BUREAU OF RECLAMATION

Near-term Colorado River Operations

Revised Draft Supplemental Environmental Impact Statement

October 2023

U.S. Department of the Interior
Bureau of Reclamation
Upper and Lower Colorado Basins
Interior Regions 7 and 8

BUREAU OF RECLAMATION

Mission Statements

The **Department of the Interior** protects and manages the Nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its trust responsibilities or special commitments to American Indians, Alaska Natives, and affiliated island communities.

The mission of the **Bureau of Reclamation** is to manage, develop, and protect water and related resources in an environmentally and

Photo by Connie Castle, Bureau of Reclamation, 2023, Flickr.com

The water level behind the Hoover Dam on July 28, 2023.

Dear Reader:

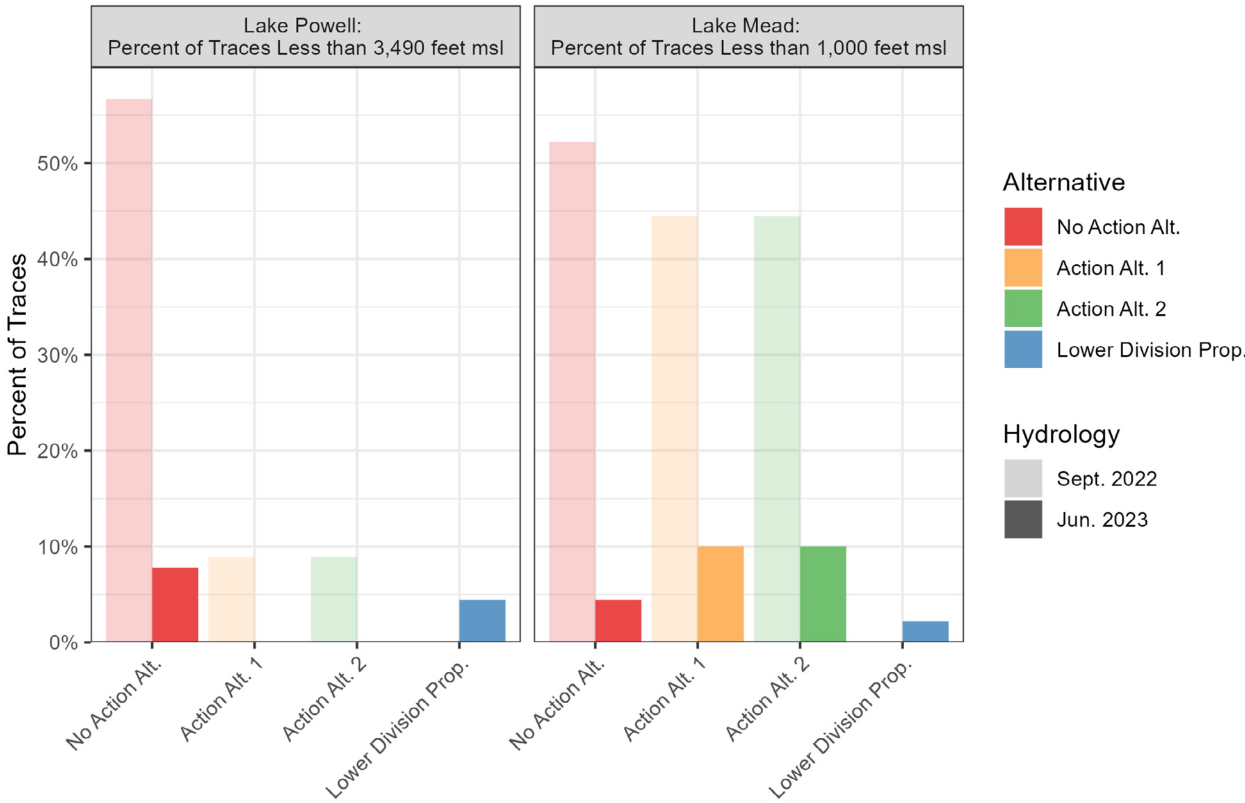
Thank you for taking the time to review this Revised Draft Supplemental Environmental Impact Statement (SEIS). In the original Draft SEIS issued April 14, 2023, Action Alternatives 1 and 2 were considered and fully analyzed along with the No Action Alternative. The analysis in the original Draft SEIS was based on hydrology from September 2022. Since issuing the original Draft SEIS, two key developments have occurred that require reassessment of the range of alternatives: improved hydrology and a proposal for a new alternative. The improved hydrology represents new circumstances that would significantly change the environmental impacts evaluated in the original Draft SEIS, and the proposal for a new alternative is a change to the Proposed Action that would result in significant impacts not evaluated in the original Draft SEIS.

First, hydrology in the Colorado River Basin has improved compared with the hydrology at the time the SEIS analysis began. Analysis in the original Draft SEIS was based on hydrology from September 2022. Using the September 2022 hydrology, the percent of traces reaching critical elevations at Lake Powell (i.e., below 3,490 feet) through 2026 was 57 percent, and the percent of traces reaching critical elevations at Lake Mead (i.e., below 1,000 feet) was 52 percent without additional action. With improved hydrology from June 2023, the percent of traces declining below critical elevations is 8 percent at Lake Powell and 4 percent at Lake Mead through 2026.

Regarding the hydrology modeling discussed here (and in the original Draft SEIS), it is important to note that the window of analysis is short (through 2026), and the modeling explores a wider range of low-flow hydrologic scenarios beyond those experienced during the recent 30 years (1991–2020) to account for increased climate change risks. This approach presents a cautious approach to the risk of reaching critical elevations at Lake Powell and Lake Mead for the interim period at issue in the SEIS. While modeling information about future conditions can never be certain, Reclamation's modeling using this cautious approach to risk and the short timeframe attempts to account for near-term climate change considerations to best inform the National Environmental Policy Act of 1969 (NEPA) analysis.

Second, in May 2023, after the original Draft SEIS was issued, the Lower Division States proposed an alternative for approximately 3 million acre-feet of mostly funded conservation to protect critical levels at Lake Mead ("Lower Division Proposal"). The Upper Division States recommended that this proposed alternative be analyzed in the NEPA process. After the Lower Division Proposal was submitted, Reclamation temporarily withdrew the Draft SEIS so that it could fully analyze the effects of the proposal under the NEPA.

To assess the effects of these developments, Reclamation conducted modeling analysis of the No Action Alternative, Action Alternative 1, Action Alternative 2, and the Lower Division Proposal with updated hydrology from June 2023 and slightly modified assumptions, as described in **Attachment B-1 to Appendix B**. The results of that modeling analysis indicate that the risk of reaching critical elevations at Lake Powell and Lake Mead has been reduced substantially by hydrology. For example, in Action Alternatives 1 and 2, the percent of traces reaching critical elevations at Lake Powell (i.e., below 3,490 feet) through 2026 decreased from 9 percent to 0 percent using the updated June 2023 forecast. Similarly, the percent of traces reaching critical elevations at Lake Mead (i.e., below 1,000 feet) decreased from 44 percent to 10 percent using the updated June 2023 forecasts.



The modeling results (see **Appendix B**) also indicate how Action Alternatives 1 and 2, the Lower Division Proposal, and No Action Alternative protect critical elevations at Lake Powell and Lake Mead relative to one another under the updated hydrology. Regarding Lake Powell, under the Lower Division Proposal, 4 percent of traces show Lake Powell reaching critical levels through 2026, which is an improvement over the 8 percent of traces under the No Action Alternative. Action Alternatives 1 and 2 have operational components that avoid critical elevations at Lake Powell and do not show traces declining below critical elevations through 2026.

Modeling results show more variance for Lake Mead critical elevations. The No Action Alternative shows 4 percent of traces reaching critical elevations. The Lower Division Proposal shows fewer traces reaching Lake Mead critical elevations relative to Action Alternatives 1 and 2 (4 percent versus 10 percent).

Based on these modeling results, and as explained in the bullet points below, Reclamation will continue the SEIS process with detailed consideration of the No Action Alternative and the Lower Division Proposal. The Lower Division Proposal will be designated as the Proposed Action. Action Alternatives 1 and 2 will be addressed as alternatives considered but eliminated from detailed analysis.

- Based on June 2023 hydrology modeling, Action Alternatives 1 and 2 show no risk of reaching critical elevations at Lake Powell due to a protection elevation provision, while the Proposed Action shows a decreased risk of reaching critical elevations compared with the No Action Alternative; Action Alternatives 1 and 2 also show increased risk of reaching critical elevations at Lake Mead relative to the Proposed Action. Based on these updated hydrology modeling results, the Proposed Action achieves many of the same objectives as Action Alternatives 1 and 2—reducing the potential that continued low-runoff conditions could lead Lake Powell and Lake Mead to decline to critically low elevations; protecting critical infrastructure at both reservoirs; and balancing overall operational risks in the Colorado River Basin—but with additional risk reduction.

- Although a single action alternative is not preferred in NEPA analysis, the updated hydrology modeling shows that even no action presents much lower risk of reaching critical elevations at Lake Powell and Lake Mead through 2026 than prior hydrology modeling from September 2022. While the No Action Alternative is often not a reasonable mechanism to achieve the purpose and need of a federal action, the change in hydrology, short timeframe, and corresponding change in risk may make the No Action Alternative viable here.

- The Proposed Action is consistent with the purpose and need objective of reducing the potential that continued low-runoff conditions in the Basin could lead Lake Powell and Lake Mead to decline to critically low elevations, impacting operations through the remainder of the interim period. Moreover, as the SEIS is supplemental to the original EIS, it is meant to address a specific circumstance during a limited timeframe. Thus, it is reasonable that fewer alternatives are considered in the SEIS than the original Draft SEIS.

- The Proposed Action is consistent with Congressional actions to fund water conservation in the Colorado River Basin. In Section 50233 of the Inflation Reduction Act (Public Law 117-169), Congress provided 4 billion dollars to mitigate the impacts of drought, with priority to the Colorado River Basin and other basins experiencing comparable levels of long-term drought. The conservation efforts that are part of the Proposed Action are consistent with this Congressional direction.

In summary, it is appropriate for the SEIS analysis to consider the No Action Alternative and the Proposed Action as a reasonable range of alternatives to reduce the risk of reaching critical elevations at Lake Powell and Lake Mead to acceptable levels in the pre-2026 SEIS timeframe. The reduced risks from improved hydrology, cautious modeling approach, and short timeline will allow Reclamation to efficiently consider tools to address critical elevations at Lake Powell and Lake Mead, allowing the entire Colorado River Basin and its many water users to focus on longer-term planning efforts during development of the Post-2026 Operational Guidelines and Strategies for Lake Powell and Lake Mead. It was wholly appropriate for Reclamation to include Action Alternatives 1 and 2 based on the hydrologic facts when the SEIS process began, but those facts have changed in the short term and the alternatives have changed accordingly.

Thank you,

Department of the Interior

Revised Draft Supplemental Environmental Impact Statement for Near-term Colorado River Operations

Proposed Action: Reclamation is proposing to revise the 2007 Interim Guidelines for the operation of Glen Canyon and Hoover Dams beginning in the 2024 operating year to address the potential for continued low-runoff conditions in the Colorado River Basin. The potential impacts of low runoff conditions in the remainder of the interim period (prior to January 1, 2027) pose unacceptable risks to routine operations of Glen Canyon and Hoover Dams; therefore, modified operating guidelines should be expeditiously developed.

Lead agency: Bureau of Reclamation, Upper Colorado Basin Interior Region 7 and Lower Colorado Basin Interior Region 8

Cooperating agencies:
Bureau of Indian Affairs
National Park Service
Western Area Power Administration
US Fish and Wildlife Service
US Section of the International Boundary and Water Commission

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Acronyms and Abbreviations

Acronym/Abbreviation	Full Phrase
1944 Water Treaty	United States-Mexico Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande
2006 Flaming Gorge Dam ROD	2006 Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement
2007 FEIS	2007 Interim Guidelines Final Environmental Impact Statement
2007 Interim Guidelines	Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead
2007 ROD	2007 Interim Guidelines Record of Decision
2012 Aspinall ROD	2012 Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement
μg/L	micrograms per liter
af	acre-feet
afy	acre-feet per year
AOP	Annual Operating Plan
APE	area of potential effects
Basin	Colorado River Basin
Basin Fund	Upper Colorado River Basin Fund
Basin States	Colorado River Basin States
BCPA	Boulder Canyon Project Act
BIA	Bureau of Indian Affairs
BWSCP	Binational Water Scarcity Contingency Plan
°C	degrees Celsius
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CBRFC	Colorado Basin River Forecast Center
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cfs	cubic feet per second
CLNP	Canyonlands National Park
CNRA	California Natural Resources Agency
CO_2e	carbon dioxide equivalent
Compact	Colorado River Compact of 1922
CRIR	Colorado River Indian Reservation
CRMMS	Colorado River Mid-term Modeling System
CRMP	Colorado River Management Plan
CRSP	Colorado River Storage Project
CRSS	Colorado River Simulation System
CVWD	Coachella Valley Water District

Dam Fund	Colorado River Dam Fund
DCP	Drought Contingency Plan
DCPA	2019 Colorado River Drought Contingency Plan Authorization Act
Department	United States Department of the Interior
Development Fund	Colorado River Basin Development Fund
DO	dissolved oxygen
DROA	Drought Response Operations Agreement
EA	environmental assessment
EC	extraordinary conservation
EIA	United States Energy Information Administration
EIS	environmental impact statement
EPA	United States Environmental Protection Agency
ESA	Endangered Species Act
ESP	Ensemble Streamflow Prediction
GCMRC	Grand Canyon Monitoring and Research Center
GCNP	Grand Canyon National Park
GCNRA	Glen Canyon National Recreation Area
GCPA	Grand Canyon Protection Act of 1992
GDP	gross domestic product
GEMSS	Generalized Environmental Modeling System
GHG	greenhouse gas(es)
GIS	geographic information system
GRIC	Gila River Indian Community
GTMax	Generation and Transmission Maximization
GWh	gigawatt hours
HCP	Habitat Conservation Plan
HFE	High-Flow Experiment
IBWC	International Boundary and Water Commission
ICS	intentionally created surplus
IID	Imperial Irrigation District
Indian	American Indians
IPAC	Information for Planning and Consultation
ITAs	Indian trust assets
ITCA	Inter-Tribal Council of Arizona
LCR MSCP	Lower Colorado River Multi-Species Conservation Plan
LMNRA	Lake Mead National Recreation Area
LTEMP	Long-Term Experimental and Management Plan
m^2	square meter
maf	million acre-feet
M&I	municipal and industrial
Mexico	United Mexican States
mg/L	milligrams per liter

MOA	memorandum of agreement
MOU	memorandum of understanding
Msl	mean sea level
MST	mountain standard time
MT	metric tons
MW	megawatts
MWD	Metropolitan Water District of Southern California
MWh	megawatt hours
NAAQS	National Ambient Air Quality Standards
NDOW	Nevada Department of Wildlife
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act of 1966
NIA	non-Indian agriculture
NIB	Northerly International Boundary
NOI	Notice of Intent
NPS	National Park Service
NRHP	National Register of Historic Places
NWR	National Wildlife Refuge
PA	programmatic agreement
PABCO	Pacific Coast Building Products
P-DP	Parker-Davis Project
PM	particulate matter
PO&M	power operations and maintenance
ppb	parts per billion
PPR	present perfected right
PRPA	Paleontological Resource Protection Act
PSD	Prevention of Significant Deterioration
Reclamation	Bureau of Reclamation
RM	river mile
ROD	Record of Decision
Secretary	Secretary of the Interior
SEIS	supplemental environment impact statement
Service	United States Fish and Wildlife Service
SHPO	State Historic Preservation Office
SIB	Southerly International Boundary
SNWA	Southern Nevada Water Authority
SNWP	Southern Nevada Water Project
SRWYC	Sacramento River Water Year Classification
SSAM	Salton Sea Accounting Model
SUIT	Southern Ute Indian Tribe
TCP	traditional cultural property
TDS	total dissolved solids
THPO	Tribal Historic Preservation Officer

US	United States
USC	United States Code
USGS	United States Geological Survey
USIBWC	United States Section of the International Boundary and Water Commission
WAPA	Western Area Power Administration
WECC	Western Electricity Coordinating Council

Chapter 1. Purpose and Need

1.1 Introduction

The Colorado River Basin (Basin) provides essential water supplies to approximately 40 million people, nearly 5.5 million acres of agricultural lands, hydroelectric renewable power, recreational opportunities, habitat for ecological resources, and other benefits across the western United States and northwestern United Mexican States (Mexico). The Basin occupies an area of approximately 250,000 square miles in the western United States and 3,500 square miles in northwestern Mexico. The Colorado River Compact of 1922 (Compact) divided the Colorado River system into two sub-basins, the Upper Basin and the Lower Basin, and divided the seven states within the Basin into the Upper Division and the Lower Division (**Map 1-1**). Upper Division states include Colorado, New Mexico, Utah, and Wyoming, and the Lower Division includes Arizona, California, and Nevada. Additionally, there are 30 federally recognized Tribes in the Basin (see **Section 4.4** for more information).

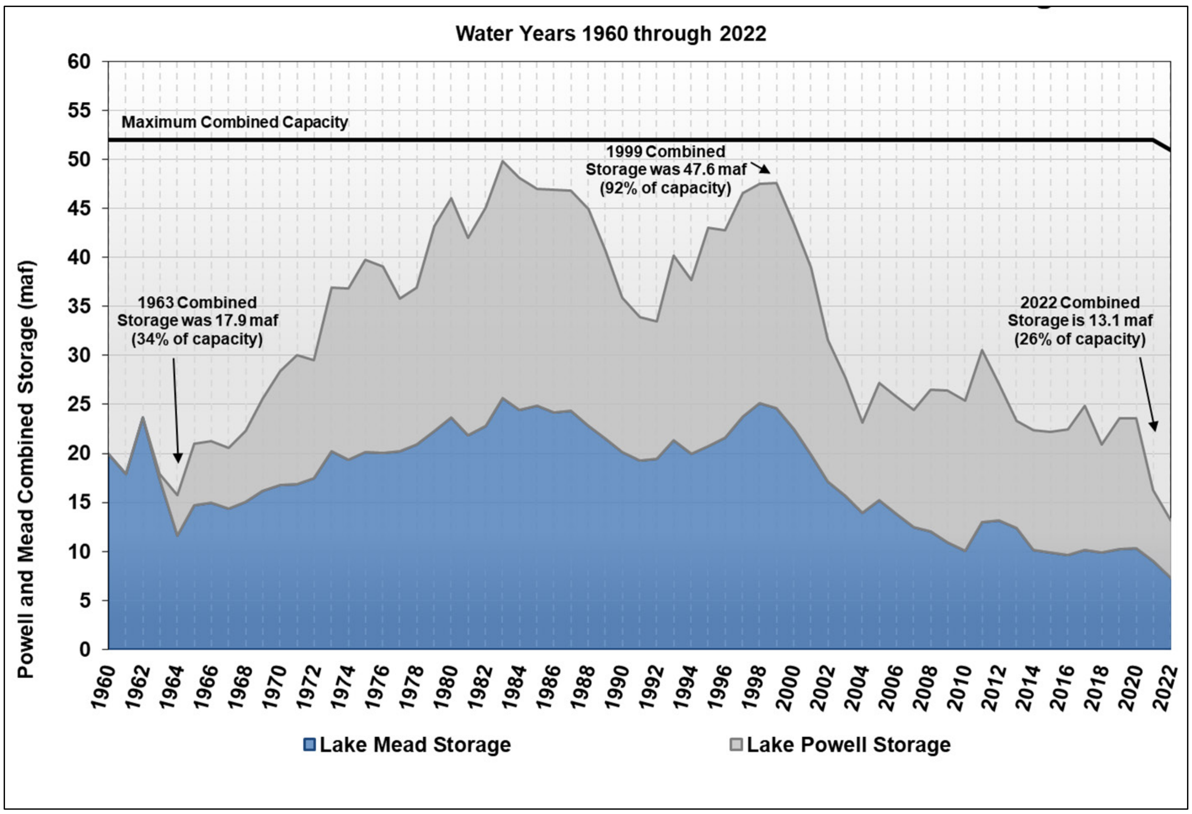
The Secretary of the Interior (Secretary) is vested with the responsibility to manage the mainstream waters of the lower Colorado River and operate federal facilities pursuant to applicable federal law. This responsibility is carried out consistent with a body of documents that are commonly referred to as the "Law of the River." While there is no single accepted formal definition of this phrase, the Law of the River comprises numerous operating criteria, regulations, administrative decisions, direction included in federal statutes, interstate compacts, court decisions and decrees, an international treaty with Mexico, and contracts.

The Department of the Interior's (Department) Bureau of Reclamation (Reclamation) is tasked with operating facilities in both the Upper and Lower Basins. Reclamation operates four major dams and various irrigation and diversion structures along the mainstream river, along with five dams on tributaries, as part of the Upper Basin Colorado River Storage Project (CRSP). Reclamation operates Hoover Dam and other major facilities in the Lower Basin pursuant to the Boulder Canyon Project Act (BCPA) and other related federal statutes. Operations include managing water supplies and hydrologic power generation. **Appendix A**, Overview of Colorado River Operations, provides additional information about the Law of the River, water apportionment among the Upper and Lower Division States, and river operations.

The Colorado River is approximately 1,450 miles in length, originating along the Continental Divide in Rocky Mountain National Park in Colorado and historically flowing to the Sea of Cortez. Most of the total annual flow in the Basin is runoff from mountain snowmelt. As such, snowpack that accumulates through April provides a reasonable basis for forecasting the majority of the runoff through the remainder of the operating year.[1] Major tributaries to the Colorado River include the Green, San Juan, Yampa, Gunnison, and Gila Rivers.

Climate varies significantly throughout the Basin. Most of the Basin is arid or semi-arid, and generally receives less than 10 inches of precipitation per year. In contrast, many of the mountainous areas that rim the northern portion of the Basin receive historical averages exceeding 40 inches of precipitation per year. While the annual flow of the Colorado River and its tributaries varies considerably from year to year, the Basin is currently experiencing a prolonged period of aridification caused by climate change, with extended periods of drought and record low-runoff conditions. The period from 2000 through 2022 is the driest 23-year period in more than a century and one of the driest periods in the last 1,200 years. This has resulted in historically low reservoir levels at Lake Powell and Lake Mead (**Figure 1-1**).

Figure 1-1
Lake Powell and Lake Mead End of Operating Year Storage



[1] The operating year for Glen Canyon Dam runs from October 1 through September 30; the operating year for Hoover Dam runs from January 1 through December 31. Throughout this SEIS, the term "operating year" is used instead of "water year."

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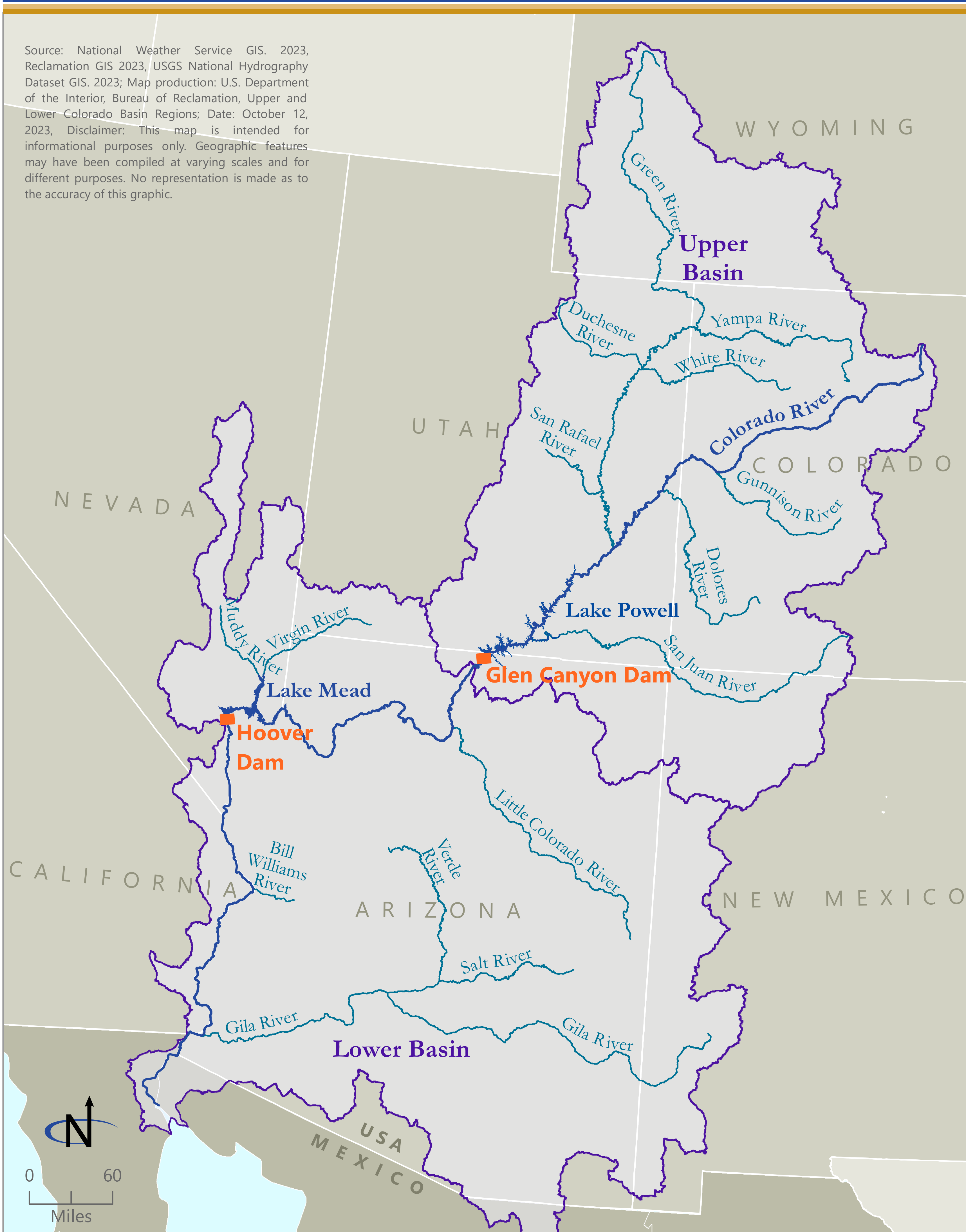

Map 1-1
Upper and Lower Division States of the Colorado River

- Colorado River
- Colorado River tributary
- Dam
- Colorado River Basin, Upper and Lower Basins

States in the Colorado River Basin (Wyoming, Colorado, Utah, and New Mexico are Upper Division states, and Arizona, California, and Nevada are Lower Division states)

While portions of northwestern Mexico are part of the Basin, these areas are not within the geographic scope of analysis for this SEIS. This SEIS does not address water deliveries to Mexico.

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Reclamation, the Department, Colorado River Basin States (Basin States), Mexico, Tribes, and other Basin water users have undertaken a series of intensive efforts to respond to the extended drought and historically low reservoir levels in the Basin. In December 2007, the Department signed the Record of Decision (ROD) for the Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines; DOI 2007). The 2007 Interim Guidelines, which were anticipated to be in place through 2026, provide operating criteria for Lake Powell and Lake Mead, including provisions designed to provide a greater degree of certainty to water users about timing and volumes of potential water delivery reductions, and additional operating flexibility to conserve and store water in the system.

The 2007 Interim Guidelines adopted ranges of releases from Glen Canyon and Hoover Dams that were linked to reservoir elevations in Lake Powell and Lake Mead, respectively. The 2007 Interim Guidelines were adopted for a limited period ("interim") to provide an opportunity for Reclamation and interested entities to gain valuable experience for the management of Lake Powell and Lake Mead under modified operations, with the goal of improving the analytical bases for making future operational decisions, whether during the interim period or after.

Additional key actions that influence operations of the Colorado River include the 2016 Glen Canyon Dam Long-Term Experimental and Management Plan (LTEMP) and the 2019 Upper Basin and Lower Basin Drought Contingency Plans (DCPs). In 2016, Reclamation and the National Park Service (NPS) developed and implemented the LTEMP to adaptively manage Glen Canyon Dam operations over the next 20 years, consistent with the Grand Canyon Protection Act of 1992 (GCPA) and other provisions of applicable federal law (Reclamation and NPS 2016).[2]

In 2019, a number of DCPs were signed, as directed by Congress in the 2019 Colorado River Drought Contingency Plan Authorization Act (DCPA) (Public Law 116-14), outlining strategies to address the ongoing drought and low-runoff conditions in the Upper and Lower Basins.[3] The DCPs addressed operations in both the Upper and Lower Basins.[4] The Upper Basin DCP is designed to reduce the risk of reaching critical elevations at Lake Powell, help assure continued compliance with the Compact, and facilitate and encourage storage of conserved water in the Upper Basin that could help establish the foundation for a demand management program that may be developed in the future. The Lower Basin DCP is designed to require additional contributions of water to Lake Mead storage at predetermined elevations and create new flexibility to incentivize additional voluntary conservation of water to be stored in Lake Mead. Additional information on the operating criteria, regulations, administrative decisions, and statutes affecting Colorado River operations are included in **Appendix A** of this Supplemental Environmental Impact Statement (SEIS) and in Section 5.1 of the 2007 Interim Guidelines Final EIS (2007 FEIS; Reclamation 2007).

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[2] More information at: https://ltempeis.anl.gov/

[3] More information at: https://www.usbr.gov/dcp/

[4] In particular, given the focus on Glen Canyon Dam operations since 2021, the DCP addressing Upper Basin operations that has been the key operational document is the Drought Response Operations Agreement (DROA). The DROA identifies a process to temporarily move water stored in the CRSP Initial Units above Lake Powell—Blue Mesa (a component of the Aspinall Unit), Flaming Gorge, and Navajo—to Lake Powell when it is projected to approach or decline below elevation 3,525 feet. See more information at: https://www.usbr.gov/dcp/droa.html.

The Department has taken multiple steps to respond to historic drought and low-runoff conditions in the Basin since 2007, including several unprecedented and emergency actions since 2021:

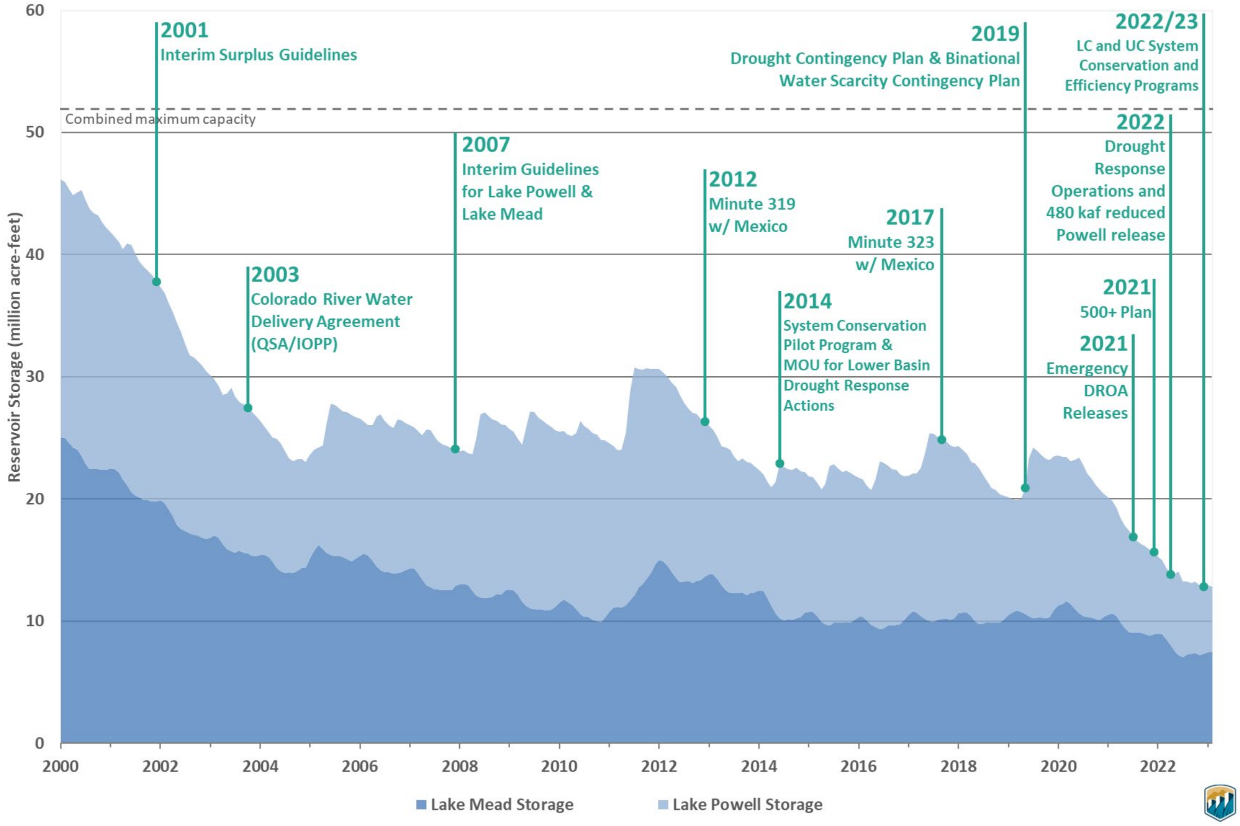
- **2014 – System Conservation Programs:** A 2014 agreement among Reclamation and the major municipal water providers (Denver Water, Central Arizona Water Conservation District [CAWCD], Metropolitan Water District of Southern California [MWD], and Southern Nevada Water Authority [SNWA]) in both the Upper and Lower Basin established a pilot program to fund the creation of Colorado River system water through voluntary, measurable reductions in consumptive use for the benefit of all users to help offset declining reservoir elevations.
- **2019 – Drought Contingency Plans:** As described above, the DCPs provide a framework for additional actions to help the Basin adapt to drought.
- **2021 – Emergency Drought Response Operations Agreement (DROA) Releases:** Consistent with DROA provisions to protect Lake Powell's target elevation, Reclamation increased releases from the upstream initial units of the CRSP to deliver an additional 181,000 acre-feet (af) of water to Lake Powell by the end of December 2021.
- **2021 – 500 Plus Plan:** Recognizing the history of low-runoff conditions and the variability of flows in the Basin, workgroups concluded an additional 500,000 af or more per year of additional reductions in water use were required. The plan was to conserve additional water above what is required under a Lower Basin shortage condition and contributions under the Lower Basin DCP. The 500 Plus Plan's parties identified and are funding projects in each of the three Lower Division States. The projects include Tribal, agricultural, and municipal water users.
- **2022 – Drought Response Operations and 480,000-af Reduced Lake Powell Release:** On May 3, 2022, Reclamation announced two separate drought response actions to help increase Lake Powell storage by nearly 1.0 million acre-feet (maf) from May 2022 through April 2023. These actions were (1) releasing approximately 500,000 af of water from Flaming Gorge Reservoir under the DROA and (2) holding 480,000 af in Lake Powell by reducing Glen Canyon Dam's annual release volume from 7.48 maf to 7.00 maf.[5]
- **2022/2023 – Lower Colorado and Upper Colorado System Conservation and Efficiency Programs:** The programs were created to address the unprecedented drought in the Basin and are part of the commitment made by the Department on August 16, 2022, to address the drought crisis with prompt and responsive actions and investments to create programs and improve water management efforts across the Basin.

Figure 1-2 shows how reservoir elevations have declined despite these efforts.[6]

[5] Letter from Tanya Trujillo, Assistant Secretary for Water and Science, Department, to Thomas Buschatzke, Governor's Representative, State of Arizona, May 3, 2022. https://www.usbr.gov/uc/DocLibrary/Plans/20220503-2022DROA-GlenCanyonDamOperationsDecisionLetter-508-DOI.pdf https://www.usbr.gov/uc/DocLibrary/Plans/20220503-2022DROA-GlenCanyonDamOperationsDecisionLetter-508-DOI.pdf

[6] This SEIS does not affect the provisions of the 1944 Water Treaty and the implementing minutes; this is because the SEIS is not considering alternative actions that would change water deliveries to Mexico.

Figure 1-2
Actions and Agreements to Protect Lake Powell and Lake Mead Reservoir Elevations (since 2000)



While these actions, especially the DCPs, were intended to preserve Reclamation's ability to undertake post-2026 operational planning with a stable system and avoid crisis planning, Colorado River water supplies continue to decline, resulting in historically low reservoir levels at Lake Powell and Lake Mead. Following adoption of the DCPs in 2019, the Basin experienced three of the lowest consecutive years of inflow on record from 2020 through 2022, with 2021 among one of the lowest inflow years on record. During this time, the combined storage of Lake Powell and Lake Mead declined from about 50 percent to 25 percent of total live capacity. Absent a meaningful and unexpected change in hydrologic conditions and trends, water use patterns, or both, Colorado River reservoirs will continue to decline to critically low elevations, threatening essential water supplies across seven states in the United States and two states in Mexico. Although hydrology improved in 2023, it is foreseeable that without appropriate responsive actions and under a continuation of poor hydrologic trends, major Colorado River reservoirs could continue to decline to "dead pool" in the coming years.[7]

Given the declining reservoir elevations, the anticipated continuing trend of low-runoff conditions, and the need to protect infrastructure and Colorado River operations, the Department published a

[7] Dead pool refers to elevations at which water cannot be regularly released from a reservoir, which would effectively preclude Colorado River diversions to downstream users.

Notice of Intent (NOI) in the *Federal Register* on November 17, 2022. The NOI provided the public with the Department's intent to "promptly identify and analyze modified operating guidelines to address current and foreseeable hydrologic conditions" (87 *Federal Register* 69042, 69043 (November 17, 2022)). Under the 2007 Interim Guidelines, 2019 DCPs, and related agreements, Reclamation currently lacks the operational tools necessary to address projected extreme drought conditions and is prioritizing implementation of near-term actions to stabilize the decline in reservoir storage and prevent system collapse. The modification of operating guidelines noted in the *Federal Register* notice is focused on the 2023–2026 period (i.e., the remainder of the interim period). Any actions adopted pursuant to this SEIS process would be separately developed from operational planning for the period beyond 2026; however, these tools may inform such later planning.

1.2 Proposed Federal Action

Recognizing the risks facing the Basin, the Department concluded in 2022 that immediate development of additional operational tools for Lake Powell and Lake Mead was necessary to ensure continued operations that are prudent or necessary for safety of dams, public health and safety, and other emergency situations.

Accordingly, Reclamation is proposing to revise the 2007 Interim Guidelines for the near-term operation of Glen Canyon and Hoover Dams to address the potential for continued low-runoff conditions in the Basin.[8] Reclamation has concluded that the potential impacts of low-runoff conditions pose unacceptable risks to routine operations of Glen Canyon and Hoover Dams during the remainder of the interim period (prior to January 1, 2027) and that modified operating guidelines need to be expeditiously developed.

As described in the **Dear Reader Letter**, hydrology in the Colorado River Basin has improved compared with the hydrology at the time the SEIS analysis began. The updated hydrologic modeling from June 2023 shows a much lower risk of reaching critical elevations at Lake Powell and Lake Mead through 2026 than prior hydrologic modeling from September 2022. However, the risk of reaching critical elevations remains, as does the need to develop tools to address the risk of reaching critical elevations. This revised draft SEIS analyzes those tools, making appropriate adjustments based on improved hydrology, as described in the **Dear Reader Letter**.

[8] The 2024 operating year for Glen Canyon Dam begins October 1, 2023; the 2024 operating year for Hoover Dam begins January 1, 2024.

Given the potential risks to infrastructure[9] and public health and safety, the Department will promptly identify and analyze modified operating guidelines through this SEIS to address current and foreseeable hydrologic conditions. The Proposed Action would modify and/or add to the following sections of the 2007 Interim Guidelines Record of Decision (2007 ROD) published at 73 *Federal Register* 19881 (April 11, 2008):

- Section 2. Determination of Lake Mead Operation During the Interim Period
- Section 6. Coordinated Operation of Lake Powell and Lake Mead During the Interim Period
- Section 7. Implementation of Guidelines

Reclamation has already begun efforts that will lead to preparation of an additional Environmental Impact Statement (EIS) for operating guidelines after 2026. See 87 *Federal Register* 37884 (June 24, 2022) and 88 *Federal Register* 39455 (June 16, 2023).

This document, prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), analyzes potential modifications to existing reservoir operations. As these analyses are developed, it is important to note that reservoir operation is an inherently ongoing process that must continue while a new operation is being analyzed and determined. As water flows into a reservoir, inflows stored above the dam must be managed in light of the specific physical and operational characteristics of the dam and reservoir. These can include storage capacity, types and elevations of structures to release water, or the need to preserve space for additional inflow as snow melts. As stored water is released from the reservoir, it must be released consistent with the specific physical and operational characteristics of the release structures and the river below, which can include maximum and minimum flow rates; safety restrictions to protect downstream facilities or water uses; considerations to meet ecological conditions, such as the time of year or temperature when water is released; or physical limits where water can no longer be released.

Reservoir operators must routinely—and continuously—adjust releases for these characteristics; there is no option for reservoir operations to simply stop while new rules are developed. Operators must continuously adjust to changing hydrologic conditions—both high-water events, such as being prepared for unexpected snowmelt, and low-water events, such as elevations that approach dead pool—regardless of the timelines or process to determine new reservoir operating rules. These adjustments are further complicated with the coordinated operation of the largest reservoirs in the

[9] In recent months, a primary concern for the Department has been to identify and implement actions to ensure Glen Canyon Dam continues to provide downstream water deliveries as designed and intended (i.e., it remains above elevations at/about 3,490 feet above mean sea level). While additional analysis may find that water can be released through the hydropower units when Lake Powell is at slightly lower levels, at this time, 3,490 feet is the cutoff for routine operations. Below this elevation, all water could only be released through Glen Canyon Dam's four river outlet works (reducing operational redundancy and, thus, increasing the operational risk for downstream releases). This would create a risk of water supply interruptions to water users that rely on Lake Powell for water supply, hydropower interruptions to users that rely on Glen Canyon Dam for power supplies, and increased uncertainty regarding downstream releases should Lake Powell continue to decline. As discussed herein, if strategies are adopted to reduce Glen Canyon Dam releases to protect the reliability of routine operations, Lake Mead's water levels will decline at an accelerated rate, increasing the risk of Lake Mead declining to critically low levels and threatening water deliveries to those that rely on Lake Mead for water supplies.

Basin (Lake Powell and Lake Mead) and the other system reservoirs (both upstream of Lake Powell and downstream of Lake Mead).

In operating these major facilities, the Department must consider the overall conditions in the Basin in order to make the most prudent operational decisions. The overall sound and prudent operation of the major reservoirs on the Colorado River system during a period of declining inflows and historically low reservoirs will almost certainly lead to objection by specific entities to the impacts of one or more aspects of water management decisions. The Department will follow applicable federal law and prudent reservoir operations with respect to any modified operating guidelines, recognizing that with current reservoir elevations at historic lows, even one additional low-runoff winter season could have unprecedented adverse consequences across the Basin.

1.3 Purpose of and Need for Action

The purpose of the SEIS is to supplement the 2007 Interim Guidelines to modify guidelines for operation of the Glen Canyon and Hoover Dams to address historic drought, historically low reservoirs, and low-runoff conditions in the Basin. The need for the modified operating guidelines is based on the potential that continued low-runoff conditions in the Basin could lead Lake Powell and Lake Mead to decline to critically low elevations, impacting operations through the remainder of the interim period (prior to January 1, 2027).

To ensure Glen Canyon Dam continues to operate under its intended design for purposes of maintaining downstream water releases and protecting infrastructure from the potential consequences of operating at or below critical elevations, Reclamation may need to modify current operations and reduce Glen Canyon Dam downstream releases, impacting downstream resources and reservoir elevations at Lake Mead. Consequently, to protect Hoover Dam operations, system integrity, and public health and safety, Reclamation also may need to modify current operations and reduce Hoover Dam downstream releases.

Such modified Hoover Dam operations would, among other issues, address Section 7.B.4 of the 2007 Interim Guidelines as well as the commitments set forth in Section V.B.2 of Exhibit 1 to the 2019 DCPs. Both the 2007 Interim Guidelines and the 2019 DCPs contemplate the need for additional measures to protect Lake Mead elevations, with the DCPs adding the commitment of participating Lower Basin DCP parties to take "individual and collective action in the Lower Basin to avoid and protect against the potential for the elevation of Lake Mead to decline to elevations below 1,020 feet." As noted above, Section 7.D of the 2007 Interim Guidelines contemplates that modified operating provisions may be required if "extraordinary circumstances arise. Such circumstances could include operations that are prudent or necessary for safety of dams, public health and safety, other emergency situations, or other unanticipated or unforeseen activities arising from actual operating experience." The Department finds that such circumstances exist currently.

1.4 Lead and Cooperating Agencies

The Secretary is responsible for the operation of Glen Canyon Dam and Hoover Dam pursuant to applicable federal law. The Secretary is also vested with the responsibility of managing the mainstream waters of the lower Colorado River pursuant to federal law. This responsibility is carried out consistent with the Law of the River. Reclamation, as the agency designated to act on the Secretary's behalf with respect to these matters, is the lead federal agency for the development of this SEIS in accordance with NEPA.

Five federal agencies are cooperating for purposes of assisting with environmental analysis and preparation of this SEIS. These cooperating agencies are the Bureau of Indian Affairs (BIA), the United States Fish and Wildlife Service (Service), the NPS, Western Area Power Administration (WAPA), and the United States Section of the International Boundary and Water Commission (USIBWC).

The BIA has responsibility for the administration and management of lands held in trust by the United States for American Indians (Indian) and Indian Tribes located within the Basin. Developing forestlands, leasing assets on these lands, directing agricultural programs, protecting water and land rights, and developing and maintaining infrastructure and economic development are all part of the BIA's responsibility.

The Service is involved in the conservation, protection, and enhancement of fish, wildlife, and plants and their habitats for the continuing benefit of the American people. The Service manages the resources within four national wildlife refuges along the Colorado River. Among its many other key functions, the Service administers and implements federal wildlife laws, protects endangered species, manages migratory birds, restores nationally significant fisheries, conserves and restores wildlife habitat such as wetlands, and assists foreign governments with international conservation efforts. It also oversees the federal aid program that distributes hundreds of millions of dollars in excise taxes on fishing and hunting equipment to state fish and wildlife agencies.

The NPS administers areas of national significance along the Colorado River, including Glen Canyon National Recreation Area (GCNRA), Grand Canyon National Park (GCNP), and Lake Mead National Recreation Area (LMNRA). The NPS is primarily responsible for conservation of natural and cultural resources and visitor experience (including recreation) in these areas from offices located at Page, Arizona; Grand Canyon, Arizona; and Boulder City, Nevada, respectively. The NPS also grants and administers concessions for the operation of marinas and other recreation facilities at Lake Powell and Lake Mead, as well as concessions' operations along the Colorado River between Glen Canyon Dam and Lake Mead.

WAPA markets and distributes hydroelectric power and related services within a 15-state region of the central and western United States, and it is one of four power marketing administrations within the Department of Energy. Its role is to market and transmit electricity from multi-use water projects. WAPA markets and transmits power generated from the various hydropower plants within the Basin and operated by Reclamation. WAPA customers include municipalities, cooperatives, public utility and irrigation districts, federal and state agencies, investor-owned utilities (only one of which purchases firm power from WAPA), and Indian Tribes throughout the Basin. Wholesale customers, in turn, provide retail electric service to millions of consumers within the seven Basin States.

IBWC (2017) is a binational organization responsible for administration of the provisions of the February 3, 1944, United States-Mexico Treaty on Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande (1944 Water Treaty), which allots Colorado River waters to Mexico. IBWC responsibilities under the 1944 Water Treaty and other international agreements include assuring delivery of Mexico's Colorado River water allotment, protecting lands along the Colorado River from floods by levee and floodway construction projects, addressing border sanitation and other water quality problems, and preserving the Colorado River as the international boundary. The USIBWC and the Mexican Section have their headquarters in the adjacent cities of El Paso, Texas, and Ciudad Juarez, Chihuahua, respectively.

1.5 Scope of the SEIS

As a supplement, this SEIS incorporates by reference the original 2007 FEIS. The SEIS focuses on new information, changes in conditions since 2007, and impacts associated with the considered alternatives. The SEIS does not analyze the operations of the entire Colorado River system; rather, it focuses on only addressing the low-runoff and low-level conditions at Glen Canyon and Hoover Dams. Reclamation does not control the hydrology that affects inflows to Lake Powell. The best available scientific information indicates that low-runoff conditions may persist and worsen with warming conditions in the Basin.

While the potential for the current and persistent low-level conditions was recognized as a low possibility to occur during the interim period as part of the analysis supporting the development of the 2007 FEIS, the 2007 Interim Guidelines, as adopted, did not include provisions that would prevent system collapse under these persistent low-level conditions. Numerous initiatives since 2007 (for example, Minute 323 and the 2019 DCPs) have led to more robust policies; however, notwithstanding these efforts, Reclamation lacks the operating tools to sufficiently protect system operations. Therefore, in this SEIS, Reclamation is considering operations that are specifically designed to manage the respective reservoirs at lower elevations to more reliably maintain congressionally authorized infrastructure, operations, water deliveries, and power generation, and to avoid dead pool conditions, as feasible.

The hydrologic modeling performed for this SEIS examines scenarios based on flows in the Basin over the past 30 years, which includes 23 years of drought conditions. To examine even more severe drought conditions, the hydrologic modeling examines Basin flow scenarios with 90 percent and 80 percent of the flows seen over the past 30 years (up to a 20 percent reduction in flows compared with the last 30 years). The SEIS analyzes alternative operational scenarios to react to potential low-level conditions; it does not assess current or future river flow forecasts or attempt to predict actual operations. The SEIS does not include any changes to other operational agreements, such as LTEMP, DCPs, DROA, or Minute 323; operational planning and implementation would implement these agreements per their own terms, unless otherwise stated in this SEIS.

As noted above, on November 17, 2022, Reclamation published a NOI about the preparation of the SEIS (*Federal Register* Vol. 87, No. 221, 69042–69045). It also initiated a public scoping process requesting comments concerning the scope of the analysis, potential alternatives, and identification of relevant information and studies. Reclamation conducted web-based public scoping webinars on November 29 and December 2, 2022, soliciting public comments from interested parties by December 20, 2022. Reclamation also coordinated with representatives from the Basin States, Basin Tribes, and Mexico (through the USIBWC). All public comment letters, along with a scoping summary report (Reclamation 2023a), are available on the project website.[10]

Several reservoir and water management decisional documents and agreements that govern the operations of Lake Powell and Lake Mead expire at the end of 2026, including the 2007 Interim Guidelines, the 2019 DCPs, and international agreements between the United States and Mexico pursuant to Minute 323 to the 1944 Water Treaty. Concurrent to this SEIS process, Reclamation is beginning to develop successor domestic agreements for the continued operation of Lake Powell and Lake Mead ("post-2026 operations"). Such post-2026 operations will be analyzed in a separate EIS. See 87 *Federal Register* 37884 (June 24, 2022) and 88 *Federal Register* 39455 (June 16, 2023).

1.5.1 Affected Region and Interests

The geographic region that would be affected by the proposed alternatives begins with Lake Powell and extends downstream along the Colorado River floodplain to the Southerly International Boundary (SIB) with Mexico. The proposed alternatives would also potentially affect interests of organizations and individuals whose geographic distribution extends beyond the Colorado River floodplain into the service areas of certain water agencies in the Lower Division States.

1.5.2 Relevant Issues

As a result of the scoping process, Reclamation considered issues that may be relevant to the EIS analysis. **Table 1-1** lists the resources and issues potentially significantly affected and addressed in this SEIS. It also lists those that were not considered potentially significant, which are not analyzed in this SEIS. The primary impact drivers are lower flows, changing reservoir levels, and changes in releases and deliveries.

Table 1-1
Resources Considered for Detailed Analysis

Resource	Potentially Significant	Issue Areas
Water Resources		
Hydrologic Resources	Yes	Reservoir elevations, reservoir releases, river flows, groundwater
Water Deliveries	Yes	Apportionments, supply determinations, total water deliveries, shortages, public health and safety
Water Quality	Yes	Salinity, sediment, temperature, dissolved oxygen (DO), metals, nutrients/algae, and perchlorate

[10] Project website: https://www.usbr.gov/ColoradoRiverBasin/SEIS.html

Resource	Potentially Significant	Issue Areas
Physical Resources		
Air Quality	Yes	Fugitive dust and exposure of lake shoreline, greenhouse gas (GHG) emissions from alternative power sources
Visual	Yes	Attraction features, calcium carbonate ring in reservoirs, sediment deltas, Colorado River landscape character between Glen Canyon Dam and Lake Mead, broader landscape character in Lower Division States
Cultural Resources	Yes	Exposure and damage to resources (historic properties) as lake levels recede and river levels drop; disturbance to biological resources, which are contributing elements to Traditional Cultural Properties (TCPs)
Paleontology	Yes	Exposure and damage to resources as lake levels recede
Geology and Soils	No	No potential for effect; sedimentation is addressed in water quality
Minerals	No	No potential for effect
Noise	No	No potential for effect
Biological Resources		
Vegetation	Yes	Riparian and wetland habitat, weeds
Wildlife	Yes	Amphibians, fish, reptiles, raptors, mammals, waterfowl
Special Status Species	Yes	Threatened and endangered species, state and Tribal sensitive species
Human Environment		
Recreation	Yes	Shoreline public use facilities, reservoir boating, whitewater boating, and fishing
Energy and Hydropower	Yes	Economic analysis and capacity
Economic Impacts	Yes	Regional agricultural economic contributions, economic contributions from recreation activities, economic impacts from municipal and industrial (M&I) water availability
Environmental Justice	Yes	Disproportionate effects on minority and low-income populations
Indian Trust Assets (ITAs)	Yes	Water rights and trust lands
Transportation and Traffic	No	Ferries in Lake Powell are no longer running due to low levels, as analyzed in the 2007 FEIS. Impacts on ferries in Lake Havasu and on the Colorado River below Davis Dam would be the same, as analyzed in the 2007 FEIS.

1.6 Summary of the Contents of this SEIS

This SEIS describes the alternatives considered, the analysis of the potential effects of these alternatives on modified Colorado River operations and associated resources, and environmental commitments associated with the alternatives. The contents of the chapters in this volume are as follows:

- **Chapter 1, Purpose and Need,** includes background information leading to this SEIS, identification of the purpose of and need for the near-term reservoir management strategies of Lake Powell and Lake Mead being considered in the proposed alternatives, and the scope of this SEIS.
- **Chapter 2, Description of Alternatives,** describes the process of formulating alternatives and presents a range of reservoir operation strategies and guidelines considered under each alternative, as well as alternatives considered but eliminated from detailed analysis.
- **Chapter 3, Affected Environment and Environmental Consequences,** describes the affected environment for the proposed alternatives and presents evaluations of potential impacts that could result from implementation of the alternatives under consideration. The discussion also addresses environmental consequences (i.e., potential effects of the action alternatives that could occur compared with the No Action Alternative). A methodology, summary, and discussion of cumulative impacts is also included under each resource topic.
- **Chapter 4, Consultation and Coordination,** describes the public involvement process, including public notices, scoping meetings, and hearings. This chapter also describes the coordination with federal and state agencies, Indian Tribes, and Mexico (through the USIBWC) during the preparation of this document and any permitting or approvals that may be necessary for implementation of the proposed alternatives.

In addition to the above, this document includes a list of acronyms used throughout this SEIS; a glossary of commonly used terms; a list of references cited in the SEIS; a list of persons contributing to the preparation of the SEIS; and an index. This document also contains appendixes that consist of documents and other supporting material that provide detailed historical background and technical information concerning the proposed alternatives.

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Chapter 2. Description of the Alternatives

2.1 Development of the Alternatives

This chapter discusses the process used to define, develop, and analyze the range of reasonable alternatives for implementing the proposed federal action. As discussed in **Chapter 1**, Purpose and Need, and in the NOI to prepare this SEIS (87 *Federal Register* 69042, November 17, 2022), Reclamation is proposing modifications and/or additions to the following sections of the 2007 ROD published at 73 *Federal Register* 19881 (April 11, 2008), which were analyzed in the 2007 FEIS:

- **Section 2. Determination of Lake Mead Operation During the Interim Period.** Reclamation is analyzing a revision of Section 2.D, Shortage Conditions, to decrease the quantity of water that would be apportioned for consumptive use in the Lower Division States in years of low flow and low reservoir elevations.
- **Section 6. Coordinated Operation of Lake Powell and Lake Mead During the Interim Period.** Reclamation is analyzing a revision of Sections 6.C, Mid-Elevation Release Tier, and 6.D, Lower Elevation Balancing Tier, to reduce the quantity of water released from Glen Canyon Dam in years of low flow and low reservoir elevations.
- **Section 7. Implementation of Guidelines.** Reclamation is analyzing a revision of Section 7.C, Mid-Year Review, to allow for potential determinations in a mid-year review that would allow for reduced deliveries from Lake Mead, pursuant to Section 2 of the 2007 Interim Guidelines.

The descriptions of the No Action Alternative and Proposed Action, below, discuss how each alternative would modify these sections. The Proposed Action provides operations that are specifically designed to manage the respective reservoirs at lower elevations or prevent reservoir levels from declining in order to more reliably maintain congressionally authorized infrastructure, operations, water deliveries, and power generation, and to avoid dead pool conditions, as feasible.

The range of alternatives considered reflects input from Reclamation, Tribes, the cooperating agencies, stakeholders, and other interested parties, including comments submitted during the SEIS public scoping period and the public comment period on the original Draft SEIS. As described in the **Dear Reader Letter** introducing this revised Draft SEIS, Action Alternatives 1 and 2, which were considered in the original Draft SEIS, have been eliminated from detailed analysis (see **Section 2.8.10** and **Appendix B**, Hydrology Analysis for the No Action Alternative, Action Alternatives 1 and 2, and the Proposed Action).

Among the input Reclamation received were written proposals for alternatives, or components thereof, that met the proposed federal action's purpose and need. For example, in January 2023, Reclamation received a proposal from six Basin States (Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming) and a proposal from California. Reclamation carefully reviewed these proposals, along with others received. Several of these proposals were analyzed in the original Draft SEIS in Appendix B in terms of their hydrologic performance over the remainder of the interim period. These proposals were similar to the actions considered in Action Alternatives 1 and 2 in the original Draft SEIS and are similarly affected by the improved June 2023 hydrology. Reclamation is not remodeling these proposals or comparing them against the Proposed Action for the same reasons that Action Alternatives 1 and 2 have been eliminated (see the **Dear Reader Letter** and **Section 2.8.10**).

2.2 Preferred Alternative

Reclamation has not identified a preferred alternative at this time. The preferred alternative will be identified in the Final SEIS, as required by Council on Environmental Quality (CEQ) NEPA regulations (40 Code of Federal Regulations [CFR] 1502.14e)).

2.3 Environmentally Preferable Alternative

In accordance with CEQ NEPA regulations (40 CFR 1502.2(b)), Reclamation will identify the environmentally preferable alternative in the ROD for this SEIS.

2.4 Implementation

The Department anticipates adopting additional or modified guidelines for the remaining operating years in the interim period.[1] The Department may select different parts of any of the alternatives to best meet the purpose and need. The Proposed Action provides operational tools for continued low-flow conditions to provide additional protection against reservoirs declining to critically low elevations.

2.5 Common to All Alternatives

Under all alternatives, operations would continue pursuant to the continued implementation of existing agreements that control operations of Glen Canyon and Hoover Dams. Regarding coordinated reservoir operations, the tiers for determining the annual Lake Powell release, based on the volume of water in storage or the corresponding elevations of Lake Powell and Lake Mead, would be the same as described in the 2007 Interim Guidelines for all alternatives. For all alternatives, when Lake Powell's elevation is projected to be above 3,575 feet, Lake Powell would continue to operate in the Upper Elevation Balancing Tier or Equalization Tier, as described in the 2007 Interim Guidelines. Operations regarding the creation and use of intentionally created surplus (ICS) would be the same as described in the 2007 Interim Guidelines for all alternatives. For all alternatives, Section III.B. of Exhibit 1 (Lower Basin Drought Contingency Operations) to the

[1] Glen Canyon Dam and the other Upper Basin reservoir operations for the 2024 operating year begin October 1, 2023; Hoover Dam operations for 2024 begin January 1, 2024. Consistent with the 2007 Interim Guidelines, the DCPs, and Minute 323, these operating determinations will be based on projected January 1, 2024, reservoir conditions at Lake Powell and Lake Mead based on the August 2023 24-Month Study.

Lower Basin Drought Contingency Plan Agreement, as executed pursuant to Public Law 116-14 (2019), provides that DCP contributions are made based on the projected elevation of Lake Mead on January 1, using Reclamation's August 24-Month Study. DCP contributions will continue to be determined based on the elevation of Lake Mead as projected in the 24-Month Study and are in addition to the shortage volumes described in Section 2.D of the 2007 Interim Guidelines.

As noted in **Chapter 1**, there has been extensive focus on the goal of operating Glen Canyon Dam as intended for long-term operations (that is, to keep Lake Powell at or above an elevation of 3,490 feet). However, it is possible that Lake Powell may decline below this critical elevation during the 2025–2026 period. In such an event, at any given time, Glen Canyon Dam would be operated with all available river outlet works. For the purpose of analyzing impacts in this SEIS, Reclamation anticipates having three of the four river outlet works available, due to the need for periodic inspections and routine maintenance. Operations may vary from this assumption to address operating considerations at Glen Canyon Dam based on the actual operating experience at lower elevations.

Reclamation notes that intensive efforts are underway to facilitate water conservation actions in the Basin under a number of programs, including the recent congressional prioritization of funding through 2026 of 4 billion dollars for drought mitigation in western states, with priority given to the Basin and other basins experiencing comparable levels of long-term drought (Public Law 117-169 at Section 50233, August 16, 2022). The ongoing implementation of these efforts will help determine the degree to which revised operations will be implemented.

The Secretary intends to use this SEIS NEPA process to facilitate implementation of Section 7.B.2 of the 2007 Interim Guidelines with respect to the potential implementation of the alternatives.

Allocation of Colorado River water to Mexico is governed by the 1944 Water Treaty. To assess the potential effects of the alternatives in this SEIS, certain modeling assumptions (discussed in **Chapter 3**) are used that display projected water deliveries to Mexico. These assumptions include continued implementation of Minute 323 to the 1944 Water Treaty.

2.6 No Action Alternative

The No Action Alternative describes the continued implementation of existing agreements that control operations of Glen Canyon and Hoover Dams. These include the 2007 Interim Guidelines for the remainder of the interim period (through the 2026 operating year) and agreements adopted pursuant to the DCPA (Public Law 116-14).

2.6.1 Shortage Guidelines

Table 2-1, below, shows the Lower Basin shortages under the 2007 Interim Guidelines and contributions under the 2019 DCPs modeled under the No Action Alternative. The applicable operating condition would continue to be based on the August 24-Month Study projections of the January 1 system storage and reservoir water surface elevations for the following operating year.[2]

Figure 2-1 shows a graphical view of Lower Basin shortages and contributions from the 2007 Interim Guidelines and 2019 DCPs modeled under the No Action Alternative.

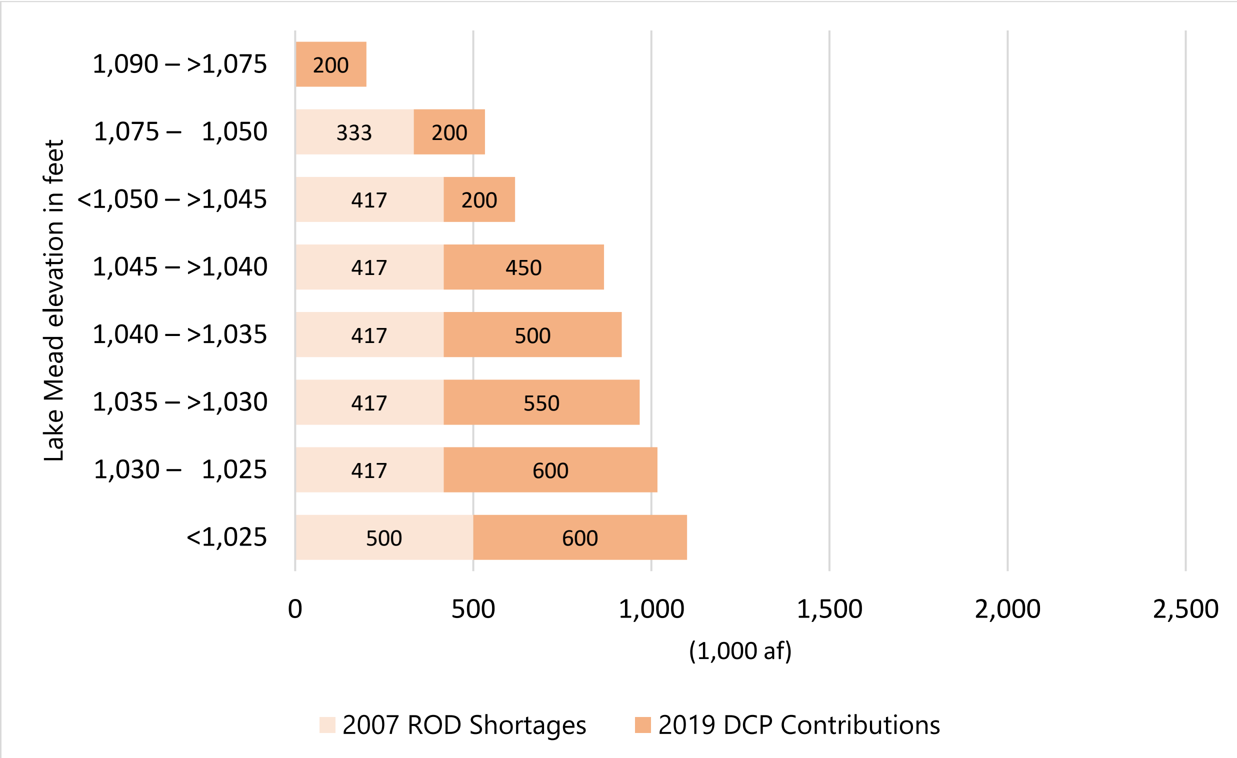
Table 2-1
Lower Division States' Shortages and DCP Contributions, No Action Alternative*

Lake Mead Elevation (feet)	2007 ROD** Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	Total ROD Shortages + Contributions (1,000 af)
1,090 – >1,075	0	200	200
1,075 – 1,050	333	200	533
<1,050 – >1,045	417	200	617
1,045 – >1,040	417	450	867
1,040 – >1,035	417	500	917
1,035 – >1,030	417	550	967
1,030 – 1,025	417	600	1,017
<1,025	500	600	1,100

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the Binational Water Scarcity Contingency Plan (BWSCP), in accordance with Minute 323 to the 1944 Water Treaty (see **Appendix D**, CRMMS Model Documentation, **Tables D-9** and **D-10**).
** Shortages listed in the 2007 ROD

[2] "24-Month Study" refers to the operational study that reflects the current Annual Operating Plan (AOP) that is updated each month by Reclamation to project future reservoir contents and releases. The projections are updated each month using the previous month's reservoir contents and the latest inflow and water use forecasts.

Figure 2-1
Modeled Lower Basin Shortages and DCP Contributions, No Action Alternative



2.6.2 Coordinated Reservoir Operations

Under the No Action Alternative, the annual Lake Powell release is based on the volume of water in storage or the corresponding elevations of Lake Powell and Lake Mead, as described in the Operational Tiers below (see **Table 2-2**).[3] The applicable Operational Tier would continue to be based on the August 24-Month Study projections of the January 1 system storage and reservoir water surface elevations for the following operating year. When Lake Powell's elevation is projected to be above 3,575 feet on January 1, Lake Powell would continue to operate in the Upper Elevation Balancing Tier or Equalization Tier, as described in the 2007 Interim Guidelines.

Mid-Elevation Release Tier

When Lake Powell's elevation is projected to be below 3,575 feet and at or above 3,525 feet on January 1, a release in the amount of 7.48 maf would be made if the projected January 1 elevation of Lake Mead is at or above 1,025 feet. If the projected January 1 Lake Mead elevation is below 1,025 feet, a release of 8.23 maf from Lake Powell would be made.

[3] The operational tiers are described in Sections 6.A through 6.D of the 2007 Interim Guidelines.

Table 2-2
Lake Powell Operational Tiers, No Action Alternative

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage** (maf)*
3,700		**23.31**
	Equalization Tier Equalize, avoid spills, or release 8.23 maf	
3,636–3,666 (see Table 2.3-1 in the 2007 FEIS)		**14.65–18.36** (2008–2026)
	Upper Elevation Balancing Tier Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	
3,575		**8.90**
	Mid-Elevation Release Tier Release 7.48 maf; if Lake Mead <1,025 feet, release 8.23 maf	
3,525		**5.55**
	Lower Elevation Balancing Tier Balance contents with a minimum/maximum release of 7.0/9.5 maf	
3,370		**0**

*Active storage values have been updated from 2007 based on the 2018 bathymetry.

Lower Elevation Balancing Tier

When the projected January 1 Lake Powell elevation is below 3,525 feet, the contents of Lake Mead and Lake Powell would be balanced, if possible, within the constraint that the release from Lake Powell would be no more than 9.5 maf and no less than 7.0 maf.

2.6.3 Implementation of Guidelines

To allow for better overall water management during the interim period, a mid-year review may be undertaken to consider revisions to the AOP based on the April 1 final forecast of the April through July runoff, currently provided by the National Weather Service's (2023) Colorado Basin River Forecast Center, and other relevant factors, such as actual runoff conditions, actual water use, and water use projections. In the mid-year review, the AOP may be modified to make a determination that a different Operational Tier will apply for the remainder of the year or operating year, as appropriate, or that an amount of water other than that specified in the applicable Operational Tier will be released for the remainder of the year or operating year, as appropriate. Revisions to shortages—compared with the AOP—associated with Lake Mead's elevation determinations in the mid-year review can be revised only to allow for additional deliveries from Lake Mead; they cannot be revised for reduced deliveries.

2.6.4 Drought Contingency Plans

Pursuant to the DCPA (Public Law 116-14), Congress directed the Secretary to carry out a number of drought-related agreements, including mandatory implementation of specific provisions for operation of Colorado River system reservoirs in the Upper and Lower Basins. The agreements include the Upper Basin DCP, which affects operations above Lee Ferry, and the Lower Basin DCP, which affects operations below Lee Ferry (primarily regarding Hoover Dam operations). Both the Upper Basin DCP and the Lower Basin DCP are supplemental to and in furtherance of the goals and operations contained in the 2007 Interim Guidelines.

Continuing current operations of Lake Powell and Lake Mead in extreme low-runoff scenarios would create the potential for water levels in one or both reservoirs to decline below minimum power pool, thereby limiting operation of Glen Canyon Dam or Hoover Dam, or both, to provide water supplies in the Basin. As described in the **Dear Reader Letter**, in such circumstances, the No Action Alternative would perform worse than the Proposed Action in meeting the federal action's purpose of and need for ensuring "that Glen Canyon Dam continues to operate under its intended design" and protecting "Hoover Dam operations, system integrity, and public health and safety" (see **Section 1.3**, Purpose of and Need for Action).

2.7 Proposed Action

This alternative describes a set of actions adopted pursuant to Secretarial authority under applicable federal law. The Proposed Action models changes to operations for both Glen Canyon Dam and Hoover Dam. The Proposed Action includes assumptions for a total of 3.0 maf of SEIS conservation[4] through 2026, with a minimum of 1.5 maf physically conserved by the end of calendar year 2024. This additional conservation would be added onto 2007 Interim Guidelines shortages and DCP contributions and would be implemented across a range of elevations in Lake Mead.

Under the Proposed Action, tier-based reductions and contributions would be limited to the existing 2007 Interim Guidelines, Lower Basin DCP, and Minute 323. Glen Canyon Dam operations would remain consistent with the existing 2007 Interim Guidelines except if Lake Powell is in the Middle Elevation Release Tier or Lower Elevation Balancing Tier, when a mid-year adjustment could be made to reduce the annual volume to no less than 6.0 maf. This mid-year adjustment would be permissible only if the minimum probable scenario in the 24-Month Study shows Lake Powell dropping below 3,500 feet at any point in the following 12 months.

[4] SEIS conservation may be a combination of system conservation, creation of ICS, or other water conservation activities that result in system benefits, as outlined in the proposal. Implementation of conservation measures would be subject to additional environmental compliance, as appropriate.

Whenever Lake Mead's content is projected to be below an elevation of 1,025 feet, based on the April 24-Month Study minimum probable projection, the Lower Division States, after consultation with the Upper Division States, would have 45 calendar days to provide Reclamation with an implementation plan to protect Lake Mead from reaching an elevation of 1,000 feet. If an implementation plan is not acceptable to Reclamation, then Reclamation may take additional action to protect 1,000 feet.

SEIS conservation up to 2.3 maf is anticipated to be federally compensated. Any remaining required SEIS conservation may be compensated by state or local entities or uncompensated.

All or a portion of the remaining required SEIS conservation may be offset with ICS created in 2023–2026; for any such ICS, the creator could not order delivery, transfer, or assignment of the ICS at any time before December 31, 2026. Because of the limitation on ICS storage space, some DCPs ICS would become system water, which is an uncompensated addition of system water.

For all operations, the Secretary reserves the right to operate Reclamation facilities to address extraordinary circumstances, as described in Section 7(D) of the 2007 Interim Guidelines, including "operations that are prudent or necessary for safety of dams, public health and safety, other emergency situations, or other unanticipated or unforeseen activities arising from actual operating experience."

2.7.1 Shortage Guidelines

Table 2-3 shows the Lower Basin shortages under the 2007 Interim Guidelines, contributions under the 2019 DCPs, and the additional SEIS conservation modeled under the Proposed Action for operating years 2023 through 2026, with at least 1.5 maf of additional conservation in 2023 and 2024. Assumptions regarding the estimated breakdown of SEIS conservation by state are shown in **Table 2-4**. Lower Division States' SEIS conservation would total at least 3.0 maf in operating years 2023 through 2026, on top of annual 2007 ROD shortages and 2019 DCP contributions.

The total amount of combined 2007 ROD shortages, 2019 DCP contributions, and SEIS conservation, in addition to other additional conservation, cannot exceed 2.083 maf in any given year, as contemplated in the 2007 FEIS.[5] Additional system conservation would require separate NEPA analysis.

Figure 2-2 shows a graphical view of Lower Basin system conservations and contributions from the 2007 Interim Guidelines and the 2019 DCPs plus the additional SEIS conservation modeled under the Proposed Action for operating years 2023 through 2026.

[5] While the 2007 FEIS contemplated reductions up to 2.083 maf, the operating guidelines only provided for reductions up to 500,000 af. Reductions up to 2.083 maf were analyzed in the shortage allocation model in the 2007 FEIS, but impacts analysis up to this amount was not provided for all resources.

Table 2-3
Lower Division States' Shortages, DCP Contributions, and SEIS Conservation, Proposed Action (2023–2026)*

Lake Mead Elevation (feet)	2007 ROD Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	SEIS Conservation (1,000 af)	Total ROD Shortages + DCP Contributions + SEIS Conservation (1,000 af) **
1,090 – >1,075	0	200	Approximately 750 annually**	**950**
1,075 – 1,050	333	200		**1,283**
<1,050 – >1,045	417	200		**1,367**
1,045 – >1,040	417	450		**1,617**
1,040 – >1,035	417	500		**1,667**
1,035 – >1,030	417	550		**1,717**
1,030 – 1,025	417	600		**1,767**
<1,025	500	600		**1,850**

* This table only shows combined Lower Division State shortages, DCP contributions, and SEIS conservation. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the BWSCP, in accordance with Minute 323 to the 1944 Water Treaty (see **Appendix D**, CRMMS Model Documentation, and **Tables D-9** and **D-10**).

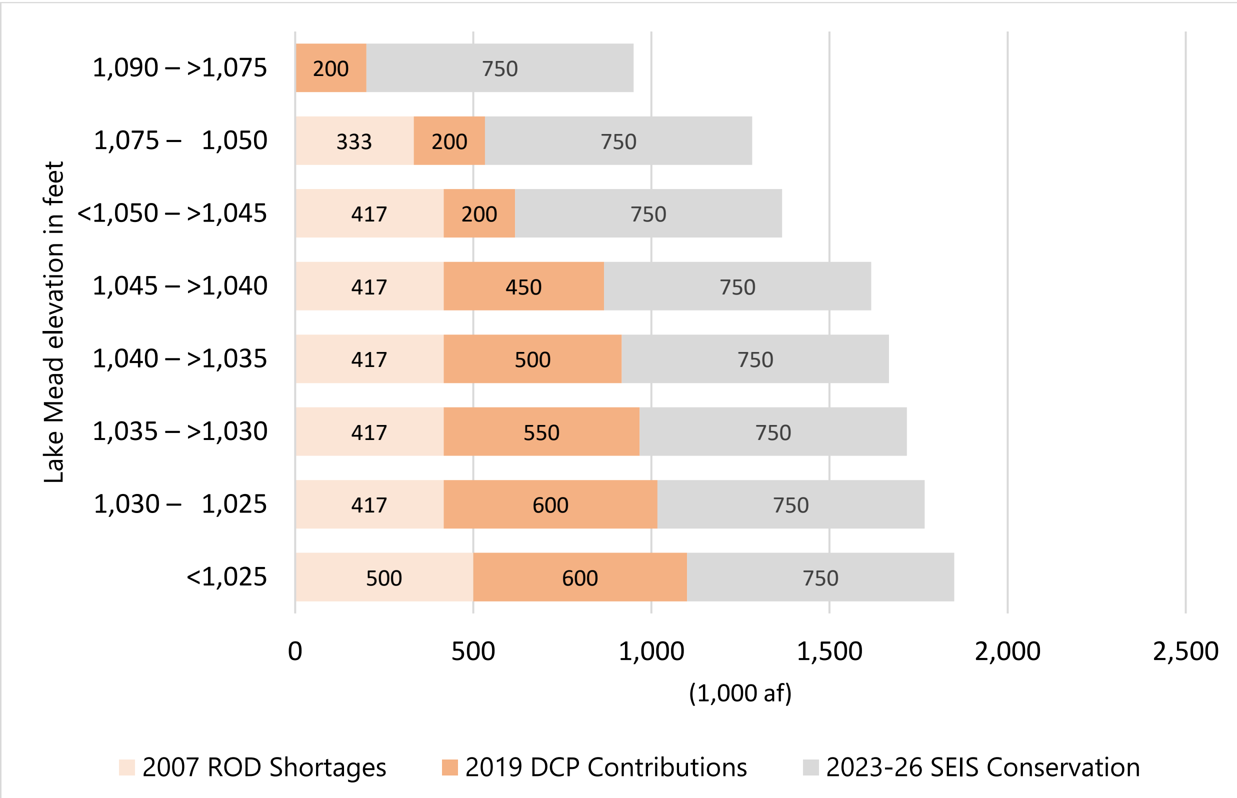
** The amount of SEIS conservation could be higher or lower in a given year depending on the conservation agreements in place in that year. The total of ROD shortages, DCP contributions, SEIS conservation, and any other additional conservation would not exceed 2.083 maf in a given year.

Table 2-4
Lower Division States' Shortages, DCP Contributions, and SEIS Conservation by State, Proposed Action (2023–2026)

Lake Mead Elevation (feet)	2007 ROD Shortages + 2019 DCP Contributions (1,000 af)				Proposed Action Modeled SEIS Conservation (1,000 af)*				Total ROD Shortages + DCP Contributions + SEIS Conservation (1,000 af)			
	AZ	NV	CA	Total	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	192	8	0	200	280	70	400	750	472	78	400	950
1,075 – 1,050	512	21	0	533					792	91	400	1,283
<1,050 – >1,045	592	25	0	617					872	95	400	1,367
1,045 – >1,040	640	27	200	867					920	97	600	1,617
1,040 – >1,035	640	27	250	917					920	97	650	1,667
1,035 – >1,030	640	27	300	967					920	97	700	1,717
1,030 – 1,025	640	27	350	1,017					920	97	750	1,767
<1,025	720	30	350	1,100					1,000	100	750	1,850

* Estimated annual SEIS conservation volumes in this table are used for comparative analysis purposes only and do not represent annual commitments by each state. Actual SEIS conservation by state may vary each year such that collectively a total of 3.0 maf of SEIS conservation would occur through 2026.

Figure 2-2
Modeled Lower Basin Shortage, DCP Contributions, and Estimated SEIS Conservation, Proposed Action (2023–2026)*



* Actual SEIS conservation may vary each year such that a total of 3.0 maf of SEIS conservation would occur through 2026. Other additional conservation could occur such that it does not exceed a total flow reduction of 2.083 maf as analyzed in the 2007 FEIS.

2.7.2 Coordinated Reservoir Operations

Under the Proposed Action, the annual Lake Powell release would be based on the volume of water in storage or the corresponding elevations of Lake Powell and Lake Mead, as described in the Operational Tiers below (see **Table 2-5**). The Equalization and Upper Elevation Balancing Tiers would be the same as under the 2007 Interim Guidelines.[6] The Mid-Elevation Release Tier and Lower Elevation Balancing Tier would be the same as under the No Action Alternative, with the exception that Reclamation may reduce releases, if needed, to a minimum release of 6.0 maf. Sub-annual releases would comply with LTEMP and would not drop below LTEMP minimum flows, with the goal of keeping the Lake Powell elevation above 3,500 feet. The applicable Operational Tier would be based on the August 24-Month Study projections of the January 1 system storage and reservoir water surface elevations for the following operating year.

[6] See Sections 6.A, Equalization Tier, and 6.B, Upper Elevation Balancing Tier, in the 2007 ROD published at 73 *Federal Register* 19881 (April 11, 2008).

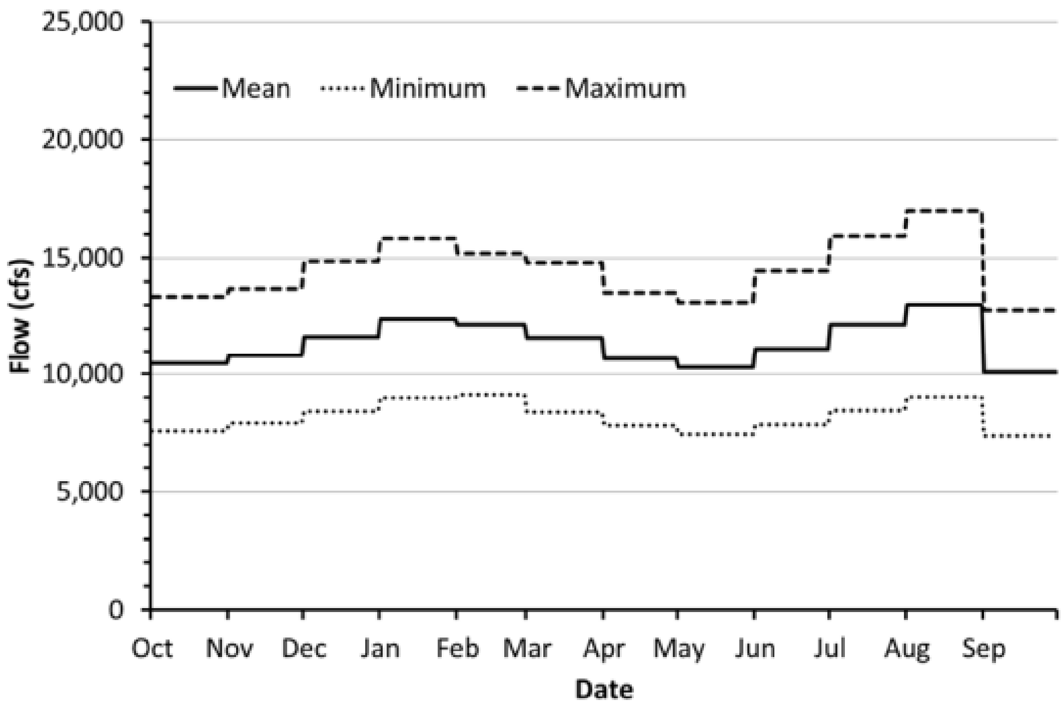
Table 2-5
Lake Powell Operational Tiers, Proposed Action

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage*** (maf)
3,700	**Equalization Tier** Equalize, avoid spills, or release 8.23 maf	**23.31**
3,636–3,666 (see Table 2.3-1 in the 2007 FEIS)	**Upper Elevation Balancing Tier** Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	**14.65–18.36** (2008–2026)
3,575	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead <1,025 feet, release 8.23 maf If any minimum probable Lake Powell elevation projection shows Lake Powell <3,500 feet over the next 12 months, reduce releases to a minimum of 6.0 maf to maintain an elevation of 3,500 feet	**8.90**
3,525	**Lower Elevation Balancing Tier** Balance contents with a minimum/maximum release of 7.0/9.5 maf If any minimum probable Lake Powell elevation projection shows Lake Powell <3,500 feet over the next 12 months, reduce releases to a minimum of 6.0 maf to maintain an elevation of 3,500 feet	**5.55**
3,500	The Secretary reserves the right to operate Reclamation facilities to protect the Colorado River system if hydrologic conditions require such action	**4.22**
3,370		**0**

*Active storage values have been updated from 2007 based on the 2018 bathymetry.

Hourly, daily, and monthly releases from Lake Powell for coordinated operations would be consistent with the parameters of the ROD for the LTEMP SEIS (Reclamation and NPS 2016). Monthly releases from Glen Canyon Dam would be distributed proportionally across the remaining months of the operating year for annual releases below 7.0 maf (see **Figure 2-3** for monthly distributions in a year when the annual release is 8.23 maf). Annual flows adjusted mid-year would be distributed to meet the goals of LTEMP, including potential distribution across monthly or experimental flow patterns, and including the unique resource considerations specific to any mid-year annual adjustments.

Figure 2-3
Mean, Minimum, and Maximum Monthly Flows under LTEMP in an 8.23-maf Year



Hourly and daily releases would follow LTEMP parameters, so long as sufficient water is available from the annual release. If sufficient water is not available from the annual release to meet hourly and daily LTEMP release parameters, hourly and daily releases would follow the base operation daily and nightly minimum flows (8,000 cfs and 5,000 cfs, respectively), for as long as possible. If sufficient water is not available from the annual release to support the base operation nightly minimum flow of 5,000 cfs, hourly and daily releases would be consistent with the run of the river to match Lake Powell inflows consistent with protecting an elevation of 3,500 feet at Lake Powell.

Mid-Elevation Release Tier

When Lake Powell's elevation is projected to be below 3,575 feet and at or above 3,525 feet on January 1, a release in the amount of 7.48 maf would be made if the projected January 1 elevation of

Lake Mead is at or above 1,025 feet. If the projected January 1 Lake Mead elevation is below 1,025 feet, a release of 8.23 maf from Lake Powell would be made. If any minimum probable scenario in the 24-Month Study shows Lake Powell dropping below 3,500 feet at any point in the following 12 months, an adjustment could be made to reduce the annual Glen Canyon Dam release volume to no less than 6.0 maf while maintaining LTEMP minimum flows subject to run-of-the-river conditions, operational constraints, and prudent operation, as determined by Reclamation, to maintain an elevation of 3,500 feet at Lake Powell.

Lower Elevation Balancing Tier

When the projected January 1 Lake Powell elevation is below 3,525 feet, the contents of Lake Mead and Lake Powell would be balanced, if possible, within the constraint that the release from Lake Powell would be no more than 9.5 maf and no less than 7.0 maf. If any minimum probable scenario in the 24-Month Study shows Lake Powell dropping below 3,500 feet at any point in the following 12 months, an adjustment could be made to reduce the annual Glen Canyon Dam release volume to no less than 6.0 maf while maintaining LTEMP minimum flows subject to run-of-the-river conditions, operational constraints, and prudent operation, as determined by Reclamation, to maintain an elevation of 3,500 feet at Lake Powell.

2.7.3 Implementation of Guidelines

The provisions for a mid-year review are the same as those under the No Action Alternative except that, if the April 24-Month Study minimum probable model in 2024, 2025, and 2026 indicates that the respective end-of-year elevation in Lake Mead will fall below 1,025 feet, the Lower Division States would have 45 calendar days from the publication of the respective 24-Month Study to propose, after consultation with the Upper Division States, an implementable plan to Reclamation to protect Lake Mead from reaching an elevation of 1,000 feet. If such an acceptable plan, as determined by Reclamation, is not developed, Reclamation may independently take action(s) to protect 1,000 feet.

As described in **Section 2.7**, the Secretary retains the authority to protect the Colorado River system if hydrologic conditions require additional action.

2.8 Alternatives Considered but Eliminated from Detailed Analysis

Reclamation received a number of submissions that represented commentors' intended operations of Colorado River reservoirs. Some submissions presented sufficient detail to potentially be considered as an action alternative. Others presented operational concepts (or components) that could potentially be used to develop a full action alternative. In either case, the following are described as "alternatives" that were brought forward during internal and public scoping. They were considered but eliminated from detailed analysis because they (1) would not fully meet the purpose and need (see **Section 1.3**); (2) are covered by the range of the alternatives; or (3) are infeasible or inconsistent with the basic policy objectives for Colorado River operations, including consistency with applicable federal laws.

Action Alternatives 1 and 2 from the original Draft SEIS have been eliminated from detailed consideration in this revised Draft SEIS for the reasons described in the **Dear Reader Letter**. Summaries of these alternatives and the rationale for eliminating them are also included in the sections below.

2.8.1 Fill Lake Powell First

Comments received during scoping proposed consideration of a recreation-based alternative that would prioritize filling Lake Powell to higher elevations, such as 3,588 feet, to serve recreational boating needs and to provide resulting benefits to mental health and local economic conditions. This alternative was not carried forward for detailed analysis because it does not meet the purpose, need, or objectives of the federal action (which focus on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period [prior to January 1, 2027]). It would not allow compliance with essential water delivery requirements, including the Law of the River and the 2007 Interim Guidelines. It also would not comply with other federal requirements and regulations, including the GCPA and the Lower Basin Drought Contingency Plan Agreement (2019).

Both the 2007 Interim Guidelines and the 2019 DCPs contemplate the need for additional measures to protect Lake Mead elevations. The DCPs added the commitment of participating Lower Basin DCP parties to "individual and collective action in the Lower Basin to avoid and protect against the potential for the elevation of Lake Mead to decline to elevations below 1,020 feet."

An alternative prioritizing recreation uses would not satisfy Reclamation's basic policy objectives and the requirements of the purpose of and need for Reclamation's action to protect both Glen Canyon Dam and Hoover Dam operations, system integrity, and public health and safety. It also would not comport with existing Colorado River law that governs allocation, appropriation, development, and exportation of the waters of the Basin. For these reasons, the alternative was not carried forward for detailed analysis.

2.8.2 Decommission Glen Canyon Dam or Operate for Run of the River

Comments received during scoping proposed either removing Glen Canyon Dam or leaving it in place while operating it to release only inflows or run of the river. This alternative would further goals of creating new recreational activities; restoring the environmental, recreational, and cultural resources of the Grand Canyon and the Basin to their pre-dam conditions; and positively affecting the health of the Colorado River ecosystem.

This alternative would not meet the federal action's purpose (which focuses on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period [prior to January 1, 2027]) and need (which is based on the potential that continued low-runoff conditions could lead Lake Powell and Lake Mead to decline to critically low elevations, which would impact operations through the remainder of the interim period). Congress authorized the construction and operation of Glen Canyon Dam for specific purposes, and those congressional purposes cannot be met if the dam is decommissioned or not operated as designed. This proposed alternative, for example, would not allow compliance with water release requirements, including, but not limited to, the division and apportionment of the use of the waters of the Colorado River system under the Compact, as well as other portions of the Law of the River and 2007 Interim Guidelines.

This proposed alternative also would not comport with existing Colorado River law requiring that allocation, appropriation, development, and exportation of the waters of the Basin be consistent with Congress's clear direction to the Secretary to operate Glen Canyon Dam under the Law of the River. For these reasons, the alternative was not carried forward for detailed analysis.

2.8.3 Fill Lake Mead First

As a counterpoint to the "Fill Lake Powell First" alternative discussed above, proponents of this alternative advocate for shifting primary water storage from Lake Powell to Lake Mead, using Lake Powell as a backup for seasonal and flood control purposes to meet the goals of reducing evaporation and seepage and increasing flexibility for implementing Grand Canyon restoration strategies.

This alternative would not meet the federal action's purpose (which focuses on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period [prior to January 1, 2027]), and need (which is based on the potential that continued low-runoff conditions in the Basin could lead Lake Powell and Lake Mead to decline to critically low elevations, which would impact operations through the remainder of the interim period).

This proposed alternative, for example, would not allow compliance with water release requirements, including, but not limited to, the division and apportionment of the use of the waters of the Colorado River system under the Compact, as well as other portions of the Law of the River and 2007 Interim Guidelines. This alternative also would not comport with existing Colorado River law requiring that allocation, appropriation, development, and exportation of the waters of the Basin be consistent with Congress's clear direction to the Secretary to operate Glen Canyon Dam under the Law of the River. For these reasons, the alternative was not carried forward for detailed analysis.

2.8.4 One-Dam Alternative

Comments received during scoping proposed an alternative that prioritizes the preservation of one dam and reservoir (Hoover Dam/Lake Mead or Glen Canyon Dam/Lake Powell) over the other. Consistent with the reasons set forth in the above discussions of "Fill Lake Powell First" and "Fill Lake Mead First," this alternative was not carried forward for detailed analysis.

2.8.5 Evaporation, Seepage, and System Losses

Comments received during scoping, as well as the proposal submitted by six Basin States (Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming), proposed that Reclamation consider an alternative that apportions among all contractors reductions to account for water evaporation, seepage, and system losses.

While Reclamation has not carried forward an alternative that focuses explicitly on accounting for evaporation, seepage, and system losses, the Proposed Action contemplates conservation amounts similar to those that would be assessed based on evaporation, seepage, and system loss calculations in the proposals received. Reclamation anticipates publishing in 2023—separately from this SEIS process—an informational report addressing potential methodologies to support assessments for evaporation and other system losses in the Basin.

2.8.6 Ecosystem-Based Alternative

Comments received during scoping suggested that Reclamation design an alternative that maintains Colorado River flows and supports ecosystem needs. An ecosystem-based alternative would also include cuts to water allocations and implementation of water conservation measures. Any operation would meet the applicable ecosystem-based requirements under applicable law.

This alternative was not carried forward for detailed analysis because it does not meet the federal action's purpose, need, or objectives. This is because it does not focus on the critically low elevations impacting operations of both Glen Canyon and Hoover Dams during the interim period (prior to January 1, 2027). Apart from concepts of beneficial-use determinations, Reclamation has limited authorities to mandate water conservation measures in the Lower Basin for ecosystem-based purposes.

2.8.7 Worst-Case Drought Alternative

Comments received during scoping suggested that Reclamation design an alternative that is responsive to worst-case drought modeling. Commenters expressed concern that the existing hydrology modeling does not represent the full range of potential drought scenarios and that an alternative is needed to address prolonged drought conditions. Comments requested updated baseflow modeling to reflect current conditions and to account for long-term climate modeling and worsening drought conditions.

The hydrologic modeling examines scenarios based on flows in the Basin over the past 30 years, which includes the driest 23-year period on record. To examine even worse drought conditions, the hydrologic modeling examines Basin flow scenarios with 90 percent and 80 percent of the flows seen over the past 30 years (up to a 20 percent reduction in flows compared with the last 30 years). The improved hydrology from June 2023 described in the **Dear Reader Letter** does not indicate a risk of operating Glen Canyon and Hoover Dams in a situation where the inflow minus losses equals outflow, subject to run-of-the-river conditions during the remainder of the interim period (prior to January 1, 2027).

Reclamation believes the range of hydrology scenarios analyzed is an appropriate worst case to analyze for conditions that might occur between now and 2026, though longer-term trends could continue to worsen. Because the need for this action is to address the potential for continued low-runoff conditions in the Basin to lead Lake Powell and Lake Mead to decline to critically low elevations that would impact operations through the remainder of the interim period (prior to January 1, 2027), an analysis of scenarios that are not reasonably foreseeable between 2024 and 2026 would not meet the purpose of and need for Reclamation's action.

2.8.8 Hydropower Prioritization Alternative

Comments suggested an alternative that includes elevation levels prioritizing preservation of hydropower production and operations and considers the contractual obligations for power delivery.

While Reclamation has not carried forward an alternative that focuses explicitly on prioritizing hydropower production, the Proposed Action contemplates protection of critical reservoir levels and the continued resulting water deliveries that accordingly relate to the ability to generate hydropower. An alternative prioritizing hydropower production over all other purposes—including water delivery—would not satisfy Reclamation's basic policy objectives. It also would not satisfy the requirements of the purpose of and need for Reclamation's action to protect both Glen Canyon and Hoover Dam operations, system integrity, and public health and safety. This is because, in addition to non-hydropower impacts, assuring hydropower operations at one facility could reduce hydropower operations at other facilities. This alternative would also need to be assessed for consistency with governing authorities. Finally, inclusion of similar protection elevations in the Proposed Action provides adequate opportunity for analysis.

2.8.9 Importation of Water

Reclamation received a number of proposals calling for the importation of water (for example, desalinizing and importing water from the Pacific Ocean). These are not considered in detail in this SEIS because the proposals received did not contain sufficient detail to analyze them. Also, they are not actionable during the interim period (before January 1, 2027). Therefore, they do not meet the purpose of and need for Reclamation's action.

2.8.10 Action Alternatives 1 and 2 from the Original Draft SEIS

The action alternatives analyzed in the original Draft SEIS described a set of actions adopted pursuant to Secretarial authority under applicable federal law (see **Appendix C**, Original Draft SEIS Action Alternatives 1 and 2). Unlike current operations that were developed and are being implemented pursuant to Basin-wide consensus (for example, the 2007 Interim Guidelines and the 2019 DCPs), Action Alternatives 1 and 2 modeled changes to operations for both Glen Canyon Dam and Hoover Dam as developed by Reclamation. Action Alternative 1 included assumptions for reduced releases from Glen Canyon Dam and additional Lower Basin shortages based on the concept of priority.[7] Action Alternative 2 included assumptions for reduced releases from Glen Canyon Dam and additional Lower Basin shortages that were not based exclusively on the concept of priority.

While both the 2007 Interim Guidelines and the 2019 DCPs encompass reductions that reflect the priority system, the additional reductions modeled in Action Alternative 2 for the remainder of the interim period assumed distribution in the same percentage across all Lower Basin water users.[8] Total additional shortage volumes for the Lower Basin were modeled to be the same under Action Alternative 2 as under Action Alternative 1. Action Alternatives 1 and 2 both modeled releases

[7] Priority refers to the distribution of Colorado River water in the Lower Division States of Arizona, California, and Nevada as subject to laws, judicial rulings and decrees, contracts, interstate compacts, and operating criteria (known as the "Law of the River"), which apportion available water between the states and establish certain priorities in use.
[8] For example, if the additional shortage amount is 1 maf, the percentage of additional shortage volume is calculated by dividing 1 maf by 7.5 maf, which equals 13 percent. Then, a 13 percent additional reduction is modeled for each Lower Basin water user based on current water use.

between 6.0 and 8.23 maf from Lake Powell when it is below 3,575 feet, with potentially lower releases to preserve the elevation of 3,500 feet.[9]

As described in the **Dear Reader Letter**, based on the June 2023 hydrologic modeling, Action Alternatives 1 and 2 show comparable, though smaller, risks of reaching critical elevations at Lake Powell compared with the No Action Alternative and the Proposed Action; however, they also show increased risk of reaching critical elevations at Lake Mead relative to the Proposed Action (see **Appendix B**). Based on these updated hydrologic modeling results, the Proposed Action would achieve many of the same purpose and need objectives—namely, reducing the potential that continued low-runoff conditions could lead Lake Powell and Lake Mead to decline to critically low elevations, protecting critical infrastructure at both reservoirs, and balancing overall operational risks in the Colorado River Basinas Action Alternatives 1 and 2. However, based on the updated hydrology, the Proposed Action would provide additional risk reduction compared with Action Alternatives 1 and 2, while implementing similar flow reductions; therefore, Action Alternatives 1 and 2 were eliminated from detailed analysis in this revised Draft SEIS.

2.9 Summary Comparison of Alternatives

Summary comparisons of the alternatives identified and analyzed in the SEIS are provided below. **Table 2-6** addresses each of the four sections of the 2007 Interim Guidelines (73 *Federal Register* 19881, April 11, 2008) identified in the NOI to prepare this SEIS (87 *Federal Register* 69042, November 17, 2022). **Table 2-7** provides a comparison of the shortage guidelines elements of the alternatives (Section 2. Determination of Lake Mead Operation During the Interim Period). **Table 2-8** provides a comparison of the coordinated reservoir operations elements of the alternatives (Section 6. Coordinated Operation of Lake Powell and Lake Mead During the Interim Period).

[9] The action alternatives would protect an elevation of 3,500 feet in Lake Powell to provide a buffer above minimum power pool, which is at 3,490 feet.

Table 2-6
Comparison of Alternatives

Alternative	**Shortage Guidelines** (Section 2. Determination of Lake Mead Operation During the Interim Period)	**Coordinated Reservoir Operations** (Section 6. Coordinated Operation of Lake Powell and Lake Mead During the Interim Period)	**Implementation of Guidelines** (Section 7. Implementation of Guidelines)
No Action Alternative	• Shortages from Lake Mead (that is, reduced deliveries to Lower Basin water users) and DCP contributions of 200,000 af at 1,090 feet to 1.1 maf below 1,025 feet. • Shortages are distributed across Lower Basin water users according to priority.	• Below 3,575 feet at Lake Powell, release 8.23 or 7.48 maf (Mid-Elevation Release Tier) or balance releases between 7.0 and 9.5 maf (Lower Elevation Balancing Tier) depending on the operating tier and elevations at Lake Powell and Lake Mead.	• Mid-year review may adjust the Lake Powell Operational Tier up or down or reduce shortages from Lake Mead (allow additional deliveries to Lower Basin water users).
Proposed Action	• Same as the No Action Alternative, plus total of 3.0 maf of SEIS conservation through 2026 with a minimum of 1.5 maf conserved by the end of operating year 2024	• Same as the No Action Alternative, except below 3,575 feet at Lake Powell, releases could be as low as 6.0 maf. • Sub-annual releases would comply with LTEMP and would not drop below LTEMP minimum flows, with the goal of keeping the Lake Powell elevation above 3,500 feet.	• If April 24-Month Study indicates the end-of-year elevation in Lake Mead will fall below 1,025 feet, Lower Division States have 45 calendar days to propose an implementable plan to protect Lake Mead from reaching an elevation of 1,000 feet. If an acceptable plan is not developed, Reclamation may independently take action(s) to protect 1,000 feet.

Table 2-7
Comparison of Shortage Guidelines, DCP Contributions, and SEIS Conservation by Alternative (volumes in 1,000 af)*

Lake Mead Elevation (feet)	No Action Alternative (Total Shortages and DCP Contributions)	Proposed Action (Total Shortages, DCP Contributions, and SEIS Conservation)**
1,090 – >1,075	200	950
1,075 – 1,050	533	1,283
<1,050 – >1,045	617	1,367
1,045 – >1,040	867	1,617
1,040 – >1,035	917	1,667
1,035 – >1,030	967	1,717
1,030 – 1,025	1,017	1,767
<1,025	1,100	1,850

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the BWSCP in accordance with Minute 323 to the 1944 Water Treaty (see **Appendix D**, CRMMS Model Documentation, and **Tables D-9** and **D-10**).

** The amount of SEIS conservation could be higher or lower in a given year depending on the conservation agreements in place in that year. The total of the ROD shortages, DCP contributions, SEIS conservation, and any other additional conservation would not exceed 2.083 maf in a given year.

Table 2-8
Comparison of Coordinated Reservoir Operations by Alternative

Lake Powell Elevation (feet)	**No Action Alternative**	**Proposed Action**	**Lake Powell Active Storage** (maf)*
3,700	**Equalization Tier** Equalize, avoid spills, or release 8.23 maf	**Equalization Tier** Equalize, avoid spills, or release 8.23 maf	**23.31**
3,636–3,666 (see Table 2.3-1 in the 2007 FEIS)	**Upper Elevation Balancing Tier** Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	**Upper Elevation Balancing Tier** Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	**14.65–18.36** (2008–2026)
3,575	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead <1,025 feet, release 8.23 maf	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead <1,025 feet, release 8.23 maf If any minimum probable Lake Powell elevation projection shows Lake Powell <3,500 feet over the next 12 months, reduce releases to a minimum of 6.0 maf to maintain an elevation of 3,500 feet.	**8.90**
3,525	**Lower Elevation Balancing Tier** Balance contents with a minimum/maximum release of 7.0/9.5 maf	**Lower Elevation Balancing Tier** Balance contents with a minimum/maximum release of 7.0/9.5 maf If any minimum probable Lake Powell elevation projection shows Lake Powell <3,500 feet over the next 12 months, reduce releases to a minimum of 6.0 maf to maintain an elevation of 3,500 feet.	**5.55**
3,500		The Secretary reserves the right to operate Reclamation facilities to protect the Colorado River system if hydrologic conditions require such action	**4.22**
3,370			**0**

*Active storage values have been updated from 2007 based on the 2018 bathymetry.

2.10 Summary of Potential Effects

Table 2-9 presents a summary of the potential effects of the alternatives. **Chapter 3**, Affected Environment and Environmental Consequences, contains detailed descriptions of these effects.

Table 2-9
Summary of Potential Effects of the Alternatives

SEIS Section	Affected Resource	Alternatives: No Action	Alternatives: Proposed Action
3.6	**Hydrologic Resources**		
	Reservoir elevations for Lake Powell	There is a higher likelihood of monthly pool elevations for the No Action Alternative dropping below the critical elevation of 3,490 feet than under the Proposed Action. Monthly pool elevations increase over time for the No Action Alternative. Modeled end-of-water-year pool elevations result in a lower median in 2026 and a smaller range of values than the Proposed Action.	The Proposed Action is designed to protect the critical elevation of 3,490 feet and minimizes the likelihood of instances of monthly elevations dropping below this to approximately 2% in 2026. Monthly pool elevations increase over time for both the No Action Alternative and the Proposed Action. Modeled end-of-water-year pool elevations result in median elevations that are the same as the No Action Alternative in 2024 and 2025 and slightly higher in 2026.
	Reservoir elevations for Lake Mead	The median monthly pool elevations are lower than the Proposed Action and exhibit a downward trend through 2026. There is a higher likelihood of monthly pool elevations dropping below the critical elevation of 1,020 feet than under the Proposed Action. Modeled end-of-calendar-year pool elevations have a lower median and a wider range than the Proposed Action, showing more uncertainty over time.	The median monthly pool elevations are higher than the No Action Alternative and exhibit an upward trend. The Proposed Action minimizes the likelihood of monthly pool elevations dropping below the critical elevation to approximately 4% in 2026. Modeled end-of-calendar-year pool elevations have a higher median and a smaller range than the No Action Alternative.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.6 *(cont.)*	Reservoir releases for Glen Canyon Dam (at Lake Powell)	Median annual releases for the No Action Alternative are higher than the Proposed Action and increase in variability through 2026. The modeled median monthly releases are consistently higher than the Proposed Action.	Under the Proposed Action, releases can be reduced to 6.0 maf if elevations in Lake Powell drop below 3,500 feet. This results in median annual releases that are slightly lower than the No Action Alternative. Lower releases from Glen Canyon are also due to the reduced releases during balancing or equalization due to higher elevations in Lake Mead. Median annual releases increase in variability through 2026. Median monthly releases are lower than the No Action Alternative, particularly on the lower end of releases.
	Reservoir releases for Hoover Dam (at Lake Mead)	Median annual releases for the No Action Alternative increase through 2026 with increasing variability. Median annual releases are approximately 0.40 to 0.57 maf higher than the Proposed Action.	Median annual releases for the Proposed Action increase through 2026 and are lower than the releases under the No Action Alternative. Lower releases are a result of SEIS conservation.
	River flows	River flows increase through 2026 for both the No Action Alternative and the Proposed Action. The No Action Alternative results in slightly higher to substantially higher flows than the Proposed Action.	The Proposed Action results in annual releases that increase through 2026 but are lower as compared to the No Action Alternative.
	Groundwater	Groundwater adjacent to Lake Powell may increase due to increasing pool elevations. Increasing river flows downstream of Glen Canyon may result in increases to groundwater. Groundwater adjacent to Lake Mead may decrease due to decreasing pool elevations. Certain portions of the river downstream of Lake Mead are anticipated to have decreased groundwater elevations in the river corridor due to decreasing river flows and shallower river stages.	Groundwater adjacent to Lake Powell may increase due to increasing pool elevations. Increasing river flows downstream of Glen Canyon may result in increases to groundwater. Groundwater adjacent to Lake Mead may increase due to increasing pool elevations. Certain portions of the river downstream of Lake Mead are anticipated to have decreased groundwater elevations in the river corridor due to decreasing river flows and shallower river stages.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.7	**Water Deliveries**		
	Apportionments in the Upper Division States	No impact.	No impact.
	Apportionments and water entitlements to and within the Lower Division States	No impact.	No impact.
	Lower Division State water supply determinations and total water deliveries	Median modeled combined shortages and DCP contributions are consistent within each state. Combined shortages and DCP contributions gradually decrease over time, likely resulting in fewer impacts on water supply determinations. Combined shortages, DCP contributions, and system conservation also gradually decrease over time, except in Nevada where no system conservation occurs. Median modeled depletions gradually increase over time, generally decreasing impacts on water deliveries.	Median combined shortages and DCP contributions are the same for both alternatives. Slight differences in maximum and minimum volumes occur between alternatives due to differences in the percent of traces at each operating tier. Combined shortages, DCP contributions, and system conservation exceed that of the No Action Alternative each year due to the impacts of SEIS conservation, resulting in greater total impacts on water supply determinations under the Proposed Action. Median modeled depletions gradually increase over time, but at lower volumes than for the No Action Alternative, resulting in greater impacts on water deliveries than under the No Action Alternative.
	Deliveries to Mexico	This SEIS does not consider actions for Mexico. There would be no change to specified reductions and recoverable savings to Mexico. Impacts on modeled reductions and recoverable savings to Mexico are possible as Lake Mead elevations decline.	Minimum modeled deliveries are higher under the Proposed Action than under the No Action Alternative, due to higher minimum elevations at Lake Mead, potentially resulting in reduced impacts on deliveries.
	Modeled distribution of shortages to and within the Lower Division States	Impacts on shortages are fewer initially but increase as reservoir levels decrease. As total shortages analyzed increase, there would be a corresponding increase in shortages allocated to Arizona 4th-priority entitlement holders, Nevada eighth-priority level users, and California DCP contributions.	Impacts on the modeled distribution of shortages are the same as under the No Action Alternative. The addition of SEIS conservation results in greater combined shortages, DCP contributions, and system conservation but could result in reduced mandatory shortages compared to the No Action Alternative.

SEIS Section	Affected Resource	Alternatives	
		No Action	**Proposed Action**
3.7 *(cont.)*	Flows into the Salton Sea	No change to current operational activities results in continuation of the current rate of decreased surface elevation and existing impacts.	The potential for additional system conservation agreements could reduce deliveries, resulting in expedited (but not additional) lake bed exposure compared with the No Action Alternative, due to the possibility of less available agricultural runoff. Lake bed exposure may be greater under the Proposed Action for the next 26 years, as estimated by the Salton Sea Modeling, but long-term impacts are the same as under the No Action Alternative.
3.8	**Water Quality**		
	Salinity	Higher lake levels result in marginally lower salinity concentrations. Modeled salinity varied greatly among the traces.	Higher lake levels result in marginally lower concentrations. Modeled salinity varied greatly between traces; however, salinity concentrations between the No Action and Proposed Action Alternatives are relatively similar.
	Temperature	Projected temperature releases at Glen Canyon Dam and Hoover Dam vary widely among the traces. Below Glen Canyon Dam, some traces exceed the 20°C threshold; however, more than half of the traces simulated are below this threshold for each water year.	Projected temperature releases at Glen Canyon Dam and Hoover Dam vary widely among the traces; however, outcomes are relatively similar between the No Action and the Proposed Action Alternatives. Below Glen Canyon Dam, the Proposed Action leads to slightly more days above 16°C in water year 2026 when compared to the No Action Alternative. As in the No Action Alternative, some traces exceed the 20 °C threshold; however, more than half of the traces simulated are below this threshold for each water year.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.8 *(cont.)*	Sediment	Sediment dredging projects in the reach below Hoover Dam would continue to ensure water deliveries to downstream users. In the Marble and Grand Canyons, each year between 2024 and 2026 spring HFEs would only be triggered approximately 15 percent of the time and fall HFEs would be triggered approximately 70 percent of the time. If Lake Powell drops below 3,500 feet, HFEs are infeasible. Sand deposition would be insufficient to build sandbars. Sandbars would progressively erode from current conditions through 2026.	April and November HFEs trigger occurrences are approximately the same as under the No Action Alternative. However, November releases are slightly lower under the Proposed Action and would result in a 5 percent reduction in HFE implementation probability for 36- and 72- hour durations in November 2024 and 2025.
	Nutrients and algae	Decreased dilution capacity could result in greater concentrations of nitrogen and phosphorus; however, quantified water quality impacts related to dilution capacity are not available, rendering it difficult to project the quantified water quality impacts based on dilution capacity.	Lower flows under the Proposed Action and decreased dilution capacity under all alternatives could result in greater concentrations of nitrogen and phosphorus; however, quantified water quality impacts related to dilution capacity are not available, rendering it difficult to project the quantified water quality impacts based on dilution capacity.
	Dissolved oxygen (DO)	Under the No Action Alternative, mean August to October DO in Lake Powell is projected to drop below 5 mg/L in 79 percent of traces.	As in the No Action Alternative, mean August to October DO in Lake Powell is projected to drop below 5 mg/L in 79 percent of traces. The percentage of low DO events occurring in the tailwater would be slightly higher under the Proposed Action.
	Metals	The No Action Alternative is unlikely to reduce dilution capacity significantly (a finding similar to that in the 2007 FEIS). Therefore, the projected elevations and corresponding changes in dilution capacity are not expected to result in a significant reduction in dilution capacity or any significant increase in concentrations of metals of concern.	As in the No Action Alternative, the likelihood of drawing down below 1,000 feet is small.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.9	**Air Quality**		
	Shoreline exposure fugitive dust	Increased shoreline exposure results in a potential increase of dust and particulate matter. Under the No Action Alternative, Lake Powell and Lake Mead would have the most acreage of exposed shoreline and therefore the greatest potential for increased fugitive dust emissions. The current shoreline area of the Salton Sea could continue to decrease at the current rate.	Shoreline exposure is anticipated to decrease compared with the No Action Alternative. If IID and CVWD take additional shortages, there would be less inflow to the Salton Sea from irrigation drainage. Salton Sea water surface elevation declines more rapidly under the Proposed Action than the No Action Alternative due to additional consumptive uses on the playa. Exposure may be greater at first under the Proposed Action but would eventually be the same as under the No Action Alternative.
	Alternative power associated with greenhouse gases	The necessity for alternative power (coal and natural gas) results in an increase of greenhouse gases. Under the No Action Alternative, there is less potential for alternative power and therefore less potential for increased greenhouse gas emissions compared with the Proposed Action.	The Proposed Action results in varying degrees of impacts on power generation. The Proposed Action results in more power generation compared with the No Action Alternative under low hydrology scenarios. Annual releases at Lake Mead are higher under the No Action Alternative, leading to less power generation at Hoover Powerplant under the Proposed Action across most hydrologic scenarios, resulting in increased need for alternative power.
3.10	**Visual Resources**		
	Visibility of attraction features	Cathedral in the Desert could be visible and accessible. More of the upstream side of Glen Canyon and Hoover Dams would be visible.	Impacts are similar to those under the No Action Alternative, except less of the upstream side of Glen Canyon and Hoover Dams would be visible.
	Lake Powell maximum height of calcium carbonate ring, 10th percentile, 2025	196 feet	190 feet
	Lake Mead maximum height of calcium carbonate ring, 10th percentile, 2025	204 feet	184 feet
	Colorado River landscape character	Initially, there would be less impacts as flows would remain above 7.0 maf; however, if Lake Powell reaches dead pool, impacts would be extensive and immediate due to a dramatic reduction in flows.	Impacts would be tempered through different release tiers to keep Lake Powell above 3,500 feet. Releases could be as low as 6.0 maf, if needed, which could result in increased impacts on the river's landscape character.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.10 *(cont.)*	Lower Division States' landscape character	Initially, there would be lower impacts; however, if Lake Mead reaches dead pool, dramatic decreases in water availability could affect the landscape character in all three Lower Division States. Based on modeling for the Salton Sea, additional exposure of the lake bed under the No Action Alternative would lead to diminishing scenic quality of landscapes adjacent to the Salton Sea.	Through application of conservation measures and water supply adjustments, based on lowering elevations of Lake Mead, changes in water availability affecting the landscape character in the Lower Division States would be tempered compared to the No Action Alternative. Management under the Proposed Action, including drought reduction and conservation measures, would expose the Salton Sea's lake bed more quickly than the No Action Alternative during the planning period. This would, further diminish the area's scenic quality through decreasing influence of water within these landscapes. Over the long term, impacts on scenic quality adjacent to the Salton Sea are similar to the No Action Alternative.
3.11	**Cultural Resources**		
	Low lake elevations exposing cultural resources	Low lake levels at Lake Mead would expose resources to increased wave action, wet/dry cycling, and visitation.	Low lake levels at Lake Mead would expose resources to increased wave action, wet/dry cycling, and visitation but to a lesser degree than the No Action Alternative.
	Low river levels exposing cultural resources	River levels and HFEs to deposit sediment would be within ranges previously analyzed under LTEMP.	Conservation measures may lead to lower water levels at the Salton Sea exposing resources.
	Alterations to traditional cultural places	Visitation to archaeological sites may increase if resources are exposed at Lake Mead.	Impacts are the same as under the No Action Alternative.
3.12	**Paleontological Resources**		
	Lower lake levels exposing paleontological resources	Very low lake levels at Lake Mead and Lake Powell would expose paleontological resources to increased wave action, erosion, wet/dry cycling, visitation, and unauthorized collecting.	Low lake levels at Lake Powell and Lake Mead would expose paleontological resources to potential impacts from wave action at lake margins, wet/dry cycles, and likely increased visitation. Projected higher lake levels at Lake Mead would likely expose fewer paleontological resources to potential impacts than the No Action Alternative.
	Lower river levels exposing paleontological resources	Lower river levels would expose more resources to visitation and unauthorized collecting but potentially increase available sediment for wind transport to protect some resources.	Projected higher river levels would expose fewer resources but may make less sediment available for wind transport to protect some resources.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.13	**Biological Resources**		
	Vegetation	Water elevations are predicted to decrease over time, resulting in short-term changes to riparian vegetation, including an increase in invasive plant species and loss of suitable habitat for native plant species.	The Proposed Action and No Action Alternative result in similar impacts on vegetation at Lake Powell and the Glen Canyon Dam to Lake Mead section until 2025. From 2025 to 2026, the Proposed Action would result in slightly higher water elevations at Lake Powell. At Lake Powell and Lake Mead, fewer acres of shoreline have the potential to be invaded by nonnative species under the Proposed Action compared with the No Action Alternative. In most scenarios, impacts on riparian vegetation in the Glen Canyon Dam to Lake Mead section and the Hoover Dam to the SIB section would be similar under the Proposed Action compared with the No Action Alternative until 2026, when water flows are reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead.
	Wildlife	Water elevations are predicted to decrease over time for the driest hydrologic futures. This would result in impacts on wildlife from decreased flows and the reduction of lake levels.	There would be similar impacts to those described under the No Action Alternative for Lake Powell. Water levels are similar compared to the No Action Alternative until 2025, at which point the Proposed Action results in higher water elevations at Lake Powell, reducing impacts on wildlife. Higher water levels at Lake Powell would result in reduced flows from the Glen Canyon Dam to Lake Mead, increasing impacts on wildlife. Similarly, Lake levels are predicted to be higher under the Proposed Action for Lake Mead, resulting in reduced flows from the Hoover Dam to the SIB. This would reduce impacts on wildlife at Lake Mead but increase impacts on wildlife in the Hoover Dam to the SIB section. However, the differences in impacts are likely to be minor.

SEIS Section	Affected Resource	Alternatives	
		No Action	**Proposed Action**
3.13 *(cont.)*	Special status species	Water elevations are predicted to decrease over time for the driest hydrologic futures. This would result in impacts on special status species from decreased flows and the reduction of lake levels.	There are impacts similar to those described under the No Action Alternative for Lake Powell. Water levels are similar compared to the No Action Alternative until 2025, at which point the Proposed Action results in higher water elevations at Lake Powell, reducing impacts on special status species. Higher water levels at Lake Powell result in reduced flows from the Glen Canyon Dam to Lake Mead, increasing impacts on special status species. Similarly, Lake levels are predicted to be higher under the Proposed Action for Lake Mead, resulting in reduced flows from the Hoover Dam to the SIB. This would reduce impacts on special status species at Lake Mead but increase impacts on special status species in the Hoover Dam to the SIB section. However, the differences in impacts are likely to be minor.
3.14	**Recreation**		
	Recreation at Lake Powell	Projected Lake Powell elevations are below the critical thresholds for most boat launch facilities, resulting in a reduction in the quality of or the loss of reservoir boating opportunities on Lake Powell. Dock access is unavailable from the Rainbow Bridge National Monument shoreline. Declining pool elevations expose additional areas of Glen Canyon, creating new visitation patterns and resource protection challenges. Sport fish populations are not expected to be impacted.	There are impacts similar to those described under the No Action Alternative, with a lesser magnitude due to the higher maximum projected 2025 pool elevation.
	Recreation from Glen Canyon Dam to Lake Mead	Daytime flows will not drop lower than the safe whitewater boating threshold of 5,000 cfs. Lethal limits for rainbow trout are not projected to be exceeded in any month. If Lake Powell were to reach dead pool beyond 2026, the resulting large increase in water temperature would lead to potentially lethal conditions for rainbow trout.	There are impacts on whitewater boating similar to those described under the No Action Alternative. Predicted release temperatures have more variability annually than under the No Action Alternative, which could lead to greater physiologic stress on rainbow trout under warmer conditions.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.14 *(cont.)*	Recreation at Lake Mead	The projected Lake Mead elevation is below the critical threshold for all boat launch facilities except the Pearce Ferry Road launch ramp, which will necessitate boat launch facilities be closed or relocated. The projected median pool elevation for Lake Mead will likely result in boaters encountering boating navigational hazards. Projected surface water temperatures are not anticipated to impact sport fish.	There are impacts similar to those described under the No Action Alternative; however, impacts are slightly reduced due to the slightly higher Lake Mead pool elevations.
	Recreation from Hoover Dam to the Salton Sea	Flow releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam are within the historical operating range; therefore, there are minimal changes in exposure to boating navigation hazards caused by changes in the river elevation or velocity, changes in access or use of rest areas and take-out points, changes in trip duration caused by changes in river velocity, or decreases in access or use of sport fishing sites caused by changes in flows. The minor changes in water temperatures that may occur downstream of Hoover Dam are not expected to affect warmwater sport fish. Under the No Action Alternative, the Salton Sea shoreline will continue to decrease at the current rate.	There are impacts similar to those described under the No Action Alternative; however, shoreline recreation on the Salton Sea shoreline could be more adversely affected if IID and CVWD contribute to SEIS conservation.
3.15	**Electrical Power Resources**		
	Glen Canyon Powerplant		
	Average annual generation	3,539,401 MWh	3,464,135 MWh
	Average August capacity	544 MW	546 MW
	Average annual total economic value of electrical energy value	$271,395,000	$268,544,000

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.15 *(cont.)*	*Hoover Powerplant*		
	Average annual generation	3,106,135 MWh	3,007,348 MWh
	Average August capacity	1,208 MW	1,280 MW
	Average annual total economic value of electrical energy value	$393,479,000	$ 383,784,000
	Parker and Davis Powerplants		
	Average annual generation	1,471,966 MWh	1,394,967 MWh
	Average August capacity	Negligible impacts	Negligible impacts
	Average annual total economic value of electrical energy value	$136,346,000	$127,183,000
	Changes in the total annual economic value of electrical energy impact on the various power funds	Reduced total hydropower value at Glen Canyon Powerplant results in reduced contributions to the Basin Fund. Reduced total hydropower value at Hoover, Parker, and Davis Powerplants results in reduced contributions to the Development Fund. Continued revenue from surcharges at Hoover, Parker, and Davis Powerplants results in minor impacts on the Dam Fund.	Reduced total hydropower value at Glen Canyon Powerplant results in reduced contributions to the Basin Fund. Reduced total hydropower value at Hoover, Parker, and Davis Powerplants results in reduced contributions to the Development Fund. Continued revenue from surcharges at Hoover, Parker, and Davis Powerplants results in minor impacts on the Dam Fund.
	The basin funds' impacts on other governmental programs	Reduced funds in the Basin Fund and Development Fund result in lower contributions to associated government programs. Continued financial resources in the Dam Fund have minor impacts on the associated government programs.	Reduced funds in the Basin Fund and Development Fund result in lower contributions to associated government programs. Continued financial resources in the Dam Fund have minor impacts on the associated government programs.

SEIS Section	Affected Resource	Alternatives	
		No Action	Proposed Action
3.16	**Socioeconomics**		
	Loss of agricultural production and associated jobs, income, and tax revenue for Indian and non-Indian agriculture in Arizona, California, and Nevada from 2024 through 2026	Arizona (Indian and Non-Indian): Production: $57–$114 million loss Jobs: 657–1,613 lost Income: $67–$108 million loss Tax revenue: $10–$24 million loss California: Production: $3–$6 million loss Jobs: 0–75 lost Income: $0–$3 million loss Tax revenue: $0–$1 million loss Nevada: No impacts	Impacts are the same as under the No Action Alternative, with reduced potential to experience the higher range of projected impacts. This is due to reduced potential to reach higher tier shortage levels for agricultural water users. Increased system conservation agreements offset to some degree the level of economic impacts associated with reduced agricultural production. There is insufficient data, however, on the degree to which this compensation would offset the regional economic impacts in the agricultural sector, due to the loss of indirect and induced jobs and income that may not be fully compensated.
	Recreation economic contributions	Economic contributions from recreation in Lake Powell and Lake Mead, river-based recreation, and adjacent land-based recreation as well as national wildlife refuges would continue. Due to anticipated reservoir levels, there is the potential for reduced contributions from reservoir-based recreation due to inaccessibility of boat launches in Lakes Powell and Mead as well as navigational issues. Economic contributions from commercial whitewater rafting are supported under all alternatives due to minimum flow requirements; however, the recreational experience would be impacted by the variation in flow. Reduction in Salton Sea elevation could impact recreation at the Salton Sea (and potentially in the region) due to changes in air quality as a result of shore bed exposure.	Impacts are similar to those described under the No Action Alternative, with a slight reduction in potential impacts on recreation use and associated spending due to the slightly higher Lake Mead and Powell pool elevations. Shoreline recreation on and near the Salton Sea and associated spending could be more adversely affected if the Proposed Action resulted in expedited (but not additional) lake bed exposure compared to the No Action Alternative, due to the possibility of less available agricultural runoff.

SEIS Section	Affected Resource	Alternatives	
		No Action	**Proposed Action**
3.16 *(cont.)*	Municipal and industrial water social and economic contributions	Under all alternatives, allocated water shortages for different water elevations in Lake Mead result in higher domestic water shortages compared with 2021 use levels. The specific economic impacts from domestic and industrial water shortages are unknown due to the variety of approaches municipalities and other entitlement holders utilize in shortage scenarios, including supply-side actions (such as groundwater recharge, water purchase agreements, and alternative water supplies) and demand-side strategies (such as water conservation measures). Under the No Action Alternative, impacts are realized at lower shortage scenarios for Arizona long-term contractors (533,000-af scenario) and Nevada entitlement holders (200,000-af scenario) compared with California; this is due to the modeled effects of the priority system in the 2007 FEIS. At a 1.100-maf shortage scenario, maximum levels of shortage would result in domestic water shortages of 178,590 af in Arizona, 30,000 af in Nevada, and 350,000 af in California (pursuant to the DCPs).	Modeled shortage scenarios under the Proposed Action are the same as under the No Action Alternative; however, the increased level of system conservation and intentionally created surplus result in higher elevations at Lake Mead, with fewer traces at higher-shortage tiers as compared to the No Action Alternative in 2025 and 2026. As a result, the potential to reach higher tier shortage levels for domestic waters users (e.g., those shortages as modeled at 967,000 to 1,100,000 af) is reduced.
3.17	**Environmental Justice**		
	Environmental justice communities	Initially, there are fewer impacts than under the Proposed Action; however, there is an increased potential for disproportionate impacts on environmental justice communities as reservoir levels decrease. The available water supply will be reduced to zero for some Arizona priorities (all 5th- and 6th-priority contracts, CAP agricultural, and other excess) located within the following Arizona environmental justice study area counties: Pinal and Pima. This study area includes two Tribes.	In the longer term, hydrologic models indicate that reservoir levels would be maintained above critical levels for a longer length of time with the implementation of proposed additional system conservations. This would contribute to reduced potential for higher modeled shortages and mandatory shortages to occur, thereby minimizing potential impacts on environmental justice communities. Therefore, impacts on environmental justice communities could be reduced compared with the No Action Alternative in the long term.

SEIS Section	Affected Resource	Alternatives	
		No Action	**Proposed Action**
3.18	**Indian Trust Assets**		
	Water rights and allocations	Tribal water rights are established by law; however, annual water deliveries may change as a result of shortages. Water deliveries and shortages are shared based on priority and as outlined in a Tribe's water settlement and/or entitlement. Executed system conservation agreements with Tribes are in place.	Impacts are the same as under the No Action Alternative. Executed system conservation agreements with Tribes are in place, with the potential for additional system conservation agreements with Tribes under development.
	Cultural and biological resources	Low river levels expose more cultural resources to visitation. As water elevations decrease, there are short-term changes to riparian vegetation, including an increase of invasive plant species and the loss of suitable habitat for native plant species.	No impacts on biological resources for ITAs occur. As with the No Action Alternative, low river levels expose more cultural resources to visitation.

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Chapter 3. Affected Environment and Environmental Consequences

3.1 Introduction

This chapter describes the affected environment and environmental consequences for the resources that could be significantly affected by the alternatives, as described in **Table 1-1**. The affected environment sections describe and update the current conditions, focusing on those that have changed since 2007. The environmental consequences sections provide analysis of the No Action and Proposed Action, as described in **Chapter 2**. The analysis is issue based, addressing the specific relevant concerns identified during scoping for a particular resource. For brevity and to avoid redundancy, the 2007 FEIS (Reclamation 2007) is incorporated by reference.

The methodology and technical assumptions used to analyze the potential impacts on the Colorado River system (such as reservoir elevations, releases, and flows) are described in **Section 3.3**. Additional methodologies and assumptions used to analyze specific resources are described in the appropriate **Chapter 3** resource sections.

3.2 Geographic and Temporal Scope

Like the 2007 FEIS, the SEIS's geographic scope of analysis (also termed study or analysis area) is the Colorado River corridor from the full pool elevation of Lake Powell to the Southerly International Boundary (SIB; see Map 3.2-1 in the 2007 FEIS). For some resources, the impact analysis area differs from this scope to account for the impacts on that specific resource; when different, the impact analysis area is defined in the resource's specific methodology section. Additionally, reservoirs upstream of Lake Powell are operated pursuant to their own criteria, which are not affected by the proposed alternatives.

In addition to the potential impacts that may occur within the mainstream Colorado River corridor, the SEIS alternatives may also affect the water supply available to specific Colorado River water users in the Lower Basin due to system conservation described in the Proposed Action. The following water agency service areas are included in the geographic scope of analysis:

- The Central Arizona Project (CAP) contract service areas, including the Central Arizona Water Conservation District service area and Tribal service areas
- The SNWA service area
- The MWD service area

- Imperial Valley and Coachella Valley service areas
- Tribal reservations

The environmental consequences analysis focuses on the period of operating years 2024 through 2026, during which the alternatives considered would be implemented, as described in **Section 2.4**, Implementation. Although impacts of the proposed alternatives could extend beyond 2026, the analysis does not examine impacts beyond 2026 because Reclamation is preparing a separate EIS to develop the post-2026 operational strategies. This post-2026 EIS will analyze a full range of alternatives and associated impacts.

3.3 Methodology

Hydrologic modeling of the Colorado River system was conducted to determine the potential hydrologic effects of the alternatives. The hydrologic modeling provided projections of potential future Colorado River system conditions (such as reservoir elevations, reservoir releases, and river flows) under the No Action Alternative for comparison with conditions under the Proposed Action. Due to uncertainties associated with future inflows into the system, multiple simulations were performed for each alternative to explore a range of possible future conditions. All statistics calculated are reflective of the hydrologic scenarios and other assumptions used in modeling. They are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance. For this reason, the environmental consequences analyses provided in the sections below may discuss the likelihood of certain scenarios or impacts occurring.

Hydrologic modeling also provided the basis for analyzing potential effects of each alternative on other environmental resources, such as recreation, biology, and energy. The potential effects on specific resource issues are identified and analyzed for the Proposed Action and compared with the potential effects on that resource issue under the No Action Alternative. These comparisons are typically expressed in terms of the incremental differences in probabilities (or projected circumstances associated with a given probability) between the No Action Alternative and the Proposed Action.

This section provides an overview of the hydrologic modeling used and the framework within which the many simulations were undertaken. Further details regarding the model and modeling assumptions are also provided in **Appendix D**, CRMMS Model Documentation, and **Appendix E**, Shortage Allocation Model Documentation. For some of the resource analyses, additional modeling using other techniques was needed to analyze the potential effects on particular resource issues. In most of these cases, the output from the hydrologic modeling was used as input to these other models. The methodologies used for the additional modeling are described in each respective resource section of **Chapter 3**. Models may be updated, as appropriate, between this Draft SEIS and publication of the Final SEIS.

3.3.1 Alternatives Modeled

A Proposed Action and a No Action Alternative are considered in this SEIS.[1] Each alternative includes specific assumptions with regard to the four sections of the 2007 Interim Guidelines that Reclamation is proposing to modify: **Section 2.D**, Shortage Conditions; **Section 6.C**, Mid-Elevation Release Tier; **Section 6.D**, Lower Elevation Balancing Tier; and **Section 7.C**, Mid-Year Review. Additional details with respect to the modeling assumptions used to represent each alternative are presented in **Section 3.3.4**; **Appendix D** and **Appendix E**.

3.3.2 Period of Analysis

As described in **Section 3.2**, this SEIS addresses guidelines that would be in effect for the remainder of the interim period under the 2007 Interim Guidelines from the 2024 through 2026 operating years for Lower Basin shortages and the coordinated operations of Lake Powell and Lake Mead.

3.3.3 Model Description

Future Colorado River system conditions during the analysis period under the No Action Alternative and the Proposed Action were simulated using Colorado River Mid-term Modeling System (CRMMS). The model framework used for this process is a commercial river modeling software called RiverWare™, a generalized river basin modeling software package developed by the University of Colorado through a cooperative arrangement with Reclamation and the Tennessee Valley Authority. While it uses the same software as Colorado River Simulation System (CRSS), which was the model used for the 2007 FEIS, CRMMS is used to produce mid-term projections of system conditions for outlooks up to 5 years, compared with the longer-term outlooks projected using CRSS.

CRMMS simulates operation of the major reservoirs on the Colorado River and provides information regarding the projected future state of the system on a monthly basis in terms of output variables, including the amount of water in storage, reservoir elevations, dam releases, the amount of water flowing at various points throughout the system, and the diversions to and return flows from water users throughout the system. The basis of the simulation is a mass balance (or water budget) calculation that accounts for water entering the system, water leaving the system (e.g., from consumptive use of water, trans-basin diversions, and evaporation), and water moving through the system (i.e., either stored in reservoirs or flowing in river reaches). Further explanation of the model is provided in **Appendix D**. The model was used to project future conditions of the Colorado River system on a monthly timestep for the period June 2023 through December 2026.

Input data for the model includes monthly unregulated inflow forecasts based on the June 2023 forecast; various physical process parameters, such as evaporation rates for each reservoir; initial reservoir conditions as of May 31, 2023; and the future depletion schedules for entities in the Lower Basin and for Mexico. For the first year of the model run, water depletion schedules use water orders that reflect shortage conditions, DCP contributions, Minute 323, and other signed system conservation agreements. For the remaining years in the model run, water depletion schedules reflect "normal" schedules and represent near-term historical trends in water use. For purposes of

[1] Reclamation analyzed external proposals for alternatives, or components thereof, as further described in **Section 2.1**, Development of the Alternatives.

this SEIS, depletions are defined as diversions from the river less the return flow credits, where applicable.

The rules of operation of the Colorado River mainstream reservoirs, including Lake Powell and Lake Mead, for each alternative are also provided as input to the model. These sets of operating rules describe how water is released and delivered under various hydrologic conditions. Further explanation of the operating rules for each alternative is provided in **Appendix D**.

The future hydrology used as input to the model consisted of three sets of 30 Ensemble Streamflow Prediction (ESP) traces.[2] The three sets are 80 percent, 90 percent, and 100 percent of the official June 2023 unregulated inflow forecast, allowing Reclamation to explore a wider range of low-flow hydrologic scenarios below those experienced during the recent 30 years (1991–2020). See **Appendix D** for additional details on these hydrologic ensembles.

3.3.4 Modeling Assumptions

Assumptions Common to All Alternatives

In addition to the specific operating rules necessary to model each of the alternatives (discussed in **Chapter 2**; **Appendix D**, CRMMS Model Documentation, **Appendix E**, Shortage Allocation Model Documentation, and the following section), the modeling of Colorado River system operations also requires certain assumptions about various aspects of water delivery and system operations common to all alternatives.

CRMMS Assumptions for All Alternatives

Detailed assumptions for CRMMS are in **Appendix D** and are summarized here. Assumptions about reduction of deliveries to the Lower Division States under each alternative are described in **Section 2.6**, **Section 2.7**, and **Section 3.3.5**, below.

- All simulations were performed with a start date of June 2023 and an end date of December 2026.
- If the pool elevation of Lake Powell drops below 3,490 feet, it is assumed that only three of the four river outlet works would be available for use at any given time because of the need for periodic inspections and routine maintenance. Reclamation believes this is a reasonable estimation, given the historical and future operations and maintenance requirements for the river outlet works. Operations may vary from this assumption to address operating considerations at Glen Canyon Dam based on the actual operating experience at lower elevations.
- DCP contributions and intentionally created surplus (ICS) assumptions are consistent with the official June 2023 CRMMS simulation.
- The analysis continues implementation of the 2007 Interim Guidelines, 2016 ROD for the Glen Canyon Dam LTEMP and Glen Canyon Dam Operating Criteria, Minute 323, and the 2019 DCPs for operations of the Glen Canyon and Hoover Dams.

[2] This input is based on an ensemble of unregulated streamflow forecasts developed by the National Weather Service's Colorado Basin River Forecasting Center.

- The analysis for each alternative includes modeled water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's recoverable water savings that contribute to the BWSCP, in accordance with Minute 323 to the 1944 Water Treaty. This differs from the assumed 16.67 percent of the total shortage analyzed in the 2007 FEIS.
- Hourly, daily, and monthly releases from Lake Powell will be consistent with LTEMP. Minimum flows analyzed in the LTEMP were 5,000 cfs at night and 8,000 cfs during the day. If these minimum flows are not possible due to the projected monthly release volume, the model could simulate flows lower than the minimum flows analyzed in LTEMP.
- For Lower Division State and Mexico use, in the first year of the model run, water depletion schedules use water orders that reflect shortage conditions, DCP contributions, reductions under low-elevation reservoir conditions, BWSCP contributions per Minute 323, and system conservation agreements. For the remaining years in the model run, water depletion schedules reflect "normal" schedules and represent near-term historical trends in water use. The 2007 FEIS consumptive use schedules were based on entitlements. These "baseline/normal" water depletion schedules are then reduced by 2007 Interim Guidelines shortages, DCP reductions, and Minute 323 reductions under low-elevation reservoir conditions and BWSCP contributions.
- It is assumed that annual releases are representative of annual flows within the reach of Davis Dam to Parker Dam, Parker Dam to Cibola Gage, and Cibola Gage to Imperial Dam.
- The 2022 DROA Plan for May 2022 through April 2023 was amended to suspend 2022 DROA Plan releases as of March 7, 2023. A total DROA release of approximately 463,000 af occurred under the 2022 DROA Plan. The CRMMS modeling does not include any assumptions regarding future DROA releases. Reclamation will attempt to maximize DROA recovery in the Upper Initial Units in operating year 2023 and through April 2024.

Shortage Allocation Model Assumptions for All Alternatives

Detailed assumptions for the Shortage Allocation Model are in **Appendix E** and are summarized below.

- The Shortage Allocation Model assumes a maximum analyzed shortage of 1.1 maf.
- The model distributes available water first among states based on the 2007 ROD and 2019 DCPs and subsequently among the entitlement holders within each state based on priority.

Modeling Assumptions for the No Action Alternative

Section 2.6 describes the No Action Alternative in detail. An overview of assumptions for the No Action Alternative includes the following:

CRMMS

- The No Action Alternative of this SEIS differs from the No Action Alternative in the 2007 FEIS in terms of updated rules to reflect the 2007 Interim Guidelines and DCPs, input hydrology, time horizon, hydrologic demands, and modeling tool (CRMMS).
- Releases from Lake Powell are based on the Operational Tiers outlined in the 2007 Interim Guidelines and described in **Section 2.6**.

- Releases from Lake Mead are based on the Lower Basin condition (normal, shortage, or surplus), as outlined in the 2007 Interim Guidelines, and on the required DCP contributions. DCP contributions and ICS assumptions are consistent with the official June 2023 CRMMS simulation.
- Lower Basin demands are reduced based on system conservation agreements that were finalized prior to the June 2023 CRMMS simulation, consistent with the official June 2023 CRMMS. System conservation volumes are summarized in **Section 3.3.5**.

Modeling Assumptions for the Proposed Action

Section 2.7 describes the Proposed Action in detail. An overview of assumptions for the Proposed Action includes:

CRMMS

- Releases from Lake Powell are based on the Operational Tiers outlined in the 2007 Interim Guidelines (and described in **Section 2.6**) with a potential mid-year adjustment to protect Lake Powell elevation of 3,500 feet. In April, when in Mid-Elevation Release Tier and Lower Elevation Balancing Tier, if Lake Powell is projected to drop below 3,500 feet by the end of the operating year or is already below 3,500 feet, monthly releases are reduced to minimize months below 3,500 feet while releasing up to the original release, and no less than 6.0 maf or the required minimum daily release as defined by LTEMP.
- Releases from Lake Mead are based on the Lower Basin condition (normal, shortage, or surplus), as outlined in the 2007 Interim Guidelines, and on the required DCP contributions. ICS assumptions are consistent with the official June 2023 CRMMS simulation, except for (1) MWD's 2023 Extraordinary Conservation ICS volume, (2) SNWA's 2023 Tributary ICS creation volume, and (3) additional types of ICS converted to system water when the maximum ICS accumulation capacity[3] is reached.[4]
- Lower Basin demands are reduced based on system conservation agreements beyond the volumes included in the official June 2023 CRMMS. The modeled system conservation volumes include executed agreements, agreements under development, and planned operations. These Proposed Action conservation volumes are modeling assumptions, do not represent mandatory shortages, and in no way commit specific water users to these reductions in use. System conservation volumes for the Proposed Action are summarized in **Section 3.3.5**.
- A sensitivity analysis of potential DROA contributions is provided in **Appendix F,** Potential DROA Contributions Sensitivity Analysis on Proposed Action.

[3] In accordance with the Lower Basin DCP, the maximum total amount of Extraordinary Conservation ICS, Binational ICS, and DCP ICS that may be accumulated by the Lower Division States is 2.7 maf.
[4] This assumption affects SNWA ICS activity for 2023–2026.

3.3.5 Shortage Sharing and Water Delivery Reduction Assumptions

A summary of modeling assumptions with respect to the reduction of deliveries to the Lower Division States, including 2007 ROD shortages, 2019 DCP contributions, and SEIS conservation, was provided in **Section 2.7**. **Table 3-1** shows the distribution of 2007 ROD shortages and 2019 DCP contributions by state. Modeling assumptions for SEIS conservation volumes by state, user, and year are summarized in **Table 3-2** and **Table 3-3** for the No Action Alternative and Proposed Action, respectively.

Table 3-1
Lower Division States' Shortages and DCP Contributions by State

Lake Mead Elevation (feet)	2007 ROD Shortages (1,000 af)				2019 DCP Contributions (1,000 af)				Total 2007 ROD Shortages + 2019 DCP Contributions (1,000 af)			
	AZ	NV	CA	Total	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	0	0	0	0	192	8	0	200	192	8	0	200
1,075 – 1,050	320	13	0	333	192	8	0	200	512	21	0	533
<1,050 – >1,045	400	17	0	417	192	8	0	200	592	25	0	617
1,045 – >1,040	400	17	0	417	240	10	200	450	640	27	200	867
1,040 – >1,035	400	17	0	417	240	10	250	500	640	27	250	917
1,035 – >1,030	400	17	0	417	240	10	300	550	640	27	300	967
1,030 – 1,025	400	17	0	417	240	10	350	600	640	27	350	1,017
<1,025	480	20	0	500	240	10	350	600	720	30	350	1,100

Table 3-2
Lower Division States' SEIS Conservation by State, No Action Alternative (2023–2026)
(All volumes in af)

Modeled SEIS Conservation*	2023	2024	2025	2026	Total
California					
System Conservation					
Palo Verde Irrigation District	58,400	39,800	—	—	98,200
Intentionally Created Surplus					
Metropolitan Water District of Southern California**	209,000	—	—	—	209,000
California Total	**267,400**	**39,800**	—	—	**307,200**
Arizona					
System Conservation					
Gila River Indian Community	91,950	125,000	125,000	—	341,950
Fort McDowell Yavapai Nation	13,933	13,933	13,933	—	41,799
Central Arizona Project Subcontractors	62,200	42,200	42,200	—	146,600
Mohave Valley Irrigation and Drainage District	12,819	—	—	—	12,819

Modeled SEIS Conservation*	2023	2024	2025	2026	Total
Yuma Mesa Irrigation and Drainage District	13,670	—	—	—	13,670
Gabrych Farms	3,240	3,240	3,240	—	9,720
Arizona Total	**197,812**	**184,373**	**184,373**	**—**	**566,558**
Nevada					
Intentionally Created Surplus					
Southern Nevada Water Authority**	65,000	—	—	—	65,000
Nevada Total	**65,000**	**—**	**—**	**—**	**65,000**
Total Modeled System Conservation	**530,212**	**224,173**	**184,373**	**—**	**938,758**

* These model assumptions reflect projected volumes as of June 2023 from executed agreements and are subject to change. These system conservation volumes are modeling assumptions, do not represent mandatory shortages, and do not commit specific water users to these reductions in use.
** 2024–2026 ICS creation and delivery vary based on modeling assumptions and modeled system conditions, including shortage conditions and available ICS accumulation capacity.

Table 3-3
Lower Division States' SEIS Conservation by State, Proposed Action (2023–2026)
(All volumes in af)

Modeled SEIS Conservation*	2023	2024	2025	2026	Total
California					
System Conservation					
Coachella Valley Water District	35,000	45,000	45,000	—	125,000
Quechan Indian Tribe	13,000	13,000	13,000	13,000	52,000
Palo Verde Irrigation District	78,000	120,000	120,000	83,000	401,000
Bard Water District	—	6,000	—	—	6,000
Imperial Irrigation District	50,000	250,000	250,000	250,000	800,000
Intentionally Created Surplus					
Metropolitan Water District of Southern California**	216,000	—	—	—	216,000
California Total	**392,000**	**434,000**	**428,000**	**346,000**	**1,600,000**
Arizona					
System Conservation					
Gila River Indian Community	91,950	145,000	145,000	20,000	401,950
Fort McDowell Yavapai Nation	13,933	13,933	13,933	—	41,799
San Carlos Apache Tribe	23,275	—	—	—	23,275
Colorado River Indian Tribes	37,000	23,000	23,000		83,000
Central Arizona Project Subcontractors	143,800	129,800	128,800	—	402,400
Mohave Valley Irrigation and Drainage District	12,819	12,819	12,819	—	38,457
Yuma Mesa Irrigation and Drainage District	13,670	13,670	13,670	—	41,010

Modeled SEIS Conservation*	2023	2024	2025	2026	Total
Gabrych Farms	3,240	3,240	3,240	—	9,720
Wellton-Mohawk Irrigation and Drainage District	9,000	12,000	12,000	9,000	42,000
Intentionally Created Surplus					
Arizona ICS Preservation Program	70,000	—	—	—	70,000
Arizona Total	**418,687**	**353,462**	**352,462**	**29,000**	**1,153,611**
Nevada					
Intentionally Created Surplus					
Southern Nevada Water Authority***	75,000	75,000	70,000	65,000	285,000
Nevada Total	**75,000**	**75,000**	**70,000**	**65,000**	**285,000**
Total Modeled SEIS Conservation	**885,687**	**862,462**	**850,462**	**440,000**	**3,038,611**

* These model assumptions reflect projected volumes as of June 2023—from executed agreements, agreements under development, and planned operations—and are subject to change. These SEIS conservation volumes are modeling assumptions, do not represent mandatory shortages, and in no way commit specific water users to these reductions in use.
** 2024–2026 ICS creation and delivery vary based on modeling assumptions and modeled system conditions.
*** Specified ICS creation by SNWA is the minimum ICS creation that will occur in each year. Modeled ICS creation will vary based on modeled system conditions, including shortage conditions and available ICS accumulation capacity.

3.3.6 Salton Sea Modeling

The Salton Sea is a terminal lake in Riverside and Imperial Counties, California. The Department owns and manages lands around the Salton Sea. Lake levels are maintained by runoff from the surrounding Imperial Valley and Coachella Valley watersheds, as well as agricultural runoff from the Imperial Irrigation District (IID) and Coachella Valley Water District (CVWD) originating in the Colorado River Basin. The Salton Sea acts as a sump for agricultural runoff. Reductions in agricultural runoff may impact lake elevations, which, in turn, may impact air quality and shoreline wildlife habitat. The California Natural Resources Agency is responsible for and leads management efforts at the Salton Sea. These efforts include implementing 29,800 acres of habitat restoration and dust-suppression projects on lake bed areas that have been, or will be, exposed by 2028. The Department is actively supporting the State in the implementation of its 10-year plan by providing technical resources, funding, and Department-owned lands for project implementation and has, therefore, included it in the analysis area for this SEIS.

Future Salton Sea conditions were modeled using the Salton Sea Accounting Model (SSAM). The SSAM was originally developed by Reclamation in the early 2000s and repurposed by the State of California to assist in its Salton Sea Management Program objectives (California Natural Resources Agency 2018). The SSAM was used to estimate the net impacts of short-term allocation reductions on key metrics such as salinity and exposed playa area. To evaluate impacts, water allocation reduction scenarios for the IID and CVWD were evaluated using the SSAM. A set of scenarios was prepared with different levels of reduction and different fallowing/efficiency considerations by the IID. The model assumptions and outputs were reviewed by the IID, CVWD, Reclamation, and California Natural Resources Agency in a series of meetings in mid- to late-2022. A final set of updates, which includes the No Action Alternative and Proposed Action, were made in 2023 and are presented in this document.

Model inputs include the initial state of the lake, freshwater inflows, and annual evaporation. To model the alternatives, different system conservation approaches proposed by the IID were used to project lake inflows. The primary outputs of the model are exposed lake bed, elevation, and salinity with data reported on an annual timestep.

3.4 Resource Issues Not Analyzed in Detail

As described in **Section 1.5.2** and **Table 1-1**, some resource issues are not considered potentially significant, given current conditions and the actions considered in the alternatives; therefore, they are not analyzed in this SEIS. **Table 1-1** summarizes the rationale for eliminating resource issues from detailed analysis. Resource issues considered but not analyzed in detail in this SEIS include:

- Geology and soils
- Minerals
- Noise
- Transportation and traffic

3.5 Cumulative Impacts

CEQ regulations (40 CFR 1500 through 1508) implementing the procedural provisions of NEPA define cumulative impacts as:

> "…the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time (40 CFR 1508.7)."

Cumulative impacts refer to two or more individual impacts that, when considered together, are significant or that compound or increase other environmental impacts. Cumulative impacts can be categorized as additive and interactive. An additive impact results from additions from one kind of source through either time or space. An interactive impact results from more than one kind of source.

This section addresses the cumulative impacts of the proposed alternatives combined with other regional water supply or closely related projects in the region. Closely related projects that could result in significant cumulative impacts are briefly described below. In addition, Reclamation considered other projects, such as the Lake Powell Pipeline Project and specific future state conservation projects, but did not bring them forward for cumulative impacts analysis. This is because the projects are currently too speculative to be considered reasonably foreseeable, do not closely relate to Basin operations and regional water supply, or would not result in significant cumulative impacts. Additional projects will be considered for analysis of cumulative impacts as part of the post-2026 EIS, as appropriate.

3.5.1 LTEMP SEIS

Reclamation's Upper Colorado Basin Region is preparing an SEIS to the LTEMP ROD and FEIS that will analyze flow options from Glen Canyon Dam to prevent smallmouth bass from establishing below the dam by preventing additional spawning. The LTEMP SEIS will also consider modifying the LTEMP High Flow Experiment (HFE) Protocol to incorporate the latest scientific information available. The decline of water levels in Lake Powell to historically low levels has contributed to record high-water temperature releases through the Glen Canyon Dam. Below the dam, these warm water releases are creating ideal spawning conditions for smallmouth bass, a predatory invasive fish species, and other warmwater nonnatives. If smallmouth bass populations continue to spawn and expand downstream into the Grand Canyon, they will likely become a threat to the federally protected humpback chub and other native fish. The purpose of Reclamation's Preliminary Proposed Action for the LTEMP SEIS is to prevent or delay the establishment of smallmouth bass below the Glen Canyon Dam using dam operations to reduce water release temperatures to minimize the efficacy of additional spawning.

Over the past several decades, scientific information on the use and timing of HFEs has improved understanding of how best to manage tributary-derived sediment supplies below the dam, particularly in low-elevation/low-flow scenarios. Current sediment accounting periods under LTEMP include a spring period from December 1 through June 30 and a fall period from July 1 through November 30. Implementation of HFEs during each accounting period can occur in March–April and October–November. The purpose of Reclamation's Preliminary Proposed Action for the LTEMP SEIS is to consider adjusting sediment accounting periods and implementation windows associated with the HFE Protocol.

3.5.2 Salton Sea

The Salton Sea's continuing decline in elevation and resulting exposure of the lake bed negatively impacts the surrounding communities and reduces the remaining habitat for fish and wildlife. The California Natural Resources Agency, the California Department of Water Resources, and the California Department of Fish and Wildlife are focused on implementing Phase I: 10-Year Plan (10-Year Plan) of the Salton Sea Management Program (SSMP) to improve conditions around the Sea. The 10-Year Plan was released in 2017 and then updated in 2018 to guide the State's projects at the Salton Sea over the next decade (2018–2028). The 10-Year Plan identifies a sequence of habitat and dust control projects around the perimeter of the Salton Sea (California Natural Resources Agency 2018 and 2021).

The US Army Corps of Engineers is preparing an Environmental Assessment for the implementation of the 10-Year Plan projects. Of the total project area (29,800 acres), at least 50 percent will be used to create habitat for fish and wildlife that depend on the Salton Sea ecosystem, and the remainder will support projects to suppress dust (US Army Corps of Engineers 2022).

3.6 Hydrologic Resources

3.6.1 Affected Environment

The 2007 FEIS described how hydrologic resources within the study area, which begins with Lake Powell and extends downstream along the Colorado River to the SIB with Mexico, would be potentially affected by the implementation of the alternatives. The proposed alternatives evaluated in this SEIS could affect the same hydrologic resources, including:

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

To analyze potential effects on these resources, the 2007 FEIS presented an overview of the hydrology of the Basin and hydrologic resources by river reach (see **Map 3-1**). The overall characteristics and connectivity of the Basin and reaches remain unchanged from information presented in the 2007 FEIS. However, three factors have affected hydrologic resources in the Basin since publication of the 2007 FEIS:

1) Interim Guidelines were established in December 2007 from the FEIS Preferred Alternative, including several operational refinements, according to the ROD for the Colorado River Interim Guidelines for Lower Basin shortages and coordinated operations for Lake Powell and Lake Mead. These 2007 Interim Guidelines were implemented to "address shortage determinations and coordinated reservoir operations" under drought and low reservoir conditions (Reclamation 2007). As listed in the ROD, the 2007 Interim Guidelines remain in effect for supply and reservoir operating decisions through 2026.
2) In May 2019, the DCPs were signed to address ongoing historic drought in the Basin. In May 2019, components of the Lower Basin DCP were implemented with full implementation occurring during the 2020 operating year. Starting in July 2021, the 2021 Upper Basin DROA, which is part of the Upper Basin DCP, was implemented. Implementation of the 2022 Upper Basin DROA began in May 2022. Management of releases and reservoir water levels continues to be conducted in accordance with these the Lower Basin DCP and the DROA element of the Upper Basin DCP.
3) As described in **Chapter 1**, a key driver for this SEIS is the worsening drought and low-runoff conditions in the Basin, which have continued to alter reservoir storage, releases, and flows.

BUREAU OF RECLAMATION

Map 3-1
Delineated Colorado River Reaches for the SEIS Analysis

Colorado River reach:

1 Gypsum Canyon to Glen Canyon Dam
2 Glen Canyon Dam to Separation Canyon
3 Separation Canyon to Hoover Dam
4 Hoover Dam to Davis Dam
5 Davis Dam to Parker Dam
6 Parker Dam to Cibola Gage
7 Cibola Gage to Imperial Dam
8 Imperial Dam to Northerly International Boundary (NIB)
9 NIB to Southerly International Boundary (SIB)

Dam or the end of a reach
Colorado River above and below the geographic scope of analysis
Colorado River tributary
Colorado River Basin, Upper and Lower Basins
States in the Colorado River Basin

While portions of northwestern Mexico are part of the Basin, these areas are not within the geographic scope of analysis for this SEIS. This SEIS does not address water deliveries to Mexico.

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The 2007 FEIS used historical hydrologic conditions within the Basin from 1906 through 2005 to inform how changes in operations could impact hydrologic conditions for the interim period between 2007 and 2026. This SEIS incorporates updated hydrologic information to better describe evolving characteristics of hydrologic resources within the affected environment. The updated information for these resources, organized by river reach, also captures the implementation of the 2007 Interim Guidelines, 2019 DCPs, Minute 323, and drought conditions within the Basin. The updated hydrologic conditions and operations within the Basin were used to inform modeling assumptions within the SEIS.

Hydrologic Overview

The 2007 FEIS presented the hydrology of the Basin, including the various hydrologic resources and river reaches in the Basin. This section provides updated descriptions of hydrologic resources within the Basin through 2022 to capture the worsening drought conditions. It also provides an update to releases and reservoir levels as a result of implementing the 2007 Interim Guidelines and Upper Basin DCP and Lower Basin DCP. The Colorado River Basin Climate and Hydrology: State of the Science (State of the Science) report (Lukas and Payton 2020) provided a comprehensive assessment of Basin hydroclimate conditions and trends through 2019. Key findings from the report are summarized below, updated through 2023, where appropriate.

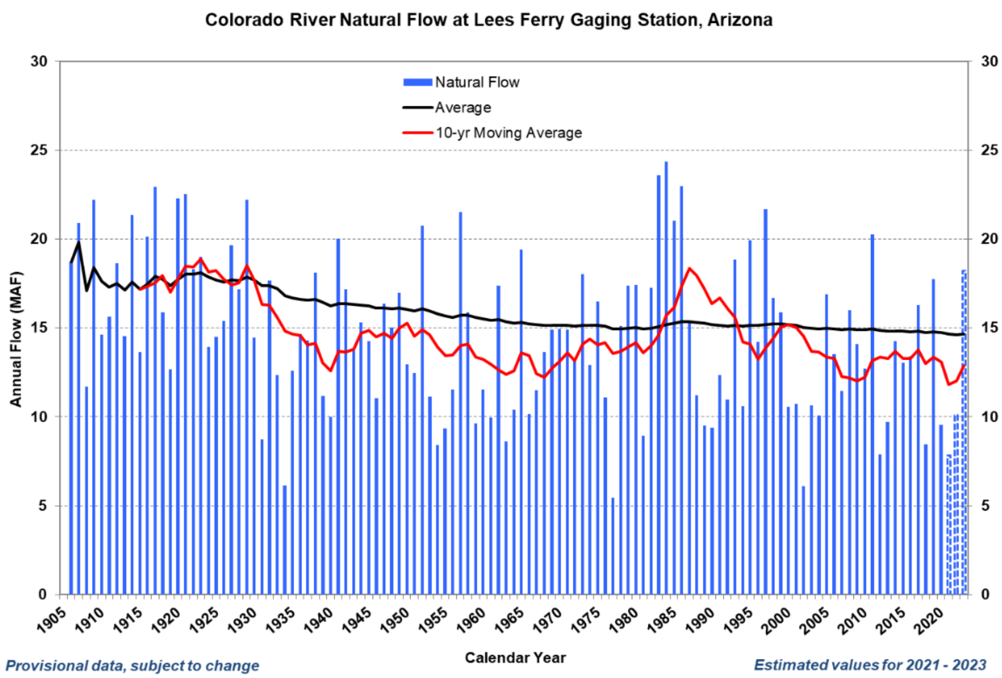
From 2000 to 2023, the Basin has experienced persistent drought conditions, exacerbated by a warming climate, leading to a 20 percent decrease in average annual Upper Basin (at Lees Ferry) natural flows (Reclamation 2022a). This period, from 2000 to 2023, is the driest 23-year period in more than a century. These conditions amount to a cumulative streamflow deficit, or difference between depletions and streamflow, of about 70 maf relative to 20th-century conditions (Reclamation 2022a). Approximately 92 percent of the natural Basin streamflow originates from the Upper Basin; snowmelt is the primary source of runoff. 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.

In addition, annual water use in the Basin has exceeded the annual inflows in most years since 2000. This resulted in a depletion of storage to 26 percent of the total combined capacity of Lake Powell and Lake Mead by the end of 2022 (Reclamation 2023b). Since issuance of the 2007 FEIS, the hydroclimate changes in the Basin include further increases in temperature, continued below-normal precipitation, declining snowpack water volume and annual streamflow, and earlier snowmelt runoff. Since 2000, the average temperature across the Basin has been 2˚F warmer than the 20th-century average. The warmest 10-year period on record occurred from 2012 to 2021 (National Oceanic and Atmospheric Administration 2023).

To describe precipitation in the Basin, the State of the Science report focused on multi-decadal trends due to the Basin's high interannual variability and the effects of short-term trends associated with the El Niño-Southern Oscillation. For both the Upper Basin and Lower Basin, a declining (but statistically nonsignificant) precipitation trend was noted over the period from 1980 to 2019. During this 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. Higher elevations in the Upper Basin are more resilient to reduced snowpack than the 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.

During the historical period analyzed in the FEIS (1906–2007), the average annual natural flow at the Lees Ferry Gaging Station was 14.916 maf. Annual natural flows during this timeframe ranged from 5.378 maf to 24.356 maf. According to the 2007 FEIS, natural flows at Lees Ferry are calculated based on observed (gage) flow and were corrected for upstream reservoir changes in storage and release, losses including evaporation, and depletions from agricultural and domestic uses. Since the implementation of the 2007 Interim Guidelines (2008 to 2022), the annual natural flow at the Lees Ferry Gaging Station have ranged from 6.733 maf (2021) to 20.303 maf (2011) and averaged 12.674 maf. **Figure 3-1** shows the natural flows (blue) calculated at the Lees Ferry Gaging Station for 1906 through 2023, as well as a running average (black), and 10-year moving average (red).

Figure 3-1
Colorado River Natural Flow at Lees Ferry Gaging Station, Arizona

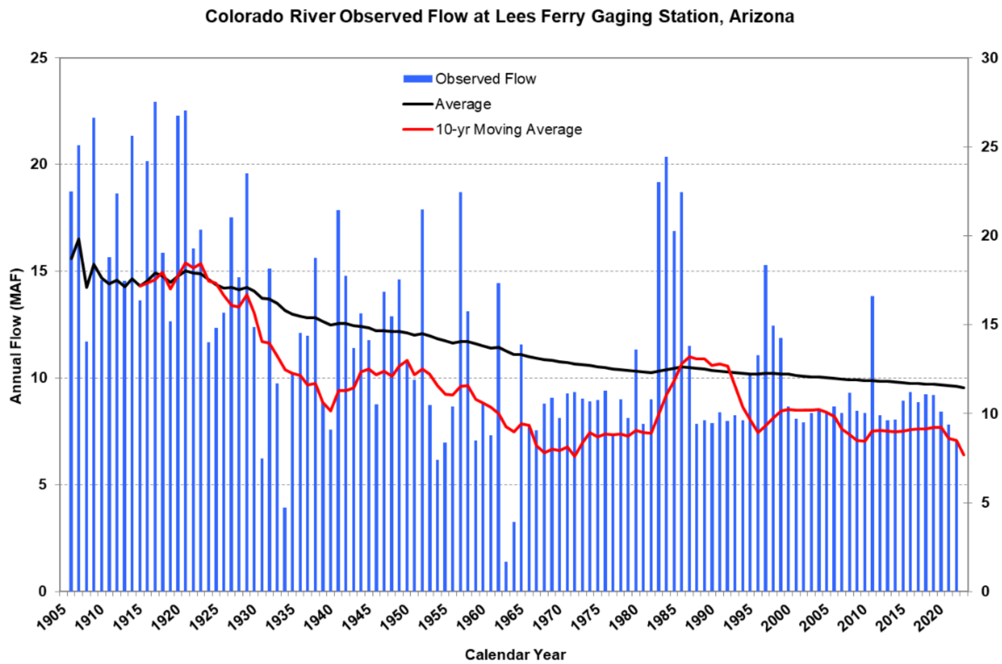


Source: Reclamation 2023c

Beginning in 2008, annual observed flows (as distinct from natural flow with no accounting for the above-mentioned factors) at the Lees Ferry Gaging Station have decreased. The annual observed flow at Lees Ferry during the historical period since the Glen Canyon Dam was built (1963–2007) ranged from 1.383 maf (when the dam was built in 1963) to 20.374 maf (1984), with an average of 9.691 maf noted in the 2007 FEIS. Since the implementation of the 2007 Interim Guidelines (2008 to mid-2023), the annual observed flows at the Lees Ferry Gaging Station have ranged from 7.041 maf to 13.846 maf and averaged 8.877 maf. This average annual observed flow is approximately

0.814 maf less than the average observed flow presented in the 2007 FEIS. The maximum annual observed flow of 13.846 maf occurred in 2011 and was approximately 6.528 maf less than the maximum flow that occurred during the 1963–2007 dataset (in 1984). **Figure 3-2** shows the observed flows recorded at the Lees Ferry Gaging Station for 1906 through mid-2022.

Figure 3-2
Colorado River Observed Flow at Lees Ferry Gaging Station, Arizona



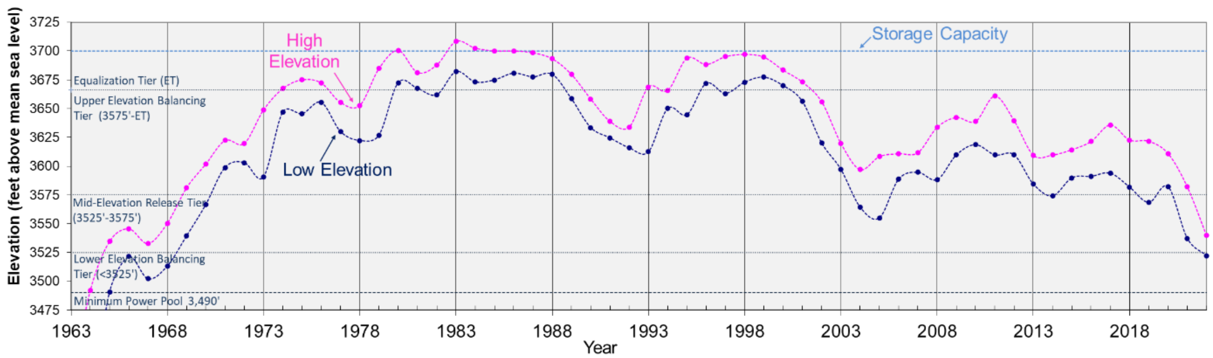
Source: Reclamation 2023c

Lake Powell and Glen Canyon Dam

As presented in the 2007 FEIS, the operating range of Lake Powell is between a water surface elevation of 3,490 feet (corresponding to the minimum power pool) and 3,700 feet (corresponding to the top of the Glen Canyon Dam spillway). Since implementation of the 2007 Interim Guidelines (2008 to 2022), water surface elevations at Lake Powell have been variable, but a steep decline began in 2018. Water surface elevation data were analyzed for 2008 through 2022 from Reclamation's Upper Basin Hydrologic dataset. The operating range during this period was between 3,522.2 feet (2022) and 3,660.9 feet (2011). The average operating elevation was 3,602.3 feet, which is well below the average elevation from 1980-1999.

Since 2017, the annual average water surface elevation at Lake Powell has declined approximately 87 feet. Lake Powell's annual high-water and low-water elevations for 1963 through 2022 are shown in **Figure 3-3**. Note that these data include changes to elevations associated with operation of Lake Powell in accordance with the 2007 Interim Guidelines, the Upper Basin DCP (activated starting in 2020), and the ROD for the Glen Canyon Dam LTEMP.[5] Minimum flows through the Glen Canyon Dam that were analyzed in the LTEMP were 5,000 cfs at night and 8,000 cfs during the day. Possible effects of the Proposed Action on future elevations at Lake Powell are discussed in **Section 3.6.2**, below.

Figure 3-3
Lake Powell Annual High and Low Elevations (1963–2022)



Source: Reclamation 2023c

The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Powell. Given connections to the groundwater system, it is likely that lower average reservoir elevations result in reduced local groundwater elevations.

Glen Canyon Dam to Lake Mead

As described in the 2007 FEIS, flows in the 265-mile river reach between Glen Canyon Dam and full pool Lake Mead are primarily controlled by Glen Canyon Dam releases from Lake Powell. Additional contributions to this reach of the Colorado River are received from tributaries, including the Paria River and Little Colorado River. Since implementation of the 2007 Interim Guidelines (2008 to 2022), annual inflow from the Little Colorado River ranged from 204,300 af to 392,900 af, averaging 274,600 af. During the same period, the annual inflow from the Paria River ranged from 8,100 af to 27,600 af, averaging 17,600 af. In comparison, during this period, the flows in the Colorado River just below the confluence of the Little Colorado River (USGS gage 09402500) ranged from 7.556 maf to 14.239 maf, averaging 9.311 maf (USGS 2023c). From 2008 to 2022, the inflows from the Paria and Little Colorado Rivers represented approximately 3.1 percent of the average streamflow within this reach of the Colorado River. This is similar to the total contribution of streamflow from the Paria and Little Colorado Rivers to this reach presented in the 2007 FEIS, which was less than 3 percent.

[5] ROD for the Glen Canyon Dam LTEMP FEIS, December 2016. Internet website: https://ltempeis.anl.gov/documents/docs/LTEMP_ROD.pdf.

The 2007 Interim Guidelines have governed annual releases from Glen Canyon Dam since they were implemented in 2008. Under the 2007 Interim Guidelines, the minimum and maximum releases from Glen Canyon Dam are determined by the assigned operating tier for Lake Powell (Equalization Tier, Upper Elevation Balancing Tier, Mid-Elevation Release Tier, or Lower Elevation Balancing Tier). Since 2008 and through 2022, the Upper Elevation Balancing Tier has been the most common operation tier, allowing releases between 7.0 maf and 9.0 maf (see **Table 3-4**). Glen Canyon Dam releases for this period have ranged from 7.04 maf to 13.85 maf and averaged 8.81 maf. The average annual releases presented in the 2007 FEIS from 1996 to 2007 were 9.98 maf. This 1.16-maf decrease in average annual releases can be attributed to hydrologic conditions in the Basin and the implementation of the 2007 Interim Guidelines. Changes to releases from Glen Canyon Dam as a result of the Proposed Action are further discussed in **Section 3.6.2**, Environmental Consequences below.

Table 3-4
Summary of Lake Powell and Lake Mead Coordinated Operations 2008–2022

Year	Lake Powell Operations					Lake Mead Operations
	Operating Tier	April Adjustment	Operating Year Unregulated Inflow (Percent Average)[7]	Release Volume (maf)	Equalization Volume (maf)	Operating Condition
2008	Upper Elevation Balancing	Equalization	126	8.98	0.75	Normal/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

Year	Lake Powell Operations					Lake Mead Operations
	Operating Tier	April Adjustment	Operating Year Unregulated Inflow (Percent Average)[7]	Release Volume (maf)	Equalization Volume (maf)	Operating Condition
2020[4]	Upper Elevation Balancing	None	61	8.23	—	Normal/ICS Surplus and DCP Contributions
2021[5]	Upper Elevation Balancing	None	36	8.23	—	Normal/ICS Surplus and DCP Contributions
2022	Mid-Elevation Release Tier	Adjusted in May 2022[6]	63	7.00[6]	—	Level 1 Shortage and DCP Contributions
2023[9]	Lower Elevation Balancing Tier	Balancing[8]	140	8.56	—	Level 2 Shortage and DCP Contributions

Source: Adapted from Reclamation 2020a

[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 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 provided by AOP (Reclamation 2020b)

[5] Supplemental data for 2021 provided by AOP (Reclamation 2021a)

[6] Lake Powell's release was reduced by 480,000 af during Water Year 2022 in May 2022: 2022 Glen Canyon Dam Operations Decision Letter (usbr.gov). Supplemental data for 2022 provided by AOP (Reclamation 2022b).

[7] The unregulated inflow statistics (percentage average) are based on a mean of the 30-year period 1991–2020 for all years.

[8] Supplemental data for 2023, provided by August 2023 Most Probable 24-Month Study (Reclamation 2023d)

[9] 2023 release volume and operating year unregulated inflow based on the August 2023 24-Month Study

As stated in the 2007 FEIS, this reach includes the Grand Canyon, which limits the hydraulic connection to groundwater. The Stream Flow and Losses of the Colorado River in the Southern Colorado Plateau White Paper 5 (White Paper 5) (Wang, J. and Schmidt, J. 2020) states that approximately 150,000 af per year are lost as seepage around the Glen Canyon Dam. The incised nature of this river corridor has remained relatively unchanged since publication of the 2007 FEIS. Based on the 2007 FEIS analyses, the 2007 Interim Guidelines were not anticipated to have affected groundwater levels in this reach; therefore, it is assumed that groundwater levels have remained consistent since 2007 for this reach.

The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Mead. Given connections to the groundwater system, it is likely that lower average reservoir elevations result in reduced local groundwater elevations.

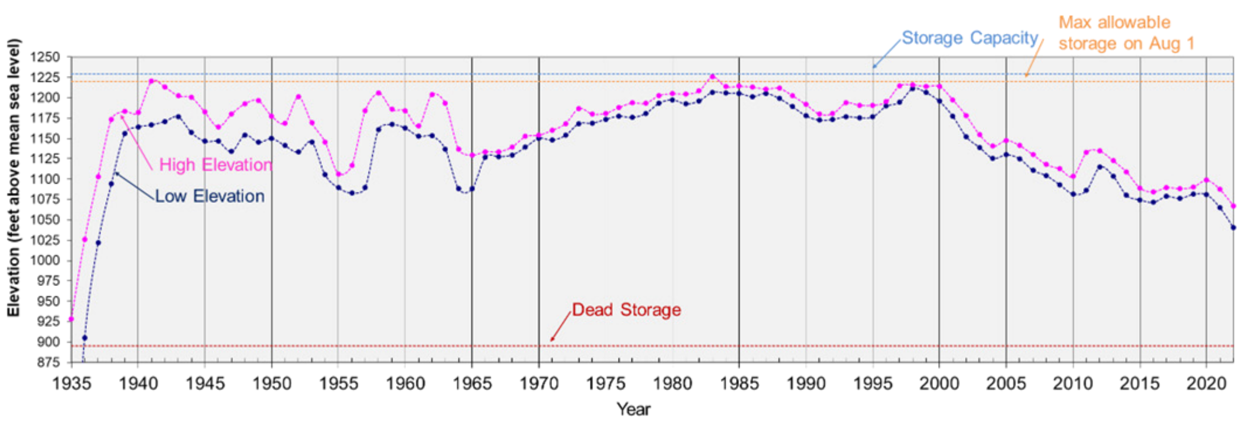
Lake Mead and Hoover Dam

The operating range of Lake Mead is between a water surface elevation of 895 feet and 1,219.6 feet. The top of the Hoover Dam spillway is at elevation 1,221 feet, which allows for 1.5 maf of flood control storage above the maximum operating elevation (1,219.6 feet). Improvements to the Hoover Dam since the 2007 FEIS include the installation of five new wide-head turbines in 2018 to improve hydropower operations at lower water levels. The new turbines lowered the minimum power pool elevation from 1,050 feet to 950 feet. At elevations between 895 and 950 feet, releases occur through the intake towers.

After the construction of the Hoover Dam in 1935, it took Lake Mead approximately 4 years to fill up to an average annual water surface elevation of 1,172 feet. The water surface elevation of Lake Mead was highly variable, fluctuating from 1,098 feet to 1,195 feet, from 1939 until the Glen Canyon Dam and Lake Powell came online in 1963. With the operation of the upstream Glen Canyon Dam, the elevations in Lake Mead began to increase steadily to an average annual peak of 1,215 feet in 1983. Elevations declined slightly through the late 1980s and early 1990s until peaking again in 1998 at an average annual elevation of 1,214 feet. After 1998, elevations began to decline sharply to a new low of 1,118 feet in 2007 when the 2007 Interim Guidelines were implemented. According to the 2007 FEIS, the average annual water surface elevation of Lake Mead during the historical period from 1939 (when Lake Mead filled) through 2007 was 1,170 feet.

Since implementation of the 2007 Interim Guidelines (2008 to 2022), water surface elevations at Lake Mead have generally declined. Water surface elevation data were analyzed for the years 2008 through 2022 from Reclamation's hydrologic database. The annual operating range during this period was between 1,040.6 feet (2022) and 1,134.5 feet (2011). The average annual operating elevation was 1,090.2 feet, which is approximately 71 feet below the average annual water surface elevation from 1939 to 2007. Since 2011, the annual average water surface elevation at Lake Mead has declined approximately 94 feet. **Figure 3-4** shows the annual high-water elevation and annual low-water elevation of Lake Mead for 1935 through 2022.

Figure 3-4
Lake Mead Annual High and Low Elevations (1935–2022)



Source: Reclamation 2023e

As with the data presented above for Lake Powell, the information presented on Lake Mead includes changes to elevations associated with operation of Lake Mead in accordance with the 2007 Interim Guidelines, Minute 323, and the 2019 Lower Basin DCP. Possible effects of the Proposed Action on future elevations at Lake Mead are discussed in **Section 3.6.2**, below.

As discussed in the 2007 FEIS, Hoover Dam releases are managed on an hourly basis to maximize the value of generated power by providing peaks during high-demand periods. A discussion regarding electrical power generation is included in **Section 3.15**.

Since the publication of the 2007 FEIS, Lake Mead operated in a normal/ICS condition each year from 2008 through 2021, in a Level 1 shortage condition in 2022, and in a Level 2a shortage condition in 2023 (see **Table 3-4**). Contributions under the Lower Basin DCP were required from 2020 through 2022. From 2008 through 2022, the elevation of Lake Mead on January 1 has ranged from 1,066.4 feet to 1,114.8 feet.

As reported in the 2007 FEIS, annual Hoover Dam releases from Lake Mead ranged from 8.275 to 12.781 maf and averaged 10.199 maf from 1996 through 2007. With the 2007 Interim Guidelines in place since publication of the 2007 FEIS, annual Hoover Dam releases since 2008 (through 2022) have ranged from 8.515 to 9.615 maf and averaged 9.185 maf. This is a decrease of 1.014 maf in average annual releases. Decreases in releases are due to the ICS activity and surplus guideline operations since the publication of the 2007 Interim Guidelines and the 2000 Interim Surplus Guidelines.

Hoover Dam to Davis Dam

As described in the 2007 FEIS, flows within the 67-mile reach from Hoover Dam (Lake Mead) to Davis Dam (Lake Mohave) are almost entirely comprised of releases from Hoover Dam, with less than 1 percent contributed from tributary inflows.

Implementation of the 2007 Interim Guidelines has reduced the average annual releases from Hoover Dam by approximately 1.014 maf (annually averaging 9.185 maf). The 2007 FEIS modeling results for the alternatives for 2008 through 2026 modeled a 46.7 percent probability of occurrence for Hoover Dam annual releases between 8.01 maf and 9 maf, 40.5 percent for releases between 9.01 maf and 10 maf, and 12.6 percent for releases greater than 10 maf. In comparison, the actual annual Hoover Dam releases since 2008 (through 2022) that were between 8.01 maf and 9 maf occurred approximately 27 percent of the time; releases between 9.01 maf and 10 maf occurred the remaining 73 percent of the time. No releases greater than 10 maf have occurred since the 2007 Interim Guidelines were implemented. The actual observed flows from 2008 to 2022 were different than the modeled flows for the 2007 FEIS federal alternative.

Similar to the alternatives evaluated in the 2007 FEIS, the proposed alternative being evaluated in this SEIS will not change how Hoover Dam is operated on an hourly and daily basis as long as sufficient water is available.

Implementation of the 2007 Interim Guidelines did not affect the target water surface elevation range of Lake Mohave at Davis Dam. Reclamation has continued to operate Lake Mohave under the same rule curve that determines end-of-month target elevations that were used prior to implementation of the 2007 Interim Guidelines. The water surface elevation continued to range from approximately 630 feet up to 645.7 feet, with lower elevations in the fall to provide flood control capacity and higher elevations in the spring. From 1996 to 2007, the average annual water surface elevation was 640.8 feet. Since 2008 (through 2022), the average annual water surface elevation remained at the same level of approximately 640.9 feet. The average storage in Lake Mohave has remained at approximately 1.6 maf for the last several decades.

As stated in the 2007 FEIS, the upper portion of this reach is within a bedrock canyon that has limited connection to groundwater. Based on the analyses performed in the 2007 FEIS, the 2007 Interim Guidelines were not anticipated to have affected groundwater levels in this reach. Therefore, Reclamation assumed that groundwater levels have remained consistent in this reach since 2007. The lower portion of the reach is dominated by Lake Mohave. The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Mohave; however, fluctuations of reservoir levels may impact adjacent groundwater levels.

Davis Dam to Parker Dam

As described in the 2007 FEIS, flows within the 84-mile reach from Davis Dam (Lake Mohave) to Parker Dam (Lake Havasu) are primarily comprised of releases from Davis Dam, with inflows from the Bill Williams River entering directly into Lake Havasu. The releases from Davis Dam are made to regulate downstream water demands. These releases are scheduled on an hourly basis and coordinated to meet daily release targets and to help meet power demands.

Implementation of the 2007 Interim Guidelines did not explicitly target the release operations of Davis Dam. However, the annual release rates have decreased since implementing the guidelines and further decreases in flow rates would occur with increasing shortage levels. The current Davis Dam minimum daily release is 1,600 cfs and the minimum hourly release is 1,300 cfs (with monitoring). The minimum release for a 30-day month is currently 95,000 af. As reported in the 2007 FEIS, annual Davis Dam releases from Lake Mohave ranged from 8.0 to 12.6 maf and averaged 9.9 maf from 1996 through 2007. Annual Davis Dam releases since 2008 (through 2022) have ranged from 8.2 to 9.3 maf and averaged 8.8 maf, a decrease of 1.1 maf in average annual releases.

Inflows from the Bill Williams River depend on the releases from Alamo Dam by the USACE; the 2007 Interim Guidelines did not affect these operations. As stated in the 2007 FEIS, the annual inflow from the Bill Williams River ranged from 1,300 to 702,000 af and averaged 102,000 af from 1906 through 2007. Annual Alamo Dam releases since 2008 (through 2022) have ranged from 15.4 af to 501,900 af and averaged 105,000 af. Contributions to Lake Havasu from the Bill Williams River have remained unchanged since implementation of the 2007 Interim Guidelines.

Reclamation has continued to operate Parker Dam at Lake Havasu under the same rule curve that determines end-of-month target elevations as prior to the 2007 Interim Guidelines. The water surface elevation continued to range from approximately 445 feet to 450 feet, with lower elevations in the fall to provide flood control capacity and higher elevations in the spring. From 1996 to 2007, the average annual water surface elevation was 447.5 feet. Since 2008 (through 2022), the average annual water surface elevation has remained at the same level of approximately 447.7 feet. Average storage in Lake Havasu has remained approximately 0.57 maf for the last several decades.

As stated in the 2007 FEIS, the upper portion of this reach is in the Mohave Valley groundwater basin, which is mostly alluvial fill. The 2007 FEIS used a combination of hydrologic and hydraulic models to relate the decreased flow rates to decreased river stage depths, which were used as an indicator for groundwater effects. The 2007 FEIS determined that the 2007 Interim Guidelines would result in decreased groundwater elevations of approximately 0.25 feet to 0.50 feet. Therefore, it is assumed that groundwater levels in this reach have decreased by approximately that much since 2007.

The lower portion of this reach is the Chemehuevi Valley groundwater basin, which is dominated by Lake Havasu. Based on the 2007 FEIS analyses, the 2007 Interim Guidelines were not anticipated to have affected groundwater levels in this reach. Therefore, Reclamation assumes that groundwater levels have remained consistent since 2007.

Parker Dam to Cibola Gage

As described in the 2007 FEIS, flows within the 105-mile reach from Parker Dam (Lake Havasu) to the Cibola Gage primarily consist of releases from Parker Dam. As the last major storage facility on the Colorado River, the releases from Parker Dam are made to regulate downstream water demands.

Implementation of the 2007 Interim Guidelines did not explicitly target the release operations of Parker Dam. These releases are scheduled on an hourly basis and coordinated to meet daily release targets and to help meet power demands. However, the annual release rates have decreased since implementation of the 2007 Interim Guidelines. The current Parker Dam minimum daily release is 1,600 cfs and the minimum hourly release is 1,400 cfs. The minimum release for a 30-day month is currently 95,000 af. As reported in the 2007 FEIS, annual Parker Dam releases from Lake Havasu ranged from 6.19 maf to 10.3 maf and averaged 7.4 maf from 1996 through 2007. Annual Parker Dam releases since 2008 (through 2022) have ranged from 6.2 maf to 6.7 maf and averaged 6.4 maf, a decrease of 1.0 maf in average annual releases.

Operations of the Headgate Rock Dam and Palo Verde Diversion Dam have remained unchanged since publication of the 2007 FEIS. These diversion dams are operated by the BIA and the Palo Verde Irrigation District, respectively.

As stated in the 2007 FEIS, the reach from Parker Dam to the Imperial Dam is in one large groundwater basin (referred to as the Parker Valley, Cibola Valley, and Palo Verde Valley) that is mostly alluvial fill. The 2007 FEIS used a combination of hydrologic and hydraulic models to relate the decreased flow rates to decreased river stage depths, which were used as an indicator for groundwater effects. The 2007 FEIS determined the 2007 Interim Guidelines would result in decreased groundwater elevations of approximately 0.15 feet to 0.30 feet. Therefore, Reclamation assumes that groundwater levels in this reach have decreased by slightly more than 0.15 feet to 0.30 feet since 2007.

Cibola Gage to Imperial Dam

As described in the 2007 FEIS, flows within the 38-mile reach from the Cibola Gage to Imperial Dam are primarily comprised of releases from Parker Dam minus the diversions at Headgate Rock Dam and Palo Verde Dam. The flows in this reach are typically comprised of the United States' water deliveries for diversions downstream of Palo Verde, including diversions at Imperial Dam, and deliveries to Mexico, as required by the 1944 Water Treaty and Minute 323.

As described above, implementation of the 2007 Interim Guidelines did not change operations of Parker Dam. However, annual releases have decreased since the guidelines' implementation in 2008 due to decreased upstream releases from Lake Powell and Lake Mead and thus, decreased inflows into Lake Havasu. Average flow rates for the Colorado River at the Cibola Gage ranged from 1,488 cfs to 18,168 cfs and averaged 8,931 cfs from the beginning of 1996 through the end of 2007. Average flow rates at the Cibola Gage since January 2008 (through the end of 2022) have ranged from 2,224 cfs to 18,751 cfs and averaged 7,632 cfs, a decrease of average flow rates of 1,299 cfs.

Implementation of the 2007 Interim Guidelines did not affect diversions at Imperial Dam, which meet water deliveries to water districts in the US and Mexico.

As stated in the 2007 FEIS, this reach is in a narrow alluvial fill valley with no adjacent irrigated land. The 2007 FEIS determined the 2007 Interim Guidelines would result in decreased groundwater elevations through this reach. (Refer to the groundwater discussion in the Parker Dam to Cibola Gage reach subsection for details.)

Imperial Dam to NIB

As stated in the 2007 FEIS, flows in the 26-mile reach from Imperial Dam to the Northerly International Boundary (NIB) are primarily comprised of releases from Imperial Dam, return flows from diversions at Imperial Dam, and inflows from the Gila River. The 2007 Interim Guidelines did not alter the operation of these diversions.

As stated in the 2007 FEIS, this reach is in the Yuma Valley groundwater basin and the South Gila Valley groundwater basin, which is small and bounded by rock. However, most water delivery from Imperial Dam to the NIB is via the All-American Canal. Based on the 2007 FEIS analyses, the 2007 Interim Guidelines were not anticipated to have affected groundwater levels in this reach. Therefore, Reclamation assumes that groundwater levels have remained the same since 2007.

NIB to SIB

As stated in the 2007 FEIS, flows in the 23.7-mile reach from the NIB to the SIB are limited. The Morelos Diversion Dam is 1.1 miles downstream of the NIB. Mexico owns, operates, and maintains the Morelos Diversion Dam for Mexico's delivery of flows. Water is diverted from the Morelos Diversion Dam into the Reforma Canal. Flows below the Morelos Diversion Dam in the river reach that extends down to the SIB consist of water in excess of Mexico's scheduled delivery resulting from flood control operations at Hoover Dam and other nontypical hydrologic events, seepage from the Morelos Diversion Dam, irrigation return flows, and groundwater accumulation.

The alternatives evaluated in the 2007 FEIS anticipated that Mexico would continue to operate the Morelos Diversion Dam at the same elevation necessary to ensure the annual 1.5-maf delivery of water, per the 1944 Water Treaty under normal conditions (Mexico agreed to reductions and savings under low elevation reservoir conditions in Minute 323 to the 1944 Water Treaty). The 2007 Interim Guidelines do not affect Mexico's allotment.

The 2007 Interim Guidelines had the potential to impact flows attributed in excess of Mexico's scheduled delivery, since they affected the volume and frequency of flood control releases upstream of Mexico's diversion point. From 1974 through 2012, the average flows to Mexico in excess of scheduled deliveries measured approximately 114,081 af. The Warren H. Brock Reservoir was completed in 2012 with the intent to conserve and reduce excess flows at the NIB. According to the Warren H. Brock Reservoir Conservation Summary Report (Summary Report) (Reclamation 2020c), prior to the completion of the Warren H. Brock Reservoir, the 10-year annual average (2003 through 2012) of flows to Mexico in excess was 82,853 af. Since the completion (through 2019), excess flows to Mexico decreased by approximately two-thirds, saving approximately 56,000 af per year. According to the Summary Report, the future volume of excess flows conserved is variable year-to-year based on hydrologic conditions, rainfall events, and other operational considerations along the lower Colorado River.

As described in the 2007 FEIS, this reach is in the large and deep Colorado River Delta groundwater basin. In the upstream portion of the reach, groundwater provides surface flow to the river (gaining reach) due to the high groundwater elevation in the nearby irrigated lands. In the downstream portion of this reach, groundwater is recharged by the river (losing reach). Based on analyses performed in the 2007 FEIS, the 2007 Interim Guidelines were not anticipated to affect gaining or losing sections of this reach.

Salton Sea

As stated in **Section 3.3.6**, the Salton Sea receives runoff from its surrounding watershed (not the Colorado River Basin) and agricultural runoff that originates in the Colorado River Basin (deliveries). Therefore, discussion regarding the Salton Sea as it relates to hydrologic resources is not necessary and further analysis of the Salton Sea is not included within this section. Please reference **Section 3.7**, Water Deliveries.

3.6.2 Environmental Consequences

Methodology

This section examines the potential effects on hydrologic resources under the No Action Alternative and the Proposed Action. The CRMMS, as described in **Section 3.3**, was used to analyze hydrologic resources. Modeling details for the No Action Alternative and the Proposed Action are described in **Section 3.3.4** and **Appendix D**, CRMMS Model Documentation.

Assumptions

Please refer to **Section 3.3.4**, **Appendix D** and **Appendix E**, Shortage Allocation Model Documentation, for a discussion pertaining to modeling assumptions.

All statistics calculated are reflective of the hydrology scenarios and other assumptions used in modeling and are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate relative performance.

Impact Indicators

For all alternatives, impacts are evaluated using output from the CRMMS model and described based on hydrologic conditions within the Basin as follows:

- **Reservoir Elevations:** Changes to reservoir elevations are described based on a quantitative assessment of projected changes to reservoir water surface elevations for Lake Powell and Lake Mead monthly and on an end-of-water-year basis.
- **Reservoir Releases:** Changes to reservoir releases are described based on a quantitative assessment of projected changes to reservoir releases for Lake Powell and Lake Mead, including release volumes and timings.
- **River Flows:** Changes to river flows are described based on a quantitative assessment of changes in river flows for various reaches, including flow volumes and altered flow patterns. River flows follow the same pattern as reservoir releases.
- **Groundwater:** Changes to groundwater are described based on a qualitative assessment of potential changes to groundwater elevations, including relative changes in river stage and groundwater storage.

Issue 1: How would changes to operational activities affect reservoir elevations?

This section presents a comparison of the No Action Alternative and the Proposed Action in three metrics: monthly pool elevations, annual pool elevations, and percentages of traces below critical elevations at Lake Powell and Lake Mead.

Lake Powell

Summary of Alternatives Comparison

The conclusions in this section are drawn from analyses of three metrics: monthly pool elevations, percentages of traces below critical elevations, and annual pool elevations. Detailed comparisons of the alternatives follow in subsequent sections.

With respect to monthly Lake Powell pool elevations, remaining above 3,490 feet in elevation is critical for preserving infrastructure and ensuring Glen Canyon Dam continues to operate under its intended design for purposes of downstream water releases. Both the No Action Alternative and the Proposed Action result in increased monthly median reservoir elevation at Lake Powell over the period of analysis, with the median Proposed Action elevations being 1 to 6 feet higher than the median No Action Alternative elevations. Under the No Action Alternative, the median monthly elevation starts at 3,567 feet in January 2024 and ends at 3,589 feet in December 2026. The range of modeled elevations under the No Action Alternative is wide, with the lowest trace reaching an elevation of 3,451 feet in December 2026 and the highest trace reaching an elevation of 3,679 feet in June 2026. Only 2 and 7 percent of traces fall below the critical elevation of 3,490 feet (minimum power pool) in 2025 and 2026, respectively, for the No Action Alternative. Under the Proposed Action, the median Lake Powell monthly pool elevation ranges from a minimum of 3,568 feet in January 2024 to 3,592 feet in December 2026. The lowest trace reaches an elevation of 3,467 feet in March 2026 while the highest trace reaches a maximum of 3,686 feet in June 2026. The percentage of traces falling below 3,490 feet under the Proposed Action is 0 and 2 percent in 2025 and 2026, respectively. The median monthly pool elevation for the Proposed Action is the same or slightly higher than the No Action Alternative and increases throughout the period of analysis. The No Action Alternative has a higher likelihood of monthly pool elevations dropping below the critical elevation of 3,490 feet than the Proposed Action.

The median modeled end-of-water-year Lake Powell pool elevations are the same for the No Action Alternative and the Proposed Action in 2024 and 2025. In 2026, the median pool elevation is 5 feet higher for the Proposed Action than the No Action Alternative. The interquartile range (the difference between the 75th and 25th percentiles) for end-of-water-year elevations in the Proposed Action is a similar width to the No Action Alternative and is approximately 1 to 3 feet higher. Likewise, the 5th to 95th percentile range for end-of-water-year elevations in the Proposed Action is a similar width to than the No Action Alternative and is approximately 0 to 6 feet higher.

Throughout the period of analysis, the No Action Alternative results in lower median monthly elevations, more traces falling below critical elevations, and lower median end-of-water-year elevations than the Proposed Action. Both the No Action Alternative and the Proposed Action result in Lake Powell median pool elevations that increase over the period of analysis. However, the 10th percentile and lower range of modeled elevations decline over time for both actions.

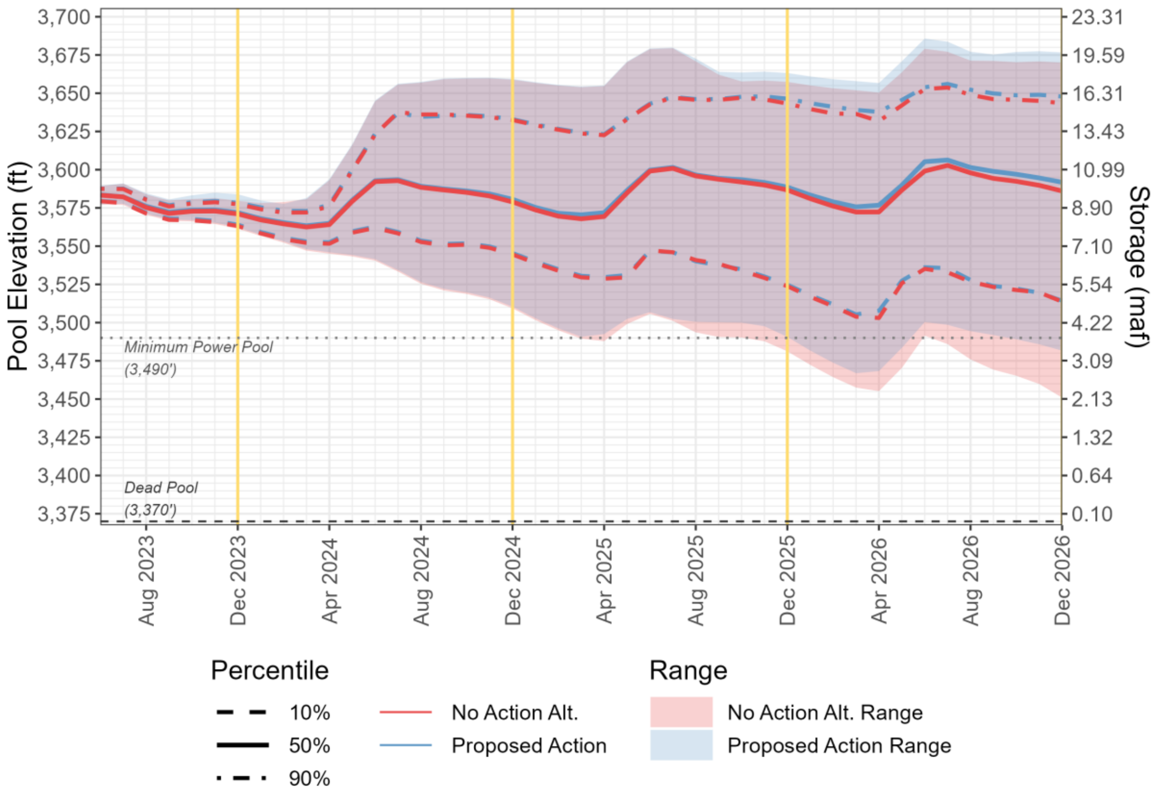
The operational modification included in the Proposed Action is designed to protect a Lake Powell elevation of 3,500 feet. If Lake Powell is in the Middle Elevation Release Tier or Lower Elevation Balancing Tier and the minimum probable scenario in a 24-Month Study shows Lake Powell elevations dropping below 3,500 feet, then the annual release volume can be reduced to 6.0 maf. This modification in the Proposed Action is effective at eliminating instances of falling below 3,490 feet in 2025, and minimizing instances to 2 percent of traces in 2026 (a 5 percent reduction compared to the No Action Alternative). During the period of analysis, all traces for both the No Action Alternative and the Proposed Action remain above the Lake Powell dead pool elevation of 3,370 feet. At dead pool, only flows that reach the reservoir, minus any diversions or losses, can be released downstream.

Monthly Pool Elevations

Figure 3-5 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Powell elevations for both alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows "clouds" representing the full ranges of modeled elevations for both alternatives through 2026.

The full range of modeled Lake Powell elevations from the No Action Alternative is shown by the red cloud in **Figure 3-5**, which spans from a low of 3,451 feet to a high of 3,679 feet in 2026, with fluctuations corresponding to seasonal reservoir levels. The bottom of the No Action Alternative cloud, which results from drier modeled traces, falls to 3,481 feet in 2025 and then to 3,451 feet in 2026. Beginning in 2026, the drier modeled traces result in pool elevations at Lake Powell that drop below the critical elevation of 3,490 feet but remain above the dead pool elevation of 3,370 feet. The top of the No Action Alternative cloud, which results from wetter modeled traces, rises to a high of 3,679 feet in 2025 and 2026. This increasing range in monthly pool elevations is consistent with increasing uncertainty over time.

Figure 3-5
Lake Powell End-of-Month Pool Elevations



The clouds for the No Action Alternative (red) and the Proposed Action (blue) are nearly completely overlapping until August 2025, when the range of the No Action Alternative cloud drops below the Proposed Action. From mid-2025 through the end of 2026, there is a clear distinction between the No Action Alternative and the Proposed Action, where the Proposed Action has both a higher minimum elevation and higher maximum elevation than the No Action Alternative. The higher minimum pool elevation in the Proposed Action results from reduced releases from Glen Canyon Dam to protect 3,500 feet. Monthly pool elevations in the Proposed Action drop below 3,500 feet since Glen Canyon Dam releases are constrained by minimum LTEMP and water releases. In 2025, the minimum modeled elevation for the Proposed Action is 3,491 feet, or 10 feet higher than the lowest elevation of the No Action Alternative elevation (3,481 feet). The minimum elevation of the Proposed Action in 2026 is 3,467 feet, or 16 feet higher than the No Action Alternative (3,451 feet).

In **Figure 3-5**, the median modeled elevations for the No Action Alternative range between a minimum of 3,561 feet and a maximum of 3,593 feet in 2024. The end-of-calendar year (December) median increases from 3,579 feet to 3,587 feet from 2024 to 2025. The median December elevation in 2026 is 3,586 feet. The December median elevations for the Proposed Action are approximately 2 feet higher than the No Action Alternative in 2024 and 2025, and increases to 6 feet higher at the end of 2026. The difference in the median is due to slightly lower balancing releases from Lake

Powell in the Upper and Lower Elevation Balancing Tier resulting from increased storage in Lake Mead (see *Issue 2*)[6].

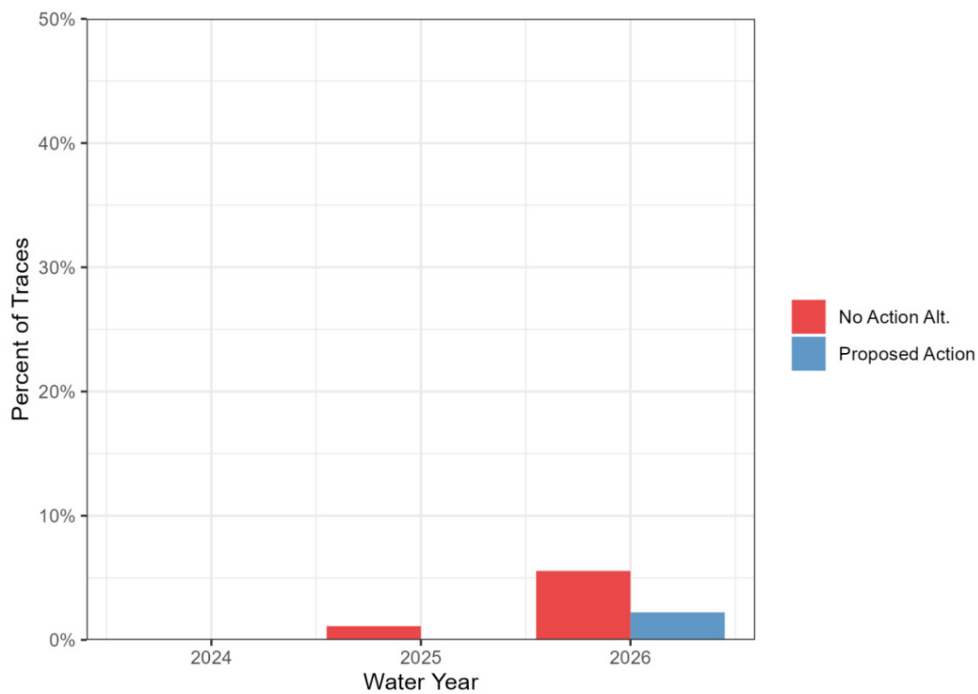
The 10th percentiles of the two alternatives are similar, differing by 0 to 5 feet, which is consistent with the overlap at the low ends of the clouds. The 90th percentiles of the two alternatives are similar, differing by 0 to 6 feet, which is consistent with the overlap at the high ends of the clouds.

Percentages of Traces Below Critical Elevations

Figure 3-6 shows the percentage of modeled traces that fall below Lake Powell's elevation of 3,490 feet (minimum power pool) at any time during an operating year for the period of analysis. Remaining above 3,490 feet is critical for protecting infrastructure and ensuring Glen Canyon Dam continues to operate under its intended design for purposes of downstream water releases.

Figure 3-6 shows that in 2024, no modeled traces fall below a Lake Powell elevation of 3,490 feet under either the No Action Alternative or the Proposed Action. In 2025, only 1.5 percent of the No Action Alternative traces fall below an elevation of 3,490 feet at some point during the water year while none of Proposed Action traces do. In 2026, the No Action Alternative results in 6 percent of traces falling below 3,490 feet, while 2 percent of the Proposed Action's traces do so.

Figure 3-6
Lake Powell Minimum Operating Year Elevation, Percent of Traces Less Than Elevation 3,490 feet



[6] Operating tiers are set on January 1, which is equivalent to midnight on December 31.

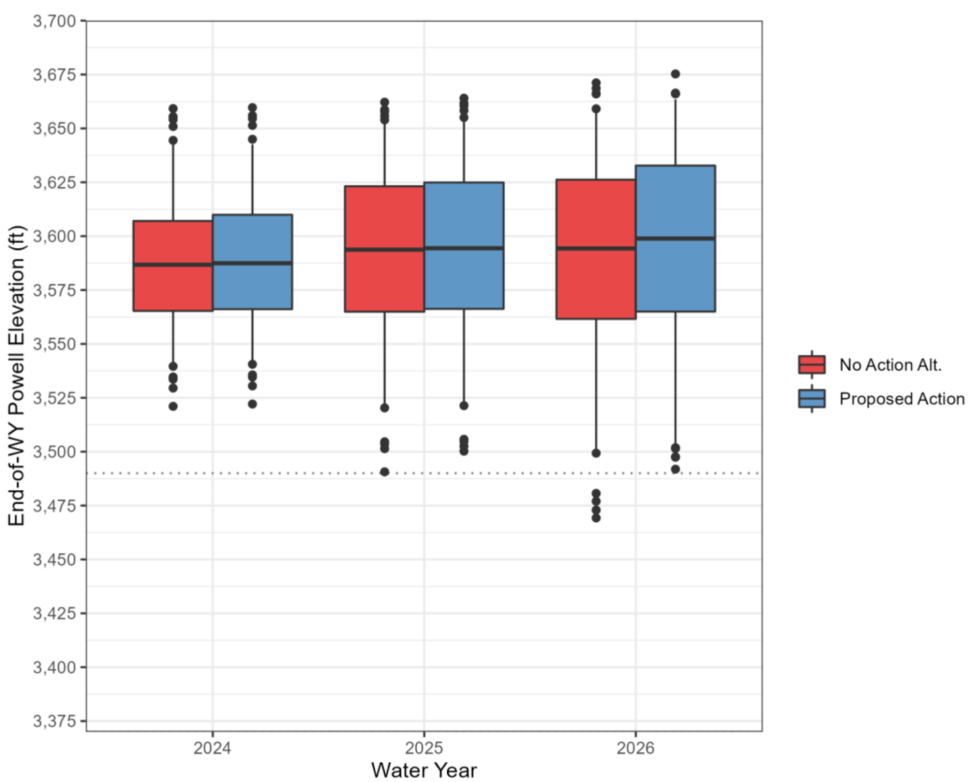
During the period of analysis, neither the No Action Alternative nor the Proposed Action result in pool elevations that approach dead pool (3,370 feet); 100 percent of traces remain above Lake Powell dead pool.

Annual Pool Elevations

Figure 3-7 shows the distributions of modeled Lake Powell elevations at the end of the operating year, on September 30 in 2024, 2025, and 2026. The bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

The No Action Alternative and Proposed Action boxplots in **Figure 3-7** show how the range of modeled end-of-water-year pool elevations at Lake Powell increases over the period of analysis. The median pool elevations of the No Action Alternative increase from 3,587 feet in 2024 to 3,594 feet in 2025, and 3,594 feet in 2026. The range of the interquartile elevations, as well as the whiskers and outliers, for the No Action Alternative becomes wider through time. The interquartile ranges for the No Action Alternative span approximately 42 feet in 2024, 58 feet in 2025, and 65 feet in 2026. The whisker ranges for the No Action alternative span approximately 103 feet in 2024, 132 feet in 2025, and 159 feet in 2026.

Figure 3-7
Powell End-of-Water-Year Pool Elevations



The Proposed Action has median end-of-water-year elevations that are slightly higher than the No Action Alternative by approximately 1 foot in 2024 (3,588 feet), 1 foot in 2025 (3,595 feet), and 5 feet in 2026 (3,599 feet). Like the No Action Alternative, the interquartile and full ranges for the Proposed Action become wider over the period of analysis. The interquartile ranges for the Proposed Action are slightly wider than the No Action Alternative and span a range of approximately 44 feet in 2024, 59 feet in 2025, and 68 feet in 2026. The whiskers for the No Action Alternative and the Proposed Action span approximately the same range; however, the whiskers for the Proposed Action are between 1 and 4 feet higher than the No Action Alternative whiskers. Likewise, the outliers for the Proposed Action are higher in elevation than the No Action Alternative outliers.

Lake Mead

Summary of Alternatives Comparison

The conclusions in this section are drawn from analyses of three metrics: monthly pool elevations, percentages of traces below critical elevations, and annual pool elevations. Detailed comparisons of the alternatives follow in subsequent sections.

With respect to all metrics, the No Action Alternative resulted in lower monthly pool elevations in Lake Mead than the Proposed Action. For 2024–2026, both alternatives have similar seasonal fluctuations and magnitudes of variability, but the distributions of elevations under the Proposed Action are shifted higher than the No Action. The median of the modeled Lake Mead elevations for the No Action Alternative exhibits a downward trend throughout the period of analysis, from 1,056 feet in 2024 to 1,052 feet in 2025, and to 1,049 feet in 2026. Conversely, the median in the Proposed Action results in higher monthly pool elevations than the No Action Alternative and exhibits an upward trend due to projected full implementation of SEIS conservation. The median monthly elevations for the Proposed Action are 1,063 feet in 2024, 1,066 feet in 2025, and 1,067 feet in 2026, which are 7 feet, 15 feet, and 18 feet higher, respectively, than the median monthly elevations for the No Action Alternative.

The percentage of traces in the No Action Alternative falling below the critical elevation in Lake Mead of 1,020 feet was 0 percent in 2024, 7 percent in 2025, and 18 percent in 2026. The percentage of traces in the Proposed Action falling below 1,020 feet was 0 percent in 2024 and 2025, and 4 percent in 2026. The percentage of traces in the No Action Alternative falling below the critical elevation in Lake Mead of 1,000 feet was 0 percent in 2024 and 2025, and 4 percent in 2026. The percentage of traces in the Proposed Action falling below 1,000 feet was 0 percent in 2024 and 2025, and 2 percent in 2026.

Both the No Action Alternative and the Proposed Action result in all traces remaining above the minimum power pool elevation of 950 feet during the period of analysis.

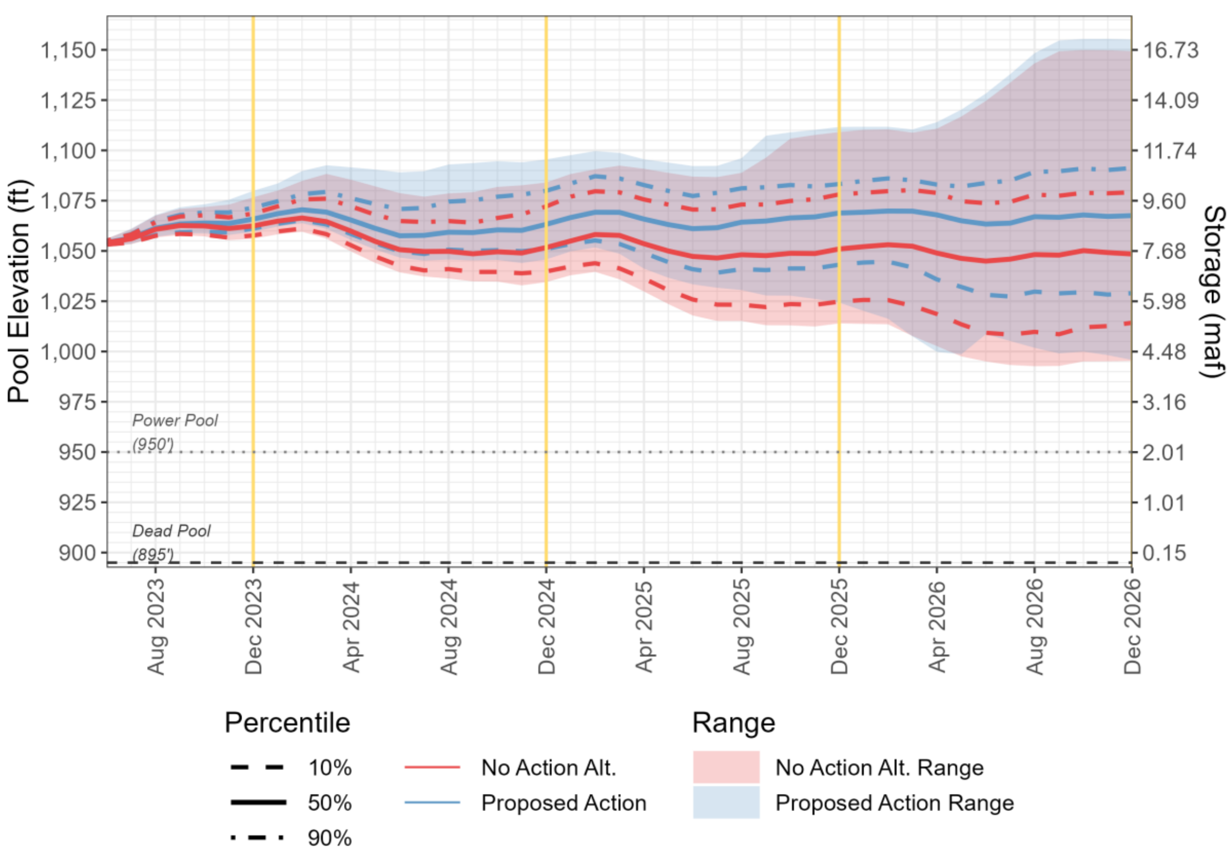
The modeled end-of-calendar-year Lake Mead median pool elevations for the Proposed Action are higher than the No Action Alternative by 11 feet in 2024, 18 feet in 2025, and 20 feet in 2026. The end of year median pool elevations in the Proposed Action trend upward throughout the period of analysis, while the median elevations in the No Action Alternative trend downward. The interquartile ranges for end-of-calendar-year elevations in the No Action Alternative are slightly wider than the Proposed Action, indicating results of the No Action Alternative are more uncertain over time. Likewise, the 5th and 95th percentile ranges for end-of-calendar-year elevations in the No Action Alternative are slightly wider than the Proposed Action.

Throughout the period of analysis, the No Action Alternative results in lower median monthly elevations; more traces falling below critical elevations; and lower median end-of-calendar-year elevations than the Proposed Action. The No Action Alternative results in Lake Mead median pool elevations that decrease over the period of analysis. Conversely, the Proposed Action results in Lake Mead median pool elevations that increase due to accumulation of SEIS conservation through 2026.

Monthly Pool Elevations

Figure 3-8 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Mead elevations for both alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows "clouds" representing the full ranges of modeled elevations for both alternatives through 2026.

Figure 3-8
Lake Mead End-of-Month Pool Elevations



The full range of modeled Lake Mead pool elevations resulting from the No Action Alternative is shown by the red cloud in **Figure 3-8**, which spans from 1,033 feet to 1,088 feet in 2024, with fluctuations corresponding to seasonal reservoir levels. The bottom of the No Action Alternative cloud, which results from drier modeled traces, falls to 1,012 feet in 2025 and then to 993 feet in 2026. Even when the bottom of the No Action Alternative cloud reaches an ultimate low of 993 feet in 2026, the pool elevation at Lake Mead remains 43 feet above the minimum power pool elevation of 950 feet and 98 feet above the dead pool elevation of 895 feet. At dead pool, only flows that reach the reservoir, minus any diversions or losses, could be released downstream through the Hoover Dam and water could not be released through the dam via gravity below this elevation. The top of the No Action Alternative cloud, which results from wetter modeled traces, rises to a high of 1,109 feet in 2025 and then to a high of 1,150 feet in 2026. This increasing range in monthly pool elevations is consistent with increasing uncertainty over time.

The clouds for the No Action Alternative (red) and the Proposed Action (blue) have similar fluctuations corresponding to seasonal reservoir levels. Throughout the period of analysis, the range of hydrologic traces (from the driest to the wettest traces) in the No Action Alternative result in lower monthly Lake Mead elevations than the Proposed Action. The cloud of the Proposed Action is consistently higher than the No Action Alternative due to SEIS conservation under the Proposed Action, except for April 2026. To protect 3,500 feet, April 2026 Glen Canyon Dam releases are reduced in the Proposed Action resulting in a lower minimum monthly pool elevation compared to the No Action Alternative. In May 2026, runoff into Lake Powell increases resulting in a higher release from Glen Canyon Dam while maintaining the Lake Powell elevation of 3,500 feet. These operational adjustments result in the different behavior in the minimum pool elevation of the Proposed Action. In 2024, the minimum modeled elevation for the Proposed Action is 1,044 feet, or 11 feet higher than the lowest elevation of the No Action Alternative (1,033 feet) in 2024. The minimum elevation of the Proposed Action in 2025 is 1,024 feet, or 12 feet higher than the No Action Alternative. The minimum elevation of the Proposed Action in 2026 is 996 feet, or 3 feet higher than the No Action Alternative.

In **Figure 3-8**, the median of the modeled Lake Mead elevations for the No Action Alternative ranges between 1,049 feet and 1,066 feet in 2024 and exhibits a downward trend throughout the period of analysis. The median elevation for the No Action Alternative drops to a low of 1,046 feet in 2025 and 1,045 feet in 2026. Due to SEIS conservation, the median monthly pool elevations for the Proposed Action are higher than the No Action Alternative and exhibit an upward trend throughout the period of analysis. The median pool elevations for the Proposed Action are approximately 7 feet higher in 2024, 15 feet higher in 2025, and 18 feet higher in 2026 than the No Action Alternative.

The 10th percentile of modeled Lake Mead elevations in **Figure 3-8** for the Proposed Action are consistently higher than the 10th percentile of the No Action Alternative throughout the period of analysis. The 10th percentiles of the Proposed Action are between 4 feet and 20 feet higher than the No Action Alternative, with the difference between the two alternatives growing larger until August 2026, when the 10th percentiles of the No Action Alternative begin to recover. The 10th percentile of elevations trends downward for both alternatives. The 90th percentiles of the two alternatives are similar, with the Proposed Action remaining 3 feet to 12 feet higher than the No Action Alternative. The 90th percentile of elevations trends upward for both alternatives.

Percentages of Traces Below Critical Elevations

Figure 3-9 shows the percent of modeled traces that fell below the Lake Mead elevation of 1,020 feet at any time during a year for the period of analysis. The elevation of 1,020 feet was identified as a critical protection elevation in the 2019 DCPs.

Figure 3-9 shows that in 2024, no modeled traces fall below a Lake Mead elevation of 1,020 feet under either the No Action Alternative or the Proposed Action. In 2025, 7 percent of the No Action Alternative traces fall below an elevation of 1,020 feet at some point during the operating year while none of the Proposed Action traces do. In 2026, the No Action Alternative results in 18 percent of traces falling below 1,020 feet, while 4 percent of the Proposed Action's traces do so.

Figure 3-9
Lake Mead Minimum Annual Elevation,
Percent of Traces Less Than Elevation 1,020 feet

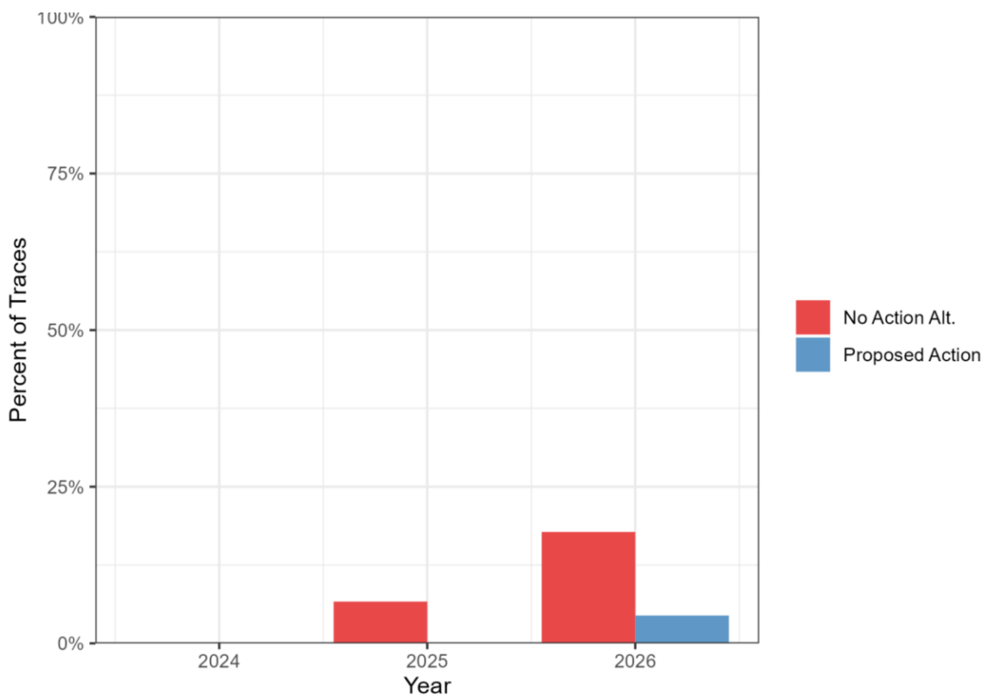
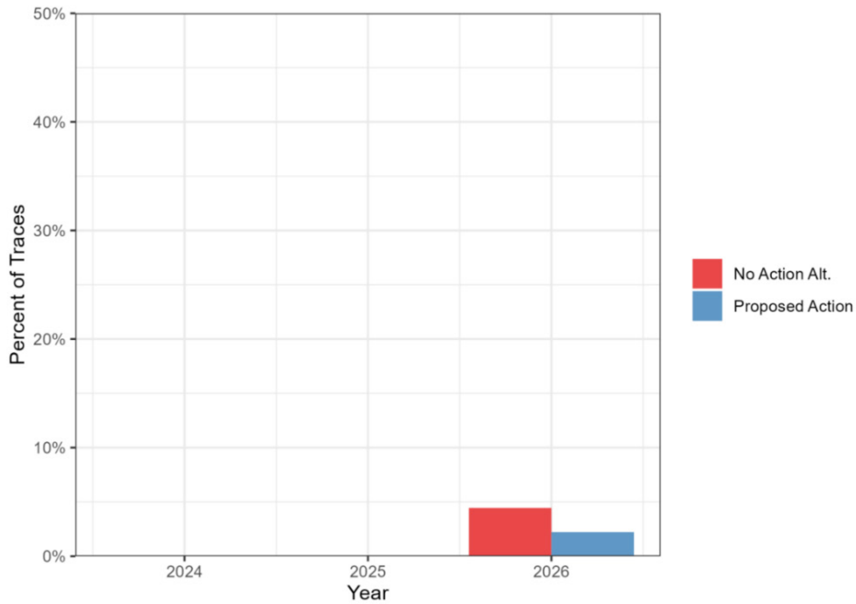


Figure 3-10 shows the percentage of modeled traces that fell below a Lake Mead elevation of 1,000 feet at any time during a year for the period of analysis. Neither the No Action Alternative or the Proposed Action result in any traces falling below 1,000 feet at Lake Mead at any time during 2024 or 2025. In 2026, the No Action Alternative results in 4 percent of traces falling below 1,000 feet, while 2 percent of the Proposed Action's traces do so.

At Lake Mead, an elevation of 950 feet is a critical elevation because it is the lowest elevation at which Hoover Dam can generate hydropower (minimum power pool). No modeled traces in either alternative fell below the Lake Mead elevation of 950 feet at any time during a year for the period of analysis. Therefore, no modeled traces approached an elevation of 895 feet, which is dead pool at Lake Mead.

Figure 3-10
Lake Mead Minimum Annual Elevation,
Percent of Traces Less Than Elevation 1,000 feet



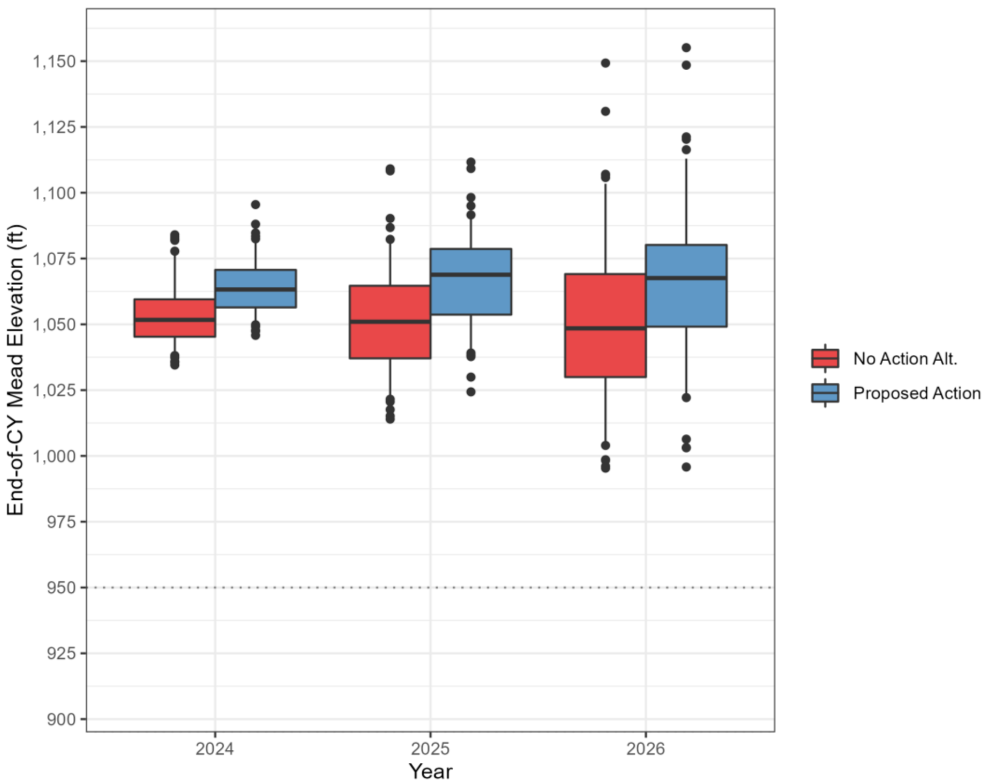
Annual Pool Elevations

Figure 3-11 shows the distributions of modeled Lake Mead elevations at the end of the calendar year, on December 31 in 2024, 2025, and 2026. This end-of-calendar-year elevation is used to determine shortage conditions for the following operational year. The bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles (interquartile range) of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

The No Action Alternative and Proposed Action boxplots in **Figure 3-11** show how the range of modeled end-of-calendar-year pool elevations at Lake Mead is projected to change over the period of analysis. The median pool elevations of the No Action Alternative decrease from 1,052 feet in 2024 to 1,051 feet in 2025, and to 1,048 feet in 2026. The range of the interquartile elevations, as well as the whiskers and outliers, become wider through time. The interquartile for the No Action Alternative spans a range of approximately 14 feet in 2024, 28 feet in 2025, and 39 feet in 2026. The whisker ranges for the No Action Alternative span approximately 38 feet in 2024, 51 feet in 2025, and 90 feet in 2026.

The Proposed Action has median end-of-calendar-year pool elevations that are higher than the No Action Alternative by approximately 11 feet in 2024 (1,063 feet), 18 feet in 2025 (1,069 feet) and 20 feet in 2026 (1,068 feet). Unlike the No Action Alternative, the Proposed Action results in median pool elevations that increase over the period of analysis. Like the No Action Alternative, the interquartile and full ranges for the Proposed Action become wider over the period of analysis. The interquartile ranges for the Proposed Action are the same or slightly smaller than the No Action

Figure 3-11
Mead End-of-Calendar-Year Elevation



Alternative and span approximately 14 feet in 2024, 25 feet in 2025, and 31 feet in 2026. The whisker ranges for the Proposed Action are smaller than the No Action Alternative ranges by approximately 6 feet in 2024 and 9 feet in 2025 and 2026.

While the elevations for Lake Mead are generally higher overall for the Proposed Action due to SEIS conservation, resulting in a stronger protection of critical elevations in Lake Mead, the lower extremes in the No Action Alternative and Proposed Action are essentially the same because of the modification in Glen Canyon Dam operations designed to protect Lake Powell at an elevation of 3,500 feet in the Proposed Action.

Lake Mohave and Lake Havasu

Summary

Lake Mohave and Lake Havasu are operated on a rule curve and have target end-of-month elevations. This manner of operation will continue in the future and would apply to operations under both alternatives. Therefore, future Lake Mohave and Lake Havasu elevations could be similar between the Proposed Action and No Action Alternative.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operating year and would result in no changes to annual reservoir levels in Lake Powell or Lake Mead. Therefore, minimal cumulative effects would occur on reservoir levels due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on hydrologic resources due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would changes to operational activities affect reservoir releases?

This section presents a comparison of reservoir release volumes under the No Action Alternative and the Proposed Action in various metrics, including reservoir operating tiers, annual release volumes, and monthly release volumes. All statistics calculated are reflective of the hydrology scenarios and other assumptions used in modeling and are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance.

Glen Canyon Dam

Summary of Alternatives Comparison

The conclusions in this section are drawn from analyses in four metrics: Lake Powell Operational Tiers, water year Glen Canyon Dam releases, monthly Glen Canyon Dam releases, and the 10-year running sum of Lees Ferry gaged flows. Detailed comparisons of the alternatives follow in subsequent sections.

Throughout the period of analysis, the No Action Alternative and the Proposed Action result in roughly the same number of traces in each of the Operational Tiers. For both alternatives, more traces shift into higher Operational Tiers in 2025 and 2026. In 2026, 10 percent of traces modeled under both the No Action Alternative and the Proposed Action operate in the Equalization Tier and 51 percent in the Upper Elevation Balancing Tier. This is the result of increasing elevations at Lake Powell.

The Mid-Elevation Release Tier and Lower Elevation Balancing Tier operations are the same for the No Action Alternative and the Proposed Action, with the exception that the Proposed Action allows for reduced releases to 6.0 maf from Glen Canyon Dam if elevations in Lake Powell are projected to drop below 3,500 feet. The percentage of traces in the Mid-Elevation Release Tier under the No Action Alternative is 94 percent in 2024, 39 percent in 2025, and 27 percent in 2026; under the Proposed Action, it is 92 percent in 2024, 40 percent in 2025, and 27 percent in 2026. The percentage of traces in the Lower Elevation Balancing Tier for both alternatives is 0 percent in 2024, 6 percent in 2025, and 12 percent in 2026.

Lake Powell operating year releases from the Glen Canyon Dam are similar for the two alternatives and increase in variability during the period of analysis. In 2024, nearly all modeled releases equaled 7.48 maf under both the No Action Alternative and Proposed Action. In 2025, the total and interquartile ranges increased under both the No Action Alternative and Proposed Action: half and just under half of the releases equal 9.0 maf or more, respectively. In 2026, the range of modeled releases further increases, although the distribution of traces with releases of 9.0 maf or more remains similar to 2025 under both the No Action Alternative and Proposed Action. The Proposed Action results in slightly lower operating year release volumes than the No Action Alternative.

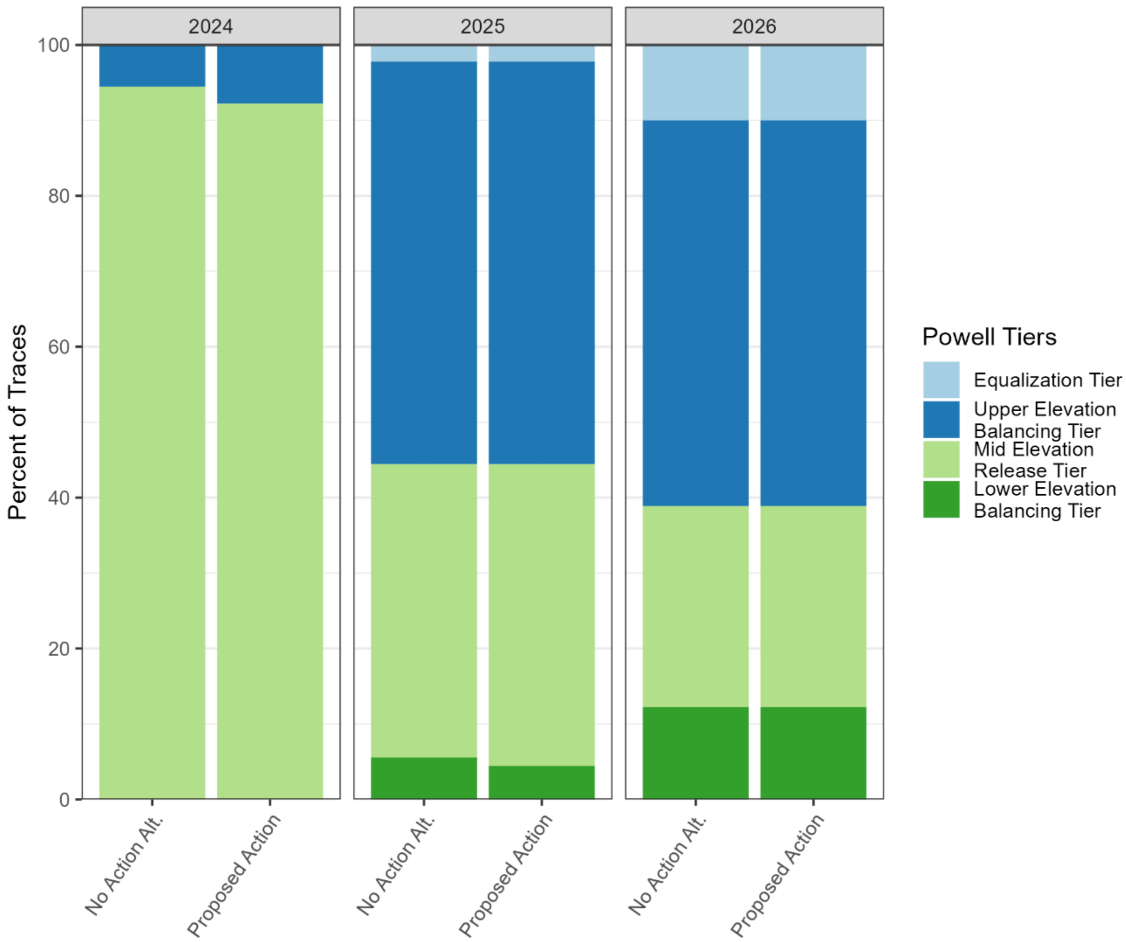
The modeled median monthly Glen Canyon Dam releases under the No Action Alternative are consistently higher than the Proposed Action, although the two alternatives span approximately the same interquartile ranges. Seasonal variations between both alternatives are similar, with a wider variability from April to September due to the potential for both larger or smaller releases due to balancing or equalization, consistent with the LTEMP monthly release pattern. There is the potential for relatively lower releases in the April to September period in the Proposed Action, which allows for a mid-year adjustment to lower releases beginning in April. Throughout the operating year, no traces fall below the estimated daily minimum flow threshold specified by the LTEMP in the Proposed Action and No Action Alternative.

Lake Powell Operating Tiers

Figure 3-12 shows the percentage of modeled traces that were within each Operational Tier for the period of analysis. Under both alternatives, the applicable Operational Tier would continue to be based on the August 24-Month Study projection of the January 1 system storage and reservoir water surface elevations for the following operating year. The Equalization and Upper Elevation Balancing Tiers are the same as under the 2007 Interim Guidelines for both alternatives. The Mid-Elevation Release Tier and Lower Elevation Balancing Tier are the same for the No Action Alternative and the Proposed Action, except that Reclamation may reduce releases in the Proposed Action to a minimum release of 6.0 maf to protect elevation 3,500 feet, subject to LTEMP minimum daily flow thresholds. Refer to **Section 2.6.2** and **Section 2.7.2** for additional details on Operational Tiers for the two alternatives.

Figure 3-12 shows that in 2024, under both the No Action Alternative and the Proposed Action, no modeled traces are in the Equalization Tier. In 2025, under both the No Action Alternative and the Proposed Action, the percentage of traces in the Equalization Tier increases to 2 percent and then to 10 percent in 2026. Under the No Action Alternative, 6 percent of modeled traces operated in the Upper Elevation Balancing Tier in 2024, in which annual releases range from 7.0 maf to 9.0 maf, and the number of traces in this tier increases to 53 percent in 2025 and then decreases slightly to 51 percent in 2026. Similarly, under the Proposed Action, the percentage of traces that operated in the Upper Elevation Balancing Tier was 8 percent in 2024, 53 percent in 2025, and 51 percent in 2026.

Figure 3-12
Lake Powell - Percent of Modeled Traces Within Each Operational Tier



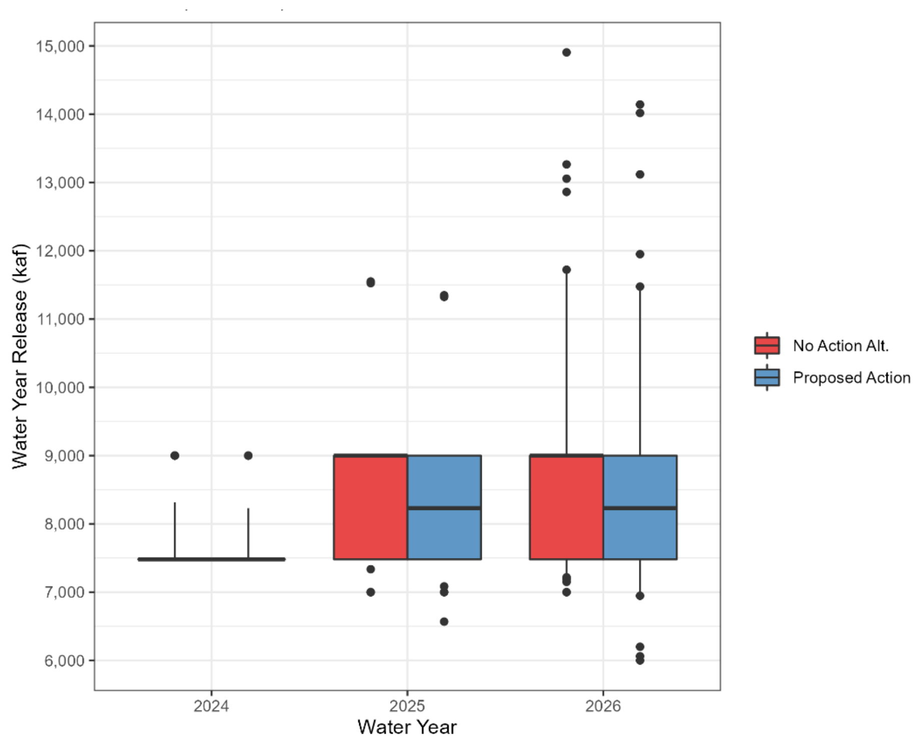
For the No Action Alternative, the percentage of traces in the Mid-Elevation Release Tier—in which the release is either 7.48 or 8.23 maf, depending on the elevation of Lake Mead—are approximately 94 percent in 2024, 39 percent in 2025, and 27 percent in 2026. For the No Action Alternative, the percentage of traces in the Lower Elevation Balancing Tier, in which releases range from 7.0 maf to 9.5 maf, increases from 0 percent in 2024 to 6 percent in 2025, and then to 12 percent by 2026. This shift toward higher tiers is a result of the wide range of hydrology traces, and is reflected in the elevations seen previously in **Figure 3-5**.

If Lake Powell is operating in the Mid-Elevation Release Tier or Lower Elevation Balancing Tier under the Proposed Action, releases are consistent with the No Action Alternative except a mid-year adjustment can reduce releases to a minimum of 6.0 maf to protect 3,500 feet. The percentage of traces that are in the Mid-Elevation Release Tier under the Proposed Action are similar to the No Action Alternative, with 94 percent of traces in 2024, 40 percent in 2025, and 27 percent in 2026. The percentage of traces under the Proposed Action that are in the Lower Elevation Balancing Tier are similar to the No Action Alternative, with 0 percent of traces in 2024, 4 percent in 2025, and 12 percent in 2026.

Annual Release Volumes

Figure 3-13 shows the distributions of modeled water year (October through September) release volumes from Glen Canyon Dam in 2024, 2025, and 2026. This volume is determined by the operating tiers, which were analyzed in the previous section. The bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles of the modeled releases, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure 3-13
Glen Canyon Dam Water Year Release



The boxplots for the No Action Alternative in **Figure 3-13** show that in 2024, the modeled releases from Glen Canyon Dam were either 7.48 maf or 9.0 maf. Approximately 94 percent of the 2024 No Action Alternative releases were 7.48 maf, corresponding with the Mid-Elevation Release Tier described above. The remaining 6 percent of releases were 9.0 maf, corresponding with the Upper Elevation Balancing Tier, and were the result of wetter hydrology traces. In 2025 and 2026, median modeled releases from Glen Canyon Dam under the No Action Alternative were 9.0 maf and represent 51 percent of traces in 2025 and 47 percent of traces in 2026. The minimum releases in 2025 and 2026 were 7.0 maf and represent 3 percent and 2 percent of traces, respectively.

In 2024, the modeled operating year releases for the Proposed Action, as shown in **Figure 3-13**, are similar to the No Action Alternative. Approximately 92 percent of Glen Canyon Dam releases in 2024 were 7.48 maf, 4 percent were 8.23 maf, and 3 percent were 9.0 maf. These releases correspond to the Mid-Elevation Release Tier or the Upper Elevation Balancing Tier. In 2025 and 2026, median modeled releases from Glen Canyon Dam under the Proposed Action were 8.23 maf but represent only 8 percent and 14 percent of modeled traces, respectively. The median release is lower in the Proposed Action compared to the No Action Alternative because Lake Mead has higher pool elevations which results in lower balancing and equalization releases from Glen Canyon Dam. In 2025 under the Proposed Action, approximately 44 percent of releases are less than or equal to 7.48 maf, and 41 percent of releases were greater than or equal to 9.0 maf. In 2026 under the Proposed Action, approximately 39 percent of releases are equal to or less than 7.48 maf and 38 percent were equal to or greater than 9.0 maf.

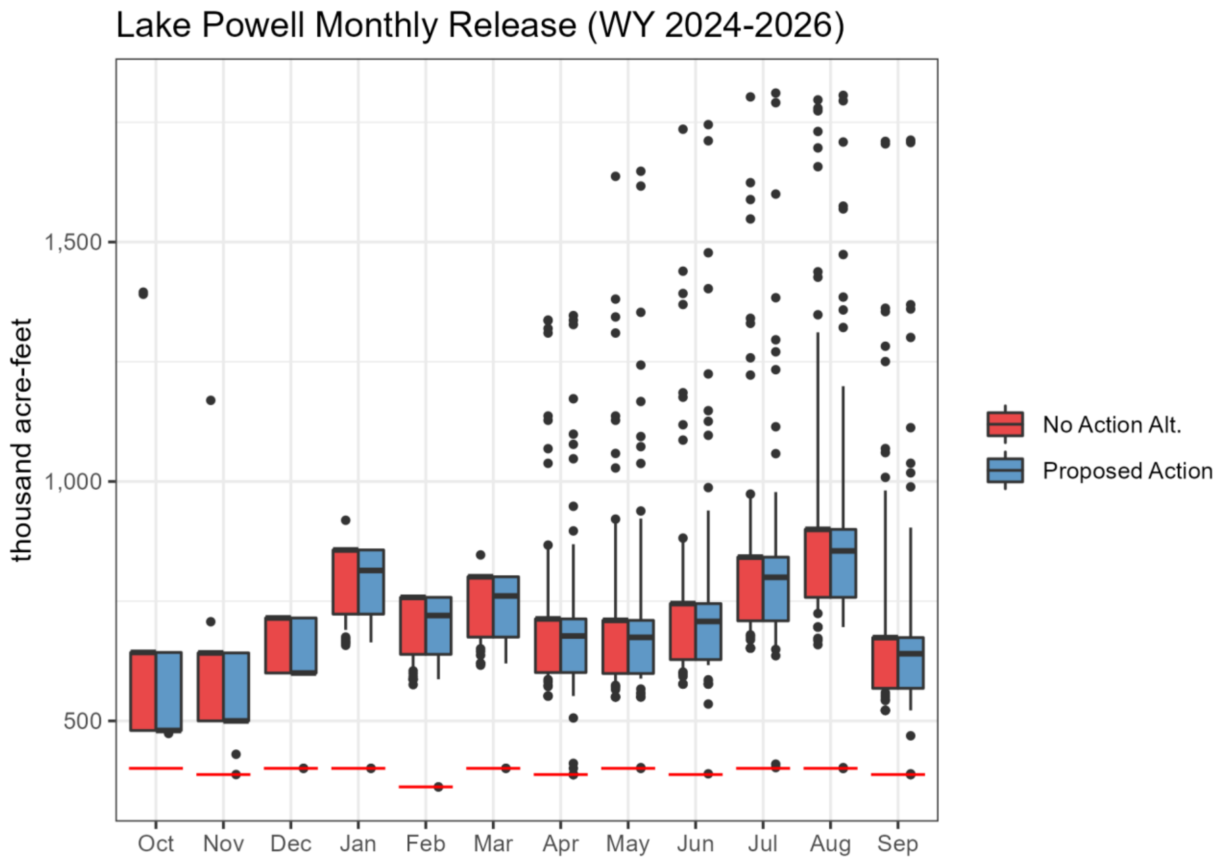
Monthly Release Volumes

Figure 3-14 shows the distributions of modeled monthly release volumes in operating years 2024, 2025, and 2026, oriented to the water year (October through September) on which Lake Powell operates. The bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles of the modeled releases and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines. The red lines reflect the estimated total monthly volume that would be released if Glen Canyon Dam met the minimum daily releases specified in the LTEMP (5,000 cfs between 7 p.m. and 7 a.m. and 8,000 cfs between 7 a.m. and 7 p.m., with ramping constraints resulting in an estimated average daily flow of 6,521 cfs). These volumes are estimates of how the annual volumes described in the previous section would be divided in consideration of authorities affecting sub-annual releases (hourly, daily, monthly, and experimental releases) from Glen Canyon Dam. See **Section 3.3.4** for more information about these modeling assumptions.

The boxplots of monthly modeled Glen Canyon Dam release volumes under the Proposed Action in **Figure 3-14** demonstrate the impacts of the annual minimum release of 6.0 maf to protect the Lake Powell elevation of 3,500 feet with a minimum release defined by LTEMP, as outlined in the Proposed Action for the Mid-Elevation Release Tier and Lower Elevation Balancing Tier. For both the No Action Alternative and the Proposed Action, the range of interquartile values are approximately the same. The difference between the 75th and 25th interquartile values for both alternatives range from a high of approximately 163 kaf in October (at the beginning of the operating year) down to approximately 111 to 126 kaf in December through June. The interquartile ranges for July and August are around 133 kaf and 142 kaf, respectively. The wide variability from April to September is mostly due to years that have an April switch to balancing or equalization. (when starting the year with an 8.23 maf release in the Upper Elevation Balancing Tier).

The monthly releases on the lower end of the distributions under the Proposed Action tend to be lower or substantially lower than those under the No Action Alternative in **Figure 3-14**. The 6.0 maf minimum operating year release in the Proposed Action causes the differences in minimum releases between the two alternatives. The minimum monthly release in the Proposed Action is the result of reduced monthly releases to protect 3,500 feet. Instances where the minimum monthly release is equal to the LTEMP minimum release (i.e., outliers on the red line) correspond to months when Lake Powell is at or below 3,500 feet and releases cannot be reduced further. No traces under the No Action Alternative or the Proposed Action are lower than the estimated daily minimum LTEMP flows. **Table 3-5** illustrates an example of the monthly release volumes for the 6.0-maf minimum operating year release under the Proposed Action. This table serves as an example for the potential monthly patterns in the event of minimum operating year releases.

Figure 3-14
Lake Powell Monthly Release, Water Years 2024–2026



Red lines reflect an estimated monthly volume based on the minimum daily release from LTEMP (5,000 cfs between 7 p.m. and 7 a.m. and 8,000 cfs between 7 a.m. and 7 p.m., with ramping constraints resulting in an estimated average daily flow of 6,521 cfs).

Table 3-5
Monthly Release Volumes under LTEMP with Example Release Pattern for 6.0 maf

	Monthly Release Volume (thousand acre-ft)				
Month	**6,000**	**7,000**	**7,480**	**8,230**	**9,000**
October	411	480	480	643	643
November	429	500	500	642	642
December	514	600	600	715	715
January	569	664	723	763	857
February	503	587	639	675	758
March	531	620	675	713	801
April	473	552	601	635	713
May	471	550	599	632	710
June	495	577	628	663	745
July	559	652	709	749	842
August	597	696	758	800	900
September	447	522	568	600	674

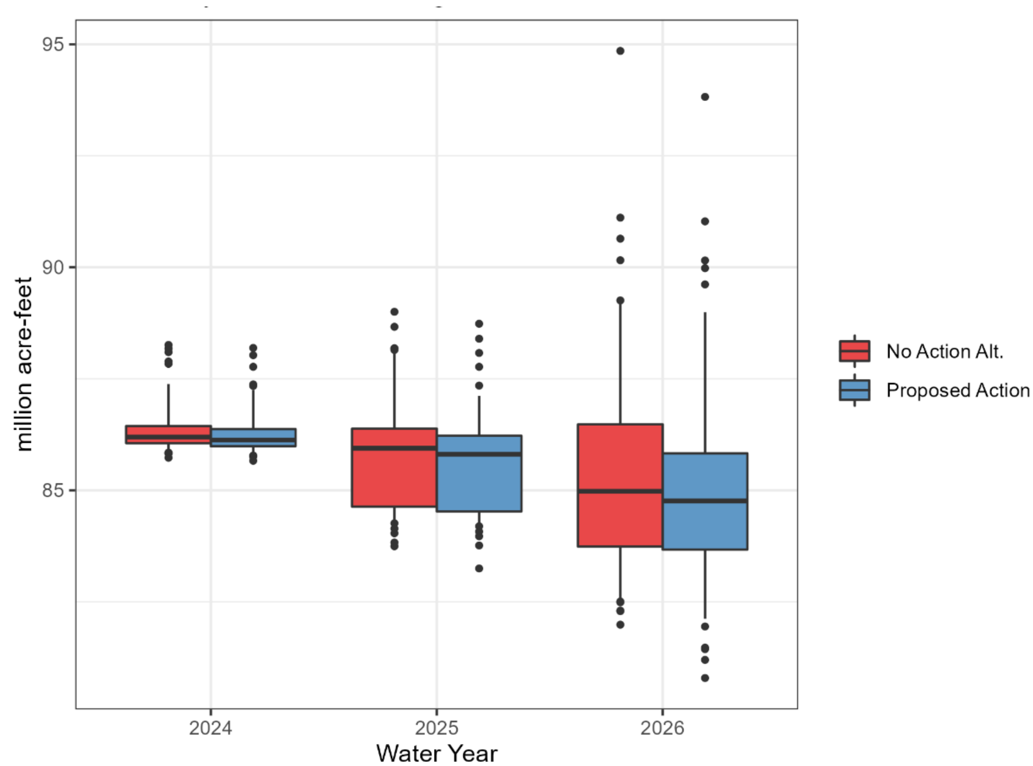
Figure 3-14 shows that the No Action Alternative median monthly release is consistently higher than the Proposed Action, consistent with results for operating year releases in **Figure 3-13**. The largest difference between the median monthly releases for the No Action Alternative and the Proposed Action occurs during the beginning of the operating year from October through December.

Ten-Year Lees Ferry Gage Flows

Figure 3-15 shows the distribution of modeled 10-year running sums of Lees Ferry gage flows in 2024, 2025, and 2026. The modeled 2024 flow is calculated using the observed flow from October 2014 through May 2023 and a modeled flow from June 2023 through September 2024. There is some variability in the 2023 volume, but it is common to both alternatives so it does not impact relative performance among alternatives. The modeled 2025 volume drops the 2015 observed operating year volume, and the modeled 2026 volume drops 2015 and 2016 to maintain the ten-year period.

In the figure below, the bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles of the modeled volumes, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure 3-15
Lees Ferry Gage 10-Year Running Total



The distributions of modeled 10-year running sums in **Figure 3-15** show that the median volumes decline over time for both alternatives, although the median flows of the Proposed Action are always lower than the medians of the No Acton Alternative. The interquartile and full ranges increase, with the ranges of the Proposed Action increasing more toward the lower end, compared with the No Action Alternative. In 2024, the median flow volumes under the No Action Alternative and Proposed Action are just over 87 maf. Median flow volumes decrease in 2025 to 86 maf under the No Action Alternative and just below 86 maf under the Proposed Action. In 2026, the median of the No Action Alternative is approximately 85 maf, while the median under the Proposed Action is just over 84 maf. Under the No Action Alternative in 2026, 5 percent of modeled 10-year Lees Ferry gage flows are below 82.3 maf, while slightly over 5 percent of modeled traces are below 82.3 maf under the Proposed Action. Neither alternative has any traces with the modeled 10-year running sum of flows at Lees Ferry below 75 maf.

Hoover Dam

Summary of Alternatives Comparison

The conclusions in this section are drawn from analyses of operating year releases from Lake Mead at the Hoover Dam. Detailed comparisons of both alternatives follow in subsequent sections.

Under the No Action Alternative, the median modeled annual release from Hoover Dam increases from 8.51 maf in 2024 to 8.65 maf in 2025, and to 8.77 maf in 2026. The ranges around these medians for each year are relatively consistent and increase over the period of analysis.

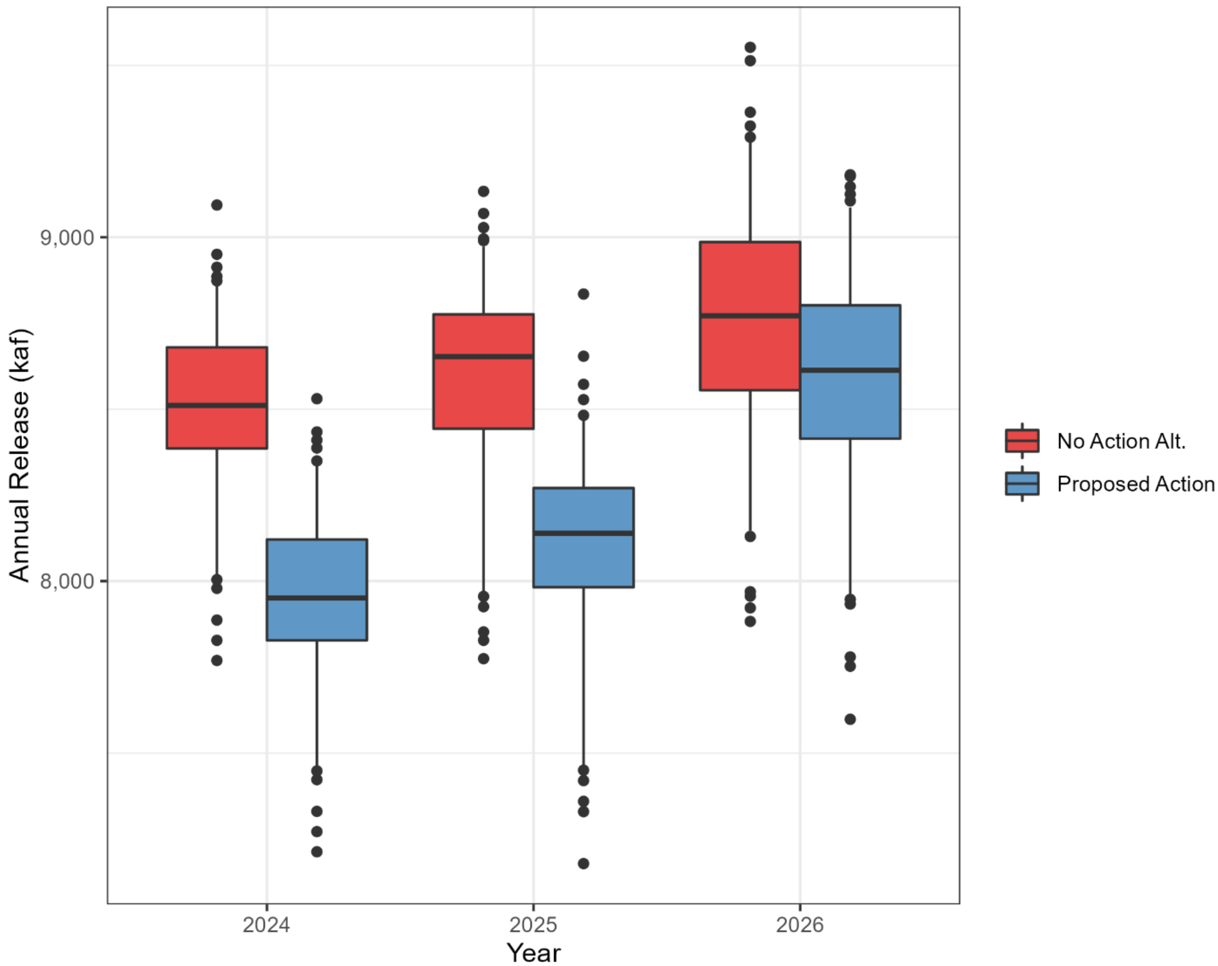
Under the Proposed Action, the median modeled annual releases from Hoover Dam increase from 7.94 maf in 2024 to 8.08 maf in 2025, and to 8.37 maf in 2026. These median annual releases are between 0.40 maf and 0.57 maf lower than the No Action Alternative. These lower median annual release volumes under the Proposed Action result in better protecting critical elevations in Lake Mead and contribute to increasing pool elevations over the period of analysis, whereas the No Action Alternative results in pool elevations that decrease over the period of analysis. The releases from Hoover Dam are based on downstream demands, which are lower in the Proposed Action due to the additional SEIS conservation.

Annual Release Volumes

Figure 3-16 shows the distributions of modeled calendar year release volumes from Hoover Dam in 2024, 2025, and 2026. The bold center line of each box represents the median. The top and bottom of each box captures the 25th to 75th percentiles of the modeled releases, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure 3-16 shows that under the No Action Alternative, the overall distribution of calendar year releases from Hoover Dam increase over the period of analysis, where the median releases are 8.51 maf in 2024, 8.65 maf in 2025, and 8.77 maf in 2026. The 25th and 75th percentiles increase over time for the No Action Alternative. The interquartile range of the No Action Alternative also increases over time, beginning with a range of 0.29 maf in 2024 to 0.43 maf in 2026. Likewise, the range of 95th and 5th percentiles increase over the period of analysis. The lowest 5th percentile value for the No Action Alternative is 8.0 maf in 2024 and 2025, and the highest 95th percentile value is 9.3 maf in 2026.

Figure 3-16
Hoover Dam Calendar Year Annual Release



Under the Proposed Action, the overall distribution of modeled calendar year releases from Hoover Dam increases over the period of analysis but remains below the modeled release volumes in the No Action Alternative. The median releases for the Proposed Action are 7.94 maf in 2024, 8.08 maf in 2025, and 8.37 maf in 2026, which are 0.57 maf lower than the No Action Alternative releases in 2024 and 2025, and 0.4 maf lower in 2026. The median releases for the Proposed Action increases more than the No Action Alternative because of higher annual depletions in the earlier parts of the analysis period.

The interquartile variability of the Proposed Action varies, from a range of 0.26 maf in 2024 to 0.19 maf in 2025, and to 0.32 maf in 2026. Likewise, the range of 95th and 5th percentiles for the Proposed Action also vary over time, while the values for the 95th and 5th percentiles increase over time.

Under the two alternatives, **Figure 3-16** shows that the median calendar year releases increase over time. The median releases for the No Action Alternative are between 0.40 maf and 0.57 maf higher than the Proposed Action. However, the ranges and variability for the two alternatives are similar throughout the period of analysis. Lower releases from Hoover Dam under the Proposed Action, due to increased SEIS conservation in the Proposed Action, results in better protecting critical elevations at Lake Mead.

Davis Dam

Summary

The conclusions in this section are drawn from analyses of operating year releases from Davis Dam. Detailed comparisons of the alternatives follow in subsequent sections.

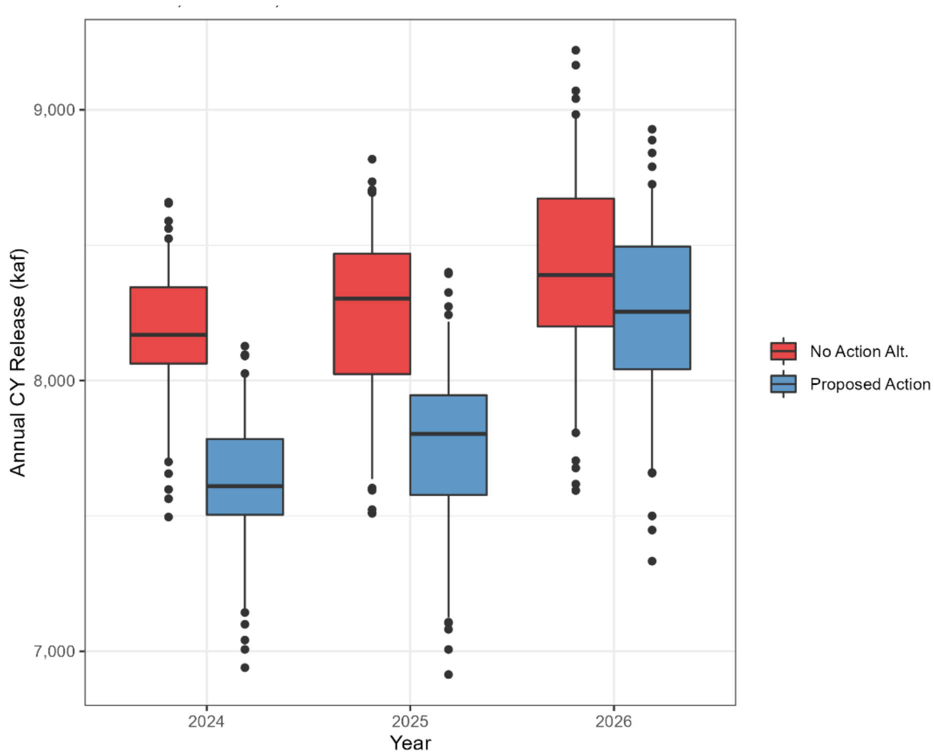
Modeled annual releases from Davis Dam under the No Action Alternative increase slightly in the medians from 8.2 maf in 2024 to 8.4 maf in 2026. The variability around these medians is also consistent. The median annual releases from Davis Dam under the Proposed Action are lower but with a similar range as the No Action Alternative. In 2024, 2025, and 2026, the medians are approximately 7.6, 7.8, and 8.3 maf, respectively. Increased SEIS conservation in 2024 and 2025 lead to increased 2026 elevations in Lake Mead and, therefore, increased releases from Hoover Dam relative to 2025.

Annual Release Volumes

Figure 3-17 shows the distributions of modeled operating year release volumes from Davis Dam in 2024, 2025, and 2026. The bold center line of each box represents the median. The boxes capture the 25th to 75th percentiles of the modeled releases and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-17 shows that under both alternatives, the distributions of modeled annual releases from Davis Dam follow the same pattern as the releases from Hoover Dam; this is because Hoover Dam releases are impounded in Lake Mohave and released from Davis Dam to generate hydropower. The median releases from Davis Dam under the No Action Alternative are 8.2, 8.3, and 8.4 maf in 2024, 2025, and 2026, respectively. The ranges increase each year, with the largest range seen in 2026. The median releases from Davis Dam under the Proposed Action are approximately 7.6, 7.8, and 8.3 maf in 2024, 2025, and 2026, respectively. The ranges in all years under the Proposed Action are similar to the ranges under the No Action Alternative.

Figure 3-17
Davis Dam Annual Release



Parker Dam

Summary

The conclusions in this section are drawn from analyses of operating year releases from Parker Dam. Detailed comparisons of the alternatives follow in subsequent sections.

Over the period of analysis, the No Action Alternative results in minimal variation in the median modeled annual release from Parker Dam of approximately 6.4 to 6.5 maf because the majority of the shortages and modeled system conservation in the No Action Alternative occur at or above Parker Dam. In 2026, the minimum Parker Dam release under the No Action Alternative is 6.1 maf.

The medians and ranges of modeled annual releases from Parker Dam are lower under the Proposed Action than the No Action Alternative, because there is additional SEIS conservation modeled below Parker Dam. The median annual releases under the Proposed Action are approximately 6.1 maf in 2024 and 2025, and a range commensurate with the differences in median to the No Action Alternative. The minimum releases in 2026 are slightly higher at 6.3 maf.

Annual Release Volumes

Figure 3-18 shows the distributions of modeled operating year release volumes from Parker Dam in 2024, 2025, and 2026. The bold center line of each box represents the median. The boxes capture the 25th to 75th percentiles of the modeled releases and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-18
Parker Dam Annual Release

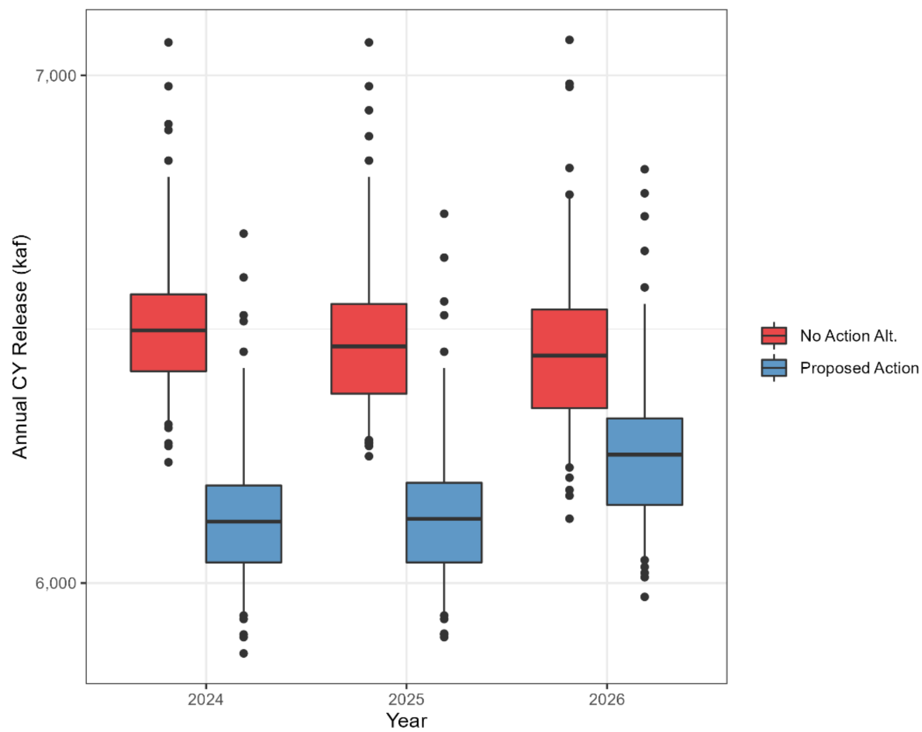


Figure 3-18 shows that under the No Action Alternative, modeled annual releases from Parker Dam decrease slightly across the medians, from 6.5 maf to 6.4 maf, while the ranges are similar through 2025. This is because most of the shortages and modeled system conservation in the No Action Alternative occur at or above Parker Dam. In 2026, the lowest modeled releases decrease from 6.2 maf to 6.1 maf.

The medians of modeled annual releases from Parker Dam are lower under the Proposed Action because there is additional SEIS conservation modeled below Parker Dam. In 2024 and 2025, the median releases under the Proposed Action are 6.1 maf, and 6.3 maf in 2026. The ranges for each year under the Proposed Action vary similarly to the medians.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operating year and would result in no changes to annual reservoir levels in Lake Powell or

Lake Mead. Therefore, minimal cumulative effects would occur on reservoir releases due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on hydrologic resources due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 3: How would changes to operational activities affect river flows?

This section presents a comparison of river flows under the No Action Alternative and the Proposed Action with various metrics, including annual, monthly, and daily release volumes. Because in most cases the river flows in each reach are mainly comprised of upstream reservoir releases, most of the discussion below will refer to figures in *Issue 2*, above.

Glen Canyon Dam to Lake Mead

Summary of Alternatives Comparison

As described in the 2007 FEIS, the river flows that occur between Glen Canyon Dam and Lake Mead result primarily from controlled releases from Glen Canyon Dam (Lake Powell). The gains from tributaries in this reach on average are less than 3 percent of the total flow, are concentrated over short periods of time, and would not be affected by the alternatives. However, future annual and monthly distribution of releases from Glen Canyon Dam may be affected by the alternatives. (See *Issue 2* for additional discussion.)

With respect to annual flows, **Figure 3-13** shows modeled distributions of operating year releases from Glen Canyon Dam for the period of analysis. In general, both the No Action Alternative and the Proposed Action result in similar distributions of releases. The Proposed Action results in lower median operating year releases in 2025 and 2026 due to lower balancing and equalization releases due to the higher pool elevation at Lake Mead. The minimum operating year releases are slightly lower in the Proposed Action than the No Action Alternative, because the Proposed Action allows releases below 7.0 maf to protect elevation 3,500 feet at Lake Powell. (See *Issue 2* for additional discussion.)

Distributions of modeled monthly flows between Glen Canyon Dam and Lake Mead for both the No Action Alternative and the Proposed Action are presented in **Figure 3-14**. The range of interquartile monthly release values for both alternatives are approximately the same, however, the No Action Alternative median monthly release is consistently higher than the Proposed Action. This is a function of lower balancing and equalization releases in the Proposed Action from Lake Powell resulting from the higher pool elevation at Lake Mead. Both alternatives have lower releases in October through March, with less variability. From April through September, the releases increase, along with the variability. (See *Issue 2* for additional discussion.)

Throughout the operating year, no traces under the No Action Alternative or the Proposed Action are lower than the estimated daily minimum LTEMP flows. Daily flows were not estimated for this SEIS. However, a table of estimates is in Section 4.3.3.1 of the 2007 FEIS. **Figure 3-14** shows how monthly releases from Glen Canyon Dam compare to an estimate of how daily minimum flows specified by the LTEMP would sum to a monthly volume. **Section 3.8** of this SEIS addresses the effects of HFEs and monthly volume releases in the Grand Canyon. The timing of releases is addressed in conjunction with other resources, such as sedimentation.

Hoover Dam to Davis Dam

Summary of Alternatives Comparison

As described in the 2007 FEIS, the river flows between Hoover Dam and Lake Mohave are comprised mainly of releases from Hoover Dam (Lake Mead) and tributary inflows. These tributary inflows, mostly from side washes, comprise less than 1 percent of the total annual flow in this reach. Future annual and monthly releases may be affected by the alternatives. However, due to the presence of Lake Mohave immediately downstream of Hoover Dam, Lake Mohave is the tailwater of Hoover Dam, and acts more as reservoir flows rather than riverine flows. Regardless, these potential changes in releases will only have an effect on hydropower generation.

Distributions of modeled annual releases from Hoover Dam are shown in **Figure 3-16**. Both the No Action Alternative and the Proposed Action result in increasing median annual releases from Hoover Dam over the period of analysis. However, the annual releases from Hoover Dam under the Proposed Action are significantly lower than releases under the No Action Alternative (by 0.40 maf to 0.57 maf). The No Action Alternative and the Proposed Action also exhibit similar variability between the range of modeled annual releases. The minimum annual releases under both alternatives occur in 2024 at 7.94 maf for the Proposed Action and 8.51 maf for the No Action Alternative. (See *Issue 2* for additional discussion.) With lower modeled annual releases from Hoover Dam in the Proposed Action, compared with the No Action Alternative, it is expected that monthly releases and river flows also would be lower.

Davis Dam to Parker Dam

Summary of Alternatives Comparison

River flows between Davis Dam and Parker Dam are mostly comprised of releases from Davis Dam and tributary inflow from the Bill Williams River. Releases from Davis Dam are the variable that would differ between alternatives, so they are used for comparison. Distributions of modeled annual releases from Davis Dam are shown in **Figure 3-17**. In general, the Proposed Action results in lower median annual releases but a similar range, compared with releases under the No Action Alternative. The minimum annual releases under both the No Action and Proposed Action occur in 2025 and 2026 at 7.5 and 6.9 maf, respectively. (See *Issue 2* for additional discussion.) With lower annual releases from Davis Dam in the Proposed Action, compared with the No Action Alternative, it is expected that monthly releases and river flows would also be lower.

With respect to annual flows near Lake Havasu National Wildlife Refuge (NWR), these river flows show the same general patterns that were observed in the distributions of modeled annual releases from Hoover Dam and Davis Dam since those dams are operated, except during flood control operations, to meet downstream demands. The differences in magnitudes between the releases from Hoover Dam, releases from Davis Dam, and flows near Havasu NWR are due to evaporation loss at Lake Mohave (which would be the same in all alternatives due to rule curve operations) and the relatively small diversions along this stretch of the river. (For more information about ecological impacts, see **Section 3.13** of this SEIS.)

Parker Dam to Cibola Gage and Cibola Gage to Imperial Dam

Summary of Alternatives Comparison

The river flows in the Parker Dam to Cibola Gage reach are essentially the releases from Parker Dam. **Figure 3-18** shows the distributions of modeled annual releases from Parker Dam for all alternatives. In general, the Proposed Action results in lower median annual releases than the No Action Alternative but similar ranges in all years. The minimum annual releases occur in 2026 under the No Action Alternative, and in 2024 and 2025 under the Proposed Action at 6.1 and 6.0 maf, respectively. (See *Issue 2* for additional discussion.)

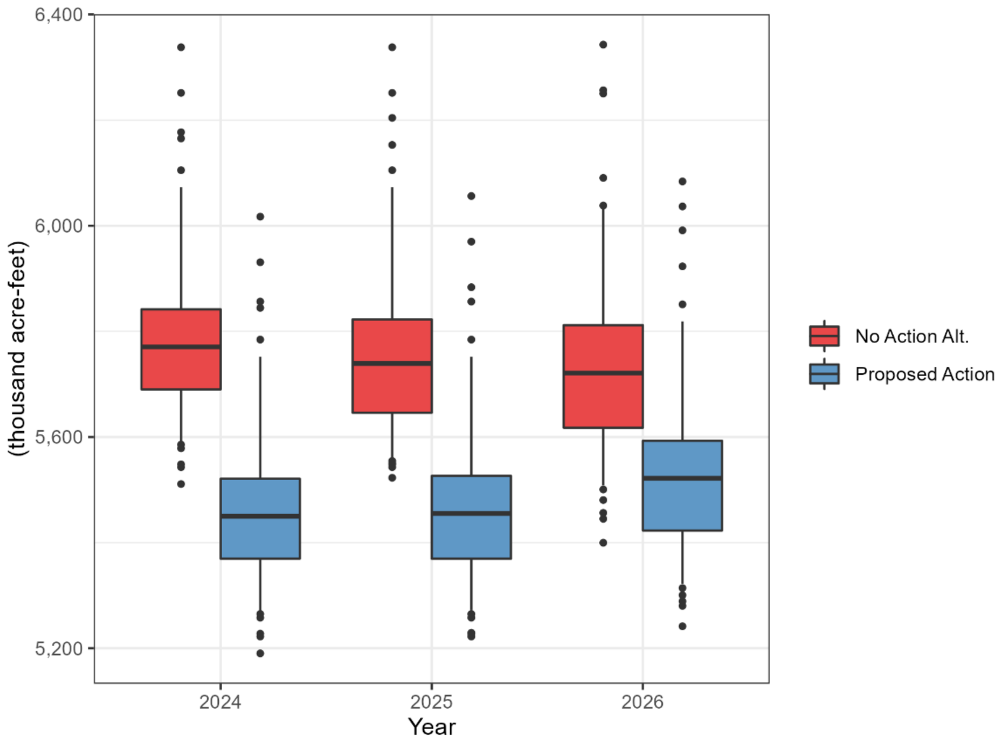
Two other points on the Colorado River are used to analyze flows in the reach between Parker Dam and Imperial Dam: flows near the Colorado River Indian Reservation (CRIR) and flows downstream of the Palo Verde Diversion Dam. The CRIR diversion is located at Headgate Rock Dam, approximately 14 miles downstream of Parker Dam. Flows in this reach of the river result primarily from releases at Parker Dam, and the annual flow values at this location generally reflect the releases from Parker Dam. Therefore, differences between the alternatives at this location can be assumed to be reflected in the comparison of releases from Parker Dam.

The flow of the Colorado River between Palo Verde Diversion Dam and Imperial Dam is normally the amount needed to meet both the consumptive use requirements in the US downstream of the Palo Verde Diversion Dam and deliveries to Mexico. The river location used to analyze the flows in the reach of the river between Palo Verde Diversion and Imperial Dam is located immediately downstream of the Palo Verde Diversion.

Figure 3-19 shows the distributions of modeled operating year release volumes downstream of the Palo Verde Diversion Dam in 2024, 2025, and 2026. The bold center line of each box represents the median. The boxes capture the 25th to 75th percentiles of the modeled volumes and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

In **Figure 3-19**, the distributions of modeled annual flow downstream of Palo Verde Diversion Dam under all alternatives follow the same pattern that was observed in the releases from Parker Dam in **Figure 3-18**; medians and variability in the No Action Alternative remain stable throughout the period of analysis. The median annual release for the Proposed Action is less than the No Action Alternative due to the additional SEIS conservation in the Proposed Action. The minimum annual flows under the No Action Alternative occurs in 2026 at 5.4 maf, while the minimum annual flow under the Proposed Action is 5.2 maf in all years.

Figure 3-19
Colorado River Annual Flow Downstream of Palo Verde Diversion Dam



Imperial Dam to NIB

Summary of Alternatives Comparison

As discussed in the 2007 FEIS, most water delivered to Mexico is diverted at Imperial Dam, conveyed via the All-American Canal and then returned to the Colorado River through the Pilot Knob and Siphon Drop Powerplants and their respective wasteway channels, 2.1 miles and 7.6 miles upstream of the NIB, respectively. The Proposed Action will not alter operations of these diversions and wasteways.

NIB to SIB

Summary of Alternatives Comparison

As discussed in the 2007 FEIS, Mexico receives most of its Colorado River supply at the NIB and diverts it into the Reforma Canal at the Morelos Diversion Dam. Outflows from the Morelos Diversion Dam into the historical Colorado River floodplain area are normally limited, except during flood control events or any potential future targeted environmental flows under Minute 323. No Lake Mead flood control releases have occurred since 2008 (after the implementation of the 2007 Interim Guidelines) and none are projected to occur in the next 4 years in the SEIS modeling. Additionally, deliveries to Mexico are outside the scope of this SEIS and, therefore, further analysis is not provided.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operating year and would result in no changes to annual reservoir levels in Lake Powell or Lake Mead. Therefore, minimal cumulative effects would occur on flow rates within the various reaches of the Colorado River due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on hydrologic resources due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 4: How would operational activities affect groundwater?

Based on the modeling assumptions discussed previously, this section presents resulting differences associated with groundwater within specific reaches along the Colorado River for the No Action Alternative and Proposed Action. This qualitative analysis is informed by the assumptions, analyses, and findings of the 2007 FEIS. Further declines to groundwater levels from potential reduced flows are assumed by Reclamation to be similar to those declines presented in the 2007 FEIS.

Glen Canyon Dam to Lake Mead

Summary of Alternatives Comparison

The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Powell; however, fluctuating reservoir elevations may be mirrored in groundwater elevations adjacent to the reservoir. As discussed in *Issue 1*, both the No Action Alternative and the Proposed Action result in increased monthly median reservoir elevation at Lake Powell, with the median Proposed Action elevations being 1 to 6 feet higher than the median No Action Alternative elevations. The groundwater elevation adjacent to Lake Powell is anticipated to be slightly lower under the No Action Alternative compared with the Proposed Action.

As stated in the 2007 FEIS, the reach of the Colorado River downstream of the Glen Canyon Dam runs through the incised Grand Canyon, where there is limited connection to groundwater. Due to these physical characteristics, Reclamation assumes there are no differences between the No Action and Proposed Action. The Proposed Action is not anticipated to affect groundwater levels within this reach.

The 2007 FEIS did not consider effects on groundwater elevations in the vicinity of Lake Mead; however, fluctuating reservoir elevations may be mirrored in groundwater elevations adjacent to the reservoir. As discussed in *Issue 1*, the No Action Alternative exhibits a declining trend in median elevations through the analysis period. The Proposed Action median elevations are higher than the

No Action Alternative elevations and exhibit an upward trend through the analysis period. Groundwater elevations adjacent to Lake Mead may fluctuate throughout the analysis period. At the end of 2026, groundwater elevation adjacent to Lake Mead is anticipated to decrease under the No Action Alternative, whereas groundwater elevations may increase under the Proposed Action.

Hoover Dam to Davis Dam

Summary of Alternatives Comparison
As stated in the 2007 FEIS, this reach of the Colorado River runs through bedrock canyon that has limited connection to groundwater, or the reach is part of a groundwater basin dominated by Lake Mohave. Reclamation assumes there are no differences between the alternatives, and the alternatives are not anticipated to impact groundwater levels within this reach.

Davis Dam to Parker Dam

Summary of Alternatives Comparison
Due to the physical characteristics of the Davis Dam to Parker Dam reach of the Colorado River, groundwater levels are anticipated to decrease in the upper portion of the reach and remain static in the lower portion under all alternatives. As discussed in *Issue 3*, river flows could decrease more under the Proposed Action. Decreasing river flows and shallower river stages in this reach have historically resulted in decreased groundwater elevations. Reductions in the groundwater elevation in the upper portion of this reach are anticipated to be larger under the Proposed Action, compared with the No Action Alternative, due to SEIS conservation volumes lowering flow rates through this portion of the Colorado River.

Parker Dam to Cibola Gage and Cibola Gage to Imperial Dam

Summary of Alternatives Comparison
Due to the physical characteristics of the Parker Dam to Imperial Dam reach of the Colorado River, groundwater levels are anticipated to decrease under all alternatives. As discussed in *Issue 3*, river flows could decrease more under the Proposed Action. Decreasing river flows and shallower river stages in this reach have historically resulted in decreased groundwater elevations. Reductions in the groundwater elevation are anticipated to be larger under the Proposed Action, compared with the No Action Alternative, due to SEIS conservation volumes lowering flow rates through this portion of the Colorado River.

Imperial Dam to NIB

Summary of Alternatives Comparison
As stated in the 2007 FEIS, this reach of the Colorado River either runs through two small rockbound groundwater basins or is diverted to the All-American Canal. Reclamation assumes there are no differences between the alternatives, and the alternatives are not anticipated to impact groundwater levels within this reach.

NIB to SIB

Summary of Alternatives Comparison
As stated in the 2007 FEIS, this reach of the Colorado River runs through the large and deep river delta. The upstream portion is a gaining reach where groundwater contributes to surface flow in the

river. The downstream portion is a losing reach where surface water from the river recharges the groundwater. While the Proposed Action alters the flow in the Lower Basin reaches differently than the No Action Alternative, impacts on groundwater levels across all alternatives are not anticipated within this reach.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS, however this would result in negligible changes to groundwater resources. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operating year and would result in no changes to annual reservoir levels in Lake Powell or Lake Mead. Therefore, no cumulative effects would occur on groundwater levels within the various reaches of the Colorado River due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on hydrologic resources due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.7 Water Deliveries

3.7.1 Affected Environment

As described in the 2007 FEIS, entities in the seven Basin States and Mexico receive water from the Colorado River. The Law of the River governs these deliveries. Since publication of the 2007 FEIS, deliveries to the Lower Division States have been adjusted to meet the 2007 Interim Guidelines under certain conditions (Shortage Condition Years) and the Lower Basin DCP (Reclamation 2019b). Actions under the Upper Basin DCP's Drought Response Operating Agreement have also been implemented since publication of the 2007 FEIS with the goal of reducing the risk of reaching critical elevations at Lake Powell and helping assure continued compliance with the Colorado River Compact by moving water within the Upper Basin. Otherwise, deliveries to these entities are guided by the same body of documents described in the 2007 FEIS.

The Compact, described in the 2007 FEIS, ultimately apportioned water for consumptive use (7.5 maf each) between the Upper and Lower Basins, with the division of the two basins at Lee Ferry, Arizona. The Upper and Lower Basins further apportion deliveries to individual states and entities within their respective basins. As discussed within this SEIS, the 2007 Interim Guidelines outline shortage guidelines that describe the agreed-upon reductions of available water for consumptive use to the Lower Division States below their apportioned 7.5 maf. Additionally, the 2007 Interim

Guidelines modified and extended the 2001 Interim Surplus Guidelines (DOI 2001) from 2016 to 2026.

This section presents updated information on the Basin through 2022 to better describe evolving characteristics of water deliveries within the affected environment. This includes updated information regarding the apportionments to Upper and Lower Division States, entitlements, depletion schedules for Lower Division States, and distribution of shortages for the Lower Division States.

Apportionments to the Upper Division States

As described in the 2007 FEIS, the Compact apportions 7.5 maf to the Upper Basin for consumptive use. Furthermore, flow at the Lee Ferry Compact Point cannot be depleted below 75 maf for any consecutive 10-year period. The annual apportionment is a percentage of the total available for consumptive use each year. The available amount within the Upper Basin is the remaining volume after Arizona's 50,000 af apportionment of Upper Basin water. Additional details on the Upper Division States' apportionments and depletion schedules are in the 2007 FEIS and apportionments are listed in **Table 3-6**. The 2007 Interim Guidelines do not affect apportionments of the Upper Division States.

Table 3-6
Upper Division States Apportionment

State	Annual Apportionment (Percent)
Colorado	51.75
New Mexico	11.25
Utah	23.00
Wyoming	14.00

Source: Reclamation 2007

Apportionments to the Lower Division States

As stated in the 2007 FEIS, the BCPA establishes water apportionments to the Lower Division States. Details on these states' apportionments are in the 2007 FEIS and are listed in **Table 3-7**.

Table 3-7
Lower Division States Apportionments

State	Annual Apportionment (maf)
Arizona	2.8
California	4.4
Nevada	0.3
Total	**7.5**

Source: Reclamation 2007

The 2007 Interim Guidelines do not affect apportionments of water to the Lower Division States. Therefore, further discussion of these apportionments is not warranted; additional details are in the 2007 FEIS.

Water Delivery Entitlements to Entities in the Lower Division States

As stated in the 2007 FEIS, the Lower Division States' apportioned water is further allocated through entitlements, in accordance with the BCPA and Consolidated Decree.[7] Approximately 10,000 af of Arizona's lower Colorado River water apportionment has not been placed under a water delivery contract. The 2007 Interim Guidelines do not affect entitlements in the Lower Division States; additional details on these entitlements are in the 2007 FEIS.[8]

Intentionally Created Surplus

Additionally, the 2007 Interim Guidelines created the mechanism of ICS, allowing Lower Basin entitlement holders with ICS exhibits and an approved ICS creation plan to store conserved water in Lake Mead. Approved conservation actions, consistent with an ICS exhibit, must be taken to create ICS in a given year. ICS creation and deliveries are subject to constraints, as defined in the 2007 ROD and 2019 DCPs agreements (specifically, Exhibit 1) and related ICS delivery agreements.

Lower Division States' Water Supply Determination

As discussed in the 2007 FEIS, the Secretary annually determines the water supply condition for the Lower Division States as a normal condition, surplus condition, or shortage condition, depending on the amount of mainstream water available to satisfy consumptive use in the Lower Division States. The 2007 Interim Guidelines provide specific guidance used to make annual water supply determinations. This guidance is based on the projected elevation of Lake Mead based on the August 24-Month Study. The guidance identifies thresholds under which the Secretary would reduce the total amount of water available—below 7.5 maf—for consumptive use from Lake Mead to the Lower Division States. The 2007 Interim Guidelines also provide a coordinated approach to reservoir management between Lake Powell and Lake Mead.

Starting in 2008, Reclamation has operated Lake Powell for each operating year based on certain release tiers, which is consistent with Section 6 of the 2007 Interim Guidelines. Similarly, Reclamation has set the condition governing operation of Lake Mead for each operating year, consistent with Section 2 of the 2007 Interim Guidelines and in accordance with Article III(3)(c) of the Operating Criteria and Article II(B)(3) of the Consolidated Decree of the Supreme Court of the US in *Arizona v. California*, 547 US 150 (2006). Starting in 2019, the Lower Basin DCP (Reclamation 2019b) also governs the operation of Lake Mead.

Each year's AOP for Colorado River reservoirs reports on both the past operations of the Colorado River reservoirs for the completed year and the projected operations and releases from these reservoirs for the current (that is, upcoming) year. Each AOP incorporates rules, guidelines, and decisions. The AOP reports how Reclamation will implement these decisions in response to changing water supply conditions as conditions become known during the upcoming year. In

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[7] As discussed in the 2007 FEIS, the Consolidated Decree was entered by the US Supreme Court in the case of *Arizona v. California*, 547 US 150 (2006).
[8] See also: https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html.

accordance with Section 2 of the 2007 Interim Guidelines, Lake Mead operated in an ICS/Surplus Condition from 2008 through 2021 and in a Shortage Condition in 2022 and 2023, with required DCP contributions in years from 2020 through 2023.

As discussed in the 7D Review Final Report, released in December 2020 (Reclamation 2020a), the Interim Guidelines provide operational criteria for the full range of potential reservoir elevations that may occur based on modeling conducted for the 2007 FEIS. The guidelines were intended to govern operations through 2026, however, the continuing drought within the Basin has increased the probability that the water supply system will be unable to make required releases. In addition, reservoir levels have continued to fall to the point that critical infrastructure and hydropower operations may be negatively affected.

This fact motivated the completion of the DCPs when, in 2018, combined storage was at the lowest point since Lake Powell filled (41 percent full), and the Basin was experiencing the second-driest year since the beginning of the drought (Reclamation 2020a). Even with the DCPs in place, the risk of continued drought and reservoir elevations declining below those considered likely in the 2007 FEIS requires the consideration of updates to the 2007 Interim Guidelines to protect the reservoir elevations of Lake Powell and Lake Mead through 2026. Proposed updates under consideration (Proposed Action) and their effect on water deliveries to Lower Division States are presented in **Section 3.7.2**, Environmental Consequences, of this SEIS.

Depletion Schedules for Lower Division States (Normal and Surplus)

Historical consumptive use for the Lower Basin from 2008 to 2022 is shown in **Table 3-8**. 2008 was selected since that is when the 2007 Interim Guidelines were implemented. At the time of this report, data was not available after 2022. Total annual depletions to the Lower Basin have declined on average from 2008 to 2022.

Table 3-8
Lower Basin Annual Historical Consumptive Use by State

Calendar Year	Arizona (af)	California (af)	Nevada (af)	Lower Basin Total (af)
2008	2,752,497	4,498,810	269,654	7,520,961
2009	2,831,711	4,358,074	248,613	7,438,398
2010	2,780,367	4,356,839	241,437	7,378,643
2011	2,781,108	4,312,661	222,847	7,316,616
2012	2,789,667	4,416,718	237,161	7,443,546
2013	2,778,867	4,475,789	223,563	7,478,219
2014	2,774,661	4,649,734	224,616	7,649,011
2015	2,604,732	4,620,756	222,729	7,448,217
2016	2,612,833	4,381,101	238,326	7,232,260
2017	2,509,503	4,026,515	243,425	6,779,443
2018	2,632,260	4,265,525	244,103	7,141,888
2019	2,491,707	3,840,686	233,996	6,566,389
2020	2,470,776	4,059,911	255,568	6,786,255

Calendar Year	Arizona (af)	California (af)	Nevada (af)	Lower Basin Total (af)
2021	2,425,736	4,404,727	242,168	7,072,631
2022	2,014,176	4,424,247	223,670	6,662,093

Source: Reclamation 2022c

Projected depletion schedules have been modified since the 2007 FEIS. **Appendix D** outlines the current depletion schedules used in normal and surplus[9] conditions. For the first year of the model run, projected depletion schedules use water orders that reflect shortage conditions, DCP contributions, and other signed system conservation agreements. For the remaining years in the model run, projected depletion schedules reflect "normal" schedules and represent near-term historical trends in water use.

Mexico's Allotment

Allotment specifics are detailed in the 2007 FEIS. The 2007 Interim Guidelines and this SEIS do not affect Mexico's allotment. The amount of Colorado River water scheduled for delivery to Mexico during each operating year has been set in accordance with the 1944 Water Treaty and Minute 323. Since 2019, this volume was further adjusted for water savings contributions, as required under Minute 323, and since 2021 for reductions under low elevation reservoir conditions. In accordance with the provisions of Minute 323,[10] Mexico may create water for or take delivery of water from Mexico's Water Reserve. The provisions also allow Mexico's Water Reserve to be converted into Mexico's Recoverable Water Savings, which offset savings contributions when Lake Mead has low reservoir elevations for recovery on a future date.

Distribution of Shortages to and within the Lower Division States

The 2007 FEIS describes the distribution of shortages within each state, in accordance with established priority systems and agreements. This section provides supplemental information that impacts the distribution of shortages since publication of the 2007 FEIS.

In the 2007 FEIS, the maximum volume of domestic shortages analyzed in the shortage allocation model was 2.083 maf. As such, the total shortages, DCP contributions, and SEIS conservation modeled in this SEIS are limited to 2.083 maf, the maximum volume contemplated in the 2007 FEIS. Working within this range of previously analyzed impacts will facilitate efficient analysis. Shortage volumes above this amount are uncertain and are unable to be analyzed in this SEIS. Delaying operational decisions to perform additional analyses would not meet the express purpose and need for this action.

The 2007 Interim Guidelines specified shortages for Arizona and Nevada based on the projected January 1 elevation of Lake Mead. The 2019 DCPs included additional contributions from Arizona,

[9] While surplus schedules exist in CRMMS, no surplus conditions are projected through 2026 in the No Action Alternative or the Proposed Action.

[10] For implementing additional details, see the *Joint Report of the Principal Engineers with the Implementing Details of the BWSCP in the Colorado River Basin dated July 11, 2019,* and the *Joint Report of the Principal Engineers with the Operational Provisions Applicable to Water for the Environment Stipulated in Minute 323 dated December 16, 2021.*

Nevada, and California at specified Lake Mead elevations. The breakdown of these volumes is described in Exhibit 1 to the Lower Basin DCP Agreement. **Table 3-9** presents this breakdown.

Table 3-9
Lower Division States' Total Shortages from the 2007 Interim Guidelines and Contributions from the 2019 DCPs

Projected January 1 Lake Mead Elevation (feet)	2007 Interim Guidelines Shortages		DCP Contributions			Combined Volumes (2007 Interim Guidelines Shortages & DCP Contributions)			
	Arizona	Nevada	Arizona	Nevada	California	Arizona	Nevada	California	Lower Division States Total
	(1,000 acre-feet)								
At or below 1,090 and above 1,075	0	0	192	8	0	192	8	0	200
At or below 1,075 and at or above 1,050	320	13	192	8	0	512	21	0	533
Below 1,050 and above 1,045	400	17	192	8	0	592	25	0	617
At or below 1,045 and above 1,040	400	17	240	10	200	640	27	200	867
At or below 1,040 and above 1,035	400	17	240	10	250	640	27	250	917
At or below 1,035 and above 1,030	400	17	240	10	300	640	27	300	967
At or below 1,030 and at or above 1,025	400	17	240	10	350	640	27	350	1,017
Below 1,025	480	20	240	10	350	720	30	350	1,100

Source: Reclamation 2019b

Distribution of Shortages within Arizona

As described in the 2007 FEIS, Arizona's 2.8 maf apportionment is further allocated to entitlement holders. A priority system was established for the delivery of mainstream Colorado River water. **Table 3-10,** which is taken from the 2007 FEIS, outlines Arizona's priority system.

As described above, the 2007 Interim Guidelines and the 2019 DCPs define shortages and contributions from Arizona, which depend on the elevation of Lake Mead. The combined shortage and contribution volumes for Arizona range from 192,000 af to 720,000 af.

Table 3-10
Arizona's Priority System for Mainstream Colorado River Water

Priority	Rights to Be Satisfied
First	Present perfected rights (PPRs) established prior to June 25, 1929
Second[1]	Federal reservations and perfected rights established or effective prior to September 30, 1968
Third[1]	Entitlements pursuant to contracts executed on or before September 30, 1968
Fourth	(1) Entitlements pursuant to contracts, Secretarial reservations, and other arrangements between the US and water users established subsequent to September 30, 1968 (2) Contract for CAP
Fifth	Any unused Arizona entitlement
Sixth	Entitlements to surplus water

Source: Reclamation 2007
[1] The Arizona second and third priorities are coequal in their priority.

Distribution of Shortages within California

As described in the 2007 FEIS, California's 4.4-maf apportionment is further distributed through a priority system, established by Secretarial regulations incorporating provisions of the California Seven-Party Agreement of 1931. **Table 3-11** from the 2007 FEIS outlines the priority system.

As outlined above, the 2019 DCPs defines contributions from California, which depend on the elevation of Lake Mead. The contribution volumes for California range from 0 af to 350,000 af.

Table 3-11
California's Seven-Party Agreement for Mainstream Colorado River Water

Priority	Rights to Be Satisfied
First	Palo Verde Irrigation District for beneficial use upon 104,500 acres
Second	Reclamation's Yuma Project for beneficial use on up to 25,000 acres
Third[1,2]	(a) IID and CVWD (b) Palo Verde Irrigation District for use on 16,000 acres on the Lower Palo Verde Mesa
Fourth[3]	MWD and/or the City of Los Angeles and/or others on the coastal plain of Southern California for 550,000 acre-feet per year (afy)
Fifth	(a) MWD and/or the City of Los Angeles and/or others on the coastal plain of Southern California for 550,000 afy (b) City and/or County of San Diego for 112,000 afy
Sixth[4]	(a) IID and CVWD (b) Palo Verde Irrigation District for use on Lower Palo Verde Mesa
Seventh	All remaining water available within California for agricultural use

Source: Reclamation 2007
[1] The total beneficial use of priorities 1, 2, and 3 shall not exceed 3,850,000 afy.
[2] Article 4.7 of the Quantification Settlement Agreement (QSA) and the Agreement for Acquisition of Conserved Water by and between IID and Coachella Valley Water District, dated October 10, 2003, contain provisions for shortage sharing between these two agencies.
[3] The sum of priorities 1 through 4 is 4,400,000 afy.
[4] The sum of priority 6 is 300,000 thousand afy.

Distribution of Shortages within Nevada

As described in the 2007 FEIS, Nevada's 0.3-maf apportionment is further distributed through a priority system, established in 1992 when Reclamation contracted with SNWA for delivery of the balance of Nevada's apportionment. **Table 3-12**, updated from the 2007 FEIS, outlines the priority system.

Table 3-12
Nevada's Priority System for Mainstream Colorado River Water

Priority	Rights to Be Satisfied
First	Fort Mojave Indian Reservation (12,534 afy) LMNRA (Diversion = 500 afy or Consumptive Use = 300 afy)
Second	LMNRA (1,500 afy, estimated)
Third	Boulder City (5,876 afy)
Fourth	City of Henderson (15,878 afy) Basic Management, Inc. (8,608 afy) SNWA (from Basic Water Company) (14,950 afy)
Fifth	Lakeview Company (0 afy) Pacific Coast Building Products (PABCO) (928 afy)
Sixth	Las Vegas Valley Water District (15,407 afy)
Seventh	US Air Force (delivery from SNWA; 4,000 afy), Boy Scouts (annexed by SNWA; 10 afy), Reclamation (300 afy), and Nevada Department of Wildlife (formerly Nevada Department of Fish and Game; 25 afy)
Eighth	Robert B. Griffith Project (308,000 afy) and Big Bend (10,000 afy) SNWA (balance of state apportionment, unused and surplus)

Source: Reclamation 2007

As outlined above, the 2007 Interim Guidelines and the 2019 DCPs define shortages and contributions from Nevada, which depend on the elevation of Lake Mead. The combined shortage and contribution volumes for Nevada range from 8,000 af to 30,000 af.

Salton Sea

The Salton Sea is a terminal lake that receives runoff from the surrounding Imperial Valley and Coachella Valley watersheds, as well as agricultural runoff from the IID and CVWD. This runoff primarily originates as deliveries from the Colorado River Basin to IID and CVWD. Historically, the Salton Sea's water level has declined, increasing lake bed exposure area over the past decades (Tetra Tech 2023). Future Salton Sea conditions were modeled using the SSAM. Additional information regarding the modeling specifics can be found in **Section 3.3.6**.

3.7.2 Environmental Consequences

Methodology

This section compares water deliveries from the Colorado River mainstream under the No Action Alternative and the Proposed Action. The CRMMS, as described in **Section 3.3**, was used to analyze water deliveries across these alternatives. Modeling details for each alternative are described in **Section 3.3.4** and **Appendix D**.

Additionally, as described in **Section 3.3**, a Shortage Allocation Model was used in addition to the CRMMS to analyze the potential impacts of the alternatives on individual water users within each Lower Division State. The Shortage Allocation Model was used to estimate delivery of water to Colorado River water users within the Lower Division States under varying levels of shortage for the No Action Alternative. The same assumptions are made for the Proposed Action; therefore, the Shortage Allocation Model is relevant to both alternatives. Modeling assumptions for the Shortage Allocation Model are summarized in **Section 3.3.4** and detailed in **Appendix E** which presents shortage impacts on entitlement holders. A list of each Lower Division State's Colorado River water-entitlement holders, listed by priority, is available at: https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html.

The new actions evaluated as part of the SEIS will not impact Upper Division States; therefore, further analysis of the Upper Division States is not necessary and not included within this section.

Assumptions

(Please refer to **Section 3.3.4**, **Appendix D**, and **Appendix E** for a discussion pertaining to modeling assumptions.)

All calculated statistics are reflective of the hydrology scenarios and other assumptions used in modeling, and they are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance.

Impact Indicators

This section will discuss impacts on the Lower Division States' water supply determination, total water deliveries to Lower Division States, deliveries to Mexico, and the distribution of shortages to and within the Lower Division States. To measure the impact of water deliveries, the following indicators are used:

- frequency and magnitude of shortages
- distribution of shortages and depletions among and within the Lower Division States

Additionally, impacts on the Salton Sea are included.

Issue 1: How would changes to operational activities affect apportionments to the Upper Division States?

The alternatives would not affect apportionments to the Upper Division States. Therefore, no impact analysis is warranted.

Issue 2: How would changes to operational activities affect apportionments and water entitlements to and within the Lower Division States?

The alternatives would not affect state apportionments or entitlements of water users within the Lower Division States. Therefore, no impact analysis is warranted.

Issue 3: How would changes to operational activities affect Lower Division States' water supply determinations and total water deliveries?

This section presents the water supply determinations and resulting water deliveries (i.e., modeled depletions) to the three Lower Division States. Deliveries to each state may deviate from a state's normal apportionment due to shortage or surplus conditions, DCP contributions, ICS creation and delivery, and other system conservation, including SEIS conservation (under the Proposed Action).

Summary of Alternatives

As discussed in **Chapter 2** and **Appendix D** shortage and DCP contribution determinations for both alternatives are determined in response to Lake Mead elevations. These volumes are outlined in **Table 3-13** for the No Action Alternative and **Table 3-14** for the Proposed Action. Additionally, the Proposed Action includes modeled SEIS conservation volumes, described in the modeling assumptions in **Section 3.3.4**.

Modeled Lake Mead elevations are lower throughout the period of analysis for the No Action Alternative compared to the Proposed Action, resulting in more traces at tiers with greater combined shortages and DCP contributions compared to the Proposed Action. Although median combined shortages and DCP contributions are the same for both alternatives throughout the period of analysis, slight differences in minimum and maximum volumes occur between alternatives due to differences in the percent of traces in each operating tier.

System conservation is greater under the Proposed Action each year compared to the No Action Alternative due to the SEIS Conservation included in the Proposed Action. This results in greater combined annual shortages, DCP contributions, and system conservation under the Proposed Action each year, except for in Nevada, where no system conservation occurs.

Table 3-13
Lower Division States' Shortages and DCP Contributions, No Action Alternative*

Lake Mead Elevation (feet)	2007 ROD** Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	Total ROD Shortages + Contributions (1,000 af)
1,090 – >1,075	0	200	**200**
1,075 – 1,050	333	200	**533**
<1,050 – >1,045	417	200	**617**
1,045 – >1,040	417	450	**867**
1,040 – >1,035	417	500	**917**
1,035 – >1,030	417	550	**967**
1,030 – 1,025	417	600	**1,017**
<1,025	500	600	**1,100**

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the Binational Water Scarcity Contingency Plan (BWSCP), in accordance with Minute 323 to the 1944 Water Treaty (see **Appendix D**, CRMMS Model Documentation, **Tables D-9** and **D-10**).

** Shortages listed in the 2007 ROD

Table 3-14
Lower Division States' Shortages, DCP Contributions, and SEIS Conservation, Proposed Action (2023-2026)*

Lake Mead Elevation (feet)	2007 ROD Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	SEIS Conservation (1,000 af)	Total ROD Shortages + DCP Contributions + SEIS Conservation (1,000 af) **
1,090 – >1,075	0	200	Approximately 750 annually**	**950**
1,075 – 1,050	333	200		**1,283**
<1,050 – >1,045	417	200		**1,367**
1,045 – >1,040	417	450		**1,617**
1,040 – >1,035	417	500		**1,667**
1,035 – >1,030	417	550		**1,717**
1,030 – 1,025	417	600		**1,767**
<1,025	500	600		**1,850**

* This table only shows combined Lower Division State shortages, DCP contributions, and SEIS conservation. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the BWSCP, in accordance with Minute 323 to the 1944 Water Treaty (see **Appendix D**, CRMMS Model Documentation, **Tables D-9** and **D-10**).
** The amount of SEIS conservation could be higher or lower in a given year depending on the conservation agreements in place in that year. The total of ROD shortages, DCP contributions, SEIS conservation, and any other additional conservation would not exceed 2.083 maf in a given year.

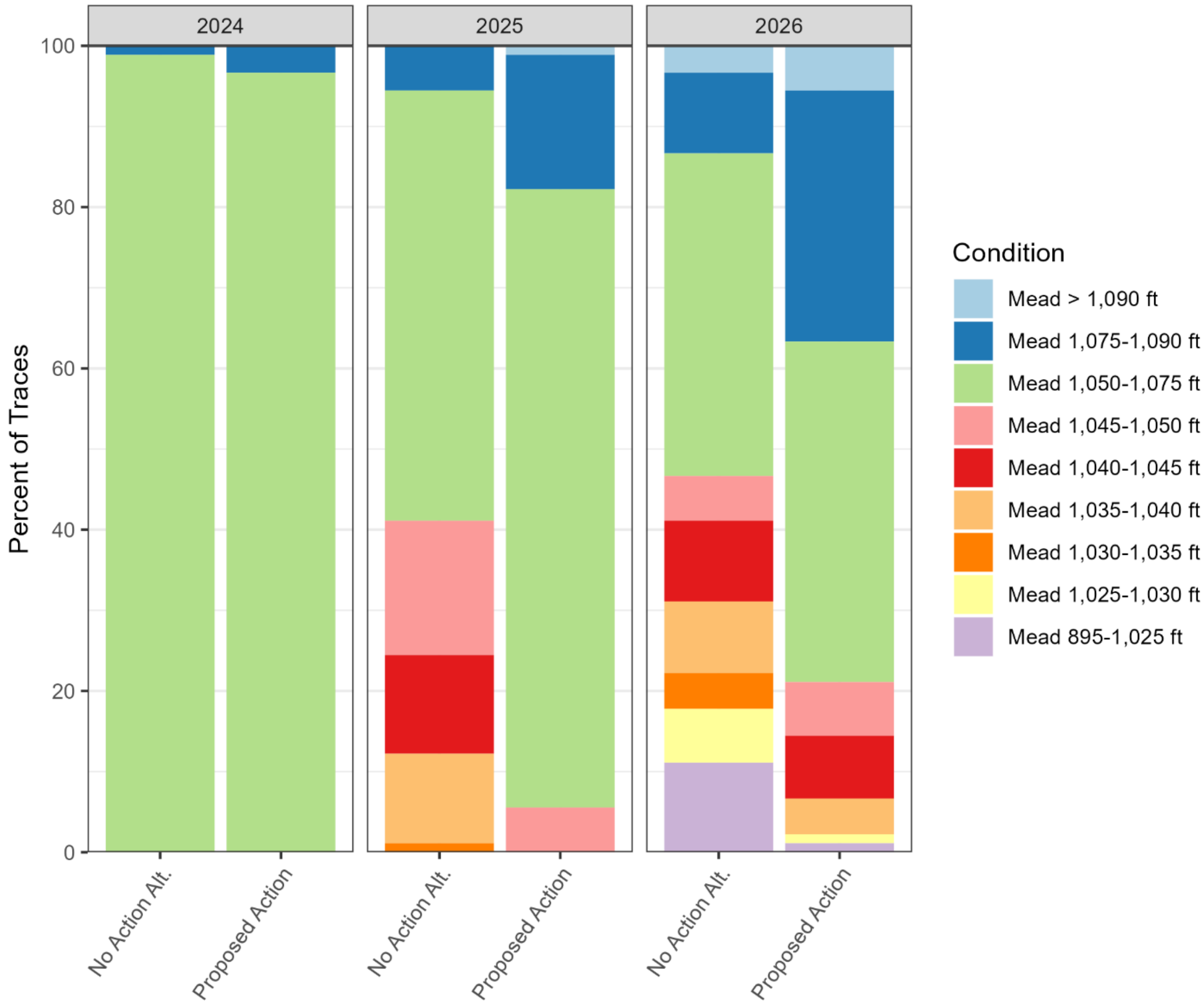
Modeled depletions, which incorporate the effects of ICS, under the No Action Alternative exceed those of the Proposed Action each year due to the additional SEIS Conservation included in the Proposed Action. However, under the Proposed Action, SEIS Conservation contributes to increasing elevations at Lake Mead, reducing the risk of shortages and DCP contributions to the Lower Division States in the later years of the analysis period.

Lower Basin Operating Condition

Figure 3-20 shows the percentage of modeled traces that were within each operational condition for the period of analysis. Under both alternatives, the applicable Operational Tier would continue to be based on the August 24-Month Study projection of the January 1 system storage and reservoir water surface elevations in Lake Mead for the following operating year. Each color represents a different threshold of shortage and DCP tier conditions based on **Table 3-13** and **Table 3-14**. **Figure 3-8** in **Section 3.6.2** shows the projected end-of-month pool elevations for Lake Mead from 2023 through 2026 for both alternatives.

As shown in **Figure 3-20**, in 2024, all modeled traces in both the No Action Alternative and Proposed Action experience December 31 Lake Mead elevations below the threshold for DCP contributions (1,090 feet) or shortages (1,075 feet). As shown in **Figure 3-8**, throughout the period of analysis, the range of hydrologic traces in the No Action Alternative result in lower monthly Lake Mead elevations than the Proposed Action. Under the Proposed Action, the median elevation of Lake Mead is higher than the No Action Alternative and exhibits an upward trend throughout the period of analysis. As a result, in each year, the No Action Alternative has more traces at operating conditions with greater combined shortages and DCP contributions compared with the Proposed Action.

Figure 3-20
Percent of Traces with Lower Division Shortage and DCP Tiers

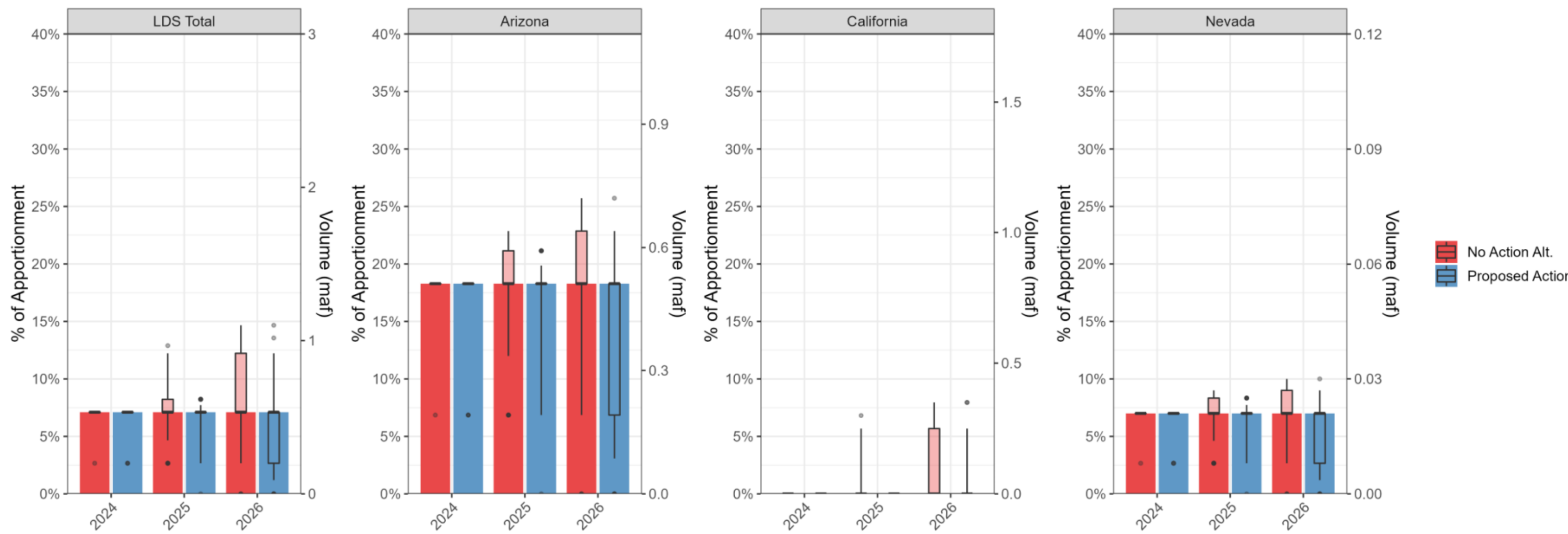


Distribution of Lower Division States Shortages and DCP Contributions

Specified shortage volumes and DCP contributions for the combined Lower Division States at different Lower Basin operating conditions are the same for both alternatives and shown in **Table 3-14**. Combined specified shortage volumes and DCP contributions broken down by Lower Division State are in **Table 3-1** in **Section 3.3.5**.

Figure 3-21 shows the distributions of Lower Division shortages and DCP contributions as a total and for each state in 2024, 2025, and 2026. The results are presented as a percent of apportionment and volume. The median modeled values are represented by the colored bar and the mid-line in the boxplots. The boxes capture the 25th to 75th percentiles of the modeled values and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-21
Distribution of Lower Division States' Combined Shortages and DCP Contributions



As shown in **Figure 3-21**, the median modeled combined annual shortage volumes and DCP contributions are the same across both alternatives at 533,000 af and are consistent within each state throughout the period of analysis. The maximum and minimum volumes change through time and between alternatives with slightly lower volumes in the Proposed Action compared to the No Action Alternative. These slight differences are due to the difference in the percent of traces in each operating tier under each alternative, as described for **Figure 3-20**.

The maximum total modeled Lower Division States combined shortage volumes and DCP contributions for operating year 2024 for the No Action Alternative and Proposed Action are 533,000 af. The maximum total modeled Lower Division States combined annual shortage volumes and DCP contributions are 967,000 af for 2025 and 1.1 maf for 2026 under the No Action Alternative. The maximum total modeled Lower Division States combined annual shortage volumes and DCP contributions are 617,000 af for 2025 and 1.1 maf for 2026 under the Proposed Action.

Combined Shortages and DCP Contributions for Arizona

For operating years 2024–2026, the median modeled combined annual shortage volumes and DCP contributions under the No Action Alternative for Arizona are constant for both alternatives and for the entire period at 512,000 af. However, the maximum volumes increase each year under both alternatives, but with slight differences in volume due to the difference in the percent of traces in each operating tier under each alternative. For the No Action Alternative, the maximum volumes are 512,000 af, 640,000 af, and 720,000 af, for 2024–2026, respectively. For the Proposed Action, the maximum combined shortage volumes and DCP contributions are 512,000 af, 592,000 af, and 720,000 af for 2024–2026, respectively.

Combined Shortages and DCP Contributions for Nevada

For operating years 2024–2026, the median modeled combined annual shortage volumes and DCP contributions under the No Action Alternative for Nevada are constant for both alternatives and for the entire period at 21,000 af. In 2024, the maximum volumes are also the same across each alternative at 21,000 af. However, the maximum volumes slightly differ between the alternatives in 2025 due to the difference in the percent of traces in each operating tier under each alternative, at 27,000 af for the No Action Alternative and 25,000 af for the Proposed Action. In 2026, the maximum volumes are again the same across the alternatives at 30,000 af.

Combined Shortages and DCP Contributions for California

California does not take shortages under either alternative, so this analysis represents only DCP Contributions for California. For operating years 2024–2026, the median modeled DCP contributions under the No Action Alternative for California are constant for both alternatives and for the entire period at zero, because the majority of traces stay above elevation 1,045 feet at Lake Mead – the elevation where California begins making DCP contributions. In 2024, California has no modeled DCP contributions in either alternative in any trace. In 2025, the maximum DCP contributions differ between the alternatives due to the difference in the percent of traces in each operating tier under each alternative, at 300,000 af under the No Action Alternative and zero for the Proposed Action. In 2026, the maximum modeled California DCP contributions are 350,000 af under both alternatives.

Distribution of Lower Division Shortages, DCP Contributions, and System Conservation

Specified shortage volumes, DCP contributions, and system conservation for the combined Lower Division States at different Lower Basin operating conditions are shown in **Table 3-14.** Combined specified shortage volumes, DCP contributions, and system conservation broken down by Lower Division State are in **Table 3-1** in **Section 3.3.5**.

Figure 3-22 shows the distributions of Lower Division shortages, DCP contributions, and system conservation as a total and for each state in 2024, 2025, and 2026. The results are presented as a percent of apportionment and volume. The median modeled values are represented by the colored bar and the mid-line in the boxplots. The boxes capture the 25th to 75th percentiles of the modeled volumes and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines. **Figure 3-22** is similar to **Figure 3-21** except that it includes modeled system conservation. Modeling assumptions, including the volumes of system conservation in each alternative, are stated in **Section 3.3.4** and are described in detail in **Appendix D.**

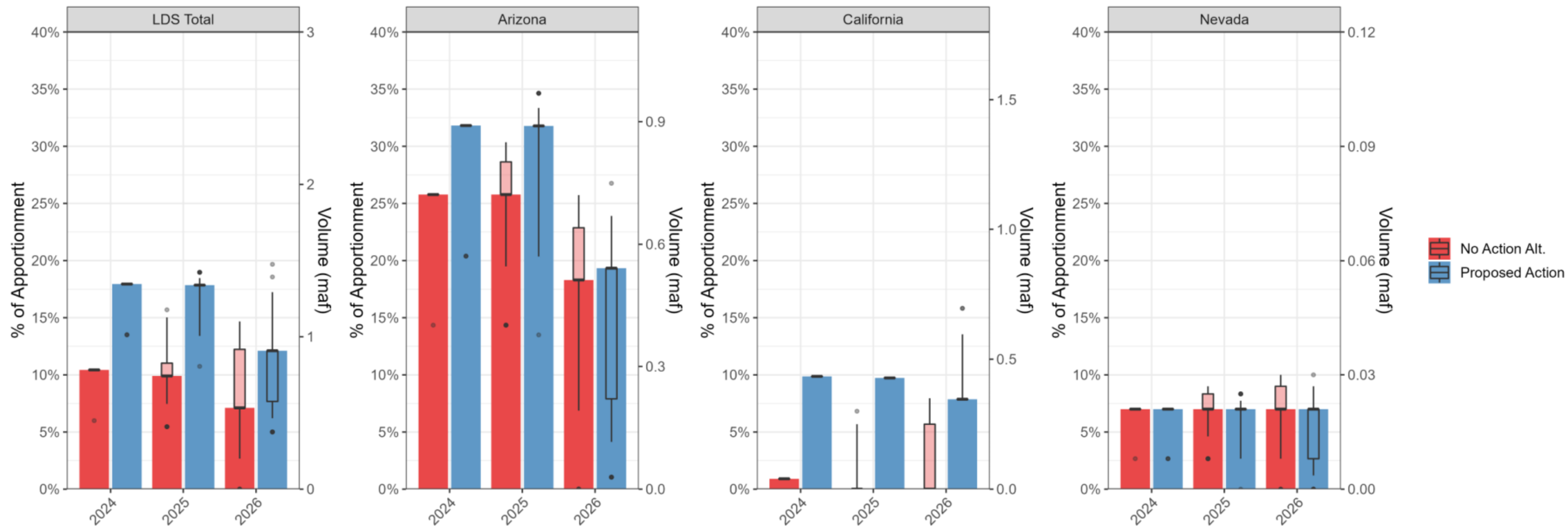
As shown in **Figure 3-22**, the total modeled Lower Division State median combined annual shortage volumes, DCP contributions, and system conservation are greater in each year under the Proposed Action compared to the No Action Alternative due to the additional SEIS conservation in the Proposed Action. For 2024–2026, the No Action Alternative has a total of 409 kaf of system conservation and the Proposed Action has a total of 1,943 kaf of SEIS conservation. If 2023 is included, the No Action Alternative has a total of 665 kaf of system conservation through 2026, and the Proposed Action has a much greater volume at a total of 2,468 kaf of SEIS conservation. Most of the SEIS conservation is modeled to occur between 2023 and 2025. A breakdown of the SEIS conservation by state and user is shown in **Table 3-2** in **Section 3.3.5**. Note that the volumes for SEIS conservation are modeling assumptions and do not represent mandatory shortages. The SEIS conservation was modeled to occur in every trace, meaning it will be a constant increase in the total modeled shortages and DCP contributions, previously described.

The median and maximum total modeled Lower Division State combined shortage volumes, DCP contributions, and system conservation for operating year 2024 for the No Action Alternative are both 782,718 af, and for the Proposed Action are both 1.346 maf. In 2025, the median and maximum total modeled Lower Division State combined annual shortage volumes, DCP contributions, and system conservation are 742,918 af and 1.179 maf, respectively, for the No Action Alternative, and 1.339 maf and 1.423 maf, respectively, for the Proposed Action. In 2026, the median and maximum total modeled Lower Division State combined annual shortage volumes, DCP contributions, and system conservation are 533,545 af and 1.101 maf, respectively, for the No Action Alternative, and 908,545 af and 1.476 maf, respectively, for the Proposed Action.

Combined Shortages, DCP Contributions, and System Conservation for Arizona

The median modeled combined annual shortage volumes, DCP contributions, and system conservation for Arizona under the No Action Alternative are 721,773 af in both 2024 and 2025 and decrease to 512,400 af in 2026. For the Proposed Action, the median volumes slightly decrease throughout the period and are 890,862 af, 889,862 af, and 541,400 af, respectively, reflecting a decrease in SEIS conservation throughout this period. Modeled SEIS Conservation for the Proposed Action for Arizona is listed in **Table 3-2** in **Section 3.3.5**.

Figure 3-22
Distribution of Lower Division States' Combined Shortages, DCP Contributions, and System Conservation[1]



[1] Combined shortages, DCP contributions, and system conservation does not include the effects of ICS, which contributes to the 3.0 maf of SEIS conservation and volumes vary in each hydrologic trace.

Combined Shortages, DCP Contributions, and System Conservation for Nevada

Nevada does not have any modeled system conservation, therefore the modeled combined annual shortage volumes, DCP contributions, and system conservation for Nevada is the same as the modeled combined annual shortage and DCP contributions in **Figure 3-21**. Modeled SEIS Conservation in the form of ICS creation for the Proposed Action for Nevada is described in **Table 3-2** in **Section 3.3.5**. The effects of ICS are not included in **Figure 3-22** but are included in **Table 3-15** and **Figure 3-23** and described in those parts of this section.

Combined Shortages, DCP Contributions, and System Conservation for California

No shortages exist for California for either alternative throughout the period of analysis. The median modeled combined annual DCP contributions and system conservation for California under the No Action Alternative vary throughout the period, with volumes of 39,945 af in 2024 and 145 af in both 2025 and 2026. For the Proposed Action, the median volumes gradually decrease throughout the period, reflecting a decrease in SEIS conservation, with volumes of 434,145 af, 428,145 af, and 346,145 af, respectively. Conservation for the Proposed Action for California is in **Table 3-2** in **Section 3.3.5**.

Intentionally Created Surplus

New ICS creation contributes to the 3.0 maf of SEIS conservation in the Proposed Action, and modeling assumptions differ for how ICS is treated when the maximum volume of ICS has been accumulated[11] between the two alternatives. This section summarizes differences in the modeled ICS activity between the two alternatives.

As described in **Appendix D** the ICS accumulation space sharing agreements allow states to share ICS accumulation space up to the capacity of 2.7 maf. When the maximum ICS has been accumulated, or at least one state is exceeding their maximum accumulation capacity, i.e., sharing accumulation space by using another state's space, ICS must be vacated if additional ICS is created. If a state is not using their maximum ICS accumulation space, as defined in the Lower Basin DCP, then the state that is 'sharing' their space must vacate ICS; if a state is already at their maximum accumulated ICS, and there is no accumulation space from another state to share, then that state must vacate ICS in order to create additional ICS. For the No Action Alterative, this is modeled by converting DCP-ICS to system water for all states if they need to vacate ICS space. Additionally, Nevada is modeled to take delivery of Extraordinary Conservation-ICS (EC-ICS) until they reach their maximum allowed ICS delivery at which point, EC-ICS is modeled to be converted to system water to vacate additional space (if necessary). The Proposed Action uses the same modeling assumptions as the No Action Alternative, except, if EC-ICS needs to be vacated, Nevada is modeled to convert all vacated EC-ICS to system water.

[11] In accordance with the Lower Basin DCP, the maximum total amount of Extraordinary Conservation ICS, Binational ICS, and DCP ICS that may be accumulated by the Lower Division States is 2.7 maf.

Figure 3-23
Lower Division State Modeled Depletions

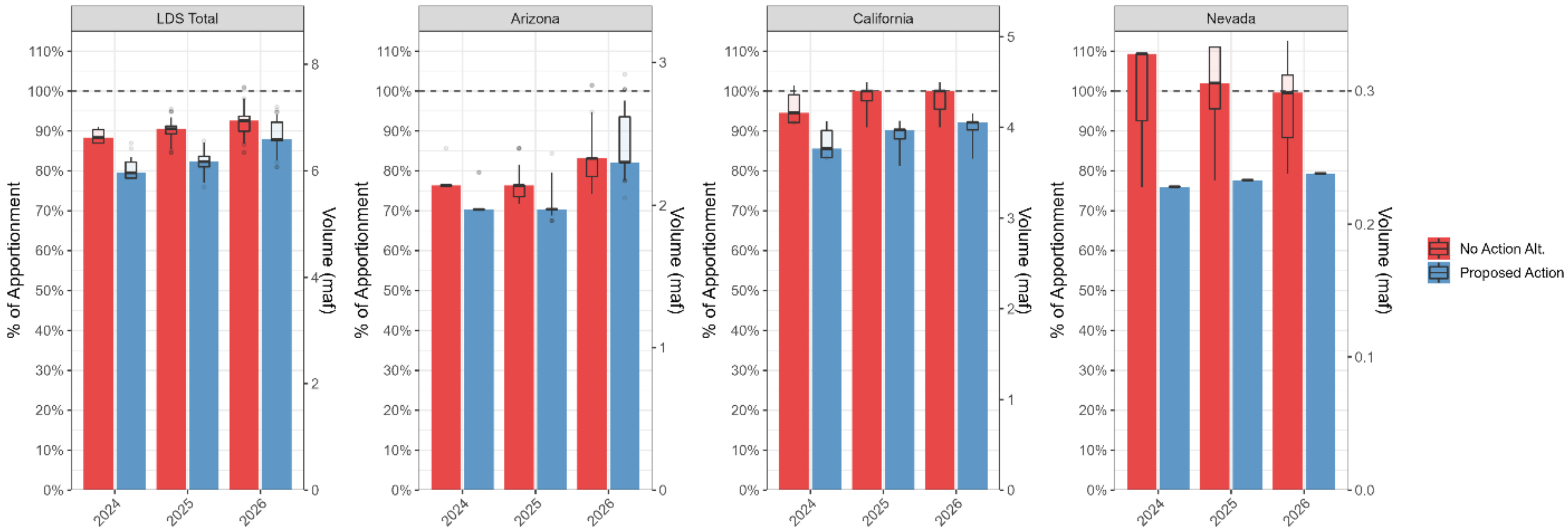


Table 3-15 shows the median modeled 2024-2026 ICS activities by state and as a Lower Division State total. For Arizona, ICS creation volumes are the same. Under the Proposed Action, there is slightly more ICS delivery modeled in Arizona because in 2026 EC-ICS is modeled to be delivered proportional to the remaining EC-ICS. Since Arizona has a lower delivery of EC-ICS in 2023 in the Proposed Action, a larger EC-ICS volume is available for delivery in 2026. For California, ICS activities are almost the same for both alternatives. The minor differences are because the Proposed Action includes additional ICS creation in 2023 (**Appendix D**), which results in a slightly smaller volume of ICS that can be created in 2024 through 2026 due to maximum ICS accumulation limits. For Nevada, the Proposed Action results in less ICS delivery, more ICS creation, and more ICS vacated to system water compared to the No Action Alternative. Since Nevada is using more than the state's individual maximum ICS accumulation, Nevada is modeled to vacate ICS so another state can create ICS. When this occurs in the No Action Alternative, it is assumed that Nevada takes delivery of Nevada's vacated ICS up to their maximum annual ICS delivery, while in the Proposed Action it is assumed that the vacated ICS is converted to system water. When combining the individual states' ICS activities, the Proposed Action has a median 397 kaf greater net positive effect on Lake Mead than the No Action Alternative.

Table 3-15
Median 2024-2026 Intentionally Created Surplus Activities

Total 2024-2026 ICS (1,000 af)*	Arizona		California		Nevada		Total Lower Division States	
	No Action Alternative	Proposed Action	No Action Alternative	Proposed Action	No Action Alternative	Proposed Action	No Action Alternative	Proposed Action
Creation	120	120	307	300	142	252	569	672
Delivery	147	161	2	2	95	0	244	163
Net Effect on Mead	-27	-41	305	298	47	252	325	509

* 2024-2026 are variable and can change with shortage conditions and ICS accumulation capacity sharing. Volumes shown in table represent the median for each alternative. In some scenarios, existing ICS water in Arizona and Nevada was modeled to be converted to system water to allow for the creation of new ICS, consistent with the Proposed Action, within ICS accumulation limitations.

Total Deliveries for the Lower Division States

Deliveries to the Lower Division States are dependent on the combined shortages, DCP contributions, and system conservation. Assumptions for ICS creation and delivery (see **Appendix D**) also affect the modeled deliveries to the Lower Division States.

Figure 3-23 shows the modeled depletions as a total for the Lower Division States and for each state in 2024, 2025, and 2026. The results are presented as a percent of apportionment and depletion volume. The median modeled values are represented by the colored bar and the mid-line in the boxplots. The boxes capture the 25th to 75th percentiles of the modeled values and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

In 2024, median Lower Division State depletions for the No Action Alternative are 6.626 maf and for the Proposed Action are 5.963 maf (**Figure 3-22**). The modeled 2025 and 2026 median total depletions for the Lower Division States are 6.791 maf and 6.946 maf under the No Action Alternative and 6.175 maf, and 6.594 maf under the Proposed Action, respectively. The total modeled depletions increase throughout the period of analysis as median combined shortages and DCP contributions remain the same, and system conservation decreases.

Modeled deliveries to the Lower Division States are lower in the Proposed Action relative to the No Action Alternative, due to the additional SEIS conservation included in the Proposed Action. Under the Proposed Action, the Lower Division States do not have depletions above their apportionment since it is assumed that Nevada converts vacated ICS to system water instead of taking delivery of the vacated ICS. However, maximum modeled combined shortages and DCP contributions are lower for the Proposed Alternative due to the impacts of SEIS conservation and resulting higher reservoir elevations in Lake Mead.

Total Deliveries to Arizona

Modeled annual depletions for Arizona are shown in **Figure 3-22**. In 2024 and 2025 under the No Action Alternative, the median modeled depletions total 2.138 maf; in 2026, the median modeled depletions total 2.328 maf. Deliveries to Arizona in the No Action Alternative increase in 2026 due to a decrease in shortages, DCP contributions, and system conservation. Under the Proposed Action, modeled water deliveries to Arizona are projected to gradually increase throughout the 3-year analysis period. This increase reflects a decrease in SEIS conservation throughout this period. In 2024–2026 under the Proposed Action, the median deliveries are 1.969 maf, 1.970 maf, and 2.301 maf, respectively. Under the Proposed Action, SEIS conservation reduces modeled deliveries to Arizona compared with the No Action Alternative. Additionally, under the Proposed Action, deliveries would likely be more reliable later in the time horizon relative to the No Action Alternative because the SEIS conservation in the Proposed Action results in higher elevations in Lake Mead.

Total Deliveries to Nevada

Modeled annual depletions for Nevada are shown in **Figure 3-22**. The trend and magnitudes of the depletions over the 3-year period differ between the alternatives. Under the No Action Alternative, water deliveries to Nevada are projected to decrease throughout the 3-year period of analysis but remain above or near full apportionment during this time. As described in **Appendix D** the ICS accumulation space sharing agreements allow states to share ICS accumulation space up to the capacity of 2.7 maf. In 2024, the ICS accumulation space fills and Nevada is required to vacate ICS so California can create ICS up to their individual state limit (in some traces). When this occurs, it is assumed that Nevada takes delivery of their vacated ICS, which results in depletions above their apportionment in 2024 and 2025 at 328,000 af and 306,000 af, respectively, despite Nevada's combined shortages and DCP contributions. In 2026, Nevada is still modeled to vacate its ICS in many instances, but the additional ICS delivery does not exceed the combined shortages and DCP contributions, resulting in a depletion just under 100 percent of apportionment at 299,000 af.

Under the Proposed Action, water deliveries are projected to increase through the 3-year analysis period. In 2024–2026, the median deliveries are 228,000 af, 233,000 af, and 238,000 af, respectively. Under the Proposed Action, it is assumed that Nevada converts vacated ICS to system water instead of taking delivery of the volume (see **Appendix D**), resulting in significantly lower depletions than under the No Action Alternative. Deliveries under this alternative would likely be more reliable later in the time horizon relative to the No Action Alternative because the SEIS conservation in the Proposed Action results in higher elevations in Lake Mead.

Total Deliveries to California

Modeled annual depletions for California are shown in **Figure 3-22**. The deliveries to California increase from 2024 to 2026 in both alternatives. In 2024–2026 under the No Action Alternative, the median deliveries gradually increase at 4.160 maf, 4.400 maf (less than 2026 prior to rounding), and 4.400 maf, respectively, reaching its full apportionment in 2026. In 2024–2026, the ICS accumulation is at capacity, and it is assumed that Nevada takes delivery of the vacated ICS so that California can create ICS. Deliveries to California increase over this period due to a reduction in system conservation between 2024 and 2025–2026[12], and a decrease in ICS creation because of the ICS accumulation limit.

Under the Proposed Action, modeled water deliveries to California are projected to increase throughout the 3-year analysis period. This increase reflects a decrease in SEIS conservation throughout this period. In 2024–2026, the median deliveries are 3.766 maf, 3.972 maf, and 4.154 maf, respectively. Under the Proposed Action, SEIS conservation reduces modeled deliveries to California compared with the No Action Alternative and also decreases maximum modeled DCP contributions. Additionally, under the Proposed Action, deliveries would likely be more reliable later in the time horizon relative to the No Action Alternative because the SEIS conservation in the Proposed Action results in higher elevations in Lake Mead.

Protect 1,000 feet at Lake Mead

The Proposed Action includes additional guidelines through which deliveries could be affected beyond the actions already described. In the Proposed Action, if Lake Mead is projected to be below an elevation of 1,025 feet, based on the April 24-Month Study minimum probable projection, the Lower Division States, after consultation with the Upper Division States, will have 45 calendar days to provide Reclamation with an implementation plan to protect Lake Mead from reaching an elevation of 1,000 feet. Though this term was not explicitly modeled in the Proposed Action, the percent of traces that fall below Lake Mead elevations of 1,025 and 1,000 feet can be used to estimate the possibility of this occurring.

Table 3-16 summarizes the percent of traces that fall below Lake Mead elevations of 1,000 and 1,025 feet in both alternatives. The Proposed Action has 1 percent of traces below 1,025 feet in 2025 and 8 percent in 2026. While only 2 percent of traces fall below 1,000 feet in 2026, this indicates that even with the SEIS conservation in the Proposed Action, additional actions may be necessary to protect 1,000 feet at Lake Mead before the end of 2026. Such actions could impact deliveries beyond the impacts of the other actions discussed. The No Action Alternative does not include modeling assumptions to protect an elevation of 1,000 feet in Lake Mead. However, to compare against the Proposed Action, the percent of traces falling below the Lake Mead elevations

[12] While California does have modeled DCP contributions throughout the period of analysis, the DCP contributions are typically modeled to be met via conversion of existing EC-ICS, so that does not reduce the annual delivery to California shown in this issue.

Table 3-16
Percent of Traces Falling Below Lake Mead Critical Elevations

Year	Percent of Traces below 1,025 feet		Percent of Traces below 1,000 feet	
	No Action Alt.	Proposed Action	No Action Alt.	Proposed Action
2024	0	0	0	0
2025	14	1	0	0
2026	23	8	4	2

is provided. In all cases there are fewer traces that fall below elevations 1,025 and 1,000 feet in the Proposed Action than in the No Action Alternative.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS but would result in no additional changes to water supply determinations or deliveries to Lower Division States. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact the distribution of shortages. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, however this would result in no changes to water supply determinations or water deliveries. Therefore, no additive cumulative effects would occur on water supply determinations or water deliveries to Lower Division States due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on water deliveries for Lower Division States due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 4: How would changes to operational activities affect deliveries to Mexico?

As stated above, Mexico's reductions and recoverable savings are in accordance with Minute 323, with a maximum of 275,000 af (of their 1,500,000 af annual water allotment) when Lake Mead is below 1,020 feet in elevation. This differs from the assumed 16.67 percent of the total shortage analyzed in the 2007 FEIS. The amount of water modeled for delivery to Mexico during each operating year has been set in accordance with the 1944 Water Treaty and Minute 323. The alternatives in this analysis do not change the specified reductions and recoverable savings to Mexico, as outlined in Minute 323; however, the Proposed Action does affect projected Lake Mead elevations (through modeled changes to Lake Powell's release and increased Lower Division State shortages). These differences in Lake Mead's elevation can result in different modeled reductions and recoverable savings for Mexico.

Figure 3-24 shows the modeled deliveries to Mexico for the No Action Alternative and Proposed Action in 2024, 2025, and 2026. The median modeled values are represented by the mid-line in the boxplots. The boxes capture the 25th to 75th percentiles of the modeled volumes and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Figure 3-24
Modeled Range of Deliveries to Mexico after Minute 323 Reductions and Savings

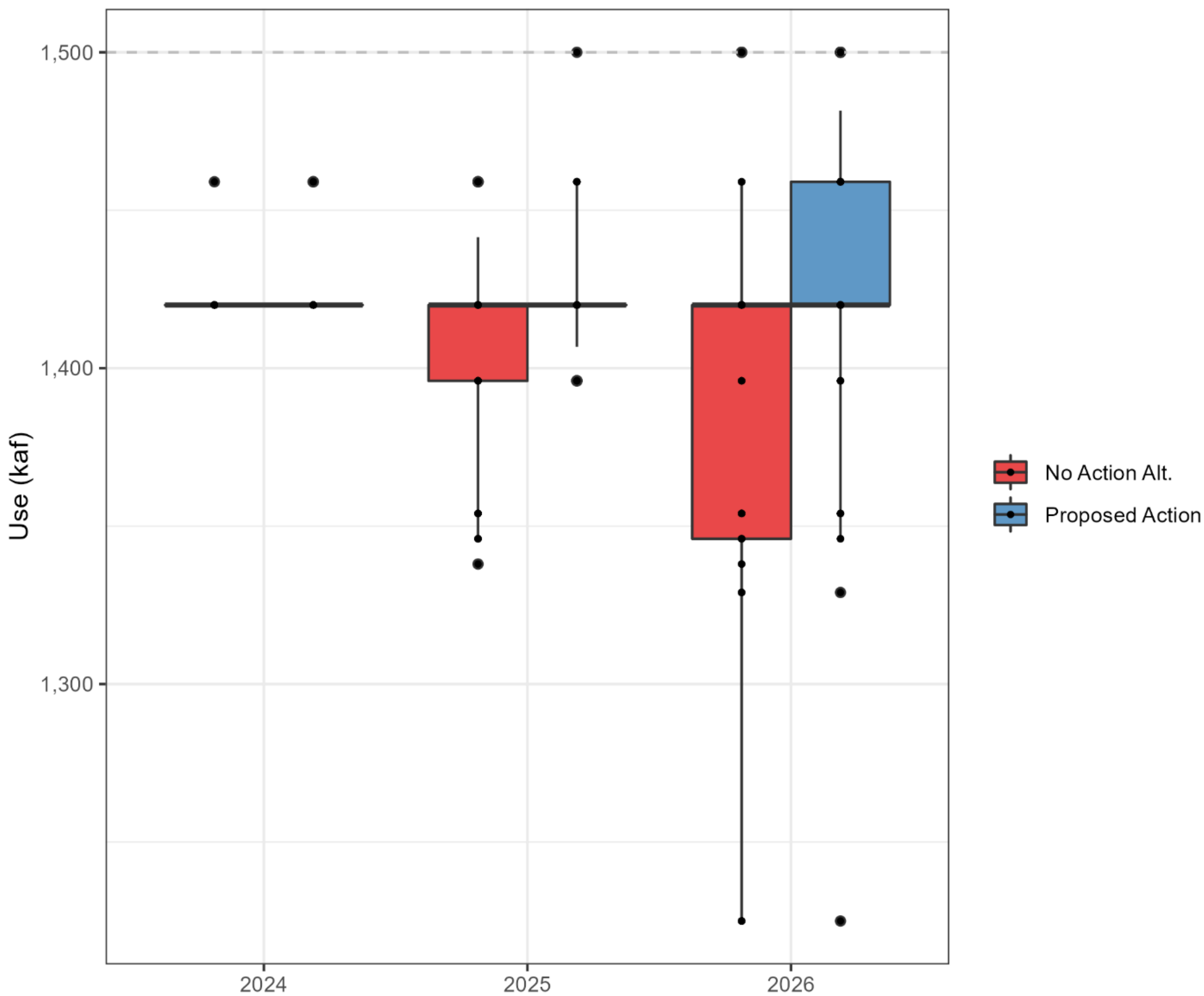


Figure 3-24 compares the modeled deliveries to Mexico for the No Action Alternative and Proposed Action. Both the No Action Alternative and Proposed Action show a median delivery to Mexico of 1.420 maf for 2024 through 2026. These deliveries are consistent with the Lake Mead elevations shown in **Figure 3-8**, which shows more consistent median elevations through 2026. Minimum modeled deliveries are lower under the No Action Alternative, consistent with lower minimum elevations at Lake Mead.

Figure 3-24 shows the modeled deliveries to Mexico for the No Action Alternative and Proposed Action in 2024, 2025, and 2026. The boxes capture the 25th to 75th percentiles of the modeled elevations and the whiskers extend to the 5th and 95th percentiles, with outliers represented as dots beyond these lines.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS but would result in no changes to water deliveries to Mexico. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact the distribution of shortages. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, however this would result in no changes to deliveries to the Lower Basin. Therefore, no additive cumulative effects would occur on water deliveries to Mexico due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on water deliveries to Mexico due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 5: How would changes to operational activities affect the modeled distribution of combined shortages and DCP contributions to and within the Lower Division States?

Summary of Alternatives

Lower Division States' shortage distributions discussed under this issue were modeled with the Shortage Allocation Model to estimate the quantity of available water to entitlement holders or water users under shortage conditions over a specified range of shortage volumes. Overall, the No Action Alternative and Proposed Action analyze the same magnitude of total shortage and DCP contributions. There is no unique Shortage Allocation Model for the Proposed Action since the distribution and priority of shortages and DCP contributions is the same as the No Action Alternative. Total Lower Division States' reduction in water delivery of up to 1.100 maf was analyzed under both alternatives. This is consistent with the 2007 Interim Guidelines shortages and 2019 DCP contributions. The distribution of these volumes is the same between the alternatives and is based on priority within each state or as provided otherwise by the 2019 DCP. Modeling details for the Shortage Allocation Model are described in **Appendix E**. While the Proposed Action considers additional volumes of system conservation, known as SEIS conservation and modeled based on the Lower Division States proposal, further discussion of SEIS conservation is not included under this issue. For the purposes of discussion, only shortages and DCP contributions, as defined by those implemented through operational decisions, are referenced in this issue.

Under the No Action Alternative and Proposed Action, the maximum total volume of the 2007 Interim Guidelines shortages and 2019 DCP contributions is 1.1 maf, when Lake Mead is below an elevation of 1,025 feet. The maximum shortage and DCP contribution volumes for Arizona and Nevada are 720,000 af and 30,000 af, respectively. The maximum DCP contributions for California are 350,000 af. A maximum reduction in water delivery of 1.1 maf is less than 15 percent of the total Lower Division States' apportionment.

Distribution of Shortages within Arizona

Table 3-17 provides a summary of the total shortage and DCP contribution impacts modeled for Arizona, broken out by the range of analyzed shortage volumes under the No Action Alternative and Proposed Action for 2024–2026. Total basin combined shortages and DCP contributions analyzed for the Lower Division States ranged from 200,000 af to 1.1 maf. This resulted in 192,000 af to 720,000 af in reductions for Arizona, in accordance with the 2007 Interim Guidelines and 2019 DCP. As the volume of total shortage analyzed increases, there is a corresponding increase in shortages allocated to Arizona 4th-priority entitlement holders, including CAP contracts and subcontracts. (Refer to **Appendix E** for additional information.)

Distribution of Shortages within Nevada

Table 3-18 provides a summary of the total shortage and DCP contribution impacts modeled for Nevada, broken out by the range of analyzed shortage volumes under the No Action Alternative and Proposed Action for 2024–2026. Total combined shortages and DCP contributions analyzed for the Lower Division States ranged from 200,000 af to 1.1 maf. This ultimately resulted in 8,000 af to 30,000 af in reductions for Nevada, in accordance with the 2007 Interim Guidelines and 2019 DCP. There is a corresponding increase in shortages allocated to Nevada (up to 30,000 af), but only at the 8th-priority level. (Refer to **Appendix E** for additional information.)

Distribution of Shortages within California

Table 3-19 provides a summary of the total shortage and DCP contribution impacts modeled for California, broken out by the range of analyzed shortage volumes under the No Action Alternative and Proposed Action for 2024–2026. Total basin combined shortages and DCP contributions analyzed for the Lower Division States ranged from 200,000 af to 1.1 maf. This resulted in 0 af to 350,000 af in reductions for California, which are attributed to only 2019 DCP contributions. (Refer to **Appendix E** for additional information.)

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact the distribution of shortages. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, however this would result in no changes to the distribution of shortages. Therefore, no additive cumulative effects would occur on water deliveries to Lower Division States due to proposed operational changes evaluated in the LTEMP SEIS.

Lastly, no additive cumulative effects would occur on water deliveries for Lower Division States due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Table 3-17
Shortage Impacts Modeled for Arizona by Priority

Summary of Shortage Impacts by State and Priority	Range of Analyzed Volumes of Total Shortage to Lower Division States							
Arizona – Priority	**200,000**	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**
5th, 6th, and CAP Agricultural and Other Excess	192,000	294,465	335,708	338,687	338,687	338,687	338,687	330,681
4th Priority I (Mainstream)	0	0	0	0	0	0	0	18,520
4th Priority ii (CAP)[1]								
NIA Priority	0	217,535	245,633	245,633	245,633	245,633	245,633	245,633
M&I Priority	0	0	0	32,302	32,302	32,302	32,302	80,877
Indian Priority	0	0	10,659	23,378	23,378	23,378	23,378	44,289
2nd and 3rd Priorities	0	0	0	0	0	0	0	0
1st Priority (PPR)	0	0	0	0	0	0	0	0
Subtotal	**192,000**	**512,000**	**592,000**	**640,000**	**640,000**	**640,000**	**640,000**	**720,000**

Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.

Note: Orange highlights indicate the level at which available water for a priority is reduced to zero.

Note: Refer to **Appendix E**, Shortage Allocation Model Documentation, for additional information.

[1]Water for AZ P5 (unused) and P6 (surplus) contracts is not available during shortage and for the purposes of this analysis, these contracts are assumed not to be fulfilled. CAP agricultural and other excess contracts do not confer a Colorado River water entitlement and cannot be exercised under any of the scenarios modeled here.

Disclaimer: These modeling results for the No Action Alternative should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation. The modeling assumptions are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and it cannot replicate the precision required of that process.

Table 3-18
Shortage Impacts Modeled for Nevada by Priority

Summary of Shortage Impacts by State and Priority	Range of Analyzed Volumes of Total Shortage to Lower Division States							
Nevada – Priority	**200,000**	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**
8th Priority (SNWA—Balance and Unused)	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000
8th Priority (SNWA and Big Bend)	0	0	0	0	0	0	0	0
7th Priority (Boy Scouts, Reclamation, and Nevada Department of Wildlife)	0	0	0	0	0	0	0	0
6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
5th Priority (PABCO and Lakeview Company)	0	0	0	0	0	0	0	0
4th Priority (Henderson and Basic Management)	0	0	0	0	0	0	0	0
3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
2nd Priority (LMNRA)	0	0	0	0	0	0	0	0
1st Priority (PPRs: LMNRA and Fort Mojave Indian Reservation)	0	0	0	0	0	0	0	0
Subtotal	**8,000**	**21,000**	**25,000**	**27,000**	**27,000**	**27,000**	**27,000**	**30,000**

Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.
Note: Refer to **Appendix E**, Shortage Allocation Model Documentation, for additional information.

Disclaimer: These modeling results for the No Action Alternative should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation. The modeling assumptions are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and they cannot replicate the precision required of that process.

Table 3-19
Shortage Impacts Modeled for California by Priority

Summary of Shortage Impacts by State and Priority	Range of Analyzed Volumes of Total Shortage to Lower Division States							
California—Priority	**200,000**	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**
4th Priority (MWD)	0	0	0	186,000	232,500	279,000	325,500	325,500
3rd Priority (IID, CVWD, Palo Verde Irrigation District)	0	0	0	14,000	17,500	21,000	24,500	24,500
2nd Priority (Yuma Project Reservation Division)	0	0	0	0	0	0	0	0
1st Priority (Palo Verde Irrigation District)	0	0	0	0	0	0	0	0
PPRs	0	0	0	0	0	0	0	0
Subtotal	**0**	**0**	**0**	**200,000**	**250,000**	**300,000**	**350,000**	**350,000**

Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.
Note: Refer to **Appendix E**, Shortage Allocation Model Documentation, for additional information.

Disclaimer: These modeling results for the No Action Alternative should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation. The modeling assumptions are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and they cannot replicate the precision required of that process.

Issue 6: How would changes to operational activities affect flows into the Salton Sea?

Summary of Alternatives

As noted above, the Salton Sea receives flows from the surrounding watershed and excess irrigation drainage from the IID and CVWD. Under the No Action Alternative, there would be no changes to current operational activities that would affect flows to the IID or CVWD. Therefore, the surface water elevation of the Salton Sea could continue to decrease at the current rate. Under the Proposed Action, there is the possibility that the IID and CVWD could enter into additional system conservation agreements; thus, there could be reduced deliveries, resulting in potentially less inflow to the Salton Sea from irrigation drainage. Therefore, the Proposed Action could result in expedited (but not additional) lake bed exposure compared with the No Action Alternative, due to less possible available agricultural runoff. Lake bed exposure may be greater under the Proposed Action for the next 26 years, as estimated by the Salton Sea Modeling (Tetra Tech 2023), but long-term impacts would be the same as under the No Action Alternative.

3.8 Water Quality

3.8.1 Affected Environment

This section describes the water quality constituents that could be affected by the alternatives. These water quality constituents of concern are:

- Salinity
- Temperature
- Sediment
- Nutrients and algae
- Dissolved oxygen
- Metals
- Perchlorate

This section describes historical and existing condition changes that have occurred since the 2007 FEIS was published. (For more information on the water quality constituents and historical conditions prior to 2007, refer to the 2007 FEIS.) While other water quality-related issues and parameters were also considered, they were determined unlikely to be affected by the alternatives, or there was insufficient data to provide an assessment; therefore, they are not discussed here.

Salinity

Historically, salinity has been a concern for the Basin. High salinity causes damage across agricultural, municipal, and industrial sectors in the US, and it negatively impacts municipal and agricultural users in Mexico (USGS 2021). (See the 2007 FEIS for more information.)

The salinity criteria for the Colorado River have not been updated since the 2007 FEIS was published. The Colorado River Basin Salinity Control Forum continues to review and make salinity criteria recommendations for the Colorado River every 3 years (Colorado River Basin Salinity Control Forum 2020). **Table 3-20** shows the current salinity criteria for the Colorado River.

Table 3-20
Salinity Criteria for the Colorado River

Station	Flow-weighted average annual salinity (mg/L)
Below Hoover Dam	723
Below Parker Dam	747
At Imperial Dam	879

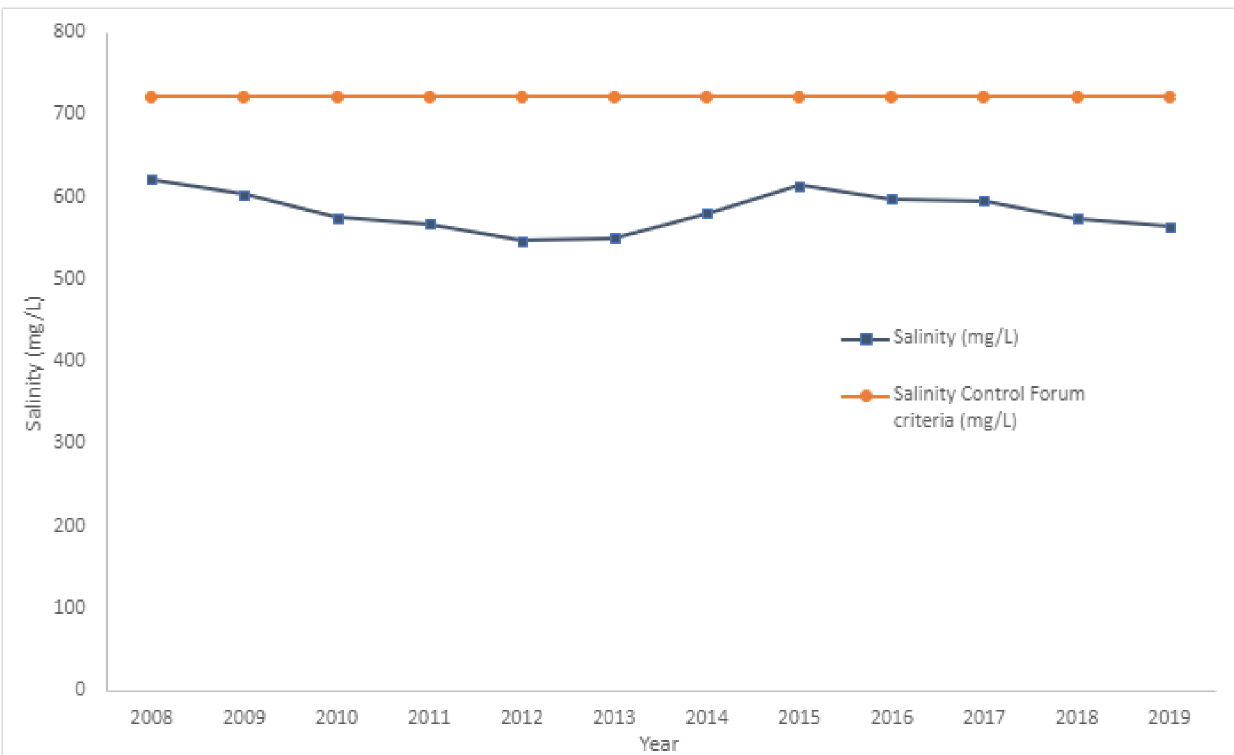
Source: Colorado River Salinity Control Forum 2020

While salinity in the Colorado River has generally decreased over the past century (USGS 2021), salinity has only slightly decreased since 2007. Implementing measures on private agricultural lands results in salinity controls. Programs like the Basin States Program and the US Department of

Agriculture's Environmental Quality Incentives Program provide cost-share assistance to landowners who install salinity control measures (Reclamation 2022d). Despite these salinity control efforts, there has been a consistent slowing of downward trends since 2000 (Rumsey 2021).

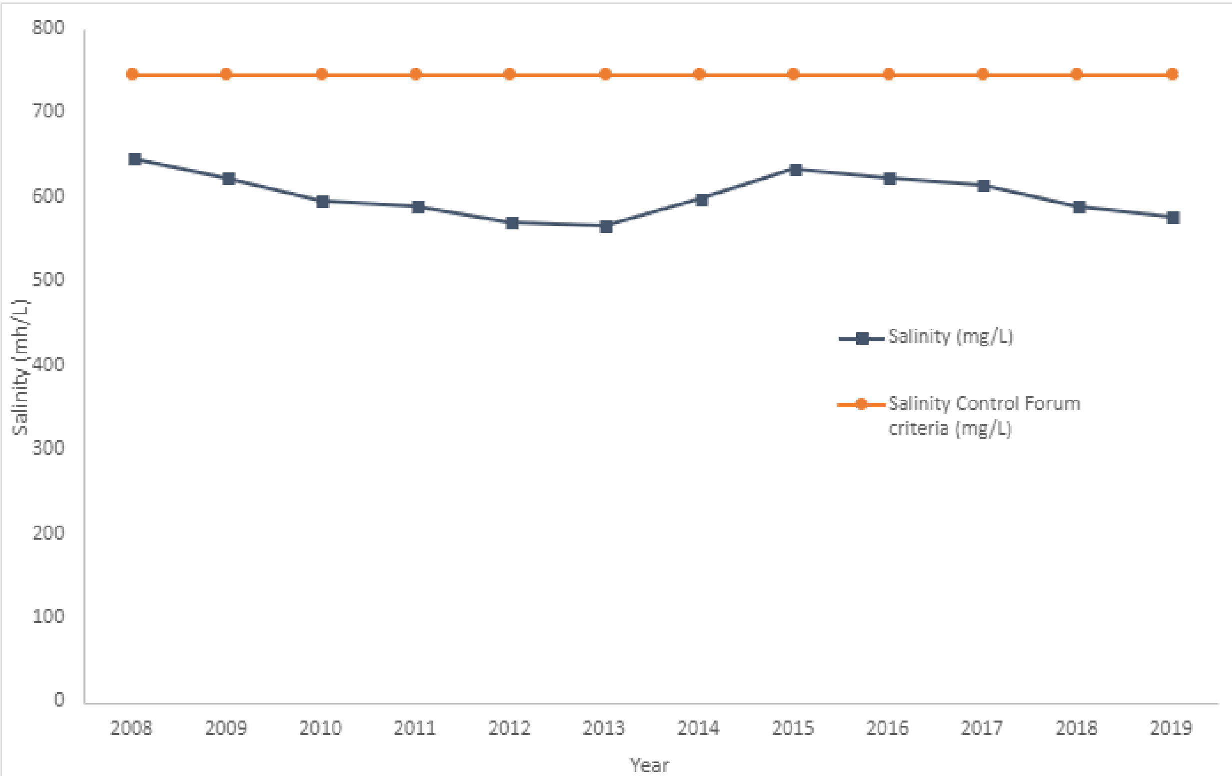
When the 2007 FEIS was released, salinity downstream of Glen Canyon Dam varied between 390 and 660 milligrams per liter (mg/L); more recently, salinity has varied between 300 and 600 mg/L (Reclamation and NPS 2016). It is important to note that releases from lower elevations in Lake Powell through the river outlet works are cooler and more saline compared with releases from higher elevations through the penstocks of Glen Canyon Dam (Reclamation and NPS 2016). In a review of sampling efforts from 2007–2019, Reclamation has not exceeded the salinity criteria for the Colorado River, which are described in **Table 3-20**. At the time of this report, data were not available after 2019 (Reclamation 2019b). (See **Figure 3-25**, **Figure 3-26**, and **Figure 3-27** for more information and historical salinity concentrations in the Lower Basin.)

Figure 3-25
Colorado River Salinity Concentrations and Flows Downstream of Hoover Dam 2008–2019



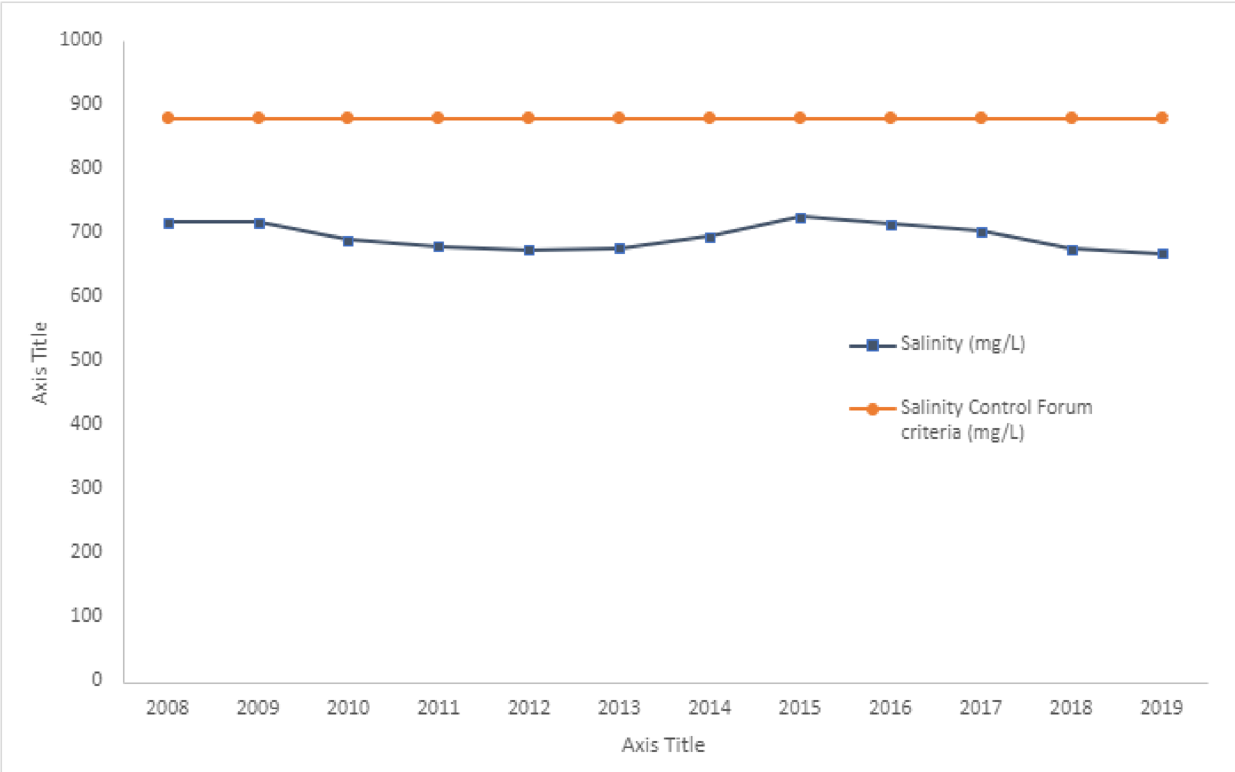
Source: Colorado River Basin Salinity Control Forum 2020

Figure 3-26
Colorado River Salinity Concentrations and Flows Downstream of Parker Dam 2007–2019



Source: Colorado River Basin Salinity Control Forum 2020

Figure 3-27
Colorado River Salinity Concentrations and Flows at Imperial Dam 2007–2019



Source: Colorado River Basin Salinity Control Forum 2020

Temperature

Since the early 2000s, drought conditions and lower water levels in Lake Powell have led to a general warming of water temperatures in the Colorado River below Glen Canyon Dam (Reclamation and NPS 2016). Temperatures in the Colorado River in the Grand Canyon are highly variable over space and time and are primarily controlled by the discharge and temperature released from Glen Canyon Dam and solar radiation dynamics along the river corridor (Mihalevich et al. 2020). As water moves farther away from Glen Canyon Dam (for example, below river mile [RM] 88), the influence of release discharges and temperature on water temperature becomes less, and local meteorological conditions become more important in determining the heat budget.

During summer periods, increases in water temperatures downstream of Glen Canyon Dam are attributed to solar radiation and air temperatures (Dibble et al. 2021). The water in the Colorado River generally warms 1˚C (33.8˚F) for every 30 miles traveled downstream during warmer months of the year under specific discharge and meteorological conditions. Some variation in lateral warming also occurs, with warmer temperatures along the shoreline and cooler water in the deep, fast-moving areas (Reclamation and NPS 2016).

Lake Powell is thermally stratified through much of the spring, summer, and early fall; this means Lake Powell is arranged into layers with distinct temperatures and chemical characteristics. Generally, Lake Powell's epilimnion, or uppermost layer, ranges from 25˚ to 30˚C (77˚ to 86˚F) in the summer and may drop to 6°–10°C (42.8°–50°F) in the winter. Lake Powell's hypolimnion, or deeper layer, ranges from 6° to 9°C (42.8° to 48.2°F). Lake Powell experiences relatively homogenous temperatures throughout the water column. In the winter, the thermal stratification breaks down, and Lake Powell experiences turnover where the different layers mix to create relatively homogenous conditions throughout the water column (Reclamation and NPS 2016). Full turnover does not occur every year, but partial turnover does.

Lake Mead is also thermally stratified. The temperature that enters Lake Mead is a function of Glen Canyon Dam discharges and downstream meteorological conditions (Reclamation and NPS 2016). Lake Mead's hypolimnion, or deepest layer, is around 12°C (53.6°F) year-round. Lake Mead's epilimnion, or uppermost layer, ranges from about 14° to 29°C (57.2° to 84.2°F) in the spring, summer, and early fall, then drops to about 13°–15°C (55.4°–59°F) in the winter (SNWA 2023). (For additional historical data, see the 2007 FEIS.)

Sediment

Sediments, as considered in this analysis, are those that are sand sized (0.06 to 2.0 millimeters) or smaller. High concentrations of fine suspended sediment (less than 0.06 millimeters) can increase turbidity (cloudiness), a water quality measure that affects light penetration and photosynthesis for aquatic species. (See **Section 3.13.2**, Biological Resources Environmental Consequences, for a description of the effects of turbidity on fish.)

Downstream of Hoover Dam, infrequent sediment inputs from the Bill Williams River and the Gila River cause sediment loading and increased turbidity. Reclamation continues to implement dredging projects upstream of Imperial and Laguna Dams to remove accumulated sediment and ensure efficient delivery of Colorado River water to downstream users (Reclamation 2021b; USGS 2022).

Sediment in the reach from Lake Powell to Lake Mead depends on a mass balance between sediment deposition, erosion, and storage. Sediment deposition occurs wherever there is more sediment influx than efflux (Grams et al. 2013). Sediment storage is a dynamic condition that varies based on the specific spatial and temporal scales considered; it can be increasing (net deposition), decreasing (net erosion), or at equilibrium.

Sand is deposited throughout the reach between Lake Powell and Lake Mead (in the Marble and Grand Canyons) in bars (or patches) on the riverbed, in eddies, and on terrace sandbars (Reclamation and NPS 2016). Sandbars and beaches are important for biological, cultural, and recreational resources along the Colorado River. They form the substrate for the limited riparian vegetation in the arid environment (Hazel et al. 2022). Low-elevation sandbars create zones of low-velocity aquatic habitat (backwaters) that juvenile native fish utilize (Grams et al. 2010). These low-elevation sandbars are also a source of sand for aeolian (wind) transport. Under National Park Service and LTEMP goals, these areas are managed to reduce vegetation to a more natural and bare condition that enables dunes to migrate upslope, help protect archaeological resources (Sankey et al. 2022), and rebuild camping beaches for river and backcountry users (Hazel et al. 2022).

Sandbars (including beaches) continuously exchange sand with the Colorado River. Thus, the sandbars commonly found along the banks of the Colorado River are generally dynamic and unstable. Since 1996, Reclamation has continued to conduct HFE releases to manage limited sediment resources to maintain or increase sandbar size. HFEs are experiments designed to improve sediment deposition, in which water releases from Glen Canyon Dam are much larger than the base flow that is typically released. HFEs are the only existing mechanism for producing river stages high enough to contribute to significant sandbar building. As regulated under LTEMP, Reclamation uses two 6-month sediment accounting windows, or periods (one during the fall and one during the spring). These are used to evaluate whether the sediment mass balance is optimal for sandbar building prior to HFE implementation. HFE releases between 34,000 and 37,000 cfs (or greater) are necessary for sandbar deposition (increased sandbar size); generally sandbars erode between HFEs (Hazel et al. 2022).

After the most recent HFE was completed in April 2023, reservoir balancing during July and August 2023 resulted in sustained high releases and net sediment export. This has effectively reduced the probability of triggering another HFE between November 2023 and April 2024.

Long-term rehabilitation of sandbars is only possible if the increases in sand volume caused by HFEs exceed the erosion during intervening operational flow periods (Schmidt and Grams 2011). This is why frequent HFEs were designed under the LTEMP protocol and why frequent HFEs are needed to allow for net building versus net erosion. This is also why high flows, such as equalization flows, should be avoided between HFEs.

River stage also affects the area of sand available for aeolian transport, as lower flows expose larger areas of bare sediment that can be mobilized by wind. Once sand has been exposed (not inundated) for a period of 3 consecutive days, that sand is approximately as mobile as the sand that was not previously inundated (Sankey et al. 2022).

Turbidity is known to increase in this reach during large sediment inputs from tributaries, such as the Paria River (USGS 2016), and during HFEs (Voichick and Topping 2010). As analyzed in the LTEMP FEIS, turbidity increases from erosion during HFEs are temporary; any observed fluctuations recover quickly when flows return to those less than flows of an HFE magnitude (Reclamation and NPS 2016). These trends would continue under both alternatives.

Nutrients and Algae

The 2007 FEIS describes how deeper or hypolimnetic releases from Glen Canyon Dam are relatively nutrient rich, whereas epilimnetic, or higher releases, may reduce nutrients available to downstream ecosystems. Nutrients, like nitrogen and phosphorus, are necessary for healthy aquatic ecosystems, but high levels of nutrients can cause algal blooms and poor water quality, threatening drinking water quality and harming aquatic life. Releases from Glen Canyon Dam and downstream Colorado River waters are generally low in nutrients (for example, the Glen Canyon Dam releases average 0.005 mg/L; Deemer et al. 2023). However, inflows from tributaries typically contain warmer, nutrient-rich water that mixes with the Colorado River (Reclamation and NPS 2016).

Total phosphorus samples at Lake Mead typically range from undetectable to 3.9 mg/L (SNWA 2023). In Lake Mead, water within the Las Vegas Bay has the highest concentration of nutrients due to the discharge of wastewater effluent from the Las Vegas metropolitan area. Wastewater is a persistent contributor to the phosphorus needed to sustain algal growth, and stormwater with higher phosphorus contributions is an acute contributor. Since phosphorus is a limiting nutrient in the Colorado River system, these contributions support algal growth (USGS 2012). Additionally, lowering reservoir levels generally increases the concentration of nutrients and temperature levels, especially in shallow areas, which are more favorable for algal growth.

In Lake Mead in 2015, increases in the temperatures of water entering Lake Mead led to a harmful algal bloom caused by a cyanobacteria, *Microcystis*, which can produce toxins harmful to humans, pets, and wildlife (Reclamation and NPS 2016). (See **Section 3.14**, Recreation, for information about harmful algal blooms' impacts on recreation.)

No new total maximum daily loads have been issued or evaluated for total phosphorus or ammonia in the Las Vegas Wash since the 2007 FEIS was published.

Dissolved Oxygen

Dissolved oxygen (DO) levels in Lake Powell and the Glen Canyon Dam tailwaters[13] have been low compared with historical DO levels. This is due to a combination of low reservoir elevations and high inflows in recent years. Resuspended sediments at the inflow areas cause low DO plumes; this is because that suspended sediment creates high biological and chemical oxygen demand (that is, bacteria and other biota consuming oxygen, and chemical reactions consuming oxygen). This problem is exacerbated whenever large sediment inputs occur, especially when sediment erodes from the reservoir banks in the springtime. Also, during low lake elevations, more bed-cutting and bank erosion occur. Under low lake elevations, the residency time in Lake Powell is shorter for the low DO plumes, and the low DO water appears at Glen Canyon Dam sooner than it would under higher starting lake elevations.

The low DO condition resolves downstream of the Paria Riffle and Badger Rapids as the water is reaerated through whitewater action. The Colorado River DO increases approximately 1 mg/L between Glen Canyon Dam and Lees Ferry. This approximation can vary between negligible re-oxygenation and approximately 3 mg/L increases during very low oxygen releases during daylight hours (GCMRC 2023). DO levels below Glen Canyon Dam vary throughout the year, starting as low as 2.2 mg/L in the summer and fall and rising as high as 9 to 10 mg/L in the spring (GCMRC 2023). This seasonal variation is due to changes in DO at the penstock level of Lake Powell during the year. In recent years, periods of low DO (less than 5 mg/L) have become more common due to the age of the reservoir and more volume of deltaic sediment available to be remobilized.

Generally, Lake Powell DO concentrations are at their highest in the spring to early summer, when inflows are well oxygenated and wind-induced mixing are high. Low DO concentrations move through the reservoir and closer to the dam during the summer into the fall because of organic matter decomposition and chemical reactions that consume oxygen. DO gradually increases in the winter as a result of the higher oxygen-carrying capacity of cold water and the natural mixing processes that occur during turnover. Notably, when water is discharged through the river outlet

[13] Tailwater is the water below the reservoir that would be more similar to reservoir waters than downstream waters.

works, such as during HFEs or the flow options evaluated here, it becomes well-aerated and increases the DO levels in the tailwaters—but only as long as the river outlet works are open.

In Lake Mead, DO levels decrease in the bottom of the Las Vegas Basin as a result of high decomposition rates. Living algae in surface waters produce oxygen, then oxygen is consumed when the algae are decomposed in bottom waters. When greater nutrients and algae exist in surface water, more decomposition and low oxygen occur in bottom waters, assuming a stratified system. Ongoing monitoring and investigations are being conducted to determine the cause of decreased DO concentrations in isolated sections, but the driver is likely higher temperatures from inflows. Backwaters in embayments have little water exchange and tend to be shallower and warmer. These conditions increase the likelihood of algae blooms and issues with low DO conditions, or hypoxia, when the algae die (Reclamation and NPS 2016). (See **Section 3.13**, Biological Resources, for information about algal blooms' effects on wildlife.)

Metals

The 2007 FEIS describes the sources of various metals, including selenium and mercury, within the planning area. Selenium and mercury are toxic to fish and wildlife and can accumulate in the food web (Walters 2015). The Environmental Protection Agency's (EPA's) drinking water maximum contaminant level (MCL) for mercury has not been updated since the 2007 FEIS; the MCL is 0.002 mg/L. The Lower Basin's selenium standard is 0.002 mg/L. The selenium in the Colorado River is about 0.001 mg/L greater than the standard. There have been no significant changes to selenium or mercury since the 2007 FEIS was published.

The 2007 FEIS also describes the soluble hexavalent chromium detected in groundwater in two known locations in the Lower Basin: at the former McCulloch Manufacturing Plant in Lake Havasu City, Arizona, and at the Pacific Gas and Electric Compressor Station near Needles, California. Since 2007, mitigation efforts and plume monitoring have been ongoing. The latest groundwater monitoring data indicate that plume migration is not occurring (California Water Boards 2022). The landowner continues to monitor the chromium associated with the former McCulloch Manufacturing Plant at Lake Havasu and Holly Avenues. Based on the latest site investigations, the groundwater chromium plume extended approximately 3,000 feet long and about 600 feet wide from the former McCulloch facility. This remained within the vicinity of the former McCulloch facility, which is several thousand feet from the Colorado River (Arizona Department of Environmental Quality 2022).

Under lower lake elevations in Lake Powell, turbidity currents reaching the dam outtake have been observed. There is uncertainty about whether any of this turbidity contains metals from deltaic sediments, such as from past mining spills (USGS 2018).

Perchlorate

The 2007 FEIS describes the perchlorate contamination linked to a groundwater plume from the Kerr McGee Chemical Company in Henderson, Nevada. Since 2007, mitigating the perchlorate contamination has been an ongoing effort. The Nevada Division of Environmental Protection and the SNWA show a decreasing trend in perchlorate concentrations over the last decade, especially after point source remediation efforts began in 2002 (Hannoun and Tietjen 2022).

Salton Sea

As stated in **Section 3.3.6**, the Salton Sea receives runoff from its surrounding watershed (not the Colorado River Basin) and agricultural runoff that originates in the Colorado River Basin (deliveries) USGS 2023b(see **Section 3.7**, Water Deliveries, for more information). The primary source of inflow to the Salton Sea is irrigation return water. As irrigation return water decreases, salinity increases as the Salton Sea's water evaporation concentrates dissolves salts and dilution by inflows with lower salinity decreases. The Salton Sea is a high-salinity body of water where some ponds have higher salinity than ocean water.

A main source of selenium for the Salton Sea is the Colorado River water due to evaporation and evapotranspiration in agricultural fields and from leaching of selenium from irrigated farmland soils from Colorado River allocations (USGS 2023b). Sediment is introduced to the Salton Sea by irrigation return water; drain management practices, such as dredging and bank stability; and natural channel scouring and bank erosion (California Water Boards 2002).

3.8.2 Environmental Consequences

Methodology

Salinity and Temperature

To understand the drivers of water quality changes in Lake Powell, a two-dimensional hydrodynamic model has been developed using the CE-QUAL-W2 model (Williams 2007) for salinity and total dissolved solids (TDS). Salinity is the measure of the amount of dissolved salt in water, where TDS measures all dissolved solids in a water sample. TDS is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity. CE-QUAL-W2 uses hydrologic and weather information to calculate the individual heat and constituent fluxes that contribute to reservoir mixing and stratification. To do this accurately, high-quality weather and hydrologic information are needed. Additionally, high-quality bathymetric data are needed to build the model grid.

Currently, the Lake Powell model is being redeveloped using updated bathymetric information (Jones and Root 2021). At the time of this modeling, the "new" version has only been tested for temperature and TDS fluxes; it was still being calibrated for other constituents. Lake Powell modeling for this SEIS uses this new version and only simulates temperature and TDS within the reservoir. Unlike CRSS used in 2007, CRMMS does not include a module for salinity.

The two primary inflows to Lake Powell are the Colorado and San Juan Rivers. Additional inflows from minor tributaries to Lake Powell exist; however, Reclamation's CRMMS did not model these minor tributaries. For this study, inflows from minor tributaries were assumed to be negligible influences on temperature and TDS predictions. CE-QUAL-W2 model simulations require higher spatial and temporal resolution data than what CRMMS provides. To achieve higher resolution flow information, total monthly inflow volumes were downscaled using daily flow data from 1991 to 2022 at four long-term US Geological Survey (USGS) gage sites: Colorado River near Cisco, Utah (09180500); Green River at Green River, Utah (09315000); San Rafael River near Green River, Utah (09328500); and San Juan River near Bluff, Utah (09379500). Note that the total inflows from the

Colorado River to Lake Powell are the summation volumes from the Cisco, Utah; Green River at Green River, Utah; and San Rafael River near Green River, Utah gages.

The average proportion of flow from these four gages between 1991 and 2022 was used to divide CRMMS total inflows among these sources. Daily inflows from each gage were resampled to match the same historical year used in the creation of the Ensemble Streamflow Prediction (ESP). Finally, flow volumes from each gage were adjusted proportionally to match the forecasted volumes from CRMMS.

Inflow temperatures to Lake Powell were reconstructed from historical daily water temperature data. Daily temperature information from 1991 to 2022 was obtained for each of the four gages. For each gage, data gaps were filled using the day-of-year average temperature. Like daily inflows, temperatures from each gage were resampled to match the same historical year used in the creation of the ESP.

A daily record of TDS concentrations at the four long-term USGS gage sites was reconstructed and used for inflow discharge. For days with no conductivity measurement, the Weighted Regressions on Time Discharge and Season models with a Kalman filter were used (Zhang and Hirsch 2019). Recommendations that there would be at least 200 concentration values spanning a period of at least a decade were used. For most tributaries, this was met using data from the hydrologic reconstruction time frame (1991–2021); however, 1985–2022 data were used for the San Rafael to incorporate at least 200 concentration values in the model. The hydrologic trace information for total Lake Powell inflows at the monthly timestep were proportioned among the four gages modeled.

A total of 120 traces were simulated in CE-QUAL-W2 for Lake Powell, including all 30 traces from the No Action 80 percent ESP, No Action 100 percent ESP, Proposed Action 80 percent ESP, and Proposed Action 100 percent ESP ensembles. Traces that most closely represent the 10th, 50th, and 90th quantiles of the projection were from the No Action Alternative and Proposed Action. Closest traces were determined by selecting the trace that resulted in the lowest root mean squared error between each trace elevation time series and the 10th, 50th, and 90th quantile elevation time series.

A two-dimensional hydrodynamic and water quality model of Lake Mead was originally developed to simulate temperature and TDS using CE-QUAL-W2 (Cole and Wells 2021) by the Upper Colorado Region of the Reclamation in 2011; several updates were made through 2018. In 2019, Hydros performed an evaluation of input development and model performance (Hydros 2019), and subsequently refined and recalibrated the model (Hydros 2020). Hydros currently runs the improved Lake Mead W2 model on a quarterly basis to provide a 24-month forecast of salinity in releases from Hoover Dam. These results are then used as inputs to additional models that forecast salinity in the Colorado River from Hoover Dam to the NIB with Mexico. The refinement, recalibration, and application of the Lake Mead W2 model is described in detail in Hydros 2020.

The Colorado River is the primary inflow to Lake Mead, with smaller contributions from the Virgin River, Muddy River, and Las Vegas Wash. As modeled by Reclamation's CRMMS, inflow to Lake Mead includes the Colorado, Virgin, and Muddy Rivers. CRMMS information received included total monthly inflow values for these three tributaries. Because the Lake Mead W2 model requires separate flows to be specified for each source at a daily—rather than monthly—resolution, the following steps were taken to disaggregate CRMMS total flow:

1. Monthly side inflow (Virgin River, Muddy River, and gains/losses in the Colorado River below Lake Powell) was estimated as the difference between CRMMS-output inflow to Lake Mead and Lake Powell releases.
2. Daily flow time series were constructed for the Virgin and Muddy Rivers using measured flows[14] from 2009 and scaling based on the ratio of CRMMS monthly side inflows to observed monthly side inflows for 2009.
3. Daily flow time series were constructed for the Colorado River using measured flows[15] from the years corresponding to each trace period (see below) and scaling based on the ratio of CRMMS monthly inflows to Lake Mead, less the estimated Virgin/Muddy River inflow, to observed monthly historical Colorado River flows.
4. Monthly gains and losses in the Colorado River between Lake Powell and Lake Mead were estimated as the difference between estimated Colorado River inflow and Lake Powell outflow.

Las Vegas Wash flows were assumed to be equal to historical observations[16] corresponding to the trace period when available,[17] and estimated as total observed return flow on a monthly basis when observations were not available.

While the exact distribution of inflows among the four main tributaries varied slightly among scenarios, the Colorado River represented the majority of inflow (approximately 97 percent) to Lake Mead in all scenarios.

Inflow temperatures for each major Lake Mead inflow were estimated using regression equations that use air temperature from the selected meteorology and the forecasted daily flow rates. For the Colorado River, the temperature regression also includes water temperatures predicted at Glen Canyon Dam by the Lake Powell W2 model and air temperatures recorded at Page, Arizona.

For the Colorado River Lake Mead inflow, projected inflow TDS values were estimated using a regression equation based on TDS outputs from the Lake Powell model, as well as forecasted outflow from Lake Powell and inflow to Lake Mead. Virgin River TDS concentrations were estimated using the USGS SLOAD Flow-TDS regression model and forecasted flows. For the Muddy River and Las Vegas Wash, the inflow TDS was projected based on regression equations using the forecasted flows for each tributary.

The Lake Mead W2 model was run for three traces under the No Action Alternative and Proposed Action. For each alternative, three hydrologic traces were identified (out of 90 traces per alternative) that represented the 10th, 50th, and 90th percentile of projected storage in Lake Mead under that alternative. The appropriate traces were identified by calculating the percentile of storage (such as

[14] Virgin River near Overton, USGS 09415250; Muddy River at Overton, USGS 09419507
[15] Colorado River near Diamond Creek, USGS 09404200
[16] Las Vegas Wash below Las Vegas, Boulder City, USGS 09419800
[17] Flow observations available 2002–2022

10th percentile) for each month across the 90 traces for that alternative to develop a time series of the percentile of storage, then selecting the trace with the lowest root mean squared error when compared with the percentile time series. This resulted in six unique scenarios using four different hydrologic traces (**Table 3-21**). For each trace simulated with the Lake Mead W2 model, simulated results from the Lake Powell W2 model for the corresponding trace were used to generate the input temperature and TDS time series for the Colorado River, as described above.

Table 3-21
Selected Traces for Each Management Alternative

Selected Trace	Reasoning
1995 80 percent ESP	50th percentile of projected storage in Lake Mead for the No Action Alternative
2013 80 percent ESP	10th percentile of projected storage in Lake Mead for the No Action Alternative and Proposed Action
2013 100 percent ESP	90th percentile of projected storage in Lake Mead for the No Action Alternative and Proposed Action
2017 100 percent ESP	50th percentile of projected storage in Lake Mead for the Proposed Action

Note that the hydrologic traces for the 10th and 90th percentiles of storage are the same for both the No Action Alternative and the Proposed Action (**Table 3-21**). This means that differences in the simulated TDS and temperatures between the management scenarios at relatively high (90th percentile) and low (10th percentile) storages can be directly attributed to the differences in how Lake Mead would be managed under the two alternatives. Because the traces used to simulate the 50th percentile scenarios differ between the two alternatives, the differences in simulated results are due to the combination of differences in management, hydrology, and meteorology. To project the Salton Sea's salinity, the SSAM for future inflow scenarios operates by water and salt mass conservation of the Salton Sea. At each annual time step, certain quantities are added or subtracted from the volume present at the beginning of the year. At each annual time step, the following quantities of water volume are added (+) or subtracted (-) from the volume present at the beginning of the year:

- (+) Freshwater inflows, a time series input from the relevant estimated hydrologic scenario, as discussed above.
- (-) Total water volume needed to satisfy evaporation demands of fixed-size conservation projects, when applicable.
- (-) Total water volume needed to meet dust suppression obligations, defined as 1 acre-foot of water annually per acre of area within the 2003 shoreline not covered by the remaining Salton Sea or any planned conservation projects in a given year.
- (-) Direct evaporation volume from the dynamically sized Salton Sea, dependent on its area and salinity in a given year, using the same quadratic polynomial regression in the USGS's original SSAM model (see below), which takes a baseline evaporation rate (calibrated to be 69.9 inches annually [see below]) and returns a smaller evaporation rate with increasing salinity.
- (+) Direct precipitation volume on the Salton Sea. Values from 2004–2012 are from PRISM. More recent years (2013–2022) are filled in from California Irrigation Management

Information System (CIMIS) Imperial Valley data. The historical average of the updated data set is approximately equal to 2.5 inches per year, and that is the value used for all future years.

Similarly, salt mass has the following additions (+) and subtractions (-) at each time step, assuming direct evaporation and precipitation of water have a minimal effect on the salt balance:

- (+) Salt coming in with freshwater inflows, using the inflow-dependent regression present in the USGS's original SSAM model, which has higher salt concentrations with lower inflow volumes
- (-) Annual salt precipitation of 0.15 percent of the current salt mass in the Salton Sea
- (-) Any salt above saturation salinity of 280 ppt

For any state of the Salton Sea, there is a 1-1-1 relationship between its elevation, area, and capacity (volume), also known as the elevation, area, and capacity relationship or elevation, area, and capacity curve. This relationship was estimated from the latest available bathymetry data. For each model run, this elevation, area, and capacity curve is used to get the initial Salton Sea volume (as the initial conditions are specified as an elevation) and to convert its volume at each time step to a Salton Sea area and Salton Sea elevation (interpolated to the nearest tenth of a foot, NAVD88). The evaporation rate from the Salton Sea's surface is reduced as salt concentration in it increases. The original Reclamation SSAM modeled this effect using a regression of the form:

$$E_{net} = E_{base}\left(\frac{a + b(\frac{S}{1000})^{2.5}}{a + b(\frac{S_{ref}}{1000})^{2.5}}\right)^2$$

In the formula:

- E_{base} is the baseline evaporation amount for freshwater.
- S is the Salton Sea's salinity at the current time step.
- S_{ref} is a reference salinity value (set to 45723.33 ppm).
- *a* and *b* are model constants with values of 0.981902618 and -1.39819E-07, respectively.

The salinity of the water specified as total inflow depends on the inflow volume in the form of a linear regression used in the original Reclamation model. $S_1 = a + b * V_I$, where *a* = 5016.07448 and *b* = −0.00204508, and this formulation has been retained in the Tetra Tech-updated version of SSAM.

The main inputs the user must provide to the model are:

- The initial Salton Sea state—these model runs were set to begin in 2020 at an elevation of 235.5 feet NAVD88 with an initial salinity of 74,250 ppm.
- Total freshwater inflow at each year, specified as a time series from the chosen starting year to 2100. This is the input that was modified to consider different drought mitigation

scenarios. The description is below of how different potential Colorado River allocations correspond to different total Salton Sea inflows.

- The baseline evaporation for each year—this was derived as a calibrated average value from historical data from 2004 to 2020. The current value has been set at 69.9 inches per year.

Although the model can simulate water use from conservation projects, the results shown in this section do not include the effects of 10-Year Plan projects, including the Species Conservation Habitat project.

DO

To project DO within Lake Powell and its water releases from Glen Canyon Dam, a long-term record of DO profiles from the reservoir forebay (site name LPCR0024; Deemer et al. 2023) were used to model and project DO concentration within a 10-meter (32.8-foot) envelope of the penstock depth for the 180 hydrologic traces generated as part of this effort. While the Lake Powell CE-QUAL-W2 does have a DO module (Williams 2007), recent observations suggested the need for its recalibration to improve performance under low water levels and with the aging of the reservoir.

A total of 132 water quality profiles from August to October (1967–2022) were used to calculate the yearly mean late summer/early fall DO concentrations in six 10-meter (32.8-foot) layers of the Lake Powell water column (Deemer 2023). These represent the heights from which water could be drawn through the penstocks under the various hydrologic traces being examined here (6 to less than 16 meters, 16 to less than 26 meters, 26 to less than 36 meters, 36 to less than 46 meters, 46 to less than 56 meters, and 56 to less than 66 meters). From these traces, linear models were built to project these water layer-specific DO concentrations as a function of minimum reservoir elevation in that year; volumes of the spring inflow, which were calculated as the inflow from April to July; and the years since the reservoir was filled.

Net deposition of sediment in sandbars in the reach from Lake Powell to Lake Mead occurs when there is enough sand for sandbar building and when HFEs are conducted. The USGS (Salter and Grams 2023) used the Mueller et al. (2021) Sandbar Model and the Wright et al. (2010) Sand Routing Model to project sandbar building and HFE implementation triggers.

Sediment

Under the Sand Routing Model, the USGS ran each hydrologic trace with 22 possible Paria River sediment loads (the Paria River is a significant sediment source and tributary to the Colorado River); each trace was associated with a 5-year period. The Sandbar Model was run with a subset of four Paria traces (1993–2003, 2006–2010, 2011–2016, and 2017–2022), representing a broad range of potential cumulative Paria sand load values. Observation data up until August 10, 2023, for the Paria sediment load time series from RM 30, RM 61, and RM 87 were used as inputs for the Sand Routing Model. The discharge records for RM 30 and RM 61 ended in late May and early June 2023. Missing observation data were calculated using the Wiele and Griffin (1997) Flow Routing Model. For future projections, predicted hourly flow releases from the WAPA Generation and Transmission Maximization Model (GTMax) and the Paria sediment load traces were used as inputs.

The Sandbar Model was calibrated to nine of the most dynamic sandbars out of the 45 sandbars that are monitored long term. The calibration period was 2015–2022. Historical and current (observation) data for sediment and flows from the RM 30 gage were used as inputs for the Sandbar Model. Sediment and flow data obtained from the Sand Routing Model at RM 30 were used to calculate the Sandbar Model future projections.

Assumptions

Salinity and Temperature

Under the CE-QUAL-W2 model, the testing of the "new" Lake Powell water quality model was carried out over a historical simulation period. This relatively long duration allowed for the evaluation of the influence modeling assumptions, such as the use of constant bathymetry and the omission of ephemeral tributary sources, which is important when modeling future climate change and/or hydrologic conditions. For this simulation, a combination of measured and modeled input data were used following the methods described by Mihalevich (2022). Reclamation provided hourly release data from Glen Canyon Dam penstocks and bypass outlets. Sub-hourly water quality data measured below Glen Canyon Dam near Page, Arizona (USGS gage #09379901), were used to evaluate model projections. Under historical conditions, the model can predict release temperatures from Glen Canyon Dam with a root mean squared error of 0.79°C and specific conductivity, which is a surrogate for TDS, of release water with a root mean squared error of 36.71 µS/cm.

Performance of the Lake Mead W2 model has been thoroughly evaluated and documented elsewhere. The improved model was calibrated to observations for 2013–2019. During this period, the mean absolute error for the simulated daily outflow temperature was 0.5 °C; the mean absolute error for the simulated daily TDS was 16 mg/L (Hydros 2020). Retrospective reviews of quarterly forecasts for TDS below the Hoover Dam in 2020 and 2021 showed that the mean absolute error was less than 15 mg/L and less than 28 mg/L, respectively. These are on par with the expected range of measurement uncertainty (Hydros 2021, 2022).

Release temperatures were evaluated based on 16°C (60.8°F) and 20°C (68°F) thresholds. When temperatures exceed a 16°C (60.8°F) threshold for extended periods of time, the likelihood that smallmouth bass and other warmwater, nonnatives species increase in abundance is much higher. When temperatures exceed 20°C (68°F) for longer periods of time, the temperatures are expected to negatively impact salmonids. Smallmouth bass and other warmwater, nonnative species pose a serious risk to native fish species in the Colorado River downstream of Glen Canyon Dam, while rainbow trout are a desired species for the Blue Ribbon fishery in the tailwater segment of Glen Canyon Dam. See **Section 3.13**, Biological Resources, for more information.

DO

The DO model was based on the best model for projecting whole-metalimnion mean DO in the late summer and fall (Deemer 2023). In cases where the reservoir elevation was less than 3,490 feet, it was projected that a high end of 8 mg/L DO concentration would pass downstream. This assumption was based on the aeration observed when water is spilled through the river outlet works (Hueftle and Stevens 2001; Vernieu 2010). Bypass releases of 15,009 cfs during the 2008 HFE resulted in supersaturated DO concentrations (12.6 mg/L; Vernieu 2010) below Glen Canyon Dam; therefore, 8 mg/L DO was considered a conservative estimate for spills under lower lake elevations with bypass spill rates of 14,620 cfs at lake elevations of 3,490 feet and spill rates dropping at lower elevations. This modeling exercise did not attempt to characterize monsoon-driven low DO events. Lake Powell can also develop low oxygen zones due to inputs from monsoon storms, as observed in 2021.

Sediment

The Sandbar and Sand Routing Models used an HFE magnitude of 40,000 cfs, with the assumption that low lake levels are likely to limit the maximum capacity (45,000 cfs) that can be released from Glen Canyon Dam. The Sandbar Model assumed a constant exponential erosion rate that is independent of discharge. It did not capture enhanced erosion rates from elevated flows. Though sand is available in the river at flows greater than the river stage (8,000 cfs), it can only be deposited on sandbars at or below the river stage. Dam operations do not allow for sustained discharges lower than 5,000 cfs at night and 8,000 cfs during the day (Reclamation and NPS 2016). Some of the hydrologic traces included discharges below these minimums; however, the model was conditioned such that HFEs would not be implemented if discharges were below the minimums. The Sandbar Model is calibrated to yield the volume of sand at and above the 8,000 cfs river stage. Some traces include elevated sustained dam releases (20,000 cfs–30,000 cfs) that are projected to produce some sandbar growth; however, given that sandbars can only be built at and below the river stage, these deposits would occur at low elevations that would not be usable for beaches (camping uses). The Sand Routing Model projects there is a relationship between sand export and HFE duration; that is, sediment loss occurs as the HFE duration increases. To find the sediment-triggered HFE duration, the Sand Routing Model results are used to generate a simplified relationship between HFE duration and sand export.

For simplicity, the analysis assumes no sediment inputs for the remainder of August 2023. Due to the large amount of sand export since July 1, 2023, and small observed inputs prior to August 10, 2023, the probability of a sediment trigger in fall 2023 is lower than for the fall of subsequent years.

Impact Indicators

For both alternatives evaluated, the following indicators were used to assess impacts:

- **Elevation protection:** Changes due to elevation protection with reservoir elevations not analyzed in the 2007 FEIS
- **Low flows:** Changes to river flows not analyzed in the 2007 FEIS
- **Upper Basin drought:** Changes due to drought in the Upper Basin not analyzed in the 2007 FEIS

Constituents Excluded from Analysis

Since the 2007 FEIS was released, perchlorate containment and reduction strategies have continued to contribute to declining detectable concentrations of perchlorate in Lake Mead, Willow Beach, Lake Havasu, and other sampling locations in the lower Colorado River, as well as in areas using Colorado River water in Arizona. From sampling completed in Lake Mead from 2013 to 2023, perchlorate concentrations ranged from indetectable levels to 5.6 parts per billion (ppb) (SNWA 2023).

Since conditions have improved and remediation efforts are ongoing, perchlorate was not brought forward for analysis.

Issue 1: How would elevation protection and low-flow conditions affect salinity within each reach?

Summary

There is no limit for the salinity concentration in waters released from Glen Canyon Dam; however, Hoover Dam has a limit of 723 mg/L, as seen in **Table 3-20**. There is a cyclical relationship between the salinity of inflows to Lake Powell and the salinity of waters below Hoover Dam; this cyclical relationship typically follows a 2-year lag. These salinity levels are a major factor driving salinity in Lake Mead (Tillman et al. 2019). The CE-QUAL-W2 two-dimensional hydrodynamic model results also illustrated a general trend between Lake Powell elevations and salinity concentrations.

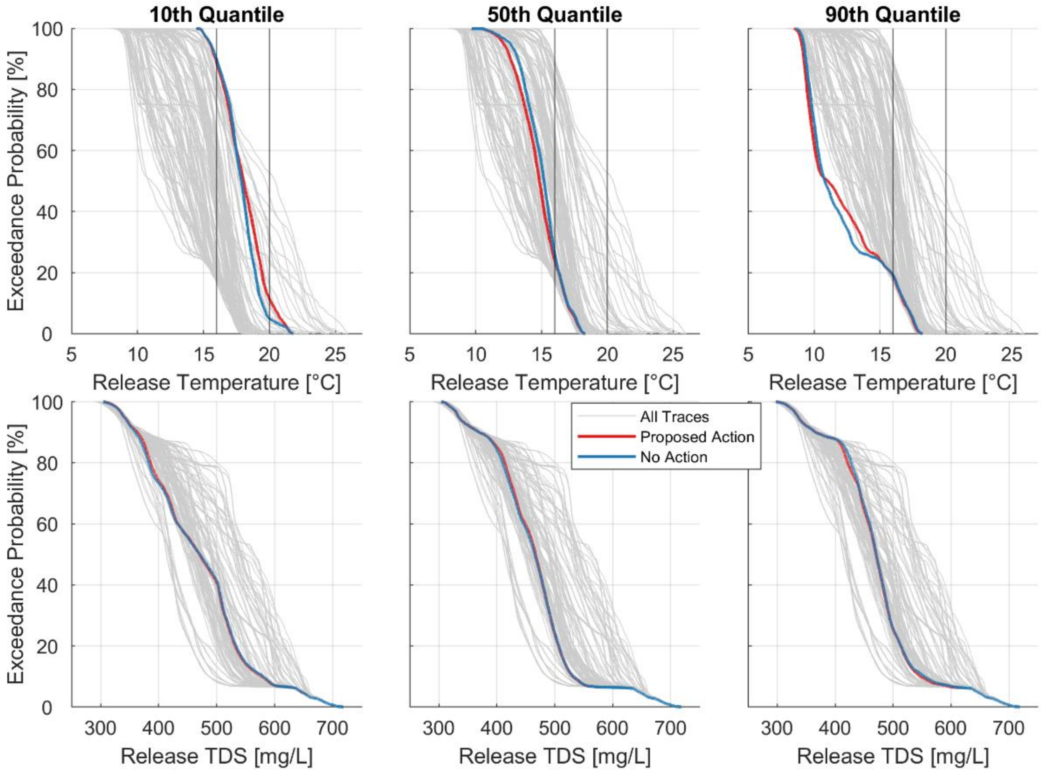
Generally, when Lake Powell's elevations were high, salinity releases were lowest; however, salinity concentrations were similar among the selected 10th, 50th, and 90th quantile reservoir elevations, as seen in **Figure 3-28**. (For a description of the traces chosen, see the Methodology section). Reservoir inflows were nearly identical among management scenarios within each trace, suggesting a strong linkage between inflow volume and release salinity. Salinity concentrations are also highly seasonal under both management scenarios due to spring inflows and seasonal turnover, which results in concentrations increasing over winter (December–March) and decreasing during the spring and summer months (May–September).

Predicted salinity from Glen Canyon Dam varied greatly between traces, but results from the No Action Alternative and Proposed Action were relatively similar.

Predicted salinity concentrations in Hoover Dam outflow vary among scenarios (**Figure 3-29**, **Figure 3-30**, and **Figure 3-31**) with variability more closely related to the hydrologic trace than management alternative. All six modeled scenarios showed a decrease in outflow salinity concentrations from the start of the simulation (June 1, 2023) through mid-2024, after which point outflow salinity concentrations tend to vary between approximately 550 and 590 mg/L (**Figure 3-29**); the exception is the No Action Alternative in the 50th percentile scenario, which continues to decrease and reaches concentrations as low as approximately 510 mg/L.

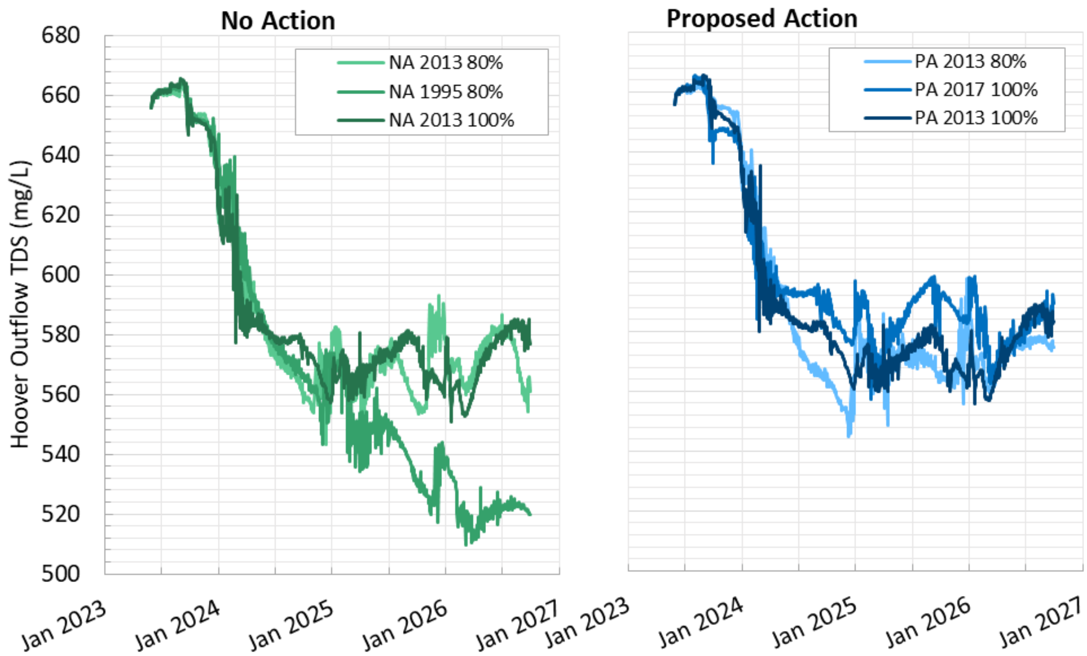
Comparing the two management alternatives under the 10th percentile and 90th percentile scenarios (**Figure 3-30**, left and right panels) shows there is little difference in simulated outflow salinity between the two management alternatives for a given hydrologic trace. The 50th percentile scenarios (**Figure 3-30**, center) show a larger difference between the two management alternatives, though this is due to differences in the underlying hydrology and meteorology used in the two model runs.

Figure 3-28
Exceedance Probability for Temperature and Salinity* Concentrations in Glen Canyon Dam Releases



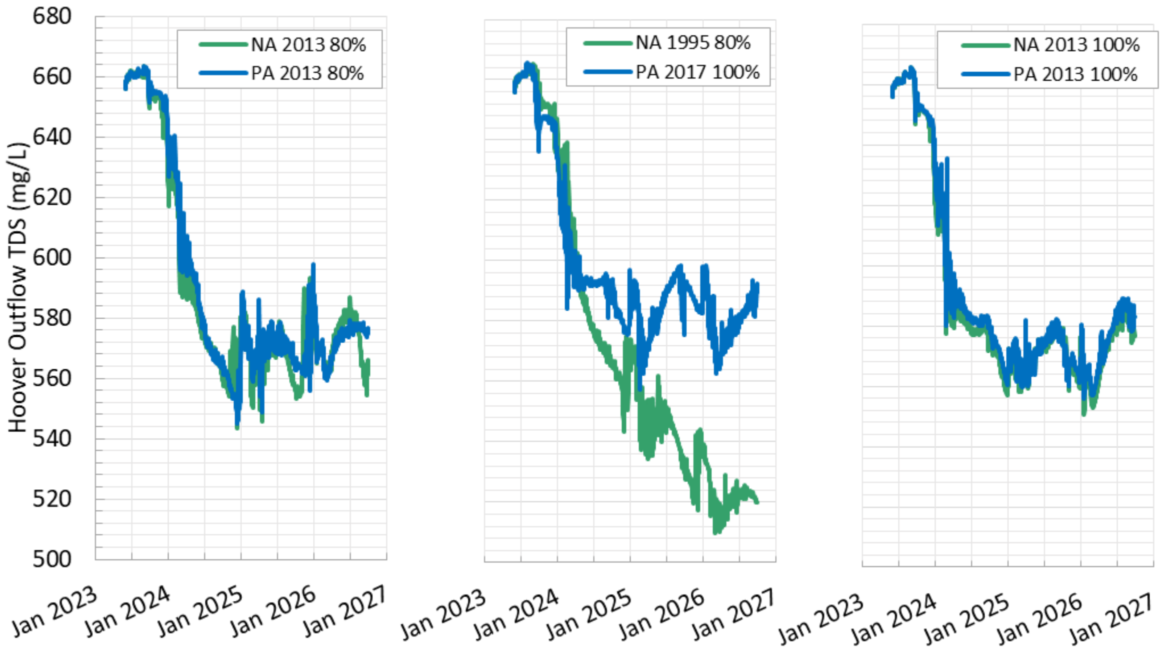
Source: USGS 2023c
* Salinity is the measure of the amount of dissolved salt in water; TDS measures all dissolved solids in a water sample, and it is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

Figure 3-29
Predicted Salinity* Concentrations below Hoover Dam for Selected Traces for the No Action Alternative and Proposed Action



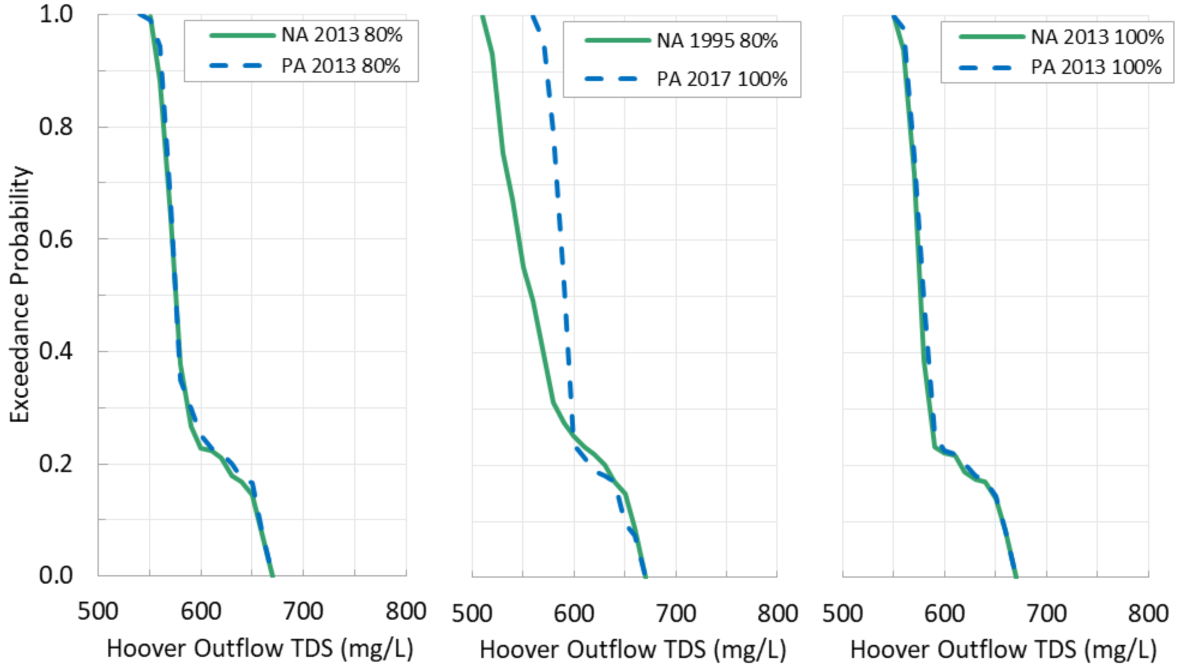
* Salinity is the measure of the amount of dissolved salt in water; TDS measures all dissolved solids in a water sample, and it is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

Figure 3-30
Predicted Outflow Salinity* Concentration for the No Action Alternative and Proposed Action, Grouped by Selected Trace Cases



* Salinity is the measure of the amount of dissolved salt in water; TDS measures all dissolved solids in a water sample, and it is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

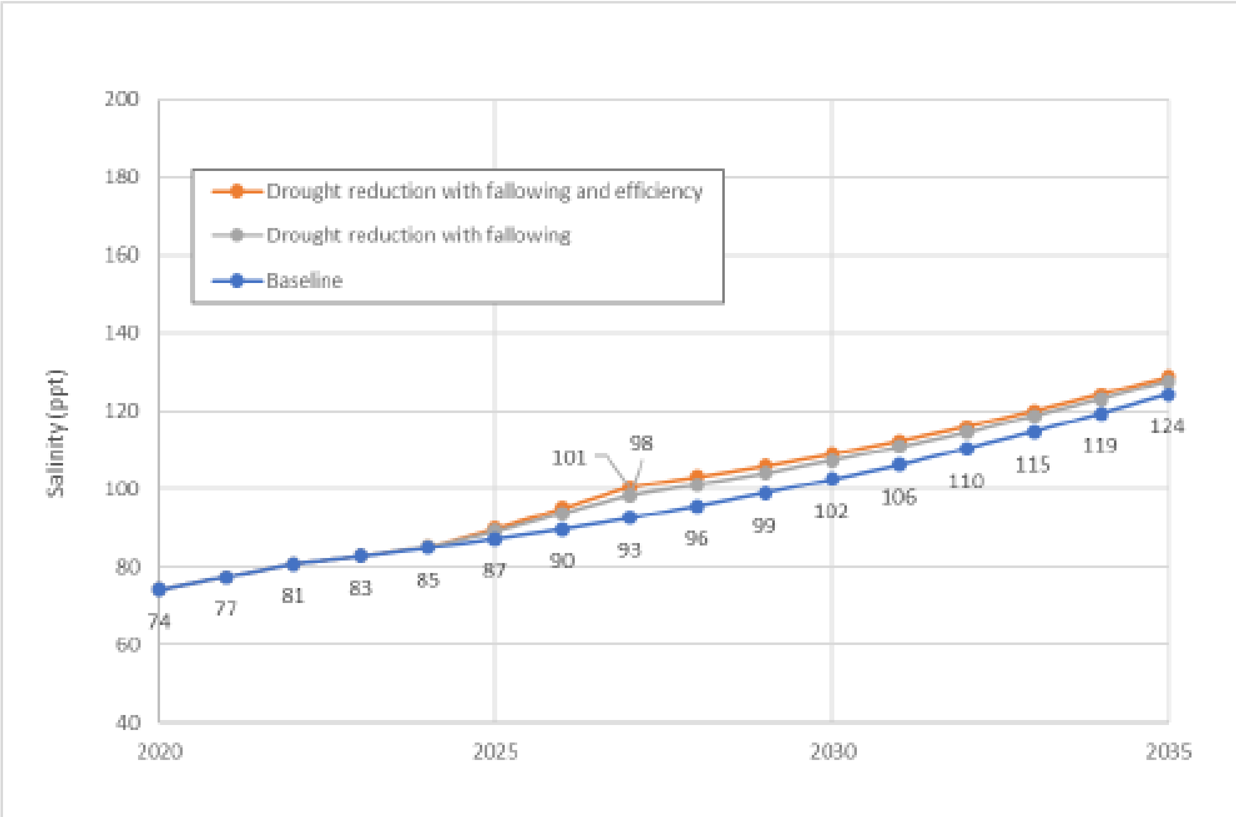
Figure 3-31
Exceedance Probability for Salinity* Concentrations in Hoover Dam Releases for Each Management Scenario, Grouped by Selected Trace Cases



* Salinity is the measure of the amount of dissolved salt in water; TDS measures all dissolved solids in a water sample, and it is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

Under the Proposed Action, the SEIS conservation measures could result in reduced deliveries to the Lower Division States, compared with under the No Action Alternative. As discussed in **Section 3.7**, Water Deliveries, reduced deliveries to the IID and CVWD could thus reduce inflows to the Salton Sea from irrigation drainage, expedite lake bed exposure, and therefore increase salinity of the Salton Sea. As seen in **Figure 3-32**, the SSAM estimates that salinity could be higher under the Proposed Action versus the No Action Alternative. It is inferred that the increase in salinity is due to system conservation agreements and the reduction of deliveries to the Lower Division States.

Figure 3-32
Impact on Salton Sea Salinity from Drought-Reduction Scenarios



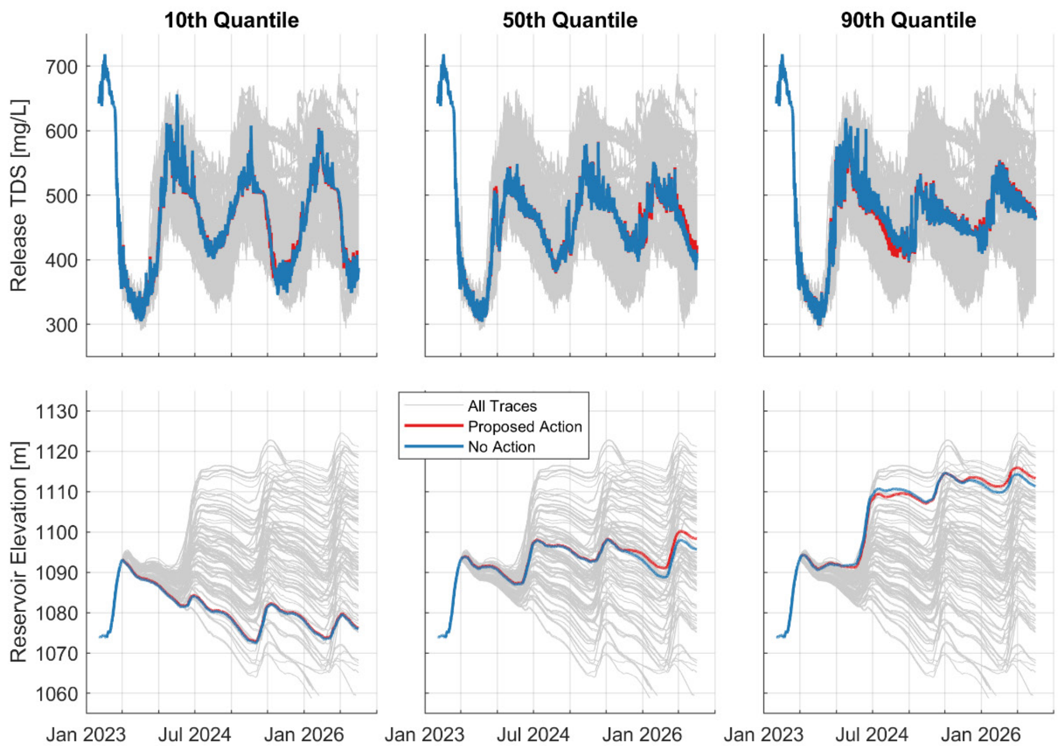
Source: Tetra Tech 2023

No Action Alternative

Under the No Action Alternative, salinity concentrations in waters released from Glen Canyon Dam and Hoover Dam would not exceed 723 mg/L, which is the numeric salinity criteria for Hoover Dam, as seen in **Figure 3-28** and **Figure 3-31**. While Glen Canyon Dam releases are related to the salinity concentrations at Lake Mead and in the waters below Hoover Dam, these modeling results do not represent Hoover Dam release concentrations.

Figure 3-33 further illustrates the trend between Lake Powell elevations and salinity concentrations, with higher lake levels resulting in marginally lower concentrations and lower levels resulting in marginally higher concentrations.

Figure 3-33
Projected Release Salinity* Concentration (mg/L) from Glen Canyon Dam over the 5-Year Simulation Period



Source: USGS 2023c
*Salinity is the measure of the amount of dissolved salt in water; TDS measures all dissolved solids in a water sample, and it is a similar constituent because it estimates the level of salt within a water sample. TDS was used in the CE-QUAL-W2 model as a proxy for salinity.

Proposed Action

Under the Proposed Action, salinity concentrations in waters released from Glen Canyon Dam and Hoover Dam would not exceed 723 mg/L, which would be the same as under the No Action Alternative, as seen in **Figure 3-28** and **Figure 3-31**.

Figure 3-33 further illustrates the trend between Lake Powell elevations and salinity concentrations, with higher lake levels resulting in marginally lower concentrations and lower levels resulting in marginally higher concentrations.

As seen in **Figure 3-32**, there would be some effects on the Salton Sea's salinity from the implementation of drought-reduction scenarios under the Proposed Action; there would be an increase in salinity when compared with the No Action Alternative.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would change how and when releases from Glen Canyon Dam take place. Several of these flow options include releasing water through the river outlet works, which are lower than the penstocks, which are where water is typically released when hydropower is generated. The difference in salinity between the penstocks and river outlet works is typically negligible during turnover; however, the salinity concentrations at the two elevations are highly variable, and they can be as high as 300 mg/L, which can increase the concentrations of salinity releases under certain conditions.

The implementation of the US Army Corps of Engineers EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions, including decreased salinity concentrations over time.

Issue 2: How would elevation protection and low-flow conditions affect the temperature within each reach?

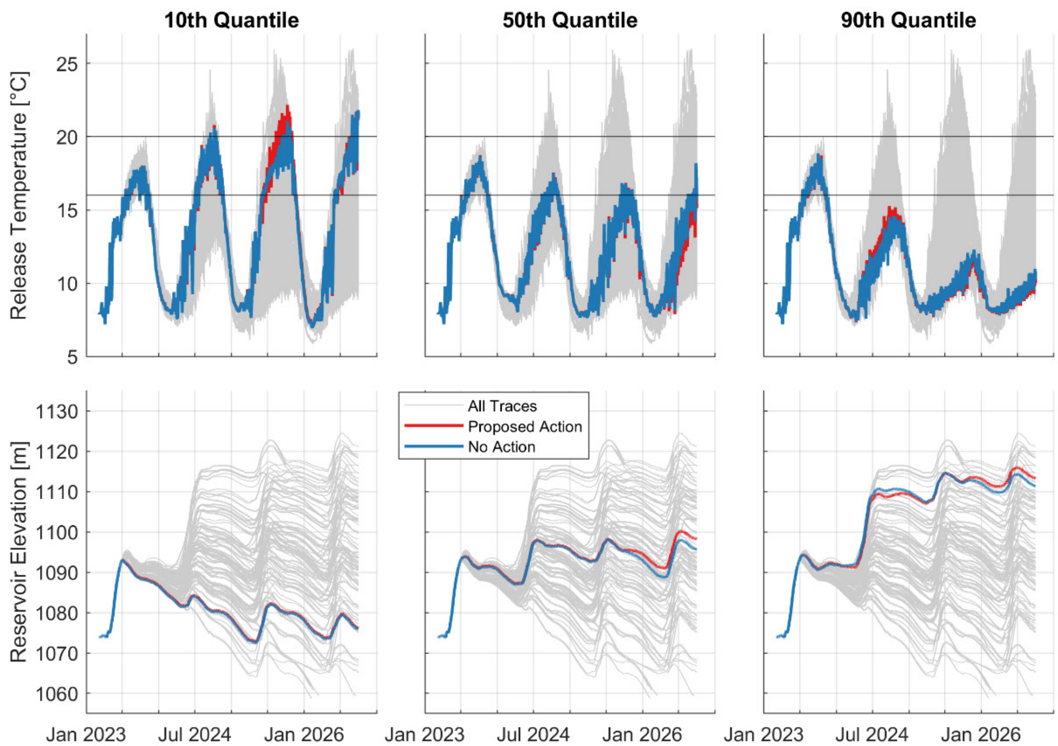
Summary

As seen in **Figure 3-34**, projected temperature releases varied greatly among different scenarios. (For a description of the traces chosen, see the Methodology section.) A key determinant of Glen Canyon Dam release temperatures is the elevation of the reservoir relative to where water is being released, either from the penstocks, which are at 3,490 feet, or from the river outlet works, which are at 3,370 feet.

As seen in the CE-QUAL-W2 model results for Glen Canyon Dam releases in **Figure 3-34**, while the projected temperature releases varied widely, outcomes were relatively similar between the No Action Alternative and the Proposed Action. Under both alternatives, release temperatures were coldest when reservoir elevations were highest.

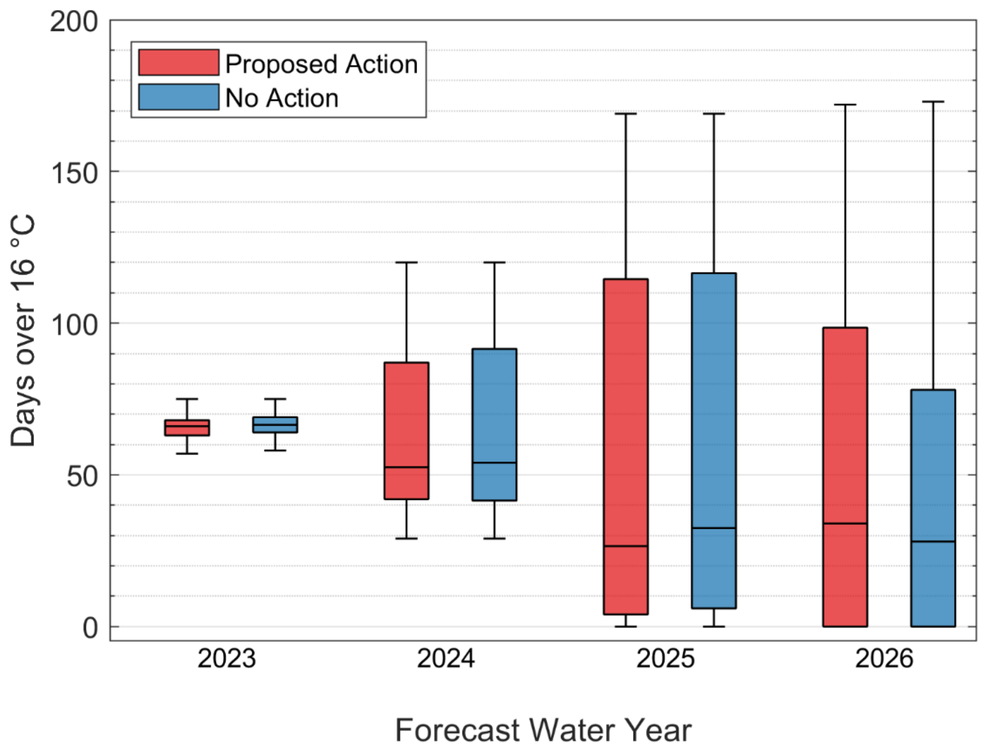
As seen in **Figure 3-35**, the temperature of Lake Powell releases was evaluated based on important temperature thresholds for smallmouth bass and rainbow trout. Smallmouth bass are a concern because the Service's 2018 species status assessment listed this invasive predator as one of the biggest threats to the federally listed humpback chub in the Grand Canyon. When temperatures exceed 16°C (60.8°F), the likelihood that smallmouth bass and other warmwater, nonnative species increase in abundance is much higher. When temperatures exceed 20°C (68°F) for longer periods of time, these higher temperatures are expected to negatively impact salmonids. Smallmouth bass and other warmwater, nonnatives pose a serious risk to native fish species in the Colorado River downstream of Glen Canyon Dam. See **Section 3.13**, Biological Resources, for more information.

Figure 3-34
Projected Release Temperatures from Glen Canyon Dam over the 5-Year Simulation Period for Each Selected Trace and Management Scenario*



Source: USGS 2023c
*Hourly projections from the model were averaged to daily values for illustrative purposes. The horizontal, black lines represent the 16°C (60.8°F) and 20°C (68°F) temperature thresholds.

Figure 3-35
Box Plots Showing the Number of Days with an Average Glen Canyon Dam Release Temperature over 16°C (60.8°F) for All CRMMS Traces and Each Alternative for Operating Years 2023–2026*



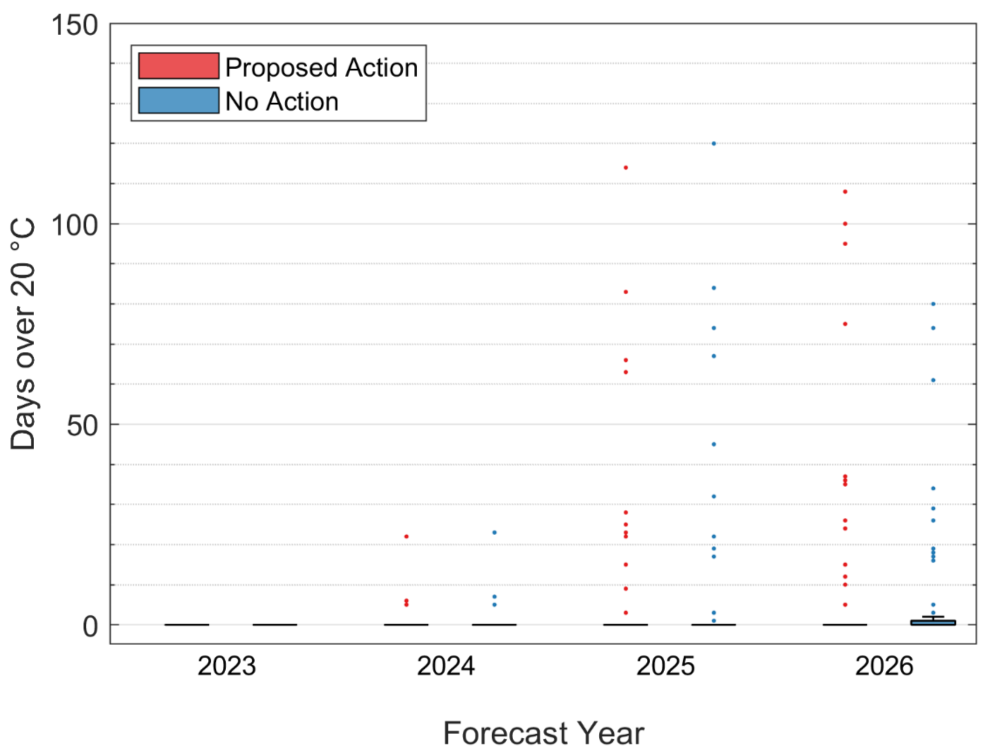
Source: USGS 2023c
* The dark line represents the median, the boxes represent the upper and lower 25 percent quantiles, and the whiskers extend to twice the interquartile range with dots representing traces with more extreme values.

In the traces modeled, release temperature predictions associated with the 10th quantile of reservoir elevations, which would be the lowest reservoir elevations, were greater than 16°C (60.8°F) over all summer months (June–August) and greater than 20°C (68°F) during 2024, 2025, and 2026 summer periods. Predicted release temperatures corresponding to the 50th quantile of reservoir elevations were never greater than 20°C (68°F), and they exceeded 16°C (60.8°F) for a shorter duration compared with lower reservoir elevations (that is, the 10th quantile). Under the 90th quantile of reservoir elevations, which would be the high reservoir elevations, predicted release temperatures only exceeded 16°C (60.8°F) in the summer of 2023 and were below the 16°C (60.8°F) threshold in subsequent years of the simulation.

Across the traces simulated in the CE-QUAL-W2 Lake Powell water quality model, the Proposed Action led to slightly more days above 16°C (60.8°F), on average, in operational years 2024 and 2025 but slightly fewer days above 16°C (60.8°F) in operational year 2026, when compared with the

No Action Alternative. Both the No Action Alternative and the Proposed Action had traces that exceed the 20°C (68°F) threshold; however, more than half of the traces simulated were below this threshold for each operational year (**Figure 3-36**). In operational year 2023, no traces exceeded the 20°C threshold. Under both alternatives, 5 and 18 percent of all traces in operational year 2024 and 2025, respectively, exceeded the 20°C threshold. In operational year 2026, 22 percent of traces exceeded the 20°C threshold under the No Action Alternative, and 25 percent of traces exceeded the 20°C threshold under the Proposed Action. Release temperatures are strongly tied to where water would be released from, which impacted the probability of whether releases from the river outlet works would be necessary under the No Action Alternative.

Figure 3-36
Box Plots Showing the Number of Days with an Average Glen Canyon Dam Release Temperature over 20°C (68°F) for All CRMMS Traces and Each Alternative for Operating Years 2023–2026*



Source: USGS 2023c
* The dark line represents the median, the boxes represent the upper and lower 25 percent quantiles, and the whiskers extended to twice the interquartile range with dots representing traces with more extreme values.

For Hoover Dam, predicted outflow temperatures vary among scenarios (**Figure 3-37**), with variability more closely related to the hydrologic trace than the management alternative. For all scenarios, outflow temperatures are similar among hydrologic traces (less than 3°C variability) when the reservoir is well mixed (fall through spring). However, during the stratified period, forecasted outflow temperatures are more variable (up to approximately 5°C) among traces for a given alternative. These differences are largely explained by the water elevation.

Simulated water surface elevation for each scenario is shown in **Figure 3-38**, with Hoover Dam outlet elevations demarcated. Because surface waters in the reservoir are warmer, as the water elevation decreases and moves closer to the outlet elevation, summer outflow temperatures increase. When water elevations are higher, water is withdrawn from deeper in the water column, and is often colder. For both scenarios using 2013 100 percent ESP (90th percentile of projected storage), outflow of surface water through the upper gate would occur for the entire simulation period (**Figure 3-38**); however, outflow of cold, deep water through the lower gate would moderate temperature variability below Hoover Dam (**Figure 3-37**). The warmest outflow temperatures under either alternative occur during late summer and fall when low storage in the reservoir only allows for water to be withdrawn from the lower outlet gates.

Figure 3-37
Predicted Temperature of Hoover Dam Outflow for Selected Traces for the No Action Alternative and Proposed Action

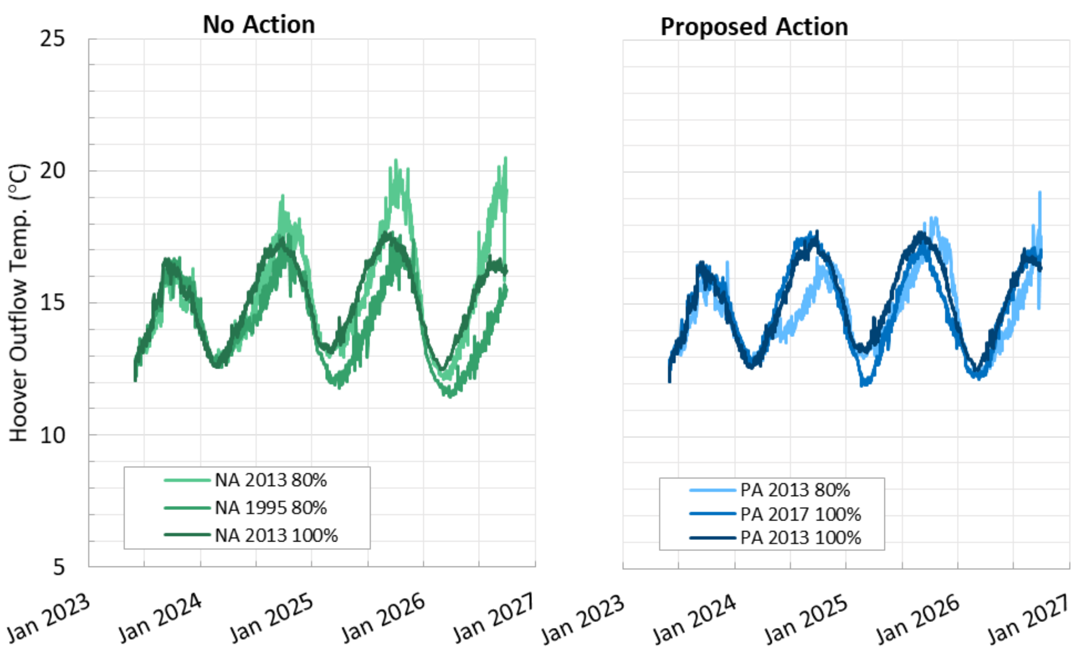
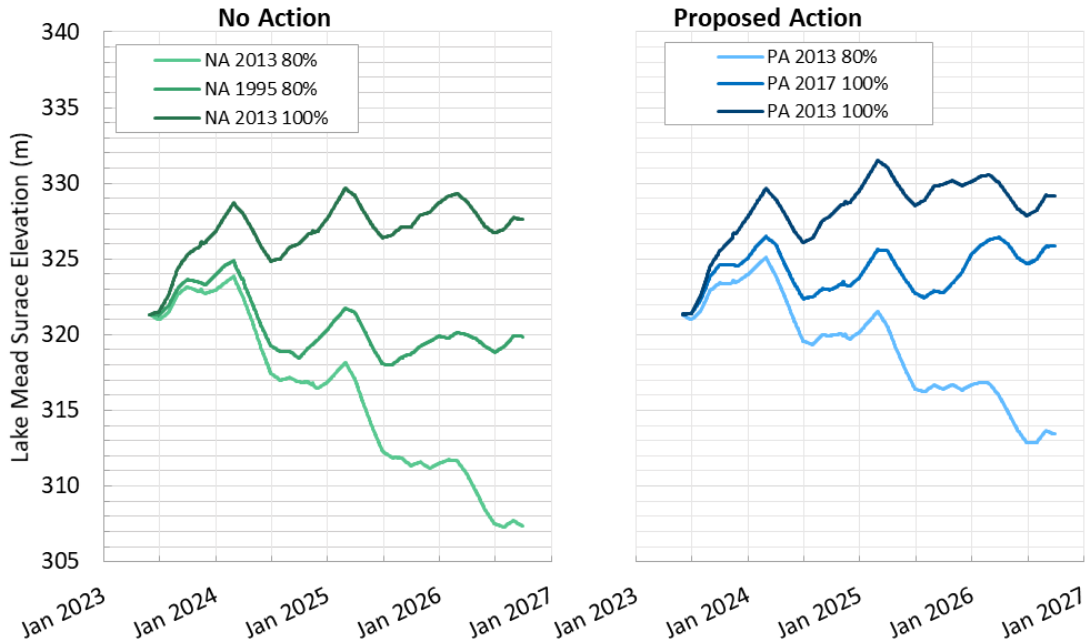


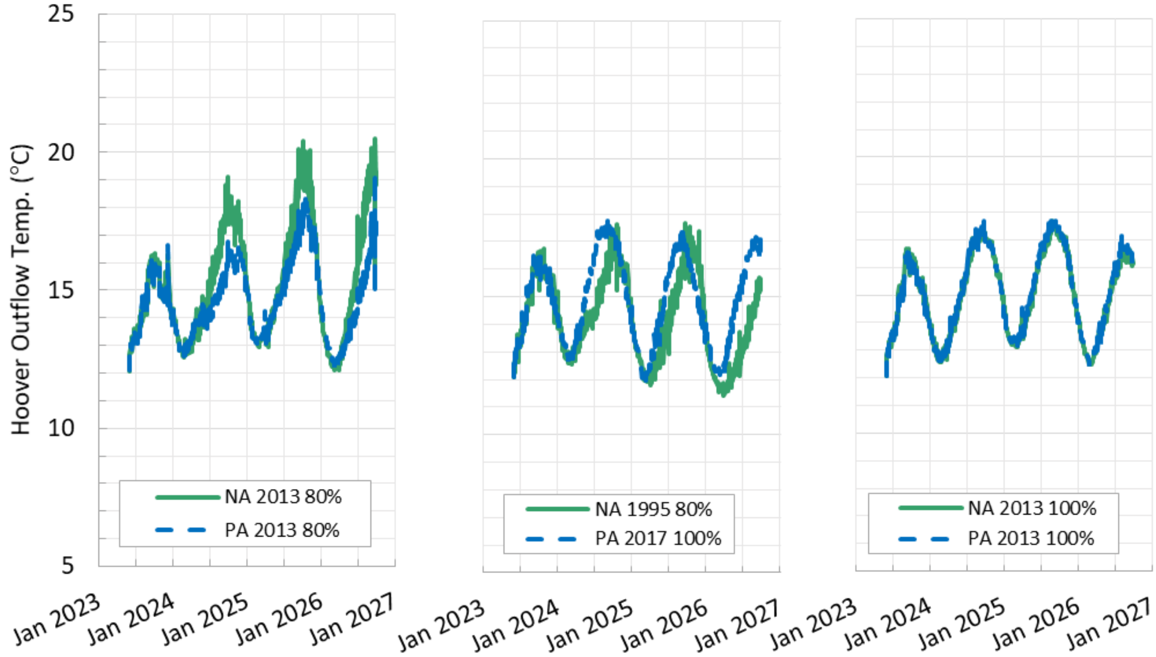
Figure 3-38
Simulated Lake Mead Water Surface Elevation for Selected Traces for the No Action Alternative and Proposed Action



Comparisons between the No Action Alternative and the Proposed Action are shown in **Figure 3-39**. For Hoover Dam, direct comparisons can be made for the two management alternatives at the 10th and 90th percentiles, as they both use the same hydrologic traces (2013 80 percent ESP and 2013 100 percent ESP). Simulated water temperatures in Hoover Dam outflows are nearly identical when the reservoir is relatively full (under the 90th percentile scenario). In the 10th percentile scenario, simulated outflow temperatures are notably higher during summer under the No Action Alternative, reflecting the lower storage under the No Action Alternative when compared with the Proposed Action (**Figure 3-39**).

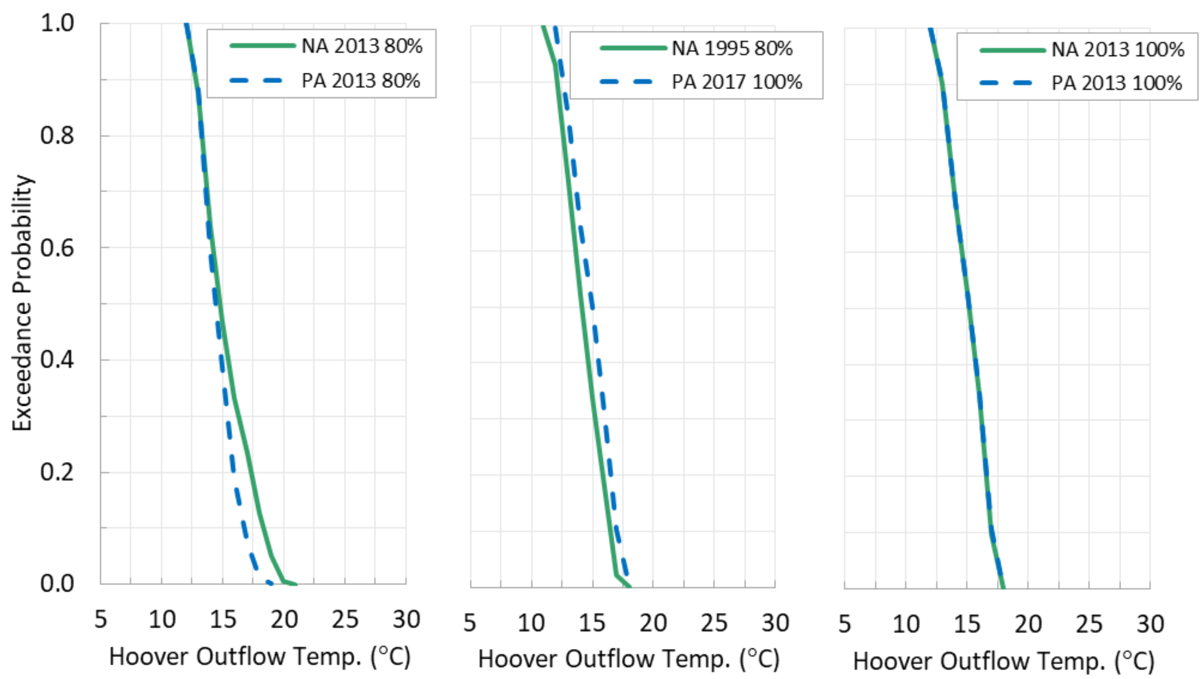
In the 50th percentile scenario, outflow temperatures tend to be higher under the Proposed Action than under the No Action Alternative, despite higher surface elevations under the Proposed Action. This result is attributed to a combination of differences in the hydrologic traces used in the 50th percentile scenario (1995 80 percent ESP for the No Action Alternative and the 2017 100 percent ESP for the Proposed Action) and the corresponding differences in meteorology used to simulate those traces (1995–1998 for the No Action Alternative and 2017–2020 for the Proposed Action). These differences in hydrology and meteorology limit the utility of the comparison of alternatives under the 50th percentile scenarios; however, based on results from the 10th and 90th percentile scenarios, it would be expected that outflow temperatures under the Proposed Action would likely be similar or cooler than outflow temperatures under the No Action Alternative.

Figure 3-39
Predicted Outflow Temperatures for Each Management Scenario, Grouped by Selected Trace Cases



Exceedance probability plots for daily outflow temperature are shown in **Figure 3-40**. The greatest variability between alternatives occurs under the 10th and 50th percentile scenarios (left and center panels, respectively). As previously mentioned, this is due to differences in projected storage elevations in the 10th percentile scenario, and differences in the simulated hydrologic trace and meteorology for the 50th percentile scenario.

Figure 3-40
Exceedance Probability for Temperature in Hoover Dam Releases for Each Management Scenario, Grouped by Selected Trace Cases



No Action Alternative

As seen in the CE-QUAL-W2 model results for Glen Canyon Dam and Hoover Dam releases in **Figure 3-34** and **Figure 3-37**, predicted release temperatures varied widely among the projected traces; the coldest release temperatures occurred when reservoir elevations were the highest.

In the traces examined using the CE-QUAL-W2 model for the No Action Alternative, release temperatures were strongly linked to the elevation of Lake Powell relative to where the water is being released, which affects the probability of exceeding specific temperature thresholds. Below Glen Canyon Dam, the No Action Alternative had traces that exceeded the 20°C (68°F) threshold; however, more than half of the traces simulated were below this threshold for each operational year (**Figure 3-36**).

Proposed Action

Like the No Action Alternative, under the Proposed Action, predicted release temperatures for both Glen Canyon Dam and Hoover Dam varied widely among the project traces; however, the outcomes were relatively similar to those under the No Action Alternative. The coldest release temperatures occurred when reservoir elevations were the highest.

Compared with the No Action Alternative, in the traces examined using the CE-QUAL-W2 model below Glen Canyon Dam, the Proposed Action would lead to slightly fewer days above the 16°C (60.8°F) threshold, on average, in operational years 2024 and 2025; however, the Proposed Action would exceed the 16°C (60.8°F) threshold on slightly more days in operational year 2026, compared with the No Action Alternative. Like the No Action Alternative, the Proposed Action had traces that exceeded the 20°C (68°F) threshold; however, more than half of the traces simulated were below this threshold for each operational year (**Figure 3-36**).

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would change how and when releases from Glen Canyon Dam would take place. Several of these flow options include releasing water through the river outlet works, which are lower than the penstocks, which are where water is typically released when hydropower is generated. Reclamation would redirect certain release volumes from the higher hydropower-generating penstocks to the lower river outlet works. Releases from the lower river outlet works would be cooler in temperature; therefore, no additive cumulative effect would occur from Glen Canyon Dam flow options.

The implementation of the US Army Corps of Engineers' EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions.

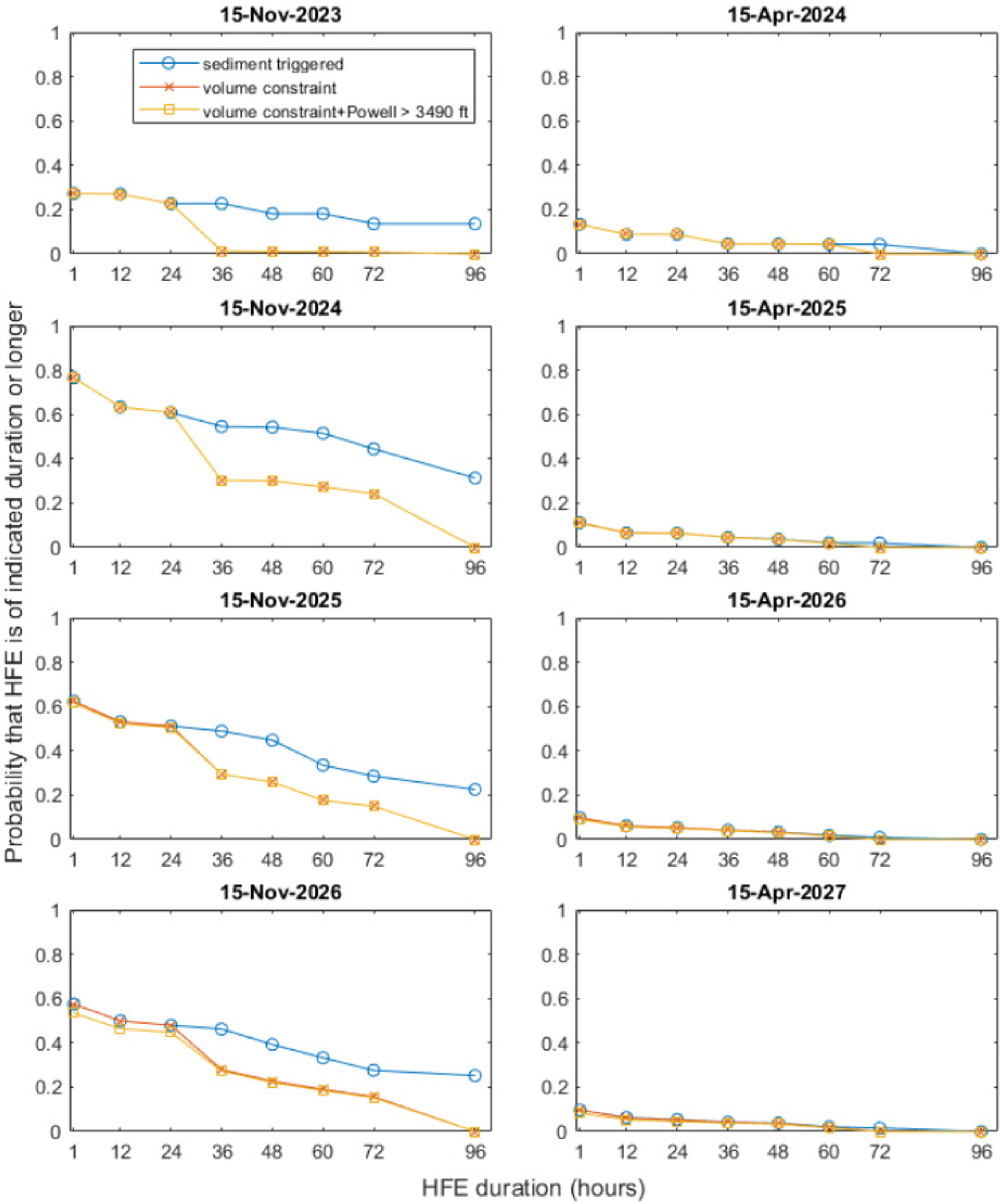
Issue 3: How would elevation protection and low-flow conditions affect the sediment within each reach?

Summary

Under both alternatives, HFEs in the reach between Lake Powell and Lake Mead (in the Marble and Grand Canyons) would not be implemented when Lake Powell elevations are below the protection level, which is 3,500 feet. Under both alternatives, and given the current LTEMP protocols, the modeling results indicate that April HFEs would be triggered for approximately 15 percent of the time, each year, between 2023 and 2026. November HFEs would be triggered approximately 25 percent of the time in November 2023 and between 60 and 80 percent of the time, each year, between 2024 and 2026 (see **Figure 3-41** and **Figure 3-42**). Between November 2024 and 2025 the probabilities for 36- and 72-hour HFE durations would decrease by approximately 5 percent under the Proposed Action, compared with the No Action Alternative. In November 2026, the Proposed Action would reduce the potential of elevations below 3,500 feet, and, therefore, would increase the probability of HFE implementation compared with the No Action Alternative.

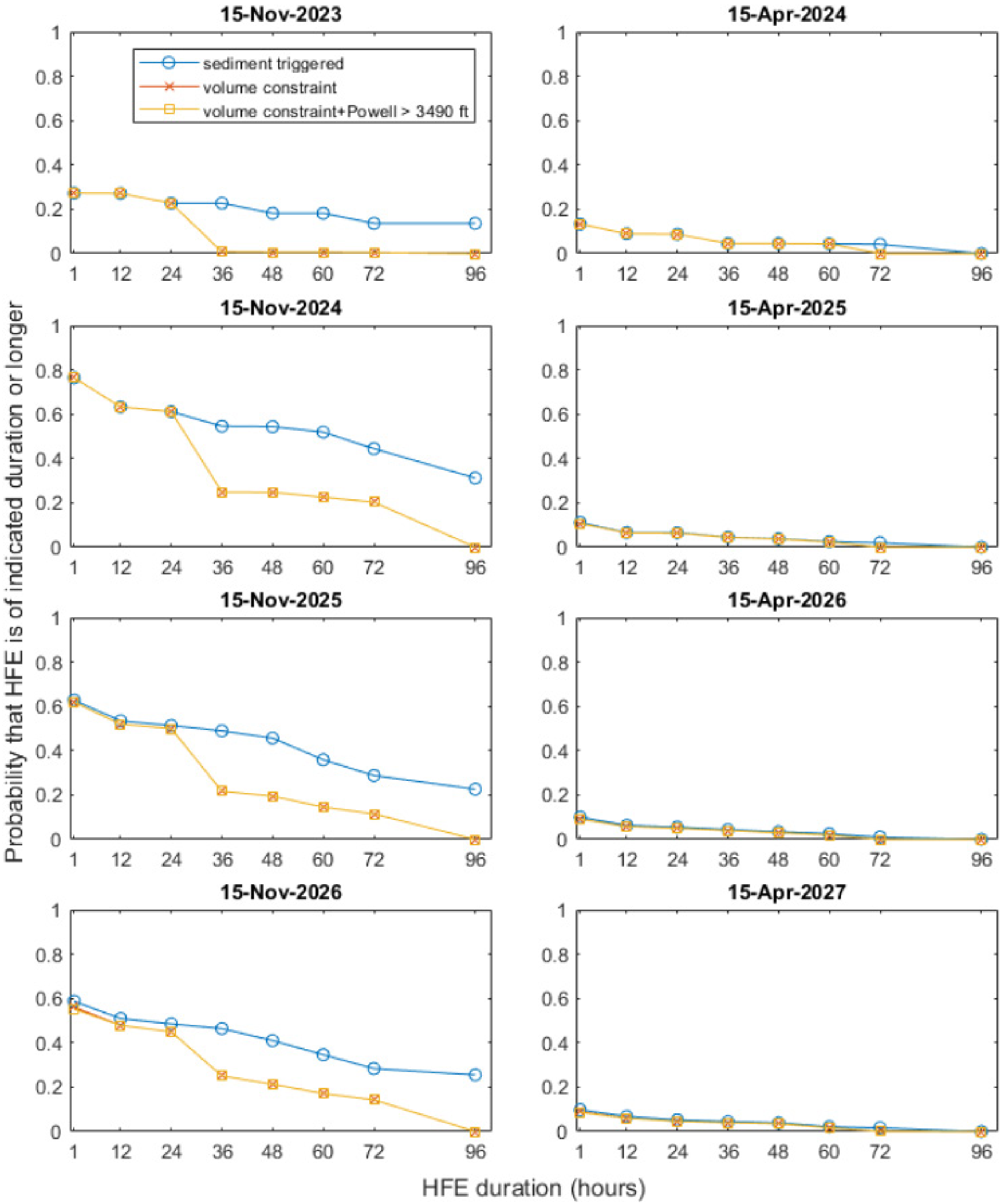
Net erosion of sandbars would occur, and sandbar building would decrease, if HFEs cannot be implemented. Due to the current net sediment export conditions and potential for future HFEs, the predicted mean annual sandbar volume is modeled to increase between 2023 and 2026 (see **Figure 3-43** and **Figure 3-44**).

Figure 3-41
Probabilities of HFE Triggers under the No Action Alternative



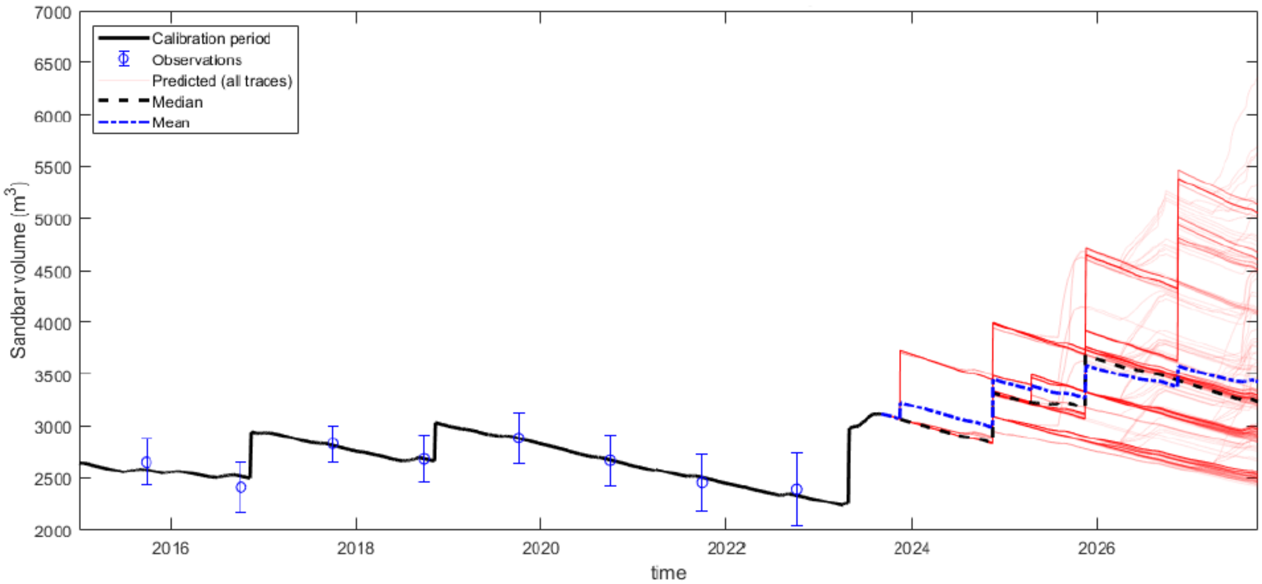
Source: Salter and Grams 2023

Figure 3-42
Probabilities of HFE Triggers under the Proposed Action



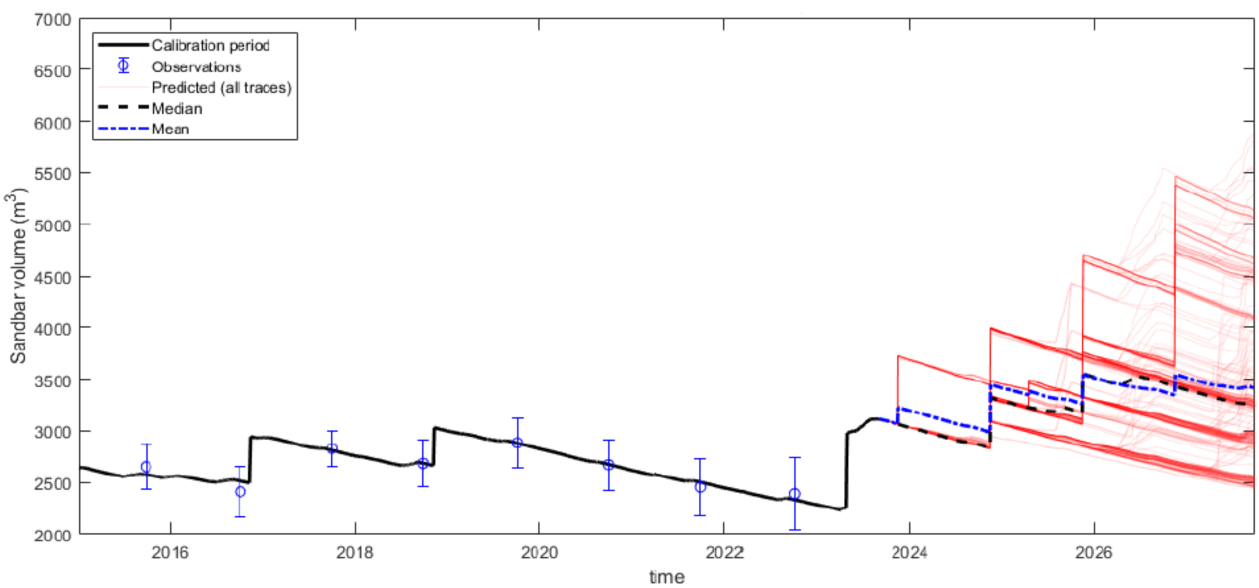
Source: Salter and Grams 2023

Figure 3-43
Observed and Predicated Sandbar Volume under the No Action Alternative



Source: Salter and Grams 2023

Figure 3-44
Observed and Predicated Sandbar Volume under the Proposed Action



Source: Salter and Grams 2023

In **Figure 3-41** and **Figure 3-42**, the "sediment-triggered" lines (differentiated with a circle at data points) represent the probability that there is enough sediment to implement an HFE of the indicated duration without causing the sand mass balance to become negative by the end of the sediment implementation window. The "volume constraint" lines (differentiated with an x at data points) represent the probability of implementing an HFE of the indicated duration (with the volume of water allocated in the implementation month) while also maintaining LTEMP-required minimum daily LTEMP releases (see **Table 3-22**). The lines differentiated with a square at data points represent the probability an HFE of the indicated duration could be implemented, given the volume constraint combined with a constraint of a Lake Powell elevation greater than 3,500 feet (the USGS model uses a more conservative constraint of 3,490 feet). Under the last scenario, even when sufficient monthly volume is available, Lake Powell's elevation could prevent HFE implementation. Similarly, both volume constraint scenarios prevent the implementation of HFEs of the duration that are triggered following the LTEMP protocol (a 96-hour HFE).

Table 3-22
Monthly Minimum Volume Constraints for HFEs

HFE Duration	0-hour	1-hour	12-hour	24-hour	36-hour	48-hour	60-hour	72-hour	96-hour
Volume (af)[1]	394,210	426,800	456,200	490,090	522,400	556,300	588,600	622,500	688,700

Source: Salter and Grams 2023
[1]Total releases less than these volumes are not possible without decreasing flows below the LTEMP-required minimum daily (8,000 cfs) and nightly (5,000 cfs) releases.

At a 0-hour duration, an HFE would not occur. The volume constraint combined with the 3,500-feet constraint would cause HFEs of longer duration (36 to 96 hours) to be substituted with 1- to 24-hour HFEs (see **Figure 3-41** and **Figure 3-42**) during the November implementation window. The probabilities for every possible HFE duration during the April implementation window are low compared with the November implementation window. The 1-hour HFEs have the highest probability of occurrence. Based on the Mueller and Grams (2021) Sandbar Model, a 1-hour HFE is projected to be less than 5 percent as effective as a 96-hour HFE; however, those HFEs with durations shorter than approximately 60 hours have never been tested, and they would be of unknown effectiveness. Short-duration HFEs were included as an option in LTEMP to be implemented when there was insufficient sediment available for longer duration HFEs (Reclamation and NPS 2016).

Sediment dredging projects in the reach below Hoover Dam that ensure water delivery to downstream users would continue under both alternatives.

No Action Alternative

Under the No Action Alternative, low-flow conditions would continue to affect the sediment mass balance by limiting sand deposition in eddies and on sandbars in the reach between Lake Powell and Lake Mead. If Lake Powell drops below 3,500 feet, HFEs are infeasible (Salter and Grams 2023). Sand deposits in the Marble and Grand Canyons would be insufficient to build sandbars.

Under the No Action Alternative and LTEMP protocols, current modeling demonstrates that April HFEs would be triggered for approximately 15 percent of the time, each year, between 2023 and 2026. November HFEs would be triggered approximately 25 percent of the time between 2023 and 2024 and between 60 and 80 percent of the time, each year, between 2024 and 2026 (see **Figure 3-41**). These results are consistent with the modeling analyses for LTEMP, which anticipated that fall HFEs would be triggered in about 77 percent of the years and spring HFEs would be triggered in about 26 percent of the years, using different hydrologic inputs and slightly different sediment assumptions (Reclamation and NPS 2016). Given the sustained high releases in July and August 2023, as described under the affected environment, and the potential for future HFEs, the mean predicted sandbar volume would increase between 2023 and 2026 (see **Figure 3-43**).

In November 2026, there is a slight risk of dropping below the 3,500-foot elevation for 5 out of the 90 modeled hydrologic traces under the No Action Alternative. This would preclude HFE implementation.

Sediment dredging projects in the reach below Hoover Dam that ensure water delivery to downstream users would continue under the No Action Alternative.

Proposed Action

According to the modeling results, April and November HFEs under the Proposed Action would be triggered for approximately the same frequency as under the No Action Alternative (see **Figure 3-42**). However, November monthly releases are slightly lower under the Proposed Action and would result in an approximate 5 percent reduction in HFE implementation probability for 36- and 72-hour durations in November 2024 and 2025. In November 2026, the potential for the elevation to drop below 3,500 feet would decrease for more hydrologic traces under the Proposed Action (in the modeling results, only one hydrologic trace dropped below 3,500 feet; Salter and Grams 2023). This would increase the potential for HFE implementation compared with the No Action Alternative, because dropping below 3,500 feet would preclude an HFE implementation altogether. Although there are differences between the alternatives for individual traces, the mean predicted sandbar volume under the Proposed Action is similar to the volume under the No Action Alternative (see **Figure 3-44**), with only a 0.3 percent mean difference of the mean sandbar volume.

Sediment accumulation in the reach downstream of Hoover Dam would continue, as described under the No Action Alternative. The need for sediment dredging projects also would continue.

Cumulative Effects

If one of the LTEMP SEIS flow options were implemented, this would alter hourly and daily releases from Glen Canyon Dam. Each likely flow option under the LTEMP SEIS includes releasing water through the river outlet works, which are lower than the penstocks (the place where water is typically released when hydropower is generated). Combined with the HFE implementation effects in this analysis, if the release volumes are 20,000 cfs or greater, the monthly flow constraint would increase relative to the probability of triggering an HFE. In turn, the probability of triggering an HFE would likely decrease. Between November 2024 and 2025, the No Action Alternative would reduce this cumulative effect, compared with the Proposed Action, because the Proposed Action would have a reduced probability (an approximate 5 percent reduction) for 36- and 72-hour HFE durations during this period. In November 2026, the Proposed Action would reduce this cumulative effect, compared with the No Action Alternative, because it would reduce the potential that Lake Powell's elevation would drop below 3,500 feet. If an HFE is triggered and the dam releases are implemented at the duration and magnitude consistent with the LTEMP protocol, sandbar building would occur.

The implementation of the US Army Corps of Engineers' EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions.

Issue 4: How would elevation protection and low-flow conditions affect DO within each reach?

Summary

Low DO events typically occur in zones of Glen Canyon Dam's metalimnion[18] in September or early October; however, they have been observed as early as August in response to large spring inflows, such as from snowmelt.

As seen in **Figure 3-45**, across both alternatives, mean August to October DO in Lake Powell is projected to drop below 5 mg/L in 79 percent of traces. The percentage of low DO events occurring in the tailwater would be slightly higher under the Proposed Action (80 percent of traces) than under the No Action Alternative (78 percent of traces). This may be due to the lower lake elevations that result from reduced hydrology, but the lake level would not be below elevation 3,490 feet, which would require releases from the river outlet works. **Figure 3-45** shows a dashed red line for 5 mg/L, which is the threshold below which oxygen concentrations are stressful to trout (see **Section 3.13**, Biological Resources, for more information), and a dashed blue line for 8 mg/L, which is the concentration modeled for bypass release. Each point represents 1 year for a total of 90 points per box whisker (30 historical reconstructions x 100 percent, 90 percent, and 80 percent).

No Action Alternative

Under the No Action Alternative, Glen Canyon Dam releases mean August–October DO levels would drop below 5 mg/L in 79 percent of traces, and tailwater low DO events were probable in 78 percent of traces. **Figure 3-45** shows the modeled mean August–October DO concentrations in Glen Canyon Dam outflows for each model year under the No Action Alternative in red.

Proposed Action

Like the No Action Alternative, under the Proposed Action, Glen Canyon Dam releases mean August–October DO levels would drop below 5 mg/L in 79 percent of traces. **Figure 3-45** shows the projections of mean August–October DO concentrations in Glen Canyon Dam releases for each projection year under the Proposed Action in blue.

[18] The metalimnion is the middle layer in a thermally stratified lake or reservoir.

Figure 3-45
Projections of Mean August–October DO Concentrations in Glen Canyon Dam Outflows for Each Projection Year under the Proposed Action and No Action Alternative

Source: USGS 2023b

Under the Proposed Action, it would be slightly likely that the tailwater below Glen Canyon Dam would have more low DO events than under the No Action Alternative. This may be due to the lower lake elevations that result from reduced hydrology but that are not low enough to trigger bypass releases.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would change hourly and daily releases from Glen Canyon Dam. Several of the flow options include releasing water through the river outlet works, which are lower than the penstocks, which are where water is typically released when hydropower is generated. However, passage through the river outlet works would also aerate the water; therefore, this likely would not lead to a cumulative effect on DO.

The implementation of the US Army Corps of Engineers' EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions.

Issue 5: How would elevation protection and low-flow conditions affect nutrients and algae within each reach?

Summary

Because the release temperature projections would be similar under the No Action Alternative and Proposed Action, both alternatives would provide opportunities for algal growth. Declining water levels in Lake Powell could promote cyanobacteria blooms, but this remains to be studied (Yang et al. 2016). These blooms could use excess available nutrients and create low DO areas.

Lower flows under the Proposed Action and decreased dilution capacity under both alternatives could result in greater concentrations of nitrogen and phosphorus; however, quantified water quality impacts related to dilution capacity are not available; therefore, it is difficult to project the quantified water quality impacts based on dilution capacity.

No Action Alternative

Under the No Action Alternative, Glen Canyon Dam releases would have similar release temperatures compared with the Proposed Action, as discussed under *Issue 2*. Therefore, there would be similar opportunities for algal growth when considering temperature.

Decreased dilution capacity could result in greater concentrations of nitrogen and phosphorus; however, quantified water quality impacts related to dilution capacity are not available; therefore, it is difficult to project the quantified water quality impacts based on dilution capacity.

Additionally, with lower reservoir levels, it is possible that phosphorus concentrations in the hypolimnion, where water would be released, could be elevated, depending on seasonality and reservoir nutrient cycling. Higher temperatures downstream and decreased concentrative power from lower water volumes could result in more opportunities for algal growth. Bypass-only scenarios would likely result in more algal growth due to steady flows versus load following flows (Deemer et al. 2022).

Under the No Action Alternative, low DO events occur in 79 percent of traces, as shown in **Figure 3-45**. This occurs in the late summer and early fall, which could lead to bioavailable phosphorus and opportunities for algal growth.

Proposed Action

Under the Proposed Action, Glen Canyon Dam releases would have similar release temperatures when compared with the No Action Alternative, as discussed under *Issue 2*. Therefore, there would be similar opportunities for algal growth when considering temperature.

Lower flows and decreased dilution capacity could result in greater concentrations of nitrogen and phosphorus; however, quantified water quality impacts related to dilution capacity are not available; therefore, it is difficult to project the quantified water quality impacts based on dilution capacity.

Additionally, phosphorus concentrations increase down the water column where releases would be made. Higher temperatures downstream and decreased concentrative power from lower water volumes could result in algal blooms and more opportunities for algal growth.

Under the Proposed Action, low DO events would occur in 79 percent of traces, as shown in **Figure 3-45**; this is the same percentage as under the No Action Alternative. The Proposed Action would have the same percentage of traces with decreased DO concentrations in the late summer and early fall when compared with the No Action Alternative, which would provide a similar amount of bioavailable phosphorus and opportunities for algal growth.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would change daily and hourly releases from Glen Canyon Dam. Several of the flow options include releasing water through the river outlet works, which are lower than the penstocks, which are where water is typically released when hydropower is generated. The resulting releases from lower in the water column would be higher in total phosphorus, which may improve food web conditions given the food-limited nature of the ecosystem. The phosphorus concentrations at depth are not markedly greater than some phosphorus concentrations that have already been released under higher lake levels; therefore, no additive cumulative effect would occur from Glen Canyon Dam flow options.

The implementation of the US Army Corps of Engineers' EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions.

Issue 6: How would elevation protection and low-flow conditions affect metals within each reach?

Summary

As elevations decrease, the dilution capacity of Lake Powell and Lake Mead would also decrease; however, this would not be expected to result in any significant decrease in dilution capacity or increase the concentrations of metals of concern. Quantitative metal modeling results were not available at the time of this report; therefore, only a qualitative discussion is included. Without more specific modeling, it is difficult to project the quantified water quality impacts, and alternatives cannot be compared.

No Action Alternative

Even with the projected drawdown, it is unlikely that the No Action Alternative would significantly increase the concentration of metals; this is because dilution capacity is not likely to reduce significantly. However, without more specific modeling, it is difficult to project the quantified water quality impacts.

Proposed Action

Under the Proposed Action, the likelihood of drawing down below 1,000 feet would be small, which is similar to what was originally analyzed in the 2007 FEIS. Therefore, the projected elevations and corresponding changes in dilution capacity would not be expected to result in a significant reduction in dilution capacity or any significant increase in concentrations of metals of concern. However, without more specific modeling, it is difficult to project the quantified water quality impacts.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would change how and when releases from Glen Canyon Dam take place. This would not result in any changes to monthly or annual release volumes, but it would change how and when those releases take place. Therefore, there is not an expected change to elevation that would impact metals' concentrations.

The implementation of the US Army Corps of Engineers' EA for the implementation of the 10-Year Plan's projects for aquatic habitat restoration would continue to improve conditions.

3.9 Air Quality

3.9.1 Affected Environment

To supplement the 2007 FEIS (Reclamation 2007), this section provides a brief summary of a more comprehensive description of the affected environment in the 2007 FEIS, supplementing, as necessary, to include changes that have occurred since 2007. For additional information, see the 2007 FEIS (Reclamation 2007) and the 2016 LTEMP FEIS (Reclamation and NPS 2016), which are incorporated by reference.

The primary air quality issue is fugitive emissions (dust) generated from shorelines exposed due to reductions in Lake Powell and Lake Mead elevations, affecting particulate levels regionally, including GCNP.

The other air quality issue, which was not addressed in the 2007 FEIS, is greenhouse gas (GHG) emissions. The alternatives analyzed may indirectly affect air quality by potentially changing the degree to which electricity demand is met within the region, with either non-emissive hydropower, wind, or solar powerplants, or emission-producing powerplants, such as fossil fuel-fired powerplants that can directly affect air quality and related resources. These air quality changes can also affect GHG emissions that can influence climate change. Therefore, dam operations can affect air quality and GHG emissions within the 11-state Western Interconnection region, which includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. This is because hydropower generation offsets generation from other generating facilities (that is, coal-fired and natural gas-fired facilities) in the Western Interconnection region.

LTEMP (Reclamation and NPS 2016, Table 3.15-3) presents criteria pollutant (carbon monoxide, nitrogen dioxide, ozone [O_3], particulate matter [PM_{10} and $PM_{2.5}$], sulfur dioxide, and lead), volatile organic compounds, and GHG emissions over the 11-state area within the Western Interconnection region.

Federal Air Quality Requirements

The federal air quality requirements described in the 2007 FEIS are unchanged. The determination that no major stationary sources are being proposed by the proposed alternatives and, therefore, that the statutory provisions are not applicable, is also unchanged. However, these standards still provide thresholds from which to evaluate potential effects on ambient air quality. Lake Powell, Lake Mead, and GCNP are still designated as Prevention of Significant Deterioration (PSD) Class II, Class II, and Class I areas, respectively. The PSD air quality constraints are most stringent in Class I areas and are progressively less stringent in the Class II and Class III areas; these areas have associated allowable particulate matter (PM) concentration increases over the baseline concentrations.

State and Local Air Quality Requirements

The federal and state National Ambient Air Quality Standards (NAAQS) presented in the 2007 FEIS have been updated as follows:

- NAAQS $PM_{2.5}$ annual standard (the primary standard is now 12 μg/m^3, reduced from 15 μg/m^3; the secondary standard is 15 μg/m^3).

The EPA is currently proposing to retain the current PM_{10} and $PM_{2.5}$ 24-hour standards but is considering revising the primary annual $PM_{2.5}$ standard from its current level of 12.0 μg/m^3 to within the range of 9.0 to 10.0 μg/m^3. These PM standards were promulgated to better protect the public from particulate exposures. Additionally, each state must develop an implementation plan describing how it will attain and maintain the NAAQS. Some states have developed more stringent ambient air quality standards for PM_{10} and $PM_{2.5}$, while others have adopted PM standards to meet the previous NAAQS, as follows:

- Nevada, Arizona, and Utah all now have a $PM_{2.5}$ 24-hour standard of 35 μg/m^3, and the annual PM_{10} standard has been removed.
- The California $PM_{2.5}$ 24-hour standard has been removed.

Three state and local air quality agencies are responsible for attaining the state and federal standards within the study area: Arizona Department of Environmental Quality; Utah Department of Environmental Quality, Division of Air Quality; and Clark County Air and Environmental Management.

Ambient Air Quality by River Reach

As the 2007 FEIS states, attainment status for each reach provides a qualitative characterization of compliance with the standards as well as an indication as to whether a specific pollutant is a significant concern. Consequently, characterizing the attainment status in the reaches provides a qualitative assessment of the significance of air pollutant emissions within the reach. The Arizona counties of Mohave, Coconino, Yavapai, and Navajo, and the Utah counties of Washington, Kane, and San Juan are in attainment for all pollutants. Clark County, Nevada—Las Vegas, in particular—is in attainment for all pollutants except 8-hour ozone. The attainment status has improved since the 2007 FEIS, as Clark County's PM_{10} was redesignated from nonattainment to maintenance in November 2014.

While some urban areas (including Las Vegas, North Las Vegas, and Henderson) within Clark County are maintenance areas under the PM_{10} NAAQS, the remainder of the county, including Lake Mead, is in attainment of the standard. Mohave County, Arizona, adjacent to Lake Mead, is also in attainment of the PM_{10} standard (Reclamation 2000). The Lake Powell and Glen Canyon Dam reach and Lake Mead and Hoover Dam reach are both in a PSD Class II area. As lake levels have decreased since 2007, PM due to dust has likely increased. In 2018, 24-hour PM_{10} levels at Lake Mead reached 116 μg/m^3, which is about 77 percent of the 150 μg/m^3 NAAQS. The State of Nevada started a regulatory PM_{10} monitor in Boulder City, Nevada, in 2021. In this first year of monitoring, 24-hour PM_{10} levels exceeded the 24-hour NAAQS at 190 μg/m^3, which is 127 percent of the standard. These current high levels demonstrate that dust is already a concern for the Lake

Mead region; with the decreasing water levels since 2007, additional dust would affect local air quality and public health for both the Lake Powell and Glen Canyon Dam reach and Lake Mead and Hoover Dam reach.

Salton Sea

The Salton Sea, as currently known, is in Imperial and Riverside Counties. Imperial County is currently designated as a nonattainment area for the federal and state O_3 and $PM_{2.5}$ and maintenance for the state PM_{10} standards. Riverside County is currently designated as a nonattainment area for the federal and state O_3 and state PM_{10} standards.

Historically, the water level and therefore shoreline area at the Salton Sea have decreased from 2003 to 2015, as noted in a 2015 study (Reclamation 2023e). The decreasing water level has the potential to increase fugitive dust. The current nonattainment status of PM_{10} and $PM_{2.5}$ for these two counties demonstrates that dust is already a concern for the Salton Sea area, and additional dust would affect local air quality and public health.

3.9.2 Environmental Consequences

This section analyzes the potential effects of the proposed alternatives on air quality resources. The following issues are addressed:

- Impacts on fugitive dust from changes in shoreline exposure due to changes in lake reservoir elevations
- Impacts on GHGs from changes in hydropower generation due to changes in lake reservoir elevations and releases

Methodology

Similar to the 2007 FEIS, this analysis evaluates the relative difference between the No Action Alternative and the Proposed Action. Fugitive emissions can result from exposed sediment on the shorelines of Lake Powell and Lake Mead as a result of fluctuations in the elevations of these reservoirs. The mass of particulates generated per acre of exposed shoreline would vary depending on sediment characteristics and other factors, such as saturation, sediment disturbance, wind speeds, and topography.

Both Lake Mead and Lake Powell have potentially experienced increased dust from newly exposed shoreline; however, neither the Glen Canyon National Recreation Area (GCNRA) nor the Lake Mead National Recreation Area (LMNRA) has current or historical air quality monitoring or modeling data to determine baseline levels. Additionally, any potential heavy metals or other contaminants in exposed sediment have not been determined due to a lack of sampling. As lake levels drop and dry out, unvegetated sediments are more likely to become airborne during wind events, causing negative impacts on air quality at localized locations due to blowing dust. Some of these areas may be at or near heavily visited marinas and beaches. The NPS advocates for deployment of air quality monitoring equipment, sediment testing, and modeling activities at both national recreation areas to appropriately inform the SEIS implementation activities prior to 2026.

To perform the shoreline exposure portion of the air quality analysis, the NPS used the 10th percentile data for the 80 percent ESP hydrologic scenario provided by Reclamation; this shows the ranges for elevations at Lake Powell and Lake Mead (NPS 2023a). In addition, geographic information system (GIS) acreage information was prepared utilizing the USGS's 2021 modified topobathymetric elevation data for Lake Powell, which is a topobathymetric digital elevation model. Topobathymetric data are a merged rendering of both topography (land elevation) and bathymetry (water depth) to provide a single product useful for inundation mapping and a variety of other applications. For a conservative assessment, the lowest extent of the 10th percentile in the 3-year period (2024, 2025, and 2026) was used to determine the elevation, inundation (acres of water), and acres of exposed shoreline at Lake Powell and Lake Mead. The results of these analyses are used throughout this section.

The way hydropower is generated has not changed since 2007. However, recent drought conditions in the Basin have led to a decrease in hydropower generation since the 2007 FEIS (Reclamation 2021d). The Glen Canyon Powerplant accounts for approximately 75 percent of the Upper Colorado Basin's annual energy production (Reclamation 2007). Despite the improved efficiency since 2007, the Glen Canyon Powerplant has still been heavily affected by drought conditions in the Basin, and the powerplant's capacity decreases as the lake elevation drops and the head gets lower. As discussed, these reductions of power generation could result in increased GHG emissions due to coal or natural gas supplementing the otherwise non-emissive hydropower energy.

Reclamation, with the assistance of WAPA, conducted a study of the potential effects of the No Action Alternative and the Proposed Action on the Colorado River system's electrical power resources, which included all major facilities. Reclamation's CRMMS helped develop potential releases, reservoir elevations, and power generation from the Proposed Action. WAPA's GTMax modeling was used to further analyze impacts on the Glen Canyon Powerplant. GTMax simulates the dispatch of electric-generating units and the economic trade of energy among utility companies using a network representation of the power grid. Using the changes in megawatt hours (MWh) under the Proposed Action and conversion emission factors for coal and natural gas from the US Energy Information Administration's (EIA) energy conversion calculator, the estimated metric tons (MT) of carbon dioxide equivalent (CO_2e) were calculated (EIA 2023). The results of these analyses are used throughout this section.

Impact Analysis Area

The impact analysis area for fugitive dust is the same as the analysis area used for the 2007 FEIS, which includes the Glen Canyon to Lake Mead reach; this is because the PM generated at the Lake Mead delta may be dispersed into this reach. The impact analysis area is divided into three sections: (1) Lake Powell and Glen Canyon Dam, (2) Glen Canyon Dam to Lake Mead, and (3) Lake Mead and Hoover Dam. Potential fugitive dust generated by changes to the Salton Sea's shoreline through changes in water availability are also discussed.

The analysis area includes every major hydropower facility along the Colorado River, from Lake Powell to the SIB. Facilities include the Glen Canyon Powerplant, the Hoover Powerplant, the Davis Powerplant, and the Parker Powerplant. Other smaller facilities along the river include Headgate Rock Powerplant, Senator Wash, Siphon Drop, and Pilot Knob. These smaller facilities would not be impacted by the Proposed Action and have, therefore, been removed from further analysis.

Given that climate change is a global phenomenon and the effects of GHG emissions are considered cumulative, the GHG impact analysis area would include the aforementioned 11-state Western Interconnection grid and the rest of the United States.

Assumptions

The method for assessing potential fugitive dust emissions from exposed shoreline sediments at Lake Powell and Lake Mead includes the following assumptions:

- The 10th percentile data for the 80 percent ESP hydrologic scenario provided by Reclamation show the ranges for elevations at Lake Powell and Lake Mead, including the 10 percent minimum, the 50 percent median, and the 90 percent maximum. It was assumed under the 10 percent minimum hydrology that the flows would be very low and steady year-round. For a conservative assessment, the lowest extent of the 10th percentile for the 80 percent ESP hydrologic scenario in the 4-year period was utilized.
- GIS acreage information was prepared utilizing the USGS's 2021 modified topobathymetric elevation data for Lake Powell, which is a topobathymetric digital elevation model comprised of four data sources published in 2021.
- The current Lake Powell reservoir level was retrieved from Reclamation for February 16, 2023, from the water operations 40-day data sets (Reclamation 2023f).
- The current Lake Mead reservoir level was retrieved from Reclamation for February 2023 from the end-of-the-month elevations data sets (Reclamation 2023f).
- Lake Powell inundation (acres of water) are provided for the 10th percentile for the 80 percent ESP hydrologic scenario, as well as the current level.
- Lake Mead inundation (acres of water) are calculated based on pre-inundation topographic maps for the 10th percentile for the 80 percent ESP hydrologic scenario.
- All calculations were completed using the North American Datum 1983 (2011) Universal Transverse Mercator Zone 12N projected coordinate system.

The method for assessing potential increased GHG emissions from decreased hydropower includes several assumptions made during the modeling process. The assumptions from CRMMS of the Upper and Lower Basin are covered in **Section 3.3**, Methodology, with additional information in **Section 3.6**, Hydrologic Resources. Following CRMMS of the Upper Basin, the GTMax modeling was only used for releases from Glen Canyon Dam. The modeling only analyzes penstock releases and does not analyze any potential releases from the river outlet works. Results from the GTMax modeling are only calculated for 1 week each month and then replicated for every week of the month. CRMMS estimates monthly releases in the Upper and Lower Colorado Basin. The GTMax Model estimates hourly releases at Glen Canyon Dam.

Megawatt hours derived from CRMMS and GTMax modeling were utilized. Then, using the EIA energy conversion calculators, the amount of coal and natural gas necessary to produce the same amount of power was determined. Finally, the EPA emission factors for GHG inventories were used to determine the metric tons per year (MT/year) of CO_2e for both natural gas and coal for the Proposed Action and No Action Alternative (EPA 2022).

Impact Indicators

Impact indicators for air quality would remain the same as previously considered for the 2007 FEIS, including fugitive dust from shoreline exposure. In addition, impact indicators for air quality would include GHG emissions from alternative power sources (coal and natural gas) due to reduced hydropower. Reservoir elevation changes determine the amount of head available, which determines both energy and capacity, and penstock water releases are what power the powerplant turbines and lead to power generation.

Issue 1: How would changing flow characteristics affect the potential exposed shoreline and fugitive dust?

Summary

The projected exposed shoreline acreages under the Proposed Action are less than those projected under the No Action Alternative at Lake Powell. The projected exposed shoreline acreages under the Proposed Action are also less than those projected under the No Action Alternative at Lake Mead.

As reservoir elevations decrease and more shoreline is exposed, the potential for increased fugitive dust emissions increases. There is also a significant potential for local "dust devils" and/or regional haboobs (intense dust storms), exposure to toxins in dust, and associated human health effects. With decreasing water levels, additional dust would affect local air quality and public health.

Without years of baseline monitoring for PM within the impact reach, changes in fugitive dust emissions would be difficult to determine. However, documentation of dust emissions has been studied at other western United States state and national parks in hopes of developing wind erosion vulnerability maps at local to regional scales. This documentation has characterized the physical and chemical properties of dust to better understand how dust influences atmospheric properties, ecosystem functions, and human health.

Although not included in this assessment, the application of mitigation strategies may also be needed due to local and regional dust impacts, including, but not limited to, mapping riparian areas for the highest potential restoration opportunities, implementing managed vegetation, allowing for shallow flooding that also affects river dynamics and HFEs, and conducting annual tillage methods and graveling. The National Resources Conservation Service is currently surveying soil content for other drying lakeshores, such as the Salton Sea in California, to formulate a dust risk index and to provide insight into potential airborne toxins and effects on human health.

No Action Alternative

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations in Glen Canyon Dam to the Lake Mead reach. Releases from Lake Powell under poor hydrologic conditions would deplete Lake Powell, exposing a large acreage of increased shoreline at Lake Powell. The stage of water in the river would likely decrease from Glen Canyon Dam to Lake Mead, but it would have comparatively little impact on dust issues. As water elevations continue to decline in Lake Powell, less water would be available for releases below this reach; this could result in additional air quality impacts at Lake Mead.

Lake Powell and Glen Canyon Dam

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations in Lake Powell. The current Lake Powell elevation is 3,573 feet, and Lake Powell surface is 57,454 acres. Snowpack and hydrology may change water levels and exposed shorelines dramatically over a broad range. In the case of the No Action Alternative 10th percentile for the 80 percent ESP hydrologic scenario (2023–2026), increased dust would be noted with much larger shorelines at Lake Powell, with an estimated exposure of an additional 28,000 acres. In the 2007 FEIS, the low Lake Powell elevation at the 10th percentile was projected for the year 2025 with about 17,000 acres of exposed shoreline (Reclamation 2007, Figure 4.6-1 and Table 4.6-1).

Glen Canyon Dam to Lake Mead, Lake Mead and Hoover Dam

The current Lake Mead elevation is 1,047 feet, which covers 10,636 acres. Snowpack and hydrology will change water levels and exposed shorelines dramatically over a broad range. In the case of the No Action Alternative 10th percentile for the 80 percent ESP hydrologic scenario (2023–2026), increased dust would be noted with much larger shorelines at Lake Mead, with an estimated exposed additional 94,350 acres. In the 2007 FEIS under the No Action Alternative, Lake Mead's elevation would be drawn down to 1,003 feet for 2025, resulting in approximately 89,000 acres of exposed shoreline (Reclamation 2007, Figure 4.6-2 and Table 4.6-2).

Proposed Action

Under the Proposed Action, potentially more shoreline would be exposed compared with under the No Action Alternative. Lake Powell's projected pool elevations are expected to be the same as under the No Action Alternative. Lake Mead's pool elevation would remain around 1,050 feet through 2024 and then would dip to approximately 1,025 feet. The increase in exposed shoreline would potentially have a negative effect on air quality. The increase in acreage susceptible to wind erosion could contribute to an exceedance of the PSD Class II threshold or the state or national air quality standards.

Salton Sea

As noted above, the Salton Sea receives flows from excess irrigation drainage, particularly from the IID and CVWD. Under the No Action Alternative, there would be no changes to current operational activities that would affect flows to the IID or CVWD. Therefore, the Salton Sea's current shoreline area could continue to decrease at the current rate. Projected exposed playa at the Salton Sea for both the Salton Sea Restoration and Renewable Energy Initiative (SSRREI) and Perimeter Lake alternatives show exposed playa will continue to increase as elevation decreases through 2047 and then stabilize. Total exposed playa in all alternatives is projected to approach 100,000 acres by around 2047 and stabilize consistent with the elevation results. The mean elevation in 2018 was 20,549; in 2047, the mean elevation is projected to be 100,303 acres. The SSRREI alternative gradually converts some newly exposed playa into wetland habitat. The Perimeter Lake alternative covers some of the exposed playa when the lake levees are completed. Both alternatives have similar final exposed playa areas at build-out, and are similar to the No Action Alternative in terms of total playa area that may need to be managed for air quality impacts.

Under the Proposed Action, there is the possibility that the IID and CVWD could take additional shortages; thus, there could be reduced river flows and thus potentially less inflow to the Salton Sea from irrigation drainage. Based on modeling, the Salton Sea water surface elevation will decline more rapidly under the Proposed Action than under the No Action Alternative due to additional consumptive uses on the playa (either shallow water habitat or perimeter lake). While the water surface elevation of the habitat and perimeter lake are stabilized under the alternatives, the Salton Sea water surface elevation is projected to decline by about 4 feet, as compared with under the No Action Alternative, by 2047. Projected playa exposure may be greater under the Proposed Action, but by 2047, it is projected to be the same as under the No Action Alternative.

Furthermore, while the No Action Alternative has the slowest decline in water surface elevation, it does not provide replacement habitat for that being lost at the Salton Sea. However, both anticipate an increase in exposed shoreline. This increase would potentially have a negative effect on air quality because the decreasing water level would increase fugitive dust. Since dust is already a concern for the Salton Sea area, additional dust would affect local air quality and public health.

Cumulative Effects

The cumulative effects are the impacts of the proposed alternatives combined with other regional water supply or closely related projects in the region. If one of the LTEMP SEIS flow options were implemented, water would be released through the river outlet works. This would have no cumulative effect on fugitive dust air quality emissions. The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact air quality. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead and would not impact air quality.

Finally, no additive cumulative effects would occur on air quality due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would lake reservoir elevations and releases impact power generation and GHG emissions?

Summary

Compared with the No Action Alternative, the Proposed Action would result in varying degrees of impacts on power generation. In 2024, the Proposed Action outperforms the No Action Alternative under all but the wettest hydrologic conditions; however, the differences in 2024 are minimal when compared to the total hydropower generation. The Proposed Action would result in more power generation compared with the No Action Alternative under low hydrologic scenarios. This is particularly true in 2026, when the No Action Alternative has the potential for dropping below minimum power pool. Annual releases at Lake Mead are higher under the No Action Alternative, leading to less power generation at Hoover Powerplant than under the Proposed Action across most hydrologic scenarios.

The difference between the power generated for the No Action Alternative and the Proposed Action is 316,826 MWh in 2024, 129,988 MWh in 2025, and 139,567 MWh in 2026. The GHG emissions under the Proposed Action for both coal and natural gas were calculated and compared with both total 11-state GHG emissions at 1,226.3 million MT CO_2e in 2010 and total US GHG emissions at 6,810.3 million MT CO_2e in 2010 (Reclamation and NPS 2016) (**Table 3-23**). Increases in GHG emissions under the Proposed Action compared with the No Action Alternative would be small, at approximately 108,329 MT/year of CO_2e for coal and 62,500 MT/year of CO_2e for natural gas. However, the totality of climate change impacts is not attributable to any single action. Albeit a small contribution, this project-related increase in emissions, in combination with a variety of GHG emission sources around the world, could exacerbate climate-related impacts.

Reservoir surfaces (and their drawdown areas) also can be potent emitters of GHGs. A preliminary survey at Lake Powell suggests relatively low surface water emissions (Waldo et al2021but the role of drawdown emissions from deltaic sediments may be significant when water levels drop (see Malenda et al. 2020). Due to uncertainty, these GHG emissions have not been quantified.

No Action Alternative

As discussed in **Section 3.12.2**, Hydropower, under the No Action Alternative, annual releases from Lake Powell and Lake Mead would continue in the Lower Elevation Balancing Tier, as outlined in the 2007 Interim Guidelines. At these rates, under the driest hydrologic conditions, there is a potential for water elevations to drop below the minimum power pool at Lake Powell. There were no modeled outcomes that resulted in reservoir elevations at Lake Mead dropping below minimum power pool. Any drop below the power pool could potentially change the degree to which electricity demand is met within the region with either non-emissive hydropower, wind, or solar powerplants, or emission-producing powerplants, such as fossil fuel-fired powerplants that can directly affect air quality and related resources. These air quality changes can also affect GHGs that can influence climate change.

Section 3.12.2, Hydropower, also includes tables showing the analyses for annual energy generation at the Glen Canyon, Hoover, Parker, and Davis Powerplants for the 2024–2026 year and the likelihood of lake elevations dropping below the minimum power pool at all major powerplants. The 10th percentile of the modeled annual generation values from these tables were selected. **Table 3-23**, below, presents the 10th percentile modeled annual generation values for the No Action Alternative.

Table 3-23
Reduction of Annual Energy Generation and Associated GHG Emissions

Measure	No Action Alternative 10th Percentile	Proposed Action 10th Percentile
2024 Total - Glen Canyon, Hoover, and Parker-Davis Generation (MWh)	7,387,918	7,071,092
2025 Total - Glen Canyon, Hoover, and Parker-Davis Generation (MWh)	7,069,272	6,939,285
2026 Total - Glen Canyon, Hoover, and Parker-Davis Generation (MWh)	6,806,870	6,667,303
Largest Difference in MWh from No Action Alternative	581,048	316,826
Coal - Mixed (Electric Power Source) (MT/year CO2e)	198,672	108,329
% of 11-State GHG Emissions	0.01	0.009
% of US GHG Emissions	0.003	0.002
Natural Gas (MT/year CO2e)	114,622	62,500
% of 11-State GHG Emissions	0.01	0.005
% of US GHG Emissions	0.001	0.0009

Proposed Action

Under the Proposed Action, the calculated GHG emission increases are compared with both total 11-state GHG emissions at 1,226.3 million MT CO2e in 2010 and total US GHG emissions at 6,810.3 million MT CO2e in 2010 (Reclamation and NPS 2016) (**Table 3-23**). Under the Proposed Action, the reduction of hydropower could result in GHG emissions of 108,329 MT/year (0.108 million MT/year) with coal as the replacement power source, or 62,500 MT/year (0.0625 million MT/year) with natural gas as the replacement power source. Differences in GHG emissions from the Proposed Action range from 0.009 percent (coal) to 0.005 percent (natural gas) relative to total 11-state GHG emissions, and from 0.002 percent (coal) to 0.0009 percent (natural gas) relative to total US GHG emissions.

Cumulative Effects

GHG emissions are inherently cumulative impacts because climate change is a global problem, and the emissions from any single project alone would be negligible. The cumulative impacts are the impacts of the proposed alternatives combined with other regional water supply or closely related projects in the region. If one of the LTEMP SEIS flow options were implemented, water would be released through the river outlet works that do not include power generation. This could result in a cumulative negative impact on power generation across both alternatives outlined in this SEIS. The changes in sediment account windows could have impacts on power generation at the Glen Canyon Powerplant.

HFEs at different times of year could result in some impacts on generation. These impacts would not be outside the range analyzed in LTEMP. However, annual volume releases from Lake Powell would not change under the LTEMP SEIS; therefore, no additional impacts would occur at any downstream powerplants. Any reduction would be offset by the purchase of replacement power. The impacts on hydropower would potentially increase GHG emissions due to more emissive alternative power sources, such as coal and natural gas. This would result in a cumulative negative impact on generation across the Proposed Action. However, when calculated, the potential GHG emissions from coal and natural gas alternatives are a very small percentage of the 11-state and US GHG emissions.

No cumulative effects would occur on power generation and GHG emissions due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.10 Visual Resources

3.10.1 Affected Environment

Visual resources are the physical features that make up the visible landscape, including land, water, vegetation, topography, and human-made features such as buildings, roads, utilities, and structures. They also include the response of viewers to those features. This SEIS builds on the 2007 FEIS (Reclamation 2007), which identified the following visual resource issues that may be affected by the No Action Alternative and Proposed Action:

- Attraction features
- Extent (height) of visible calcium carbonate ring
- Exposure of sediment deltas at reservoir inflow areas

Additionally, under this SEIS, based on proposed changes to the flow rate of the Colorado River between Glen Canyon Dam and Lake Mead, as well as potential changes in water availability in the Lower Division States, the following visual resource issues may also be affected:

- Landscape character adjacent to the Colorado River between Glen Canyon Dam and Lake Mead, including through the Grand Canyon

- Broader landscape modifications from reduced water availability, including in irrigated, agricultural landscapes within the Lower Division States

Lake Powell and Glen Canyon Dam Reach

Attraction Features

The landscapes of the Lake Powell and Glen Canyon area are characterized by sweeping vistas of red rock towers, buttes, and mesas typical of the Colorado Plateau (Fenneman 1931). The presence of Navajo Sandstone and desert varnish dominates the existing landscape character with the introduction of water, associated with Lake Powell, framing these natural features. The 2007 FEIS identified three attraction features:

- **Rainbow Bridge**: Contained within Rainbow Bridge National Monument, established in 1910, it was originally only accessible via the rugged Wetherill Trail from Navajo Mountain. Today, no facilities support visitation to Rainbow Bridge National Monument. All infrastructure (docks and restrooms) were relocated to the main channel in 2021, due to narrowing of the canyon and a delta that has formed at the back of the canyon. Some small, motorized vessels may be able to access the monument; however, they must beach their boat, and the walk may be through very soft sediment to reach the trail. Based on lower lake elevations, visitors do not see water under or near the Rainbow Bridge. Therefore, while Rainbow Bridge is an important visual resource, the potential impacts on access would be the primary effect on visitors, which are described in **Section 3.14**, Recreation.
- **Cathedral in the Desert**: This feature was inundated by the waters of Lake Powell as the reservoir filled. This feature is only exposed at lower Lake Powell elevations, and it is completely visible and accessible when reservoir elevations are below 3,550 feet. However, boats may not be able to reach it at reservoir elevations below 3,525 feet.
- **Glen Canyon Dam**: The American Society of Civil Engineers considers this dam one of the finest examples of concrete, thin-arch dams in the United States.

Calcium Carbonate Rings

As described in the 2007 FEIS, Lake Powell has deposits of calcium carbonate, which become visible as reservoir levels decrease. At lower lake elevations, the colorful sandstone canyon walls show a white band of calcium carbonate deposit between the full reservoir elevation and the lower reservoir elevation, which contrast with the natural, red-colored sandstone. At lower lake elevations, motorists view the calcium carbonate ring on Utah State Route 95 (near Hite, Utah), boaters view it on Lake Powell, recreationists see it at developed and undeveloped recreation areas (for example, Hite, Bullfrog, Halls Crossing, Antelope Point, and Wahweap), and hikers see it on trails adjacent to Lake Powell.

Sediment Deltas

As described in the 2007 FEIS, sediment deltas appear as expansive, deep, and eroding mud flats cut by river channels. Sediment exposed for more than a few months is soon colonized by tamarisk, an invasive shrub. Sediments carried by the Colorado River and the San Juan, Dirty Devil, and Escalante Rivers are deposited near the inflow areas of Lake Powell, forming downstream-progressing deltas. These sediment deltas are considered a visual distraction, particularly as the reservoir elevation decreases and the deltas become more visible. The sediment deltas can be seen from viewing areas, including Utah State Route 95 (Utah Bicentennial Scenic Byway) and scenic overlooks adjacent to these inflow areas; water-based recreationists can also see the deltas on Lake Powell.

Glen Canyon to Lake Mead

Attraction Features

This portion of the river, including GCNP, is heavily visited. It includes world-renowned whitewater rafting and other recreational opportunities along the Colorado River (see **Section 3.14**, Recreation, for more information).

Calcium Carbonate Rings

This portion of the Colorado River does not include visible calcium carbonate rings, as it is not contained within an area of fluctuating reservoir levels (such as Lake Powell or Lake Mead).

Sediment Deltas

This portion of the Colorado River does not include sediment deltas, as described for Lake Powell and Lake Mead.

Colorado River Landscape Character

The existing landscape character along the Colorado River is defined by towering cliff faces with banded rock strata containing a variety of colors, including reds, oranges, grays, browns, and white. Vegetation along the river mostly consists of riparian species, such as native willows; nonnative and invasive tamarisk (salt cedar); and isolated areas of cottonwoods and cattails, bulrushes, and reeds in return-current channels (backwaters), channel margins, and mouths of tributary streams from Glen Canyon Dam downstream to Lake Mead. These tributary streams form numerous side canyons leading away from the Colorado River, with many of these side canyons only accessible from the river.

Vegetation farther upslope along rock terraces includes saltbush, arrowweed, rabbitbrush, and other arid-adapted plant species. Previously planned and implemented HFEs from Glen Canyon Dam, to re-create natural floods common before Glen Canyon Dam's construction, have allowed for the transportation and deposition of sand, resulting in the formation of sandbars along the river. In some areas, these HFEs can strip vegetation along the existing sandbars, including tamarisk (salt cedar), which allows the landscape to appear more similar to its natural character.

Lake Mead to Hoover Dam

Attraction Features

The Lake Mead and Hoover Dam area landscapes are similar to those described for the Lake Powell area, except the adjacent landscapes are more typical of the Basin and Range physiographic province, characterized by parallel, north–south-oriented mountain ranges surrounded by nearly level, typically undrained basins (Fenneman 1931). The 2007 FEIS identified one attraction feature:

- **Hoover Dam**: Hoover Dam is a major destination and national landmark with high levels of visitation. In 1955, the American Society of Civil Engineers selected it as one of the seven engineering wonders in the United States. Since the Hoover Dam is in the narrow, steep-walled Black Canyon, only a small portion of Lake Mead is visible from Hoover Dam and adjacent visitor facilities.

Calcium Carbonate Rings

Similar to Lake Powell and as described in the 2007 FEIS, Lake Mead also has deposits of calcium carbonate, which become visible as reservoir levels decrease. At lower lake elevations, the steep rock slopes, canyon walls, and islands show a white band of calcium carbonate deposit between the full reservoir elevation and the lower reservoir elevation, which contrasts with the natural rock colors. At lower lake elevations, motorists view the calcium carbonate ring on US Highway 93 (between Boulder City, Nevada, and Hoover Dam), boaters view it on Lake Mead, and hikers see it on trails adjacent to Lake Mead.

Sediment Deltas

As described in the 2007 FEIS, sediment deltas have built up at the confluence of the Virgin River and Muddy River at the upper Overton Arm and at upper Lake Mead (Iceberg Canyon, Pearce Basin, and lower Granite Gorge). Sediment deltas are visible primarily to water-based recreationists. Visitors to LMNRA at Overton Beach and Pearce Ferry can also view them.

Broader Landscape Character

Availability of water from the Colorado River has resulted in large areas of irrigated landscapes, including agricultural lands in Nevada, Arizona, and California (Lower Division States), which have altered the existing, natural landscapes. This increased water availability has introduced vivid greens into these landscapes, associated with crops and ornamental plantings, which expand the influence of the Colorado River into adjacent arid lands beyond the narrow, natural riparian corridor. Irrigated landscapes also include lands adjacent to the Salton Sea, which the US Bureau of Land Management (BLM) inventoried as part of the Palm Springs-South Coast and El Centro Field Office's BLM visual resource inventories; the BLM determined these lands contain low to moderate scenic quality, except for the Dos Palmas area, which was inventoried as possessing a high level of existing scenic quality (BLM 2010a, 2010b). Views of potential changes to the shoreline of the Salton Sea, through adjustments in water management, would be visible from the Salton Sea State Recreation Area, Salton Sea National Wildlife Refuge, multiple California state routes (State Routes 78, 86, and 111), and adjacent residential areas.

3.10.2 Environmental Consequences

Methodology

Reclamation used similar methods for the analysis of potential impacts on visual resources as were used in the 2007 FEIS to assess the effects on attraction features, extent of the visible calcium carbonate ring, and exposure of sediment deltas at reservoir inflow areas. Based on lowering lake levels associated with Lake Powell, at and below 3,550 feet, the analysis of effects on attraction features assumes the Cathedral in the Desert may be visible (and accessible) under both the No Action Alternative and the Proposed Action.

The assessment of effects on landscape character adjacent to Lake Powell and Lake Mead used the same methods identified in the 2007 FEIS. These include using the latest 80 percent ESP analysis's 10th percentile reservoir elevations, developed by Reclamation using CRMMS, with March 2025 selected for Lake Powell and September 2025 selected for Lake Mead. The height of the calcium carbonate ring was calculated as the distance in feet from full pool elevations of Lake Powell (3,700 feet) and Lake Mead (1,221 feet) to the applicable 10th percentile reservoir elevation. The assessment of effects from sediment deltas considers these 10th percentile reservoir elevations and tiers to the analysis conducted in the 2007 FEIS.

Reclamation added two new analysis items, the Colorado River landscape character and broader landscape character, based on changes in hydrologic conditions associated with the No Action Alternative as well as management direction associated with the Proposed Action. To assess potential changes to the landscape character along the Colorado River (between Glen Canyon Dam and Lake Mead), this analysis focuses on a qualitative assessment of effects associated with lower flow rates and the potential inability to conduct HFEs from Glen Canyon Dam. This analysis considers and references the analyses contained in **Section 3.13**, Riparian Vegetation portion of Biological Resources, and **Section 3.14**, Recreation, which assess the effects of the different flow rates resulting from both alternatives on the prevalence of riparian vegetation and the visibility of river features, including Separation and Pearce Ferry rapids, respectfully.

The assessment of potential impacts on the broader landscape character in the Lower Division States considered changes in annual Colorado River water supplies available to these states to identify the extent of large-scale changes to the visual character in irrigated landscapes, including those associated with agricultural production, as well as potential changes to the Salton Sea's shoreline through changes in water availability. This analysis considers and references assessment items contained in **Section 3.16**, Socioeconomics, including the effect of each alternative's proposed distribution of water on agricultural operations in these areas.

Impact Analysis Area

The visual resource impact analysis area was defined as the area within 5 miles of the Colorado River and full pool elevations of Lake Powell and Lake Mead. The 2007 FEIS did not specifically identify an analysis area for visual resources; however, based on the typical threshold between the foreground, middle ground, and background visual distance zones where views of the change in management could attract attention in the landscape, this analysis area was selected to facilitate the assessment of the most intense potential impacts. Visual effects beyond this geographic area were considered, where appropriate, including the effects on the broader landscape character associated with potential decreased water availability for the Lower Division States, including potential changes to the Salton Sea's shoreline.

Assumptions

- The analysis methods are consistent with the 2007 FEIS. Based on lowering water levels associated with Lake Powell, the assessment of visibility and access to Cathedral in the Desert assumes Cathedral in the Desert would become visible and accessible under both alternatives.

- Deceasing flow rates along the Colorado River, and the inability to conduct HFEs from Glen Canyon Dam, would modify the river corridor's natural, visual character by limiting natural flooding processes, including through the Grand Canyon.
- Decreasing water availability for the Lower Division States would result in large-scale changes to the visual character in irrigated landscapes, including those associated with agricultural production.

Impact Indicators

- **Attraction Features:** Qualitative assessment describing the effects from continued visibility and access to Cathedral in the Desert as well as more of Glen Canyon Dam and Hoover Dam becoming visible on their upstream side, tiering to the results from the 2007 FEIS and considering current reservoir elevations and the latest 80 percent ESP analysis's 10th percentile reservoir elevations.
- **Calcium Carbonate Rings:** Potential height (in feet) of the calcium carbonate rings at Lake Powell and Lake Mead for each alternative, considering the latest 80 percent ESP analysis's 10th percentile reservoir elevations.
- **Sediment Deltas:** Qualitative assessment tiering to the analysis from the 2007 FEIS, considering the latest 80 percent ESP analysis's 10th percentile reservoir elevations.
- **Colorado River Landscape Character:** Qualitative description of the effect associated with proposed flow rates and the potential to conduct HFEs from Glen Canyon Dam under each alternative, considering modeling associated with **Section 3.13**, Riparian Vegetation portion of Biological Resources, and **Section 3.14**, Recreation.
- **Broader Landscape Character:** Qualitative description of the effects associated with potential decreases in water availability for the Lower Division States on the broader landscape character. This includes considering modeling associated with potential changes to crop production as a result of proposed distribution of water, as described in **Section 3.16**, Socioeconomics, as well as modeling for the Salton Sea depicting the projected exposed lake bed area associated with different drought-reduction scenarios.

Issue 1: How would management of reservoir elevations affect the visibility of attraction features?

Summary

Visibility and access to Cathedral in the Desert would be similar among both alternatives. Due to lower projected elevations for Lake Powell and Lake Mead associated with the No Action Alternative, more of the upstream side of Glen Canyon and Hoover Dams would be visible compared with under the Proposed Action.

No Action Alternative

Under the No Action Alternative, Lake Powell could drop below 3,550 feet during the planning period through the end of 2026. Based on lake elevations potentially dropping below this threshold, Cathedral in the Desert could be visible and accessible under the No Action Alternative during the planning period. This same modeling projects pool elevations for Lake Powell could drop below 3,500 feet through 2026, which would expose more of the upstream side of Glen Canyon Dam. The impacts associated with more of Glen Canyon Dam becoming visible would be similar to the effects described in the 2007 FEIS. Similarly, more of the upstream side of Hoover Dam would become visible due to lowering lake elevations in Lake Mead, which based on modeling, would approach and may drop below 1,000 feet in 2026.

Proposed Action

Similar to the No Action Alternative, Cathedral in the Desert could be visible and accessible under this alternative. Based on proposed management to maintain Lake Powell at 3,500 feet or above, less of the upstream side of Glen Canyon Dam would be exposed under this alternative. In a similar manner, through management of Lake Mead, water levels would remain above 1,000 feet through 2026; this would result in less of the upstream side of Hoover Dam becoming visible under this alternative compared with under the No Action Alternative.

Cumulative Effects

The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels or visibility of attraction features. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year and would result in no changes to annual reservoir levels or visibility of attraction features. Therefore, no additive cumulative effects would occur on attraction features, and effects would be the same as described above for each alternative.

Future increases in consumptive use of Colorado River water in the Upper Division States, intrastate water transfers in the Lower Division States (e.g., Quantification Settlement Agreement water transfers), implementation of the Lower Colorado River Multi-Species Conservation Plan (LCR MSCP), and various requirements and constraints applied to the operation of the Colorado River system were included in modeling of future system conditions.

No cumulative effects would occur on attraction features from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the Salton Sea 10-Year Plan's projects.

Issue 2: How would management of reservoir elevations affect the landscape character, including the visibility of calcium carbonate rings and sediment deltas?

Summary

The effects on the landscape character associated with the visibility of calcium carbonate rings and sediment deltas would be more prominent under the No Action Alternative. This is due to taller calcium carbonate rings and more extensive sediment deltas, which would become populated by vegetation, including tamarisk. This vegetation would introduce bright greens into the landscape that would contrast with the arid landscape's natural character. These changes in landscape character would be visible to boaters on Lake Powell and Lake Mead, motorists on adjacent highways, and recreationists at developed and undeveloped recreation areas.

No Action Alternative

Modeled reservoir elevations for March 2025 indicate a low Lake Powell reservoir elevation of 3,504 feet under the No Action Alternative. This would create a potential calcium carbonate ring that would be 196 feet in height. Modeled reservoir elevations for September 2025 indicate a low Lake Mead reservoir elevation of 1,017 feet under the No Action Alternative. This would create a potential calcium carbonate ring that would be 204 feet in height. As described in the 2007 FEIS, sediment deltas would continue to build up over time and would be visible as the reservoir elevations drop, including under the No Action Alternative. The expanding sediment deltas would become populated by vegetation, including tamarisk, which would introduce bright greens into the landscape that contrast with the arid landscapes adjacent to Lake Powell and Lake Mead.

Both the calcium carbonate ring and sediment deltas would modify the landscape character along the edge of Lake Powell. These modifications would be visible for motorists on Utah State Route 95, boaters on the Lake Powell, recreationists at developed and undeveloped recreation areas, and hikers on trails adjacent to Lake Powell. Similarly, the calcium carbonate ring and sediment deltas would modify the landscape character along the edge of Lake Mead; these modifications would be visible for motorists on US Highway 93 (between Boulder City, Nevada, and the Hoover Dam), boaters on Lake Mead (including visitors to Overton Beach and Pearce Ferry), and hikers on trails adjacent to Lake Mead.

Proposed Action

Modeled reservoir elevations for March 2025 indicate a low Lake Powell reservoir elevation of 3,510 feet under the Proposed Action. This would create a potential calcium carbonate ring that would be 190 feet in height. Modeled reservoir elevations for September 2025 indicate a low Lake Mead reservoir elevation of 1,037 feet under the Proposed Action. This would create a potential calcium carbonate ring that would be 184 feet in height. Based on potential higher lake elevations under this alternative, the sediment deltas would be less extensive than under the No Action Alternative. Due to the shorter calcium carbonate ring and less extensive sediment deltas, the Proposed Action would result in less modification to the landscape character along the edge of Lake Powell and Lake Mead, including impacts on viewers, than the No Action Alternative.

Cumulative Effects

The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels or the landscape character near Lake Powell and Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no changes to annual reservoir levels or the adjacent landscape character. Therefore, no additive cumulative effects would occur on the landscape character near Lake Powell and Lake Mead with the same effects described above occurring for each alternative.

Future increases in consumptive use of Colorado River water in the Upper Division States, intrastate water transfers in the Lower Division States (e.g., Quantification Settlement Agreement water transfers), implementation of the LCR MSCP, and various requirements and constraints applied to the operation of the Colorado River system were included in modeling of future system conditions.

No cumulative effects would occur on the landscape character near Lake Powell and Lake Mead from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 3: How would management of releases from Glen Canyon Dam affect landscape character along the Colorado River?

Summary

The No Action Alternative would initially have less impacts on the landscape character than the Proposed Action. This is because the No Action Alternative does not include reducing flows below 7.0 maf; however, if Lake Powell were to drop to dead pool, these impacts would be more extensive and immediate compared with under the Proposed Action. Under the Proposed Action, the different release tiers would temper these impacts with the goal of maintaining consistent flows along the Colorado River (including through the Grand Canyon) while keeping Lake Powell above 3,500 feet.

No Action Alternative

The No Action Alternative includes lowering releases from Glen Canyon Dam as Lake Powell elevations drop; this would result in releases as low as 7.0 maf when elevations drop below 3,525 feet. Since the No Action Alternative does not include reducing releases from Glen Canyon Dam under 7.0 maf, including if Lake Powell drops below power pool but remains above dead pool, there would be minor, incremental impacts on the landscape character along the Colorado River, including through the Grand Canyon. The current trends of increasing bank armoring, associated with expanding riparian vegetation areas (including tamarisk), would continue under the No Action Alternative.

Based on the current 80 percent ESP modeling, it is not anticipated that Lake Powell would reach dead pool elevation during the planning period. If the elevation of Lake Powell were to drop below dead pool, flows from Glen Canyon Dam could dramatically decrease, resulting in more extensive impacts on the landscape character, including the appearance of river features previously not visible under current conditions. Additionally, the positive influence of the moving, turbulent Colorado River adds to the existing landscape character, which would be degraded if releases from Glen Canyon Dam would be dramatically reduced. (For more information on the impacts on riparian vegetation under the No Action Alternative, refer to **Section 3.13**, Biological Resources; for impacts on recreation, including visibility of river features, refer to **Section 3.14**, Recreation.)

Proposed Action

The Proposed Action, as part of the Mid-Elevation Release Tier (below 3,575 feet) and Lower Elevation Balancing Tier (below 3,525 feet), includes a series of thresholds to reduce releases from Glen Canyon Dam. These thresholds are tied to lowering Lake Powell elevations with a release limited to 6.0 maf, if Lake Powell elevation projections show Lake Powell could drop below 3,500 feet during the subsequent 12 months. Lower releases from Glen Canyon Dam would result in less water flowing along the Colorado River (and through the Grand Canyon), which could increase existing trends of bank armoring associated with more extensive riparian vegetation, including tamarisk. Lower releases also could limit the number of times a HFE could be triggered from Glen Canyon Dam, which would only occur when the HFE furthers maintenance of target reservoir elevations. These lower flows may also result in the appearance of river features previously not visible under current conditions and less movement of the river's natural sandbars.

If the yearly elevation projection identifies that Lake Powell would be above 3,500 feet, resulting in releases of 7.0 maf or more, the impacts associated with this alternative would be similar to those described under the No Action Alternative as the increased impacts associated with the lower 6.0 maf releases from Glen Canyon Dam would be avoided. (For more information on the impacts on riparian vegetation under the Proposed Action, refer to **Section 3.13**, Biological Resources; for impacts on recreation, including visibility of river features, refer to **Section 3.14**, Recreation.)

Cumulative Effects

The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels or the landscape character along the Colorado River downstream of Glen Canyon Dam. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no additive cumulative effects on the landscape character along the Colorado River, with the same effects described above occurring for each alternative.

Future increases in consumptive use of Colorado River water in the Upper Division States, intrastate water transfers in the Lower Division States (e.g., Quantification Settlement Agreement water transfers), implementation of the LCR MSCP, and various requirements and constraints applied to the operation of the Colorado River system were included in modeling of future system conditions.

No cumulative effects would occur on the landscape character along the Colorado River from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 4: How would management of water availability for the Lower Division States affect the landscape character?

Summary

The No Action Alternative would initially have lower impacts on the character of irrigated and agricultural landscapes within the Lower Division States, compared with the Proposed Action. If the elevation of Lake Mead continues to drop toward dead pool, under the No Action Alternative, dramatic decreases in water availability could occur; this would affect all three Lower Division States. Based on current lake level modeling, these reductions in water deliveries are not anticipated during the planning period. The Proposed Action establishes a series of water supply adjustments based on lowering elevations of Lake Mead and application of conservation measures to temper these effects. Potential water shortages would be allocated across all three Lower Division States, resulting in more widely distributed, but less intense, effects on the character of irrigated and agricultural landscapes in the Lower Division States compared with under the No Action Alternative.

Based on the expeditated exposure of the Salton Sea lake bed under the Proposed Action, resulting in the diminishing influence of water on adjacent landscapes, greater indirect impacts on the landscape character adjacent to the Salton Sea during the planning period are anticipated compared with under the No Action Alternative. The long-term impacts would become the same between the No Action Alternative and Proposed Action.

No Action Alternative

Since the No Action Alternative includes minor adjustments to the distribution of water for Arizona and Nevada (no adjustments for California), based on lowering Lake Mead elevations, there would initially be a limited incremental effect on irrigated landscapes, including those in agricultural use. If elevations in Lake Mead were to drop to dead pool (895 feet), the 80 percent ESP analysis identifies that lake levels would not approach this threshold during the planning period, and flows from Lake Mead would dramatically decrease. This would result in lower water deliveries than currently allocated, affecting all three Lower Division States.

Depending on the duration of these decreased water deliveries, the character of irrigated and agricultural landscapes within the Lower Division States would be modified through aridification of these areas; this would diminish the vivid greens associated with crops and ornamental plantings. The influence of the Colorado River into adjacent lands would narrow as these areas would transition to their natural, arid condition. This would result in large-scale changes to the landscape character compared with the existing condition. (For more information on the impacts on agricultural operations under the No Action Alternative, refer to **Section 3.16**, Socioeconomics).

Based on modeling identifying the extent of the Salton Sea lake bed that could be exposed through management of water use from the Colorado River, up to 35,594 acres of lake bed could be exposed through 2026 (Tetra Tech 2023). This additional exposure of the lake bed, and the reduced influence of water into adjacent landscapes, would lead to diminishing scenic quality within these landscapes over the long term with views of these changes occurring from the Salton Sea State Recreation Area, Salton Sea National Wildlife Refuge, multiple California state routes (State Routes 78, 86, and 111), and adjacent residential areas. No modifications to the Dos Palmas landscape, an area identified as possessing a high level of existing scenic quality, are anticipated under the No Action Alternative.

Proposed Action

The Proposed Action includes a series of water supply adjustments for the Lower Division States based on lower elevations of Lake Mead. If water levels in Lake Mead drop below 1,090 feet, similar effects as described under the No Action Alternative are anticipated, with proposed SEIS conservation measures tempering these effects. As lake levels continue to drop toward 1,025 feet, all three states would receive less water from the Colorado River under this alternative through proposed shortages and conservation measures.

As Lake Mead approaches dead pool, to avoid a dramatic decrease in water releases from Hoover Dam affecting all three Lower Division States, more reductions could occur. These include further reductions in water deliveries based on extraordinary circumstances, as described in Section 7(D) of the 2007 Interim Guidelines. These reductions to avoid reaching dead pool would temper the impacts on the character of irrigated and agricultural landscapes within the Lower Division States, as described under the No Action Alternative. Lower water releases would potentially lead to aridification of areas affected by water shortages, diminishing the vivid greens associated with crops and ornamental plantings; however, they would occur more gradually than under the No Action Alternative. The influence of the Colorado River into adjacent lands would begin to narrow in all three Lower Division States as these areas would transition to their natural, arid condition. This would result in large-scale changes to the landscape character compared with the existing condition. (For more information on the impacts on agricultural operations under the Proposed Action, refer to **Section 3.16**, Socioeconomics).

Based on modeling identifying the extent of the Salton Sea lake bed that could be exposed through management of water use from the Colorado River, including the application of drought-reduction and conservation measures, up to 40,224 acres of lake bed could be exposed through 2026 (Tetra Tech 2023). This expedited exposure of the lake bed, and diminished influence of water into adjacent landscapes, would lead to the further reduction of scenic quality within these landscapes during the planning period. Long-term impacts would become similar to those under the No Action Alternative (Tetra Tech 2023). Views of these changes would occur from the Salton Sea State Recreation Area, Salton Sea National Wildlife Refuge, multiple California state routes (State Routes 78, 86, and 111), and adjacent residential areas. No modifications to the Dos Palmas landscape, an area identified as possessing a high level of existing scenic quality, are anticipated under the Proposed Action.

Cumulative Effects

The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels or water deliveries in the Lower Division States. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no changes to water deliveries in the Lower Division States. Therefore, no additive cumulative effects would occur on the landscape character in these areas, with the same effects described above occurring for each alternative.

Future increases in consumptive use of Colorado River water in the Upper Division States, intrastate water transfers in the Lower Division States (e.g., Quantification Settlement Agreement water transfers), implementation of the LCR MSCP, and various requirements and constraints applied to the operation of the Colorado River system were included in modeling of future system conditions.

The Salton Sea Management Program's 10-Year Plan identifies a series of aquatic habitat and dust suppression projects to improve conditions around the Salton Sea. The US Army Corps of

Engineers recently completed an EA for the implementation of these projects, which would result in long-term beneficial impacts on the area's scenic quality under all action alternatives. Combined with either the No Action Alternative or the Proposed Action under this SEIS, the implementation of the 10-Year Plan's aquatic habitat and dust suppression projects would result in countervailing cumulative effects that temper the impacts on scenic quality from additional exposure of the Salton Sea lake bed.

3.11 Cultural Resources

3.11.1 Affected Environment

For the cultural resources affected environment, the data and discussion are summarized from **Section 3.9**, Cultural Resources, of the 2007 FEIS. New information has been included when appropriate.

As defined in the 2007 FEIS, cultural resources "include historic and prehistoric buildings, structures, sites, and objects, including Indian sacred sites and traditional cultural properties." Historic properties are a subset of cultural resources (Reclamation 2007) that have special protections under the National Historic Preservation Act of 1966, as amended (NHPA). Per the implementing regulations of the NHPA, "historic properties" are districts, sites, buildings, structures, or objects listed on or eligible for listing on the National Register of Historic Places (NRHP); these include properties of traditional religious and cultural importance to an Indian Tribe or Native Hawaiian organization that meet the NRHP criteria (36 CFR 800.16(l)(1)).

The NPS manages GCNP, LMNRA, and GCNRA for recreation and resource protection. Reclamation manages water operations. The cultural resources in the portion of GCNRA below Glen Canyon Dam and the cultural resources in the Grand Canyon are protected under the GCPA. GCNP is also a designated United Nations Educational, Scientific, and Cultural Organization World Heritage Area.

Reclamation and the NPS have NHPA agreements for the management of historic properties under their care. For example, Lake Mead's General Management Plan Amendment/Low-Water Plan/EA of December 2018 anticipates NPS actions as the land manager and the need for resource protection at lake elevations above 950 feet. The plan states, "Archaeological and historical resources in the park have been adversely impacted from past development, vandalism, illegal activities, and natural processes. Lowering lake levels would continue to expose formerly submerged resources, which could result in adverse impacts from visitor use or vandalism. The NPS would continue to undertake measures to minimize or mitigate potential impacts through monitoring, educating the public, and restricting use in sensitive areas" (DOI 2018). LTEMP also includes a Reclamation programmatic agreement (PA) to mitigate the adverse effects on historic properties caused by dam operations.

Study Area and Area of Potential Effects

The 2007 Interim Guidelines were developed due to water shortages, "particularly under drought and low reservoir conditions" (Reclamation 2007). They identified the area of potential effects (APE) defined by Reclamation as the reaches of the Colorado River from Lake Powell to Imperial

Dam. In the reach from Davis Dam to Imperial Dam, the APE consists of the Colorado River channel from bank to bank and the backwaters, lakes, and marshes connected to the river. This APE was used for the current NEPA analysis area and will be used in this document.

Identification Efforts

For the 2007 FEIS, Reclamation compiled all available previous research on cultural resources from the NPS and available literature. These data are summarized below. The NPS provided additional and more recent data (NPS 2023b). Because most resources of concern were submerged during the creation of the lakes, no new data on archaeological sites are needed for this analysis. Cultural resources found in the deepwater zone of reservoirs are the least vulnerable to effects from wave action and other disturbances. Those in the operational zones are vulnerable, and those above the pool elevation are at risk for damage and disturbance by visitation (Reclamation 2007). A recent study by the NPS at the GCNRA of sites at Lake Powell confirmed this conclusion (Burns et al. 2022).

Section 106 of the National Historic Preservation Act and Tribal Consultation

Per Section 106 of the NHPA and its implementing regulations (36 CFR 800), Reclamation consults with the Arizona, California, Colorado, Nevada, Utah, and Wyoming State Historic Preservation Offices (SHPOs); Tribal Historic Preservation Officers (THPOs); affected Tribes without THPOs; and consulting parties regarding the effects of the undertaking on historic properties and the resolution of adverse effects not covered under existing agreement documents. Per 36 CFR 800.6, adverse effects on historic properties not covered by existing agreement documents will be resolved by the appropriate land managing agency in consultation with the SHPOs, THPOs, Tribes, and consulting parties. Reclamation has also initiated a PA for the resolution of adverse effects due to this SEIS. A description of the Section 106 consultation to date, including a list of affected Tribes, can be found in **Chapter 4**, Consultation and Coordination.

Lake Powell and Glen Canyon Dam

Of the 518 historic properties recorded around Lake Powell during the Glen Canyon Project from 1956 and 1963 (prior to the inundation of Lake Powell), 447 sites were not subjected to excavation or testing (Reclamation 2007). In addition, resources of Tribal concern have been documented in the Lake Powell and Glen Canyon Dam area. The NPS reported that at least 234 known archaeological sites are inundated at Lake Powell, but this is likely an underestimation (Morgan and Conlin 2023).

Glen Canyon Dam to Lake Mead

This reach extends from the GCNRA into GCNP, the Navajo Indian Reservation, and the Hualapai Indian Reservation.

A survey of this reach in the 1990s identified 336 sites that may be affected by the dam's operations; 313 were determined eligible for listing on the NRHP, 14 were determined ineligible, and 9 were unevaluated for listing on the NRHP. More recently within Glen Canyon, 53 archaeological sites have been identified within the GCNRA and the Navajo Nation along this reach; none of these 53 sites have had formal determinations of eligibility completed, and all are currently treated as eligible sites (NPS 2023c). For LTEMP, the analysis covered 366 sites in the Grand Canyon National Park (NPS 2023c).

As discussed in Section 3.8 of the LTEMP FEIS, research has shown that sediment within the active river channel and/or deposited by HFEs can be transported by the wind to terraces bordering aeolian deposits that contain historic properties (East et al. 2016; Hazel et al. 2022). Wind-deposited sediment can help stabilize and preserve the archaeological properties in place (East et al. 2016; Sankey et al. 2023a; Sankey et al. 2023b). Some HFEs could benefit sediment deposition to keep archaeological resources that would otherwise be exposed through erosion. Current dam operations and the absence of annual HFEs have the potential to impact in situ preservation.

Lake Mead to Hoover Dam

Nearly 1,500 prehistoric and historic-aged resources have been documented in this reach; three of these (Hoover Dam, Lost City/Pueblo Grande de Nevada, and B-29 Heavy Bomber) are listed on the NRHP (Reclamation 2007). Hoover Dam is also a National Historic Landmark. Due to the advanced age of the reservoir, no comprehensive cultural surveys were conducted prior to inundation. Early surveys and site documentation focused on large, salient resources. Many documented sites have not yet been evaluated for inclusion on the NRHP. When water in Lake Mead rose in elevation from 1,083 feet to 1,102 feet in 1937, many of these resources were submerged.

Fluctuations in the water level from 1,083 to 1,226 feet have resulted in the repeated exposure of resources and wave action in that zone, which has adversely affected the resources' integrity (Reclamation 2007). However, submerged resources are likely to still maintain integrity for listing on the NRHP. Over 100 resources have been recorded in the Lake Mead operational zone (1,083–1,226 feet); some resources have been damaged or destroyed, while others retain a moderate to high level of integrity (NPS 2023b). Over 50 resources are below 1,083 feet and may retain integrity (NPS 2023b). Sonar scans indicated that thick sediments may be protecting some resources (Reclamation 2007).

Lake Mohave and Davis Dam

Previous surveys identified 89 sites within or adjacent to Lake Mohave and Davis Dam (Reclamation 2007). Resources between 628 and 647 feet have been subjected to wave action and likely have lost integrity; sites below 628 feet may still retain greater integrity than those between 628 and 647 feet. An NRHP-listed traditional cultural property (TCP) important to several Tribes is found within this reach.

Davis Dam to Parker Dam

This portion of the system is split into the river reach from Davis Dam to Upper Lake Havasu and the reach of Lake Havasu and Parker Dam.

Davis Dam to Upper Lake Havasu

Prehistoric and historic resources have been documented within this reach; however, many of them have been significantly impacted by development, flood events, and alterations to the reach during the 1950s (Reclamation 2007).

Lake Havasu and Parker Dam

Eight historic cultural resources have been documented beneath Lake Havasu, and 20 prehistoric sites have been documented at the edge of the lake or on islands or peninsulas in the lake (Reclamation 2007). Several historic Chemehuevi Indian villages are known to have been located along the river in the Chemehuevi Valley. Resources within the lake's current or historical operational zone (ranging from 450.5 to 445.8 feet) will have been affected by the rising and falling water levels. Resources that have remained submerged are likely to have been protected (Reclamation 2007).

Parker Dam to Imperial Dam

Three individual resources have been recorded within the analysis area/APE; these are Parker Dam, Imperial Dam, and the Old Parker Road alignment. One historic district, the Parker Dam Historic District, extends into the analysis area/APE (Reclamation 2007).

Imperial Dam to SIB

Two resources within the reach are listed on the NRHP: the Ocean-to-Ocean Bridge and the Yuma Crossing and Associated Sites National Historic Landmark (Reclamation 2007).

Salton Sea

Information provided in the records search and pedestrian survey of dust suppression opportunity areas found in the Salton Sea Management Program's Phase 1: 10-Year Plan EA (US Army Corps of Engineers 2022) can be used to demonstrate possible resource types to be found along the shore of the Salton Sea. The records search resulted in six previously conducted surveys and two previously recorded sites. The dust suppression opportunity area survey covered 2,000 acres and concluded that (1) some of the opportunity areas are un-surveyed, (2) those areas that are surveyed lack prehistoric sites and have a few ineligible historic-age sites connected to recreation, and (3) the resource potential of the dry lake bed is unknown because no subsurface investigations have been done (US Army Corps of Engineers 2022).

Ethnographic Resources and Traditional Cultural Properties

From time immemorial, the Colorado River and its canyons have been sacred places for Native communities. The Colorado River features prominently in the cosmology and culture of Indigenous peoples of the Southwest (Reclamation 2016). For the Tribes, the Colorado River and its canyons are living, sentient entities consisting of sacred spaces, the homes of their ancestors, the residence of the spirits of their dead, and the source of culturally important resources. Many Tribes see themselves as stewards of the Colorado River and its canyons, which are a vital part of the living world; caring for the river and the canyons is their responsibility.

The river and canyons are considered by many Indigenous groups to be a type of historic property known as a TCP. Per *National Register Bulletin* 38, a TCP is a historic property that is eligible for the NRHP for "its association with cultural practices or beliefs of a living community that (a) are rooted in that community's history, and (b) are important in maintaining the continuing cultural identity of the community" (Parker and King 1990). Of the groups concerned, the Hualapai Tribe (Coulam 2011), Hopi Tribe (Hopi CPO 2001), Navajo Nation (Maldonado 2011), and Pueblo of Zuni

(Dongoske 2011) have prepared NRHP nomination forms for the Colorado River and its canyons as a TCP.

3.11.2 Environmental Consequences

Methodology

In the 2007 FEIS, the 10th percentile as the "worst-case scenario" for Lake Powell was used for each alternative to assess the impacts of lake elevation on cultural resources. Based on this, the lowest Lake Powell water elevation accounted for was 3,496 feet. Anticipated lake elevations below 3,496 feet will be addressed in the current analysis. For Lake Mead, an elevation of 1,080 feet was used as the lowest elevation in the 2007 FEIS. In the current analysis, elevations below 1,080 feet will be assessed also using the 10th percentile as the worst-case scenario. For resources along the river, the 2007 FEIS states that "[P]rocesses that might result in a loss of integrity vary by reach and property type; consequently, methods of assessing effects differ by reach" (Reclamation 2007). However, most impacts within the reaches were assessed by comparing anticipated flows between alternatives.

The USGS has conducted a study of the availability of windblown sediment in the reach between Glen Canyon Dam and Bright Angel Creek (Kasprak et al. 2023). Windblown (or aeolian) sediment can be important for the protection of archaeological sites from erosion. Dry sediment is transported by the wind from the riverbed to archaeological sites along the river where the sediment covers and protects the sites. Currently, Reclamation conducts HFEs from Glen Canyon Dam to replace sediment along beaches and sandbars along the reach. The results of this study are discussed below.

Adverse effects on historic properties will be resolved by the appropriate land management agency based on existing mitigation documents and through the PA under development for this SEIS (36 CFR 800).

Impacts Analysis Area

The impacts analysis area for cultural resources is consistent with that used in the 2007 FEIS. It consists of the reaches of the Colorado River from Lake Powell to Imperial Dam and the reach from Davis Dam to Imperial Dam. The APE consists of the Colorado River channel from bank to bank and the backwaters, lakes, and marshes connected to the river.

Assumptions

The assumptions for the following analysis are:

- Archaeological site data, as discussed in the 2007 FEIS and without specific locations, were used.
- Impacts on cultural resources can be characterized based on projected lake elevations and river flows by describing expected impacts in zones exposed or inundated.

Impact Indicators

Impact indicators for this analysis are:

- Projected lake elevations that fall below levels previously analyzed in the 2007 FEIS that may expose historic properties to damage from wave action, wet/dry cycling, or increased visitation
- Projected changes in river flows that are not addressed within LTEMP that may contribute to erosion and exposure of resources that may expose historic properties to damage from erosion, wet/dry cycling, or increased visitation
- Availability of windblown sediments to protect archaeological sites
- Negative effects on TCPs that were not discussed in the 2007 FEIS or LTEMP FEIS
- Changes in access to sacred sites

Issue 1: How would changes in lake elevations from water releases from Lake Mead and from equalizing and balancing Lake Mead and Lake Powell affect previously submerged archaeological sites, as well as those at the lake margins?

Summary

Both alternatives would result in lake elevations that may further expose resources to damage from wave action, wet/dry cycling of fluctuating water levels, increased visitation, and unauthorized collection or vandalism at Lake Mead but not at Lake Powell. Lake Powell's elevation is expected to remain above 3,500 feet. This would protect those cultural resources below that level. For Lake Mead, the Proposed Alternative would have fewer negative impacts on cultural resources than the No Action Alternative because pool elevations would be slightly higher. Resources at the lake margins would still be vulnerable to wave action and wet/dry cycling, and resources above the lake elevation could be subjected to more visitation. Adverse effects on historic properties would be resolved through the PA for this SEIS, which is currently under development. .

No Action Alternative

Under the No Action Alternative, Lake Powell's projected pool elevation for the 10th percentile through 2024 is approximately 3,550 feet. In 2025 through 2026, pool elevations for the 10th percentile are projected to dip as low as 3,500 feet. The lake pool elevation will not dip to or below minimum power pool. Resources below 3,496 feet are not expected to be exposed.

Lake Mead pool elevations are occasionally below 1,080 feet and, for the 10th percentile, are projected to dip to approximately 1,040 feet by the end of 2024. Between 2025 and 2026, the 10th-percentile scenario is for the pool elevation at Lake Mead to dip almost to 1,000 feet. The lake pool elevation will not dip to or below minimum power pool. Known resources between 1,000 and 1,080 feet are primarily prehistoric sites recorded prior to the inundation of the lake; these could be exposed for an extended period. These sites could be affected by wave action at the lake margins and wet/dry cycles. They also could experience increased visitation from hikers.

Proposed Action

Under the Proposed Action, Lake Powell's projected pool elevations are expected to be the same as under the No Action Alternative. Lake Mead's pool elevation would remain around 1,050 feet through 2024 and then would dip to approximately 1,025 feet. Resources between 1,025 and 1,080 feet would be exposed for an extended period and could be affected by wave action, wet/dry cycles, and increased visitation.

Cumulative Effects

One reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources is the LTEMP SEIS. Reclamation is analyzing flow options to prevent smallmouth bass from establishing below Glen Canyon Dam and will analyze new information regarding the sediment accounting window associated with the HFE protocol. All proposed flow adjustments analyzed in the LTEMP SEIS will adhere to operational and regulatory constraints for lake elevations as outlined in LTEMP.

The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no changes to annual reservoir levels in Lake Powell or Lake Mead.

Reclamation is consulting with stakeholders regarding any potential adverse effects under Section 106 of the NHPA. If Reclamation determines there is an adverse effect on a historic property or its contributing elements, the effect will be resolved under the LTEMP PA and the Nonnative Fish MOA. If potential adverse effects can be resolved, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River **o**perations.

No cumulative effects would occur on previously submerged archaeological sites from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would changes in river flows from water releases from Lake Mead and from equalizing and balancing Lake Mead and Lake Powell affect archaeological sites along the river and the Salton Sea?

Summary

For both alternatives, water releases will be within those defined for LTEMP. Reclamation does not anticipate any additional impacts on archaeological sites other than those analyzed under LTEMP. No additional impacts on resources at the Salton Sea would occur under either alternative. Adverse effects on historic properties would be resolved through the LTEMP PA or land management agency NHPA agreements. Any additional adverse effects on historic properties not covered under existing agreements will be resolved through the PA for this SEIS.

No Action Alternative

Under the No Action Alternative, releases from Glen Canyon Dam would be within the range of LTEMP releases, and river water levels would be consistent with LTEMP. Reclamation would not anticipate additional impacts on archaeological resources other than those analyzed under LTEMP.

Under the No Action Alternative, exposed, dry sand available for windblown transport would range from a mean of 1,489,311 square meters (m^2) at the 100th percentile to 1,572,250 m^2 at the 80th percentile (Kasprak et al. 2023). However, under the No Action Alternative, HFEs to replenish beach and sandbar sediment would occur as defined under LTEMP (Salter and Grams 2023). The HFEs would allow more sediment to be available for windblown transport to cover archaeological sites with protective sediment.

Flows into the Salton Sea from the Imperial Irrigation District and Coachella Valley Water District would continue at levels similar to today; no changes to impacts on cultural resources from those analyzed in the Salton Sea Management Program's Phase 1: 10-Year Plan EA (US Army Corps of Engineers 2022) are expected. Exposed resources may be subjected to increased wave action, wet/dry cycling, and visitation. However, the lack of previously recorded NRHP-eligible historic properties along the current shoreline likely means the risk of exposing significant cultural resources is low.

Proposed Action

Under the Proposed Action, releases from Glen Canyon Dam would be within those defined by LTEMP. If releases need to be reduced to protect the 3,500-foot level due to low water levels in Lake Powell, releases would be at least the minimum under LTEMP. Like under the No Action Alternative, no additional impacts from low river water levels are anticipated under the Proposed Action.

Available sediment for wind-borne transport would be about the same as under the No Action Alternative. Also, under the Proposed Action, the likelihood that HFE releases to restore sediment would occur is essentially the same as under the No Action Alternative.

Under the Proposed Action, if conservation measures are required and implemented, less water would flow into the Salton Sea, which may lead to the exposure of cultural resources in the lake bed more quickly than under the No Action; however, exposed cultural resources would eventually be the same as under the No Action Alternative.

Cumulative Effects

One reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources is the LTEMP SEIS. Reclamation is analyzing flow options to prevent smallmouth bass from establishing below Glen Canyon Dam and will analyze new information regarding the sediment accounting window associated with the HFE protocol. All proposed flow adjustments analyzed in the LTEMP SEIS will adhere to operational and regulatory constraints for lake elevations as outlined in LTEMP. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact river levels. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect river levels.

Reclamation is consulting with stakeholders regarding any potential adverse effects under Section 106 of the NHPA. If Reclamation determines there is an adverse effect on a historic property or its contributing elements, the effect will be resolved under the LTEMP PA and the Nonnative Fish MOA. If potential adverse effects can be resolved, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River **o**perations.

For the Salton Sea, the Salton Sea 10-Year Plan, as analyzed in the Salton Sea Management Program's Phase 1: 10-Year Plan EA (US Army Corps of Engineers 2022) may also, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on cultural resources. Because of gaps in survey and resource evaluation, it is unknown the extent that management activities described within the 10-Year Plan may impact historic properties; however, a PA has been developed to provide procedures for identifying and evaluating historic properties, as well as measures to resolve adverse effects on historic properties. If potential adverse effects can be resolved, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River **o**perations.

Issue 3: How would changes in operations affect TCPs and resources of concern to Native Americans?

Summary

Impacts on TCPs and resources of concern to Native Americans would be the same under both alternatives and would consist primarily of lower water levels at Lake Mead, which may expose sacred sites to visitors. Any adverse effects on TCPs would be resolved through the LTEMP PA or the PA for this SEIS, which is currently being developed.

No Action Alternative

Under the No Action Alternative, the water level at Lake Powell is not expected to drop below 3,500 feet, which is above the 3,496 feet analyzed under the 2007 Interim Guidelines. No additional impacts on resources at Lake Powell are expected. At Lake Mead, sacred sites could be more accessible to visitors above 1,040 feet in 2024 and above 1,025 feet in 2025 and 2026. Because releases from Lake Powell will be within those defined by LTEMP, no additional impacts on resources along the river are expected. There would be little change of habitat for native riparian plant species (Butterfield and Palmquist 2023c). No significant adverse effects would occur on fish that are a contributing element to the Colorado River TCP and to the health of the ecosystem as a whole.

Proposed Action

Impacts on TCPs and resources of concern to Native Americans would be the same for the Proposed Action as the No Action Alternative.

Cumulative Effects

One reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on TCPs is the LTEMP SEIS.

Reclamation is analyzing flow options to prevent smallmouth bass from establishing below Glen Canyon Dam and will analyze new information regarding the sediment accounting window associated with the protocol. All proposed flow adjustments analyzed in the LTEMP SEIS will adhere to operational and regulatory constraints for lake elevations as outlined in LTEMP. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead.

The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no changes to annual reservoir levels in Lake Powell or Lake Mead.

Reclamation is consulting with stakeholders regarding any potential adverse effects under Section 106 of the NHPA. If Reclamation determines there is an adverse effect on a TCP, the effect will be resolved under the LTEMP PA and the Nonnative Fish MOA; therefore, the project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

No cumulative effects would occur on TCPs and resources of concern to Native Americans from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.12 Paleontological Resources

3.12.1 Affected Environment

Paleontological resources include (with some exceptions) any fossilized remains, traces, or imprints of organisms preserved in or on the earth's crust. The Paleontological Resources Preservation Act of 2009 (PRPA; 16 United States Code [USC] 470aaa–470aaa-11) and its implementation rule (43 CFR 49) require that the Department agencies preserve, manage, and protect paleontological resources on lands administered by the BLM, Reclamation, the NPS, and the Service and ensure these federally owned resources are available for current and future generations to enjoy and study as part of America's national heritage.

The 2007 FEIS (Reclamation 2007) and the 2017 LTEMP FEIS do not address paleontological resources as a separate resource concern; however, many of the potential impact issues related to reservoir levels and changes in river flows are analogous to those for cultural resources, such as archaeological sites.

The NPS is primarily responsible for conservation of natural and cultural resources and the visitor experience, including recreation, at Lake Mead and Lake Powell. Reclamation manages water operations. Both agencies comply with the PRPA. For example, Lake Mead's General Management

Plan Amendment/Low-Water Plan/EA of December 2018 anticipates NPS actions and resource protection at lake elevations above 950 feet.

Study Area

In this region, the fossil record near the Colorado River can be traced back to 1.2 billion years ago. The thick sequence of overlying Paleozoic sedimentary strata preserve abundant fossil remains and traces of marine and terrestrial invertebrates, vertebrates, and plants. An extensive cave system developed into marine limestones preserves the remains of a diverse Pleistocene fauna (Santucci and Tweet 2021).

The study area for paleontological resources consists of the reaches of the Colorado River from Lake Powell to Imperial Dam and the reach from Davis Dam to Imperial Dam. It includes the Colorado River channel from bank to bank and the backwaters, lakes, and marshes connected to the river. Special attention is paid to known and unknown resources in Lake Powell and Lake Mead. It is anticipated that most potential resources and localities were submerged during the filling of the reservoirs. There are minimal data developed on potential paleontological resources in the deepwater zone of the reservoirs, but these resources may be the least vulnerable to effects from wave action and other disturbances. Resources in the operational zones are vulnerable, and those above the fluctuating pool elevation are at risk for damage and disturbance by visitation.

Lake Powell and Glen Canyon Dam

Lake Powell is 186 miles long and contains 1,960 miles of shoreline, which includes 96 major side canyons. The landscape includes over 10,000 vertical feet of sedimentary rocks that represent approximately 300 million years of earth's history. This geologic history includes several mountain-building events, the formation of the supercontinent Pangea, multiple incursions of shallow seas onto the North American continent, vast deserts with Sahara-like sand dunes, the rise and demise of the dinosaurs, unique igneous intrusions known as laccoliths, and the carving of the Colorado River system. Features in the sedimentary rock strata document marine, nearshore marine, fluvial, and eolian environments that have transformed the landscape of southeastern Utah through geologic time.

Current available GIS data for known paleontological sites are approximate locations and come from a variety of data sets and reports of varying quality and accuracy. NPS staff from the GCNRA, Intermountain Region, and Washington Office are working on a 2-year project to compile and update existing data into one authoritative source. Initial work on this project suggests the current understandings of the resources are limited. Actual distribution and the significance of resources are likely underrepresented in current data, yielding insufficient insight into potential impacts. The current database lacks information pertaining to several surveys prior to the 1990s and designations of scientific significance for each locality, despite several holotypes originating from the area.

These deficiencies aside, based on current best available GIS paleontological data, at approximately 3,522 feet (the current elevation as of February 16, 2023), 39.68 percent of known paleontological sites are inundated. Specific studies of the effects of inundation on paleontological locations are not known from Lake Powell. Anecdotal evidence from staff working in the field has resulted in documentation of sandstone becoming friable and crumbly after previous inundation and exposure.

It is assumed that certain kinds of paleontological resources, especially trackways, found in softer bedrock, such as sandstone, would be destroyed or severely impacted by the inundation and subsequent exposure, resulting in the loss of rock outcrop integrity.

However, it is not known whether greater damage is caused only by inundation, or by repeated cycles of inundation and exposure. It is assumed that paleontological resources, including both fossils and trackways, would have similar impacts as those in archaeological sites from similar processes. The No Action Alternative would result in greater exposure of bedrock outcrops and greater exposure of previously inundated paleontological sites to wet/dry cycling; thus, it has the potential to result in greater numbers of paleontological sites being subject to exposure-related erosion and damage.

Erosion is the primary agent that exposes paleontological resources on the surface. Reclamation manages a significant amount of land along the Colorado River corridor. The effects of fluctuating water levels and wave action resulting in higher-than-normal erosional rates and an increased potential for the exposure of paleontological resources. From a scientific perspective, elevated erosion levels along waterways provide an opportunity because fossil resources may be exposed more quickly, allowing for more frequent discoveries. Yet from a management perspective, these elevated erosion levels present the concern for elevated levels of loss potential (Bonde and Slaughter 2020). During a survey conducted in March of 2023, a known dinosaur trackway on a ledge experienced increased rates of undercutting, leading to resource loss as it breaks away

The GCNRA has one of the most extensive exposures of rocks from the Mesozoic era of any NPS unit, providing exceptional documentation of ecosystems and paleoclimates from approximately 252 million to 66 million years ago. Marine fossils are common in Paleozoic limestones, while dinosaur tracks are found in the terrestrial Mesozoic units. Pollen extracted from dung and packrat middens has provided evidence for the ecology and climate during the more recent Quaternary period. The NPS maintains an inventory and monitoring database for known fossil sites in the GCNRA. Natural degradation and fossil theft remain a concern for resource managers.

Because of Glen Canyon Dam, sediment is continuously deposited in Lake Powell. Sediment deposition has impacted several locations in the lake, including paleontological sites. Sediment deposition may prevent exposure of paleontological resources (Graham 2016).

Lake Mead and Hoover Dam

The LMNRA does not have a comprehensive paleontological inventory of locations, but there are known and likely many unknown submerged paleontological resources. There are fossil sites that are exposed at recent lake levels and are subject to disturbance from fluctuating water levels and visitor impacts. Lake Mead has formations with high fossil potential, including the Miocene Horse Spring Formation, Muddy Creek Formation, and Pliocene and Pleistocene river gravels. Where these formations outcrop along the lake, they are now more spatially exposed, providing a high chance to find new fossil localities with them. Increased exposure of fossil-bearing geologic formations around the lake would be anticipated with lower lake levels and exposed shorelines.[19]

Salton Sea

The Salton Sea is situated in the Salton Trough, a major topographic depression extending north from the Sea of Cortez. Over the past 7 million years, a relatively complete geologic record of fossil-bearing sediment has been deposited. Paleontological remains are widespread and very diverse. Fossils range from both large and small marine organisms from when the ancestral Gulf of California filled the sea to later periods when sediments isolated the prehistoric Lake Cahuilla from the ocean. This playa lake, the precursor of the Salton Sea, was intermittently fed by the Colorado River, and it supported a wide variety of plants and animals. There is the potential for paleontological resources to be present within the playa margins.

Methodology

There was no formal analysis of effects on paleontological resources in the 2007 FEIS. Methods to qualitatively assess the potential for effects on paleontological resources use a proxy based on lake elevations developed for analyzing the potential for impacts on cultural resources. For cultural resources in the 2007 FEIS, Reclamation used the 10th percentile as the "worst-case scenario" for Lake Powell to assess the impacts for each alternative (Reclamation 2007). Similar to the cultural resource analysis in this SEIS, the lowest Lake Powell water elevation accounted for was 3,496 feet. The effects of anticipated lake elevations below 3,496 feet are addressed in this current analysis.

For Lake Mead, an elevation of 1,080 feet was used as the lowest elevation (Reclamation 2007). In this analysis, elevations below 1,080 feet will be assessed also using the 10th percentile as the "worst-case scenario." For resources along the river, the potential for impacts within the river reaches were assessed by comparing anticipated flows with the historical minimum and maximum river flows.

The USGS has conducted a study of the availability of windblown sediment by alternative in the reach between Glen Canyon Dam and Bright Angel Creek (Kasprak et al. 2023). Windblown (or aeolian) sediment can be important for assessing the potential exposure of paleontological resources. Dry sediment is transported by the wind from the riverbed to locations where paleontological resources may occur along the river and where the sediment covers and protects the sites. The results of this study are discussed below.

Impact Analysis Area

The impact analysis area for paleontological resources consists of the reaches of the Colorado River from Lake Powell to Imperial Dam and the reach from Davis Dam to Imperial Dam. It includes the Colorado River channel from bank to bank and the backwaters, lakes, and marshes connected to the river.

[19] Chris Nycz, Cultural Resource Manager, LMNRA, email to Kevin Doyle, EMPSi resource lead, on February 17, 2023, regarding paleontological resources at LMNRA.

Assumptions
The assumptions for the following analysis are:

- Impacts on paleontological resources can be characterized based on projected lake elevations and river flows.
- The impact analysis area includes known paleontological resources that are being exposed and rock units that are sensitive for the presence of scientifically important paleontological resources.
- Specific paleontological locations are not discussed in this analysis, but the level of information available is assumed to be sufficient for this broad-based analysis.
- The exposure of paleontological resources may lead to the discovery of scientifically important fossils; however, the process and practical means of recovering paleontological resources within the reservoirs or associated with the Colorado River channel would be limited.
- Landforms with a higher degree of slope experience increased impacts from wave action erosion compared with low-slope areas.

Impact Indicators
Impact indicators for this analysis are:

- Projected lower lake elevations that may expose resources to damage from wave action, wet/dry cycling of fluctuating water levels, increased visitation, and unauthorized collection or vandalism
- Projected changes in river flows that are not within the historical minimum and maximum that may contribute to erosion
- Availability of windblown sediments to protect paleontological localities or exposed fossils

Issue 1: How would changes in lake elevations from water releases from Lake Mead and from equalizing and balancing Lake Mead and Lake Powell affect previously submerged paleontological resources, as well as those at the lake margins?

Summary
Both alternatives would result in lake elevations that may further expose resources to damage from wave action, wet/dry cycling of fluctuating water levels, increased visitation, and unauthorized collection or vandalism. Because Lake Powell's elevation is expected to remain above 3,500 feet, there would be less risk of negative impacts on paleontological resources below that level. For Lake Mead, any paleontological resources at the lake margins would be vulnerable to wave action and wet/dry cycling. Exposed fossils above the lake elevation may be subject to more visitation and possible damage or unauthorized collection. Pool elevations at Lake Mead would be slightly higher under the Proposed Action, and there would be less potential for negative impacts when compared with the No Action Alternative. Implementation of the PRPA by both the NPS and Reclamation would continue to provide protections and fines for disturbances to paleontological resources.

No Action Alternative

Under the No Action Alternative, Lake Powell pool elevations for the 10th percentile through 2024 are approximately 3,550 feet. In 2025 through 2026, pool elevations may dip to 3,500 feet; however, they would not dip below the minimum power pool, and additional paleontological resources would not be exposed.

Lake Mead pool elevations are occasionally below 1,080 feet; under the 10th percentile scenario, they are projected to dip to approximately 1,040 feet by the end of 2024. The 10th percentile scenario for Lake Mead between 2025 and 2026 is a pool level of almost 1,000 feet, potentially exposing paleontological resources. The elevation would not dip below the minimum power pool. Exposed fossil locations may be affected by wave action at lake margins, wet/dry cycles, and likely increased visitation.

Proposed Action

Under the Proposed Action, Lake Powell pool elevations are anticipated to be the same as under the No Action Alternative. Lake Mead pool elevations are projected to remain around 1,050 feet through 2024 and then drop to 1,025 feet during 2025 and 2026. The elevation would not dip below the minimum power pool. Fossils that may be present between 1,025 and 1,080 feet would be exposed and subject to potential impacts from wave action at lake margins, wet/dry cycles, and likely increased visitation.

Cumulative Effects

A reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on paleontological resources is the LTEMP SEIS. Reclamation is analyzing flow options to prevent smallmouth bass from establishing below Glen Canyon Dam and will analyze new information regarding the sediment accounting window associated with the HFE protocol. All proposed flow adjustments analyzed in the LTEMP SEIS will adhere to operational and regulatory constraints for lake elevations as outlined in LTEMP.

The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell or Lake Mead. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell and Lake Mead. These differences are expected to be minor, temporary, and resolved by the end of the operational year; they would result in no changes to annual reservoir levels in Lake Powell or Lake Mead. The project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

No cumulative effects would occur on previously submerged paleontological resources from the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would changes in river flow from Lake Mead water releases and from equalizing and balancing Lake Mead and Lake Powell affect paleontological resources along the river and the Salton Sea shore?

Summary

Both alternatives would result in releases within those defined for LTEMP and would fluctuate river levels, lead to changes in river channel, and possibly expose paleontological resources to some impacts. No additional impacts on resources at the Salton Sea would occur under either alternative. However, the Proposed Action would more evenly distribute flows and reduce the potential for impacts on paleontological resources from fluctuating river levels. Sediment would be available for longer amounts of time and at more regular intervals than under the No Action Alternative.

No Action Alternative

Under the No Action Alternative, releases from Glen Canyon Dam would be within the range of LTEMP releases, and water levels would be consistent with LTEMP. Impacts on paleontological resources may occur from changes in erosion or depositional processes between Lake Powell and Lake Mead.

Under the No Action Alternative, the median acreages of available sediment for windblown transport would range from 1,489,311 m^2 at the 100th percentile to 1,572,186 m^2 at the 80th percentile (Kasprak et al. 2023). Increases in available sediment are a beneficial impact of low river flows because the sediment reduces the potential exposures of paleontological resources.

If reduced releases result in a low river level, they may increase visitor access to previously inundated and/or buried paleontological resources between Lake Powell and Lake Mead. For locations with increased access, there may be new deterioration of paleontological resources because of increased visitation. While lower river levels could give access to new paleontology sites, they could also restrict access to older ones that are no longer eye level or that have increased difficulty to reach due to an elevation gain or terrain (cliffs) acting as a barrier.

Flows into the Salton Sea from the Imperial Irrigation District and Coachella Valley Water District would continue at levels similar to today's levels; no changes to impacts on paleontological resources are expected, other than those analyzed in the Salton Sea Management Program's Phase 1: 10-Year Plan EA (US Army Corps of Engineers 2022). These impacts would include damage during construction and erosion of paleontologically sensitive sediment, which could unearth and disperse fossils. Exposed resources may be subject to increased wave action, wet/dry cycling, and visitation.

Proposed Action

Under the Proposed Action, releases from Lake Powell would be consistent with those approved and analyzed under LTEMP, while conditions permit. If insufficient water is available, releases would be coordinated to protect the minimum power pool elevation of 3,500 feet in Lake Powell.

As with the No Action Alternative, lower river levels due to changes in release volumes may also increase access to paleontological resources between Lake Powell and Lake Mead. For locations with increased access, there may be new deterioration of paleontological resources because of increased visitation. While lower river levels would give access to new paleontological sites, they could also restrict access to older ones that are no longer eye level or that have increased difficulty to reach due to an elevation gain or terrain (cliffs) acting as a barrier.

Under the Proposed Action, if conservation measures are required and implemented, less water would flow into the Salton Sea. This may lead to the exposure of paleontological resources in the lake bed more quickly than under the No Action; however, exposure would eventually be the same as under the No Action Alternative. Exposed resources may be subjected to increased wave action, wet/dry cycling, and visitation.

Cumulative Effects

One reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on paleontological resources is the LTEMP SEIS. Reclamation is analyzing flow options to prevent smallmouth bass from establishing below Glen Canyon Dam and will analyze new information regarding the sediment accounting window associated with the HFE protocol. All proposed flow adjustments analyzed in the LTEMP SEIS will adhere to operational and regulatory constraints for lake elevations as outlined in LTEMP. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact river levels.

The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect river levels. The proposed releases are within the previously approved flows and are unlikely to cause any additional impacts on paleontological resources. The project should not contribute to cumulative impacts in conjunction with the proposed near-term Colorado River operations.

For the Salton Sea, the Salton Sea 10-Year Plan, as analyzed in the Salton Sea Management Program's Phase 1: 10-Year Plan EA (US Army Corps of Engineers 2022), may also, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on paleontological resources. These would include damage during construction and erosion of paleontologically sensitive sediment, which could unearth and disperse fossils. Exposed resources may be subject to increased wave action, wet/dry cycling, and visitation. Violations of the PRPA by visitors can result in punishments under law. Negative impacts on paleontological resources may be anticipated in the near and long term from increased visitation and unauthorized collection or vandalism. However, with mitigations described in the 10-Year Plan, the project should not contribute to cumulative impacts, in conjunction with the proposed near-term Colorado River operations.

3.13 Biological Resources

3.13.1 Affected Environment

In order to supplement the 2007 FEIS (Reclamation 2007), this section provides a brief summary of a more comprehensive description of the affected environment in the 2007 document, supplementing as necessary to include changes that have occurred since 2007. For additional information, see the 2007 FEIS (Reclamation 2007), the 2016 LTEMP FEIS (Reclamation and NPS 2016), and the LCR MSCP Habitat Conservation Plan (HCP; Reclamation 2004a), which are incorporated by reference.

The elevation gradient, soil types, and flow characteristics along the Colorado River corridor create diverse vegetation and habitat communities that support plants, wildlife, and special status species (Reclamation 2007). Vegetation along the Colorado River is heavily influenced by flow characteristics, which are manipulated through dam operations (Reclamation and NPS 2016). This manipulation of flow characteristics can alter shoreline sand bars and vegetation communities along the Colorado River corridor, thereby impacting plants, wildlife, and special status species.

The vegetation, wildlife, and special status species typical of each section are outlined below, based on the 2007 FEIS; the 2016 LTEMP FEIS (Reclamation and NPS 2016); the LCR MSCP HCP (Reclamation 2004a); and a query of BLM sensitive species in the natural heritage databases for Utah (BLM 2018), Arizona (BLM 2017a), Nevada (BLM 2017b), and California (BLM 2014).

Vegetation

Circumstances that have resulted in substantial changes to vegetation beyond what was analyzed in the 2007 FEIS in the overall biological resources analysis area include: drought conditions, low inflows, and historically low water levels; the introduction of the tamarisk leaf beetle (*Diorhabda* spp.); changes in vegetation community composition below Glen Canyon Dam due to changes in river flow, particularly in alluvial areas; experimental vegetation treatments (per LTEMP ROD) that remove nonnative plants and replace them with native plants at selected sites along the river; and the creation of riparian habitat in conservation areas below Hoover Dam associated with actions conducted by the LCR MSCP. These changes are described below under their respective geographic analysis area.

Lake Powell

As described in the 2007 FEIS, riparian vegetation around Lake Powell is extremely restricted because of the desert terrain that extends directly to the water's edge, and the continuously fluctuating lake elevations. Fluctuations in lake elevations have resulted in standing water and backwater pools in the side canyons of Lake Powell where riparian vegetation has become established. Dominant plants found in these canyons include Fremont cottonwood (*Populus fremontii*), tamarisk (*Tamarix* spp.), and cattail (*Typha* spp.).

Lake Powell is currently operating at a historically low water level due to prolonged drought. Since 2007, the increase in acreage of exposed shoreline has increased Russian thistle (*Salsola* spp.) and tamarisk establishment. Currently, tamarisk and Russian thistle are the dominant vegetation type along the shores of Lake Powell. Dense stands of tamarisk displace native plants, degrade wildlife habitat, reduce livestock forage, limit human access, interfere with the natural fluvial process, change the ecology and hydrology of riparian systems, and increase the risk of severe wildfires (NPS 2023d).

Russian thistle easily takes root in disturbed or bare ground, moving in before native species can establish. Drought conditions like those experienced in recent years only promote the plant's proliferation. The dryness hinders the growth of native species, while the Russian thistle seed requires very little moisture to germinate and grow where native species otherwise would have. This can have deleterious effects on natural ecological functioning and increase the wildfire risk (NPS 2023d).

Springs and seeps are common in alcoves along the walls in GCRNA, as are water pockets located in canyons and uplands. These areas are recognized for their significance as wetland habitats and as unique ecosystems within the desert. These seeps support hanging gardens, which are a specialized vegetation community (Welsh et al. 1987). The water sources that support hanging gardens originate from natural springs and seeps within the Navajo Sandstone formation and are independent of Lake Powell. Livestock grazing is allowed at GCNRA, with the Bureau of Land Management administering the grazing permits. Vegetation monitoring occurs in the upland areas of the recreation area, but no studies have been conducted on the riparian habitat along the lakeshore.

Glen Canyon Dam to Lake Mead

Vegetation along the reach of the Colorado River corridor from Glen Canyon Dam to Lake Mead is affected by the peak magnitudes, daily fluctuations, and seasonal pattern of river flows, and most evidence indicates that riparian vegetation composition, structure, distribution, and function are closely tied to ongoing Glen Canyon Dam operations (Reclamation and NPS 2016).

Existing vegetation communities for this reach are described in detail in the LTEMP FEIS (Reclamation and NPS 2016), which provides a framework for managing Glen Canyon Dam operations and experimental actions over a 20-year period. As described in the LTEMP FEIS, terrestrial plant communities along the Colorado River from Glen Canyon Dam to Lake Mead are highly diverse due to great variations in landforms, geologic features, and physical characteristics such as topography, elevation, and aspect. As described in the LTEMP FEIS (Reclamation and NPS 2016), vegetation zones along the river reflect the frequency of inundation and disturbance. The fluctuating zone supports flood-tolerant marsh species, such as sedges, rushes, cattail, horsetail, and common reed. These species occupy return-current channels and successional backwaters that are inundated daily for at least part of the year (i.e., up to the elevation of the average annual daily maximum discharge of about 20,000 cfs). As depicted in Figure 3.6-1 of the LTEMP FEIS (Reclamation and NPS 2016), vegetation in the fluctuating and new high-water zones are greatly influenced by river flow and dam operations. The new high-water zone, inundated by flows up to 45,000 cfs, supports woody riparian species, many herbaceous-obligate riparian species (e.g., *Carex* spp., *Juncus* spp., *Equisetum* spp., *Phragmites australis*, and *Typha* spp.), with bunchgrasses such as sand dropseed and shrubs such as spiny aster at upper elevations.

Riparian vegetation communities can be affected by dam operations through scouring and erosion during high flows, drowning, burial by new sediments, and reductions in soil moisture levels; consistent availability of water at low elevations (e.g., below 25,000 cfs) from elevated base flows can promote vegetation growth. Responses of riparian vegetation are affected by the timing, frequency, duration, and magnitude of the river's hydrology, as well as the variability between years and sequencing of flows (Palmquist et al. 2018). Additional factors related to flow that influence riparian vegetation include characteristics of deposited sediments (such as water-holding capacity, aeration, and nutrient levels), depth to groundwater, and anoxia in the root zone. The export of sediments (particularly silts and clays and organic matter) was observed to coarsen substrates, affect nutrient concentrations, and reduce opportunities for subsequent recruitment of tamarisk and native shrubs such as coyote willow and Emory seepwillow (Reclamation and NPS 2016).

During development of the LTEMP FEIS, the effects of dam operations on riparian vegetation health along the river corridor were evaluated, and modeling results suggested long-term declines, particularly in native plant communities. With operational flows limited to less than 45,000 cfs, the overall extent and health of the riparian areas in GCNP have been and would continue to be altered, and nonnative vegetation and monoculture species would likely increase. Therefore, a 20-year experimental riparian-restoration project was developed by the NPS and other agencies, as designated in the environmental commitments of the LTEMP ROD. The restoration projects specifically seek to address the following four specific vegetation issues that emerged in the LTEMP FEIS as being influenced by dam operations: (1) encroachment of vegetation on sandbars, (2) decrease in native plant species, (3) erosion of archaeological resources, and (4) narrowing and loss of plants in the old high-water zone (Reclamation and NPS 2016). Implementation of High Flow Experiments (HFEs) under the LTEMP have influenced riparian vegetation in this reach. In 2012 an HFE protocol was developed to improve sediment conservation downstream of the Paria River. This protocol was adopted under the LTEMP and has influenced riparian vegetation in this reach. Since 2012, six HFEs have been conducted, the most recent being in April 2023. In August 2021, the NPS, in coordination with Grand Canyon Monitoring and Research Center (GCMRC), developed a Long Term Experimental and Management Plan Riparian Vegetation Project Plan that provides guidance for nonflow experimental vegetation treatments to accomplish the following objectives: (1) control nonnative plant species affected by dam operations, including tamarisk and other highly invasive species; (2) develop native plant materials for replanting through partnerships and the use of regional greenhouses; (3) replant native plant species to priority sites along the river corridor, including native species of interest to Tribes; (4) remove vegetation encroaching on campsites; and (5) manage vegetation to assist with cultural site protection.

Lake Mead

The highest concentration of vegetated habitat associated with Lake Mead is found in the Colorado and Virgin River deltas. Fluctuating lake elevations influence the shoreline vegetation. Riparian vegetation that does develop within the range of Lake Mead elevation fluctuations is temporary, as fluctuating lake elevations either dewater or inundate these areas through time. Linear riparian woodlands may be present along the shoreline of the Lake Mead delta following high-water flows and associated sediment deposition and exposure. The sediment deposition and the associated growth of riparian vegetation at the Lake Mead delta has occurred for decades. However, riparian vegetation is historically thought to be sparse, even along much of the historical Colorado River corridor that Lake Mead submerged, and much of the existing shoreline is sparsely vegetated (Engel et al. 2014).

Water levels at Lake Mead have declined to some of the lowest elevations for an extended period of time due to prolonged drought. Decreasing water levels reduce the lake perimeter while increasing the amount of shoreline area relative to the unsubmerged amount when the lake is at full pool. The consistent decline in water level since 1998 has prevented the establishment of a stable riparian community. The drawdown of Lake Mead from 1998 to 2011 reduced the lake's perimeter by more than 248 miles (400 kilometers) while exposing more than 61,776 acres (25,000 hectares) of formerly submerged land. Engel et al. (2014) observed that, consistent with previous research, the abundance of the tamarisk declined with increasing surface age. Conversely, the cover of native species was greatest overall on older surfaces across sites. Early successional native perennial species colonized the 13-year-old surface. While Lake Mead's drawdown might be viewed negatively from a perspective of maintaining full pool water storage, it has reexposed a vast area of new terrestrial habitat increasingly colonized by native species as invasive species abundance declines through time (Engel et al. 2014).

The vegetation at Lake Mead has also been influenced by defoliation from the tamarisk leaf beetle. Beetles were released along the Virgin River in St. George, Utah, in 2006, and widespread defoliation of tamarisk was first observed in St. George in 2008. The area of tamarisk defoliation on the Virgin River expanded downstream annually, encompassing the entire stretch of the Virgin River to Lake Mead, Nevada, by the end of the breeding season in 2011.

Hoover Dam to SIB

Vegetation for this reach is described in detail in the LCR MSCP HCP (Reclamation 2004a). Fourteen land cover types are described in the LCR MSCP planning area. Five woody riparian types are divided into multiple structural types, and the marsh land cover type is divided into seven compositional types based on plant composition and vegetation structure. Aquatic land cover types include river, reservoir, and backwater. A summary of the land cover types and their characteristics, found from Lake Mead to the SIB, is provided in Table 3.8-1 of the 2007 FEIS and in more detail in Section 3.4 of the LCR MSCP HCP (Reclamation 2004a).

Since released in 2006, tamarisk beetles have continued to spread downstream from Lake Mead along the LCR, and by 2019, large beetle populations were detected along the Imperial stretch of the LCR. In 2020, tamarisk beetles were present, and defoliation was documented in or around all LCR MSCP study areas (Reclamation 2021c).

The LCR MSCP has adopted a habitat-based approach to the conservation of covered species. Riparian communities identified in the LCR MSCP HCP as covered species habitat include cottonwood-willow, honey mesquite, marsh, and backwater land cover types. The HCP requires the creation of over 8,100 acres (3,277 hectares) of various land cover types to provide habitat for targeted LCR MSCP covered species. Since 2006, over 3,000,000 cottonwood and willow trees have been established within conservation areas in addition to a host of other varieties such as honey mesquite, wetlands plants, and salt grass plugs. As of 2021, a total of 4,274 acres of cottonwood-willow, 2,046 acres of mesquite, 362 acres of marsh, and 158 acres of backwater have been established and are managed by the LCR MSCP (LCR MSCP 2022).

Salton Sea

The Salton Sea currently contains a mix of saltwater and freshwater habitats, marshes, desert upland, and ryegrass fields (Service 2023). Permanent wetlands are around the Salton Sea where the agricultural drains back up or flood, or where land is deliberately flooded for habitat. Vegetation varies from invasive species, such as tamarisk, to cattails (*Typha* spp.) and bulrush (*Scirpus* spp.). Exposed dry playa near the water shoreline consists of sparse vegetation and woody debris. Sparsely vegetated mudflat, sandflat, and beach habitat also occurs near the shoreline.

Over the past decades, the Salton Sea's water level has been declining, and it has been the subject of various modeling efforts to quantify the decline, assess environmental impacts, and evaluate various mitigation and conservation efforts.

Wildlife

Lake Powell

Lake Powell and its associated upland habitat support a wide variety of wildlife species. The limited riparian habitat around Lake Powell is a highly valuable resource for wildlife species dependent on riparian habitat in this portion of the analysis area. The 2007 FEIS lists common amphibians (e.g., Canyon tree frog [*Hyla arenicolor*]), aquatic and riparian birds (e.g., American wigeon [*Anas americana*]), and mammal species (e.g., beavers [*Castor canadensis*]) found in Lake Powell and its associated upland habitat (Reclamation 2007).

Lake Powell is the second-largest impoundment on the Colorado River, and it provides habitat for primarily lacustrine fish species. However, inflows to the lake also provide riverine habitat for various fish species. The fish community in Lake Powell is dominated by nonnative species, with a total of fourteen nonnative species (Reclamation 2007). Recreational fishing is an important industry in the Colorado River, and Lake Powell supports a sport fishery for striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), walleye (*Sander vitreus*), and smallmouth bass (*Micropterus dolomieui*). Management actions in this reservoir have also introduced nonnative forage fish to support this sport fishery. Five species of native fish have been found in Lake Powell, including the flannelmouth sucker *(Catostomous latipinnis*), razorback sucker (*Xyrauchen texanus*), Colorado pikeminnow *(Ptychocheilus lucius*), bonytail (*Gila elegans*), and speckled dace (*Rhinichthys osculus*) (Valdez and Williams 1993; Karp and Mueller 2002; Durst and Francis 2016).

Deltaic deposits have formed in the inflows of the Colorado and San Juan Rivers, and new river habitat has become exposed with receding lake levels in the past 20 years. These rivers have carved new channels into the deposits and expanded riparian areas and the riverine habitat of fish, including native and nonnative species. In the Colorado River, riverine habitat has been expanded by about 35 miles (56 kilometers) relative to full pool. In the San Juan River inflow, riverine habitat has been expanded by about 30 miles (48 kilometers) and a 20-foot (6-meter) waterfall has formed at the upper end that now prevents upstream movement by fish. The current waterfall emerged in 2001 and has only been inundated (thus passable) once, in 2011 for 2 weeks in late July and mid-August (Durst and Francis 2016).

At the time of the FEIS (Reclamation 2007), it was unclear whether zebra mussels or quagga mussels were established in Lake Powell. Quagga mussels were discovered in 2012, however, and sampling in subsequent years (2014–2019) indicated that this species has continued to spread throughout the reservoir (Utah Department of Natural Resources 2021). The Asian clam (*Corbicula fluminea*) is also an invasive bivalve of Lake Powell, first reported in the lake in the mid to late 1900s. The Asian clam filters large amounts of nutrients from a water body and can accumulate in large numbers that can clog canals, ditches, and other water infrastructures. The National Park Service has also identified several species of invasive invertebrates, including the virile crayfish (*Orconectes virilis*).

Glen Canyon Dam to Lake Mead

The terrestrial habitat from Glen Canyon Dam to Lake Mead is predominantly canyon habitat, including portions of GCNRA and GCNP. Canyon habitat provides a variety of vegetation types that support upland and obligate riparian species. Riparian habitat is more common along this stretch of the Colorado River compared with Lake Powell. Vegetation in this section is dominated by the invasive tamarisk plant; however, the introduction of the tamarisk leaf beetle has had recent impacts along this stretch of the river, changing community composition and reducing tamarisk cover. The beetle will likely play a large role in habitat composition over the next several years (Reclamation and NPS 2016, Bransky et al. 2021). Many species of amphibians (e.g., canyon tree frog [*Hyla arenicolor*], red-spotted toad [*Bufo punctatus*], and Woodhouse's toad [*Bufo woodhousii*]), aquatic and riparian birds (e.g., yellow warbler [*Dendroica petechia*], great blue heron [*Ardea herodias*], and osprey [*Pandion haliaetus*]), and mammal species (e.g., coyote [*Canis latrans*], desert bighorn sheep [*Ovis canadensis nelsoni*], muskrat [*Ondatra canadensis*], and American beaver [*Castor canadensis*]) are found in this portion of the analysis area and its associated upland habitat (Reclamation 2007; Holm et al. 2023).

For aquatic species, this section includes the Colorado River below Glen Canyon Dam through Grand Canyon for approximately 290 miles (466 kilometers) and the Lake Mead inflow for an additional 25 miles (40 kilometers). A large rapid has formed near Pearce Ferry (river mile [RM] 280) that serves as a partial barrier to upstream fish movement. The entire reach from the dam to Lake Mead includes approximately eighteen species of nonnative fish and five native species (Valdez and Carothers 1998). The largest reproducing population of humpback chub (*Gila cypha*) in the Colorado River system is found in the Little Colorado River. Translocated populations occur in Havasu, Bright Angel, and Shinumo Creeks. A large and relatively recent population of humpback chub has been identified in the western Grand Canyon (Van Havebeke et al. 2017, 2022). Razorback sucker (*Xyrauchen texanus*) occur primarily downstream of Lava Falls Rapid (RM 180), but have been detected beginning at RM 127 (above Lava Falls). Sonic-tagged razorback sucker were released at Bright Angel Creek in 2021, and one of them was detected at the mouth of this creek in 2022.

A Blue Ribbon trout fishery consisting of rainbow trout exists in the 15 miles (24 kilometers) of river below Glen Canyon Dam (Lees Ferry), although in recent years populations of brown trout, a more predatory species of trout, have been increasing (Runge et al 2018). Smallmouth bass, which are an invasive and predatory fish, were detected below Glen Canyon Dam in the summer of 2022. Though they had been detected below the dam previously, warmer water temperatures created conditions suitable for reproduction of smallmouth bass.

The Lake Mead inflow is characterized by deltaic sediments exposed with the declining lake level, through which the river has carved a channel. This new river channel has expanded riverine habitat by about 40 miles (64 kilometers) from approximately Separation Canyon to below Pearce Ferry. A large rapid has formed near Pearce Ferry (RM 280) that serves as a partial barrier to upstream fish movement.

In addition to smallmouth bass, green sunfish, walleye, striped bass, bluegill, and black crappie were detected in 2022 below Glen Canyon Dam in higher numbers than is typically observed. When the reservoir level is close to the level of the penstocks there is concern that the risk of fish entrainment (passing through the dam) increases. The warmwater invasive species also thrive with the warmer water temperatures below Glen Canyon Dam.

Quagga mussels are not considered an issue in this section due to the riverine habitat (Reclamation 2007). However, the New Zealand mudsnail (*Potamopyrgus antipodarum*) has recently been documented in the Colorado River downstream of Glen Canyon Dam (Cross et al. 2010).

Lake Mead

Similar to Lake Powell, Lake Mead and its associated upland habitat support a wide variety of wildlife species. Riparian habitat in the Lake Mead section is generally limited to the Lake Mead and Virgin River deltas. These areas undergo frequent water level fluctuation, which results in fluctuating riparian habitat availability. The 2007 FEIS refers to the Lake Mead section of the analysis area as having similar common wildlife species as the Lake Powell section and the Glen Canyon Dam to Lake Mead section of the analysis area (Reclamation 2007).

With declining lake elevations in the last 20 years, the Colorado and Virgin Rivers have expanded as river channels carved into the deltaic sediment deposits. The Colorado River inflow has expanded in length about 40 miles (64 kilometers), from full pool elevation at Separation Canyon downstream to Pearce Ferry, and the Virgin River has expanded about 20 miles (32 kilometers), providing additional riverine habitat for aquatic species. The largest population of humpback chub in the Colorado River system has recently become established in this newly carved channel. Lake Mead provides lacustrine habitat for nonnative and native fish species. The lake supports a sport fishery for primarily striped bass, largemouth bass, crappie, bluegill, and catfish. Lake Mead also supports the largest self-sustaining population of razorback suckers in the Colorado River system, with most of the fish found in the Colorado River and Virgin River inflows.

Both Lake Mead and Lake Mohave have experienced algal blooms since the early 2000s. These blooms are the result of nutrients within the Colorado River generally derived from decaying vegetation in the largely undeveloped watershed as well as nutrients from the Virgin River, Muddy River, and Las Vegas Wash. These nutrients arrive in the form of treated wastewater, urban runoff, and agricultural runoff. Lower lake levels affect lake nutrients and nutrient dynamics, which in turn affect the amounts and location of algae produced in these reservoirs. Starting in the year 2000, the wastewater treatment plants along Las Vegas Wash have enhanced their phosphorus removal, improving water quality and reducing the potential for algal blooms. Monitoring has revealed that these blooms include blue-green algae, which bloomed in large amounts in 2011–2015 and again in recent years since 2020. Blue-green algae produces a toxin called microcystin that can cause health issues in people and wildlife. The effects of these algal blooms on fish and wildlife are not well understood, and monitoring will need to be continued to better understand the relationship between reservoir elevations, algal blooms, and effects on fish populations in both Lake Mead and Lake Mohave.

In 2007, quagga mussels were documented in Lake Mead (Reclamation 2007), and they persist there.

Hoover Dam to the SIB

The lower section of the Colorado River supports diverse habitat types, which in turn support a variety of wildlife species. Restoration activities described in the LCR MSCP have increased the amount of desirable habitat communities, including riparian vegetation, marsh habitat, backwater habitat, and wetlands (Reclamation 2004a). The 2007 FEIS lists common amphibians (e.g., bullfrog [*Rana catesbeiana*]), aquatic and riparian birds (e.g., avocet [*Recurvirostra americana*]), and mammal species (e.g., bobcat [*Felis rufus*]) found in this portion of the analysis area and its associated upland habitat (Reclamation 2007).

Fish habitat exists in this section where surface water is perennial. This section is dominated by nonnative species (Reclamation 2007).

Since Quagga mussel life history includes a pelagic larval stage, it is reasonable to assume that these mussels are present below Hoover Dam in any areas where suitable habitat is present. The Asian clam (*Corbicula fluminea*) is also an invasive bivalve of Lake Mead, first reported in the lake around 1955. The Asian clam filters large amounts of nutrients from a water body and can accumulate in high numbers that can clog canals, ditches, and other water infrastructures.

Salton Sea

The Salton Sea is an important migratory stopover site for birds (Service 2023). Over 400 bird species have been recorded at the Salton Sea, and the area is considered an Audubon Important Bird Area of global significance. While the Salton Sea primarily supports migratory birds, 109 species are year-round residents (Service 2023).

The Salton Sea provides globally important shorebird habitat. Over 100,000 shorebirds of 25 different species utilize the Salton Sea during annual migration, making it one of the most important shorebird habitat areas west of the Rocky Mountains (Service 2023). Common species include western sandpiper (*Calidris mauri*), willet (*Tringa semipalmata*), least sandpiper (*Calidris mantilla*), American avocet (*Recurvirostra americana*), dowitchers (*Limnodromus* spp.), red-necked phalarope (*Phalaropus lobatus*), whimbrel (*Numenius phaeopus*), and black-necked stilt (*Himantopus mexicanus*) (Service 2023). Amphibians are not very common around the Salton Sea, with only a few species generally found on the Sonny Bono Salton Sea National Wildlife Refuge. The most common species include bullfrogs, but there have been records of Woodhouse's toads and red-spotted toads (Service 2023).

Given the dry desert habitat surrounding the Salton Sea (see the Vegetation section for a discussion of habitat types), reptiles are more common around the Salton Sea than amphibians. Common species include snakes, such as gopher snake (*Pituophis catenifer*) and western diamondback rattlesnake

(*Crotalus atrox*); lizards, such as whiptail lizard (*Aspidoscelis* sp.) and side-blotched lizard (*Uta stansburiana*); and turtles, such as spiny soft-shell turtle (*Apalone spiniferus*) (Service 2023).

Common mammal species include desert cottontail (*Sylvilagus audubonii*), raccoon (*Procyon lotor*), muskrat, striped skunk (*Mephitis mephitis*), bobcat, coyote, and several bat and small rodent species (Service 2023).

The Salton Sea is characterized as a hypersaline water body. The California Department of Fish and Wildlife (CDFW) conducted quarterly fish surveys of the Salton Sea between 2003 and 2008, after which that project was discontinued. Data from these surveys captured species including tilapia, mollies, mullet, pupfish (unreported species), shad (unreported species), striped bass (*Morone saxitilis*), corvina (*Cynoscion xanthulus*), and Gulf croaker (*Bairdiella icistia*). Between 2003 and 2008, captures were dominated by tilapia (a total of 55,613), croaker (a total of 80), and corvina (a total of 19). During the last year of surveys in 2008, however, only two species were captured, including 14,380 tilapia and 2 mollies. Tilapia species present in the Salton Sea are redbelly (*Tilapia zillii*), Mozambique tilapia (*Oreochromis mossambicus*), and their hybrid (Riedel 2016).

The most recent survey of the Salton Sea was conducted jointly by the CDFW and Service in 2017; this survey captured only tilapia. A total of 327 tilapia were captured with 3 size classes present, indicating successful recent spawning (CDFW and USFWS 2017). While 327 tilapia were captured in 2017, this total and catch-per-unit-effort (CPUE) of 1.11 fish per net hour for 2017 were very low compared with previous years (2003–2008), especially when compared with site-specific CPUE for 2008.

Many freshwater species were extirpated by 1929 (Evermann 1916; Riedel 2016). Current conditions may not be habitable by many species due to the water's high and increasing salinity. This trend of increasing salinity may result in the extirpation of tilapia as well (Riedel 2016). Salinity refuges are localized around confluences with streams, and these areas may be extremely important for the continued persistence of fish in the Salton Sea (Riedel 2016). The 2017 survey (CDFW and USFWS 2017) captured the most tilapia around the freshwater inputs, thus indicating these inflows may be important for the persistence of fish in the Salton Sea, especially with lower salinities in these areas.

Special Status Species

Special status species include federally threatened, endangered, or proposed species as well as species on the state BLM sensitive species lists for Utah (BLM 2018), Arizona (BLM 2017a), Nevada (BLM 2017b), and California (BLM 2014). Species on these lists were queried with the state natural heritage databases for each of the four states to determine which species had records in the analysis area. Only those species identified as present in the natural heritage databases were included in this analysis. The resulting data were used to populate **Table 3-24** and **Table 3-25**.

Table 3-24
Federally Listed Species Potentially Affected by the Alternatives

Common Name	Scientific Name	Listing Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Fish							
Bonytail	*Gila elegans*	Endangered BLM NV	Present (rare, stocked)			Present (stocked)	
Colorado pikeminnow	*Ptychocheilus lucius*	Endangered	Present (rare in lake, common in inflows)				
Humpback chub	*Gila cypha*	Threatened		Present	Present (new population below full pool elevation in Colorado River Inflow)		
Razorback sucker	*Xyrauchen texanus*	Endangered BLM NV	Present	Present (primarily below Lava Falls Rapid)	Present	Present	
Desert pupfish	*Cyprinodon macularius*	Endangered CA					Present (not reported since 2007)
Birds							
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered BLM AZ BLM CA BLM NV	No habitat present for this species	Present (breeding habitat limited to areas unaffected by water fluctuations)	Habitat only in Lower Las Vegas Wash within full pool of Lake Mead	Present	No breeding habitat present for this species
Western yellow-billed cuckoo	*Coccyzus americanus*	Threatened BLM AZ BLM CA BLM NV	No habitat present for this species	Present (possible breeding habitat limited to areas unaffected by water fluctuations)	Habitat only in Lower Las Vegas Wash within full pool of Lake Mead	Habitat in LCR MSCP conservation areas	No breeding habitat present for this species
Yuma Ridgway's rail	*Rallus obsoletus yumanensis*	Endangered BLM AZ BLM CA BLM NV	No habitat present for this species	No habitat present that could be affected by water fluctuations	No habitat present that could be affected by water fluctuations	Present	Present
Mammals							
None							

Common Name	Scientific Name	Listing Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Reptiles and Amphibians							
Desert tortoise	*Gopherus agassizii*	Threatened BLM NV	Not present	Not present	Present	Present	Not present
Northern Mexican garter snake	*Thamnophis eques megalops*	Threatened	Not present	Not present	Not present	Present	Not Present
Invertebrates							
None							
Plants							
None							

Table 3-25
Non-ESA-listed Special Status Species Potentially Affected by the Alternatives

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Fish							
Bluehead sucker	*Catostomus discobolus*	BLM AZ BLM UT		X	X (rare)		
Desert sucker	*Catostomus clarkii*	BLM AZ				X (found in tributaries)	
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	X	X	X	X	
Gila longfin dace	*Agosia chrysogaster chrysogaster*	BLM AZ				X (found in tributaries)	
Sonora sucker	*Catostomus insignis*					X (found in tributaries)	
Speckled dace	*Rhinichthys osculus*	BLM AZ	X (rare)	X	X	X	
Virgin spinedace	*Lepidomeda mollispinis*				X (found in Virgin River upstream of project area)		
Woundfin	*Plagopterus argentissimus*				X (found in Virgin River upstream of project area)		
Birds							
American peregrine falcon	*Falco peregrinus*	BLM AZ BLM NV		X	X	X	X
American white pelican	*Pelecanus erythrorhynchos*	BLM UT	X			X[1]	X
Arizona bell's vireo	*Vireo bellii arizonae*	BLM CA				X	
Arizona grasshopper sparrow	*Ammodramus savannarum ammolegus*	BLM AZ		X	X	X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Bald eagle	*Haliaeetus leucocephalus*	BLM AZ BLM NV BLM UT	X	X	X	X	
Bank swallow	*Riparia riparia*	BLM CA				X	
Bendire's thrasher	*Toxostoma bendirei*	BLM CA				X	
Black swift	*Cypseloides niger*	BLM UT	X				
Burrowing owl	*Athene cunicularia*	BLM AZ BLM UT BLM NV	X		X[1]	X	X
Cactus ferruginous pygmy owl	*Glaucidium brasilianum cactorum*	BLM AZ		X	X	X	
California black rail	*Laterallus jamaicensis coturniculus*	BLM AZ BLM CA				X	X
California brown pelican	*Pelecanus occidentalis californicus*	BLM CA				X	X
California condor	*Gymnogyps californianus*	BLM AZ	X	X			
Crissal thrasher	*Toxostoma crissale*	BLM CA				X	X
Elf owl	*Micrathene whitneyi*	BLM CA				X	
Ferruginous hawk	*Buteo regalis*	BLM UT	X				
Gila woodpecker	*Melanerpes uropygialis*	BLM CA				X	
Gilded flicker	*Colaptes chrysoides*	BLM AZ BLM CA				X	
Golden eagle	*Aquila chrysaetos*	BLM UT BLM AZ	X	X	X[1]	X	
Least bittern	*Ixobrychus exilis*	BLM NV			X	X[1]	X
LeConte's thrasher	*Toxostoma lecontei*	BLM AZ		X	X	X	
Lucy's warbler	*Leiothlypis luciae*	BLM CA				X	
Mountain plover	*Charadrius montanus*	BLM CA				X	X
Northern goshawk	*Accipiter gentilis*	BLM AZ		X			
Phainopepla	*Phainopepla nitens*	BLM NV			X	X[1]	
Swainson's hawk	*Buteo swainsoni*	BLM CA				X	
Tricolored blackbird	*Agelaius tricolor*	BLM CA				X	
Western snowy plover	*Charadrius nivosus nivosus*	BLM NV			X		
White-tailed kite	*Elanus leucurus*	BLM CA				X	X
Mammals							
Allen's big-eared bat	*Idionycteris (=Plecotus) phyllotis*	BLM AZ BLM NV BLM UT	X		X		
Allen's lappet-browed bat	*Idionycteris phyllotis*	BLM AZ		X			
Arizona myotis	*Myotis occultus*	BLM AZ		X	X	X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Big brown bat	*Eptesicus fuscus*	BLM NV	X	X	X	X[1]	
Big free-tailed bat	*Nyctinomops macrotis*	BLM NV			X	X[1]	
California leaf-nosed bat	*Macrotus californicus*	BLM AZ BLM NV			X	X	
California myotis	*Myotis californicus*	BLM NV	X	X	X	X[1]	
Canyon bat	*Parastrellus hesperus*	BLM NV	X	X	X	X[1]	
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	X	X	X	X	
Desert bighorn sheep	*Ovis canadensis nelsoni*	BLM CA	X	X	X	X	
Fringed myotis	*Myotis thysanodes*	BLM UT BLM NV	X		X		
Hoary bat	*Lasiurus cinereus*	BLM NV			X	X[1]	
Houserock Valley chisel-toothed kangaroo rat	*Dipodomys microps leucotis*	BLM AZ		X			
Kit fox	*Vulpes macrotis*	BLM UT	X				
Long-eared myotis	*Myotis evotis*	BLM CA				X	
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	X	X	X	X[1]	
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	X	X	X	X	
Pallid bat	*Antrozous pallidus*	BLM NV	X	X	X	X	
Palm springs pocket mouse	*Perognathus longimembris bangsi*	BLM CA				X	
Palm springs round-tailed ground squirrel	*Xerospermophilus tereticaudus chlorus*	BLM CA				X	
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	X	X	X	X[1]	
Spotted bat	*Euderma maculatum*	BLM AZ BLM NV BLM UT		X		X	
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM AZ BLM CA BLM NV BLM UT	X		X	X	
Western mastiff bat	*Eumops perotis*	BLM AZ BLM NV		X	X	X	
Western red bat	*Lasiurus blossevillii*	BLM NV BLM UT			X	X[1]	
Western small-footed myotis	*Myotis ciliolabrum*	BLM CA BLM NV			X	X	
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	X	X	X	X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Reptiles and Amphibians							
Arizona striped whiptail	*Aspidoscelis arizonae*	BLM AZ		X	X	X	
Arizona toad	*Anaxyrus microscaphus*	BLM AZ BLM UT BLM NV	X			X	
Banded gila monster	*Heloderma suspectum cinctum*	BLM NV			X	X	
Coast horned lizard	*Phrynosoma blainvillii*	BLM CA				X	
Coronado skink	*Plestiodon skiltonianus interparietalis*	BLM CA				X	
Couch's spadefoot	*Scaphiopus couchii*	BLM CA				X	
Desert box turtle	*Terrapene ornata luteola*	BLM AZ		X	X	X	
Flat-tailed horned lizard	*Phrynosoma mcallii*	BLM AZ				X	
Foothill yellow-legged frog (south coast DPS)	*Rana boylii*	BLM CA				X	
Lowland burrowing treefrog	*Smilisca fodiens*	BLM AZ		X	X	X	
Lowland leopard frog	*Rana yavapaiensis*	BLM AZ BLM CA			X	X	
Mohave fringe-toed lizard	*Uma scoparia*	BLM AZ		X	X	X	
Northern leopard frog	*Lithobates [=Rana] pipiens*	BLM AZ	X[2]	X			
Relict leopard frog	*Rana onca*	BLM AZ BLM NV			X	X	
Sinoloan narrow-mouthed toad	*Gastrophryne mazatlanensis*	BLM AZ		X	X	X	
Sonoran green toad	*Bufo retiformis*	BLM AZ		X	X	X	
Two-striped garter snake	*Thamnophis hammondii*	BLM CA				X	
Western pond turtle	*Emys marmorata*	BLM CA				X	
Western spadefoot	*Spea hammondii*	BLM CA				X	
Yuman desert fringe-toed lizard	*Uma rufopunctata*	BLM AZ		X	X	X	
Invertebrates							
Apache springsnail	*Pyrgulopsis arizonae*	BLM AZ		X	X	X	
Gila tyronia	*Tryonia gilae*	BLM AZ		X	X	X	
Grand wash springsnail	*Pyrgulopsis bacchus*	BLM NV		X	X	X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Kingman springsnail	*Pyrgulopsis conica*	BLM AZ		X	X	X	
MacNeill's sooty-winged skipper	*Hesperopsis gracielae*	BLM NV			X	X[1]	
Mojave gypsum bee	*Andrena balsamorhizae*	BLM NV			X		
Mojave poppy bee	*Perdita meconis*	BLM NV			X		
Monarch butterfly	*Danaus plexippus plexippus*	Candidate BLM NV		X	X	X	
Sonoran talussnail	*Sonorella magdalenensis*	BLM AZ		X	X	X	
Thorne's hairstreak	*Callophrys thornei*	BLM CA				X	
Plants							
Alkali mariposa lily	*Calochortus striatus*	BLM NV			X		
Aravaipa sage	*Salvia amissa*	BLM AZ		X	X	X	
Aravaipa woodfern	*Thelypteris puberula* var. *sonorensis*	BLM AZ		X			
Arizona eryngo	*Eryngium sparganophyllum*	BLM AZ		X	X	X	
Arizona sonoran rosewood	*Vauquelinia californica* ssp. *sonorensis*	BLM AZ		X	X	X	
Bartram stonecrop	*Graptopetalum bartramii*	BLM AZ		X	X	X	
Beaver dam breadroot	*Pediomelum castoreum*	BLM NV			X		
Blue diamond cholla	*Cylindropuntia X multigeniculata*	BLM NV			X		
Blue sand lily	*Triteleiopsis palmeri*	BLM AZ		X	X	X	
California flannelbush	*Fremontodendron californicum*	BLM AZ		X	X	X	
California screw moss	*Tortula californica*	BLM CA				X	
Chaparral sand-verbena	*Abronia villosa* var. *aurita*	BLM CA				X	
Cochise sage	*Carex ultra*	BLM AZ		X	X	X	
Coulter's goldfields	*Lasthenia glabrata* ssp. *coulteri*	BLM CA				X	
Deane's milkvetch	*Astragalus deanei*	BLM CA				X	
Decumbent goldenbush	*Isocoma menziesii* var. *decumbens*	BLM CA				X	
Delicate clarkia	*Clarkia delicata*	BLM CA				X	
Dunn's mariposa lily	*Calochortus dunnii*					X	
Fish creek fleabane	*Erigeron piscaticus*	BLM AZ		X	X	X	
Felt-leaved monardella	*Monardella hypoleuca* ssp. *lanata*	BLM CA				X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Gander's pitcher sage	*Lepechinia ganderi*	BLM CA				X	
Gander's ragwort	*Packera ganderi*	BLM CA				X	
Gold butte moss	*Ceratodon purpureus*	BLM NV			X		
Grand Canyon rose	*Rosa stellata* var. *abyssa*	BLM AZ		X			
Harrison's barberry	*Berberis harrisoniana*	BLM AZ		X	X	X	
Harwood's eriastrum	*Eriastrum harwoodii*	BLM CA				X	
Hohokam agave	*Agave murpheyi*	BLM AZ		X	X	X	
Horn's milkvetch	*Astragalus hornii* var. *hornii*	BLM CA				X	
Huachuca golden aster	*Heterotheca rutteri*	BLM AZ		X	X	X	
Lace-leaf rockdaisy	*Perityle ambrosiifolia*	BLM AZ		X	X	X	
Lakeside ceanothus	*Ceanothus cyaneus*	BLM CA				X	
Las Vegas bearpoppy	*Arctomecon californica*	BLM NV			X		
Las Vegas buckwheat	*Eriogonum corymbosum* var. *nilesii*	BLM NV			X		
Latimer's woodland-gilia	*Saltugilia latimeri*	BLM CA				X	
Lincoln rockcress	*Boechera lincolnensis*	BLM CA				X	
Little San Bernardino Mtns. linanthus	*Linanthus maculatus* ssp. *maculatus*	BLM CA				X	
Long-spined spineflower	*Chorizanthe polygonoides* var. *longispina*	BLM CA				X	
Marble canyon milkvetch	*Astragalus cremnophylax* var. *hevronii*	BLM AZ		X			
Mecca-aster	*Xylorhiza cognata*	BLM CA				X	
Mojave indigo bush	*Psorothamnus arborescens* var. *pubescens*	BLM AZ		X			
Mojave tarplant	*Deinandra mohavensis*	BLM CA				X	
Mokiak milkvetch	*Astragalus mokiacensis*	BLM NV			X		
Mt Trumbull beardtongue	*Penstemon distans*	BLM AZ		X			
Nuttall's scrub oak	Quercus dumosa	BLM CA				X	
Oil neststraw	*Stylocline citroleum*	BLM CA				X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Orcutt's brodiaea	*Brodiaea orcuttii*	BLM CA				X	
Orocopia Mountains spurge	*Euphorbia jaegeri*	BLM CA				X	
Otay manzanita	*Arctostaphylos otayensis*	BLM CA				X	
Otay Mountain ceanothus	*Ceanothus otayensis*	BLM CA				X	
Parish's meadowfern	*Limnanthes alba* ssp. *parishi*	BLM CA				X	
Parish's phacelia	*Phacelia parryi*	BLM NV			X		
Parry's spineflower	*Chorizanthe parryi* var. *parryi*	BLM CA				X	
Parry's tetracoccus	*Tetracoccus dioicus*	BLM CA				X	
Pima Indian mallow	*Abutilon parishii*	BLM AZ		X	X	X	
Pinto beardtongue	*Penstemon bicolor* ssp. *roseus*	BLM AZ				X	
Polished blazing star	*Mentzaelia laevicaulis*	BLM NV			X		
Rainbow manzanita	*Arctostaphylos rainbowensis*	BLM CA				X	
Ramona horkelia	*Horkelia truncata*	BLM CA				X	
Reveal's buckwheat	*Eriogonum contiguum*	BLM CA				X	
Robinson's monardella	*Monardella robisonii*	BLM CA				X	
Rosy twotone beardtongue	*Penstemon bicolor* ssp. *roseus*	BLM NV			X		
Salt marsh bird's beak	*Chloropyron maritimum* ssp. *maritimum*	BLM CA				X	
San Bernadino milkvetch	*San Bernardino milkvetch*	BLM CA				X	
San Diego goldenstar	*Bloomeria clevelandii*	BLM CA				X	
San Diego gumplant	*Grindelia hallii*	BLM CA				X	
San Diego milkvetch	*Astragalus oocarpus*	BLM CA				X	
Sandfood	*Pholisma sonorae*	BLM AZ		X	X	X	
San Jacinto mariposa lily	*Calochortus palmeri* var. *munzii*	BLM CA				X	
San Luis Obispo sedge	*Carex obispoensis*	BLM CA				X	
San Miguel savory	*Clinopodium chandleri*	BLM CA				X	
Sanford's arrowhead	*Sagittaria sanfordii*	BLM CA				X	

Common Name	Scientific Name	Status	Location				
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea
Santa Lucia dwarf rush	*Juncus luciensis*	BLM CA				X	
Scaly sandplant	*Pholisma arenarium*	BLM AZ		X	X	X	
Shevock's copper moss	*Mielichhoferia shevockii*	BLM CA				X	
Siler fishhook cactus	*Sclerocactus sileri*	BLM AZ		X			
Silverleaf sunray	*Enceliopsis argophylla*	BLM AZ BLM NV		X	X	X	
Small wirelettuce	*Stephanomeria exigua* ssp. *exigua*	BLM AZ		X	X	X	
Snake cholla	*Cylindropuntia californica* var. *californica*	BLM CA				X	
Spring mountains milkvetch	*Astragalus remotus*	BLM NV			X		
Sticky buckwheat	*Eriogonum viscidulum*	BLM AZ BLM NV			X		
Sticky dudleya	*Cylindropuntia californica* var. *californica*	BLM CA				X	
Sticky ringstem	*Anulocaulis leiosolenus*	BLM NV			X		
Summer holly	*Comarostaphylis diversifolia* ssp. *diversifolia*	BLM CA				X	
Tecate cypress	*Hesperocyparis forbesii*	BLM CA				X	
Tecate tarplant	*Deinandra floribunda*	BLM CA				X	
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*	BLM NV			X		
Tumamoc globeberry	*Tumamoca macdougalii*	BLM AZ		X	X	X	
Variegated dudleya	*Dudleya variegata*	BLM CA				X	
White bearpoppy	*Arctomecon merriamii*	BLM NV			X		
White margined beardtongue	*Penstemon albomarginatus*	BLM NV			X		
White-bracted spineflower	*Chorizanthe xanti* var. *leucotheca*	BLM CA				X	
Wiggins' croton	*Croton wigginsii*	BLM CA				X	
Yellow twotone beardtongue	*Penstemon bicolor* ssp. *bicolor*	BLM NV			X		
Yucaipa onion	*Allium marvinii*	BLM CA				X	

[1]Additional location information received from personal communication with Carolyn Ronning, Wildlife Group Manager, Reclamation, on March 3, 2023

[2]Additional location information received from the NPS (2023b)

See the vegetation and general wildlife sections for a description of habitat within each of the four sections of the analysis area, as these descriptions are not repeated below. For habitat requirements for the species in **Table 3-24** and **Table 3-25**, see NatureServe Explorer (2023), which is incorporated by reference. Information pertaining to Endangered Species Act (ESA)-listed species is still being drafted in the biological assessments. Updated information will be incorporated into the final SEIS when it is available.

Lake Powell

Table 3-24 lists all federally threatened, endangered, or proposed species and whether they occupy Lake Powell. **Table 3-25** lists all non-ESA-listed BLM special status species and whether they occupy Lake Powell.

In the Colorado River inflow to Lake Powell, Colorado pikeminnow have been historically found as larvae and age-0 fish (Valdez and Williams 1993) that were transported from upstream; however, since 2014 no larvae were identified in the Colorado River or San Juan River arms of Lake Powell (Steven Platania, personal communication, 2023). Periodically, large adult Colorado pikeminnow are found in the inflow as transient members of upstream populations in the Green and Upper Colorado Rivers (Service 2022). Razorback suckers are also found in the river inflows of Lake Powell. These fish are usually found as adults from upstream populations, and there are some fish that move across Lake Powell from the San Juan inflow (Service 2018a). Razorback sucker have also been captured in the Glen Canyon Dam forebay near the dam as evidenced by a recent capture in August 2023 by Utah State University (Barrett Friesen, personal communication, August 13, 2023). Excess numbers of bonytail from the Wahweap State Fish Hatchery (Utah) are released periodically into Lake Powell, but they are not part of a formal stocking plan (Smith 2022).

Colorado pikeminnow are stocked in the San Juan River annually as juveniles (Service 2022), and razorback sucker are stocked as large subadults. These fish are successfully reproducing in the San Juan River, but survival of young and recruitment of both species are low. These populations are currently maintained through stocking. Some fish are displaced from upstream populations into the Lake Powell inflow, and they are prevented from returning upstream by a 20-foot (6-meter) waterfall that has formed as the river has partly carved a new channel on the deltaic sediments. Razorback suckers have been detected in the approximately 30 miles of newly carved river each in the San Juan River and Colorado River inflows while Colorado pikeminnow have been detected sporadically.

Glen Canyon Dam to Lake Mead

Table 3-24 lists all federally threatened, endangered, or proposed species and whether they occupy the Glen Canyon Dam to Lake Mead section. **Table 3-25** lists all non-ESA-listed BLM special status species and whether they occupy the Glen Canyon Dam to Lake Mead section. The *Impact Analysis Area* discussion in **Section 3.13.2** explains the methodology for narrowing down this list from the broader list of species included in **Appendix G, Table of Sensitive Species**. The NPS also identified special status species in Grand Canyon National Park that are not on the BLM sensitive species list (NPS 2023e). These species include the Grand Canyon cave pseudoscorpion (*Archeolarca cavicola*), Kanab ambersnail (*Oxyloma haydeni kanabensis*), Niobrara ambersnail (*Ocylom ahydeni*), long-legged myotis bat (*Myotis volans*), pocketed free-tailed bat (*Nyctinomops fermosacca*), southwestern myotis bat (*Myotis auriculus*), southwestern river otter (*Lontra canadensis sonora*), and several plant species (NPS 2023e). Impacts on these species will be captured through the analysis of BLM sensitive species that use the same habitat types in the Glen Canyon Dam to Lake Mead sections.

The flannelmouth sucker and bluehead sucker are "conservation species" that are included in a rangewide conservation agreement among six states (Utah Department of Natural Resources 2006). These species are found as self-sustaining populations and are common in the Colorado River from Glen Canyon Dam to Lake Mead. They are seasonally abundant during spring spawning runs into tributaries of the Colorado River, such as the Paria River, Havasu Creek, and Tapeats Creek. Both species have adjusted to changing riverine conditions following construction of Glen Canyon Dam (Paukert and Rogers 2004; Valdez and Carothers 1998). Speckled dace are common to abundant locally in and near tributary inflows, as well as on rocky debris fans formed by debris flows from side canyons (Valdez and Ryel 1995).

Humpback chub populations have recently expanded into the western Grand Canyon. This is likely due to the warmer water in the lower Grand Canyon and due to the lack of predators (Van Haverbeke et al. 2017; Rogowski et al. 2018). The most recent information as of 2023 shows a population of 40,000–60,000 adults between Havasu Rapids and Pearce Ferry (Dzul et al 2023).

Since 2000, larvae and adult razorback suckers have also been found in the Colorado River inflow at the lower end of the Grand Canyon, including sonic-tagged adults moving from one of the three Lake Mead populations (Kegerries et al. 2017). A confirmed spawning site was located in 2010 about 10 miles downstream of Pearce Ferry (Valdez et al. 2012). Although annual surveys for larval and small-bodied razorback suckers have been conducted in the Grand Canyon since 2014, no small-bodied fish have been detected and larval fish have not been detected since 2019. The razorback sucker in the Grand Canyon is found primarily downstream of Lava Falls Rapid.

Lake Mead

Table 3-24 lists all federally threatened, endangered, or proposed species and whether they occupy Lake Mead. **Table 3-25** lists all non-ESA-listed BLM special status species and whether they occupy Lake Mead.

Two native sucker species, flannelmouth sucker and razorback sucker, occupy this area (Reclamation 2007). The largest self-sustaining population of razorback sucker in the Lower Basin is found in Lake Mead, primarily in the Colorado River and Virgin River inflows. Colorado pikeminnow do not occur in this reach.

Humpback chub have become established in the Colorado River extended channel as far downstream as below Pearce Ferry (Rogowski et al. 2018), but they do not occur in the current footprint of Lake Mead. It is unlikely the species would move into the lake since it is primarily a riverine species. However, the only self-sustaining population of razorback sucker exists in Lake Mead, and the fish are reproducing in the upper reservoir near and in the inflows of both rivers (Albrecht et al. 2017). The newly hatched larvae shelter in emergent vegetation that is inundated with spring runoff, although predation by nonnative fish is high and survival and recruitment are low (Service 2018b). In the Colorado River inflow, the razorback sucker has been detected where it spawns on cobble shoals in April and May. The flannelmouth sucker is also found in the inflow, but at much lower numbers.

The endangered woundfin and the Virgin River roundtail chub are found in the Virgin River, but they do not occur downstream of Mesquite, Nevada, except when transported from upstream populations by large floods.

Hoover Dam to the SIB

Table 3-24 lists all federally threatened, endangered, or proposed species and whether they occupy the Hoover Dam to the SIB section. **Table 3-25** lists all non-ESA-listed BLM special status species and whether they occupy the Hoover Dam to the SIB section. Species that are not on the BLM sensitive species list but have also been identified as special status species due to their inclusion and coverage under the LCR MSCP (Reclamation 2004a) include the western yellow bat (*Lasiurus xanthinus*), Colorado River cotton rat (*Sigmodon arizonae plenus*), Yuma hispid cotton rat (*Sigmodon hispidus eremicus*), vermilion flycatcher (Pyrocephalus rubinus), Sonoran yellow warbler (*Dendroica petechia sonorana*), and summer tanager (*Piranga rubra*). Impacts on these species will be captured through the analysis of BLM sensitive species that use the same habitat types in the Hoover Dam to the SIB section.

The endangered razorback sucker and bonytail are introduced from hatchery stocks into Lake Mohave, Lake Havasu, and the reach of river between Parker Dam and Imperial Dam as part of mitigation for the LCR MSCP. They are also stocked into lakeside rearing ponds in Lake Mohave and in created backwaters at Imperial National Wildlife Refuge (NWR). There is some evidence of reproduction by these species, but self-sustaining populations have become established only in the disconnected backwaters of Imperial and Cibola NWRs.

The flannelmouth sucker and bluehead sucker are "conservation species" that are included in a rangewide conservation agreement among six states (Utah Department of Natural Resources 2006). The flannelmouth sucker is found in the riverine reach downstream of Hoover Dam.

Salton Sea

Table 3-24 lists all federally threatened, endangered, or proposed species and whether they occupy the Salton Sea. **Table 3-25** lists all non-ESA-listed BLM special status species and whether they occupy the Salton Sea.

The desert pupfish is a federal and state endangered species. This species has high tolerances for water temperature, salinity, and dissolved oxygen concentration (Service 1993). It occurs in nearshore pools of the Salton Sea and irrigation drains to the Salton Sea (Reidel 2016; Service 2010). Surveys conducted by the CDFW between 2003 and 2008 captured a total of four individuals with three in 2004 and one in 2007 in nearshore habitats. However, this species was not captured during surveys in 2017 (CDFW and Service 2017). The desert pupfish occurs in wetland areas downstream of agricultural drains that drain onto the exposed lakebed. The biological opinion for the Salton Sea 10-Year Management Program, issued to the Army Corps on February 23, 2023, provides baseline desert pupfish occurrences in these locations. Razorback sucker was once present in the Salton Sea but was extirpated in the 1920s (Minckley et al. 1991). Additionally, archaeological remains of Colorado pikeminnow and bonytail were found in the ancient Salton Sea (Gobalet and Wake 2000).

3.13.2 Environmental Consequences

Methodology

Analyses in this section rely on the hydrologic modeling presented in **Sections 3.4** and **3.5** as well as models of vegetation impacts produced by Reclamation (2023g) and the US Geological Survey (USGS) (Butterfield and Palmquist 2023a; 2023b). However, given the lack of comprehensive quantitative modeling results for vegetation impacts across the analysis area, the description of effects of this project on biological resources are largely qualitative.

These analyses also rely on hydrologic modeling for hourly releases from Glen Canyon Dam with the GTMax model run by the Western Area Power Administration (WAPA) and the smallmouth bass model developed by the USGS (Eppehimer and Yackulic 2023). As with vegetation analyses, fisheries impacts could not be quantitatively determined from relationships of flow to habitat or habitat to fish abundance; rather, the analyses are based on evaluation of the hydrology associated with each alternative and professional scientific assessment.

Similar to the 2007 FEIS, this analysis evaluates the relative difference between the No Action Alternative and the Proposed Action (Reclamation 2007). The level of available information varies with the study sections; therefore, the methodology is adjusted according to the availability of information for a particular section or group of sections. Impacts are only considered through December 2026.

Impact Analysis Area

The impact analysis area for vegetation and terrestrial wildlife is the same as the analysis area used for the 2007 FEIS, which includes the riparian vegetation and aquatic habitat from the northern tip of Lake Powell in Utah south to the SIB (**Map 1-1**; Reclamation 2007). The impact analysis area is divided into five sections: (1) Lake Powell, (2) Glen Canyon Dam to Lake Mead, (3) Lake Mead, (4) Hoover Dam to the SIB, and (5) Salton Sea. Note that the impact analysis area is not synonymous with the area where impacts could occur. The impact analysis area is a broader area intended to ensure all potential impacts are considered. The analysis below includes only species and impacts that would occur as a result of the alternatives analyzed. For example, many of the wildlife species listed as present in the impact analysis area would not actually be affected by the project. See **Appendix G** for information narrowing the species in the impact analysis area to those potentially affected by the alternatives.

The analysis area for fish and aquatic species includes the Colorado River and associated aquatic habitat that is contiguous with the mainstream Colorado River, including the interface with the riparian area, where applicable. The affected environment boundaries are demarcated from the northern tip of Lake Powell in Utah south to the SIB (**Map 1-1**).

Assumptions

Vegetation, Wildlife, and Special Status Species

The vegetation and wildlife and fish assumptions are the same as those described in the 2007 FEIS (Reclamation 2007). Desert scrub plant communities, and the wildlife that rely on these habitat types, would not be affected by operational changes at Glen Canyon and Hoover Dam and are, therefore, not considered in this analysis. Davis Dam and Parker Dam would continue to operate to meet target reservoir elevations, and these operations would remain the same for all alternatives. The biological analysis is dependent upon the data inputs, modeling assumptions, and validity of the hydrology and riparian vegetation models. Impacts on fish species are based on hourly releases from Glen Canyon Dam using the GTMax model runs by WAPA. Dissolved oxygen and temperature of releases from Glen Canyon Dam are from modeling by the USGS, and information on smallmouth bass is from the smallmouth bass model developed by the USGS.

Impact Indicators

Vegetation

Impacts on vegetation within the analysis area are assessed based on changes in water elevation under the alternatives resulting in changes in vegetation, abundance, general location, and plant community composition. Impact indicators for vegetation remain the same as previously considered for the 2007 FEIS, including hydrologic modeling for the No Action Alternative (Reclamation 2007). Additionally, impacts on vegetation incorporate riparian and backwaters vegetation models provided by Reclamation and the USGS.

Wildlife

Similar to the 2007 FEIS, the analysis of impacts on terrestrial species is based on the vegetation impact analysis. Where impacts are noted for riparian vegetation, impacts are assumed for riparian terrestrial species. Impacts on fish incorporate findings from the 2007 FEIS where the hydrologic analysis was used to inform impacts. Additionally, impacts on the fish community incorporate model results from the GTMax Model and USGS Smallmouth Bass Model, where applicable.

Special Status Species

Similar to the 2007 FEIS, the analysis of impacts on terrestrial special status species are based on the vegetation impact analysis. Where impacts are noted for riparian vegetation, impacts are assumed for riparian special status species. Impacts on fish incorporate findings from the 2007 FEIS where the hydrologic analysis was used to inform impacts. Additionally, impacts on the fish community incorporate model results from the GTMax Model and USGS Smallmouth Bass Model, where applicable.

Issue 1: How would changing flow characteristics affect vegetation?

Summary

Under the No Action Alternative, with no modifications to water management to address worsening drought conditions, water elevations are projected to decrease over time in Lake Powell and Lake Mead to sustain flows in the Glen Canyon Dam to Lake Mead section and the Hoover Dam to the SIB section, resulting in short-term changes to riparian vegetation, including an increase of invasive plant species and loss of suitable habitat for native plant species.

Overall, the types of impacts on riparian vegetation associated with the Proposed Action would be greater than the No Action Alternative;. The No Action Alternative would result in similar impacts on vegetation at Lake Powell and the Glen Canyon Dam to Lake Mead section compared with the Proposed Action until 2025 because the alternatives only vary by Lower Basin system conservation measures and Powell releases below 7.0 maf. From 2025 to 2026, the Proposed Action would result in slightly higher water elevations at Lake Powell. At Lake Powell and Lake Mead, fewer acres of shoreline have the potential to be invaded by nonnative species under the Proposed Action compared with the No Action Alternative. In most scenarios, impacts on riparian vegetation in the Glen Canyon Dam to Lake Mead section and the Hoover Dam to the SIB section would be similar under the Proposed Action compared with the No Action Alternative until 2026, when water flows are reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead.

No Action Alternative

Lake Powell

Under the No Action Alternative, the 2007 FEIS and subsequent agreements would continue to guide operations in Lake Powell. With no modifications to water management to address worsening drought conditions, water elevations are projected to decrease over time as water resources become depleted (**Figure 3-5**). **Figure 3-5** displays the median and resulting range of pool elevations that may occur in Lake Powell through 2026 based on CRMMS. In some of the driest potential hydrologic futures (**Section 3.6.2**, **Figure 3-5**), water elevations are projected to decline by approximately 15 to 20 feet from the summer of 2023 through 2026. Beginning in 2026, the drier modeled traces result in pool elevations at Lake Powell that drop below the critical elevation of 3,490 feet but remain above the dead pool elevation of 3,370 feet. Therefore, it is expected that the trends discussed above in **Section 3.11.1** (i.e., encroachment of emergent wetland vegetation, increase in invasive species, etc.) would continue under this alternative.

Under the No Action Alternative, the NPS estimates that any additional acreage of exposed shoreline around Lake Powell has the potential to be invaded by invasive plant species such as tamarisk and Russian thistle. An increase in tamarisk establishment would result in increased fire hazard, particularly during drought conditions. In addition, with lower reservoir elevations, cattle and wildlife may be forced to utilize springs and seeps rather than the reservoir for water, causing increased negative impacts such as trampling, spreading of invasive species, and decreased water quality. Very little aquatic vegetation has established at Lake Powell, primarily because of the large (≥10 meters) year-to-year fluctuations in reservoir levels. Thus, aquatic beds of pondweed and shoreline wetlands of emergent vegetation are rare. These wetlands are important to plants and wildlife; if reservoir levels decline further, these wetlands may be further affected (NPS 2023d).

Glen Canyon Dam to Lake Mead

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations at Glen Canyon Dam. Beginning in late 2026, releases from Lake Powell under poor hydrologic conditions would reduce water levels at Lake Powell, exposing shoreline. but maintaining similar release levels from Glen Canyon Dam to Lake Mead unless lake levels drop below the critical elevation of 3,490 feet. Therefore, it is expected that the current vegetation conditions, as described above and in the LTEMP FEIS, would persist.

Hydrological niche modeling of 47 common riparian plant species growing on sand bars between Glen Canyon Dam and Diamond Creek at RM225 was conducted for the No Action Alternative (Butterfield and Palmquist 2023a). Separate analyses were conducted within three floristically distinct regions of the Colorado River—Marble Canyon (RM 0–RM 61), eastern Grand Canyon (RM 61–RM 161), and western Grand Canyon (RM 161–RM 226)—and for native and nonnative plant species. The modeling results show projected net changes in suitable habitat for combined native and nonnative species across years (2023–2027) and ESPs (80 percent, 90 percent, and 100 percent), along with projected losses and gains in suitable habitat for each species within each region. For the 100 percent ESP, projected trends for native and nonnative plant species for the period 2024–2027 under the No Action Alternative are as follows:

- Native plant species, as a group, are projected to lose suitable habitat in Marble Canyon (-3.4 percent), eastern Grand Canyon (-0.8 percent), and western Grand Canyon (-0.9 percent). Total change in habitat (either from suitable to unsuitable or vice versa) is projected to be 19.6 percent of the riparian area in Marble Canyon, 18.6 percent of eastern Grand Canyon, and 22.8 percent of western Grand Canyon. Other ESP scenarios have similar patterns.
- Nonnative plant species, as a group, are projected to gain suitable habitat in Marble Canyon (0.4 percent) and lose suitable habitat in eastern Grand Canyon (-4.7 percent) and western Grand Canyon (-6.6 percent). The total change in habitat (either from suitable to unsuitable or vice versa) is projected to be 24.8 percent of the riparian area in Marble Canyon, 16.8 percent of eastern Grand Canyon, and 14.4 percent of western Grand Canyon. Other ESP scenarios have similar patterns.
- Twelve native plant species exhibited overall increases in suitable habitat under these scenarios (no action and 100 percent ESP) in Marble Canyon, while 17 exhibited losses. In eastern Grand Canyon, 15 native species exhibited overall increases, while 15 exhibited losses. In western Grand Canyon, 10 species exhibited increases, while 13 exhibited losses.
- Eight nonnative plant species exhibited overall decreases in suitable habitat under these scenarios (no action and 100 percent ESP) in Marble Canyon, while 4 exhibited increases. In eastern Grand Canyon, 10 nonnative species exhibited overall losses, while 4 exhibited gains, with weeping lovegrass (*Eragrostis curvula*) exhibiting a large increase. In western Grand Canyon, 7 nonnative species exhibited losses, while 2 exhibited modest or minor gains (Butterfield and Palmquist 2023a).

The probabilities of HFEs under the No Action Alternative and Proposed Action are nearly identical. Thus, the No Action Alternative was compared with the Proposed Action with and without HFEs (Butterfield and Palmquist 2023b). The results of this comparative modeling are described below under the Proposed Action.

Lake Mead

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations in Lake Mead. With no modifications to water management to address worsening drought conditions, water elevations are projected to decrease over time as water resources become depleted (**Figure 3-8**). Water elevations are projected to decline in the summer of 2023 and continue through 2026. Therefore, it is expected that the trends discussed above in

Section 3.11.1 (i.e., encroachment of emergent wetland vegetation, increase in invasive species, etc.) would continue under this alternative.

Hoover Dam to the SIB
Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations at Hoover Dam. Releases from Lake Mead would remain the same as existing conditions, depleting Lake Mead but maintaining similar water elevations from Lake Mead to the SIB. Therefore, it is expected that the current vegetation conditions, as described above in **Section 3.11.1** and in the LCR MSCP HCP, would persist. However, with continued drought conditions, as water elevations continue to decline in Lake Powell and the lake drops below minimum power pool elevation and approaches dead pool, less water would be available for release in this reach (**Table 3-26**), at which point riparian habitat may be affected.

Salton Sea
Under the No Action Alternative, riparian vegetation surrounding the Salton Sea would continue to be influenced by decreasing water levels and increased salinity, resulting in an increase in exposed playa as described above in **Section 3.13.1**.

Proposed Action

Lake Powell
Implementation of the Proposed Action would result in similar water levels in Lake Powell until 2026, when the Proposed Action begins to diverge from the No Action Alternative (**Figure 3-5**). Lake Powell would be maintained at an elevation above 3,500 feet, which is the same as or slightly higher than the No Action Alternative, and by late 2026 the median elevation is projected to be approximately 3,570 feet, which is within the Mid-Elevation Release Tier (see **Section 3.6.2**). Overall, there would be no measurable differences in vegetation from implementation of the Proposed Action compared with the No Action Alternative at Lake Powell.

Glen Canyon Dam to Lake Mead
Hydrological niche modeling for the Proposed Action scenario as it relates to the No Action Alternative shows projected net changes in proportion of native cover, total species richness, and total vegetation cover in 2024 across ESPs (80 percent, 90 percent, and 100 percent), along with projected losses and gains for each metric within each region from 2025 to 2027 (Butterfield and Palmquist 2023b). In general, the riparian vegetation model did not project substantial differences in habitat suitability under the Proposed Action compared with the No Action Alternative. Either with or without HFEs, the small differences in monthly volumes between the No Action Alternative and the Proposed Action had little to no effect on the hydrologic variables that drive habitat suitability for riparian plant species.

Thus, the majority of traces resulted in zero predicted difference in vegetation metrics between the No Action Alternative and Proposed Action scenarios, either with or without HFEs, with one exception. The largest predicted effect of the Proposed Action was a 1.7 percent increase in proportion of native cover in the western Grand Canyon under the driest 10 percent of traces. Overall, the predicted effects of the Proposed Action versus the No Action Alternative on riparian vegetation metrics are negligible (**Table 3-26**, **Table 3-27**, and **Table 3-28**; Butterfield and Palmquist 2023b).

Table 3-26
Projected Change in Native Vegetation Cover under the Proposed Action as Compared with the No Action Alternative

No HFE		Predicted Value in 2024 (Proportion)			Predicted Change: Absolute (Proportion)			Predicted Change: Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	0.79	0.78	0.80	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	0.79	0.78	0.80	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	0.79	0.78	0.79	0.00	-0.01	0.00	-0.6	-0.8	-0.4
	0-10%	0.79	0.78	0.79	-0.01	-0.01	0.00	-0.8	-1.0	-0.6
Eastern	50-100%	0.73	0.71	0.74	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	0.73	0.71	0.74	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	0.73	0.72	0.74	0.00	0.00	0.00	0.0	-0.1	0.1
	0-10%	0.73	0.72	0.73	0.00	0.00	0.00	-0.1	-0.2	0.0
Western	50-100%	0.64	0.62	0.67	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	0.64	0.62	0.67	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	0.64	0.63	0.66	0.00	0.00	0.00	-0.3	-0.5	0.0
	0-10%	0.64	0.63	0.65	0.00	0.00	0.00	-0.1	-0.4	0.1

With HFE		Predicted Value in 2024 (Proportion)			Predicted Change: Absolute (Proportion)			Predicted Change: Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	0.68	0.67	0.69	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	0.68	0.67	0.69	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	0.68	0.68	0.69	0.00	-0.01	0.00	-0.7	-0.9	-0.5
	0-10%	0.68	0.68	0.69	0.00	-0.01	0.00	-0.6	-0.8	-0.5
Eastern	50-100%	0.58	0.56	0.60	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	0.58	0.56	0.60	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	0.58	0.57	0.59	0.00	0.00	0.01	0.6	0.3	1.0
	0-10%	0.58	0.57	0.59	0.00	0.00	0.01	0.8	0.5	1.1
Western	50-100%	0.47	0.46	0.47	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	0.47	0.46	0.47	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	0.47	0.46	0.47	0.00	0.00	0.00	0.4	-0.1	0.9
	0-10%	0.47	0.46	0.47	0.00	0.00	0.01	1.0	0.4	1.7

Source: Butterfield and Palmquist 2023b

Note: Predicted net change in proportion native cover, calculated as the difference between cumulative habitat gains and losses, comparing the Proposed Action with the No Action Alternative, with or without HFEs, across all sandbars and years (2025–2027). Suitable habitat totals under the No Action Alternative scenario in 2024 were used to calculate the relative (percentage) change values. Different trace classes represent the lowest (0 to 10 percent) to the highest (50 to 100 percent) lake level quantiles.

Table 3-27
Projected Change in Species Richness under the Proposed Action as Compared with the No Action Alternative

No HFE		Predicted Value in 2024 (Species per Sandbar)			Predicted Change					
					Absolute (Species)			Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	34.68	33.77	35.60	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	34.68	33.77	35.60	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	34.68	34.10	35.27	0.05	-0.01	0.10	0.1	0.0	0.3
	0-10%	34.68	34.29	35.08	-0.04	-0.09	0.01	-0.1	-0.3	0.0
Eastern	50-100%	31.69	31.10	32.29	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	31.69	31.10	32.29	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	31.69	31.31	32.07	-0.02	-0.11	0.07	-0.1	-0.4	0.2
	0-10%	31.69	31.44	31.95	-0.14	-0.22	-0.05	-0.4	-0.7	-0.1
Western	50-100%	21.38	19.98	22.77	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	21.38	19.98	22.77	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	21.38	20.50	22.25	0.07	-0.02	0.16	0.3	-0.1	0.8
	0-10%	21.38	20.79	21.96	-0.02	-0.09	0.06	-0.1	-0.4	0.3

With HFE		Predicted Value in 2024 (Species per Sandbar)			Predicted Change					
					Absolute (Species)			Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	32.58	32.14	33.02	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	32.58	32.14	33.02	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	32.58	32.29	32.86	0.05	-0.01	0.11	0.2	0.0	0.3
	0-10%	32.58	32.38	32.77	0.03	-0.01	0.07	0.1	0.0	0.2
Eastern	50-100%	30.54	29.93	31.15	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	30.54	29.93	31.15	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	30.54	30.14	30.93	-0.08	-0.15	-0.01	-0.3	-0.5	0.0
	0-10%	30.54	30.27	30.81	-0.13	-0.19	-0.06	-0.4	-0.6	-0.2
Western	50-100%	21.13	20.29	21.96	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	21.13	20.29	21.96	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	21.13	20.59	21.66	0.08	-0.04	0.21	0.4	-0.2	1.0
	0-10%	21.13	20.76	21.49	0.05	-0.02	0.11	0.2	-0.1	0.5

Source: Butterfield and Palmquist 2023b

Note: Predicted net change in species richness, calculated as the difference between species gains and losses, comparing the Proposed Action to the No Action Alternative scenario, with or without HFEs, across all sandbars and years (2025–2027). Suitable habitat totals under the No Action Alternative scenario in 2024 were used to calculate the relative (percentage) change values. Different trace classes represent the lowest (0 to 10 percent) to the highest (50 to 100 percent) lake level quantiles.

Table 3-28
Projected Change in Total Vegetation Cover under the Proposed Action as Compared with the No Action Alternative

No HFE		Predicted Value in 2024 ($10^5 m^2$)			Predicted Change					
					Absolute ($10^3 m^2$)			Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	11.27	8.77	13.77	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	11.27	8.77	13.77	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	11.27	9.66	12.87	-1.84	-5.61	1.92	-0.2	-0.5	0.2
	0-10%	11.27	10.18	12.36	-5.22	-8.83	-1.61	-0.5	-0.8	-0.1
Eastern	50-100%	6.03	4.41	7.64	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	6.03	4.41	7.64	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	6.03	5.00	7.06	-0.79	-3.07	1.50	-0.1	-0.5	0.2
	0-10%	6.03	5.33	6.72	-2.90	-5.30	-0.50	-0.5	-0.9	-0.1
Western	50-100%	5.70	4.19	7.21	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	5.70	4.19	7.21	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	5.70	4.76	6.65	-0.95	-3.41	1.52	-0.2	-0.6	0.3
	0-10%	5.70	5.07	6.34	-3.05	-6.49	0.39	-0.5	-1.1	0.1

With HFE		Predicted Value in 2024 ($10^5 m^2$)			Predicted Change					
					Absolute ($10^3 m^2$)			Relative (%)		
Region	Traces	Mean	95% CI		Mean	95% CI		Mean	95% CI	
Marble	50-100%	9.35	8.18	10.53	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	25-50%	9.35	8.18	10.53	0.00	0.00	0.00	0.0	0.0	0.0
	10-25%	9.35	8.59	10.12	1.97	0.08	3.87	0.2	0.0	0.4
	0-10%	9.35	8.83	9.87	0.95	-0.61	2.50	0.1	-0.1	0.3
Eastern	50-100%	5.37	4.45	6.28	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	5.37	4.45	6.28	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	5.37	4.77	5.96	-0.14	-1.35	1.08	0.0	-0.3	0.2
	0-10%	5.37	4.96	5.77	-1.13	-2.59	0.34	-0.2	-0.5	0.1
Western	50-100%	4.91	4.15	5.66	0.00	0.00	0.00	0.0	0.0	0.0
Grand	25-50%	4.91	4.15	5.66	0.00	0.00	0.00	0.0	0.0	0.0
Canyon	10-25%	4.91	4.42	5.39	-1.84	-4.85	1.18	-0.4	-1.0	0.2
	0-10%	4.91	4.57	5.24	-2.43	-4.65	-0.21	-0.5	-0.9	0.0

Source: Butterfield and Palmquist 2023b
Note: Predicted net change in suitable habitat for vegetation, calculated as the difference between cumulative habitat gains and losses, comparing the Proposed Action with the No Action Alternative scenario, with or without HFEs, across all sandbars and years (2025–2027). Suitable habitat totals under the No Action Alternative scenario in 2024 were used to calculate the relative (percentage) change values. Different trace classes represent the lowest (0 to 10 percent) to the highest (50 to 100 percent) lake level quantiles.

Lake Mead

Implementation of the Proposed Action would cause an initial decrease in the elevation of Lake Mead followed by a steady increase starting in mid-2024. By the end of 2026, the median elevation is projected to be approximately 1,055 feet, which is still within shortage conditions. Overall, more water would be preserved in Lake Mead under this alternative compared with the No Action Alternative and impacts on vegetation would be similar to those described for Lake Powell. However, these impacts would be less pronounced at Lake Mead due to differences in geomorphology and because the projected difference in the lake elevation for the Proposed Action compared with the No Action Alternative is smaller than that at Lake Powell.

Hoover Dam to the SIB

In general, impacts on vegetation within this stretch from implementation of the Proposed Action would be greater than impacts from the No Action alternative. Modeling using Reclamation's 2000 backwater mapping was conducted to determine potential changes in marshes/backwater emergent vegetation under this alternative using the methodology described in Appendixes J and K of the LCR MSCP HCP. The model showed that with an increase in flow reduction from Hoover Dam, there would be a corresponding short-term increase in impacts on backwater emergent wetland vegetation and open-water areas of backwaters and marsh lands due to the changes in flow over the 3-year period of analysis in this SEIS.

Salton Sea

According to the updated Salton Sea Accounting Model (SSAM) and projections of future IID water delivery using Reclamations CRSS model, the Proposed Action would cause a decrease in water level and a corresponding increase in exposed playa beginning in late 2025/early 2026 as compared with the No Action Alternative. An increase in exposed playa would result in an increased risk for the establishment of invasive species along with an increase in fugitive dust, which could have a detrimental effect on the productivity of adjacent vegetation. However, water levels would stabilize by 2040 and would be similar to the No Action Alternative (TetraTech 2023).

Cumulative Effects

If one of the LTEMP SEIS flow options were implemented, it would not have a measurable effect on vegetation. Generally, all other actions that could result in cumulative impacts on vegetation have been incorporated into the modeling of future system conditions and described under the affected environment in **Section 3.11.1**. Therefore, no cumulative effects on vegetation are anticipated.

Issue 2: How would changing flow characteristics affect wildlife?

Riparian habitat is common along the banks of the Colorado River, and the vegetation community in this area is most affected by changes in flow characteristics. Many wildlife species that utilize the analysis area are habitat generalists that use a combination of upland and riparian habitat (Reclamation and NPS 2016). These species are less susceptible to changes in riparian habitat availability. However, some species are obligate riparian species, relying on riparian habitat for all stages of their life cycle. These species can be sensitive to changes in habitat availability (Reclamation and NPS 2016). Species that utilize riparian habitat are discussed further below.

Numerous upland wildlife species that do not rely on riparian vegetation are found within the analysis area. Consistent with the analysis in the 2007 FEIS, no impacts of these alternatives are expected to these species (Reclamation 2007). Therefore, these species are not discussed further in this analysis.

Native and nonnative fish are sensitive to changes in flow, and flow can be a tool used to manage the species. Reduced flows may impact fish species depending on the developmental phase or life history. Furthermore, volumes of discharge and lake elevations also affect water temperatures, which can affect fish species. For example, a reduction of release volumes through the dam could reduce available lacustrine habitat while increasing riverine habitat. Impacts from reduced flows on habitat availability were evaluated on a reach-specific basis.

Summary

The impacts associated with each alternative are similar because they vary only by Lower Basin system conservation measures and Lake Powell annual releases below 7.0 maf. The No Action Alternative would result in similar impacts on terrestrial wildlife at the Lake Powell, Glen Canyon Dam to Lake Mead, and Salton Sea sections compared with the Proposed Action until 2025. From 2025 to 2026, the Proposed Action would have higher elevations, resulting in reduced impacts on terrestrial wildlife, although the differences in impacts are likely to be minor.

In the driest years, the reduced elevation of Lake Powell would slightly increase the length of the new river channels carved from deltaic deposits in both the Colorado River and San Juan River inflows, resulting in a slight increase of riverine habitat. The elevation of Lake Powell is not expected to increase enough to prevent the waterfall in the San Juan River inflow from remaining a barrier to upstream fish movement. Under the No Action Alternative, the elevation of Lake Powell could reach a high level of 3,660 feet (see **Figure 3-5**) in 2024, which would allow fish to move upstream into the San Juan River.

The major reproducing population of humpback chub was historically located in the Little Colorado River, but an extension of the greater Grand Canyon population has recently occurred between Havasu Creek and Pearce Ferry and is currently the largest reproducing population in the canyon. Reduced releases could result in less low-velocity habitat along talus shorelines and in backwaters for young fishes. In the Colorado River mainstream, backwaters are ephemeral habitats. Warmer temperatures would lead to faster growth of humpback chub and other native fishes. However, warmer temperatures are beneficial for nonnative fishes such as smallmouth bass, which could become established if additional actions are not taken. Impacts on terrestrial wildlife at Lake Mead and Hoover Dam to the SIB would be slightly higher under the No Action Alternative compared with the Proposed Action. However, the differences in impacts are likely to be minor. Water reduction from Hoover Dam to the SIB would reduce the extent and connectivity of available backwater habitat used by razorback sucker and bonytail. Survival of razorback sucker in this reach is low, and recruitment is nonexistent. The No Action Alternative and Proposed Action are not expected to substantially change those demographics. There is low survival and no recruitment of bonytail, and the No Action Alternative and Proposed Action are not expected to change those demographics.

Water elevations are predicted to be lower under the Proposed Action for the Salton Sea, exacerbating existing issues of water availability and salinity for migratory birds and terrestrial wildlife. Slight reductions in water levels and increased salinity in the Salton Sea will likely have no detrimental impact on fisheries if sufficient input of freshwater is present. Rivers that inflow into the Salton Sea include the New River, Alamo River, and Whitewater River. Tilapia is likely the only species present in Salton Sea, as they were the only species captured in the most recent surveys in 2017 (CDFW and Service 2017). Reductions in flow and increased salinity may reduce habitat for tilapia. There are previous accounts of desert pupfish in 2004 and 2007 from CDFW surveys of the Salton Sea, and it is possible but unlikely that this species is still present in the Salton Sea. If desert pupfish are present, they are likely in small numbers and it is not likely that the alternatives will be detrimental to the persistence of this species. Reduction in water and increase in salinity could potentially change habitat distribution of this species; however, this species has high tolerances of water quality changes and can move to suitable habitat where available. Mozambique tilapia are tolerant of salinities up to 65 parts per thousand (ppt, or grams/liter) (Sartella et al 2004). However, salinity in the Salton Sea is currently at approximately 75 ppt and is expected to increase to approximately 87 ppt by the year 2025 (see **Figure 3-32**). As a consequence of increased salinity, tilapia are expected to retreat to inflow areas where salinity is lower. Cellular necrosis of tilapia occurred at 95 g/L (Sartella et al 2004), and salinity may exceed that by the year 2027. Desert pupfish salinity tolerance is 68 g/L (Service 1993). Based on increased salinity, the Salton Sea will become increasingly less tolerable to even the most saline-tolerant freshwater species such as tilapia and desert pupfish.

No Action Alternative

Lake Powell

In some of the driest potential hydrologic futures (**Section 3.6.2**, **Figure 3-5**), water elevations are projected to decline in summer 2023 and continue to decline through 2026.

Reduced water elevation would alter riparian vegetation, with increased invasive vegetation colonizing newly exposed sediments (see vegetation section), thus impacting terrestrial wildlife species that utilize riparian habitat. In this portion of the analysis area, riparian habitat is a limited resource. Given the limited amount of riparian habitat available around Lake Powell, most species that utilize riparian habitat in this area are likely habitat generalists that have adapted to changing riparian habitat availability over the preceding years (Reclamation 2007). Therefore, impacts on terrestrial wildlife would be similar to those described in the 2007 FEIS (Reclamation 2007), with an increasing magnitude of effects as reservoir elevations decrease.

If reduced water availability, declining lake levels, and reduced available flows for release continue, there are likely multiple potential outcomes for aquatic species. The low lake levels have already exposed deltaic deposits and carved new channels in the Colorado River and San Juan River. Declining lake levels would likely continue to expand or increase riverine habitat, which would benefit riverine species in the inflows to Lake Powell.

Glen Canyon Dam to Lake Mead

If water elevations of Lake Powell continue to decline and hydrologic conditions do not provide sufficient moisture, less water will be available for release through Glen Canyon Dam. Riparian vegetation along this stretch would be affected as water levels dropped. Some vegetation in the current riparian zone would be expected to die, while new vegetation would colonize the lower riparian zone. The timing of this transition is unknown but may begin by 2026. During this transitional period, there could be impacts on species that utilize riparian habitat (Butterfield and Palmquist 2023c; Holm et al. 2023).

There are several species of nonnative fish (Valdez and Carothers 1998) that have been detected in the Colorado River below Glen Canyon Dam through the Grand Canyon; however, most of them are not established as self-sustaining populations. The fish community is predominantly composed of native species. The lowered lake elevation and reduction in water volumes through Glen Canyon Dam would result in increased water temperatures that would benefit native species such as humpback chub, which experience increased growth rates with warmer temperatures. However, it could also benefit nonnative fish species such as smallmouth bass, common carp, channel catfish, bullheads, green sunfish, fathead minnows, and red shiners, which could lead to increased predation and competition on native fish.

Species such as rainbow trout and brown trout prefer colder water, and the warmer water temperatures would provide less suitable conditions for both trout species. A reduction in water released through Glen Canyon Dam may increase the river's water clarity, allowing sight predators, such as rainbow trout and brown trout, to more efficiently prey on native fish (Ward et al. 2016). However, these trout species are also less efficient swimmers when water temperatures are warmer, whereas warmwater native species—such as humpback chub, razorback sucker, and flannelmouth sucker—experience improved efficiency with warmer temperatures (Valdez and Carothers 1998). With increased temperatures (above 18°C), parasites such as Asian tapeworm (*Bothriocephalus acheilognathi*) and anchorworms (*Lernaea cyprinacea*) may increase. The Asian tapeworm can block the intestine of fish and lead to death, and anchorworm can cause infections on attachment points on the body and fins.

Sandbars that form as reattachment bars associated with large, recirculating eddies form recurrent channels that are backwaters used by native fish in the Colorado River through the Grand Canyon. At certain flow ranges, these backwaters are used extensively by young humpback chub and flannelmouth suckers. These backwaters provide warm, sheltered habitats for these fish and are important habitats for improved survival and recruitment of native fish (Dodrill et al. 2014). These backwaters may be affected by different releases from Glen Canyon Dam, as low releases may desiccate these habitats and high releases may inundate them. However, backwaters are rare and ephemeral habitats, so they contain only a small portion of the overall population.

According to the USGS Smallmouth Bass Model (Eppehimer and Yackulic 2023), smallmouth bass entrainment through Glen Canyon Dam into Lees Ferry is expected to be less than 50 propagules per year across both the No Action Alternative and Proposed Action from 2024 to 2026, but greater entrainment rates (more than 100 propagules per year) are possible in 2025 and 2026. Smallmouth bass entrainment rates are expected to be similar between the No Action Alternative and Proposed Action scenarios under most, but not all, hydrologic scenarios. For example, under dry hydrologic conditions, the Proposed Action is expected to increase smallmouth bass entrainment relative to the No Action Alternative. Also, the forecasted smallmouth bass population growth rate (lambda) was similar, on average, between the No Action Alternative and Proposed Action from 2024 to 2026, whether forecasted at Lees Ferry or the confluence with the Little Colorado River.

There could be both positive and negative effects on fish populations downstream of Glen Canyon Dam when the temperature of the water released shifts from warmwater to cold water. This colder release could temporarily shock juvenile and adult rainbow trout in the Lees Ferry reach (although they are a coldwater fish) as well as eggs and fry that would be in the gravel beds at that time. Coldwater releases could inhibit spawning of smallmouth bass and other warmwater nonnatives.

Lake Mead

Given the limited amount of riparian habitat available around Lake Mead, most species that utilize riparian habitat in this area are likely habitat generalists that have adapted to changing riparian habitat availability over the preceding years (Reclamation 2007). Therefore, impacts on terrestrial wildlife would be similar to those described in the 2007 FEIS (Reclamation 2007), with an increasing magnitude of effects as water elevations decrease. In areas where new sediments are exposed, larger animals may become stuck in deep mud and die. This is currently occurring and may be exacerbated with declining lake levels under this alternative.

The No Action Alternative may improve and increase habitat for nonnative fish that prey upon native species because of lower lake levels. Additionally, reduced lake levels may reduce the amount of available habitat for forage fish that are used to support the nonnative fishery for sportfish in the lake. Like Lake Powell, Lake Mead has a large variety of nonnative fish species that are valuable as sport fish and as forage fish. Reductions in lake levels would not have as extensive an effect on shoreline spawners as in Lake Powell because the shoreline of Lake Mead is gentle and sloping with cobble shoals that extend at a variety of lake levels. Reduced lake levels will also maintain or slightly extend the length of the river channel in the Colorado River inflow that has been recently populated by a new and large population of humpback chub. Lower lake levels are not likely to affect the razorback sucker, as spawning habitat (talus/cobble shoreline) and nursery habitat (emergent vegetation) are available through a range of lake elevations.

Both Lake Mead and Lake Mohave have experienced algal blooms since the early 2000s. These blooms are the result of nutrients within the Colorado River generally derived from decaying vegetation in the largely undeveloped watershed, as well as nutrients from the Virgin River, Muddy River, and Las Vegas Wash. These nutrients arrive in the form of treated wastewater, urban runoff, and agricultural runoff. Lower lake levels affect lake nutrients as well as nutrient dynamics. These in turn affect the amounts and location of algae produced in these reservoirs. Starting in the year 2000, the wastewater treatment plants along Las Vegas Wash have enhanced their phosphorus removal, improving water quality and reducing the potential for algal blooms. Monitoring has revealed that these blooms include blue-green algae, which bloomed in large amounts in 2011–2015 and again in recent years since 2020. Blue-green algae produces a toxin called microcystin that can cause health issues in people and wildlife. The effects of these algal blooms on fish and wildlife are not well understood, and monitoring will need to be continued to better understand the relationship between reservoir elevations, algal blooms, and effects on fish populations in Lakes Mead and Mohave.

Hoover Dam to the SIB

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations at Hoover Dam. Releases from Lake Mead would remain the same as existing conditions, depleting Lake Mead but maintaining similar water elevations from Hoover Dam to the SIB. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be similar to those described in the 2007 FEIS (Reclamation 2007).

Under the No Action Alternative, flows would be lower but no substantive effects to water quality would be expected. However, lower flows may affect the connectivity and extent of backwaters. Overall, reductions in water availability would have the same impacts on native fish through reduction of habitat such as backwater and floodplains. Reduced flows and increased water temperatures may also improve suitable habitat for nonnative fish such as flathead catfish and channel catfish, thereby also increasing the potential for predation on native species.

Even in some of the driest potential hydrologic futures (**Section 3.6.2**, **Figure 3-8**), Lake Mead does not hit dead pool. Therefore, water is projected to be available to be released downstream through 2026.

Salton Sea

SALSA and SSAM predict a decline in lake levels at the Salton Sea through 2026 under the No Action Alternative, which would reduce aquatic habitat availability as well as increase salinity. Decreased aquatic habitat and increased salinity could impact terrestrial wildlife through decreases in aquatic food supply.

The Salton Sea is an important migratory stopover site for birds, and a decrease in food supply could result in impacts on large numbers of migratory waterbirds on the West Coast. An increase in exposed playa could result in an increased risk for the establishment of invasive species, thereby reducing habitat quality for terrestrial wildlife species along the shoreline.

Water elevations have been dropping at the Salton Sea, and salinity has been rising past the point of submergent vegetation tolerance for several years. While the No Action Alternative may exacerbate this problem, ongoing issues with Salton Sea water elevations and salinity are the main driver of impacts on terrestrial wildlife in this section (Imperial Irrigation District 2018a).

Based on the fisheries surveys of the Salton Sea conducted by CDFW between 2003 and 2008, most fish species were tilapia with small numbers of other species, including four desert pupfish. No desert pupfish were captured in 2017; tilapia were the only species captured. Under the No Action Alternative, a reduction in water and an increase in salinity could potentially reduce lacustrine habitat for tilapia. As desert pupfish utilize nearshore pools, this could also reduce habitat for this species; however, this species has not been recently documented in the Salton Sea. If desert pupfish are still present, it is likely this species will not be largely affected because it can move into other nearshore pools where habitat is suitable. As long as freshwater inflows do not cease, it is likely that impacts under the No Action Alternative will not be detrimental to the fish that currently occupy the Salton Sea.

Proposed Action

Lake Powell

Overall, the Proposed Action maintains similar water levels to the No Action Alternative in Lake Powell until late 2025, when the Proposed Action begins to diverge from the No Action Alternative. More water is available in Lake Powell under the Proposed Action. Therefore, the magnitude of effects would be greater under the No Action Alternative. However, impacts on vegetation are predicted to be the same between the two alternatives (**Section 3.13.2 Issue 1**). Given that the predicted elevations and vegetation models are only marginally different, no population level impacts are expected on terrestrial wildlife.

Under certain hydrologic scenarios, the Proposed Action could negatively impact the nonnative sport fish in the lake. As lake elevations change, available shoreline habitat also changes, affecting sport fish populations. When lake elevations are higher, the length of riverine habitat associated with the inflow into Lake Powell would be reduced compared with scenarios where lake elevation is reduced. The lake level fluctuates annually, however, and it is unlikely to have a significant impact on habitat to affect the species.

Glen Canyon Dam to Lake Mead

If the Proposed Action is implemented, releases from Lake Powell would be similar to the No Action Alternative through late 2025, at which point releases would be lower than the No Action Alternative to 2026, which would result in lower river flows in this section. Therefore, the magnitude of effects would be greater under the Proposed Action. However, the riparian vegetation model projects similar native plant species cover and richness under the Proposed Action compared with the No Action Alternative in all modeled areas. Nonnative plant species cover and richness is projected to be similar under the Proposed Action compared with the No Action Alternative. Compared with native species, nonnative plant species typically provide lower-quality habitat for wildlife species and can lead to monotypic habitat types that support fewer wildlife species (NatureServe 2023). Given the predicted flows and vegetation models are only marginally different, no population level impacts are expected on terrestrial wildlife.

Impacts on the invertebrate and algal communities in the Lees Ferry reach would differ depending on whether a fall (October–November) or spring (March–April) HFE was implemented. Fall HFEs can scour the benthic community at a time that is characterized by low sun angle and low photosynthetic productivity that can limit benthic recovery. Spring HFEs occur at a time of increasing photosynthetic activity that can help the benthos recovery more quickly. Because of low hydrology conditions in the Colorado River system, the likelihood of HFEs is lower.

According to the USGS Smallmouth Bass Model (Eppehimer and Yackulic 2023), smallmouth bass entrainment (that is, passage from the reservoir through the penstocks into the river) would be similar between the No Action Alternative and the Proposed Action. There are some differences in hydrologies with inflows less than about 8 maf, as 4 traces show more entrainment with the Proposed Action and 7 traces show more entrainment with the No Action Alternative. These No Action traces show relative increases less than 100 propagules, whereas the Proposed Action traces show relative increases from 100 to 300 propagules.

The Proposed Action is likely to slightly decrease the risk of entrainment of smallmouth bass compared with the No Action Alternative under most, but not all hydrologic scenarios (Eppehimer and Yackulic 2023). However, entrainment depends on specific hydrologic traces, and hydrologic traces where low inflows occur may increase entrainment even under the Proposed Action. In dry hydrologic traces, the Proposed Action would have increased entrainment and population growth compared with the No Action Alternative. Population growth is expected to be the same between the No Action Alternative and the Proposed Action in wet years.

With respect to smallmouth bass population growth, there was very little difference between the Proposed Action and No Action Alternative regardless of hydrologies. There are three traces in driest hydrologies in which the Proposed Action shows slower growth. As indicated, entrainment and population growth of the smallmouth bass population will largely depend on whether the hydrologic scenario resembles a dry, moderate, or wet hydrological trace, with the highest levels of entrainment and population growth of smallmouth bass occurring in the driest hydrologic scenarios that do not drop below power pool.

Lake Mead

Overall, the Proposed Action maintains higher water levels compared to the No Action Alternative in Lake Mead. Therefore, the magnitude of effects would be greater under the No Action Alternative. Given the limited amount of riparian habitat available around Lake Mead, most species that utilize riparian habitat in this area are likely habitat generalists that have adapted to changing riparian habitat availability over the preceding years (Reclamation 2007). Given that the predicted elevations are only marginally different, no population level impacts are expected on terrestrial wildlife. Impacts associated with wildlife becoming trapped in soft sediments would be less likely under the Proposed Action compared with the No Action Alternative, as fewer sediments would be exposed.

Reduction of lake elevation is expected to occur at a lesser rate than the No Action Alternative under the 80 percent ESP until approximately August 2025. This would likely improve and increase habitat for nonnative fish. Additionally, reduced lake levels may reduce the amount of available habitat for forage fish that are used to support the nonnative fishery for sport fish in the lake. Following August 2025, this reduction would lessen and result in increased lake elevations compared with the No Action Alternative.

The Proposed Action would help to stabilize the elevation of Lake Mead and therefore continue to provide extended riverine habitat for the humpback chub in the Colorado River inflow. This area could also provide suitable habitat for the razorback sucker. Stabilized lake elevation would also provide more stable spawning habitat for razorback sucker and a greater likelihood of emergent vegetation as cover for larvae, which could increase survival and recruitment.

Hoover Dam to the SIB

Releases from Lake Mead would be reduced to maintain higher elevations in Lake Mead, reducing water elevations from Hoover Dam to the SIB. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be greater under the Proposed Action than the No Action Alternative. Reduced flows resulting from the Proposed Action would result in lower river stage in this section, which could have impacts on emergent marsh vegetation. This may cause direct loss of vegetation through desiccation and the fragmentation or reduction in the extent of habitat patches. Therefore, the magnitude of effects would be greater under the Proposed Action (**Section 3.6.2**, **Figure 3-8**). However, given that the predicted flows are only marginally different, no population level impacts are expected on terrestrial wildlife species.

The fish community is dominated by nonnative fish, and the lower river flows in this reach under the Proposed Action would result in improved habitat for nonnative species, continued pressure on native species, and potentially more interactions between nonnative and native species. Backwater habitats that currently occur in this reach and support stocked populations of razorback sucker and bonytail will be reduced in habitat area, and possibly connectivity, under the Proposed Action as compared with the No Action Alternative. Of particular concern is reduced area of the Cibola NWR backwater that supports a self-sustaining population of bonytail, as the water elevation and water quality of this backwater is dependent on river flows.

Salton Sea

According to the updated SSAM and projections of future IID water delivery using Reclamation's CRSS model, the Proposed Action would expedite previously anticipated decreases in water level and corresponding increases in exposed playa at the Salton Sea beginning in 2024 as compared with the No Action Alternative, worsening existing issues of water availability and salinity for terrestrial wildlife (Imperial Irrigation District 2018a). However, given that the predicted flows are only marginally different, no population level impacts are expected on terrestrial wildlife species. Similarly, impacts on fisheries are also predicted to be the same between the two alternatives.

Cumulative Effects

One of the stated purposes of the Salton Sea Management Program's 10-Year Plan is to improve habitat for fish and wildlife through mitigating effects of decreasing water levels and increased salinity in recent years (California Natural Resources Agency 2021). The construction of ponds and aquatic habitat to support fish and wildlife is intended to restore habitat at appropriate salinity levels to support fish and wildlife. This will result in a positive impact on terrestrial wildlife species.

Reclamation's Upper Colorado Basin Region is preparing an SEIS to the LTEMP regarding experimental operations at the Glen Canyon Dam that will analyze flow options from Glen Canyon Dam to prevent smallmouth bass from establishing below the dam by preventing additional spawning. If one of the flow options from the LTEMP SEIS were to be implemented, this action would cumulatively impact aquatic species within the Colorado River below Glen Canyon Dam to Lake Mead due to a reduction in the temperature of water released. The intent of this potential action is to disrupt spawning of smallmouth bass by releasing cold water through the river outlets to move smallmouth bass off nests or prevent them from spawning. Smallmouth bass are adept predators with wide diet variability, and this change may impact native fish (Bestgen and Hill 2016). Changes to the timing and frequency of HFEs resulting from the potential change to sediment accounting windows was previously analyzed in LTEMP. Any cumulative effects of these changes would fall within the previously analyzed range.

Smallmouth bass entrainment rates are expected to be similar between the No Action Alternative and Proposed Action scenarios under most, but not all, hydrologic scenarios. For example, under dry hydrologic conditions, the Proposed Action alternative is expected to increase smallmouth bass entrainment relative to No Action. On average, smallmouth bass entrainment through Glen Canyon Dam into Lees Ferry is expected to be less than 50 propagules per year across both the No Action Alternative and Proposed Action from 2024 through 2026, but more extreme entrainment rates (>100 propagules per year) are possible in 2025 and 2026. Forecasted smallmouth bass population growth rate was similar, on average, between the No Action Alternative and Proposed Action from 2024 through 2026, whether forecasted at Lees Ferry or at the confluence with the Little Colorado

River. In a typical year, 11–17 percent of the hydrologic traces predict population growth in Lees Ferry with the majority of those traces predicting high growth rates. Forecasted population growth rates at the Colorado River's confluence with the Little Colorado River are higher than those at Lees Ferry due to downriver warming. Under most hydrologic traces, there was very little relative difference in smallmouth bass population growth between the No Action and Proposed Action scenarios (Eppehimer and Yackulic 2023).

Issue 3: How would changing flow characteristics affect special status species?

Numerous upland special status species are found within the analysis area that neither rely on riparian vegetation nor grow in riparian habitat. Consistent with the finding of the 2007 FEIS analysis, no impacts of the alternatives analyzed in this SEIS are expected on these species (Reclamation 2007). A complete list of all special status species from **Table 3-29** and **Table 3-30** not analyzed in detail, and their habitat needs, is included in **Appendix G**.

The analysis below provides a table of those species evaluated for impacts within each section (Lake Powell, Glen Canyon Dam to Lake Mead, Lake Mead, Hoover Dam to the SIB, and the Salton Sea). The following analysis addresses only those species found in each section with habitat that could be affected by proposed operations within the analysis time frame through December 2026.

Summary

The types of impacts associated with each alternative are similar, as described above, as alternatives only vary by Lower Basin system conservation measures and Lake Powell annual releases below 7.0 maf. The No Action Alternative would result in similar impacts on special status species at Lake Powell and the Glen Canyon Dam to Lake Mead section compared with the Proposed Action until 2025. From 2025 to 2026, the Proposed Action would result in slightly higher water elevations at Lake Powell, resulting in reduced impacts on special status terrestrial wildlife, although the differences in impacts are likely to be minor.

Impacts on special status terrestrial wildlife at the Hoover Dam to the SIB would be slightly higher under the Proposed Action compared to the No Action Alternative; this is because water flows would be reduced to these sections to maintain higher water elevations in Lake Powell and Lake Mead.

Under the Proposed Action, the elevations of Lake Powell and Lake Mead would be expected to remain relatively stable (relative to the steady declines of the No Action Alternative). Under the driest hydrologic conditions, releases from Glen Canyon Dam under the Proposed Action would remain more consistent (steady declines) than under the No Action Alternative (with a large drop off in 2026), providing more stable habitats for the early life stages of humpback chub and other native fishes in the Colorado River. However, under slightly wetter hydrologies, releases from Glen Canyon could potentially decrease under the Proposed Action by up to 1.000 maf compared with the No Action Alternative. Such reductions under the Proposed Action would thus result in more reductions in habitat for native and listed fish species than the No Action Alternative.

The Proposed Action would have greater impacts than the No Action Alternative in the driest of potential hydrologic futures. Over the period of analysis, both alternatives would result in increased entrainment of smallmouth bass through Glen Canyon Dam, increased smallmouth bass population growth, and potentially more interactions between native and nonnative fish resulting in increased predation. Technically there is a window of no entrainment for the No Action Alternative when releases are switched to the bypass valves where cold water would be released, and entrainment would stop. Under the Proposed Action, where lake elevations are high enough to negate the use of bypass valves, releases would switch to the penstocks through which entrainment could occur.

The No Action Alternative would result in greater impacts to fish compared with the Proposed Action for the driest hydrologic traces. Declining reservoir elevations in Lake Powell and Lake Mead have exposed deltaic sediments through which the Colorado River has carved a new channel. In Lake Powell, new channels—each about 30 miles long—have formed in the Colorado River and the San Juan River inflow. Razorback sucker and a few Colorado pikeminnow have been detected in these inflow areas. In Lake Mead, a new river channel of about 40 miles in length has been carved from Separation Canyon to Pearce Ferry, enabling the expansion of the population of humpback chub. Under the No Action Alternative, lake elevations would continue to decline; these riverine channels would continue to expand, which would potentially create more habitat. Under the Proposed Action, reservoir elevations would remain relatively stable and habitat would also remain stable.

No Action Alternative

Lake Powell

In some of the driest potential hydrologic futures (**Section 3.6.2**, **Figure 3-5**), Lake Powell elevations are projected to decline starting in summer 2023 and continue to decline through 2026.

Bald eagles and American white pelicans are the only special status species that utilize open-water habitat for foraging that have the potential to be affected (**Table 3-29**, also see **Appendix G**). Open-water habitat is expected to decline in Lake Powell during the analysis period. This could reduce foraging opportunities for these species. However, as a scavenger species, bald eagles, as well as golden eagles and California condors, may experience short-term benefits, as some carrion may become available during low water periods.

Bats often forage for insects over open water and riparian vegetation. Many insects use wet areas and riparian vegetation for breeding. Reduced water levels and velocity often benefit insect species. Increased habitat for insects could expand their populations, thereby increasing foraging opportunities for bats. Lower water levels could also increase invertebrate biodiversity and have subsequent effects on bat species. Therefore, the No Action Alternative may benefit bat species.

Table 3-29
Special Status Species with Records at Lake Powell and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Colorado pikeminnow	*Ptychocheilus lucius*	Endangered	Habitat expansion due to declining lake levels as result of increased riverine habitat
Razorback sucker	*Xyrauchen texanus*	Endangered	Habitat expansion due to declining lake levels as result of increased riverine habitat
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	Habitat expansion due to declining lake levels as result of increased riverine habitat
Bluehead sucker	*Catostomus discobolus*	BLM AZ BLM UT	Habitat expansion due to declining lake levels as result of increased riverine habitat
American white pelican	*Pelecanus erythrorhynchos*	BLM UT	Changes to open-water habitat availability, impacting foraging habitat
Bald eagle	*Haliaeetus leucocephalus*	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
California condor	*Gymnogyps californianus*	BLM AZ	Changes to water levels potentially increasing scavenging opportunities
Golden eagle	*Aquila chrysaetos*	BLM UT BLM AZ	Changes to water levels potentially increasing scavenging opportunities
Allen's big-eared bat	*Idionycteris* (=*Plecotus*) *phyllotis*	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	*Eptesicus fuscus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	*Myotis californicus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Canyon bat	*Parastrellus hesperus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Fringed myotis	*Myotis thysanodes*	BLM UT BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat

For species utilizing riparian areas along the waterline of Lake Powell, as water levels drop, the distance from the water's edge to existing riparian habitat would increase, potentially desiccating existing vegetation and reducing habitat quality until riparian vegetation grows along the newly established waterline. Newly exposed bank would likely be colonized by plant species that can establish quickly, which often include invasive species such as tamarisk (see the vegetation section). These fast-establishing plants provide cover for species utilizing these habitats, reducing potential impacts of declining water levels.

Glen Canyon Dam to Lake Mead

For the duration of the action, impacts on special status species would be similar to those described in the 2007 FEIS (Reclamation 2007) except for special status fish, as discussed below. The following discussion for non-fish species pertains to 2026, when flows could decrease depending on hydrology over the next couple of years and habitat declines would be expected to occur if water elevations continue to decrease.

Table 3-30
Special Status Species with Records between Glen Canyon Dam and Lake Mead and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Razorback sucker	*Xyrauchen texanus*	Endangered	• Potential exists for reduced low velocity backwaters, although these are rare, ephemeral habitats. • If smallmouth bass increase or become established, there could be increased competition and predation, which would be negative for razorback sucker. • Increased temperatures and decreased range in flow fluctuations are expected to have a positive impact on food base production and diversity.

Common Name	Scientific Name	Status	Potential Impacts
Humpback chub	*Gila cypha*	Threatened	• Potential exists for reduced low velocity backwaters, although these are rare ephemeral habitats, but most important habitat is in the Little Colorado River, which would not be affected by the action. • Humpback chub grow faster with warmer temperatures, which allows them to evade predation. • Warmer temperatures are beneficial for nonnative fish such as smallmouth bass, which if they increase or become established, could be negative for humpback chub. • Reduced turbidity could lead to increased predation by nonnative fish.
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	• Warmer temperatures are beneficial for nonnative fish such as smallmouth bass, which if they increase or become established, could be negative for flannelmouth sucker. • Warmer temperatures are beneficial for flannelmouth sucker spawning and growth.
Bluehead sucker	*Catostomus discobolus*	BLM AZ BLM UT	• Warmer temperatures are beneficial for nonnative fish such as smallmouth bass, which if they increase or become established, could be negative for bluehead sucker. • Warmer temperatures are beneficial for bluehead sucker spawning and growth.
California black rail	*Laterallus jamaicensis coturniculus*	BLM AZ BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Yuma Ridgway's rail	*Rallus obsoletus yumanensis*	Endangered BLM AZ BLM CA BLM NV	Neither this species nor its habitat occurs in the area where the proposed action would have any affect.
Allen's lappet-browed bat	*Idionycteris phyllotis*	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Arizona myotis	*Myotis occultus*	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Big brown bat	*Eptesicus fuscus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	*Macrotus californicus*	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
California myotis	*Myotis californicus*	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Canyon bat	*Parastrellus Hesperus*	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Greater western bonneted bat	*Eumops perotis*	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Spotted bat	*Euderma maculatum*	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Western mastiff bat	*Eumops perotis*	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Monarch butterfly	*Danaus plexippus plexippus*	BLM NV ESA Candidate	Changes to riparian habitat availability, impacting breeding and foraging habitat

Species that use riparian habitat and shallow water along the banks, such as the California black rail, could be affected through changes in habitat availability. As water levels drop, the distance from the water's edge to existing riparian habitat would increase, potentially desiccating existing vegetation and reducing habitat quality until riparian vegetation grows along the newly established waterline. Newly exposed bank would likely be colonized by plant species that can establish quickly, which often include invasive species such as tamarisk (see the vegetation section). These fast-establishing plants would provide cover for species utilizing these habitats, reducing potential impacts of declining water levels.

Bats often forage for insects over open water and riparian vegetation. Many insects use wet areas and riparian vegetation for breeding. Reduced water levels and velocity often benefit insect species. Increased habitat for insects could expand their populations, thereby increasing foraging opportunities for bats. Lower water levels could also increase invertebrate biodiversity and have subsequent effects on bat species. Therefore, the No Action Alternative may benefit bat species.

Monarch butterflies utilize meadows and areas with nectar-producing flowers as foraging habitat. They rely on milkweed (*Asclepias* spp.) for egg laying. This habitat type is found throughout the United States, Canada, and Mexico, and some milkweeds are riparian species (NatureServe 2023). It is unlikely that high-quality foraging habitat for this species would be affected by changes in flows, but some milkweeds are likely present in riparian and backwater areas. A reduction in flows may cause water stress to milkweeds and other flowering plants. Therefore, the No Action Alternative may impact individuals.

Adult humpback chub use deep water recirculating eddies that are not affected by flow changes; however, age-0 individuals and juveniles use shoreline talus habitats that could be negatively affected by reduced flows, depending on the amount of water released. Although the core reproducing population of humpback chub is still in the Little Colorado River, a more recent aggregation in the western Grand Canyon has become established from Havasu Creek downstream to Pearce Ferry. This is likely due to the warmer water temperatures over the last 10 years and the formation of Pearce Ferry Rapid as a partial barrier to upstream movement of nonnative predators. Surveys from 2022 estimated the abundance of humpback chub in the western Grand Canyon as 40,000–60,000 between Havasu Rapid and Pearce Ferry (USGS 2023e). Because there are so few razorback suckers in the Grand Canyon, they are unlikely to be affected by reduced flows. However, if the flows were to result in a change to Pearce Ferry Rapid, nonnative fish could move into the Grand Canyon. A change in the hydrology and/or geomorphology of the Pearce Ferry Rapid could also lead to an increase of razorback sucker in Grand Canyon by allowing movement from Lake Mead.

Low reservoir elevation of Lake Powell and warm downstream releases increase the risk of warmwater predatory fish entering the Colorado River through the Grand Canyon. Green sunfish and smallmouth bass are found in the forebay, based on ongoing studies by Utah State University, and some are passing through the penstocks and being found in the slough below Glen Canyon Dam and other locations. These invasive species pose a predatory threat to the native fishes, including the largest population of humpback chub.

The interaction of flow, water temperature, and turbidity are likely to impact nonnative fish as well. Reduced flows and warming water temperatures are likely to provide more suitable conditions for spawning, egg incubation, and survival of young of warmwater nonnative species. Many of these species (e.g., channel catfish, bullheads, green sunfish, smallmouth bass, and largemouth bass) prey on and compete with native fish..

Cobble bars at tributary inflows like Spencer Creek may be used for spawning and would be desiccated by reduced flows. Warmer water temperatures may provide more suitable conditions for spawning and survival of young nonnative fish that are predators of native fish species.

Under the No Action Alternative, the GTMax model shows the elevation of Lake Powell would decline to minimum power pool (3,490 feet) from January through April 2024, which would require water to be released through the river outlets. Release temperatures through Glen Canyon Dam are projected to be as high as 20°C for certain hydrologic scenarios, and switching to releasing water through the river outlets would mean much colder release temperatures of 10–12°C. This cold-release regime would be similar to releases prior to 2004, when the reservoir was above 3,600 feet (Valdez et al. 2015). There could be an effect, however, on fish populations downstream of Glen Canyon Dam if water temperature releases rapidly shift from warm water to cold water. This colder release could temperature shock juvenile and adult rainbow trout in the Lees Ferry reach, as well as eggs and fry if they were in the gravel beds at the time the initial switch to cold water occurred, but they would be expected to recover. The water would warm longitudinally downstream, and the impact would be minimal on juvenile and adult humpback chub, razorback sucker, flannelmouth sucker, and bluehead sucker. However, sudden colder releases could temperature shock eggs, larvae, and age-0 members of these species depending on the timing of the switch to cold water through the river outlets.

Under the No Action Alternative, the likelihood that Lake Powell elevation would decrease below minimum power pool would increase. While daytime flows would not drop below the threshold of 8,000 cfs, they would likely be static, with less variation in river flows annually, seasonally, and daily. In Glen Canyon, rainbow trout would likely benefit from colder water released through the river outlets. The minimum, maximum, and optimal temperatures for growth of rainbow trout are 12, 21, and 16°C, respectively (Valdez et al 2015). Lethal temperature for rainbow trout is approximately 29°C (Chen et al. 2015), and modeling does not project water temperatures reaching or exceeding rainbow trout lethal temperatures in any month.

Lake Mead

Bald eagles are the only special status species that utilize open-water habitat for foraging that have the potential to be affected by project operations (**Table 3-31**, see also **Appendix G**). Open-water habitat is expected to decline in Lake Mead during the analysis period. This could reduce foraging opportunities for this species. However, as a scavenger species, bald eagles may experience short-term benefits, as some carrion may become available during low water periods.

Table 3-31
Special Status Species with Records at Lake Mead and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Razorback sucker	*Xyrauchen texanus*	Endangered	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Humpback chub	*Gila cypha*	Threatened	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Bluehead sucker	*Catostomus discobolus*	BLM AZ BLM UT	Changes to water levels, impacting spawning and rearing habitat and increased predation on young
Bald eagle	*Haliaeetus leucocephalus*	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat

Common Name	Scientific Name	Status	Potential Impacts
Yuma Ridgway's rail	*Rallus obsoletus yumanensis*	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Allen's big-eared bat	*Idionycteris (=Plecotus) phyllotis*	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Arizona myotis	*Myotis occultus*	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	*Eptesicus fuscus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Big free-tailed bat	*Nyctinomops macrotis*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	*Macrotus californicus*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	*Myotis californicus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Canyon bat	*Parastrellus hesperus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	Changes to riparian habitat availability and prey diversity, impacting foraging habitat
Desert bighorn sheep	*Ovis canadensis nelsoni*	BLM CA	Exposed soft sediments trapping individuals and causing mortality
Fringed myotis	*Myotis thysanodes*	BLM UT BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Hoary bat	*Lasiurus cinereus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Pallid bat	*Antrozous pallidus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western mastiff bat	*Eumops perotis*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Western red bat	*Lasiurus blossevillii*	BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western small-footed myotis	*Myotis ciliolabrum*	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Lowland leopard frog	*Rana yavapaiensis*	BLM AZ BLM CA	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Gold butte moss	*Ceratodon purpureus*	BLM NV	Changes to hydrology, impacting suitable habitat
Mojave poppy bee	*Perdita meconis*	BLM NV	Changes to hydrology, impacting suitable habitat
Monarch butterfly	*Danaus plexippus plexippus*	BLM NV ESA Candidate	Changes to riparian habitat availability, impacting breeding and foraging habitat
Mokiak milkvetch	*Astragalus mokiacensis*	BLM NV	Changes to hydrology, impacting suitable habitat
Sticky buckwheat	*Eriogonum viscidulum*	BLM AZ BLM NV	Changes to hydrology, impacting suitable habitat

Species that utilize riparian habitat and shallow water along the banks, such as Yuma Ridgway's rail or lowland leopard frog, could be affected through changes in habitat availability (see vegetation section). Impacts on riparian habitats used by these species would be similar to those described above in the Lake Powell section. Impacts on bat species would be similar to those described in the Glen Canyon Dam to Lake Mead section.

Southwestern willow flycatchers rely on dense riparian vegetation and large cottonwood trees for nesting and foraging habitat (NatureServe 2023). These habitats would take longer to reestablish along the new shoreline, potentially impacting southwestern willow flycatchers. This species would likely adjust its distribution to the unaffected tributaries that support riparian vegetation until new riparian vegetation reestablished along Lake Mead. The No Action Alternative may impact individuals, as described in the 2007 FEIS (Reclamation 2007), but it would not likely lead to population declines of southwestern willow flycatchers.

Impacts on bats would be similar to those described in the Lake Powell section of the No Action Alternative. In areas where new sediments are exposed, larger animals may become stuck in deep mud and die. This is currently occurring and may be exacerbated with declining lake levels under this alternative.

Special status plant species that grow in riparian habitat or in wet soils could be affected through changes in water availability. Some plant species have deep roots and can tolerate changes in water levels, while others are sensitive to change. Species that can tolerate drought periods and lower water levels may experience an increase in habitat availability as water levels recede, while species sensitive to these changes would likely experience a decrease in habitat availability.

Declining lake elevations would increase riverine habitat for humpback chub, razorback sucker, flannelmouth sucker, and bluehead sucker in the Colorado River inflow. While this may be a benefit for overall riverine habitat, declining elevation would also reduce shoreline spawning habitat for razorback sucker and nursery habitat for larvae in embayments and vegetated shorelines. Reduced lake elevation in spring would bring the lake below levels of emergent vegetation that are used by the larvae and age-0 fish for shelter and feeding. This would reduce survival and recruitment for the species.

Hoover Dam to the SIB

Under the No Action Alternative, the 2007 Interim Guidelines and subsequent agreements would continue to guide operations at Hoover Dam. Releases from Lake Mead would remain the same as existing conditions, depleting Lake Mead but maintaining similar water elevations from Lake Mead to SIB. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be similar to those described in the 2007 FEIS (Reclamation 2007).

Even in some of the driest potential hydrologic futures (**Section 3.6.2**, **Figure 3-8**), Lake Mead does not hit dead pool. Therefore, water is projected to be available to be released downstream through 2026.

Bald eagles are the only special status species that utilize open-water habitat for foraging that have the potential to be affected by project operations (**Table 3-32**, see also **Appendix G**). Open-water habitat is expected to decline in the Hoover Dam to SIB section during the analysis period. This could reduce foraging opportunities for this species. However, as a scavenger species, bald eagles, as well as golden eagles, may experience short-term benefits, as some carrion may become available during low water periods.

Table 3-32
Special Status Species with Records between Hoover Dam and the SIB and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Razorback sucker	*Xyrauchen texanus*	Endangered	Changes to water levels, impacting spawning and nursery habitat
Bonytail chub	*Gila elegans*	Threatened	Changes to water levels, impacting spawning and nursery habitat
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	Changes to water levels, impacting spawning and nursery habitat
Desert pupfish	*Cyprinodon macularius*	Endangered	Changes to water levels, impacting spawning and nursery habitat
Arizona bell's vireo	*Vireo bellii arizonae*	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Bald eagle	*Haliaeetus leucocephalus*	BLM AZ BLM NV BLM UT	Changes to water levels, impacting foraging habitat
California black rail	*Laterallus jamaicensis coturniculus*	BLM AZ BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Crissal thrasher	*Toxostoma crissale*	BLM CA	Changes to water levels, impacting foraging and nesting habitat

Common Name	Scientific Name	Status	Potential Impacts
Gila woodpecker	*Melanerpes uropygialis*	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Gilded flicker	*Colaptes chrysoides*	BLM AZ BLM CA	Changes to water levels, impacting foraging and nesting habitat
Golden eagle	*Aquila chrysaetos*	BLM UT BLM AZ	Changes to water levels, potentially increasing scavenging opportunities
Lucy's warbler	*Leiothlypis luciae*	BLM CA	Changes to water levels, impacting foraging and nesting habitat
Mountain plover	*Charadrius montanus*	BLM CA	Changes to water levels, impacting foraging habitat
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
Tricolored blackbird	*Agelaius tricolor*	BLM CA	Changes to riparian habitat availability, impacting foraging and nesting habitat
Western yellow-billed cuckoo	*Coccyzus americanus*	Threatened BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging and nesting habitat
White-tailed kite	*Elanus leucurus*	BLM CA	Changes to riparian habitat availability, impacting foraging habitat
Yuma Ridgway's rail	*Rallus obsoletus yumanensis*	Endangered BLM AZ BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Arizona myotis	*Myotis occultus*		Changes to riparian habitat availability, impacting foraging habitat
Big brown bat	*Eptesicus fuscus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California leaf-nosed bat	*Macrotus californicus*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
California myotis	*Myotis californicus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Long-eared myotis	*Myotis evotis*	BLM CA	Changes to riparian habitat availability, impacting foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	Changes to riparian habitat availability, impacting foraging habitat
Pallid bat	*Antrozous pallidus*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Spotted bat	*Euderma maculatum*	BLM AZ BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM AZ BLM CA BLM NV BLM UT	Changes to riparian habitat availability, impacting foraging habitat
Western mastiff bat	*Eumops perotis*	BLM AZ BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Western small-footed myotis	*Myotis ciliolabrum*	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	Changes to riparian habitat availability, impacting foraging habitat
Arizona toad	*Anaxyrus microscaphus*	BLM UT BLM NV	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Couch's spadefoot	*Scaphiopus couchii*	BLM CA	Changes to riparian habitat availability, impacting foraging and breeding habitat
Lowland leopard frog	*Rana yavapaiensis*	BLM AZ BLM CA	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Northern Mexican garter snake	*Thamnophis eques megalops*	Threatened	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Relict leopard frog	*Rana onca*	BLM AZ BLM NV	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat

Common Name	Scientific Name	Status	Potential Impacts
Monarch butterfly	*Danaus plexippus plexippus*	BLM NV ESA Candidate	Changes to riparian habitat availability and water levels, impacting breeding and foraging habitat
Mojave tarplant	*Deinandra mohavensis*	BLM CA	Changes to hydrology, impacting suitable habitat
Parish's meadowfern	*Limnanthes alba* ssp. *parishii*	BLM CA	Changes to hydrology, impacting suitable habitat
Variegated dudleya	*Dudleya variegata*	BLM CA	Changes to hydrology, impacting suitable habitat

Impacts on monarch butterflies would be similar to those described in the Glen Canyon to Lake Mead section.

Species that utilize riparian vegetation, such as many of the birds and amphibians listed in **Table 3-32**, could benefit initially as new sediments are exposed and riparian habitat grows into areas that were previously inundated. However, beyond the 2026 analysis window, long-term impacts would likely be detrimental, given the level of water reductions expected in this reach.

Northern Mexican garter snakes have been detected at Havasu NWR and the Bill Williams NWR. This species was previously considered extirpated from these areas. This species relies on wetland and aquatic habitat for foraging on small fish and amphibians (Northern Arizona University 2023). Reduced water elevations could impact riparian habitat and wetlands used by Northern Mexican garter snakes.

Impacts on bat species would be similar to those described in the Lake Powell section. Impacts on special status plant species would be similar to those described in the Lake Mead section.

Overall, reductions in water availability would have the same impacts on native fish through reduction of habitat such as backwater and floodplains for larval razorback sucker, bonytail chub, and flannelmouth sucker.

Salton Sea

According to the updated SSAM and projections of future IID water delivery using Reclamation's CRSS model, the No Action Alternative would exacerbate a decrease in water level and a corresponding increase in exposed playa beginning in late 2025/early 2026, thereby exacerbating existing issues of water availability and salinity for special status species. As shortages increase over time, riparian vegetation along the banks of the Salton Sea is likely to become exposed and thus more likely to be colonized by invasive species (see vegetation section). Decreasing water levels would also increase salinity, potentially leading to reductions in aquatic prey availability for wildlife that utilize the Salton Sea as foraging and migration habitat.

Table 3-33
Special Status Species with Records at the Salton Sea and Potential Habitat Impacts

Common Name	Scientific Name	Status	Potential Impacts
Desert pupfish	*Cypinodon macularius*	Endangered	Changes in water volume, impacting habitat availability of nearshore pools
Yuma Ridgway's rail	*Rallus obsoletus yumanensis*	Endangered BLM AZ BLM CA BLM NV	Changes to riparian and wetland habitat, impacting foraging and nesting habitat
American white pelican	*Pelecanus erythrorhynchos*	BLM UT	Changes to open-water habitat availability and salinity, impacting foraging habitat
California black rail	*Laterallus jamaicensis coturniculus*	BLM AZ BLM CA	Changes to riparian habitat, impacting foraging and nesting habitat
California brown pelican	*Pelecanus occidentalis californicus*	BLM CA	Changes to open-water habitat availability and salinity, impacting foraging habitat
Crissal thrasher	*Toxostoma crissale*	BLM CA	Changes to riparian habitat, impacting foraging and nesting habitat
Mountain plover	*Charadrius montanus*	BLM CA	Changes to riparian and open-water habitat availability and salinity, impacting foraging and nesting habitat
White-tailed kite	*Elanus leucurus*	BLM CA	Changes to riparian and open-water habitat availability and salinity, impacting foraging and nesting habitat

American white pelicans and California brown pelicans utilize open-water habitat for foraging. Open-water habitat is expected to decline in the Salton Sea under the No Action Alternative during the analysis period, which would result in increased salinity. This could reduce foraging opportunities for these species, which rely on the Salton Sea as an important migration stopover site.

Species that use riparian habitat, such as the Crissal thrasher, mountain plover, and white-tailed kite, and those that use shallow water along the banks, such as the California black rail and Yuma Ridgway's rail, could be affected through changes in habitat availability (see the vegetation section). As water levels drop, the distance from the water's edge to existing riparian habitat would increase, potentially desiccating existing vegetation and reducing habitat quality until riparian vegetation grows along the newly established waterline. Newly exposed bank would likely be colonized by plant species that can establish quickly, which often include invasive species such as tamarisk (see the vegetation section). These fast-establishing plants provide cover for species utilizing these habitats, reducing potential impacts of declining water levels.

Proposed Action

Lake Powell

Overall, the Proposed Action would maintain water levels similar to those of the No Action Alternative in Lake Powell until late 2025, when the Proposed Action would begin to diverge from the No Action Alternative. More water would be available in Lake Powell under the Proposed Action. Therefore, the magnitude of effects is greater under the No Action Alternative. However, impacts on vegetation are predicted to be the same between the two alternatives (**Section 3.13.2 Issue 1**). Given that the predicted elevations and vegetation models are only marginally different, no population level impacts are expected on special status species of terrestrial wildlife.

Under the Proposed Action, the elevation of Lake Powell would not be allowed to drop below the minimum power pool elevation of 3,500 feet, although the driest hydrologic traces show that it may drop below this level. Lake Powell releases can be reduced to as low as 6.0 maf to maintain this elevation. This alternative would maintain extended fish habitat in the Colorado River and San Juan River inflows. If the elevation of the lake rises in 2026, some of the newly created river habitat would be reduced, but the species in the inflows have adapted to these changes. About 30 miles of inflow riverine habitat has been created by lowered lake elevations in the Colorado River inflow and the San Juan River inflow, but the amount that would be inundated by an increasing lake elevation is not likely to be significant.

Glen Canyon Dam to Lake Mead

Water elevation at Lake Powell would be similar to the No Action Alternative through late 2025 and then higher than the No Action Alternative to 2026, which would result in lower river flows in this section. Therefore, the magnitude of effects would be greater under the Proposed Action. However, the riparian vegetation model projects similar native plant species cover and richness under the Proposed Action compared with the No Action Alternative in all modeled areas. Nonnative plant species cover and richness is projected to be similar under the Proposed Action compared with the No Action Alternative. Nonnative plant species typically provide lower-quality habitat than native species for wildlife species and can lead to monotypic habitat types that support fewer wildlife species (NatureServe 2023). Given that the predicted flows and vegetation models are only marginally different, no population level impacts are expected on special status terrestrial wildlife.

Under the Proposed Action, operations would be adjusted to maintain an elevation above 3,500 feet. Lake Powell releases can be reduced to as low as 6.0 maf to maintain this elevation. This would allow water to continue to be released through Glen Canyon Dam, although at a reduced level in some years. In years when reduced water was released, reduced shoreline habitat and backwaters would be available for use by age-0, juvenile, and subadult humpback chub (although the major reproducing population of humpback chub is in the Little Colorado River, which would be unaffected by the reduced flows). If a nonnative fish, such as smallmouth bass, were to increase and become established, there would likely be an increase in predation on native species.

With the Proposed Action there would be a greater chance of staying above power pool and having more variability annually, seasonally, and daily in river flows. This would mean there may be some individual years of low flow, but those may be followed by higher annual flow years. In Glen Canyon, there may be warmer or cooler years and years with low dissolved oxygen followed by years with no dissolved oxygen concerns. There would be increased chances of warmwater nonnative fishes increasing in numbers and preying on rainbow trout during these low flow releases.

Lake Mead

Overall, the Proposed Action would maintain higher water levels than those of the No Action Alternative in Lake Mead. Given the limited amount of riparian habitat available around Lake Mead, most species that utilize riparian habitat in this area are likely habitat generalists that have adapted to changing riparian habitat availability over the preceding years (Reclamation 2007). Therefore, the magnitude of effects would be greater under the No Action Alternative. Given that the predicted elevations are only marginally different, no population level impacts are expected on special status terrestrial wildlife.

Hoover Dam to the SIB

Releases from Lake Mead would be reduced to maintain higher elevations in Lake Mead, reducing water elevations from Hoover Dam to the SIB. Impacts on riparian vegetation and terrestrial wildlife species would, therefore, be greater under the Proposed Action than the No Action Alternative. Reduced flows resulting from the Proposed Action would result in a lower river stage in this section that could have impacts on emergent marsh vegetation. This may cause direct loss of vegetation through desiccation and the fragmentation or reduction in the extent of habitat patches. Therefore, the magnitude of effects would be greater under the Proposed Action (**Section 3.6.2**, **Figure 3-8**). However, given that the predicted flows are only marginally different, no population level impacts are expected on special status terrestrial wildlife species.

Loss of fish habitat would be proportional to loss of backwater areas described by Reclamation in the backwater model. Razorback sucker and bonytail that are stocked in these backwaters would have less habitat when total volume of water is reduced. Under the Proposed Action, flows would be lower but there would be no substantive effects expected to water quality. However, lower flows may affect connectivity and extent of backwaters.

Salton Sea

According to the updated SSAM and projections of future IID water delivery using Reclamation's CRSS model, the Proposed Action would expedite previously anticipated decreases in water level and corresponding increases in exposed playa at the Salton Sea beginning in 2024, worsening existing issues of water availability and salinity for special status species as compared with the No Action Alternative. Desert pupfish were not captured in 2017, and it is not expected that they are present in the Salton Sea. However, impacts on this species (if it is present) would be similar to those of the No Action Alternative, since there is no substantial difference in changes to water when comparing the two alternatives. No impacts beyond those described in the No Action Alternative are expected for special status species.

Cumulative Effects

One of the stated purposes of the Salton Sea Management Program's 10-Year Plan is to improve habitat for fish and wildlife through mitigating effects of decreasing water levels and increased salinity in recent years (California Natural Resources Agency 2021). The construction of ponds and aquatic habitat is intended to restore habitat at appropriate salinity levels to support fish and wildlife.

This will result in a positive impact on special status terrestrial wildlife species, including Yuma Ridgway's rail.

Reclamation's Upper Colorado Basin Region is preparing an SEIS to the LTEMP regarding experimental operations at the Glen Canyon Dam that will analyze flow options from Glen Canyon Dam to prevent smallmouth bass from establishing below the dam by preventing additional spawning. If one of the flow options that is being evaluated through the LTEMP SEIS were to be implemented, this action would cumulatively impact aquatic species within the Colorado River below Glen Canyon Dam to Lake Mead by reducing the temperatures of water released. The intent of this cumulative action is to prevent spawning of smallmouth bass. If Lake Powell were to decrease to minimum power pool elevation of 3,490 feet, water would be released through the river outlets out of necessity, nullifying this cumulative action. Implementation of one of the LTEMPS SEIS flow options would not result in changes to the annual volumes of reservoir releases from Glen Canyon Dam (Lake Powell) or Hoover Dam (Lake Mead).

Smallmouth bass entrainment rates are expected to be similar between the No Action and Proposed Action scenarios under most, but not all, hydrologic scenarios. For example, under dry hydrologic conditions, the action alternative is expected to increase smallmouth bass entrainment relative to No Action. On average, smallmouth bass entrainment through Glen Canyon Dam into Lees Ferry is expected to be less than 50 propagules per year across both the No Action Alternative and Proposed Action from 2024 through 2026, but more extreme entrainment rates (>100 propagules per year) are possible in 2025 and 2026. Forecasted smallmouth bass population growth rate was similar, on average, between the No Action Alternative and Proposed Action from 2024 through 2026, whether forecasted at Lees Ferry or the confluence with the Little Colorado River. In a typical year, 11–17 percent of the hydrologic traces predict population growth in Lees Ferry, with the majority of those traces predicting high growth rates. Forecasted population growth rates at the Colorado River's confluence with the Little Colorado River are higher than those at Lees Ferry due to downriver warming. Under most hydrologic traces, there was very little relative difference in smallmouth bass population growth between the No Action and Proposed Action scenarios (Eppehimer and Yackulic 2023).

3.14 Recreation

3.14.1 Affected Environment

This SEIS builds on the 2007 FEIS, which identifies and describes in detail the following key recreation resources or issues:

- Shoreline public use
- Reservoir boating
- River and whitewater boating
- Sport fishing

This section provides updated information, data, and conditions for these resources since the publication of the 2007 FEIS.

Shoreline Public Use

The following sections describe shoreline public use associated with boating facilities (marinas, boat docks, and boat launch ramps), access to points of interest, and other opportunities within each Colorado River reach. Recreational boating in the study area depends on these major shoreline access points. While fluctuation in pool elevations is a normal aspect of reservoir operations, changes in pool elevations or increased variations or rates in pool elevation fluctuation could result in changes in operation costs and temporary closures. Below critical pool elevations and river flows, certain facilities may be rendered inoperable or may require relocation to maintain their operation. (Additional information on recreational boating and boating facilities can be found in the 2007 FEIS Section 3.12.1; the information is incorporated by reference.)

Lake Powell and Glen Canyon Dam

Lake Powell is entirely within the GCNRA, which receives approximately three to four million visitors each year (NPS 2023f). **Table 3-34** summarizes visitation to GCNRA for the most recent 6 years.

Table 3-34
Glen Canyon National Recreation Area Recreational Visitors

Year	Recreational Visitors
2017	4,574,940
2018	4,219,441
2019	4,330,563
2020	2,553,392
2021	3,144,318
2022	2,842,776

Source: NPS 2023f

Table 3-35 summarizes the total number of visits to GCNRA by visitor segment for 2022, the most recent year for which data are available.

Table 3-35
Glen Canyon National Recreation Area Visits by Visitor Segment for 2022

Recreation Visitors	Non-Recreation Visitors*	Concession Lodging	Tent Campers	RV Campers	Concession Camping	Backcountry Camping	Misc. Campers	Total Overnight Stays
2,842,776	23,322	23,636	9,647	10,799	2,286	2,308	518,772	567,449

Source: NPS 2023g

*The NPS defines reportable non-recreation visits to include:

- Persons going to and from inholdings across significant parts of park land
- Commuter and other through traffic using NPS-administered roads or waterways through a park for their convenience
- Tradespeople with business in the park

- Any civilian activity that is a part of or incidental to the pursuit of a gainful occupation (for example, guides)
- Government personnel (other than NPS employees) with business in the park
- Citizens using NPS buildings for civic or local government business, or attending public hearings
- Outside research activities (visits and overnights), if they are independent of NPS-legislated interests (for example, meteorological research) (NPS 2022c)

Lake Powell, with its many side canyons and related natural, cultural, and geologic resources, is the primary recreation feature of GCNRA. Recreation that occurs at Lake Powell includes swimming and sunbathing, power boating, waterskiing, fishing, off-beach activities associated with boat trips (such as hiking and exploring archaeological sites), house boating, personal watercraft use, canoeing, kayaking, sailing, wildlife viewing, photography, sightseeing, diving, and other activities. Visitors can enjoy camping opportunities ranging from going to remote and undeveloped campsites to going to fully developed campgrounds. Visitors can also see archaeologically and culturally important sites throughout the GCNRA.

Boating Facilities

Recreational boating is the most important recreational activity on Lake Powell, with nearly two million visitors accessing the reservoir by either private boat or rental (NPS 2023h). Specific boating facilities and reservoir elevations important to their operation are discussed in the 2007 FEIS. Water-based recreational facilities at Lake Powell include Wahweap, Halls Crossing, Bullfrog, and Antelope Point marinas. Since the publication of the 2007 FEIS, declining water levels have rendered the Dangling Rope Marina inoperable since 2021; this marina previously provided boating access to Rainbow Bridge National Monument. The Hite Launch Ramp has also been closed since 2012 due to the ramp being out of the water (NPS 2023i).

Changes to the shoreline affect the usability of boat launch ramps throughout the year, especially in warmer months. Launch ramp closures resulting from declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks (NPS 2023i).

In 2022, the NPS received $26 million in Disaster Supplemental Funding to provide additional boating access at Lake Powell. Design work is proceeding for a North Lake Powell ramp that reaches an elevation of 3,450 feet in the Stanton Creek area. The NPS is also working to develop schematic designs for the Antelope Point Public Ramp, Halls Crossing Public Ramp, and primitive ramp and take-out area at the Hite Marina. The NPS continues to seek funding necessary for potential reconstruction. The NPS is also continuing to seek funds to replace the services previously offered at Dangling Rope Marina, a long-term solution for lake access to Rainbow Bridge National Monument, and a Navigable Waterway Congestion Study in South Lake Powell (NPS 2023i).

Table 3-36
Critical Elevations for Lake Powell by Boating Facility

Lake Elevation (feet)	Impact and Facility
3,700	Full pool
3,645	Hite Marina would need to be reconfigured and possibly moved; Hite Public Launch Ramp closed
3,587	Antelope Point Public Ramp closed

Lake Elevation (feet)	Impact and Facility
3,580	Castle Rock Cut closed
3,562	Stateline Public Launch Ramp closed
3,553	Halls Crossing Marina would need to be reconfigured and possibly moved
3,551	Wahweap Main Ramp closed
3,530	Antelope Point Business Ramp closed
3,525	Bullfrog North Ramp closed
3,522	Stateline Auxiliary closed
3,490	Main Bullfrog Launch Ramp closed

Source: Heidie Grigg, GCNRA Acting Chief of External Affairs, NPS, personal communications, March 16, 2023

Access to Points of Interest

As previously mentioned, as of 2021 there is no longer dock access to the Rainbow Bridge National Monument shoreline. Access is limited to the Rainbow Bridge Trail. Visitors generally have to leave boats and small vessels at the shoreline and often traverse through mud, debris, sand, and water before reaching the established trail. While no longer connected to the shoreline, the Rainbow Bridge dock system is accessible with restroom facilities. The concessionaire-operated tours to the monument are no longer able to access the area, thus removing access for most GCNRA visitors. Visitors can also access Rainbow Bridge National Monument by obtaining a permit from the Navajo Nation Parks and Recreation Department to backpack for multiple days on Navajo Tribal lands from Navajo Mountain; however, this is not possible for many visitors (NPS 2021).

Harmful Algal Blooms

Warming water temperatures and increased inputs of nutrients from monsoonal storms create conditions that are more conducive to the growth of harmful algal blooms. Harmful algal blooms produce toxins that pose serious health risks to humans and animals (NPS 2019). (Water quality concerns are described in detail in **Section 3.8**.)

Quagga Mussel Shells on Shorelines

Quagga mussels were first detected at Lake Powell in 2012. They are particularly prevalent toward the southern area of the lake, where seasonally low water levels are now exposing mussel-encrusted shoreline (NPS 2016). Quagga mussel shells eventually wash up on beaches and can cut through skin, clothing, and pet paws.

Hiking and Sightseeing in Glen Canyon

Declining water levels have exposed approximately 100,000 acres of Glen Canyon that were previously inundated by Lake Powell, creating new opportunities to view landscapes and archaeological sites that have been underwater since the late 1960s (Baker 2022; Kolbert 2021). These include arches, side canyons, other rock formations, and lush desert ecosystems. This has created new hiking and sightseeing opportunities for GCNRA visitors since the publication of the 2007 FEIS.

Glen Canyon Dam to Lake Mead

The 15.5-mile river reach downstream of Glen Canyon Dam to Lees Ferry is managed by GCNRA; it is used by anglers, campers, commercial float trip operators, kayakers, and other boaters. Fishing opportunities for rainbow and brown trout also occur downstream of this reach.

The NPS manages most of the reach, except where it is bordered on the east by the Navajo Indian Reservation and on the south by the Hualapai Indian Reservation. GCNP staff regulates visitor use of the Colorado River downstream of Lees Ferry in accordance with the Colorado River Management Plan (NPS 2006a, 2006b).

Grand Canyon National Park begins downstream of the Lees Ferry boat ramp at the confluence of the Colorado and Paria Rivers. Designated a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site in 1979, Grand Canyon National Park is valued for its superlative natural and cultural resources as well as its varied recreational experiences. Approximately 94 percent of GCNP (1,143,918 acres) qualifies as wilderness, as described in the 1964 Wilderness Act (Public Law 88-577) and NPS Management Policies 2006 (NPS 2006b). This includes 10,919 acres of potential wilderness along the Colorado River corridor.

The Colorado River corridor borders Tribal lands for nearly half the distance from the put-in at Lees Ferry to the last takeout at Pearce Ferry. The Navajo Indian Reservation borders GCNP along the eastern bank of the Colorado River from near Lees Ferry to the confluence with the Little Colorado River at river mile (RM) 61.8. The Hualapai Indian Reservation borders the river corridor for approximately 108 miles from upstream of National Canyon (RM 167) to approximately RM 274. The Hualapai Indian Reservation offers camping, fishing, hiking, and big game hunting. Tribal enterprises offer rafting trips on the Colorado River between Diamond Creek and Pearce Ferry. The NPS coordinates with Tribal neighbors to address resource management and visitor use concerns along shared boundaries. Access permits from the Navajo Nation, Havasupai Tribe, or Hualapai Tribe are required by each respective Tribe to access and recreate on Tribal lands.

GCNP receives 4 to 6 million visitors each year (NPS 2023j). **Table 3-37** summarizes visitation to GCNP for the most recent 6 years.

Table 3-37
Grand Canyon National Park Recreational Visitors

Year	Recreational Visitors
2017	6,254,238
2018	6,380,495
2019	5,974,411
2020	2,897,098*
2021	4,532,677
2022	4,732,101

Source: NPS 2023j
*Park closure April–May due to the COVID-19 pandemic

Table 3-38 summarizes the total number of visits to GCNP by visitor segment for 2022, the most recent year for which data are available.

Table 3-38
GCNP Visits by Visitor Segment for 2022

Recreation Visitors	Non-Recreation Visitors*	Concession Lodging	Tent Campers	RV Campers	Concession Camping	Backcountry Camping	Misc. Campers	Total Overnight Stays
4,732,101	7,720	526,467	89,825	56,759	39,400	331,623	14,141	1,058,215

Source: NPS 2023k
*The NPS defines reportable non-recreation visits to include:

- Persons going to and from inholdings across significant parts of park land
- Commuter and other through traffic using NPS-administered roads or waterways through a park for their convenience
- Tradespeople with business in the park
- Any civilian activity that is a part of or incidental to the pursuit of a gainful occupation (for example, guides)
- Government personnel (other than NPS employees) with business in the park
- Citizens using NPS buildings for civic or local government business, or attending public hearings
- Outside research activities (visits and overnights), if they are independent of NPS-legislated interests (for example, meteorological research) (NPS 2022a)

The Lees Ferry to Diamond Creek reach has relatively low-use densities and levels of development that provide opportunities for solitude on the Colorado River as well as at many camps and attraction sites. This section of the Colorado River is where the majority of whitewater boating occurs. Takeouts are at Diamond Creek and Pearce Ferry. The reach downstream of Diamond Creek offers different recreation opportunities from those of the river reach upstream as it transitions to a more populated and developed setting. Whitewater boating trips become intermingled with very high levels of general boating and recreation use in the Quartermaster area. **Section 3.16** describes the social and economic importance of whitewater boating in the Grand Canyon.

Helicopter operations authorized by the Hualapai Tribe transport people into the Grand Canyon and connect them with motorized pontoon boats that give 20-minute tours of the Quartermaster area. These same helicopters provide a dual service in flying out boaters who have traveled from Diamond Creek on commercial motor day trips.

Boating Facilities

No boating facilities are within GCNP. Development along the Colorado River within the park is limited to the development at Phantom Ranch (RM 88) and Pipe Creek (RM 89.5). Other focal points include the launch ramp at Lees Ferry (within GCNRA), the helipad near Whitmore Wash (RM 187) on the Hualapai Reservation, the road access and minor structures operated by the Hualapai Tribe at Diamond Creek (RM 226), and the tourist area near Quartermaster Canyon (RM 260).

Camping between Glen Canyon Dam and Lake Mead occurs in GCNP on undeveloped beaches (sandbars) along the Colorado River. The number and usability of campsites vary from year to year based on the magnitude of releases from Glen Canyon Dam and local topography. Additional factors include vegetation changes; erosion from tributary flooding, wind, and recreation use; and the closure of sites to protect sensitive resources (NPS 2006a).

The average annual release volume was 9.1 maf from 2007 to 2019 and 8.1 maf from 2020 to 2022. The recent years of low release volumes have allowed accumulation of sand on the riverbed; sand was not redistributed to camping beaches from 2019 through 2022 due to a lack of HFEs. From 2012 to 2018, there were more frequent HFEs, which build more sandbars and beaches, on average, in Marble and Grand Canyons. The lack of HFEs from 2019 through 2022 has resulted in greater erosion than deposition on the high-elevation sandbars, due to erosive flows in the main channel and gullying from side channels with no rebuilding. Also, the lack of HFEs has contributed to more vegetation encroachment since 2018 (USGS 2023f).

Of the 276 campsites referenced in Section 3.12.1.1 of the 2007 FEIS, 195 sites are still classified as “camps”; 68 sites have been classified as “noncamps” due to sand erosion, vegetation overgrowth, or both; 2 sites could not be ascertained based on the float-by methodology used during the November 2022 NPS Colorado River Management Plan (CRMP) monitoring trip; and 10 campsites were not evaluated (Kearsley 2023).

Lake Mead and Hoover Dam

LMNRA contains 1.5 million acres. It encompasses the 110-mile-long Lake Mead, the 67-mile-long Lake Mohave, the surrounding desert, and the isolated Shivwits Plateau in Arizona. Recreation such as camping, boating, fishing, and hiking occurs on upper Lake Mead. The Overton Wildlife Management Area provides opportunities for wildlife viewing and photography, waterfowl and upland game bird hunting, hiking, and fishing. The Overton Wildlife Management Area has an average of 4,226 annual visitor use days (Nevada Department of Wildlife, personal communication, 2023).

LMNRA extends along the lower Colorado River from the western border of Grand Canyon National Park to Davis Dam. Primary recreational activities on Lake Mead include cruising/sailing, personal watercraft usage, waterskiing, fishing, swimming, and diving. A number of campgrounds and picnic areas, including Boulder Beach, Calville Bay, Echo Beach, Las Vegas Bay, and Temple Bar, provide additional recreational opportunities. LMNRA had approximately 5.6 million visitors in 2022 (NPS 2023l).

Table 3-39 summarizes recreational visits to LMNRA for the last 6 years.

Table 3-39
Lake Mead National Recreation Area Recreational Visitors

Year	Recreational Visitors
2017	7,882,339
2018	7,578,958
2019	7,499,049

Year	Recreational Visitors
2020	8,016,510
2021	7,603,474
2022	5,578,226

Source: NPS 2023l

Table 3-40 summarizes the total number of visits to LMNRA by visitor segment for 2022, the most recent year for which data are available.

Table 3-40
Lake Mead National Recreation Area Visits by Visitor Segment for 2022

Recreation Visitors	Non-Recreation Visitors*	Concession Lodging	Tent Campers	RV Campers	Concession Camping	Backcountry Camping	Misc. Campers	Total Overnight Stays
5,578,226	202,320	28,256	43,138	54,901	226,803	28,747	48,949	430,793

Source: NPS 2023m

*The NPS defines reportable non-recreation visits to include:

- Persons going to and from inholdings across significant parts of park land
- Commuter and other through traffic using NPS-administered roads or waterways through a park for their convenience
- Tradespeople with business in the park
- Any civilian activity that is a part of or incidental to the pursuit of a gainful occupation (for example, guides)
- Government personnel (other than NPS employees) with business in the park
- Citizens using NPS buildings for civic or local government business, or attending public hearings
- Outside research activities (visits and overnights), if they are independent of NPS-legislated interests (for example, meteorological research) (NPS 2022a)

Water quality concerns are increasing and are described in detail in **Section 3.8**. In the spring and summer of 2015, both Lake Mead and Lake Mohave experienced notable concentrations of harmful blue-green algae, which triggered harmful algal bloom advisories for various locations across the lakes (NPS 2023n). In 2022, a swimmer was fatally infected with a brain-eating amoeba at Lake Mead. Brain-eating amoebas are commonly found in bodies of warm freshwater, such as lakes, rivers, and geothermal water (NPS 2022c). These trends may continue to increase as water temperatures warm.

Declining reservoir elevations at Lake Mead in recent years have exposed mudflats along several areas of the shoreline. These have created dangerous conditions where recreationists have periodically become stuck in wet, muddy deposits. Some of these areas have access roads that previously enabled visitors to drive close to the shoreline when reservoir elevations were higher. As reservoir elevations have declined over recent years, visitors have often attempted to chase the shoreline both in their vehicles and by foot to gain access to the changing shoreline for such purposes as fishing, hiking, and other recreational activities. In doing so, they and their vehicles have become stuck in these muddy conditions, requiring assistance from NPS personnel and others to extract themselves and/or their vehicles.

Boating Facilities

LMNRA is considered one of the premier water-based recreation areas in the Nation. Most visitors participate in water-based recreational activities, primarily between May and September. These recreational activities are supported by marina and launch ramp facilities developed along the Lake Mead shoreline. On average, the majority of boats are personal watercraft. (Section 3.12.1.3 of the 2007 FEIS provides additional information on boating and shoreline public use facilities at LMNRA; the information is incorporated by reference.) **Table 3-41** shows critical elevations identified by the NPS for Lake Mead, below which marinas, boat docks, or boat launch ramps become inoperable.

Table 3-41
Critical Elevations for Lake Mead by Boating Facility

Lake Elevation (feet)	Impact and Facility
1,221	Full pool
1,150	Las Vegas Bay and Government Wash public launch ramps closed
1,125	Overton Beach Marina, Calville Ramp, and South Cove Ramp closed
1,112	Lake Mead Marina – Relocation of "C Dock" to Hemenway
1,110	Overton public launch ramps closed
1,100	Lake Mead Marina must relocate out of the protected harbor
1,080	Lake Mead Marina public launch ramp closed; Hemenway public launch ramp closed; Temple Bar public launch ramp closed
1,050	Echo Bay public launch ramp closed

Source: Henderson 2006

Since the publication of the 2007 FEIS, the Echo Bay, Boulder Harbor, and South Cove boat ramps have closed due to low water levels. The NPS facilities at the Temple Bar Marina are also inoperable; however, the concessionaire launch operations remain operable. The Pearce Bay launch ramp, a take-out point for rafts and whitewater boats, previously closed at elevation 1,175 feet. Access to Lake Mead was closed at Pearce Ferry in 2001 when the water elevation dropped to 1,175 feet. In 2010, the NPS extended Pearce Ferry Road 2 miles to the Colorado River to provide for river take-out operations for private and commercial river runners (NPS 2010).

Changes to water levels affect the usability of the remaining boat launch ramps throughout the year, especially in warmer months. Launch ramp closures resulting from declining water levels have resulted in longer lines, limited parking, and congestion at boat ramps and docks. In addition, ongoing maintenance and construction at ramps have resulted in temporary closures.

Hoover Dam to Davis Dam

Recreational opportunities available at Lake Mohave include boating, canoeing on northern parts of the lake, camping, exploring, fishing, photography, picnicking, swimming, parasailing, cliff diving (two locations), and water skiing. There are also hundreds of beaches that can only be accessed by boat. (The main shoreline access points and facilities for public use and boat launching for Lake

Mohave are described in Section 3.12.1.4 in the 2007 FEIS; this information is incorporated by reference.)

Davis Dam to Parker Dam

The Davis Dam to Parker Dam reach includes several recreational areas along the Colorado River, including Laughlin, Bullhead City, Davis Camp, Needles, Havasu NWR, Lake Havasu State Park, and Bill Williams River NWR. (Relevant recreational areas are briefly described in Section 3.12.1.5 in the 2007 FEIS; the information is incorporated by reference.) Lake Havasu is the premier attraction area within the Davis Dam to Parker Dam reach. **Table 3-42** lists the visitation at Arizona's Lake Havasu and Cattail Cove State Parks.

Table 3-42
Visitation at Arizona's Lake Havasu and Cattail Cove State Parks

Year	Lake Havasu State Park Visitation	Cattail Cove State Park Visitation
2016	477,283	70,442
2017	519,704	106,545
2018	551,203	111,376
2019	488,597	111,262
2020	598,403	116,822
2021	492,074	95,179

Source: Northern Arizona University 2022a, 2022b

Parker Dam to Cibola Gage

The Parker Dam to Cibola Gage reach includes several recreational areas, including Parker Strip Recreation Area, Palo Verde Diversion Dam, Blythe, and Cibola NWR. (Relevant recreational areas are briefly described in Section 3.12.1.6 in the 2007 FEIS; this information is incorporated by reference.)

Cibola Gage to Imperial Dam

The Cibola Gage to Imperial Dam reach includes a few recreational areas: Picacho State Recreation Area, Imperial NWR, and Martinez Lake. (Relevant recreational areas are briefly described in Section 3.12.1.7 in the 2007 FEIS; this information is incorporated by reference.)

Imperial Dam to NIB

The Imperial Dam to the NIB reach includes a few recreational areas along the Colorado River, including Betty's Kitchen and Mittry Lake Wildlife Area. (Relevant recreational areas are briefly described in Section 3.12.1.8 in the 2007 FEIS; the information is incorporated by reference.)

NIB to SIB

The NIB to the SIB reach includes shoreline public use facilities in the city of Yuma, Arizona. Typical water activities within this reach—which is located on the edge of the historical floodplain to the east of the Colorado River—include boating, swimming, and sport fishing.

Salton Sea

The Salton Sea is California's largest lake, and it contains approximately 130 miles of shoreline. The Salton Sea includes two primary recreation areas: the Salton Sea State Recreation Area and Sonny Bono Salton Sea NWR.

The Salton Sea State Recreation Area encompasses 14 miles of the northeastern shore and receives approximately 200,000 visitors annually (California Department of Parks and Recreation 2023a, 2023b). The season of peak use has typically been from October through May, when daytime temperatures are milder compared to summer months. Salton Sea State Recreation Area is a popular site for campers, boaters, and anglers. The Salton Sea has historically been stocked with sport fish; however, increasing salinity in the Salton Sea basin has reduced the number of fish species present, and most fish currently caught are tilapia. The area has five campgrounds with a total of 1,600 campsites, hundreds of day use sites, a boat ramp and wash area, trails, a visitor center (open during the peak season), a play area for children, and fishing jetties (California Department of Parks and Recreation 2023a).

The Sonny Bono Salton Sea NWR contains two separately managed units 18 miles apart. They are bordered by the Salton Sea on the north and by farmlands on the east, south, and west (Service 2023). The refuge provides visitors with unique opportunities for hunting, fishing, hiking, and educational programs. The Sonny Bono Salton Sea NWR contains a visitor center and headquarters, self-guided trails, an observation tower, and picnic areas (Service 2023).

Reservoir Boating

Reservoir boating is affected by fluctuating reservoir elevations; these fluctuations specifically cause changes in exposure to boating navigation hazards and changes in safe boating capacities. Hazards such as exposed rocks may become more evident, and changes in navigation patterns may be necessary as reservoir elevations decline. At low-pool elevations, special buoys or markers may be placed within reservoirs to warn boaters of navigation hazards. In addition, signs may be placed in areas that are deemed unsuitable for navigation.

Lake Powell

The navigation system on Lake Powell utilizes regulatory buoys and other marking devices to warn boat operators of hazardous conditions associated with subsurface obstructions or changes in subsurface conditions that could be hazardous for safe passage. Section 3.12.2.1 of the 2007 FEIS describes safe boating navigation and safe boating capacity on Lake Powell; the information is incorporated by reference. Placement of many of these marking devices depends on the lake elevation. Recreational boating is the most frequent type of boating activity on Lake Powell. One of the most popular activities at Lake Powell is taking out houseboats and motorboats for multiple day excursions to explore the reservoir. As the pool elevation decreases, the surface area suitable for boats as well as navigability also decreases. Since the pool elevation has decreased since the publication of the 2007 FEIS, the safe boating capacity at Lake Powell has subsequently decreased.

Thousands of adult quagga mussels have been found at Lake Powell attached to canyon walls, Glen Canyon Dam, boats, and other underwater structures. Quaggas rapidly multiply, are easy to spread, and encrust and clog boat engines, shorelines, and anywhere else conducive to their growth. These impacts are particularly prevalent in the southern portions of the reservoir. Adult mussel populations are expected to expand and increase over the next few years (NPS 2023n).

Lake Mead

Regulatory buoys and other marking devices are used on Lake Mead to warn boat operators of dangers, obstructions, and changes in subsurface conditions in the main channel or side channels. (Section 3.12.2.2 of the 2007 FEIS describes safe boating navigation and safe boating capacity on Lake Mead; this information is incorporated by reference.) Since the publication of the 2007 FEIS, the NPS has extended the Pearce Ferry launch ramp to provide river take-out operations for private and commercial river runners. However, due to the close proximity of the developing Pearce Ferry Rapid, the public launch of boats is prohibited (NPS 2010). Since the pool elevation has decreased since the publication of the 2007 FEIS, the safe boating capacity at Lake Mead has subsequently decreased.

Lake Mohave and Lake Havasu

Because Lake Mohave and Lake Havasu will continue to be operated to meet monthly target elevations, reservoir boating safe navigation and capacity in these reaches will not be affected by the proposed alternatives.

River and Whitewater Boating

Whitewater boating is the key recreational activity in the Grand Canyon from Lees Ferry to the Diamond Creek or Pearce Ferry takeouts. Other reaches are not predominantly whitewater localities; therefore, they will not be discussed in this section.

Glen Canyon Dam to Lake Mead

Grand Canyon river trips launch at Lees Ferry in GCNRA and take out at Diamond Creek on the Hualapai Indian Reservation or at Pearce Ferry in LMNRA. River trips are conducted using a variety of types and sizes of boats and rafts; group sizes can range up to 32 people (including guides). Trip lengths range up to 25 days and can be run by commercial companies or by private individuals. There are various means of joining trips, including launching from Lees Ferry, hiking into or out of the canyon to join and leave a trip, and gaining limited access by vehicle and helicopter (commercial use only) to join trips in the western portion of the Grand Canyon.

GCNP regulates recreational boating in accordance with the CRMP (NPS 2006a). The CRMP prescribes management of recreational use by establishing limits on the number of daily launches, group size, trip length, and motorized and nonmotorized use periods. In general, whitewater navigability can be affected by lower flows and by large amounts of side canyon debris that gets washed into the river channel. Because of these factors and reduced water levels, Separation Rapid is now visible, and it is consequentially more difficult to navigate. As Lake Mead has receded, the Colorado River has scoured a new channel in the silts deposited by the waters of Lake Mead. While most of the river still follows the old river channel, a new channel has developed near Pearce Ferry, creating a new impassible (going upstream) class VI rapid known as the Pearce Ferry Rapid (Joel 2016). Intermittent, larger-volume and higher-magnitude flows could improve navigability at some of these rapids.

Hoover Dam to SIB

The proposed alternatives are not expected to adversely affect river and whitewater boating between Hoover Dam and the SIB.

Sport Fishing

There are no specific reservoir elevation thresholds or river stages related to sport fishing identified from the literature reviewed. Catch rates for reservoir fishing are assumed to be directly related to reservoir habitat. Fishing satisfaction is assumed to be directly related to 1) the general recreation issues of boating access to water via shoreline facilities, and 2) the boating navigation potential for hazards or reservoir detours due to low reservoir elevations.

Lake Powell and Glen Canyon Dam

Lake Powell supports a popular warmwater sport fishery composed mainly of striped and smallmouth bass. The striped bass depend on threadfin shad for a significant portion of their diet. The threadfin shad in Lake Powell are at the northernmost portion of their range, and they are sensitive to fluctuations in water temperature. Gizzard shad may become an important striped bass forage fish. In addition to striped and smallmouth bass, Lake Powell supports largemouth bass, walleye, channel catfish, bluegill, and black crappie. Angler use in 2018 was at a 40-year low, mainly attributed to a decline in the percentage of boat days that were spent angling (Blommer and Gustaveson 2021).

Glen Canyon Dam to Lake Mead

The 15.5-mile Glen Canyon reach of the Colorado River supports a Blue Ribbon recreational rainbow trout fishery that attracts local, national, and international anglers. The NPS, in coordination with the Arizona Game and Fish Department and the Service, manages fish in all waters within the GCNRA and GCNP. The intention of Blue Ribbon management is to provide a quality fishing opportunity where anglers can catch larger-than-average trout, at a relatively high catch rate, in a unique recreational setting. Most angling is done from boats or is facilitated by boat access, often provided by guide services. Some anglers also wade or fish from shore.

Fishing in the Glen Canyon reach occurs year-round. Peak usage is in April and May; however, substantial fishing has occurred from March through October in most years (Rogowski and Boyer 2020). An estimated total of 7,654 anglers used the rainbow trout fishery in 2019; of these, 5,469 were boat anglers and 2,185 were walk-in anglers (Rogowski and Boyer 2020).

Section 3.13.1 provides further information on rainbow trout dynamics in the Glen Canyon reach.

Lake Mead and Hoover Dam

Lake Mead has an excellent warmwater sport fishery composed of largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. The majority of the catch consists of striped bass. Fishing is generally better in the fall months of September, October, and November. Larger fish are caught by deepwater trolling in spring from March through May.

The Lake Mead Fish Hatchery, operated by the Nevada Department of Wildlife (NDOW), historically raised rainbow trout, endangered razorback suckers, and bonytail chub. Since the publication of the 2007 FEIS, the Lake Mead Fish Hatchery ceased operations in 2022 in response to Lake Mead declining below 1,060 feet, the point at which the hatchery drew its water (Peterson 2022). The NDOW and SNWA are currently developing a project to replace the hatchery's water supply line to draw deeper in the water column.

Hoover Dam to Davis Dam

Lake Mohave's fishery is similar to Lake Mead's fishery. In Lake Mohave, there are largemouth bass, striped bass, channel catfish, rainbow trout, bullhead catfish, sunfish, crappie, and bluegill. Largemouth and striped bass are in deep water in the winter and move into shallow water to spawn in the spring. Fishing is open year-round, but the best fishing generally occurs in September, October, and November. For deepwater trolling, March through May tends to provide the best conditions.

Davis Dam to Parker Dam

Striped bass is the dominant sport fish in Lake Havasu. They can be caught throughout the year, but the best fishing locations change with the seasons and with water temperature. The largemouth bass population supports tournaments nearly every weekend from September through May. The smallmouth bass population has experienced an increase in numbers over the past couple of years. Channel catfish are abundant and average 2 to 4 pounds in size. Flathead catfish grow to large sizes in Lake Havasu. Only a limited number of anglers fish specifically for catfish. Black crappie numbers are limited due to overharvesting and a lack of habitat.

Parker Dam to SIB

Fishing in Cibola NWR is limited to certain times of the year. Cibola NWR is managed to protect wintering waterfowl that use Cibola Lake. The lake is closed to fishing from Labor Day to March 15. Sport fishing in Cibola Lake includes largemouth, smallmouth, and striped bass; channel and flathead catfish; crappie; sunfish; tilapia; and common carp.

The Imperial NWR is managed as a refuge and breeding area for migratory birds and other wildlife. Hunting and fishing are permitted in some areas, according to state regulations, and fishing by boat is allowed in the mainstream Colorado River any time of the year.

3.14.2 Environmental Consequences

Methodology

This section examines the potential effects of the No Action Alternative and the Proposed Action on recreation within the analysis area. Reclamation's CRMMS modeling results helped develop potential releases, reservoir elevations, and flow rates from the alternatives. The results of these analyses are used throughout this section.

Method Used to Assess Shoreline Public Use Facilities

This section analyzes the impacts that reservoir elevations decreasing below critical thresholds would have for using selected marinas, boat docks, and launch ramps, as well as whether these elevations could impact access to or use of attraction features. (Threshold reservoir elevations were determined using the methodology in the 2007 FEIS.) The threshold elevations were used as indicators of recreational facilities that might be rendered inoperable or that might require relocation or modification to maintain their operation. **Figure 3-5** provides the projections of reservoir elevations for 2024, 2025, and 2026 (the end of the interim period). The narrative of the alternatives' effects is provided below for selected facilities at both Lake Powell and Lake Mead. These facilities are representative of the alternatives' potential effects on shoreline recreational opportunities at each reservoir.

Method Used to Assess Reservoir Boating and Navigation Hazards

This analysis assesses the impacts of reservoir elevations decreasing below critical thresholds, which would result in boating navigation hazards and changing navigable areas and passageways. It also assesses whether corresponding decreases in reservoir surface areas might affect safe boating capacities. (Threshold pool elevations were determined using the methodology identified in the 2007 FEIS.)

Method Used to Assess Whitewater Boating

This analysis uses river flow data from **Section 3.6** to analyze whether there would be increased exposures to boating navigation hazards, changes in access or use of rest areas and take-outs, or changes in trip durations resulting under the Proposed Action, as compared with the No Action Alternative. (Threshold river flows were determined using the methodology identified in the 2007 FEIS.) Whitewater boating is the key recreational activity in the Grand Canyon downstream of Lees Ferry and upstream of Lake Mead. The 2007 FEIS analysis also includes a discussion of areas on the Colorado River that could become unsafe for whitewater boating at certain flows due to hazards such as exposed rocks, changes in navigation patterns caused by obstructions, and increased or decreased flow velocities. These flows were also analyzed to determine elevations at or below which various whitewater boating facilities (rest areas and take-out points) might be rendered inoperable or require modification to maintain their operation.

Method Used to Assess Sport Fishing

This analysis evaluates changes in sport fishing opportunities by river reach under the Proposed Action as compared with the No Action Alternative. The assessment of sport fishing was based on a literature review to determine the current status of fish assemblages in the analysis area. No specific reservoir elevation thresholds related to sport fishing were found. A general discussion about changes in flow and salinity and possible effects on sport fish is also provided.

A more detailed analysis of effects on rainbow trout based on changes in water temperature is used for the Colorado River reach between Glen Canyon Dam and Lake Mead. Water temperature changes may affect sport fish. Rainbow trout were chosen for the analysis based on the importance of their recreational fishery in the Colorado River reach below Glen Canyon Dam.

Striped bass and threadfin shad in Lake Powell and Lake Mead were selected to represent the reservoir sport fishery; striped bass are a sport fish, and threadfin shad are their food source.

Assumptions

In addition to being consistent with the modeling assumptions, this analysis assumes that recreation in the impact analysis area will increase over time, provided dead pool is not reached.

Impact Indicators

- Threshold reservoir elevations
- Threshold river flows
- Water temperatures
- Rainbow trout water temperature thresholds
- Striped bass and threadfin shad populations

Issue 1: How would reduced reservoir levels impact recreation at Lake Powell?

Section 3.14.1, **Table 3-36** identifies the threshold elevations below which shoreline recreational facilities at Lake Powell could be affected**.** Below these elevations, facility adjustments or capital improvements would be required, creating potential impacts on recreation at Lake Powell.

Summary

Under both the No Action Alternative and the Proposed Action, projected Lake Powell elevations for much of the analysis period would be below the critical thresholds for most boat launch facilities and for safely navigating Castle Rock and Gregory Butte. This would result in a reduction in the quality of or the loss of reservoir boating opportunities on Lake Powell. Under both alternatives, dock access would continue to be unavailable from the Rainbow Bridge National Monument shoreline, which would continue until a long-term access solution was developed.

Under both alternatives, impacts on public health resulting from harmful algal blooms would likely increase as lake elevations decline. Under both alternatives, declining reservoir elevations would expose additional areas of Glen Canyon that were previously inundated by Lake Powell. This would continue to create new visitation patterns and resource protection challenges due to access to new areas, as described in the affected environment. Both alternatives are not expected to significantly impact sport fish populations. Recreation impacts at Lake Powell would be slightly reduced under the Proposed Action because the Proposed Action would preserve more water in Lake Powell and reduce overall variability in water surface elevations.

No Action Alternative

Boat Launch Facilities

Under the No Action Alternative, the median modeled Lake Powell elevations start at a minimum monthly elevation of 3,561 feet in 2024 and end at a maximum monthly elevation of 3,605 feet in 2026. The median modeled Lake Powell elevation (3,561 feet) is below the critical threshold for all Lake Powell boat launch facilities, which would necessitate they be closed or relocated. If the median 2024 projected Lake Powell elevation were to be reached before a launch ramp at Stanton Creek area is developed, then Lake Powell would be unable to provide reservoir boating opportunities. The ability for boat launch access to continue under the No Action Alternative would depend on how quickly new boat launch facilities were constructed.

Safe Boating Capacities and Exposure to Navigation Hazards

In general, as reservoir elevations drop, hazards such as submerged snags and boulders can become exposed or become closer to the surface, increasing the likelihood that boats can come in contact with them. The elevations of such hazards are often unknown until the hazards become exposed. At a Lake Powell elevation of 3,620 feet, hazardous obstructions result in boating being prohibited around Castle Rock and Gregory Butte. Under the No Action Alternative, the median 2024 projected Lake Powell elevation is below this threshold, which would result in boating restrictions around Castle Rock and Gregory Butte. These restrictions would likely be in place throughout the analysis period, unless the upper projections for 2026 (3,686 feet) were reached.

Access or Use of Rainbow Bridge

Under the No Action Alternative, dock access would continue to be unavailable from the Rainbow Bridge National Monument shoreline. Access would continue to be limited to the Rainbow Bridge Trail. Boat and small vessel shoreline access would likely become more difficult to impossible as pool elevations decrease. These impacts would continue until long-term access solution was developed.

Harmful Algal Blooms

Under the No Action Alternative, reduced reservoir elevations could create conditions that would be more conducive to the growth of harmful algal blooms. Harmful algal blooms may increasingly pose serious health risks to humans and animals. (Water quality concerns are described in detail in **Section 3.8**.)

Lake Powell Sport Fish Populations

Under the No Action Alternative, the maximum lethal limits of 37°C and 33°C for threadfin shad and striped bass, respectively, would not be exceeded. These water temperatures are for the upper 10 feet of the reservoir; lower depths provide cooler water. Striped bass and threadfin shad would be able to move into the cooler thermocline during the summer months. Under the No Action Alternative, water temperatures would not drop below the lower lethal limit of 5°C for striped bass or threadfin shad. Because surface temperatures would not exceed the lethal tolerances of either species, and it is assumed that both species would have adequate thermal refugia, substantial temperature-related impacts on the reservoir sport fishery are not anticipated to occur under the No Action Alternative.

Proposed Action

In general, impacts on recreation under the Proposed Action would be similar to those described under the No Action Alternative. Impacts on recreation under the Proposed Action that differ from the No Action Alternative are presented below.

Boat Launch Facilities

Under the Proposed Action, the median of Lake Powell monthly pool elevations would range from a minimum of 3,562 feet in 2024 to a maximum of 3,603 feet in 2026. Similar to the No Action Alternative, the median projected monthly Lake Powell elevations would be below the critical threshold for all Lake Powell boat launch facilities, which would result in impacts similar to those described under the No Action Alternative. Projected Lake Powell elevations under the No Action Alternative and Proposed Action would be similar until August 2025, when the range of the No Action Alternative cloud drops below the Proposed Action. The maximum projected 2025 pool elevation under the Proposed Action (3,640 feet) would be higher than under the No Action Alternative, which would increase the likelihood that the Wahweap Marina, Antelope Point Marina, Bullfrog Marina, and Halls Crossing Marina would remain operable. This would slightly reduce the impacts on boat launch facilities under the Proposed Action, as compared with the No Action Alternative.

Cumulative Effects

The operating tiers established by this SEIS will determine annual release volumes in the LTEMP SEIS. The LTEMP SEIS includes two elements: smallmouth bass flow options and a potential adjustment to HFE sediment account periods and implementation windows. The smallmouth bass flow options would result in temporary changes to daily and hourly flows, which would not impact reservoir levels. Therefore, the potential change of smallmouth bass flow options would result in no changes to annual or monthly reservoir levels in Lake Powell. The potential adjustment to HFE sediment accounting periods and implementation windows could result in changes in the timing of HFEs, which could minimally affect monthly reservoir levels in Lake Powell. These differences are expected to be minor, temporary, and resolved by the end of the operating year and would result in no changes to annual reservoir levels in Lake Powell. Therefore, minimal cumulative effects would occur on reservoir levels due to proposed operational changes evaluated in the LTEMP SEIS. The potential change included in the LTEMP SEIS flow options would result in no changes to annual or monthly reservoir levels in Lake Powell. Therefore, proposed operational changes evaluated in the LTEMP SEIS would not cumulatively affect recreation on Lake Powell.

No cumulative effects would occur on recreation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would reduced flows downstream of Lake Powell affect recreation from Glen Canyon Dam to Lake Mead?

Summary

Under both alternatives, daytime flows would not drop lower than the safe whitewater boating threshold of 5,000 cfs. Therefore, there would be no change in exposure to unsafe boating conditions caused by changes in river levels. Under both alternatives, lethal limits for rainbow trout are not projected to be exceeded in any month throughout the analysis period. As seen in **Figure 3-37**, release temperatures are predicted to exceed 20°C during the 2026 summer period under the No Action Alternative, but temperatures are not predicted to exceed this threshold in any year under the Proposed Action. If temperatures were to reach or exceed 23°C, this could result in adverse impacts on rainbow trout growth, which would negatively impact the rainbow trout fishery in the Glen Canyon reach. Warmer water temperatures will not reach lethal limits for the native fishes, which are all warmwater species and can tolerate water temperatures of over 30°C (Bulkley et al. 1982).

No Action Alternative

Boating

Current operation of Glen Canyon Dam under the LTEMP SEIS and ROD requires a minimum flow release of 8,000 cfs between 7:00 a.m. and 7:00 p.m. and 5,000 cfs at night. Boating safety was among the issues considered and addressed in developing the minimum flows. Because compliance with the minimum release will continue under the No Action Alternative, daytime flows would not drop lower than the safe whitewater boating threshold of 5,000 cfs. Releases from Glen Canyon Dam would generally be higher than these minimum flows. Therefore, there would be no change in exposure to unsafe boating conditions caused by changes in river levels. Minor changes in exposure to boating navigation hazards caused by a change in river velocity, changes in access or use of rest areas and take-out points, changes in trip duration caused by changes in river velocity, or changes in the ability to use sport fishing sites caused by a change in flows may occur under the No Action Alternative. These changes would not be substantial, and they would not significantly affect recreational boating use or opportunities.

However, under the No Action Alternative, Lake Powell would be more likely to decrease below minimum power pool (3,490 feet). If Lake Powell were to reach minimum power pool, it would likely result in lower releases that could have the potential to create unsafe whitewater boating conditions in the Grand Canyon.

Releases from Glen Canyon Dam throughout the analysis period have the potential to be below the threshold to produce HFEs, which would result in reduced sandbar building. In the long term, this would negatively impact the availability of campsites for boaters in the Grand Canyon. See **Section 3.8.2** for further details on the impacts on sandbar building.

As analyzed in the LTEMP FEIS and ROD, a slight increase (2 percent) in suspended sediment would occur at Hualapai recreational facilities in the western Grand Canyon when HFEs are implemented (Reclamation and NPS 2016). The probability of triggering HFEs under the alternatives is described in **Section 3.8.2**, under Issue 3. Reclamation would address any concerns related to these facilities in the manner stated in the 2012 letter between Reclamation and the Hualapai Tribe (Walkoviak 2012; Reclamation and NPS 2016).

Sport Fish Populations

Water temperatures above 21°C have the highest potential to affect spawning, incubation, growth, and mortality of rainbow trout. Temperatures 23°C and above have the potential to stop growth, and temperatures 25°C and above are known to be lethal (FAO 2023). Under the No Action Alternative, water temperatures are projected to exceed 20°C during the 2026 summer period (**Figure 3-37**). Under the No Action Alternative, lethal limits for rainbow trout are not projected to be exceeded in any month. See **Section 3.13.2** for further details on the impacts on fish species.

Proposed Action

Boating

Under the Proposed Action, daytime flows would not drop lower than the safe whitewater boating threshold of 8,000 cfs. Therefore, impacts on whitewater boating would be similar to those described under the No Action Alternative (assuming power pool conditions are not reached under the No Action Alternative).

Sport Fish Populations

Under the Proposed Action, there would be slightly more days above the 16°C (60.8°F) threshold on average in operating years 2024 and 2025; however, the Proposed Action would exceed the 16°C

(60.8°F) threshold on fewer days in operating year 2026 compared with the No Action Alternative (**Figure 3-35**). This could lead to greater physiological stress on rainbow trout under warmer conditions. There are no predicted periods of temperatures exceeding the 20°C threshold under the Proposed Action. Overall, the impacts on the rainbow trout fishery would be similar to those described under the No Action Alternative.

Cumulative Effects

The LTEMP SEIS flow options would likely have a cumulative impact on the rainbow trout sport fishery within the Glen Canyon Dam to Lake Mead reach of the Colorado River due to changes in the water temperature released from Glen Canyon Dam. Reducing water temperatures to prevent smallmouth bass establishment would benefit rainbow trout by reducing water temperatures to a range conducive to rainbow trout, aerating the water, and limiting the potential for smallmouth bass establishment. Under both alternatives, the effects of this cumulative action would be beneficial to rainbow trout, unless water levels in Lake Powell reached minimum power pool levels. At this elevation, all flows passing through Glen Canyon Dam would be directed through the river outlet works out of necessity, nullifying this cumulative action.

If the LTEMP SEIS flow options were not implemented, the Proposed Action may result in poorer outcomes for rainbow trout due to increased water temperatures, predation from smallmouth bass, increased entrainment of nonnative fish species, and lower dissolved oxygen when the dam would be operated near 3,500 feet. These dynamics are further described in **Section 3.13.2.**

No cumulative effects would occur on recreation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 3: How would reduced reservoir levels impact recreation at Lake Mead?

Section 3.14.1, **Table 3-41** identifies the threshold elevations below which shoreline recreational facilities at Lake Mead could be affected. Facility adjustments or capital improvements would be required below these elevations, creating potential impacts on recreation at Lake Mead.

Summary

Under the No Action Alternative, the highest median projected Lake Mead elevation is below the critical threshold to allow access at all Lake Mead boat launch facilities except the Pearce Ferry Road launch ramp (used only for takeout). This would necessitate closing the boat launch facilities or relocating them throughout the entire analysis period. The slight increase in Lake Mead elevations under the Proposed Action could marginally help limit the closure or relocation of boat launch facilities at Lake Mead in 2026, compared with the No Action Alternative. Additionally, under both alternatives, the projected median elevation for Lake Mead would be at a level at which boaters are likely to encounter boating navigational hazards. Under both alternatives, projected surface water temperatures at Lake Mead are not anticipated to impact sport fish.

No Action Alternative

Access or Use of Lake Mead Boating Facilities

Under the No Action Alternative, the highest median projected Lake Mead elevation (1,056 feet) is below the critical threshold for all Lake Mead boat launch facilities except the Pearce Ferry Road launch ramp (used only for takeout). This would necessitate closing the boat launch facilities or relocating them throughout the entire analysis period. Launch ramp closures resulting from declining water levels would result in longer lines, limited parking, congestion at boat ramps and docks, and the potential loss of most facilities. Declining water levels would also likely continue to contribute to public safety concerns as recreationists attempt to navigate through exposed mudflats to access shoreline recreation opportunities, as described under **Section 3.14.1**.

Safe Boating and Navigation Hazards

Over the years, sediment has built up in the section of the reservoir between Grand Wash Cliffs and Pearce Ferry. When Lake Mead's elevation drops below 1,170 feet, there is no well-defined river channel in this upper portion of Lake Mead, making it dangerous for boaters (NPS 2006a). In general, as reservoir elevations drop, hazards such as submerged snags and boulders can become exposed or become closer to the surface, increasing the likelihood that boats can come in contact with them. The elevations of such hazards are often unknown until the hazards become exposed. Under the No Action Alternative, the projected median pool elevation for Lake Mead would be below 1,170 feet throughout the period of analysis, which would result in boaters encountering navigational hazards in upper Lake Mead.

Sport Fish Populations

The effects of water temperatures on striped bass and threadfin shad in Lake Powell are expected to be similar at Lake Mead. However, threadfin shad are near the northern limit of their range at Lake Powell. Threadfin shad are less likely to be affected by cold winter temperatures at Lake Mead.

Proposed Action

Access or Use of Lake Mead Boating Facilities

Under the Proposed Action, the 2024 median projected Lake Mead elevation would be below the critical threshold for all Lake Mead boating facilities except for the Pearce Ferry Road launch ramp (used only for takeout); therefore, the impacts on boating facilities would be similar to those described under the No Action Alternative for 2024. While the 2026 median pool elevation projection (1,067 feet) remains below the critical threshold for access for most Lake Mead boating facilities, the upper range of projections for 2026 could enable the Echo Bay public launch ramp to reopen, unlike under the No Action Alternative. Overall, the slight rebound in Lake Mead elevations under the Proposed Action could marginally help limit the closure or relocation of boat launch facilities and public safety risks due to shoreline access at Lake Mead in 2026 compared with the No Action Alternative.

Safe Boating and Navigation Hazards

Under the Proposed Action, the projected median pool elevation for Lake Mead would be below 1,170 feet throughout the period of analysis, which would result in boating navigational hazards similar to those described under the No Action Alternative. These impacts could be slightly reduced in 2025 and 2026 due to the slightly higher Lake Mead pool elevations under the Proposed Action, as compared with the No Action Alternative.

Sport Fish Populations

Impacts on sport fish populations would be similar to those described under the No Action Alternative.

Cumulative Effects

As with Lake Powell, minimal cumulative effects would occur on reservoir levels due to proposed operational changes evaluated in the LTEMP SEIS. Therefore, the LTEMP SEIS flow options would not cumulatively affect recreation at Lake Mead.

No cumulative effects would occur on recreation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 4: How would reduced flows downstream of Lake Powell affect recreation from Hoover Dam to the Salton Sea?

Summary

Under both alternatives, flow releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam would all be within the historical operating range. Therefore, there would be minimal changes in exposure to boating navigation hazards caused by changes in the river's elevation, changes in exposure to boating navigation hazards caused by changes in the river's velocity, changes in access or use of rest areas and take-out points, changes in trip duration caused by changes in the river's velocity, or decreases in access or use of sport fishing sites caused by changes in flows. The sport fishery in this reach is primarily in warm water. The minor changes in water temperatures that may occur downstream of Hoover Dam would not be expected to affect warmwater sport fish. The current shoreline area of the Salton Sea could continue to decrease, resulting in similar impacts on shoreline recreation as described under the affected environment.

No Action Alternative

Under the No Action Alternative, flow releases from Hoover Dam, Davis Dam, Parker Dam, and Imperial Dam would all be within the historical operating range. Therefore, there would be minimal changes in exposure to boating navigation hazards caused by changes in the river's elevation, changes in exposure to boating navigation hazards caused by the changes in the river's velocity, changes in access or use of rest areas and take-out points, changes in trip duration caused by changes in the river's velocity, or decreases in access or use of sport fishing sites caused by changes in flows. The sport fishery in this reach is primarily in warm water. The minor changes in water temperature that may occur downstream of Hoover Dam would not be expected to affect warmwater sport fish. Under the No Action Alternative, the Salton Sea shoreline would continue to decrease at the current rate.

Proposed Action

Under the Proposed Action, impacts on recreation from Hoover Dam to the SIB would be the same as those described under the No Action Alternative. Under the Proposed Action, there is the possibility that IID and CVWD could take additional shortages, which could reduce river flows and inflow to the Salton Sea from irrigation drainage. This could diminish the Salton Sea shoreline more than the No Action Alternative would, thereby adversely affecting shoreline recreation.

Cumulative Effects

The LTEMP SEIS flow options would not result in changes to reservoir releases from Glen Canyon Dam (Lake Powell) or Hoover Dam (Lake Mead); thus, they would not cumulatively affect recreation from Hoover Dam to the Salton Sea. No additive cumulative effects would occur on recreation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.15 Electrical Power Resources

3.15.1 Affected Environment

This section provides an overview of electrical power (that is, hydropower) generation, power marketing, and the Colorado River Basin power funds used to manage electrical power revenues and expenditure requirements for mainstream Colorado River dams. The 2007 Interim Guidelines describe in detail the electrical power resources that occur within the Colorado River Basin and within the analysis area. This section analyzes the same resources as the 2007 Interim Guidelines and provides updated information, data, and conditions since the publication of the 2007 Interim Guidelines (Reclamation 2007). The electrical power resources analyzed are as follows:

- Amount of electrical power generation and capacity
- Economic value of electrical power produced
- Electrical power-related contributions to the different Colorado River Basin power funds and programs supported by these funds

Overview

The primary power resources affected by the proposed alternatives include the Glen Canyon Powerplant, Hoover Powerplant, and Parker-Davis Project Powerplants. Other smaller facilities along the river include Headgate Rock Powerplant, Senator Wash, Siphon Drop, and Pilot Knob. Reclamation is responsible for the operation and maintenance of Glen Canyon, Hoover, Parker, and Davis facilities. WAPA is responsible for marketing and transmitting the power across the Upper and Lower Basins (Reclamation 2007).

Hydropower Generation

Hydropower generation occurs when water stored in a reservoir passes through a turbine located on a generating unit. The amount of power generated is directly related to the amount of water passing through the turbines and the elevation of the reservoir. The depth of the reservoir controls the force, or head (that is, the pressure caused by a difference in water depth—in this case, the difference between the lake reservoir elevation and the hydroelectric generators), the water has when moving through the turbines. Hydropower generation has two main measurable components: energy, which is the amount of power generation that occurs over time and is measured in MWh, and capacity, which is the maximum amount of energy that can be produced instantaneously and is measured in megawatts (MW).

Energy is mainly affected by the amount of water that passes through the generators and the depth of the reservoir. The higher the reservoir elevation, the more force, or head, the water can exert when passing through the turbines. Capacity is mainly affected by the depth of the reservoir and the availability of generators. Additional information on power generation, control, regulation, reserves, and ramping can be found in 2007 FEIS Section 3.11.1.1 (Reclamation 2007); the information is incorporated by reference.

There have been no changes to the manner in which hydropower is generated since 2007. However, regulations such as the LTEMP have led to changes in typical operations. In addition, recent drought conditions in the Basin have led to a substantial decrease in hydropower generation since the 2007 Interim Guidelines (Reclamation 2021d). Changes in hydropower generation are described in the powerplant-specific subsections below.

Power Marketing

WAPA markets and administers power contracts for electricity generated from Reclamation-owned and -operated hydropower facilities (that is, Glen Canyon, Hoover, Parker, Davis, and the smaller generation facilities). The BIA administers Headgate Rock Powerplant.

WAPA markets energy and capacity to its customers. Power marketing comes in two terms: 1) firm—or guaranteed to be available—capacity and energy; and 2) nonfirm, which only includes charges for energy delivered. Firm and nonfirm contracts can be short or long term. The majority of Colorado River Storage Project (CRSP) power is sold under long-term, firm contracts. Customers can purchase firm and nonfirm power through contracts with individual hydropower facilities. Contracts for the Hoover Powerplant have been re-signed since the 2007 Interim Guidelines. Contracts for Parker-Davis Project were signed before the 2007 Interim Guidelines and terminate in 2028. It is expected new contracts will be signed to replace the expiring contract. The contract for Glen Canyon Dam terminates in 2024, and new contracts effective 2024 through 2057 have been executed with nearly identical terms and conditions (Reclamation 2021d).

Table 3-43 shows the total generation capability of each Western Electricity Coordinating Council (WECC) area. These WECC areas cover the entire Upper and Lower Colorado River Basins. Glen Canyon, Hoover, Parker, and Davis Powerplants account for approximately 2.2 percent of the total capacity.

Table 3-43
Generation Capability in WECC Areas

WECC Area	Available Capacity (MW)
Rocky Mountain Region	34,053.99
Southwest Region	45,483.61
California-Mexico Region	89,925.74

Source: WECC 2023

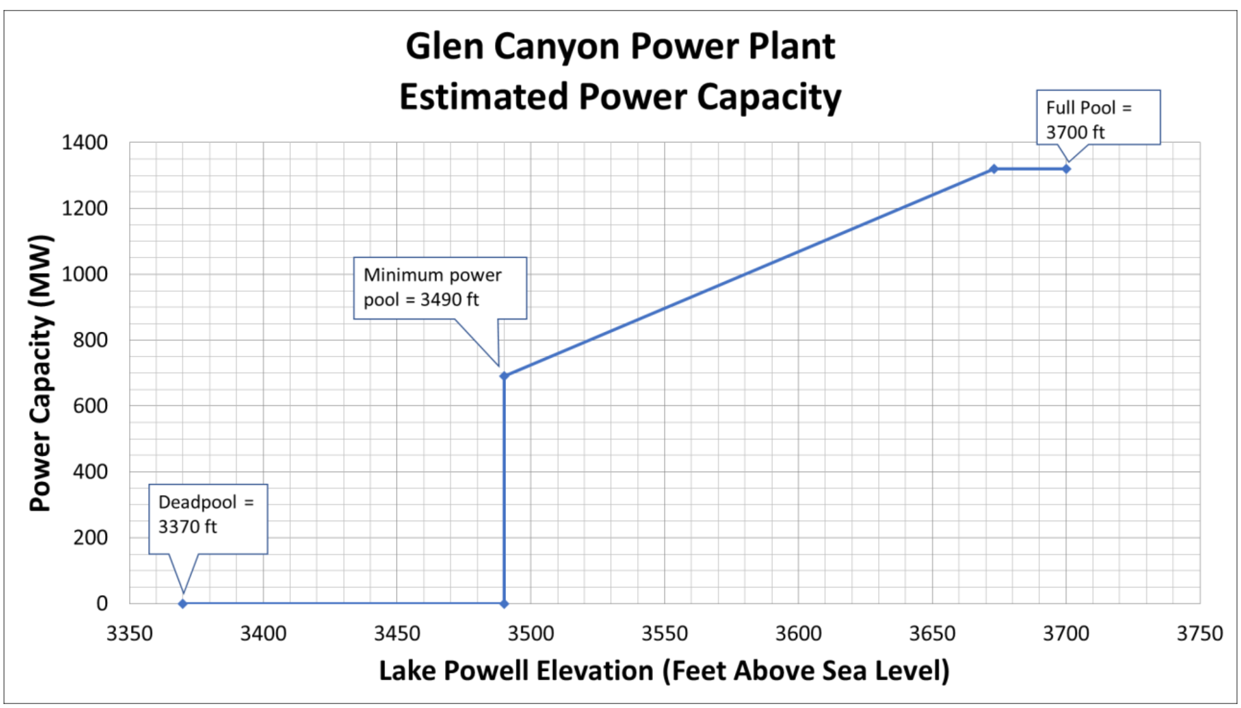
Lake Powell and Glen Canyon Dam

The Glen Canyon Powerplant accounts for approximately 75 percent of the Upper Colorado Basin's annual energy production (Reclamation 2007). Since the 2007 Interim Guidelines were published, the powerplant has undergone projects to improve efficiency, including replacement of all eight turbines (Reclamation 2004b). Reclamation also optimized software within the facility, resulting in higher efficiency. Standard operations and maintenance work also have continued throughout this time (Reclamation 2021d).

Despite the improved efficiency, Glen Canyon Powerplant's capacity to generate power decreases as the lake elevation drops. **Figure 3-46** shows the estimated capacity at a range of lower lake elevations. This "plant" capacity is calculated from lake elevations and does not take into account the operating constraints. The modeled data in the environmental consequences section is "marketable" capacity, which considers both lake elevation and operating constraints. A discussion on modeled capacity is provided below. This decrease in elevation, and therefore head, has been the primary mechanism of reduced power generation since 2007. At minimum power pool (elevation 3,490 feet), the powerplant has an estimated capacity of 630 MW (Reclamation 2021d).

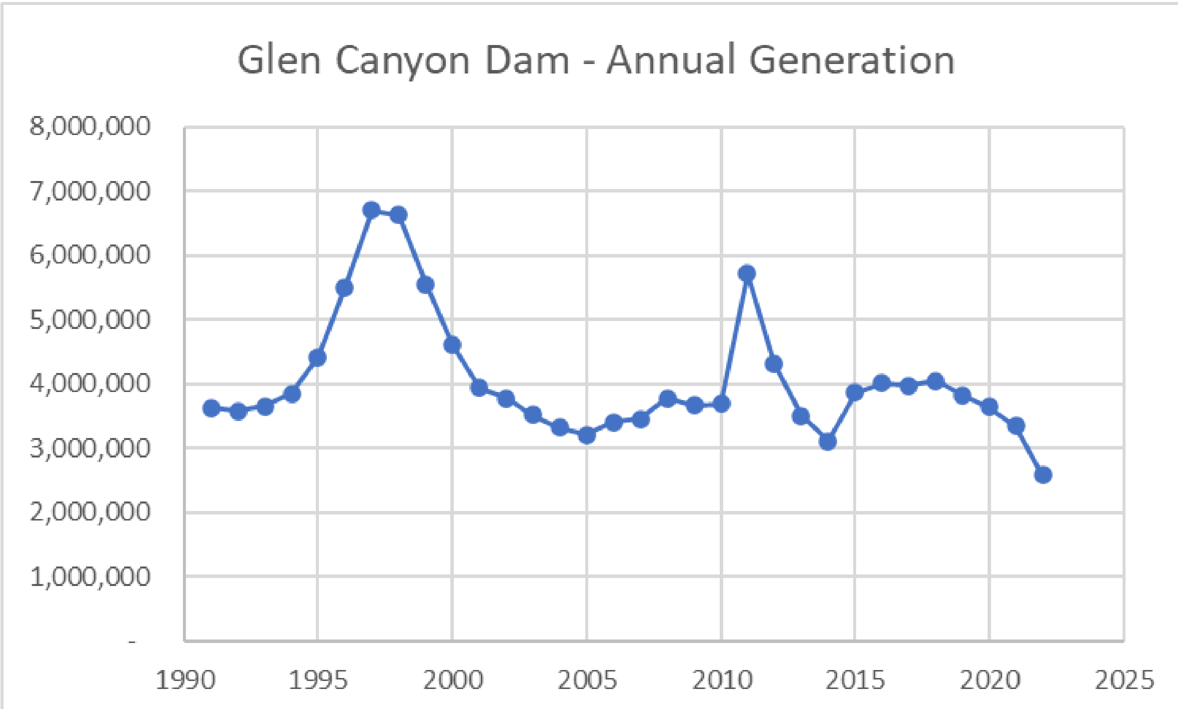
Despite a decrease in head since 2007, sustained annual flows have allowed power generation to continue with an average annual energy production of 3,833 gigawatt hours (GWh) from 2000 through 2020. However, a decrease in flows from 2020 through 2021 resulted in a decline in energy generation (Reclamation 2021d). **Figure 3-47** shows the historical annual generation at Glen Canyon Powerplant from 1991 to 2022.

Figure 3-46
Glen Canyon Powerplant Estimated Power Capacity



Source: Reclamation 2021d

Figure 3-47
Glen Canyon Dam – Annual Generation (MWh)



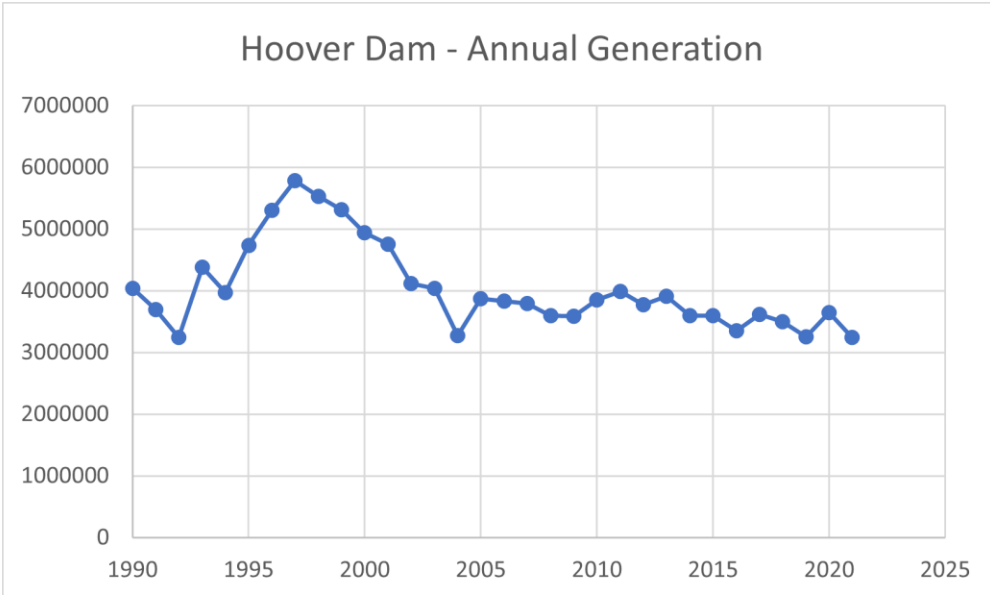
Source: Reclamation 2023h

Lake Mead and Hoover Dam

The Hoover Powerplant remains the largest hydropower-generation facility in the Colorado River Basin. Since the 2007 Interim Guidelines, Reclamation has replaced five existing turbines at the powerplant with "wide-head" turbines that run more efficiently at all reservoir elevations at and above the minimum power pool (8NewsNow 2022). These turbines allow Hoover Dam to produce power at elevations 950 feet and greater. In addition to the upgraded turbines, the Hoover Powerplant's staff has upgraded wicket gates (which can open and close to allow or stop water from entering the turbines) at most units, allowing more water to pass through the turbines. Reclamation has also modernized all unit controls, which has also increased efficiency. The facilities also have undergone typical operations and maintenance (Reclamation 2021d).

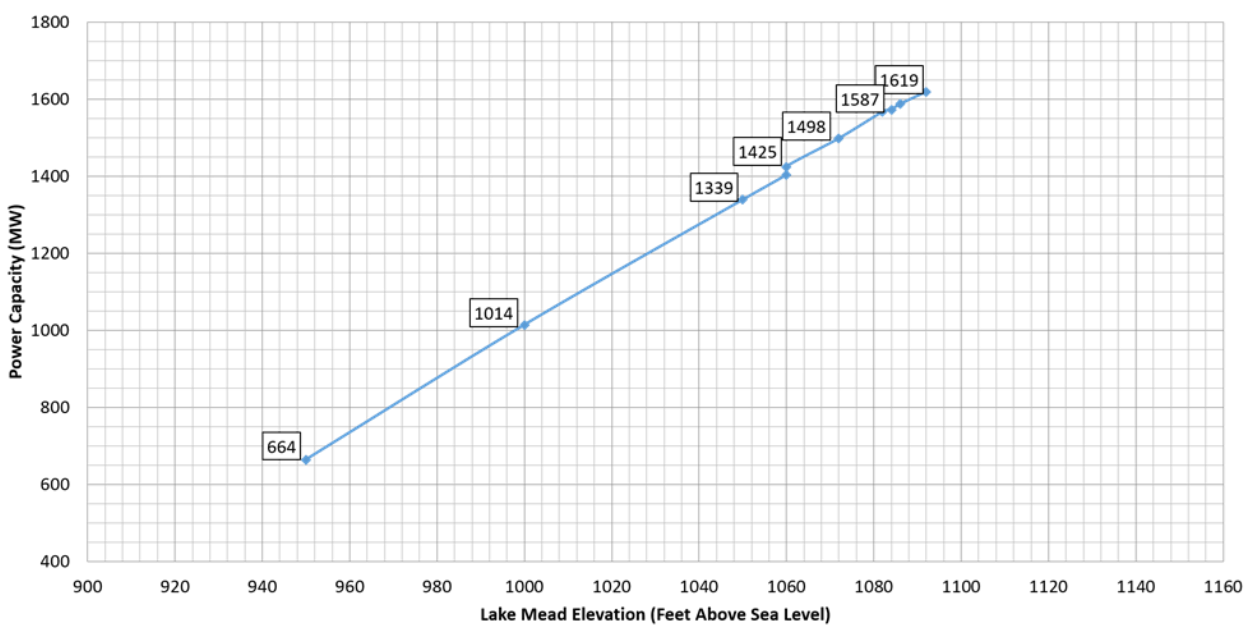
Similar to conditions at Glen Canyon, the Hoover Powerplant has experienced significant impacts since 2007 due to drought conditions. **Figure 3-48** shows the historical annual generation at Hoover Powerplant from 1991 to 2022. A decrease in lake elevation has led to a decrease in head, resulting in a lower plant capacity. **Figure 3-49** shows the relationship between lake elevation and plant capacity at the Hoover Powerplant. This reduction in head has led to a steady decline in energy production starting in 2015 (Reclamation 2021d).

Figure 3-48
Hoover Dam – Annual Generation (MWh)



Source: Reclamation 2021d

Figure 3-49
Low Lake Power Capacity Expectations for Hoover Powerhouse



Source: Reclamation 2021d

A new contract for hydropower was signed in 2018. Under the new contract, the Hoover Powerplant provides power to 46 customers across Arizona, California, and Nevada. All contracts are nonfirm, which could impact contractors if droughts result in a further reduction in electric power generation (Reclamation 2007, 2021c).

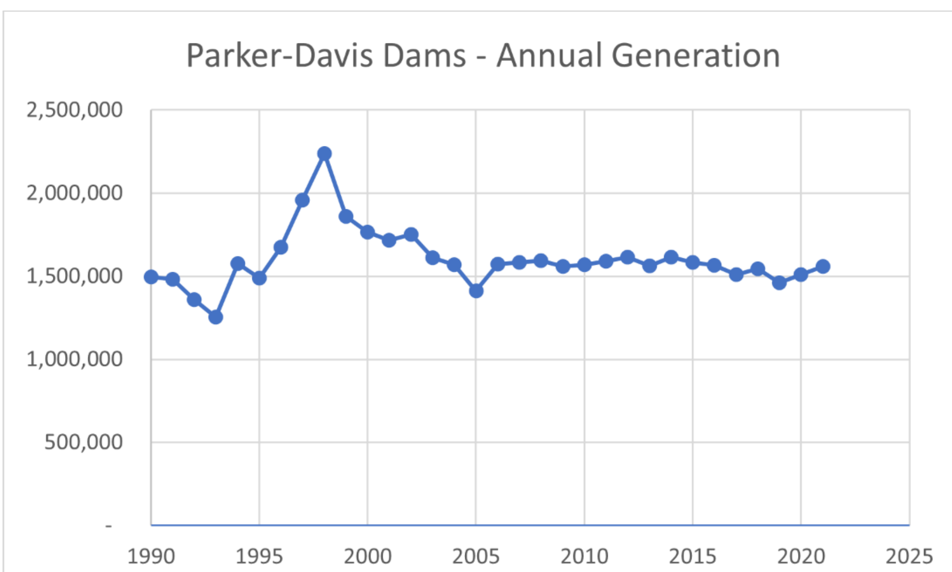
Parker-Davis Project

The Parker-Davis Project consists of the Davis Powerplant with five generators and the Parker Powerplant with four generators (Reclamation 2023h). Since 2007, the Parker-Davis Project facilities have not undergone many significant upgrades. The Parker Powerplant's staff replaced all four turbines between 2004 and 2010. Both powerplants have undergone typical operations and maintenance work since 2007, which has helped with efficiency (Reclamation 2021d).

The drought has had less of an impact on the Parker and Davis Powerplants compared with the Hoover and Glen Canyon Powerplants. This is mostly because the elevations of the lake reservoirs (Lake Havasu above Parker Dam and Lake Mohave above Davis Dam) remain relatively constant. Both dams are run of the river, with some flexibility to control releases (Reclamation 2021d). **Figure 3-50** shows the historical combined annual generation at the Parker and Davis Powerplants.

Due to the relatively constant reservoir elevations, the Parker and Davis Powerplants have had little impact on their capacities. The main impact from drought has been a slight reduction in flows. This reduction in flows has caused a reduction in electric power generation, which has affected the 40 power customers who have contracts with the Parker-Davis Project.

Figure 3-50
Parker-Davis Dam – Annual Generation (MWh)



Source: Reclamation 2023h

Other Small Hydropower Facilities

Several smaller hydropower facilities are below Parker Dam, including Headgate Rock Dam, Senator Wash, Siphon Drop, and Pilot Knob. Headgate Rock Dam is a run-of-the-river powerplant owned and operated by the BIA. Headgate Rock Dam has an elevation protection, resulting in continued generation during the drought. These facilities have been affected only slightly by drought since 2007. Due to the elevation protection and run-of the-river operations, both alternatives would not have a substantial impact on Headgate Rock Powerplant. The other small facilities would not be affected by any of the alternatives and are, therefore, not analyzed further. There are no hydropower facilities adjacent to the Salton Sea; therefore, no impacts on the Salton Sea are analyzed in this section.

Power Funds

Upper Colorado River Basin Fund

The CRSP Act of 1956 (43 USC 620d) established the Upper Colorado River Basin Fund (Basin Fund), which collects revenues from the operation of the CRSP facilities and remains available until expended to carry out the project's purposes and operations. The Basin Fund's financial resources are used to repay costs of original investments and to fund operation and maintenance of CRSP units and the CRSP transmission system. The Basin Fund is the sole source of funds for WAPA and Reclamation's operations and maintenance of CRSP facilities. Money in the Basin Fund can be used to fund various governmental programs (GCDAMP 2020). Maintaining a sufficient Basin Fund balance is critical to operating and maintaining reliable CRSP facilities in delivering water to water users and generating and transmitting power to power customers. Additional contributions and uses of the Basin Fund can be found in Section 3.11.6.1 of the 2007 FEIS (Reclamation 2007); this information is incorporated by reference.

Since the 2007 Interim Guidelines, there have been no changes to the manner in which the Basin Fund operates. WAPA remains responsible for the transmission and marketing of CRSP power, which impacts the finances of the Basin Fund. However, the Basin Fund has been heavily affected by drought conditions. The reduction of power generation has reduced available resources in the Basin Fund (Reclamation 2021d).

Lower Colorado River Power Funds

The Lower Colorado River Basin Funds consist of three separate funds: the Lower Colorado River Basin Development Fund (Development Fund), the Colorado River Dam Fund (Dam Fund), and the Parker-Davis Account. The Development Fund operates in a similar manner to the Basin Fund, the Dam Fund is specifically tied to Hoover Dam and the Boulder Canyon Project, and the Parker-Davis Account is tied to the Parker-Davis Project facilities. The funds help repay the CAP, the Lower Colorado River Multi-Species Conservation Program, and the Salinity Control Project (Reclamation 2021d, 2022d). Additional information on how the funds operate can be found in Section 3.11.6.2 of the 2007 FEIS (Reclamation 2007) and is incorporated by reference.

All three funds have been affected by drought conditions since 2007, but the decrease in financial resources has been manageable. These reductions in financial resources have affected money delivered to the CAP, the Lower Colorado River Multi-Species Conservation Program, and the Salinity Control Project (Reclamation 2021d).

Table 3-44 and **Table 3-45** show the amount of money spent on governmental programs from 2015 to 2020 for Hoover Powerplant and the Parker and Davis Powerplants, respectively.

Table 3-44
Historical Revenue Collections at Hoover Powerplant

Fiscal Year	2015	2016	2017	2018	2019	2020
Lower Colorado River Multi-Species Conservation Program ($1,000 per year)	0.0	0.0	0.0	2,227	2,447	2,547
Development Fund – Arizona ($1,000)	3,543	3,131	2,245	2,865	3,444	2,975
Salinity Control Project – California and Nevada ($1,000)	6,568	7,260	7,328	6,590	6,747	6,583

Source: Reclamation 2021d

Table 3-45
Historical Revenue Collections at Parker-Davis Powerplants

Fiscal Year	2015	2016	2017	2018	2019	2020
Development Fund – Arizona Fund ($1,000)	2,715	2,595	2,844	2,732	2,708	2,895
Salinity Control Project – California and Nevada ($1,000)	1,560	1,576	1,451	1,512	1,632	1,475

Source: Reclamation 2021d

Water Supply Systems

The 2007 Interim Guidelines outline three water supply systems that operate from Lake Powell to Lake Mead: the Navajo Generating Station, the City of Page Water Supply Intake, and the Southern Nevada Water Authority Lake Mead Intake. Since the 2007 Interim Guidelines, the Navajo Generating Station has been decommissioned and is no longer withdrawing water from Lake Powell. The City of Page Water Supply Intake at Lake Powell was recently connected to the river outlets, allowing for continued withdrawals down to a lake elevation of 3,370 feet. It withdraws approximately 2,650 af per year, and the City of Page pays the energy costs associated with pumping the water, including operations and maintenance of the pump station. The Southern Nevada Water Authority Intake at Lake Mead was upgraded to allow for water withdrawals down to a reservoir elevation of 825 feet. There have been no changes in operations since 2007.

Surcharges and Ancillary Services

The 2007 Interim Guidelines provide details on surcharges and ancillary services such as regulation and reserve. Surcharges remain in place and help fund government programs by charging customers surcharges on purchases. Reserves are used to quickly replace lost generation from an outage and in times of high energy demands. Releases from Glen Canyon and Hoover Powerplants have continued to allow for regulation and reserve to operate since 2007. However, drought conditions could potentially drop releases so low that regulation and reserve are no longer possible.

Information on conservation before shortage surcharges, ancillary services, regulation, and reserves can be found in Section 4.11.2.6 of the 2007 FEIS (Reclamation 2007).

3.15.2 Environmental Consequences

This section analyzes the potential effects of the Proposed Action on electrical power (or hydropower) resources. The following issues are addressed:

- Impacts on power generation from changes in lake reservoir elevations and releases
- Impacts on the economic value from changes in power generation
- Effects on Upper and Lower Colorado Basin Funds
- Impacts on government programs

Methodology

Reclamation, with the assistance of WAPA, conducted a study of the potential effects of the No Action Alternative and the Proposed Action on electrical power resources of the Colorado River system that included all major facilities. Reclamation's CRMMS modeling results helped develop potential releases, reservoir elevations, power generation D, and economic impacts from the alternatives. WAPA's GTMax modeling was used to further analyze impacts on the Glen Canyon Powerplant. The results of these analyses are used throughout this section. All tables in this section were produced using results from either the CRMMS or GTMax modeling results.

Impact Analysis Area

The analysis area includes every major hydropower facility along the Colorado River, from Lake Powell to the SIB. Facilities include the Glen Canyon Powerplant, Hoover Powerplant, Davis Powerplant, and Parker Powerplant. The impact analysis for Parker and Davis Powerplants has been combined because these facilities operate very similarly. Other smaller facilities along the river include Headgate Rock Powerplant, Senator Wash, Siphon Drop, and Pilot Knob. These smaller facilities would not be substantially affected by the alternatives and have, therefore, been removed from further analysis.

Assumptions

There were several assumptions made during the modeling process. The assumptions from the CRMMS modeling of the Upper and Lower Basin are covered in **Section 3.3**, Methodology, with additional information in **Section 3.6**, Hydrologic Resources, and **Appendix D**, CRMMS Model Documentation. Following the CRMMS modeling of the Upper Basin, the GTMax modeling was used for releases from Glen Canyon Dam. Results from the GTMax modeling are only calculated for 1 week each month and then replicated for every week of the month. The CRMMS and GTMax models included estimates of the economic value of electrical energy for each dam. Economic impacts on the various basin funds and federal programs can be difficult to accurately model. A qualitative analysis of the impacts is based on the economic value of electrical energy model results.

Impact Indicators

Electrical power resources are typically evaluated based on hydrologic and economic conditions. The following indicators were used for the analysis:

- Reservoir elevation changes determine the amount of head available, which controls both energy and capacity. Monthly reservoir elevation data were used at Lake Powell, Lake Mead, Lake Havasu, and Lake Mohave.
- Penstock water releases are what power the powerplant turbines and lead to power generation. The CRMMS model estimates monthly releases in the Upper and Lower Colorado Basin. The GTMax model estimates hourly releases at Glen Canyon Dam.
- The economic value of electrical energy is an estimation of economic value at each dam. The value is calculated using modeled generation, capacity, rates, and other economic indicators. These values help analyze impacts on operations, basin funds, and customers.

Issue 1: How would lake reservoir elevations and releases impact power generation?

The electrical power-generation analysis is derived from the GTMax model for the Upper Basin and the CRMMS model for the Lower Basin. These models simulate releases and lake reservoir elevations to calculate an estimated generation. Using the modeled annual elevations and releases, the median, 10th, and 90th percentile annual energy-generation statistics were calculated from operating years 2024–2026 for Glen Canyon, Hoover, Parker, and Davis Powerplants using combined data from 80 percent ESP, 90 percent ESP, and 100 percent ESP. These calculations provide an estimated amount of annual generation under dry hydrologic conditions (minimum and 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile and maximum).

Summary

Compared with the No Action Alternative, the Proposed Action results in varying degrees of impacts on Glen Canyon Powerplant. In 2024, the Proposed Action would outperform the No Action Alternative under all but the wettest hydrologic conditions. The differences in 2024 would be minimal when compared to the total hydropower generation at Glen Canyon Powerplant. The Proposed Action would continue to outperform the No Action Alternative under the driest conditions, particularly in 2026 when the No Action Alternative has the potential for dropping below minimum power pool and the Proposed Action would greatly outperform the No Action Alternative. However, in 2026 under dry conditions when the No Action Alternative does not drop below power pool, the No Action Alternative would outperform the Proposed Action due to the higher releases from Lake Powell. Under the wettest hydrologic conditions, the No Action Alternative outperforms the Proposed Action in all 3 operating years. This difference is due to the higher releases from Glen Canyon Powerplant under the No Action Alternative. The difference is more varied around the typical hydrologic scenarios due to the possibility of the dams releasing under different Operational Tiers. The differences are not substantially different until 2026, under the driest and wettest hydrologic scenarios. The difference was calculated by subtracting the estimated annual generation of the action alternative from the estimated annual generation of the No Action Alternative. This was repeated for every year and every statistical scenario. **Table 3-46** shows the difference in Glen Canyon Powerplant generation under each action alternative compared with the No Action Alternative.

Table 3-46
Difference in Glen Canyon Powerplant Annual Energy Generation (MWh) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	6,336	5,833	5,325	13,201	-25,181
2025	75,244	6,326	-132,360	-12,522	-93,521
2026	754,572	-181,065	-98,764	15,476	-280,072
Total	**836,153**	**-168,905**	**-225,799**	**16,156**	**-398,774**

Source: WAPA 2023

Reduced annual releases at the Hoover Powerplant under the Proposed Action would result in a decrease in generation across all hydrologic scenarios. The impacts would be greater in 2024 with diminishing impacts through 2025–2026. Under dry and typical hydrologic conditions, the Proposed Action begins to outperform the No Action Alternative in 2026. **Table 3-47** shows the difference in Hoover Powerplant generation under each action alternative compared with the No Action Alternative. The difference was calculated by subtracting the estimated annual generation of the Proposed Action by the estimated annual generation of the No Action Alternative.

Table 3-47
Difference in Hoover Powerplant Annual Energy Generation (MWh) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	-230,740	-214,646	-218,260	-207,873	-209,390
2025	-80,220	-56,763	-101,470	-111,232	-132,850
2026	2,880	78,691	23,370	-7,864	-129,220
Total	**-308,080**	**-192,718**	**-296,360**	**-326,969**	**-471,460**

Source: Reclamation 2023i

Reduced annual releases at both Parker and Davis Powerplants under the Proposed Action would result in a combined decrease in generation across all hydrologic scenarios. While elevations would be protected to ensure power generation can continue, the reduced releases would impact generation. **Table 3-48** shows the difference in Parker-Davis Powerplants' combined generation under each action alternative compared with the No Action Alternative. The difference was calculated by subtracting the estimated annual generation of the Proposed Action from the estimated annual generation of the No Action Alternative.

Table 3-48
Difference in Parker-Davis Powerplants Annual Energy Generation (MWh) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	-108,269	-108,013	-106,629	-106,486	-100,908
2025	-91,075	-79,551	-83,219	-82,586	-81,160
2026	-48,190	-37,193	-41,150	-47,411	-53,765
Total	**-247,534**	**-224,757**	**-230,998**	**-236,483**	**-235,833**

Source: Reclamation 2023i

Overall, the Proposed Action would result in less generation under all but the driest hydrologic conditions when compared to the No Action Alternative. This is the result of lower release volumes throughout the system. Under the driest hydrologic conditions, the No Action Alternative has the potential to drop below power pool at the Glen Canyon Powerplant in 2026, which would result in the Proposed Action substantially outperforming the No Action Alternative. In every other scenario, lower reservoir releases would result in decreased generation under the Proposed Action. Under most hydrologic conditions, decreases in power generation would occur at the highest rates in 2024 and diminish over the lifetime of the SEIS. **Table 3-49** shows the total difference in energy generation across all four powerplants analyzed.

Table 3-49
Total Difference in Annual Energy Generation (MWh) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	-332,673	-316,826	-319,564	-301,158	-335,479
2025	-96,051	-129,988	-317,049	-206,340	-307,531
2026	709,262	-139,567	-116,544	-39,799	-463,057
Total	**280,539**	**-586,380**	**-753,157**	**-547,296**	**-1,106,067**

Source: Reclamation 2023i; WAPA 2023

No Action Alternative

Under the No Action Alternative, annual releases from Lake Powell and Lake Mead would continue as outlined in the 2007 Interim Guidelines. At these rates, under the driest hydrologic conditions, there is a potential for water elevations to drop below the minimum power pool at Lake Powell. There were no modeled outcomes that resulted in reservoir elevations at Lake Mead dropping below minimum power pool. Elevation protections at Parker and Davis Dams would allow generation to continue; however, it would drop significantly as releases decrease.

The following tables show the values for annual energy generation at the four analyzed powerplants for the operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled annual generation values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of generation over the 3 years analyzed.

Table 3-50 shows the annual generation at Glen Canyon Powerplant under the No Action Alternative. Under the driest hydrologic conditions, reservoir elevations drop below minimum power pool at certain times during 2026, resulting in a complete halt in generation during these times. Under more typical hydrologic conditions, generation would continue at a rate that is relatively stable but still well below historical rates, as shown in **Figure 3-47**. Under wetter hydrologic conditions, generation at Glen Canyon Dam would increase over the 3 operating years due to the potential for higher releases.

Table 3-50
No Action Alternative – Glen Canyon Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,892,718	2,981,905	3,089,765	3,250,747	3,799,233
2025	2,252,933	2,862,174	3,742,452	4,155,556	5,707,082
2026	454,455	2,781,503	3,785,988	4,347,656	7,331,062

Source: WAPA 2023

Table 3-51 shows annual generation at Hoover Powerplant under the No Action Alternative. Under the drier hydrologic conditions, generation decreases over time with the reduction in reservoir elevation and releases. Generation remains relatively stable under typical and wet conditions for the 3 operating years. There is no likelihood of generation going to zero under any conditions.

Table 3-51
No Action Alternative – Hoover Dam Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,729,760	2,996,873	3,152,860	3,286,199	3,522,870
2025	2,583,500	2,812,435	3,083,350	3,337,283	3,590,920
2026	2,361,180	2,647,398	3,082,195	3,428,333	3,908,150

Source: Reclamation 2023i

Table 3-52 shows annual combined generation for the Parker and Davis Powerplants under the No Action Alternative. Due to the elevation protections at both dams, generation is able to continue at a relatively constant rate across most hydrologic conditions. There would be minor changes in generation across the hydrologic scenarios but negligible changes throughout the 3 operating years. These trends mirror those found at the Hoover Dam.

Table 3-52
No Action Alternative – Parker-Davis Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,308,158	1,409,140	1,476,437	1,541,944	1,661,481
2025	1,313,909	1,394,663	1,475,690	1,547,319	1,669,437
2026	1,285,039	1,377,969	1,463,771	1,549,229	1,679,770

Source: Reclamation 2023i

Table 3-53 shows the combined total annual generation across all four powerplants under the No Action Alternative. The trend under the drier hydrologic conditions typically decreases in generation over the 3-year operating period. Under the typical and wet hydrologic conditions, the trend increase each year.

Table 3-53
No Action Alternative – Total Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	6,930,636	7,387,918	7,719,062	8,078,890	8,983,584
2025	6,150,342	7,069,272	8,301,492	9,040,158	10,967,439
2026	4,100,674	6,806,870	8,331,954	9,325,218	12,918,982

Source: Reclamation 2023i; WAPA 2023

Proposed Action

Under the Proposed Action, additional SEIS conservations would occur below the Glen Canyon Dam. There would also be protections at Lake Powell to avoid dropping below minimum power pool. This Action would have a varying impact on Glen Canyon Powerplant under different hydrologic conditions. The more substantial impacts would be seen at the Hoover and Parker-Davis Powerplants due to the additional SEIS conservation.

The following tables show the values for annual energy generation at the four analyzed powerplants for operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled annual generation values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of generation over the 3 years analyzed.

Table 3-54 shows the values for annual energy generation at the Glen Canyon Powerplant for operating years 2024–2026 under the Proposed Action. Under the drier hydrologic conditions, generation would decrease annually over the course of the operating period with a substantial decrease in 2026 under the driest conditions due to the declining releases associated with the elevation protections. However, the protections at Lake Powell would protect minimum power pool and allow for continued generation even at a lower rate. Under typical and wet conditions, trends mirror the No Action Alternative with increases each year.

Table 3-54
Proposed Action – Glen Canyon Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,899,055	2,987,738	3,095,090	3,263,948	3,774,052
2025	2,328,177	2,868,501	3,610,092	4,143,034	5,613,562
2026	1,209,028	2,600,438	3,687,223	4,363,132	7,050,990

Source: WAPA 2023

Table 3-55 shows the annual generation at Hoover Powerplant under the Proposed Action. Generation would be lowest under dry conditions and higher under wet conditions, similar to the No Action Alternative. Generation under dry hydrologic conditions would be slightly variable year to year. Under typical and wet conditions, generation would increase each operating year. There would be no likelihood of generation going to zero under any conditions.

Table 3-55
Proposed Action – Hoover Powerplant Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	2,499,020	2,782,227	2,934,600	3,078,326	3,313,480
2025	2,503,280	2,755,672	2,981,880	3,226,051	3,458,070
2026	2,364,060	2,726,089	3,105,565	3,420,469	3,778,930

Source: Reclamation 2023i

Table 3-56 shows the annual combined generation at Parker and Davis Powerplants under the Proposed Action. Generation would lowest under dry conditions and higher under wet conditions, similar to the No Action Alternative. Under any hydrologic condition, generation would slowly increase each operating year.

Table 3-56
Proposed Action – Parker-Davis Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	1,199,889	1,301,127	1,369,808	1,435,458	1,560,573
2025	1,222,834	1,315,112	1,392,471	1,464,733	1,588,277
2026	1,236,849	1,340,776	1,422,621	1,501,818	1,626,005

Source: Reclamation 2023i

Table 3-57 shows the total combined annual generation across all four powerplants under the Proposed Action. The drier scenarios show annual decreases, with a substantial impact under the driest conditions in 2026 due to the likelihood of dropping below minimum power pool at Lake Powell. Generation would increase annually under typical and wet conditions.

Table 3-57
Proposed Action – Total Annual Energy Generation

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	6,597,964	7,071,092	7,399,498	7,777,732	8,648,105
2025	6,054,291	6,939,285	7,984,443	8,833,818	10,659,909
2026	4,809,937	6,667,303	8,215,409	9,285,419	12,455,925

Source: Reclamation 2023i; WAPA 2023

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options could result in an impact in power generation at the Glen Canyon Powerplant. If implemented, some of the flow options could alter how water is released through Glen Canyon Dam by releasing water through the river outlets as opposed to the power-generating penstocks. This could result in a cumulative negative impact on power generation across all alternatives outlined in this SEIS. The changes in sediment accounting windows could have impacts on hydropower generation at the Glen Canyon Powerplant. HFEs at different times of year could result in some impacts on generation. These impacts would not be outside of the range analyzed in LTEMP. Annual volume releases from Lake Powell would not change under the LTEMP SEIS; therefore, no additional impacts would occur at any downstream powerplants.

No cumulative effects would occur on power generation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would changes in lake reservoir elevations impact capacity?

The capacity analysis is derived from the GTMax model for the Upper Basin and the CRMMS model for the Lower Basin. These models simulate lake reservoir elevations and generator availability to calculate an estimated capacity. Using the modeled annual elevations and unit availability, the median, 10th, and 90th percentile monthly capacity statistics were calculated for operating years 2024–2026 for Glen Canyon, Hoover, Parker, and Davis Powerplants using combined data from 80 percent ESP, 90 percent ESP, and 100 percent ESP. These calculations provide an estimated amount of annual capacity under dry hydrologic conditions (minimum and 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile and maximum). WAPA and Reclamation used the estimated capacity for the month of August as a yearly representation due to the peak energy demands and available capacity during that month.

The capacity at the Parker and Davis Powerplants does not fluctuate greatly due to the lake reservoir elevation protections. It is expected that these capacities will remain relatively constant across all alternatives. Therefore, the Parker and Davis Powerplants are not included in the capacity analysis.

Summary

Compared with the No Action Alternative, the Proposed Action would result in minor variations in capacity at Glen Canyon Powerplant under all but the most extreme hydrologic scenarios. The differences are primarily due to the differences in lake elevation and releases. Overall, the differences are relatively minor across most years and under most hydrologic conditions. The No Action Alternative outperforms the Proposed Action in 2025 under the driest and wettest hydrologic scenarios by 154 and 125 MW respectively. The Proposed Action would outperform the No Action Alternative in 2026 by 207 MW, due to the potential for the No Action Alternative to drop below minimum power pool. The difference was calculated by subtracting the estimated August capacity of the action alternative from the estimated August capacity of the No Action Alternative. This was repeated for every year and every statistical scenario. **Table 3-58** shows the difference in Glen Canyon Powerplant capacity under each action alternative compared with the No Action Alternative.

Table 3-58
Difference in Glen Canyon Powerplant August Capacity (MW) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	2	1	2	8	6
August 2025	-154	-1	3	-8	-125
August 2026	207	-21	1	22	19

Source: WAPA 2023

Lake reservoir elevations at Lake Mead are variable across the different hydrologic conditions, resulting in variable capacity differences between alternatives. Under all hydrologic conditions the Proposed Action would outperform the No Action Alternative across all 3 operating years. The amount of difference is variable, with the Proposed Action outperforming the No Action Alternative in 2025–2026 under dry hydrologic conditions. **Table 3-59** shows the difference in Hoover Powerplant capacity under the Proposed Action compared with the No Action Alternative. The difference was calculated by subtracting the estimated August capacity of the Proposed Action from the estimated August capacity of the No Action Alternative.

Table 3-59
Difference in Hoover Powerplant August Capacity (MW) Compared with the No Action Alternative

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	45	47	45	39	62
August 2025	90	89	79	36	27
August 2026	66	115	92	49	16

Source: Reclamation 2023i

No Action Alternative

Under the No Action Alternative, annual operations at Lake Powell and Lake Mead would continue as outlined in the 2007 Interim Guidelines. At these operations, under the driest hydrologic conditions, there is potential for Lake Powell's reservoir elevations to drop below minimum power pool, which would result in a complete loss of capacity.

The following tables show the values for August capacity at Glen Canyon and Hoover Powerplants for operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled August capacity values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of potential capacity over the 3 years analyzed.

Table 3-60 shows the August capacity at Glen Canyon Powerplant under the No Action Alternative. Under drier hydrologic conditions, lake elevations drop, resulting in less capacity compared with the wetter hydrologic scenarios. Under more typical and wetter hydrologic conditions, capacity would increase over the operating period as Lake Powell would begin to fill and lake reservoir elevations would increase.

Table 3-60
No Action Alternative – Glen Canyon August Capacity

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	430	458	495	550	602
August 2025	364	447	567	655	1,108
August 2026	0	433	569	666	1,116

Source: WAPA 2023

Table 3-61 shows August capacity at Hoover Powerplant under the No Action Alternative. Similar to Glen Canyon, under dry hydrologic conditions, the lake elevation would decline, resulting in diminished capacity, with the potential for elevations to continue to drop over the 3-year period. Under typical or wet hydrologic conditions, capacity would be maintained at a relatively similar rate across the 3 operating years. The wettest hydrologic conditions would result in a large increase in capacity in 2026.

Table 3-61
No Action Alternative – Hoover Dam August Capacity

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	1150	1170	1217	1291	1352
August 2025	1034	1078	1204	1327	1399
August 2026	890	990	1203	1351	1603

Source: Reclamation 2023i

Proposed Action

Under the Proposed Action, actions would be taken to maintain an elevation of 3,500 feet at Lake Powell, allowing for continued capacity at Glen Canyon Powerplant even under the driest hydrologic conditions. This alternative would include protections to avoid dropping below the minimum power pool at Glen Canyon Dam. However, protecting elevations at Lake Powell under the drier conditions could result in a decrease in elevation at Lake Mead in operating year 2026.

The following tables show the values for August capacity at Glen Canyon and Hoover Powerplants for operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled August capacity values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of capacity over the 3 years analyzed.

Table 3-62 shows the values for August capacity at the Glen Canyon Powerplant for operating years 2024–2026 under the Proposed Action. Capacity would continue in August across all hydrologic conditions due to the elevation protection at Lake Powell. However, under the drier conditions, capacity would continue to drop over the 3-year operating period due to decline lake elevations. Under typical and wetter conditions, capacity would increase over the operating period as lake elevations rise.

Table 3-62
Proposed Action – Glen Canyon August Capacity

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	432	459	497	558	608
August 2025	210	446	570	647	983
August 2026	207	412	570	688	1,135

Source: WAPA 2023

Table 3-63 shows the August capacity at Hoover Powerplant under the Proposed Action. Under the drier hydrologic conditions, the capacity at Hoover Dam would be low due the low reservoir elevation and would continue to decrease over the 3-year period. The capacity would be higher under each wetter hydrologic condition and would continue to increase over the 3-year period. This would be the result of maintained higher reservoir elevations.

Table 3-63
Proposed Action – Hoover Powerplant August Capacity

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
August 2024	1195	1217	1261	1329	1415
August 2025	1124	1167	1283	1364	1426
August 2026	957	1105	1295	1400	1619

Source: Reclamation 2023i

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options could result in an impact to power capacity at the Glen Canyon Powerplant during the implementation of these flow options. If one of the flow options were to be implemented, water could be released through the river outlets as opposed to the power-generating penstocks. This could result in additional operating constraints during these flow periods. The cumulative negative impact on capacity could occur across all alternatives outlined in this SEIS. These impacts would be temporary—only occurring during the timeframe the flow options were implemented—and would not impact capacity outside of these periods. The changes in sediment account windows could have minimal temporary impacts on capacity at the Glen Canyon Powerplant. Changes in when HFEs occur would change capacity during these events. The amount and magnitude of the HFEs would be within the bounds analyzed in LTEMP. Annual volume releases from Lake Powell would not change; therefore, no additional impacts would occur at any downstream powerplants.

No cumulative effects would occur on hydropower capacity due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 3: How would changes in power generation and capacity impact the economic value of electrical energy?

The economic value of electrical energy analysis is also derived from the GTMax model for the Upper Basin and the CRMMS model for the Lower Basin. Given the calculated energy generation and capacity, estimates can be made on the average annual economic value of electrical energy for each powerplant. Economic modeling from Reclamation and WAPA uses an hourly operation schedule that maximizes the economic value of hydropower generation. Hourly pricing data used in WAPA's study are derived from the Palo Verde hub and supplemented by other sources. Using the modeled energy-generation values, the minimum, median, maximum, 10th percentile, and 90th percentile annual economic value of electrical energy statistics were calculated for operating years 2024 to 2026 for the Glen Canyon, Hoover, Parker, and Davis Powerplants using combined data from 80 percent ESP, 90 percent ESP, and 100 percent ESP. These calculations provide an estimated amount of annual hydropower value under dry hydrologic conditions (minimum and 10th percentile), typical conditions (median), and wet hydrologic conditions (90th percentile and maximum).

In addition to the economic modeling, WAPA also conducted an analysis on impacts on rates for the Salt Lake City Area/Integrated Projects (SLCA/IP). This analysis on rates is included at the end of this issue.

Summary

The Proposed Action would result in varied economic value of electrical energy at Glen Canyon Powerplant when compared with the No Action Alternative. The difference would be larger under the driest hydrologic scenarios due to the likelihood of dropping below minimum power pool under the No Action Alternative in 2026. The remaining hydrologic scenarios are more varied but generally see the No Action Alternative slightly outperform the Proposed Action, particularly in operating year 2026. The additional protections at Lake Powell under the Proposed Action would result in slightly lower releases, which would decrease the economic value of electrical energy when compared to the No Action. These differences are relatively small when compared to the long-term revenues. For example, the total difference in economic value under typical hydrologic conditions shows the No Action Alternative outperforming the Proposed Action by $8,554,000; this would only be a 4.8 percent decrease in the annual revenue from the SLCA/IP annual revenue from 2021 (WAPA, 2021). **Table 3-64** shows the difference in the Glen Canyon Powerplant under the Proposed Action when compared with the No Action Alternative.

Table 3-64
Difference in the Glen Canyon Powerplant's Economic Value of Electrical Energy Compared with the No Action Alternative (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$509	$461	$403	$1,675	-$2,387
2025	-$11,984	$476	-$4,693	-$375	-$13,459
2026	$64,575	-$12,458	-$4,265	$4,256	-$10,181
Total	**$53,100**	**-$11,521**	**-$8,554**	**$5,557**	**-$26,027**

Source: WAPA 2023

Reduced generation under the Proposed Action would result in a decrease in total economic value of electrical energy across all hydrologic scenarios at the Hoover Powerplant when compared with the No Action Alternative. The difference would be largest under the wetter hydrologic conditions due to the additional value from higher releases under the No Action Alternative. While these differences are greater than those at Glen Canyon Powerplant, they are still relatively small compared to annual revenue. **Table 3-65** shows the difference in the Hoover Powerplant under the Proposed Action when compared with the No Action Alternative.

Table 3-65
Difference in the Hoover Powerplant's Economic Value of Electrical Energy Compared with the No Action Alternative (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	-$23,912	-$22,591	-$22,864	-$22,434	-$22,688
2025	-$4,915	-$4,685	-$9,708	-$12,847	-$15,285
2026	$389	$10,821	$3,489	-$4,546	-$17,940
Total	**-$28,438**	**-$16,455**	**-$29,083**	**-$39,827**	**-$55,913**

Source: Reclamation 2023i

The combined reduced generation under the Proposed Action would result in a decrease in the economic value of electrical energy across all hydrologic scenarios at the Parker and Davis Powerplants when compared with the No Action Alternative. The decrease in value would be very consistent between hydrologic conditions. Decreases would begin to diminish over the 3-year period. **Table 3-66** shows the difference in the combined Parker and Davis Powerplants under the Proposed Action when compared with the No Action Alternative.

Table 3-66
Change in the Parker-Davis Powerplants' Economic Value of Electrical Energy Compared with the No Action Alternative (Thousands of Dollars)

Year	Minimum	10^{th} Percentile	Median	90^{th} Percentile	Maximum
2024	-$11,856	-$12,012	-$11,821	-$11,714	-$11,303
2025	-$10,454	-$9,383	-$9,621	-$9,614	-$9,615
2026	-$6,302	-$5,644	-$6,048	-$6,559	-$7,166
Total	**-$28,612**	**-$27,039**	**-$27,490**	**-$27,887**	**-$28,084**

Source: Reclamation 2023i

Table 3-67 combines the total economic value of electrical energy for all four powerplants to analyze overall economic impacts under the Proposed Action when compared with the No Action Alternative. The No Action Alternative outperforms the Proposed Action under all hydrologic conditions. The greatest differences are found in the wettest hydrologic conditions due to the higher releases at both Glen Canyon and Hoover Dams. The only time when the Proposed Action outperforms the No Action Alternative is under the driest conditions during operating year 2026 at Lake Powell when the No Action Alternative has the potential dropping below minimum power pool.

Table 3-67
Total Change in the Economic Value of Electrical Energy Compared with the No Action Alternative (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	-$35,259	-$34,142	-$34,282	-$32,473	-$36,378
2025	-$27,353	-$13,592	-$24,022	-$22,836	-$38,359
2026	$58,662	-$7,281	-$6,824	-$6,849	-$35,287
Total	**-$3,950**	**-$55,015**	**-$65,127**	**-$62,157**	**-$110,024**

Source: Reclamation 2023i; WAPA 2023

No Action Alternative

Under the No Action Alternative, annual releases from Lake Powell and Lake Mead would continue as outlined in the 2007 Interim Guidelines. At these rates, the likelihood of water elevations dropping below the minimum power pool at Lake Powell increases. As lake elevations decline, generation and capacity would decrease and halt as soon as elevations drop below the minimum power pool. Economic value of electrical energy trends typically mirror generation and capacity trends; therefore, when generation and capacity are reduced or stop, the economic value of electrical energy is also reduced or halted. Therefore, the economic value of electrical energy is much lower under low hydrologic scenarios.

The following tables show the annual economic value of electrical energy at the four analyzed powerplants for operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled annual generation values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of economic value of electrical energy over the 3 years analyzed.

Table 3-68 shows the annual economic value of electrical energy at the Glen Canyon for operating years 2024–2026 under the No Action Alternative. Under the drier hydrologic conditions, the economic value of electrical energy decreases annually over the operating period. Generation and capacity are near or below minimum power pool under the driest hydrologic conditions in 2026, resulting in a near or complete halt in total hydropower value. At typical and wet hydrologic conditions, the economic value of electrical energy increases annually over the 3-year operating period.

Table 3-68
No Action Alternative – Glen Canyon Dam Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$224,591	$233,241	$245,110	$261,680	$300,694
2025	$181,657	$219,699	$285,810	$317,923	$483,331
2026	$42,894	$208,929	$283,265	$325,065	$566,485
Total	**$449,142**	**$661,869**	**$814,185**	**$904,668**	**$1,350,510**

Source: WAPA 2023

Revenue from the Hoover Powerplant customer contracts is set each year. However, impacts from decreases in generation and capacity are still felt. When generation and capacity are reduced or halted, the impacts on electrical energy value are still substantial. The wetter hydrologic scenarios result in consistent economic value of electrical energy through the 3 operating years. In the typical and drier hydrologic scenarios, the economic value of electrical energy is substantially affected by the reduction in generation and capacity. These drier scenarios also see a continued decrease in value over the 3-year operating period. **Table 3-69** shows the annual economic value of electrical energy for Hoover Powerplant under the No Action Alternative.

Table 3-69
No Action Alternative – Hoover Dam Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$360,784	$387,085	$404,852	$422,404	$449,904
2025	$333,570	$358,756	$391,697	$424,177	$454,242
2026	$295,801	$329,456	$383,887	$427,496	$489,071
Total	**$990,155**	**$1,075,297**	**$1,180,436**	**$1,274,077**	**$1,393,217**

Source: Reclamation 2023i

Revenue from the combined Parker and Davis Powerplants' customer contracts is set each year and impacts from decreases in generation and capacity are much less compared with the Glen Canyon and Hoover Powerplants. The Parker and Davis Powerplants have low but variable revenue over the 3-year period under the driest hydrologic conditions. The revenue increases with each wetter scenario. However, each scenario does show decreases over the 3-year operating period. **Table 3-70** shows the combined annual economic value of electrical energy for Parker and Davis Powerplants under the No Action Alternative.

Table 3-70
No Action Alternative – Parker-Davis Dams Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$124,798	$133,904	$140,161	$146,394	$158,147
2025	$122,542	$129,318	$136,762	$143,419	$155,210
2026	$116,295	$124,298	$132,115	$139,681	$151,975
Total	**$363,635**	**$387,520**	**$409,038**	**$429,494**	**$465,332**

Source: Reclamation 2023i

Table 3-71 shows the combined total economic value of electrical energy across all four powerplants under the No Action Alternative. The trend typically mirrors those from Glen Canyon, as they exhibit the dominant changes across hydrologic scenarios and operating years. The driest hydrologic scenario results in a substantial decrease in hydropower value each year as Lake Powell approaches and drops below minimum power pool.

Table 3-71
No Action Alternative – Total Annual Economic Value of Electrical Power (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$710,173	$754,230	$790,123	$830,478	$908,745
2025	$637,769	$707,773	$814,269	$885,519	$1,092,783
2026	$454,990	$662,683	$799,267	$892,242	$1,207,531
Total	**$1,802,932**	**$2,124,686**	**$2,403,659**	**$2,608,239**	**$3,209,059**

Source: Reclamation 2023i; WAPA 2023

Proposed Action

Under the Proposed Action, power generation and capacity at the Glen Canyon Powerplant would vary under different hydrologic conditions, resulting in varying impacts on the economic value of electrical energy. The economic value of electrical energy at the Hoover Powerplant would decrease as lake elevations and releases decline at Lake Mead. Revenue from generation at Parker and Davis Powerplants would remain relatively consistent but would also decrease as releases decline.

The following tables show the annual economic value of electrical energy at the four analyzed powerplants for operating years 2024–2026. These values represent the minimum, maximum, median, 10th percentile, and 90th percentile of the modeled annual generation values. These values represent dry hydrologic scenarios (minimum and 10th percentile), typical conditions (median), and wet hydrologic scenarios (90th percentile and maximum). These tables help show the trend of hydropower value over the 3 years analyzed.

Table 3-72 shows the values for the annual economic value of electrical energy at the Glen Canyon Powerplant for operating years 2024–2026 under the Proposed Action. Under the drier hydrologic conditions, the economic value of electrical energy would decline annually as lake elevations and releases continue to drop. The wetter conditions would show annual increases in the economic value of electrical energy. These trends mirror lake elevation and release trends outlined in **Section 3.6**.

Table 3-72
Proposed Action – Glen Canyon Dam Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$225,100	$233,702	$245,514	$263,355	$298,307
2025	$169,673	$220,175	$281,117	$317,548	$469,871
2026	$107,469	$196,471	$279,000	$329,321	$556,305
Total	**$502,242**	**$650,348**	**$805,631**	**$910,224**	**$1,324,484**

Source: WAPA 2023

Table 3-73 shows the annual economic value of electrical energy at the Hoover Powerplant under the Proposed Action. The economic value of electrical energy would be lowest under the drier hydrologic conditions and would continue to decrease over the 3-year operating period. The typical hydrologic conditions would show consistent value, with a slight uptick in operating year 2026. The wetter hydrologic scenarios would show higher total hydropower value that increases with each operating year. Alternative sources of revenue, such as visitor fees to Hoover Dam, would continue; however, these are only targeted to be enough to cover the cost of visitor services.

Table 3-73
Proposed Action – Hoover Dam Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$336,872	$364,494	$381,988	$399,970	$427,216
2025	$328,655	$354,071	$381,989	$411,330	$438,957
2026	$296,190	$340,277	$387,376	$422,950	$471,131
Total	**$961,717**	**$1,058,842**	**$1,151,353**	**$1,234,250**	**$1,337,304**

Source: Reclamation 2023i

Table 3-74 shows the combined annual economic value of electrical energy at the Parker and Davis Powerplants. The combined total economic value of electrical energy would increase with wetter hydrologic conditions. Each scenario would show slight decreases in economic value of electrical energy over the course of the 3-year operating period.

Table 3-74
Proposed Action – Parker-Davis Dams Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$112,942	$121,892	$128,340	$134,680	$146,844
2025	$112,088	$119,935	$127,141	$133,805	$145,595
2026	$109,993	$118,654	$126,067	$133,122	$144,809
Total	**$335,023**	**$360,481**	**$381,548**	**$401,607**	**$437,248**

Source: Reclamation 2023i

Table 3-75 shows the total combined annual economic value of electrical energy across all four powerplants under the Proposed Action. Trends typically mirror Glen Canyon Powerplant, as it shows the most variation in impacts from the Proposed Action. The economic value of electrical energy would decrease annually under the drier hydrologic conditions and increase annually under the typical and wet conditions.

Table 3-75
Proposed Action – Total Annual Economic Value of Electrical Energy (Thousands of Dollars)

Year	Minimum	10th Percentile	Median	90th Percentile	Maximum
2024	$674,914	$720,088	$755,842	$798,005	$872,367
2025	$610,416	$694,181	$790,247	$862,683	$1,054,423
2026	$513,652	$655,402	$792,443	$885,393	$1,172,245
Total	**$1,798,982**	**$2,069,671**	**$2,338,532**	**$2,546,081**	**$3,099,036**

Source: Reclamation 2023i; WAPA 2023

Rates

CRSP estimated the impact of the Proposed Action and No Action Alternative on the SLCA/IP firm power rate. WAPA's CRSP office markets SLCA/IP electrical energy and power as a firm electrical product. Mostly this consists of electrical power from the large CRSP dams. The SLCA/IP rate change requires that WAPA engage in an official rule-making process. The estimated rate impact in **Table 3-76** below does not include all the steps and processes that would be included in an official rate proceeding. These numbers are for comparative purposes only.

Expenses constitute the numerator in the calculation of the SLCA/IP rate. This number is divided by the expected number of KWhs WAPA expects to sell in a year. The result (expenses divided by sales) gives the revenue requirement per KWh sold: the SLCA/IP rate. For expenses, WAPA used the current proposed expenses from its 206 rate process for the years 2024–2026. For the expected sales for each year, WAPA used the generation numbers it modeled for the No Action Alternative and the Proposed Action.

Table 3-76
SLCA/IP Firm Electric Service Impacts

No Action Alternative	Composite Rate ($/MWh)	Difference between Alternatives	Percent Difference
2024	31.75	0.04	0.13%
2025	30.68	-0.21	-0.68%
2026	29.91	-0.07	-0.23%
Average	30.78	-0.08	-0.26%
Proposed Action			
2024	31.71	-0.04	-0.13%
2025	30.89	0.21	0.68%
2026	29.98	0.07	0.23%
Average	30.86	0.08	0.26%

Source: WAPA 2023

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options could result in a decrease in power generation and capacity—and, therefore, economic value—of electrical energy at the Glen Canyon Powerplant if flows typically released through the penstocks are rerouted through the river outlet works. The reduction in generation could be offset by the purchase of replacement power. These operational changes would have no impacts on the economic value of hydropower at Hoover, Parker, or Davis Powerplants.

Changes in when HFEs occur would change the economic value of electrical energy during these events. The amount and magnitude of the HFEs would be within the bounds analyzed in LTEMP. Annual volume releases from Lake Powell would not change; therefore, no additional impacts would occur at any downstream powerplants.

No cumulative effects on power generation, capacity, or (therefore) economic value of electrical energy would occur due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 4: How would changes in economic value of electrical energy impact the various power funds?

The various power funds are operated in different manners and, therefore, are affected differently based on the alternative and the associated revenue. The Basin Fund receives revenue from customers based on contracts and operations at the Glen Canyon Powerplant. The Development Fund receives revenue from customers based on contracts and operations at the Hoover, Parker, and Davis Powerplants. The Dam Fund and Parker-Davis Account receive a set revenue directly from customers based on contracts. Implementation of the various alternatives would likely result in more variation in the power funds and could lead to additional actions, such as power rate adjustments, rate surcharges, or reductions to customer allocations, to respond to shortfalls in revenue under dry conditions.

The following qualitative analysis is based on revenue and economic value of electrical energy modeling associated with each analyzed powerplant under each action alternative. Quantitative impacts are difficult to accurately model.

Summary

Lake Powell has the potential to drop below minimum power pool under the No Action Alternative. Loss of generation would result in multiple severe impacts, including the loss of revenues necessary for the Basin Fund to support critical operations at WAPA and Reclamation. Additional analysis on the impacts from economical changes in electrical energy can be found in **Section 3.16** and **Section 3.17**. Compared with the No Action Alternative, the Proposed Action would result in increased economic value of electrical energy at the Glen Canyon Powerplant under the driest conditions in 2026 and, therefore, would ensure that there would be sufficient resources available in the Basin Fund to support operations and maintenance. The Proposed Action has varying impacts on the economic value of electrical energy under the other hydrologic conditions but would typically negatively impact economic value of electrical energy and therefore the Basin Fund. These impacts would be greatest in 2024 and diminish over the operating period as described in Issue 3.

Compared with the No Action Alternative, the Proposed Action would decrease the economic value of electrical energy at Hoover Dam, resulting in a decrease in financial resources for the Development Fund. Under the Proposed Action, the Parker and Davis Powerplants would also see a decrease in economic value of electrical energy and would continue to impact the Development Fund. The No Action Alternative would allow for greater hydropower value at the Hoover, Parker, and Davis Powerplants and would result in the least number of impacts on the Development Fund.

The Dam Fund and Parker-Davis Account would receive the same amount of revenue from customers under both alternatives and would only be affected by operations and maintenance costs. It can be assumed that the impacts under the Proposed Action would be greater than the impacts under the No Action Alternative due to the decreased releases and economic value of electrical energy.

No Action Alternative

Under the No Action Alternative, the economic value of electrical energy and Basin Fund would decrease annually at the Glen Canyon Powerplant under the drier hydrologic conditions. Elevations of Lake Powell have the potential to drop below the minimum power pool, halting generation and drastically reducing the economic value of electrical energy. Any large reduction or halt in the economic value of electrical energy would have severe impacts on the Basin Fund. Under wetter hydrologic conditions, electrical energy increases annually and would therefore increase the Basin Fund.

The Development Fund would remain relatively unaffected under wet hydrologic scenarios under the No Action Alternative. However, during the driest hydrologic scenarios, economic value of electrical energy could be affected, particularly later in the project timeline, and could result in impacts on the Development Fund.

The Dam Fund and Parker-Davis Account receive a set amount of revenue directly from customers and would only see minor impacts from the No Action Alternative. Reduced generation and capacity at the Hoover Powerplant would have slight impacts on the Dam Fund. The lake reservoir elevation protections at Lake Havasu and Lake Mohave allow for continued generation, capacity, and hydropower value at the Parker and Davis Powerplants. There would be a slight decrease in releases, which would impact the generation and economic value of electrical energy; this would result in minor impacts on the Parker-Davis Account.

Proposed Action

Under the Proposed Action, the economic value of electrical energy would decrease over the operating period under the drier hydrologic conditions. This would result in a decline in the Basin Fund. Maintaining the elevation of Lake Powell at 3,500 feet would allow for the economic value of electrical energy to continue. During wetter hydrologic conditions, the economic value of electrical energy would increase over the operating period, resulting in increases to the Basin Fund.

Under the Proposed Action, Lake Mead reservoir elevations and releases could drop under the dry hydrologic conditions and negatively impact the Development Fund. These impacts would be greater as the operating period progresses. The impacts on the Development Fund would be less under the typical and wetter hydrologic conditions and would decrease over the course of the operating period. These impacts would be slightly exacerbated by the decrease in economic value of electrical energy at the Parker and Davis Powerplants. Overall, the Proposed Action would result in greater impacts on the Development Fund when compared with the No Action Alternative.

The Dam Fund and Parker-Davis Account receive a set amount of revenue directly from customers and would only see minor impacts from the Proposed Action. Reduced economic value of electrical energy at the Hoover Powerplant would have impacts on the Dam Fund. The lake reservoir elevation protections at Lake Havasu and Lake Mohave allow for continued generation, capacity, and hydropower value at the Parker and Davis Powerplants. There would be a slight decrease in releases, which would impact the generation and economic value of electrical energy; this would result in minor impacts on the Parker-Davis Account.

Cumulative Effects

The potential operational changes included in LTEMP SEIS could result in a decrease in the economic value of electrical energy at the Glen Canyon Powerplant and a potential decrease in the associated contributions to the Basin Fund. The further impacts on economic value of electrical energy from the Proposed Action could deepen this decrease in value at Glen Canyon Powerplant. Overall, the Basin Fund would see a decrease in value compared with recent annual values. The LTEMP SEIS would not impact the economic value of electrical energy at the Lower Basin powerplants. Therefore, there would be no additional impacts on other Lower Basin power funds.

No cumulative effects on the economic value of electrical energy would occur due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 5: How would impacts on the basin funds affect other governmental programs?

The various power funds provide funding for multiple governmental programs in the Upper and Lower Colorado Basin, including the Colorado River Basin Salinity Control Program, the CAP, the Lower Colorado River Multi-Species Conservation Program, and other projects, as directed by the Arizona Water Rights Settlements Act. The programs and projects would be directly affected by any changes in financial reserves within the power funds. Some programs are able to receive flexible funding from both Upper and Lower Basin power funds, which could help reduce impacts.

These impacts are difficult to model accurately; therefore, a qualitative analysis has been included based on economic value of electrical energy modeling and impacts on the power funds, as outlined in Issue 4.

Summary

Compared with the No Action Alternative, available funding in the Basin Fund under the Proposed Action would vary widely. Additional economic value under dry hydrologic conditions would help provide funding for the government programs that rely on funding from the Basin Fund. A decrease in economic value under wet hydrologic conditions would hinder the government programs that rely on the Basin Fund. Impacts on the Development Fund and Dam Fund are harder to analyze but would most likely be negatively affected by the Proposed Action under all hydrologic scenarios.

No Action Alternative

Under the No Action Alternative, the Basin Fund and Development Fund would be affected due to reduced economic value of electrical energy from power generation and capacity, particularly in low hydrology scenarios. These impacts would get worse over the course of the operating periods. Funding would increase over the operating period in wetter hydrologic conditions but would still be less than historic values. The Basin Fund provides funding for the Colorado River Basin Salinity Control Program. This program could see reductions in funding from the Basin Fund. The Development Fund helps fund the Lower Colorado River Multi-Species Conservation Program, the Colorado River Basin Salinity Control Program, the CAP, and projects as directed by the Arizona Water Rights Settlements Act. All these programs could see reductions in funding and repayment from the Development Fund.

The Dam Fund and Parker-Davis Account would be less affected under the No Action Alternative compared with the Basin and Development Funds. However, there would be slight impacts on the economic value of electrical energy and therefore contributions to the Dam Fund and the Parker-Davis Account. The Dam Fund and Parker-Davis Account help fund the Lower Colorado River Multi-Species Conservation Program, the Colorado River Basin Salinity Control Program, the CAP, and projects as directed by the Arizona Water Rights Settlements Act. All these programs could see slight reductions in funding and repayment from the Dam Fund and Parker-Davis Account.

Proposed Action

Under the Proposed Action, the Basin Fund would see similar impacts compared with the No Action Alternative. Funding for the Colorado River Basin Salinity Control Program would experience decreased funding. These impacts would be greater compared with the No Action Alternative.

The Development Fund would potentially experience significant impacts on available funding. Available funding would decrease as the reservoir elevation and releases dropped. This would result in a decrease in the economic value of electrical energy and would mean funding would be reduced for the Lower Colorado River Multi-Species Conservation Program, the Colorado River Basin Salinity Control Program, the CAP, and other projects, as directed by the Arizona Water Rights Settlements Act. Impacts on these programs could be worse compared with the No Action Alternative.

Under the Proposed Action, the Dam Fund and Parker-Davis Account would be less affected compared with the Basin and Development Funds. However, there would be impacts on the economic value of electrical energy and therefore contributions to the Dam Fund and Parker-Davis Account. The Dam Fund and Parker-Davis Account help fund the Lower Colorado River Multi-Species Conservation Program, the Colorado River Basin Salinity Control Program, the CAP, and projects, as directed by the Arizona Water Rights Settlements Act. All these programs could experience reductions in funding and repayment from the Dam Fund and Parker-Davis Account.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options could result in a substantial decrease in funds available in the Basin Fund and, therefore, a decrease in available funds for the governmental programs aided by the Basin Fund. The further impacts on economic value of electrical energy from the Proposed Action could worsen the decrease in funds. There would be no additional impacts on the Lower Basin funds and the governmental programs that receive funding from them.

No cumulative effects would occur on funds available in the Basin Fund due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 6: How would impacts on the power generation affect ancillary services?

Ancillary services, such as regulation and reserve, require certain lake reservoir elevations and releases so that generation and capacity can continue at a rate that allows for up and down regulation along with the necessary reserves. Ancillary services see only minor impacts until elevations and releases drop near or below minimum power pool. If penstock releases dropped below those levels or stopped completely, these ancillary services would be negatively affected.

At Glen Canyon Dam, flows are required to be approximately 1,000–2,000 cfs above the minimum flows, as outlined in the LTEMP, for ancillary services to continue. As a result, flows must be 9,000–10,000 cfs during the daytime and 6,000–7,000 cfs at nighttime to reliably support ancillary services. The Glen Canyon Powerplant typically holds approximately 40 MW in regulation.

Hoover Dam ancillary services would be proportionately affected as lake levels and projected energy generation drop. Flexibility of release and the ability to leverage downstream storage at Davis and Parker Dams creates significant opportunities to utilize ancillaries such as regulation and reserves from Hoover Dam. Parker and Davis Dams would have minor impacts on ancillary services.

Summary

Ancillary services at Glen Canyon Dam would be affected under both the No Action Alternative and Proposed Action as reservoir elevations approached minimum power pool in low hydrologic conditions. In dry hydrologic scenarios, under the No Action Alternative, reservoir elevations at Lake Powell could drop below the minimum power pool, resulting in a complete halt of generation, capacity, and ancillary services. Ancillary services at Glen Canyon Dam would be more affected under the No Action Alternative than under the Proposed Action. The protections at Lake Powell under the Proposed Action would reduce the potential of reaching minimum power pool. Ancillary services at the Hoover Powerplant would not be substantially affected under either alternative, as lake elevations are not expected to drop near minimum power pool. Parker-Davis Powerplants would have minor impacts on ancillary services due to the lake reservoir elevation protections.

No Action Alternative

Under the No Action Alternative, penstock releases from Glen Canyon, Hoover, Parker, and Davis Dams would continue as outlined in the 2007 FEIS. Under the drier hydrologic scenarios, this could result in reservoir elevations dropping below the minimum power pool at Lake Powell. This would result in a complete halt in ancillary services such as regulation and reserve. It may or may not be feasible for WAPA to find other facilities to make up for the decrease in regulation and reserve. Lake Mead's elevations would decrease, but not enough to impact ancillary services.

The Parker and Davis Powerplants would be able to continue with ancillary services due to the lake reservoir elevation protections. However, under the driest hydrologic conditions, these lake elevations and releases could drop to the point where ancillary services may be affected.

Under the wet hydrologic scenarios, ancillary services at all four analyzed powerplants would be able to continue.

Proposed Action

Overall, the Glen Canyon Powerplant ancillary services would be less affected under the Proposed Action than under the No Action Alternative. Protection elevations at Lake Powell would allow ancillary services to continue without a complete halt. Ancillary services at the Glen Canyon Powerplant would continue unaffected as long as minimum flows remained at approximately 1,000–2,000 cfs above minimum LTEMP regulations. If releases dropped below these levels, ancillary services would be negatively affected. If this occurs, it may or may not be feasible for WAPA to find other facilities to make up for the decrease in regulation and reserve.

Lake Mead elevations are projected to be well above minimum power pool, resulting in minimal impacts on ancillary services.

The Parker and Davis Powerplants would be able to continue with ancillary services due to the lake reservoir elevation protections. However, under the driest hydrologic conditions, these lake elevations and releases could drop to the point where ancillary services may be affected.

Under the wetter hydrologic scenarios, ancillary services at all four analyzed powerplants would be able to continue unaffected.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options could have substantial negative impacts on ancillary services at Glen Canyon Dam if reservoir elevations drop toward minimum power pool and releases drop below LTEMP minimums flows. Additional water could be released through the river outlet works, resulting in less generation and potentially negative impacts on regulation and reserve. The LTEMP SEIS would not impact operations at the Lower Basin powerplants. Therefore, the LTEMP SEIS would not result in any additional impacts on ancillary services at Hoover, Parker, or Davis Dams.

No cumulative effects would occur on ancillary services due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.16 Socioeconomics

This section provides an overview of socioeconomic conditions in the study area. The baseline information and analysis tier off the 2007 FEIS (Reclamation 2007). In the 2007 FEIS, consumptive use was apportioned between the Upper and Lower Basins of the Colorado River and then further apportioned to individual states and entities based on a range of anticipated shortage amounts. The risk of continued drought and reservoir elevations declining below those considered likely in the 2007 FEIS requires consideration of updates to the 2007 Interim Guidelines to protect the reservoir elevations of Lake Powell and Lake Mead, as analyzed in this SEIS.

Information is provided in this document to update the analysis, as appropriate, to reflect overall changes in social and economic conditions in the Basin with the potential to be affected by management decisions and to reflect updated information on the water use levels for key use sectors and associated economic contributions. The potentially affected socioeconomic issues addressed in this section include:

- Agricultural production and the resulting changes in employment, income, and tax revenues
- Municipal and industrial uses of water and the resulting changes in economic activity
- Reservoir-related and river-related recreation and the resulting changes in employment, income, and consumer surplus value

Financial impacts from changes to hydropower availability and power costs are addressed in **Section 3.15**, Electrical Power Resources.

3.16.1 Affected Environment

Socioeconomic Study Area

The study area for this SEIS is the same as that described in the 2007 FEIS; this is due to the potential for additional water shortages throughout the Lower Division States.

The Arizona study area consists of Coconino, Gila, La Paz, Maricopa, Mohave, Pima, Pinal, and Yuma Counties (counties either directly adjacent to Lake Powell, Lake Mead, or the Colorado River, or counties in which shortages would likely occur). The counties in which measurable shortages could potentially occur, resulting in reductions in agricultural production or reduced municipal and industrial deliveries, are La Paz, Maricopa, Mohave, Pinal, Pima, and Yuma Counties. Although Coconino County would not experience a water shortage attributable to the proposed alternatives, it is included in the study area because it is adjacent to the Colorado River and may be affected by changes in recreation-related economic activity as a result of changes in river flows.

The California study area consists of Imperial, Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties. These counties were selected because they are either directly adjacent to the lower Colorado River, or they are within the MWD service area. While not adjacent to the lower Colorado River or within the MWD service area, Riverside and Imperial County are also relevant to include because the SEIS analysis includes the Salton Sea, which has the potential to be affected by the Proposed Action. Although Ventura County is also in the MWD service area, it does not receive any water from the Colorado River; therefore, it is not included in the study area.

The Nevada study area consists of Clark County. The study area was limited to Clark County because it is adjacent to Lake Mead and encompasses the SNWA's service area. Shortages in Nevada would be limited to the SNWA's service area.

The Utah study area consists of Garfield, Kane, and San Juan Counties. Although Utah will not experience shortages under any alternative, changes in storage at Lake Powell could result in changes in recreation-related expenditures made in these counties.

Baseline Economic Conditions

This section provides an overview of baseline economic conditions related to Colorado River water use with the potential to be affected by water shortages. For additional details, refer to the 2007 FEIS.

Arizona

Population

Population is a driver of demand for consumptive water use, particularly for municipal water. Populations throughout the western US have followed increasing trends over the past decade. With the exception of La Paz County (loss of 18 percent) and Gila County (loss of 0.1 percent), Arizona study area counties follow this trend of increasing population, with the biggest increase in Pinal County (27.7 percent). **Table 3-77**, below, provides an overview.

Employment

Table 3-78, below, provides an overview for employment by sector for the counties in the study area in Arizona. Comparisons are made, where applicable, to 2004 data provided in the 2007 FEIS. Full- and part-time employment in Arizona totaled 4,055,932 jobs in 2021, an increase of approximately 1,008,389 jobs from 2004 levels. Farm employment totaled 29,309 jobs in 2021 and accounted for 0.7 percent of total employment in the state; this is the same percentage as in 2004.

Employment in the study area counties represents approximately 93 percent of total employment in Arizona. Employment in the agricultural sector in the eight counties totaled 16,349 jobs in 2021 and represented less than 1 percent of total employment in the study area counties (Bureau of Economic Analysis 2023a).

Personal Income

Total personal income in Arizona totaled just over $403.7 billion in 2021, compared with $227.9 billion in 2004 (adjusted to 2021$). Likewise, per capita income increased from approximately $40,960 in 2004 (adjusted to 2021$) to approximately $55,487 in 2021; this is a 35 percent increase (see **Table 3-79**; Bureau of Economic Analysis 2023b).

Table 3-77
Arizona Population 2010–2021

Population	Coconino County	Gila County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Population 2010	131,824	53,272	20,549	3,751,410	199,177	964,462	329,297	190,526	6,246,816
Population 2021	144,942	53,211	16,845	4,367,186	211,274	1,035,063	420,625	202,944	7,079,203
Percent Change 2010–2021	10.0	-0.1%	-18.0	16.4	6.1	7.3	27.7	6.5	13.3

Source: Headwaters Economics Economic Profile System 2023

Table 3-78
Arizona Employment by Industry (2021)

Employment	Coconino County	Gila County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Total employment	84,555	20,790	7,801	2,860,955	78,406	537,770	109,679	91,280	4,055,932
Wage and salary employment	64,693	15,078	6,259	2,202,144	56,716	404,217	68,886	73,885	3,076,770
Proprietors' employment	19,862	5,712	1,551	658,811	21,690	130,553	40,793	17,395	979,162
Farm employment (number and percentage of total employment)	2,117	177	458	6,453	520	1,161	2,287	3,353	29,309
	2.5%	0.9%	5.9%	0.2%	0.7%	0.2%	2.1%	19.1%	0.7%
Non-farm employment (number and percentage of total employment)	82,438	20,613	7,352	2,854,520	77,886	533,609	107,392	87,927	4,026,623
	97.5%	99.1%	94.1%	99.8%	99.3%	99.8%	97.9%	80.9%	99.3%

Employment	Coconino County	Gila County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Employment by Industry (Number and Percentage of Total Employment)									
Forestry, fishing, and related	266	101	D	2,553	D	490	572	7,157	13,832
	0.3%	0.5%	D	0.1%	D	0.1%	0.5%	7.8%	0.3%
Mining, quarrying, and oil and gas extraction	142	941	59	6,453	445	3,300	1,256	88	17,894
	0.2%	4.5%	0.8%	0.2%	0.6%	0.6%	1.1%	0.1%	0.4%
Utilities	196	66	21	8,309	405	2,095	332	165	12,720
	0.2%	0.3%	0.8%	0.3%	0.5%	0.4%	0.3%	0.2%	0.3%
Construction	4,034	1,306	184	184,242	6,557	28,062	6,283	4,920	253,184
	4.8%	6.3%	2.4%	6.4%	8.4%	5.2%	5.7%	5.4%	6.2%
Manufacturing	3,661	1,326	257	141,468	3,401	29,734	5446	3,044	195,722
	4.3%	6.4%	3.3%	4.9%	4.3%	5.6%	5.0%	2.1%	4.8%
Wholesale trade	1,204	173	130	92,909	1,691	8,857	1,944	1,925	115,142
	1.4%	0.8%	1.7%	3.2%	2.2%	1.7%	1.8%	2.1%	2.8%
Retail trade	8,669	2,375	1,673	282,511	12,180	52,464	14,072	9,909	413,565
	10.3%	11.4%	21.4%	9.9%	15.5%	9.8%	12.8%	10.9%	10.2%
Transportation and warehousing	2,384	486	193	169,998	2,960	28,933	6,359	3,220	224,294
	2.8%	2.3%	2.5%	5.9%	3.8%	5.4%	5.8%	3.5%	5.5%
Information	645	135	87	48,230	656	6,653	872	482	59,769
	0.8%	0.6%	1.1%	1.7%	0.8%	1.2%	0.8%	0.5%	1.5%
Finance and insurance	1,962	658	D	243,962	2,808	24,871	4,315	3,692	290,236
	2.3%	3.2%	D	8.5%	3.6%	4.7%	3.9%	4.0%	7.2%
Real estate rental and leasing	4,147	1,068	D	172,770	4,821	28,896	5,946	3,143	234,832
	4.9%	5.1%	D	7.3%	6.1%	5.4%	5.4%	3.4%	5.8%
Professional, scientific, and technical services	3,735	777	D	39,192	2,909	33,399	5,017	3,709	269,961
	4.4%	3.7%	D	1.4%	3.7%	6.2%	4.6%	4.1%	6.7%
Management of companies and enterprises	468	D	D	244,023	222	2,726	434	353	44,165
	0.6%	D	D	8.5%	0.3%	0.5%	0.4%	0.4%	1.1%

Employment	Coconino County	Gila County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Administrative, support, and waste management	2,626	D	150	65,739	4,211	37,001	7,968	6,191	313,831
	3.1%	D	1.9%	2.3%	5.4%	6.9%	7.3%	6.8%	7.7%
Educational services	1,075	189	D	325,464	805	9,300	2,205	697	85,070
	1.3%	0.9%	D	11.4%	1.0%	1.7%	2.0%	0.8%	2.1%
Health care and social assistance	9,627	1,698	D	56,772	9,491	70,081	7,241	9,221	459,980
	11.4%	8.2%	D	2.0%	12.1%	13.1%	6.6%	10.1%	11.3%
Arts, entertainment, and recreation	3,083	375	D	56,772	D	11,588	2,676	683	81,541
	3.6%	1.8%	D	2.0%	D	2.2%	2.4%	0.7%	2.0%
Accommodation and food services	13,716	1,806	D	193,676	9,572	38,277	7,385	7,055	293,749
	16.2%	8.7%	D	6.8%	12.2%	7.2%	6.7%	7.7%	7.2%
Other services	3,695	977	D	135,811	5,109	29,315	6,872	4,148	200,894
	4.4%	4.7%	D	4.7%	6.5%	5.5%	6.3%	4.5%	5.0%
Government and government enterprises	17,103	5,407	2,022	234,204	8,352	87,567	20,197	18,125	446,242
	20.2%	26.0%	25.9%	8.2%	10.7%	16.4%	18.4%	19.9%	11.0%

Source: Bureau of Economic Analysis 2023a

D = not shown to avoid disclosure of confidential information; estimates are included in higher-level totals.

Table 3-79
Arizona Personal Income and Earnings (2021)

Income/Earnings	Coconino County	Gila County	La Paz County	Maricopa County	Mohave County	Pima County	Pinal County	Yuma County	Arizona
Personal income ($1,000s)	$8,255,426	$2,612,568	$819,303	$268,713,717	$8,997,444	$55,696,681	$19,687,597	$9,169,548	$403,739,312
Per capita personal income	$56,914	$48,752	$49,933	$59,759	$41,331	$52,942	$43,793	$44,299	$55,487
Earnings by place of work	$4,633,046	$1,050,392	$365,268	$192,958,723	$3,807,031	$31,731,662	$5,182,726	$5,472,861	$258,941,005
Wages and salaries	$3,154,528	$763,967	$281,717	$146,954,704	$2,626,349	$22,652,731	$3,512,696	$3,732,656	$193,197,269
Supplements to wages and salaries	$810,341	$194,781	$72,577	$27,989,246	$591,791	$5,328,512	$870,907	$1,013,969	$39,417,203
Proprietors' income	$668,177	$91,644	$10,974	$18,014,773	$588,891	$3,750,419	$799,123	$726,236	$26,326,533

Source: Bureau of Economic Analysis 2023b

Among the eight counties, average per capita income ranged from a low of approximately $41,331 per year in La Paz County to a high of $59,759 per year in Maricopa County. Only Maricopa and Coconino Counties had per capita income above the state of Arizona average ($55,487). The total personal income generated in the eight counties represented around 93 percent of the state total (Bureau of Economic Analysis 2023b).

Agriculture

Approximately 36 percent of Arizona's land area in 2018 was used for agricultural purposes (either crop or livestock production). According to an agricultural economic profile on Arizona counties for 2017 (Duval et al. 2020)[20], the total market value of agricultural production in Arizona contributed $23.3 billion to Arizona's economy. Direct contributions from the sale of farm products; the manufacture of crop inputs; and crop processing, marketing, and distribution accounted for $14.8 billion, with an additional $8.5 billion coming indirectly from economic activity generated as a result of agricultural income (Lahmers and Edan 2018). The types of crops, amount of water used for agriculture, and the role of agriculture in county economics vary across the state. The top agricultural industries by employment include citrus, hay farming, cotton farming, and crop harvesting (Lahmers and Edan 2018).

Central and southwestern Arizona have long been the center of agricultural production in Arizona; central and southwestern Arizona farms contribute the largest share of agricultural production in terms of sales values. In 2017, the market value of agricultural production occurring within the Arizona study area accounted for nearly 62 percent of the statewide on-farm agricultural production value and 0.41 percent of Arizona total gross domestic product (GDP). In 2017, production values ranged from a low of approximately $17.1 million in La Paz County to a high of $1.2 billion in Yuma County (Duval et al. 2020). **Table 3-80** presents a summary of the market value of on-farm agricultural production with respect to county and state GDP.

In the western US, while agriculture represents a relatively small share of the US production, it requires large amounts of irrigation water. The most water-intensive crops include crops for food, feed, and fiber production. In Arizona, irrigated agriculture accounts for about 75 percent of the state's water use; more than 50 percent of this is from surface waters. According to the 2007 FEIS, urbanization of agricultural lands and heavy investment by the irrigated agricultural industry in conservation measures both on farms and in the delivery system have resulted in a reduction in the percentage (from as high as 90 percent) of water used by agricultural irrigation. Improvements in irrigation technology; voluntary fallowing programs that compensate farmers who reduce water consumption; and utilization of more effective irrigation strategies, such as changes to irrigation timing, have resulted in a reduction in agriculture's share of water consumption (Lahmers and Edan 2018).

[20] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.

Table 3-80
Market Value of On-Farm Agricultural Production in Arizona Study Area (2017)[1]

Area	Market Value of Production ($1,000,000)	Percentage of County GDP	Percentage of Arizona GDP
Maricopa County	89.4	0.04	0.03
Pima County	64.5	0.14	0.02
Pinal County	28.1	0.37	0.01
Total within CAP Counties	**182.0**	**0.06**	**0.05**
La Paz County	17.1	2.55	0.00
Mohave County	27	0.47	0.01
Yuma County	1,200	14.46	0.34
Total within Arizona Study Area[2]	**1,426.1**	**0.45**	**0.41**

Source: Duval et al. 2020
Note: CAP values are aggregated values of Maricopa, Pima, and Pinal Counties.
[1] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.
[2] Coconino County is included in the Arizona study area due to the potential for recreation-related impacts, but it currently does not receive Colorado River irrigation water and is excluded from this table.

Agricultural lands receiving water for irrigation from the CAP are generally within Pinal, Maricopa, and Pima Counties. The three counties account for approximately 50 percent of statewide irrigated and harvested cropland (USDA 2019a). These three counties also account for approximately 70 percent of Arizona's harvested cotton acreage, 50 percent of the state's hay crops, and approximately 44 percent of irrigated wheat cultivation (USDA 2019a).

Agricultural resources in western Arizona are primarily along the Colorado River in Mohave, La Paz, and Yuma Counties and along the Gila River Valley in Yuma County. These three western Arizona counties account for approximately 54 percent of statewide irrigated wheat cultivation, 76 percent of vegetable crops, and 36 percent of hay crops (USDA 2019a). Yuma County alone produces 75 percent of the state's total vegetable crops. **Table 3-81** provides a summary of county-wide irrigated agricultural lands within the Arizona study area.

Table 3-82 shows changes between 2012 and 2017 in acres of irrigated cropland compared with changes to acres of total cropland in each county. In general, there is a correlation between the percent change in irrigated cropland and the percent change in total cropland within the CAP counties. Changes can be due to changing cropping patterns or technological and farming strategy modifications that contribute to expansion of nonirrigated agriculture in Arizona, where irrigation would otherwise be essential. For example, an increase in total Yuma County cropland between 2012 and 2017 was due to expansion of nonirrigated cropland (USDA 2019a).

Table 3-81
Irrigated Acres of Harvested Agriculture in the Arizona Study Area (2017)[1]

Area	Irrigated Cropland (Acres)	Total Cropland (Acres)	Percent Irrigated Cropland
Maricopa County	177,975	187,467	95
Pima County	29,154	29,192	100*
Pinal County	231,092	235,185	98
Total within CAP Counties	**438,221**	**451,844**	**97**
La Paz County	(D)	96,204	(D)
Mohave County	20,713	22,002	94
Yuma County	181,244	193,823	94
Total Arizona[2]	**876,272**	**915,647**	**96**

Source: USDA 2019a
Note: CAP values are aggregated values of Maricopa, Pima, and Pinal Counties. Totals for the Arizona study area are not presented due to a lack of data for some counties.
* Percent irrigated cropland is 99.9 percent of total cropland in Pima County.
(D) = data determined too sensitive to disclose.
[1] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.
[2] Coconino County is included in the Arizona study area due to the potential for recreation-related impacts, but it does not receive Colorado River irrigation water and is excluded from this table.

Table 3-82
Irrigation Trend for Harvested Agriculture in the Arizona Study Area (2012–2017)[1]

Area	Percent Change in Irrigated Cropland	Percent Change in Total Cropland
Maricopa County	-6.6	-4.9
Pima County	1.7	1.6
Pinal County	4.1	3.6
Total within CAP Counties	**-0.7**	**-0.2**
La Paz County	(D)	-7.6
Mohave County	(D)	(D)
Yuma County	0.0	5.1
Total Arizona[2]	**2.6**	**2.9**

Source: USDA 2019a
Note: CAP values are aggregated values of Maricopa, Pima, and Pinal Counties. Totals for the Arizona study area are not presented due to a lack of data for some counties.
(D) = data withheld in USDA 2019a source document to avoid disclosing data for individual farms.
[1] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.
[2] Coconino County is included in the Arizona study area due to the potential for recreation-related impacts, but it does not receive Colorado River irrigation water and is excluded from this table.

Table 3-83 shows the proportion of irrigation water that comes from all surface water resources in each county. In general, there is a correlation between the trend in the change of the percentage of irrigation water that comes from surface waters and the trend in total acre-feet of surface water used for irrigating croplands. However, all or part of the change in the volume of irrigation water from surface water resources may be due to changes in contributions from groundwater. In Mohave County, although the percentage of irrigated cropland sourced from surface waters decreased from 75 percent in 2010 to 56 percent by 2015, the total acres of irrigated cropland receiving surface water increased by 14 percent. Between 2010 and 2015, Mohave County's total water usage, which includes groundwater sources in addition to surface waters, increased more rapidly than the increase in acre-feet of water from surface waters alone. The proportion from surface water's contribution decreased.

Table 3-83
Percent Irrigated Water from Surface Water Sources

Area	Percent Agricultural Water from Surface Waters (2010)	Percent Agricultural Water from Surface Waters (2015)[1]	Percent Change in Acre-Feet of Irrigation Water from Surface Waters (2010–2015)
Maricopa County	27	21	-22
Pima County	33	39	18
Pinal County	76	62	-18
Total within CAP Counties	**51**	**39**	-24
La Paz County	92	87	-5
Mohave County	75	56	-25
Yuma County	85	90	6
Total within Arizona Study Area[2]	**70**	**61**	-13
Total Arizona	**64**	**57**	**-11**

Source: USGS 2015

Note: CAP values are aggregated values of Maricopa, Pima, and Pinal Counties. Surface water sources include all sources; they are not exclusive to the Colorado River.

[1] The 2015 USGS water use (for specific purposes, such as irrigation) data by source (surface water or groundwater, etc.) are the most recent available county-level data.

[2] Coconino County is included in the Arizona study area due to the potential for recreation-related impacts, but it does not receive Colorado River irrigation water and is excluded from this table.

Industrial and Municipal Water Uses

In models of water yield and demand in the western US to 2070, data indicate that demands for municipal water are increasing across the SEIS socioeconomic study area, while projected water availability is decreasing (see, for example, Warziniack and Brown 2019). While this trend is seen throughout the western US, the Colorado River region has the largest percentage increases in projected domestic water use as well as the greatest percentage decreases in projected water yield from all sources, including Colorado River water (Warziniack and Brown 2019).

As described in the 2007 FEIS, municipalities potentially affected by the proposed alternatives include Phoenix, Tucson, Scottsdale, and other Arizona towns and cities served by the CAP, as well as Arizona municipalities along the Colorado River that have post-1968 Colorado River water delivery contracts, such as Lake Havasu City. In Arizona, industrial land uses on the Colorado River include the major power facilities of Glen Canyon Dam in Coconino County, Hoover and Davis Dams on the Arizona-Nevada border in Mohave County (and Clark County, Nevada) and Parker Dam in La Paz County (and San Bernardino County, California).

California

Population

In California, the population has increased by approximately 7.7 percent in the past decade. With the exception of Los Angeles, the study area counties' growth all surpassed that of the state. The largest increase in population was in Riverside County (14.2 percent; see **Table 3-84**).

Table 3-84
California Population 2010–2021

Population	Imperial County	Los Angeles County	Orange County	Riverside County	San Bernardino County	San Diego County	California
Population 2010	168,052	9,758,256	2,965,525	2,109,464	2,005,287	3,022,468	36,637,290
Population 2021	180,051	10,019,635	3,182,923	2,409,331	2,171,071	3,296,317	39,455,353
Percent change 2010–2021	7.1	2.7	7.3	14.2	8.3	9.1	7.7

Source: Headwaters Economics Economic Profile System 2023

Employment

Full- and part-time employment in California totaled 23.9 million jobs in 2021, an increase of approximately 3.9 million jobs from 2004 levels. Full- and part-time employment in the six-county study area totaled 13 million jobs in 2021, representing 55 percent of total California employment. Farm employment was higher in Imperial County (5.2 percent) than in California overall (1.0 percent) and lower in all other counties (see **Table 3-85**).

Table 3-85
California Employment by Industry (2021)

Employment	Imperial County	Los Angeles County	Orange County	Riverside County	San Bernardino County	San Diego County	California
Total employment	82,115	6,428,159	2,253,070	1,127,161	1,122,017	2,131,117	23,906,353
Wage and salary employment	67,229	4,597,519	1,675,102	813,146	858,597	1,619,417	17,891,462
Proprietors' employment	14,886	1,830,640	577,968	314,015	263,420	511,700	6,014,891
Farm employment (number and percentage of total employment)	4,229	4,110	1,363	7,293	2,467	10,820	229,419
	5.2%	0.1%	0.1%	0.6%	0.2%	0.5%	1.0%

Employment	Imperial County	Los Angeles County	Orange County	Riverside County	San Bernardino County	San Diego County	California
Non-farm employment (number and percentage of total employment)	77,886	6,424,049	2,251,707	1,119,868	1,119,550	2,120,297	23,676,934
	94.8%	99.9%	99.9%	99.4%	99.8%	99.5%	99.0%
Forestry, fishing, and related	6,934	2,747	1,327	6,950	1,153	3,030	250,669
	8.4%	<0.0%	0.1%	0.6%	0.1%	0.1%	1.0%
Mining, quarrying, and oil and gas extraction	395	5,738	2,436	1,689	1,351	1,810	33,528
	0.5%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Utilities	525	13,326	3,403	1,903	3,898	5,465	65,390
	0.6%	0.2%	0.2%	0.2%	0.3%	0.3%	0.3%
Construction	2,501	252,952	132,853	98,788	60,656	113,440	1,253,884
	3.0%	3.9%	5.9%	8.8%	5.4%	5.3%	20.8%
Manufacturing	2,532	341,233	158,005	49,600	56,632	123,412	1,375,410
	3.1%	5.3%	7.0%	4.4%	5.0%	5.8%	5.8%
Wholesale trade	2,222	242,952	90,733	32,519	48,346	51,850	731,178
	2.7%	3.8%	4.0%	2.9%	4.3%	2.4%	3.1%
Retail trade	9,604	520,666	185,913	120,232	112,569	176,273	2,031,941
	11.7%	8.1%	8.3%	10.7%	10.0%	8.3%	8.5%
Transportation and warehousing	3,686	398,305	73,131	104,835	163,147	83,983	1,371,207
	4.5%	6.2%	3.2%	9.3%	14.5%	3.9%	5.7%
Information	D	252,429	30,588	8,228	6,621	28,470	643,367
	D	3.9%	1.4%	0.7%	0.6%	1.3%	2.7%
Finance and insurance	1,896	320,290	166,014	42,930	37,784	106,550	1,191,722
	2.3%	5.0%	7.4%	3.8%	3.4%	5.0%	5.0%
Real estate rental and leasing	1,962	393,202	157,319	53,359	42,016	115,531	1,250,434
	2.4%	6.1%	7.0%	4.7%	3.7%	5.4%	5.2%
Professional, scientific, and technical services	2,021	520,666	220,542	52,231	46,030	232,087	2093532
	2.5%	8.1%	9.8%	4.6%	4.1%	10.9%	8.8%
Management of companies and enterprises	178	77,980	42,667	4,674	5,587	27,703	277,998
	0.2%	1.2%	1.9%	0.4%	0.5%	1.3%	1.1%
Administrative, support, and waste management	3,459	406,452	198,480	85,653	89,927	132,174	1,526,406
	4.2%	6.3%	8.8%	7.6%	8.0%	6.2%	6.4%
Educational services	387	172,964	53,545	14,692	16,275	46,095	543,623
	0.5%	2.7%	2.4%	1.3%	1.5%	2.2%	2.3%
Health care and social assistance	11,023	855,509	159,818	129,950	134,728	218,439	2,822,918
	13.4%	13.3%	7.1%	11.5%	12.0%	10.2%	11.8%
Arts, entertainment, and recreation	348	223,083	56,418	22,842	14,023	47,031	566,938
	0.4%	3.5%	2.5%	2.0%	1.2%	2.2%	2.4%
Accommodation and food services	4,452	408,321	159,818	86,805	14,023	152,988	1,575,223
	5.4%	6.4%	7.1%	7.7%	1.2%	7.2%	6.6%
Other services	D	414,016	123,440	72,847	73,055	115,935	1,346,871
	D	6.4%	5.5%	6.5%	6.5%	5.4%	5.6%
Government and government enterprises	19,271	600,175	160,559	129,141	65,928	338,030	2,724,695
	23.5%	9.3%	7.1%	11.5%	5.9%	15.9%	11.4%

Source: Bureau of Economic Analysis 2023a

D = not shown to avoid disclosure of confidential information; estimates are included in higher-level totals.

Personal Income

Total personal income in California totaled $3 trillion in 2021, compared with $1.84 trillion in 2004 (when adjusted for inflation). Statewide per capita income also increased from approximately $49,435 in 2004 (adjusted for inflation) to approximately $76,614 in 2021 (Bureau of Economic Analysis 2023b; see **Table 3-86**).

In 2004, total personal income ranged from a low of approximately $8.6 billion in Imperial County to a high of $728.8 billion in Los Angeles County. When combined, the total personal income of the six counties represents 48.8 percent of the state total. Per capita income ranged from a low of approximately $47,653 in Imperial County to a high of approximately $81,034 in Orange County.

Table 3-86
California Personal Income and Earnings (2021)

Income/ Earnings	Imperial County	Los Angeles County	Orange County	Riverside County	San Bernardino County	San Diego County	California
Personal income ($1,000s)	$8,570,390	$728,772,915	$256,700,438	$125,820,553	$108,623,799	$238,691,713	$3,006,183,929
Per capita personal income	$47,653	$74,141	$81,034	$51,180	$49,493	$72,637	$76,614
Earnings by place of work	$5,137,777	$510,862,232	$181,016,988	$64,353,758	$69,548,586	$167,563,948	$2,102,644,661
Wages and salaries	$3,249,301	$359,122,730	$128,811,520	$45,029,294	$49,466,149	$123,893,955	$1,533,988,242
Supplements to wages and salaries	$1,122,878	$78,557,777	$26,652,410	$11,516,385	$12,705,654	$29,637,025	$314,285,006
Proprietors' income	$765,598	$73,181,725	$25,553,058	$7,808,079	$7,376,783	$14,032,968	$254,371,413

Source: Bureau of Economic Analysis 2023b.

Agriculture

The percentage of cropland that is irrigated in the California study area, with an average of 94 percent—which is the same as the percentage of irrigated cropland for all of California—varies across the different counties. The percentage of irrigated cropland ranges from a low of 68 percent in Orange County to a high of 98 percent in Imperial County. The proportion of irrigated croplands within the California study area represents approximately 12 percent of total irrigated croplands in the state. **Table 3-87** shows acres of irrigated and total cropland within the California study area.

Table 3-87
Irrigated Acres of Harvested Agriculture in the California Study Area (2017)[1]

Area	Irrigated Cropland (Acres)	Total Cropland (Acres)	Percent Irrigated Cropland
Imperial County	455,768	467,445	98
Los Angeles County	10,104	12,806	79
Orange County	3,946	5,803	68
Riverside County	125,363	143,628	87

Area	Irrigated Cropland (Acres)	Total Cropland (Acres)	Percent Irrigated Cropland
San Bernardino County	21,487	22,145	97
San Diego County	41,607	49,080	85
Total California Study Area	**876,272**	**915,647**	**94**
California	**7,348,690**	**7,857,512**	**94**

Source: USDA 2019b

[1] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.

Industrial and Municipal Water Uses

As noted in the 2007 FEIS, municipalities potentially affected by the proposed alternatives include 88 cities in Los Angeles County, 34 cities in Orange County, 24 cities in Riverside County, 31 cities in San Bernardino County, and 18 cities in San Diego County.

Nevada

Population

Following trends seen in other study area states, the population of Nevada grew by over 16 percent from 2010 through2021. Clark County's population change (17.7 percent) was higher than that of the state overall (see **Table 3-88**).

Table 3-88
Nevada Population 2010–2021

Population	Clark County	Nevada
Population 2010	1,895,521	2,633,331
Population 2021	2,231,147	3,059,238
Percent Change 2010–2021	17.7	16.2

Source: Headwaters Economics Economic Profile System 2023

Employment

Full- and part-time employment in Nevada totaled 1,875,709 jobs in 2021, an increase of approximately 472,402 jobs from 2004 levels. In 2021, employment in the arts, entertainment, and recreation sector totaled 55,322 jobs, or approximately 3 percent of total employment in the state. Farm employment represented only 0.3 percent of total employment.

Full- and part-time employment in Clark County totaled 1,368,492 jobs in 2021, an increase of approximately 370,492 jobs from 2004. Total employment in Clark County represented almost 70 percent of total employment in Nevada. In 2021, employment in the arts, entertainment, and recreation sector totaled 41,400 jobs, or approximately 3 percent of total employment in the county. Similar to statewide totals, farm employment represented only 0.03 percent of total employment. See **Table 3-89**.

Table 3-89
Nevada Employment by Industry (2021)

Employment	Clark County	Nevada
Total employment	1,368,492	1,875,709
Wage and salary employment	1,019,149	1,409,465
Proprietors' employment	349,343	466,244
Farm employment (number and percentage of total employment)	409	5,028
	0.03%	0.3%
Non-farm employment (number and percentage of total employment)	1,368,083	1,870,681
	>99.9%	99.7%
Forestry, fishing, and related	457	1,937
	<0.0%	0.1%
Mining, quarrying, and oil and gas extraction	1,577	4,526
	0.1%	0.2%
Utilities	86,255	4,526
	6.3%	0.2%
Construction	86,255	120,249
	6.3%	6.4%
Manufacturing	29,758	66,978
	2.2%	3.6%
Wholesale trade	29,275	43,982
	2.1%	2.3%
Retail trade	136,244	185,306
	10.0%	9.9%
Transportation and warehousing	104,271	137,427
	7.6%	7.3%
Information	15,961	21,137
	1.2%	1.1%
Finance and insurance	80,765	103,909
	5.9%	5.5%
Real estate rental and leasing	79,184	110,419
	5.8%	5.9%
Professional, scientific, and technical services	79,184	109,638
	5.8%	5.8%
Management of companies and enterprises	79,597	32,573
	5.8%	1.7%
Administrative, support, and waste management	26,541	132,423
	1.9%	7.1%
Educational services	16,473	21,845
	1.2%	1.2%
Health care and social assistance	118,625	160,792
	8.7%	8.6%
Arts, entertainment, and recreation	41,400	55,322
	3.0%	2.9%

Employment	Clark County	Nevada
Accommodation and food services	229,369	276,961
	16.8%	14.8%
Other services	67,012	89,948
	4.9%	4.8%
Government and government enterprises	119,106	177,141
	8.7%	9.4%

Source: Bureau of Economic Analysis 2023a

Personal Income

Total personal income in Nevada totaled $189.3 billion in 2021, an 89 percent increase over 2004 levels (when adjusted for inflation). Statewide per capita income increased from approximately $23,800 in 1994 (inflation-adjusted levels) to approximately $33,800 in 2004. See **Table 3-90.**

In 2021, per capita income in Clark County was $58,276, which was slightly lower than the state average. The total personal income of Clark County represents more than 70 percent of the state total. See **Table 3-90**.

Table 3-90
Nevada Personal Income and Earnings (2021)

Income/Earnings	Clark County	Nevada
Personal income ($1,000s)	$133,596,955	$189,308,244
Per capita personal income	$58,276	$ 60,213
Earnings by place of work	$83,182,161	$117,154,278
Wages and salaries	$60,447,133	$ 84,993,156
Supplements to wages and salaries	$13,352,162	$ 19,168,471
Proprietors' income	$9,382,866	$ 12,992,651

Source: Bureau of Economic Analysis 2023b
(D) = Not shown to avoid disclosure of confidential information; estimates are included in higher-level totals.

Agriculture

Agriculture in the Nevada study area was relatively small (2,722 acres, which are less than 0.01 percent of the agricultural study area) compared with the agricultural areas in Arizona and California study areas. The Nevada agricultural study area was also relatively small (0.5 percent) compared with total agricultural cropland in the state. Of the total harvested agricultural lands in Clark County, which makes up the Nevada study area, 100 percent were irrigated cropland, which is comparable with the percentage of irrigated cropland in Nevada (99 percent). **Table 3-91** shows the acres of irrigated and total cropland within the Nevada study area.

Table 3-91
Irrigated Acres of Harvested Agriculture in the Nevada Study Area (2017)[1]

Area	Irrigated Cropland (Acres)	Total Cropland (Acres)	Percent Irrigated Cropland
Clark County	2,722	2,722	100
Total Nevada	**567,978**	**573,785**	**99**

Source: USDA 2019c

[1] The 2017 agricultural census from the National Agricultural Statistics Service (used in reports developed by Duval et al. 2020) provides the most recent available data on the market value of agricultural production at the county level. The next agricultural census data release is due in the spring/summer 2024.

Municipal and Industrial Water Use

As noted in the 2007 FEIS, municipalities potentially affected by the proposed alternatives include Boulder City, Henderson, Las Vegas, and North Las Vegas due to their reliance on Colorado River water supplied by SNWA.

Utah

Reclamation does not anticipate that the counties in the Utah study area would be affected by agricultural, industrial, or municipal water shortages as a result of proposed management. As a result, no detailed information is included for the population, employment, and income, or the agriculture, municipal, or industrial uses in the study area.

Economic Contributions from Recreation

As discussed in **Section 3.14**, Recreation, recreational activities with the potential to be affected by proposed management include recreation (boating, camping, hiking, etc.) on and adjacent to reservoirs at Lake Powell and Lake Mead, as well as river-based recreation downstream in Glen Canyon and Grand Canyon. Information is also included on wildlife refuges on the Colorado River; these refuges may be affected by the Proposed Action.

Economic benefits result when visitors spend dollars on recreation. Those benefits include increased sales, income, and jobs. Direct economic benefits occur when businesses sell goods and services to area visitors. Additional jobs and economic activity are supported when businesses purchase supplies and services from other local businesses, thus creating indirect effects from visitor spending. In addition, employees use their income to purchase goods and services in the local economy, generating further induced effects from visitor spending.

Table 3-92, below, displays the total economic contributions from recreation occurring in the GCNRA, LMNRA, and GCNP. Information is included in **Table 3-92** related to economic contributions from wildlife refuges. Economic contributions are estimated by multiplying total visitor spending by regional economic multipliers. Total visitor spending includes spending by both local visitors who live in gateway regions and nonlocal visitors who travel to NPS sites from outside gateway regions. Spending by nonlocal visitors represents an influx of dollars from outside the local economy. In addition, nonlocal visitors typically have higher levels of spending on food, lodging, and other activities on a per-trip basis.

Table 3-92
Summary of Economic Contributions for NPS-Based Recreation (2021)

NPS Unit	Total Recreation Visits	Visitor Spending (1,000s of 2021$)	Jobs	Labor Income (1,000s of 2021$)	Value Added (1,000s of 2021$)	Economic Output (1,000s of 2021$)	% of Spending from Nonlocals
GCNRA	3,144,318	$332,150	3,839	$139,418	$234,458	$409,546	96
GCNP	4,352,667	$710,256	9,390	$324,318	$539,433	$944,693	99
LMNRA	7,603,474	$373,668	4,054	$167,550	$281,033	$457,279	88

Source: NPS 2022d

Note: Jobs measure annualized full- and part-time jobs that are supported by NPS visitor spending. Labor income includes employee wages, salaries, and payroll benefits, as well as proprietors' incomes that are supported by NPS visitor spending. Value added measures the contribution of NPS visitor spending to the GDP of a regional economy. Value added is equal to the difference between the amount an industry sells a product for and the production cost of the product. Economic output is a measure of the total estimated value of the production of goods and services supported by NPS visitor spending. Economic output is the sum of all intermediate sales (business to business) and final demand (sales to consumers and exports).

The GCNRA, LMNRA, and GCNP had 96 percent, 88 percent, and 99 percent of spending from nonlocal visitors, respectively. A discussion of recreation-related economic activity occurring on the Colorado River downstream of Lake Powell and Lake Mead was not included; this is because no change in recreation and resulting changes in economic activity are expected under the proposed alternatives. For additional details on recreation and levels of use, see **Section 3.14**, Recreation.

As shown in **Table 3-93**, below, recreational visits to the GCNRA and GCNP correspond with a wide array of job sectors within local (predominately small town and rural) economies. In 2021, GCNRA recreation supported 3,839 jobs, including 921 indirect and induced jobs. GCNP recreation supported 9,390 jobs, including 2,243 indirect and induced jobs (NPS 2022d). LMNRA recreation supported 4,054 total jobs in 2021 (specific job data unavailable).

Table 3-93
Jobs by Sector Supported by Economic Contributions from NPS-Based Recreation (2021)

Jobs	GCNRA	GCNP
Direct Jobs by Sector		
Camping	76	143
Gas	73	94
Groceries	98	127
Hotels	1,200	2,400
Recreation industries	610	1,880
Restaurants	580	1,500
Retail	155	439
Transportation	126	564
Indirect and Induced Jobs	**921**	**2,243**
Total Jobs	**3,839**	**9,390**

Source: NPS 2022d

In addition to general recreation sector contributions, visitor use supports concessionaires, including those associated with water-based recreation. Contributions from GCNRA concessioners and small business permittees are estimated at $130 million annually in gross receipts (NPS 2022e). This spending represents an important contribution to local communities in Coconino County in Arizona and Garfield, San Juan, Wayne, and Kane Counties in Utah. Based on communication with the NPS, the State of Utah believes recreational access to Lake Powell contributes up to $8 million to the state's economy.

In terms of river-based recreation, it is estimated that Grand Canyon river outfitters retain roughly 1,100 employees, not including the contracted transportation and training services and numerous food, sundries, and river supply vendors required to support the operations.[21]

In addition to the direct economic impact on GCNP and the NPS, it is estimated that the regional economic impact of commercial river trips sustains hundreds of additional jobs and generates millions more of additional revenue throughout the mostly rural communities and small businesses of northern Arizona and southern Utah each season. All river recreation in GCNP is regulated through the NPS CRMP (to protect the resource and the visitor experience). River trips are closely regulated, and this experience is generally reserved an average of 12–18 months in advance. River trips include approximately 22,000 visitors annually, generating more than $50 million in revenues to the region (NPS 2006a).

In terms of wildlife refuges, economic contributions are associated with recreational visitors paying for recreation through entrance fees, lodging near the refuges, and purchases from local businesses for items to pursue their recreational experience. This spending supports economic activity throughout the local economy (Caudill and Carver 2019). **Table 3-94** displays the estimated contributions from the two refuges receiving Colorado River water, Imperial NWR and Bill Williams River NWR.

Table 3-94
Economic Contributions from National Wildlife Refuges (2017 Data)

NWR	Total Recreation Visits	Total Economic Output ($1,000)	Total Employment Income ($1,000)	Total Jobs
Bill Williams River NWR (Arizona)	326,344	$11,345.3	$2,944.2	113
Imperial NWR (Arizona and California)	274,159	$11,069.8	$3,228.6	100

Source: Service 2019a, 2019b

[21] Laurie Dyer, NPS supervisory concessions management specialist in the Commercial Services Division at GCNP, personal communication provided on March 15, 2023.

3.16.2 Environmental Consequences

Methodology

Agriculture

The purpose of the agricultural impact assessment is to estimate the change in agricultural production as a result of a reduction of irrigation water. The change in the value of agricultural production is directly related to the acres of cropland chosen to be fallowed and the estimated revenue per acre of the fallowed crop. In addition to revenue loss from agricultural products, agricultural jobs and wages would potentially be lost.

As described in **Section 3.3**, Reclamation used CRMMS to analyze water deliveries across alternatives. Modeling details for each alternative are described in **Section 3.3.4** and **Appendix D**, CRMMS Model Documentation. Additionally, as described in **Section 3.3**, Reclamation used a Shortage Allocation Model in addition to CRMMS to analyze the potential impacts of the alternatives on individual agricultural water users within each Lower Division State under different shortage scenarios.

Reclamation then applied the 2007 agricultural modeling framework, using crops' profitability in each county to determine which crops farmers are most likely to fallow in times of reduced water availability. In this analysis, water shortages are assumed to result in temporary acres of fallowed cropland during the period in which shortages would occur. While farmers may use groundwater and other surface water resources to mitigate impacts from allocated shortages, it is difficult to project exactly how individual farmers, irrigation districts, or each Lower Division State may mitigate potential future agricultural impacts from shortages. Therefore, similar to the assumption made in the 2007 FEIS, the projected change in agricultural production was based on the conservative assumption that other sources of water would not replace the estimated water shortage.

The decision to fallow lands is based on the farmer's ability to cover the variable cost of production of a given crop. If the cost of water exceeds the maximum amount a farmer can pay or if water is not available, a crop is taken out of production and the land is fallowed during the year shortages would occur. Considering crop profitability gives an indication of crops that face larger reductions compared with other crops (Dale and Dixon 1998; Frisvold et al. 2012). The least profitable crop would be fallowed first. Crops would continue to be fallowed in the order of least profitable crop, until the full volume of water shortage is offset or until the crop is completely fallowed within the county.

Irrigated crops in the analysis area include field crops, vegetables and melons, and trees and vines. Field crops have lower earnings per acre-foot of water than other crops; therefore, they are more vulnerable to changes in water costs and shortages. Studies on fallowing patterns in the southwestern US show that field crops account for 98 to 100 percent of fallowed crops (Frisvold et al. 2012; Dale and Dixon 1998). Fallowed crops for the No Action Alternative were limited to cotton, wheat, and alfalfa. Crops considered in this analysis included irrigated crops for which data were available; farmers may choose to fallow other crops, such as corn or other forage and grain crops, for which data were unavailable or unreliable.

Calculation of crop profitability per acre-foot of water followed the method outlined in Appendix H of the 2007 FEIS, which used the difference between revenue and the variable costs per acre of land required to grow a given crop. In the Arizona and Nevada analy, calculations were updated with the most recent available data from the US Department of Agriculture[22] (USDA 2019a). County-level revenue for each crop was based on 5-year (2014 to 2018) averages of yield[23] and prices. The US Department of Agriculture does not provide recent county-level data for California; yield, acreage, and price data for the California study area between 2014 and 2018 were obtained from reports produced by each county's agricultural commissioner/weight and measures departments (Imperial County 2014, 2015, 2016, 2017, 2018b; Riverside County 2014, 2015, 2016, 2017, 2018; San Bernardino County 2014, 2015, 2016, 2017, 2018).

County-level production cost data for each crop, including the difference in irrigation cost, are not updated frequently. To capture the difference in the irrigation cost for each crop in different counties in Arizona, variable costs-of-production estimates were based on historical crop and livestock budgets developed by the University of Arizona for 1999 (University of Arizona 2001); these were the same cost-of-production data used in the 2007 analysis. For the California counties, estimates were based on budgets developed by the University of California Davis (UC Davis 2023) for a range of years (from 1970 to 2004, depending on the type of crop and the county for which it was developed). All dollar values were converted to 2022 dollars. The purpose of using the cost estimates was only to determine the order in which crops would be fallowed; the estimates are not considered an accurate measure of the current cost and return estimates.

To determine how much a farmer would be willing to pay for water before a choice is made to fallow a crop, the irrigation cost of growing each crop was added back to the calculated revenue over the variable production cost. To account for each crop's required amount of water (different for each crop), the estimated return plus irrigation cost was divided by the amount of water per acre[24] needed to grow that crop (University of Arizona 2001; UC Davis 2023). Based on this method, the order in which crops would be fallowed varied across the counties in the study area. In Arizona and Nevada, cotton is most likely to be fallowed first. In California, wheat and alfalfa would be fallowed before cotton; vegetables would be expected to be fallowed last in the entire study area.

As in the 2007 FEIS, the socioeconomic effects of changes in agricultural production in Arizona were analyzed using the IMPLAN input-output economic model. IMPLAN is a regional economic model that describes the flows from producers to intermediate and final consumers using a series of economic multipliers. The IMPLAN model describes for each county the transfers of money between all industries and institutions. This model of county-level economic interactions is used to project total changes to regional economic activity based on the direct change estimated in agricultural production. In addition to the direct loss in agricultural output, reduced expenditures

[22] The most recent available yield and price data for alfalfa hay were from 2018. More recent cotton and wheat data (2019 to 2022) were available; however, for consistency across the different crops, 2018 data were the latest data used in this analysis.
[23] The cottonseed revenue estimates that were included in the 2007 model were excluded from current revenue estimates due to a lack of county-level yield data for cottonseed in Arizona.
[24] Water (per acre) required by a particular crop is assumed to be relatively constant over time.

occur from a drop in business-to-business purchases and in reduced household expenditures. These changes, known as indirect and induced economic effects, were also estimated using IMPLAN.

This analysis of economic impacts from fallowed crops is based on a uncompensated reduction in agricultural production associated with modeled levels of shortage. System conservation included in the No Action Alternative and Proposed Action would result in a voluntary reduction of water use for agricultural purposes, for which entities would receive compensation per the details of existing agreements (under the No Action Alternative) and the states' proposed alternative (for the Proposed Action). The regional economic impacts from system conservation are discussed qualitatively.

Impact Analysis Area

Potential changes in agricultural production within the study area due to estimated shortages were quantitatively assessed for the counties expected to experience impacts; these include La Paz, Maricopa, Mohave, Pima, Pinal, and Yuma Counties in Arizona; Imperial, Riverside, and San Bernardino Counties in California; and Clark County in Nevada.

Assumptions

- Farmers would fallow irrigated crops in response to water shortages or an increased cost of irrigation.
- Farmers would fallow crops that generate the lowest returns per acre-foot of water.
- Crops have a constant profitability per acre of land and per acre-foot of water.
- Changes in the amount of irrigated crops would be the result of changes in water deliveries from the Colorado River sources; they do not involve changes to allocations or to irrigation water from groundwater or other surface water sources.
- Estimated shortages in the agricultural sector are based on the Shortage Allocation Model (**Appendix E**, Shortage Allocation Model Documentation).
- DCP contributions and ICS assumptions are consistent with the official June 2023 CRMMS simulation, as detailed in **Appendix D**.
- The Shortage Allocation Model does not account for the use or conversion of ICS to meet DCP contributions, and it models DCP contributions as shortages to Lower Division States and users.
- Shortages and required DCP contributions are distributed between Nevada and Arizona, and between California parties, as described in the 2007 Interim Guidelines and the 2019 DCPs.
- For all alternatives, available water is distributed within the CAP based on the CAP priority system, and shortage volumes are calculated relative to scheduled 2024–2026 use. Non-Indian CAP agricultural districts currently do not hold long-term CAP contacts, but they are shown as absorbing significant shortage based on their historical use of CAP excess water.
- In most cases, the contractor, subcontractor, or recipient of an allocation is shown as the entity bearing shortage, by sector. In some cases, water allocated to one contractor, subcontractor, or recipient (for example, a Tribal CAP contractor) may lease its allocation to other users (for example, to a non-Indian municipality). The Shortage Allocation Model does not replicate those arrangements, and it only provides approximate estimates at the contract or subcontract allocation level. The CAP contractor, subcontractor, and/or parties to those

arrangements would have specific decisions to make during shortage conditions to administer those arrangements that Reclamation cannot predict with sufficient certainty to analyze in this SEIS.

Impact Indicators

- Acres of fallowed cropland
- Crop profitability per acre-foot of water
- Jobs and income associated with agriculture

Recreation

A qualitative discussion is provided related to social and economic impacts from changes in recreational access and experiences as a result of changes in reservoir elevations and river flows, as discussed in **Section 3.14**, Recreation.

In addition, a discussion of net economic value changes is provided for a subset of recreational activities, including for anglers and whitewater rafters in Glen and Grand Canyons. This analysis is provided following the approach used in the recreation economic analysis for the LTEMP SEIS (Gaston et al. 2015). Models were informed from past survey research and were used to project the change in net economic value for angling in Glen Canyon and whitewater rafting in Grand Canyon; these were compared with the Proposed Action and No Action Alternative scenarios. The analysis was based on whitewater boater and angler surveys that examined different river flow scenarios to estimate the net economic value of an individual trip as a function of river flow. The function used to estimate the net economic value is for conditions where within-day fluctuations are less than 10,000 cfs, consistent with the Proposed Action and No Action Alternative.

Impact Analysis Area

The impact analysis area consists of the counties adjacent to the Colorado River from Lake Powell to the SIB.

Assumptions

Recreation spending per trip for anglers and whitewater rafting (adjusted for inflation) would follow results from willingness-to-pay surveys (Gaston et al. 2015) with variation based on river flows.

Impact Indicators

- Recreation’s economic contributions

Municipal and Industrial Uses

Impacts on municipal and industrial uses of water are discussed qualitatively based on anticipated water shortages of various magnitudes, as determined under the Shortage Allocation Model. The analysis then examines whether a particular shortage event would affect the M&I sector as compared with the No Action Alternative. For example, a shortage in Arizona would affect parts of the agricultural sector first before affecting M&I uses. In contrast, a shortage in Nevada would primarily affect M&I users, because Nevada has a small agricultural sector that uses high-priority Colorado River water.

For situations likely to have an effect on the M&I sector, each state's ability to manage shortages to the M&I sector is analyzed. The M&I shortages allocated to each state are compared with the drought plans or actions that state or local agencies could institute during a shortage. The analysis then qualitatively discusses whether such drought-planning mechanisms are adequate to address shortages to the M&I sector and the existing and estimated conservation measures to be applied under the No Action Alternative and Proposed Action.

Impact Analysis Area

The analysis area for M&I water shortages is the same as the overall analysis area for socioeconomics, as described in **Section 3.15.1**.

Assumptions

The analysis is based on shortage levels as modeled in the Shortage Allocation Model, and the frequency and magnitude of shortages based on modeled CRMMS output.

Impact Indicators

- The potential for economic impacts due to shortages and depletions among and within the Lower Division States

Issue 1: How would anticipated water shortages affect economic contributions from agriculture?

Summary

Anticipated water shortages would result in a temporary increase in acres of fallowed cropland and agricultural production loss under both alternatives. The modeled agricultural production loss would in turn result in short-term impacts on the associated jobs, income, and tax revenue . The No Action Alternative has the potential to result in up to $116 million in agricultural revenue loss, $112 million in income loss from jobs lost, and $25 million in tax revenue loss. Impacts also have the potential to occur in California and Arizona under this alternative.

Under the Proposed Action, the total range of agricultural sector losses and the associated impacts on jobs, income, and tax revenue, prior to consideration of compensated SEIS conservation, would be the same as modeled under the No Action Alternative. Increased SEIS conservation would result in more compensated conservation than under the No Action Alternative (**Table 3-95**). This would offset, to some degree, the level of economic impacts associated with reduced agricultural production. There are insufficient data, however, on the degree to which this compensation would offset the regional economic impacts in the agricultural sector, due to the loss of indirect and induced jobs and income that may not be fully compensated.

In addition, the long-term preservation of reservoir levels above a critical value (dead pool) due to proposed system conservation would help limit the potential for higher levels of shortage modeled. This is anticipated to lessen the long-term (potentially permanent) economic impacts.

Table 3-95
State-Level Comparison of Modeled Conservation for Irrigation Water Users (2023–2026 af Totals)

State		No Action Alternative	Proposed Action
		System Conservation	System Conservation
Arizona	Tribal	383,700	550,000
	Non-Tribal	36,200	138,400
California	Tribal	—	52,000
	Non-Tribal	98,200	1,582,000
Nevada	—	—	—

Source: Based on Shortage Allocation Model allocations for the type of use and CRMMS model assumptions for modeled conservation. ICS is not included due to no identified ISC for irrigated water users.

In addition, the Proposed Action would result in higher elevations at Lake Mead, with fewer traces at higher shortage tiers, as compared with the No Action Alternative, in 2025 and 2026. As a result, the potential to reach higher-tier shortage levels for domestic water users (for example, those shortages as modeled at 967,000 to 1,100,000 af) would be reduced. This would, in turn, result in a decreased potential to reach higher levels of economic impacts on the regional economy compared with the modeled impacts under the No Action Alternative.

No Action Alternative

Temporary impacts (during periods of lower water elevations) from allocated shortages under the No Action Alternative (200,000 af to 1.100 maf of water) would result in up to 98,485 acres of fallowed cropland and up to $120 million in loss of agricultural production. The impacts would be restricted to the Arizona analysis area and would be limited to field crops. Under the No Action Alternative, cotton, wheat, and hay were analyzed in detail, and impacts did not extend to additional crops. **Table 3-96** shows the total estimated acres of fallowed cropland and the reduction in the dollar value of agricultural production for different shortage volumes under the No Action Alternative.

While non-Indian agriculture is expected to experience short-term impacts for every allocated shortage amount, lower shortage volumes (between 200,000 and 533,000 af) would not result in impacts on Indian agriculture. However, for shortages greater than 617,000 af, up to $13 million in agricultural production loss would be due to fallowed Indian agricultural lands, which account for up to 11 percent of total agricultural production loss in the study area.

In the long term, if the current guidelines of the No Action Alternative remained in effect, the water levels would be expected to decline below a critical level in Lake Mead; if water levels decline below this threshold, farmers across the analysis areas in Arizona, California, and Nevada would experience long-term (potentially permanent) production loss from fallowed crops.

Table 3-96
Acres of Fallowed Cropland and the Loss of Market Value of Agricultural Production in Arizona and California – No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture – Arizona		Non-Indian Agriculture – California		Indian Agriculture		Total Agriculture in the Study Area	
	Fallowed Cropland (Acres)	Change in Production Value	Fallowed Cropland (Acres)	Change in Production Value	Fallowed Cropland (Acres)	Change in Production Value	Fallowed Cropland (Acres)	Change in Production Value
200	50,067	$57,566,506	0	$0	0	$0	50,067	$57,566,506
533	74,269	$89,980,128	0	$0	0	$0	74,269	$89,980,128
617	82,482	$98,932,404	0	$0	2,456	$3,052,073	84,938	$101,984,477
867	83,065	$99,797,208	2,154	$3,367,803	5,387	$6,693,991	90,606	$109,859,002
917	83,065	$99,797,208	2,692	$4,209,854	5,387	$6,693,991	91,144	$110,701,053
967	83,065	$99,797,208	3,231	$5,051,825	5,387	$6,693,991	91,683	$111,543,024
1,017	83,065	$99,797,208	3,769	$5,893,795	5,387	$6,693,991	92,221	$112,384,994
1,100	83,895	$101,374,907	3,769	$5,893,795	10,821	$12,967,706	98,485	$120,236,408

Source: Values were calculated using input from the Shortage Allocation Model and crop profitability, according to the methodology described above.

Note: Modeling results should only be used to compare the relative magnitude of impacts that are reasonably expected to occur under the alternatives. The results are not a substitute for agricultural production loss estimates in the analysis area; the results are subject to uncertainties from built-in assumptions and data limitations.

For those Tribes identified by Reclamation to use the full or a substantial amount of their water entitlement for agricultural operations, this analysis assumed 100 percent of consumptive-use water, as well as allocated shortages, were used for irrigation; the exact proportion of water used for agricultural operations for these Tribes was not known.

Due to data limitations for Indian agriculture, such as those involving privacy concerns, particularly for Tribes where three or fewer farms for a given crop exist, estimates did not account for the full allocated shortage volumes. Therefore, economic impacts may be larger than the estimated values.

Table 3-97 provides an overview of the jobs, income, and total economic output associated with the estimated change in agricultural production value due to fallowed crops under each shortage level for the No Action Alternative. This analysis covers anticipated shortages for operating years 2024 through 2026. **Table 3-98** provides an overview of the change to tax revenue from agricultural production losses over the same period. Under the No Action Alternative, shortages and related economic impacts have the potential to occur in Arizona and California agriculture.

The estimates provided above do not account for compensated conservation. Under the No Action Alternative, existing agreements would be in place for approximately 518,100 af of irrigation user-associated water (see **Table 3-95**). Of this amount, California system conservation agreements are associated with the Palo Verde Irrigation District in Riverside and Imperial Counties (98,200 af), and Arizona conservation agreements with Tribal entities are associated with 383,700 af of water allocation. Non-Tribal system conservation agreements include approximately 36,200 af in Mohave, Yuma, and La Paz Counties.

Table 3-97
Estimated Jobs and Income under the No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture – Arizona		Non-Indian Agriculture – California		Indian Agriculture		Total	
	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income	Total Jobs	Total Income
200	657	$67,037,544	0	$0	0	$0	657	$60,442,632
533	1,082	$86,934,411	0	$0	0	$0	1,082	$86,934,411
617	1,506	$97,623,780	0	$0	31	$2,780,000	1,537	$100,403,780
867	1,539	$98,418,089	43	$1,860,665	68	$6,097,798	1,650	$106,376,552
917	1,539	$98,418,089	54	$2,325,831	68	$6,097,798	1,661	$106,841,718
967	1,539	$98,418,089	65	$2,790,997	68	$6,097,798	1,672	$107,306,884
1,017	1,539	$98,418,089	75	$3,256,163	68	$6,097,798	1,682	$107,772,050
1,100	1,525	$100,082,619	75	$3,256,163	88	$8,368,185	1,688	$111,706,967

Source: Agricultural model output and IMPLAN 2021 software and data
Note: Total jobs include direct, indirect, and induced jobs. Due to model limitations and market uncertainties, modeling results should only be used to compare the relative magnitude of impacts that are reasonably expected to occur under the alternative.

Table 3-98
Estimated Tax Revenue Change under the No Action Alternative

Shortage Amount (1,000 af)	Non-Indian Agriculture – Arizona ($)	Non-Indian Agriculture – California ($)	Indian Agriculture ($)
200	10,465,107	0	0
533	14,395,033	0	0
617	16,646,755	0	2,087,855
867	16,814,136	646,886	4,579,323
917	16,814,136	808,608	4,579,323
967	16,814,136	970,329	4,579,323
1,017	16,814,136	1,132,051	4,579,323
1,100	17,211,487	1,132,051	6,404,036

Source: Agricultural model output and IMPLAN 2021 software and data
Note: Includes local, state, and federal tax revenue. Tax amounts are affected by agricultural subsidies. The agricultural sectors in IMPLAN have significant amounts of government subsidies. Because tax revenue is net of subsidies, it can be negative for a given industry in a given year, if that industry receives more subsidies from the government than it pays out in these specific taxes in that year. Due to model limitations and market uncertainties, modeling results should only be used to compare the relative magnitude of impacts that are reasonably expected to occur under the alternative.

Existing system conservation agreements would offset, to some degree, the level of economic impacts associated with reduced agricultural production. There are insufficient data, however, on the degree to which this compensation would offset the regional economic impacts in the agricultural sector, due to the loss of indirect and induced jobs and income that may not be fully compensated. For example, compensation agreement funds may not be distributed to the agricultural workers who may, therefore, still experience a loss of labor income. Similarly, funds may not be distributed to regional retail stores, restaurants, and other businesses that would typically be beneficiaries of the induced spending of labor income.

Proposed Action

Under the Proposed Action, the range of agricultural sector losses prior to consideration of compensation would be the same as modeled under the No Action Alternative. Increased system conservation would result in a higher level of compensated conservation than under the No Action Alternative. Estimated system conservation agreements include a total of 2,312,700 af of irrigation user-associated water (see **Table 3-95**). Of this amount, additional system conservation agreements modeled in California are associated with the Bard Water District and Imperial Irrigation District in Imperial County, and the Coachella Valley Water District in Riverside County. Tribal system conservation modeled in California includes the Quechan Indian Tribe in Imperial County.

In Arizona, system conservation agreements modeled with Tribal entities are associated with 550,000 af of water allocation for Tribes in Maricopa, Pinal, and Gila Counties. Additional Non-Tribal system conservation agreements include approximately 138,400 af in Mohave, Yuma, and La Paz Counties

As noted in the No Action Alternative, system conservation agreements would offset, to some degree, the level of economic impacts associated with reduced agricultural production. There are insufficient data, however, on the degree to which this compensation would offset the regional economic impacts in the agricultural sector, due to the loss of indirect and induced jobs and income that may not be fully compensated.

In addition, the Proposed Action would result in higher elevations at Lake Mead, with fewer traces at higher shortage tiers, as compared with the No Action Alternative, in 2025 and 2026. As a result, the potential to reach higher-tier shortage levels for agricultural water users (for example, those shortages as modeled at 967,000 to 1,100,000 af) would be reduced. This would, in turn, result in a decreased potential to reach higher levels of economic impacts on jobs, income, and tax revenue for the regional economy compared with those modeled under the No Action Alternative.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would not result in changes to water diversion amounts, water available for agriculture, or associated economic contributions.

No cumulative effects would occur on economic contributions from agriculture due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would changes to reservoir levels as a result of water shortages impact economic activity associated with recreation?

Summary

Under both alternatives, economic contributions from recreation in Lake Powell; Lake Mead; and other reservoirs, including Lake Havasu; river-based recreation; and adjacent land-based recreation would continue. Contributions from recreation at national wildlife refuges would also continue. Due to anticipated reservoir levels, there is the potential for reduced contributions from reservoir-based recreation due to inaccessibility of boat launches in Lakes Powell and Mead as well as navigational issues. These issues would be present under both alternatives, but slightly reduced under the Proposed Action.

For river-based recreation, activities and the associated economic contributions and nonmarket values would be supported under both alternatives due to minimum flow requirements. The net economic value for whitewater rafting and anglers as a function of river flow would be similar across both alternatives, as would impacts on recreation and the associated visitor spending in the Salton Sea region. No impact on recreation contributions associated with Lake Havasu is anticipated due to a lack of anticipated changes to reservoir levels. For national wildlife refuges, no data are available to support a change in water-based recreation levels and the associated economic contributions as a result of the Proposed Action.

No Action Alternative

Under the No Action Alternative, water levels in Lake Powell would remain below thresholds for boat launching, as discussed in **Section 3.1.4**; this would impact the visitor experience for recreational boating in the reservoir. At LMNRA and GCNRA, the No Action Alternative would make boat ramps and marina services partially or completely unavailable, limiting recreation and the associated contributions and representing costs associated with maintaining access. Concessioners have spent $6 million in the last 3 years on projects directly tied to mitigating the impacts of low Lake Powell elevations (NPS 2022e).

The degree to which water levels would result in a reduction in economic contributions would depend on the impact on total visitation and related spending; these are difficult to predict given that water-based recreation is only one source of recreation-related economic contributions. Water-based recreation does, however, represent a large portion of visitor activity. Based on the most recent GCNRA visitor survey, 46 percent of visitors to the GCNRA participated in some form of motorized boating activity (NPS 2018). Water-based recreation is likely to be affected by lake volume.

Nehr et al. (2013) found lake volume in Lake Powell to be predictor of visitation levels in the summer season. This model projected that a 100,000-af increase in Lake Powell volume over a year was associated with 5,280 additional recreational visits to Lake Powell and $374,000 in additional visitor spending in tourism-related sectors in Coconino County, Arizona. The Lake Powell volume-visitation and volume-spending models imply the average visitor to Lake Powell spends $71 in the lodging, restaurant and bar, and amusement/recreation sectors in Coconino County. This estimate is generally consistent with independent estimates of visitor spending derived from prior NPS visitor surveys (Nehr 2013). Based on correlation in Nehr 2013, it was estimated that lake elevation reductions from 3,675 to 3,625 feet would result in a more than 25 percent reduction in visitation (Johnson et al. 2016). As discussed in **Section 3.14.2**, the importance of land-based recreation may be increasing with decreasing lake elevations, which could influence total reductions in economic contributions when water levels decrease.

For Lake Mead, a similar potential for a reduction in economic contributions associated with water-based recreation is possible; this is because all but one boat launch would be inaccessible under modeled reservoir levels under this alternative. Navigational hazards would also be present, further impacting the visitor experience and potentially the level of spending ($327 million in 2021, as detailed in the affected environment section).

The availability of camping near the lakeshore during the shoulder seasons increases revenue for gateway businesses and LMNRA since the fall and spring months are the best times of year for fishing. This effectively extends the season for visitation at LMNRA, which makes revenue streams more stable for tourist-dependent businesses over a greater part of the year. As access to the shoreline changes, campers attracted for fishing opportunities may be discouraged from visiting, thus reducing income to LMNRA and local businesses.

The loss of visitation and the associated visitor spending due to low lake levels could have significant impacts on the revenue associated with LMNRA and GCNRA, including declines in entry and camping fees, as well as impacts on concessioners due to declining visitation and commercial-use fees. If operations are no longer economically viable, some concessionaires and small businesses may no longer be able to operate. This, in turn, could result in a loss of visitor services provided by concessionaries, including, but not limited to, lodging, food and beverage facilities, fuel boat tours, and a medical clinic. A loss of these services can impact the visitor experience in opportunities available, as well as travel time and visitor safety. The economies of gateway communities could be significantly affected from a loss of direct visitor spending and the associated indirect and induced spending.

No impact on recreation's contributions associated with other reservoirs, including Lake Havasu, is anticipated due to a lack of anticipated changes to reservoir levels.

For river-based recreation, commercial recreation upstream of Lake Powell may continue at present levels under the No Action Alternative and the Proposed Action. High variability of flows has and will continue to make this section of the river less popular for commercial operation.

For whitewater rafting from Glen Canyon to Lake Mead, including GCNP, it is anticipated that minimum flow requirements for Glen Canyon Dam would result in continued commercial operations. As a result, it is anticipated that economic contributions would continue to be supported under the No Action Alternative; however, the variation in flow may impact the recreational experience and the related value that users obtain from this experience.

The net economic value supported for whitewater rafting and anglers in Glen and Grand Canyons is shown in **Table 3-99**. It should be noted that the modeling estimates are based on flow and do not account for other factors that may impact boating or anglers. For example, in terms of fishing opportunities, under the No Action Alternative there is the potential for seasonal impacts on rainbow trout from temperatures at lower lake elevations in Lake Powell (see **Section 3.14.2** for additional details). Impacts on the visitor experience and level of visitation for commercial whitewater rafting have the potential to impact the associated economic contributions, which are important for rural communities and small business in northern Arizona and southern Utah, as discussed in the affected environment section.

Table 3-99
Mean Low to High Annual Net Economic Value for River-Based Recreation in Glen and Grand Canyons (Millions of $2022)

Activity	
Whitewater rafting	24.57 to 38.37
Angling	1.30 to 1.71

Note: Use values are based on methods in Gaston et al. 2015. Mean annual high and low values are based on high and low values by month from 90 ESP traces, with values provided for a 60-month simulation period. Estimated individual whitewater trips per month (NPS 2006a) are multiplied by the net economic value per trip to obtain the aggregate net economic value for whitewater rafting. The analysis does not include reservoir use, water-based day use in Glen Canyon, and recreational rafting in the lower Grand Canyon below Diamond Creek. Net economic value is indexed to 2022 dollars using the consumer price index (US Bureau of Labor Statistics 2023). The information in the table represents estimates based on best available data and should be used for the purpose of alternative comparison only.

For national wildlife refuges, no data are available to support a change in water-based recreation levels and the associated economic contributions as a result of the No Action Alternative.

In addition to potential impacts on river and reservoir recreation, there is also the potential for impacts on recreation on the Salton Sea and the surrounding region. As noted in **Section 3.14**, Recreation, the Salton Sea's shoreline would be anticipated to continue to decrease at current rates, which would increase the potential for impacts on local air quality (see **Section 3.9**, Air quality). Decreased air quality has been correlated with decreased visitor satisfaction and spending levels not only adjacent to the Salton Sea, but in the greater Palm Springs region (Tourism Economics 2014).

Proposed Action

As described for the No Action Alternative, under the Proposed Action, projected Lake Powell elevations would be below the critical thresholds for most boat launch facilities and safely navigating Castle Rock and Gregory Butte. This would result in lower visitor satisfaction and may impact visitation numbers and economic contributions. Recreation impacts at Lake Powell would be slightly reduced under the Proposed Action because the Proposed Action would preserve more water in Lake Powell and reduce overall variability in water surface elevations; this would result in a slight potential for reduced impacts on recreation visitation and related spending. Similarly, the slight rebound in Lake Mead pool elevations under the Proposed Action could marginally help limit the closure or relocation of boat launch facilities at Lake Mead in year 2026, compared with the No Action Alternative. This could result in a slight decrease in the potential for related impacts on recreation visitation and spending.

Impacts on whitewater boating would be the same as those described under the No Action Alternative.

As described in **Section 3.7.2**, Issue 6, under the Proposed Action, there is the possibility that IID and CVWD could enter into additional system conservation agreements; thus, there could be reduced deliveries, resulting in potentially less inflow to the Salton Sea from irrigation drainage. Therefore, the Proposed Action could result in expedited (but not additional) lake bed exposure, compared with the No Action Alternative, due to less possible available agricultural runoff. As described in **Section 3.9**, lake bed exposure can result in air quality impacts. This could result in impacts occurring on regional recreation and the associated spending in an expedited fashion compared with the No Action Alternative.

Cumulative Effects

As discussed above, this SEIS's alternatives would result in relatively minor changes in use values and economic activity associated with reservoir and river recreation. The LTEMP SEIS flow options would have the potential for cumulative impacts on economic contributions associated with sport fisheries within the Glen Canyon Dam to Lake Mead reach of the Colorado River due to changes in the water temperature released from Glen Canyon Dam, as detailed in **Section 3.14.2**.

No cumulative effects would occur on economic activity associated with recreation due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 3: How would water shortages impact M&I uses of water?

Summary

Under both alternatives, allocated water shortages for different elevations in Lake Mead would result in domestic (e.g., M&I) water shortages compared with 2021 use levels, the last non-shortage year in the Lower Basin. The economic impacts from domestic and industrial water shortages are unknown due to the variety of approaches the municipalities and other entitlement holders use in shortage scenarios, including supply-side actions (such as groundwater recharge, water purchase agreements, and alternative water supplies) and demand-side strategies (such as water conservation measures). One study estimated that if all Colorado water were lost for 1 year, this would result in impacts on 16 million job years and $871 billion in labor income in $2014 for the Upper and Lower Basin regions (James et al. 2014).

Under the No Action Alternative, impacts would be realized at lower shortage scenarios for Arizona entitlement holders (533,000-af scenario) and Nevada entitlement holders (200,000-af scenario) compared with California; this is due to the modeled effects of the 2007 Interim Guidelines and 2019 DCPs. Impacts on California entitlement holders would be realized at the 867,000-af shortage scenario. At a 1.100-maf shortage scenario, maximum levels of shortage would result in domestic water shortages of 179,364 af in Arizona, 30,000 af in Nevada, and 325,500 af in California (based on California's DCP contribution).

Conservation measures applied under both alternatives would reduce the potential to reach higher levels of shortage, by increasing the potential that Lake Mead levels would remain above critical levels. **Table 3-100** shows a comparison of conservation measures by alternative for users with primarily domestic use.

Table 3-100
Comparison of Modeled Conservation for Domestic Water Users (2023–2026 af totals)

State	No Action Alternative		Proposed Action	
	System Conservation	ICS	System Conservation	ICS
Arizona	209,000	—	402,400	41,800
California	146,000	—	—	216,000
Nevada	—	65,000	—	285,000

Source: Based on Shortage Allocation Model designations for the type of use and CRMMS assumptions for modeled conservation.

Modeled shortage scenarios under the Proposed Action would be the same as those under the No Action Alternative; however, the increased level of system conservation and ICS would result in higher elevations at Lake Mead, with fewer traces at higher shortage tiers as compared with the No Action Alternative in 2025 and 2026. As a result, the potential to reach higher-tier shortage levels for domestic waters users (such as those shortages modeled at 967,000 to 1,100,000 af) would be reduced.

No Action Alternative

The driest region of the country—the Census Bureau's Mountain division, comprising Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming—is expected to grow by approximately 45 percent between 2010 and 2040 (Kearney et al. 2014). Population growth combined with precipitation decreases is leading to increasing demand for municipal water throughout the study area.

As discussed in the 2007 FEIS, shortages to the Arizona M&I sector would be addressed through the state's and each local jurisdiction's drought responses and plans. These responses include supply-side and demand-side actions. Supply-side actions may include groundwater recharge, water purchase agreements, and alternative water supplies, such as brackish water and reclaimed water. Demand-side strategies focus on implementing different stages of water conservation measures as drought progresses. Existing conservation measures at the state level are shown in **Table 3-100**.

Due to shortages triggered pursuant to the 2007 Interim Guidelines in 2022 and 2023 and contributions that were made under the DCPs and other programs in the Lower Division States, some municipalities are already enacting drought response programs. These programs often include a combination of voluntary and enforced restrictions, depending on the anticipated shortage levels (see, for example, Gilbert, Arizona's Supply Reduction Management Plan 2022). **Table 3-101**, below, shows estimated shortages for domestic use.

In 2024, Arizona M&I shortages would range from approximately 89,525 af during a 533,000-af shortage to 179,364 af during a 1.100-maf shortage (see **Table 3-101**).

Table 3-101
No Action Alternative—Impacts on Arizona Domestic Water Shortages from the Range of Analyzed Volumes of Total Shortages (af)

County	200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
Coconino County	0	0	0	0	0	0	0	0
Gila County	0	0	0	156	156	156	156	390
La Paz County	0	0	0	0	0	0	0	1
Maricopa County	0	78,174	85,482	104,683	104,683	104,683	104,683	134,332
Mohave County	0	0	0	0	0	0	0	3,314
Pima County	0	7,317	7,317	17,986	17,986	17,986	17,986	34,031
Pinal County	0	4,034	4,034	5,337	5,337	5,337	5,337	7,296
Yuma County	0	0	0	0	0	0	0	0
Arizona Domestic Shortages	**0**	**89,525**	**96,833**	**128,162**	**128,162**	**128,162**	**128,162**	**179,364**

An estimated 146,600 af of system conservation measures for domestic uses are associated with existing signed agreements with CAP subcontractors. These may be fulfilled in part by implementing statewide and local demand-side and supply-side strategies, although conservation agreements do not dictate the specifics of how conservation is achieved.

In California, deliveries to MWD are not anticipated to be adversely affected for Lower Basin shortages until 867,000 af under the No Action Alternative; these reductions are associated with California's contributions under the DCPs, which are made notwithstanding the Lower Basin priority system, as modeled in the 2007 FEIS. For the purpose of this analysis, these reductions are assumed to result in reduced water availability to MWD, although Reclamation acknowledges that flexibility exists for how the DCP contributions may be made.

Table 3-102 shows the estimated shortages for domestic use. However, total shortage amounts would be higher than those in Arizona for the higher range of analyzed shortage amounts. The Colorado River supplies approximately 25 percent of MWD water. Drought plans are under development and include storage systems, including groundwater and surface water reservoirs, reverse flow to enhance flexibility of delivery systems, partnership agreements for additional water supply, and in-region programs with member agencies to provide cost-offset opportunities and additional flexibility (MWD 2023). No system conservation measures are in place for domestic users in California under the No Action Alternative. ICS includes 209,000 af associated with the MWD.

Table 3-102
No Action Alternative—Impacts on California Domestic Water Shortages from the Range of Analyzed Volumes of Total Shortages (af)

State	200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
California Domestic Shortages[1]	0	0	0	186,000	232,500	279,000	325,500	325,500

[1] Includes the combined area of Los Angeles, Orange, San Diego, Riverside, and San Bernardino Counties supplied by the MWD

In Nevada, shortages to the M&I sector would mostly be borne by the SNWA, which has prepared a water resources plan (SNWA 2023) and adaptive management techniques to address water shortages. Estimated shortages for domestic use are shown below in **Table 3-103**.

Management includes voluntary and involuntary conservation programs as well as water banking. This includes ICS for domestic uses in Clark County at a level of 65,000 af.

Table 3-103
No Action Alternative—Impacts on Nevada Domestic Water Shortages from the Range of Analyzed Volumes of Total Shortages (af)

State	200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
Nevada Domestic Shortages	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000

In the long term, if the current guidelines under the No Action Alternative remain in effect, the water levels would be expected to decline below a critical level in Lake Mead; if water levels decline below this threshold, more severe domestic shortages would be triggered with the potential for additional social and economic impacts.

Proposed Action

Under the Proposed Action, modeled shortages would be the same as outlined in the No Action Alternative. Under this alternative, however, additional system conservation would be applied. **Table 3-100** provides an overview of the additional SEIS system conservation for domestic water users under the Proposed Action, based on Shortage Allocation Model assumptions regarding the primary type of water usage by each entitlement holder. It should be noted that these values of additional SEIS system conservation are based on modeling assumptions; they do not represent mandatory system conservation, and they in no way commit specific water entitlement holders to system conservation.

As shown in **Figure 3-20**, Percent of Traces with Lower Division Shortage and DCP Tiers, due to system conservation measures, the Proposed Action would result in higher elevations at Lake Mead with fewer traces at higher shortage tiers, as compared with the No Action Alternative, in 2025 and 2026. As a result, the potential to reach higher-tier shortage levels for domestic water users (such as those shortages as modeled at 967,000 to 1,100,000 af) would be reduced.

Cumulative Effects

The potential operational changes included in the LTEMP SEIS flow options would not impact water shortage amounts for M&I uses or the associated economic contributions.

No cumulative effects would occur on M&I uses of water due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.17 Environmental Justice

3.17.1 Affected Environment

Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (59 *Federal Register* 7629, February 11, 1994; US President 1994b), formally requires federal agencies to incorporate environmental justice as part of their missions. Specifically, it directs them to address, as appropriate, any disproportionately high and adverse human health or environmental effects of their actions, programs, or policies on minority and low-income populations.

Analysis consists of two steps: (1) screening of populations within the study area to identify the presence of communities for further environmental justice consideration, and (2) review of impacts to determine the potential for disproportionate adverse impacts on these communities.

As in the 2007 FEIS, the environmental justice study area is defined by those counties that may be affected by management direction that could result in water shortages or changes to water-based recreation.

While the California, Nevada, and Utah study areas are the same as those described in the 2007 FEIS and detailed in the Socioeconomic section, the Arizona study area for this SEIS has been expanded to include four additional counties: Apache, Gila, Graham, and Navajo. This is because as of 2023, there are Indian water rights settlements involving CAP water and/or non-CAP Colorado River water delivered through the CAP with several Tribes, including White Mountain Apache, which overlaps the aforementioned counties (more information is provided in subsequent paragraphs). The Arizona study area from the 2007 FEIS consisted of Coconino, La Paz, Maricopa, Mohave, Pima, Pinal, Yuma, and Yavapai Counties. The Arizona study area for this SEIS includes 12 counties. Information is provided below on locations within these counties that receive water deliveries and the rationale for the expansion of the study area.

As of 2023, there are Indian water rights settlements involving CAP water and/or non-CAP Colorado River water delivered through the CAP with the Ak-Chin Indian Community, Fort McDowell Yavapai Nation, Gila River Indian Community (GRIC), San Carlos Apache Tribe, Salt River Pima-Maricopa Indian Community, Tohono O'odham Nation, Yavapai-Prescott Indian Tribe, Hualapai Tribe, and White Mountain Apache Tribe. Other Tribes hold CAP contracts (Pascua Yaqui Tribe, Sif Oidak District of the Tohono O'odham Nation, Tonto Apache Tribe, and Yavapai-Apache Tribe). CAP water is also retained for a future water rights settlement agreement approved by an act of Congress that settles the Navajo Nation's claims to water in Arizona. Additional details are included in **Section 3.18**, Indian Trust Assets (ITAs).

The California study area for this SEIS consists of six counties, including Riverside and Imperial Counties, where the Salton Sea is located.

Map 3-2 provides an overview of the environmental justice study area and population centers within it. **Map 3-2** also displays the environmental justice study area counties in relation to the two major storage reservoirs (Lake Powell and Lake Mead) with major fluctuations in the water's surface level.

BUREAU OF RECLAMATION

Map 3-2
Environmental Justice Study Area

- Environmental justice study area: counties that may be affected by management direction, resulting in water shortages or changes to water-based recreation
- Populated place
- Dam
- Colorado River
- Colorado River tributary
- Colorado River Basin, Upper and Lower Basins
- States in the Colorado River Basin

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While not shown in this map, several other mainstream dams are present. While this analysis presents data and identifies environmental justice communities at the county level, it should be noted that additional environmental justice communities may be present at a smaller geographic scale.

Each county was screened to identify the presence of low-income, minority, and Native American populations that would meet the criteria for identification as populations for further consideration for environmental justice concerns.

This section identifies environmental justice communities in the analysis area based on the following criteria:

- CEQ 1997 guidance states that minority or low-income populations should be identified where either (1) the minority or low-income population of the affected area exceeds 50 percent, or (2) the minority or low-income population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. The total minority populations are defined as the total population minus those who identify as White, of non-Hispanic descent. For the meaningfully greater analysis, Reclamation used 110 percent of the minority percentage of the geographic reference area as the threshold for meaningfully greater. For Arizona, California, Nevada, and Utah, 110 percent of the total minority population is 35.1 percent, 43.5 percent, 32.2 percent, and 15.8 percent, respectively.
- Low-income populations are defined relative to the annual statistical poverty thresholds from the US Census Bureau (CEQ 1997). The guidance does not provide criteria for determining low-income populations as specifically as it does for minority populations. Therefore, for this analysis, low-income populations are defined as people whose income is less than or equal to twice (200 percent of) the federal poverty level. For this analysis, populations are considered low-income populations when (1) 50 percent of the population is classified as low income, or (2) any geographic area of analysis has a low-income percentage of the population equal to or higher than the reference area.
- Federally recognized Tribes are considered environmental justice populations in and of themselves; when possible, they are included in the analysis as separate minority populations. For this analysis, additional screening was utilized to review US Census Bureau data for those who identify as American Indian or Alaska Native alone or in combination with one or more other races. Reclamation also used a threshold analysis and meaningfully greater analysis to identify Indigenous populations that meet the criteria for environmental justice consideration. The 50 percent threshold analysis involves identifying any block groups with a total Indigenous population 50 percent or greater.

Table 3-104 provides an overview of the environmental justice screening results for the study area.

Table 3-104
Study Area Environmental Justice Screening Results (2021)

Geographic Area	Minority Population Percentage of Geographic Area (Meaningfully Greater Percentage)	Indigenous Population Percentage of Geographic Area	Low-income Population Percentage of Geographic Area	Meets Criteria for Environmental Justice Communities of Concern?
Reference Area				
Arizona	31.9 (35.1)	5.8	31.7	—
California	39.5 (43.5)	2.3	28.5	—
Nevada	29.3 (32.2)	2.5	31.2	—
Utah	14.4 (15.8)	2.0	24.7	—
Apache County, Arizona	82.3*	75.0*	59.3*	Yes
Coconino County, Arizona	14.6	28.7*	37.4*	Yes
Gila County, Arizona	38.9*	19.6*	40.9*	Yes
Graham County, Arizona	49.6*	14.6*	42.3*	Yes
La Paz County, Arizona	28.3	18.4*	44.3*	Yes
Maricopa County, Arizona	31.5	3.2	28.6	No
Mohave County, Arizona	24.1	3.6	38.3*	Yes
Navajo County, Arizona	58.7*	46.3*	49.9*	Yes
Pima County, Arizona	38.0*	6.1*	34.4*	Yes
Pinal County, Arizona	30.9	6.5*	31.3	Yes
Yavapai County, Arizona	20.6	3.2	32.0*	Yes
Yuma County, Arizona	64.7*	2.8	44.0*	Yes
Imperial County, California	85.1*	2.3	46.6*	Yes
Los Angeles County, California	48.7*	2.1	32.2*	Yes
Orange County, California	34.0	1.5	23.3	No
Riverside County, California	50.3*	2.2	30.4*	Yes
San Bernardino County, California	54.6*	2.6*	34.4*	Yes
San Diego County, California	34.3	2.0	25.2	No
Clark County, Nevada	31.8*	2.0	32.5*	Yes
Garfield County, Utah	6.2	4.6*	40.2*	Yes
Kane County, Utah	3.2	5.1*	31.5*	Yes
San Juan County, Utah	6.0	49.8*	44.1*	Yes

*Meets the criteria for environmental justice community of concern
Source: US Census Bureau 2021a, 2021b, 2021c

Overall, 19 of the 22 study area counties met at least one environmental justice criterion (11 Arizona counties, 1 Nevada county, 3 Utah counties, and 4 California counties). As such, the study area has 19 environmental justice populations at the county level. In Arizona, Apache, Gila, Graham, Navajo, and Pima Counties had minority, low-income, and Indigenous populations that met the criteria. San Bernadino County, California, also had minority, low-income, and Indigenous populations that met the criteria. See **Table 3-104** for more information; details for each indicator are provided below.

Additional information is also provided below on Tribal populations with the potential to be affected by the proposed management.

Further, of the 12 Arizona study area counties that each contain communities that receive Colorado River water, either through CAP or mainstream diversions, 11 counties are identified as environmental justice communities, based on the criteria described above. The only exception is Maricopa County, which did not have minority, low-income, or Indigenous populations that exceeded the respective thresholds. While Maricopa County did not have an Indigenous or minority population that met the criteria, it is important to note that both the Salt River Pima-Maricopa Indian Community and the Fort McDowell Yavapai Nation, and portions of the GRIC and Tohono O'odham Nation, are within Maricopa County.

Minority Population

In Arizona, 6 of the 11 counties had total minority populations that exceeded the meaningfully greater threshold of 35.1 percent. In addition, Apache, Navajo, and Yuma Counties had total minority populations well above 50 percent, ranging from 58.7 percent to 82.3 percent. The total minority population in Clark County, Nevada, exceeded the meaningfully greater threshold of 32.2 percent and is considered an environmental justice community. In California, all counties, excluding Orange and San Diego Counties, had minority populations that met the meaningfully greater threshold of 43.5 percent. No counties in Utah had minority populations that exceeded the meaningfully greater threshold of 15.8 percent. As such, there were no identified environmental justice communities in Utah. **Map 3-3** displays the minority populations at the county level.

Indigenous Population

In Arizona, all counties, excluding Maricopa, Mohave, and Yavapai Counties, had Indigenous populations exceeding the state average Indigenous population (5.8 percent). In California, only San Bernadino County had an Indigenous population exceeding the state average (2.3 percent). No counties in Nevada had an Indigenous population that exceeded the state average (2.5 percent). In Utah, all three counties had Indigenous populations that exceeded the state average (2.0 percent), and the Indigenous population in San Juan County, Utah, was notably higher than the other study area counties. **Map 3-4** displays the Indigenous populations at the county level.

It should be noted that the information above pertains to those counties that met or exceeded thresholds for total Indigenous population. Additional Tribal populations at the Tribe and reservation levels are identified in the *Tribal Populations* section below.

Low-Income Population

For Arizona, all study area counties, excluding Maricopa County (28.6 percent) and Pinal County (31.3 percent), had low-income populations exceeding the state average (31.7 percent). For California, all study area counties, excluding Orange County (23.3 percent) and San Diego County (25.3 percent), had low-income populations that exceeded the state average (28.5 percent). All three study area counties in Utah and the single study area county in Nevada had low-income populations that exceeded the state averages (24.7 percent and 31.2 percent, respectively). **Map 3-5** displays low-income populations at the county level.

Tribal Populations

Tribal populations with potential to be affected by project management include those with current entitlements to receive Colorado River water in the Lower Basin (**Map 3-6**). The following Tribes were identified:

Tribes with entitlements related to CAP water:

- Ak-Chin Indian Community
- Fort McDowell Yavapai Nation
- Gila River Indian Community
- Pascua Yaqui Tribe
- Salt River Pima-Maricopa Indian Community
- San Carlos Apache Tribe
- Tohono O'odham Nation
- Tonto Apache Tribe
- Yavapai-Apache Nation
- White Mountain Apache Tribe

Tribes with entitlements held in the reservation's name:

- Cocopah Indian Reservation
- Fort Mojave Indian Reservation
- Fort Yuma Indian Reservation
- Colorado River Indian Reservation
- Chemehuevi Indian Reservation

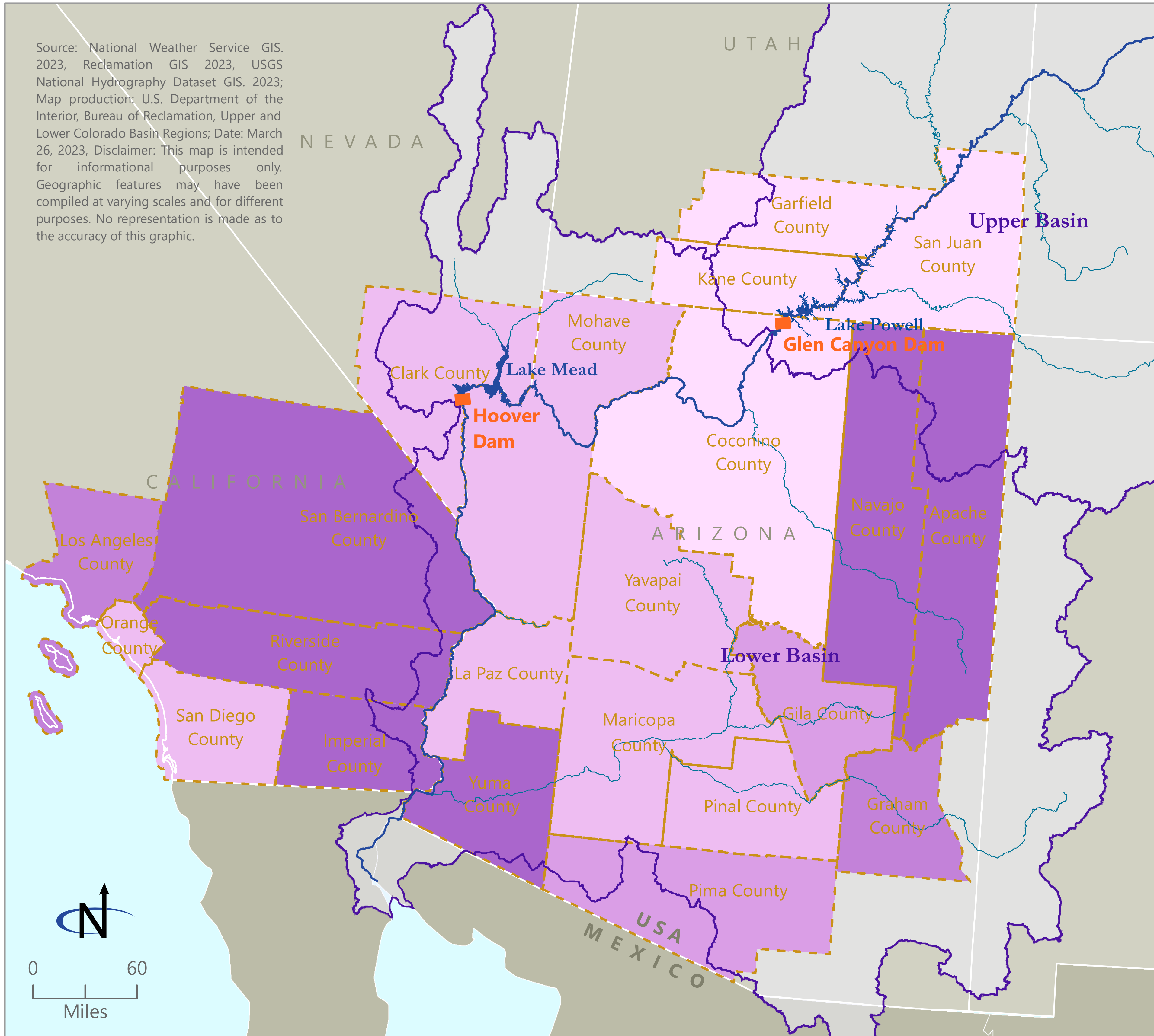
In addition to the list above, the Hopi Tribe holds a contract for delivery of Colorado River water for use along the mainstream river, rather than on reservation lands.

3.17.2 Environmental Consequences

Methodology

This section relies on the analyses in other resource sections to identify whether either alternative would be likely to have adverse human health or environmental impacts. These impacts are discussed in the context of the potential for disproportionate adverse impacts on identified environmental justice communities.

This analysis also relies on modeling assumptions and modeling output from two models: CRMMS (see **Appendix D**, CRMMS Model Documentation) and the Shortage Allocation Model (see **Appendix E**, Shortage Allocation Model Documentation). While more detailed information can be found in **Appendixes D** and **E**, summary information is provided here for context.



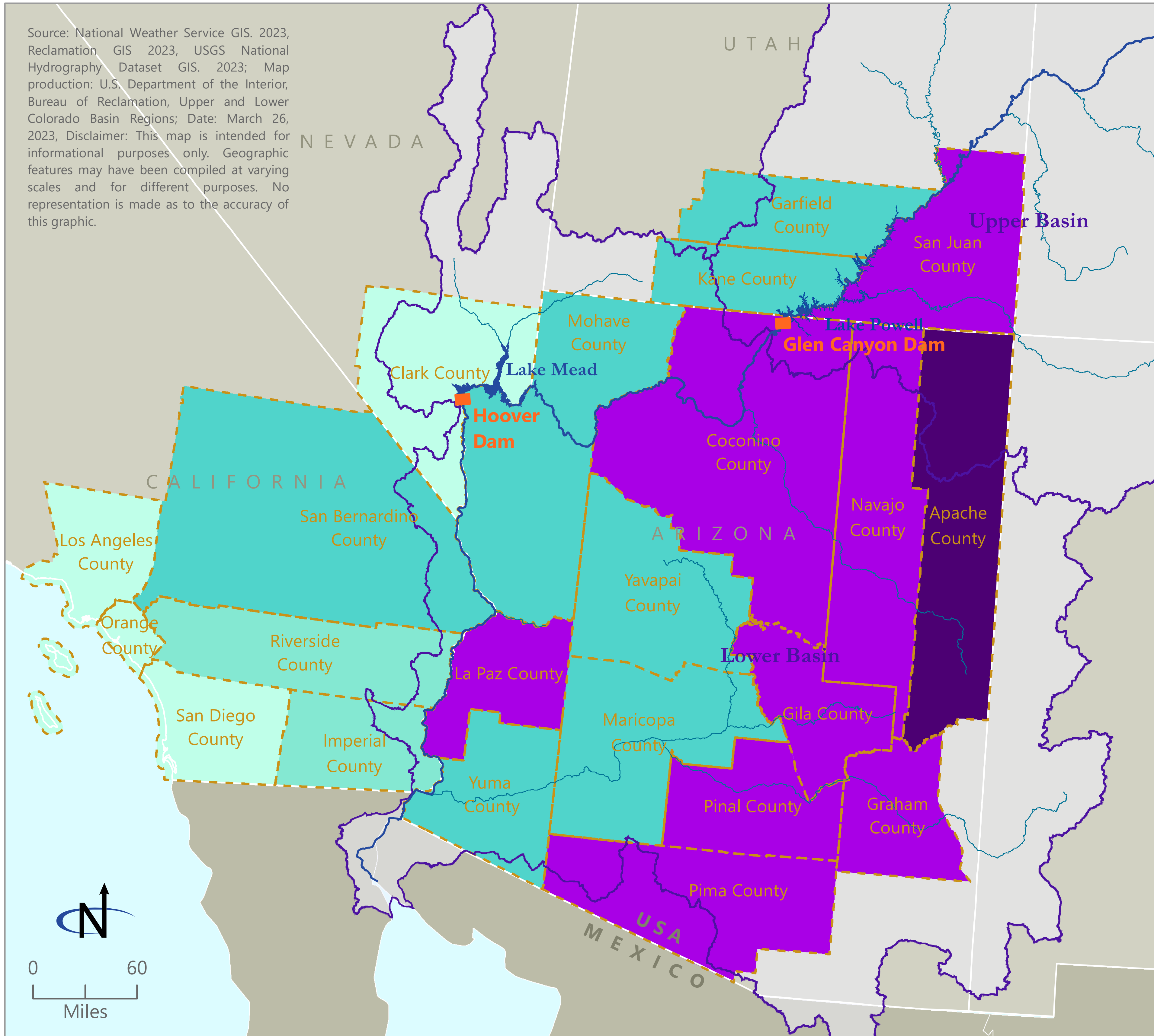
Map 3-3
Minority Populations for Environmental Justice Consideration

Percent of the population identifying as a racial and/or ethnic minority at the county level

- 0-15.0
- 15.1-35.0
- 35.1-45.0
- 45.1-50.0
- 50.1-85.1

State	% minority population meaningfully greater threshold
Arizona	35.1
California	43.5
Nevada	32.2
Utah	15.8

- Environmental justice study area: counties that may be affected by management direction, resulting in water shortages or changes to water-based recreation
- Dam
- Colorado River
- Colorado River tributary
- Colorado River Basin, Upper and Lower Basins
- States in the Colorado River Basin



BUREAU OF RECLAMATION

Map 3-4
Indigenous Populations for Environmental Justice Consideration

Percent of the population identifying as a American Indian or Alaska Native (alone or in combination with one or more other races) at the county level

- 1.5- 2.2
- 2.3- 2.5
- 2.5- 5.7
- 5.8-50.0
- 50.1-75.0

State	% Indigenous population state threshold
Arizona	5.8
California	2.3
Nevada	2.5
Utah	2.0

- Environmental justice study area: counties that may be affected by management direction, resulting in water shortages or changes to water-based recreation
- Dam
- Colorado River
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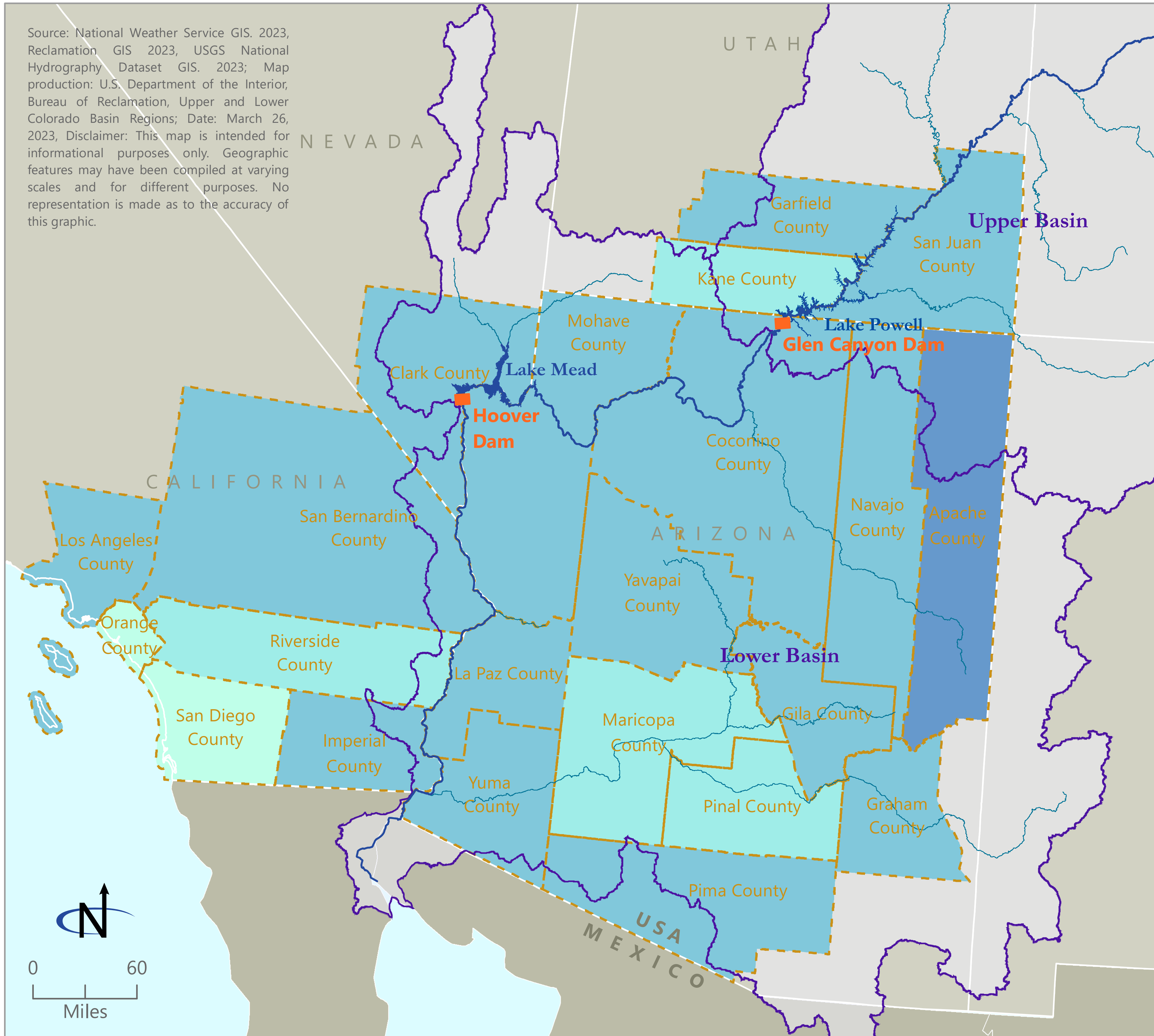
- Colorado River Basin, Upper and Lower Basins
- States in the Colorado River Basin



BUREAU OF RECLAMATION

Map 3-5
Low-income Populations for Environmental Justice Consideration

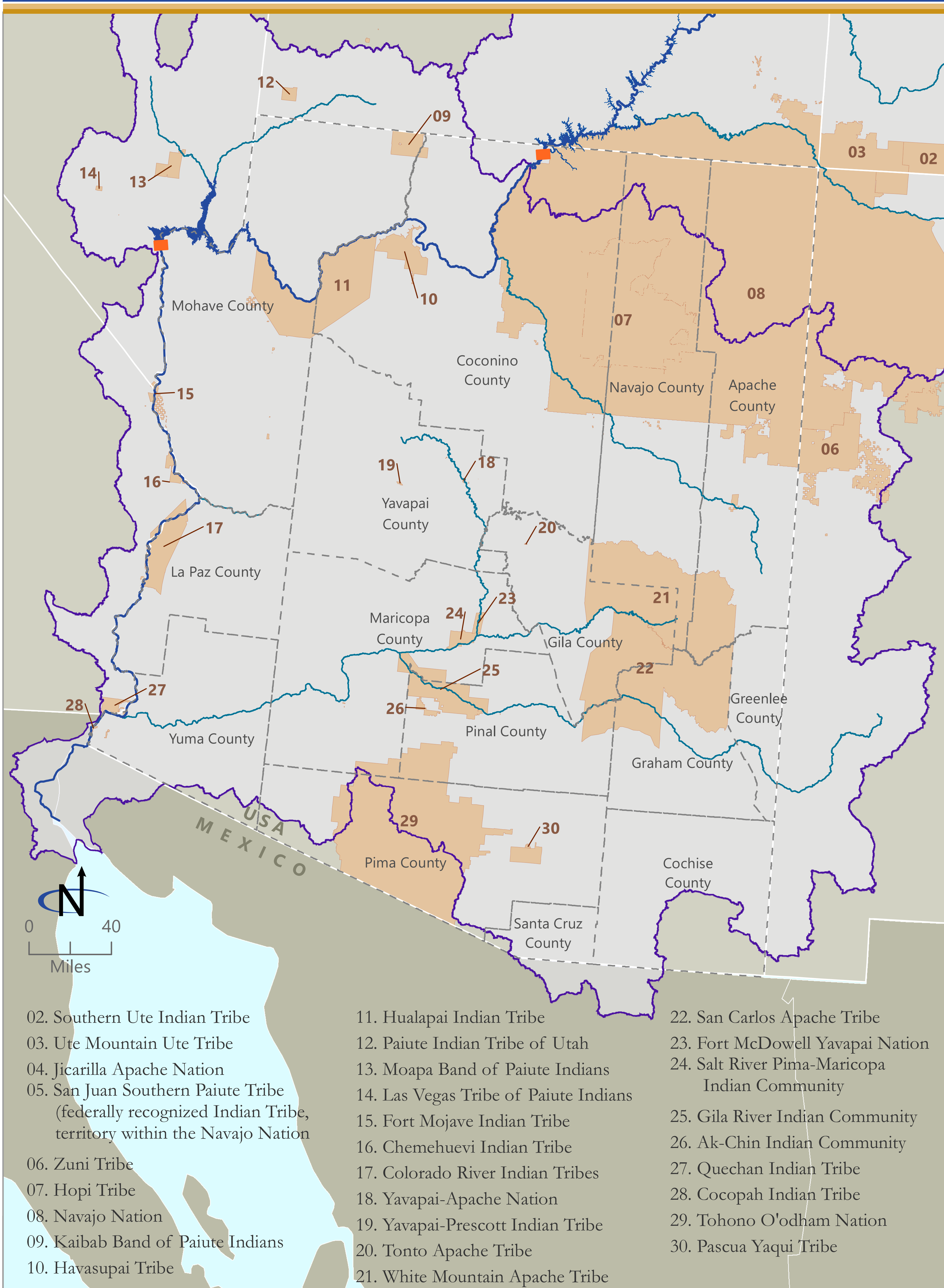
Percent of the population identifying as living at or below 200 percent of the federal poverty level

- 23.0-28.4
- 28.5-31.5
- 31.6-50.0
- 50.1-59.3

State	% low-income population state threshold
Arizona	31.7
California	28.5
Nevada	31.2
Utah	24.7

- Environmental justice study area: counties that may be affected by management direction, resulting in water shortages or changes to water-based recreation
- Dam
- Colorado River
- Colorado River tributary
- Colorado River Basin, Upper and Lower Basins
- States in the Colorado River Basin

BUREAU OF RECLAMATION



Map 3-6 Tribal Populations

Tribal Reservation and off-reservation trust land
Colorado River
Colorado River tributary
Dam
Colorado River Basin, Upper and Lower Basins
States in the Colorado River Basin

Source: National Weather Service GIS. 2023, Reclamation GIS 2023, USGS National Hydrography Dataset GIS. 2023; Map production: U.S. Department of the Interior, Bureau of Reclamation, Upper and Lower Colorado Basin Regions; Date: October 13, 2023, Disclaimer: This map is intended for informational purposes only. Geographic features may have been compiled at varying scales and for different purposes. No representation is made as to the accuracy of this graphic.

Impact Analysis Area

The impacts analysis area is the same as that described in **Section 3.17.1**. This analysis provides baseline information for the environmental justice study area counties; however, there are communities who could experience more impacts from water shortages and changes to water deliveries. For instance, there are areas within the Arizona environmental justice study area counties in which there currently are no replacement or alternative water sources. Should these areas experience water shortages that result in available Colorado River water deliveries being reduced to zero, impacts would be more severe compared with areas where replacement or alternative water sources exist.

Assumptions

The Shortage Allocation Model does not account for replacement or alternative water sources. Refer to **Appendix E** for more information on the Shortage Allocation Model assumptions.

The modeled SEIS conservation assumptions are used to conduct CRMMS modeling. These assumptions are provided in **Section 3.7**, Issue 6, and **Appendix** D.

Impact Indicators

- Disproportionate and adverse human health or environmental impacts
- Shortage levels at which available water would be reduced to zero for priorities/users within environmental justice study area counties
- Percentage of traces with Lower Division shortage and DCP tiers

Issue 1: How would management decisions affect environmental justice communities?

Summary

Under the No Action Alternative, no modeled shortage levels resulted in available water being reduced to zero under any priorities for California and Nevada. However, if shortages reached 533,000 af, available water would be reduced to zero for certain entitlements within the CAP in Arizona's fourth priority, extending to additional entitlements at a shortage of 617,000 af. Arizona fifth and sixth priorities are assumed not to be available in any level of shortage. Some users in Maricopa, Pinal, and Pima Counties would have their CAP water supply reduced to zero.

It should be noted that shortage levels modeled for the No Action Alternative would be the same as those for the Proposed Action in the short term. However, projections based on low-flow hydrologic scenarios indicate that, without a change to current operational guidelines, decreasing reservoir levels would result in increased system shortages, potentially limiting the ability to deliver water. This could result in an increased level of impacts on environmental justice communities.

Under the Proposed Action, modeled shortage levels are the same as those under the No Action Alternative. As a result, available water would be reduced for the same counties in Arizona (Maricopa, Pinal, and Pima Counties, which represent the current CAP service area where CAP deliveries occur) as under the No Action Alternative. Impacts on irrigation and domestic use from water shortages would be the same as those described for the No Action Alternative. While the shortage levels at which available water would be reduced to zero would vary by state and priority, the same environmental justice study area counties would experience available water being reduced, or impacts from available water being reduced, under the Proposed Action for this time period. In the longer term, hydrologic models indicate that reservoir levels would be maintained above critical levels for a longer length of time with the implementation of the Proposed Action. Therefore, impacts on environmental justice communities could be reduced compared with the No Action Alternative in the long term.

Compared with the No Action Alternative, the Proposed Action would result in an increased level of system conservation, through the proposed SEIS system conservation. This would allow for a reduced potential for higher levels of modeled shortages and mandatory shortages to occur, and provide greater predictability for water users. For example, if an entity chose to enter into a system conservation agreement and voluntarily conserve Colorado River water, this would contribute to maintaining water levels in the system overall. It also would reduce the potential that mandatory shortages would be triggered in lower operational years. As a result, the Proposed Action would reduce the likelihood of the impacts on individual users from higher modeled shortage amounts, including those within environmental justice counties.

No Action Alternative

Existing system conservation and ICS were modeled using CRMMS. Under the No Action Alternative, total modeled system conservation is estimated to be 938,758 af. Detailed assumptions are provided in **Appendix D**. System conservation is Colorado River water conserved through agreements with individual users who are compensated. In contrast, ICS is not compensated. Under the No Action Alternative, existing modeled system conservation includes executed agreements with the following entities in Maricopa, Pinal, Pima, Mohave, Yuma, and La Paz Counties, Arizona: GRIC, Fort McDowell Yavapai Nation, CAWCD and certain CAP subcontractors, Mohave Valley Irrigation and Drainage District, Yuma Mesa Irrigation and Drainage District, and Gabrych Farms. Additionally, modeled system conservation includes an executed agreement with Palo Verde Irrigation District in Riverside and Imperial Counties, California.

Under the No Action Alternative, a range of volumes of total shortage to Lower Division States were analyzed using a Shortage Allocation Model. Potential water shortages would not impact water deliveries in California or Nevada to the degree that there would be zero water for any priorities under the No Action Alternative, as detailed in **Section 3.7**, Water Deliveries.

Eleven of the Arizona counties are environmental justice communities. Two of the three counties comprising the CAP service area are environmental justice communities (Pinal and Pima). Given the assumption that Arizona fifth and sixth priorities are assumed not to be available in any level of shortage, a Lower Basin shortage would cause the reduction of water deliveries first to the Arizona fourth-priority Colorado River entitlements, which include CAP Arizona fourth-priority (P4[ii]) and other post-1968 Arizona fourth-priority Colorado River contractors (P4[i]).

Under the No Action Alternative, there are shortage levels where available water for users under some priorities would be reduced to zero in Arizona. According to the model results, at water shortage levels ranging from 533,000 af to 1.100 maf, some water users within the Arizona environmental justice study area counties would be reduced to zero water availability under certain priorities of Colorado River water. These impacts are discussed in further detail below. The degree to which these shortages would result in disproportionate adverse impacts would depend on the availability and cost of alternative water supplies.

Irrigation

At shortage levels of 533,000 af and greater, available water for users under the Arizona fifth- (unused entitlement/apportionment) and sixth- (surplus) priority entitlements, and users of the CAP excess pool in Maricopa, Pinal, and Pima Counties, Arizona, would be reduced to zero.

Pinal and Pima Counties are identified as environmental justice communities. As such, the water users within these counties who would have water delivery reduced to zero would face disproportionate consumptive-use impacts on irrigation. Farmers who have used CAP excess water to irrigate crops would need to use alternative water supplies, such as groundwater, if available, to continue agricultural production.

The Salton Sea receives flows from excess irrigation drainage, particularly from the IID and CVWD, which are in Riverside and Imperial Counties, California. These two counties are considered environmental justice counties. Under the No Action Alternative, there would be no changes to current operational activities that would affect flows to the IID or CVWD. Therefore, the surface water elevation of the Salton Sea could continue to decrease at the current rate. Surface water elevation decreases could impact all communities adjacent to the Salton Sea, including environmental justice communities.

Domestic Use

Consumptive-use impacts on domestic uses would vary by the volume of total shortage to the Lower Division States. The number of counties, different types of priority holders, and different types of entitlement holders who would face zero water supply would increase as the volume of total shortage to Lower Division States increased (see **Appendix E**).

At levels of shortage of 533,000 af and greater, domestic water supply from the CAP NIA-B[25] priority in Maricopa, Pinal, and Pima Counties would not be available. If water shortages reached 617,000 af, available water for users under the CAP NIA-A priority would also be reduced to zero.

Tribal Allocations

The allocations discussed in this section are based on the Shortage Allocation Model, which is more detailed and specific than the regional analysis presented in **Section 3.7.2**, Issue 6 (see also **Appendix E**).

Under the No Action Alternative, available water for all users under CAP NIA-A priority in Maricopa, Pima, and Pinal Counties will be reduced to zero if water shortages reach 617,000 af. The Tohono O'odham Nation and GRIC hold CAP NIA allocations in this pool that would be reduced to zero. Beyond the CAP NIA pool, at higher levels of modeled shortage, the available water supply for Tribes holding other entitlements to Arizona fourth-priority water (P4[i] or P4[ii]) are projected

[25] NIA refers to the CAP Non-Indian Agricultural Priority subcontracts. The NIA-A and NIA-B designations approximate the shortage sharing provisions in applicable contracts and subcontracts, including paragraph 4.7(b)–(c) of the NIA subcontracts.

to be reduced. At the allocation level, this impacts six Tribal entitlements in Arizona (Hopi Tribe, GRIC, Ak-Chin Indian Community, San Carlos Apache Tribe, Salt River Pima-Maricopa Indian Community, and Tohono O'odham Nation [Schuk Toak and San Xavier Districts]); however, the Shortage Allocation Model does not account for the existence of external arrangements and commitments that would affect alternate water availability to these Tribes or the ultimate impacts of water unavailability to the entitlement (see **Appendix E**). However, even if water deliveries are reduced to Tribes during shortages, the entitlement to the underlying water rights would not be affected.

Proposed Action

As with the No Action Alternative, existing system conservation and ICS were modeled using CRMMS. However, the modeling assumptions for the Proposed Action also include additional SEIS conservation for operational years 2023 through 2026.

Under the Proposed Action, total modeled system conservation (including system conservation and ICS) is estimated to be 3,038,611 af. The modeling assumptions indicate an anticipated increased level of system conservation, compared with the No Action Alternative. Under the Proposed Action, additional entities in California and Arizona would participate in system conservation, with a total of nine entities in Arizona and five entities in California.

In addition to the existing system conservation being carried out by the entities described under the No Action Alternative, the San Carlos Apache Tribe, Colorado River Indian Tribes, and Welton-Mohawk Irrigation and Drainage District are assumed to participate in system conservation under the Proposed Action in Arizona. In California, additional system conservation would be carried out by two water districts (Coachella Valley Water District and Bard Water District), one irrigation district (Imperial Irrigation District), and one Tribe (Quechan Indian Tribe).

Further, the CRMMS modeling output demonstrates a reduced potential for higher shortage volumes to occur. Part of CRMMS modeling involves generating multiple time series, or "traces," of forecasted streamflow. The percentage of traces below critical elevations at Lake Powell and Lake Mead help us understand how changes to operational activities would affect reservoir elevations. Reservoir elevations are one metric that help characterize impacts on hydrologic resources and thereby characterize potential impacts on communities, including environmental justice communities who rely on such resources. As described in **Section 3.7.2**, the Proposed Action would result in higher elevations at Lake Mead, with fewer traces at higher shortage tiers, as compared with the No Action Alternative, in 2025 and 2026 (see **Figure 3-20**). In other words, the Proposed Action would reduce the potential for mandatory shortages to occur based on Lake Mead elevations.

The Shortage Allocation Model does not have a version unique to the Proposed Action since the distribution and priority of shortages are the same as under the No Action Alternative. However, the Shortage Allocation Model results provide for a meaningful comparison of alternatives, as they help to characterize existing conditions and thereby assess how the Proposed Action and associated proposed system conservations would impact overall water supply to specific water entitlement holders.

Hydrologic Resources and Water Deliveries

Irrigation

Under both alternatives, at higher levels of modeled shortage, available water would be reduced to zero for Arizona 5th- and 6th-priority contracts and CAP agricultural and other excess water users (see **Appendix E**). Under the Proposed Action, if higher levels of modeled shortage occurred, the irrigation impacts would be the same as those described under the No Action Alternative. However, under the Proposed Action modeled system conservation is estimated to be higher (compared with the No Action Alternative), as three additional California irrigation users (CVWD, BWD, and IID) and one Arizona irrigation user (Wellton-Mohawk Irrigation and Drainage District) would voluntarily conserve based on modeled assumptions. The additional system conservation proposed under the Proposed Action would contribute to a reduced potential for higher levels of modeled shortage to occur.

By avoiding higher levels of modeled shortage through increased system conservation, available water supply for irrigation use would be maintained in a manner that would reduce irrigation impacts for all entities who rely on the Lower Basin water supply for irrigation use, including those located in environmental justice counties in Arizona (La Paz, Mohave, and Yuma Counties) and California (Imperial and Riverside Counties).

While system conservation would result in some users located within environmental justice counties voluntarily reducing use of available water supply for irrigation, the voluntary nature of such reductions could reduce the severity of impacts on irrigation as compared with those resulting from mandatory reductions. For instance, irrigation users may have greater capacity to plan for and adjust to reduced water supply. This includes irrigation users who would face irrigation impacts at higher levels of modeled shortage.

The irrigation districts, irrigation and drainage districts, and water districts participating in system conservation in Arizona and California would be compensated under these system conservation agreements. As described in **Section 3.16**, a higher level of compensated conservation would offset to some degree the economic impacts associated with reduced agricultural production. However, the ultimate distribution of compensatory funds within the economy is unknown. There is insufficient data to determine the economic impacts of compensation on the agricultural sector due to the loss of indirect and induced jobs and income that may not be fully compensated. For example, compensated conservation funds may not be distributed from the entitlement holder to the agricultural workers, who may therefore still experience a loss of labor income. Similarly, funds may not be distributed to regional retail stores, restaurants, and other businesses that would typically be beneficiaries of the induced spending of labor income. While the water entitlement holder would be compensated, end point impacts would depend on compensation distribution. This is true for all water user groups (irrigation, domestic, and Tribal) who participate in system conservation.

As described in **Section 3.7.2**, Issue 6, under the Proposed Action there is the possibility that IID and CVWD could enter into additional system conservation agreements. Thus there could be reduced deliveries, resulting in potentially less inflow to the Salton Sea from irrigation drainage. Therefore, the Proposed Action could result in expedited (but not additional) lake bed exposure compared to the No Action Alternative, due to the possibility of less available agricultural runoff. As described in **Section 3.9**, lake bed exposure can result in air quality impacts. These air quality impacts could potentially impact nearby environmental justice communities to a higher degree.

Domestic Use

Under the Proposed Action, domestic use impacts would be the same as those described under the No Action Alternative. Under both alternatives, at higher levels of modeled shortage, available water supply for domestic use would be reduced to zero for CAP NIA-A and CAP NIA-B entitlement holders (see **Appendix E**). However, the additional system conservation proposed under the Proposed Action would contribute to a reduced potential for higher levels of modeled shortage to occur. By avoiding higher levels of modeled shortage through increased system conservation, available water supply for domestic use would be maintained in a manner that would reduce consumptive-use impacts on domestic uses for all entities, including users with CAP NIA-A and NIA-B priority entitlements located in environmental justice counties.

Under the Proposed Action, there would be additional system conservation carried out by domestic users (certain CAP subcontractors) in Arizona.

Tribal Allocations

Under the Proposed Action, impacts would be the same as those described under the No Action Alternative. Modeled system conservation is estimated to be higher, however, and two additional Tribal entitlement holders in Arizona (San Carlos Apache Tribe and Colorado Indian River Tribes) and one in California (Quechan Indian Tribe) would voluntarily conserve under the Proposed Action. These entities would be compensated for system conservation. While the water entitlement holder would be compensated, end point impacts would depend on compensation distribution.

The additional system conservation proposed under the Proposed Action would contribute to a reduced potential for higher levels of modeled shortage to occur. By avoiding higher levels of modeled shortage through increased system conservation, the potential for and severity of impacts on water supply for Tribal allocations would be reduced.

Gila, La Paz, Pima, Pinal, and Yuma Counties are identified as environmental justice communities. As such, the Tribal water entitlement holders located within these counties could face temporary, disproportionate consumptive-use impacts on irrigation and domestic use. Production on Tribal lands provides an important economic base for many Tribal communities, including those in the Arizona study area (Deol and Colby 2018). A lack of water supply could result in reduced agricultural production and a loss of Tribal revenue. Further, other Tribal uses of the entitlements include domestic, municipal and industrial, stock, and like uses, and a lack of water supply could result in reduced water availability for these purposes and a loss of Tribal revenue. However, it is important to note that losses in revenue are affected by other factors, including, but not limited to, the implementation of water rights settlements and availability of other resources. The Shortage Allocation Model does not account for the existence of external arrangements and commitments that would affect alternate water availability to these Tribes or the ultimate impacts of water unavailability to the entitlement.

Studies have documented impacts associated with losses in revenue. For example, one Utah State University study, which included several Tribes in Arizona, including the Tohono O'odham Nation, found that reductions in cattle and hay production due to drought result in reduced economic activity in related sectors and significant economic losses for Tribal economies in Arizona (Drugova et al. 2020). As detailed in **Section 3.16.2**, shortage may result in the loss of production for Tribal agricultural lands for a given year. Water delivery reductions may result in the fallowing of some Indian lands, with the potential for economic impacts, as described above. However, even if water deliveries are reduced to Tribes during shortage, the entitlement to the underlying water rights would not be affected. See **Section 3.18** for further information.

Water Quality

Potential changes to water quality were evaluated for salinity, temperature, metals, and perchlorate. Effects on these parameters would be minor and would not disproportionately affect any environmental justice communities in the study area. As elevations decrease, the dilution capacity of Lake Powell and Lake Mead would also decrease but would not likely result in any significant decrease in dilution capacity or increase in concentrations of metals of concern, including for environmental justice communities. However, quantified water-quality impacts related to dilution capacity are not available; therefore, it is difficult to project the quantified water-quality impacts, and alternatives cannot be compared (**Section 3.8**). Under any alternative, salinity would not exceed numeric salinity criteria established by the Colorado River Basin Salinity Control Forum.

Air Quality and Climate Change

As described in **Section 3.9.2**, under the Proposed Action there would potentially be more shoreline exposed at Lake Mead and Lake Powell as compared with the No Action Alternative. The increase in exposed shoreline would potentially have a negative effect on air quality.

At the Salton Sea, the current shoreline area could continue to decrease at the current rate. Under the Proposed Action, there is the possibility that IID and CVWD could take additional shortages; if so, there could be reduced river flows and thus potentially less inflow to the Salton Sea from irrigation drainage. However, both alternatives anticipate an increase in exposed shoreline, and this increase would potentially have a negative effect on air quality because the decreasing water level would increase fugitive dust. Since dust is already a concern for the Salton Sea area, additional dust would affect local air quality and public health.

The Salton Sea is located in two environmental justice counties in California: Riverside and Imperial. Under the Proposed Action, additional dust could result in disproportionate impacts on these environmental justice communities.

Under the Proposed Action, the reduction of hydropower could result in an increase in GHG emissions due to alternative power sources (see **Section 3.9**, Air Quality). When calculated, however, the potential GHG emissions from coal and natural gas alternatives are a very small percentage of the 11-state and US GHG emissions. The totality of climate change impacts is not attributable to any single action; nonetheless, this project-related emission, in combination with a variety of GHG emission sources around the world, could exacerbate climate-related impacts (albeit as a small contribution). Therefore, the Proposed Action could result in contributions to potential disproportionate effects on environmental justice communities.

Visual Resources

As described in **Section 3.10**, potential impacts on visual resources were considered (for both Lake Mead and Lake Powell) for attraction features, calcium carbonate rings, and sediment deltas, which would be viewed from adjacent highways, from the lake surface, and from trails in the area. Based on the potential higher lake elevations associated with the Proposed Action, there would be less modification to landscape character along the edge of Lake Powell and Lake Mead, including impacts on viewers, than under the No Action Alternative.

While some of these features (for example, Rainbow Bridge) are located within San Juan County, Utah, an environmental justice community, effects are not disproportionate or unique to any environmental justice community.

Also considered were potential impacts on landscape character along the Colorado River between Glen Canyon Dam and Lake Mead (associated with potentially lower flows through Grand Canyon) and impacts on landscape character associated with decreasing water deliveries/allocations in the Lower Division States (see **Section 3.10**, Visual Resources). Changes to the natural landscape character along the Colorado River between Glen Canyon Dam and Lake Mead would impact any environmental justice communities located within these areas. Additionally, there could be impacts on the irrigated, agricultural landscapes within the Lower Division States, where the influence of the Colorado River into adjacent lands could narrow as these areas would begin transition to their natural, arid condition, resulting in changes to landscape character compared with the existing condition. These changes to visual resources would also impact environmental justice communities within or adjacent to these landscapes. However, under the Proposed Action, the different release tiers would temper impacts on landscape character with the goal of maintaining consistent flows along the Colorado River (including through the Grand Canyon) while keeping Lake Powell above 3,500 feet. The proposed SEIS conservation would temper visual impacts on environmental justice communities.

Biological Resources

Potential impacts on vegetation, wildlife, and fish due to the No Action Alternative and Proposed Action would be similar, as the alternatives vary only by system conservation measures. The Proposed Action would result in slightly reduced impacts on wildlife. In some cases, impacts on fish and vegetation would be slightly higher under the Proposed Action, due to reduced water flows. However, potential impacts on biological resources would not disproportionately impact any environmental justice community identified within the study area.

Scoping and subsequent consultation did not result in the identification of any environmental justice community for whom indigenous fish, vegetation, or wildlife constituted a significant portion of their diet. There would be no difference in rates or patterns of subsistence consumption by environmental justice communities, including Indian Tribes, in comparison to the general population in the study area. See **Section 3.13**, Biological Resources, for more detailed information.

Cultural Resources

Section 3.11.2 analyzes how changes in operations would affect TCPs and resources of concern to Native Americans. For Lake Mead, the Proposed Action would have fewer negative impacts on cultural resources due to site exposure than the No Action Alternative, as pool elevations would be slightly higher. Adverse effects on sacred sites and TCPs could disproportionately impact Tribes for whom these resources provide cultural or spiritual significance and value. However, adverse effects on TCPs would be resolved through the LTEMP PA, land management agency actions, or the NHPA Section 106 process. See **Section 3.11**, Cultural Resources, for detailed information. Overall, the additional SEIS conservation would allow for reduced potential of higher modeled shortages and would result in fewer negative impacts on cultural resources than the No Action Alternative, as pool elevations would be slightly higher.

Under the Proposed Action, if conservation measures are required and implemented, less water would be flowing into the Salton Sea; this may lead to the exposure of cultural resources in the lake bed more quickly than under the No Action Alternative, but the result will eventually be the same as under the No Action Alternative. As such, disproportionate impacts on environmental justice communities are not anticipated.

Indian Trust Assets

Reclamation has concluded that the Proposed Action would have no significant impacts on Indian Trust Assets (ITAs). Reclamation is committed to protecting and maintaining ITAs and rights reserved by or granted to Indian Tribes or individual Indians by treaties, statutes, and executive orders. See **Section 3.18**, Indian Trust Assets, for more detailed information.

Electrical Power Resources

Changes to electrical power production have the potential to affect environmental justice communities disproportionately through possible increases in electricity rates resulting from decreased electrical power generation under the Proposed Action. Decreases in electrical power generation under the Proposed Action are anticipated to be highest in 2024 and decrease over the life of the project. However, the facilities potentially affected produce less than 2 percent of the total power produced in the region. Therefore, no substantial environmental justice effects are anticipated.

A decrease in available hydropower could result in reliance on other fuel sources for electricity generation. In California, utilities increased fossil fuel generation of electricity to compensate for the drought-driven decline in hydroelectricity, increasing state carbon dioxide emissions in 2011–2012 by 1.8 million tons of carbon, the equivalent of emissions from roughly 1 million cars (USGCRP 2018). Other southwestern states also shifted some generation from hydropower to fossil fuels (USGCRP 2018). If water shortages resulted in the need to rely on other fuel sources, environmental justice communities could face disproportionate health impacts associated with carbon dioxide emissions; such impacts are well documented (CDC 2021; EPA 2017; USGCRP 2018).

Recreation

Potential recreational impacts are primarily associated with reduced reservoir elevations affecting access or necessitating capital alterations to shoreline facilities around Lake Powell and Lake Mead.

Impacts on recreation are generally similar under both alternatives. Recreation impacts at Lake Powell would be slightly reduced under the Proposed Action because the Proposed Action preserves more water in Lake Powell and reduces overall variability in water surface elevations.

Individuals and businesses within San Juan County, Utah, the population of which is greater than 50 percent minority, could be affected by these recreational impacts. However, the effect would not be disproportionate to the recreational impacts experienced by other counties adjacent to Lake Powell and Lake Mead.

Socioeconomics

Under the Proposed Action, there is potential for shortages to result in economic impacts due to agricultural value changes, municipal water shortages, and changes to recreation-based economic contributions. The locations of impacts would vary by shortage level. While higher levels of modeled shortage could still occur under the Proposed Action, the higher level of system conservation would reduce the potential for higher levels of modeled shortage to occur, thereby maintaining water in the system and lessening socioeconomic impacts—including those to environmental justice communities—associated with higher levels of modeled shortage.

As described in **Section 3.12**, anticipated water shortages would result in agricultural production loss under both alternatives. Under both alternatives there would be an estimated potential of up to $116 million in agricultural revenue loss; however, these impacts would be tempered by system conservations under the Proposed Action. Potential agricultural revenue loss could result in disproportionate impacts on environmental justice communities, including Tribal populations, depending on how much Tribes rely on revenue from water deliveries. However, this analysis cannot characterize the level of magnitude of such impacts, as Tribal revenue data are not available.

Under the Proposed Action, the range of agricultural sector losses prior to consideration of compensation would be the same as modeled under the No Action Alternative. Increased system conservation would result in a higher level of compensated conservation than under the No Action Alternative (**Table 3-95**). This would offset to some degree the level of economic impacts associated with reduced agricultural production. As noted above, system conservation would be compensated under both alternatives. However, economic impacts associated with system conservation compensation, and resulting impacts on environmental justice communities, are difficult to determine. Depending on distribution of funds, there is potential for disproportionate adverse impacts on low-income and minority populations. Further, water being conserved through system conservation may no longer contribute to certain uses, resulting in potential for economic loss.

Cumulative Effects

The LTEMP SEIS flow options would not result in any changes to disproportionate adverse health or environmental impacts. Therefore, there is no expected change in impacts on environmental justice communities.

Food production, electricity generation, and human health in the Southwest are vulnerable to water shortages. In the Southwest, severe drought, wildfire, and temperatures have increased and are anticipated to continue. Trends of population growth have affected—and will continue to affect—

the demand for water, agricultural products, electricity, and housing. These trends will contribute to cumulative effects. Environmental justice communities, including Native Americans, are among the most at risk from climate change, often experiencing the worst effects because of higher exposure, higher sensitivity, and lower adaptive capacity for historical, socioeconomic, and ecological reasons (CDC 2021; EPA 2017; USGCRP 2018).

No cumulative effects would occur on environmental justice communities due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

3.18 Indian Trust Assets

3.18.1 Affected Environment

This section is summarized from Section 3.10, Indian Trust Assets (ITA), from the 2007 FEIS (Reclamation 2007) and is updated with changes since 2007. ITAs are assets held in trust by the federal government for the benefit of Native American Tribes or individuals (DOI 2023a). ITAs can be on or off reservation lands and can consist of land, water rights, mineral rights, hunting and fishing rights, grazing rights, or other assets.

Reclamation is consulting with Tribes, including those Tribes with water rights and water delivery contracts, regarding the proposed changes to the 2007 Interim Guidelines.

Analysis of the impacts on the Salton Sea are not relevant to this resource.

Water Rights and Trust Lands

Following the 2007 Interim Guidelines, water rights and trust lands include "federal reserved Indian rights to Colorado River water including rights established pursuant to *Arizona v. California*, Colorado River water Tribal delivery contracts where such contracts are part of a congressional approved water rights settlement; and Indian reservations" (Reclamation 2007). Reservations are treated as trust assets for the analysis, although they are not "technically synonymous with trust lands" (Reclamation 2007).

Indian Trust Assets Determined under *Arizona v. California*

Water rights of the Chemehuevi Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Fort Yuma-Quechan Tribe, and Cocopah Indian Tribe under the 1964 *Arizona v. California* decision and the 2006 Consolidated Decree are summarized in Table 3.10-1, Colorado River Mainstream Diversion Entitlement (Water Rights) in Favor of Indian Reservations, in Section 3.10.11 of the 2007 FEIS (Reclamation 2007).

Since the 2007 Interim Guidelines, water rights have been settled or partially settled for three additional Tribes (DOI 2023b). Water rights for the Navajo Nation in New Mexico were settled by the Northwestern New Mexico Rural Water Project Act of 2009 and for the Navajo Nation in Utah by the Navajo Utah Water Rights Settlement in 2022. The White Mountain Apache Tribe Water Rights Quantification Act of 2010 settled water rights for the White Mountain Apache Tribe. Water rights in Arizona for the Hualapai Tribe were settled under the Hualapai Tribe Water Rights Settlement Act of 2022. In addition, the Colorado River Indian Tribes Water Resiliency Act of 2022 authorizes the Colorado River Indian Tribes to enter into lease or exchange agreements, storage agreements, and agreements for conserved water.

Central Arizona Project

Tribal entitlements to CAP water and/or non-CAP Colorado River water delivered through the CAP in central Arizona are administered pursuant to water delivery contracts between Tribes and the Secretary. A summary of water rights settlements as of 2007 is presented in Section 3.10.1.2 of the 2007 FEIS (Reclamation 2007), and water rights for the CAP Tribes as of 2007 are summarized in Table 3.10-2, Central Arizona Project Indian Tribal Diversion Entitlements (Water Rights) (Reclamation 2007). As of 2023, water rights settlements involving CAP water have been executed with the Ak-Chin Indian Community, Fort McDowell Yavapai Nation, GRIC, San Carlos Apache Tribe, Salt River Pima-Maricopa Indian Community, Tohono O'odham Nation, Yavapai-Prescott Indian Tribe, Hualapai Tribe, and White Mountain Apache Tribe. CAP water is also retained for a future water rights settlement agreement approved by an Act of Congress that settles the Navajo Nation's claims to water in Arizona.

Hydroelectric Power and Generation

The Bureau of Indian Affairs operates Headgate Rock Dam and Powerplant, which supplies electricity to the Colorado River Indian Tribes and others (Reclamation 2007). The powerplant depends on Colorado River flows; however, "Reclamation has determined that the water appropriated to non-Colorado River Indian Tribes entities that flows through Headgate Rock Dam and generates powers is not an ITA" (Reclamation 2007) and will not be further discussed in this SEIS.

Cultural and Biological Resources

No cultural or biological resources that were considered ITAs for the 2007 Interim Guidelines analysis were identified by Tribes; however, concerns were expressed regarding TCPs, archaeological sites, sacred sites, fish and wildlife, wildlife habitat, and vegetation (Reclamation 2007).

3.18.2 Environmental Consequences

Methodology

Impacts on ITAs are drawn from several sources, including water deliveries (**Section 3.7**), socioeconomics (**Section 3.16**), and cultural resources (**Section 3.11**). Water deliveries are based on CRMMS modeling assumptions developed for the SEIS.

Impact Analysis Area

The impact analysis area consists of Native American Tribes with settled water rights, Native American reservations adjacent to the Colorado River, and the cultural resources analysis area (see **Section 3.10.2**).

Assumptions

The assumptions for the following analysis are:

- Changes in water deliveries will not affect settled water rights.
- Previously gathered data on TCPs and Tribal concerns are sufficient.
- Tribes may supply any additional information they believe should be considered in the ITA assessment.

Impact Indicators

Impact indicators for this analysis are:

- Changes in water allocations due to shortages
- Access changes to sacred sites
- Negative effects on TCPs not discussed in the 2007 FEIS or LTEMP

Issue 1: How would management of Colorado River allocations affect Tribal water rights and allocations?

Summary

Tribal water rights are established by law; however, annual water deliveries may change as a result of shortages and conservation measures. The Proposed Action may result in decreased water deliveries to Tribes that have agreed to conservation measures. This means under the Proposed Action more Tribes—those who participate in conservation measures—may have decreased deliveries in comparison to the No Action Alternative at a given surface water elevation at Lake Mead.

Water rights for individual Tribes are established by law. The determination of water allocations to individual entities is beyond the scope of this SEIS. As with the 2007 Interim Guidelines, "no vested water right of any kind, quantified or unquantified, including federally reserved Indian rights to Colorado River water, rights pursuant to the Consolidated Decree or Congressionally-approved water right settlements utilizing CAP water, will be altered as a result of any of the alternatives under consideration" (Reclamation 2007). A discussion of potential impacts on Tribal agricultural lands by alternative can be found in **Section 3.17**, Environmental Justice, in this SEIS.

See also **Section 3.7**, Water Deliveries, for a full discussion of impacts on water deliveries to all parties, as well as **Appendix E**, Shortage Allocation Model Documentation.

No Action Alternative

Under the No Action Alternative, water deliveries for Tribes follow the 2007 Interim Guidelines as analyzed in Section 4.10.1 of the 2007 FEIS (Reclamation 2007), the DCPs, and the current conservation measures agreed to by the Fort McDowell Yavapai Nation and the GRIC. Water deliveries to Tribes will fluctuate with water availability in Lake Powell and Lake Mead, as they will fluctuate for all entities that receive water from the Colorado River. Initially, water deliveries may remain near long-term averages, but reduced deliveries may occur if lake levels decline. Any water available will be distributed by priority among and within each state. As discussed in **Section 3.17.2**, Environmental Justice, this means that Tribes in Arizona who hold entitlements to CAP NIA-A priority water may have their available CAP NIA-A priority water reduced to zero if shortages reach a threshold level and Tribes with Arizona fourth priority water may also have their water reduced. In addition, shortages based on priority may result in the loss of production for Tribal agricultural lands. Any annual variability in water deliveries will not affect the underlying settled water rights.

Proposed Action

Under the Proposed Action, impacts would be the same as under the No Action Alternative; however, additional system conservation measures that would reduce water deliveries may be necessary if Lake Mead drops below 1,025 feet. Three additional Tribes (the Colorado River Indian Tribes, San Carlos Apache Tribe, and Quechan Indian Tribe) have agreed to voluntary conservation measures. Tribes that participate in the system conservation would be compensated.

Cumulative Effects

Reclamation has identified one past, present, and reasonably foreseeable future project that may, in conjunction with the proposed near-term Colorado River operations, contribute to cumulative effects on ITAs; this is the LTEMP SEIS. Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations and implement more HFEs to deposit sediment along sandbars and beaches. These proposed actions would not contribute to cumulative impacts on water deliveries. No cumulative impacts on water deliveries to Tribes are anticipated.

No cumulative effects would occur on water deliveries to Tribes due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

Issue 2: How would management of Lake Powell and Lake Mead water flows and lake levels affect cultural resources or biological resources?

Summary

Previously inaccessible sacred sites at Lake Mead would be more accessible to visitation under both alternatives. No other impacts are expected.

No Action Alternative

Under the No Action Alternative, decreases in the pool elevations at Lake Mead may increase visitor access to sacred sites that were previously inaccessible or under water (see **Section 3.11.2**, above). No impacts on important elements of TCPs important to Native Americans, such as plants or animals, are anticipated for the No Action Alternative.

Proposed Action

Impacts on sacred sites and TCPs are the same under the Proposed Action as the No Action Alternative.

Cumulative Effects

Reclamation is proposing to regulate flows from the Glen Canyon Dam to control smallmouth bass populations and implement more HFEs to deposit sediment along sandbars and beaches. The proposed releases are within the previously approved flows analyzed in the LTEMP FEIS, but they may impact TCPs important to Native Americans. Adverse effects on TCPs, as historic properties, will be resolved under the LTEMP PA, land management agency actions, and the nonnative fish MOA in development. These effects should not contribute to cumulative impacts.

Adverse effects on TCPs are not anticipated from the proposed near-term Colorado River operations; however, if adverse effects are present, they will be resolved either under the LTEMP PA or Section 106 of the NHPA process. Therefore, the proposed near-term Colorado River operations will not contribute to cumulative impacts on ITAs.

No cumulative effects would occur on TCPs due to the proposed management plan evaluated in the Salton Sea 10-Year Plan or the environmental assessment for the implementation of the 10-Year Plan's projects.

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Chapter 4. Consultation and Coordination

4.1 Introduction

This chapter describes Reclamation's public involvement program and coordination with specific federal, state, and local agencies, along with Tribal consultations.

4.2 General Public Involvement Activities

The public involvement program leading to this Revised Draft SEIS included project scoping, consultation, and coordination with Tribes, agencies, stakeholders, and the public. Reclamation developed and implemented a public involvement plan to satisfy the public participation requirements set forth in NEPA and to establish a consistent and constant level of engagement with interested parties and stakeholders. The multifaceted approach consisted of informational materials, consultation and coordination meetings, general and stakeholder outreach, and media relations.

A variety of informational materials to educate and inform audiences about the study and related issues were employed. A website was established and maintained for this SEIS. It contained project documents, points of contact, and the project schedule. An electronic mailing list was used to notify interested parties of website postings, project meetings, and documents. A project email account was maintained live during the entire period of preparing this SEIS for interested parties to express opinions, ask questions, and submit comments.

Reclamation published an NOI to prepare an SEIS and a modified Record of Decision for the 2007 Interim Guidelines in the *Federal Register* on November 17, 2022. A 30-day scoping comment period was held from November 17, 2022, to December 20, 2022. Reclamation notified interested parties of the NOI and scoping comment period through an email notification to the project mailing list on December 1, 2022. The email consisted of an NOI and information on two public webinars.

Reclamation held two virtual public webinars during the scoping period. One meeting was held on November 29, 2022, from 10:00 a.m. to noon mountain standard time, and 184 people attended. The second virtual public meeting was held on December 2, 2022, from 11:00 a.m. to 1:00 p.m. mountain standard time, and 241 people attended. The webinars included an opening statement, a presentation that summarized the NOI, a range of hydrologic and operational scenarios that informed people about the SEIS analysis, an overview of potential alternatives being considered in the SEIS, information on the SEIS process schedule, and a question-and-answer session. The webinars were recorded and published on the project website.[1] Public comments were accepted during the comment period by email and mail. A scoping summary report was prepared to summarize all public comments received during scoping. Reclamation made the public scoping

[1] https://www.usbr.gov/ColoradoRiverBasin/SEIS.html

comments and the scoping summary report available for public viewing in an accessible format on the project website.

On April 14, 2023, the EPA published a Notice of Availability in the *Federal Register* for the original Draft SEIS. This kicked off a 45-day review period that ended on May 30, 2023. In May 2023, Reclamation held four virtual public meetings to provide information on the original Draft SEIS, answer questions, and take verbal comments. Each meeting presentation covered the same information. The question-and-answer and public comment portions of the meetings varied based on the public participants at each meeting. The webinars were recorded and published on the project website.

On May 22, 2023, representatives from the seven Colorado River Basin States proposed a new alternative for consensus-based system conservation in the Lower Basin. Reclamation filed with the EPA to withdraw the original Draft SEIS from public review. This resulted in the revision and reissuance of the Draft SEIS. Public comments received on the original Draft SEIS were reviewed, and they helped inform the revision of this Draft SEIS.

This Revised Draft SEIS is available for public review on the project website. Reclamation will hold two virtual open house meetings to provide opportunities to learn more about the project, provide analysis, speak with Reclamation managers and resource specialists, ask questions, and provide comments. Public comments will be accepted for 45 calendar days following the EPA's publication of the Notice of Availability in the *Federal Register*. Comments may be provided by email to CRinterimops@usbr.gov or by mail to Reclamation 2007 Interim Guidelines SEIS Project Manager, Upper Colorado Basin Region, 125 South State Street, Suite 8100, Salt Lake City, Utah 84138.

4.3 Cooperating Agency Involvement

In compliance with NEPA and its implementing regulations, Reclamation worked with five cooperating agencies in the preparation of this SEIS. As described in **Chapter 1**, cooperating agencies included the BIA, Service, NPS, WAPA, and USIBWC. In developing the Draft SEIS, Reclamation hosted seven cooperating agency virtual meetings to obtain data, information, resource analysis, and review of internal documents. Additionally, individual agencies provided specific assistance, including the following:

- The BIA administers the federal trust responsibility to Indian Tribes.
- The Service has jurisdiction by law and special expertise with respect to the ESA and biological resources within the study area and its administration of several wildlife refuges in the study area. The Service provided resource expertise and worked closely with Reclamation in developing two biological assessments to support consultation under Section 7 of the ESA.
- Given its jurisdiction of NPS units within the Basin and administration of recreation on Lake Powell and Lake Mead, the NPS provided data and analysis of potential impacts on resources under its management.
- The WAPA provided hourly release volume models for Glen Canyon Dam to aid in resource-specific modeling. The WAPA also provided hydroelectric modeling to assess

impacts on power generation and revenue across the major generation facilities in the Upper and Lower Basins.

- The USIBWC provided guidance and reviewed internal documents to ensure the SEIS adequately addressed treaty obligations and international commitments. The USIBWC has worked with Reclamation to ensure that Mexico has been kept informed of all permissibly available information regarding the SEIS process.

While not a cooperating agency, the USGS also contributed expertise and resource modeling support.

4.4 Tribal Consultation and Coordination

For purposes of this NEPA process, Reclamation is consulting and coordinating with Tribes who have entitlements to or contracts for Colorado River water and those that may be affected by or have interests in the proposed federal action. Representatives of various Indian Tribes also attended the scoping meetings in November and December 2022. Eighteen Tribes provided Reclamation with written comments on the proposed federal action and its potential effects on resources of Tribal concern, including ITAs.

4.4.1 Summary of Tribal Consultation and Coordination

There are many federally recognized Tribes with entitlements to or contracts for Colorado River water or who may be affected or have interests in the proposed federal action. There are 30 federally recognized Tribes within the geographic Basin. Reclamation consults regularly with these Tribes regarding Colorado River issues. These Tribes are listed in **Table 4-1** and shown on **Map 4-1**.

Table 4-1
Basin Tribes

• Ak-Chin Indian Community	• Pascua Yaqui Tribe
• Chemehuevi Indian Tribe	• Quechan Indian Tribe
• Cocopah Indian Tribe	• Salt River Pima-Maricopa Indian Community
• Colorado River Indian Tribes	• San Carlos Apache Tribe
• Fort McDowell Yavapai Nation	• San Juan Southern Paiute
• Fort Mojave Indian Tribe	• Southern Ute Indian Tribe
• Gila River Indian Community	• Tohono O'odham Nation
• Havasupai Tribe	• Tonto Apache Tribe
• Hopi Tribe	• Ute Indian Tribe of the Uintah and Ouray Reservation
• Hualapai Indian Tribe	• Ute Mountain Ute Tribe
• Jicarilla Apache Nation	• White Mountain Apache Tribe
• Kaibab Band of Paiute Indians	• Yavapai-Apache Nation
• Las Vegas Tribe of Paiute Indians	• Yavapai-Prescott Indian Tribe
• Moapa Band of Paiute Indians	• Zuni Tribe
• Navajo Nation	
• Paiute Indian Tribe of Utah	

The Ten Tribes Partnership is a coalition of 10 federally recognized Tribes with rights and unresolved claims to Colorado River water. The partnership was created in 1992 and has an ongoing consultation relationship with Reclamation. Federally recognized Tribes of the Ten Tribes Partnership are listed in **Table 4-2**.

Table 4-2
Ten Tribes Partnership Tribes

• Ute Mountain Ute Tribe	• Fort Mojave Indian Tribe
• Southern Ute Indian Tribe	• Colorado River Indian Tribes
• Ute Indian Tribe of the Uintah and Ouray Reservation	• Chemehuevi Indian Tribe
• Jicarilla Apache Nation	• Quechan Indian Tribe
• Navajo Nation	• Cocopah Indian Tribe

Of the 22 federally recognized Tribes in Arizona, 14 have fully resolved, adjudicated rights, or partially resolved rights to water from the Colorado River. A significant portion of that water is provided through the CAP. Reclamation has a long-standing and ongoing consultation relationship with Tribes receiving Colorado River water through the CAP. **Table 4-3** lists CAP Tribes.

Table 4-3
CAP Tribes

• Ak-Chin Indian Community	• San Carlos Apache Tribe
• Fort McDowell Yavapai Nation	• Tohono O'odham Nation
• Gila River Indian Community	• Tonto Apache Tribe
• Hualapai Tribe	• White Mountain Apache Tribe
• Pascua Yaqui Tribe	• Yavapai-Apache Nation
• Salt River Pima-Maricopa Indian Community	• Yavapai-Prescott Tribe

Reclamation consults not only with Tribes who hold water rights or are located within the geographic boundary of the Basin, but also Tribes who may be affected or have interests in actions on the Colorado River. **Table 4-4** lists the 43 federally recognized Tribes with whom Reclamation consults on issues regarding the Colorado River.

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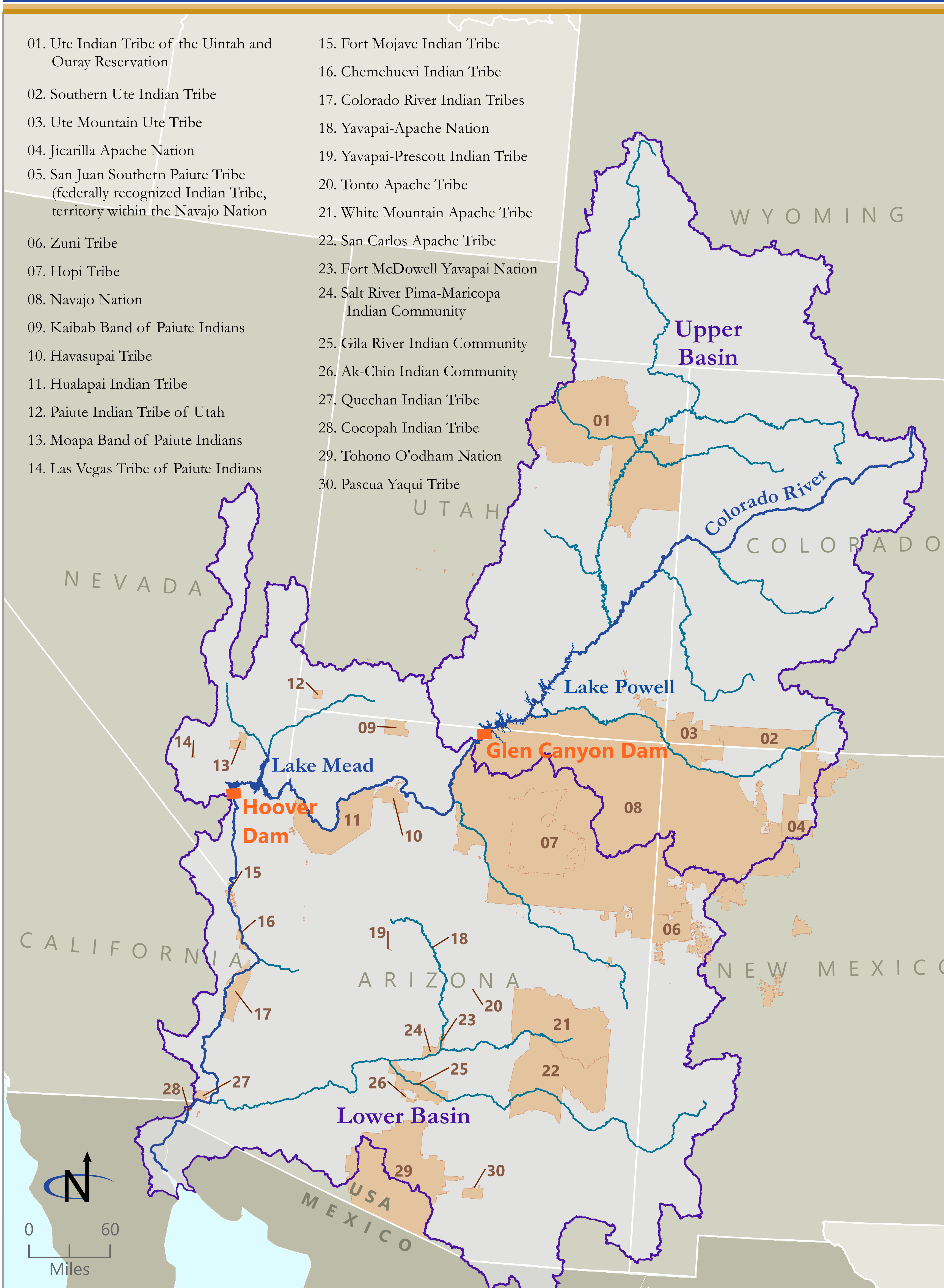

Map 4-1 Colorado River Basin Tribes

Tribal Reservation and off-reservation trust land

Colorado River

Colorado River tributary

Dam

Colorado River Basin, Upper and Lower Basins

States in the Colorado River Basin

Source: National Weather Service GIS. 2023, Reclamation GIS 2023, USGS National Hydrography Dataset GIS. 2023; Map production: U.S. Department of the Interior, Bureau of Reclamation, Upper and Lower Colorado Basin Regions; Date: March 25, 2023, Disclaimer: This map is intended for informational purposes only. Geographic features may have been compiled at varying scales and for different purposes. No representation is made as to the accuracy of this graphic.

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Table 4-4
Tribes Consulted on Colorado River Issues

• Ak-Chin Indian Community	• Pueblo of Pojoaque
• Chemehuevi Indian Tribe	• Pueblo of San Felipe
• Cocopah Tribe of Arizona	• Pueblo of San Juan
• Colorado River Indian Tribes	• Pueblo of Sandia
• Fort McDowell Yavapai Nation	• Pueblo of Santa Ana
• Fort Mojave Indian Tribe	• Pueblo of Santa Clara
• Gila River Indian Community	• Pueblo of Tesuque
• Havasupai Indian Tribe	• Pueblo of Zia
• Hopi Tribe	• Quechan Indian Tribe
• Hualapai Indian Tribe	• Salt River Pima-Maricopa Indian Community
• Jicarilla Apache Nation	• San Carlos Apache Tribe
• Kaibab Band of Paiute Indians	• San Juan Southern Paiute Tribe
• Las Vegas Tribe of Paiute Indians	• Southern Ute Indian Tribe
• Moapa Band of Paiute Indians	• Tohono O'odham Nation
• Navajo Nation	• Tonto Apache Tribe
• Paiute Indian Tribe of Utah	• Ute Indian Tribe of the Uintah and Ouray Reservation
• Pascua Yaqui Tribe	• Ute Mountain Ute Tribe
• Pueblo of Acoma	• White Mountain Apache Tribe
• Pueblo of Cochiti	• Yavapai-Apache Nation
• Pueblo of Jemez	• Yavapai-Prescott Tribe
• Pueblo of Laguna	• Zuni Tribe
• Pueblo of Nambe	

4.4.2 Tribal Consultation Efforts

An NOI to prepare this SEIS was published in the *Federal Register* on November 17, 2022. Since that date, Reclamation has engaged regularly with the Tribes described above. **Table 4-5** provides a summary of those Tribal consultation and coordination efforts conducted by Reclamation between publication of the NOI and August 30, 2023.

Table 4-5
Summary of Tribal Consultation Efforts

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
11/17/2022	Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Basin
11/22/2022	SEIS NOI Publication and Public Scoping Webinar Information Email Notification	Email communicating the Department's SEIS NOI publication in the *Federal Register* on November 17, 2022, and sharing of the upcoming scoping webinar information for the SEIS	Tribal leaders and representatives for Tribes throughout the Basin
11/23/2022	SEIS NOI Publication and Public Scoping Webinar Information Email Notification	Email communicating the Department's SEIS NOI publication in the *Federal Register* on November 17, 2022, and sharing of the upcoming scoping webinar information for the SEIS	San Juan-Chama project stakeholders
11/28/2022	SEIS NOI Publication, Purpose, and Public Scoping Process Correspondence	Letter from regional directors communicating the Department's SEIS NOI publication in the *Federal Register* on November 17, 2022, its purpose, and information on the scoping process for the SEIS	Tribal leaders for Tribes throughout the Basin
12/9/2022	Inter-Tribal Council of Arizona (ITCA) Tribal Leaders Water Policy Council and Colorado River Tribal Roundtable Meeting	Special ITCA meeting with all Basin Tribal leaders to provide an update on the SEIS NOI and scoping and an update on the post-2026 process	The ITCA extended an invitation outside Arizona to all Tribal leaders and representatives for Tribes throughout the Basin.
12/14/2022	Quechan Indian Tribe Meeting	Meeting with the Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Quechan Indian Tribe
12/15/2022	Ten Tribes Partnership Meeting	Bimonthly meeting with member Tribes of the Ten Tribes Partnership	The 10 member Tribes of the Ten Tribes Partnership

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
12/15/2022	Upper Basin Tribe Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Jicarilla Apace Nation, Navajo Nation, Paiute Indian Tribe of Utah, Southern Ute Indian Tribe, Ute Indian Tribe, and Ute Mountain Ute Tribe
12/15/2022	Navajo Nation Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Navajo Nation
12/15/2022	Ute Mountain Ute Tribe Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Ute Mountain Ute Tribe
12/15/2022	Colorado River Indian Tribes Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Colorado River Indian Tribes
12/15/2022	Jicarilla Apache Nation Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Jicarilla Apache Nation
12/15/2022	Ute Indian Tribe Meeting	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Ute Indian Tribe of the Uintah and Ouray Reservation
12/15/2022	Gila River Indian Community Consultation	The Gila River Indian Community requested government-to-government consultation to discuss the SEIS scoping process; relevant information to the SEIS process, such as hydrologic updates; and other system conservation offers.	Gila River Indian Community

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
12/15/2022	Southern Ute Indian Tribe Consultation	Meeting with Department and Reclamation leadership to discuss current issues on the Basin, including the SEIS scoping process and relevant information	Southern Ute Indian Tribe
1/13/2023	Southern Ute Indian Tribe Consultation	The Southern Ute Indian Tribe Council requested a meeting with Upper Basin regional leadership to discuss the contents of the Southern Ute Indian Tribe's SEIS scoping comment letter.	Southern Ute Indian Tribe
1/19/2023	Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Basin
2/8/2023	Ten Tribes Partnership Meeting	Bimonthly meeting with member Tribes of the Ten Tribes Partnership	The 10 member Tribes of the Ten Tribes Partnership
3/7/2023	SEIS Process and Tribal Consultation Timeline Correspondence	Letter from regional directors communicating Reclamation's planned timeline and process for government-to-government consultation on the Draft SEIS	Tribal leaders and representatives for Tribes throughout the Basin
3/17/2023	Upper Basin Tribes-States Dialogue Meeting	Reclamation invited to participate in semi-regular meeting between Upper Basin Tribes and States	Leaders and representatives of the six Upper Basin Tribes
3/23/2023	Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Basin
4/11/2023	Colorado River/SEIS Press Event	Press event at Glen Canyon Dam to announce the release of the Draft SEIS	Cocopah (representing Colorado River Basin Tribes)
4/11/2023	Colorado River Basin Tribal Information Exchange	Monthly meeting	Tribal Leaders and Representatives for Tribes throughout the Colorado River Basin
4/12/2023	Ten Tribes Partnership Meeting	Bimonthly meeting with member Tribes of the Ten Tribes Partnership	The 10 member Tribes of the Ten Tribes Partnership
4/25/2023	Ak-Chin Indian Community SEIS Consultation	Government-to-government consultation on the Draft SEIS in Maricopa, Arizona	Ak-Chin Indian Community

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
4/27/2023	Navajo Nation SEIS Technical Briefing	Navajo Nation requested an individual briefing on the Draft SEIS document.	Navajo Nation
4/28/2023	Chemehuevi Indian Community SEIS Consultation	Briefing to the council on the Draft SEIS in Havasu Lake, California	Chemehuevi Indian Tribe
5/1/2023	Navajo Nation SEIS Consultation	Government-to-government consultation on the Draft SEIS in Window Rock, Arizona	Navajo Nation
5/2/2023	Jicarilla Apache Nation SEIS Consultation	Government-to-government consultation on the Draft SEIS in Dulce, New Mexico	Jicarilla Apache Nation
5/3/2023	Tohono O'odham SEIS Consultation	Government-to-government consultation on the Draft SEIS in Sells, Arizona	Tohono O'odham Nation
5/4/2023	Southern Ute Indian Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in Ignacio, Colorado	Southern Ute Indian Tribe
5/4/2023	Gila River Indian Community SEIS Consultation	Government-to-government consultation on the Draft SEIS in Phoenix, Arizona	Gila River Indian Community
5/5/2023	Ute Mountain Ute Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in Towaoc, Colorado	Ute Mountain Ute Tribe
5/9/2023	Colorado River Indian Tribes SEIS Consultation	Government-to-government consultation on the Draft SEIS in Parker, Arizona	Colorado River Indian Tribes
5/10/2023	Fort Mojave Indian Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in Needles, California	Fort Mojave Indian Tribe
5/10/2023	Upper Basin Tribes-States Dialogue Meeting	Reclamation invited to participate in semi-regular meeting between Upper Basin Tribes and States. The meeting included a briefing on the Draft SEIS.	Upper Basin Tribes (SUIT, Ute Mountain Ute Tribe, Ute Indian Tribe, Jicarilla-Apache Nation, Navajo Nation, and Paiute Indian Tribe of Utah)
5/11/2023	Hopi Tribe SEIS Consultation	Government-to-government consultation (virtual) on the Draft SEIS	Hopi Tribe
5/15/2023	Hualapai Tribe SEIS Consultation	Government-to-government consultation (virtual) on the Draft SEIS	Hualapai Tribe
5/16/2023	Yavapai-Apache Nation SEIS Consultation	Government-to-government consultation (virtual) on the Draft SEIS	Yavapai-Apache Nation

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
5/17/2023	Colorado River Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Colorado River Basin
5/23/2023	San Carlor Apache Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in San Carlos, Arizona	San Carlos Apache Tribe
5/24/2023	Cocopah Indian Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in Yuma, Arizona	Cocopah Indian Tribe
5/24/2023	Quechan Indian Tribe SEIS Consultation	Government-to-government consultation on the Draft SEIS in Winterhaven, California	Quechan Indian Tribe
5/25/2023	Gila River Indian Community Second SEIS Consultation	Government-to-government consultation on the Draft SEIS in Chandler, Arizona	Gila River Indian Community
5/26/2023	Pascua Yaqui Tribe SEIS Consultation	Government-to-government Consultation (virtual) on the Draft SEIS	Pascua Yaqui Tribe
6/13/2023	Meeting with Gila River Indian Community	Virtual meeting	Gila River Indian Community
6/14/2023	Ten Tribes Partnership Meeting	Bimonthly meeting with member Tribes of the Ten Tribes Partnership	The 10 member Tribes of the Ten Tribes Partnership
6/15/2023	Colorado River Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Colorado River Basin
6/15/2023	Southern Ute Indian Tribe Visit	Southern Ute invited Upper Colorado Basin leadership to meet with the council to discuss the Colorado River, Tribal water infrastructure needs, and tour projects on the reservation.	Southern Ute Indian Tribe
7/20/2023	Colorado River Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Colorado River Basin
7/28/2023	SEIS Modeling Assumptions Technical Meeting for Tribes	Meeting with Colorado River Basin Tribal technical and legal representatives to discuss modeling assumptions used in the revised Draft SEIS	Tribal leaders and representatives for Tribes throughout the Colorado River Basin

Date	Meeting Title/Subject of Correspondence	Purpose	Tribes Invited
8/8/2023	Meeting with Gila River Indian Community	Hybrid meeting; in person in Washington, DC	Gila River Indian Community
8/9/2023	Ten Tribes Partnership Meeting	Bimonthly meeting with member Tribes of the Ten Tribes Partnership	The 10 member Tribes of the Ten Tribes Partnership
8/9/2023	Ak-Chin Indian Community SEIS Consultation	Government-to-government consultation on the Draft SEIS in Maricopa, Arizona	Ak-Chin Indian Community
8/24/2023	Colorado River Basin Tribal Information Exchange	Monthly meeting	Tribal leaders and representatives for Tribes throughout the Colorado River Basin
8/29/2023	Jicarilla Apache Nation Visit	Jicarilla Apache invited Upper Colorado Basin leadership to meet with the council to discuss the Colorado River and Tribal concerns	Jicarilla Apache Nation
8/30/2023	Ute Mountain Ute Tribe Visit	Ute Mountain Ute invited Upper Colorado Basin leadership to meet with the council to discuss the Colorado River, Tribal water infrastructure needs, and tour projects on the reservation.	Ute Mountain Ute Tribe

4.5 Endangered Species Act Section 7 Consultation

In 2007, the Service finalized ESA Section 7 consultation for the Interim Guidelines due to impacts on the threatened and endangered species described in **Section 3.13.1**. This SEIS to the Interim Guidelines effectively requires reinitiation of the 2007 consultation and the 2005 MSCP consultation. The ESA Section 7 interagency consultations (16 USC 1531) were initiated with the Service in January 2023. They continued through a series of meetings and email exchanges, during which listed species were identified, actions and action areas were discussed, and conservation measures were developed. Two biological assessments were developed, one for the Lower Colorado River[2] in relation to the Multi-Species Conservation Program, and one for the Upper Colorado River[3] in relation to LTEMP. Consultation is ongoing with an anticipated finalization of two biological opinions in the spring 2024.

[2] From Lake Mead to the SIB
[3] Lake Powell, Glen Canyon Dam, and the Colorado River downstream to Lake Mead

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List of Preparers

The Draft SEIS was prepared by Reclamation with resource modeling and analysis support from the National Park Service, Northern Arizona University, US Geological Survey, and Western Area Power Administration. This is a list of preparers who developed significant background material and various sections or they participated, to a significant degree, in the preparation of this Draft SEIS.

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Lisa Devore	NPS	Air Quality
Lynne Koontz	NPS	Socioeconomics and Recreation
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Rob Billerbeck	NPS	Recreation, Socioeconomics, Natural and Cultural Resources
Paul Larson	NPS - CLNP	GCNRA Recreation (Upstream)
Steve Young	NPS - CLNP	GCNRA Recreation (Upstream)
Brandon Holton	NPS - GCNP	Threatened and endangered birds and other wildlife
Elyssa Shalla	NPS - GCNP	Recreation and Socioeconomics
Emily Omana	NPS - GCNP	Fish
Greg Holmes	NPS - GCNP	Threatened and endangered birds and other wildlife
Jan Balsom	NPS - GCNP	Recreation
Jen Dierker	NPS - GCNP	Cultural resources
Michael Kearsley	NPS - GCNP	Recreation
Miranda Terwillinger	NPS - GCNP	Threatened and endangered birds and other wildlife
Amy Schott	NPS - GCNRA	Cultural Resources
Buddy Fazio	NPS - GCNRA	Natural and Cultural Resources
Heidie Grigg	NPS - GCNRA	Recreation and Socioeconomics
Kendall Neisess	NPS - GCNRA	Recreation and Socioeconomics
Mark Sappington	NPS - LMNRA	Water and Air Quality

Name	Agency	Role
Michelle Kerns	NPS - GCNRA	Recreation and Socioeconomics
Taryn Preston	NPS - GCNRA	Natural and Cultural Resources
Vanessa Glynn-Linaris	NPS - GCNRA	Air Quality
Mike Gauthier	NPS - LMNRA	Recreation and Socioeconomics
Jodi Bailey	NPS - LMNRA	Recreation and Socioeconomics
Chris Nycz	NPS - LMNRA	Cultural Resources
Bradley Butterfield	Northern Arizona University	Riparian vegetation modeling
A J Vale	Service	Fish and wildlife
Dan Leavitt	Service	Fish and wildlife
Jeff Servoss	Service	Fish and wildlife
Jess Newton	Service	Fish and wildlife
Julie Crawford	Service	Fish and wildlife
Kirsty Bramlett	Service	Fish and wildlife
Mark Lamb	Service	Fish and wildlife
Melissa Mata	Service	Fish and wildlife
Nichole Engelmann	Service	Fish and wildlife
Rebecca Chester	Service	Fish and wildlife
Scott Richardson	Service	Fish and wildlife
Bridget Deemer	USGS Grand Canyon Monitoring and Research Center	Water quality modeling
Bryce Mihalevich	USGS Grand Canyon Monitoring and Research Center	Water quality modeling
Charles Yackulic	USGS Grand Canyon Monitoring and Research Center	Fisheries modeling
Drew Eppehimer	USGS Grand Canyon Monitoring and Research Center	Fisheries modeling
Emily Palmquist	USGS Grand Canyon Monitoring and Research Center	Riparian vegetation modeling
Gerard Salter	USGS Grand Canyon Monitoring and Research Center	Sediment modeling
Joel Sankey	USGS Grand Canyon Monitoring and Research Center	Cultural (sediment) modeling
Lucas Bair	USGS Grand Canyon Monitoring and Research Center	Recreation impact modeling
Adrian Cortez	USIBWC	International considerations
Jennifer Peña	USIBWC	International considerations
Sally Spener	USIBWC	International considerations
Clayton Palmer	WAPA	Upper Basin hydroelectric generation and economic modeling
Jerry Wilhite	WAPA	Upper Basin hydroelectric generation and economic modeling
John Paulsen	WAPA	Lower Basin economic modeling
Xavier Gonzalez	WAPA	Lower Basin hydroelectric generation modeling

Contractor Technical Team and Support Staff

Name	Education	Experience (years)	Project Role
Prime Contractor – EMPSi: Environmental Management and Planning Solutions, Inc.			
Amy Cordle	BS, Civil Engineering	26	Climate Change
Amy Lewis	MS, Environmental Science	26	NEPA Specialist
Andy Spellmeyer	MS, Biology	8	508 Compliance
Bronson Pace	Ph.D., Water Resources: Law, Management, and Policy	3	Information Manager/ Bibliography Lead
Camila Reiswig	MS, Agriculture and Applied Economics	10	Agricultural and Energy Economics
Chelsea Ontiveros	MS, Geographic Information Systems Technology	2	GIS
David Batts	MS, Natural Resource Management	30	Project Manager
David Scott	BS, Environmental Science,	5	Hydrology Lead/Hydropower
Jessie Olson	MLA, Environmental Planning	20	Technical Review
Katie Patterson	JD, Environmental Law	12	Deputy Project Manager
Kevin Doyle	BA, Sociology	37	NEPA Lead
Kirsten Davis	BS, Environmental Science	4	Transportation
Marcia Rickey, GISP	MS, Biology	21	GIS Lead
Megan Stone	BA, Environmental Studies	5	Environmental Justice
Noelle Crowley	MENV, Sustainability Planning and Management	4	Recreation
Shine Roshan	MS, Physics	4	Socioeconomics
Eduardo Sanchez Jr.	MNRS, Ecological Restoration	3	Technical Review
Valerie Stanson	MPH, Environmental Health	3	Water Resources
Zoe Ghali	MS, Integrative Physiology	14	Socioeconomics/ Environmental Justice Lead
Subcontractor - SWCA			
Adrian Hogel	MS, Ecology	17	Vegetation
Adrienne Tremblay	Ph.D., Anthropology	17	Cultural Resources
Alexandra Shin	MS, Env. Policy and Management	10	Public Agency and Coordination Team Lead/ Comment Management
Amanda Nicodemus	MS, Biology	20	Technical Team Lead
Erin Wielenga	BS, Botany	12	Air Quality
Jill Grams	MLA, Landscape Architecture	25	NEPA Advisor
Kelly Beck	Ph.D., Anthropology	21	Section 106/Tribal Coordination Lead
Kevin Rauhe	BLA, Landscape Architecture	10	Visual Resources
Mary Anne McLeod	MS, Wildlife Conservation	30	Section 7/Avian Species

Name	Education	Experience (years)	Project Role
Matt Westover	MS, Wildlife and Wildlands Conservation	10	Biologist Lead
Meg Perry	MEM, Ecosystem Science and Conservation	12	Public Involvement Support
Randa Horton	BS, Environmental Studies	15	Indian Trust Assets/Section 106 Support
Rich Valdez, CFS	Ph.D., Fisheries Ecology	52	Section 7/Fisheries
Stephanie Graham	MS, Wildlife Biology	17	Section 7/Biological Assessment Lead
Stephanie Trapp	MS, Wildlife Science	7	Wildlife/Special Status Species
Stephen Zipper	MS, Natural Resources	13	Fisheries
Suzanne Griset	Ph.D., Anthropology	44	Section 106 Tribal Coordination Support
Subcontractor – Hazen and Sawyer			
Angela Bacigalupa, PE, ENV SP	BS, Environmental Engineering	9	Hydrology/Water Deliveries
Diane Roher, PE	MS, Environmental Engineering	6	Hydrology/Water Deliveries
Elizabeth Crafton	Ph.D., Civil Engineering	9	Hydrology/Water Quality
Greg Gates, PE	MS, Environmental Health Engineering	30	Expert Scientist/Engineer
Luke Wang, PE	MS, Earth and Environmental Engineering	12	Database Manager
Melissa Estep	MS, Civil Engineering	11	Hydrology/Water Deliveries
Other Subcontractors			
Jeff Lukas	MS, Forestry	25	Climate Change
Robert Thomson	MS, Ecology	45	Senior NEPA Advisor
Kevin Wheeler, PE	Ph.D., Transboundary Water Management	22	Hydrologist

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Glossary

acre-foot (af)—Volume of water (43,560 cubic feet) that would cover 1 acre to a depth of 1 foot.

adaptive management—A method for examining alternative strategies for meeting measurable biological goals and objectives, and then, if necessary, adjusting future conservation management actions according to what is learned.

affected environment—Existing biological, physical, social, and economic conditions of an area that are subject to change, both directly and indirectly, as the result of a proposed human action.

algae—Simple plants containing chlorophyll; most live submerged in water.

allocation, allotment—Refers to a distribution of water through which specific persons or legal entities are assigned individual rights to consume pro rata shares of a specific quantity of water under legal entitlements. For example, a specific quantity of Colorado River water is distributed for use within each Lower Division State through an apportionment. Water available for consumptive use in that state is further distributed among water users in that state through the allocation. An allocation does not establish an entitlement; the entitlement is normally established by a written contract with the United States government. *See also* Lower Division States.

alluvium—Sedimentary material transported and deposited by the action of flowing water.

ambient—Surrounding natural conditions (or environment) in a given place and time.

amphibian—A vertebrate animal that has a life stage in water and a life stage on land. (Examples include salamanders, frogs, and toads.)

annual flow-weighted average concentration—A weighted average of monthly total dissolved solids (TDS) concentrations for a year, where the weight for each month is based on the relative flow for each month.

Annual Operating Plan for Colorado River Reservoirs (AOP)—A document describing how Reclamation will manage Colorado River resources over a 12-month period, consistent with the Long-Range Operating Criteria and the *Arizona v. California* 1964 Supreme Court Decree. The AOP is prepared annually by Reclamation in cooperation with the Basin States, Mexico, appropriate federal agencies, Indian Tribes, state and local agencies, and the general public, including governmental interests, as required by federal law. As part of the AOP process, the Secretary of the Department of the Interior (Secretary) makes annual determinations regarding the availability of Colorado River water for deliveries to the Lower Division States of the Colorado River Basin. *See also* Lower Division States.

apportionment—Refers to the distribution of water available to each Lower Division State in Normal, Surplus or Shortage condition years, as set forth, respectively, in Articles II(B)(1), II(B)(2), and II(B)(3) of the 1964 Supreme Court Decree in the case of *Arizona v. California*.

appropriative rights—The right to divert a specified quantity of water at a specified point of diversion for reasonable and beneficial uses at a specified place of use for a specified manner of use. Appropriative rights are generally "first-in-time, first-in-right"(that is, one appropriative right has priority over appropriative rights established later).

backwater—A relatively small, generally shallow area of a river with little or no current.

banked groundwater—Water that has been stored temporarily in a groundwater aquifer. Banked groundwater can be recovered for use at a later time.

base load—Minimum load in a power system over a given period of time.

Basin States—In accordance with the Colorado River Compact of 1922, the Colorado River Basin within the United States consists of those parts of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming within and from which waters drain naturally into the Colorado River. These seven states are referred to as the Basin States. *See also* Colorado River Compact of 1922.

biological assessment (BA)—A document identifying the likely effects of a proposed federal action on threatened and endangered species. To facilitate compliance with Section 7(a)(2) of the Endangered Species Act (ESA), federal agencies must prepare a BA pursuant to Section 7(c)(1) of the ESA. *See also* Endangered Species Act.

biological opinion (BO)—A document stating the opinion of the United States Fish and Wildlife Service (Service) and/or the National Marine Fisheries Service as to whether a federal action is likely to jeopardize the continued existence of a threatened or endangered species or result in the destruction or adverse modification of critical habitat.

bypass flows—Saline agricultural return flows from the Wellton-Mohawk Irrigation and Drainage District that are routed to the Cienega de Santa Clara in Mexico to ensure compliance with the salinity provisions of Minute 242 of the 1944 Water Treaty.

bypass tubes—Another term for river outlet works.

candidate species—A plant or animal species that is not yet officially listed as threatened or endangered under the ESA but is undergoing status review by the Service.

capacity—The maximum amount of energy that can be instantaneously produced.

catch—At a recreational fishery, refers to the number of fish captured, whether they are kept or released.

channel (watercourse)—An open conduit either naturally or artificially created that periodically or continuously contains moving water, or that forms a connecting link between two bodies of water.

Some terms used to describe natural channels are river, creek, run, branch, and tributary. Natural channels may be single or braided. Two terms used to describe artificial channels are canal and floodway.

Cladophora—Filamentous green alga important to the food chain in the Colorado River downstream of Glen Canyon Dam.

Colorado River Basin (Basin)—The drainage area of the Colorado River system. The Basin occupies an area of approximately 250,000 square miles in the southwestern United States and 3,500 square miles in northwestern Mexico. The Colorado River Compact of 1922 divided the Colorado River system into two subbasins: the Upper Basin and the Lower Basin. It also divided the seven states within the Basin into the Upper Division and the Lower Division. Upper Division States include Colorado, New Mexico, Utah, and Wyoming; Lower Division States include Arizona, California, and Nevada. Additionally, 30 federally recognized Tribes are in the Basin.

Colorado River Basin Project Act of 1968 (CRBPA)—An act authorizing construction of a number of water development projects, including the Central Arizona Project (CAP), and requiring the Secretary to develop the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs, or Long-Range Operating Criteria (LROC).

Colorado River Basin Salinity Control Forum—The organization dedicated to controlling Colorado River salinity; it consists of representatives of the seven Basin States.

Colorado River Compact of 1922—The agreement concerning the apportionment of the use of the waters of the Colorado River Basin, dated November 24, 1922, and executed by commissioners for Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. It was approved and proclaimed effective by Herbert Hoover, the president of the United States, and representative of the United States for purposes of the Compact, on June 25, 1929.

Colorado River Simulation System (CRSS)—An operational model of the Colorado River Basin based on a monthly time step.

Colorado River system—The portion of the Colorado River and its tributaries within the United States as defined in the Colorado River Compact of 1922.

compact—The Colorado River Compact of 1922.

compact point—The reference point designated by the Colorado River Compact of 1922 as dividing the Colorado River Basin into two subbasins, the Upper Basin and the Lower Basin. The compact point is Lee Ferry, Arizona. *See also* Lee Ferry Compact Point.

conductivity—A measure of water's ability to pass an electrical current.

Consolidated Decree—A decree entered by the United States Supreme Court on March 27, 2006, in the case of *Arizona v. California,* 547 US 150 (2006), incorporating all applicable provisions of the earlier-issued decisions and decrees in the matter. The Supreme Court reached a decision in the case of *Arizona v. California* in 1963 and implemented this decision in a 1964 decree, which was supplemented over time after its adoption.

consumptive use—For purposes of this supplemental environmental impact statement (SEIS), diversions of water from mainstream Colorado River, including water withdrawn from the mainstream through underground pumping, minus any measured and unmeasured return flows.

contractors—Those who hold entitlements to Colorado River water. Contractors consist of the federal government, states, Indian Tribes, and various public and private entities that are recognized under the Consolidated Decree, hold a Section 5 Contract with the Secretary, or have a Secretarial Reservation of water. *See also* Consolidated Decree.

conveyance loss—Water that is lost in transit from a pipe, canal, conduit, or ditch by leakage or evaporation. If the water is lost due to leakage, it may be considered return flow if it percolates to an aquifer and is available for reuse. If the water evaporates, it is considered consumptive use.

cooperating agency—With respect to the National Environmental Policy Act of 1969, as amended (NEPA) process, an agency that has jurisdiction by law or special expertise concerning an aspect of a proposed federal action and that is requested by the lead agency to participate in the preparation of an environmental impact statement (EIS).

covered species—Those species addressed in the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) for which conservation measures would be implemented and for which authorization for "take" is being requested under Section 10 of the ESA. *See also* take.

criteria—Standards used for making a determination.

critical habitat—Specific areas with physical or biological features essential to the conservation of a listed species and that may require special management considerations or protection. These areas have been legally designated via *Federal Register* notices.

cubic foot per second (cfs)—A measure of water flow equal to 1 cubic foot of water passing a point on the stream in 1 second of time.

cultural resource—A building, site, district, structure, or object significant in history, architecture, archaeology, culture, or science.

dead pool—Elevation at which water cannot be regularly released from a reservoir, which would effectively preclude Colorado River diversions to downstream users.

dead storage—Reservoir space from which stored water cannot be evacuated by gravity.

delta sediment—Deposit formed at the mouth of the Colorado River and other rivers where they enter Lake Powell, Lake Mead, or the Gulf of California.

depletion—Loss of water from a stream, river, or basin resulting from consumptive use.

deposition—Settlement of material out of the water column and on to the streambed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.

discharge (flow)—Volume of water that passes a given point within a given period of time; expressed in this SEIS in cubic feet per second (cfs). *See also* cubic foot per second.

dissolved oxygen (DO)—Amount of free oxygen found in water; perhaps the most commonly employed measurement of water quality. Low DO levels adversely affect fish and other aquatic life. The ideal dissolved oxygen for fish life is between 7 milligrams per liter (mg/L) and 9 mg/L; most fish cannot survive when DO falls below 3 mg/L.

diversion(s)—Colorado River water withdrawn from the mainstream, including water diverted from reservoirs or drawn from the mainstream by underground pumping.

domestic use—Refers to the use of water for household, stock, municipal, mining, milling, industrial, and other like purposes; excludes the generation of electrical power.

draw down—Lowering of a reservoir's elevation; process of depleting a reservoir or groundwater storage.

ecosystem—Complex system composed of a community of fauna and flora and that system's chemical and physical environments.

electric power system—Physically connected facilities for electricity generation, transmission, and distribution that are operated as a unit under one control.

electrical demand—Energy requirement placed upon a utility's generation at a given instant or averaged over any designated period of time.

endangered species—A species or subspecies whose survival is in danger of extinction throughout all or a significant portion of its range.

Endangered Species Act (ESA)—The Endangered Species Act (ESA) of 1973 (16 USC 1531–1544), as amended; under Section 9, it provides for the prohibition of "take" of any fish or wildlife species listed as threatened or endangered under the ESA unless specifically authorized by regulation. *See also* take.

energy—What is produced by power plants; measured in kilowatt hours.

entitlement—Refers to an authorization to beneficially consume Colorado River water pursuant to a decreed right; a contract with the United States through the Secretary or a Secretarial Reservation of water.

epilimnion—Thermal layering of water in lakes and streams. *See also* stratification.

firm energy or power—Non-interruptible energy or power guaranteed by the supplier to be available at all times except for reasons of uncontrollable forces or "continuity of service" contract provisions.

flood—An overflow or inundation that comes from a river or other body of water, and causes or threatens damage. Any relatively high streamflow overtopping the natural or artificial banks in any reach of a river or stream. A relatively high flow as measured by either gage height or discharge quantity.

flood control pool—Reservoir volume above the active conservation and joint-use pool that is reserved for flood runoff and then evacuated as soon as possible to keep that space ready for the next flood.

flood control release—The release of water from Lake Mead and the operation of Hoover Dam for flood control purposes pursuant to the reservoir operating criteria specified in the February 8, 1984, Field Working Agreement between the United States Army Corps of Engineers (USACE) and the Bureau of Reclamation (Reclamation), and the USACE regulations contained in 33 Code of *Federal Regulations* (CFR) 208.11.

flow—Volume of water passing a given point per unit of time expressed in cubic foot per second. *See also* cubic foot per second.

forage fish—Generally, small fish that reproduce prolifically and are consumed by predators.

fore bay—Impoundment immediately above a dam or hydroelectric plant intake structure. The term is applicable to all types of hydroelectric developments (storage, run-of-river, and pumped storage).

fry—Life stage of fish between the egg and fingerling stages.

full pool—Volume of water in a reservoir at maximum design elevation.

gaging station—Specific location on a stream where systematic observations of hydrologic data are obtained through mechanical or electrical means.

gigawatt-hour (GWh)—One billion watt-hours of electrical energy.

headwater—The source and upper part of a stream.

historic property—Any district, site, building, structure, or object listed on or eligible for listing on the National Register of Historic Places (36 CFR 800.16(l)(1)).

hydropower—The use of water to produce electricity.

hypolimnetic zone—The deep portion of a lake or reservoir volume generally classified as below the level of the thermocline.

hypolimnion—Thermal layering of water in lakes and streams; the lower stratum of the water column of a reservoir. This layer is generally undisturbed, and respiration and decomposition predominate. *Also see* stratification.

important farmlands—Prime farmland, unique farmland, farmland of statewide importance, and farmland of local importance, as defined by the United States Department of Agriculture Natural Resources Conservation Service (formerly the Soil Conservation Service). The categorization of farmland is based on a soil classification system that accounts for the physical and chemical characteristics of the land and the suitability of the land for producing crops. Important farmlands are afforded special protection due to their importance to agricultural production.

impoundment—Body of water created by a dam.

in situ—In archaeology, and as used in this SEIS, an artifact that has not been moved from its original place of deposit.

incidental take—Defined under the ESA as take that is "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (50 CFR 17.22 and 17.32). *See also* take.

Indian trust assets (ITAs)—"legal interests" in "assets" held in "trust" by the federal government for federally recognized Indian Tribes or individual Indians.

inflow—Water flowing into a lake or reservoir from a river and/or its tributaries, or water entering a river from tributaries.

irrigated area—The gross farm area upon which water is artificially applied for the production of crops, with no reduction for access roads, canals, or farm buildings.

irrigation—The controlled application of water to arable lands to supply water requirements not satisfied by rainfall.

juvenile—Young fish older than 1 year but not having reached reproductive age.

kilowatt-hour (kWh)—One thousand watt-hours of electrical energy.

land cover type—A classification system to describe vegetation and other habitat types (such as cottonwood willow, honey mesquite, and marsh).

landscape character—Overall visual appearance of a given landscape based on the form, line, color, and texture associated with the landscape's vegetation, landforms/water, and human-made modifications. These factors give the area a distinctive quality that distinguishes it from its immediate surroundings.

Las Vegas Valley—The topographic basin containing the city of Las Vegas, the city of North Las Vegas, the city of Henderson, and certain unincorporated townships of Clark County.

Las Vegas Wash—The natural drainage channel for the entire Las Vegas Valley. It is dominated by wastewater flows from the city of Las Vegas, Clark County Sanitation District, and city of Henderson wastewater treatment plants. It terminates in the Las Vegas Bay of Lake Mead.

Law of the River—As applied to the Colorado River, a body of documents the Secretary uses to carry out the responsibility to manage the mainstream waters of the Lower Basin pursuant to applicable federal law. The Secretary is vested with this responsibility. This collective set of documents comprising numerous operating criteria, regulations, and administrative decisions included in federal and state statues, interstate compacts, court decisions and decrees, an international treaty, and contracts with the Secretary apportions the Colorado River waters and regulates the use and management of the Colorado River among the seven Basin States and Mexico.

lead agency—An agency initiating and overseeing the preparation of an EIS. For this SEIS, Reclamation is the lead agency for compliance with NEPA.

Lee Ferry Compact Point—Identified the reference point that marks the division between the two subbasins—the Upper Basin and the Lower Basin—created by the division of the Colorado River Basin in the Colorado River Compact of 1922. This reference point is in the mainstream Colorado River in Arizona, 1 mile below the confluence of the Colorado River with the Paria River.

Lees Ferry Gaging Station—The site of the United States Geological Survey (USGS) stream gage (Lees Ferry Gaging Station) in Arizona on the Colorado River upstream of its confluence with the Paria River, downstream of Glen Canyon Dam. Also, the location of Colorado River ferry crossings (1873 to 1928).

limnology—Scientific study of physical characteristics and the biology of lakes, ponds, and streams.

load—Amount of electrical power or energy delivered or required at a given point.

Lower Basin (States)—Those parts of the states of Arizona, California, Nevada, New Mexico, and Utah within and from which waters drain naturally into the Colorado River below the Lee Ferry Compact Point in Arizona. The Colorado River Compact of 1922 divided the Colorado River system into two subbasins: the Upper Basin and the Lower Basin. *See also* Lee Ferry Compact Point.

Lower Division (States)—Arizona, Nevada, and California. The Colorado River Compact of 1922 divided the seven Colorado River Basin states into two groups: Upper Division States and Lower Division States. The Lower Division States are Arizona, Nevada, and California. *See also* Basin States.

magnitude—A number characteristic of a quantity and forming a basis for comparison with similar quantities, such as flows.

mean monthly flow—Average flow for the month, usually expressed in cubic feet per second.

mean sea level (msl)—The average height of the surface of the oceans and seas measured throughout all stages of the tidal cycle, determined from hourly readings of tidal height, and computed over a long (usually 19-year) period. It is used as a datum plane (that is, it serves as the reference surface from which elevations and depths are measured).

median—Middle value in a distribution, above and below which lie an equal number of values.

megawatt (MW)—One million watts of electrical power (capacity).

megawatt-hour (MWh)—One million watt-hours of electrical energy.

Mesozoic era—The second-to-last era of earth's geological history, lasting from about 252 to 66 million years ago, comprising the Triassic, Jurassic, and Cretaceous periods.

metalimnion—Thermal layering of water in lakes and streams. *See also* stratification.

milligram per liter (mg/L)—Equivalent to one part per million.

National Environmental Policy Act of 1969, as amended (NEPA)—Law requiring federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. To meet this requirement, federal agencies prepare a detailed statement known as an environmental impact statement, or EIS.

National Register of Historic Places (NRHP)—The Nation's official list of cultural resources worthy of preservation. Authorized under the National Historic Preservation Act of 1966, the NRHP is part of a national program to coordinate and support public and private efforts to identify, evaluate, and protect our historic and archaeological resources. Properties listed on the NRHP include districts, sites, buildings, structures, and objects that are significant in American history, architecture, archaeology, engineering, and culture.

natural flow—The flow of any stream un-depleted by human activities.

non-system water—Waters originating from outside the Colorado River system.

normal condition—When the Secretary has determined that there is available for annual release 7.5 million acre-feet (maf) to satisfy consumptive use in the Lower Division States pursuant to Article II(B)(1) of the Consolidated Decree.

oligotrophic—A body of water characterized by low dissolved plant nutrient and organic matter, and rich in oxygen at all depths.

Paleontological resources—Any fossilized remains, traces, or imprints of organisms preserved in or on the earth's crust.

Paleozoic era (541–252 million years ago)—Means ancient life. The oldest animals on earth appeared just before the start of this era.

Pangea—A supercontinent that existed from about 300 to 200 million years ago and included most of the continental crust of the earth.

peak flow—Maximum instantaneous flow in a specified period of time.

peak load—Maximum electrical demand in a stated period of time.

penstock—Conduit pipe used to convey water from the reservoir through the dam under pressure to the turbines of a hydroelectric plant.

percentile—A statistical term. A descriptive measure that splits ranked data into 100 parts, or hundredths. For example, the 10th percentile is the value that splits the data in such a way that 10 percent of the values are less than or equal to the 10th percentile.

piscivorous—Habitually feeding on fish.

PM_{10} (PM10)—Particulate matter (PM) (dust particles) standard that includes particles with a diameter of 10 micrometers or less.

power—Electrical capacity generated, transferred, or used.

Present Perfected Right (PPR)—Many Colorado River water rights that originated as "perfected rights" specified in the 1964 United States Supreme Court Decree in the case of *Arizona v. California.* PPRs are the highest-priority Colorado River water rights that the 1964 Decree defines as those perfected rights existing on June 25, 1929 (the effective date of the Boulder Canyon Project Act of 1928).

priority—A ranking with respect to diversions of water relative to other water users.

probability—In this SEIS, the relative frequency with which a range of modeled values occurs. For example, the probability of Lake Mead's elevation exceeding 1,180 feet msl in June 2005 is equal to the number of modeled elevations greater than 1,180 feet msl in June 2005, divided by the total number of modeled elevations in June 2005.

public involvement—Process of obtaining citizen input into each stage of development of planning documents. Required as a major input into any EIS.

Quaternary period—A geologic time period that encompasses the most recent 2.6 million years, including the present day.

ramp rate—The rate of change in instantaneous output from a powerplant. The ramp rate is established to prevent undesirable effects due to rapid changes in loading or, in the case of hydroelectric plants, discharge.

rated head—Water depth for which a hydroelectric generator and turbines were designed.

reach—A specified segment of a river, stream, channel, or other water conveyance facility.

recruitment—Survival of young plants and animals from birth to a life stage less vulnerable to environmental change.

reregulating reservoir—A reservoir for reducing diurnal fluctuations resulting from the operation of an upstream reservoir for power production.

resampling—The digital process of changing the sample rate or dimensions of sampled data (for example, digital imagery or audio) by temporarily or areally analyzing and sampling the original data.

reserved water—In the case of Indian reservations, rights based on the doctrine of Indian reserved rights; in the case of federal establishments other than Indian reservations, a federal reservation of water for use on property under federal jurisdiction.

reservoir—A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

return flow—The portion of water previously diverted from a river or stream and subsequently returned to that river or stream; it is available for consumptive use by others.

return flow credit—In the accounting of consumptive use in the Lower Basin, Colorado River water that is returned to the river and is available for consumptive use by others in the year in which it was diverted is credited against a water user's total diversions.

riffle—A stretch of choppy water caused by an underlying rock shoal or sandbar.

riparian—Of, on, or pertaining to the bank of a river, pond, or lake.

river mile (RM)—Numbered along the Colorado River from south to north starting with RM 0.0 at the Southerly International Boundary (SIB) with Mexico. Dam locations are noted at their respective river miles.

river outlet works—Dam structures that conduct water from the reservoir to the river without passing through a powerplant; also referred to as jet tubes, bypass tubes, or outlet works.

river stage—Water surface elevation of a river above a datum.

RiverWare™—A commercial river system simulation computer program that was configured to simulate operation of the Colorado River for this SEIS.

runoff—That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of humans in or on the stream channels.

sacred site—A specific location identified by a Native American Tribe as sacred for its religious significance to, or ceremonial use by, a Native American religion.

salinity—A term used to refer to the dissolved minerals in water; also referred to as total dissolved solids (TDS). *See also* total dissolved solids.

sandbar—A long, narrow deposition of sediment within a river.

Secretary—The Secretary of the Department of the Interior, and duly appointed successors, representatives, and others with properly delegated authority.

Section 10(a)(1)(B) permit—The section of the ESA that authorizes the Service to issue nonfederal entities a permit for the incidental take of endangered and threatened wildlife species. This permit allows the nonfederal entity to proceed with an activity that is legal in all other respects, but that results in the "incidental to, and not the purpose of, the carrying out of an otherwise lawful activity." *See also* take.

sediment—Unconsolidated solid material that comes from weathering of rock and is carried by, suspended in, or deposited by water or wind.

sediment load—Mass of sediment passing through a stream.

seepage—Relatively slow movement of water through a medium, such as sand.

SEIS conservation— Part of the specific proposal submitted by the Lower Basin states in the Proposed Action. It has a specific amount as part of that action – 3.0 maf of SEIS conservation by the end of 2026, with at least 1.5 maf of that conserved in 2023 and 2024.

shortage condition—When the Secretary has determined that there is available for annual release less than 7.5 maf to satisfy consumptive use in the Lower Division States pursuant to Article II(B)(3) of the Consolidated Decree.

spawn—To lay eggs, especially fish.

spills—Water releases from a dam in excess of powerplant capacity.

spillway—Overflow facility at a dam, usually consisting of a sill at the full-reservoir elevation.

spinning reserves—Available capacity of generating facilities synchronized to the interconnected electric system so that it can be called upon for immediate use in response to system problems or sudden load changes.

stage—Reservoir elevation.

standards—A means established by authority as a rule for the measure of quality, such as cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water.

storage—Water artificially impounded in surface or underground reservoirs for future use. Water naturally detained in a drainage basin, such as groundwater, channel storage, and depression storage. The term "drainage basin storage" or simply "basin storage" is sometimes used to refer collectively to the amount of water in natural storage in a drainage basin. *See also* conservation storage and dead storage.

stormwater—Consists of water that originates from precipitation, such as heavy rain or snow.

stratification—Thermal layering of water in lakes and streams. Lakes usually have three zones of varying temperature: (1) epilimnion—top layer with essentially uniform warmer temperature, (2) metalimnion—middle layer of rapid temperature decrease with depth, and (3) hypolimnion—bottom layer with essentially uniform colder temperatures.

streamflow—The discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than runoff, as streamflow may be applied to discharge whether it is affected by diversion or regulation.

suspended load—Sediment that is supported by the upward components of turbulence in a stream and that stays in suspension for an appreciable length of time.

surplus condition—When the Secretary has determined that there is available for annual release more than 7.5 maf to satisfy consumptive use in the Lower Division States pursuant to Article II(B)(2) of the Consolidated Decree.

system conservation— a voluntary reduction of Consumptive Use of Colorado River water that can be estimated or measured.

system storage—The total volume of water available in the Colorado River Basin at a specific point in time.

system water—Waters originating from the Colorado River system.

tail water—Water immediately downstream of the outlet from a dam or hydroelectric powerplant where the water is more similar to that in the reservoir than farther downstream.

take—As defined by the ESA, a means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 United States Code 1531[18]).

thermocline—The zone of maximum change in temperature in a waterbody, separating upper (epilimnetic) from lower (hypolimnetic) zones.

threatened species—A species or subspecies that is likely to become endangered in the foreseeable future.

total dissolved solids (TDS)—Dissolved materials in the water, including ions such as potassium, sodium, chloride, carbonate, sulfate, calcium, and magnesium. In many instances, the term "TDS" is used to reflect salinity, since these ions are typically in the form of salts.

traces —Multiple time series of forecasted streamflow used in hydrological modeling. Multiple traces are sometimes referred to as an ensemble.

traditional cultural place—A type of historic property that is rooted in a community's history and important to that community's cultural identity.

tributary—River or stream flowing into a larger river or stream.

turbidity—Cloudiness of water, measured by how deeply light can penetrate into the water column from the surface.

turbine—A rotary mechanical device that uses water flow to turn and convert it into useful energy.

Upper Basin (States)—Those parts of the states of Arizona, Colorado, New Mexico, Utah, and Wyoming within and from which waters drain naturally into the Colorado River above the Lee Ferry Compact Point in Arizona. The Colorado River Compact of 1922 divided the Colorado River system into two subbasins: the Upper Basin and the Lower Basin. *See also* Lee Ferry Compact Point.

Upper Colorado River Commission—Commission established by the Upper Colorado River Compact of appointed members from the Upper Division States whose purpose is to secure the storage of water for beneficial consumptive use in the Upper Basin.

Upper Division (States)—Colorado, New Mexico, Utah, and Wyoming. The Colorado River Compact of 1922 divided the seven Colorado River Basin states into two groups: Upper Division States and Lower Division States. The Upper Division States are Colorado, New Mexico, Utah, and Wyoming. *See also* Basin States.

Visual resources—Physical features that make up the visible landscape (features such as land, water, vegetation, topography, and human-made features such as buildings, roads, utilities, and structures) as well as the response of viewers to those features.

Water Year—That period of 12 months ending September 30 of each year.

Waters of the United States—In accordance with the Clean Water Act, waters of the United States include (1) all waters that may be susceptible to use in interstate or foreign commerce; (2) all interstate waters, including interstate wetlands; (3) all other waters, such as intrastate lakes, rivers, streams (including intermittent streams), mud flats, sand flats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation, or destruction of which could affect interstate or foreign commerce, including any such waters; (4) all impoundments of waters otherwise defined as waters of the United States; (5) tributaries of waters identified in this SEIS; (6) the territorial seas; and (7) wetlands adjacent to waters (other than waters that are themselves wetlands) identified in this SEIS.

watershed—The drainage area upstream of a specified point on a stream.

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Appendix A

Overview of Colorado River Operations

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Appendix A. Overview of Colorado River Operations

A.1 Introduction

This appendix summarizes Colorado River operations, including the distribution of Colorado River water under the Law of the River, and the reservoirs and diversion facilities through which the water supply is administered.

A.2 Apportionment of Water Supply

This section summarizes the Law of the River, Colorado River apportionments of the Basin States, and the allotment to Mexico pursuant to the 1944 Water Treaty.

A.2.1 The Law of the River

The Secretary is vested with the responsibility to manage the mainstream waters of the Colorado River Basin pursuant to applicable federal law. This responsibility is carried out consistent with a body of documents commonly referred to as the Law of the River. The Law of the River comprises numerous operating criteria, regulations, and administrative decisions included in federal and state statutes, interstate compacts, court decisions and decrees, an international treaty, and contracts with the Secretary. Documents that are generally considered part of the Law of the River include, but are not limited to, those listed in **Table A-1**, below.

Table A-1
Selected Documents Included in the Law of the River

▪ The River and Harbor Act of March 3, 1899 ▪ The Reclamation Act of June 17, 1902 ▪ Reclamation of Indian Lands in Yuma, Colorado River and Pyramid Lake Indian Reservations Act of April 21, 1904 ▪ Yuma Project authorized by the Secretary of the Interior on May 10, 1904, pursuant to Section 4 of the Reclamation Act of June 17, 1902 ▪ Warren Act of February 21, 1910 ▪ Protection of Property Along the Colorado River Act of June 25, 1910 ▪ Patents and Water-Right Certificates Acts of August 9, 1912, and August 26, 1912	▪ The Colorado River Storage Project Act of April 11, 1956 ▪ The Water Supply Act of July 3, 1958 ▪ The Boulder City Act of September 2, 1958 ▪ Report of the Special Master, Simon H. Rifkind, *Arizona v. California*, et al., December 5, 1960 ▪ The Consolidated Decree entered by the United States Supreme Court in the case of *Arizona v. California*, 547 US 150 (2006) (Consolidated Decree) ▪ International Flood Control Measures, Lower Colorado River Act of August 10, 1964

Table A-1
Selected Documents Included in the Law of the River

- Yuma Auxiliary Project Act of January 25, 1917
- Availability of Money for Yuma Auxiliary Project Act of February 11, 1918
- Sale of Water for Miscellaneous Purposes Act of February 25, 1920
- Federal Power Act of June 10, 1920
- The Colorado River Compact of November 24, 1922
- The Colorado River Front Work and Levee System Acts of March 3, 1925, and January 21,1927–June 28, 1946
- The Boulder Canyon Project Act of December 21, 1928 (BCPA)
- The California Limitation Act of March 4, 1929
- The California Seven Party Agreement of August 18, 1931
- The Parker and Grand Coulee Dams Authorization of August 30, 1935
- The Parker Dam Power Project Appropriation Act of May 2, 1939
- The Reclamation Project Act of August 4, 1939
- The Boulder Canyon Project Adjustment Act of July 19, 1940
- The Flood Control Act of December 22, 1944
- Treaty between the United States and Mexico Relating to the Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande of February 3, 1944 (1944 Water Treaty)
- Gila Project Act of July 30, 1947
- The Upper Colorado River Basin Compact of October 11, 1948
- The Consolidated Parker Dam Power Project and Davis Dam Project Act of May 28, 1954
- The Palo Verde Diversion Dam Act of August 31, 1954
- Change Boundaries, Yuma Auxiliary Project Act of February 15, 1956
- Southern Nevada (Robert B. Griffith) Water Project Act of October 22, 1965
- The Colorado River Basin Project Act of September 30, 1968
- Criteria for the Coordinated Long-Range Operation of Colorado River Reservoirs, June 8, 1970, amended March 21, 2005
- Supplemental Irrigation Facilities, Yuma Division Act of September 25, 1970
- 43 CFR 417, Lower Basin Water Conservation Measures, September 7, 1972
- Minute 218, March 22, 1965; Minute 241, July 14, 1972 (replaced Minute 218); Minute 242, August 30, 1973 (replaced Minute 241); Minute 306, December 12, 2000; Minute 317, June 27, 2010; and Minute 323, September 21, 2017, of the 1944 Water Treaty
- The Colorado River Basin Salinity Control Act of June 24, 1974
- The Hoover Power Plant Act of August 17, 1984
- Numerous Colorado River Water Delivery and Project Repayment Contracts with the States of Arizona and Nevada, cities, water districts, and individuals
- Hoover and Parker-Davis Power Marketing Contracts
- The Reclamation States Emergency Drought Relief Act of 1991
- The Grand Canyon Protection Act of October 30, 1992
- Operation of Glen Canyon Dam, Record of Decision (1996)
- Interim Surplus Guidelines Record of Decision, January 17, 2001 (66 *Federal Register* 7772)
- Interim 602(a) Storage Guideline, May 19, 2004 (69 *Federal Register* 28945)
- The Colorado River Water Delivery Agreement of October 10, 2003 (69 *Federal Register* 12202)
- Glen Canyon Dam Long-Term Experimental and Management Plan – Final EIS and ROD, December 2016 (Reclamation 2016)
- Colorado River Basin Drought Contingency Plans (Reclamation 2019)

Among other provisions of applicable federal law, NEPA and the ESA, as amended, provide a statutory overlay on certain actions taken by the Secretary. For example, as noted in **Chapter 1**, preparation of this SEIS has been undertaken pursuant to NEPA.

A.2.2 Apportionment to the Basin States

The initial apportionment of water from the Colorado River was determined as part of the Colorado River Compact (1922), which divided the Colorado River system into two subbasins, the Upper Basin and the Lower Basin, and divided the seven Basin States into Upper Division States and Lower Division States (**Map A-1**).

The compact apportioned to the Lower Basin and the Upper Basin, in perpetuity, the exclusive beneficial consumptive use of 7.5 maf of water per year. In addition to this apportionment, Article III(b) of the compact gives the Lower Basin the right to increase its beneficial consumptive use by 1.0 maf per year. The compact also stipulates in Article III(d) that the Upper Division States will not cause the flow of the river at the Lee Ferry Compact Point to be depleted below an aggregate of 75 maf for any period of 10 consecutive years.

The compact, in Article VII, states that nothing in the compact shall be construed as affecting the obligations of the United States to Indian Tribes. While the rights of most Indian Tribes to Colorado River water were subsequently adjudicated, some Tribal rights remain unadjudicated. To the extent that Indian Tribes consumptively use water from the Colorado River, such uses are included in the apportionment of the appropriate Basin State.

Upper Division State Apportionments. The Upper Colorado River Basin Compact of 1948 established the Upper Division State apportionments. These apportionments allocate the Upper Division States' consumptive use after deduction of up to 50,000 afy for Arizona as follows: Colorado, 51.75 percent; New Mexico, 11.25 percent; Utah, 23.00 percent; and Wyoming, 14.00 percent. The Upper Division State apportionments have not yet been fully developed.

Lower Division State Apportionments. Lower Division State apportionments were established by Congress in the BCPA and by the Secretary's water delivery contracts under the BCPA. These apportionments are Arizona (2.8 maf), California (4.4 maf), and Nevada (0.3 maf), totaling 7.5 maf, subject to annual increases or reductions pursuant to Secretarial determinations of a Surplus or a Shortage Condition. Under Article II(B)(2) of the Consolidated Decree, when the Secretary determines there is a Surplus Condition, 46 percent of the available water supply in excess of 7.5 maf may be apportioned for use in Arizona, 50 percent may be apportioned for use in California, and 4 percent may be apportioned for use in Nevada.

The Consolidated Decree confirms the apportionments to the Lower Division States established by the BCPA and guides the Secretary's operation of facilities, including Hoover Dam, on the lower Colorado River. If water apportioned for use in a Lower Division State is not consumed by that state in any year, the Secretary may release the unused water for use in another Lower Division State. Water that is stored off stream by a Lower Division State is accounted as consumptive use to the state that stored the water in the year it was stored.

All mainstream Colorado River waters apportioned to the Lower Basin, except for approximately 10,000 af remaining of Arizona's apportionment, have been fully allocated to specific entities and, except for certain federal establishments, placed under permanent water delivery contracts with the Secretary for irrigation or domestic use. Federal establishments with federal reserved rights established pursuant to Article II(D) of the Consolidated Decree are not required to have a contract with the Secretary; however, the water allocated to a federal establishment is included within the apportionment of the Lower Division State in which the federal establishment is located.

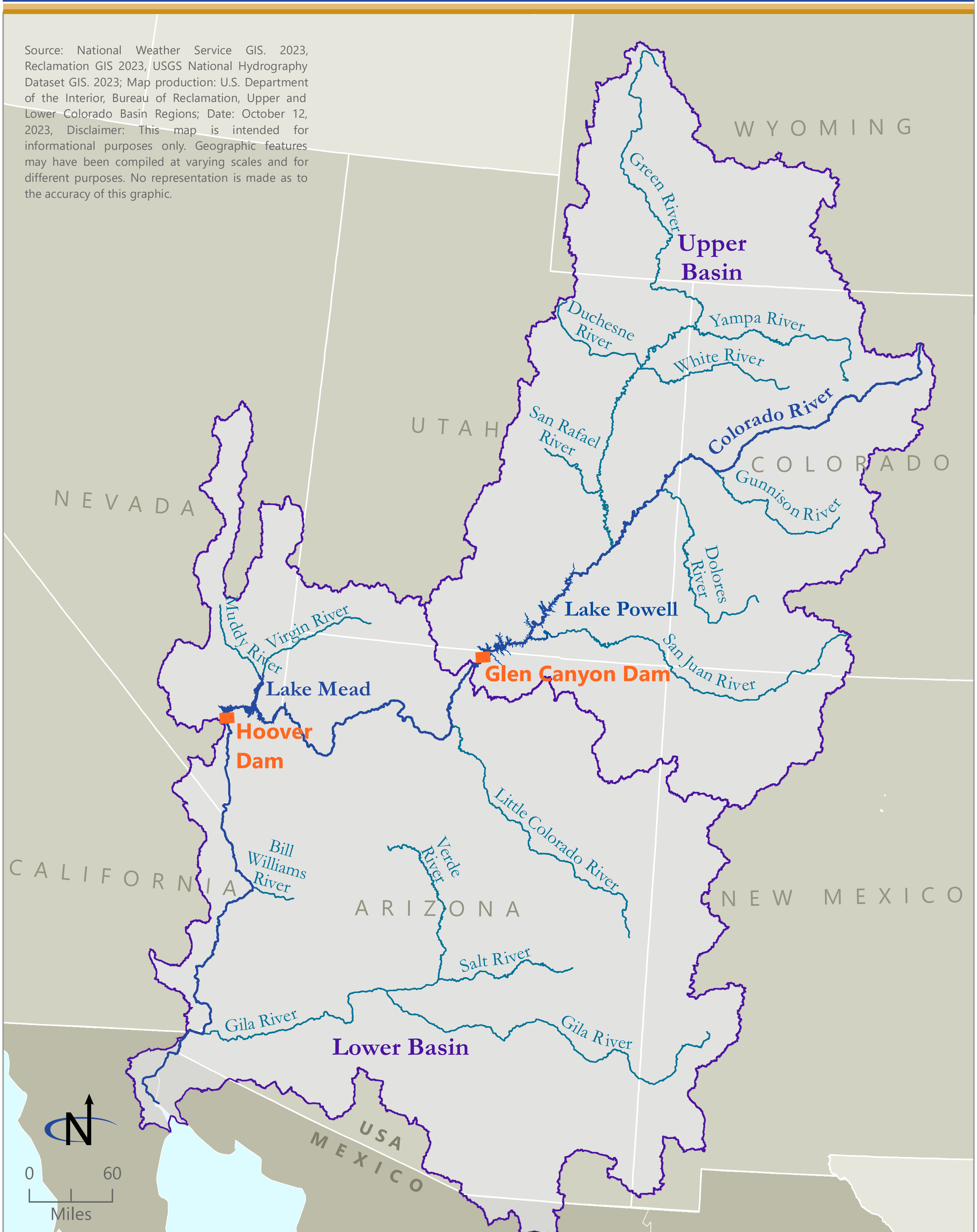
The highest-priority lower Colorado River water rights are PPRs, which the Consolidated Decree defines as those perfected rights existing on June 25, 1929, which is the BCPA's effective date. The Consolidated Decree also recognizes federal Indian reserved rights for the quantity of water necessary to irrigate all the practicably irrigable acreage on five Indian reservations along the lower Colorado River (the Chemehuevi Indian Tribe, Colorado River Indian Tribes, Fort Mojave Indian Tribe, Fort Yuma-Quechan Tribe, and Cocopah Indian Tribe). The Consolidated Decree defines the rights of Indian and other federal reservations to be federal establishment PPRs, and further prescribes a specific order in which federal establishment and other PPRs must be satisfied, generally by priority date without regard to state lines. In any year in which less than 7.5 maf of Colorado River water is available for consumptive use in the Lower Division States, PPRs will be satisfied first.

Waters available to a Lower Division State within its apportionment, but having a priority date later than June 25, 1929, have been allocated by the Secretary through execution of water delivery contracts to water users within that state, as required by Section 5 of the BCPA. The Lower Division States have separate intrastate priority systems in accordance with those contracts.

A.2.3 Allotment to Mexico (Pursuant to the 1944 Water Treaty)

Allocation of Colorado River water to Mexico is governed by the 1944 Water Treaty. To assess the potential effects of the alternatives in this SEIS, certain modeling assumptions (discussed in **Chapter 2**) are used that display projected water deliveries to Mexico. These assumptions include continued implementation of Minute 323 to the 1944 Water Treaty. Reclamation's modeling assumptions are not intended to constitute an interpretation or application of the 1944 Water Treaty or to represent current United States policy or a determination of future United States policy regarding deliveries to Mexico.

The United States will conduct all necessary and appropriate discussions regarding the Proposed Action and implementation of the 1944 Water Treaty with Mexico through the USIBWC in consultation with the Department of State.



Map A-1
Upper and Lower Division States of the Colorado River

- Colorado River
- Colorado River tributary
- Dam
- Colorado River Basin, Upper and Lower Basins
- States in the Colorado River Basin (Wyoming, Colorado, Utah, and New Mexico are Upper Division states, and Arizona, California, and Nevada are Lower Division states)

While portions of northwestern Mexico are part of the Basin, these areas are not within the geographic scope of analysis for this SEIS. This SEIS does not address water deliveries to Mexico.

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A.3 Water Operations

A.3.1 Lake Powell and Lake Mead and the Diversion Facilities

The Colorado River system contains numerous reservoirs that provide an aggregate of approximately 60 maf of storage. Of these reservoirs, Lake Powell and Lake Mead constitute approximately 83 percent of this storage; Lake Powell provides 23.3 maf of this storage, and Lake Mead can store up to 26.2 maf.

A.3.2 Hydropower Generation

Reclamation is authorized by legislation to produce electric power at both Glen Canyon Dam and Hoover Dam. While Reclamation is the federal agency authorized to produce power at the major Colorado River system dams, WAPA is the federal agency authorized to market and deliver this power. WAPA enters into electric service contracts on behalf of the United States with public and private utility systems for distribution of hydroelectric power produced at Reclamation facilities in excess of project demand.

A.3.3 Current Operational Guidelines

The following details the post-2007 Colorado River operational guidelines:

- Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead – Final EIS and ROD, November 2007 (Reclamation 2007)

  The 2007 Interim Guidelines are the specific interim guidelines for Lower Basin shortages and coordinated operations for Lake Powell and Lake Mead. These interim guidelines were intended to remain in effect for determinations to be made through 2025 regarding water supply and reservoir operating decisions through 2026. They also would provide guidance each year in development of the AOP. The 2007 Interim Guidelines considered four operational elements that collectively are designed to address the purpose and need for the proposed federal action. The 2007 Interim Guidelines were used by the Secretary to:

  - determine those circumstances under which the Secretary would reduce the annual amount of water available for consumptive use from Lake Mead to the Lower Division States (Arizona, California, and Nevada) below 7.5 maf (a "Shortage") pursuant to Article II(B)(3) of the Consolidated Decree;
  - define the coordinated operation of Lake Powell and Lake Mead to provide improved operation of these two reservoirs, particularly under low reservoir conditions;
  - allow for the storage and delivery, pursuant to applicable federal law, of conserved Colorado River system and nonsystem water in Lake Mead to increase the flexibility of meeting water use needs from Lake Mead, particularly under drought and low reservoir conditions; and
  - determine those conditions under which the Secretary may declare the availability of surplus water for use within the Lower Division States.

- Glen Canyon Dam Long-Term Experimental and Management Plan – Final EIS and ROD, December 2016 (Reclamation 2016)

Reclamation and the NPS developed and implemented the LTEMP for operations of Glen Canyon Dam, the largest unit of the CRSP. The LTEMP provides a framework for adaptively managing Glen Canyon Dam's operations through 2036, consistent with the GCPA and other provisions of applicable federal law. The LTEMP determines the specific options for dam operations, non-flow actions, and appropriate experimental and management actions that meet the GCPA's requirements and minimize impacts on resources within the area affected by dam operations, commonly referred to as the Colorado River Ecosystem, including those of importance to American Indian Tribes.

- Colorado River Basin Drought Contingency Plans

  In 2019, the DCPs were signed pursuant to congressional direction provided in Public Law 116-14. The DCPs outline strategies to address the ongoing historic drought in the Colorado River Basin. The Upper Basin DCP is designed to reduce the risk of reaching critical elevations at Lake Powell and to help assure continued compliance with the 1922 Colorado River Compact.

  The DROA is one element of the Upper Basin DCP. The DROA identifies a process to temporarily move water stored in the CRSP Initial Units above Lake Powell—Blue Mesa Reservoir (a component of the Aspinall Unit), Flaming Gorge, and Navajo—to Lake Powell when Lake Powell is projected to approach elevation 3,525 feet, which was identified in the DROA as the target elevation. This elevation provides a 35-foot buffer above the minimum power pool of 3,490 feet. Maintaining an elevation above 3,525 feet will help ensure compliance with interstate water compact obligations, maintain the ability to generate hydropower at Glen Canyon Dam, and minimize adverse effects on resources and infrastructure in the Upper Basin.

  Pursuant to the DROA, Reclamation worked with the Upper Division States on a DROA in 2022 with the goal of implementing operational measures to augment water deliveries from the three upstream CRSP Initial Units (that is, Aspinall, Flaming George, and Navajo) to prop up Lake Powell. Reclamation continues to closely monitor hydrologic conditions and projections to identify appropriate upstream release volumes to maintain Lake Powell's water level above the target elevation.

Appendix B

Hydrology Analysis for the No Action Alternative, Action Alternatives 1 and 2, and the Proposed Action

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Appendix B. Hydrology Analysis for the No Action Alternative, Action Alternatives 1 and 2, and the Proposed Action

B.1 Introduction

Action Alternatives 1 and 2 were analyzed in the original Draft SEIS issued April 14, 2023, which modeled changes to operations for both Glen Canyon Dam and Hoover Dam as developed by Reclamation. As described in **Chapter 2**, Action Alternatives 1 and 2 were eliminated from detailed analysis in this revised Draft SEIS due to updated hydrology and the addition of the Proposed Action, which provides a similar risk reduction compared with Action Alternatives 1 and 2. This appendix provides a detailed hydrologic analysis of the No Action Alternative, Action Alternatives 1 and 2, and the Proposed Action; this analysis was used to inform Reclamation's decision to eliminate Action Alternatives 1 and 2 from detailed analysis.

Reclamation updated the modeling assumptions for Action Alternatives 1 and 2 since publication of the original Draft SEIS due to updated hydrology (see the **Dear Reader Letter)**; these assumptions are summarized in **Section B.2.1**. This analysis does not cover the breadth of resources or geographic locations included in **Chapter 3** of this revised Draft SEIS; instead, it focuses on higher-level comparisons with respect to hydrologic resources and water deliveries, which are the primary categories from which relative effects on other resources can be inferred.

B.2 Modeling Approach

This section summarizes the assumptions that Reclamation used in the hydrologic modeling and the metrics used to analyze the alternatives. Future Colorado River system conditions during the analysis period for all alternatives were simulated using the June 2023 CRMMS. Details on the modeling assumptions used for the comparative analysis are found in **Sections B.3.1, B.3.2**, and **B.3.3**. **Section B.3.4** summarizes the metrics used to compare the submitted alternatives.

B.2.1 Modeling Assumptions

The No Action Alternative and the Proposed Action are described in **Chapter 2** with detailed modeling assumptions in **Section 3.3.4** and **Appendix D,** CRMMS Model Documentation.

The following section summarizes the assumptions for Action Alternatives 1 and 2, which have been updated since the original Draft SEIS. In this revised Draft SEIS, no additional shortages are modeled in 2024, and shortages for Action Alternatives 1 and 2 are the same in 2025 and 2026, with a maximum total shortage of 2.083 maf. Additionally, no potential DROA contributions are modeled in this revised Draft SEIS. Assumptions common to all alternatives that were summarized in **Section 3.3.4** also apply to Action Alternatives 1 and 2.

The hydrologies used in this appendix are derived from the June 2023 Colorado Basin River Forecast Center's ESP Upper Basin forecast and associated Lower Basin intervening flows. Three sets of ESPs are used in the SEIS modeling:

- 100 percent ESP: There is no adjustment to the streamflow forecasts.
- 90 percent ESP: Streamflow forecasts are reduced by 10 percent.
- 80 percent ESP: Streamflow forecasts are reduced by 20 percent.

Detailed hydrologic inputs, initial conditions, and other modeling assumptions not described in the following sections are consistent with the assumptions included for the No Action Alternative and Proposed Action (see **Appendix D**).

Assumptions for Action Alternative 1

Assumptions for Action Alternative 1 are summarized below. Detailed modeling assumptions for CRMMS can be found in **Attachment B-1.**

- Only operational changes for Lake Powell and Lake Mead, as per Section 2.D, Section 6.C, and Section 6.D of the 2007 Interim Guidelines, were considered; otherwise, operations for Lake Powell and Lake Mead are consistent with operations under the No Action Alternative.
- The Mid-Elevation Release Tier and Lower Elevation Balancing Tier in Lake Powell are replaced with the Lower Elevation Release Tier in operating years 2025 and 2026.
- The new Lower Elevation Release Tier in Lake Powell is operational if the elevation in Lake Powell at the end of the year is below 3,575 feet. Releases will be between 6.0 and 8.23 maf depending on the elevation of Lake Powell and the hydrology. Releases may be further reduced to prevent Lake Powell from dropping below 3,500 feet.
- Deliveries to the Lower Division States during Shortage Condition Years 2025 and 2026 (up to 2.083 maf) are described in **Section B.2.3**.
- Shortage reductions in excess of the 2007 ROD shortages and 2019 DCP contributions are distributed to the Lower Basin based on priority.
- DCP contributions and ICS assumptions are consistent with the official June 2023 CRMMS simulation.
- System conservation volumes in 2023 and 2024 are consistent with the official June 2023 CRMMS simulation. In 2025 and 2026, system conservation volumes are set to zero.

Assumptions for Action Alternative 2

Assumptions for Action Alternative 2 are summarized below. Detailed modeling assumptions for CRMMS can be found in **Attachment B-1.**

- Only operational changes for Lake Powell and Lake Mead, as per Section 2.D, Section 6.C, and Section 6.D of the 2007 Interim Guidelines, were considered; otherwise, operations for Lake Powell and Lake Mead are consistent with operations under the No Action Alternative.

- The Mid-Elevation Release Tier and Lower Elevation Balancing Tier in Lake Powell are replaced with the Lower Elevation Release Tier, which is operated the same way as in Action Alternative 1.
- Deliveries to the Lower Division States during Shortage Condition Years 2025 and 2026 (up to 2.083 maf) are described in **Section B.2.3**.
- Shortage reductions in excess of the 2007 ROD shortages and 2019 DCP contributions are distributed in the same percentage across all Lower Basin water users at the specified Lake Mead elevations. The distribution of reductions is based on each user's consumptively used water in 2021.
- DCP contributions and ICS assumptions are consistent with the official June 2023 CRMMS simulation.
- System conservation volumes in 2023 and 2024 are consistent with the official June 2023 CRMMS simulation. In 2025 and 2026, system conservation volumes are set to zero.

B.2.2 Coordinated Reservoir Operations

Under Action Alternatives 1 and 2, the annual Lake Powell release is based on the volume of water in storage or the corresponding elevation of Lake Powell and Lake Mead, as described in the Operational Tiers below (see **Table B-1**). The Equalization and Upper Elevation Balancing Tiers are the same as under the No Action Alternative. In operating years 2025 and 2026, the Mid-Elevation Release Tier and Lower Elevation Balancing Tier are combined into a single Lower Elevation Release Tier, and a protection level is also included. The applicable Operational Tier is based on the August 24-Month Study projections of the January 1 system storage and reservoir water surface elevations for the following operating year.

Hourly, daily, and monthly releases from Lake Powell for coordinated operations would be consistent with the parameters of the ROD for the LTEMP FEIS (Reclamation and NPS 2016). Monthly releases from Glen Canyon Dam would be distributed proportionally across months for annual releases below 7.0 maf (see **Figure B-1** for monthly distributions in a year when the annual release is 8.23 maf). If annual flows were adjusted mid-year, they would be distributed to meet the goals of LTEMP, including the potential distribution across monthly or experimental flow patterns, and including the unique resource considerations specific to any mid-year annual adjustments.

Hourly and daily releases would follow LTEMP parameters, so long as sufficient water is available from the annual release. If sufficient water is not available from the annual release to meet hourly and daily LTEMP release parameters, hourly and daily releases would follow the base operation daily and nightly minimum flows (8,000 cfs and 5,000 cfs, respectively), for as long as possible. If sufficient water is not available from the annual release to support the base operation nightly minimum flow of 5,000 cfs, hourly and daily releases would be consistent with the run of the river[1] to match Lake Powell inflows consistent with protecting an elevation of 3,500 feet at Lake Powell.

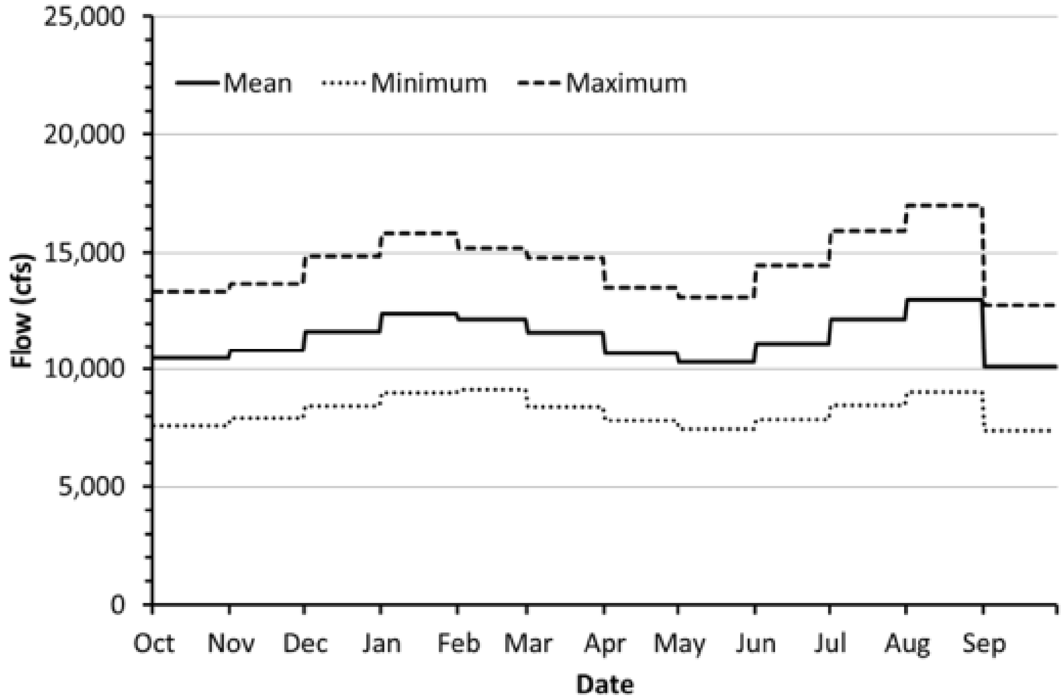
[1] In general, "run of the river" means the inflow equals the outflow, adjusted for operational considerations, such as evaporation, seepage, and release capacity.

Table B-1
Lake Powell Operational Tiers, Action Alternatives 1 and 2

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage*** (maf)
3,700	**Equalization Tier** Equalize, avoid spills, or release 8.23 maf	**23.31**
3,636–3,666 (see Table 2.3-1 in the 2007 FEIS)	**Upper Elevation Balancing Tier** Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	**14.65–18.36** (2008–2026)
3,575	**Lower Elevation Release Tier** Set initial release of 6.0 maf; adjust releases based on the April Lake Powell end-of-water-year elevation projection: ≥3,575 feet, release 8.23 maf <3,575 feet AND ≥3,550 feet, release 7.48 maf <3,550 feet AND ≥3,525 feet, release 7.0 maf <3,525 feet AND ≥3,500 feet, maintain release of 6.0 maf <3,500 feet, reduce releases (gains equal losses) such that Lake Powell ends the operating year at 3,500 feet	**8.90**
3,500	**Protection Level** <3,500 feet, in any month, reduce releases (gains equal losses) such that Lake Powell ends the operating year at 3,500 feet	**4.22**
3,370		**0**

*Active storage values have been updated from 2007 based on the 2018 bathymetry.

Figure B-1
Mean, Minimum, and Maximum Monthly Flows under LTEMP in an 8.23-maf Year



Lower Elevation Release Tier

When the projected January 1 Lake Powell elevation is below 3,575 feet, an initial annual release in the amount of 6.0 maf would be set from Lake Powell. Reclamation may then adjust the annual release based on the April 24-Month Study, as outlined below:

- If the April 24-Month Study projects the end-of-water-year elevation to be at or above 3,575 feet, an adjustment would be made to release 8.23 maf from Lake Powell.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,575 feet and at or above 3,550 feet, an adjustment would be made to release 7.48 maf from Lake Powell.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,550 feet and at or above 3,525 feet, an adjustment would be made to release 7.0 maf from Lake Powell.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,525 feet and at or above 3,500 feet, the release of 6.0 maf from Lake Powell would be maintained.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,500 feet, the dam would be operated to maintain an elevation of at least 3,500 feet. Additionally, up to 6.0 maf would be released over the year with a goal of maintaining LTEMP minimum flows, subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

Protection Level

If, in any month, Lake Powell's elevation is below 3,500 feet, the Lake Powell release would be set to maintain or increase the elevation with a maximum release of 6.0 maf; the goal would be to maintain LTEMP minimum flows, subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

B.2.3 Shortage Sharing and Water Delivery Reduction Assumptions

A summary of the modeling assumptions for the alternatives, with respect to the reduction of deliveries due to shortage and DCP contributions to the Lower Division States, including the distribution of shortages by state for 2025 and 2026, is provided in **Table B-2**, **Table B-3**, and **Table B-4**. The distribution of shortages to individual users based on CRMMS modeling assumptions for Action Alternatives 1 and 2 can be found in **Attachment B-2**. System conservation volumes are summarized in **Attachment B-1**, **Table Attachment B-3**.

Table B-2 shows the Lower Basin shortages under the 2007 Interim Guidelines, contributions under the 2019 DCPs, and additional shortages modeled under Action Alternatives 1 and 2 in calendar years 2025 and 2026. **Table B-3** shows the assumptions for Action Alternative 1 regarding the breakdown of shortages and contributions by state, according to priority.

Table B-2
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2 (2025–2026)*

Lake Mead Elevation (feet)	Existing 2007 ROD Shortages and 2019 DCP Contributions			Additional Shortages under Action Alternatives 1 and 2	
	2007 ROD Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	Total (1,000 af)	Additional Shortages (1,000 af)	Total Shortages + Contributions (1,000 af)
1,090 – >1,075	0	200	200	200	**400**
1,075 – 1,050	333	200	533	533	**1,066**
<1,050 – >1,045	417	200	617	617	**1,234**
1,045 – >1,040	417	450	867	867	**1,734**
1,040 – >1,035	417	500	917	1,166	**2,083**
1,035 – >1,030	417	550	967	1,116	**2,083**
1,030 – 1,025	417	600	1,017	1,066	**2,083**
<1,025	500	600	1,100	983	**2,083**

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the Binational Water Scarcity Contingency Plan, in accordance with Minute 323 to the 1944 Water Treaty.

Table B-3
Lower Division States' Shortages and DCP Contributions by State, Action Alternative 1 (2025–2026)

Lake Mead Elevation (feet)	2007 ROD Shortage + 2019 DCP Contributions (1,000 af)				Action Alternative 1 Additional Shortage* (1,000 af)				Total Shortages + Contributions (1,000 af)			
	AZ	NV	CA	Total	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	192	8	0	200	192	8	0	200	384	16	0	400
1,075 – 1,050	512	21	0	533	511	22	0	533	1,023	43	0	1,066
<1,050 – >1,045	592	25	0	617	593	24	0	617	1,185	49	0	1,234
1,045 – >1,040	640	27	200	867	912	42	0	955	1,552	69	200**	1,734***
1,040 – >1,035	640	27	250	917	987	56	123	1,166	1,627	83	373	2,083
1,035 – >1,030	640	27	300	967	987	56	73	1,116	1,627	83	373	2,083
1,030 – 1,025	640	27	350	1,017	987	56	23	1,066	1,627	83	373	2,083
<1,025	720	30	350	1,100	907	53	23	983	1,627	83	373	2,083

*The additional shortage volumes decrease at elevation 1,025 feet because the shortages under the 2007 Interim Guidelines increase by the same amount. Therefore, the additional shortage amounts necessary to get to the 2.083 maf total are lower.
**In this elevation tier, the 2019 DCP contributions for California exceed what would be required under Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.
***Because the 2019 DCP contributions for California exceed the total shortage and contribution volume as modeled by the shortage allocation model, the sum of the three state totals exceeds the total shortage and contribution volume.

Figure B-2 shows a graphical view of Lower Basin shortages and contributions from the 2007 Interim Guidelines and the 2019 DCPs, plus additional shortages modeled under Action Alternative 1.

For Action Alterative 2, **Table B-4** displays the percentage of the additional shortage volumes at specified Lake Mead elevations and the distribution for each Lower Division State. As stated above, the total additional shortage volumes for the Lower Basin are the same under Action Alternative 2 as under Action Alternative 1. The additional shortage volumes identified in **Table B-2** for calendar years 2025 and 2026 would be achieved by a reduction of available Lower Basin annual consumptive use, distributed in the same percentage across all Lower Basin water users at the specified Lake Mead elevations. The distribution of reductions modeled for Action Alternative 2 is based on each user's consumptively used water in 2021, as reported in Reclamation's final Colorado River Accounting and Water Use Report: Arizona, California, and Nevada. This report was prepared pursuant to Article V of the Supreme Court's decree in *Arizona v. California* (as adjusted for conservation).

Figure B-2
Modeled Lower Basin Shortages and DCP Contributions, Action Alternatives 1 and 2

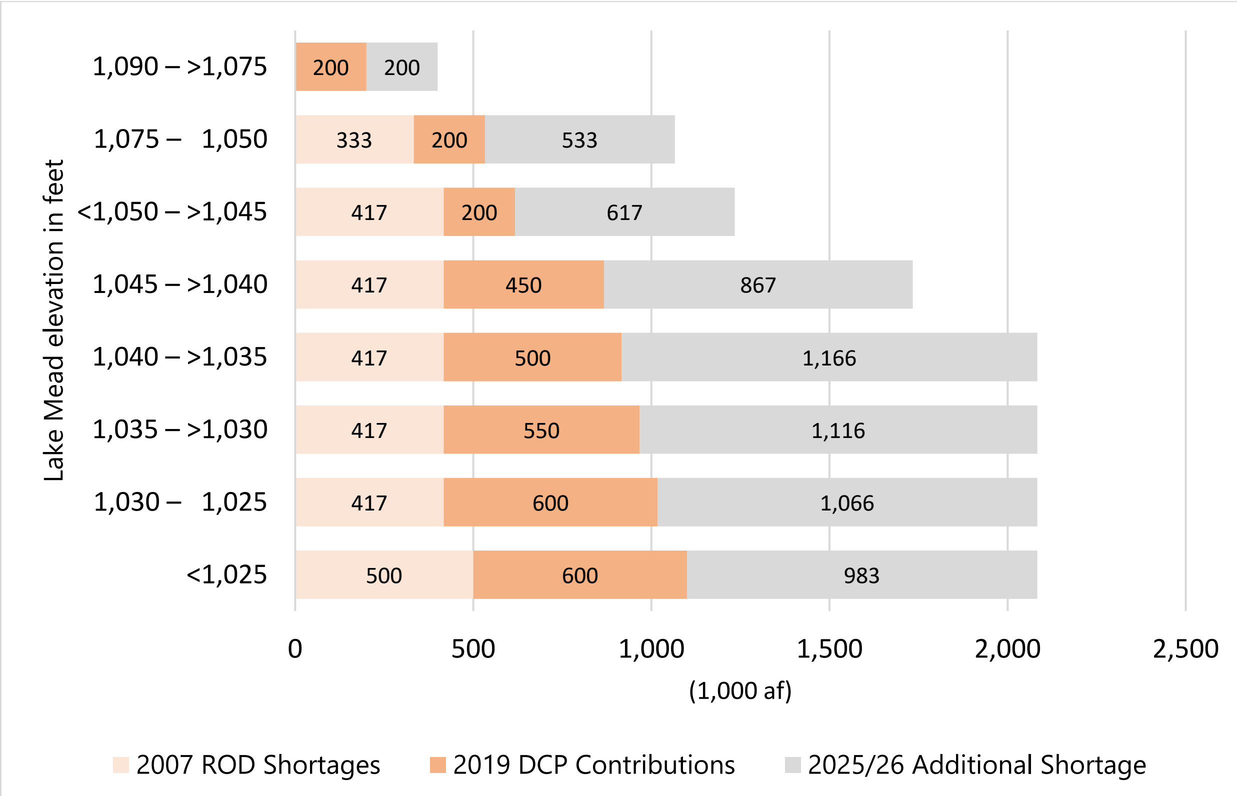


Table B-4
Lower Division States' Shortages and DCP Contributions by State, Action Alternative 2 (2025–2026)

Lake Mead Elevation (feet)	2007 ROD Shortages + 2019 DCP Contributions (1,000 af)				Additional Shortage* (1,000 af)					Total Shortage + Contributions (1,000 af)			
	AZ	NV	CA	Total	Percentage Additional Reduction**	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	192	8	0	200	2.67	75	8	117	200	267	16	117	400
1,075 – 1,050	512	21	0	533	7.11	199	21	313	533	711	42	313	1,066
<1,050 – >1,045	592	25	0	617	8.23	230	25	362	617	822	50	362	1,234
1,045 – >1,040	640	27	200	867	11.56	324	35	509	867	964	62	709	1,734
1,040 – >1,035	640	27	250	917	15.55	435	47	684	1,166	1,075	74	934	2,083
1,035 – >1,030	640	27	300	967	14.88	417	45	655	1,116	1,057	72	955	2,083
1,030 – 1,025	640	27	350	1,017	14.21	398	43	625	1,066	1,038	70	975	2,083
<1,025	720	30	350	1,100	13.11	367	39	577	983	1,087	69	927	2,083

*The additional shortage volumes decrease at elevation 1,025 feet because the shortages under the 2007 Interim Guidelines increase by the same amount. Therefore, the additional shortage amounts necessary to get to the 2.083 maf total are lower.
**Percentage of 2021 consumptive use

B.2.4 Comparison Metrics

All modeled alternatives are compared in **Section B.3** using the following metrics:

Lake Powell

- Monthly pool elevation
- Percentages of traces that fall below an elevation of 3,490 feet in any month in a water year
- End-of-water-year pool elevation
- Annual water year release
- Ten-year Lees Ferry gage flows

Lake Mead

- Monthly pool elevation
- Percentages of traces that fall below an elevation of 1,020 feet in any month in a calendar year
- End-of-calendar-year pool elevation
- Annual calendar year release

Shortage Sharing and Water Delivery

- Depletions by Lower Division States
- Annual shortages and DCP contributions to Lower Division States
- Annual shortages, DCP contributions, and system conservation for the Lower Division States

B.3 Modeling Results

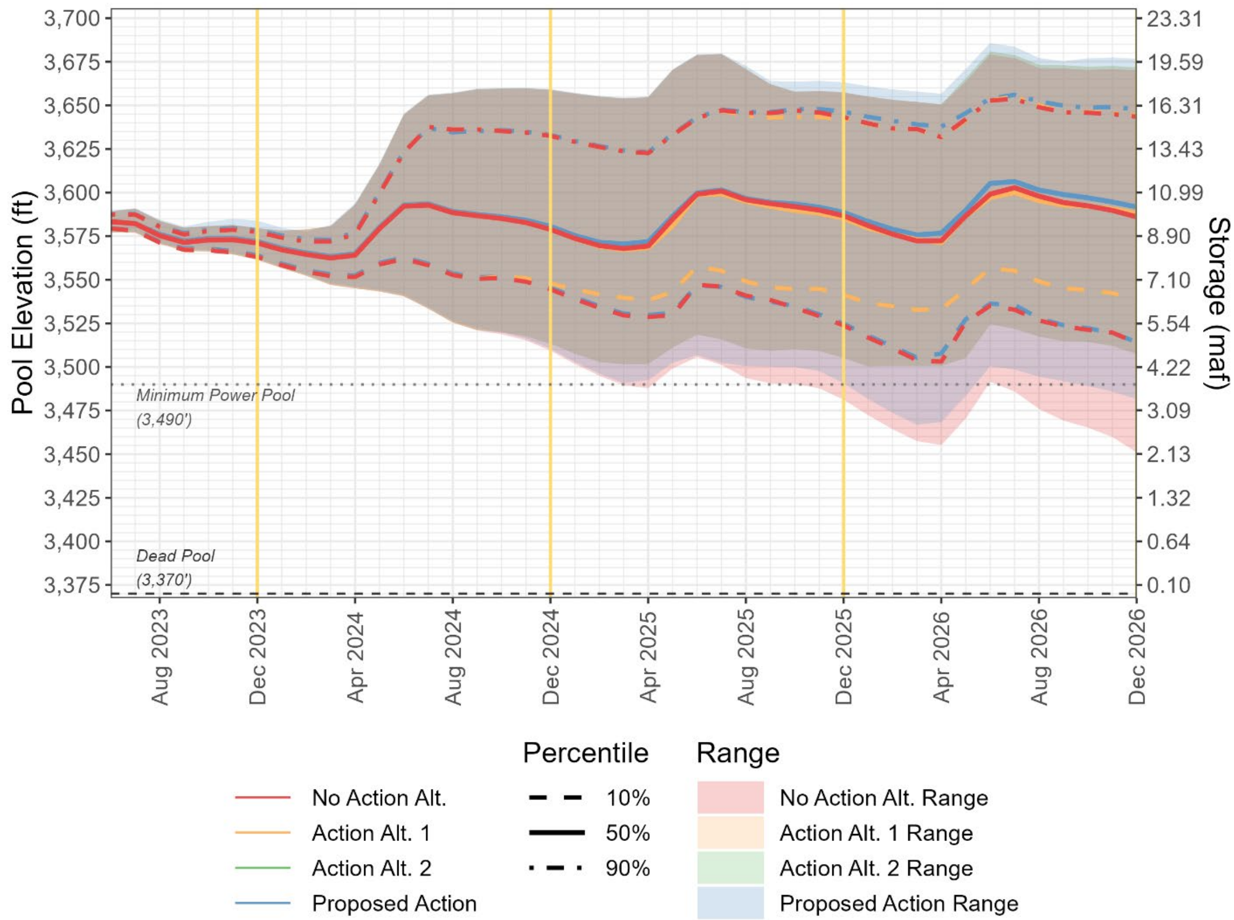
This section compares the No Action Alternative, Action Alternative 1, Action Alternative 2, and the Proposed Action. All statistics calculated reflect the hydrologic scenarios and other assumptions used in modeling; the statistics are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance. See **Appendix D** for more information about the hydrologic scenarios used and other modeling assumptions.

B.3.1 Lake Powell

Monthly Pool Elevations

Figure B-3 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Powell elevations for all alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows “clouds” representing the full ranges of modeled elevations for the alternatives through 2026.

Figure B-3
Lake Powell End-of-Month Pool Elevations



In **Figure B-3**, the cloud extents, or full ranges of modeled Lake Powell elevations, are similar for all alternatives at the high end and median. The lower bound of the No Action Alternative and Proposed Action cloud drops to 3,500 feet in 2025 and decreases to a minimum of 3,451 feet and 3,467 feet in 2026, respectively. The lower bound of the clouds for Action Alternatives 1 and 2 does not drop below 3,490 feet; this is because these alternatives include a provision to protect a Lake Powell elevation of 3,500 feet.

In **Figure B-3,** the 10th percentiles of the No Action Alternative and Proposed Action are nearly identical; they decrease to a Lake Powell elevation of nearly 3,500 feet in April 2026. Action Alternatives 1 and 2 are highest at the 10th percentile and have the same Lake Powell elevation through 2026; this is because Glen Canyon Dam operations are the same under both alternatives.

Percentages of Traces below Critical Elevations

Figure B-4 shows the percentage of modeled traces that fall below a Lake Powell elevation of 3,490 feet at any time during a water year for 2024 through 2026. Remaining above 3,490 feet is critical to ensuring Glen Canyon Dam can continue to operate as designed.

Figure B-4
Lake Powell Minimum Water Year Elevation, Percentage of Traces Less than Elevation 3,490 Feet

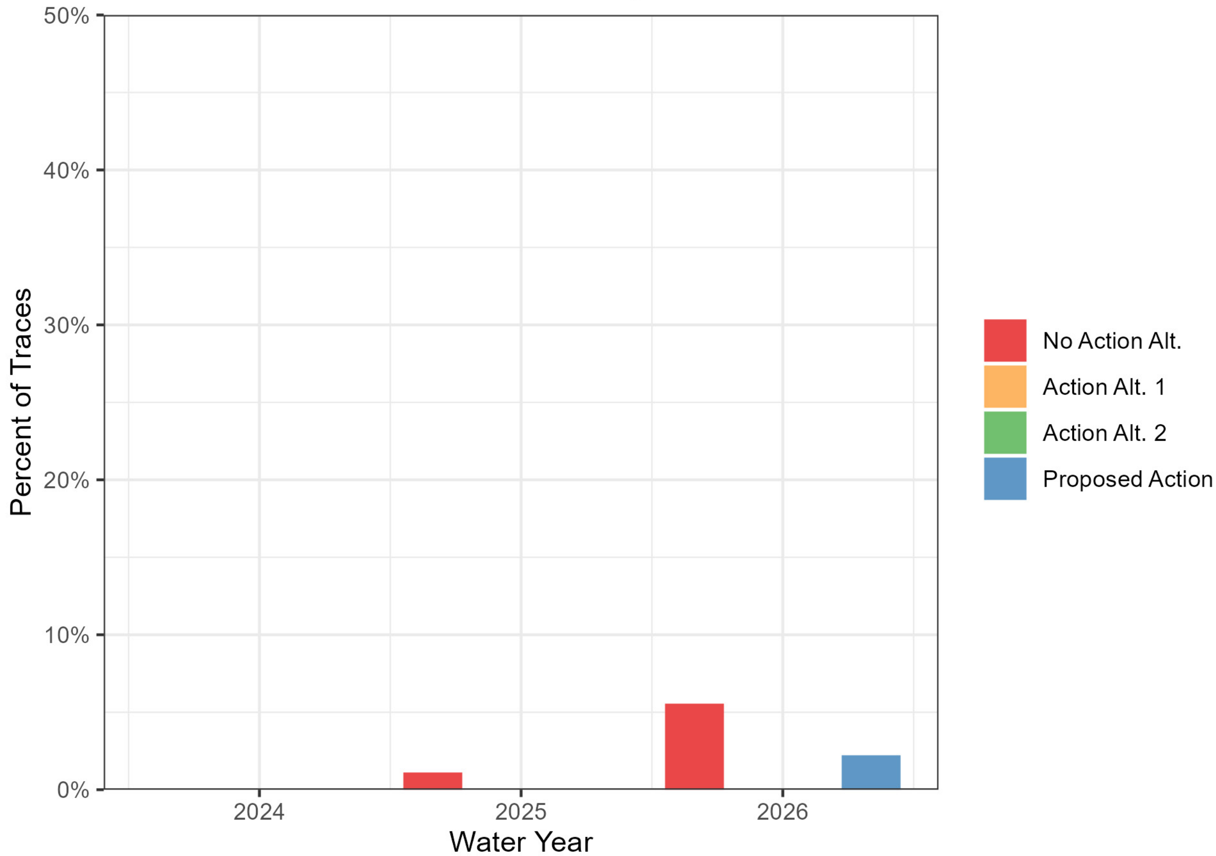


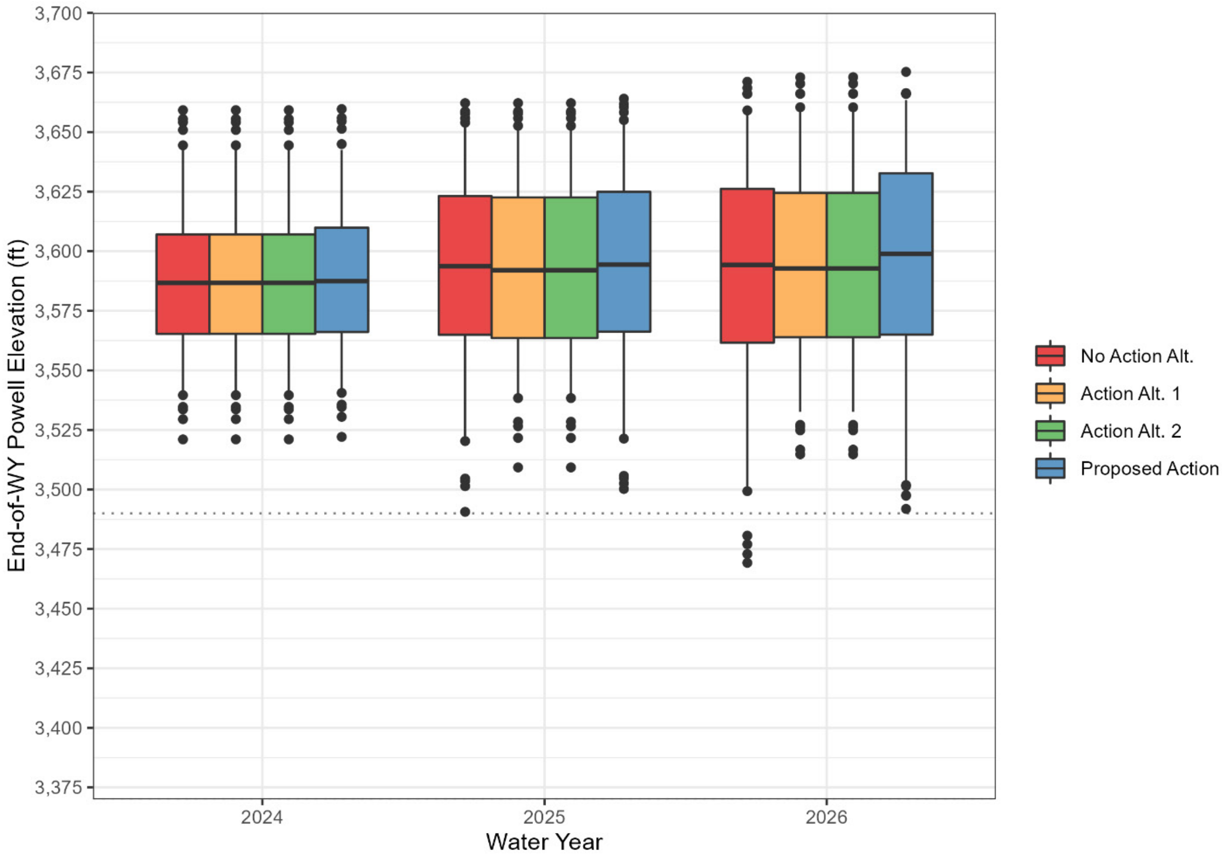
Figure B-4 shows that no alternatives drop below a Lake Powell pool elevation of 3,490 feet until 2025. Under the No Action Alternative, 1.5 percent of modeled traces in 2025 and 6.0 percent of modeled traces in 2026 result in the Lake Powell pool elevation dropping below 3,490 feet. Under Action Alternatives 1 and 2, no traces drop below a Lake Powell pool elevation of 3,490 feet due to the operations for the protection level of 3,500 feet. The Proposed Action has 2 percent of traces falling below 3,490 feet at Lake Powell in 2026.

Annual Pool Elevations

Figure B-5 shows the distributions of modeled Lake Powell elevations on September 30 in 2024, 2025, and 2026. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines.

Figure B-5 comparisons are consistent with those described above for **Figure B-3**. All alternatives have a similar range, especially at the highest pool elevations. The end-of-water-year Lake Powell pool elevations in 2025 and 2026 are lowest under the No Action Alternative, followed by the

Figure B-5
Lake Powell End-of-Water-Year Pool Elevations



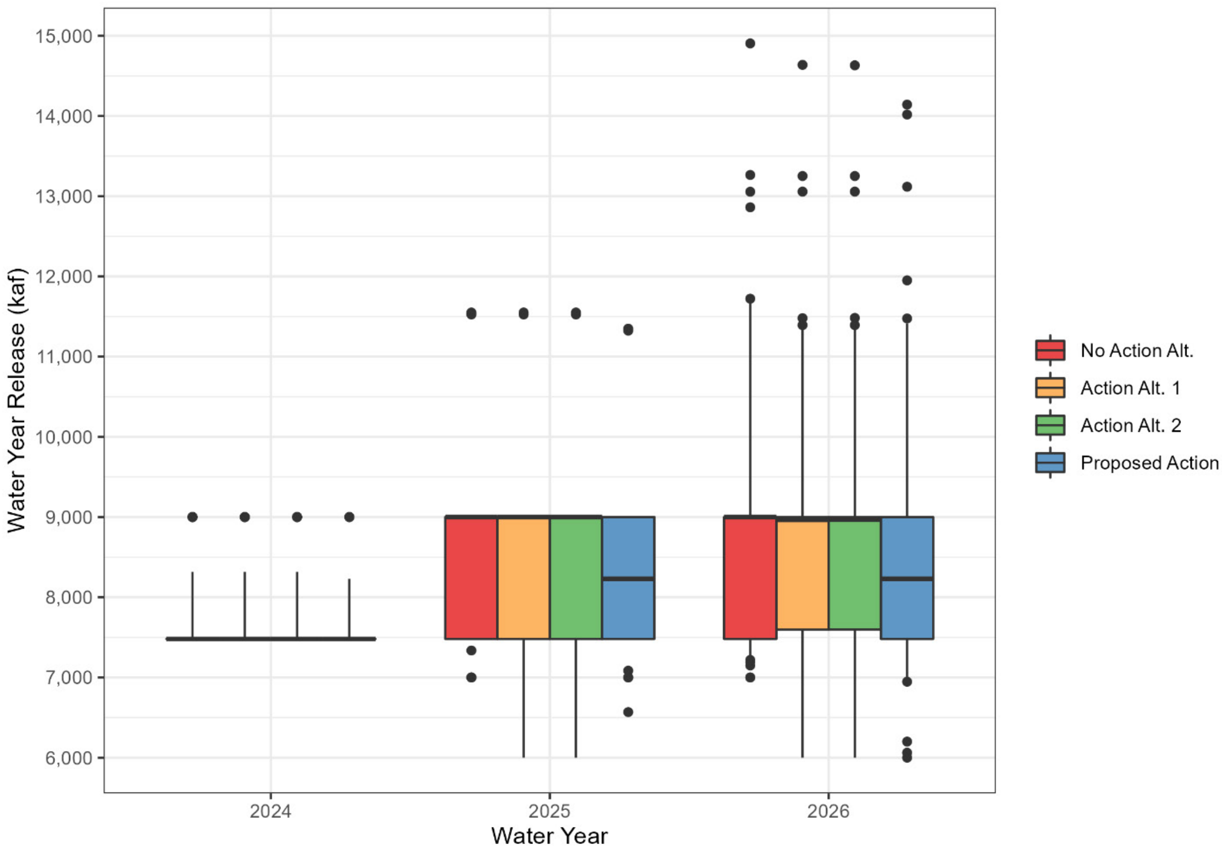
Proposed Action. Since Action Alternatives 1 and 2 protect the 3,500-foot elevation, the lowest end-of-water-year pool elevations are higher than under the No Action Alternative and the Proposed Action. The median end-of-water-year pool elevation for the Proposed Action is the highest at 3,599 feet in 2026, compared with the No Action Alternative and Action Alternatives 1 and 2, which have a median pool elevation of 3,594 and 3,593 feet, respectively.

Annual Releases

Figure B-6 shows the distributions of modeled Glen Canyon Dam water year releases in 2024, 2025, and 2026. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines.

The modeled Glen Canyon Dam water year releases shown in **Figure B-6** reflect the different approaches to Lake Powell operations assumed in the alternatives. The Proposed Action and Action Alternatives 1 and 2 limit releases to protect a Lake Powell elevation of 3,500 feet using different methods. The Proposed Action limits releases once an elevation of 3,500 feet is projected to be reached, while Action Alternatives 1 and 2 adjust releases before a 3,500-foot elevation is reached. Therefore, they have a slightly different distribution of releases at the low end.

Figure B-6
Glen Canyon Dam Water Year Releases



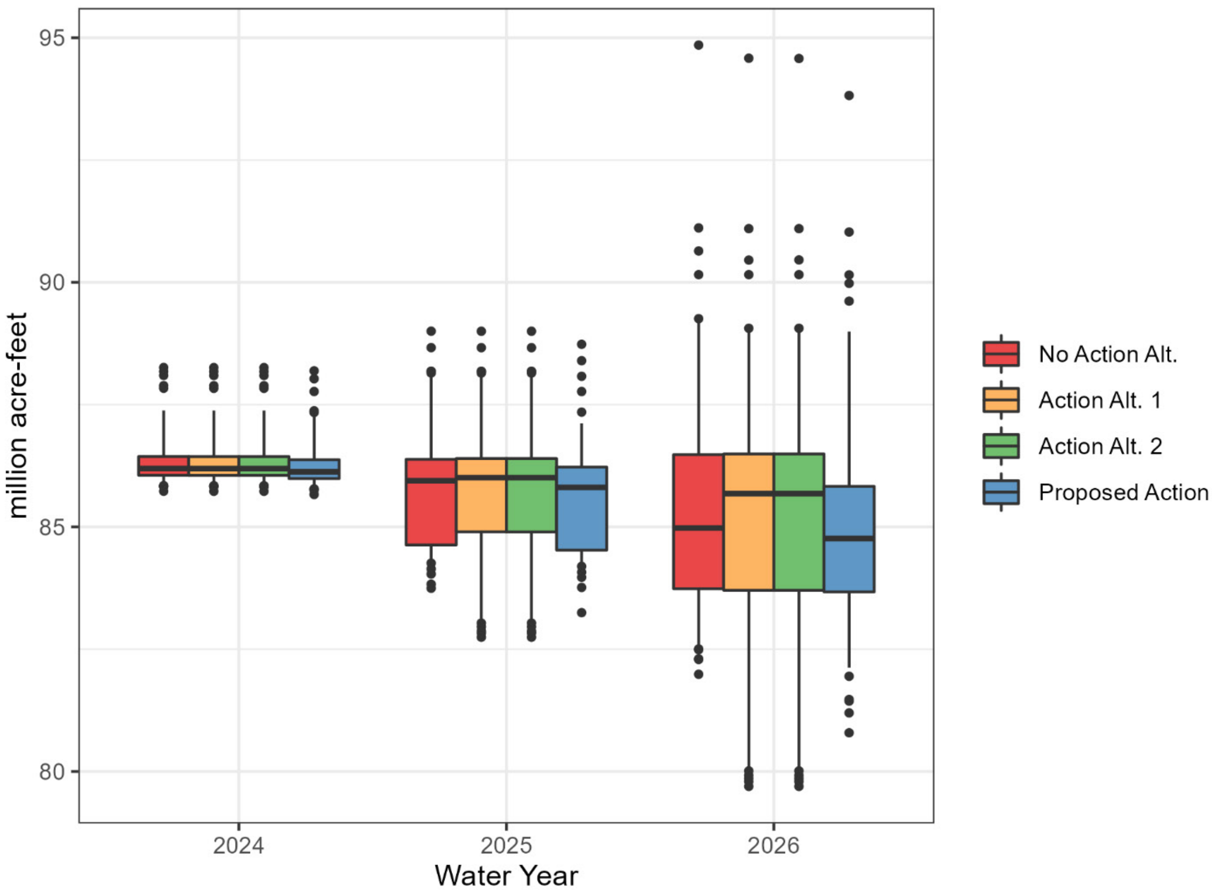
When Lake Powell is between elevations 3,500 and 3,575 feet, Action Alternatives 1 and 2 only have set release volumes (not balancing). Under Action Alternatives 1 and 2, the set releases range between 6 and 8.23 maf, which can be seen in the height of the box and whiskers. The No Action Alternative and Proposed Action set release volumes by balancing the storage of Lakes Powell and Mead when Lake Powell is below 3,525 feet; therefore, the No Action Alternative and Proposed Action have more variability in release volumes.

At the median, the No Action Alternative and Action Alternatives 1 and 2 are the same at 9.0 maf in 2025 and 2026. The Proposed Action has a lower release in 2025 and 2026. This is due to decreased balancing releases in the Upper and Lower Elevation Balancing Tiers resulting from increased storage in Lake Mead.

Ten-Year Lees Ferry Gage Flows

Figure B-7 shows the distribution of modeled 10-year running sums of Lees Ferry gage flows in 2024, 2025, and 2026. The modeled 2024 flow is calculated using the observed deliveries from 2015 through 2022, and a modeled delivery volume in 2023. There is some variability in the 2023 volume; however, it is common to all alternatives except the Proposed Action, which has small changes to balancing releases due to changes in releases from Lake Mead. The modeled 2025 volume is

Figure B-7
Lees Ferry Gage 10-Year Running Total



calculated without the 2015 observed volume, and the modeled 2026 volume is calculated without the 2015 and 2016 observed volumes.

Figure B-7 shows the 10-year volume resulting from a single hydrologic trace. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines.

Figure B-7 shows that under all alternatives, the median modeled 10-year total flows decline over time. This is partially because relatively high Glen Canyon Dam releases from 7 or more years ago drop out of the running total. All action alternatives have lower 10-year flows in the driest modeled traces than the No Action Alternative; this is because they model limited releases to protect Lake Powell's elevation of 3,500 feet.

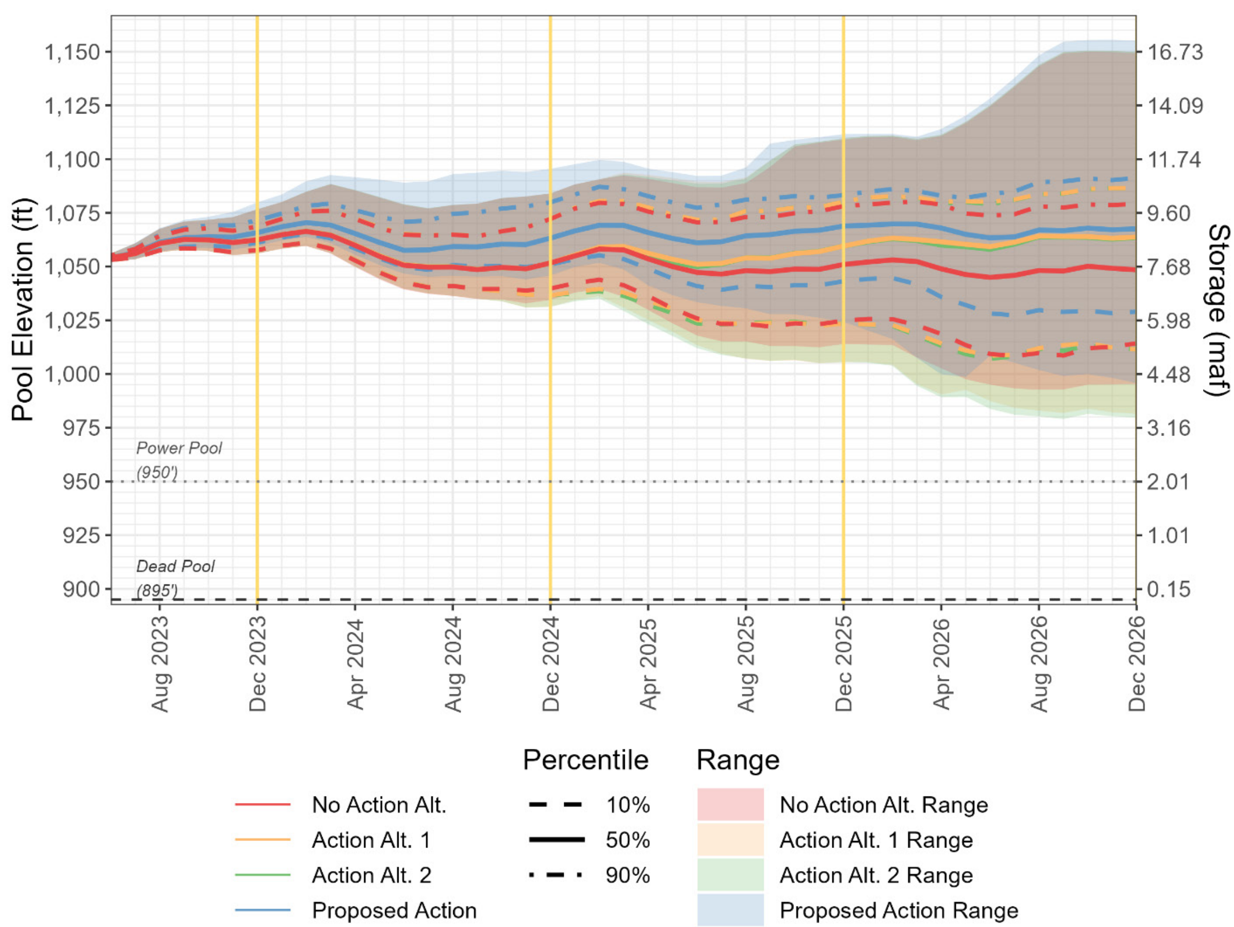
The median 10-year flows under Action Alternatives 1 and 2 are higher than under the No Action Alternative and the Proposed Action in 2025 and 2026. The Proposed Action has the lowest median 10-year flows because Lake Powell releases are lower in 2025 and 2026. By 2025, all alternatives result in 10-year totals below 82.3 maf in some modeled traces. In 2026, 2 percent of traces fall below the 10-year totals of 82.3 maf under the No Action Alternative, 16 percent of traces fall below the 10-year totals of 82.3 maf under Action Alternatives 1 and 2, and 6 percent of traces fall below the 10-year totals of 82.3 maf under the Proposed Action. There are no modeled traces that fall below 75 maf for the 10-year total.

B.3.2 Lake Mead

Monthly Pool Elevations

Figure B-8 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Mead elevations for all alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows clouds representing the full ranges of modeled elevations for the alternatives through 2026.

Figure B-8
Lake Mead End-of-Month Pool Elevations



The upper bounds of the clouds in **Figure B-8** vary slightly between all alternatives, especially the Proposed Action. The Proposed Action's upper bound increases and is higher than the upper bound for the other alternatives, especially in 2024, due to larger volumes of SEIS conservation[2] starting in 2023. In 2026, the No Action Alternative and Action Alternatives 1 and 2 have the lowest upper bound of modeled Lake Mead elevations, while the Proposed Action has the highest upper bound. The alternatives have more variability between them at the lower bounds of the clouds. The Proposed Action has the highest lower bound at the end of 2024, while the No Action Alternative and Action Alternatives 1 and 2 have the lowest elevations at the lower bound.

In May 2026, the Proposed Action's minimum increases slightly due to adjustments in Glen Canyon Dam releases to protect 3,500 feet. These adjustments result in lower releases in April 2026 and higher releases in May 2026 as inflows to Lake Powell increase during the runoff season; these inflows can be released from Glen Canyon Dam while maintaining 3,500 feet. At the end of 2026, Action Alternatives 1 and 2 have the lowest modeled elevations at 982 feet and 980 feet, respectively, while the No Action Alternative and Proposed Action end 2026 approximately 13 to 16 feet higher at around 995 feet and 996 feet, respectively.

In **Figure B-8**, the 10th percentiles of modeled Lake Mead elevations have a slightly different result than the lower bound. At the 10th percentile, the No Action Alternative and Action Alternatives 1 and 2 are approximately the same, while the Proposed Action has higher elevations. At the median, the Proposed Action has higher pool elevations than the other alternatives through 2026. Initially, the other alternatives have a decreasing pool elevation at the median through the end of 2024. In 2025, Action Alternatives 1 and 2 start to have an increasing median pool elevation due to additional Lower Division State shortages, compared with the No Action Alternative. By the end of 2026, the Proposed Action is only 4 feet above Action Alternatives 1 and 2 at the median, while the No Action Alternative is 20 feet lower than the Proposed Action. At the 90th percentiles of modeled elevations, the No Action Alternative is lower than the other alternatives, with the Proposed Action having the highest elevations.

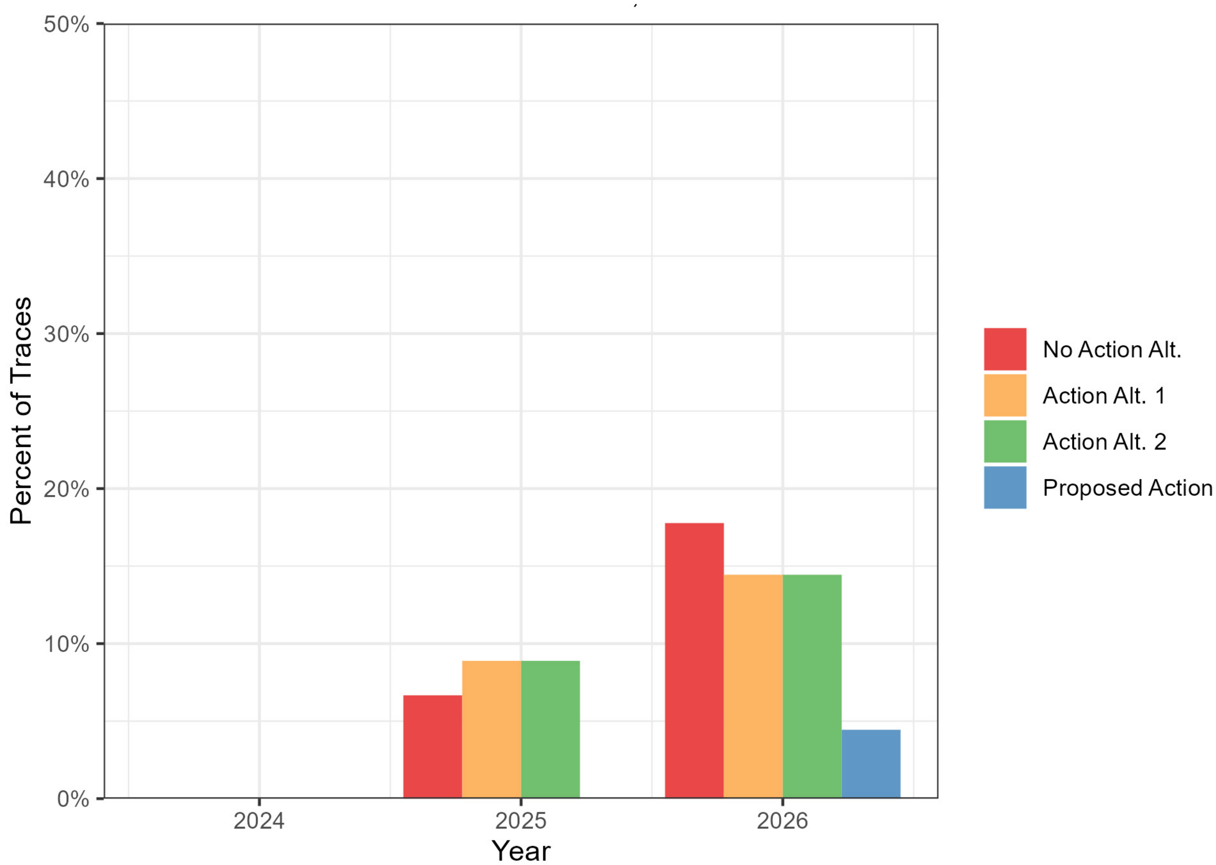
Percentages of Traces below Critical Elevations

Figure B-9 shows the percentage of modeled traces that fall below a Lake Mead elevation of 1,000 feet at any time during a year for the period of analysis. An elevation of 1,020 feet was identified as a critical elevation in the 2019 DCPs.

In **Figure B-9**, no alternatives have modeled traces falling below a Lake Mead elevation of 1,020 feet in 2024. In 2025, all alternatives except the Proposed Action have similar percentages of modeled traces falling below 1,020 feet; the No Action Alternative has approximately 7 percent, Action Alternatives 1 and 2 have the highest percentage at 9 percent, and the Proposed Action has the fewest traces at 0 percent. Over the period of analysis, the percentage of traces falling below an elevation of 1,020 feet increases under all alternatives. In 2026, the No Action Alternative has 18

[2] SEIS conservation may be a combination of system conservation, creation of ICS, or other water conservation activities that result in system benefits, as outlined in the proposal. Implementation of conservation measures would be subject additional environmental compliance, as appropriate.

Figure B-9
Lake Mead Minimum Calendar Year Elevation, Percentage of Traces Less than Elevation 1,020 Feet



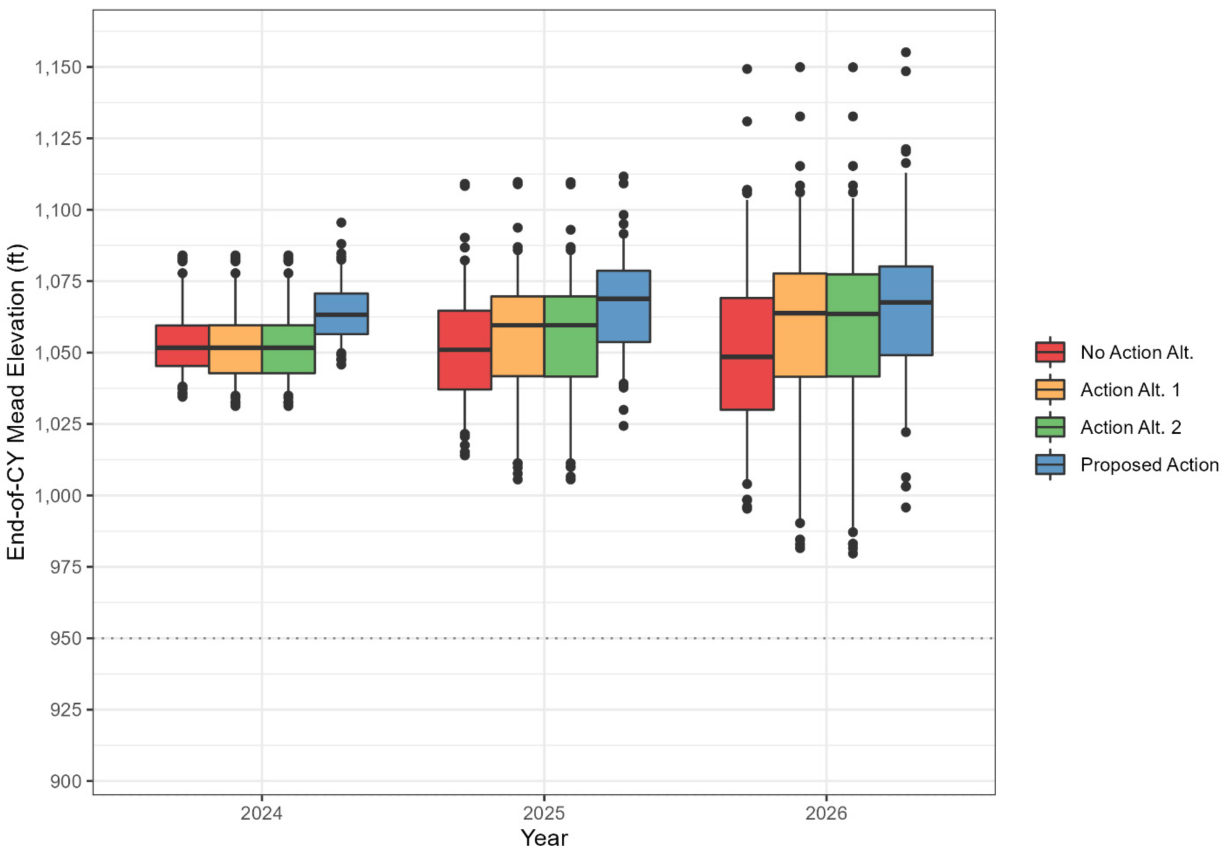
percent of traces falling below 1,020 feet, Action Alternatives 1 and 2 have 14 percent of traces, and the Proposed Action has 4 percent of traces.

Annual Pool Elevations

Figure B-10 shows the distributions of modeled Lake Mead elevations on December 31 in 2024, 2025, and 2026. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines.

The distributions of modeled end-of-calendar-year Lake Mead elevations for the alternatives shown in **Figure B-10** exhibit the same dynamics as those described under **Figure B-8**. The medians of the No Action Alternative decline from 2024 to 2026, and the variability increases. Action Alternatives 1 and 2 display wide ranges in all years, but the medians and ranges consistently shift upward over the period of analysis. Compared with the other alternatives, the Proposed Action has the highest pool elevation at all quantiles from 2024 to 2026.

Figure B-10
Lake Mead End-of-Calendar-Year Pool Elevations

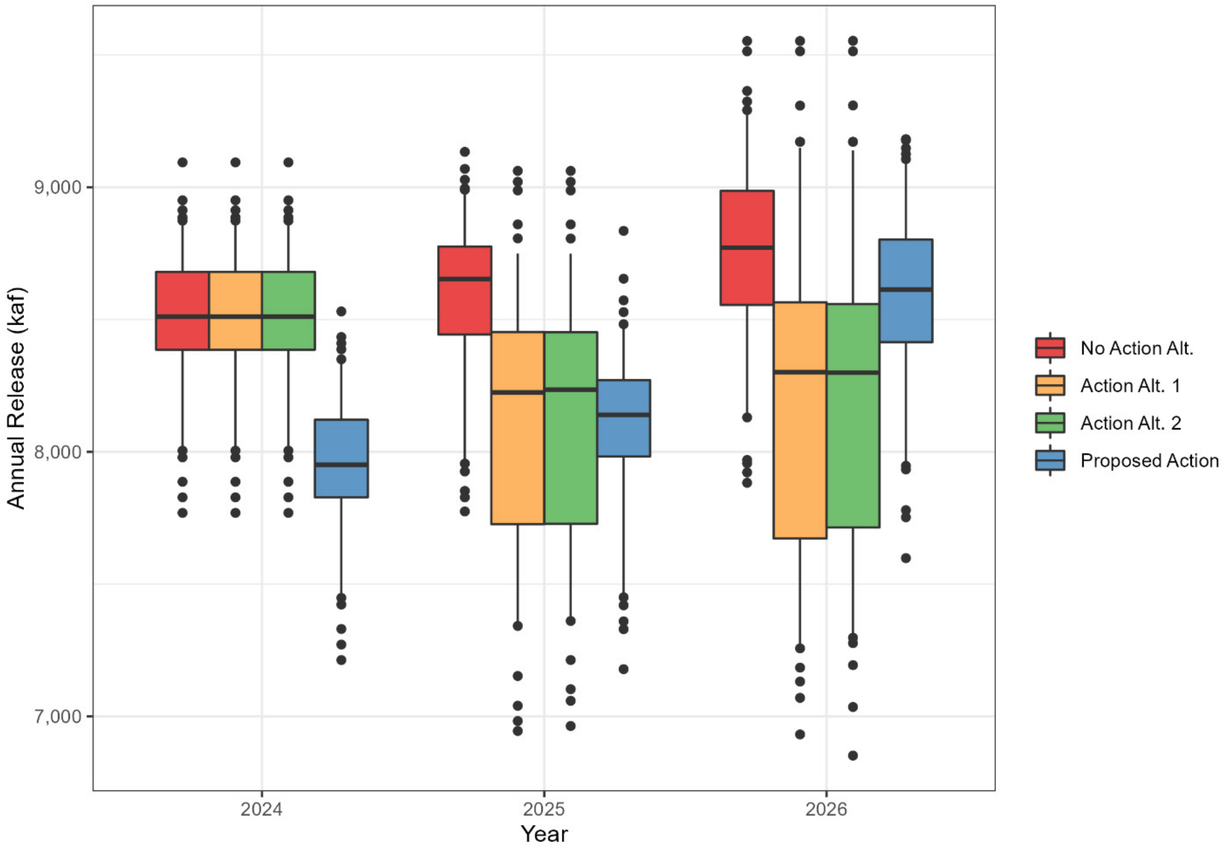


Annual Releases

Figure B-11 shows the distributions of modeled annual releases from Hoover Dam in 2024, 2025, and 2026. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines.

Figure B-11 shows that under the No Action Alternative, the modeled releases from Hoover Dam in 2024 to 2025 have ranges of approximately 1.3 maf, with medians that increase slightly from approximately 8.51 to 8.65 maf. In 2026, the median release again increases slightly to 8.77 maf, while the highest releases increase to above 9.5 maf. In 2024, Action Alternatives 1 and 2 have the same releases as the No Action Alternative. In 2025 and 2026, releases are lower than under the No Action Alternative, and variability increases due to the potential of increased Lower Division State shortage volumes. With a median of 7.95 maf, the Proposed Action has lower releases than the other alternatives in 2024. In 2025, the release increases but is still lower than it is under Action Alternatives 1 and 2 at the median. In 2026, the Proposed Action release is higher at the median at 8.61 maf and has less variability than under Action Alternatives 1 and 2; however, the median is still lower than it is under the No Action Alternative.

Figure B-11
Hoover Dam Calendar Year Releases



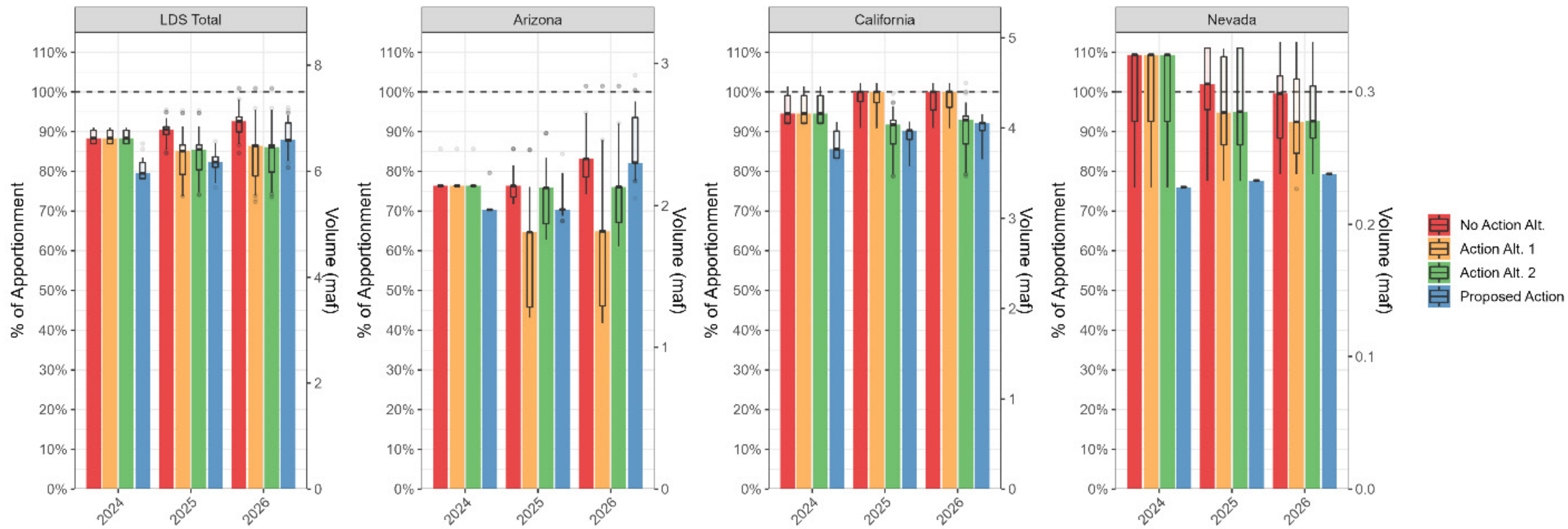
B.3.3 Shortage Sharing and Water Delivery

Lower Division Depletions by State

Figure B-11 shows the distribution of modeled Lower Division States' depletions represented as a percentage of the state's apportionment and by volumes in 2024, 2025, and 2026. The median depletions are represented by the colored bar and the mid-line of each box. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled depletions, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines. From left to right, the four panels display depletions for the Lower Division States (the total), Arizona, California, and Nevada, respectively. The figure is oriented to facilitate the comparison of a state's modeled depletions across each alternative over the period of analysis.

Figure B-12 reports the distributions of modeled Lower Division States' depletions that would occur after adjustments to demands based on shortages, DCP contributions, ICS delivery or creation, and system conservation.

Figure B-12
Lower Division States' Modeled Depletions



The left panel of **Figure B-12** shows a comparison of how total modeled Lower Division States' depletions were affected by the different alternatives. In 2024, the No Action Alternative and Action Alternatives 1 and 2 show the same median depletions at 88 percent of apportionment; this is because no additional shortages are applied in 2024 for Action Alternatives 1 and 2. The Proposed Action depletion for 2024 is lower than for the other alternatives at 80 percent of apportionment; this is because an additional Lower Division State system conservation was modeled. In 2025 and 2026, the medians for Action Alternatives 1 and 2 decline, and the variability increases due to additional shortages taking effect. The median for the No Action Alternative is the highest among the alternatives in 2025 and 2026. The Proposed Action results in lower use than the other alternatives in 2025 and slightly higher depletions than Action Alternatives 1 and 2 in 2026.

In the second panel of **Figure B-12**, Arizona's modeled annual 2025 and 2026 depletions are lowest under Action Alternative 1. Under Action Alternative 1, shortages are applied based exclusively on the concept of priority, so Arizona's junior users are significantly affected. The No Action Alternative and Action Alternative 2 have similar depletions in 2025; this is due to additional shortages and a reduction in system conservation modeled in Action Alternative 2. The No Action Alternative and Proposed Action have higher depletions in 2026 than Action Alternatives 1 and 2 since no additional shortages are applied in those alternatives.

In the third panel of **Figure B-12**, modeled annual depletions for California are highest under the No Action Alternative and Action Alternative 1 throughout the period of analysis; this is because there are no additional shortages applied to California due to high-priority users under those alternatives. In 2025 and 2026, Action Alternative 2 and the Proposed Action have similar median depletions, with a larger range in Action Alterative 2. Action Alternative 2 has additional shortage applied to California when shortage volumes are distributed based on each user's consumptively used water, while the Proposed Action includes system conservation.

The fourth panel of **Figure B-12** shows the modeled annual depletions for Nevada. In 2024, median depletions for all alternatives except the Proposed Action are approximately 109 percent of apportionment. This is a result of how the ICS accumulation space[3] sharing is modeled for these alternatives. An ICS accumulation space-sharing agreement allows states to share ICS accumulation space up to the total capacity of 2.7 maf. In 2024, some model traces show the ICS accumulation at capacity. Since Nevada is using more than the state's individual maximum ICS accumulation, Nevada is modeled to vacate the ICS so another state can create ICS. When this occurs, it is assumed that Nevada takes delivery of Nevada's vacated ICS up to the state's maximum delivery, which results in depletions above Nevada's apportionment. This also occurs in 2025 and 2026. The Proposed Action does not have depletions above Nevada's apportionment since it is assumed that Nevada converts vacated ICS to system water instead of taking delivery of the volume. Due to this assumption, the depletions under the Proposed Action are substantially lower than they are under the other alternatives.

[3] In accordance with the Lower Basin DCP, the maximum total amount of Extraordinary Conservation ICS, Binational ICS, and DCP ICS that may be accumulated by the Lower Division States is 2.7 maf.

Annual Shortage and DCP Contribution Volumes by State

Figure B-13 shows the distributions of modeled shortages plus DCP contributions to Lower Division States represented as a percentage of apportionment and volumes in 2024, 2025, and 2026. The volumes represent water required to meet DCP contributions, 2007 ROD shortages, and additional proposed shortages during a year. The median reductions are represented by the colored bar and the mid-line of each box. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines. From left to right, the four panels display shortage and DCP contributions for Lower Division States (the total), Arizona, California, and Nevada, respectively.

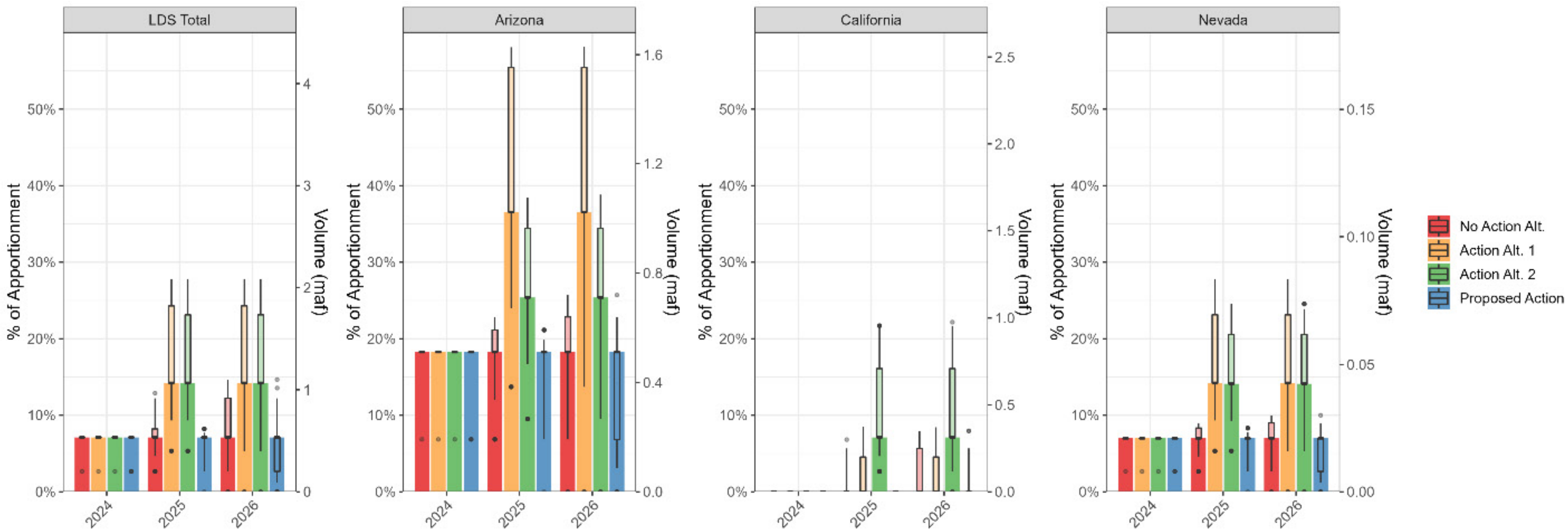
The left panel in **Figure B-13** shows that 2024 Lower Division States' total shortages and DCP contributions are the same across all alternatives since the alternatives have the same 2024 Lake Mead operating condition. In 2025 and 2026, Lower Division States' total shortages and DCP contributions for the No Action Alternative and Proposed Action are similar at the median with 7 percent of apportionment. Also, Action Alternatives 1 and 2 are similar at the median with 14 percent of apportionment. The range of shortages and DCP contributions in 2025 and 2026 for Action Alternatives 1 and 2 is larger than it is for the other alternatives due to the wider range of potential shortages.

The distributions of modeled Arizona shortages and DCP contributions shown in the second panel of **Figure B-13** reflect dynamics between alternatives that have been observed in previous figures and discussions. The No Action Alternative and Proposed Action have lower shortages and DCP contributions than Action Alternatives 1 and 2. Delivery reductions under Action Alternative 1 are higher than they are under Action Alternative 2; this is because Action Alternative 1 distributes shortage volumes based on the concept of priority, as opposed to using the same percentage across all Lower Basin water users to distribute shortages.

The third panel in **Figure B-13** shows the same dynamics in modeled distributions of California's shortages and DCP contributions that were described for Arizona, except the relative higher and lower magnitudes between Action Alternatives 1 and 2 are reversed. Distributing shortages based fully or largely on proportionality results in higher reductions for California under Action Alternative 2; using the priority system as a basis for Action Alternative 1 results in lower delivery reduction volumes for California.

With respect to modeled shortages and DCP contributions assigned to Nevada, the right panel of **Figure B-13** shows that distributing shortages based on the concept of priority versus using the same percentages across all Lower Basin water users is not as strong of a determinant of magnitudes as it is for Arizona and California. Action Alternatives 1 and 2 have the same shortages and DCP contributions at the median, with Action Alternative 1 having a slightly higher maximum shortage compared with Action Alternative 2. Consistent with the other states, the No Action Alternative and Proposed Action have the same shortages and DCP contributions.

Figure B-13
Distribution of Lower Division Shortages and DCP Contributions



Annual Shortage, DCP Contribution, and System Conservation Volumes by State

Figure B-14 shows the distributions of modeled shortages, DCP contributions, and system conservation to Lower Division States represented as a percentage of apportionment and volumes in 2024, 2025, and 2026. The figure reflects **Figure B-13** with the addition of system conservation volumes. The median reductions are represented by the colored bar and the mid-line of each box. The top and bottom of each box capture the 25th and 75th percentile, respectively, of the modeled elevations, and the whiskers extend to the 5th and 95th percentiles. The outliers are represented as dots beyond these lines. From left to right, the four panels display the total shortages, DCP contributions, and system conservation for Lower Division States (the total), Arizona, California, and Nevada, respectively.

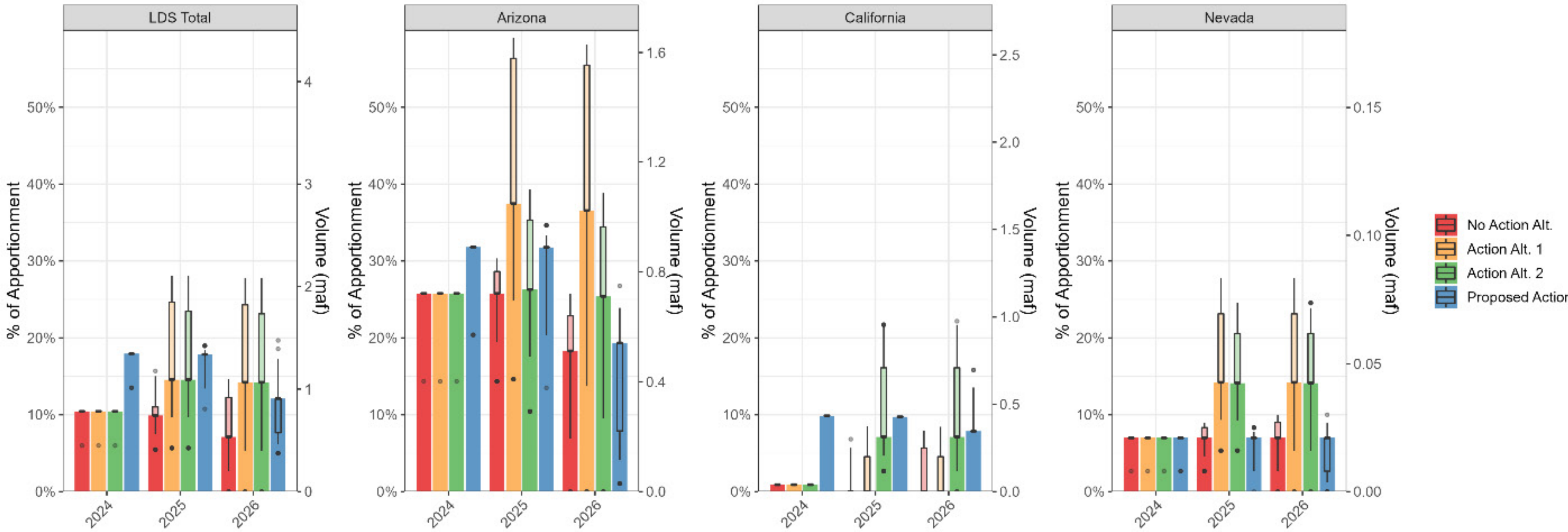
The left panel in **Figure B-14** reflects the difference in system conservation between the alternatives. In 2024 and 2025, the Proposed Action has more system conservation than the other alternatives, resulting in higher volumes that are approximately at 18 percent of Lower Division States' apportionment at the median. Compared with Action Alternatives 1 and 2, under the Proposed Action the assumed system conservation in 2025 results in larger shortages, DCP contributions, and system conservation volumes. In 2026, the Proposed Action has lower volumes than Action Alternatives 1 and 2 since less system conservation is assumed to occur in 2026.

The distributions of modeled Arizona shortages, DCP contributions, and system conservation shown in the second panel of **Figure B-14** reflect the addition of system conservation volumes to **Figure B-13**. The Proposed Action has higher volumes than the other alternatives in 2024. In 2025, Action Alternative 1 has higher volumes at 38 percent of apportionment compared with the Proposed Action, which is 32 percent of apportionment. In 2026, Action Alternatives 1 and 2 have higher volumes than the Proposed Action, which has volumes similar to those under the No Action Alternative at the median.

The third panel in **Figure B-14** shows the Proposed Action has larger total shortages, DCP contributions, and system conservation volumes for California than the other alternatives. In 2024, the Proposed Action results in volumes of 10 percent of apportionment, which are all due to system conservation. The other alternatives have lower volumes at 1 percent of apportionment due to lower assumed system conservation. In 2025 and 2026, Action Alternative 2 has total shortages, DCP contributions, and system conservation volumes only slightly below those of the Proposed Action at the median, while the No Action Alternative and Action Alterative 1 have volumes at 0 percent of apportionment at the median.

With respect to modeled total shortages, DCP contributions, and system conservation volumes assigned to Nevada, the right panel of **Figure B-14** is the same as the panel for Nevada in **Figure B-13**. There is no assumed system conservation for any alternatives in Nevada. The Proposed Action assumes changed assumptions for ICS (see the discussion for **Figure B-12**); this results in different depletions but does not affect the volumes in **Figure B-14**.

Figure B-14
Distribution of Lower Division Shortages, DCP Contributions, and System Conservation



B.4 Summary

At Lake Powell, modeling for the alternatives shows similar monthly and end-of-water-year elevations at the median and high end of the range. Compared with the No Acton Alternative, all three alternatives have higher lower bounds of elevations and a lower incidence of reaching 3,490 feet; this is because they include some protection of elevation 3,500 feet. Action Alternatives 1 and 2 and the Proposed Action show variation over time and are comparable with one another in their distributions of Glen Canyon Dam releases based on whether they include balancing releases below a Lake Powell elevation of 3,575 feet and the volumes of specified releases below 3,575 feet. Action Alternatives 1 and 2 have no balancing below 3,575 feet after 2024; also, their modeled median releases are stable in 2025 and 2026 at 9 maf with ranges that tend to increase over time. The Proposed Action median modeled Glen Canyon Dam releases are lower than they are for the other alternatives by approximately 0.77 maf in 2025 and 2026. The No Action Alternative's medians are similar to the medians of Action Alternatives 1 and 2.

Because of the assumption to protect a Lake Powell elevation of 3,500 feet, there are more modeled traces resulting in 10-year Lees Ferry gage flows less than 82.3 maf in 2026 under Action Alternatives 1 and 2 and the Proposed Action. In 2026, depending on the alternative, 6 to 16 percent of traces fall below 82.3 maf over 10 years under Action Alternatives 1 and 2 and the Proposed Action.

At Lake Mead, the Proposed Action differs from the other alternatives because it includes additional SEIS conservation in 2023 through 2026. Thus, monthly and end-of-calendar-year pool elevations are higher under the Proposed Action for the analysis period. Median pool elevations for Action Alternatives 1 and 2 are higher than they are under the No Action Alternative starting in 2025, which is when additional shortage volumes take effect for Action Alternatives 1 and 2. A combination of increased shortages under Action Alternatives 1 and 2 and decreased Glen Canyon Dam releases under the Proposed Action causes the median modeled Lake Mead elevations under Action Alternatives 1 and 2 to increase up to the elevations for the Proposed Action starting in 2025. At the end of 2026, the elevations under Action Alternatives 1 and 2 are 20 feet below the elevations under the Proposed Action. This dynamic is reflected in the percentage of traces that drop below 1,020 feet at Lake Mead in 2026; the Proposed Action results in 4 percent of traces dropping below 1,020 feet, while Action Alternatives 1 and 2 and the No Action Alternative have 14 and 18 percent of traces, respectively.

Releases from Hoover Dam are significantly lower under Action Alternatives 1 and 2 and the Proposed Action than releases modeled under the No Action Alternative. This is because Action Alternatives 1 and 2 and the Proposed Action apply additional shortages or SEIS conservation. The release medians and ranges for Action Alternatives 1 and 2 are generally consistent in 2025 and 2026, while the releases under the Proposed Action increase through the analysis period based on modeled SEIS conservation and lower shortage volumes.

In terms of shortage sharing and water deliveries to the Lower Division States, three major factors drive the differences among Action Alternatives 1 and 2 and the Proposed Action: (1) additional shortage volumes, (2) how shortages are distributed among users, and (3) assumed system conservation volumes. Overall, Action Alternatives 1 and 2 result in higher modeled shortages (and lower modeled depletions) in 2025 and 2026 than the No Action Alternative. The Proposed Action results in only minor differences in shortages compared with the No Action Alternative. However, when system conservation is considered, reductions are more similar to those under Action Alternatives 1 and 2, though exact volumes vary by year. In 2024, depletions are lower for the Proposed Action than for the other alternatives; however, in 2025 and 2026, depletions are approximately the same as they are for Action Alternatives 1 and 2.

The additional shortages applied to individual states vary among Action Alternatives 1 and 2, which are the only alternatives that assume additional shortages. Action Alternative 1 uses the concept of priority as the basis for distributing additional shortages. This results in the modeled shortages and DCP contributions being relatively higher in Arizona and lower in California, compared with Action Alternative 2. In contrast, Action Alternative 2 bases additional shortage distributions on the proportions of water used by different users; this results in relatively higher magnitudes of reductions in California and lower reductions in Arizona. For Nevada, the two approaches to distributing shortages do not have a strong impact on shortage magnitudes.

When system conservation and additional shortages are both considered, the Proposed Action shows higher reductions for California than any of the other alternatives. For Arizona, the Proposed Action has lower reductions than Action Alternative 1 but higher reductions than Action Alternative 2 in 2025 and reductions similar to the No Action Alternative in 2026. Since Nevada has no assumed system conservation, additional reductions are only due to additional shortages under Action Alternatives 1 and 2. Changes in modeled ICS behavior result in much lower depletions by Nevada under the Proposed Action compared with under the other alternatives.

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Attachment B-1

Action Alternatives 1 and 2 CRMMS Modeling Assumptions

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Attachment B-1. CRMMS Modeling Assumptions

This attachment describes the CRMMS modeling assumptions for Action Alternatives 1 and 2. CRMMS modeling assumptions for the No Action Alterative and Proposed Action are detailed in **Appendix D**. The assumptions common to all alternatives in **Appendix D, Section D.6.1** and **Section D.7.1** also apply to Action Alternatives 1 and 2.

B-1.1 Lake Powell Operations under Action Alternatives 1 and 2

The Lake Powell operations under Action Alternatives 1 and 2 are the same. For operating year 2023 and 2024, CRMMS solves for Lake Powell operations as described for the No Action Alternative (**Appendix D, Section D.6.2**). For operating years 2025 and 2026, CRMMS solves for the Lake Powell operating tier and operating year release as follows using the projected physical pool elevation:

- If the projected Lake Powell end-of-calendar-year pool elevation is greater than or equal to the equalization level (**Appendix D**, **Table D-8**), the Equalization Tier operations govern the operating year releases (see **Section D.6.3.1**).
- If the Lake Powell end-of-calendar-year pool elevation is less than the equalization level and greater than or equal to 3,575 feet, the Upper Elevation Balancing Tier governs the operating year releases (see **Section D.6.3.2**).
- If the Lake Powell end-of-calendar-year pool elevation is less than 3,575 feet, the new Lower Elevation Release Tier governs the operating year releases (see **Section D.6.3.3**).

The operating year release calculation for each tier is described below for Action Alternatives 1 and 2.

B-1.1.1 Equalization Tier

The Equalization Tier method for Lake Powell under Action Alternatives 1 and 2 is identical to that under the No Action Alternative (**Appendix D**, **Section D.6.2**).

B-1.1.2 Upper Elevation Balancing Tier

The Upper Elevation Balancing Tier method for Lake Powell under Action Alternatives 1 and 2 is identical to that under the No Action Alternative (**Appendix D**, **Section D.6.2**).

B-1.1.3 Lower Elevation Release Tier

Operating year 2023 operates in the Lower Elevation Balancing Tier, as set by the August 2022 24-Month Study. The calculation of the Lake Powell annual release for operating year 2023 is identical to that for the No Action Alternative (**Appendix D**, **Section D.6.2**). Operating year 2024 also operates consistent with operating year 2024 under the No Action Alternative.

For operating years beyond 2024, the Lower Elevation Release Tier is modeled by first setting the annual release volume to 8.23 maf. Lake Powell resolves with the 8.23-maf annual release for monthly releases and pool elevations. Next, a rule checks the projected Lake Powell end-of-water-year pool elevation (for example, September 30, 2024, when the model is executing in August 2023) and sets the operating year release as follows:

- If the projected Lake Powell end-of-water-year pool elevation is greater than or equal to 3,575 feet, set the operating year release to 8.23 maf.
- If the projected Lake Powell end-of- water-year pool elevation is less than 3,575 feet and greater than or equal to 3,550 feet, set the operating year release to 7.48 maf.
- If the projected Lake Powell end-of-water-year pool elevation is less than 3,550 feet and greater than or equal to 3,525 feet, set the operating year release to 7.00 maf.
- If the Lake Powell end-of-water-year pool elevation is less than 3,525 feet, set the operating year release to 6.00 maf.

B-1.1.4 Protection Level

Action Alternatives 1 and 2 specify a protection level at Lake Powell such that if, in any month, Lake Powell's elevation is below 3,500 feet, the Lake Powell release would be set to maintain or increase the elevation with a maximum release of 6.0 maf. The goal would be to maintain LTEMP minimum flows, subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

In CRMMS, this is modeled by constraining monthly releases to ensure the pool elevation does not drop below 3,500 feet. If the operating year starts with Lake Powell below 3,500 feet and if the monthly release will cause the elevation to decrease, then the monthly release is decreased to maintain the current elevation. It is also constrained by the river outlet works' capacity. If the monthly outflow results in an increase in pool elevation, the method will try to release any constrained volume from earlier in the operating year while staying above the protection elevation of 3,500 feet.

If Lake Powell is greater than or equal to 3,500 feet at the beginning of the operating year, then all monthly releases are constrained such that the end-of-month pool elevation does not fall below 3,500 feet. The constrained release volume is tracked throughout the operating year. If a release for a given month is above 3,500 feet, then the method will try to release the previously constrained volume such that Lake Powell remains at or above 3,500 feet at the end of the month.

B-1.1.5 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases using the same method used for the No Action Alternative. To assist in the solution of monthly releases, an additional column was added to **Table Attachment D-1** for a 6.0-maf annual release (**Table Attachment B-1**). This monthly distribution is used for modeling purposes only.

Table Attachment B-1
Monthly Distribution of Lake Powell Releases for a 6.0-maf Annual Release (af)

Annual Total	**6,000,000**
October	410,000
November	430,000
December	510,000
January	570,000
February	500,000
March	530,000
April	470,000
May	470,000
June	500,000
July	560,000
August	600,000
September	450,000

B-1.2 Lake Mead Operations under Action Alternatives 1 and 2

In CRMMS, Lake Mead operations are modeled by solving for the Lower Basin condition, Lower Basin and Mexico diversions, and ICS and other conservation activity.

B-1.2.1 Action Alternative 1

The Lake Mead operations and Lower Basin conditions for Action Alternative 1 are similar to those under the No Action Alternative (that is, the shortage and DCP contribution volumes are based on Lake Mead elevations). For operating years 2023 and 2024, CRMMS solves for the Lake Mead operations as described in the No Action Alternative; the physical pool elevation is used to calculate Lake Mead operations and the Lower Basin conditions. For operating years 2025 and 2026, CRMMS solves for the Lake Mead operations and Lower Basin conditions using the physical elevations at Lake Mead with additional shortages applied at different Lake Mead elevations.

Surplus

The surplus model assumptions for the Lower Basin under Action Alternative 1 are identical to those under the No Action Alternative (**Appendix D**, **Section D.7.2**).

Normal Condition

The normal condition model assumptions for the Lower Basin under Action Alternative 1 are identical to those under the No Action Alternative (**Appendix D**, **Section D.7.2**).

Shortage Condition

Under Action Alternative 1, for operating years 2025 and 2026, the Lower Basin is modeled to operate in a shortage condition when the projected Lake Mead end-of-calendar-year pool elevation is at or below 1,090 feet. For 2023 and 2024, operations are identical to those under the No Action Alterative. In CRMMS, a rule solves for the shortage condition in January by comparing Lake

Mead's previous end-of-calendar-year pool elevation with the defined pool elevations in **Table Attachment B-2**; the total Lower Division States' shortage volumes correspond to the shortage condition and operating year in **Table Attachment B-2**. The total shortage is then distributed by priority among the Lower Division States and water users by following the method used in the shortage allocation model for Action Alternative 1 (see **Appendix E**, Shortage Allocation Model Documentation).

Table Attachment B-2
Lower Division States' Shortages and DCP Contributions (1,000 af)

Lake Mead Elevation (feet)	Shortages	DCP Contributions	Additional Shortages under Action Alternatives 1 and 2	Total Combined (Shortages + DCP Contribution s)
	2007 Interim Guidelines	2019 DCPs	Additional Shortage in 2025–2026	Action Alts 1 and 2 2025–2026
1,090 to >1,075	0	200	200	400
1,075 to 1050	333	200	533	1,066
<1,050 to >1,045	417	200	617	1,234
1,045 to >1,040	417	450	867	1,734
1,040 to >1,035	417	500	1,166	2,083
1,035 to >1,030	417	550	1,116	2,083
1,030 to 1,025	417	600	1,066	2,083
<1,025	500	600	983	2,083

The distribution of shortages among water users was computed outside CRMMS and is applied in two stages. When distributing shortage volumes by priority using the shortage allocation model method, total reductions include the reductions specified by the 2007 ROD and 2019 DCPs. In Stage 1, Nevada and Arizona users are shorted. Nevada is assigned 4 percent of the total reduction, which is Nevada's apportionment divided by the total Lower Division States' apportionment (that is, 300,000 af/7,500,000 af). The remainder of the total reduction is assigned to Arizona, which is 96 percent of the total reduction. Once Arizona Priority 4 entitlements are fully shorted (that is, water use is set to zero), Stage 2 is entered.

In Stage 2, all Lower Division States' uses are reduced proportionally to the remaining consumptive uses scheduled in CRMMS. Reductions taken by Nevada and Arizona in Stage 1 are subtracted from each state's annual scheduled consumptive use when determining state reductions.

$$Stage2Reduction_n = Stage2Reduction * \left(\frac{ScheduledUse_n - Stage1Reduction_n}{LDSTotalUse - Stage1Reduction}\right)$$

where n is an individual state.

Once the total state reductions are calculated for each Lower Basin shortage condition, total reductions are split into reduction types (that is, 2007 ROD shortage, Action Alternative 1 shortage, and 2019 DCP contributions). The 2019 DCP contributions can be larger than the specified additional shortage based on the modeled application of Action Alternative 1. In this case, the larger volume is applied, which causes larger total reductions than the volumes based on a given elevation range. A summary of the modeled shortage by state and priority for Action Alternative 1 is in **Attachment B-3**, **Table Attachment B-7**, **Table Attachment B-8**, and **Table Attachment B-9**. Tables are provided for 2025 and 2026 separately because CRMMS depletion schedules vary slightly each year, which results in slightly different distributions of shortages.

Within each state, reductions are distrusted by priority, where the lowest-priority users are shorted completely before shorting any higher-priority user. The assumed priorities of CRMMS users are summarized in **Attachment B-3**. Shortages that are assigned to a specific priority are distributed proportionally across users in a priority group based on CRMMS input annual water depletion schedules.

$$MonthlyShortage_i = AnnualShortage_P * \left(\frac{AnnualWaterUse_i}{AnnualWaterUse_P}\right) * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i}\right)$$

where P is a group of water users in the same priority within a state, and i is the specific water user within the priority group.

Minute 323 High- and Low-Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under Action Alternative 1 are identical to those under the No Action Alternative.

DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under Action Alternative 1 are identical to those under the No Action Alternative.

ICS

The ICS model assumptions for the Lower Basin under Action Alternative 1 are identical to those under the No Action Alternative.

System Conservation

In addition to shortage and DCP contributions based on Lake Mead operations, Lower Basin demands are assumed to be reduced for system conservation after agreements have been finalized. **Table Attachment B-3** shows the system conservation modeled for Action Alternative 1. The volumes in 2023 and 2024 match those under the No Action Alternative.

Table Attachment B-3
System Conservation under Action Alternative 1

Modeled SEIS Conservation	2023	2024	2025	2026	Total
California					
System Conservation					
Palo Verde Irrigation District	58,400	39,800	—	—	98,200
California Total	**58,400**	**39,800**	—	—	**98,200**
Arizona					
System Conservation					
Gila River Indian Community	91,950	125,000	—	—	216,950
Fort McDowell Yavapai Nation	13,933	13,933	—	—	27,866
Central Arizona Project Subcontractors	62,200	42,200	—	—	104,400
Mohave Valley Irrigation and Drainage District	12,819	—	—	—	12,819
Yuma Mesa Irrigation and Drainage District	13,670	—	—	—	13,670
Gabrych Farms	3,240	3,240	—	—	6,480
Arizona Total	**197,812**	**184,373**	—	—	**382,185**
Total Modeled System Conservation	**256,212**	**224,173**	—	—	**480,385**

B-1.2.2 Action Alternative 2

The Lake Mead operations and Lower Basin conditions under Action Alternative 2 are similar to those under the No Action Alternative (that is, shortage and DCP contribution volumes are based on Lake Mead elevations). For operating years 2023 and 2024, CRMMS solves for Lake Mead operations as described in the No Action Alternative; the physical pool elevation is used to calculate Lake Mead operations and the Lower Basin conditions. For operating years 2025 and 2026, CRMMS solves for the Lake Mead operations and Lower Basin conditions using the physical elevations at Lake Mead with additional shortages applied at different Lake Mead elevations.

Surplus

The surplus model assumptions for the Lower Basin under Action Alternative 2 are identical to those under the No Action Alternative.

Normal Condition

The normal condition model assumptions for the Lower Basin under Action Alternative 2 are identical to those under the No Action Alternative.

Shortage Condition

Under Action Alternative 2, the Lower Division States' total shortage volumes are the same as they are under Action Alternative 1 (**Table Attachment B-2**); however, the shortage distribution between states and water users is different. For Action Alternative 2, shortages in addition to the 2007 ROD shortages and 2019 DCP contributions are distributed in the same percentage across all Lower Basin water users based on the 2021 adjusted consumptive use for CRMMS water users. The total shortage distributed among the Lower Division States and water users follows the method used in the shortage allocation model for Action Alternative 2 (see **Appendix D**).

The distribution of shortages to individual water users is performed outside CRMMS. Specific shortage volumes for each water user and the shortage conditions are input into CRMMS. These shortages are computed by determining the percentage reduction for each water user based on the additional shortage's percentage of the total Lower Division States' consumptive use:

$$UserAdditionalShortage_i = \frac{TotalLDSShortage}{7{,}500{,}000} * UserDepletionScheduleUse_i$$

where i is each Lower Division State's water user modeled in CRMMS.

In applying shortages and DCP contributions under Action Alternative 2, first, the 2007 ROD shortages and 2019 DCP contributions are applied to the users identified in these CRMMS modeling assumptions. Then, the additional shortages are applied using the above equation. A rule applies the shortage to water users by spreading the annual shortage over all months proportionally to the users' monthly depletion schedules.

$$MonthlyShortage_i = AnnualShortage_i * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i}\right)$$

where i is an individual water user.

A summary of the modeled shortage by state for Action Alternative 2 is in **Attachment B-3**, **Table Attachment B-9**.

Minute 323 High- and Low-Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under Action Alternative 2 are identical to those under the No Action Alternative.

DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under Action Alternative 2 are identical to those under the No Action Alternative.

ICS

The ICS model assumptions for the Lower Basin under Action Alternative 2 are identical to those under the No Action Alternative.

System Conservation

The system conservation assumptions for the Lower Basin under Action Alternative 2 are identical to those under Action Alternative 1.

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Attachment B-2

CRMMS Lower Basin Water User Priorities

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Attachment B-2. CRMMS Lower Basin Water User Priorities

Table Attachment B-4 through **Table Attachment B-6** list the CRMMS users and the corresponding assumed priorities that are used for purposes of distributing shortages under Action Alternative 1. Water user depletion schedules are summarized in **Appendix D**, **Table Attachment D-2**. The water user names are provided exactly as they show up in CRMMS; abbreviations are not defined.

Table Attachment B-4
CRMMS Water Users by Priority for Arizona

Arizona		
Priority 1 (P1)	**Priority 2, 3 (P2,3)**	**Priority 4 (P4)**
AzPumpersBlwImp P1	CibolaNWR	AzPumpersAbvImp
BrookeWater P1	City of Yuma P3	AzPumpersBlwImp P4
City of Parker P1	DavisDamProject	AzPumpersDvsToPkr
City of Yuma P1	DesertLawnMemorial	BrookeWater P4
Cocopah Indian Res	Gila Monster Farms P2,3	BullheadCity
CRIRAz	HavasuNWR	CAP P4
Ft Yuma	ImperialNWR	CibolaValleyIID
FtMohaveAz	LMNRA Az Mead	City of Parker P4
Gila Monster Farms P1	LMNRA Az Mohave	Ehrenberg
MohaveValleyIID P1	MCAirStation	Gila Monster Farms P4
NGVIDD P1	NGVIDD P 2,3	GoldenShores
UnitB P1	SouthernPacific	LakeHavasuCity
YCWUA P1	UnitB P2,3	MohaveValleyIID P4
	UofA	MohaveWaterConsDist
	WMIDD	
	YAO	
	YCWUA P2,3	
	YID	
	YMIDD	
	YumaProvingGround	
	YumaUnionHighScl	
	CAP P3	

Table Attachment B-5
CRMMS Water Users by Priority for Nevada

Nevada		
Present Perfected Rights (PPRs)	**SNWP Non-PPRs**	**Non-PPRs, Non-SNWP**
FtMohaveNv	BasicManagement	BigBend
LMNRA Mead PPR	BoulderCanyonProject	LMNRA Mohave P2
LMNRA Mohave PPR	City of Henderson	SCE
	LMNRA Mead P2	
	LVWashReturns	
	NvDeptFishGame	
	PacificCoastBuilding	
	SNWADiversion	
	SNWP	

Table Attachment B-6
CRMMS Water Users by Priority for California

California					
Present Perfected Rights (PPRs)	**Priority 1 (P1)**	**Priority 2 (P2)**	**Priority 3 (P3)**	**Priority 4 (P4)**	**No Priority (Pnone)**
CaPumpersDvsToPkr - PPR	PaloVerde P1	YumaProject	Coachella	MWD	CaPumpersAbvImp
Chemehuevi			IID – P3		CaPumpersDvsToPkr-Pnone
CRIRCa					SaltonSea
FtMohaveCa					YumaIsland
FYIR_Ranches					
IID – PPR					
Needles					
PaloVerde PPR					
Winterhaven					
YumaProject					

Attachment B-3

CRMMS Action Alternatives’ Shortages and DCP Contributions

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Attachment B-3. CRMMS Action Alternatives' Shortages and DCP Contributions

Table Attachment B-7 through **Table Attachment B-9** include the assumed shortages and DCP contributions by state and priority (for Action Alternative 1) that were computed using the methods described in **Sections B.7.3.3** and **B.7.4.3**. These shortage volumes are imported to CRMMS to model Action Alternatives 1 and 2. Different tables are provided for 2025 and 2026 because CRMMS depletion schedules vary slightly between 2025 and 2026; this causes slightly different distributions of shortages.

Table Attachment B-7
2025 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in af)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages[1]								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090–1,075	0	0	192,000	8,000	0	192,000	0	8,000	0[2]	0[2]	0[2]	0[2]	0[2]	384,000	16,000	0	400,000
1,075–1050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0[2]	0[2]	0[2]	0[2]	0[2]	1,023,360	42,640	0	1,066,000
1,050–1,045	400,000	17,000	192,000	8,000	0	592,640	0	24,360	0[2]	0[2]	0[2]	0[2]	0[2]	1,184,640	49,360	0	1,234,000
1,045–1,040	400,000	17,000	240,000	10,000	200,000	880,311	32,011	42,389	0[2]	0[2]	0[2]	0[2]	0[2]	1,552,322	69,389	200,000	1,821,711
1,040–1,035	400,000	17,000	240,000	10,000	250,000	880,311	106,320	56,417	122,953	0	0	0	0	1,626,630	83,417	372,953	2,083,000
1,035–1,030	400,000	17,000	240,000	10,000	300,000	880,311	106,320	56,417	72,953	0	0	0	0	1,626,630	83,417	372,953	2,083,000
1,030–1,025	400,000	17,000	240,000	10,000	350,000	880,311	106,320	56,417	22,953	0	0	0	0	1,626,630	83,417	372,953	2,083,000
<1,025	480,000	20,000	240,000	10,000	350,000	800,311	106,320	53,417	22,953	0	0	0	0	1,626,630	83,417	372,953	2,083,000

Footnotes:
[1]AZ-P4 = Arizona Priority 4; AZ-P2,3 = Arizona Priority 2 and Priority 3; CA-P4 = California Priority 4; CA-Pnone = California users with no priority; CA-P3 = California Priority 3; CA-P2 = California Priority 2; CA-P1 = California Priority 1; CA-PPR = California Priority Perfected Right; CRMMS users are categorized by priority in **Table Attachments B-4**, **B-5**, and **B-6**.

[2]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

Disclaimer: These modeling inputs (for Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as Reclamation's position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled; the model methodology cannot replicate the precision required of that annual process.

Table Attachment B-8
2026 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in af)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages[2]								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090–1,075	0	0	192,000	8,000	0	192,000	0	8,000	0[1]	0[1]	0[1]	0[1]	0[1]	384,000	16,000	0	400,000
1,075–1050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0[1]	0[1]	0[1]	0[1]	0[1]	1,023,360	42,640	0	1,066,000
1,050–1,045	400,000	17,000	192,000	8,000	0	592,640	0	24,360	0[1]	0[1]	0[1]	0[1]	0[1]	1,184,640	49,360	0	1,234,000
1,045–1,040	400,000	17,000	240,000	10,000	200,000	880,311	32,519	42,360	0[1]	0[1]	0[1]	0[1]	0[1]	1,552,830	69,360	200,000	1,822,190
1,040–1,035	400,000	17,000	240,000	10,000	250,000	880,311	108,007	56,320	121,363	0	0[1]	0	0[1]	1,628,317	83,320	371,363	2,083,000
1,035–1,030	400,000	17,000	240,000	10,000	300,000	880,311	108,007	56,320	71,363	0	0	0	0	1,628,317	83,320	371,363	2,083,000
1,030–1,025	400,000	17,000	240,000	10,000	350,000	880,311	108,007	56,320	21,363	0	0	0	0	1,628,317	83,320	371,363	2,083,000
<1,025	480,000	20,000	240,000	10,000	350,000	800,311	108,007	53,320	21,363	0	0	0	0	1,628,317	83,320	371,363	2,083,000

Footnotes:
[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.
[2]AZ-P4 = Arizona Priority 4; AZ-P2,3 = Arizona Priority 2 and Priority 3; CA-P4 = California Priority 4; CA-Pnone = California users with no priority; CA-P3 = California Priority 3; CA-P2 = California Priority 2; CA-P1 = California Priority 1; CA-PPR = California Priority Perfected Right; CRMMS users are categorized by priority in **Table Attachments B-4**, **B-5**, and **B-6**.

Disclaimer: These modeling inputs (for Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as Reclamation's position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled; the modeled methodology cannot replicate the precision required of that annual process.

Table Attachment B-9
2025–2026 Action Alternative 2 CRMMS Shortage Volume Table (values in af)

Lake Mead Pool Elevation (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages			Total Shortages			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ	NV	CA	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0
1,090–1,075	0	0	192,000	8,000	0	74,666	8,001	117,333	266,666	16,001	117,333	400,000
1,075–1050	320,000	13,000	192,000	8,000	0	198,986	21,321	312,693	710,986	42,321	312,693	1,066,000
1,050–1,045	400,000	17,000	192,000	8,000	0	230,349	24,680	361,971	822,349	49,680	361,971	1,234,000
1,045–1,040	400,000	17,000	240,000	10,000	200,000	323,677	34,681	508,642	963,677	61,681	708,642	1,734,000
1,040–1,035	400,000	17,000	240,000	10,000	250,000	435,307	46,640	684,053	1,075,307	73,640	934,053	2,083,000
1,035–1,030	400,000	17,000	240,000	10,000	300,000	416,640	44,639	654,721	1,056,640	71,639	954,721	2,083,000
1,030–1,025	400,000	17,000	240,000	10,000	350,000	397,974	42,640	625,386	1,037,974	69,640	975,386	2,083,000
<1,025	480,000	20,000	240,000	10,000	350,000	366,988	39,319	576,693	1,086,988	69,319	926,693	2,083,000

Disclaimer: These modeling inputs (for Action Alternative 2) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as Reclamation's position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled; the modeled methodology cannot replicate the precision required of that annual process.

Appendix C

Original Draft SEIS Action Alternatives 1 and 2

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Appendix C. Original Draft SEIS Action Alternatives 1 and 2

C.1 Introduction

This appendix describes Action Alternatives 1 and 2 from the original Draft SEIS, which was withdrawn after submittal of the Lower Division Proposal.

C.2 Action Alternative 1

This alternative describes a set of actions adopted pursuant to Secretarial authority under applicable federal law. Unlike current operations that were developed, and are being implemented, pursuant to basin-wide consensus (for example, the 2007 Interim Guidelines and the 2019 DCPs), Action Alternative 1 models changes to operations for both Glen Canyon Dam and Hoover Dam as developed by Reclamation. Action Alternative 1 includes assumptions for reduced releases from Glen Canyon Dam and additional Lower Basin shortages based on the concept of priority.[1] Action Alternative 1 models releases between 6.0 maf and 8.23 maf from Lake Powell when it is below 3,575 feet, with potentially lower releases to preserve the elevation of 3,500 feet.[2]

Action Alternative 1 models progressively larger additional shortages as Lake Mead's elevation declines. It also models larger additional shortages in 2025–2026 as compared with 2024. The total shortages and DCP contributions in 2024, as modeled, are limited to 2.083 maf. This is because this is the maximum volume analyzed in the 2007 FEIS, and to analyze shortages greater than 2.083 maf would require additional detailed analysis and stakeholder coordination. Working within this range of previously analyzed impacts will facilitate completing this SEIS process in the time available in advance of the 2024 operating year. Delaying operational decisions to perform additional analyses would not meet the express purpose of and need for this action.

For all operations, including, but not limited to when Lake Powell is approaching 3,500 feet or when Lake Mead is approaching 950 feet, the Secretary reserves the right to operate Reclamation facilities to address extraordinary circumstances, as described in Section 7(D) of the 2007 Interim Guidelines, including "operations that are prudent or necessary for safety of dams, public health and safety,

[1] Priority refers the distribution of Colorado River water in the Lower Division States of Arizona, California, and Nevada as subject to laws, judicial rulings and decrees, contracts, interstate compacts, and operating criteria, known as the "Law of the River," which apportion available water between the states and establish certain priorities in use.
[2] The action alternatives would protect an elevation of 3,500 feet in Lake Powell to provide a buffer above minimum power pool, which is at 3,490 feet.

other emergency situations, or other unanticipated or unforeseen activities arising from actual operating experience."

C.2.1 Shortage Guidelines

Table C-1 shows the Lower Basin shortages under the 2007 Interim Guidelines, contributions under the 2019 DCPs, and additional shortages modeled under Action Alternative 1 in calendar year 2024. Assumptions regarding the breakdown of shortages and contributions by state, according to priority, are shown in **Table C-2**. Reclamation may consider additional shortages in Shortage Condition Year 2025 and 2026 (see **Table C-3**). This consideration would occur as part of the future analysis referenced in **Section 1.2** before the 2025 operating year operating condition determination.

Figure C-1 shows a graphical view of Lower Basin shortages and contributions from the 2007 Interim Guidelines and the 2019 DCPs plus additional shortages modeled under Action Alternative 1.

Whenever Lake Mead's content is projected to be below an elevation of 1,000 feet, based on the January 1 projection or a mid-year review, additional reductions may be needed to protect the minimum power pool (elevation 950 feet) and to reduce the risk of declining to dead pool (elevation 895 feet).

Table C-1
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2 (2024)*

Lake Mead Elevation (feet)	No Action Alternative			Additional Shortages under Action Alternatives 1 and 2 (2024)	
	2007 ROD Shortages (1,000 af)	2019 DCP Contributions (1,000 af)	No Action Total (1,000 af)	2024 Additional Shortages (1,000 af)	2024 Total Shortages + Contributions (1,000 af)
1,090 – >1,075	0	200	200	200	**400**
1,075 – 1,050	333	200	533	533	**1,066**
<1,050 – >1,045	417	200	617	617	**1,234**
1,045 – >1,040	417	450	867	867	**1,734**
1,040 – >1,035	417	500	917	1,166	**2,083**
1,035 – >1,030	417	550	967	1,116	**2,083**
1,030 – 1,025	417	600	1,017	1,066	**2,083**
<1,025 – 1,000	500	600	1,100	983	**2,083**
<1,000 – 975	500	600	1,100	983	**2,083**
<975 – 950	500	600	1,100	983	**2,083**
<950	500	600	1,100	983	**2,083**

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the Binational Water Scarcity Contingency Plan, in accordance with Minute 323 to the 1944 Water Treaty.

Table C-2
Lower Division States' Shortages and DCP Contributions by State, Action Alternative 1 (2024)

Lake Mead Elevation (feet)	2007 ROD Shortage + 2019 DCP Contributions (1,000 af)				2024 Action Alternative 1 Additional Shortage* (1,000 af)				2024 Total Shortages + Contributions (1,000 af)			
	AZ	NV	CA	Total	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	192	8	0	200	192	8	0	200	384	16	0	400
1,075 – 1,050	512	21	0	533	511	22	0	533	1,023	43	0	1,066
<1,050 – >1,045	592	25	0	617	593	24	0	617	1,185	49	0	1,234
1,045 – >1,040	640	27	200	867	1,025	42	0**	1,067	1,665	69	200	1,734***
1,040 – >1,035	640	27	250	917	1,098	56	12	1,166	1,738	83	262	2,083
1,035 – >1,030	640	27	300	967	1,098	56	0**	1,154	1,738	83	300	2,083***
1,030 – 1,025	640	27	350	1,017	1,098	56	0**	1,154	1,738	83	350	2,083***
<1,025 – 1,000	720	30	350	1,100	1,018	53	0**	1,071	1,738	83	350	2,083***
<1,000 – 975	720	30	350	1,100	1,018	53	0**	1,071	1,738	83	350	2,083***
<975 – 950	720	30	350	1,100	1,018	53	0**	1,071	1,738	83	350	2,083***
<950	720	30	350	1,100	1,018	53	0**	1,071	1,738	83	350	2,083***

*The additional shortage volumes decrease at elevation 1,025 feet because the shortages under the 2007 Interim Guidelines increase by the same amount. Therefore, the additional shortage amounts necessary to get to the 2.083 maf total are lower.
**In this elevation tier, the 2019 DCP contributions for California exceed what would be required under Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.
***Because the 2019 DCP contributions for California exceed the 2024 total shortage and contribution volume as modeled by the Action Alternative 1 Shortage Allocation Model, the sum of the three state totals exceeds the total shortage and contribution volume. While the total amount of the three states' total shortage and contribution volume exceeds 2.083 maf in the elevation tiers below elevation 1,035 feet, the ROD would not exceed a total shortage and contribution volume of 2.083 maf in calendar year 2024.

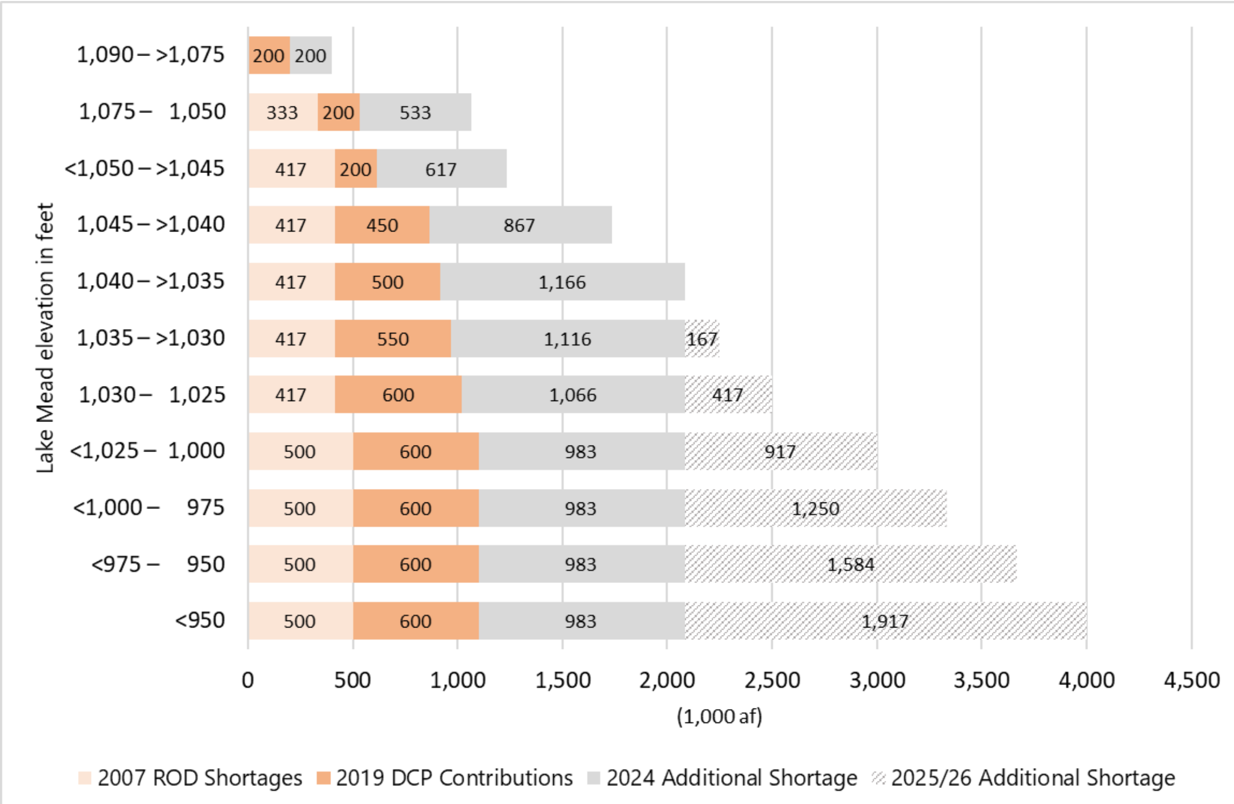
Table C-3
Lower Division States' Shortages and DCP Contributions, Action Alternatives 1 and 2 (2025–2026)*

Lake Mead Elevation (feet)	No Action Alternative			Additional Shortages under Action Alternatives 1 and 2 (2025–2026)	
	2007 ROD Shortage (1,000 af)	2019 DCP Contributions (1,000 af)	No Action Total (1,000 af)	2025–2026 Additional Shortage** (1,000 af)	2025–2026 Total Shortages + Contributions (1,000 af)
1,090 – >1,075	0	200	200	200	**400**
1,075 – 1,050	333	200	533	533	**1,066**
<1,050 – >1,045	417	200	617	617	**1,234**
1,045 – >1,040	417	450	867	867	**1,734**
1,040 – >1,035	417	500	917	1,166	**2,083**
1,035 – >1,030	417	550	967	1,283	**2,250**
1,030 – 1,025	417	600	1,017	1,483	**2,500**
<1,025 – 1,000	500	600	1,100	1,900	**3,000**
<1,000 – 975	500	600	1,100	2,233	**3,333**
<975 – 950	500	600	1,100	2,567	**3,667**
<950	500	600	1,100	2,900	**4,000**

* This table only shows combined Lower Division State shortage volumes and DCP contributions. In addition to the volumes shown in this table, the analysis for each alternative includes water delivery reductions to Mexico under low-elevation reservoir conditions and Mexico's savings that contribute to the Binational Water Scarcity Contingency Plan, in accordance with Minute 323 to the 1944 Water Treaty.

The scope of this NEPA analysis, including potential actions in 2025–2026, is discussed further in **Sections 1.2 and **1.5**.

Figure C-1
Modeled Lower Basin Shortages and DCP Contributions, Action Alternatives 1 and 2



C.2.2 Coordinated Reservoir Operations

Under Action Alternative 1, the annual Lake Powell release is based on the volume of water in storage or the corresponding elevation of Lake Powell and Lake Mead, as described in the operational tiers below (see **Table C-4**). The Equalization and Upper Elevation Balancing Tiers are the same as under the No Action Alternative. The Mid-Elevation Release Tier and Lower Elevation Balancing Tier are combined into a single Lower Elevation Release Tier, and a Protection Level is also included. The applicable operational tier is based on the August 24-Month Study projections of the January 1 system storage and reservoir water surface elevations for the following operating year.

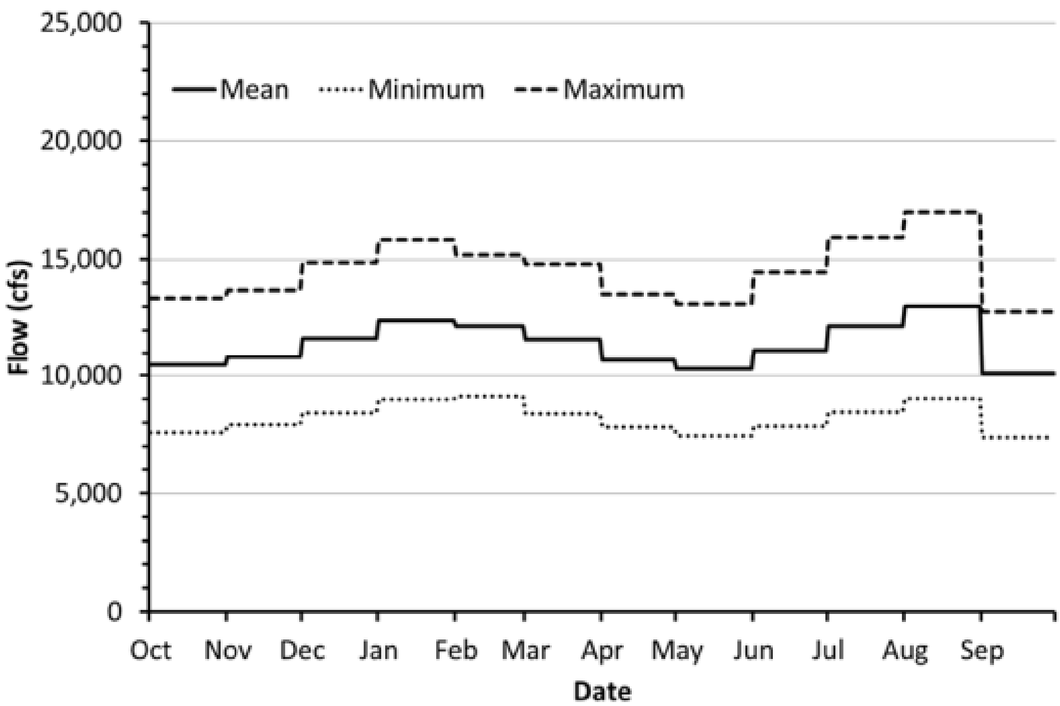
Hourly, daily, and monthly releases from Lake Powell for coordinated operations would be consistent with the parameters of the ROD for the LTEMP EIS (Reclamation and NPS 2016). Monthly releases from Glen Canyon Dam would be distributed proportionally across months for annual releases below 7.0 maf (see **Figure C-2** for monthly distributions in a year when the annual release is 8.23 maf). If annual flows were adjusted mid-year, they would be distributed to meet the goals of the LTEMP, including potential distribution across monthly or experimental flow patterns, and including the unique resource considerations specific to any mid-year annual adjustments.

Table C-4
Lake Powell Operational Tiers, Action Alternatives 1 and 2

Lake Powell Operational Tiers (subject to April adjustments or mid-year review modifications)		
Lake Powell Elevation (feet)	**Lake Powell Operational Tier**	**Lake Powell Active Storage*** (maf)
3,700		**23.31**
	Equalization Tier Equalize, avoid spills, or release 8.23 maf	
3,636–3,666 (see Table 2.3-1 in the 2007 FEIS)		**14.65–18.36** (2008–2026)
	Upper Elevation Balancing Tier Release 8.23 maf; if Lake Mead <1,075 feet, balance contents with a minimum/maximum release of 7.0/9.0 maf	
3,575		**8.90**
	Lower Elevation Release Tier Set initial release: 6.0 maf; adjust releases based on the April Lake Powell end-of-water-year elevation projection: ≥3,575 feet, release 8.23 maf <3,575 feet AND ≥3,550 feet, release 7.48 maf <3,550 feet AND ≥3,525 feet, release 7.0 maf <3,525 feet AND ≥3,500 feet, maintain release of 6.0 maf <3,500 feet, then reduce releases (gains equals losses) such that Lake Powell ends the operating year at 3,500 feet	
3,500		**4.22**
	Protection Level <3,500 feet, in any month, reduce releases (gains equals losses) such that Lake Powell ends the operating year at 3,500 feet	
3,370		**0**

*Active storage values have been updated from 2007 based on the 2018 bathymetry.

Figure C-2
Mean, Minimum, and Maximum Monthly Flows under LTEMP in an 8.23-maf Year



Hourly and daily releases would follow LTEMP parameters, so long as sufficient water is available from the annual release. If sufficient water is not available from the annual release to meet hourly and daily LTEMP release parameters, hourly and daily releases would follow the base operation daily and nightly minimum flows (8,000 cubic feet per second [cfs] and 5,000 cfs, respectively), for as long as possible. If sufficient water is not available from the annual release to support the base operation nightly minimum flow of 5,000 cfs, hourly and daily releases would be consistent with the run of the river[3] to match Lake Powell inflows consistent with protecting an elevation of 3,500 feet at Lake Powell.

Lower Elevation Release Tier

When the projected January 1 Lake Powell elevation is below 3,575 feet, an initial annual release in the amount of 6.0 maf would be set from Lake Powell. Adjustments to the annual release may then be made based on the April 24-Month Study, as outlined below.

- If the April 24-Month Study projects the end-of-water-year elevation to be at or above 3,575 feet, an adjustment would be made to release 8.23 maf from Lake Powell.

[3] In a general sense, "run of the river" means the inflow equals the outflow, adjusted for operational considerations, such as evaporation, seepage, and release capacity.

- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,575 feet and at or above 3,550 feet, an adjustment would be made to release 7.48 maf from Lake Powell.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,550 feet and at or above 3,525 feet, an adjustment would be made to release 7.0 maf from Lake Powell.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,525 feet and at or above 3,500 feet, the release of 6.0 maf from Lake Powell would be maintained.
- If the April 24-Month Study projects the end-of-water-year elevation to be below 3,500 feet, the dam would be operated to maintain an elevation of at least 3,500 feet. Additionally, up to 6.0 maf would be released over the year with a goal of maintaining LTEMP minimum flows subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

Protection Level

If, in any month, Lake Powell's elevation is below 3,500 feet, the Lake Powell release would be set to maintain or increase the elevation with a maximum release of 6.0 maf; the goal would be to maintain LTEMP minimum flows subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

C.2.3 Implementation of Guidelines

The provisions for a mid-year review are the same as those under the No Action Alternative except revisions to shortages associated with Lake Mead elevation determinations in the mid-year review can be revised to allow for either further reduced deliveries or additional deliveries.

C.3 Action Alternative 2

This alternative describes a set of actions adopted pursuant to Secretarial authority under applicable federal law. Unlike current operations that were developed, and are being implemented, pursuant to basin-wide consensus (for example, the 2007 Interim Guidelines and the 2019 DCPs), Action Alternative 2 models changes to operations for both Glen Canyon Dam and Hoover Dam as developed by Reclamation. Action Alternative 2 models releases between 6.0 maf and 8.23 maf from Lake Powell when it is below 3,575 feet, with potentially lower releases to preserve an elevation of 3,500 feet and assumes additional inflow to Lake Powell pursuant to the 2019 DCPs.

Action Alternative 2 includes assumptions for reduced releases from Glen Canyon Dam and additional Lower Basin shortages that are not based exclusively on the concept of priority. While both the 2007 Interim Guidelines and the 2019 DCPs encompass reductions that reflect the priority system, the additional reductions identified in Action Alternative 2 for the remainder of the interim period would be distributed in the same percentage across all Lower Basin water users.[4] [5] Total additional shortage volumes for the Lower Basin are the same under Action Alternative 2 as under Action Alternative 1.

As under Action Alternative 1, Action Alternative 2 models progressively larger Lower Basin reductions as Lake Mead's elevation declines and models larger Lower Basin reductions in 2025–2026 as compared with 2024. The total shortages and DCP contributions in 2024, as modeled, are limited to 2.083 maf; this is because this is the maximum volume analyzed in the 2007 FEIS. Working within this range of previously analyzed impacts will facilitate completing this SEIS process in the time available in advance of the 2024 operating year. Delaying operational decisions to perform additional analyses would not meet the express purpose of and need for this action.

This alternative includes actions and modeling assumptions that have precedent in actions previously undertaken by Reclamation under applicable federal law in both the Upper Basin (2021–2022) and Lower Basin (see the 1964 Determination by Secretary Udall to impose equivalent percentile reductions in light of reduced flows from Glen Canyon Dam). The goal is to operate Colorado River system reservoirs in a manner that ensures continued operations in a prudent manner throughout a range of projected future hydrologic conditions.

For all operations, including, but not limited to when Lake Powell is approaching 3,500 feet or when Lake Mead is approaching 950 feet, the Secretary reserves the right to operate Reclamation facilities to address extraordinary circumstances, as described in Section 7(D) of the 2007 Interim Guidelines, including "operations that are prudent or necessary for safety of dams, public health and safety, other emergency situations, or other unanticipated or unforeseen activities arising from actual operating experience."

C.3.1 Shortage Guidelines

As stated above, total additional shortage volumes for the Lower Basin are the same under Action Alternative 2 as under Action Alternative 1. The additional shortage volumes identified in **Table C-1** and **Table C-3** for calendar years 2024 and 2025–2026, respectively, would be achieved by a reduction of available Lower Basin annual consumptive use, distributed in the same percentage across all Lower Basin water users at the specified Lake Mead elevations. The distribution of reductions as modeled in Action Alternative 2 is based on each user's consumptively used water in 2021, as reported in Reclamation's final Colorado River Accounting and Water Use Report: Arizona, California, and Nevada prepared pursuant to Article V of the Supreme Court's Decree in *Arizona v. California* (as adjusted for conservation).

[4] Entities holding an entitlement to Mainstream water under (a) the Consolidated Decree, (b) a water delivery contract with the United States through the Secretary, or (c) a reservation of water by the Secretary.

[5] For example, if the additional shortage amount is 1 maf, the percentage of additional shortage volume is calculated by dividing 1 maf by 7.5 maf, which equals 13 percent. Then, a 13 percent additional reduction is modeled for each Lower Basin water user based on current water use.

Table C-5 displays the percentage of the additional shortage volumes at specified Lake Mead elevations and the distribution for each Lower Division State as modeled in Action Alternative 2. Reclamation may consider additional shortages in Shortage Condition Years 2025 and 2026 (see **Table C-3**). This consideration would occur as part of the future analysis referenced in **Section 1.2** before the 2025 operating year operating condition determination.

Figure C-1 shows a graphical view of Lower Basin shortages and contributions from the 2007 Interim Guidelines and 2019 DCPs plus additional shortages modeled under Action Alternative 2.

Like Action Alternative 1, whenever Lake Mead's content is projected to be below an elevation of 1,000 feet, based on the January 1 projection or a mid-year review, additional reductions may be needed to protect the minimum power pool (elevation 950 feet) and to reduce the risk of declining to dead pool (elevation 895 feet).

Table C-5
2024 Lower Division States' Shortages and DCP Contributions by State, Action Alternative 2 (2024)

Lake Mead Elevation (feet)	2007 ROD Shortages + 2019 DCP Contributions (1,000 af)				2024 Additional Shortage* (1,000 af)					2024 Total Shortage + Contributions (1,000 af)			
	AZ	NV	CA	Total	Percentage Additional Reduction**	AZ	NV	CA	Total	AZ	NV	CA	Total
1,090 – >1,075	192	8	0	200	2.67%	75	8	117	200	267	16	117	400
1,075 – 1,050	512	21	0	533	7.11%	199	21	313	533	711	42	313	1,066
<1,050 – >1,045	592	25	0	617	8.23%	230	25	362	617	822	50	362	1,234
1,045 – >1,040	640	27	200	867	11.56%	324	35	509	867	964	62	709	1,734
1,040 – >1,035	640	27	250	917	15.55%	435	47	684	1,166	1,075	74	934	2,083
1,035 – >1,030	640	27	300	967	14.88%	417	45	655	1,116	1,057	72	955	2,083
1,030 – 1,025	640	27	350	1,017	14.21%	398	43	625	1,066	1,038	70	975	2,083
<1,025 – 1,000	720	30	350	1,100	13.11%	367	39	577	983	1,087	69	927	2,083
<1,000 – 975	720	30	350	1,100	13.11%	367	39	577	983	1,087	69	927	2,083
<975 – 950	720	30	350	1,100	13.11%	367	39	577	983	1,087	69	927	2,083
<950	720	30	350	1,100	13.11%	367	39	577	983	1,087	69	927	2,083

*The additional shortage volumes decrease at elevation 1,025 feet because the shortages under the 2007 Interim Guidelines increase by the same amount. Therefore, the additional shortage amounts necessary to get to the 2.083 maf total are lower.
**Percentage of 2021 consumptive use

C.3.2 Coordinated Reservoir Operations

The modifications to annual Lake Powell releases and operational tiers are the same as those under Action Alternative 1.

C.3.3 Implementation of Guidelines

The provisions for a mid-year review are the same as those under Action Alternative 1.

Appendix D

CRMMS Model Documentation

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Appendix D. CRMMS Model Documentation

D.1 Introduction

Reclamation's CRMMS for the Basin is a Basin-wide operations model used to evaluate future system conditions for out to 5 years into the future. Specifically, the September 2022 CRMMS version is used for hydrologic modeling for this SEIS. This appendix provides a detailed overview of the model and its components, as well as the reservoir operations simulated in the model.

Reclamation uses two primary Basin-wide modeling and decision support tools: CRMMS and the Colorado River Simulation System (CRSS). CRMMS is run in two modes, the 24-Month Study Mode and the Ensemble Mode. The CRMMS 24-Month Study Mode is used to produce the 24-Month Study and the Annual Operating Plan. The 24-Month Study is an operational model with a 2-year outlook that uses a single most probable inflow forecast (updated monthly) provided by the National Weather Service's Colorado Basin River Forecast Center (CBRFC). The 24-Month Study is limited in its ability to incorporate hydrologic uncertainty because future reservoir operations must be input manually. Additionally, CRMMS can be run in Ensemble Mode to produce 1- to 5-year probabilistic projections of Basin conditions. CRMMS uses the CBRFC's Ensemble Streamflow Prediction (ESP) forecast (updated monthly) to provide more information about the risk and uncertainty for operations.

CRSS, which is used in long-term planning studies (for example, the 2007 FEIS) and the Colorado River Basin Water Supply and Demand Study), is a planning model that simulates Basin conditions decades into the future. Although CRSS accounts for hydrologic uncertainty in its ability to simulate hundreds of future hydrologic scenarios, it is limited in its ability to incorporate real-time forecasts and operations.

The CRMMS Ensemble Mode (referred to as CRMMS for the remainder of the appendix) provides probabilistic information about the uncertainty associated with Basin reservoir operations and future states of the system in the 1- to 5-year time frame. By supplementing the most probable projection of Basin conditions developed in the 24-Month Study, CRMMS provides a wider range of information for planning, risk analysis, and operational decision-making in the short- to mid-term planning horizons.

D.2 Overview

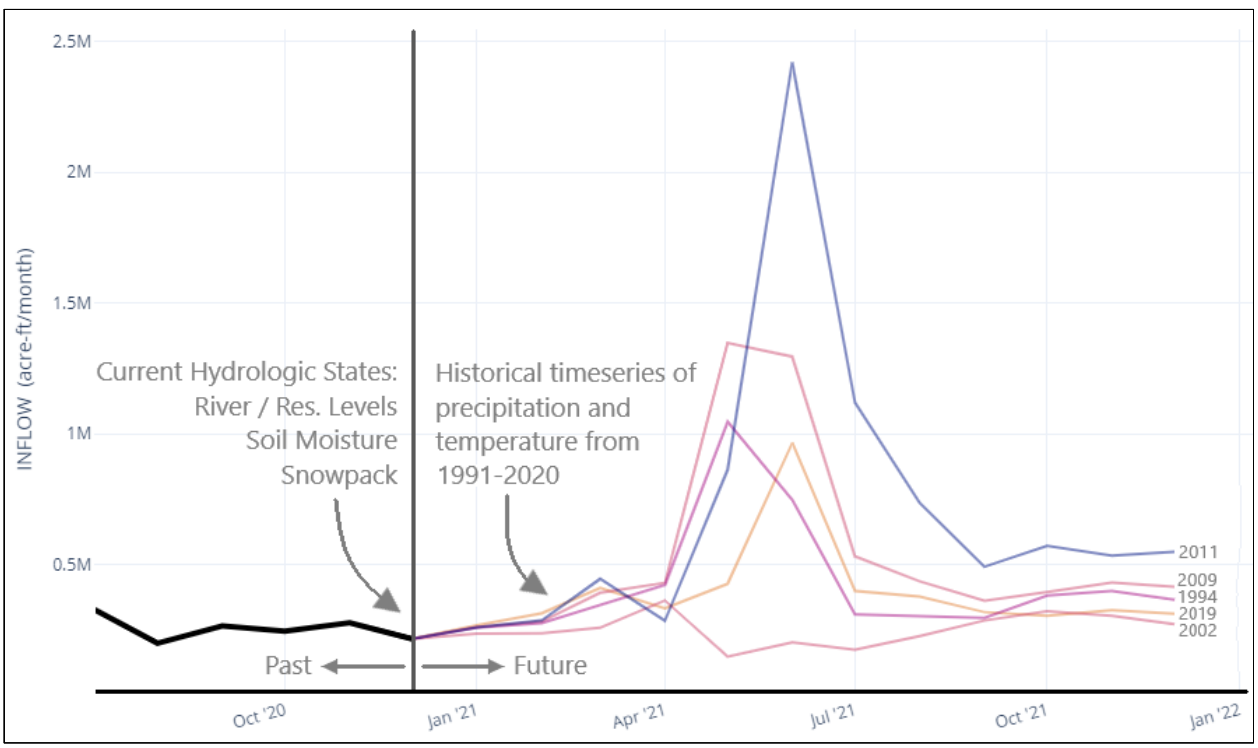
CRMMS is implemented in the commercial river modeling software called RiverWare™ developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder. Reclamation's Upper and Lower Basin Regions update and maintain the models continually, including review of model outputs.

The Basin-wide model simulates the operation of the major reservoirs on the Colorado River system and provides information regarding the projected future state of the system on a monthly basis. Output variables include the volume of water in storage, reservoir elevations, releases from the dams, energy generation, streamflow, and diversions to and return flows from water users throughout the system. Input data include physical parameters (such as individual reservoir storage capacity, evaporation rates, and reservoir release capabilities), initial reservoir conditions, and the depletion schedules for entities in the Lower Division States and for the United Mexican States (Mexico).

Upper Basin depletion schedules are not explicitly modeled in CRMMS; this is because the unregulated streamflow forecasts provided by the CBRFC include the impact of most Upper Basin depletions, except for three diversions: Gunnison Tunnel, Azotea Tunnel, and the Navajo Indian Irrigation Project (NIIP), which are individually input. These simulations use a mass balance (or water budget) calculation, which accounts for all water entering, stored in, and leaving the system. CRMMS contains a modeling "rule set," which simulates how water is released and delivered under various hydrologic conditions with the aim of simulating actual operations.

CRMMS provides information about risk and uncertainty for operations within a 1- to 5-year planning horizon. CRMMS uses an ensemble of unregulated streamflow forecasts developed by the CBRFC using ESP forecasts. **Figure D-1** depicts an example of ESP forecasts of future potential hydrologic inflows.

Figure D-1
Process for Developing ESP Forecasts



Source: Reclamation 2022e

D.2.1 Model Simulations

CRMMS simulates the operations of nine reservoirs in the Upper Basin, three reservoirs in the Lower Basin, river flows, energy generation, and diversions throughout the Basin. A description of each reservoir, the drivers of operation, and how reservoir operations are modeled in CRMMS are discussed in **Sections D.5** through **D.8**.

In understanding how CRMMS simulates operations, it is helpful to first understand the modeling process used to produce the 24-Month Study, which CRMMS attempts to replicate. To produce the 24-Month Study, Reclamation modelers first manually set releases for the reservoirs at the Upper Basin headwaters (**Table D-1**). Once operations are set for reservoirs farthest upstream, operations for the next downstream reservoirs can be entered. Information about upstream reservoir operations is required before operations can be set for the downstream reservoirs; this is because a full year of projected regulated inflow is needed to plan the reservoir releases at those downstream reservoirs. Additionally, operations for Lake Powell and Lake Mead are frequently set in an iterative manner, as Lake Powell and Lake Mead operations are coordinated based on their respective releases and resulting elevations and storages.

To simulate operations in CRMMS in a manner similar to the manual process used in producing the 24-Month Study, CRMMS takes advantage of a RiverWare feature called "run cycles." By using run cycles, RiverWare has the capability of cycling through the simulation (from the first time step to the last time step) multiple times during the run. With the aid of rule logic, CRMMS uses four run cycles to solve or "operate" the reservoirs from the Upper Basin headwaters downstream through the Lower Basin. **Table D-1** shows which reservoirs and outflows are solved within each run cycle. To initiate the model run for each year of the model run duration, Lower Basin depletion schedules are set with a default assumption of "normal condition" so that the entire Basin will solve when the rule logic solves for Lake Powell. Lower Basin Shortage and Surplus are assessed and applied in later run cycles; this is similar to the iterative process completed manually in the production of the 24-Month Study.

Table D-1
How Run Cycles Solve Reservoir Operations in CRMMS

Run Cycle	Operations Solved
1	Upper Basin headwater reservoirs: Taylor Park, Vallecito, and Fontenelle; Initial Lower Basin diversions and Lake Mead outflow
2	Additional Upper Basin reservoirs: Flaming Gorge, the Aspinall Unit, and Navajo
3	Lake Powell, Lake Mead, and the remainder of the Lower Basin (initial Lake Mead outflow was solved in run cycle 1; the flood control, surplus, shortage, and hydrologic demand variability are first solved in run cycle 3)
4	Lake Powell, Lake Mead, and the remainder of the Lower Basin may resolve again (Lake Powell releases are fine tuned to achieve balancing when appropriate, and Lower Basin operations are adjusted, if necessary, after Lake Powell releases have been modified)

An additional feature of CRMMS is that the model run duration period changes depending on the model run's initial time step. The model run duration ranges from 60 to 68 months in an ensemble run. Extending the length of the model run is required in the months of February through September to complete Lake Powell operations for the entire operating year (October through September) in the last year of the model run. Each model run's duration is specified in **Table D-2**. The modeling analysis for the SEIS uses the September 2022 version of CRMMS, but it limits the analysis period to September 2022–December 2026.

Table D-2
Model Run Duration for Ensemble Model Runs

Initial Time Step (Month)	Ensemble Run Duration (Months)
January	60
February	68
March	67
April	66
May	65
June	64
July	63
August	62
September	61
October	60
November	60
December	60

D.2.2 Model Uncertainty

CRMMS projections are subject to multiple sources of uncertainty. One source is the model, which is a simplified representation of a complex system. Another component of uncertainty is the need to estimate physical processes, such as reservoir evaporation and transpiration from plants. The most impactful source of uncertainty is the future itself; models rely on assumptions about how the hydrology, water demand, and policy and operations will unfold. Reclamation works with stakeholders and scientists to develop the best modeling practices and most appropriate assumptions in light of the purpose of the model. It is important to understand the purpose, approach, and assumptions associated with projections and their inherent uncertainty to properly interpret the information they provide.

Projections are most sensitive to assumptions about future hydrology, and future flows are highly uncertain. Assumptions about future hydrology can produce very different pictures of risk. Using ESP, CRMMS generates a wide range of hydrologic possibilities based on an assumption that the future precipitation and temperature will be similar to those experienced during the recent 30 years (1991–2020); this allows an evaluation of the Proposed Action under a wide range of future flows.

Projections farther in the future have more uncertainty. This is apparent when comparing the different ranges of possible conditions in the next 1 to 5 years. As time horizons extend and uncertainty increases, projections of statistics-based measures, such as risks of certain system conditions, become less reliable as representations of the true probabilities that specific events may occur. All statistics calculated reflect the hydrologic scenarios and other assumptions used in modeling for this SEIS; the statistics are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance.

D.3 Hydrology

To simulate reservoir operations for up to 5 years, a hydrologic forecast of 60–68 months at 12 Upper Basin forecast points and 7 Lower Basin forecast points must be input into the model. The Upper Basin hydrology inputs are unregulated inflow forecasts for each forecast point. Unregulated flow is the forecasted flow that would arrive at a specific point if there were no dams upstream of that point. The total unregulated inflow for each forecast point includes the entire flow from the Basin upstream from that point. In other words, each downstream forecast point reflects the sum of the unregulated inflows from all forecast points above it in the Upper Basin.

Reclamation develops the Lower Basin hydrology inputs and generates them using 30 years of calculated historical intervening flows. The 30-year period of historical flows matches the CBRFC's 30-year calibration period (currently 1991 through 2020) to provide consistency in the periods of record used to produce flow assumptions for the Upper and Lower Basin portions of the model. Historical, intervening flows in the Lower Basin are calculated based on a mass balance approach, as discussed in **Section D.3.2**. Intervening flows for this purpose are defined as the amount of flow entering the system between the upstream point and the downstream point.

D.3.1 Upper Basin Hydrology

The CBRFC provides ESP forecasts at 12 Upper Basin forecast points (**Table D-3**). The ESP method generates multiple time series (that is, traces) of forecasted streamflows. Forecasts are created using the Sacramento Soil Moisture Accounting hydrologic model, which is initialized with current Basin conditions for soil moisture and snowpack and forced with a set of historical time series of precipitation and temperature that match the model calibration period (currently 1991 through 2020). This process results in a 30-member ensemble for monthly streamflow forecasts based on current Basin conditions and temperature and precipitation that match the 1991–2020 climatological period.

Table D-3
Upper Basin Forecast Points

Fontenelle Inflow
Flaming Gorge Unregulated Inflow
Yampa River Inflow
Taylor Park Inflow
Blue Mesa Unregulated Inflow
Crystal Unregulated Inflow
Morrow Point Unregulated Inflow
Gains Crystal to Grand Junction
Vallecito Unregulated Inflow
Animas River Inflow
Navajo Unregulated Inflow
Powell Unregulated Inflow

D.3.2 Lower Basin Hydrology

For modeling purposes in CRMMS, the Lower Basin is the portion of the model below the Lees Ferry gage. Although the intervening flows between Glen Canyon Dam and the Lees Ferry gage are physically located in the Upper Basin above the Lee Ferry Compact Point, the methodology used to project these flows matches the methodology used to project the Lower Basin inflows; therefore, flows at the Lees Ferry gage are included in this section. The hydrologic inputs for the Lower Basin are intervening flows (**Table D-4**), which may be positive, representing a gain in the reach, or negative, representing a loss in the reach.

Table D-4
Lower Basin Intervening Flow Points

Glen Canyon Dam to Lees Ferry
Lees Ferry to the USGS gage at Grand Canyon
USGS gage at Grand Canyon to Hoover Dam
Hoover Dam to Davis Dam
Davis Dam to Parker Dam
Parker Dam to Imperial Dam
Imperial Dam to Northerly International Boundary with Mexico

The intervening inflows are the estimated volumes calculated by Reclamation's Lower Colorado Gain-Loss Model. This method calculates the intervening inflows using a mass balance approach. CRMMS uses the calculated intervening inflow values from the same 30-year period for which the CBRFC produces forecast traces (1991 through 2020).

Just as the model rotates through Upper Basin inflow traces corresponding to a particular year in the 30-year calibration period, the model also rotates through intervening flows in the Lower Basin corresponding to the same year. For example, the Upper Basin inflow forecast corresponding to the

1991 trace is generated from the temperature and precipitation from 1991 through 1995. In this 1991 trace, the intervening inflows for all seven reaches below Glen Canyon Dam are the historical, calculated, intervening inflows from 1991 through 1995.

D.3.3 Hydrology Used in CRMMS SEIS Modeling

The hydrologic scenarios used in the SEIS are derived from the June 2023 ESP Upper Basin forecast and associated Lower Basin intervening flows. Three sets of ESPs are used in the SEIS modeling:

- 100 percent ESP: There is no adjustment to the streamflow forecasts.
- 90 percent ESP: Streamflow forecasts are reduced by 10 percent.
- 80 percent ESP: Streamflow forecasts are reduced by 20 percent.

ESP forecasts are adjusted at each forecast location by reducing the monthly streamflow forecast by the desired percentage. The following equation was used to reduce each month's streamflow forecast:

$$AdjustedMonthlyStreamflow_i = MonthlyStreamflow_i - |MonthlyStreamflow_i| \times PercentReduction$$

where, *PercentReduction* is the percent reduction (i.e., 0.1 or 0.2 for the 90 percent ESP and 80 percent ESP, respectively), and i is a single forecast location for all locations described in **Sections D.3.1** and **D.3.2**.

The equation allows for the adjustment of both negative and positive forecasts.

The three sets of ESPs—100 percent ESP, 90 percent ESP, and 80 percent ESP—are combined into a 90-member hydrologic scenario for SEIS analysis purposes. The three sets of ESPs allow for an analysis of a wider range of low-flow hydrologic scenarios beyond those experienced during the recent 30 years (1991–2020). It is possible, however, that future flows may include periods of wet or dry conditions that are outside the 90-member scenario sequences analyzed.

D.4 Initial Reservoir Conditions

CRMMS was initialized with the observed May 2023 end-of-month reservoir conditions shown in **Table D-5**.

Table D-5
End-of-Month Reservoir Conditions Used as Initial Conditions

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Fontenelle	6,494.66	249,866
Flaming Gorge	6,020.21	2,917,394
Taylor Park	9,316.35	80,454
Blue Mesa	7,491.44	588,968

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Morrow Point	7,153.72	111,993
Crystal	6,751.16	16,449
Vallecito	7,651.55	90,920
Navajo	6,063.70	1,340,268
Powell	3,561.42	7,887,844
Mead	1,054.28	7,995,261
Mohave	641.83	1,666,824
Havasu	446.26	547,344

D.5 Reservoirs Upstream of Lake Powell

Nine Upper Basin reservoirs are simulated in CRMMS. Each of the nine Upper Basin reservoirs included in the model has an individual operation plan. Some facilities are operated to meet storage or elevation targets, while others feature environmentally regulated, controlled, consistent releases. Within the model, each reservoir has a set of rules to guide the specific operations. The model solves by using the logic in those operating rules. The following briefly describes the various Upper Basin reservoirs along with a high-level description of the logic in RiverWare for simulating operations within the Upper Basin. The operations of the Upper Basin reservoirs above Lake Powell are modeled the same for the No Action Alternative and the Proposed Action.

In a rule-based model, such as CRMMS in Ensemble Mode, general assumptions must be made for the model to solve. The rules developed for CRMMS are, ideally, the best representation of operations that can be projected. In practice, however, there are sometimes differences between the projected operations produced by the model and actual operations. For example, many reservoirs in the Upper Basin are operated following the principles of adaptive management. As such, operations may be altered to meet various objectives of the reservoirs' adaptive management work groups on an ad hoc or experimental basis. Such ad hoc or experimental operations cannot be known in advance, within the 5-year model outlook. As such, CRMMS Ensemble Mode projections may differ from actual operations, even under similar hydrologic conditions.

D.5.1 Fontenelle Reservoir

Fontenelle Reservoir is on the Green River about 24 miles southeast of La Barge, Wyoming. Fontenelle Reservoir is operated to meet various target elevations throughout the year while staying within practical and authorized limits.

D.5.2 Flaming Gorge Reservoir

Flaming Gorge Reservoir is on the Green River about 32 miles downstream of the Utah-Wyoming border and upstream of the confluence with the Yampa River. The operations of Flaming Gorge Reservoir meet the requirements detailed in the 2006 Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement (2006 Flaming Gorge ROD; Reclamation 2006a) that were designed to achieve the authorized purposes of the Colorado River Storage Project Act, while addressing environmental requirements. The 2006 Flaming Gorge ROD outlines the operational guidelines of Flaming Gorge and implements, to the extent possible, recommendations to assist in the recovery of four endangered fish species, outlined in the 2000 Flow and Temperature Recommendations for Endangered Fish in the Green River Downstream of Flaming Gorge Dam (Muth 2000).

Flaming Gorge operations are governed by the April through July unregulated inflow into the reservoir, which determines the corresponding hydrologic classification, spring peak, and base flow targets from the 2006 Flaming Gorge ROD (Reclamation 2006a) for the year. The April through July releases are modeled at the daily time step in CRMMS to approximate the sub-monthly component of the spring peak targets. The model logic determines typical daily operations from April through July before summing to a monthly release. During the March to April transition period, Flaming Gorge operations try to achieve a May 1 storage target. Actual annual operations at Flaming Gorge are determined in a consultation process with other agencies. The CRMMS Ensemble Mode cannot model these adaptive management decisions; therefore, model results do not include possible future adaptive management decision changes to the logic described above.

D.5.3 Taylor Park Reservoir

Taylor Park Reservoir is on the Taylor River, a tributary of the Gunnison River on the western slope of Colorado's Rocky Mountains. Taylor Park Reservoir is operated with a rule curve to meet various target elevations throughout the year, while staying within practical and authorized limits.

D.5.4 Aspinall Unit Reservoirs – Blue Mesa, Morrow Point, and Crystal

The Aspinall Unit consists of three reservoirs—Blue Mesa, Morrow Point, and Crystal—in series along the Gunnison River in western Colorado. The operations of the Aspinall Unit meet the requirements detailed in the April 2012 Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement (2012 Aspinall ROD; Reclamation 2012) and the decree quantifying the Federal Reserved Water Right for the Black Canyon of the Gunnison, which specify the spring peak outflow hydrographs and base flows for the rest of the year based on the hydrologic conditions upstream of Blue Mesa Reservoir. The 2012 Aspinall ROD provides specifications to avoid jeopardizing the continued existence of fish listed under the Endangered Species Act and to ensure the dam's operations do not result in the destruction or adverse modification of critical habitat in the Gunnison River.

Aspinall Unit operations are governed by the April through July unregulated inflow into the reservoir, which determines spring peak and base flow targets for the rest of the year based on the hydrologic conditions above Blue Mesa Reservoir. CRMMS approximates daily flow targets in the 2012 Aspinall ROD and Federal Reserved Water Right for the Black Canyon of the Gunnison by first modeling typical daily operations for both the spring and baseflow periods and then summing to a monthly release. Morrow Point and Crystal Reservoirs are modeled to maintain elevation targets of 7,153.73 and 6,753.04 feet, respectively.

D.5.5 Vallecito Reservoir

Vallecito Reservoir is on the Pine River, which flows into the San Juan River. The reservoir is 18 miles northeast of Durango, Colorado. Vallecito Reservoir is operated with a rule curve to meet various target elevations throughout the year, while staying within practical and authorized limits.

D.5.6 Navajo Reservoir

Navajo Reservoir is on the San Juan River above the confluence with the Animas River. The reservoir is operated to meet environmental requirements outlined in the July 2006 Record of Decision for the Navajo Reservoir Operations, Navajo Unit-San Juan River New Mexico, Colorado, Utah Final Environmental Impact Statement (Reclamation 2006b). Navajo Reservoir also provides for the diversion of NIIP water from Navajo Reservoir, and other municipal and industrial uses throughout the San Juan Basin. The minimum active storage at Navajo Reservoir is at 5,990 feet; at that point, the NIIP can no longer divert water.

Navajo Reservoir operations are modeled to first meet the environmental baseflow requirements at downstream gages stated in the July 2006 Record of Decision for the Navajo Reservoir Operations, Navajo Unit-San Juan River New Mexico, Colorado, Utah Final Environmental Impact Statement (Reclamation 2006b); because of the CRMMS spatial scale, it is assumed that all flow targets are for the San Juan River near Farmington, New Mexico. If available additional water is released as a spring peak, a spring release pattern is selected to bring Navajo Reservoir closest to the September 30 storage target, while staying within practical and authorized limits, including maintaining NIIP diversions. If the reservoir pool elevation is projected to go below 5,990 feet, the minimum elevation for NIIP diversions, the outflow, and NIIP diversions are proportionally reduced.

D.5.7 DROA Year 2022 Contribution Assumptions

The CRMMS modeling assumes no DROA releases, which is consistent with the June 2023 CRMMS simulation. The DROA releases from Flaming Gorge totaled 463,000 af for May 2022 through March 2023.[1] Starting March 2023, recovery of DROA releases began. By June 2023, 178,000 af had been recovered at Flaming Gorge, which was reflected in the initial reservoir conditions. CRMMS modeling does not include any assumptions regarding future DROA releases. Reclamation will attempt to maximize DROA recovery in the Upper Initial Units in water year 2023 and through April 2024.

D.6 Lake Powell Operation

Lake Powell is the most downstream reservoir in the Upper Basin; it is impounded by Glen Canyon Dam. Near Page, Arizona, Glen Canyon Dam is 17 miles upstream of Lee Ferry, the delineation point between the Upper and Lower Basins.

In CRMMS, Lake Powell operations logic calculates the annual operating year release, followed by disaggregating the annual release to monthly releases. The sections below summarize these operations. **Section D.6.1** describes modeling assumptions common to all alternatives. **Section D.6.2** describes model assumptions for Lake Powell operating tiers used in the No Action Alternative and the Proposed Action.

[1] The projected 500,0000 af DROA release was reduced on March 7, 2023, and recovery began in March 2023.

D.6.1 Assumptions Common to All Alternatives

CRMMS solves for Lake Powell operating tiers in CRMMS run cycles 3 and 4. CRMMS solves for the following rules in run cycles 3 and 4. In August, operations of Lake Powell are set for the entire following operating year (that is, October through September). An initial operating year release of 8.23 maf is used to solve for the end-of-calendar-year pool elevation, which is used to determine the operating tier and annual operating year release volume. The annual release is then disaggregated into monthly releases using the Long-term Experimental and Management Plan release patterns. The Lake Powell assumed monthly releases for CRMMS are in **Attachment D-1**.

The monthly releases solved using **Table Attachment D-1** can be constrained due to physical limitations at Glen Canyon Dam. Water can be released through the powerplant turbines until the pool elevation drops below 3,490 feet. Once Lake Powell is below 3,490 feet, releases are made through the river outlet works. There are four river outlet works at Glen Canyon Dam. The capacity of the river outlet works varies with the elevation of Lake Powell; the higher the pool elevation, the higher the potential release through the river outlet works. CRMMS computes the maximum monthly release based on the Lake Powell elevation using **Table D-6** and interpolates for the capacity between elevations listed in **Table D-6**. For the SEIS modeling, three out of four river outlet works are assumed available for use at any given time; this is because of the need for periodic inspections and any associated maintenance activities. Reclamation believes this is a reasonable estimation given the historical and future operations and maintenance requirements for the river outlet works.

Table D-6
CRMMS Modeled River Outlet Works' Capacity by Lake Powell Elevation

Lake Powell Elevation	Capacity (1 river outlet work)		Capacity (3 river outlet works)	
feet	cfs	af/month*	cfs	af/month*
3,490	3,660	225,045	10,980	675,134
3,480	3,620	222,585	10,860	667,755
3,470	3,520	216,436	10,560	649,309
3,460	3,380	207,828	10,140	623,484
3,450	3,140	193,071	9,420	579,213
3,440	2,860	175,855	8,580	527,564
3,430	2,560	157,408	7,680	472,225
3,420	2,200	135,273	6,600	405,818
3,410	1,760	108,218	5,280	324,655
3,400	1,200	73,785	3,600	221,355
3,390	800	49,190	2,400	147,570
3,380	400	24,595	1,200	73,785
3,370	0	0	0	0

* Computed using 31 days per month

D.6.2 No Action Alternative

Lake Powell operating tiers are determined based on the projected end-of-calendar-year pool elevation at Lake Powell. For operating year 2023, the August 2022 24-Month Study projected the

January 1, 2023, effective[2] pool elevation to be less than 3,525 feet, which results in 2023 operations being governed by the Lower Elevation Balancing Tier. CRMMS rules are then used to solve for the 2023 annual release in the Lower Elevation Balancing Tier.

For operating years beyond 2023, CRMMS will solve for the Lake Powell operating tier and annual release for the entire operating year in August. The first step of solving for the Lake Powell operating tier is to set the annual release to 8.23 maf. This allows CRMMS to solve for Lake Powell releases for the entire operating year and to solve for storage and other parameters, since CRMMS solves for the inflow in run cycle 2. This includes the end-of-calendar-year pool elevation, which is used to set the Lake Powell operating tier.

CRMMS solves for the Lake Powell operating tier and operating year release as follows using the projected end-of-calendar-year pool elevation:

- If the projected Lake Powell end-of-calendar-year pool elevation is greater than or equal to the equalization level (**Table D-7**), the Equalization Tier operations govern the operating year releases.
- If the projected Lake Powell end-of-calendar-year pool elevation is less than the equalization level and greater than or equal to 3,575 feet, the Upper Elevation Balancing Tier governs the operating year releases.
- If the projected Lake Powell end-of-calendar-year pool elevation is less than 3,575 feet and greater than or equal to 3,525 feet, the Mid-Elevation Release Tier governs the operating year releases.
- If the projected Lake Powell end-of-calendar-year pool elevation is less than 3,525 feet, the Lower Elevation Balancing Tier governs the operating year releases.

The annual release for each tier is described below for the No Action Alternative. The last section describes how Lake Powell operating year releases are disaggregated to a monthly scale.

Table D-7
Lake Powell Equalization Level Table

Year	Equalization Elevation (feet)
2023	3,662
2024	3,663
2025	3,664
2026	3,666

[2] The reduction of releases from Lake Powell from 7.48 to 7.00 maf in operating year 2022 resulted in a reduced release volume of 0.48 maf that normally would have been released from Glen Canyon Dam to Lake Mead as part of a 7.48-maf annual release volume, consistent with routine operations under the 2007 Interim Guidelines. The reduction of releases from Glen Canyon Dam in operating year 2022 (resulting in increased storage in Lake Powell) did not affect the operation determination for 2023; it was accounted for "as if" this volume of water had been delivered to Lake Mead, which is referred to as "effective" pool elevation. In April 2023, Reclamation removed the operational neutrality of the 0.48 maf that was retained in Lake Powell under the May 2022 action, such that 2023 balancing releases are based on the projected end-of-water-year physical contents of Lake Powell and Lake Mead.

D.6.2.1 Equalization Tier

Under the No Action Alternative, the equalization of storage between Lake Powell and Lake Mead is modeled with a rule that first calculates how much water would be released to equalize Lakes Powell and Mead. The release for equalization is computed by taking half of the difference between the predicted end-of-water-year volumes of Lake Powell and Lake Mead. Evaporation and bank storage losses at Lake Powell and Lake Mead are estimated in the calculation. The equalization release is then constrained by choosing the minimum of the equalization release, the release to take Lake Mead to 1,105 feet, and the release to take Lake Powell to 20 feet below the equalization level. The rule then sets the Lake Powell operating year release to the maximum of the constrained equalization volume and an 8.23-maf release. Monthly releases from Lake Powell are then calculated for the operating year using **Table Attachment D-1**.

After Lake Powell and Lake Mead have both resolved, a higher-priority rule refines the equalization release. This rule is also used to refine the Upper Elevation Balancing Tier equalization releases. The rule calculates the volume deviation of the end-of-water-year storage at Lake Powell and Lake Mead from target levels (that is, equalization to achieve Lake Mead at 1,105 feet or to achieve Lake Powell 20 feet below the equalization level). The deviation volume then adjusts Lake Powell's release to achieve the end-of-water-year target, subject to a minimum release of 8.23 maf. This rule is allowed to iterate so that end-of-water-year target elevations are achieved to within a specified tolerance.

D.6.2.2 Upper Elevation Balancing Tier

Once it is determined that Lake Powell is starting the year in the Upper Elevation Balancing Tier, the projected end-of-water-year pool elevation at the end of the next operating year (for example, September 30, 2024, when the model has set the operating tier in August 2023) is used to determine how much water is released.

If the projected Lake Powell end-of-water-year pool elevation is above the equalization level, then an April switch to equalization is modeled, and the operating year release is set based on equalization logic (described in the previous section) and constrained to a minimum of 8.23 maf. Otherwise, if Lake Powell's projected end-of-water-year pool elevation is less than or equal to the equalization level, Lake Powell's releases are modeled consistent with the Upper Elevation Balancing constraints and depend on Lake Mead's end-of-water-year pool elevation:

- If the Lake Mead end-of-calendar-year pool elevation is greater than or equal to 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead's end-of-water-year storage is calculated but constrained to be within the range of 8.23 to 9.0 maf.
- If the Lake Mead end-of-calendar-year pool elevation is greater than 1,075 feet, and the Lake Powell end-of-water-year pool elevation is less than or equal to 3,575 feet, the operating year release is 8.23 maf.
- If the Lake Mead end-of-calendar-year pool elevation is less than 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead end-of-water-year storage is calculated but constrained to be within the range of 7.0 to 9.0 maf.

D.6.2.3 Mid-Elevation Release Tier

The Mid-Elevation Release Tier is modeled by first checking Lake Mead's projected end-of-calendar-year pool elevation. If the Lake Mead end-of-calendar-year pool elevation is greater than or equal to 1,025 feet, Lake Powell's operating year release is set to 7.48 maf. Otherwise, the operating year release is set to 8.23 maf.

D.6.2.4 Lower Elevation Balancing Tier

For operating years 2023 and 2024, the Lower Elevation Balancing Tier operations are modeled in a way that protects critical elevations at Lake Powell. This is done by assessing potential balancing releases in April 2023 and limiting any balancing releases (with a minimum of 7.00 maf) to protect Lake Powell from declining below an elevation of 3,525 feet at the end of December of the following year. For operating years 2025 and 2026, balancing releases are not limited to protect Lake Powell from declining below critical elevations.

In CRMMS, the Lower Elevation Balancing Tier is modeled by first setting the Lake Powell operating year release to 7.0 maf, which causes Lake Powell to resolve for monthly releases and pool elevations. Next, Lower Elevation Balancing Tier releases are calculated with different constraints, which depend on the operating year, as previously described.

- In operating years 2023 and 2024:
  - If the Lake Powell end-of-water-year pool elevation is greater than the protection threshold of 3,535 feet,[3] two potential annual releases are calculated: (1) the operating year release necessary to balance Lake Powell and Lake Mead's end-of-water-year storage; the release is calculated but constrained to be within the range of 7.0 to 9.5 maf.; and (2) the release needed so that Lake Powell's end-of-water-year pool elevation is 3,535 feet. The minimum of these two releases is used to set Lake Powell's annual release. If the end-of-water-year Lake Powell pool elevation is less than the protection threshold of 3,535 feet with a 7.0 maf release, the release is not adjusted.
- In operating years 2025 and beyond:
  - The operating year release necessary to balance Lake Powell and Lake Mead's end-of-water-year storage is calculated but constrained to be within the range of 7.0 to 9.5 maf.

D.6.2.5 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases anytime the operating year release volume is set for Lake Powell. The operating year volume is used to select the closest operating year release pattern from **Table Attachment D-1**; for operating year releases between set values, the monthly releases are interpolated between the two columns with the closest operating year release. Except for certain circumstances, as noted below, the water year volume is preserved when interpolating monthly releases.

There are a few special cases where the monthly releases are not interpolated directly from **Table Attachment D-1**. If there is an equalization outflow in the Upper Elevation Balancing Tier, then the

[3] The protection threshold of 3,535 feet was used for modeling purposes since it is the end-of-water-year elevation needed during an average year to achieve an end-of-calendar-year elevation of 3,525 feet (or higher).

outflows from October until March follow a path of a 9.0-maf release and then will be either the maximum powerplant release or the remaining amount of volume to meet the equalization annual release volume. The April through September releases are calculated to attempt to release the remainder operating year release volume, while constraining releases to the powerplant capacity. If the operating year release volume is less than 8.23 maf, the release pattern is set to the 7.48-maf pattern for October through December. For January through September, the remainder of the operating year release volume is released proportional to **Table Attachment D-1**.

The disaggregated monthly releases are further constrained so that the monthly releases do not exceed what can be moved through the river outlet works. If a monthly release is constrained, the volume is tracked and is attempted to be released later in the operating year to maintain the desired operating year release, if possible.

D.6.3 Proposed Action

CRMMS solves for Lake Powell operations as described for the No Action Alternative, except for a protection-level provision described in **Section D.6.3.5**.

D.6.3.1 Equalization Tier

The Equalization Tier method for Lake Powell under the Proposed Action is identical to that under the No Action Alternative.

D.6.3.2 Upper Elevation Balancing Tier

The Upper Elevation Balancing Tier method for Lake Powell under the Proposed Action is identical to that under the No Action Alternative.

D.6.3.3 Mid-Elevation Release Tier

The Mid-Elevation Release Tier method for Lake Powell under the Proposed Action is identical to that under the No Action Alternative, except when additional adjustments are necessary to protect an elevation of 3,500 feet. See **Section D.6.3.5** for additional details on these additional adjustments.

D.6.3.4 Lower Elevation Balancing Tier

The Lower Elevation Balancing Tier method for Lake Powell under the Proposed Action is identical to that under the No Action Alternative, except when additional adjustments are necessary to protect an elevation of 3,500 feet. See **Section D.6.3.5** for additional details on these additional adjustments.

D.6.3.5 Protection Level

The Proposed Action specifies a protection level of 3,500 feet at Lake Powell such that Reclamation can make a mid-year adjustment to reduce the operating year release no less than 6.0 maf, if Lake Powell is projected to drop below 3,500 feet in the next 12 months.

In CRMMS, this is modeled by checking Lake Powell pool elevations from April through the end of the water year when Lake Powell is operating in the Mid-Elevation Release Tier or Lower Elevation Balancing Tier. If the Lake Powell pool elevation is projected to drop below 3,500 feet or is already below 3,500 feet, monthly releases will be adjusted for April through September. The monthly release will be decreased such that the Lake Powell pool elevation is maintained at or above 3,500 feet; however, it is subject to the following constraints: the minimum water year release is 6.0 maf, and the monthly releases will release a volume not less than the volume necessary to meet the minimum daily LTEMP release. If releases are adjusted in April through September and Lake Powell pool elevation increases above 3,500 feet, monthly releases can be increased to release up to the original annual release volume for the given Lake Powell operating tier.

If the protection of 3,500 feet is triggered in April, Lake Powell's release can be adjusted to protect 3,500 feet during the following water year. The same logic applies to the second water year, but releases can be adjusted starting at the beginning of the water year.

D.6.3.6 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases using the same method as under the No Action Alternative.

D.7 Lake Mead Operation

Lake Mead is the uppermost reservoir in the Lower Basin. Located 35 miles southeast of Las Vegas, the 726-foot-high Hoover Dam impounds Lake Mead. In CRMMS, Lake Mead operations are modeled by solving for the Lower Basin condition, Lower Basin and Mexico diversions, and intentionally created surplus (ICS) and other conservation activity. **Section D.7.1** describes modeling assumptions common to all alternatives. **Sections C.7.2** and **C.7.3** describe Lake Mead operations for the No Action Alternative and Proposed Action, respectively.

D.7.1 Assumptions Common to All Alternatives

CRMMS solves for the Lower Basin operating condition in CRMMS run cycles 3 and 4. In August, operations of Lake Powell are set for the entire following operating year (that is, October through September). Once Lake Powell releases are set for the entire operating year, the Lower Basin condition can be solved, which occurs in the January time step. After the condition is set, depletion schedules for the Lower Division States and Mexico may be modified in accordance with the requirements of the operating condition for the entire calendar year, based on the 2007 Interim Guidelines, 2019 DCPs, Minute 323, and system conservation agreements. Assumed ICS activity may also affect the water user depletions. Once demands below Lake Mead are calculated, Lake Mead's release is set to meet downstream demands.

For Lower Division States and Mexico use, in the first year of the model run, depletion schedules use water orders that reflect shortage conditions, Lower Basin DCP contributions, reductions under low-elevation reservoir conditions, Binational Water Scarcity Contingency Plan (BWSCP) contributions per Minute 323, and signed system conservation agreements. For the remaining years in the model run, depletion schedules reflect "normal" schedules, and represent near-term historical trends in water use. All additional reductions (2007 Interim Guidelines shortages, DCP reductions, and reductions under low-elevation reservoir conditions and BWSCP contributions per Minute 323) reduce these "baseline/normal" depletion schedules. Depletion schedules for CRMMS water users that were used in the June 2023 CRMMS modeling are summarized in **Attachment D-2**.

D.7.1.1 Lake Mead/Hoover Dam Flood Control

The Lake Mead flood control logic in CRMMS is based on the 1984 Field Working Agreement between Reclamation and the United States Army Corps of Engineers. Three flood control procedures are in effect for different times of the year. The first procedure is in effect throughout the year. Its objective is to maintain a minimum space of 1.5 maf in Lake Mead, primarily for extreme storm events. This space is referred to as exclusive flood control space and is represented by the space above elevation 1,219.6 feet. The second procedure is used during the period from January to July. The objective during this period is to route the maximum inflow forecast through the reservoir system using specific rates of Hoover Dam outflow, assuming that Lake Mead will fill to elevation 1,219.6 feet at the end of July. The third procedure is used during the space-building or drawdown period of August through December. The objective during this period is to gradually draw down the reservoir system, to meet the total system space requirements in each month in anticipation of the next year's runoff.

This logic matches the logic used in the 2007 FEIS. Given the June 2023 conditions and inflow forecast ensemble, there were no instances of simulating flood control operations in the SEIS modeling through 2026.

D.7.2 No Action Alternative

Lake Mead operations and Lower Basin conditions are modeled based on projected end-of-calendar-year pool elevation at Lake Mead.

D.7.2.1 Surplus

The Lower Basin operates in a Surplus Condition if the Lake Mead elevation is above 1,145 feet and below an elevation that would trigger space-building or flood control releases pursuant to the 1984 Field Working Agreement between Reclamation and the US Army Corps of Engineers (described in **Section D.7.1.1**).

The 2007 Interim Guidelines define two levels of Surplus. A Domestic Surplus is determined if the Lake Mead elevation is above 1,145 feet and below the elevation that triggers a Quantified Surplus. Under a Domestic Surplus, depletion schedules are modified in the Lower Division States consistent with the 2007 Interim Guidelines Section 2.B.2. A Quantified Surplus is determined if water needs to be delivered to reduce the risk of potential reservoir spills based on the 70R Strategy (see 2007 FEIS, Appendix A, Section A.6.2.4). Under a Quantified Surplus, depletion schedules are modified in the Lower Division States consistent with the 2007 Interim Guidelines Section 2.B.3.

D.7.2.2 Normal Conditions

The Lower Basin operates in a Normal Condition if the Lake Mead elevation is above 1,075 feet and below 1,145 feet. If the model determines that a Normal Condition exists, the model retains the default Normal schedules initially assigned in run cycle 1. Depletion schedules might be modified due to ICS creation or delivery logic or for DCP contributions. An ICS Surplus Condition is a type of Normal Condition that is determined when Lake Mead's elevation is above 1,075 feet and below 1,145 feet, and there is an ICS creation plan in place for at least one Lower Basin entity.

D.7.2.3 Shortage Conditions

A Lower Basin Shortage Condition is modeled if the Lake Mead elevation is less than or equal to 1,075 feet. A rule solves for the Shortage Condition in January by comparing Lake Mead's end-of-calendar-year pool elevation to defined pool elevations, as shown in **Table D-8**.

Once the Shortage Condition is set, shortage volumes (**Table D-8**) are assigned to users proportionally to a user's monthly and annual scheduled water use:

$$MonthlyShortage_i = AnnualShortage_i * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i}\right)$$

where i is an individual water user.

Diversions for water users are then adjusted with the user's monthly shortage. In Nevada, Southern Nevada Water Project (SNWP) users incur the entire shortage volume; in Arizona, the entire shortage volume is modeled to be incurred by the Central Arizona Project.

Table D-8
Lower Division State Shortage Volumes

Lake Mead Elevation (feet)	Arizona Shortage (af)	Nevada Shortage (af)	Total Shortage (af)
>1,075	0	0	0
1,075 to 1,050	320,000	13,000	333,000
<1,050 to 1,025	400,000	17,000	417,000
<1,025	480,000	20,000	500,000

D.7.2.4 Minute 323 High- and Low-Elevation Reservoir Conditions

Minute 323 defines reductions to Mexico under low-elevation reservoir conditions based on the projected Lake Mead end-of-calendar-year pool elevation. **Table D-9** shows Mexico's reductions. Adjustments to Mexico's delivery assume the same method to disaggregate the annual reduction to a monthly reduction as the adjustments due to shortage in the Lower Division States (**Section D.7.2.3**).

Table D-9
Mexico Minute 323 Reductions

Lake Mead Elevation (feet)	Mexico Reduction (af)
>1,075	0
1,075 to 1,050	50,000
<1,050 to 1,025	70,000
<1,025	125,000

Distribution of flows to Mexico under high-elevation reservoir conditions are modeled in accordance with Minute 323 Section II, when the Lake Mead end-of-calendar-year pool elevation is at or above 1,145 feet.

D.7.2.5 2019 DCPs and BWSCP

CRMMS models the 2019 DCP contributions in accordance with Exhibit 1 to the Lower Basin DCP agreement and the Minute 323 BWSCP. The contribution volumes (**Table D-10**) are based on the projected Lake Mead end-of-calendar-year pool elevation, similar to the Shortage Condition. For modeling purposes, DCP contributions can be made through conversion of existing ICS, simultaneous ICS creation and conversion to DCP-ICS, and/or reducing depletions to create system water. Additional CRMMS ICS assumptions are described in **Section D.7.2.6**.

As previously mentioned, in the first year of the model run, depletion schedules use water orders that reflect shortage conditions, Lower Basin DCP contributions, and Minute 323 reductions and contributions. These first-year depletion schedules reflect more guidance and input from states, water users, and Mexico than exist for the subsequent modeled years. In the subsequent years, model assumptions are developed with states, water users, and Mexico to provide a reasonable assumption for how DCP and BWSCP contributions might be made, as described below.

Table D-10
2019 DCP and Minute 323 BWSCP Contribution Volumes

Lake Mead Elevation (feet)	DCP (1,000 af) Arizona	DCP (1,000 af) Nevada	DCP (1,000 af) California	Minute 323 BWSCP (1,000 af)
>1,090	0	0	0	0
1,090 – 1,075	192	8	0	41
1,075 – 1,050	192	8	0	30
<1,050 – >1,045	192	8	0	34
1,045 – >1,040	240	10	200	76
1,040 – >1,035	240	10	250	84
1,035 – >1,030	240	10	300	92
1,030 – 1,025	240	10	350	101
<1,025	240	10	350	150

In Nevada, the DCP contribution is generally made by converting extraordinary conservation (EC)-ICS to DCP-ICS. If there is not enough EC-ICS available to meet the full DCP contribution, Nevada simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS accumulation limit[4] space exists to create DCP-ICS, then contributions are made via system water.

In California, the agreement between the Metropolitan Water District of Southern California (MWD) and Coachella Valley Water District (Coachella) is modeled in CRMMS; however, the entire DCP-ICS balance in CRMMS is tracked in the MWD's ICS account. This means that CRMMS decreases Coachella's water use schedule by 7 percent of California's DCP contribution. Then, the MWD makes 100 percent of the DCP contribution by converting EC-ICS to DCP-ICS, and can then take delivery of the unused water created by Coachella. If the MWD's EC-ICS balance is insufficient to meet the full DCP contribution, the MWD simultaneously creates EC-ICS and

[4] In accordance with the Lower Basin DCP, the maximum total amount of EC-ICS, Binational ICS, and DCP-ICS that may be accumulated by the Lower Division States is 2.7 maf.

converts it to DCP-ICS in the year it is required. If there is 2.7 maf of accumulated ICS, and/or there is insufficient EC-ICS to meet the entire DCP contribution, then the MWD creates non-ICS water (that is, system water) to meet the DCP contribution.

In Arizona, the DCP contributions are assumed to be made through simultaneous creation of EC-ICS and conversion to DCP-ICS in the year it is required, and through non-ICS water. If there is 2.7 maf of accumulated ICS, then Central Arizona Water Conservation District (CAWCD) makes the entire DCP contribution through non-ICS water.

In Mexico, BWSCP contributions are assumed to be made through reductions to Mexico's delivery (that is, via system water), unless Mexico provides other input and assumptions.

D.7.2.6 ICS Assumptions

ICS may be created through various mechanisms, including EC, tributary conservation, system efficiency projects, importation of non-Colorado River water, and transfer of Mexico's Water Reserve to Binational ICS. For modeling purposes in CRMMS, ICS creation and delivery is a combination of inputs and logic.

In CRMMS, ICS is modeled in multiple steps. First, non-junior priority ICS accounts are solved. Second, the preliminary ICS for junior priority accounts is solved. Preliminary ICS represents the ICS creation or delivery volumes that each junior priority entity would like under their ideal scenario. Using the preliminary ICS values, CRMMS then solves the ICS accumulation space sharing. ICS accumulation space sharing, per the agreements signed in 2020 and 2021, allows Lower Division States to take advantage of the full 2.7 maf of ICS storage through a sharing mechanism. Following the ICS accumulation space sharing, the model then adjusts the preliminary ICS accounts appropriately to finalize ICS creation, deliveries, and balances. Finally, water users' diversions are adjusted to reflect ICS creation and deliveries.

D.7.2.6.1 Constants

Table D-11 list the ICS-related assumptions used in CRMMS.

Table D-11
Annual Creation and Delivery Limits

State	Maximum Annual Creation (1,000 af)	Maximum Annual Delivery (1,000 af)
Arizona	100	300
California	400	400
Nevada	125	300

CRMMS models the ICS accumulation space sharing agreements from 2020 and 2021. Therefore, the accumulation limits (**Table D-12**) reflect volumes that differ somewhat from those specified in the 2007 Interim Guidelines and Lower Basin DCP. Additionally, there is logic in CRMMS that allows one or more states to exceed their maximum accumulation limit as long as the total Lower Basin ICS accumulation as defined in the Lower Basin DCP (i.e., sum of EC-ICS, DCP-ICS, and Binational ICS) is less than or equal to 2.7 maf. A state may be required to vacate ICS and/or not create ICS if the ICS accumulation is at 2.7 maf and the state has exceeded its individual accumulation limit. If a state is required to vacate ICS, it will take the following actions until the required volume has been vacated: (1) convert DCP-ICS to system water, (2) take delivery of Tributary ICS and Imported ICS (Nevada only), (3) take delivery of EC-ICS, and (4) take delivery of Binational ICS. Annual ICS assessments for evaporation depend on the entity and year (**Table D-13**).

Table D-12
Accumulation Limits by Entity in CRMMS

Accumulation Limit (af)	Arizona			California			Nevada
	CAWCD	Tribal	Total	IID	MWD	Total	Total
	300,000	300,000	**600,000**	50,000	1,600,000	**1,650,000**	**450,000**

Table D-13
Annual ICS Assessments (percentages)

Entity	Year 1	Year 2	Year 3
Arizona	10	—	—
IID[1]	5	3	3
MWD	10	—	—
Nevada	10	—	—

[1] After the year of creation, a 3 percent evaporation assessment is applied in all non-shortage years.

D.7.2.6.2 Arizona ICS Assumptions

In general, information about the ICS creation is provided to Reclamation by the state, and CRMMS logic is used to model the future ICS delivery and type of ICS created.

Reclamation generally inputs ICS creation volumes for all entities in Arizona based on existing and anticipated ICS creation plans (**Table D-14**). CRMMS allows CAWCD's DCP contribution to be made through creation of ICS and non-ICS water. A default creation volume is input, and rule logic determines whether CAWCD's ICS creation is EC-ICS or DCP-ICS based on the operating condition of the current year.

Table D-14
Assumed ICS Creation and Delivery Volumes in Arizona

		2023	2024	2025	2026
CAWCD	EC-DCP Creation (af)	60,000	60,000	60,000	0
	Binational Creation (af)	9,092	0	0	9,092
	System Efficiency Creation (af)	0	0	0	0
	Default Delivery[1] (af)	80,000	0	0	0
GRIC	EC Creation (af)	0	0	0	0
	Delivery (af)	0	0	0	0

[1]CAWCD delivers an additional 60,000 af when the operating condition is between 1,075 and 1,025 feet for mitigation purposes. Starting in 2026, CAWCD is assumed to also try to take delivery of its remaining ICS by 2036, based on the operating condition.

Reclamation also inputs the assumed ICS delivery volumes for all entities in Arizona, except CAWCD and the GRIC. Assumed delivery volumes for CAWCD incorporate a default assumption provided by CAWCD plus an assumed delivery for mitigation water. Starting in 2026, CAWCD is modeled to try to take delivery of its remaining ICS by 2036, based on the operating condition. Assumed ICS delivery volumes for GRIC are based on the Arizona Firming Agreement and are assumed to start in 2027. There are no ICS deliveries when Lake Mead is projected to decline below elevation 1,025 feet on January 1.

D.7.2.6.3 California ICS Assumptions

CRMMS includes ICS assumptions in California for the IID and MWD (**Table D-15**). Creation volumes of Binational ICS (assumed conversion from Mexico's Water Reserve pursuant to Minute 323) for the IID and MWD, and System Efficiency ICS for the MWD are input into CRMMS.

Table D-15
Assumed ICS Creation Volumes by IID and MWD (af)*

		2023	2024	2025	2026
MWD	**EC-ICS Creation (af)**	**209,000**	—	—	—
	Binational ICS Creation (af)	9,092	0	0	9,092
	System Efficiency ICS Creation (af)	0	0	0	0
IID	Binational ICS Creation (af)	9,092	0	0	9,092

* The 2023 MWD EC-ICS creation is a static volume. For 2024–2026, EC-ICS creation or delivery volumes are dynamic and based on the Sacramento River Water Year Classification (SRWYC; see **Table D-16**).

In general, IID tries to keep its ICS accumulation at its capacity (50,000 af). As such, approximately 1,500 af of EC-ICS can be created in normal, ICS surplus, and domestic surplus years. This volume is enough to keep the EC-ICS accumulation at capacity and cover the annual evaporative assessment (**Table D-13**).

There is no logic to create additional EC-ICS by IID above the 1,500 af lost to evaporation during normal and surplus years. Therefore, if the EC-ICS balance decreases more than 1,500 af due to the assumed behavior in flood control surplus conditions, that ICS balance is not currently replenished in the year(s) following the flood control release.

There is currently no assumed delivery of Binational ICS or EC-ICS by IID.

For the MWD, EC-ICS creation and ICS delivery volumes are based on the annual SRWYC. The SRWYC index is obtained at http://cdec.water.cC.gov/cgi-progs/iodir/WSIHIST and then resampled using the index sequential method, for use with each inflow trace scenario, consistent with the year the Lower Basin hydrology input is from. Other constraints are described below.

EC-ICS will be created per **Table D-16** in Normal and Shortage conditions, subject to ICS accumulation and annual creation limits. ICS creation is also limited to make sure the MWD's annual diversion does not fall below its specified annual minimum diversion of 500,000 af. No creation occurs during surplus or flood control conditions.

Table D-16
EC-ICS Creation and Delivery Volumes by SRWYC

SRWYC	Creation (af)	Delivery (af)
Wet	300,000	0
Above Normal	150,000	0
Below Normal	0	0
Dry	0	100,000
Critical	0	200,000

If a DCP contribution is needed, the MWD converts EC-ICS to meet its contribution. If not enough EC-ICS is available to meet the full DCP contribution, the MWD simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS accumulation space exists to create DCP-ICS, then contributions are made via system water.

D.7.2.6.4 Nevada ICS Assumptions

Creation of Tributary Conservation, Imported ICS, and Binational ICS are all inputs in CRMMS (**Table D-17**).

If a DCP contribution is needed, the SNWP converts EC-ICS to meet its contribution. If there is not enough EC-ICS available to meet the full DCP contribution, the SNWP simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS accumulation space exists to create DCP-ICS, then contributions are made via system water.

EC-ICS is assumed to be created from Nevada's unused apportionment as long as there is ICS accumulation space available. The SNWP's unused apportionment equals the SNWP's apportionment minus shortages and DCP contributions, if EC-ICS was not converted in that year, minus SNWP's annual normal demand.

Table D-17
Assumed ICS Creation Volumes by the SNWP

	2023	2024	2025	2026
Tributary Conservation (af)	30,000	30,000	30,000	30,000
Imported ICS creation (af)	0	0	0	0
Binational ICS creation (af)	9,092	0	0	9,092

ICS can be used to meet the SNWP's water demands; however, it is typically only used when the demands exceed apportionment, or to offset delivery reductions resulting from shortages. In the 5-year modeling period of the June 2023 CRMMS run, the demands do not exceed the SNWP's apportionment.

D.7.2.7 System Conservation

In addition to shortage and DCP contributions based on Lake Mead operations, Lower Basin demands are assumed to be reduced for system conservation after these agreements have been finalized. **Table D-18** shows the system conservation modeled for the No Action Alternative.

Table D-18
No Action Alternative Modeled System Conservation Volumes (af)

Modeled System Conservation	2023	2024	2025	2026	Total
California					
Palo Verde Irrigation District	58,400	39,800	—	—	98,200
California Total	**58,400**	**39,800**	**—**	**—**	**98,200**
Arizona					
Gila River Indian Community	91,950	125,000	125,000	—	341,950
Fort McDowell Yavapai Nation	13,933	13,933	13,933	—	41,799
Central Arizona Project subcontractors	62,200	42,200	42,200	—	146,600
Mohave Valley Irrigation and Drainage District	12,819	—	—	—	12,819
Yuma Mesa Irrigation and Drainage District	13,670	—	—	—	13,670
Gabrych Farms	3,240	3,240	3,240	—	9,720
Arizona Total	**197,812**	**184,373**	**184,373**	**—**	**566,558**
Total Modeled System Conservation	**256,212**	**224,173**	**184,373**	**—**	**664,758**

[1] These model assumptions reflect projected volumes as of June 2023 from executed agreements, and are subject to change. These system conservation volumes are modeling assumptions; they do not represent mandatory shortages, and they do not commit specific water users to these reductions in use.

D.7.3 Proposed Action

The Lake Mead operations and Lower Basin conditions for the Proposed Action are similar to those under the No Action Alternative (that is, shortage and DCP contribution volumes are based on Lake Mead elevations).

D.7.3.1 Surplus

The surplus model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative.

D.7.3.2 Normal Conditions

The normal condition model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative.

D.7.3.3 Shortage Condition

The shortage condition model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative.

D.7.3.4 Minute 323 High- and Low-Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative.

D.7.3.5 DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative.

D.7.3.6 ICS Assumptions

The ICS model assumptions for the Lower Basin under the Proposed Action are identical to those under the No Action Alternative, except for the following updates:

- MWD's 2023 EC-ICS creation volume is set to 216,000 af. The No Action Alterative assumes 209,000 af of ICS creation (see **Table D-17**).
- SNWA's 2023 tributary ICS creation was converted to system water due to the ICS accumulation limit.
- The assumed behavior of a state's ICS activity when the ICS accumulation capacity is full was updated. If a state is required to vacate ICS (as described in **Section D.7.2.6.1** for the No Action Alternative), a state will convert EC-ICS and tributary ICS (Nevada only) to system water instead of taking delivery of the ICS volume.

C.7.3.6 System Conservation

The Proposed Action includes additional system conservation beyond the volumes included under the No Action Alternative. **Table D-19** reports the assumed system conservation modeled for this SEIS.

Table D-19
Proposed Action Modeled SEIS Conservation Volumes (af)

Modeled SEIS Conservation	2023	2024	2025	2026	Total
California					
Coachella Valley Water District	35,000	45,000	45,000	—	125,000
Quechan Indian Tribe	13,000	13,000	13,000	13,000	52,000
Palo Verde Irrigation District	78,000	120,000	120,000	83,000	401,000
Bard Water District	—	6,000	—	—	6,000
Imperial Irrigation District	50,000	250,000	250,000	250,000	800,000
California Total	**176,000**	**434,000**	**428,000**	**346,000**	**1,384,000**
Arizona					
Gila River Indian Community	91,950	145,000	145,000	20,000	401,950
Fort McDowell Yavapai Nation	13,933	13,933	13,933	—	41,799
San Carlos Apache Tribe	23,275	—	—	—	23,275
Colorado River Indian Tribes	37,000	23,000	23,000	—	83,000
Central Arizona Project Subcontractors	143,800	129,800	128,800	—	402,400
Mohave Valley Irrigation and Drainage District	12,819	12,819	12,819	—	38,457
Yuma Mesa Irrigation and Drainage District	13,670	13,670	13,670	—	41,010
Gabrych Farms	3,240	3,240	3,240	—	9,720
Wellton-Mohawk Irrigation and Drainage District	9,000	12,000	12,000	9,000	42,000
Arizona Total	**348,687**	**353,462**	**352,462**	**29,000**	**1,083,611**
Total Modeled SEIS Conservation	**524,687**	**787,462**	**780,462**	**375,000**	**2,467,611**

[1] These model assumptions reflect projected volumes as of June 2023 from executed agreements, agreements that are under development, and planned operations; these assumptions are subject to change. These SEIS conservation volumes are modeling assumptions; they do not represent mandatory shortages, and they in no way commit specific water users to these reductions in use.

D.8 Lake Mohave and Lake Havasu Operations

Lake Mohave and Lake Havasu are operated to meet user-specified target storages at the end of each month. These operations remain consistent for both alternatives. The storage targets and the corresponding elevations for Lake Mohave and Lake Havasu are presented in the following sections.

D.8.1 Lake Mohave/Davis Dam

Lake Mohave is operated to meet monthly elevation targets (**Table D-20**). These elevation targets are based on effective storage space targets set by the US Army Corps of Engineers for Lower Basin flood control purposes, as well as for endangered species operations developed in conjunction with the Fish and Wildlife Service.

Table D-20
Lake Mohave Monthly Elevation and Storage Targets

Month	Lake Mohave Target Elevation (feet)	Lake Mohave Target Storage (1,000 af)
January	641.8	1,666
February	641.8	1,666
March	642.5	1,685
April	643.0	1,699
May	643.0	1,699
June	643.0	1,671
July	642.0	1,658
August	642.0	1,658
September	640.0	1,617
October	630.5	1,371
November	635.0	1,486
December	638.7	1,583

D.8.2 Lake Havasu/Parker Dam

Lake Havasu is operated to meet monthly elevation targets (**Table D-21**). These elevation targets are based on effective storage space targets set by the US Army Corps of Engineers for Lower Basin flood control purposes, as well as for seasonal needs to meet downstream water demands.

Table D-21
Lake Havasu Monthly Elevation and Storage Targets

Month	Lake Havasu Target Elevation (feet)	Lake Havasu Target Storage (1,000 af)
January	446.5	552
February	446.5	552
March	446.7	555
April	448.7	593
May	448.7	593
June	448.7	593
July	448.0	580
August	447.5	571
September	447.5	571
October	447.5	571
November	447.5	571
December	446.5	552

D.9 Energy Generation

RiverWare™ includes a variety of methods that can be chosen to compute electrical power generation and estimate generation capacity. All methods compute power and energy on a monthly basis. These results can be used to estimate revenue and total economic value. The following sections describe the methods used to compute power at Glen Canyon Dam, Hoover Dam, Davis Dam, and Parker Dam.

D.9.1 Glen Canyon Dam

While CRMMS includes a RiverWare™ method to compute electrical power generated from Glen Canyon Dam, the power generation data used in **Section 3.15** are computed using Generation Transmission Maximization Model (GTMax) Lite.

If the previous month's elevation is less than 3,490 feet, there is no power or energy generated for the current month. This elevation reflects the minimum power pool elevation at Lake Powell.

D.9.2 Hoover Dam

The method that computes power and energy generated at Hoover Dam, which is the same method used in CRSS for the 2007 FEIS, assumes two levels of power generation. The lower level of generation occurs at base flow, while the upper level occurs at peak flow. The method computes the fraction of the month that the powerplant is operated at peak flow and base flow. The peak flow is the most efficient flow through the turbines for the current operating head, while the base flow represents the minimum flow through the turbines to produce energy.

The base flow and corresponding power generation are based on the outflow for the current month. The peak flow must be computed through an iterative procedure using operating head, tailwater elevation, and turbine release. The initial turbine release is assumed to be that corresponding to maximum power production. Tailwater elevation at Hoover Dam is computed as a function of Lake Mohave elevation and Hoover Dam release.

The monthly Hoover Dam release volume at the base flow is computed by applying the base flow over the month. The monthly release volume at the peak flow is computed as:

$$PeakFlowVolume = TurbineReleaseVolume - BaseFlowVolume$$

Next, the number of hours required for operation at base and peak flows are computed as:

$$PeakHours = \frac{PeakFlowVolume}{(PeakFlow - BaseFlow) * 3600}$$

$$BaseHours = \frac{SecondsInMonth}{3600} - PeakHours$$

where 3,600 is the amount of seconds per hour.

If the peak hours are greater than the length of the month, the peak hours' value is set equal to the length of the month, and the base hours value is set to zero. The peak and base hours are then multiplied by the powerplant capacity at each level and added together to obtain the total energy produced for the month. Power is computed as the energy divided by the length of the month in hours.

The algorithm described above allows power generation at elevations below approximately 950 feet, which is the minimum power pool at Lake Mead. According to the algorithm, power is generated as long as the minimum operating head of 304 feet is available, corresponding to an elevation of about 950 feet. Because there is no operating experience at these elevations, it is impossible to verify whether CRMMS mimics the actual turbine performance at such low heads. It is, therefore, critical to view energy results from CRMMS in a relative manner and not in a strict numeric sense.

Power capacity is the power that could be generated if the flow is directed through the penstock turbine(s) with a given operating head. This is computed to distinguish between actual power production and the power that could be produced.

D.9.3 Davis Dam

The method that computes power and energy generations at Davis Dam uses an empirical relationship as a function of flow, operating head, plant efficiency, and user-specified power coefficients. This empirical relationship is estimated by Reclamation and was last updated in 2019 using January 2012–September 2018 historical data. Energy is computed using this empirical relationship as:

$$Energy\ (MWH) = \left(C_1 * \frac{62.4}{737.5} * Outflow\ (1000\ cfs) * HoursInMonth * \frac{OperatingHead\ (ft)}{1000} - C_2\right) * eff * 1000$$

where 62.4 is the unit weight of water in pounds per cubic foot; 737.5 represents foot-pounds per second per kilowatt; C_1 is estimated to be 0.88 based on historical data; C_2 is estimated to be 0; and eff is set to 1.0. C_1 and eff are representations of the efficiency of the powerplant, where C_1 must be a static value through the entire simulation; eff can vary (by month and/or year). C_2 represents any energy consumed within the powerplant, and is set to 0 because Reclamation does not have necessary data to determine C_2.

This energy method is different from the method used in CRSS for the 2007 FEIS; this is because the analysis of energy methods in RiverWare indicated the new method simulates historical energy generation better than the method previously used in CRSS. This new method does not currently estimate the power capacity at Davis Dam, which was computed by the method used for the 2007 FEIS.

D.9.4 Parker Dam

The method that computes power and energy generation at Parker Dam is the same method used for Davis Dam, except C_1 is set to 1.0; C_2 is estimated to be 0; and eff varies by month, as shown in **Table D-22**. The monthly efficiency coefficients are based on an analysis of historical data from PO&M reports (January 2000–April 2021).

Table D-22
Parker Dam Monthly Efficiency Coefficients

Month	Coefficient
January	0.8192
February	0.8583
March	0.8645
April	0.8732
May	0.8705
June	0.8703
July	0.8658
August	0.8631
September	0.8588
October	0.8636
November	0.8369
December	0.7710

In June 2022, this energy method was implemented in CRMMS for Parker Dam after performing analyses of different methods in RiverWare and comparing the simulated energy to actual energy as reported in historical reports. The new method was shown to outperform the previous method (used in the 2007 FEIS), particularly at higher flow and generation levels.

D.10 References

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Reclamation (Bureau of Reclamation). 2006a. Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement. February 2006. Internet website: https://www.usbr.gov/uc/envdocs/rod/fgFEIS/final-ROD-15feb06.pdf.

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Western Water Assessment. 2020. Colorado River Basin Climate and Hydrology State of the Science. Western Water Assessment. Chapter 3 Primary Planning Tools. April 2020. Internet website: https://wwa.colorado.edu/sites/default/files/2021-06/ColoRiver_StateOfScience_WWA_2020_Chapter_3.pdf

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Attachment D-1

CRMMS Lake Powell Assumed Monthly Releases

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Attachment D-1. CRMMS Lake Powell Assumed Monthly Releases

Table Attachment D-1
CRMMS Lake Powell Assumed Monthly Releases
(Values in af)

Annual Total	October	November	December	January	February	March	April	May	June	July	August	September
0	0	0	0	0	0	0	0	0	0	0	0	0
7,000,000	480,000	500,000	600,000	664,000	587,000	620,000	552,000	550,000	577,000	652,000	696,000	522,000
7,480,000	480,000	500,000	600,000	723,000	639,000	675,000	601,000	599,000	628,000	709,000	758,000	568,000
8,230,000	643,000	642,000	715,000	763,000	675,000	713,000	635,000	632,000	663,000	749,000	800,000	600,000
9,000,000	643,000	642,000	715,000	857,000	758,000	801,000	713,000	710,000	745,000	842,000	900,000	674,000
9,500,000	643,000	642,000	715,000	919,000	813,000	858,000	764,000	761,000	798,000	902,000	963,000	722,000
10,000,000	643,000	642,000	715,000	980,000	870,000	920,000	810,000	810,000	850,000	960,000	1,030,000	770,000
10,500,000	643,000	642,000	715,000	1,041,000	921,000	973,000	866,000	862,000	905,000	1,022,000	1,091,000	819,000
11,000,000	643,000	642,000	715,000	1,102,000	975,000	1,030,000	917,000	913,000	958,000	1,082,000	1,156,000	867,000
11,500,000	643,000	642,000	715,000	1,160,000	1,030,000	1,090,000	970,000	960,000	1,010,000	1,140,000	1,220,000	920,000
12,000,000	643,000	642,000	715,000	1,225,000	1,083,000	1,145,000	1,020,000	1,014,000	1,064,000	1,202,000	1,284,000	963,000
12,500,000	643,000	642,000	715,000	1,290,000	1,140,000	1,200,000	1,070,000	1,060,000	1,120,000	1,260,000	1,350,000	1,010,000
13,000,000	643,000	642,000	715,000	1,347,000	1,192,000	1,259,000	1,121,000	1,116,000	1,171,000	1,322,000	1,413,000	1,059,000
13,500,000	643,000	642,000	715,000	1,410,000	1,250,000	1,320,000	1,170,000	1,170,000	1,220,000	1,380,000	1,480,000	1,100,000
14,000,000	643,000	642,000	715,000	1,470,000	1,300,000	1,373,000	1,223,000	1,217,000	1,277,000	1,443,000	1,537,000	1,160,000
14,500,000	643,000	642,000	715,000	1,530,000	1,350,000	1,430,000	1,270,000	1,270,000	1,330,000	1,500,000	1,600,000	1,220,000
15,000,000	643,000	642,000	715,000	1,590,000	1,410,000	1,490,000	1,320,000	1,320,000	1,380,000	1,560,000	1,670,000	1,260,000
15,500,000	650,000	650,000	750,000	1,650,000	1,450,000	1,540,000	1,370,000	1,370,000	1,420,000	1,620,000	1,730,000	1,300,000
16,000,000	650,000	650,000	800,000	1,720,000	1,490,000	1,590,000	1,410,000	1,420,000	1,480,000	1,670,000	1,780,000	1,340,000
16,500,000	650,000	650,000	800,000	1,770,000	1,550,000	1,650,000	1,470,000	1,460,000	1,530,000	1,730,000	1,850,000	1,390,000
17,000,000	650,000	650,000	800,000	1,840,000	1,600,000	1,700,000	1,510,000	1,510,000	1,590,000	1,790,000	1,920,000	1,440,000
17,500,000	650,000	650,000	800,000	1,900,000	1,650,000	1,760,000	1,560,000	1,570,000	1,640,000	1,850,000	1,980,000	1,490,000
18,000,000	650,000	650,000	800,000	1,960,000	1,710,000	1,820,000	1,620,000	1,620,000	1,690,000	1,910,000	2,040,000	1,530,000
20,000,000	800,000	800,000	1,000,000	2,000,000	1,760,000	1,880,000	1,980,000	2,040,000	1,980,000	2,040,000	2,040,000	1,680,000
30,000,000	1,600,000	1,600,000	1,900,000	2,500,000	1,900,000	2,500,000	2,500,000	2,800,000	3,100,000	3,400,000	3,400,000	2,800,000
50,000,000	2,666,667	2,666,667	3,166,667	4,166,667	3,166,667	4,166,667	4,166,667	4,666,667	5,166,667	5,666,667	5,666,667	4,666,667
75,000,000	4,000,000	4,000,000	4,750,000	6,250,000	4,750,000	6,250,000	6,250,000	7,000,000	7,750,000	8,500,000	8,500,000	7,000,000

Footnote:
Releases from 7.0 to 14.0 maf are from LTEMP; releases outside this range are interpolated from LTEMP patterns for modeling purposes.

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Attachment D-2

CRMMS Lower Basin Water User Depletion Schedules

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Attachment D-2. CRMMS Lower Basin Water User Depletion Schedules

Table Attachment D-2
CRMMS Input Annual Lower Basin Water User Depletion Schedules (Values in af)

State	CRMMS Water User	2023	2024	2025	2026
Arizona	AzPumpersAbvImp	5,742	5,678	5,678	5,678
	AzPumpersBlwImp	8,984	8,984	8,984	8,984
	AzPumpersDvsToPkr	949	949	949	949
	BrookeWater	318	327	327	327
	BullheadCity	8,246	8,799	8,799	8,799
	CAP	851,619	1,524,366	1,524,366	1,524,366
	CibolaNWR	14,329	14,264	14,264	14,264
	CibolaValleyIID	12,761	13,090	13,090	13,090
	City of Parker	386	418	418	418
	City of Yuma	14,747	15,151	15,151	15,151
	Cocopah Indian Res	1,770	1,822	1,822	1,822
	CRIRAz	352,860	360,641	360,641	360,641
	DavisDamProject	2	2	2	2
	DesertLawnMemorial	27	27	27	27
	Ehrenberg	263	260	260	260
	Ft Yuma	3,123	3,123	3,123	3,123
	FtMohaveAz	39,285	44,280	44,280	44,280
	Gila Monster Farms	4,221	4,833	4,833	4,833
	GoldenShores	287	287	287	287
	HavasuNWR	2,924	3,564	3,564	3,564
	ImperialNWR	3,567	3,799	3,799	3,799
	LakeHavasuCity	8,850	9,052	9,052	9,052
	LMNRA Az Mead	69	68	68	68
	LMNRA Az Mohave	219	218	218	218
	MCAirStation	1,173	1,265	1,265	1,265
	MohaveValleyIID	17,279	22,815	22,815	22,815
	MohaveWaterConsDist	765	749	749	749
	NGVIDD	8,474	9,486	9,486	9,486
	SouthernPacific	29	29	29	29
	UnitB	13,980	12,220	12,220	12,220
	UofA	832	897	897	897
	WMIDD	253,149	278,000	278,000	278,000
	YAO	206	206	206	206
	YCWUA	260,208	277,259	277,259	277,259
	YID	35,774	38,958	38,958	38,958
	YMIDD	97,109	108,402	108,402	108,402
	YumaProvingGround	457	486	486	486
	YumaUnionHighScl	138	150	150	150

State	CRMMS Water User	2023	2024	2025	2026
Nevada	BasicManagement	0	0	0	0
	BigBend	4,080	4,704	4,704	4,704
	BoulderCanyonProject	300	300	300	300
	City of Henderson	0	0	0	0
	FtMohaveNv	3,666	4,623	4,623	4,623
	LMNRA Mead	1,241	1,500	1,500	1,500
	LMNRA Mohave	394	500	500	500
	LVWashReturns	234,967	222,204	222,204	222,204
	NvDeptFishGame	0	0	0	0
	PacificCoastBuilding	889	928	928	928
	SCE	0	0	0	0
	SNWADiversion	436,780	509,772	509,772	509,772
California	CaPumpersAbvImp	53	53	53	53
	CaPumpersDvsToPkr	414	414	414	414
	Chemehuevi	183	183	183	183
	Coachella	370,647	394,000	399,000	404,000
	CRIRCa	4,380	4,380	4,380	4,380
	FtMohaveCa	8,197	8,994	8,994	8,994
	FYIR_Ranches	2,331	2,332	2,332	2,332
	IID	2,580,442	2,612,800	2,607,800	2,607,800
	MWD	802,932	875,507	875,507	797,400
	MWDDiversion	805,543	878,107	878,107	800,000
	MWDReturns	2,611	2,600	2,600	2,600
	Needles	1,403	1,605	1,605	1,605
	PaloVerde	388,784	362,104	362,104	362,104
	SaltonSea	0	0	0	0
	Winterhaven	58	58	58	58
	YumaIsland	1,463	1,463	1,463	1,463
	YumaProject	44,844	48,668	48,668	48,668
Mexico	MexicoSched	1,404,713	1,500,000	1,500,000	1,500,000
	MexicoBypass	123,169	117,192	117,192	117,192
	MexicoExcess	35,781	28,963	28,963	28,963
	MexicoTJ	2,348	0	0	0

Footnotes:
Water user names in the table reflect the water user names in the June 2023 CRMMS. Water user names may have been updated in the Lower Basin Water Accounting Reports, and/or they may not match the Lower Basin Water Accounting Reports.

Appendix E

Shortage Allocation Model Documentation

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Contents

Tables

Attachments

Acronyms and Abbreviations

Acronym/Abbreviation	Full Phrase
2007 FEIS	2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead Final Environmental Impact Statement
2007 ROD	Record of Decision for the adoption of Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead
ADWR	Arizona Department of Water Resources
af/AF	acre-foot/feet
AFY	acre-feet per year
AOP	Annual Operating Plan
AWSA	2004 Arizona Water Settlements Act
CAP	Central Arizona Project
CAWCD	Central Arizona Water Conservation District
CRBPA	Colorado River Basin Project Act of 1968
CRMMS	Colorado River Mid-term Modeling System
CU	Consumptive Use
CVWD	Coachella Valley Water District
DCP	2019 Lower Basin Drought Contingency Plan
ICS	Intentionally Created Surplus
Interim Guidelines	2007 Colorado River Interim Guidelines for Lower Basin Shortages and Coordinated Operations for Lake Powell and Lake Mead
KAF	thousand acre-feet
LCWSP	Lower Colorado Water Supply Project
LMNRA	Lake Mead National Recreation Area
Lower Division States	Arizona, California, and Nevada
M&I	Municipal and Industrial (priority)
maf	million acre-feet
MWD	The Metropolitan Water District of Southern California
NIA	Non-Indian Agricultural (priority)
PABCO	Pacific Coast Building Products, Inc.
PPR	Present Perfected Right
QSA	Quantification Settlement Agreement
Reclamation	Bureau of Reclamation

Secretary	Secretary of the Interior
SEIS	Supplemental Environmental Impact Statement
SNWA	Southern Nevada Water Authority

Appendix E. Shortage Allocation Model Documentation

This appendix describes the Shortage Allocation Model and assumptions that were used to allocate shortages to water users in the States of Arizona, California, and Nevada (Lower Division States) as part of the analysis of alternatives in this Draft SEIS. Similar material was contained within Appendix G, Table of Sensitive Species, to 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 FEIS).

E.1 Introduction

In order to help assess the general effects of changes in the quantity of Colorado River water supplies available to water users in the Lower Division States[1] under the alternatives analyzed in this Draft SEIS, the Bureau of Reclamation developed a Shortage Allocation Model and documented the specific modeling assumptions in this appendix. This work is a supplement to a 2007 Shortage Allocation Model developed as part of the 2007 FEIS, reflecting the current conditions of Colorado River water use in the Lower Division States and the operating guidelines under review in this Draft SEIS.

E.2 Background and Purpose

The Shortage Allocation Model was created to estimate the quantity of Colorado River water that would be available to water entitlement holders or water users under shortage conditions on the mainstream lower Colorado River over a specified range of shortage volumes. A shortage condition would exist during a year when the Secretary of the Department of the Interior (Secretary), as documented in the Annual Operating Plan (AOP), determines that there is less than 7.5 million acre-feet (maf) of water available to the Lower Division States.

The Shortage Allocation Model, which is described in detail in the following sections, requires certain modeling assumptions with regard to how shortages may be allocated. Reclamation acknowledges there may be other interpretations of how shortages could be distributed. These modeling assumptions are not intended to represent current or future policy with respect to shortage sharing or to limit Secretarial discretion to distribute shortages. The Shortage Allocation Model is not a substitute for the annual process of reviewing water orders and determining annual water

[1] The US will conduct all necessary and appropriate discussions regarding the proposed federal action and implementation of the 1944 Water Treaty with Mexico through the International Boundary and Water Commission in consultation with the Department of State.

availability for each water entitlement holder on the lower Colorado River and, as such, cannot replicate the precision required for that process.

The Shortage Allocation Model simulates shortage allocations and adjusts deliveries of Colorado River water in accordance with the priority of entitlements within each of the Lower Division States' apportionments. Entitlement holders are all persons or entities authorized to beneficially use Colorado River water pursuant to: 1) a right decreed by the United States Supreme Court, 2) a contract for the delivery of Colorado River water through the Secretary, or 3) a Secretarial reservation. For a current list of each state's Colorado River water entitlement holders, please see: https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html. The Shortage Allocation Model for this Draft SEIS only reflects the application of the priority system over a limited range of shortage volumes representing current commitments pursuant to the 2007 Interim Guidelines and 2019 Lower Basin Drought Contingency Plan (DCP).

For the purposes of this SEIS, shortages implemented through operational decisions are referred to as "shortages", whereas shortages incurred as a result of unplanned or unforeseen hydrologic events and when water delivery requirements cannot be met are referred to as "system shortages". The Shortage Allocation Model cannot represent the effect of potential system shortages or physical limitations on access to water due to low river stage.

The Shortage Allocation Model developed for this Draft SEIS is not intended as an implementation tool, and it should only be used for decision support as part of this Draft SEIS.

E.3 Shortage Allocation Model Assumptions

The alternatives describe the continued implementation of existing agreements that control operations of Glen Canyon and Hoover Dams. These include the 2007 Interim Guidelines for the remainder of the interim period (through the 2026 operating year) and the 2019 DCPs. The Shortage Allocation Model is a set of Microsoft Excel worksheets that simulate shortages and distribute available water first among the Lower Division States based on the 2007 ROD and 2019 DCP and then among the entitlement holders within each state based on priority or as otherwise provided by the 2019 DCP.

The discrete volumes of total shortage to the Lower Division States considered in the Shortage Allocation Model comprise the 2007 Interim Guidelines shortage reductions and 2019 DCP water savings contributions, based on Lake Mead elevations. These volumes (in AF) are:

- 200,000
- 533,000
- 617,000
- 867,000
- 917,000
- 967,000

- 1,017,000
- 1,100,000

E.3.1 Distribution Among States

The Shortage Allocation Model distributes shortages among states based on state reductions specified in the 2007 Interim Guidelines. The Shortage Allocation Model also simulates water savings contributions that were distributed among states as agreed to in the 2019 DCP. For the purpose of analyzing the impacts of alternatives considered in this Draft SEIS, DCP contributions are assumed to represent reductions in deliveries, although parties retain flexibility in how to meet those contribution commitments.

Table E-1 below shows a distribution of shortage among the Lower Division States (which consists of both 2007 Interim Guidelines shortages and 2019 DCP water savings contributions) and corresponding volumes of water available to each Lower Division State.

Table E-1
Summary of Shortage Volumes by Lower Division State Under the Shortage Allocation Model

Total Lower Division States Shortage Volumes (AF)	Arizona Shortage Volume (AF)	Arizona Available Water (AF)	California Shortage Volume (AF)	California Available Water (AF)	Nevada Shortage Volume (AF)	Nevada Available Water (AF)
(200,000)	(192,000)	2,608,000	-	4,400,000	(8,000)	292,000
(533,000)	(512,000)	2,288,000	-	4,400,000	(21,000)	279,000
(617,000)	(592,000)	2,208,000	-	4,400,000	(25,000)	275,000
(867,000)	(640,000)	2,160,000	(200,000)	4,200,000	(27,000)	273,000
(917,000)	(640,000)	2,160,000	(250,000)	4,150,000	(27,000)	273,000
(967,000)	(640,000)	2,160,000	(300,000)	4,100,000	(27,000)	273,000
(1,017,000)	(640,000)	2,160,000	(350,000)	4,050,000	(27,000)	273,000
(1,100,000)	(720,000)	2,080,000	(350,000)	4,050,000	(30,000)	270,000

E.3.2 Distribution Within States

E.3.2.1 Introduction

In accordance with Section II(B)(3) of the Consolidated Decree and Section 301(b) of the CRBPA, the Secretary has the authority to declare and allocate shortages to the Lower Division States. Some explicit guidance is given by the Supreme Court and Congress with regard to how shortages would be allocated according to priority, and additional detail is based on interpretation of intra-state priority systems and water delivery contracts executed on behalf of the Secretary in accordance with Section 5 of the Boulder Canyon Project Act.

To estimate the impacts of given levels of shortage, assumptions were made with regard to how shortages might be shared. These assumptions are made to facilitate analysis of the potential impacts and they are not intended to represent current or future policy with respect to shortage allocation. The Shortage Allocation Model is not designed to replicate some of the annual processes that must be undertaken in determining the quantity of water that can be approved for diversion by specific users.

E.3.2.2 General State Assumptions

- Each state is using its entire apportionment each year.
- For the purpose of analyzing the impacts of alternatives considered in this Draft SEIS, DCP contributions are assumed to represent reductions in deliveries, although parties retain flexibility in how to meet those contribution commitments.
- Because state apportionments are quantified in terms of consumptive use, unquantified and diversionary entitlements were estimated in terms of an equivalent consumptive use. For diversionary entitlements, the consumptive use to diversion ratios for calculating consumptive use equivalent entitlements were derived from the 2021 *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*[2] or equivalent source data for each entitlement holder (with the exception of Present Perfected Rights (PPRs) for which the Supreme Court estimated both a diversion and consumptive use). Unquantified entitlements were modeled at their level of consumptive use in 2021, including conservation activities; this should not be taken as a limit on the future exercise of those entitlements.
    - As of the date the Shortage Allocation Model was prepared for this Draft SEIS, Reclamation's determination of a 2024 Shortage Condition was forthcoming, including documentation of the 2022 published water accounting data that will affect contractual determinations of Colorado River water availability in 2024. This Appendix E therefore uses 2021 water accounting data to remain consistent with Attachments E-1 and E-2, the most current available official documentation of some of the shortage calculations referenced in this document.
- Entitlement holders with multiple priorities are assumed to divert their highest-priority water first, until it is fully utilized, although specific geographic restrictions may exist for the actual use of various priorities.
- Entitlements are used as the basis for distributing the available water supply to individual users.
- With the exception of PPRs, entitlement holders within a priority or sub-priority share in a pro-rata distribution of available water on the basis of entitlement, unless another distribution is prescribed by contract or other determination. Within priorities other than PPRs, priority dates are not considered except as they pertain to grouping entitlements by priority.
- Current and/or future paybacks of overruns or underruns under the Inadvertent Overrun and Payback Policy, creation or use of Intentionally Created Surplus (ICS), or interstate storage and release are not considered in the Shortage Allocation Model.

[2] Internet website: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2021/2021.pdf, also known as "Decree Accounting".

- PPRs (on a consumptive use or equivalent basis) are not included in the distribution of shortage within each state; they are subtracted from the water calculated to be available to each state, which water is then distributed in satisfaction of non-PPR entitlements, and the PPRs are accounted for in a separate PPR worksheet. A fill order is assumed for PPRs (see **Section E.3.3**), although no shortages are modeled to invoke that fill order.
- Individual entitlements are assigned to one of three categories (domestic, irrigation, or Tribal) by their primary use or intended benefit, for the purpose of generalizing shortage impacts. No attempt is made to pro-rate shared irrigation and domestic entitlements by actual use. The current proportions of irrigation and domestic use of these entitlements may change in a shortage condition due to contract-specific terms and conditions and/or the discretion of the entitlement holder.

E.3.2.3 Nevada Assumptions

- Nevada has eight water delivery priorities as established in the Robert B. Griffith Water Project Contract No. 7-07-30-W0004, as amended, for delivery of Colorado River water between the US and the State of Nevada; the contract also provides for the Southern Nevada Water Authority (SNWA) to divert the balance of any remaining un-allocated, unused, and surplus water in Nevada. **Table E-2** summarizes that priority system, which is also available at https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html.
- Deliveries to Nevada are no longer assumed to be constrained by Lake Mead surface elevation as assumed in the 2007 FEIS; however, the Shortage Allocation Model does not reflect the effect of potential system shortages or physical limitations on access to water.
- The Shortage Allocation Model calculates shortage to Nevada entitlement holders relative to their consumptive use entitlement (or equivalent); however, the discrete volumes of total shortage considered in the Shortage Allocation Model pursuant to the 2007 Interim Guidelines and 2019 DCP do not result in priority system-based reductions to Nevada parties other than SNWA. The SNWA member agencies may make further arrangements for the distribution of water amongst themselves during a Shortage Condition.

Table E-2
Framework for Priority-Based Distribution of Available Water Within Nevada

Priority	Entitlement Holder	Contract No.	Priority Date	Use	Entitlements: Diversion (AFY)	Entitlements: CU or Estimated Equivalent (AFY)[1]	Entitlements: Cumulative CU (AFY)
9thth	Any contracts dated after 3-2-1992, SNWA Contract						
8thth – Balance & Surplus	Southern Nevada Water Authority	2-07-30-W0266	3/2/1992	M&I	balance + surplus	93,975	
	TOTAL					93,975	291,303
8thth	Big Bend Water District	2-07-30-W0269	3/2/1992	M&I	10,000	4,718	
	Robert B. Griffith Project Sub. to City of Boulder City (8,918af) Sub. to City Henderson (27,021af) Sub. to City of North Las Vegas (26,635af) Sub. to Las Vegas Valley Water District (232,426af)	7-07-30-W0004	3/2/1992	M&I	308,000	146,342	
	TOTAL				**318,000**	151,060	197,327
7th	Southern Nevada Water Authority (Formerly Boy Scouts of America)[2]	9-07-30-W0011	11/8/1978	M&I	10	5	
	Bureau of Reclamation (includes Sportsman Park)	Secretarial Res.	11/9/1998	M&I	300	168	
	Nevada Dept. of Wildlife (formerly Nevada Dept. of Fish & Game)	14-06-300-2405	10/18/1972	M&I		25	
	US Air Force (4,000af) (Delivery from SNWA)[2]	F26600-78-DOO11, amended by F-26600-01-D-A111 (Included in 07-07-30-W0004 in P8)	1/23/1978, amended 5/1/2000		4,000	1,901	
	TOTAL				**4,310**	2,099	46,267
6th	Las Vegas Valley Water District[2]	14-06-300-2130	9/22/1969	M&I	15,407	7,320	
	TOTAL				**15,407**	7,320	44,169
5th	Lakeview Company (Hacienda Casino)	14-06-300-1523	2/12/1965	M&I	0	0	
	Pacific Coast Building Products, Inc. (PABCO)	5-07-30-W0089	6/19/1985	M&I	928	928	
	TOTAL				**928**	928	36,848

Priority	Entitlement Holder	Contract No.	Priority Date	Use	Entitlements		
					Diversion (AFY)	CU or Estimated Equivalent (AFY)[1]	Cumulative CU (AFY)
4th	Basic Water Company (formerly Basic Management, Inc.)	14-06-300-2083	9/18/1969	M&I	8,208	8,208	
	City of Henderson	0-07-30-W0246	9/18/1969	M&I	15,878	14,503	
	Southern Nevada Water Authority (From Basic Water Company)[2]	2-07-30-W0266	9/18/1969	M&I	14,950	7,103	
	TOTAL				**39,036**	29,814	35,920
3rd	Boulder City[3]	14-06-300-978	5/15/1931	M&I	5,876	5,876	
	TOTAL				5,876	5,876	6,106
2nd	Lake Mead National Recreation Area[4], Executive Order No. 5339	1964 Decree	4/25/1930	M&I	Unquantified, estimated ~1,500	230	
	TOTAL				**1,500**	230	230
NEVADA TOTALS					385,057	291,303	

Note: CU means Consumptive Use. All units are in acre-feet per year. The Cumulative CU column is included as a reference for the estimated amount of water that would need to be available to Nevada priorities two through eight to fulfill a given priority on this table.

Subcontracts are displayed below the Entitlement Holder and indented five spaces.

In a shortage, PPRs are delivered water in order of priority date regardless of state lines. PPRs are not included in this table and they are accounted for in a separate PPR worksheet.

[1]2021 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

[2]Water for this entitlement is delivered through the Robert B. Griffith Project. 2021 Decree Accounting for the Robert B. Griffith Project and Las Vegas Wash return flows were used to estimate the consumptive use equivalent for these diversions.

[3]Though Boulder City's entitlement is delivered through the Robert B. Griffith Project, there are no return flows from Boulder City, so its consumptive use was assumed to be equivalent to diversion.

[4]This unlimited entitlement is estimated based on 2021 use, minus the Lake Mead National Recreation Area PPR.

E.3.2.4 California Assumptions

- Entitlements shown in **Table E-3** for California priorities one through three exclude the full volume of PPR entitlements held by those same parties, which are subject to a separate priority system (see **Section E.3.3**).
- Reclamation recognizes that the Quantification Settlement Agreement (QSA) and related agreements help California parties meet the water needs of PPRs by agreeing that certain parties to the Seven Party Agreement would make water available to satisfy the requirements of the PPR holders while keeping the priorities within the Seven Party Agreement intact. In addition, the QSA helped quantify entitlements in the Seven Party Agreement, which is necessary to model shortages.
  - The quantified entitlements in the QSA for the Imperial Irrigation District and the Coachella Valley Water District were modeled in the Shortage Allocation Model.
  - QSA transfers and exchanges were not modeled in the Shortage Allocation Model since the shortage levels simulated do not trigger QSA shortage provisions.
- Although the Metropolitan Water District of Southern California (MWD) has a fourth priority Seven Party Agreement entitlement of 550,000 af, MWD's consumptive use equivalent entitlement is calculated (for modeling purposes) to equal the balance of California's apportionment after full use of higher priority entitlements. During a shortage, MWD may acquire a minimum of 25,000 af from the Palo Verde Irrigation District, though this is not modeled in the Shortage Allocation Model.
- The Shortage Allocation Model attributes 93% of California DCP contributions to MWD and 7% of California DCP contributions to Coachella Valley Water District pursuant to a May 20, 2019 DCP Implementation Agreement Between Metropolitan Water District of Southern California and Coachella Valley Water District. No shortages from the 2007 Interim Guidelines are applicable to California.
- Entitlements associated with each California entitlement holder are available at: https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html.
- Shortage to California entitlement holders, in this case comprised solely of DCP contributions, is calculated relative to their consumptive use entitlement (or equivalent).

Table E-3
Framework for Priority-Based Distribution of Available Water Within California

Priority	Entitlement Holder	Contract No.	Priority Date	Use	Diversion (AFY)	CU Entitlement (AFY)	Entitlements	
							CU or Estimated Equivalent (AFY)	Cumulative CU (AFY)
4th	The Metropolitan Water District of Southern California (MWD) (4)	I1r-645	1930, 1931	M&I		550,000	429,852	**1,705,724**
	TOTAL				**0**	**550,000**	**429,852**	
3rd	Palo Verde Irrigation District (3b) – Lower Palo Verde Mesa Lands[1]	PVID20733C_P5	1933	Ag	≤16,000 acres	Unquantified	4,156	
	Coachella Valley Water District (CVWD) Total (3a)	I1r-781	1934			330,000	330,000	
	Imperial Irrigation District (IID) (3a)[2]	I1r-747	1932			615,000	615,000	
	TOTAL[3]					**945,000**	**949,156**	**1,275,872**
2nd	Yuma Project, Reservation Division (Bard Unit Only – Indian Unit Under PPRs)[4]	Water Certificates	1905	Ind./Ag	≤25,000 acres		3,459	
	TOTAL				**0**	**0**	**3,459**	**326,716**
1st	Palo Verde Irrigation District – Valley Lands (1)[5]	PVID20733C_P2	1933	Ag	≤104,500 acres	Unquantified	323,258	
	TOTAL				**0**	**0**	**323,258**	**323,258**
	CALIFORNIA TOTALS						**1,705,724**	

Notes: CU means Consumptive Use; all units are in AFY (acre feet per year). The Cumulative CU column is included as a reference for the estimated amount of water that would need to be available to California priorities one through four to fulfill a given priority on this table.

Priorities are based on the California Seven Party Agreement, modified for the PPRs identified by the Consolidated Decree (which are accounted for in the PPRs tab).

Unless otherwise noted, 2021 Decree Accounting values and Diversion/CU conversion ratios were used to estimate not specified and unquantified entitlements.

PPRs are not included in this table and they are accounted for in a separate PPR worksheet.

[1]PVID Lower Palo Verde Mesa Lands' 2022 Diversion of 9,134 af was assumed to be more representative of future conditions than the 2021 Diversion. The CU/Diversion ratio of about 0.455 for the entire PVID, based on 2021 accounting, was used to estimate the CU equivalent.

[2]Non-Colorado River water is pumped from the Lower Colorado Water Supply Project (LCWSP) wellfield and discharged into the All-American Canal for delivery to IID. IID forbears the consumptive use of an equivalent amount of Colorado River, up to a maximum of 10,000 af per year, to make such water available, via exchange, to the LCWSP beneficiaries (includes MWD and the City of Needles and its subcontractors). For purposes of the Shortage Allocation Model, the 10,000 af is included in IID's estimated CU equivalent; if the LCWSP was non-operational, that water would be diverted from the Colorado River by IID.

[3]QSA transfers and exchanges are not modeled in the Shortage Allocation Model since shortages to California are not triggered at the modeled shortage levels.

[4]The Yuma Project CU Estimated Equivalent is based on the 2021 CU from the Bard Unit, plus the amount conserved by the Bard Unit that was made available to MWD, minus the CU from PPR 28, which is accounted for in the PPRs tab. The Yuma Project Reservation Division Indian Unit is not accounted for here, since its use is fully satisfied by PPR 23, also listed in the PPRs tab.

E.3.2.5 Arizona Assumptions

- In 2007, consumptive use schedules were provided by the Arizona Department of Water Resources (ADWR) for use in the Shortage Allocation Model for the period 2008 through 2060. ADWR and Reclamation have not undertaken a process to update those schedules; shortage to Arizona entitlement holders is instead assessed relative to recent available data as described below for each priority.
- Central Arizona Project (CAP) excess and unused water contracts and mainstream unused apportionment or surplus (fifth and/or sixth priority) entitlements are not available in shortage and they are assumed to bear the remainder of any shortage not assigned to other parties within Arizona; they are assumed to be out of priority in all levels of shortage and they are not itemized.
- The Shortage Allocation Model does not attempt to redistribute water that may be available within a priority but is unordered by any specific entitlement holder.
- Entitlements associated with each Arizona entitlement holder are available at: https://www.usbr.gov/lc/region/g4000/contracts/entitlements.html.

Water available to entitlement holders in Arizona is distributed through each priority according to the following assumptions. These assumptions do not necessarily reflect operational procedure, but they are necessary to produce a general approximation of the effect of shortages on specific priorities and entitlement holders for the purpose of comparing alternatives in this Draft SEIS.

E.3.2.5.1 Arizona Priority Two and Three Assumptions

Arizona priority two is for Secretarial Reservations and Perfected Rights established or effective prior to September 30, 1968. Arizona priority three is for entitlements pursuant to contracts between the US and water users in the State of Arizona executed on or before September 30, 1968. The second and third priorities are coequal.

Water supply to the Arizona second and third priorities is not projected to be affected at the specified levels of shortage and DCP contributions contemplated in the Shortage Allocation Model, because the Arizona fourth priority is not projected to be fully reduced. Thus it is unnecessary to analyze the relative priority of individual entitlements within the second and third priorities for purposes of assessing impacts within those priorities in this Appendix E; however, because information on the Arizona second and third priorities is included in the Shortage Allocation Model worksheets and second and third priority entitlements are enumerated in summary tables in this Appendix, modeling assumptions are described below.

The available supply to Arizona priorities two and three is calculated as the available supply to Arizona minus an average of the 4 highest of the last 5 years (2017–2021) of use by the first priority (PPR), or 519,154 AF. That supply is divided between priorities two and three in proportion to the sum of the consumptive use (or equivalent) entitlements within each priority: about 10 percent to priority two and about 90 percent to priority three. The 2007 Shortage Allocation Model did not distinguish between priority two and three supplies. The following assumptions for distribution within those priorities are intended to improve the accuracy of estimated impacts by considering contract-specific priority language.

Shortage is measured by the difference between water available to an entitlement during shortage and the 2021 adjusted consumptive use of that entitlement. Shortage is assumed to begin for priorities two and three when available supply is less than total 2021 adjusted consumptive use for both priorities, not reflecting the potential difference between orders and use. In addition, distributions of available water on the basis of entitlement may result in a shortage to certain entitlements and no shortage to others. The Shortage Allocation Model does not contain data for estimated orders in this priority or attempt to redistribute water that may be available, but unordered.

Water available to priority two is distributed among its five entitlements in proportion to their consumptive use (or equivalent) entitlement relative to the total for priority two.

Water available to priority three is distributed among its 28 entitlements in six groups according to project and/or division or pertinent contract terms. The alphanumeric sub-priority naming conventions for the six groups (shown in **Table E-4** below) are not operational or contractual designations, and they are only used as an organizational tool specific to this analysis. Five of the six groups are assumed to be coequal within priority three, and they are distributed water in proportion to the sum of the consumptive use (or equivalent) entitlements within each group, relative to the total for all five groups. They are discussed in detail in the sections that follow.

Table E-4
Framework for Priority-Based Distribution of Available Water Within Arizona Priorities 2 and 3

Priority	Water Allocation % by Priority	Sub-Priority	Project	Division	Water Allocation % by Project/Division	Entitlement Holder	Contract No.	Priority Date	Use	Entitlements: Diversion (AFY)	Entitlements: CU or *Estimated Equivalent* (AFY)
2nd	9.94%	N/A	N/A	N/A	N/A	Cibola National Wildlife Refuge	Secretarial Res.	8/21/1964	M&I	34,500	16,793
						Lake Mead National Recreation Area	Consolidated Decree	4/25/1930	M&I	unquantified	*306*
						Bureau of Reclamation – Davis Dam	Secretarial Res.	4/26/1941	M&I	100	*3*
						Imperial National Wildlife Refuge	Consolidated Decree	2/14/1941	M&I	28,000	23,000
						Havasu National Wildlife Refuge	Consolidated Decree	1/22/1941	M&I	41,839	37,399
										P2 Total	**77,501**
3rd	90.06%	3b	Boulder Canyon		Remainder	City of Yuma	14-06-W-106	11/12/1959	M&I		48,522
										Project/Division Subtotal	**48,52**
		3a5 Subordinate	Gila	Yuma Mesa	33.03%	Union Pacific Railroad (formerly Southern Pacific Co.)	14-06-303-1524	12/21/1959	M&I	48	*29*
						Kaman, Inc.	14-06-303-1555	12/2/1959	M&I	2	0
						Department of the Navy, MCAS	14-06-300-937	1/1/1959	M&I	3,000	*3,000*
						City of Yuma (cemetery)	14-06-303-1078	5/1/1956	M&I	60	0
						Yuma Mesa Fruit Growers' Association	14-06-303-1196	10/1/1956	M&I	15	0
						Desert Lawn Memorial Park Association	14-06-300-1079	5/1/1956	M&I	200	*140*
						Sturges, Harold	I76R-733	1/1/1952	Ag	335	*0*
						Sturges, Irma	I76R-735	1/1/1952	Ag	385	*0*
		3a5				**Yuma Mesa Irrigation & Drainage District (10,000af M&I)**	5-07-30-W0095	5/26/1956	M&I/Ag		141,519
						Yuma Irrigation District (5,000af M&I)	5-07-30-W0093	7/23/1962	M&I/Ag		67,278
						North Gila Valley Irrigation and Drainage District (2,500af M&I)	5-07-30-W0094	5/12/1953	M&I/Ag		*3,920*
										Project/Division Subtotal	***215,88***
		3a4	Gila	Wellton-Mohawk	42.53%	**Wellton-Mohawk Irrigation and Drainage District (12,000af M&I)**	1-07-30-W0021	3/4/1952	M&I/Ag		278,000
										Project/Division Subtotal	***278,00***
		3a3	Various		11.73%	Ak-Chin Indian Community	1985 Settlement Contract	1/1/1956	M&I/Ag	50,000	*50,000*
						Chandler (Salt River Pima-Maricopa Exchange)	9-07-30-W0235	3/4/1952	M&I	4,278	*4,278*
						Gilbert (Salt River Pima-Maricopa Exchange)	9-07-30-W0241	3/4/1952	M&I	6,762	*6,762*
						Glendale (Salt River Pima-Maricopa Exchange)	9-07-30-W0236	3/4/1952	M&I	3,000	*3,000*
						Mesa (Salt River Pima-Maricopa Exchange)	9-07-30-W0239	3/4/1952	M&I	2,760	*2,760*
						Phoenix (Salt River Pima-Maricopa Exchange)	9-07-30-W0240	3/4/1952	M&I	5,000	*5,000*
						Scottsdale (Salt River Pima-Maricopa Exchange)	9-07-30-W0237	3/4/1952	M&I	100	*100*
						Tempe (Salt River Pima-Maricopa Exchange)	9-07-30-W0238	3/4/1952	M&I	100	*100*
						Department of the Army — Yuma Proving Ground	I76r-696	6/12/1951	M&I	1,129	*1,129*
						Gila Monster Farms (formerly Sturges)	6-07-30-W0337	1/1/1952	Ag	6,285	3,516
										Project/Division Subtotal	***76,64***
		3a2 Subordinate	Yuma		10.69%	Yuma Union High School District	14-06-303-179	1/1/1953	M&I	200	*150*
		3a2				**Yuma County Water Users' Association (14,701af M&I includes YAO)**	14-06-300-621 & Certificates	4/1/1957	M&I/Ag	unquantified	*69,690*
										Project/Division Subtotal	***69,84***
		3a1 Subordinate	Yuma Auxiliary		2.02%	University of Arizona	14-06-300-144	1/1/1954	Ag	1,088	*1,088*
						Camille Allec, Jr. (Formerly Yuma Mesa Grapefruit Company)	14-06-303-528	12/23/1953	Ag	120	0
		3a1				**Unit B Irrigation & Drainage District**	14-06-300-44	12/22/1952	Ag	unquantified	*12,145*
Grand Total	**100.00%**									**Project/Division Subtotal**	**13,233**
										P3a Total	**653,605**
										P3 Total	**702,127**
										P 2 & 3 Grand Total	**779,628**

The Yuma Mesa Division of the Gila Project

Approximately 33 percent of the available priority three water, up to the limit of the sum of the consumptive use (or equivalent) entitlements within the Division, is distributed among the Division's 11 entitlements. That water is first made available to Yuma Mesa Irrigation and Drainage District, Yuma Irrigation District, and North Gila Valley Irrigation and Drainage District coequally in proportion to their consumptive use entitlements.[3]

Any water remaining for the Division after satisfaction of the district contracts is made available to Union Pacific Railroad, Department of the Navy (Marine Corps Air Station), and Desert Lawn Memorial Park Association coequally in proportion to their consumptive use equivalent entitlements.[4]

The Kaman, City of Yuma (Cemetery), Yuma Mesa Fruit Growers Association, Harold Sturges, and Irma Sturges entitlements[5] are assumed to be unexercised and they are not distributed water; they are shown with a consumptive use equivalent entitlement of zero.

The Wellton-Mohawk Division of the Gila Project

Approximately 43 percent of the available priority three water, up to the limit of Wellton-Mohawk Irrigation and Drainage District's consumptive use entitlement, is made available to the District.[4]

The Yuma Project

Approximately 11 percent of the available priority three water is first made available to the Yuma County Water Users Association up to the limit of its consumptive use equivalent entitlement. Any water remaining for the Yuma Project after satisfaction of the Association contract is made available to Yuma Union High School District.[5]

The Yuma Auxiliary Project

Approximately 2.0 percent of the available priority three water, up to the limit of the sum of the consumptive use equivalent entitlements within the Yuma Auxiliary Project, is distributed among the Yuma Auxiliary Project's three entitlements. That water is first made available to Unit B Irrigation and Drainage District up to the limit of its consumptive use equivalent entitlement. Any water remaining for the Yuma Auxiliary Project after satisfaction of the District contract is made available to the University of Arizona.[5] The Camille Allec, Jr. entitlement[5] is assumed to be unexercised and it is not distributed water; it is shown with a consumptive use equivalent entitlement of zero.

Various Entitlements

A group of 10 entitlements established under various authorities shares approximately 12 percent of the available priority three water, up to the limit of the sum of the consumptive use (or equivalent) entitlements within the group. Water is distributed to the Ak-Chin Indian Community; the Arizona cities of Chandler, Gilbert, Glendale, Mesa, Phoenix, Scottsdale, and Tempe; the Department of the Army (Yuma Proving Ground); and Gila Monster Farms coequally in proportion to their

[3] Domestic use within each district's entitlement is assumed to be subordinated to irrigation use in the district, but is not itemized separately.
[4] Water use is subject to availability and is assumed not to be detrimental to water service for the project or prior appropriators.

consumptive use (or equivalent) entitlements. The distribution of water is stated in terms of quantities available at the mainstream point of diversion, and no assumptions are made about the further distribution of priority three water delivered through the CAP.

The City of Yuma

The City of Yuma gets a distribution of all remaining priority three water, up to the limit of its consumptive use entitlement (minus a portion assumed to be satisfied by PPR No. 21), reflecting that water delivery under its Contract No. 14-06-W-106 is subject to the prior fulfillment of contracts for the diversion of Colorado River water at Imperial Dam and for the delivery of such water through the Gila Gravity Main Canal or the All-American Canal for the irrigation of lands in the State of Arizona.

E.3.2.5.2 Arizona Priority Four Assumptions

Reclamation implemented the State of Arizona's August 6, 2009, Arizona Shortage Sharing Recommendation and the "pool" approach described by letter dated January 25, 2021, to inform approval of fourth priority water orders for operational years 2022 and 2023. Consistent with the Arizona mainstream Colorado River water priority system, the approach recognizes that the fourth priority Colorado River water entitlements of the P4(i) or 'mainstream' users and the CAP (P4(ii)) are coequal.

The Shortage Allocation Model uses the same fourth priority shortage sharing assumptions documented and described in:

- Reclamation's September 14, 2022 letter notifying interested parties of a Tier 2 Shortage Condition and required DCP contributions in operational year 2023 (Attachment E-1 to this Appendix E)
- Reclamation's September 28, 2022 letter to the Central Arizona Water Conservation District announcing the operational year 2023 Available CAP Supply (Attachment E-2 to this Appendix E)

Those assumptions result in the P4(i) pool receiving 9.85 percent of the Arizona fourth priority Colorado River water available under the modeled shortage scenarios, while the remainder is available for diversion as fourth priority water by the CAP to fulfill CAP contracts and subcontracts.

E.3.2.5.3 P4(i) (Mainstream) Framework and Assumptions

Water is distributed to each entitlement within the P4(i) pool in proportion to its diversion[5] volume relative to the current total for the pool, 151,274 AFY, which does not include outstanding ADWR recommendations, unallocated water, or the 3,500 AFY reserved for use in a future Navajo-Hopi

[5] Historically Arizona P4(i) entitlements have been quantified on a diversion basis. More recently some entitlements, currently including the Bureau of Land Management's and Town of Queen Creek's Arizona P4(i) entitlements, specify consumptive use volumes (consumptive use = diversions minus return flows). These entitlements are shown in Table E-5 as their diversion equivalents (consumptive use + return flows = diversion equivalent) for modeling purposes because distribution during shortage within the Arizona P4(i) pool currently is administered in proportion to all users' diversion volumes, not in proportion to consumptive use volumes, for uniformity and consistency. The diversion equivalency volumes listed in Table E-5 are necessary to analyze the distribution of the Arizona P4(i) entitlements with a uniform metric, do not modify the entitlements, and are consistent with applicable contracts and agency decision documents.

Indian water rights settlement in accordance with subsection 11.3 of the 2006 Arizona Water Settlement Agreement. (See **Table E-5**)

Contracts and subcontracts are itemized separately, meaning an entity's total modeled supply may be the sum of multiple distributions.

Table E-5
Framework for Priority-Based Distribution of Available Water Within Arizona P4(i) (Mainstream)

4th Priority Mainstream Entitlement Holders	4th Priority Contract Information				Initial Proportional Distribution of 4thth Priority Mainstream Available Supply			
	Contract Number(s)	Date	Type of Use	Diversion Entitle-ment in AFY	Divided By	Sum of Entitle-ments in AFY	Equals	Proportionate Share of 4th Priority Mainstream Pool
Arizona Game and Fish Commission	07-XX-30-W0509	2007	Irrigation	2,838.00	/	151,274	=	1.876%
Arizona State Land Department	4-07-30-W0317	1999	Irrigation	6,607.00	/	151,274	=	4.368%
Beattie Farms, Southwest	05-XX-30-W0446	2006	Irrigation	1,110.00	/	151,274	=	0.734%
Bishop, Alfred F. and Erma Jean Family Trust	21-XX-30-W0718	1983	Irrigation	420.00	/	151,274	=	0.278%
Cathcart, Bruce Y. and Lora M. and James Y. and Maria E.	21-XX-30-W0719	1983	Irrigation	126.00	/	151,274	=	0.083%
ChaCha, LLC	09-XX-30-W0539	2009	Irrigation	2,100.00	/	151,274	=	1.388%
Cibola Sportsman's Club, Inc.	21-XX-30-W0717	1983	Irrigation	216.00	/	151,274	=	0.143%
Cibola Valley Irrigation and Drainage District	2-07-30-W0028	1983	Irrigation/Domestic	7,442.52	/	151,274	=	4.920%
Cocopah Indian Reservation	Consolidated Decree in AZ v. CA	1974	Irrigation/Domestic	2,026.00	/	151,274	=	1.339%
Curtis, Armon	3-07-30-W0037	1983	Irrigation	300.00	/	151,274	=	0.198%
Gila Monster Farms, Inc.	6-07-30-W0337	1997	Irrigation	1,435.00	/	151,274	=	0.949%
GM Gabrych Family Limited Partnership	17-XX-30-W0628	2018	Irrigation	4,500.00	/	151,274	=	2.975%
GSC Farm, LLC[6]	13-XX-30-W0571	2013	Irrigation	69.93	/	151,274	=	1.926%
Hopi Tribe	04-XX-30-W0432	2004	Irrigation	4,278.00	/	151,274	=	2.828%
JRJ Partners, L.L.C.	06-XX-30-W0448	2007	Irrigation	1,080.00	/	151,274	=	0.714%
Mohave Valley Irrigation and Drainage District	14-06-W-204	1968	Irrigation/Domestic	35,060.00	/	151,274	=	23.176%
North Baja Pipeline, LLC	04-XX-30-W0433	2005	Irrigation/Domestic	480.00	/	151,274	=	0.317%
Ogram Boys Enterprises, Inc.	01-XX-30-W0402	2005	Irrigation	924.00	/	151,274	=	0.611%
Ott, Larry and Gina, and Lee C. and Candace M.	18-XX-30-W0639	2018	Irrigation	480.00	/	151,274	=	0.317%
Pasquinelli, Gary J. and Barbara J.	5-07-30-W0065	1986	Irrigation	486.00	/	151,274	=	0.321%
Red River Land Company, LLC	17-XX-30-W0630	2018	Irrigation	300.00	/	151,274	=	0.198%
Western Water, LLC	16-XX-30-W0619	2018	Irrigation	536.48	/	151,274	=	0.355%
Arizona State Land Department	7-07-30-W0358	2004	Domestic	1,534.00	/	151,274	=	1.014%
Arizona State Parks Board - Windsor Beach	7-07-30-W0364	1998	Domestic	90.00	/	151,274	=	0.059%
B&F Investment, LLC	06-XX-30-W0453	2006	Domestic	60.00	/	151,274	=	0.040%
Bullhead City	2-07-30-W0273	1994	Domestic	15,210.00	/	151,274	=	10.055%
Bullhead City (MCWA Subcontract)	Subcontract to 04-XX-30-W0431	2004	Domestic	2,139.00	/	151,274	=	1.414%
Bullhead City (MCWA Subcontract)	Subcontract No. 95-102 to 5-07-30-W0320	1995	Domestic	7,000.00	/	151,274	=	4.627%
Bureau of Land Management (diversion equivalent)	8-07-30-W0373	2000	Domestic	6,169.00	/	151,274	=	4.078%
Crystal Beach Water Conservation District	6-07-30-W0352	1997	Domestic	132.00	/	151,274	=	0.087%
Desert Lawn Memorial Park Association, Inc.	14-06-300-2587	1975	Domestic	360.00	/	151,274	=	0.238%
Ehrenburg Improvement District	8-07-30-W0006	1977	Domestic	735.00	/	151,274	=	0.486%
EPCOR Water Arizona Inc.	20-XX-30-W0690	2021	Domestic	1,874.00	/	151,274	=	1.239%
Fisher's Landing Water and Sewer Works, L.L.C.	06-XX-30-W0450	2006	Domestic	53.00	/	151,274	=	0.035%
Frontier Communications West Coast Inc.	14-06-300-2506	1974	Domestic	1.00	/	151,274	=	0.001%
Gold Dome Mining Corporation	0-07-30-W0250	1990	Domestic	7.00	/	151,274	=	0.005%
Gold Standard Mines Corp.	3-07-30-W0038	1983	Domestic	75.00	/	151,274	=	0.050%

[6] On April 28, 2023, the US executed a partial assignment and transfer of Arizona P4(i) Colorado River water from GSC Farm, LLC to the Town of Queen Creek. Table E-5, which previously only included the GSC Farm, LLC entitlement, has been revised to include the assignment and transfer volumes, and the Shortage Allocation Model reflects an updated proportionate share of the Arizona P4(i) entitlement pool for both GSC Farm, LLC and the Town of Queen Creek (with the nontransferable historical return flow volume modeled in the diversion equivalent volume). Otherwise, the assignment and transfer does not modify the Arizona P4(i) pool volume under contract or the framework and assumptions discussed herein.

4th Priority Mainstream Entitlement Holders	4th Priority Contract Information				Initial Proportional Distribution of 4thth Priority Mainstream Available Supply			
	Contract Number(s)	Date	Type of Use	Diversion Entitle-ment in AFY	Divided By	Sum of Entitle-ments in AFY	Equals	Proportionate Share of 4th Priority Mainstream Pool
Golden Shores Water Conservation District	9-07-30-W0203	1989	Domestic	2,000.00	/	151,274	=	1.322%
Hillcrest Water Company	5-07-30-W0078	1985	Domestic	84.00	/	151,274	=	0.056%
Lake Havasu City	3-07-30-W0039	1995	Domestic	19,192.70	/	151,274	=	12.687%
Lake Havasu City (MCWA Subcontract)	Subcontract to 04-XX-30-W0431	2004	Domestic	2,139.00	/	151,274	=	1.414%
Lake Havasu City (MCWA Subcontract)	Subcontract No. 95-101 to 5-07-30-W0320	1995	Domestic	7,250.00	/	151,274	=	4.793%
La Paz County	08-XX-30-W0530	2008	Domestic	350.00	/	151,274	=	0.231%
McAlister Family Trust	7-07-30-W0355	1998	Domestic	40.00	/	151,274	=	0.026%
Mohave Valley Irrigation and Drainage District (MCWA Subcontract)	Subcontract No. 09-101 to 5-07-30-W0320	1995	Domestic	1,250.00	/	151,274	=	0.826%
Mohave Water Conservation District	9-07-30-W0012	1979	Domestic	1,800.00	/	151,274	=	1.190%
Mohave Water Conservation District (MCWA Subcontract)	Subcontract No. 95-103 to 5-07-30-W0320	1995	Domestic	3,000.00	/	151,274	=	1.983%
Parker, Town of	2-07-30-W0025	1982	Domestic	1,030.00	/	151,274	=	0.681%
Quartzsite, Town of	7-07-30-W0353	1999	Domestic	1,070.00	/	151,274	=	0.707%
Queen Creek, Town of (mainstream diversion equivalent)	20-XX-30-W0689	2023	Domestic	2,843.37	/	151,274	=	1.880%
Roy, Estates of Anna R. and Edward P.	6-07-30-W0124	1986	Domestic	1.00	/	151,274	=	0.001%
Shepard Water Company, Incorporated	08-XX-30-W0535	2009	Domestic	50.00	/	151,274	=	0.033%
Somerton, City of	03-XX-30-W0419	2006	Domestic	750.00	/	151,274	=	0.496%
Springs Del Sol Domestic Water Improvement District	08-XX-30-W0524	2008	Domestic	100.00	/	151,274	=	0.066%
TV Marble Canyon AZ, LLC	5-07-30-W0322	1996	Domestic	70.00	/	151,274	=	0.046%
Total				**151,274**				**100%**

Each entitlement's proportional share of the available P4(i) supply is initially calculated on a diversion (or mainstream diversion equivalent) basis, then converted to a consumptive use equivalent using consumptive use to diversion ratios from the operational year 2021 *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*[7] or equivalent source data. Shortage is calculated as the difference between each entitlement's consumptive use equivalent supply and its 2021 consumptive use adjusted for participation in conservation programs (if applicable). The Shortage Allocation Model does not contain data for estimated orders in this priority, and therefore cannot illustrate the potential effect of the pool approach to redistributing water that may be available but unordered under any specific entitlement.

E.3.2.5.4 CAP Framework and Assumptions

In the Shortage Allocation Model, Arizona priority three Colorado River water entitlements delivered through the CAP are assumed to be fully satisfied consistent with their Colorado River third priority, and Arizona fourth priority (P4(i)) water transported through the CAP is assumed to be satisfied according to its priority. Terms and conditions for priority in case of shortage to the Available CAP Supply relate only to CAP fourth priority water (P4(ii)). The Shortage Allocation Model attempts to reflect the legislative and contractual terms and conditions applicable to CAP (P4(ii)) shortages, which shortage would impact the CAP P4(ii) distribution to CAP contractors and subcontractors.

Levels of shortage to date have not required the implementation of shortage provisions in all CAP contracts, and their modeling should be understood as theoretical.

[7] Internet website: https://www.usbr.gov/lc/region/g4000/4200Rpts/DecreeRpt/2021/2021.pdf, also known as Decree Accounting.

Available CAP Supply is first made available to Indian and Municipal & Industrial (M&I) Priority long-term contracts and subcontracts, and then to Non-Indian Agricultural (NIA) Priority long-term contracts and subcontracts. After all long-term CAP contracts and subcontracts are fulfilled[8], the remaining available water could be ordered under one-year excess contracts; however, none of the modeled shortage volumes are assumed to provide for enough available supply for excess contracts under the assumptions of the model.

The Shortage Allocation Model calculates Available CAP Supply as described in Reclamation's September 28, 2022 letter to the Central Arizona Water Conservation District (Attachment E-2 to this Appendix). A range of Available CAP Supply from zero to 1,251,317 AF, in rounded 10,000 af increments except at pivotal quantities, is presented in **Table E-6** below; all of these discrete levels of supply are contained within the Shortage Allocation Model, but because this Draft SEIS only includes a distribution analysis over a specified range of shortage volumes, certain rows on **Table E-6** below an Available CAP Supply of 810,000 AF are not projected to be implicated under the assumptions of the Shortage Allocation Model. These rows are shaded gray to indicate inactivity in the analysis, but are included in this Appendix E for constancy.

Table E-6
Discrete Levels and Distribution of Available CAP Supply Modeled in the Shortage Allocation Model

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
1,251,317	Full Supply	343,079	638,823	269,415
1,250,000	Full Supply	343,079	638,823	268,098
1,240,000	Full Supply	343,079	638,823	258,098
1,230,000	Full Supply	343,079	638,823	248,098
1,220,000	Full Supply	343,079	638,823	238,098
1,210,000	Full Supply	343,079	638,823	228,098
1,200,000	Full Supply	343,079	638,823	218,098
1,190,000	Full Supply	343,079	638,823	208,098
1,180,000	Full Supply	343,079	638,823	198,098
1,170,000	Full Supply	343,079	638,823	188,098
1,160,000	Full Supply	343,079	638,823	178,098
1,150,000	Full Supply	343,079	638,823	168,098
1,140,000	Full Supply	343,079	638,823	158,098
1,130,000	Full Supply	343,079	638,823	148,098
1,120,000	Full Supply	343,079	638,823	138,098
1,110,000	Full Supply	343,079	638,823	128,098
1,100,000	Full Supply	343,079	638,823	118,098
1,090,000	Full Supply	343,079	638,823	108,098
1,080,000	Full Supply	343,079	638,823	98,098

[8] Under Article 3.(b) of the 1985 Contract Between the United States and the Ak-Chin Indian Community to Provide Permanent Water and Settle Interim Water Rights, in any year in which sufficient surface water is available, the Secretary shall deliver certain additional water to the Ak-Chin Indian Community. Such water is assumed to be available if there is unused CAP water after CAP orders under long-term contracts and subcontracts are fulfilled; however, there is assumed to be no unused CAP water at the volumes of shortage modeled.

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
1,070,000	Full Supply	343,079	638,823	88,098
1,060,000	Full Supply	343,079	638,823	78,098
1,050,000	Full Supply	343,079	638,823	68,098
1,040,000	Full Supply	343,079	638,823	58,098
1,030,000	Full Supply	343,079	638,823	48,098
1,020,000	Full Supply	343,079	638,823	38,098
1,010,000	Full Supply	343,079	638,823	28,098
1,000,000	Full Supply	343,079	638,823	18,098
990,000	Full Supply	343,079	638,823	8,098
981,902	Formula	343,079	638,823	-
980,000	Formula	342,595	637,405	-
970,000	Formula	340,051	629,949	-
960,000	Formula	337,508	622,492	-
950,000	Formula	334,964	615,036	-
940,000	Formula	332,420	607,580	-
930,000	Formula	329,876	600,124	-
920,000	Formula	327,332	592,668	-
910,000	Formula	324,789	585,211	-
900,000	Formula	322,245	577,755	-
890,000	Formula	319,701	570,299	-
880,000	Formula	317,157	562,843	-
870,000	Formula	314,613	555,387	-
860,000	Formula	312,070	547,930	-
853,079	36.37518%	310,309	542,770	-
850,000	36.37518%	309,189	540,811	-
840,000	36.37518%	305,552	534,448	-
830,000	36.37518%	301,914	528,086	-
820,000	36.37518%	298,276	521,724	-
819,828	36.37518%	298,214	521,614	-
810,000	36.37518%	294,639	515,361	-
801,574	36.37518%	291,574	510,000	-
800,000	36.37518%	291,001	508,999	-
790,000	36.37518%	287,364	502,636	-
780,000	36.37518%	283,726	496,274	-
770,000	36.37518%	280,089	489,911	-
760,000	36.37518%	276,451	483,549	-
750,000	36.37518%	272,814	477,186	-
740,000	36.37518%	269,176	470,824	-
730,000	36.37518%	265,539	464,461	-
720,000	36.37518%	261,901	458,099	-
710,000	36.37518%	258,264	451,736	-
700,000	36.37518%	254,626	445,374	-
690,000	36.37518%	250,989	439,011	-
680,000	36.37518%	247,351	432,649	-
670,000	36.37518%	243,714	426,286	-
660,000	36.37518%	240,076	419,924	-

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
650,000	36.37518%	236,439	413,561	-
640,000	36.37518%	232,801	407,199	-
630,000	36.37518%	229,164	400,836	-
620,000	36.37518%	225,526	394,474	-
610,000	36.37518%	221,889	388,111	-
600,000	36.37518%	218,251	381,749	-
590,000	36.37518%	214,614	375,386	-
580,000	36.37518%	210,976	369,024	-
570,000	36.37518%	207,339	362,661	-
560,000	36.37518%	203,701	356,299	-
550,000	36.37518%	200,064	349,936	-
540,000	36.37518%	196,426	343,574	-
530,000	36.37518%	192,788	337,212	-
520,000	36.37518%	189,151	330,849	-
510,000	36.37518%	185,513	324,487	-
500,000	36.37518%	181,876	318,124	-
490,000	36.37518%	178,238	311,762	-
480,000	36.37518%	174,601	305,399	-
470,000	36.37518%	170,963	299,037	-
460,000	36.37518%	167,326	292,674	-
450,000	36.37518%	163,688	286,312	-
440,000	36.37518%	160,051	279,949	-
430,000	36.37518%	156,413	273,587	-
420,000	36.37518%	152,776	267,224	-
410,000	36.37518%	149,138	260,862	-
400,000	36.37518%	145,501	254,499	-
390,000	36.37518%	141,863	248,137	-
380,000	36.37518%	138,226	241,774	-
370,000	36.37518%	134,588	235,412	-
360,000	36.37518%	130,951	229,049	-
350,000	36.37518%	127,313	222,687	-
340,000	36.37518%	123,676	216,324	-
330,000	36.37518%	120,038	209,962	-
320,000	36.37518%	116,401	203,599	-
310,000	36.37518%	112,763	197,237	-
300,000	36.37518%	109,126	190,874	-
290,000	36.37518%	105,488	184,512	-
280,000	36.37518%	101,851	178,149	-
270,000	36.37518%	98,213	171,787	-
260,000	36.37518%	94,575	165,425	-
250,000	36.37518%	90,938	159,062	-
240,000	36.37518%	87,300	152,700	-
230,000	36.37518%	83,663	146,337	-
220,000	36.37518%	80,025	139,975	-
210,000	36.37518%	76,388	133,612	-
200,000	36.37518%	72,750	127,250	-

Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	M&I Priority Supply (AF)	NIA Priority Supply (AF)
190,000	36.37518%	69,113	120,887	-
180,000	36.37518%	65,475	114,525	-
170,000	36.37518%	61,838	108,162	-
160,000	36.37518%	58,200	101,800	-
150,000	36.37518%	54,563	95,437	-
140,000	36.37518%	50,925	89,075	-
130,000	36.37518%	47,288	82,712	-
120,000	36.37518%	43,650	76,350	-
110,000	36.37518%	40,013	69,987	-
100,000	36.37518%	36,375	63,625	-
90,000	36.37518%	32,738	57,262	-
80,000	36.37518%	29,100	50,900	-
70,000	36.37518%	25,463	44,537	-
60,000	36.37518%	21,825	38,175	-
50,000	36.37518%	18,188	31,812	-
40,000	36.37518%	14,550	25,450	-
30,000	36.37518%	10,913	19,087	-
20,000	36.37518%	7,275	12,725	-
10,000	36.37518%	3,638	6,362	-
-	36.37518%	-	-	-

Through term-limited or temporary arrangements, to the extent that such arrangements may be allowed under specific long-term CAP contracts or other legal authority, CAP contractors and subcontractors may make their water available for end use by others. The Shortage Allocation Model does not replicate those arrangements, and it only provides approximate estimates at the contract or subcontract allocation level that interested parties could then consider in planning for administering their respective arrangements during shortage conditions. The CAP contractor, subcontractor, and/or parties to those arrangements would have specific decisions to make during shortage conditions to administer those arrangements that Reclamation cannot predict with sufficient certainty to analyze in this Draft SEIS.

The Shortage Allocation Model does not attempt to replicate the provisions of the CAP priority system that provide for unordered water to be made available to other contractors or subcontractors within a priority, or unordered water from one priority to be made available to another.

Shortage volumes are calculated as the difference between available water distributed to each allocation and the 2024–2026 projected water orders associated with that allocation, as compiled for the 2023 Arizona DCP Implementation Plan Exhibit 7.1 dated December 15, 2022[9]. Allocations which are currently unused are shown as bearing no shortage, and unallocated or water not yet placed under contract (including the Secretary's retention of 6,411 AFY of CAP NIA Priority water for use for a future water rights settlement agreement approved by an Act of Congress that settles the Navajo Nation's claims to water in Arizona, consistent with the Arizona Water Settlements Act

[9] Internet website: https://new.azwater.gov/sites/default/files/media/2022.12.15%20Exhibit%207.1%20Public%20Posting.pdf.

of 2004, section 104(a)) is not reflected in the distribution of available water and is not shown as bearing shortage. These modeling assumptions reflect only that it cannot be speculated when or whether such water or volumes may be allocated or placed under contract, but are not intended to preclude allocations or the entry of contracts during the remainder of the interim period consistent with applicable law and authority.

CAP Indian Priority Assumptions

The overall deliverable quantity of Indian Priority supply is calculated as authorized in the 2004 Arizona Water Settlements Act (AWSA) (Public Law 108-451) section 104(d). The available Indian Priority supply is then distributed as described in applicable law, contracts, and subcontracts and as noted below.

Shortage to the Ak-Chin Indian Community's Indian Priority irrigation allocation is shown at the allocation level, and it does not reflect the conditional entitlement to a portion of that allocation that is held by the San Carlos Apache Tribe. In addition, the shortages attributed to Indian Priority allocations, pursuant to the internal priority system of the Indian Priority pool, do not account for the existence of external arrangements and commitments that would affect the ultimate impacts of shortage. For example, the ultimate impact of shortage may fall in whole or in part on a lessor who has leased a portion of a contractor's Indian Priority water, but the terms and duration of such leasing arrangements are varied, and the arrangement does not change the underlying allocation-holder. Shortages attributed to Indian Priority allocations in the Shortage Allocation Model form the basis for additional analyses on a case-by-case basis as necessary to administer shortage consistent with applicable contracts and subcontracts.

Further, the Shortage Allocation Model does not analyze any applicable Secretarial obligations to deliver certain contractors or subcontractors other sources of water in any given year, which might have the effect of offsetting or negating the numerical impacts shown to specific Indian Priority pool allocations and could appear to understate the regional effect of a Colorado River shortage. This Draft SEIS presents the worst case impacts of a regional loss of supply relative to the quantified volumes of Colorado River water the Secretary has allocated and contracted for and actively administers, rather than attempting to analyze and monetize the loss relative to all sources of water supply any given water user may have available.

For the purpose of calculating water available to individual Indian Priority allocations, the Indian Priority supply is distributed under a set of assumptions consistent with AWSA section 104(d) and the approach described in Exhibit 5.3.4.1 to the Tohono O'odham Settlement Agreement[10], *Secretary's Approach for Determining the Amount of Water Available to the Nation During a Time of Shortage Under 1980 Contract*, except as provided in the following paragraph.

Calculations for the distribution of water are performed as though all Indian Priority entitlements were fully used during the most recent operational year which was not a Time of Shortage.

[10] Attachment E-3 to this Appendix E

These assumptions yield the distribution of available Indian Priority water shown in **Table E-7** for a range of discrete Available CAP Supplies. All of these discrete levels of supply are contained within the Shortage Allocation Model, but because this draft SEIS only includes a distribution analysis over a specified range of shortage volumes, certain rows on **Table E-7** below a CAP Available Supply of 810,000 AF are not projected to be implicated under the assumptions of the Shortage Allocation Model. These rows are shaded gray to indicate inactivity in the analysis, but are included in this Appendix E for constancy.

Table E-7
Distribution of CAP Indian Priority Supply

	Post-AWSA Contracts						Pre-AWSA Contracts									
			Distribution to Contractors (AF)						Distribution to Contractors (AF)							
Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	Gila River Indian Community	Tohono O'odham Nation (SX & ST)	White Mountain Apache Tribe	Scottsdale (Yavapai Prescott Indian Tribe)	Indian Priority Share	Indian Priority Supply (AF)	Ak-Chin Indian Community	Fort McDowell Yavapai Nation	Pascua Yaqui Tribe	San Carlos Apache Tribe	Salt River Pima-Maricopa Indian Community	Sif Oidak District	Tonto Apache Tribe	Yavapai Apache Nation
990,000	Full Supply	343,079	191,200	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
981,902	Formula	343,079	191,200	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
980,000	Formula	342,595	190,716	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
970,000	Formula	340,051	188,172	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
960,000	Formula	337,508	185,629	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
950,000	Formula	334,964	183,085	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
940,000	Formula	332,420	180,541	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
930,000	Formula	329,876	177,997	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
920,000	Formula	327,332	175,453	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
910,000	Formula	324,789	172,910	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
900,000	Formula	322,245	170,366	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
890,000	Formula	319,701	167,822	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
880,000	Formula	317,157	165,278	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
870,000	Formula	314,613	162,734	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
860,000	Formula	312,070	160,191	37,800	1,218	500	Full Supply	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
853,079	36.37518%	310,309	158,430	37,800	1,218	500	Imputed	343,079	58,300	18,233	500	12,700	13,300	8,000	128	1,200
850,000	36.37518%	309,189	157,802	37,800	1,218	500	Imputed	340,000	57,951	18,233	500	12,684	13,220	7,952	128	1,200
840,000	36.37518%	305,552	155,762	37,800	1,218	500	Imputed	330,000	56,820	18,233	500	12,631	12,962	7,797	128	1,200
830,000	36.37518%	301,914	153,723	37,800	1,218	500	Imputed	320,000	55,688	18,233	500	12,579	12,704	7,642	128	1,200
820,000	36.37518%	298,276	151,683	37,800	1,218	500	Imputed	310,000	54,556	18,233	500	12,527	12,446	7,486	128	1,200
819,828	36.37518%	298,214	151,648	37,800	1,218	500	Imputed	309,828	54,536	18,233	500	12,526	12,441	7,484	128	1,200
810,000	36.37518%	294,639	149,644	37,800	1,218	500	Imputed	300,000	53,424	18,233	500	12,474	12,188	7,331	128	1,200
801,574	36.37518%	291,574	147,925	37,800	1,218	500	Either	291,574	52,470	18,233	500	12,430	11,970	7,200	128	1,200
800,000	36.37518%	291,001	147,635	37,726	1,216	499	36.37518%	291,001	52,367	18,197	499	12,406	11,946	7,186	128	1,198
790,000	36.37518%	287,364	145,789	37,254	1,200	493	36.37518%	287,364	51,712	17,970	493	12,251	11,797	7,096	126	1,183
780,000	36.37518%	283,726	143,944	36,783	1,185	487	36.37518%	283,726	51,058	17,742	487	12,095	11,648	7,006	125	1,168
770,000	36.37518%	280,089	142,098	36,311	1,170	480	36.37518%	280,089	50,403	17,515	480	11,940	11,499	6,916	123	1,153
760,000	36.37518%	276,451	140,253	35,839	1,155	474	36.37518%	276,451	49,749	17,287	474	11,785	11,349	6,827	121	1,138
750,000	36.37518%	272,814	138,407	35,368	1,140	468	36.37518%	272,814	49,094	17,060	468	11,630	11,200	6,737	120	1,123
740,000	36.37518%	269,176	136,562	34,896	1,124	462	36.37518%	269,176	48,439	16,832	462	11,475	11,051	6,647	118	1,108

	Post-AWSA Contracts						Pre-AWSA Contracts										
Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	Distribution to Contractors (AF)				Indian Priority Share	Indian Priority Supply (AF)	Distribution to Contractors (AF)								
			Gila River Indian Community	Tohono O'odham Nation (SX & ST)	White Mountain Apache Tribe	Scottsdale (Yavapai Prescott Indian Tribe)			Ak-Chin Indian Community	Fort McDowell Yavapai Nation	Pascua Yaqui Tribe	San Carlos Apache Tribe	Salt River Pima-Maricopa Indian Community	Sif Oidak District	Tonto Apache Tribe	Yavapai Apache Nation
730,000	36.37518%	265,539	134,717	34,425	1,109	455	36.37518%	265,539	47,785	16,605	455	11,320	10,901	6,557	117	1,093
720,000	36.37518%	261,901	132,871	33,953	1,094	449	36.37518%	261,901	47,130	16,377	449	11,165	10,752	6,467	115	1,078
710,000	36.37518%	258,264	131,026	33,482	1,079	443	36.37518%	258,264	46,476	16,150	443	11,010	10,603	6,377	113	1,063
700,000	36.37518%	254,626	129,180	33,010	1,064	437	36.37518%	254,626	45,821	15,923	437	10,855	10,453	6,288	112	1,048
690,000	36.37518%	250,989	127,335	32,538	1,048	430	36.37518%	250,989	45,167	15,695	430	10,700	10,304	6,198	110	1,033
680,000	36.37518%	247,351	125,489	32,067	1,033	424	36.37518%	247,351	44,512	15,468	424	10,545	10,155	6,108	109	1,018
670,000	36.37518%	243,714	123,644	31,595	1,018	418	36.37518%	243,714	43,857	15,240	418	10,390	10,005	6,018	107	1,003
660,000	36.37518%	240,076	121,798	31,124	1,003	412	36.37518%	240,076	43,203	15,013	412	10,235	9,856	5,928	105	988
650,000	36.37518%	236,439	119,953	30,652	988	405	36.37518%	236,439	42,548	14,785	405	10,080	9,707	5,839	104	973
640,000	36.37518%	232,801	118,108	30,181	972	399	36.37518%	232,801	41,894	14,558	399	9,924	9,557	5,749	102	958
630,000	36.37518%	229,164	116,262	29,709	957	393	36.37518%	229,164	41,239	14,330	393	9,769	9,408	5,659	101	943
620,000	36.37518%	225,526	114,417	29,237	942	387	36.37518%	225,526	40,584	14,103	387	9,614	9,259	5,569	99	928
610,000	36.37518%	221,889	112,571	28,766	927	381	36.37518%	221,889	39,930	13,875	381	9,459	9,109	5,479	97	913
600,000	36.37518%	218,251	110,726	28,294	912	374	36.37518%	218,251	39,275	13,648	374	9,304	8,960	5,389	96	898
590,000	36.37518%	214,614	108,880	27,823	897	368	36.37518%	214,614	38,621	13,420	368	9,149	8,811	5,300	94	883
580,000	36.37518%	210,976	107,035	27,351	881	362	36.37518%	210,976	37,966	13,193	362	8,994	8,661	5,210	93	868
570,000	36.37518%	207,339	105,190	26,880	866	356	36.37518%	207,339	37,311	12,966	356	8,839	8,512	5,120	91	853
560,000	36.37518%	203,701	103,344	26,408	851	349	36.37518%	203,701	36,657	12,738	349	8,684	8,363	5,030	89	838
550,000	36.37518%	200,064	101,499	25,936	836	343	36.37518%	200,064	36,002	12,511	343	8,529	8,213	4,940	88	823
540,000	36.37518%	196,426	99,653	25,465	821	337	36.37518%	196,426	35,348	12,283	337	8,374	8,064	4,850	86	808
530,000	36.37518%	192,788	97,808	24,993	805	331	36.37518%	192,788	34,693	12,056	331	8,219	7,915	4,761	85	793
520,000	36.37518%	189,151	95,962	24,522	790	324	36.37518%	189,151	34,039	11,828	324	8,064	7,765	4,671	83	778
510,000	36.37518%	185,513	94,117	24,050	775	318	36.37518%	185,513	33,384	11,601	318	7,909	7,616	4,581	81	763
500,000	36.37518%	181,876	92,272	23,579	760	312	36.37518%	181,876	32,729	11,373	312	7,753	7,467	4,491	80	749
490,000	36.37518%	178,238	90,426	23,107	745	306	36.37518%	178,238	32,075	11,146	306	7,598	7,317	4,401	78	734
480,000	36.37518%	174,601	88,581	22,635	729	299	36.37518%	174,601	31,420	10,918	299	7,443	7,168	4,312	77	719
470,000	36.37518%	170,963	86,735	22,164	714	293	36.37518%	170,963	30,766	10,691	293	7,288	7,019	4,222	75	704
460,000	36.37518%	167,326	84,890	21,692	699	287	36.37518%	167,326	30,111	10,463	287	7,133	6,869	4,132	73	689
450,000	36.37518%	163,688	83,044	21,221	684	281	36.37518%	163,688	29,456	10,236	281	6,978	6,720	4,042	72	674
440,000	36.37518%	160,051	81,199	20,749	669	274	36.37518%	160,051	28,802	10,008	274	6,823	6,571	3,952	70	659
430,000	36.37518%	156,413	79,354	20,278	653	268	36.37518%	156,413	28,147	9,781	268	6,668	6,421	3,862	69	644
420,000	36.37518%	152,776	77,508	19,806	638	262	36.37518%	152,776	27,493	9,554	262	6,513	6,272	3,773	67	629
410,000	36.37518%	149,138	75,663	19,334	623	256	36.37518%	149,138	26,838	9,326	256	6,358	6,123	3,683	65	614
400,000	36.37518%	145,501	73,817	18,863	608	250	36.37518%	145,501	26,183	9,099	250	6,203	5,973	3,593	64	599
390,000	36.37518%	141,863	71,972	18,391	593	243	36.37518%	141,863	25,529	8,871	243	6,048	5,824	3,503	62	584
380,000	36.37518%	138,226	70,126	17,920	577	237	36.37518%	138,226	24,874	8,644	237	5,893	5,675	3,413	61	569
370,000	36.37518%	134,588	68,281	17,448	562	231	36.37518%	134,588	24,220	8,416	231	5,738	5,525	3,323	59	554
360,000	36.37518%	130,951	66,436	16,977	547	225	36.37518%	130,951	23,565	8,189	225	5,583	5,376	3,234	57	539
350,000	36.37518%	127,313	64,590	16,505	532	218	36.37518%	127,313	22,911	7,961	218	5,427	5,227	3,144	56	524
340,000	36.37518%	123,676	62,745	16,033	517	212	36.37518%	123,676	22,256	7,734	212	5,272	5,077	3,054	54	509

	Post-AWSA Contracts						Pre-AWSA Contracts									
			Distribution to Contractors (AF)						Distribution to Contractors (AF)							
Available CAP Supply (AF)	Indian Priority Share	Indian Priority Supply (AF)	Gila River Indian Community	Tohono O'odham Nation (SX & ST)	White Mountain Apache Tribe	Scottsdale (Yavapai Prescott Indian Tribe)	Indian Priority Share	Indian Priority Supply (AF)	Ak-Chin Indian Community	Fort McDowell Yavapai Nation	Pascua Yaqui Tribe	San Carlos Apache Tribe	Salt River Pima-Maricopa Indian Community	Sif Oidak District	Tonto Apache Tribe	Yavapai Apache Nation
330,000	36.37518%	120,038	60,899	15,562	501	206	36.37518%	120,038	21,601	7,506	206	5,117	4,928	2,964	53	494
320,000	36.37518%	116,401	59,054	15,090	486	200	36.37518%	116,401	20,947	7,279	200	4,962	4,779	2,874	51	479
310,000	36.37518%	112,763	57,208	14,619	471	193	36.37518%	112,763	20,292	7,051	193	4,807	4,629	2,785	50	464
300,000	36.37518%	109,126	55,363	14,147	456	187	36.37518%	109,126	19,638	6,824	187	4,652	4,480	2,695	48	449
290,000	36.37518%	105,488	53,518	13,676	441	181	36.37518%	105,488	18,983	6,596	181	4,497	4,331	2,605	46	434
280,000	36.37518%	101,851	51,672	13,204	425	175	36.37518%	101,851	18,328	6,369	175	4,342	4,181	2,515	45	419
270,000	36.37518%	98,213	49,827	12,732	410	168	36.37518%	98,213	17,674	6,142	168	4,187	4,032	2,425	43	404
260,000	36.37518%	94,575	47,981	12,261	395	162	36.37518%	94,575	17,019	5,914	162	4,032	3,883	2,335	42	389
250,000	36.37518%	90,938	46,136	11,789	380	156	36.37518%	90,938	16,365	5,687	156	3,877	3,733	2,246	40	374
240,000	36.37518%	87,300	44,290	11,318	365	150	36.37518%	87,300	15,710	5,459	150	3,722	3,584	2,156	38	359
230,000	36.37518%	83,663	42,445	10,846	349	143	36.37518%	83,663	15,056	5,232	143	3,567	3,435	2,066	37	344
220,000	36.37518%	80,025	40,599	10,375	334	137	36.37518%	80,025	14,401	5,004	137	3,412	3,285	1,976	35	329
210,000	36.37518%	76,388	38,754	9,903	319	131	36.37518%	76,388	13,746	4,777	131	3,256	3,136	1,886	34	314
200,000	36.37518%	72,750	36,909	9,431	304	125	36.37518%	72,750	13,092	4,549	125	3,101	2,987	1,796	32	299
190,000	36.37518%	69,113	35,063	8,960	289	119	36.37518%	69,113	12,437	4,322	119	2,946	2,837	1,707	30	284
180,000	36.37518%	65,475	33,218	8,488	274	112	36.37518%	65,475	11,783	4,094	112	2,791	2,688	1,617	29	269
170,000	36.37518%	61,838	31,372	8,017	258	106	36.37518%	61,838	11,128	3,867	106	2,636	2,539	1,527	27	254
160,000	36.37518%	58,200	29,527	7,545	243	100	36.37518%	58,200	10,473	3,639	100	2,481	2,389	1,437	26	240
150,000	36.37518%	54,563	27,681	7,074	228	94	36.37518%	54,563	9,819	3,412	94	2,326	2,240	1,347	24	225
140,000	36.37518%	50,925	25,836	6,602	213	87	36.37518%	50,925	9,164	3,185	87	2,171	2,091	1,258	22	210
130,000	36.37518%	47,288	23,991	6,130	198	81	36.37518%	47,288	8,510	2,957	81	2,016	1,941	1,168	21	195
120,000	36.37518%	43,650	22,145	5,659	182	75	36.37518%	43,650	7,855	2,730	75	1,861	1,792	1,078	19	180
110,000	36.37518%	40,013	20,300	5,187	167	69	36.37518%	40,013	7,200	2,502	69	1,706	1,643	988	18	165
100,000	36.37518%	36,375	18,454	4,716	152	62	36.37518%	36,375	6,546	2,275	62	1,551	1,493	898	16	150
90,000	36.37518%	32,738	16,609	4,244	137	56	36.37518%	32,738	5,891	2,047	56	1,396	1,344	808	14	135
80,000	36.37518%	29,100	14,763	3,773	122	50	36.37518%	29,100	5,237	1,820	50	1,241	1,195	719	13	120
70,000	36.37518%	25,463	12,918	3,301	106	44	36.37518%	25,463	4,582	1,592	44	1,085	1,045	629	11	105
60,000	36.37518%	21,825	11,073	2,829	91	37	36.37518%	21,825	3,928	1,365	37	930	896	539	10	90
50,000	36.37518%	18,188	9,227	2,358	76	31	36.37518%	18,188	3,273	1,137	31	775	747	449	8	75
40,000	36.37518%	14,550	7,382	1,886	61	25	36.37518%	14,550	2,618	910	25	620	597	359	6	60
30,000	36.37518%	10,913	5,536	1,415	46	19	36.37518%	10,913	1,964	682	19	465	448	269	5	45
20,000	36.37518%	7,275	3,691	943	30	12	36.37518%	7,275	1,309	455	12	310	299	180	3	30
10,000	36.37518%	3,638	1,845	472	15	6	36.37518%	3,638	655	227	6	155	149	90	2	15
-	36.37518%	-	-	-	-	-	36.37518%	-	-	-	-	-	-	-	-	-

CAP M&I Priority Assumptions

The M&I Priority supply is calculated as the remainder of Available CAP Supply (up to 981,902 AF) not made available for delivery as Indian Priority supply. When Available CAP Supply equals or exceeds 981,902 AF, the Indian and M&I Priorities both receive a full supply.

The available M&I Priority supply is distributed to each allocation in proportion to 2024–2026 projected water orders, relative to total projected orders for M&I Priority water. (The proportions are shown below in **Table E-8**) This assumption is consistent with a joint consultation undertaken by Reclamation and the Central Arizona Water Conservation District (CAWCD) with M&I Priority water users in 2022.[11]

Table E-8
Distribution of CAP M&I Priority Water in Proportion to 2024-2026 Orders

M&I Contractor or Subcontractor	2024-2026 Orders (AF)	Percentage of Orders
Freeport-Morenci (SCAT Lease)	5,645	0.94%
Scottsdale (SCAT Lease)	12,500	2.07%
ASARCO	21,000	3.48%
Avondale	5,416	0.90%
AZSLD	5,200	0.86%
AZWC, Casa Grande	8,884	1.47%
AZWC, Coolidge	2,000	0.33%
AZWC, Superstition	6,285	1.04%
AZWC, White Tank	968	0.16%
Buckeye	223	0.04%
CAGRD	6,426	1.07%
Carefree WC	886	0.15%
Cave Creek	2,606	0.43%
Chandler	8,654	1.44%
Chaparral City WC	8,909	1.48%
Circle City	-	0.00%
El Mirage	508	0.08%
Eloy	2,171	0.36%
EPCOR, AF	11,093	1.84%
EPCOR, PV	3,231	0.54%
EPCOR, SC	4,189	0.70%
EPCOR, SCW	2,372	0.39%
Florence	2,048	0.34%
Freeport-Miami	2,906	0.48%
FWID	2,854	0.47%
Gilbert	7,235	1.20%
Glendale	17,236	2.86%
Goodyear	10,742	1.78%
Greater Tonopah, Water Utility	64	0.01%
Green Valley CWC	-	0.00%
Green Valley DWID	-	0.00%
Marana	2,336	0.39%
Maricopa Cty P&R	665	0.11%

[11] As documented by Letter Agreement No. 22-XX-30-W0743LA between Reclamation and CAWCD, dated May 15, 2023.

M&I Contractor or Subcontractor	2024-2026 Orders (AF)	Percentage of Orders
Mesa	43,503	7.22%
Metro DWID (Includes ICS Creation)	13,460	2.23%
Oro Valley	10,305	1.71%
Peoria	27,121	4.50%
Phoenix	122,204	20.28%
Pine	-	0.00%
Queen Creek	495	0.08%
Rio Verde Utilities	812	0.13%
San Tan ID	-	0.00%
Scottsdale	52,810	8.76%
Spanish Trail WC	3,037	0.50%
Surprise	10,249	1.70%
Tempe	4,315	0.72%
Tonopah	-	0.00%
Tonto Hills DWID	71	0.01%
Tucson	144,191	23.93%
Vail WC	1,857	0.31%
WUCFD, Apache Junction	2,919	0.48%
TOTAL	**602,601**	**100.00%**

CAP NIA Priority Assumptions

Only when Available CAP Supply is calculated to be greater than 981,902 AF, the NIA Priority supply is calculated as the difference between Available CAP Supply and the sum of the Indian and M&I Priority entitlements. NIA Priority supply is assumed not to be available when Available CAP Supply is less than 981,902 AF.

The Shortage Allocation Model does not contain data for CAP water use in the most recent year that a full NIA Priority supply (inclusive of NIA-A and NIA-B) was available. However, in this modeling, available water is distributed first to NIA Priority contractors and subcontractors assumed to have used CAP NIA Priority Water in the last year in which the Available CAP Supply was sufficient to fill all orders for CAP NIA Priority Water (NIA-A) (**Table E-9**), before available water is distributed to the other NIA Priority contracts and subcontracts (NIA-B) (**Table E-10**).[12] Within each sub-priority, available water is modeled as being distributed to each allocation in proportion to 2024-2026 projected water orders, relative to total projected orders for the sub-priority.

[12] The CAP NIA Priority Water is distributed in accordance with the CAP NIA Priority Water subcontracts, in particular paragraph 4.7(b)-(c) of such subcontracts, and the settlement agreements with the Gila River Indian Community and the Tohono O'odham Nation. The Hualapai Tribe's CAP NIA Priority water will be distributed in accordance with its settlement agreement (pending enforceability) and the Hualapai Tribe Water Rights Settlement Act of 2022, in particular section 13.

Table E-9
Distribution of CAP NIA-A Priority Water in Proportion to 2024-2026 Orders

NIA A Priority Contractor or Subcontractor	2024-2026 Orders (AF)	Percentage of Orders
GRIC (own account)	102,415	50.93%
Tohono O'odham - Schuk Toak & San Xavier	28,200	14.02%
CAGRD [GRIC]	18,185	9.04%
Phoenix	37,280	18.54%
Chandler	3,924	1.95%
Gilbert	1,537	0.76%
Glendale	682	0.34%
Mesa	5,551	2.76%
Scottsdale	3,306	1.64%
Tempe	23	0.01%
TOTAL	**201,103**	**100.00%**

Table E-10
Distribution of CAP NIA-B Priority Water in Proportion to 2024–2026 Orders

NIA B Priority Contractor or Subcontractor	2024-2026 Orders (AF)	Percentage of Orders
WMAT	-	0.00%
Buckeye	2,786	6.26%
CAGRD	18,185	40.84%
Carefree WC	112	0.25%
Cave Creek	386	0.87%
El Mirage	1,318	2.96%
EPCOR, San Tan (ST)	3,217	7.22%
Freeport	5,678	12.75%
Gilbert	1,832	4.11%
Marana	515	1.16%
Queen Creek	4,162	9.35%
Resolution Copper	2,238	5.03%
Rosemont Copper	1,124	2.52%
SRP	2,160	4.85%
WUCFD, Apache Junction	817	1.83%
TOTAL	**44,530**	**100.00%**

E.3.3 Present Perfected Rights Assumptions

This analysis does not result in a reduction to PPRs according to the fill order provided below in **Table E-11** (bottom up), derived from Paragraph 5 of the Appendix to the Consolidated Decree. As set forth in the Consolidated Decree, the PPR priority system is administered without regard to state lines. This information is included for reference in cases where the Shortage Allocation Model distinguished PPRs from other priorities of water held by a single entitlement holder. PPRs are also enumerated in summary tables, but are shown as bearing no shortage under the alternatives.

Table E-11
Present Perfected Right Summary and Assumed Fill Order

Entitlements

Arizona, California, and Nevada Summary	CU Equivalent (AF)	Diversion (AF)
Arizona Total	567,499	1,077,971
California Total	2,694,276	3,019,573
Nevada Total	8,697	13,034
Total	3,270,473	4,110,578

Entitlement Holders	CU Equivalent (AF)†	Diversion (AF)	PPR No.	Date	State	Category	Cumulative Consumptive Use Equivalent (AF)
Lake Mead National Recreation Area (Overton Area, EO 5105)	300	500	82	1929	NV	Federal Establishments & Water Projects	3,270,473
Molina	64	318	15	1928	AZ	Miscellaneous	3,270,173
Sonny Gowan (Grannis)	108	180	32	1928	CA	Miscellaneous	3,270,109
Diehl*	0.6	1	59	1928	CA	Miscellaneous	3,270,001
Stallard*	0.6	1	66	1928	CA	Miscellaneous	3,270,000
Estrada*	0.6	1	77	1928	CA	Miscellaneous	3,269,999
Corrington*	0.6	1	79	1928	CA	Miscellaneous	3,269,999
Tolliver*	0.6	1	80	1928	CA	Miscellaneous	3,269,998
Randolph*	0.6	1	65	1926	CA	Miscellaneous	3,269,998
Keefe*	0.6	1	67	1926	CA	Miscellaneous	3,269,997
Sturges (Gila Monster Farms, Inc.)	436	780	16	1925	AZ	Miscellaneous	3,269,996
Chagnon	72	120	41	1925	CA	Miscellaneous	3,269,560
Faubion*	0.6	1	48	1925	CA	Miscellaneous	3,269,488
Earle*	0.6	1	58	1925	CA	Miscellaneous	3,269,487
Whittle*	0.6	1	78	1925	CA	Miscellaneous	3,269,487
Beauchamp*	0.6	1	51	1924	CA	Miscellaneous	3,269,486
McGee*	0.6	1	63	1924	CA	Miscellaneous	3,269,486
Stallard*	0.6	1	64	1924	CA	Miscellaneous	3,269,485
Hadlock*	0.6	1	72	1924	CA	Miscellaneous	3,269,484
Stephenson	137	240	30	1923	CA	Miscellaneous	3,269,484
Draper, G.*	0.6	1	46	1923	CA	Miscellaneous	3,269,347
Dudley*	0.6	1	49	1922	CA	Miscellaneous	3,269,346
Colorado River Sportsmen's League	58	96	36	1921	CA	Miscellaneous	3,269,346
Andrade	37	66	38	1921	CA	Miscellaneous	3,269,288
Conger*	0.6	1	45	1921	CA	Miscellaneous	3,269,251
Vaulin*	0.6	1	70	1920	CA	Miscellaneous	3,269,251
Salisbury*	0.6	1	71	1920	CA	Miscellaneous	3,269,250
McDonough*	0.6	1	47	1919	CA	Miscellaneous	3,269,249
Cate*	0.6	1	62	1919	CA	Miscellaneous	3,269,249
Milpitas	65	108	34	1918	CA	Miscellaneous	3,269,248
Yuma Auxiliary Project, Unit B	4,176	6,800	5	1905	AZ	Federal Establishments & Water Projects*	3,269,183
North Gila Valley Unit, Yuma Mesa Division, Gila Project	4,959	24,500	6	1905	AZ	Federal Establishments & Water Projects*	3,265,007

Entitlement Holders	CU Equivalent (AF)†	Diversion (AF)	PPR No.	Date	State	Category	Cumulative Consumptive Use Equivalent (AF)
Reservation Division/Yuma Project (non-Indian portion)	18,599	38,270	28	1905	CA	Federal Establishments & Water Projects*	3,260,049
Valley Division, Yuma Project (Yuma County Water Users' Association)	180,834	254,200	4	1901	AZ	Federal Establishments & Water Projects*	3,241,450
Imperial Irrigation District & CVWD lands	2,485,000	2,600,000	27	1901	CA	Federal Establishments & Water Projects*	3,060,615
Palo Verde Irrigation District	100,231	219,780	26	1877	CA	Federal Establishments & Water Projects*	575,615
Cocopah Indian Reservation	4,941	7,681	1	1917	AZ	Indian Reservations	475,384
Schneider*	0.6	1	56	1917	CA	Miscellaneous	470,443
Douglas*	0.6	1	50	1916	CA	Miscellaneous	470,442
Clark*	0.6	1	52	1916	CA	Miscellaneous	470,442
Graham*	0.6	1	61	1916	CA	Miscellaneous	470,441
Powers	624	960	7	1915	AZ	Miscellaneous	470,441
United States (Cocopah Indian Tribe)	733	1,140	8	1915	AZ	Miscellaneous	469,817
Lawrence	72	120	42	1915	CA	Miscellaneous	469,083
Lawrence*	0.6	1	53	1915	CA	Miscellaneous	469,011
Milpitas	41	69	37	1914	CA	Miscellaneous	469,011
Graham, J.*	0.6	1	54	1914	CA	Miscellaneous	468,969
Morgan	90	150	33	1913	CA	Miscellaneous	468,969
Zozaya (MVIDD)	389	720	17	1912	AZ	Miscellaneous	468,879
Reid*	0.6	1	60	1912	CA	Miscellaneous	468,490
Fitz*	0.6	1	75	1912	CA	Miscellaneous	468,489
EPCOR CSA #2 (Formerly Brooke Water Company) (Graham)	241	360	9	1910	AZ	Miscellaneous	468,489
Geiger*	0.6	1	55	1910	CA	Miscellaneous	468,248
Williams*	0.6	1	76	1909	CA	Miscellaneous	468,247
Chemehuevi Indian Reservation	6,091	11,340	22	1907	CA	Indian Reservations	468,246
Parker, City of	400	630	20	1905	AZ	Miscellaneous	462,155
Cooper	36	60	40	1905	CA	Miscellaneous	461,755
Reynolds	22	36	39	1904	CA	Miscellaneous	461,719
Ferguson, C.*	0.6	1	68	1903	CA	Miscellaneous	461,698
Ferguson, W.*	0.6	1	69	1903	CA	Miscellaneous	461,697
Streeter*	0.6	1	73	1903	CA	Miscellaneous	461,696
Draper, J.*	0.6	1	74	1903	CA	Miscellaneous	461,696
Hulet (MVIDD)	648	1,080	10	1902	AZ	Miscellaneous	461,695
Hurschler (First American Title Insurance Agency of Mohave, Inc.) (MVIDD)	567	1,050	11	1902	AZ	Miscellaneous	461,047
Miller (MVIDD)	130	240	12	1902	AZ	Miscellaneous	460,480
McKellips and Granite Reef Farms (MVIDD)	437	810	13	1902	AZ	Miscellaneous	460,351
Sherrill & Lafollette (MVIDD)	583	1,080	14	1902	AZ	Miscellaneous	459,913
Swan (MVIDD)	518	960	18	1902	AZ	Miscellaneous	459,330
Phillips, Milton and Jean	25	42	19	1900	AZ	Miscellaneous	458,812
Atchison, Topeka, and Santa Fe Railway Co.	273	1,260	44	1896	CA	Miscellaneous	458,786
Martinez*	0.6	1	57	1895	CA	Miscellaneous	458,513
Yuma, City of	1,478	2,333	21	1893	AZ	Miscellaneous	458,513
Mendivil (Picacho Development Corp. and CA Dept. of Parks and Rec.)	72	120	31	1893	CA	Miscellaneous	457,035
Fort Mojave Indian Reservation	40,806	75,566	3	1890	AZ	Indian Reservations	456,963
Fort Mojave Indian Reservation	15,103	27,969	3	1890	AZ	Indian Reservations	416,157
Fort Mojave Indian Reservation	8,995	16,720	25	1890	CA	Indian Reservations	401,054

Entitlement Holders	CU Equivalent (AF)†	Diversion (AF)	PPR No.	Date	State	Category	Cumulative Consumptive Use Equivalent (AF)
Fort Mojave Indian Reservation	8,397	12,534	81	1890	NV	Indian Reservations	392,059
Simons	36	60	35	1889	CA	Miscellaneous	383,662
City of Needles	950	1,500	43	1885	CA	Miscellaneous	383,626
Fort Yuma Indian Reservation	39,594	71,616	23	1884	CA	Indian Reservations	382,676
Fort Yuma Indian Reservation	4,039	6,350	3a	1884	AZ	Indian Reservations	343,081
Colorado River Indian Reservation	3,417	5,860	24	1876	CA	Indian Reservations	339,043
Colorado River Indian Reservation	23,966	51,986	2	1874	AZ	Indian Reservations	335,626
Colorado River Indian Reservation	23,463	40,241	24	1874	CA	Indian Reservations	311,660
Colorado River Indian Reservation	116,179	252,016	2	1873	AZ	Indian Reservations	288,198
Colorado River Indian Reservation	6,265	10,745	24	1873	CA	Indian Reservations	172,018
Colorado River Indian Reservation	165,222	358,400	2	1865	AZ	Indian Reservations	165,753
Yuma Associates LTD and Winterhaven Water District (formerly Wavers)	531	780	29	1856	CA	Miscellaneous	531
Total	**3,270,473**	**4,110,578**					

†Calculated consumptive use equivalents in italics (factor of .6 were given by the Court; for IID/CVWD, 115,000af of return flow; all others according to their CU/diversion ratio from Reclamation's *Colorado River Accounting and Water Use Report: Arizona, California, and Nevada*). The Cumulative Consumptive Use Equivalent column is included as a reference for the estimated amount of water that would need to be available to PPRs to fulfill a given entitlement on this table.

*Fill order reflects paragraph (5) of the Appendix to the 2006 Consolidated Decree in Arizona v. California: "In the event of a determination of insufficient mainstream water to satisfy present perfected rights pursuant to Article II(B)(3) of this decree, the Secretary of the Interior shall, before providing for the satisfaction of any of the other present perfected rights except for those listed herein as “MISCELLANEOUS PRESENT PERFECTED RIGHTS” (rights numbered 7–21 and 29–80 below) in the order of their priority dates without regard to state lines, first provide for the satisfaction in full of all rights of the Chemehuevi Indian Reservation, Cocopah Indian Reservation, Fort Yuma Indian Reservation, Colorado River Indian Reservation, and the Fort Mojave Indian Reservation as set forth in Article II(D)(1)–(5) of this decree...".

E.3.4 Shortage Allocation Model Results

The tables in this section summarize the results of the Shortage Allocation Model over the range of total shortages to the Lower Division States that comprise the 2007 Interim Guidelines shortage reductions and 2019 DCP water savings contributions.

Table E-12 below summarizes the shortage attributed to each priority within the Lower Division States in the Shortage Allocation Model. Contracts for Arizona fifth and sixth priority and unused water within CAP, and CAP excess contracts, are immediately affected and potentially fully reduced. The only other priority group potentially fully reduced in the Shortage Allocation Model is CAP NIA Priority, although other priorities are affected to some degree.

Table E-12
Shortage Allocation Model Regional Summary

Summary of Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
		200,000	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**
Arizona	**Priority**								
	5th, 6th, and CAP Agricultural and Other Excess	192,000	294,465	335,708	338,687	338,687	338,687	338,687	330,681
	4th Priority i (Mainstream)	0	0	0	0	0	0	0	18,520
	4th Priority ii (CAP)[1]								
	NIA Priority	0	217,535	245,633	245,633	245,633	245,633	245,633	245,633
	M&I Priority	0	0	0	32,302	32,302	32,302	32,302	80,877
	Indian Priority	0	0	10,659	23,378	23,378	23,378	23,378	44,289
	2nd & 3rd Priorities	0	0	0	0	0	0	0	0
	1st Priority (Present Perfected Rights)	0	0	0	0	0	0	0	0
	Subtotal	**192,000**	**512,000**	**592,000**	**640,000**	**640,000**	**640,000**	**640,000**	**720,000**
California	**Priority**								
	4th Priority (MWD)	0	0	0	186,000	232,500	279,000	325,500	325,500
	3rd Priority (IID, CVWD, PVID, QSA Diversions by MWD)	0	0	0	14,000	17,500	21,000	24,500	24,500
	2nd Priority (Yuma Project Reservation Division)	0	0	0	0	0	0	0	0
	1st Priority (PVID)	0	0	0	0	0	0	0	0
	Present Perfected Rights (PPRs)	0	0	0	0	0	0	0	0
	Subtotal	**0**	**0**	**0**	**200,000**	**250,000**	**300,000**	**350,000**	**350,000**

Summary of Shortage Impacts by State and Priority		Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
Nevada	**Priority**								
	8th Priority (SNWA - Balance & Unused)	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000
	8th Priority (SNWA & Big Bend)	0	0	0	0	0	0	0	0
	7th Priority (Boy Scouts, Reclamation, NV Dept. of Wildlife)	0	0	0	0	0	0	0	0
	6th Priority (Las Vegas Valley Water District)	0	0	0	0	0	0	0	0
	5th Priority (PABCO & Lakeview Co.)	0	0	0	0	0	0	0	0
	4th Priority (Henderson & Basic Management)	0	0	0	0	0	0	0	0
	3rd Priority (Boulder City)	0	0	0	0	0	0	0	0
	2nd Priority (Lake Mead National Rec. Area)	0	0	0	0	0	0	0	0
	1st Priority (PPRs: LMNRA & Fort Mojave Indian Reservation)	0	0	0	0	0	0	0	0
	Subtotal	**8,000**	**21,000**	**25,000**	**27,000**	**27,000**	**27,000**	**27,000**	**30,000**
	Total	**200,000**	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**

Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.
Note: Orange highlights indicate the level at which available water for a priority is reduced to zero.
[1]Agricultural and other CAP excess contracts do not confer a Colorado River water entitlement, and are assumed to be unavailable for the purpose of this analysis.
Disclaimer: These modeling results should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and it cannot replicate the precision required for that process.

Table E-13 below summarizes the shortage impacts on Tribes according to the Shortage Allocation Model. Tribal entitlements within the Arizona fourth priority are potentially affected, and CAP NIA Priority entitlements are potentially fully reduced.

Table E-13
Shortage Allocation Model Tribal Summary

Summary of Consumptive Use Impacts on Tribal Allocations			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
Arizona			200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
Priority	Entitlement Holder	County								
4(i)	Hopi Tribe[1]	La Paz County	0	0	0	0	0	0	0	1,164
4(i)	Cocopah Indian Reservation[2]	Yuma County	0	0	0	0	0	0	0	0
CAP Indian Priority	Gila River Indian Community[1]	Maricopa and Pinal Counties	0	0	10,659	23,378	23,378	23,378	23,378	39,517
CAP Indian Priority	Tohono O'odham Nation (Schuk Toak & San Xavier Districts)[1]	Pima County	0	0	0	0	0	0	0	0
CAP Indian Priority	White Mountain Apache Tribe	Apache, Gila, and Navajo Counties	0	0	0	0	0	0	0	0
CAP Indian Priority	Ak-Chin Indian Community[1]	Pinal County	0	0	0	0	0	0	0	3,744
CAP Indian Priority	Fort McDowell Yavapai Nation	Maricopa County	0	0	0	0	0	0	0	0
CAP Indian Priority	Pascua Yaqui Tribe	Pima County	0	0	0	0	0	0	0	0
CAP Indian Priority	San Carlos Apache Tribe	Gila County	0	0	0	0	0	0	0	173
CAP Indian Priority	Salt River Pima-Maricopa Indian Community	Maricopa County	0	0	0	0	0	0	0	854
CAP Indian Priority	Tohono O'odham Nation Sif Oidak District	Pinal County	0	0	0	0	0	0	0	0
CAP Indian Priority	Tonto Apache Tribe	Gila County	0	0	0	0	0	0	0	0
CAP Indian Priority	Yavapai Apache Nation	Gila County	0	0	0	0	0	0	0	0
CAP M&I Priority	San Carlos Apache Tribe	Gila County	0	0	0	973	973	973	973	2,435
CAP NIA-A Priority	Tohono O'odham Nation (Schuk Toak & San Xavier Districts)	Pima County	0	24,260	28,200	28,200	28,200	28,200	28,200	28,200
CAP NIA-A Priority	Gila River Indian Community	Maricopa and Pinal County	0	103,750	120,600	120,600	120,600	120,600	120,600	120,600
CAP NIA-B Priority	White Mountain Apache Tribe	Apache, Gila, and Navajo Counties	0	0	0	0	0	0	0	0
3	Ak-Chin Indian Community[1]	Pinal County	0	0	0	0	0	0	0	0

Summary of Consumptive Use Impacts on Tribal Allocations			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
1 (PPR)	Cocopah Indian Reservation[1]	Yuma County	0	0	0	0	0	0	0	0
1 (PPR)	United States (Cocopah Indian Tribe)[1]	Yuma County	0	0	0	0	0	0	0	0
1 (PPR)	Fort Mojave Indian Reservation[1]	Mohave County	0	0	0	0	0	0	0	0
1 (PPR)	Fort Yuma Indian Reservation[1]	Yuma County	0	0	0	0	0	0	0	0
1 (PPR)	Colorado River Indian Reservation[1]	La Paz County	0	0	0	0	0	0	0	0
		Subtotal	**0**	**128,010**	**159,459**	**173,151**	**173,151**	**173,151**	**173,151**	**196,688**
California										
Priority	**Entitlement Holder**	**County**								
PPR	Chemehuevi Indian Reservation[1]	San Bernardino	0	0	0	0	0	0	0	0
PPR	Fort Mojave Indian Reservation[1]	San Bernardino	0	0	0	0	0	0	0	0
PPR	Fort Yuma Indian Reservation[1]	Imperial	0	0	0	0	0	0	0	0
PPR	Colorado River Indian Reservation[1]	San Bernardino, Riverside	0	0	0	0	0	0	0	0
		Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Nevada										
Priority	**Entitlement Holder**	**County**								
1 (PPR)	Fort Mojave Indian Reservation[1]	Clark	0	0	0	0	0	0	0	0
		Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Total	**0**	**128,010**	**159,459**	**173,151**	**173,151**	**173,151**	**173,151**	**196,688**
Summary by County										
	<u>Arizona</u>	**# of Entitlement Holders /County**								
	Coconino County	0	0	0	0	0	0	0	0	0
	Gila County	4.33	0	0	0	973	973	973	973	2,609
	La Paz County	2	0	0	0	0	0	0	0	1,164
	Maricopa County	2.3	0	31,125	39,378	43,193	43,193	43,193	43,193	48,889
	Mohave County	1	0	0	0	0	0	0	0	0
	Pima County	3	0	24,260	28,200	28,200	28,200	28,200	28,200	28,200
	Pinal County	3.70	0	72,625	91,881	100,785	100,785	100,785	100,785	115,826

Summary of Consumptive Use Impacts on Tribal Allocations			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
	Yuma County	4	0	0	0	0	0	0	0	0
	Apache County	0.33	0	0	0	0	0	0	0	0
	Navajo County	0.33	0	0	0	0	0	0	0	0
	Subtotal Arizona Tribal	**21**	**0**	**128,010**	**159,459**	**173,151**	**173,151**	**173,151**	**173,151**	**196,688**
	California									
	San Bernardino	2.5	0	0	0	0	0	0	0	0
	Riverside	0.50	0	0	0	0	0	0	0	0
	Imperial	1	0	0	0	0	0	0	0	0
	Subtotal California Tribal	**4**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
	Nevada									
	Clark	1	0	0	0	0	0	0	0	0
	Subtotal Nevada Tribal	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Note: PPRs are included here to provide a complete list of tribal entitlements, but they are not affected at the evaluated levels of shortage.
Note: Orange highlights indicate the level at which available water for a user under this priority is reduced to zero.
Note: This preliminary analysis attributes shortage to the base allocation or entitlement according to its priority. The ultimate impacts, both financial and in terms of the lost productive value of water, are diverse according to their varied uses and compensation structures under a large body of exchanges, leases, and other federal and non-federal arrangements and commitments. This distribution of shortage to the base allocation only provides the initial necessary information to assess impacts in detail as part of administering the related contracts; actual water orders received each year will affect those impacts.
Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.
[1]Denotes full or substantial use in Tribal agricultural operations, which may or may not be affected according to the terms of related agreements.
[2]This user also holds a PPR entitlement, which is not affected at these levels of shortages.

Table E-14 below summarizes the shortage impacts on irrigation according to the Shortage Allocation Model. Contracts for Arizona fifth and sixth priority and unused[13] water within CAP, and CAP excess contracts, are immediately affected and potentially fully reduced, but other irrigation entitlements are potentially affected at the deepest levels of shortage.

Table E-14
Shortage Allocation Model Irrigation Summary

Summary of Consumptive Use Impacts on Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
Arizona			200,000	533,000	617,000	867,000	917,000	967,000	1,017,000	1,100,000
Priority	Entitlement Holder	County								
All Other	5th and 6th Priority Contracts, and CAP Agricultural and Other Excess	Maricopa, Pinal, and Pima Counties	192,000	294,465	335,708	338,687	338,687	338,687	338,687	330,681
4(i)	Arizona Game and Fish Commission	La Paz County	0	0	0	0	0	0	0	772
4(i)	Arizona State Land Department	Yuma County	0	0	0	0	0	0	0	1,545
4(i)	Beattie Farms, Southwest	Yuma County	0	0	0	0	0	0	0	138
4(i)	Bishop, Alfred F. and Erma Jean Family Trust	La Paz County	0	0	0	0	0	0	0	0
4(i)	Cathcart, Bruce Y. and Lora M. and James Y. and Maria E.	La Paz County	0	0	0	0	0	0	0	7
4(i)	ChaCha, LLC	Yuma County	0	0	0	0	0	0	0	31
4(i)	Cibola Sportsman's Club, Inc.	La Paz County	0	0	0	0	0	0	0	43
4(i)	Cibola Valley Irrigation and Drainage District[2]	La Paz County	0	0	0	0	0	0	0	2,027
4(i)	Curtis, Armon	Yuma County	0	0	0	0	0	0	0	41
4(i)	Gila Monster Farms, Inc.[3]	Yuma County	0	0	0	0	0	0	0	0
4(i)	GM Gabrych Family Limited Partnership	La Paz County	0	0	0	0	0	0	0	1,087
4(i)	GSC Farm, LLC	La Paz County	0	0	0	0	0	0	0	19
4(i)	JRJ Partners, L.L.C.	Yuma County	0	0	0	0	0	0	0	227
4(i)	Mohave Valley Irrigation and Drainage District[2,3]	Mohave County	0	0	0	0	0	0	0	6,992
4(i)	North Baja Pipeline, LLC[2]	La Paz County	0	0	0	0	0	0	0	4
4(i)	Ogram Boys Enterprises, Inc.	Yuma County	0	0	0	0	0	0	0	221

[13] Under Article 3.(b) of the 1985 Contract Between the United States and the Ak-Chin Indian Community to Provide Permanent Water and Settle Interim Water Rights, in any year in which sufficient surface water is available, the Secretary shall deliver certain additional water to the Ak-Chin Indian Community. Such water is assumed to be available if there is unused CAP water, after CAP orders under long-term contracts and subcontracts are fulfilled; it is not itemized, but there is only unused water projected to be available at the 200,000 af level of total shortage in the Shortage Allocation Model.

Summary of Consumptive Use Impacts on Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
4(i)	Ott, Larry and Gina, and Lee C. and Candace M.	Yuma County	0	0	0	0	0	0	0	33
4(i)	Pasquinelli, Gary J. and Barbara J.	Yuma County	0	0	0	0	0	0	0	0
4(i)	Red River Land Company, LLC	La Paz County	0	0	0	0	0	0	0	80
4(i)	Western Water, LLC	La Paz County	0	0	0	0	0	0	0	0
3	Sturges, Harold	Yuma County	0	0	0	0	0	0	0	0
3	Sturges, Irma	Yuma County	0	0	0	0	0	0	0	0
3	Yuma Mesa Irrigation & Drainage District (10,000af M&I)[1]	Yuma County	0	0	0	0	0	0	0	0
3	Yuma Irrigation District (5,000af M&I)[1]	Yuma County	0	0	0	0	0	0	0	0
3	North Gila Valley Irrigation District (2,500af M&I)[1,3]	Yuma County	0	0	0	0	0	0	0	0
3	Wellton-Mohawk Irrigation and Drainage District (12,000af M&I)[1]	Yuma County	0	0	0	0	0	0	0	0
3	Gila Monster Farms (formerly Sturges)[3]	Yuma County	0	0	0	0	0	0	0	0
3	Yuma County Water Users' Association (14,701af M&I includes YAO's 489.95af conversion)[2,3]	Yuma County	0	0	0	0	0	0	0	0
3	University of Arizona	Yuma County	0	0	0	0	0	0	0	0
3	Camille Allec, Jr. (Formerly Yuma Mesa Grapefruit Company)	Yuma County	0	0	0	0	0	0	0	0
3	Unit B Irrigation & Drainage District[3]	Yuma County	0	0	0	0	0	0	0	0
		Subtotal	**192,000**	**294,465**	**335,708**	**338,687**	**338,687**	**338,687**	**338,687**	**343,948**
California										
3	Palo Verde Irrigation District (3b) - Lower Palo Verde Mesa Lands	Riverside County	0	0	0	0	0	0	0	0
3	Coachella Valley Water District (CVWD) (3a)	Riverside County	0	0	0	14,000	17,500	21,000	24,500	24,500
3	Imperial Irrigation District (IID) (3a)	Imperial County	0	0	0	0	0	0	0	0
2	Yuma Project, Reservation Division4 (Bard Unit Only - Indian Unit Under PPRs)	Imperial County	0	0	0	0	0	0	0	0
1	Palo Verde Irrigation District - Valley Lands	Riverside, Imperial	0	0	0	0	0	0	0	0
		Subtotal	**0**	**0**	**0**	**14,000**	**17,500**	**21,000**	**24,500**	**24,500**

Summary of Consumptive Use Impacts on Irrigation			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
Nevada										
None	None		0	0	0	0	0	0	0	0
		Subtotal	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
		Total	**192,000**	**294,465**	**335,708**	**352,687**	**356,187**	**359,687**	**363,187**	**368,448**
Summary by County										
	Arizona	**# of Entitlement Holders /County**								
	Coconino County	0	0	0	0	0	0	0	0	0
	La Paz County	10	0	0	0	0	0	0	0	4,040
	Mohave County	1	0	0	0	0	0	0	0	6,992
	Yuma County	20	0	0	0	0	0	0	0	2,236
	Pima County	0.2	38,400	58,893	67,142	67,737	67,737	67,737	67,737	66,136
	Pinal County	0.5	96,000	147,233	167,854	169,344	169,344	169,344	169,344	165,340
	Maricopa County	0.3	57,600	88,340	100,712	101,606	101,606	101,606	101,606	99,204
	Subtotal Arizona Irrigation	31	192,000	294,465	335,708	338,687	338,687	338,687	338,687	343,948
	California									
	Riverside County	2.5	0	0	0	14,000	17,500	21,000	24,500	24,500
	Imperial County	2.5	0	0	0	0	0	0	0	0
	Subtotal California Irrigation	5	0	0	0	14,000	17,500	21,000	24,500	24,500
	Nevada									
	None	None	0	0	0	0	0	0	0	0

[1]Combined irrigation and domestic entitlement where domestic use is contractually subordinated to irrigation.
[2]Combined irrigation and domestic entitlement where priority of domestic and irrigation uses may be subject to an annual determination that varies based on the water supply conditions.
[3]This user also holds a PPR entitlement, which is not affected at these levels of shortages and it was not included here.
Note: PPR entitlements are not affected at these levels of shortage.
Note: Orange highlights indicate the level at which available water for a user under this priority is reduced to zero.
Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.
Disclaimer: These modeling results from the Shortage Allocation Model should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and it cannot replicate the precision required for that process.

Table E-15 below summarizes the shortage impacts on domestic use according to the Shortage Allocation Model. Within the Arizona P4(i), certain domestic users may be affected at the deepest level of modeled shortage. CAP M&I Priority uses are potentially affected, and CAP NIA Priority uses are potentially fully reduced. Domestic impacts within California and Nevada are limited to MWD and SNWA, respectively.

Table E-15
Shortage Allocation Model Domestic Summary

Summary of Consumptive Use Impacts on Domestic Uses			**Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)**							
Arizona			**200,000**	**533,000**	**617,000**	**867,000**	**917,000**	**967,000**	**1,017,000**	**1,100,000**
Priority	**Entitlement Holder**	**County**								
4(i)	Arizona State Land Department	Yuma County	0	0	0	0	0	0	0	0
4(i)	Arizona State Parks Board - Windsor Beach	Mohave County	0	0	0	0	0	0	0	0
4(i)	B&F Investment, LLC	La Paz County	0	0	0	0	0	0	0	0
4(i)	Bullhead City	Mohave County	0	0	0	0	0	0	0	2,337
4(i)	Bullhead City (Mohave County Water Authority (MCWA) Subcontract)	Mohave County	0	0	0	0	0	0	0	0
4(i)	Bullhead City (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0
4(i)	Bureau of Land Management (diversion estimated)	La Paz County	0	0	0	0	0	0	0	0
4(i)	Crystal Beach Water Conservation District	Mohave County	0	0	0	0	0	0	0	20
4(i)	Desert Lawn Memorial Park Association, Inc.	Yuma County	0	0	0	0	0	0	0	0
4(i)	Ehrenburg Improvement District	La Paz County	0	0	0	0	0	0	0	0
4(i)	EPCOR Water Arizona Inc.[1]	Mohave County	0	0	0	0	0	0	0	0
4(i)	Fisher's Landing Water and Sewer Works, L.L.C.	Yuma County	0	0	0	0	0	0	0	0
4(i)	Frontier Communications West Coast Inc.	La Paz County	0	0	0	0	0	0	0	1
4(i)	Gold Dome Mining Corporation	Yuma County	0	0	0	0	0	0	0	0
4(i)	Gold Standard Mines Corp.	Mohave County	0	0	0	0	0	0	0	0
4(i)	Golden Shores Water Conservation District	Mohave County	0	0	0	0	0	0	0	0
4(i)	Hillcrest Water Company	La Paz County	0	0	0	0	0	0	0	0

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
4(i)	Lake Havasu City	Mohave County	0	0	0	0	0	0	0	638
4(i)	Lake Havasu City (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0
4(i)	Lake Havasu City (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0
4(i)	La Paz County	La Paz County	0	0	0	0	0	0	0	0
4(i)	McAlister Family Trust	Mohave County	0	0	0	0	0	0	0	0
4(i)	Mohave Valley Irrigation and Drainage District (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	257
4(i)	Mohave Water Conservation District	Mohave County	0	0	0	0	0	0	0	62
4(i)	Mohave Water Conservation District (MCWA Subcontract)	Mohave County	0	0	0	0	0	0	0	0
4(i)	Parker, Town of[1]	La Paz County	0	0	0	0	0	0	0	0
4(i)	Quartzsite, Town of	La Paz County	0	0	0	0	0	0	0	0
4(i)	Queen Creek, Town of	Maricopa County	0	0	0	0	0	0	0	774
4(i)	Roy, Estates of Anna R. and Edward P.	Yuma County	0	0	0	0	0	0	0	0
4(i)	Shepard Water Company, Incorporated	Yuma County	0	0	0	0	0	0	0	0
4(i)	Somerton, City of	Yuma County	0	0	0	0	0	0	0	0
4(i)	Springs Del Sol Domestic Water Improvement District	La Paz County	0	0	0	0	0	0	0	0
4(i)	TV Marble Canyon AZ, LLC	Coconino County	0	0	0	0	0	0	0	0
CAP Indian	Scottsdale (Yavapai Prescott Indian Tribe Allocation)	Maricopa County	0	0	0	0	0	0	0	0
CAP M&I	ASARCO	Pima County	0	0	0	1,126	1,126	1,126	1,126	2,818
CAP M&I	Avondale	Maricopa County	0	0	0	290	290	290	290	727
CAP M&I	Arizona State Land Department (AZSLD)	Maricopa County	0	0	0	279	279	279	279	698
CAP M&I	Arizona Water Company, Casa Grande	Pinal County	0	0	0	476	476	476	476	1,192
CAP M&I	Arizona Water Company, Coolidge	Pinal County	0	0	0	107	107	107	107	268
CAP M&I	Arizona Water Company, Superstition	Pinal County	0	0	0	337	337	337	337	844
CAP M&I	Arizona Water Company, White Tank	Maricopa County	0	0	0	52	52	52	52	130
CAP M&I	Buckeye	Maricopa County	0	0	0	12	12	12	12	30

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
CAP M&I	Central Arizona Groundwater Replenishment District (CAGRD)	Maricopa County	0	0	0	344	344	344	344	862
CAP M&I	Carefree Water Company	Maricopa County	0	0	0	47	47	47	47	119
CAP M&I	Cave Creek	Maricopa County	0	0	0	140	140	140	140	350
CAP M&I	Chandler	Maricopa County	0	0	0	464	464	464	464	1,161
CAP M&I	Chaparral City Water Company	Maricopa County	0	0	0	478	478	478	478	1,196
CAP M&I	Circle City	Maricopa County	0	0	0	0	0	0	0	0
CAP M&I	El Mirage	Maricopa County	0	0	0	27	27	27	27	68
CAP M&I	Eloy	Pinal County	0	0	0	116	116	116	116	291
CAP M&I	EPCOR, Agua Fria	Maricopa County	0	0	0	595	595	595	595	1,489
CAP M&I	EPCOR, Paradise Valley	Maricopa County	0	0	0	173	173	173	173	434
CAP M&I	EPCOR, Sun City	Maricopa County	0	0	0	225	225	225	225	562
CAP M&I	EPCOR, Sun City West	Maricopa County	0	0	0	127	127	127	127	318
CAP M&I	Florence	Pinal County	0	0	0	110	110	110	110	275
CAP M&I	Freeport-Miami	Gila County	0	0	0	156	156	156	156	390
CAP M&I	Flowing Wells Irrigation District (FWID)	Pima County	0	0	0	153	153	153	153	383
CAP M&I	Gilbert	Maricopa County	0	0	0	388	388	388	388	971
CAP M&I	Glendale	Maricopa County	0	0	0	924	924	924	924	2,313
CAP M&I	Goodyear	Maricopa County	0	0	0	576	576	576	576	1,442
CAP M&I	Greater Tonopah, Water Utility	Maricopa County	0	0	0	3	3	3	3	9
CAP M&I	Green Valley Community Water Company	Pima County	0	0	0	0	0	0	0	0
CAP M&I	Green Valley Domestic Water Improvement District	Pima County	0	0	0	0	0	0	0	0
CAP M&I	Marana	Pima County	0	0	0	125	125	125	125	314
CAP M&I	Maricopa County Parks & Recreation	Maricopa County	0	0	0	36	36	36	36	89
CAP M&I	Mesa	Maricopa County	0	0	0	2,332	2,332	2,332	2,332	5,839
CAP M&I	Metropolitan Domestic Water Improvement District (Includes ICS Creation)	Pima County	0	0	0	722	722	722	722	1,807
CAP M&I	Oro Valley	Pima County	0	0	0	552	552	552	552	1,383
CAP M&I	Peoria	Maricopa County	0	0	0	1,454	1,454	1,454	1,454	3,640
CAP M&I	Phoenix	Maricopa County	0	0	0	6,551	6,551	6,551	6,551	16,401
CAP M&I	Pine	Gila County	0	0	0	0	0	0	0	0
CAP M&I	Queen Creek	Maricopa County	0	0	0	27	27	27	27	66

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
CAP M&I	Rio Verde Utilities	Maricopa County	0	0	0	44	44	44	44	109
CAP M&I	San Tan Irrigation District	Maricopa County	0	0	0	0	0	0	0	0
CAP M&I	Scottsdale	Maricopa County	0	0	0	2,831	2,831	2,831	2,831	7,088
CAP M&I	Spanish Trail Water Company	Pima County	0	0	0	163	163	163	163	408
CAP M&I	Surprise	Maricopa County	0	0	0	549	549	549	549	1,376
CAP M&I	Tempe	Maricopa County	0	0	0	231	231	231	231	579
CAP M&I	Tonopah	Maricopa County	0	0	0	0	0	0	0	0
CAP M&I	Tonto Hills Domestic Water Improvement District	Maricopa County	0	0	0	4	4	4	4	10
CAP M&I	Tucson	Pima County	0	0	0	7,729	7,729	7,729	7,729	19,352
CAP M&I	Vail Water Company	Pima County	0	0	0	100	100	100	100	249
CAP M&I	Water Utilities Community Facilities District, Apache Junction	Pinal County	0	0	0	156	156	156	156	392
CAP NIA-A	Phoenix	Maricopa County	0	32,071	37,280	37,280	37,280	37,280	37,280	37,280
CAP NIA-A	Chandler	Maricopa County	0	3,376	3,924	3,924	3,924	3,924	3,924	3,924
CAP NIA-A	Gilbert	Maricopa County	0	1,322	1,537	1,537	1,537	1,537	1,537	1,537
CAP NIA-A	Glendale	Maricopa County	0	587	682	682	682	682	682	682
CAP NIA-A	Mesa	Maricopa County	0	4,775	5,551	5,551	5,551	5,551	5,551	5,551
CAP NIA-A	Scottsdale	Maricopa County	0	2,844	3,306	3,306	3,306	3,306	3,306	3,306
CAP NIA-A	Tempe	Maricopa County	0	20	23	23	23	23	23	23
CAP NIA-B	Buckeye	Maricopa County	0	2,786	2,786	2,786	2,786	2,786	2,786	2,786
CAP NIA-B	Central Arizona Groundwater Replenishment District (CAGRD)	Maricopa County	0	18,185	18,185	18,185	18,185	18,185	18,185	18,185
CAP NIA-B	Carefree Water Company	Maricopa County	0	112	112	112	112	112	112	112
CAP NIA-B	Cave Creek	Maricopa County	0	386	386	386	386	386	386	386
CAP NIA-B	El Mirage	Maricopa County	0	1,318	1,318	1,318	1,318	1,318	1,318	1,318
CAP NIA-B	EPCOR, San Tan (ST)	Pinal County	0	3,217	3,217	3,217	3,217	3,217	3,217	3,217
CAP NIA-B	Freeport	Pima County	0	5,678	5,678	5,678	5,678	5,678	5,678	5,678
CAP NIA-B	Gilbert	Maricopa County	0	1,832	1,832	1,832	1,832	1,832	1,832	1,832
CAP NIA-B	Marana	Pima County	0	515	515	515	515	515	515	515
CAP NIA-B	Queen Creek	Maricopa County	0	4,162	4,162	4,162	4,162	4,162	4,162	4,162
CAP NIA-B	Resolution Copper	Maricopa County	0	2,238	2,238	2,238	2,238	2,238	2,238	2,238
CAP NIA-B	Rosemont Copper	Pima County	0	1,124	1,124	1,124	1,124	1,124	1,124	1,124
CAP NIA-B	SRP	Maricopa County	0	2,160	2,160	2,160	2,160	2,160	2,160	2,160
CAP NIA-B	Water Utilities Community Facilities District, Apache Junction	Pinal County	0	817	817	817	817	817	817	817
3	City of Yuma[1]	Yuma County	0	0	0	0	0	0	0	0

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
3	Union Pacific Railroad (formerly Southern Pacific Co.)	Yuma County	0	0	0	0	0	0	0	0
3	Kaman, Inc.	Yuma County	0	0	0	0	0	0	0	0
3	Department of the Navy, MCAS	Yuma County	0	0	0	0	0	0	0	0
3	City of Yuma (cemetery)	Yuma County	0	0	0	0	0	0	0	0
3	Yuma Mesa Fruit Growers' Association	Yuma County	0	0	0	0	0	0	0	0
3	Desert Lawn Memorial Park Association	Yuma County	0	0	0	0	0	0	0	0
3	Chandler (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Gilbert (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Glendale (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Mesa (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Phoenix (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Scottsdale (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Tempe (Salt River Pima-Maricopa Exchange)	Maricopa County	0	0	0	0	0	0	0	0
3	Department of the Army - Yuma Proving Ground	Yuma County	0	0	0	0	0	0	0	0
3	Yuma Union High School District	Yuma County	0	0	0	0	0	0	0	0
2	Cibola National Wildlife Refuge	La Paz County	0	0	0	0	0	0	0	0
2	Lake Mead National Recreation Area	Mohave County	0	0	0	0	0	0	0	0
2	Bureau of Reclamation - Davis Dam	Mohave County	0	0	0	0	0	0	0	0
2	Imperial National Wildlife Refuge	La Paz County	0	0	0	0	0	0	0	0
2	Havasu Lake National Wildlife Refuge	Mohave County	0	0	0	0	0	0	0	0
		Subtotal	**0**	**89,525**	**96,833**	**128,162**	**128,162**	**128,162**	**128,162**	**179,364**

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
California										
Priority	**Entitlement Holder**	**County**								
4	Metropolitan Water District of Southern California (MWD) (4)	Los Angeles, Orange, San Diego, Riverside, San Bernardino	0	0	0	186,000	232,500	279,000	325,500	325,500
3	MWD Diversions from QSA (3a from IID and CVWD)		0	0	0	0	0	0	0	0
		Subtotal	**0**	**0**	**0**	**186,000**	**232,500**	**279,000**	**325,500**	**325,500**
Nevada										
Priority	**Entitlement Holder**	**County**								
8 - Balance & Surplus	Southern Nevada Water Authority (SNWA)	Clark	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000
8	Big Bend Water District	Clark	0	0	0	0	0	0	0	0
8	Robert B. Griffith Project	Clark	0	0	0	0	0	0	0	0
7	Southern Nevada Water Authority (Formerly Boy Scouts of America)	Clark	0	0	0	0	0	0	0	0
7	Bureau of Reclamation (includes Sportsman Park)	Clark	0	0	0	0	0	0	0	0
7	Nevada Dept. of Wildlife (formerly NV Dept of Game & Fish)	Clark	0	0	0	0	0	0	0	0
7	US Air Force (4,000af) (Delivery from SNWA)	Clark	0	0	0	0	0	0	0	0
6	Las Vegas Valley Water District	Clark	0	0	0	0	0	0	0	0
5	Lakeview Company (Hacienda Casino)	Clark	0	0	0	0	0	0	0	0
5	Pacific Coast Building Products, Inc. (PABCO)	Clark	0	0	0	0	0	0	0	0
4	Basic Water Company (formerly Basic Management, Inc.)	Clark	0	0	0	0	0	0	0	0
4	City of Henderson	Clark	0	0	0	0	0	0	0	0
4	Southern Nevada Water Authority (From Basic Water Company)	Clark	0	0	0	0	0	0	0	0
3	Boulder City	Clark	0	0	0	0	0	0	0	0
2	Lake Mead National Recreation Area4, Executive Order No. 5339	Clark	0	0	0	0	0	0	0	0
		Subtotal	**8,000**	**21,000**	**25,000**	**27,000**	**27,000**	**27,000**	**27,000**	**30,000**
		Total	**8,000**	**110,525**	**121,833**	**341,162**	**387,662**	**434,162**	**480,662**	**534,864**

Summary of Consumptive Use Impacts on Domestic Uses			Range of Analyzed Volumes of Total Shortage to Lower Division States (AF)							
Summary by County										
	Arizona	**# of Entitlement Holders /County**								
	Coconino County	1	0	0	0	0	0	0	0	0
	Gila County	2	0	0	0	156	156	156	156	390
	La Paz County	11	0	0	0	0	0	0	0	1
	Maricopa County	56	0	78,174	85,482	104,683	104,683	104,683	104,683	134,332
	Mohave County	18	0	0	0	0	0	0	0	3,314
	Pima County	13	0	7,317	7,317	17,986	17,986	17,986	17,986	34,031
	Pinal County	8	0	4,034	4,034	5,337	5,337	5,337	5,337	7,296
	Yuma County	16	0	0	0	0	0	0	0	0
	Subtotal Arizona Domestic	**125**	**0**	**89,525**	**96,833**	**128,162**	**128,162**	**128,162**	**128,162**	**179,364**
	California									
	Los Angeles, Orange, San Diego, Riverside, San Bernardino	6	0	0	0	186,000	232,500	279,000	325,500	325,500
	Subtotal California Domestic	**6**	**0**	**0**	**0**	**186,000**	**232,500**	**279,000**	**325,500**	**325,000**
	Nevada									
	Clark	15	8,000	21,000	25,000	27,000	27,000	27,000	27,000	30,000
	Subtotal Nevada Domestic	**15**	**8,000**	**21,000**	**25,000**	**27,000**	**27,000**	**27,000**	**27,000**	**30,000**

[1]This user also holds a PPR entitlement, which is not affected at these levels of shortages and it was not included here.

Note: PPRs are not affected at these levels of shortage.

Note: Orange highlights indicate the level at which available water for a user under this priority is reduced to zero.

Note: This analysis does not reflect an operational estimate of when water may cease to be physically available to certain users.

Disclaimer: These modeling results from the Shortage Allocation Model should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This model is not a substitute for the annual process of reviewing water orders and determining which can be filled, and it cannot replicate the precision required for that process.

E.3.5 Relationship between CRMMS and the Shortage Allocation Model

CRMMS was used to model a variety of river and reservoir parameters in the Colorado River Basin, including shortage amounts, reservoir elevations, and river flows (**Appendix D**, CRMMS Model Documentation). The Shortage Allocation Model provides a more detailed allocation of shortages to entitlement holders in the Lower Division States, specifically within Arizona.

The Shortage Allocation Model does not account for the use or conversion of ICS to meet DCP contributions, and it models DCP contributions as shortages to Lower Division States and users. CRMMS can model the conversion of Extraordinary Conversion ICS to DCP ICS for purposes of meeting DCP contributions without reducing diversions in a specific year.

In CRMMS, when Lake Mead is projected to decline to dead pool (elevation 895 feet) and all downstream water demands cannot be met, water users are modeled to be shorted "hydrologically", i.e., upstream users access water before downstream users. In this case, system shortages are reported as a total for the entire Lower Basin because there are no explicit assumptions made in CRMMS associated with how these shortages are distributed in the Lower Basin. The Shortage Allocation Model does not attempt to represent the effect of potential system shortages and how these shortages might be distributed should such conditions occur, or the effect of physical limitations on access to water due to low river stage

Furthermore, the distribution of shortage within each state according to the Shortage Allocation Model is slightly different than CRMMS, because CRMMS uses projected water depletion schedules for distributing the available water supply to individual users in Arizona, California, and Nevada. For the first year of the model run, water depletion schedules use water orders that reflect the current year's actual shortage conditions, DCP contributions, and other signed system conservation agreements. For the remaining years in the model run, default water depletion schedules reflect "normal" schedules, and they represent near-term historical trends in water use. For California and Nevada, the Shortage Allocation Model assumes entitlement holders in these states are using their full entitlements and distributes available water on that basis. For Arizona, the methods for distributing available water vary between priorities in the Shortage Allocation Model, but they are not based on CRMMS schedules.

E.4 Changes Made to the Shortage Allocation Modeling and this Appendix E After Publication of the Original Draft SEIS in April 2023

E.4.1 Water Transfer from GSC Farm, LLC to Town of Queen Creek

On April 28, 2023, a partial assignment and transfer of Arizona P4(i) Colorado River water was finalized from GSC Farm, LLC to the Town of Queen Creek. Tables E-5, E-14, and E-15 have been revised accordingly, and the Shortage Allocation Model reflects an updated proportionate share of the Arizona P4(i) entitlement pool for both GSC Farm, LLC and the Town of Queen Creek. (See **Section E.3.2.5.3** for more information.)

E.4.2 Removal of Previous Action Alternatives 1 and 2 From Consideration

As described in Chapters 1 and 2 of this Draft SEIS, shortages under the 2007 Interim Guidelines and contributions pursuant to the 2019 DCP are the basis for the alternatives now under consideration; accordingly, the Shortage Allocation Model results described in this Appendix E are limited to the effects of the 2007 Interim Guidelines and 2019 DCP.

E.4.3 Refinement to Attribution of California DCP Contributions

The Shortage Allocation Model described in this Appendix E attributes 7% of California's DCP contributions to Coachella Valley Water District pursuant to the May 20, 2019 Drought Contingency Plan Implementation Agreement Between Metropolitan Water District of Southern California and Coachella Valley Water District.

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Attachment E-1

Reclamation's September 14, 2022 letter notifying interested parties of a Tier 2 Shortage Condition and required DCP contributions in operational year 2023

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United States Department of the Interior

BUREAU OF RECLAMATION
P.O. Box 61470
Boulder City, NV 89006-1470

IN REPLY REFER TO:
LCB-4200
2.2.4.23

Subject: Notification of Tier 2 Shortage Condition and Drought Continency Plan (DCP) Contributions for the Lower Colorado River in Calendar Year (CY) 2023

Dear Interested Party:

On December 13, 2007, the Secretary of the Interior signed the Record of Decision for *Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead* (2007 Interim Guidelines), which, among other things, identified operational strategies for managing the reservoirs of the Colorado River System under drought and low reservoir conditions. In accordance with the process set forth in the 2007 Interim Guidelines, the Secretary uses the August 24-Month Study projections for the following January 1 system storage and reservoir water surface elevations to determine Lake Mead operations for the following CY. In accordance with the 2007 Interim Guidelines, the Annual Operating Plan for Colorado River Reservoirs for CY 2023 will document the Secretary's determination, which affects the volume of mainstream Colorado River water available for use in CY 2023 within the Lower Division States of Arizona, California, and Nevada.

On August 16, 2022, the Bureau of Reclamation released its Colorado River Basin August 2022 24-Month Study, which projects Lake Mead's January 1, 2023, operating determination elevation to be 1,047.61 feet.[1] Following the release of the August 2022 24-Month Study, Reclamation announced that Lake Mead and the lower Colorado River will operate in a Tier 2 Shortage Condition in CY 2023, consistent with Section XI.G.2.D.1.b of the 2007 Interim Guidelines and in accordance with Article III(3)(c) of the *Criteria For Coordinated Long-Range Operation of Colorado River Reservoirs* and Article II(B)(3) of the 2006 Consolidated Decree of the United States Supreme Court in *Arizona* v. *California*. In addition, the *Lower Basin Drought Contingency Plan Agreement* (LB DCP Agreement) dated May 20, 2019, will also govern the operation of Lake Mead for CY 2023. The projected operation determination elevation of 1,047.61 feet is within the DCP elevation band of 1,045 and 1,050 feet and reflects what is commonly referred to a "Tier 2a" Shortage Condition.

In accordance with the 2007 Interim Guidelines and the LB DCP Agreement, the Tier 2a Shortage Condition results in the following mandatory shortage reductions and DCP Contributions in CY 2023:

[1]The CY 2023 operating determination elevation of 1,047.61 feet was calculated by taking Lake Mead's projected end of CY 2022 physical elevation of 1,040.78 feet, as reported in the August 2022 24-Month Study, and adding 480,000 acre-feet (AF) of water held back in Lake Powell to Lake Mead's capacity to maintain operational neutrality. For more information: https://www.usbr.gov/lc/region/g4000/24mo/.

- Arizona: a shortage reduction of 400,000 AF and DCP Contributions of 192,000 AF, for a total reduction of 592,000 AF, which is approximately 21 percent of the state's annual basic apportionment of 2.8 million AF of Colorado River water.
- Nevada: a shortage reduction of 17,000 AF and DCP Contributions of 8,000 AF, for a total reduction of 25,000 AF, which is 8 percent of the state's annual basic apportionment of 300,000 AF of Colorado River water.
- California: There is no shortage reduction or DCP Contributions required for California in CY 2023.

Additionally, in accordance with Minute 323 to the 1944 Water Treaty,[2] Mexico's Colorado River water delivery will be reduced in the amount of 70,000 AF and Mexico will contribute 34,000 AF of Mexico's Recoverable Water Savings to the Binational Water Scarcity Contingency Plan,[3] for a total Colorado River water delivery reduction of 104,000 AF, which is approximately 7 percent of Mexico's annual allotment of 1.5 million AF of Colorado River water.

Arizona Operations in CY 2023

In accordance with Section XI.G.2.D.1.b of the 2007 Interim Guidelines, 2.4 million AF is apportioned for consumptive use in the state of Arizona in CY 2023 (a reduction of 400,000 AF from its 2.8 million AF basic apportionment). Additionally, in accordance with Section III.B.1.a of Exhibit 1 to the LB DCP Agreement,[4] the state of Arizona will be required to make DCP Contributions in the total amount of 192,000 AF in CY 2023. Consistent with the Arizona mainstream Colorado River water priority system, there are no reductions to the water supply available to first, second and third priority entitlement holders for CY 2023.

Reclamation will implement the state of Arizona's August 6, 2009,[5] Arizona Shortage Sharing Recommendation and the "pool" approach described by letter dated January 25, 2021,[6] to distribute the available Arizona fourth priority Colorado River water supply. Consistent with the Arizona mainstream Colorado River water priority system, the pool approach recognizes that the fourth priority Colorado River water entitlements of the "on-river" mainstream users and the Central Arizona Project (CAP) are co-equal. The Arizona fourth priority Colorado River water available supply for CY 2023 is 1,078,962 AF,[7] which will be shared between the on-river mainstream entitlement holders and CAP. Reclamation anticipates that the available fourth priority supply will be sufficient to satisfy all on-river mainstream water orders, and is coordinating with the Central Arizona Water Conservation District on the distribution of available water supply within the CAP.

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[2] Referring to *Extension of Cooperative Measures and Adoption of a Binational Water Scarcity Contingency Plan in the Colorado River Basin*. Available at: https://www.ibwc.gov/Files/Minutes/Min323.pdf.

[3]The implementing details of Mexico's Binational Water Scarcity Contingency Plan are provided in the *Joint Report of the Principal Engineers with the Implementing Details of the Binational Water Scarcity Contingency Plan in Colorado River Basin*. Available at: https://www.ibwc.gov/Files/joint_report_min323_bi_water_scarcity_contingency_plan_final.pdf.

[4] Referring to *Lower Basin Drought Contingency Operations*. Available at: https://www.usbr.gov/lc/region/g4000/dcpdocs/Attachment-B-Exhibit-1-LB-Drought-Operations.pdf.

[5] Available at: https://new.azwater.gov/sites/default/files/8-6-2009_ADWR_Shortage_%20ecommendation.pdf.

[6] Available at: https://new.azwater.gov/sites/default/files/01.25.21_ADWR_CAWCD_shortage_recommendationLetter.pdf.

[7] Calculated as Arizona's 2.8 million AF basic apportionment, less the average historical consumptive use by Arizona first, second, and third priority users (1,129,038 AF), less the required shortage reduction (400,000 AF), less the required DCP Contributions (192,000 AF). The average historical consumptive use by Arizona first, second, and third priority users is based on the four highest years of consumptive use during the five-year period from 2017-2021.

No unused Arizona mainstream water entitlement will be available for use by Arizona fifth priority mainstream water entitlement holders.

California Operations in CY 2023
In accordance with Section XI.G.2.D.1.b of the 2007 Interim Guidelines, 4.4 million AF is apportioned for consumptive use in the state of California in CY 2023 (no reduction from its basic apportionment). In accordance with Section III.B of Exhibit 1 to the LB DCP Agreement, the state of California is not required to make DCP Contributions in CY 2023.

Nevada Operations in CY 2023
In accordance with Section XI.G.2.D.1.b of the 2007 Interim Guidelines, 283,000 AF is apportioned for consumptive use in the state of Nevada in CY 2023 (a reduction of 17,000 AF from its 300,000 AF basic apportionment). Additionally, in accordance with Section III.B.2.a of Exhibit 1 to the LB DCP Agreement, the state of Nevada is required to make DCP Contributions in the total amount of 8,000 AF in CY 2023. The Southern Nevada Water Authority (SNWA) is the junior priority entitlement holder in the state of Nevada and SNWA and its member agencies hold entitlements of 276,000 AF per year of the state of Nevada's annual 300,000 AF basic apportionment. Pursuant to its cooperative agreement among its member agencies, as amended, SNWA may implement a shortage plan among its member agencies and can coordinate with them to absorb Colorado River water use reductions. SNWA does not, however, anticipate a need for shared reductions in Colorado River water deliveries in CY 2023 because Nevada's total annual consumptive use is anticipated to be lower than the reduced quantity of Colorado River water that will be available in CY 2023.

Lower Colorado River Basin-wide Considerations
Given the projections that Lake Mead's elevation will continue to decline in CY 2023, Reclamation encourages all Colorado River entitlement holders to prudently manage the use of available water supplies. Additionally, Reclamation would like to highlight that, in accordance with the *Inadvertent Overrun and Payback Policy*,[8] **accumulations of inadvertent overruns are not permitted in CY 2023 and are suspended as long as a Shortage Condition is in in effect**. To assist entitlement holders in monitoring their Colorado River water use to ensure they remain within available quantities, Reclamation will project diversions and consumptive use of Colorado River water during CY 2023 and will make these projections available daily on Reclamation's website.[9] Reclamation encourages Colorado River water entitlement holders to use the projections to adjust diversions to remain within their Reclamation-approved annual Colorado River water order.

[8] Available at: https://www.usbr.gov/lc/region/g4000/IOPP.pdf.
[9] Available at: https://www.usbr.gov/lc/region/g4000/hourly/forecast.pdf.

My staff will continue to monitor Colorado River hydrology and water use. We are available to work with you before and during shortage operations. Should you have questions, please contact Daniel A. Bunk, Chief, Boulder Canyon Operations Office, at (702) 293-8013 or dbunk@usbr.gov. Individuals in the United States, who are deaf, deafblind, hard of hearing, or have a speech disability may dial 711 (TTY, TDD, or TeleBraille) to access telecommunication relay services. Individuals outside the United States should use the relay services offered within their country to make international calls to the point-of-contact in the United States.

Sincerely,

JACKLYNN GOULD
Digitally signed by JACKLYNN GOULD
Date: 2022.09.14 13:54:52 -07'00'

Jacklynn L. Gould, P.E.
Regional Director

Attachment E-2

Reclamation's September 28, 2022 letter to the Central Arizona Water Conservation District announcing the operational year 2023 Available CAP Supply

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United States Department of the Interior

BUREAU OF RECLAMATION
P.O. Box 61470
Boulder City, NV 89006-1470

IN REPLY REFER TO:
PXAO-3000
2.2.4.21

VIA ELECTRONIC MAIL ONLY

Theodore C. Cooke
General Manager
Central Arizona Water Conservation District
23636 North 7th Street
Phoenix, AZ 85024

Subject: Calendar Year (CY) 2023 Announcement of Available Central Arizona Project (CAP) Supply

Dear Theodore C. Cooke:

As the Regional Director of the Lower Colorado Basin Region of the Bureau of Reclamation, who is delegated the authority and responsibility of the Secretary of the Interior, the "water master" on the lower Colorado River and the "Contracting Officer" for CAP contracts, I am hereby announcing the Available CAP Supply for the upcoming CY in accordance with contractual commitments. The Available CAP Supply for CY 2023 is 940,836 acre-feet (AF).

As you know, the Colorado River is the primary source of CAP water. Therefore, the Available CAP Supply for CY 2023 is primarily determined by and is subject to the availability of Colorado River water in CY 2023. The Secretary determines the water supply condition on the lower Colorado River for the upcoming year in accordance with the Consolidated Decree in *Arizona* v. *California* 547 U.S. 150 (2006), the *Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs Pursuant to the Colorado River Basin Project Act of September 30, 1968 (Public Law 90-537)* as amended, and the procedures set forth in the *Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operation for Lake Powell and Lake Mead* (2007 Guidelines) and the Lower Basin Drought Contingency Plan Agreement (LB DCP Agreement).

In its letter dated September 14, 2022 (enclosed), Reclamation announced that Lake Mead and the lower Colorado River will operate in a Tier 2a Shortage Condition in CY 2023 with Drought Contingency Plan (DCP) Contributions required, reducing the volume of Colorado River water available to the state of Arizona by 592,000 AF. As noted in the September 14th letter's overview of Arizona operations in CY 2023, the Arizona fourth priority Colorado River water available supply for CY 2023 is 1,078,962 AF on a consumptive use (CU) basis. Of that amount, 106,318 AF,[1] on a diversion basis, will be available for distribution among mainstream fourth priority or "P4(i)" entitlement holders for use in CY 2023 in accordance with the state of Arizona's August 6, 2009,[2] Arizona Shortage Sharing Recommendation and the "pool" approach described by letter dated January 25, 2021.[3] The remainder is available for diversion as fourth priority water by CAP to fulfill CAP contracts and subcontracts.

Contract No. 14-06-W-245, Amendment No. 2, Between the United States and the Central Arizona Water Conservation District for the Delivery of Water and Repayment of Costs of the Central Arizona Project, dated November 30, 2007, defines Available CAP Supply as "... for any given Year all Fourth Priority Water available for delivery through the Central Arizona Project, water available from CAP dams and reservoirs other than Modified Roosevelt Dam, and return flows captured by the Secretary for CAP use." Available CAP Supply, as calculated below for CY 2023, will be used in contractual determinations related to a CAP Time of Shortage and the distribution of water among CAP contractors and subcontractors.

Determinant of Available CAP Supply	**AF of CU for CY 2023**
Fourth Priority Supply	1,078,962
Minus P4(i) Available Supply (CU Equivalent of 106,318 AF)	- 65,917
Minus Other Use in Arizona[4]	- 809
Equals Fourth Priority Water Available to CAP Contractors and Subcontractors at the CAP Point of Diversion	**= 1,012,236**
Minus CAP System Loss Associated with Fourth Priority CAP Project Water	- 71,400
Plus Water Available from CAP Dams and Reservoirs other than Modified Roosevelt Dam	+ 0
Plus Return Flows Captured by the Secretary for CAP Use	+ 0
Equals Available CAP Supply	**= 940,836**

The Available CAP Supply is the amount of fourth priority water that Reclamation estimates will be available and can be committed for delivery to CAP contractors and subcontractors in CY 2023. However, the Central Arizona Water Conservation District must adjust its CY 2023 CAP Colorado River water diversion as needed to remain within the diversion volume approved by Reclamation that reflects uses by higher priority Colorado River water entitlement holders as they occur during CY 2023. As Reclamation works throughout the basin to adapt to these unprecedented drought conditions, the Lower Colorado Basin Regional Office and the Phoenix Area Office are committed to ongoing coordination with CAP stakeholders.

[1] The P4(i) pool will receive 9.85% of the Arizona fourth priority Colorado River water available for CY 2023, calculated as 164,652 AF divided by the difference between Arizona's 2,800,000 AF basic apportionment and the average historical consumptive use by Arizona first, second, and third priority users (1,129,038 AF). The average historical consumptive use by Arizona first, second, and third priority users is based on the four highest years of consumptive use during the five-year period from 2017-2021.

[2] Available at: https://new.azwater.gov/sites/default/files/8-6-2009_ADWR_Shortage_%20ecommendation.pdf.

[3] Available at: https://new.azwater.gov/sites/default/files/01.25.21_ADWR_CAWCD_shortage_recommendationLetter.pdf.

[4] Three-year average of consumptive use on Cibola Island and outside Present Perfected Right No. 7

Should you have questions, please contact Alexander B. Smith, Deputy Area Manager, Phoenix Area Office, at (623) 773-6215 or alexandersmith@usbr.gov. Individuals in the United States, who are deaf, deafblind, hard of hearing, or have a speech disability may dial 711 (TTY, TDD, or TeleBraille) to access telecommunication relay services. Individuals outside the United States should use the relay services offered within their country to make international calls to the point-of-contact in the United States.

Sincerely,

Acting for STACY WADE Digitally signed by STACY WADE Date: 2022.09.28 09:44:46 -07'00'

Jacklynn L. Gould, P.E.
Regional Director

Enclosure

cc: Thomas Buschatzke
Director
Arizona Department of Water Resources
1110 W. Washington Street, Suite 310
Phoenix, AZ 85007

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Attachment E-3

Exhibit 5.3.4.1 to the Tohono O'odham Settlement Agreement, *Secretary's Approach for Determining the Amount of Water Available to the Nation During a Time of Shortage Under 1980 Contract*

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EXHIBIT 5.3.4.1

SECRETARY'S SHORTAGE SHARING APPROACH

UNDER THE 1980 CONTRACT

Secretary's Approach for Determining
The Amount of Water Available to the Nation
During a Time of Shortage Under 1980 Contract

If the Available CAP Supply is insufficient to fill all orders for CAP water, the Secretary shall take the following steps, in succession, as necessary to match the available supply with orders for the delivery of CAP water in each of the categories described below:

1. First, miscellaneous uses of CAP water are reduced, pro rata. If, after eliminating all miscellaneous uses of CAP water, there is still insufficient available CAP water to meet outstanding orders for the delivery of CAP water, the Secretary shall take the following measure.
2. Uses of CAP NIA Priority Water are reduced, pro rata. If, after eliminating all uses of CAP NIA Priority Water, there is still insufficient available CAP water to meet outstanding orders for delivery of CAP water, then the Secretary shall take the following measure.
3. Uses of CAP M&I Priority Water in excess of 510,000 acre-feet are reduced, pro rata. If, after eliminating all uses of CAP M&I Priority Water in excess of 510,000 acre-feet, there is still insufficient available CAP water to meet outstanding orders for delivery of CAP water, then the Secretary shall take the following measure.
4. If the preceding reductions do not bring CAP water orders in line with the Available CAP Supply, uses of CAP Indian Priority Water in excess of 291,574 acre-feet are reduced, in accordance with the Secretarial Decision published in the Federal Register on March 24, 1983.

5. If the preceding reductions do not bring CAP water orders in line with the Available CAP Supply, the available CAP water supply will be allocated between users of CAP Indian Priority Water and users of CAP M&I Priority Water on a 36.37518 and 63.62482 percentage basis, respectively.

6. If step 5 is implemented, the amount of water available for the Nation shall be determined by multiplying the amount of CAP Indian Priority Water by the ratio of the amount of water delivered pursuant to the Nation's CAP Water Delivery Contract in the latest non-shortage Year relative to the total quantity of water delivered to all CAP Contracts for Indian Priority Water in that same Year.

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Appendix F

Potential DROA Contributions Sensitivity Analysis on Proposed Action

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Contents

Table

Figures

Attachment

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Appendix F. Potential DROA Contributions Sensitivity Analysis on Proposed Action

F.1 Introduction

Potential DROA contributions are analyzed in this appendix to provide a comparative analysis of the effects of potential DROA contributions on the Proposed Action.

F.2 Modeling Approach

This section summarizes the assumptions that were used in the hydrologic modeling and metrics used to compare the Proposed Action (with no DROA contributions) with the Proposed Action with potential DROA contributions (hereafter referred to as Proposed Action, DROA). Future Colorado River system conditions during the analysis period for both alternatives were simulated using the June 2023 CRMMS.

F.2.1 Modeling Assumptions

The following section summarizes the assumptions for the Proposed Action, DROA. The Proposed Action is described in **Chapter 2** with detailed modeling assumptions in **Section 3.3.4** and **Appendix D**.

The hydrologies used in this appendix are derived from the June 2023 Colorado Basin River Forecast Center Ensemble Streamflow Prediction (ESP) Upper Basin forecast and associated Lower Basin intervening flows. Three sets of ESPs are used in the SEIS modeling:

- 100 percent ESP: no adjustment to the streamflow forecasts
- 90 percent ESP: streamflow forecasts are reduced by 10 percent
- 80 percent ESP: streamflow forecasts are reduced by 20 percent

Detailed hydrology inputs, initial conditions, and other modeling assumptions not described in the following sections are consistent with assumptions included in the Proposed Action (see **Appendix D**).

Assumptions for the Proposed Action with Potential DROA Contributions

Modeling assumptions are consistent with the Proposed Alternative assumptions in **Section 3.3.4**. Additional assumptions for potential DROA contributions are summarized below. Detailed assumptions for CRMMS can be found in **Appendix D**.

- The modeling assumption regarding potential DROA contributions of up to 500,000 af per DROA year (May 1–April 30) will conform to the DROA and its implementing documents; the assumption also will be made only to help protect a Lake Powell elevation of 3,500 feet. These potential DROA contributions of zero to 500,000 af are modeled to occur if the projected Lake Powell end-of-water-year pool elevation is less than 3,525 feet for 2024 through 2026.

F.2.2 Comparison Metrics

The Proposed Action and Proposed Action, DROA are compared in **Section F.4** using the following metrics:

Lake Powell

- Monthly pool elevation
- Percentages of traces that fall below an elevation of 3,490 feet in any month in a water year
- Annual water year release

Lake Mead

- Monthly pool elevation
- Percentages of traces that fall below an elevation of 1,020 feet in any month in a calendar year
- Annual calendar year release

F.3 Modeling Results

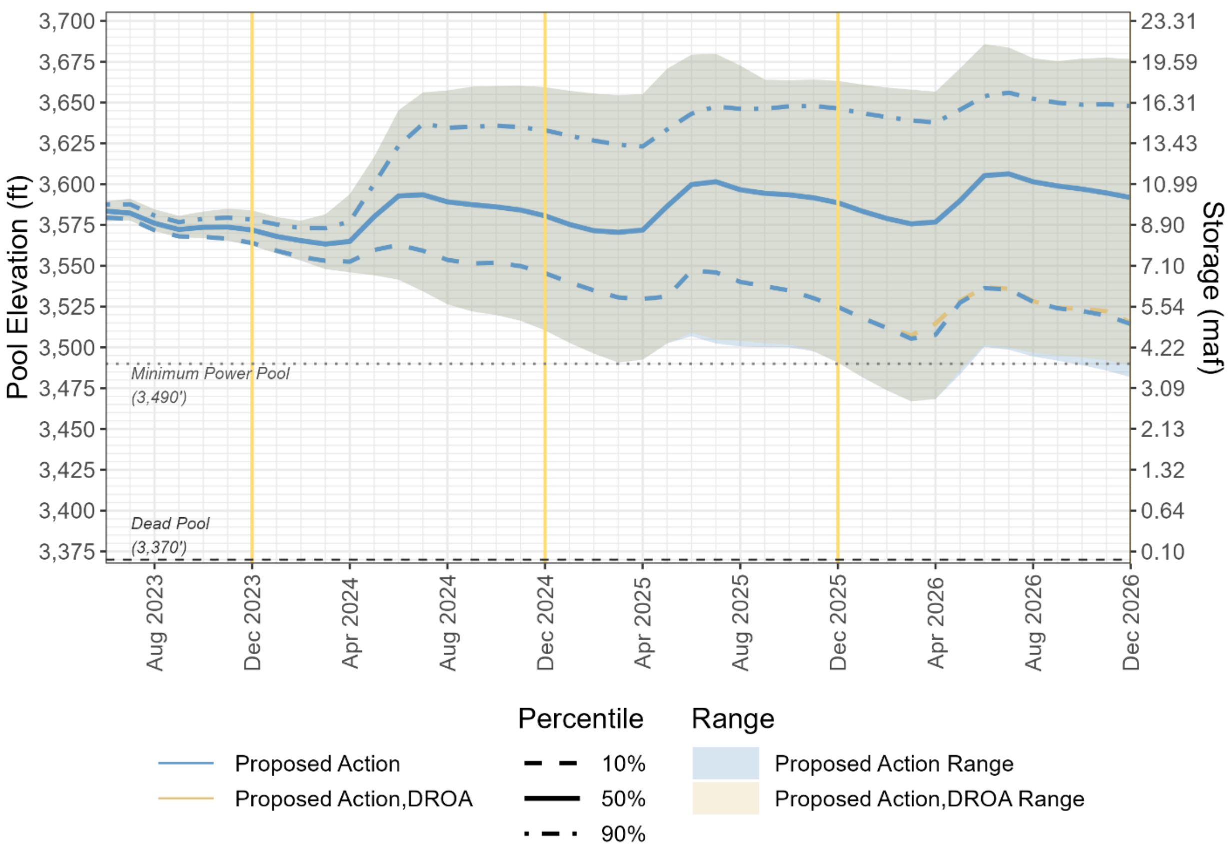
This section compares the Proposed Action with the Proposed Action, DROA. All statistics calculated reflect the hydrology scenarios and other assumptions used in modeling; they are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance. See **Appendix D** for more information about the hydrology scenarios used and modeling assumptions.

F.3.1 Lake Powell

Monthly Pool Elevations

Figure F-1 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Powell elevations for both alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows "clouds" representing the full ranges of modeled elevations for the alternatives through 2026.

Figure F-1
Lake Powell End-of-Month Pool Elevations



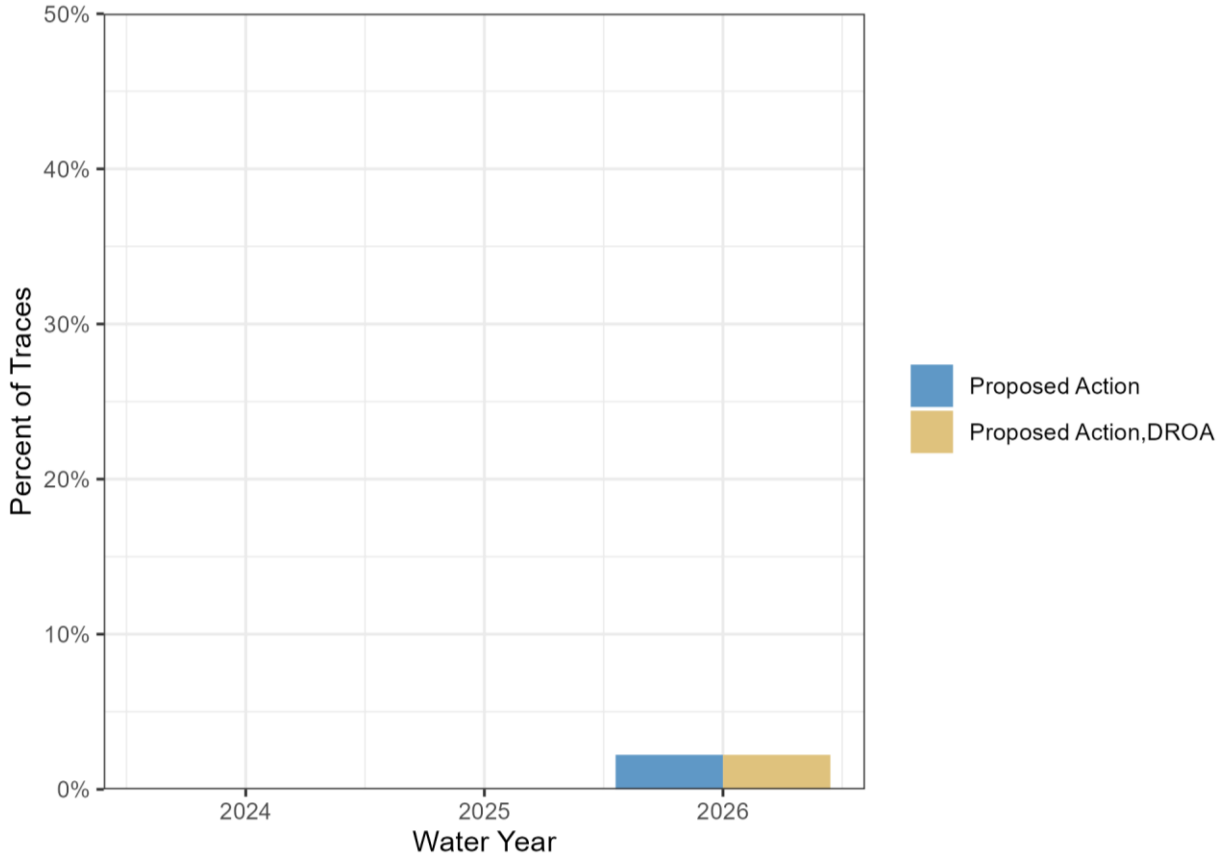
The median, 90th percentile, and highest modeled Lake Powell elevations in **Figure F-1** are exactly the same for the Proposed Action and the Proposed Action, DROA. The 10th percentile and minimum modeled pool elevations show slight differences as the pool elevations drop to 3,525 feet, which triggers DROA contributions. Modeled DROA releases are triggered in 3 percent of traces in 2025 and 9 percent of traces in 2026. In 2026, the Proposed Action, DROA has a slightly higher pool elevation at the 10th percentile—with a minimum in March 2026 of 3,507 feet compared to 3,505 feet under the Proposed Action—resulting from increased inflow into Lake Powell from modeled DROA releases.

Percentages of Traces below Critical Elevations

Figure F-2 shows the percentage of modeled traces that fall below a Lake Powell elevation of 3,490 feet at any time during a year for 2024 through 2026. Remaining above 3,490 feet is critical to ensuring that Glen Canyon Dam can continue to operate as designed.

Figure F-2 shows the same percentage of traces drop below a Lake Powell pool elevation of 3,490 feet for both alternatives. Under the Proposed Action and Proposed Action, DROA, , 2 percent of traces in 2026 result in the Lake Powell pool elevation dropping below 3,490 feet.

Figure F-2
Lake Powell Minimum Water Year Elevation, Percentage of Traces Less than an Elevation of 3,490 feet

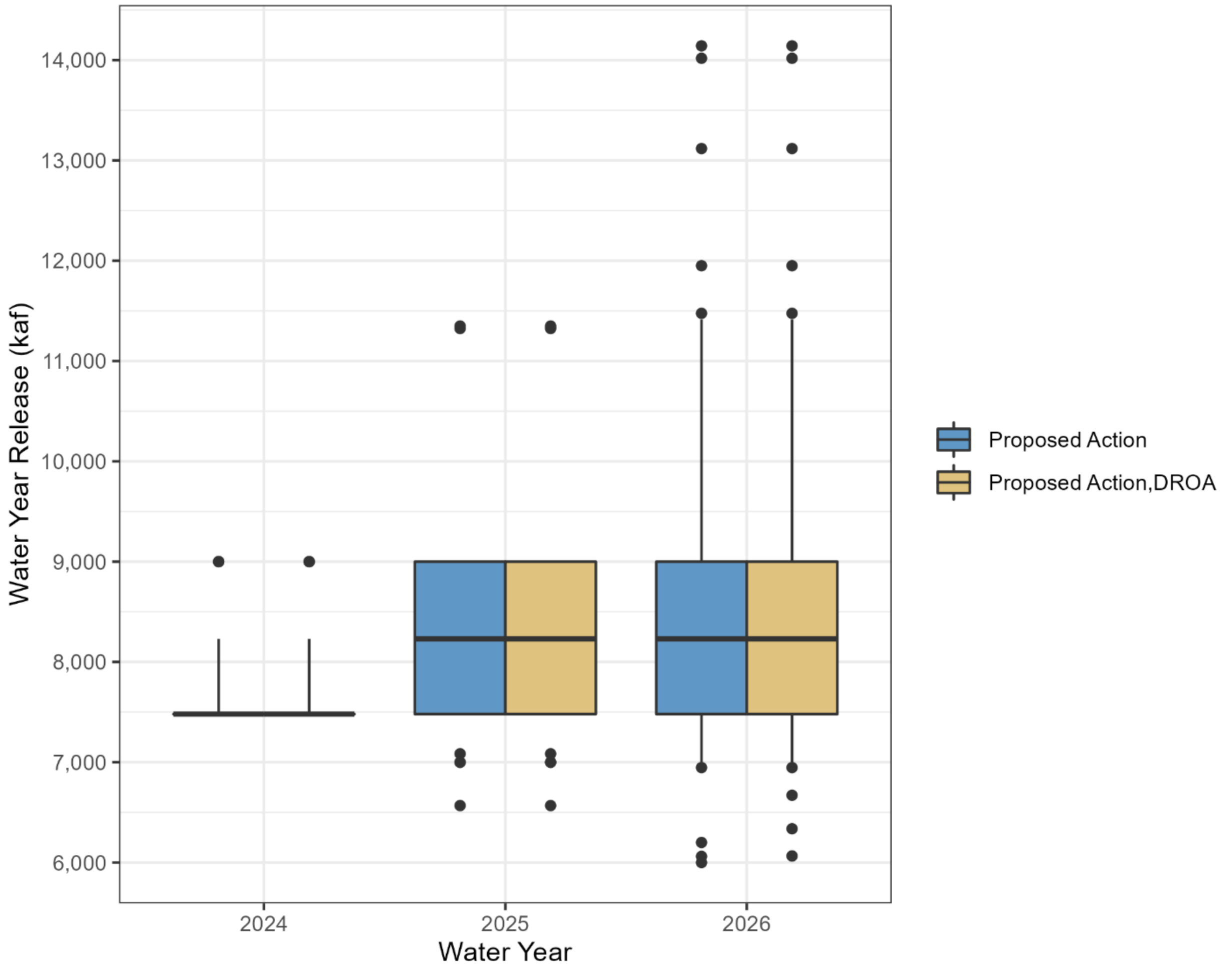


Annual Releases

Figure F-3 shows the distributions of modeled Glen Canyon Dam water year releases in 2024, 2025, and 2026. The top and bottom of each box capture the 25th to 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

The modeled Glen Canyon Dam water year releases shown in **Figure F-3** reflect small differences in Glen Canyon Dam's annual release that result from potential DROA releases from the Upper Basin Upper Initial Units. The releases for 2024 and 2025 are the same, reflecting that DROA releases do not impact Glen Canyon Dam releases during these years. In 2026, when Glen Canyon Dam releases were reduced below 7.0 maf to protect 3,500 feet, the lowest 5 percent of releases were affected by potential DROA contributions. In these modeled traces, extra inflows to Lake Powell from potential DROA contributions slightly increased Lake Powell's storage, allowing for more water to be released.

Figure F-3
Glen Canyon Dam Water Year Release



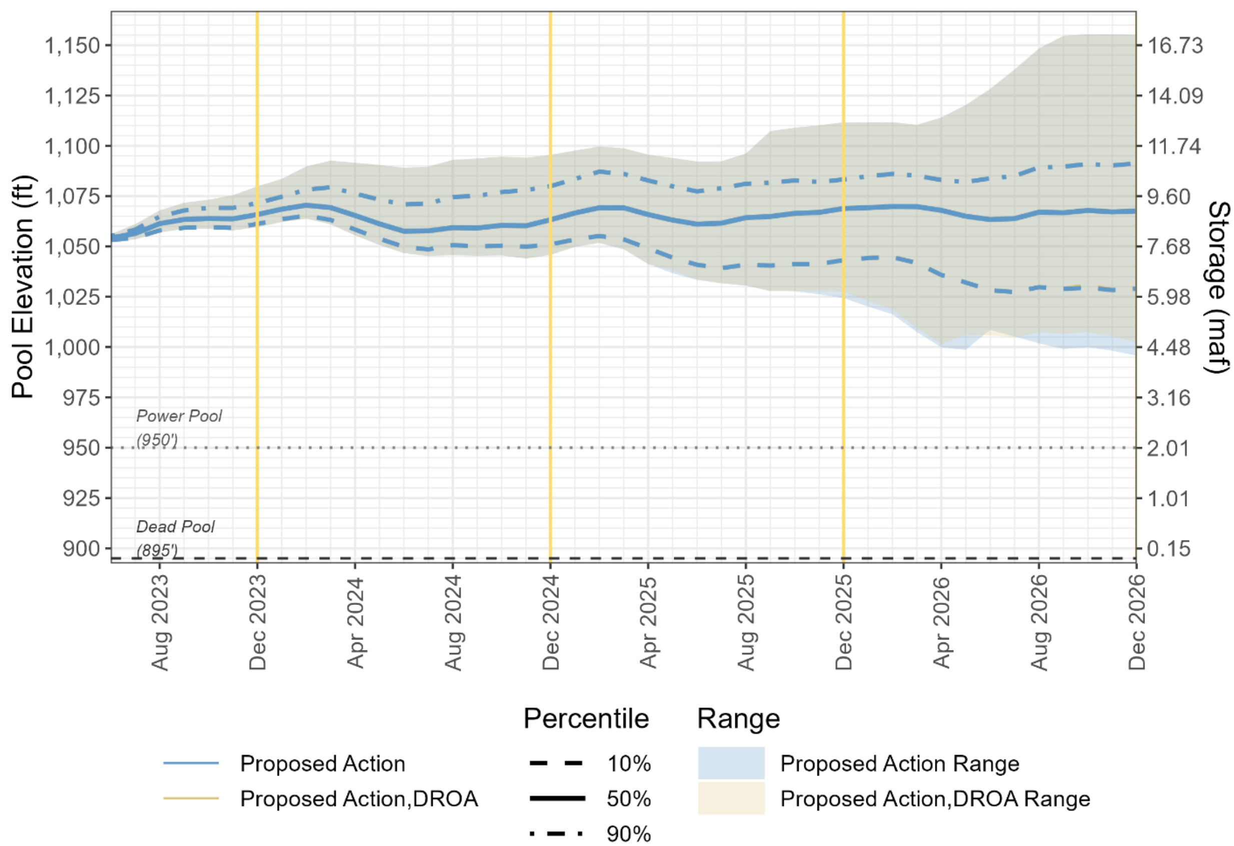
F.3.2 Lake Mead

Monthly Pool Elevations

Figure F-4 presents a comparison of the 10th, 50th, and 90th percentiles of modeled Lake Mead elevations for all alternatives as dashed, solid, and dash-dotted lines, respectively. It also shows clouds representing the full ranges of modeled elevations for the alternatives through 2026.

In **Figure F-4**, the only differences between the modeled Lake Mead elevation occur at the lower bound or minimum pool elevation starting in water year 2026. The Proposed Action, DROA pool elevations are slightly higher than those for the Proposed Action by 7 feet at the end of 2026; this is due to changes in Glen Canyon Dam's release.

Figure F-4
Lake Mead End-of-Month Pool Elevations

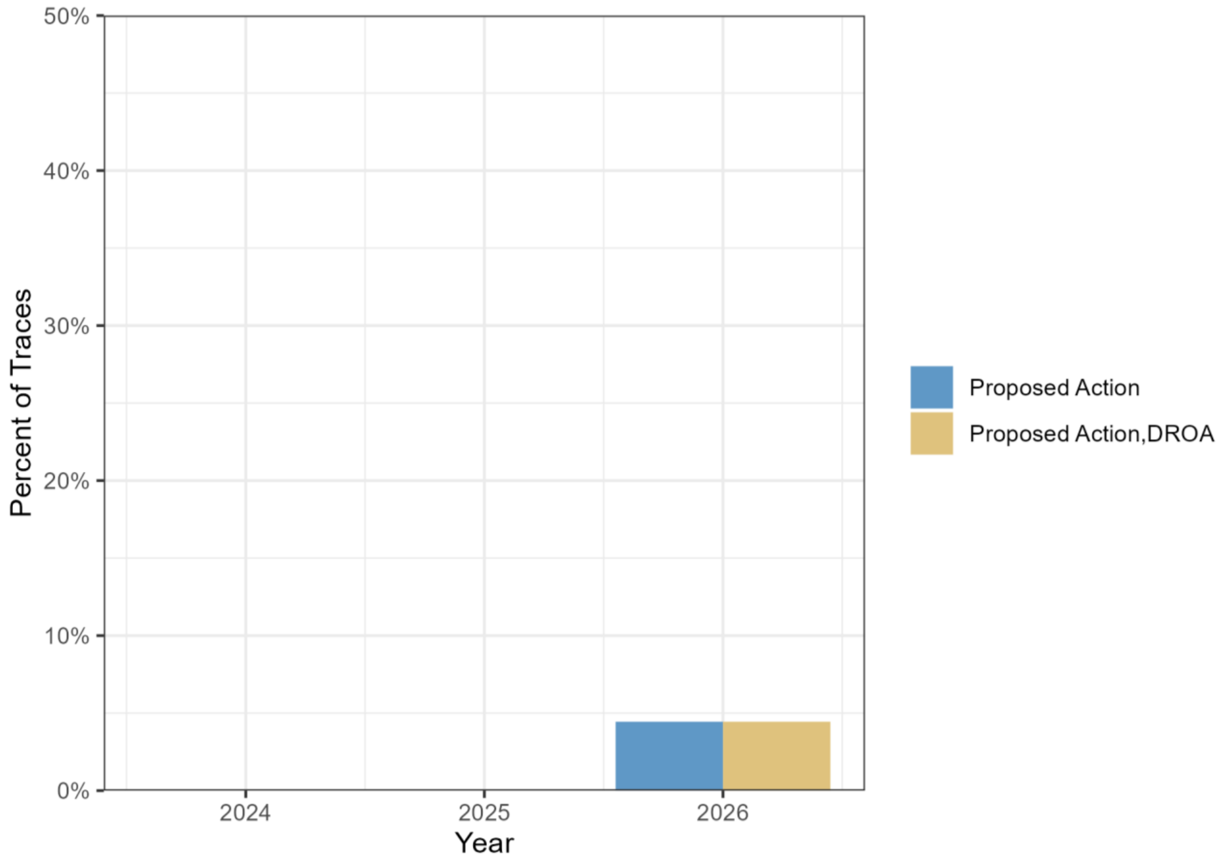


Percentages of Traces below Critical Elevations

Figure F-5 shows the percentage of modeled traces that fall below a Lake Mead elevation of 1,000 feet at any time during a year for the period of analysis. An elevation of 1,020 feet was identified as a critical elevation in the 2019 DCP.

In **Figure F-5**, the Proposed Action and Proposed Action, DROA have no modeled traces falling below a Lake Mead elevation of 1,020 feet in 2024 and 2025. In 2026, both alternatives show 4 percent of traces falling below 1,020 feet; this shows that DROA releases do not affect the percentage of traces dropping below 1,020 feet at Lake Mead.

Figure F-5
Lake Mead Minimum Calendar Year Elevation, Percentage of Traces Less than Elevation of 1,020 feet

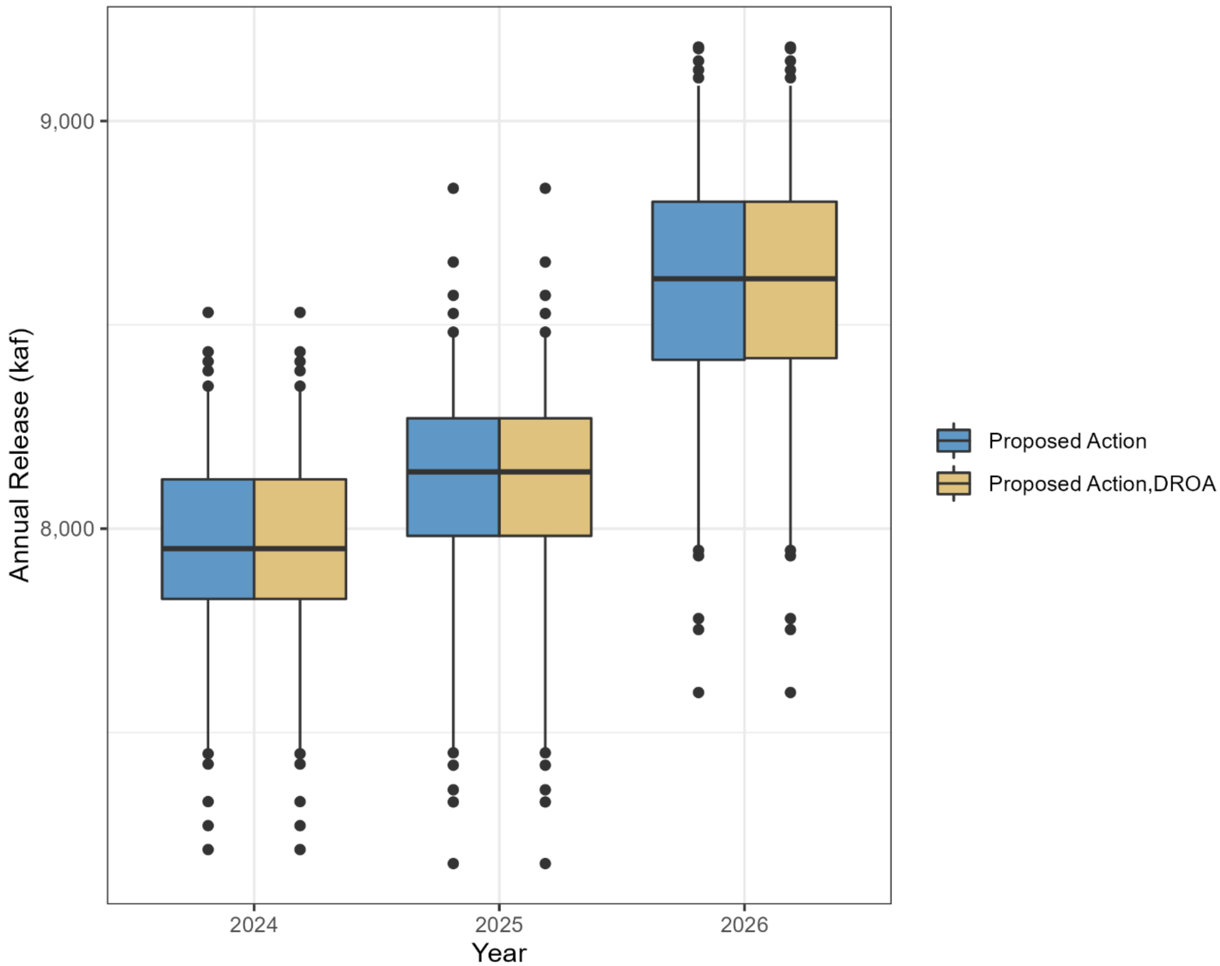


Annual Releases

Figure F-6 shows the distributions of modeled annual releases from Hoover Dam in 2024, 2025, and 2026. The top and bottom of each box capture the 25th to 75th percentile, respectively, of the modeled elevations. The median is the mid-line of the box, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure F-6 shows that modeled releases from Hoover Dam in 2024 to 2025 are the same. In 2026, there are some minor differences in Lake Mead's release. Due to slightly increased Glen Canyon Dam releases resulting from DROA contributions, 2 percent of modeled traces result in lower shortage and DCP contributions in 2026.

Figure F-6
Hoover Dam Calendar Year Release



F.4 Summary

The potential DROA contributions have a minimal impact on Lake Powell and Lake Mead operations, except under the driest modeled traces. In the driest traces, which reduce Glen Canyon Dam's releases below 7.0 maf to protect 3,500 feet, the potential DROA contributions increase Lake Powell pool elevations and releases from Glen Canyon Dam compared to the Proposed Action. At Lake Mead, the Proposed Action, DROA has slightly higher pool elevations for traces projecting the minimum Lake Mead pool elevations. This affects the shortage tier and DCP contributions in 2026; 2 percent of traces have lower reductions resulting from increased releases from Glen Canyon Dam.

Attachment F-1

CRMMS Modeling Assumptions

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Attachment F-1. CRMMS Modeling Assumptions

This attachment describes the CRMMS modeling assumptions for potential DROA contributions.

F-1.1 Potential DROA Contribution Assumptions

CRMMS includes modeling assumptions for potential DROA contributions to Lake Powell for DROA Years 2024 through 2026 (that is, May 2024 through the end of the simulation). Potential DROA contributions range from zero to 500,000 af per DROA Year when Lake Powell is projected to be below 3,525 feet at the end of the operating year, depending on the water available for potential DROA contributions from Flaming Gorge, Navajo, and Blue Mesa Reservoirs. Potential DROA contributions are distributed proportionally across Flaming Gorge, Navajo, and Blue Mesa Reservoirs based on each reservoir's storage above key reservoir elevation targets.

In CRMMS, the potential DROA contribution is calculated in August of run cycle 4. The rules are a higher priority than the Lake Powell operations; therefore, they solve after the Lake Powell operating tier and operating year releases have been calculated. The potential DROA contributions are only assumed to occur if Lake Powell is projected to be below 3,525 feet during Lake Powell's initial calculation in the Lower Elevation Balancing Tier. The potential DROA contributions' rules then distribute up to an additional 500,000-af release from Flaming Gorge, Blue Mesa, and Navajo Reservoirs.

To determine the portion of the 500,000-af additional release applied to Flaming Gorge, Blue Mesa, and Navajo Reservoirs, the available storage that can be released from all three reservoirs is calculated. For Flaming Gorge Reservoir, the storage available for a DROA contribution is calculated by taking the difference between the projected storage at the end of the DROA year (that is, April in the following operating year) and the storage at 5,890 feet (19 feet above minimum power pool). For Blue Mesa Reservoir, the storage available for a DROA contribution is calculated by taking the difference between the storage at the end of December of the following year and the storage at 7,412 feet (19 feet above minimum power pool). For Navajo Reservoir, the storage available for a DROA contribution is calculated by taking the difference between the projected storage at the end of September of the following year and the storage at 6,050 feet (60 feet above the Navajo Indian Irrigation Project diversion intake).

The total available storage for DROA contributions is calculated as the sum of each reservoir's available storage volume. If the total available storage for DROA contributions is less than 500,000 af, then the potential DROA contribution is set to the volume of available storage. Each reservoir's storage available for a DROA contribution is constrained to be nonnegative.

The percentages of the potential DROA contributions from Flaming Gorge, Blue Mesa, and Navajo Reservoirs are calculated as:

$$PotentialContributionPercent_i = \frac{AvailableStorage_i}{\sum_i AvailableStorage_i}$$

where i is each reservoir (Flaming Gorge, Blue Mesa, and Navajo).

The potential DROA contributions are released over the DROA Year using the monthly proportions in **Table F-1-1**. These monthly distributions are based off the monthly distribution of DROA releases in past planned DROA releases (that is, DROA Year 2022 for Flaming Gorge Reservoir and 2021 for Blue Mesa and Navajo Reservoirs).

Table F-1-1
Monthly Distribution of Potential DROA Contributions

Month	Flaming Gorge Reservoir	Blue Mesa Reservoir	Navajo Reservoir
	Percent	Percent	Percent
January	8.58	0.00	0.00
February	7.78	0.00	0.00
March	8.58	0.00	0.00
April	4.79	0.00	0.00
May	21.56	0.00	0.00
June	2.40	0.00	0.00
July	3.59	0.00	0.00
August	9.78	38.89	0.00
September	9.58	50.00	0.00
October	7.58	11.11	0.00
November	7.19	0.00	50.00
December	8.59	0.00	50.00

In the calculation of monthly releases for the DROA year, the additional DROA contribution is added to the reservoir's current release. The new projected release is then constrained to ensure it would not cause the reservoir to drop below dead pool or below the Navajo Indian Irrigation Project diversion at Navajo. Morrow Point and Crystal Reservoirs are then resolved for the DROA Year since their inflow has been adjusted due to the potential DROA contributions. These reservoirs adjust their outflow to ensure they stay at their storage targets, passing the DROA contribution from Blue Mesa Reservoir.

Appendix G

Table of Sensitive Species

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Appendix G. Table of Sensitive Species

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Fish								
Bluehead sucker	*Catostomus discobolus*	BLM AZ BLM UT	—	X	X	X	—	Yes
Bonytail	*Gila elegans*	Endangered BLM NV	X (rare, stocked)	—	—	X (stocked)	—	Yes
Colorado pikeminnow	*Ptychocheilus lucius*	Endangered	X	—	—	—	—	Yes
Desert pupfish	*Cyprinodon macularis*	Endangered	—	—	—	—	—	No
Desert sucker	*Catostomus clarkii*	BLM AZ	—	—	—	X	—	Found only in tributaries—not in the project area
Flannelmouth sucker	*Catostomus latipinnis*	BLM AZ BLM UT	X	X	X	X	—	Yes
Gila longfin dace	*Agosia chrysogaster chrysogaster*	BLM AZ	—	—	—	X	—	No; found in tributaries, not in the project area
Humpback chub	*Gila cypha*	Threatened	—	X	X	—	—	Yes; present in inflow to Lake Mead
Pahrump poolfish	*Empetrichthys latos*	BLM NV	—	—	—	—	—	Not present in the project area
Razorback sucker	*Xyrauchen texanus*	Endangered BLM NV	X	X	X	X	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Roundtail chub	*Gila robusta*	BLM AZ BLM UT	X	X	X	X	—	Not in the project area; does not occur downstream of Mesquite, Nevada
Sonora sucker	*Catostomus insignis*	—	—	—	—	X	—	No; found in tributaries, not in the project area
Speckled dace	*Rhinichthys osculus*	BLM AZ	X	X	X	X	—	No; found in tributaries
Virgin spinedace	*Lepidomeda mollispinis*	BLM Sensitive	—	—	X	—	—	Not in the project area; this species does not occur downstream of Mesquite, Nevada
Woundfin	*Plagopterus argentissimus*	—	—	—	X	—	—	Not present in the project area; does not occur downstream of Mesquite, Nevada
Birds								
American peregrine falcon	*Falco peregrinus*	BLM AZ BLM NV	—	X	X	X	X	No. This species forages over diverse habitat types, and it nests on exposed cliffs and buildings, which will not be impacted by any alternative.
American white pelican	*Pelicanus erythrorhynchos*	BLM UT	X	—	—	X	X	Yes
Arizona Bell's vireo	*Vireo bellii arizonae*	BLM CA	—	—	—	X	—	Yes
Arizona grasshopper sparrow	*Ammodramus savannarum ammolegus*	BLM AZ	—	X	X	X	—	No. This species utilizes dry upland grassland habitat for foraging and nesting, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Bald eagle	*Haliaeetus leucocephalus*	BLM AZ BLM NV BLM UT	X	X	X	X	—	Yes
Bank swallow	*Riparia riparia*	BLM CA	—	—	—	X	—	No. This species is a migrant that does not breed in the analysis area. It would not be impacted by any alternative.
Bendire's thrasher	*Toxostoma bendirei*	BLM CA	—	—	—	X	—	No. This species utilizes dry grassland and desert habitat for foraging and nesting, which will not be impacted by any alternative.
Black swift	*Cypseloides niger*	BLM UT	X	—	—	—	—	No. This species forages over diverse habitat types. It nests behind waterfalls, which will not be impacted by any alternative.
Burrowing owl	*Athene cunicularia*	BLM UT BLM NV	X	—	X	X	X	No. This species utilizes dry grassland and desert habitat for foraging and nesting, which will not be impacted by any alternative.
Cactus ferruginous pygmy owl	*Glaucidium brasilianum cactorum*	BLM AZ	—	X	X	X	—	No. This species utilizes desert habitat with cacti for foraging and nesting; these will not be impacted by any alternative.
California black rail	*Laterallus jamaicensis coturniculus*	BLM AZ BLM CA	—	—	—	X	X	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
California brown pelican	*Pelecanus occidentalis californicus*	BLM CA	—	—	—	X	—	No. This species is rarely detected.
California condor	*Gymnogyps californianus*	BLM AZ	X	X	—	—	—	Yes
Crissal thrasher	*Toxostoma crissale*	BLM CA	—	—	—	X	X	Yes
Elf owl	*Micrathene whitneyi*	BLM CA	—	—	—	X	—	Yes
Ferruginous hawk	*Buteo regalis*	BLM UT	X	—v	—	—	—	No. This species forages over diverse habitat types. It nests on exposed cliffs or solitary trees or infrastructure, which will not be impacted by any alternative.
Gila woodpecker	*Melanerpes uropygialis*	BLM CA	—	—	—	X	—	Yes
Gilded flicker	*Colaptes chrysoides*	BLM AZ BLM CA	—	—	—	X	—	Yes
Golden eagle	*Aquila chrysaetos*	BLM UT BLM AZ	X	X	X	X	—	Yes
Least bittern	*Ixobrychus exilis*	BLM NV	—	—	X	X	X	No. This species is not found in habitat that would be impacted by any alternatives.
LeConte's thrasher	*Toxostoma lecontei*	BLM AZ	—	X	X	X	—	No. This species utilizes dry and desert habitat types for foraging and nesting; these will not be impacted by any alternative.
Lucy's warbler	*Vermivora luciae*	BLM CA	—	—	—	X	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Mountain plover	*Charadrius montanus*	BLM CA	—	—	—	X	X	Yes
Northern goshawk	*Accipiter gentilis*	BLM AZ	—	X	—	—	—	No. This species utilizes upland forested habitat with high canopy cover for foraging and nesting; this habitat will not be impacted by any alternative.
Phainopepla	*Phainopepla nitens*	BLM NV	—	—	X	X	—	No. This species utilizes habitat that would not be impacted by any alternative.
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered BLM AZ BLM CA BLM NV	X	—	X	X	—	Yes
Swainson's hawk	*Buteo swainsoni*	BLM CA	—	—	—	X	—	No. This species forages over diverse habitat types, which will not be impacted by any alternative.
Tricolored blackbird	*Agelaius tricolor*	BLM CA	—	—	—	X	—	Yes
Western snowy plover	*Charadrius nivosus nivosus*	BLM NV	—	—	X	—	—	No. This species is not present in any habitat that would be impacted by any of the alternatives.
Western yellow-billed cuckoo	*Coccyzus americanus*	Threatened BLM AZ BLM CA BLM NV	X	X	X	X	—	Yes
White-tailed kite	*Elanus leucurus*	BLM CA	—	—	—	X	X	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Yuma Ridgeway's rail	*Rallus obsoletus yumaniensis*	Endangered BLM AZ BLM CA BLM NV	—	X	X	X	X	Yes
Mammals								
Allen's big-eared bat	*Idionycteris phyllotis*	BLM AZ BLM NV BLM UT	X	—	X	—	—	Yes
Allen's lappet-browed bat	*Idionycteris phyllotis*	BLM AZ	—	X	—	—	—	Yes
Arizona myotis	*Myotis occultus*	BLM AZ	—	X	X	X	—	Yes
Big brown bat	*Eptesicus fuscus*	BLM NV	X	X	X	X	—	Yes
Big free-tailed bat	*Nyctinomops macrotis*	BLM NV	—	—	X	X	—	Yes
California leaf-nosed bat	*Macrotus californicus*	BLM AZ BLM NV	—	—	X	X	—	Yes
California myotis	*Myotis californicus*	BLM NV	X	X	X	X	—	Yes
Canyon bat	*Parastrellus hesperus*	BLM NV	X	X	X	X	—	Yes
Cave myotis	*Myotis velifer*	BLM AZ BLM NV	X	X	X	X	—	Yes
Desert bighorn sheep	*Ovis canadensis nelsoni*	BLM CA	X	X	X	X	—	Yes
Fringed myotis	*Myotis thysanodes*	BLM UT BLM NV	X	—	X	—	—	Yes
Hoary bat	*Lasiurus cinereus*	BLM NV	—	—	X	X	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Houserock Valley chisel-toothed kangaroo rat	*Dipodomys microps leucotis*	BLM AZ	—	X	—	—	—	No. This species utilizes dry and desert habitat types for foraging; these will not be impacted by any alternative.
Kit fox	*Vulpes macrotis*	BLM UT	X	—	—	—	—	No. This species utilizes dry and desert habitat types for foraging and denning; these will not be impacted by any alternative.
Long-eared myotis	*Myotis evotis*	BLM CA	—	—	—	X	—	Yes
Mexican free-tailed bat	*Tadarida brasiliensis*	BLM NV	X	X	X	X	—	Yes
Mexican long-tongued bat	*Choeronycteris mexicana*	BLM AZ	—	X	—	X	—	Yes
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	BLM AZ	X	X	X	X	—	Yes
Pallid bat	*Antrozous pallidus*	BLM NV	X	X	X	X	—	Yes
Palm Springs pocket mouse	*Perognathus longimembris bangsi*	BLM CA	—	—	—	X	—	No. This species utilizes dry and desert habitat types for foraging; these will not be impacted by any alternative.
Palm Springs round-tailed ground squirrel	*Xerospermophilus tereticaudus chlorus*	BLM CA	—	—	—	X	—	No. Not in the project area.
Silver-haired bat	*Lasionycteris noctivagans*	BLM NV	X	X	X	X	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Spotted bat	*Euderma maculatum*	BLM AZ BLM NV BLM UT	—	X	—	X	—	Yes
Townsend's big-eared bat	*Corynorhinus townsendii*	BLM AZ BLM CA BLM NV BLM UT	X	—	X	X	—	Yes
Western mastiff bat	*Eumops perotis*	BLM NV	—	X	X	X	—	Yes
Western red bat	*Lasiurus blossevillii*	BLM NV BLM UT	—	—	X	X	—	Yes
Western small-footed myotis	*Myotis ciliolabrum*	BLM CA BLM NV	—	—	X	X	—	Yes
Yuma myotis	*Myotis yumanensis*	BLM CA BLM NV	X	X	X	X	—	Yes
Reptiles and Amphibians								
Arizona striped whiptail	*Aspidoscelis arizonae*	BLM AZ	—	X	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Arizona toad	*Anaxyrus microscaphus*	BLM UT BLM NV	—	—	—	X	—	Yes
Banded Gila monster	*Heloderma suspectum cinctum*	BLM NV	—	—	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Coast horned lizard	*Phrynosoma blainvillii*	BLM CA	—	—	—	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Coronado skink	*Plestiodon skiltonianus interparietalis*	BLM CA	—	—	—	X	—	No. This specie's range is outside of areas impacted by any alternatives.
Couch's spadefoot	*Scaphiopus couchii*	BLM CA	—	—	—	X	—	Yes
Desert box turtle	*Terrapene ornata luteola*	BLM AZ	—	X	X	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Desert tortoise	*Gopherus agassizii*	BLM NV	—	X	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Flat-tailed horned lizard	*Phrynosoma mcallii*	BLM AZ	—	—	—	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Foothill yellow-legged frog (south coast DPS)	*Rana boylii*	BLM CA	—	—	—	X	—	No. This specie's range is outside of areas impacted by any alternatives.
Lowland burrowing treefrog	*Smilisca fodiens*	BLM AZ	—	X	X	X	—	No. This specie's range is outside of areas impacted by any alternatives.
Lowland leopard frog	*Rana yavapaiensis*	BLM AZ BLM CA	—	—	X	X	—	Yes
Mohave fringe-toed lizard	*Uma scoparia*	BLM AZ	—	X	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Northern leopard frog	*Lithobates [=Rana] pipens*	BLM AZ	X	X	—	—	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Northern Mexican gartersnake	*Thamnophis eques megalops*	Threatened	—	—	—	X	—	Yes
Relict leopard frog	*Rana onca*	BLM AZ BLM NV	—	—	X	X	—	Yes
Sinaloan narrow-mouthed toad	*Gastrophryne mazatlanensis*	BLM AZ	—	X	X	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Sonoran green toad	*Bufo retiformis*	BLM AZ	—	X	X	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Two-striped Gartersnake	*Thamnophis hammondii*	BLM CA	—	—	—	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Western pond turtle	*Emys marmorata*	BLM CA	—	—	—	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Western spadefoot	*Spea hammondii*	BLM CA	—	—	—	X	—	No. This species does not occur in habitat that would be impacted by any alternative.
Yuman desert fringe-toed lizard	*Uma rufopunctata*	BLM AZ	—	X	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Invertebrates								
Apache springsnail	*Pyrgulopsis arizonae*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Gila tyronia	*Tryonia gilae*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Grand wash springsnail	*Pyrgulopsis bacchus*	BLM NV	—	X	X	X	—	No. This species is only found in a watershed feeding Lake Mead; this watershed will not be influenced by project operations.
Kingman springsnail	*Pyrgulopsis conica*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
MacNeill's sooty-winged skipper	*Hesperopsis gracielae*	BLM NV	—	—	X	X	—	No. This species utilizes upland habitat, which will not be impacted by any alternative.
Mojave gypsum bee	*Andrena balsamorhizae*	BLM NV	—	—	X	—	—	No. This species is restricted to areas with its host plant, the sunray, which is an upland plant species.
Mojave poppy bee	*Perdita meconis*	BLM NV	—	—	X	—	—	Yes
Monarch butterfly	*Danaus plexippus plexippus*	BLM NV	—	X	X	X	—	Yes
Sonoran talussnail	*Sonorella magdalenensis*	BLM AZ	—	X	X	X	—	No. This species utilizes upland talus and rocky slopes, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Thorne's hairstreak	*Callophrys thornei*	BLM CA	—	—	—	X	—	No. This species relies on tecate cypress, which will not be impacted by any alternative.
Plants								
Alkali mariposa lily	*Calochortus striatus*	BLM NV	—	—	X	—	—	No. This species' range is outside of areas impacted by any alternatives.
Aravaipa sage	*Salvia amissa*	BLM AZ	—	X	X	X	—	No. This species grows in habitat with silt or sand in dry canyon bottoms; this habitat will not be impacted by any alternative.
Aravaipa woodfern	*Thelypteris puberula* var. *sonorensis*	BLM AZ	—	X	—	—	—	No. This species is only known from locations that will not be impacted by any alternatives.
Arizona eryngo	*Eryngium sparganophyllum*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Arizona Sonora rosewood	*Vauquelinia californica* ssp. *sonorensis*	BLM AZ	—	X	X	X	—	No. This species grows in upland desert habitat, which will not be impacted by any alternative.
Bartram stonecrop	*Graptopetalum bartramii*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.

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			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Beaver dam breadroot	*Pediomelum castoreum*	BLM NV	—	—	X	—	—	No. This species grows in upland desert habitat, which will not be impacted by any alternative.
Blue diamond cholla	*Cylindropuntia X multigeniculata*	BLM NV	—	—	X	—	—	No. This species grows in dry gypsiferous limestone, which will not be impacted by any alternative.
Blue sand lily	*Triteleiopsis palmeri*	BLM AZ	—	X	X	X	—	No. This species grows on sand dunes, which will not be impacted by any alternative.
California flannelbush	*Fremontodendron californicum*	BLM AZ	—	X	X	X	—	No. This species grows in well-draining rocky hillsides and ridges, which will not be impacted by any alternative.
California screw moss	*Tortula californica*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
Chaparral sand-verbena	*Abronia villosa var. aurita*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Cochise sedge	*Carex ultra*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Coulter's goldfields	*Lasthenia glabrata ssp. coulteri*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Deane's milkvetch	*Astragalus deanei*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Decumbent goldenbush	*Isocoma menziesii var. decumbens*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Delicate clarkia	*Clarkia delicata*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Dunn's mariposa lily	*Calochortus dunnii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Fish creek fleabane	*Erigeron piscaticus*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Felt-leaved monardella	*Monardella hypoleuca ssp. lanata*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gander's pitcher sage	*Lepechinia ganderi*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gander's ragwort	*Packera ganderi*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Gold butte moss	*Ceratodon purpureus*	BLM NV	—	—	X	—	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Grand Canyon rose	*Rosa stellata* var. *abyssa*	BLM AZ	—	X	—	—	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Harrison's barberry	*Berberis harrisoniana*	BLM AZ	—	X	X	X	—	No. This species grows on talus slopes on and along canyon sides, which will not be impacted by any alternative.
Harwood's eriastrum	*Eriastrum harwoodii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Hohokam agave	*Agave murpheyi*	BLM AZ	—	X	X	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Horn's milk-vetch	*Astragalus hornii var. hornii*	BLM CA	—	—	—	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Huachuca golden aster	*Heterotheca rutteri*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Lace-leaved rockdaisy	*Perityle ambrosiifolia*	BLM AZ	—	X	X	X	—	No. This species is only known from a few locations that will not be influenced by project operations.
Lakeside ceanothus	*Ceanothus cyaneus*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Las Vegas bearpoppy	*Arctomecon californica*	BLM NV	—	—	X	—	—	No. This species grows in upland desert in gypsum soils, which will not be impacted by any alternative
Las Vegas buckwheat	*Eriogonum corymbosum* var. *nilesii*	BLM NV	—	—	X	—	—	No. This species grows in upland gypsum soils, which will not be impacted by any alternative.
Latimer's woodland-gilia	*Saltugilia latimeri*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Lincoln rockcress	*Boechera lincolnensis*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Little San Bernardino Mtns. linanthus	*Linanthus maculatus ssp. maculatus*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Long-spined spineflower	*Chorizanthe polygonoides var. longispina*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Marble Canyon milkvetch	*Astragalus cremnophylax* var. *hevronii*	BLM AZ	—	X	—	—	—	No. This species grows along canyon edges, which will not be impacted by any alternative.
Mecca-aster	*Xylorhiza cognata*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Mojave indigo bush	*Psorothamnus arborescens*	BLM AZ	—	X	—	—	—	No. This species grows in upland desert, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Mojave tarplant	*Deinandra mohavensis*	BLM CA	—	—	—	X	—	Yes
Mokiak milkvetch	*Astragalus mokiacensis*	BLM NV	—	—	X	—	—	Yes
Mount Trumbull beardtongue	*Penstemon distans*	BLM AZ	—	X	—	—	—	No. This species grows in upland forest/woodland habitat, which will not be impacted by any alternative.
Nuttall's scrub oak	*Quercus dumosa*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Oil neststraw	*Stylocline citroleum*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Orcutt's brodiaea	*Brodiaea orcuttii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Orocopia Mountains spurge	*Euphorbia jaegeri*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Otay manzanita	*Arctostaphylos otayensis*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Otay Mountain ceanothus	*Ceanothus otayensis*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Parish's meadowfern	*Limnanthes alba ssp. parishii*	BLM CA	—	—	—	X	—	Yes

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Parish's phacelia	*Phacelia parryi*	BLM NV	—	—	X	—	—	No. This specie's range is outside of areas impacted by any alternatives.
Parry's spineflower	*Chorizanthe parryi var. parryi*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Parry's tetracoccus	*Tetracoccus dioicus*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Pima Indian mallow	*Abutilono parishii*	BLM AZ	—	X	X	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Pinto beardtongue	*Penstemon bicolor* ssp. *roseus*	BLM AZ	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Polished blazing star	*Mentzaelia laevicaulis*	BLM NV	—	—	X	—	—	No. This species grows in upland sandy and rocky habitat, which will not be impacted by any alternative.
Rainbow manzanita	*Arctostaphylos rainbowensis*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Ramona horkelia	*Horkelia truncata*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Reveal's buckwheat	*Eriogonum contiguum*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.

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			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Robinson's monardella	*Monardella robisonii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Rosy twotone beardtongue	*Penstemon bicolor* ssp. *roseus*	BLM NV	—	—	X	—	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Salt marsh bird's-beak	*Chloropyron maritimum ssp. maritimum*	BLM CA	—	—	—	X	—	No. This species grows in coastal salt marsh habitat, which will not be impacted by any alternative.
San Bernadino milk-vetch	*San Bernardino milk-vetch*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego goldenstar	*Bloomeria clevelandii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego gumplant	*Grindelia hallii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
San Diego milk-vetch	*Astragalus oocarpus*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Sandfood	*Pholisma sonorae*	BLM AZ	—	X	X	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
San Jacinto mariposa-lily	*Calochortus palmeri var. munzii*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.

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			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
San Luis Obispo sedge	*Carex obispoensis*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
San Miguel savory	*Clinopodium chandleri*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
Sanford's arrowhead	*Sagittaria sanfordii*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
Santa Lucia dwarf rush	*Juncus luciensis*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
Scaly sandplant	*Pholisma arenarium*	BLM AZ	—	X	X	X	—	No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.
Shevock's copper moss	*Mielichhoferia shevockii*	BLM CA	—	—	—	X	—	No. This species' range is outside of areas impacted by any alternatives.
Siler fishhook cactus	*Sclerocactus sileri*	BLM AZ	—	X	—	—	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Silverleaf sunray	*Enceliopsis argophylla*	BLM AZ BLM NV	—	X	X	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Small wirelettuce	*Stephanomeria exigua* ssp. *exigua*	BLM AZ	—	X	X	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Snake cholla	*Cylindropuntia californica var. californica*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Spring Mountain milkvetch	*Astragalus remotus*	BLM NV	—	—	X	—	—	No. This species grows in upland talus and rocky slopes, which will not be impacted by any alternative.
Sticky buckwheat	*Eriogonum viscidulum*	BLM AZ BLM NV	—	—	X	—	—	Yes
Sticky dudleya	*Dudleya viscida*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Sticky ringstem	*Anulocaulis leiosolenus*	BLM NV	—	—	X	—	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Summer holly	*Comarostaphylis diversifolia ssp. diversifolia*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Tecate cypress	*Hesperocyparis forbesii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Tecate tarplant	*Deinandra floribunda*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Threecorner milkvetch	*Astragalus geyeri* var. *triquetrus*	BLM NV	—	—	X	—	—	No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.

Common Name	Scientific Name	Listing Status	Location					Potential Species Impacts?
			Lake Powell	Glen Canyon Dam to Lake Mead	Lake Mead	Hoover Dam to the SIB	Salton Sea	
Tumamoc globeberry	*Tumamoca macdougalii*	BLM AZ	—	X	X	X	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Variegated dudleya	*Dudleya variegata*	BLM CA	—	—	—	X	—	Yes
White bearpoppy	*Arctomecon merriamii*	BLM NV	—	—	X	—	—	No. This species grows in upland desert, which will not be impacted by any alternative.
Whitemargined beardtongue	*Penstemon albomarginatus*	BLM NV	—	—	X	—	—	No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.
White-bracted spineflower	*Chorizanthe xanti var. leucotheca*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Wiggins' croton	*Croton wigginsii*	BLM CA	—	—	—	X	—	No. This species grows in upland sand and dune habitat, which will not be impacted by any alternative.
Yellow twotone beardtongue	*Penstemon bicolor* ssp. *bicolor*	BLM NV	—	—	X	—	—	No. This species grows in upland habitat, which will not be impacted by any alternative.
Yucaipa onion	*Allium marvinii*	BLM CA	—	—	—	X	—	No. This species grows in upland habitat, which will not be impacted by any alternative.