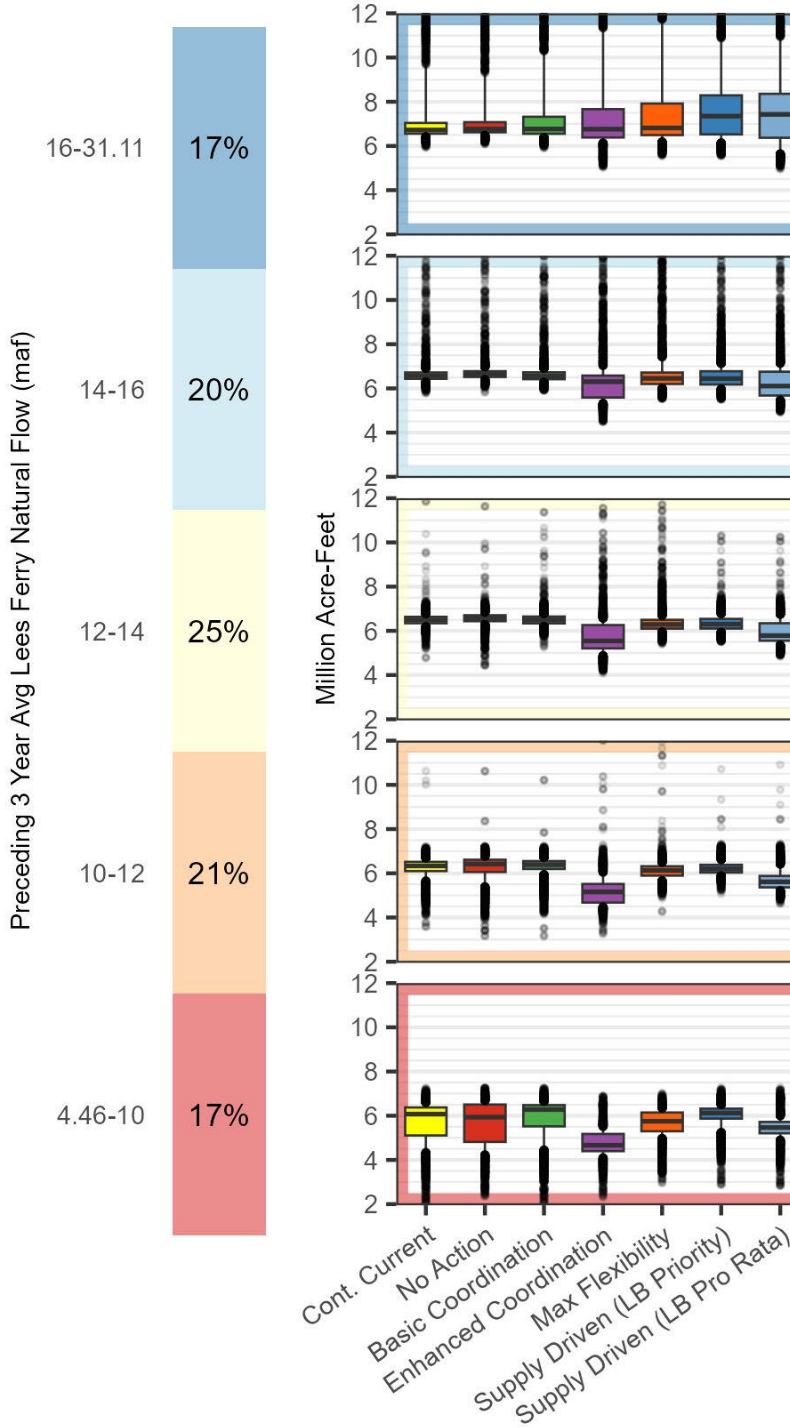
Table TA 3-24 below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River below Parker Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes. **Figure TA 3-30** below looks at the response of annual Colorado River flow volumes below Parker Dam to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-24** in a conditional box plot.

In the Average Flow Category (12.0–14.0 maf), the median annual flow volumes below Parker Dam are 5.5 maf for the Enhanced Coordination Alternative, 5.89 maf for the Supply Driven Alternative (LB Pro Rata approach), 6.3 maf for the Maximum Operational Flexibility and Supply Driven (LB Priority approach) Alternatives, 6.5 maf for the Basic Coordination Alternative and CCS Comparative Baseline, and 6.6 maf for the No Action Alternative. The No Action Alternative, Basic Coordination Alternative, and CCS Comparative Baseline have the least interquartile variability, with interquartile annual flow volume ranges spanning about 300.0 kaf. The Enhanced Coordination Alternative has the greatest interquartile variability, with an interquartile annual flow volume range of 1.1 maf.

Table TA 3-24
Annual Flow Volume Below Parker Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	34.8	9.7	7.0	6.7	6.6	6.4	5.9
CCS Comparative Baseline	14-16	19.9	6.9	6.7	6.6	6.4	6.3	5.8
CCS Comparative Baseline	12-14	18.7	6.8	6.6	6.5	6.3	6.2	4.8
CCS Comparative Baseline	10-12	10.6	6.7	6.5	6.3	6.1	5.7	3.6
CCS Comparative Baseline	< 10	7.2	6.6	6.4	6.1	5.1	4.3	2.0
No Action	> 16	34.4	9.3	7.1	6.8	6.6	6.5	6.1
No Action	14-16	19.6	7.0	6.8	6.6	6.5	6.4	5.8
No Action	12-14	19.7	6.8	6.7	6.6	6.4	6.3	4.4
No Action	10-12	10.6	6.8	6.6	6.4	6.1	5.4	3.2
No Action	< 10	7.3	6.7	6.5	5.9	4.8	4.2	2.4
Basic Coordination	> 16	34.6	10.3	7.3	6.8	6.6	6.4	5.9
Basic Coordination	14-16	19.2	6.9	6.7	6.6	6.4	6.3	5.9
Basic Coordination	12-14	19.1	6.8	6.6	6.5	6.3	6.2	5.2
Basic Coordination	10-12	10.2	6.7	6.6	6.4	6.2	5.9	3.1
Basic Coordination	< 10	7.2	6.7	6.5	6.3	5.5	4.5	2.1
Enhanced Coordination	> 16	34.9	11.3	7.7	6.8	6.4	6.1	5.0
Enhanced Coordination	14-16	20.1	7.0	6.6	6.3	5.6	5.3	4.5
Enhanced Coordination	12-14	21.1	6.6	6.3	5.5	5.2	4.9	4.1
Enhanced Coordination	10-12	12.0	6.0	5.5	5.2	4.7	4.5	3.2
Enhanced Coordination	< 10	6.9	5.5	5.2	4.7	4.4	4.1	2.3
Max. Operational Flexibility	> 16	35.0	11.7	7.9	6.8	6.5	6.2	5.5
Max. Operational Flexibility	14-16	20.6	7.4	6.7	6.5	6.2	6.0	5.5
Max. Operational Flexibility	12-14	21.7	6.7	6.5	6.3	6.1	5.9	5.4
Max. Operational Flexibility	10-12	14.5	6.5	6.3	6.1	5.9	5.7	4.3
Max. Operational Flexibility	< 10	7.0	6.3	6.1	5.8	5.3	5.0	2.9
Supply Driven (LB Priority)	> 16	34.8	10.9	8.3	7.3	6.5	6.1	5.5
Supply Driven (LB Priority)	14-16	17.7	7.1	6.8	6.4	6.2	6.0	5.5
Supply Driven (LB Priority)	12-14	16.4	6.8	6.5	6.3	6.1	5.9	5.5
Supply Driven (LB Priority)	10-12	10.7	6.6	6.4	6.2	6.0	5.9	5.1
Supply Driven (LB Priority)	< 10	7.3	6.5	6.3	6.1	5.9	5.3	2.9
Supply Driven (LB Pro Rata)	> 16	34.8	10.9	8.4	7.4	6.4	5.6	5.0
Supply Driven (LB Pro Rata)	14-16	17.7	7.1	6.8	6.1	5.7	5.5	4.9
Supply Driven (LB Pro Rata)	12-14	16.4	6.8	6.3	5.8	5.6	5.3	4.8
Supply Driven (LB Pro Rata)	10-12	10.9	6.4	5.9	5.6	5.4	5.2	4.6
Supply Driven (LB Pro Rata)	< 10	7.3	6.0	5.7	5.5	5.2	4.9	2.8

Figure TA 3-30
Annual Flow Volume Below Parker Dam



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

In the Dry Flow Category (less than 10.0 maf), the median annual volumes range from 4.7 maf (Enhanced Coordination Alternative) to 6.3 maf (Basic Coordination Alternative). The interquartile variability ranges grew notably for the CCS Comparative Baseline and the No Action and Basic Coordination Alternatives. The No Action Alternative has the largest variability with an interquartile range spanning 4.8 to 6.5 maf.

Reach 5: Cibola Gage to Imperial Dam

This reach of the river (starting from the Cibola Gage) is 38-miles long and is bounded on the downstream end by Imperial Dam at Imperial Reservoir. Flows in this reach primarily consist of releases from Parker Dam. The Imperial Dam impoundment in this reach operates at a nearly constant elevation to meet water delivery requirements.

Table TA 3-25 below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River at Imperial Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes.

Figure TA 3-31 below looks at the response of annual Colorado River flow volumes at Imperial Dam to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-25** in a conditional box plot. Note that the range of volumes has been truncated at the high end to facilitate comparisons in the Average and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median annual flow volumes at Imperial ranges from 4.6 maf (Enhanced Coordination Alternative) to 5.6 maf (No Action Alternative). The CCS Comparative Baseline and No Action and Basic Coordination Alternatives have the least interquartile variability, with interquartile annual flow volume ranges spanning around 100.0 to 200.0 kaf. The Enhanced Coordination Alternative has the greatest interquartile variability, with interquartile annual flow volume ranges spanning around 900.0 kaf.

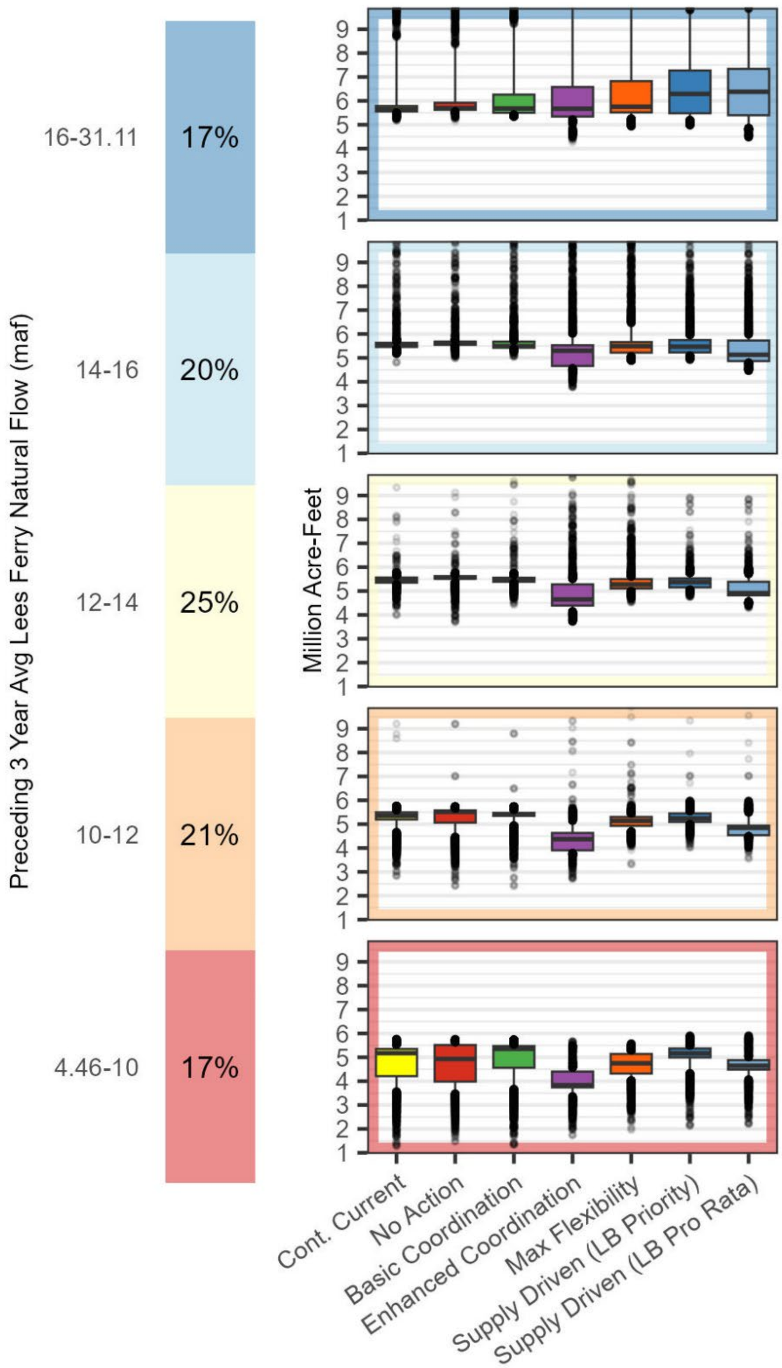
In the Dry Flow Category (less than 10.0 maf), the median annual flow volumes ranges from 3.8 maf under the Enhanced Coordination Alternative to 5.4 maf under the Basic Coordination Alternative. The interquartile variability ranges grew notably for the CCS Comparative Baseline and No Action and Basic Coordination Alternatives. The No Action Alternative has the largest variability with an interquartile range spanning 4.0 to 5.5 maf.

Across the flow categories, the Enhanced Coordination Alternative has lower median annual flows than the other alternatives in all the hydrologic conditions except for the Wet Flow Category (greater than 16.0 maf). The small deviation in median annual flows across the alternatives is due to the fact that flows downstream of Parker Dam are largely dictated by delivery requirements, as outlined in the 1944 Water Treaty and Minute 323. Because the alternatives analyzed do not affect these deliveries, required flows are similar across the majority of hydrologic traces.

Table TA 3-25
Annual Flow Volume at Imperial Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	33.5	8.7	5.8	5.7	5.6	5.5	5.2
CCS Comparative Baseline	14-16	19.1	5.7	5.6	5.5	5.5	5.4	4.8
CCS Comparative Baseline	12-14	17.3	5.7	5.6	5.5	5.3	5.3	4.0
CCS Comparative Baseline	10-12	9.2	5.6	5.5	5.3	5.2	4.7	2.8
CCS Comparative Baseline	< 10	5.8	5.5	5.3	5.2	4.2	3.6	1.3
No Action	> 16	33.1	8.3	5.9	5.7	5.6	5.6	5.1
No Action	14-16	18.7	5.7	5.7	5.6	5.5	5.5	5.0
No Action	12-14	18.2	5.7	5.6	5.6	5.5	5.4	3.7
No Action	10-12	9.2	5.7	5.6	5.5	5.1	4.5	2.4
No Action	< 10	5.8	5.6	5.5	4.9	4.0	3.5	1.5
Basic Coordination	> 16	33.2	9.2	6.3	5.7	5.5	5.4	5.3
Basic Coordination	14-16	17.7	5.7	5.7	5.5	5.4	5.4	5.1
Basic Coordination	12-14	17.6	5.7	5.6	5.5	5.4	5.3	4.4
Basic Coordination	10-12	8.8	5.6	5.5	5.4	5.3	4.9	2.4
Basic Coordination	< 10	5.7	5.5	5.5	5.4	4.6	3.7	1.3
Enhanced Coordination	> 16	33.5	10.3	6.6	5.7	5.3	5.2	4.3
Enhanced Coordination	14-16	18.7	6.0	5.5	5.3	4.7	4.6	3.8
Enhanced Coordination	12-14	19.6	5.5	5.3	4.6	4.4	4.1	3.7
Enhanced Coordination	10-12	10.6	5.1	4.6	4.4	3.9	3.8	2.7
Enhanced Coordination	< 10	5.7	4.6	4.4	3.8	3.7	3.4	1.7
Max. Operational Flexibility	> 16	33.7	10.7	6.8	5.8	5.5	5.3	4.9
Max. Operational Flexibility	14-16	19.2	6.4	5.7	5.5	5.2	5.1	4.9
Max. Operational Flexibility	12-14	20.4	5.6	5.5	5.3	5.1	5.0	4.5
Max. Operational Flexibility	10-12	13.2	5.5	5.3	5.1	4.9	4.7	3.3
Max. Operational Flexibility	< 10	5.6	5.3	5.1	4.7	4.3	4.0	2.0
Supply Driven (LB Priority)	> 16	33.5	9.8	7.3	6.3	5.5	5.2	4.9
Supply Driven (LB Priority)	14-16	16.3	6.0	5.7	5.5	5.2	5.1	4.9
Supply Driven (LB Priority)	12-14	15.3	5.8	5.5	5.4	5.2	5.0	4.8
Supply Driven (LB Priority)	10-12	9.3	5.6	5.4	5.2	5.1	5.0	4.0
Supply Driven (LB Priority)	< 10	5.9	5.5	5.4	5.2	5.0	4.3	2.1
Supply Driven (LB Pro Rata)	> 16	33.5	9.8	7.3	6.4	5.4	4.9	4.5
Supply Driven (LB Pro Rata)	14-16	16.3	6.0	5.7	5.1	4.9	4.8	4.5
Supply Driven (LB Pro Rata)	12-14	15.3	5.7	5.4	4.9	4.8	4.5	4.3
Supply Driven (LB Pro Rata)	10-12	9.5	5.5	4.9	4.8	4.5	4.5	3.6
Supply Driven (LB Pro Rata)	< 10	5.9	5.0	4.9	4.6	4.5	4.1	2.2

Figure TA 3-31
Annual Flow Volume at Imperial Dam[14]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[14] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

Reach 6: Imperial Dam to NIB

This reach of the river (starting from the Imperial Dam) is 26-miles long and is bounded on the downstream end by NIB between the United States and Mexico. Flows in this reach primarily consist of releases from Imperial Dam to make delivery requirements. Flows in this reach also include water leaked from the AAC's sluiceway gates and return flow from Imperial Dam diversions.

Table TA 3-26 below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River below Imperial Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes.

Figure TA 3-32 below looks at the response of annual Colorado River flow volumes below Imperial Dam to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-26** in a conditional box plot. Note that the range of volumes has been truncated at the high end to facilitate comparisons in the Average and Dry Flow Categories.

In the Average Flow Category (12.0–14.0 maf), the median annual flow volumes below Imperial ranges from 0.9 maf (Maximum Operational Flexibility Alternative) to 1.1 maf (No Action Alternative and Supply Driven Alternative [LB Pro Rata approach]). The CCS Comparative Baseline and all action alternatives have low interquartile variability in the Average Flow Category, with interquartile annual flow volume ranges spanning around 40.0 to 300.0 kaf. There is a wide range of median annual flow outliers extending above the median and interquartile flow values.

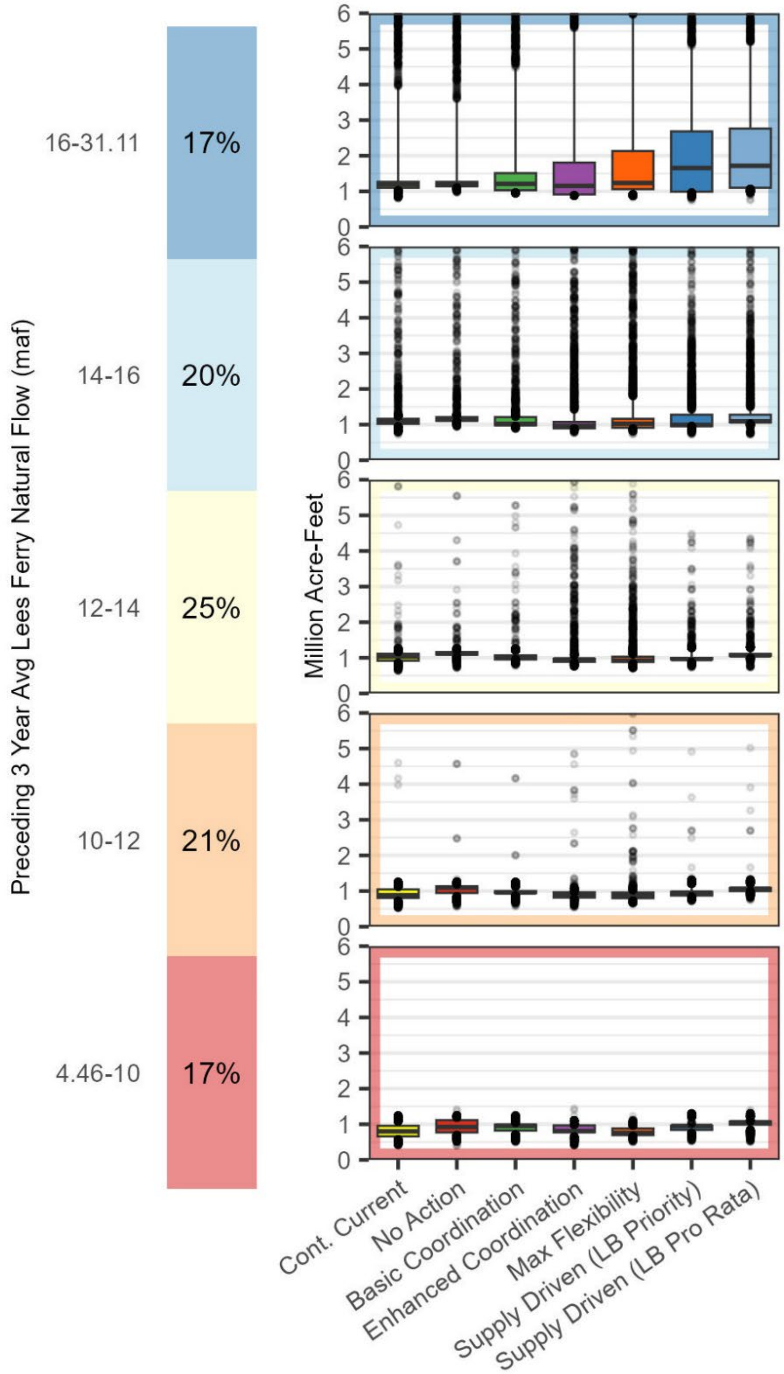
In the Dry Flow Category (less than 10.0 maf), the median annual flow volumes range from 0.8 maf (CCS Comparative Baseline, Enhanced Coordination Alternative, and Maximum Operational Flexibility Alternative), to 1.1 maf (Supply Driven Alternative [LB Pro Rata approach]). The interquartile variability ranges remain low while the outlier variability decreases notably compared to Wet Flow Categories.

Across the flow categories, the Maximum Operational Flexibility Alternative has lower median annual flows than the other alternatives in all the hydrologic conditions. The small deviation in median annual flows across the alternatives is due to the fact that flows downstream of Imperial Dam are largely dictated by delivery requirements. Because the alternatives analyzed do not affect these deliveries, required flows are similar across the majority of hydrologic traces.

Table TA 3-26
Annual Flow Volume Below Imperial Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	28.7	3.9	1.3	1.2	1.1	1.0	0.8
CCS Comparative Baseline	14-16	14.3	1.2	1.2	1.1	1.0	0.9	0.7
CCS Comparative Baseline	12-14	12.6	1.2	1.1	1.0	0.9	0.9	0.6
CCS Comparative Baseline	10-12	4.6	1.1	1.0	0.9	0.8	0.7	0.5
CCS Comparative Baseline	< 10	1.2	1.1	1.0	0.8	0.7	0.6	0.4
No Action	> 16	28.2	3.6	1.3	1.2	1.1	1.1	1.0
No Action	14-16	13.9	1.3	1.2	1.1	1.1	1.1	0.9
No Action	12-14	13.5	1.2	1.2	1.1	1.1	1.0	0.7
No Action	10-12	4.6	1.2	1.1	1.1	0.9	0.8	0.6
No Action	< 10	1.4	1.2	1.1	0.9	0.8	0.7	0.4
Basic Coordination	> 16	28.4	4.5	1.5	1.2	1.0	1.0	0.9
Basic Coordination	14-16	12.9	1.2	1.2	1.0	1.0	1.0	0.9
Basic Coordination	12-14	12.8	1.2	1.1	1.0	1.0	1.0	0.8
Basic Coordination	10-12	4.2	1.1	1.0	1.0	0.9	0.9	0.6
Basic Coordination	< 10	1.3	1.0	1.0	1.0	0.8	0.7	0.5
Enhanced Coordination	> 16	28.7	5.6	1.8	1.2	0.9	0.9	0.9
Enhanced Coordination	14-16	13.9	1.4	1.1	1.0	0.9	0.9	0.8
Enhanced Coordination	12-14	14.9	1.1	1.0	1.0	0.9	0.9	0.8
Enhanced Coordination	10-12	6.1	1.0	1.0	0.9	0.8	0.8	0.6
Enhanced Coordination	< 10	1.4	1.0	1.0	0.8	0.8	0.7	0.4
Max. Operational Flexibility	> 16	28.9	5.9	2.1	1.2	1.1	0.9	0.8
Max. Operational Flexibility	14-16	14.4	1.8	1.2	1.0	0.9	0.9	0.7
Max. Operational Flexibility	12-14	15.6	1.1	1.0	0.9	0.9	0.8	0.7
Max. Operational Flexibility	10-12	8.7	1.0	1.0	0.9	0.8	0.7	0.6
Max. Operational Flexibility	< 10	1.2	1.0	0.9	0.8	0.7	0.7	0.5
Supply Driven (LB Priority)	> 16	28.6	5.1	2.7	1.7	1.0	1.0	0.7
Supply Driven (LB Priority)	14-16	11.5	1.4	1.3	1.0	1.0	1.0	0.7
Supply Driven (LB Priority)	12-14	10.6	1.3	1.0	1.0	1.0	0.9	0.7
Supply Driven (LB Priority)	10-12	4.9	1.2	1.0	1.0	0.9	0.8	0.7
Supply Driven (LB Priority)	< 10	1.3	1.0	1.0	1.0	0.8	0.8	0.5
Supply Driven (LB Pro Rata)	> 16	28.6	5.2	2.8	1.7	1.1	1.1	0.7
Supply Driven (LB Pro Rata)	14-16	11.5	1.5	1.3	1.1	1.1	1.0	0.7
Supply Driven (LB Pro Rata)	12-14	10.6	1.3	1.1	1.1	1.1	1.0	0.7
Supply Driven (LB Pro Rata)	10-12	5.0	1.2	1.1	1.1	1.0	1.0	0.8
Supply Driven (LB Pro Rata)	< 10	1.4	1.1	1.1	1.1	1.0	0.8	0.5

Figure TA 3-32
Annual Flow Volume Below Imperial Dam[15]



Note: Supply Driven LB Priority and Supply Driven LB Pro Rata results differ primarily because of how the two shortage-distribution approaches interact with the modeled assumptions governing the storage and delivery of conserved water (see **Appendix B**, Modeling Assumptions: Lake Powell and Lake Mead Storage and Delivery of Conserved Water).

[15] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

Reach 7: NIB in the Limitrophe to SIB

This reach of the river (starting from the NIB) is split into two sub reaches. Approximately 1.1-miles downstream from the NIB is Moreles Dam where, under normal operations, the entirety of the remaining Colorado River is diverted by Mexico for water supply into the Reforma Canal.

Downstream of Morelos Diversion Dam, the reach continues to the SIB and the Colorado River Delta. Flows through this reach, referred to as the limitrophe, consist of water in excess of Mexico's scheduled delivery. Flows in excess could be due to Flood Control operations at Hoover Dam, seepage from Morelos Diversion Dam, irrigation return flows, groundwater inflow, and any water released for environmental purposes in the Colorado River Delta.

Table TA 3-27 below shows the statistical breakdown of annual flow volumes (in maf) in the Colorado River below Morelos Diversion Dam, for each of the different hydrologic conditions under different alternatives. These values include the maximum, 90th percentile, 75th percentile, median, 25th percentile, 10th percentile, and minimum annual flow volumes.

Figure TA 3-33 below looks at the response of annual Colorado River flow volumes below Morelos Diversion Dam to different hydrologic conditions under different alternatives by looking at the preceding three-year average of Lees Ferry natural flow. The figure visualizes the same data that are included in **Table TA 3-27** in a conditional box plot. Note that the range of volumes has been truncated at the high end to facilitate comparisons in the Average and Dry Flow Categories.

In the Wet Flow Category (greater than 16.0 maf), flows in the Colorado River below Morelos Diversion Dam occur in 50 percent or less of the hydrologic futures for the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches) only. For the Basic Coordination Alternative, Enhanced Coordination Alternative, and Maximum Operational Flexibility Alternative flows occur below Morelos Diversion Dam in 25 percent or less of hydrologic futures. The No Action Alternative and the CCS Comparative Baseline have more infrequent flows, with flows occurring in only 10 percent or less of hydrologic futures.

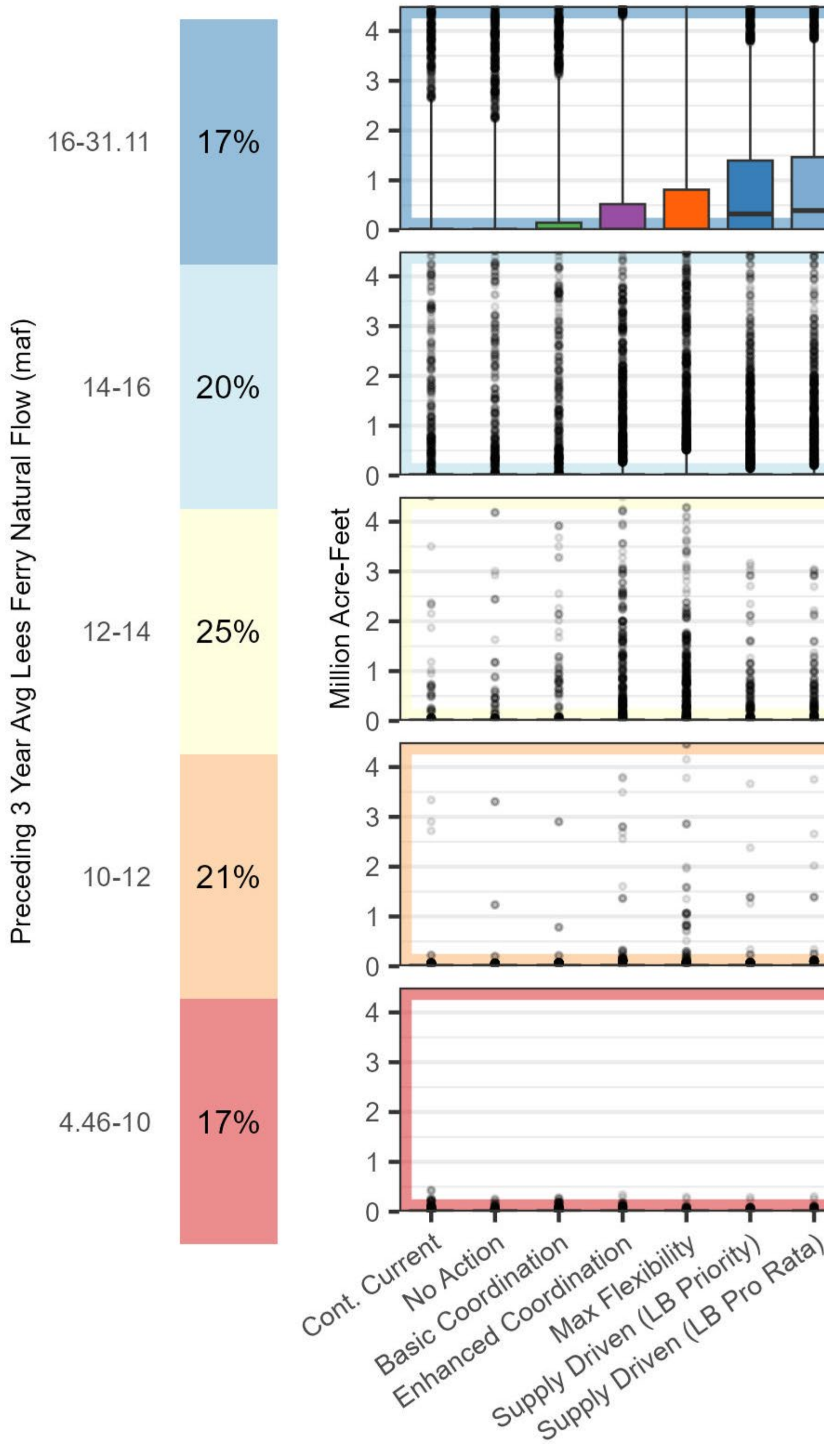
Beginning in the Average Flow Category (12.0–14.0 maf), flows in the Colorado River below Morelos Diversion Dam are infrequent, occurring in less than 10 percent of hydrologic futures for the No Action Alternative, the CCS Comparative Baseline, and all action alternatives.

Although infrequent, in all hydrologic categories except for the driest, there is always a possibility of large volume flows in the limitrophe. These are the result of exceptionally high flows that could occur in some of the hydrologic futures considered in the modeling analysis.

Table TA 3-27
Annual Flow Volume Below Morelos Diversion Dam (maf)

Alternative	Flow Category	Max (maf)	90% (maf)	75% (maf)	50% (maf)	25% (maf)	10% (maf)	Min (maf)
CCS Comparative Baseline	> 16	27.4	2.6	0.0	0.0	0.0	0.0	0.0
CCS Comparative Baseline	14-16	13.0	0.0	0.0	0.0	0.0	0.0	0.0
CCS Comparative Baseline	12-14	11.3	0.0	0.0	0.0	0.0	0.0	0.0
CCS Comparative Baseline	10-12	3.3	0.0	0.0	0.0	0.0	0.0	0.0
CCS Comparative Baseline	< 10	0.4	0.0	0.0	0.0	0.0	0.0	0.0
No Action	> 16	26.9	2.2	0.0	0.0	0.0	0.0	0.0
No Action	14-16	12.5	0.0	0.0	0.0	0.0	0.0	0.0
No Action	12-14	12.2	0.0	0.0	0.0	0.0	0.0	0.0
No Action	10-12	3.3	0.0	0.0	0.0	0.0	0.0	0.0
No Action	< 10	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Basic Coordination	> 16	27.1	3.1	0.2	0.0	0.0	0.0	0.0
Basic Coordination	14-16	11.6	0.0	0.0	0.0	0.0	0.0	0.0
Basic Coordination	12-14	11.5	0.0	0.0	0.0	0.0	0.0	0.0
Basic Coordination	10-12	2.9	0.0	0.0	0.0	0.0	0.0	0.0
Basic Coordination	< 10	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Enhanced Coordination	> 16	27.4	4.3	0.5	0.0	0.0	0.0	0.0
Enhanced Coordination	14-16	12.6	0.3	0.0	0.0	0.0	0.0	0.0
Enhanced Coordination	12-14	13.6	0.0	0.0	0.0	0.0	0.0	0.0
Enhanced Coordination	10-12	5.1	0.0	0.0	0.0	0.0	0.0	0.0
Enhanced Coordination	< 10	0.3	0.0	0.0	0.0	0.0	0.0	-0.1
Max. Operational Flexibility	> 16	27.5	4.6	0.8	0.0	0.0	0.0	0.0
Max. Operational Flexibility	14-16	13.0	0.5	0.0	0.0	0.0	0.0	0.0
Max. Operational Flexibility	12-14	14.2	0.0	0.0	0.0	0.0	0.0	0.0
Max. Operational Flexibility	10-12	7.5	0.0	0.0	0.0	0.0	0.0	0.0
Max. Operational Flexibility	< 10	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Priority)	> 16	27.3	3.7	1.4	0.3	0.0	0.0	0.0
Supply Driven (LB Priority)	14-16	10.1	0.1	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Priority)	12-14	9.2	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Priority)	10-12	3.7	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Priority)	< 10	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Pro Rata)	> 16	27.3	3.8	1.5	0.4	0.0	0.0	0.0
Supply Driven (LB Pro Rata)	14-16	10.1	0.2	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Pro Rata)	12-14	9.2	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Pro Rata)	10-12	3.8	0.0	0.0	0.0	0.0	0.0	0.0
Supply Driven (LB Pro Rata)	< 10	0.3	0.0	0.0	0.0	0.0	0.0	0.0

Figure TA 3-33
Annual Flow Volume Below Morelos Diversion Dam[16]



[16] High end of range is cut off to improve comparisons in Average and Dry Flow Categories.

TA 3.2.5 Issue 5: Groundwater

Issue 5 addresses how operational activities for the various alternatives would affect groundwater adjacent to reservoirs and within specific reaches along the Colorado River. This was evaluated by comparing the various action alternatives to the No Action Alternative and the CCS Comparative Baseline for the following metrics:

- Qualitative discussion of possible groundwater impacts based on relative changes to Colorado River flows for each reach, and relative changes to reservoir elevations where applicable.
- Hydraulic connectivity between groundwater and the reservoirs and river reaches of the Colorado River vary depending on a number of factors, including physical geotechnical characteristics, vegetative groundcover, whether irrigation is occurring nearby, and distance from the river.

Regional scale changes to groundwater are complex and hard to quantify without extensive data records and groundwater models. Current data on groundwater at a regional scale is limited in scope and historical duration.

There are no legal requirements to not deplete groundwater for nearby wells, although decreasing reservoir elevations may contribute to decreased groundwater elevations depending on hydraulic connectivity. Secondary impacts on groundwater are not considered in this analysis (e.g., if actions under the various alternatives would result in more groundwater pumping occurring in order to supplement decreased supply).

Reach 1: Lake Powell to Lake Mead

Fluctuations in elevations at Lake Powell may be reflected in groundwater elevations adjacent to the reservoir, depending on the hydraulic connectivity between the reservoir and nearby groundwater wells. Relating back to the Issue 1 analysis, the water surface elevations at Lake Powell vary by alternative with the Maximum Operational Flexibility Alternative and the Enhanced Coordination Alternative being the most robust at keeping elevations above 3,500 feet in 100 percent of months over the full modeling period (87 percent and 82 percent, respectively). Since these two alternatives are the most robust for reservoir elevations, groundwater elevations adjacent to Lake Powell are anticipated to be slightly higher under these alternatives compared to the others. The CCS Comparative Baseline is the third most robust (29 percent) followed by the Basic Coordination Alternative (25 percent) and both approaches of the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches; 24 percent). The No Action Alternative is the least robust at keeping Lake Powell elevations above 3,500 feet and is therefore anticipated to result in lower groundwater elevations adjacent to the reservoir.

Reach 1 of the Colorado River extends from downstream of Glen Canyon Dam, through the Grand Canyon National Park, to Lake Mead. The Grand Canyon restricts hydraulic connection to groundwater to sandbars. Due to physical geotechnical characteristics, changes to groundwater levels in this reach are not anticipated to be affected by the various alternatives.

Black Canyon, which is dammed by Hoover Dam, is made of bedrock that limits the connection to groundwater with a few small sandbars. As such, groundwater basins adjacent to Lake Mead are generally small in size and are bounded by zones of non-water bearing rock. Changes in water surface elevations at Lake Mead are not anticipated to be affected by the various alternatives.

Reach 2: Hoover Dam to Davis Dam

Reach 2 of the Colorado River extends from downstream of Hoover Dam to Lake Mohave (formed by Davis Dam) and runs through a bedrock canyon that limits the connection to groundwater. Due to physical geotechnical characteristics of the bedrock canyon, changes to groundwater levels in this reach are not anticipated to be affected by the various alternatives

Groundwater elevations adjacent to Lake Mohave are not anticipated to be affected by the various alternatives because the release rule curve that Lake Mohave operates under is the same for all alternatives in this analysis. The rule curve keeps water surface elevations of Lake Mohave within a tight range and Reclamation will continue to operate releases from Davis Dam in this manner.

Reach 3: Davis Dam to Parker Dam

Reach 3 of the Colorado River extends from downstream of Davis Dam to Lake Havasu (formed by Parker Dam) and flows through two different groundwater basins. The upper portion of this reach is within the Mohave Valley groundwater basin, which is alluvial fill, and fluctuations in river flows through this section may affect groundwater in the alluvial basin.

Relating back to the Issue 4 analysis, the river flows in this reach are mostly comprised of releases from Davis Dam and tributary inflow from the Bill Williams River. Releases from Davis Dam vary by alternative, with the Basic Coordination Alternative having the highest flows in the reach under the Dry Flow Category (less than 10.0 maf). Therefore, groundwater elevations through the Mohave Valley groundwater basin are anticipated to be higher under this alternative during dry conditions, compared to the others. Following this connection between river flows and adjacent groundwater elevations, the CCS Comparative Baseline is anticipated to have the second highest groundwater elevations during dry conditions, closely followed by both the Supply Driven Alternatives (both LB Priority and LB Pro Rata approaches). The Enhanced Coordination and the Maximum Operational Flexibility Alternatives are anticipated to result in lower groundwater elevations in dry conditions compared to the other alternatives.

The lower portion of this reach is within the Chemehuevi Valley and is dominated by Lake Havasu. Similar to Lake Mohave, the groundwater elevations adjacent to Lake Havasu are not anticipated to be affected by the various alternatives because of the strict release rule curve is the same for all alternatives within this analysis. The rule curve keeps water surface elevations of Lake Havasu within a tight range and Reclamation will continue to operate releases from Parker Dam in this manner.

Reach 4: Parker Dam to Cibola Gage

Reach 4 of the Colorado River extends from downstream of Parker Dam to the USGS gage station known as Cibola Gage. This reach flows through one large alluvial fill groundwater basin and fluctuations in river flows through this section may affect groundwater in this alluvial basin.

Relating back to the Issue 4 analysis, the river flows in this reach are mostly comprised of releases from Parker Dam which vary by alternative. In the Dry Flow Category (less than 10.0 maf), The Basic Coordination Alternative has the highest flows in the reach, therefore, groundwater elevations through this reach of the river are anticipated to be higher under this alternative compared to others. The Supply Driven Alternative (LB Priority approach) and the CCS Comparative Baseline are anticipated to have the second highest groundwater elevations during dry hydrologic conditions, closely followed by the No Action Alternative and then the Maximum Operational Flexibility Alternative. The Supply Driven Alternative (LB Pro Rata approach) is anticipated to have the second lowest groundwater elevations during dry conditions and the Enhanced Coordination Alternative is anticipated to have the lowest groundwater elevations.

Reach 5: Cibola Gage to Imperial Dam

Reach 5 of the Colorado River extends from the USGS gage station known as Cibola Gage down to Imperial Dam and runs through a narrow alluvial fill valley. Fluctuations in river flows through this section may affect groundwater.

Flows in this reach primarily consist of releases from Parker Dam and mirror trends in reach 4. As such, groundwater elevations in this reach of the river also mirror trends for relative groundwater elevations in Reach 4. In the Dry Flow Category (less than 10.0 maf), The Basic Coordination Alternative is anticipated to have the highest groundwater elevations compared to the other alternatives. The Supply Driven Alternative (LB Priority approach) and the CCS Comparative Baseline are anticipated to have the second highest groundwater elevations during dry conditions, closely followed by the No Action Alternative and then the Maximum Operational Flexibility Alternative. The Supply Driven Alternative (LB Pro Rata approach) is anticipated to have the second lowest groundwater elevations during dry conditions and the Enhanced Coordination Alternative is anticipated to have the lowest groundwater elevations.

Reach 6: Imperial Dam to NIB

Reach 6 of the Colorado River extends from downstream of Imperial Dam to the NIB and bypasses most of the river channel as it runs through a series of lined canals and sluiceways. Therefore, the proposed alternatives are not anticipated to affect groundwater basins adjacent to this reach.

Reach 7: NIB in the Limitrophe to SIB

Reach 7, referred to as the limitrophe, of the Colorado River extends from the NIB to the SIB and consists of the deep Colorado River Delta groundwater basin. Infrequent flows in this reach may occur due to releases at Morelos Diversion Dam under exceptionally wet hydrologic conditions.

The upstream portion of this reach is considered a gaining reach because high groundwater elevations from nearby irrigated fields results in flow to the surface. The proposed alternatives would not affect irrigation to nearby fields, therefore, there are no anticipated impacts on the groundwater in this section of the reach.

The downstream portion of this reach is considered a losing reach because groundwater is recharged from the river. Groundwater elevations in this section of the reach have historically declined and are likely to continue to decline under dry conditions.

TA 3.2.6 Summary Comparison of Alternatives

Issue 1: Reservoir Elevations

For all alternatives and the CCS Comparative Baseline, median WY elevations at Lake Powell generally perform similarly under wet hydrologic flow conditions, except for the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) which have lower median values. As flow categories become drier, elevations at Lake Powell decrease and deviations in trends increase, because as elevations get lower operations vary widely across alternatives. In the two drier flow categories, the Enhanced Coordination Alternative has the highest median reservoir elevations, followed by the Maximum Operational Flexibility Alternative having the second highest median elevations compared to the other alternatives and the CCS Comparative Baseline. Median reservoir elevations for both the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative stay notably above the critical threshold of 3,500 feet even in the Dry Flow Category. Conversely, the median elevations for the No Action Alternative and the Basic Coordination Alternative drop below this critical threshold in the Dry Flow Category.

The Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative are the most robust at staying above elevation 3,500 feet in Lake Powell in 100 percent of months over the full modeling period, doing so in 87 percent and 82 percent of the futures, respectively. The CCS Comparative Baseline, No Action Alternative, and all other action alternatives are less robust at maintaining elevations in Lake Powell, doing so in less than 29 percent of futures.

The median CY elevations at Lake Mead decrease as flow categories become drier and each alternative generally follows the same trend. For example, the Supply Driven Alternative (LB Pro Rata approach) consistently has the highest median reservoir elevations across all flow categories, followed by the Supply Driven Alternative (LB Priority approach) having the second highest median elevations. The No Action Alternative consistently has the lowest median elevations in Lake Mead across all flow categories, followed by the CCS Comparative Baseline having the second lowest median elevations. All of the action alternatives have wide interquartile variability with the exception of the Maximum Operational Flexibility Alternative, which most reliably stays above 975 feet.

The Supply Driven Alternative (LB Pro Rata approach), the Maximum Operational Flexibility Alternative, and the Enhanced Coordination Alternative are the most robust at staying above elevation 1,000 feet in Lake Mead in 90 percent of months over the full modeling period, doing so in 81 percent, 80 percent, and 78 percent of the futures, respectively. The No Action Alternative is less robust at maintaining elevations in Lake Mead, doing so in less than 25 percent of futures.

Lake Mohave and Lake Havasu are operated under an existing rule curve that determines specific target elevations at the end of each month. Because the same reservoir operations were used for all alternatives and the CCS Comparative Baseline as part of this analysis, elevations at Lake Mohave and Lake Havasu are not impacted.

Issue 2: System Storage

For all alternatives and the CCS Comparative Baseline, median combined system storage volumes decrease as flow categories become drier.

Combined Storage at Lake Powell and Lake Mead

For all alternatives and the CCS Comparative Baseline, EOWY Lake Powell and Lake Mead combined system storage decreases as hydrologic conditions become drier. Across all flow categories, the relationships between the alternatives and the CCS Comparative Baseline remain consistent, with the action alternatives resulting in higher median storage volumes when compared to the CCS Comparative Baseline and the No Action Alternative. The Maximum Operational Flexibility Alternative consistently has the highest combined storage capacity across all flow categories while the No Action Alternative consistently has the lowest combined storage capacity. In the Dry Flow Category (less than 10.0 maf), almost 50 percent of years fall below the lowest observed combined system storage of 26.55 percent. For the Supply Driven Alternative (LB Pro Rata approach), slightly more than 50 percent of modeled years fall below the lowest observed storage, while for the Basic Coordination Alternative, the No Action Alternative and the CCS Comparative Baseline, approximately 75 percent or more years fall below the lowest observed storage. The Maximum Operational Flexibility Alternative is the only alternative that does not reach 0 percent storage in any year.

The alternatives, listed in order from highest Lake Powell and Lake Mead combined system storage to lowest combined storage in all flow categories are: Maximum Operational Flexibility Alternative, Enhanced Coordination Alternative, Supply Driven Alternative (LB Pro Rata approach), Supply Driven Alternative (LB Priority approach), Basic Coordination Alternative, CCS Comparative Baseline, and the No Action Alternative.

Combined Storage at CRSP Reservoirs:

Lake Powell accounts for approximately 80 percent of CRSP capacity. Since storage at the CRSP UIUs varies minimally between alternatives the majority of the performance differences result from Lake Powell operations. As such, the alternatives generally perform similarly under wet hydrologic flow conditions, except for the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches) which have lower median values. As flow categories become drier, combined CRSP reservoir storage capacities decrease and deviations in trends increase. The alternatives, listed in order from highest combined CRSP storage to lowest combined storage in Average and Dry Flow Categories are: Enhanced Coordination Alternative, Maximum Operational Flexibility Alternative, the Supply Driven Alternative (both LB Priority and LB Pro Rata approaches), the No Action Alternative, the CCS Comparative Baseline, and the Basic Coordination Alternative. This differs slightly from the performance ranking seen for Lake Powell elevations in the Dry Flow Category, because the No Action Alternative has a higher median combined CRSP storage capacity than the CCS Comparative Baseline, and the Basic Coordination Alternative.

Combined Storage at Seven-Reservoirs:

The seven system reservoirs include Flaming Gorge, Navajo, Blue Mesa, Lake Powell, Lake Mead, Lake Mohave, and Lake Havasu. Lake Powell and Lake Mead make up approximately 90 percent of the total seven-reservoir system storage capacity, so trends in seven-reservoir capacity closely resemble trends for the Lake Powell and Lake Mead combined storage. The alternatives, listed in order from highest combined Seven-Reservoir storage in all flow categories to lowest combined storage in all flow categories: Maximum Operational Flexibility Alternative, Enhanced Coordination

Alternative, Supply Driven Alternative (LB Pro Rata approach), Supply Driven Alternative (LB Priority approach), Basic Coordination Alternative, and the No Action Alternative.

Issue 3: Reservoir Releases

For all alternatives and the CCS Comparative Baseline, median annual reservoir releases decrease as flow categories become drier. The smallest range for interquartile variability typically occurs for the CCS Comparative Baseline and all action alternatives in the Average Flow Category (12.0–14.0 maf), with variability increasing as conditions get wetter or drier.

Annual releases from the Glen Canyon Dam are highest in both the Supply Driven Alternative approaches in the wetter conditions, however, as conditions become drier the Basic Coordination Alternative, No Action Alternative, and the CCS Comparative Baseline have the higher annual releases. In the Average and Dry Flow Categories, the Enhanced Coordination Alternative has the lowest annual releases from Glen Canyon Dam. In these drier conditions, the Maximum Operational Flexibility Alternative typically has median annual releases that rank between the Enhanced Coordination Alternative and both the Supply Driven Alternative approaches (among the Average median annual releases in the Dry Flow Categories).

The median 10-year flows through the Lee Ferry Compact Point is the highest under both the Supply Driven Alternatives (84.6 maf each). This is followed by the No Action Alternative (83.6 maf), the CCS Comparative Baseline (83.3 maf), the Basic Coordination Alternatives (83.0 maf), the Maximum Operational Flexibility Alternative (82.3 maf), and finally the Enhanced Coordination Alternative (81.3 maf) which has the lowest flows.

Annual releases from the Hoover Dam are highest in both the Supply Driven Alternative approaches in the wetter conditions, however, as conditions become drier the Basic Coordination Alternative, No Action Alternative, and the CCS Comparative Baseline have the higher annual releases. In the Average and Dry Flow Categories, the Enhanced Coordination Alternative and the Maximum Operational Flexibility Alternative have the lowest annual releases from Glen Canyon Dam.

Releases from Davis Dam and Parker Dam follow similar trends as Hoover Dam releases.

Under the Dry Flow Category (less than 12.0 maf), releases from Parker Dam under the Supply Driven Alternative (LB Priority approach) become notably higher than releases under the Supply Driven Alternative (LB Pro Rata approach) and releases under the Maximum Operational Flexibility Alternative become notably higher than releases under the Enhanced Coordination Alternative.

Morelos Diversion Dam infrequently releases water in excess of Mexico’s scheduled delivery.

Issue 4: River Flows

For most reaches of the Colorado River, flows are mostly comprised of releases from upstream reservoirs and impacts on river flows mirror trends seen for Issue 3 reservoir releases. Inflows from perennial tributaries are minor and do not change between alternatives.

For all alternatives and the CCS Comparative Baseline, median annual river flows decrease as flow categories become drier. The smallest range for interquartile variability typically occurs for the CCS Comparative Baseline and all action alternatives in the Average Flow Category (12.0–14.0 maf), with variability increasing as conditions get wetter or drier.

Trends in river flows can be broken out into the upper reaches (Reaches 1 through 5) from the Glen Canyon Dam to the Imperial Dam, and the reaches near the NIB and SIB(reaches 6 and 7). In Reaches 1 through 5, the Enhanced Coordination Alternative consistently has the lowest median annual flow, across all flow categories compared to the other alternatives and the CCS Comparative Baseline. The No Action Alternative has the higher median annual flow in Reaches 1 through 5 in wetter conditions, however, as conditions become drier the Basic Coordination Alternative has the higher median flows. The Maximum Operational Flexibility Alternative typically has median annual flows that rank between the Enhanced Coordination Alternative (the lowest median annual flows) and both the Supply Driven Alternative approaches (among the Average median annual flows).

Reach 6 runs through a series of lined canals and sluiceways and bypasses most of the river channel. Flows through this reach primarily consist of releases from Imperial Dam. The Supply Driven (LB Pro Rata approach) consistently has the highest median flows, across all flow categories. The Maximum Operational Flexibility Alternative consistently has the lowest median flows, across all flow categories. Flows through the limitrophe in the lower portion of Reach 7 are infrequent and only occur when Morelos Diversion Dam releases water in excess of Mexico's scheduled delivery. Both approaches of the Supply Driven Alternative are the most likely to see flows occur in this reach, doing so in less than 50 percent of the hydrologic futures in the Wet Flow Category. The No Action Alternative and the CCS Comparative Baseline are the least likely to see flows occur in this reach, doing so in less than 10 percent of hydrologic futures in the Wet Flow Category.

Issue 5: Groundwater Elevations

Groundwater elevations adjacent to reservoirs and within specific reaches along the Colorado River may be affected by the various alternatives, depending on the hydraulic connectivity and geotechnical characteristics of the area. In reaches of the Colorado River that have a direct connection to groundwater, changes in river flows and changes in reservoir elevations are anticipated to affect groundwater elevations.

For areas adjacent to reservoirs, anticipated impacts on groundwater elevations mirror trends seen for Issue 1 reservoir elevations, where alternatives that result in higher water surface elevations can likewise be expected to result in higher groundwater elevations. The Maximum Operational Flexibility Alternative is the most robust at keeping elevations at Lake Powell above critical thresholds and is therefore expected to be the most robust at maintaining higher groundwater elevations compared to the CCS Comparative Baseline and the action alternatives. Whereas the No Action Alternative is the least robust at maintaining reservoir elevations and is therefore expected to be the least robust at maintaining groundwater elevations.

For reaches of the river that are alluvial fill, anticipated impacts on groundwater elevations mirror trends seen for Issue 4 river flows, where alternatives that result in higher flows in the reach can likewise be expected to result in higher groundwater elevations. The Basic Coordination Alternative is anticipated to have the highest flows in the Colorado River and is therefore assumed to result in the highest groundwater elevations adjacent to the river. The Enhanced Coordination Alternative is anticipated to have the lowest flows in the Colorado River and is therefore assumed to result in the lowest groundwater elevations adjacent to the river.

For reaches that contain bedrock or otherwise have limited hydraulic connectivity, groundwater is not anticipated to be affected by the operational changes outlined in the various alternatives.

TA 3.3 References

Arizona Department of Water Resources (ADWR). 2025. Arizona Groundwater Site Inventory. Internet website: https://azwatermaps.azwater.gov/gwsiweb/.

Bureau of Reclamation (Reclamation). 2007a. Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead–Final Environmental Impact Statement. November 2007. Internet website: https://www.usbr.gov/lc/region/programs/strategies/FEIS/index.html.

_____. 2007b. Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Record of Decision. December 2007. Internet website: https://www.usbr.gov/lc/region/programs/strategies/RecordofDecision.pdf.

_____. 2016. Record of Decision for the Glen Canyon Dam Long-Term Experimental and Management Plan Final Environmental Impact Statement. December 2016. Internet website: https://ltempeis.anl.gov/news/index.cfm#LTEMP-ROD-Signed.

_____. 2019. Colorado River Drought Contingency Plans. May 2019. Internet website: https://www.usbr.gov/ColoradoRiverBasin/dcp/finaldocs.html

_____. 2020. Annual Operating Plan for Colorado River Reservoirs 2020. Internet website: https://www.usbr.gov/uc/water/rsvrs/ops/aop/AOP20.pdf.

_____. 2021. Annual Operating Plan for Colorado River Reservoirs 2021. Internet website: https://www.usbr.gov/uc/water/rsvrs/ops/aop/AOP21.pdf.

_____. 2022a. Annual Operating Plan for Colorado River Reservoirs 2022. Internet website: https://www.usbr.gov/lc/region/g4000/aop/AOP22.pdf.

_____. 2022b. United States Department of the Interior Office of the Secretary Letter from Tanya Trujillo, Assistant Secretary for Water and Science, to Thomas Buschatzke, Governor's Representative for the State of Arizona. May 3, 2022. Internet website: https://www.usbr.gov/uc/DocLibrary/Plans/20220503-2022DROA-GlenCanyonDamOperationsDecisionLetter-508-DOI.pdf.

______. 2023. Annual Operating Plan for Colorado River Reservoirs 2023. Internet website: https://www.usbr.gov/uc/water/rsvrs/ops/aop/AOP23.pdf.

______. 2024a. Near-Term Colorado River Operations Final Supplemental Environmental Impact Statement. March 2024. Internet website: https://www.usbr.gov/ColoradoRiverBasin/documents/NearTermColoradoRiverOperations/20240300-Near-termColoradoRiverOperations-FinalSEIS-508.pdf.

______. 2024b. Drought Response Operations Summary Sheet. March 15, 2024. Internet website: https://www.usbr.gov/ColoradoRiverBasin/documents/dcp/DROA/DROSummarySheet.pdf.

______. 2024c. Establishment of Interim Operating Guidance for Glen Canyon Dam During Low Reservoir Levels at Lake Powell Technical Decision Memorandum. Internet website: https://www.usbr.gov/uc/DocLibrary/Memos/20240326-EstablishmentInterimOperatingGuidanceGlenCanyonDamLowReservoirLevels-TechnicalDecisionMemo-508-TSC.pdf.

______. 2024d. Annual Operating Plan for Colorado River Reservoirs 2024. Internet website: https://www.usbr.gov/lc/region/g4000/aop/AOP24.pdf.

______. 2024e. Near-term Colorado River Operations Record of Decision. May 2024. Internet website: https://www.usbr.gov/ColoradoRiverBasin/documents/NearTermColoradoRiverOperations/20240507-Near-termColoradoRiverOperations-SEIS-RecordofDecision-signed_508.pdf.

______. 2024g. Annual Operating Plan for Colorado River Reservoirs 2025. Internet website: https://www.usbr.gov/uc/water/rsvrs/ops/aop/AOP25.pdf.

______. 2025a. Colorado River Basin Natural Flow Data. Internet website: https://www.usbr.gov/lc/region/g4000/NaturalFlow/provisional.html.

______. 2025b. Interior Region 7 Upper Colorado Basin Water Operations HydroData. Internet website: https://usbr.gov/uc/water/hydrodata/reservoir_data/site_map.html.

______. 2025c. Lake Powell Unregulated Inflow Water Year 2025 Forecast Comparison with History. Internet website: https://www.usbr.gov/uc/water/crsp/studies/images/PowellForecast.png.

______. 2025d. Annual Operating Plan for Colorado River Reservoirs 2025. Internet website: https://www.usbr.gov/uc/water/rsvrs/ops/aop/AOP25.pdf.

______. 2025e. DRAFT Annual Operating Plan for Colorado River Reservoirs 2026. Internet website: https://www.usbr.gov/lc/region/g4000/AOP2026/AOP26_draft.pdf.

______. 2025f. Lees Ferry Annual Natural Flow Data from November 2025.

Lukas, J. and E. Payton. 2020. Colorado River Basin Climate and Hydrology: State of the Science. Western Water Assessment. April 2020. Internet website: https://doi.org/10.25810/3hcv-w477.

Meko, D.M., C.A. Woodhouse, C.A. Baisan, T. Knight, J.J. Lukas, M.K. Hughes, and M.W. Salzer. 2007. Medieval drought in the upper Colorado River Basin. Geophysical Research Letters, 34. May 2007. Internet website: https://doi.org/10.1029/2007GL029988.

National Oceanic and Atmospheric Administration (NOAA). 2025. Climate at a Glance Regional Time Series. Retrieved from National Centers for Environmental Information. Internet website: https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/regional/time-series.

United States Geological Survey (USGS). 2024. USGS Water Data For the Nation: Gage Data for Colorado River Near Grand Canyon, AZ USGS Gage 09402500. Internet website: https://waterdata.usgs.gov/monitoring-location/USGS-09402500.

______. 2025a. USGS Water Data For the Nation: Gage Data for Paria River at Lees Ferry, AZ USGS Gage 09382000. Internet website: https://waterdata.usgs.gov/monitoring-location/USGS-09382000.

______. 2025b. USGS Water Data For the Nation: Gage Data for Bill Williams River Near Parker, AZ. USGS Gage 09426620. Internet website: https://waterdata.usgs.gov/monitoring-location/USGS-09426620.

Wahl, E.R., E. Zorita, H.F. Diaz, and A. Hoell. 2022. Southwestern United States drought of the 21st century presages drier conditions into the future. Communications Earth & Environment, 3. September 2022. Internet website: https://www.nature.com/articles/s43247-022-00532-4.

Wang, J. and J. Schmidt. 2020. Stream flow and Losses of the Colorado River in the Southern Colorado Plateau. Internet website: https://qcnr.usu.edu/coloradoriver/files/news/FS-White-Paper-5.pdf.

Woodhouse, C.A., S.T. Gray, and D.M. Meko. 2006. Updated streamflow reconstructions for the Upper Colorado River Basin. Water Resources Research, 42, W05415. May 2006. Internet website: https://sheppard.ltrr.arizona.edu/presession/woodhouse%26gray2006.pdf.

This page intentionally left blank.